

**64TH** INTERNATIONAL  
CONFERENCE  
FOR STUDENTS OF  
**PHYSICS AND  
NATURAL SCIENCES**



# OPEN READINGS

## 2021

MARCH 16-19 VILNIUS LITHUANIA

# ABSTRACT BOOK

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Dear participants,

Last year, as we were writing the opening word for “Open Readings 2020”, we still had hopes to see you all in Vilnius. That hope remains for next year, and for now we are still happy to meet you all virtually. It’s incredibly exciting to see that so many young scientists are eager to participate and share their work and passion with others.

We hope that you will enjoy this online conference experiment. The oral and poster sessions, the invited speakers’ lectures, the social events all remain. As long as you treat yourself to a cup of coffee during the breaks, hopefully it will feel just as any other “Open Readings” conference before this. And just like science experiments, we hope it will be about adjusting and adapting, and never giving up. We aim to help you find inspiration in the talks by world-class scientists and joy in exchanging ideas with your peers.

Yours sincerely,

“Open Readings” organizing team

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**Mihir Pendharkar**

*Stanford University,*

*USA*

## **TOPOLOGICAL QUANTUM COMPUTING: A MATERIALS PERSPECTIVE**

A quantum computer is theorized to aid in simulating nature quantum mechanically and various approaches to building a quantum computer are actively being pursued. Common to all approaches is the requirement for building a fault tolerance from errors due to external environmental perturbations (noise). Inherent fault tolerance is only native to one approach – topological quantum computation. This approach is based upon Majorana Zero Modes which are quasi-particles with no measurable charge or mass, that are bound to zero-energy. Quantum information is said to be stored non-locally in interactions of MZMs. These MZMs have been predicted to arise at the ends of 1D chain of electrons with strong spin-orbit coupling, when such a chain is transparently coupled to an s-wave superconductor and an external magnetic field is applied along the length of the chain. Signatures of MZMs were first reported in 2012 [1].

This talk will focus on the materials aspects of the challenge of topological quantum computing focusing primarily on exploring new superconductors and semiconductors for use in super-semi hybrid systems. Semiconductors like InAs and InSb when coupled to a superconductor like aluminum (Al), have been claimed to show zero energy end modes reminiscent of MZMs, though further proof is necessary. Increasing spin-orbit interaction in the host semiconductor is one proposed way of increasing topological protection from the environment [2]. InAsSb is one such compound semiconductor and this talk will discuss the growth of 1D nanowires and 2D quantum wells in this material system. On the same lines, increasing the superconducting energy gap is another parallel pathway to increasing topological protection. This talk will discuss the observation of two electron charging in superconducting tin, the first such reported observation after aluminum [3]. As tin offers a larger superconducting gap and higher in-plane critical field than aluminum, it is presented as a robust alternative for next generation super-semi devices. While confirming the observation of MZMs remains an outstanding challenge, exploration of novel superconductor-semiconductor combinations may help find the elusive Majoranas.

[1] V. Mourik, et al., *Science* **336** (6084), pp. 1003-1007 (2012)

[2] J.D. Sau, et al., *Phys. Rev. B* **85**, 064512 (2012)

[3] M. Pendharkar, B. Zhang, H. Wu, A. Zarassi, P. Zhang, et al., arXiv:1912.06071 (2019)



## **Chennupati Jagadish**

*Research School of Physics, Australian National  
University*

*Australia*

### **SEMICONDUCTOR NANOSTRUCTURES FOR OPTOELECTRONICS APPLICATIONS**

Semiconductors have played an important role in the development of information and communications technology, solar cells, solid state lighting. Nanowires are considered as building blocks for the next generation electronics and optoelectronics. In this talk, I will introduce the importance of nanowires and their potential applications and discuss about how these nanowires can be synthesized and how the shape, size and composition of the nanowires influence their structural and optical properties. I will present results on axial and radial heterostructures and how one can engineer the optical properties to obtain high performance lasers, THz detectors, solar cells and to engineer neuronal networks. Future prospects of the semiconductor nanowires will be discussed.



**Klaus-Dieter Kreuer**

*Physical Chemistry of Solids, Max Planck  
Institute for Solid State Research*

*Germany*

## **ENABLING HYDROGEN AS FUTURE ENERGY CARRIER: FROM THE LITHUANIA CRADLE TO WHERE WE ARE TODAY**

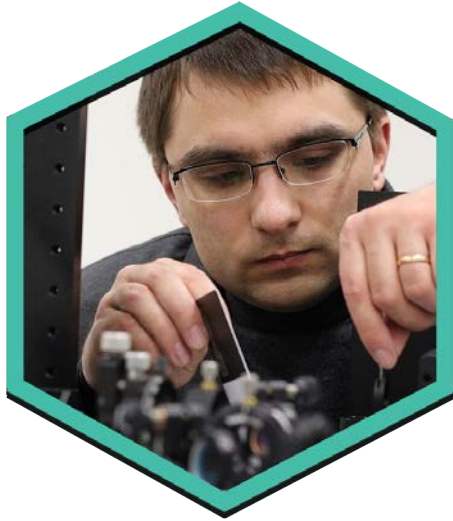
The expected end of the “oil age” (for environmental reasons) will lead to increasing focus and reliance on alternative energy conversion devices and ways for storing energy. Future scenarios may comprise “hydrogen” as an energy carrier with high energy density and potentially high conversion efficiency into electric energy and vice versa [1]. A lot will depend on further progress in PEM (polymer electrolyte membrane) electrolyzer and fuel cell technology with many fundamental and engineering problems waiting to be solved.

The first who actually proposed a theory on the decomposition of water into hydrogen and oxygen by means of “électricité galvanique” [2] was the Lithuanian Freiherr Christian Johann Dietrich Theodor von Grotthuß. He introduced a concept of ionic conductivity which already captured in a qualitative way what 100 years later was described by the Nernst-Einstein relationship. In my presentation, I will tell the story starting from von Grotthuß all the way to state of the art research in an anecdotic way. I will touch upon i) the long standing issue of understanding proton conduction phenomena as an example of a process which, by no means, is unidirectional in nature, ii) the complex issue of developing materials with high performance, longevity and environmental benignity meeting critical cost targets and iii) exciting recent findings (fresh out of the lab) narrowing the gap between our visions and facts proven by good scientific practice.

[1] K. D. Kreuer ed.: Fuel Cells, Springer 2013, ISBN 978-1-4614-5785-5

[2] C. J. T. de Grotthuss: Mémoire sur la décomposition de l'eau et des corps qu'elle tient en dissolution à l'acide de l'électricité galvanique, Annales Chim. (Paris) vol. 58, 1806, 54 - 74





## **Tomas Tamulevičius**

*Institute of Materials Science, Kaunas  
University of Technology*

*Lithuania*

### **SELF – ASSEMBLED NANOPHOTONICS**

Noble metal-related resonant optical effects were puzzling humankind for centuries. In the modern era, plasmonics and related nanotechnologies gain even more attention. The peculiarities of localized surface plasmon resonances (LSPR) observed in nanostructures of silver, gold, copper, aluminum, and several more materials are well documented these days. However, the breakthrough necessary for bringing LSPR based consumer products is still on the way. The necessary precision and repeatability of manufacturing are the main technological bottlenecks impeding the scaling up. Bottom-up nanomaterial synthesis methods were always up-and-coming because of the resulting qualities and yields, but they were rarely capable of providing positional control, repeatability. A templated deposition is bridging the advantages of the two worlds, the high monodisperse and superb optical quality wet synthesized nanostructures are following deposition sites with the clean-room lithography-defined positional accuracies. Such artificially manmade two-dimensional materials or metasurfaces become functioning nano-optics devices. On-demand light absorption and scattering properties open new pathways for novel emerging applications in energy harvesting, light-filtering, nanolasing, sensing, and many others.



**Urtė Neniškytė**

*Department of Neurobiology and Biophysics, Life  
Sciences Center*

*Lithuania*

## **GARDENING THE BRAIN: INTERDISCIPLINARY APPROACH TO INVESTIGATE SYNAPTIC PRUNING IN DEVELOPING BRAIN**

The mature brain connectome emerges through synaptic pruning of superfluous connections in developing brain. Microglia have central role in this process: they refine neuronal circuitry by phagocytosis and trophocytosis of synaptic structures. While a range of microglial receptors and soluble proteins have been identified to mediate synaptic pruning, up until now there has been limited data on neuronal „eat-me“ molecules that would label unnecessary synapses for microglial elimination. Since exposed phosphatidylserine is a well-established „eat-me“ signal for phagocytosis, we investigated the role of phosphatidylserine scrambling in synaptic pruning. We found that phosphatidylserine was preferentially exposed on synaptic structures and promoted microglia-synapse interaction. Phosphatidylserine exposure was developmentally upregulated and required the activity of Xkr8 – a major phospholipid scramblase, which was expressed throughout the brain and was developmentally upregulated after birth.

Conditional Xkr8 knock-out in excitatory neurons diminished axonal bouton trophocytosis and caused insufficient elimination of excitatory synapses. Furthermore, Xkr8 cKO brains had significantly higher axonal density in corticospinal tracts of pyramidal neurons, indicating reduced elimination of the whole axons. These morphological aberrations were followed by abnormal electrophysiological profiles of Xkr8-deficient neurons that exhibited increased spontaneous activity and the failure of functional synaptic maturation. Finally, Xkr8 deficiency led to increased global connectivity of the brain that was maintained into adulthood, as measured by functional MRI. This is the first evidence that mammalian synaptic pruning requires developmental phosphatidylserine exposure via scramblase activity, identifying the first „eat-me“ signal that is exposed on unnecessary synapses for their developmental removal.



**Eglė Čekanavičiūtė**

*Space Biosciences Research Branch, NASA Ames*

*USA*

### **NEUROIMMUNE RESPONSES TO SPACE RADIATION**

The main health risks of human deep space exploration involve the damage to the central nervous system (CNS) and the immune system caused by exposure to ionizing radiation beyond the protective magnetic field of the Earth. The extent of CNS damage is partially mediated by the blood-brain barrier, which regulates interactions between CNS and the rest of the body. However, studies on blood-brain barrier in regulating CNS responses to ionizing radiation have been limited, especially in human tissue/organ analogs. Therefore, we developed a high-throughput 3D organ-on-a-chip system to study human blood-brain barrier impairments caused by deep space radiation, and here will present our first results using this system. Furthermore, in our lab we have been exploring the individual variability, genomic associations and secreted biomarkers of immune responses to space radiation, all of which might be used to address personalized health risks for astronauts. Ultimately, we aim to expand upon these results to uncover novel cellular and mechanistic targets for countermeasure development to reduce human CNS and immune damage in deep space exploration.



**Daniele Faccio**

*School of Physics and Astronomy, University of  
Glasgow*

*United Kingdom*

## **IMAGING WITH TIME: FROM MULTIPATH IMAGING TO HEALTHCARE APPLICATIONS**

I will review some of our work in the area of computational imaging based on, or inspired by quantum technologies for light detection. The key aspect we have been investigating is the role of temporal (time-of-flight) information that can be recorded using single photon counting (and other) techniques. This temporal information allows a range of applications such as non-line-of-sight imaging or tracking, which I will briefly overview as an introduction to more general “multi-path” imaging, i.e. use of return echoes from a scene that have bounced multiple times between objects before being detected. Temporal information alone of multipath echoes can be sufficient to reconstruct a full 3D image of the scene and can be equally applied to light, radar and acoustic sensing. An extreme example of multipath information is diffuse imaging, i.e. imaging through highly scattering media with potential applications for through-body imaging (e.g. imaging inside the brain) and remote heart activity monitoring.

# Conference programme

16 March, TUESDAY

<b>09:00</b>	Mihir Pendharkar TOPOLOGICAL QUANTUM COMPUTING: A MATERIALS PERSPECTIVE		
<b>10:00</b>	BREAK		
	<b><u>ORAL SESSION O1</u></b>		
<b>10:15</b>	Algita Stankevičiūtė, Łukasz Wyrzykowski EXPLORING BLACK HOLES WITH MICADO - THE FIRST LIGHT IMAGER OF E-ELT	O1-1	p. 33
<b>10:30</b>	Matas Tartėnas, Kastytis Zubovas IMPROVING BLACK HOLE ACCRETION TREATMENT IN NUMERICAL SIMULATIONS	O1-2	34
<b>10:45</b>	Kasparas Karlauskas, Vidas Dobrovolskas, Arūnas Kučinskas EUROPIUM ABUNDANCE IN THE RED-GIANT BRANCH STARS OF GALACTIC GLOBULAR CLUSTER 47 TUCANAE	O1-3	35
<b>11:00</b>	Marcos Muñiz Cueli, Laura Bonavera, Joaquín González-Nuevo González, Andrea Lapi A DIRECT AND ROBUST METHOD TO OBSERVATIONALLY CONSTRAIN THE HALO MASS FUNCTION	O1-4	36
<b>11:15</b>	Martynas Laužikas, Kastytis Zubovas EVOLUTION OF TWO-PHASE GAS SYSTEM: IMPACT OF AGN-DRIVEN OUTFLOWS ON FRAGMENTATION OF TURBULENT MOLECULAR CLOUDS	O1-5	37
	<b><u>ORAL SESSION O2</u></b>		
<b>10:15</b>	Egle Ezerskyte, Arturas Katelnikovas SYNTHESIS AND OPTICAL PROPERTIES INVESTIGATION OF MULTI-COLOUR EMITTING GDPO <sub>4</sub> :CE <sup>3+</sup> /TB <sup>3+</sup> ,EU <sup>3+</sup> NANOPARTICLES	O2-1	38
<b>10:30</b>	Did not participate	O2-2	39
<b>10:45</b>	Paulius Gaigalas, Vaclovas Klimas, Arūnas Jagminas IMPACT OF L-CYSTEINE ON THE COMPOSITION AND ELECTROCATALYTIC PROPERTIES OF MoS <sub>2</sub> FILMS	O2-3	40
<b>11:00</b>	Kernius Vilkevičius, Evaldas Stankevičius FEMTOSECOND LASER GENERATION OF MICROBUMPS ON GOLD THIN FILMS	O2-4	41
<b>11:15</b>	Lukas Naimovičius, Edvinas Radiunas, Barbara Chatinovska, Augustina Jozeliūnaitė, Edvinas Orentas, Karolis Kazlauskas DYKETOPYRROLOPYRROLE EMITTERS FOR NIR-TO-VISIBLE PHOTON UPCONVERSION	O2-5	42
<b>11:30</b>	BREAK		
	<b><u>ORAL SESSION O3</u></b>		
<b>11:45</b>	Did not participate	O3-1	43
<b>12:00</b>	Mantas Vaičiulis, Kazimieras Nomeika, Ramūnas Aleksiejūnas CARRIER LOCALIZATION IN InGaN STRUCTURES INVESTIGATED BY LIGHT-INDUCED TRANSIENT GRATING TECHNIQUE	O3-2	44
<b>12:15</b>	Daniil Pashnev, Tommi Kaplas, Vadym Korotyeyev, Vytautas Janonis, Andrzej Urbanowicz, Justinas Jorudas and Irmantas Kašalynas TEMPERATURE DEPENDENT ELECTRON EFFECTIVE MASS IN AlGaIn/GaN HETEROSTRUCTURES MEASURED VIA THz SPECTROSCOPY OF 2D PLASMONS	O3-3	45
<b>12:30</b>	Justinas Jorudas, Artūr Šimukovič, Irmantas Kašalynas ELECTRICAL CHARACTERISTICS OF „BUFFER-FREE“ AlGaIn/GaN HETEROSTRUCTURES	O3-4	46
<b>12:45</b>	Ričardas Norkus, Jan Devenson, Remigijus Juškėnas, Arūnas Krotkus TERAHERTZ EMISSION FROM ULTRATHIN BISMUTH LAYERS	O3-5	47
<b>13:00</b>	Evelina Dudutienė, Dominykas Sanda, Algirdas Jasinskas, Joshya Shyamala Rajagopal, Hélène Carrere, Bronislovas Čechavičius, Renata Butkutė PHOTOLUMINESCENCE STUDY OF GaAsBi/GaAs QUANTUM WELLS	O3-6	48
	<b><u>ORAL SESSION O4</u></b>		
<b>11:45</b>	Maciej Nowagiel, Mateusz J. Samsel, Tomasz K. Pietrzak IMPROVING SODIUM BATTERIES CATHODES: THERMAL NANOCRYSTALLIZATION OF GLASSY ALLUAUDITES	O4-1	49
<b>12:00</b>	Maryna Dryhailo, Yuliia Taranets RESEARCH OF IMPACT OF PRESENCE OF VITAMINS B2, B3, AND C ON CALCIUM OXALATE MONOHYDRATE CRYSTALLIZATION PROCESSES IN SIMULATED BODY FLUID	O4-2	50
<b>12:15</b>	Ondrej Friedrich, Jan Valtera FREQUENCY CONTROLLED AC ELECTROSPINNING FOR ENHANCED NANOFIBER PRODUCTION	O4-3	51
<b>12:30</b>	Magdalena Bartolewska, Matej Buzgo, Aiva Simaite BLEND ELECTROSPINNING OF CONTROLLED-RELEASE DRUG DELIVERY SYSTEMS WITH MMP INHIBITORS	O4-4	52
<b>12:45</b>	Renata Butrimienė, Vesta Skrodenytė-Arbačiauskienė, Danguolė Montvydienė, Živilė Jurgelėnė, Dalius Butkauskas, Nijolė Kazlauskienė EFFECTS OF Cd BASED, Cd FREE QUANTUM DOTS AND Cd <sup>2+</sup> ON ISOLATED GUT MICROBIOTA OF <i>Salmo trutta</i> FRY	O4-5	53
<b>13:00</b>	Mona Fadel, M.P. Fernandez-Garcia, Pedro Gorria, Jesus A. Blanco, David Martinez-Blanco, Fabian Suarez-Garcia, Julian Martin-Jimeno, and Alaa Adawy CHARACTERIZATION OF CARBONACEOUS MATERIALS WITH CONTROLLED POROSITY AND MORPHOLOGY	O4-6	54

13:15 TIME FOR INDUSTRY

15:00 BREAK

15:15-16:00 **POSTER SESSION P1**

16:00 BREAK

16:15-17:00 **POSTER SESSION P2**

17:00 **Social event: "ITER – Future energy"**

## 17 March, WEDNESDAY

09:00 Chennupati Jagadish

SEMICONDUCTOR NANOSTRUCTURES FOR OPTOELECTRONICS APPLICATIONS

10:00 BREAK

### **ORAL SESSION O5**

		p.
10:15	Justina Jaseliūnaitė INTERFERENCE OF ANTI PHASE-SYNCHRONIZED VORTEX SHEDDING IN FLOW PAST AN INLINE MICRO-CYLINDER ARRAY	05-1 55
10:30	Marijus Ambrozas, Andrius Juodagalvis IMPROVED FAKE LEPTON BACKGROUND ESTIMATION FOR THE DRELL-YAN DIFFERENTIAL CROSS SECTION MEASUREMENT USING 2016 CERN CMS DATA	05-2 56
10:45	Anton Kunčinas, Per Osland, Margarida Nesbitt Rebelo MULTI-HIGGS DOUBLET MODELS AND GROUP THEORY	05-3 57
11:00	Giedrius Žlabys, Chu-hui Fan, Egidijus Anisimovas, Krzysztof Sacha ENGINEERING TIME-SPACE CRYSTALLINE STRUCTURES	05-4 58
11:15	Kazimieras Tamoliūnas, Jevgenij Chmeliov, Andrius Gelžinis MODELLING OF INTERACTION BETWEEN PHOTOSYNTHETIC PIGMENTS USING QUANTUM CHEMISTRY METHODS	05-5 59

### **ORAL SESSION O6**

10:15	Deimante Vaitukaityte, Cristina Momblona, Kasparas Rakstys, Albertus Adrian Sutanto, Bin Ding, Vygintas Jankauskas, Alytis Gruodis, Tadas Malinauskas, Abdullah M. Asiri, Paul J. Dyson, Vytautas Getautis, Mohammad Khaja Nazeeruddin ENAMINE-DERIVED SPIROBIFLUORENES AS HOLE TRANSPORTING MATERIALS FOR PEROVSKITE SOLAR CELLS	06-1 60
10:30	Jakub Wręczycki, Grzegorz Mlostoń, Katarzyna Urbaniak, Dariusz M. Bieliński THE FLUORIDE ANION CATALYZED SULFURIZATION OF THIOKETONES WITH ELEMENTAL SULFUR LEADING TO SULFUR-RICH HETEROCYCLES	06-2 61
10:45	Mantas Marcinkas, Tadas Malinauskas SYNTHESIS AND INVESTIGATION OF ORGANOMETALLIC PRECURSORS FOR CONVENIENT COPPER (I) THIOCYANATE LAYER DEPOSITION	06-3 62
11:00	Ieva Agne Cechanaviciute, Wolfgang Schuhmann HIGH ENTROPY ALLOYS AS CATALYSTS FOR SELECTIVE GLYCEROL OXIDATION	06-4 63
11:15	Augustina Jozeliunaite, Edvinas Orentas AN EFFICIENT HETEROGENOUS CARBON-BASED PHOTOCATALYST FOR SELECTIVE SULFIDE OXIDATION TO SULFOXIDES	06-5 64

11:30 BREAK

### **ORAL SESSION O7**

11:45	Mantas Drazdys, Darija Astrauskytė, Ramutis Drazdys INVESTIGATION OF INITIAL GROWTH RATE OF DIELECTRICAL THIN FILMS DEPOSITED BY ATOMIC LAYER DEPOSITION	07-1 65
12:00	Did not participate	07-2 66
12:15	Kamilė Bareikaitė, Rokas Skaisgiris, Jelena Dodonova, Sigita Tumkevičius, Saulius Juršėnas PHOTOPHYSICAL PROPERTIES OF PYRIMIDINE-BASED TADF EMITTERS	07-3 67
12:30	Rusnė Ivaškevičiūtė-Povilauskienė, Dalius Seliuta, Alesia Paddubskaya, Domas Jokubauskis, Linas Minkevičius, Andrzej Urbanowicz, Ieva Matulaitienė, Lina Mikoliūnaitė, Gintaras Valušis OPTICAL MODULATION OF MONO AND BI-LAYER GRAPHENE	07-4 68
12:45	Rokas Jasiūnas, Vidmantas Jašinskas, Huotian Zhang, Feng Gao, Vidmantas Gulbinas CHARGE CARRIER TRANSPORT IN CLOSE TO REAL WORKING CONDITIONS OF ORGANIC SOLAR CELLS	07-5 69
13:00	Nerijus Jurkūnas, Algirdas Jasinskas, Simona Pūkienė, Andrius Bičiūnas, Bronislovas Čechavičius, Virginijus Bukauskas and Renata Butkutė GROWTH AND INVESTIGATION OF BI-CONTAINING COMPOUND PIN STRUCTURES	07-6 70

**ORAL SESSION O8**

<b>11:45</b>	Austėja Mikalčiūtė, Andrius Gelžinis, Jevgenij Chmeliov CRYSTALLOGRAPHY-BASED MODELLING OF THE INTER-PIGMENT INTERACTION IN THE FUCOXANTHIN- CHLOROPHYLL PROTEIN COMPLEX	O8-1	71
<b>12:00</b>	Daria Pashneva, Julija Pauraite, Agnė Minderytė, Vadimas Dudoitis, Kristina Plauškaitė, Inga Garbarienė, Lina Davulienė, Steigvilė Byčenkienė OUTDOOR AND INDOOR LEVELS OF BLACK CARBON IN AN URBAN ENVIRONMENT	O8-2	72
<b>12:15</b>	Monika Baublytė, Edita Garškaitė, Denis Sokol, Ramūnas Skaudžius IN SITU GdPO <sub>4</sub> :Eu HYDROTHERMAL SYNTHESIS IN WOODS MATRIX	O8-3	73
<b>12:30</b>	Jan Albert Zienkiewicz, Dorota Kowalska, Katarzyna Fedoruk, Mariusz Stefański, Adam Pikul, Maciej Ptak NOVEL HYBRID ORGANIC-INORGANIC PEROVSKITE WITH PROTONATED UNSYMMETRICAL DIMETHYLHYDRAZINE – SYNTHESIS AND PHYSICOCHEMICAL CHARACTERIZATION	O8-4	74
<b>12:45</b>	Joanna Stocka, Rasa Platakytė, Justinas Čeponkus, Valdas Šablinskas, Gamil A. Guirgis, Paweł Rodziewicz COMPUTATIONAL AND EXPERIMENTAL VIBRATIONAL STUDY OF 1-CHLOROMETHYL-1- FLUOROSILACYCLOHEXANE CONFORMATIONS AND ITS REARRANGEMENTS	O8-5	75
<b>13:00</b>	Sridhar Hariharaputran, Arul Murugan Natarajan, Zilvinas Rinkevicius, Patrick Norman MODELING OF STRUCTURAL AND PHOTOPHYSICAL PROPERTIES OF AN OPTICAL PROBE IN AQUEOUS AND MEMBRANE ENVIRONMENTS	O8-6	76
<b>13:15</b>	BREAK		
<b>14:00</b>	Klaus-Dieter Kreuer ENABLING HYDROGEN AS FUTURE ENERGY CARRIER: FROM THE LITHUANIA CRADLE TO WHERE WE ARE TODAY		
<b>15:00</b>	BREAK		
<b>15:15-16:00</b>	<b>POSTER SESSION P3</b>		
<b>16:00</b>	BREAK		
<b>16:15-17:00</b>	<b>POSTER SESSION P4</b>		
<b>17:00</b>	<b>Social event - discussion: "Life after Science"</b> Simona Liukaitytė, Renata Butkutė, Paulius Saudargas (Goda Raibytė)		

**18 March, THURSDAY**

**09:00** Tomas Tamulevičius  
SELF-ASSEMBLED NANOPHOTONICS

**10:00** BREAK

**ORAL SESSION O9**

<b>10:15</b>	Vytautas Paura, Virginijus Marcinkevičius HYPERSPETRAL UNMIXING: ALGORITHMS REVIEW AND BENCHMARKING	O9-1	p. 77
<b>10:30</b>	Rugilė Lukaševičiūtė, Lena Golubewa, Renata Karpicz CHARACTERIZATION OF BORON NITRIDE QUANTUM DOTS SYNTHESIZED BY A SINGLE STEP HYDROTHERMAL METHOD	O9-2	78
<b>10:45</b>	Cristina Mendez-Lopez, Luis J. Fernandez-Menendez, Cristina Gonzalez-Gago, Jorge Pisonero, Nerea Bordel EFFECTS OF NEBULIZED CALCIUM NITRIDE CONCENTRATION ON A LASER-INDUCED PLASMA EMISSION AND PARAMETERS	O9-3	79
<b>11:00</b>	Reinis Lazda, Laima Bušaitė, Florians Gahbauers, Andris Bērziņš, Mārcis Auziņš MEASURING THE VECTOR OF A MAGNETIC FIELD USING A DIAMOND CRYSTAL.	O9-4	80

**ORAL SESSION O10**

<b>10:15</b>	Inga Songailienė, Jonas Juozapaitis, Giedrė Tamulaitienė, Audrone Ruksenaite, Sigitas Sulcius, Giedrius Sasnauskas, Česlovas Venclovas, Virginijus Siksnys HEPN-MNT TOXIN-ANTITOXIN SYSTEM AS A PROPOSED BACTERIAL ATP SENSOR	O10-1	81
<b>10:30</b>	Justina Kavaliauskaitė, Auksė Kazlauskaitė, Juozas Lazutka, Arūnas Stirkė ACTIVATION OF NUCLEAR FACTOR NF-κB RECOGNITION PROMOTER-CONTROLLED REPORTER GENE TRANSCRIPTION BY PULSED ELECTRIC FIELD TREATMENT IN VIABLE HEP-2C AND CHO-K1 CELLS	O10-2	82
<b>10:45</b>	Ewa Borowska, Mateusz Abram, Joanna Kargul NOVEL APPROACH ON APPLICATION OF AN EXTREMOPHILIC RED ALGA CYANIDIOSCHYZON MEROLAE IN PHYTOREMEDIATION	O10-3	83
<b>11:00</b>	Greta Gančytė, Povilas Šimonis, Arūnas Stirkė INVESTIGATION OF OSMOTIC SHOCK EFFECTS ON YEAST CELL RESPONSES TO PULSED ELECTRIC FIELD TREATMENT	O10-4	84
<b>11:15</b>	Agne Rimkute, Dovile Stravinskiene, Gintautas Zvirblis BIOSYNTHESIS OF RECOMBINANT ALLERGENS USING MAMMALIAN CELLS EXPRESSION SYSTEM	O10-5	85

**11:30 BREAK**

**ORAL SESSION O11**

<b>11:45</b>	Karolina Maleckaitė, Jelena Dodonova, Stepas Toliautas, Rugilė Žilėnaitė, Džiugas Jurgutis, Vitalijus Karabanovas, Sigitas Tumkevičius, Aurimas Vyšniauskas DESIGNING A VISCOSITY-SENSITIVE BODIPY FLUOROPHORE FOR A LIVE CELL IMAGING	O11-1	86
<b>12:00</b>	Julija Grigorjevaite, Arturas Katelnikovas OPTICAL PROPERTIES INVESTIGATION OF BLUE-EXCITABLE RED-EMITTING $K_2Bi(PO_4)(MoO_4):PR^{3+}$ POWDERS	O11-2	87
<b>12:15</b>	Agata Jarocka, Paweł Dębowski, Tomasz K. Pietrzak, Marek Wasiucionek INFLUENCE ANALYSIS OF SELECTED FACTORS ON THE EUROPIUM IONS REDUCTION IN THE GLASSY MATRIX	O11-3	88
<b>12:30</b>	Katarzyna Polak, Andrzej Sitkiewicz, Arkadiusz Leniart, Paweł Majewski THERMAL ANNEALING OF PS-B-PMMA DIBLOCK COPOLYMER THIN FILMS	O11-4	89
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<b>11:45</b>	Vytautas Rudokas, Gintautas Žvirblis, Aurelija Žvirblienė DEVELOPMENT OF MONOCLONAL ANTIBODIES AGAINST HOUSE DUST MITE ALLERGEN DER P 21 FOR THE QUANTIFICATION OF ALLERGEN COMPONENT IN ALLERGEN EXTRACTS	O12-1	92
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<b>12:45</b>	Mykolas Mačiulis, Viktoras Mažeika, Martynas Riauka, Lukas Kontenis, Danutė Bulotienė, Vitalijus Karabanovas, Edvardas Žurauskas, Virginijus Barzda THIRD-HARMONIC GENERATION MICROSCOPY OF COLLAGEN IN BIOLOGICAL TISSUES STAINED WITH HEMATOXYLIN AND EOSIN	O12-5	96
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**13:15 BREAK**

**14:00** Urtė Neniškytė  
GARDENING THE BRAIN: INTERDISCIPLINARY APPROACH TO INVESTIGATE SYNAPTIC PRUNING IN DEVELOPING BRAIN

**15:00 BREAK**

**15:15-16:00 POSTER SESSION P5**

**16:00 BREAK**

**16:15-17:00 POSTER SESSION P6**

## 19 March, FRIDAY

**09:00** Eglė Čechanavičiūtė  
NEUROIMMUNE RESPONSES TO SPACE RADIATION

**10:00 BREAK**

**ORAL SESSION O13**

<b>10:15</b>	Evaldas Kažukauskas, Simas Butkus, Piotr Tokarski, Vytautas Jukna, Carlos Vytautas Diamond Manikas, Martynas Barkauskas, Valdas Sirutkaitis. MICROMACHINING OF TRANSPARENT BIOCOMPATIBLE POLYMERS APPLIED IN MEDICINE USING BURSTS OF FEMTOSECOND LASER PULSES	O13-1	p. 98
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<b>10:30</b>	Vytenis Girdauskas, Paulius Mackonis, Augustinas Petrulėnas, Aleksėj Rodin TOWARDS 50 FS SWIR PULSES BY TRANSIENT STIMULATED RAMAN CHIRPED-PULSE AMPLIFICATION WITH SPECTRUM SYNTHESIS	O13-2	99
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<b>11:45</b>	Robertas Grigutis, Vytautas Jukna, Marius Navickas, Gintaras Tamošauskas, Kęstutis Staliūnas, Audrius Dubietis CONICAL THIRD HARMONIC GENERATION FROM FEMTOSECOND LASER INDUCED NANOGRATING IN TRANSPARENT MATERIALS DURING FILAMENTATION AT HIGH REPETITION RATES	O15-1	108
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IN RATS

**13:15** BREAK

**14:00** Daniele Faccio  
IMAGING WITH TIME: FROM MULTIPATH IMAGING TO HEALTHCARE  
APPLICATIONS

**15:00** BREAK

**15:15-16:00** POSTER SESSION P5

**16:00** BREAK

**16:15-17:00** POSTER SESSION P6

**17:00** Closing remarks

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# EXPLORING BLACK HOLES WITH MICADO - THE FIRST LIGHT IMAGER OF E-ELT

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Intermediate Mass Black Holes (IMBHs) are hypothetical missing building blocks of larger black holes, Super-Massive Black Holes (SMBH), which are found in the centres of galaxies [1,2]. The left-over population of IMBHs should be discoverable in the present Universe, however, current attempts resulted only in weak candidates [3].

Firstly, we have to rely on the unique and up-to-date methods that can find, explore and quantify the traces of IMBHs. Among the most persuasive techniques, the Gravitational Microlensing phenomenon [4] becomes a very powerful probing technique which can be used to study the structure of the Milky Way no matter how faint objects are [5]. This method is based on Einstein's general relativity theory which means that incoming light wavefront can bend around massive object (e.g., black hole) as a consequence of its gravity when so called "lensing star" is passing by [6].

However, missing piece of information in microlensing is the separation between the lensed images, as they are of order of milliarcseconds. First high resolution imaging of microlensed images was obtained with ESO's (European Southern Observatory) VLTI (Very Large Telescope Interferometer) instrument GRAVITY [7]. Nevertheless, to get more information and details of our desired astronomical object, we must have telescope with bigger diameter in order to reach to more common but weaker sources. The bigger the telescope, the higher angular resolution that we can get. ESO's E-ELT (Europe's Extremely Large Telescope) will be the biggest "eye" on Earth in 2025 with 39.3 m diameter primary segmented mirror [8].

In this research, we are presenting the capabilities of detecting IMBHs with E-ELT first light imager MICADO (Multi-Adaptive Optics Imaging Camera for Deep Observations) (the set-up is showed in Fig. 1). By applying, multi-adaptive optics systems, we can be able to resolve images without a huge impact coming from atmosphere but the we must to get a proper calibration of the instrument. This work will present the factors that determine the difficulties faced by the calibration.

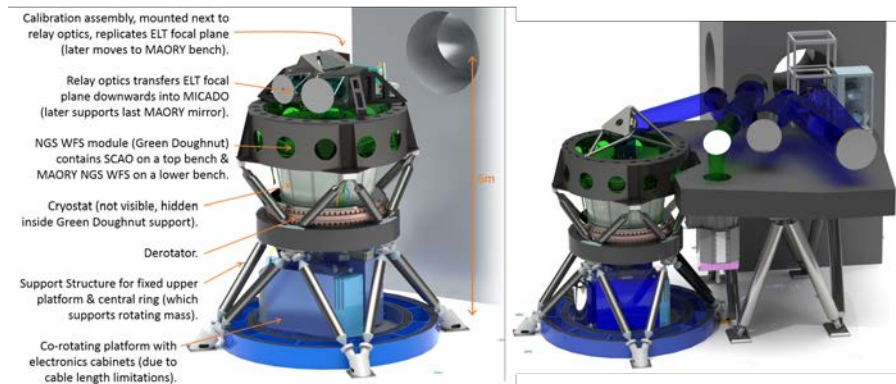


Fig. 1. The overview of MICADO instrument.

In summary, MICADO will be able to perform high resolution (5 - 12 milliarcsec) near infrared observations and it is very promising future instrument to detect microlensed candidates of IMBHs. In the future, we are hoping to simulate the probability of IMBHs candidates with milliarcsec resolution of MICADO and get required spectroscopic information from the research that we presented.

We would like to acknowledge dr. Gabriele Rodeghiero (INAF OAS Bologna, Italy), dr. Robert J. Harris and dr. Jörg-Uwe (Max Planck Institute for Astronomy, Heidelberg, Germany) for contribution in working with MICADO calibration assembly.

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# IMPROVING BLACK HOLE ACCRETION TREATMENT IN NUMERICAL SIMULATIONS

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Gas accretion on to a supermassive black hole (SMBH) is the engine supporting active galactic nuclei (AGN). Most of the luminosity is generated by a sub-parsec scale accretion disc which forms if a significant amount of gas comes close to the SMBH, but to fully understand how activity is initiated and supported over a longer period of time, we have to study gas dynamics on various galactic spatial scales. Gas from kiloparsec scales is observed to migrate toward the centre and is seen to be accumulated in  $\sim 10 - 100$  pc circumnuclear rings [1], which, as seen in recent ALMA local AGN observations, may become the reservoirs of gas feeding the SMBH [2].

One of the most important tools in studying gas dynamics are 3D hydrodynamical models. But current models have trouble accurately simulating phenomena that occur on vastly different spatial scales, e.g. ranging from the circumnuclear gas reservoir at  $\sim 10$  pc from the SMBH to the accretion disc at  $< 0.01$  pc. Our aim is to improve simulations of the vicinity of AGN by adding a more detailed model of accretion. We do this by implementing a sub-grid accretion disc coupled to the black hole particle. We use a standard thin  $\alpha$ -prescription [3] that consists of a number of concentric rings and is dynamically evolved with a separate time criterion than the hydrodynamic simulation as a whole.

We test our approach by simulating a several-parsec-wide region with conditions similar to those at the centre of our Galaxy using 3D hydrodynamical code Gadget-3. The model consists of three main components: the central SMBH ( $M_{\text{bh}} = 4 \times 10^6 M_{\odot}$ ), the Circumnuclear Ring-like toroidal gas ring ( $M_r = 10^5 M_{\odot}$ ,  $R_{\text{in}} = 1.5$  pc,  $R_{\text{out}} = 4$  pc) and an infalling molecular cloud ( $M_{\text{mc}} = 10^5 M_{\odot}$ ,  $R_{\text{mc}} = 3$  pc). A retrograde collision between the molecular cloud and the gas ring results in significant accretion, where the accretion disc is fed by the gas that crosses a sink boundary ( $r_{\text{sink}} = 0.01$  pc) in the hydrodynamical model.

Initial results show promise. The more detailed accretion prescription does not significantly increase the computational cost. Accretion occurs more smoothly over a longer period of time as the gas moves through the viscous disc (Fig. 1, left). Various parameters of the accretion disc can be followed over time (e.g. the surface density in Fig. 1, right), which allows us to add a more precise prescription for feedback and mass loss due to luminosity exceeding the Eddington rate, which we plan to do in the future.

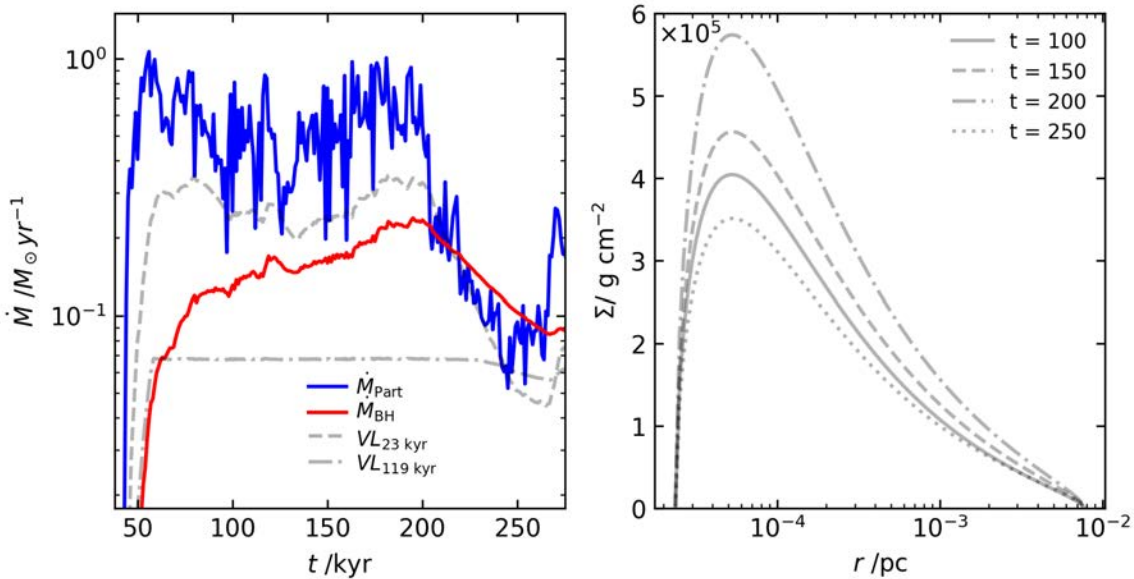


Fig. 1. Left: mass accretion rate on to the disc particle (blue) and SMBH mediated by the accretion disc (red). Grey lines show results from a simple two-state accretion model limited by the constant accretion disc viscosity timescale. Right: surface density of the accretion disc at various times during the simulation run.

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# EUROPIUM ABUNDANCE IN THE RED-GIANT BRANCH STARS OF GALACTIC GLOBULAR CLUSTER 47 TUCANAE

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Galactic globular clusters (GGCs) were long thought to be simple stellar populations – stellar populations that have the same age and initial chemical composition. This view has changed with the discovery of multiple populations (MP) in the GGCs: *first population* (1P) with the chemical composition of Galactic field stars, and *second population* (2P) with anomalous chemical composition (enhanced He, N, Na and depleted O, C) [1]. It is therefore thought that the chemical composition of 2P stars has been modified during the cluster evolution. However, it is unclear how this could have happened because none of the mechanisms proposed so far is capable of explaining all observable properties of MPs in the GGCs [2].

Further and more stringent constraints on the possible evolutionary scenarios of the GGCs could be obtained by investigating abundance patterns of chemical elements that were produced by various processes of stellar nucleosynthesis, including those synthesised by neutron capture reactions. In this context, correlations between the elemental abundances may hint at their common origin and may help to identify the most likely evolutionary scenarios of the GGCs.

In this study we used ATLAS9 1D stellar atmosphere models and spectrum synthesis package SYNTHE [3] to determine europium abundance in the atmospheres of 93 red-giant branch (RGB) stars in Galactic globular cluster 47 Tucanae. Our results suggest the existence of weak but statistically significant [Eu/Fe]–[Na/Fe] correlation (Fig. 1). This is the first observational evidence that the 2P stars in the GGCs could have been enriched with the r-process elements. These r-process elements should have been synthesised by the same polluters that enriched the 2P stars with the light chemical elements. Because europium is produced only during explosive nucleosynthesis events (e.g. in Type II supernovae), this sets a new constraint on the candidate evolutionary scenarios of the GGCs, i.e. they should be capable of explaining the enrichment of 2P stars in *both* the light and r-process elements simultaneously.

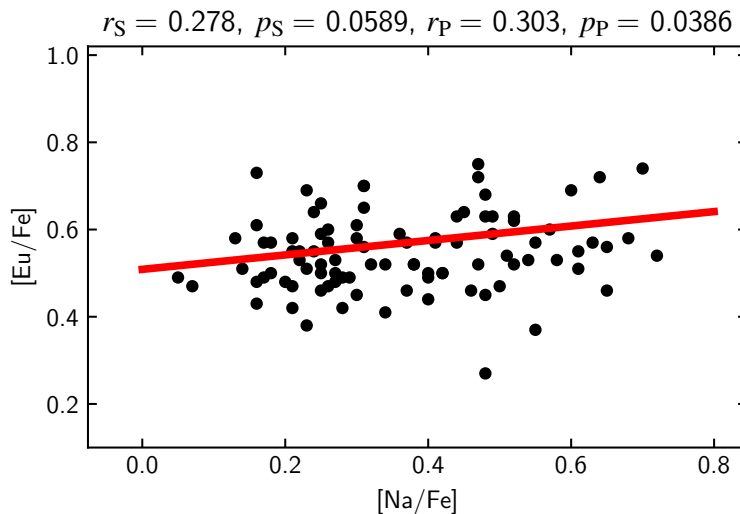


Fig. 1. Abundance of europium determined in the sample of 93 RGB stars in Galactic globular cluster 47 Tuc, plotted in the [Eu/Fe]–[Na/Fe] plane (full circles). Red solid line is linear best fit to the data. Pearson’s and Spearman’s correlation coefficients, as well as the corresponding  $p$ -values, are indicated at the top of the figure.

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# A DIRECT AND ROBUST METHOD TO OBSERVATIONALLY CONSTRAIN THE HALO MASS FUNCTION

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Within the standard paradigm of cosmology, the hierarchical growth of dark matter perturbations is an essential assumption to explain galaxy formation. As a consequence, the relevance of dark matter halos for probing large-scale structure has motivated the search for a quantitative understanding of their mass distribution. Although computational cosmology has so far been the main arena for determining the number density of halos, numerical simulations are subject to systematic differences regarding, for instance, the modeling of baryon physics. The present proof of concept thus pursues the objective of determining the halo mass function (HMF) through the observation of the (weak lensing) magnification bias effect on high-redshift submillimeter galaxies, given the suitability of these sources for a study of this kind.

In essence, in this work [1] we have measured the angular cross-correlation function between a foreground sample of GAMA galaxies ( $0.2 < z < 0.8$ ) and a background sample of H-ATLAS submillimeter galaxies ( $1.2 < z < 4.0$ ) via a modified version of the Landy & Szalay estimator. This measurement is then checked against the theoretical prediction within the halo model picture, which yields

$$w(\theta) = 2(\beta - 1) \int_0^\infty \frac{dz}{\chi^2(z)} n_f(z) W^{lens}(z) \int_0^\infty \frac{dl}{2\pi} l P_{g-dm} \left( \frac{l}{\chi(z)}, z \right) J_0(l\theta), \quad (1)$$

where  $\beta$  is the logarithmic slope of the background source number counts,  $\chi(z)$  is the comoving distance up to redshift  $z$ ,  $n_f(z)$  is the unit-normalized foreground redshift distribution,  $W^{lens}(z)$  is the so-called lensing kernel,  $J_0$  is the zeroth-order Bessel function and  $P_{g-dm}$  is the galaxy-dark matter cross-power spectrum.

Within the halo model formalism, the cross-power spectrum contains information about the number density of dark matter halos (via the HMF and the parameters characterizing it) and about the mean number of galaxies which populate these halos (via the so-called halo occupation distribution (HOD) parameters). By means of a Markov chain Monte Carlo algorithm, we have derived posterior probability distributions for the HMF and HOD parameters (both jointly and fixing the latter to common literature values) following two well-known HMF models, namely the Sheth and Tormen (ST) [2] and Tinker [3] templates. For the former model, we have also relaxed the usual assumptions about normalization and allowed negative values for one of its parameters (what we call the "free" ST fit). Sampling these distributions, we have obtained Bayesian credible intervals for the  $z = 0$  HMF at different halo masses, as shown in Fig 1.

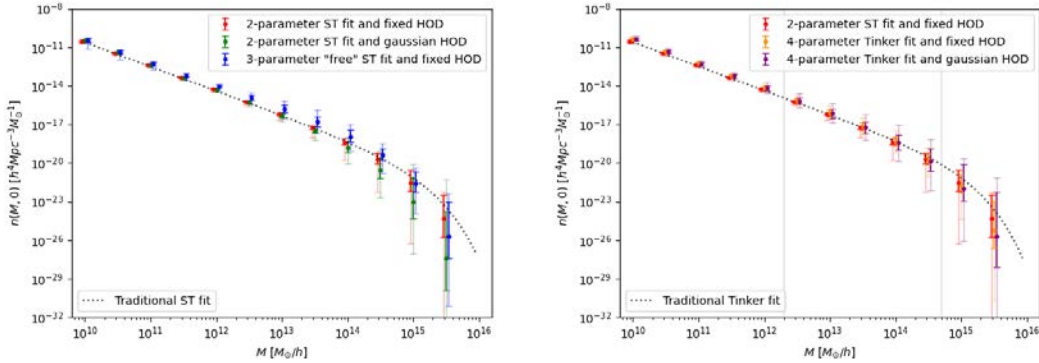


Fig. 1. Credible intervals (68% in bold and 95% in faint colors) for the  $z = 0$  HMF at different mass values. For each mass, the results from the three different cases shown in each legend are displaced horizontally and in order.

Under the assumption that all HMF parameters are positive, the ST fit only seems to fully explain the data by forcing the mean number of satellite galaxies in a halo (captured by one HOD parameter) to increase substantially from its prior mean value. The Tinker fit, on the other hand, provides a robust description of the data without relevant changes in the HOD parameters, but with some dependence on the prior range of two of its parameters. While all cases are in agreement with numerical simulations, the involved parameters are, however, better determined by considering the "free" ST model.

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# EVOLUTION OF TWO-PHASE GAS SYSTEM: IMPACT OF AGN-DRIVEN OUTFLOWS ON FRAGMENTATION OF TURBULENT MOLECULAR CLOUDS

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It is well established, that nearly every galaxy had multiple episodes of activity during its evolution. During this period matter is accreted by the central super massive black hole (SMBH) and an associated increase in brightness is observed. During such events outflows of hot matter, powered by accretion, sweep through the inner parts of the galaxy interacting with gas and dust on its way. Outflows cool, condense and lose momentum as they reach the outer regions. During this process interactions with denser molecular clouds (MC) take place. Molecular clouds are usually in delicate equilibrium with the surrounding medium and evolve relatively slowly but interactions with outflows change this equilibrium. These clouds are cradles for stars, responsible for the chemical evolution of the galaxy as a whole. Young massive stars evolve rapidly, dispersing newly created elements into the surrounding medium. It is typically assumed that AGN-driven outflows tend to be destructive and inhibit star formation. However, the result of the interaction can be very different depending on the properties of the outflow, such as gas temperature and momentum. Therefore, it is of particular interest to explore interaction of MCs with outflows of low momentum.

The analysis of such interaction is not new. While there are numerous models, a common approach is to reduce number of unknowns in the system. Such simplifications are useful as they help isolate certain evolutionary effects. But to make models more realistic, as much physical processes as possible must be included. It is very tempting to build a method that is suitable for a wide variety of systems and account for as many as physical processes as possible.

We use Arepo [1], a modern hydrodynamical code, which utilises a moving mesh to discretize the flow of matter. The code flexibility, combined with numerical accuracy and availability of different modules makes this tool a good candidate for this task. A model can be described as a virtual wind tunnel - an elongated volume with periodic boundary conditions on the sides and special boundaries at the ends. On the central axis, a turbulent molecular cloud of uniform density is placed with no initial velocity. The rest of the volume is filled with interstellar medium (ISM). We tested a range of ISM and cloud parameters: ISM temperatures  $10^4 - 10^7$  K and velocities  $10 - 100 \text{ km s}^{-1}$ ; cloud masses  $10^3 - 10^5 M_{\odot}$ . Figure 1 illustrates one of the modelled systems. There is a tendency for faster flows to destroy clouds, while hotter flows compress them. The effect of cloud mass (coupled with density and radius) is to be determined.

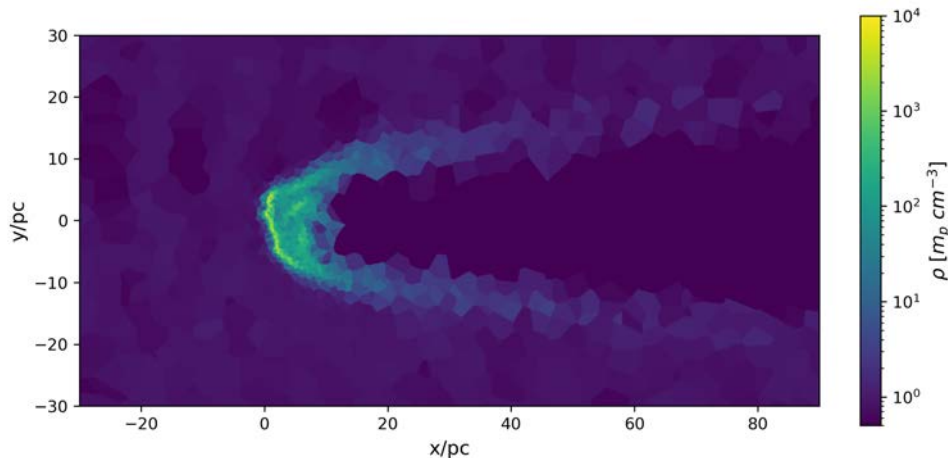


Fig. 1. Density slice of evolved system. MC is ablated by hot wind, and dense compressed threads of material are visible. They will become birthplace of stars.

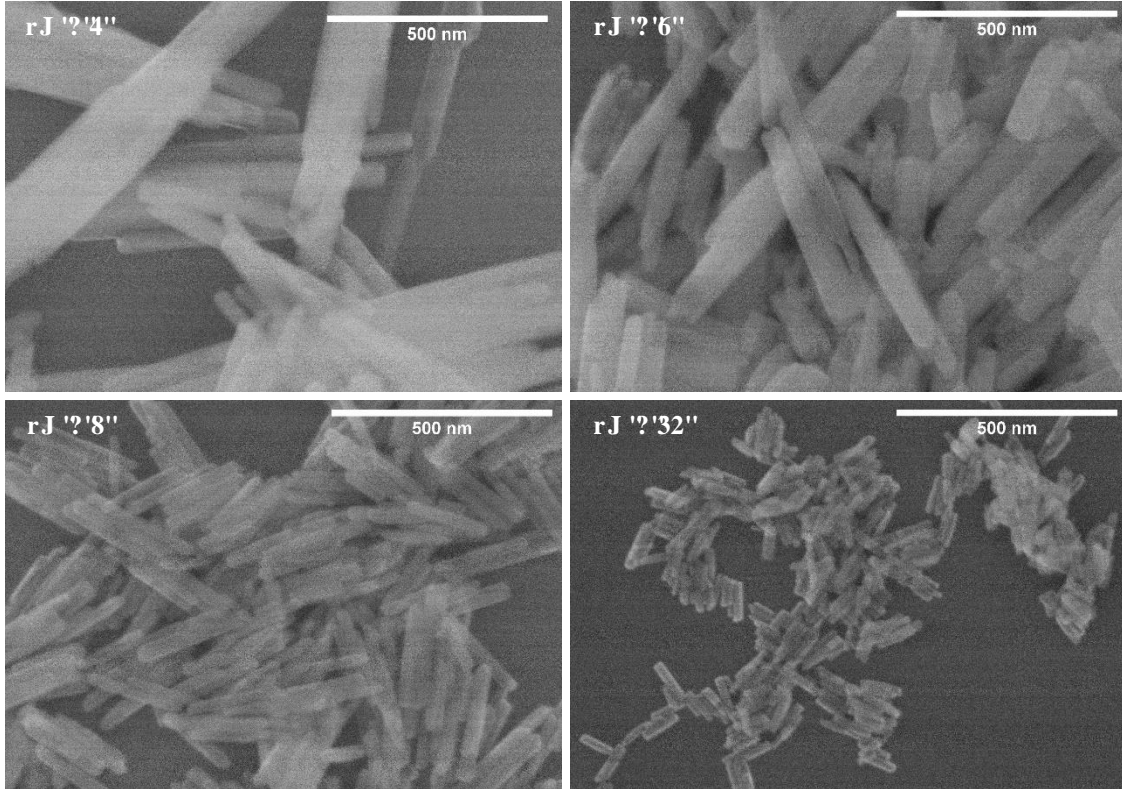
Modeled processes include gravity, cooling and heating, ionisation reactions, turbulence and, soon, star formation. The final goal is to map a parameter space where a boundary could be drawn separating destructive and nondestructive flows. A side product of simulations with the thermo-chemistry package is a possibility to trace chemical elements and ionisation states, which enables a more direct connection with observations.

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V j w u " f g v c k n g f " c p c n f u k u " c p f " q d v c k p g f " t g u w m u " q h ' Z T F " r c w g t p u . " U G O " k o c i g u . " t g h g e v k p p . " g z e k e v k p p " c p f " g o k u k q p " u r g e v c " q h ' I f R Q 6 - E g 5 - . V d 5 - . G w 5 - " c p f " I f R Q 6 - E g 5 - I V d 5 - . G w 5 - " r j q u r j q t u ' y k n i d g ' r t g u g p v g f 0 "

---

**C e n p q y n g f i g o g p w u** " V j k u ' r t q l g e v ' j c u " t g e g k x g f " h w p f k p i " h t q o " G w t q r g c p " U e k e n i " H w p f " \* t q l g e v " P q 0 2 ; 0 6 / N O V / M / 9 3 4 / 4 4 / 2 4 9 3 + " w p f g t " i t c p v " c i t g g o g p v y k j " y j g " T g u g c t e j " E q w p e k r i q h " N k s j w c p k " \* N O V N V - 0 "

O2-2

DID NOT PARTICIPATE



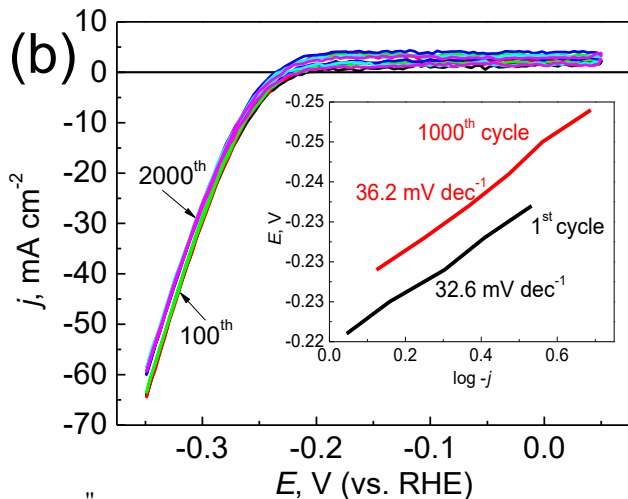
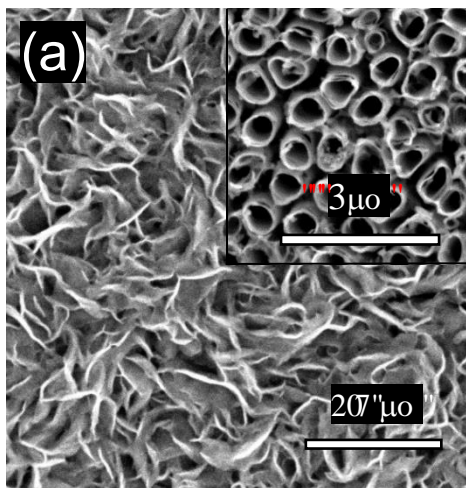
**KO RCE V'QH'N/E[ UVGK'G'QP'VJ G'E'QO RQUK'KQP'CPF''**  
**GNGE'VTQE'CVCN[ VKE'RT'QRGT'VKGU'QH'O qU'HKNO U''**  
Rcwku'I cki cnu<sup>3</sup>. 'Xcemxcu'Mko cu<sup>3</sup>. 'Ct pcu'Lei o kpcu<sup>3</sup>

"Ucv'gT'gugctej "Kpukw'g'E'gpv'g'ht'Rj {ulecni'Uelgpegu'cpf'V'gej pqm} {."Ucwn vgnk'cxg05.'NV/32479."  
 Xkpkwu.'Nkj wpcle"  
r cwrku'f cki cnuB ho e0w'

Ergcp'cpf'tgpgy cdrg'gpgti {"uqwtegu'ewtgpv'ctg'qh'i tgc'v'lpv'gt'gu'v'ht'o cp {"tgugctej gt.u.'f'wg'v'q'v'j'g'g'xgt/i tqy kpi " f go cpf'qh'gpgti {"cpf'ewtgpv'tgk'peg'qp'hquuki'hw'gri'equuwo r vkp0J {f tqi gp'i cu'3J 4+'ku'eqpukf gt'gf'qpg'qh'v'g'engcp'gu'v' gpgti {"uqwtegu'cxck'cdrg.'y'j'lej'ecp'dg'qdv'kpg'f'd {"wukpi 'pqdrg'o gcn'gr'gevt'qecv'cn'usu'ht'q'v'cvt'ur'rk'w'kpi'0J'qy'g'xgt.'v'j'g' uectek'f'cpf'equ'q'h'pqdrg'o gvcni'ku'c'j'kpf'tc'peg'v'q'uveegu'hw'cr'r'nc'ek'v'k'p'qh'v'cvt'ur'rk'w'kpi'ht'j' {"f tqi gp'i'gp'gt'v'k'p'qp' cp'kpf'w'nt'kn'uecrg'j3\_0'V'j'gt'gh'q'g.'cngt'p'v'k'x'g'gr'gevt'qecv'cn'usu'ctg'v'j'qt'q'w'j' n'k'p'x'g'uk'i'c'v'g'f.'y'k'j' "o'qn'df'gp'wo'f'k'w'nt'k'f'g' "O qU<sub>4</sub>+d'g'k'p'i't'ge'qi'p'k'gf'cu'c'r'tq'o'k'uk'p'i't'gr'nc'ego'gp'v'ht'pqdrg'o'gcn'gr'gevt'qecv'cn'usu'j4\_0'

Kp'v'j'ku'uw'f {"pcpqr'rv'g'rv'v'j'cr'gf'j' {"dtkf' "O qU<sub>4</sub>'h'k'ro' u'y'gt'g'hd't'k'ec'v'f'qp'v'q'cp'q'f'k'gf' "VK'uw'd'ut'c'v'g'u'x'k'c'j' {"f tqy'g'to'cni' u'p'v'j'g'uk'i'ht'q'o'c' "u'q'w'k'p' "eq'p'uk'k'p'i' "qh'v'j'k'q'w'g'c'."co'o'q'p'k'w'o'j'gr'w'o'qn'df'c'v'g' "cpf' "N'e {u'v'g'k'p'g'0J {f tqy'g'to'cni' u'p'v'j'g'uk'i' y'cu'ec'tt'k'f' "q'w'c'v'442'0'4'°E'ht'7'v'q'32'j' "wuk'p'i'c' "V'g'ht'p'p'k'p'g'f' "u'v'g'g'ni'c'w'q'ec'x'g'0'

UGO "ko'ci'gu'qh'hd't'k'ec'v'f' "O qU<sub>4</sub>'pcp'q'ut'w'ew't'gu' "H'ki'0'3'c'0' "t'g'x'g'cn'v'j'c'v'o'qn'df'gp'wo'f'k'w'nt'k'f'g' "h'k'ro' u' "u'p'v'j'g'uk'f'gf' "dq'v'j' "y'k'j' "cpf' "y'k'j' q'w'N'e {u'v'g'k'p'g' "r'qu'gu'u'c' "pcpqr'rv'g'rv'v'o'q't'r'j'q'm'i' {"f'gr'q'uk'g'f' "qp'v'q'v'j'g' "u'w'ht'c'eg'qh'w'k'p'k'w'o' "pcp'q'w'd'gu' "H'ki'3'c'0' "k'p'ug'v' "h'q't'o'gf' "d {" "VK'cp'q'f'k'k'p'i'."y'j'lej' "ku'eq'p'uk'v'p'v'v'j'k'j' "q'w't' "r' "t'g'x'k'q'w' "h'k'p'f'k'p'i' u'0' "G'gr'gevt'qecv'cn' "v'e' "r' "t'q'r' "g't' "v'g'u' "q'h'j' {"dtkf' "O qU<sub>4</sub>'h'k'ro' u'y'gt'g' "c'ung'ung'f' "d {" "r'k'p'g'c't' "u'y'g'g'r' "x'q'nc'o' "o'q'i' "t'c'o' "u' "H'ki'0'3'd'0' "k'v'ec'p' "d'g' "u'g'g'p' "v'j'c'v'c'f'f'k'k'q'p' "q'h'N'e {u'v'g'k'p'g' "v'q'v'j'g' "u'p'v'j'g'uk'i' "u'q'w'k'p' "r'g'c'f' "u' "v'q' "cp' "k'p'et'g'c'ug' "q'h'ew't'gp'v'f' "g'p'uk'v'f'."t'g'c'ej'k'p'i' "c'r'r' "t'q'z'k'o' "c'v'g'n' {"87' "o' "C'le'o' "4' "c'v' /2057' "X'0' "H'w'v'j'g't'o'q't'g'j' {"dtkf' "O qU<sub>4</sub>'gr'gevt'qecv'cn'usu'p'v'j'g'uk'f'gf' "y'k'j' "N'e {u'v'g'k'p'g'f' "k'ur'c' "o' "w'ej' "d'g'v'g't' "gr'gevt'qecv'cn' "v'e' "u'c'd'k'k'v' "y'k'j' "g' "ew't'gp'v'f' "g'p'uk'v'f' "f'g'et'g'c'uk'p'i' "d {" "e: ' " "c'h'g't' "4222' "e' "erg'u' "y'j' "gt'g'c'u' "u'c'o' "r' "rg'u' "y'k'j' "q'w'N'e {u'v'g'k'p'g' "g'z'j' "k'k'v'c' "f' "g'et'g'c'ug' "q'h' "c'd'q'w' "92' " "qh' "k'p'k'c'ni' "ew't'gp'v'f' "g'p'uk'v'f' "c'h'g't' "l'w'v' "472' "e' "erg'u'0'



H'ki'0'3' "V'qr' "u'k'f'g' "UGO' "x'k'g'y' "c' "cpf' "e' {erle' "x'q'nc'o' "o'q'i' "t'c'o' "u' "d' "q'h' "O qU<sub>4</sub>' "h'k'ro' "hd't'k'ec'v'f' "qp'v'q'v'j'g' "cp'q'f'k'gf' "VK' uw'd'ut'c'v'g' "x'k'c'j' {"f tqy'g'to'cni' u'p'v'j'g'uk'i'k'p'v'j'g' "u'q'w'k'p' <7' "co'o'q'p'k'w'o'j'gr'w'o'qn'df'c'v'g'."; 2'v'j'k'q'w'g'c'cpf' "5' "o' "q'ni'N<sup>3</sup>'q'h'N' e {u'v'g'k'p'g' "c'v'442' "A'E' "ht'7'j'0'

V'j'g' "V'ch'gn' "un'qr' "gu' "H'ki'0'3'd'0' "k'p'ug'v' "q'h' "u'c'o' "r' "rg'u' "y'k'j' "N'e {u'v'g'k'p'g' "y'gt'g' "h'q'w'p'f' "v'q' "d'g' "em'ug' "v'q' "v'j'c'v'q'h' "R'v' "E'."y'j'lej' "ku' eq'p'uk'f'gt'gf' "cp' "k'f'g'cn' "J' "G'T' "gr'gevt'qecv'cn' "u'0' "Z'R'U' "c'p'cn' "uku' "u'w'i' "i' "gu'u' "v'j'c'v' "J' "G'T' "u'c'd'k'k'v' "cpf' "c'v'k'k'v' "qh' "O qU<sub>4</sub>' "N'e {u'v'g'k'p'g' gr'gevt'qecv'cn'usu'k'p'et'g'c'ug'ct'g't'gr'v'g'f' "v'q'v'j'g' "h'q't'o' "c'v'k'p' "q'h'c' "4'F' "eq'o' "r' "q'uk'g' "eq'o' "r' "q'ug'f' "q'h'c' "f' "q'o' "k'p'c'v'k'p'i' "o' "g'v'c'nt'k'e' "cpf' "j' "k'j' "n' "c'v'k'x'g' "3'V' "O qU<sub>4</sub>' "cpf' "O qU<sub>4</sub>' "r' "j' "c'ug'u' "k'p'v'g'ht'c'eg'f' "y'k'j' "v'j'g' "u'go' "k'ep'q'f' "v'w'k'p'i' "4'J' / "O qU<sub>4</sub>' "cpf' "O qU<sub>5</sub>' "r' "j' "c'ug'u' "0' "C'f'f' "k'k'p'c'ni' "t' "g'ug'c'tej' "ku' "v'q' "d'g' "w'p'f' "g't' "c'ng'p' "k'p' "q't'f' "g't' "v'q' "i' "c'k'p' "h'w'v'j'g't' "k'p'uk'i' "j' "v' "q'p' "v'j'g' "k'p'hw'g'p'eg' "q'h' "c'o' "k'p'q' "c'ek'f' "u' "q'p' "v'j'g' "h'q't'o' "c'v'k'p' "o' "g'ej' "c'p'k'uo' "qh'j' {"dtkf' "O qU<sub>4</sub>' "h'k'ro' "u'0'

[3\_0'0'0'Y'cngt'."G'N'0'Y'ctt'gp'."L'0'0'0'eM'k'p'g'."U'Y'0'D'q'g'w'ej'gt'."S'0'0'k' "G'0'0'U'c'p'v'q't'k' "P' "L'U'N'g'y'ku'."U'q'p'rt' "y'cvt' "ur'rk'w'k'p'i' "eg'mu'."E'j'go'0'T'g'x'0'332'."86686 8695'4232+ "

[4\_0'0'U'j'g'p'i' "g'v'c'ni' "E'q't'g'nc'v'k'p'i' "j' {"f tqi'gp' "q'z'k'f' "c'v'k'p' "cpf' "g'x'q'w'k'p' "c'v'k'k'v' {"q'p' "r' "v'k'p'w'o' "c'v'f' "h'g'et'gp'v' "J' "y'k'j' "o' "g'c'uw'g'f' "j' {"f tqi'gp' "d'k'p'f'k'p'i' "gp'gti' {" "P'c'v'0' E'q'o' "o' "w'p'0'8.'7: 6: "4237+ "

# FEMTOSECOND LASER GENERATION OF MICROBUMPS ON GOLD THIN FILMS

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The processing of material with ultrashort laser pulses induces the formation of wavelength-size microstructures. Due to the high elasticity of gold, using single pulses of femtosecond laser complex structures on a metal surface can be generated. With relatively small energies, just above film modification energy, microscopic protrusions called microbumps can be produced. These hollow structures are formed due to the melting and solidification processes of the irradiated gold layer [1].

Arrayed microstructures of noble metals like gold and silver exhibit unique optical properties one of which is surface plasmon resonance phenomena [2]. When irradiated, in the periodic gold microstructures surface plasmons are excited and the resonant wavelength is absorbed.

Usually, such microstructures are fabricated using lithography methods which are a fast and efficient way to produce small periodic arrays [3]. However, the diameter of the beam limits the area of the array and microstructures are not identical due to the energy distribution profile of the beam. Thus, another direct laser writing method is used for the formation of similar and high reproducibility microbumps in a periodic array. The produced grating and several microbumps are represented by a scanning electron microscope (SEM) in Fig. 1.

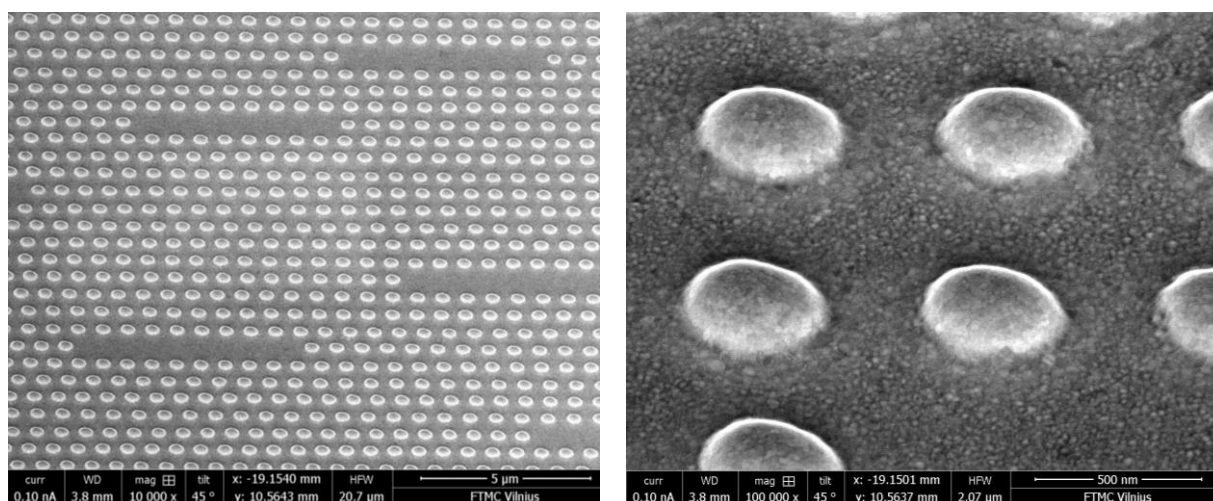


Fig. 1. SEM micrograph of microbump array tilted by 45° (left) and a zoomed view of several microbumps tilted by 45° (right).

The periodic arrays of microbumps were investigated using spectrophotometer and measuring excited plasmon resonances. The gratings demonstrated the hybrid lattice plasmon polaritons in the visible/near-infrared (VIS/NIR) range. There was investigated resonant wavelength dependence on the period of the array, polarization of incident light, and angle of incidence. It was found out that depending on the polarization of incident light different diffractive resonance modes were excited – one resonance strongly dependent on the angle of the incidence and another almost fixed resonance. Also, the grating period influence was observed – with higher period plasmon resonance shifts to higher wavelengths.

To compare practical values and determine the nature of excited plasmons, the theoretical model was used for calculating the resonant wavelength of the diffraction grating. The measured values were in good agreement with the theoretical estimation.

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- [1] Y.P. Meshcheryakov, N.M. Bulgakova. Thermoelastic modeling of microbump and nanojet formation on nanosize gold films under femtosecond laser irradiation, *Applied Physics A* **82(2)**, 363–368 (2006).  
[2] V.G. Kravets, et al. Plasmonic Surface Lattice Resonances: A Review of Properties and Applications. *Chemical Reviews* **118(12)**, 5912–5951 (2018).  
[3] B. Voisiat, et al. Flexible Microstructuring of Thin Films Using Multi-beam Interference Ablation with Ultrashort Lasers. *Journal of Laser Micro/Nanoengineering* **6(3)**, 185–190 (2011).

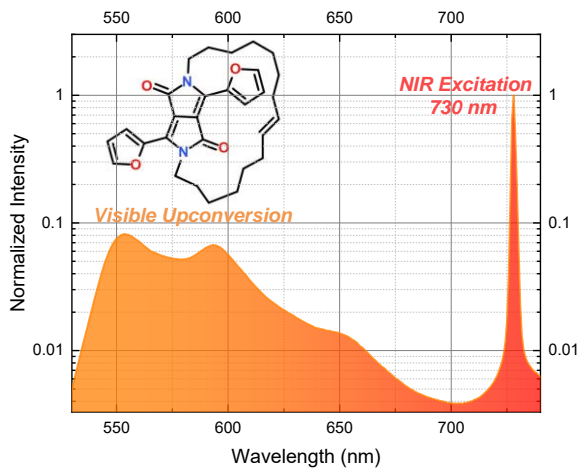
# F[ MGVQR[ TTQNQR[ TTQNG'GO KVVGTUHQ T'P KT/VQ/XKUKDNG'' RJ QVQP 'WREQP XGTUKP''

Nwne'u'P clo qxk kw<sup>3</sup>. 'Gf xkpcu'T cf kypcu<sup>3</sup>. 'Detdctc'Ej cvkpxunc<sup>4</sup>. 'Cwi wukpc'Lq| grk pckv<sup>4</sup>. 'Gf xkpcu'  
Qtgpcu<sup>4</sup>. 'Mctqrk'Mc| rwwne'u<sup>3</sup>"

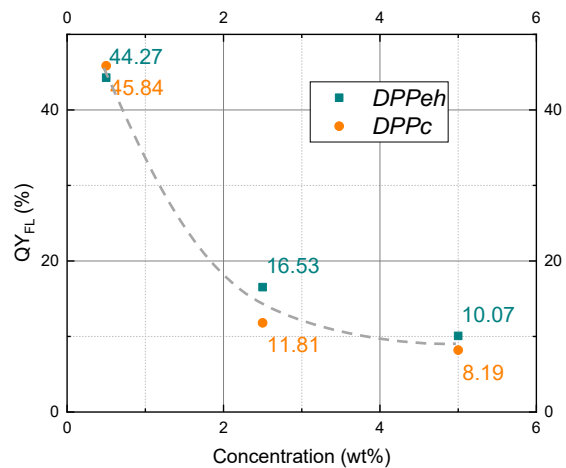
<sup>3</sup>Kpukwag'qh'Rj qvqpleu'cpf 'P cpqvej pqrqi { . 'Hcew' 'qh'Rj { uku. 'Xkpkwu'Wpkxgtukv{ . 'Nkj wpc'k'  
<sup>4</sup>F gr ctwo gpv'qh'Qti cpl'e'Ej go kut { . 'Hcew' 'qh'Ej go kut { 'cpf 'I gquckpogu. 'Xkpkwu'Wpkxgtukv{ . 'Nkj wpc'k'  
nwne'uclo qxlekuB Hkxw'w"

Vtk rgv'vtr rgv'cpplj kvkqp '\*VVC'+o gf kvv'f 'P KT/vq/xkukdng'r j qvqp'wr eqpxgtukqp '\*WE+'ku'c'tcr kf n' 'cf xcpelki 'Hgrf'  
qh'r j qvqpleu'y kj 'pwo gtqwu'r qvqpcr'cr r rdecvqpu0]3\_'Vj'g'o quv'r tqo kulpi 'VVC/WE'cr r rdecvqpu'kpermf g'r j qvqpcr'kcu.  
r j qvqpcr'uku. 'pki j v'xkukp. 'vcti gvgf 'f twi 'f grkxgt { 'cpf 'dk/ko ci lpi 0]3/5\_'WE'u' u'vgo u'ctg'v' r kccm' 'eqo r qugf 'qh'c'  
ugpukki gt 'cpf 'cp'go kvgt0'Vj'g'ugpukki gt 'ku'tgur qpukdng'ht' 'cduqr vqp'qh'ry' 'gpgti { 'r j qvqpu'cpf 'vtr rgv'i gpgtcvkqp'xlc'  
kpvgtu{ungo 'etquulpi. 'y j gtcu'y'g'go kvgt' 'ht'ceewo wvkvq'qh'vtr rgu'cpf 'VVC.'y j lej 'ku'hqmy gf 'd' 'go kulqp'qh'j ki j gt'  
gpgti { 'r j qvqpu0] qy gxt. 'ugxgtc'lej cmgpi gu'tgrcv'f 'vq'c'rcen'qh'VVC'go kvgtu'lp'P KT'tcpi g. 'y j gk 'vgp'gpe { 'vq'ci i tgi cv'g'  
cpf 'ry' 'WE's wcpwo { 'kgrf 'ctg' { gv'v'dg'qxgteqo g0H'qo 'y j ku'r qlp'v'qh'xkgy. 'f krgvr { ttqmr { ttqng'F RR+'go kvgtu'uggo 'vq'  
dg'cp'cwtcvkx'g'cngt'cvkx'vq'c'y kf gn' 'wugf 'twdt'gpg'j3\_'qt'r gt { rpg'f'ko kf g'j5\_0'

Vj g'y qtnku'hqewugf 'qp'tgxc'kpi 'y j g'ko r cev'qh'f h'ht'gpv'ukf g/o qlg'v'gu'qh'F RR'eqo r qwpf u'qp'y j g'ci i tgi cvkqp/ecwugf'  
go kulqp's wpej lpi. 'cpf 'uwdugs wgpv'f. 'WE'r gthqto cpeg0'Vq'y ku'gpf. 'r j qvqr j { ulecn'r tqr g'v'gu'qh'gy { rj gz { n'uwdukw'g'  
eqo r qwpf 'F RR'gj '+cu'y gm'cu'qh'cm'f n'lej clp'utcr r gf 'eqo r qwpf 'F RR'e+y g'g'y qtqwi j n' 'cuugugf 0'Guugp'v'cm'f. 'y j g'F RR'  
f g'k'cvkx'gu'zr tgu'gf 'j ki j 'HN's wcpwo { 'kgrf '\*, 3' '+lp'y j g'ku'v'v'f 'h'qto 'cpf 'f go qp'v'cv'f 'y j g'hcuk'k'k'v'f 'ht' 'VVC'lp'c'  
uq'v'k'p'0'WE'o gcu'w'go gpv'qh'F RR'uq'v'k'p'cu'f o k'zgf 'y j kj 'r j vj cm'e { cp'k'p'g'F RR'e+'ugpukki gt 'lp'qz { i gp'ht'gg'cvo qur j g'g'  
t'g'x'g'c'rg'f 'P KT/vq/xk'wr eqpxgtukqp'y kj 'WE's wcpwo { 'kgrf 'qh'4Q' 'H'i 03+0C'nj qwi j 'y j g'k'p'v'q'f vev'k'p'qh'f h'ht'gpv'ukf g/  
o qlg'v'gu'lp'v'q'F RR'f'kf 'p'q'v'cngt'ku'ci i tgi cvkqp'p'q'v'eg'cdn' 'H'i 04+'y j g'q'v'cv'k'p'g'f 'gh'k'p'v'WE'eq'p'ht'o gf 'y j g'r qvqpcr'qh'  
y j g'g'f g'k'cvkx'gu'ht' 'VVC/WE'cr r rdecvqpu0'



Hk 03'WE'ur gev'tc'qh'F RR'e IRf Re'\*: 'o O B7 O '+lp'  
v'q'w'g'p'g'0



Hk 04'HN's wcpwo { 'kgrf 'qh'F RR'e'cpf 'F RR'gj 'cu'c'  
h'p'ev'k'p'qh'y j g'k'eq'p'eg'p'v'cv'k'p'lp'r qn' u'v' t'g'p'g'0'

[3\_]O 0Y w'gv'c'rd'0'U'qr'f /uv'v'g'lp'ht'ct'gf /vq/xkukdng'wr eqpxgtukqp'ugpukki gf 'd' { 'eq'v'k'f'cr'p'ep'qet { ucn'u.0'P cv0Rj qvqpleu.'xq'f'032.'p'q'03.'r r 053656.'\*4238-'  
[4\_]T'cf kypcu.'G0'gv'c'rd'0'K6 r cev'q'h'e'v' /dw'f n'uwdukw'k'p'c'v'w'dt'g'p'g'go kvgt'ht' 'u'q'v'f 'uv'v'g'P KT/vq/xkukdng'r j qvqp'wr eqpxgtukqp0Rj { u0Ej go 0Ej go 0Rj { u0'  
44.'95; 469625'\*4242-0'  
[5\_]Dj cto qtlc.'R0'gv'c'rd'0'Vtk rgv'vtr rgv'cpplj kvkqp'dcu'gf 'p'g'ct'lp'ht'ct'gf 'vq'xkukdng'o q'rg'ew'ct'r j qvqp'wr eqpxgtukqp0Ej go 0'U'q'e'0T'g'x'06; . '874; 68776'  
\*4242-0'

O3-1

DID NOT PARTICIPATE

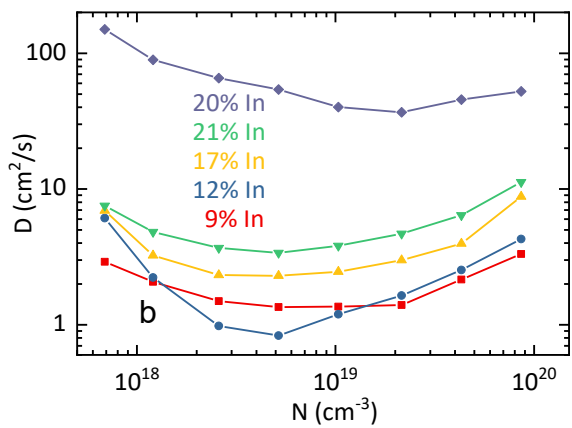
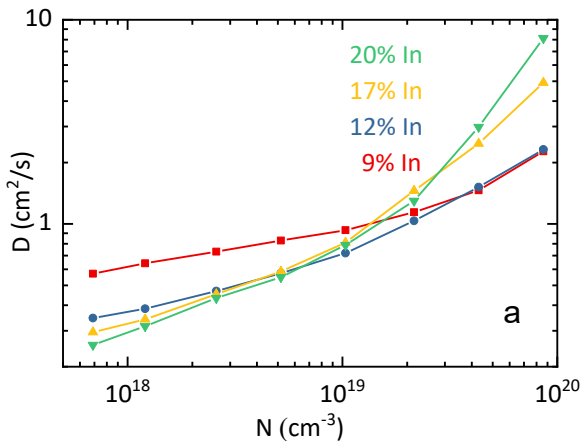
**ECTTKGT'NQECNK CVKQP 'K' KPI cP'UVTWEVWTGU'K'XGUVH CVGF'DI''  
NK J V/R'F WEGF'VTCPUKGP V'I TCVKPI 'VGEJ P K S WG''**

O cpvcu'Xck kwku.'Mc| lo kgtcu'P qo gknæ.'Tco pcu'Crgmikgl pcu''

3) Kpukwag'qh'Rj qvqpleu'cpf 'P cpqvej pqrni { . 'HcewM' 'qh'Rj { ukeu.'Xkrpkwu'Wpkxgtuks{ . 'Ucwa vgnku'Cx05.'NV/32479''  
Xkrpkwu.'Nkj wcpkc''  
o cpvcu'XckkwkuB hñwaf'kwñ''

Nqecrk' cvkqp'qh'ej cti g'ecttktu'lp'uj cmqy 'r qvqpleu'no kpkc c'lwu'dgny 'vj g'dcpf 'gf i gu'ku'v' r kecn'htq'o cvgtknu'cpf''  
utwewt gu'y kj 'uqo g'rgxgn'qh'f kuqtf gt'0Vj ku'r tqeagu'ku'y gni'npqy p'lp'kkkpkstkf gu'cmq { u'y j gtg'k'ku'dgrkxgf 'vq'dg'vj g''  
o clp'tgcuqp'htq'j ki j 'lpv'gpcr's wcpwo "ghhekepe { . 'f gur kg'j ki j 'f ghgev'f gpukv' ]3\_0Vj g'gzcev'ghhev'qh'ecttkt' mcecrk' cvkqp''  
vq'ecttkt' t'cpur qt'v'cpf 't'geqo d'lp'cvkqp'ku'f k'hwew'v'q'cpcn' | g'0S wcpwo 'y gmi'qh'v'gtpct { 'pktkf g'cmq { u'ku'c'xgt { 'eqo r r'gz''  
utwewt g'v' y wu.'lp'xgunki cvkqp'qh'ecttkt' mcecrk' cvkqp' f go cpf u'c'eqo r wcv'kqpcn'j gcx { "o qf g'kpi " ]4\_ "cpf' uqr j k'wecv'gf''  
g'zr g'tko g'pvc'no g'v' qf u' ]5\_0''

Opg'y c { "vq'gzr g'tko g'pvcn' { 'uwf { 'vj g'ecttkt' mcecrk' cvkqp'ku'd { "qdugt'kpi 'vj g'r' tqr g'v'ku'qh'ecttkt' f' k'hwukp'0'k'p'vj ku''  
rtgug'p'cvkqp." y g' tgr'qt'v' 'vj g' tguwu' qd'v'cp'gf' d { " Nki j v'k'f' wegf' " Vt'cpukgp'v' I t'cvkpi " \*NKVI + " v'ej pl'k' w'g' " kp''  
k'p' c'p' II c'p' l'uc' r'j k'g' utwewt gu'i t'qy p'd { " O QEXF " v'ej pl'k' w'g' c'np'pi 'vj g'r' q'rc' " \*e+ " et { u'cmq'j t'cr j k'e' " f' k'g'ev'k'p'u'0'Y g'ectt { ''  
q'w'NKVI " g'zr g'tko g'p'v'v'q' " o g'c'w'g'v'j g' " co d'k' q'rc' " f' k'hwukp' " eq'gh'he'k'gp'v' \*F + " q'h'r j q'v'g'z'ek'g'f' " ecttktu'lp' s' wcpwo 'y gmi'cpf''  
vj k'eni'rc' { g'tu'0'ht'qo 'vj g'f' gr' g'p'f' g'p'ek'gu'qh'F' " qp'ecttkt' f' gpukv' " cpf' " r'j q'v'g'z'ek'v'k'p' " y c'x'g'p'pi v'j . 'y g' " c'p'c'n' | g'v'j g' " ko r'cev'q'h''  
ecttkt' mcecrk' cvkqp' " qp'vj g'k' " t'cpur qt'v'cpf 't'geqo d'lp'cvkqp' " r'cv'j y c { u'0''



Hki 03<F k'hwukp' f' gr' g'p'f' g'p'eg'kp'S Y u' \*c+ 'cpf' "rc { g'tu' "d+ 'y kj 'f' h'ht' g'p'v'k'p' " eq'p'v'g'p' " qp'ecttkt' f' gpukv' { 0S Y " uco r' ngu' eq'p'ku'v'qh'v'g'p' " S''  
po 'vj k'eni'rc' wcpwo 'y gmi.' y j k'g' "rc { g't' uco r' ngu' " ct'g' " k'p'i ng'72' " po 'vj k'eni'rc' { g't. " g'z'egr' v'ht'q' "43' " k'p' " uco r' ng.' y j k'ej 'ku'q'p'n' "47' " po 'vj k'eni'rc' "

Kp'S Y u'F \*P +f' gr' g'p'f' g'p'eg' " ecp' " dg'f' k'k'f' g'f' " k'p'v' " y q' " t'gi k'p'u'qh'ecttkt' f' gpukv'ku'0'Vj g' " h'k' u'v' " t'gi k'p' " ecp' " dg'f' g'uet'k'd'g'f' " d { ''  
ulo r' r'k'k'f' " G'k'p'v'k'p' " t'g'w'k'p' " . " x'c'rk' " h'q' " p'q'p'f' g' " g'p'g't'c'v'g' " ugo k'ep'f' v'ev'q' " cv' " g's w'k'k'd't'k'wo " eq'p'f' k'k'p'0'Vj g' " k'p'et'g'c'ug' " qh'F' " y kj''  
ecttkt' f' gpukv' " k'p' " v'j g' " uge'q'p'f' " t'gi k'p' " ecp' " dg'f' c'w'k'd'w'g'f' " v'q' " ecttkt' f' g' " g'p'g't'c'e { . " y j g'p' " s' w'cuk' " h'g'to k' " r'g'x'gn' " cr' r' " tq'cej' gu' " v'j g''  
d'cp'f' u' ]6\_ " j qy g'x'g't. " k'v'j cu' " d'gg'p' " u'j qy p' " t'g'eg'p'w' " v'j cv'f' g' " g'p'g't'c'e { " c'mp'p'g' " ku' " p'q'v'g'p'q'w' j " v'q' " c'ee'q'w'p'v' " h'q' " v'j g' " F \*P +f' gr' g'p'f' g'p'eg''  
kp' " k'p' c'p' O' " Ecttkt' " mcecrk' cvkqp' " v'q' " m'eci' " r' q'v'q'pleu' " no k'pkc c' " h'q'to g'f' " d { " t'cp'f' qo " cmq { " h'w'ew'c'k'p'u' " ]7\_ " cu' " y gmi'cu' " ecttkt' ''  
f' g'p'q'ecr'k' cvkqp' ]8\_ " ct'g' " c'nu'q' " eq'p'v'k'd'w'k'p'i " h'cev'q'tu' " k'p' " g'zr' " r'ck'p'k'p'i " F \*P +0'

Kp' "rc { g'tu' " j ki j " f' k'hwukp' " eq'gh'he'k'gp'v' " cv' " n'qy " " ecttkt' f' gpukv'ku' " eq'w'f' " dg' " g'zr' " r'ck'p'g'f' " d { " r' g'te'q'rc'v'k'p' " v'j g'q't { " cpf' " v'j g''  
f' g'et'g'c'ug' " qh'f' k'hwukp' " y kj " v'j g' " k'p'et'g'c'ug' " qh' " ecttkt' f' gpukv' " eq'w'f' " dg' " g'zr' " r'ck'p'g'f' " d { " Eq'w'q'o d' " d'q'eni'k'p'i " k'p' " v'j g' " r' g'te'q'rc'v'k'g''  
r'cv'j u'0'Cu' " v'j g' " ecttkt' f' gpukv' " k'p' " v'j g' " u' " k'p'et'g'c'ug' " u'q' " f' q'g'u' " v'j g' " Eq'w'q'o d' " k'p'v'g't'c'ev'k'p' " dg'y g'g'p' " v'j g' " e'j c'ti g''  
ecttktu' " y j k'ej " j k'p'f' g'tu' " v'j g'k' " o q'x'g'o g'p'v' ]9\_0'Vj g' " eg'p'v'g't' " t'gi k'p' " qh' " u'ny " f' k'hwukp' " eq'gh'he'k'gp'v' " e'j c'p'i g' " ecp' " dg'f' g'uet'k'd'g'f' " d { ''  
G'k'p'v'k'p' " t'g'w'k'p'0'Vj g' " k'p'et'g'c'ug' " qh'f' k'hwukp' " eq'gh'he'k'gp'v' " cv'j ki j " ecttkt' f' gpukv'ku' " ecp' " dg'f' c'w'k'd'w'g'f' " v'q' " j q'rg' " f' k'hwukp' " k'p' " c''  
f' g' " g'p'g't'c'v'g' " ugo k'ep'f' v'ev'q' " y kj " f' kuqtf' g't' " ]7\_0''

[3\_ " UOEj k'ej k'd'w'g'v' " cr'0' " U' " r'cv'c'm' " t'g'u'q'k'g'f' " e'cy' qf' q'mo k'p'g'ue'g'p'eg' " ur' g'ev'c' " qh'k'p'i c'p' " s' wcpwo 'y gmi.' " C'r'r' " r'0'j { u'0'Ngw'093.'45686456: \*3; ; 9-0'  
[4\_ " E'0M'N'k'g'v' " cr'0' " N'q'ecr'k' cvkqp' " r'cp'f' u'ec'r' g' " v'j g'q't { " q'h'f' kuqtf' g't' " k'p' " ugo k'ep'f' v'ev'q'u' " k'k'k'c'r' " r' " d'ec'v'k'p' " v'q' " ecttkt' " t'cpur qt'v'cpf 't'geqo d'lp'cvkqp' " k'p' " i'ki j v'go k'v'k'p'i " " f' k'q'f' gu.' " R'j { u'0T'gx'0D'; 7.'366428' \*4239-0'  
[5\_ " Y'0'J' c'j p' " g'v' " cr'0' " G'x'k'f' g'p'eg' " qh' " p'ep'q'ue'c'g' " C'p'f' g'tu'q'p' " mcecrk' cvkqp' " k'p'f' wegf' " d { " k'p'v'k'p'ule' " eq'o r' q'uk'k'p'c'ni' " f' kuqtf' g't' " k'p' " k'p'i c'p' II c'p' " s' wcpwo 'y gmi' " d { ''  
u'ec'p'k'p'i " w'p'p'g'k'p'i " h'wo k'p'g'ue'g'p'eg' " ur' g'ev'q'ue'q'r { 0R'j { u'0T'gx'0D'; ; . '267527' \*423: -0'  
[6\_ " V'0O' c'ri'p'c'w'nu'cu' " g'v' " cr'0' " F' k'hwukp' " cpf' " t'geqo d'lp'cvkqp' " q'h'f' g' " g'p'g't'c'v'g' " ecttkt' " r' " nu'o c' " k'p' " I c'p' . " R'j { u'lec' " U'c'w'u' " U'q'ri'k' " k' \*E + " E'w't'g'p'v' " V'q'r' k'eu' " k'p' " U'q'ri'k' " U'c'w'g''  
R'j { u'keu.' " 8 \*U'W'RR'N'04+; 9656968' \*422: -0'  
[7\_ " T'0' " C'rg'm'k'gl' " pcu' " g'v' " cr'0' " k'o r'cev' " qh' " C'mq { /F' kuqtf' g't' /k'p'f' wegf' " N'q'ecr'k' cvkqp' " qp' " J' q'rg' " F' k'hwukp' " k'p' " J' ki j n' " G'z'ek'g'f' " e' " /R'rc'p'g' " cpf' " " o' /R'rc'p'g' " \*k'p' " I c'p' " " S' wcpwo 'Y gmi.' " R'j { u'k'eci' " T'g'x'lg'y " C'r'r' " r'k'g'f' . " 36\*7+ " 3633' \*4242-+''  
[8\_ " M'0P' qo g'knæ' " g'v' " cr'0' " k'o r'cev' " qh' " ecttkt' " mcecrk' cvkqp' " cpf' " f' k'hwukp' " qp' " r'j q'v'q'mo k'p'g'ue'g'p'eg' " k'p' " j ki j n' " g'z'ek'g'f' " e { cp' " cpf' " i' " t'gg'p' " k'p'i c'p' " N'G'F' " utwewt'gu.' " " I'q'w'p'c'ri'q'h' " N'wo k'p'g'ue'g'p'eg' . " 3: : . " 5236528' \*4239-0'  
[9\_ " J' " 0'G'0' " T'qo g't'q' " g'v' " cr'0' " E'q'w'q'o d' " d'q'eni'f' g' " cpf' " J' q'r' " r'p'i " E'q'p'f' v'ev'k'p' " k'p' " R'd'U'g' " S' wcpwo 'F' q'u.' " R'j { u'0T'gx'0Ngw'0; 7.'378: 23' \*4227-0'

# VGO RGT CVWT G'F GRGP F GP V'GNGE VT QP 'GHHGE VKXG'O CUU'P "

## Cñ cP II CP 'J GVG TQUV TWEVWT GU'O GCUWT GF 'XKC'VJ | "

### URGEVT QUEQR[ 'QH'4F 'RNCUO QP U'

F cplklRcuj pgx. "Vqo o kMcr rnu. "Xcf { o "Mqtqv[ g{ gx. "X{ vawcuLcpqpk. "Cpf t| gl "Wtdcpqy kel. "

LwukpcuLqtwf cu'cpf "Kco cpvcuMc-en{ pcu""

VJ | 'rj qvqpkcu'rdqtqv[ { .F gr ctwo gpv'qh'Qr vgrgevtqple. 'Egpvt'ht' Rj { ulecn'Uekpegu'cpf "

Vgej pqrqi { . "Xkpkku. "Nkj wcpk ""

f cplkl[ cui pgxB ho eOw'

Vj g' Cñ cP II cP "j gvg tquv wewtgu'ctg'y kf gn[ "wug' "cu"o clp"grgo gpv'u'qh'o cp{ "qr vgrgevtqple "f gxlegu "kpenw' kpi " f gvevqtu" ]3\_ "cpf "o qf wrcvqtu" ]4\_ "qh'VJ | "tcf k'vqpp'0Vj g' j ki j "grgevtqpp"o qdrlkv[ "t'cpukvqt' \*J GO V' utwewtgu' dcugf "qp" Cñ cP II cP 'y kj 'e'vy q/f ko gpukqpcn'grgevtqpp' i cu' \*4F GI -t quguukpi "o qdrlkv[ 'qh'3; '222' \*ht' '99' M' c' p' f' "4422' eo "4X u' \*ht' "522' M' " ]5\_ "6\_ "ctg' r tqo kulpi "ht' "vj g' f g' xgnr o gpv'qh' t' guqpcp' v' VJ | "f gvevqtu' c' p' f' "go kvgtu' dcugf "qp' "y g' r' rnuo c' y cxgu" r j gpqo gpc' ]7\_ "8\_ OF gur kv[ vj g' e'apuk' g' tcdng' kvgt' guv' vj g' grgevtqpp' g' h' ge' v' k' g' o cuu' e' q' p' c' k' pu' u' ki pl' h' e' cp' v' p' e' g' t' c' k' p' v' k' u' g' u' v' j' g' u' g' j gvg tquv wewtgu' y kj " xcwng' " lpetgcug' htqo " 208; /2047' o g' \*o g' htgg" grgevtqpp" o cuu' " cv' et { qi gple " vgo r gtcwgtgu' w' " vq" 205/208' o g' "cv' tqo " vgo r gtcwgt' ]9\_ 0"

I tcvpi /eqwr n[ f' Cñ cP II cP "J GO V' utwewtgu'gzj kkv' t' guqpcp' v' d' g' j cxkwt "f wq' "v' c' "4F "r' rnuo qpu' g' zek' v' k' p' "y' j' g' VJ | "t' c' p' i' ]5\_ :\_ O' Vj g' r' qukkqp' qh' vj g' t' guqpcp' e' g' u' f' gr' g' p' f' u' q' p' vj g' grgevtqpp' e' q' e' g' p' e' g' v' t' c' v' k' p' . g' h' h' e' v' k' x' g' o cuu. " c' p' f' " y' g' y' c' x' g' " x' g' e' v' t' " l' p' " y' g' r' w' k' e' g' " l' p' " c' e' e' q' t' f' c' p' e' g' " v' q' " c' p' c' n' [ v' e' c' n' b' q' f' g' n' u' ] : o ; \_ " y' j' kv[ vj g' h' w' n' u' k' f' vj " c' v' j' c' n' i' b' c' z' k' o w' " q' h' vj g' t' g' u' q' p' c' e' g' r' g' e' m' i' e' c' p' " d' g' t' g' r' v' g' f' " v' q' " y' j' g' grgevtqpp' u' e' c' v' g' t' k' p' i' " v' k' o' g' O' Vj g' t' g' u' q' p' c' p' v' 4F " r' rnuo q' p' " h' e' c' w' t' g' u' " e' c' p' " d' g' " q' d' u' g' t' x' g' f' " l' p' " d' q' y' " c' o' r' r' k' w' f' g' " c' p' f' " r' j' c' u' g' " u' r' g' e' v' t' c' " o' g' c' u' w' t' g' f' " d' { " y' j' g' " VJ | " v' k' o' g' / f' q' o' c' l' p' " u' r' g' e' v' t' q' u' e' q' r' { " \*V' F' U' " u' { u' g' o " ]5\_ O' Vj wu. " VJ | " V' F' U' " c' m' y' u' " f' k' t' g' e' v' " k' p' x' g' u' k' i' c' v' k' p' " q' h' vj g' grgevtqpp' g' h' h' e' v' k' x' g' o cuu' f' g' r' g' p' f' p' e' g' " q' p' " e' c' t' t' k' g' t' " f' g' p' u' k' " { q' t' " v' g' o' r' g' t' c' w' t' g' " l' p' " r' rnuo q' p' l' e' " u' t' w' e' w' t' g' u' ] : " 32\_ O'

Vj g' Cñ cP II cP "j gvg tquv wewtgu' y g' t' g' i' t' q' y' p' " q' p' " c' " 722 " o y j keni' u' g' o k' k' p' u' w' r' v' k' p' i " U' k' e' " u' w' d' u' t' c' v' g' o' r' g' e' t' k' f' k' e' c' n' i' o' g' e' c' n' i' i' t' c' v' p' i' u' h' t' " g' z' e' k' c' v' k' p' " q' h' 4F " r' rnuo q' p' u' y' g' t' g' h' d' t' k' e' c' v' g' f' " q' p' " y' j' g' j' g' v' g' t' q' u' v' w' e' w' t' g' u' t' h' e' g' " l' p' " c' p' " t' g' c' e' g' " q' h' 4z4' b' o' o' 4O' h' q' w' " u' c' o' r' r' n' g' u' " y' k' j' " i' t' c' v' p' i' " r' c' t' c' o' g' v' t' u' q' h' vj g' y' k' f' vj " r' g' t' k' f' " q' h' 572' 1822' 6621: 22. '752' 3252. 'c' p' f' " : 52' 13222' l' p' " p' c' p' q' o' g' v' t' u' y' g' t' g' k' p' x' g' u' k' i' c' v' g' f' " l' p' " t' c' p' u' k' u' k' p' i' " g' q' o' g' t' { " w' u' k' p' i' " c' " e' q' o' o' g' t' e' k' n' i' u' r' g' e' v' t' o' g' v' t' " v' / U' R' G' E' " : 22' \*V' g' t' c' X' k' n' i' " l' p' " y' j' g' t' g' w' p' e' { " t' c' p' i' g' " 208' / 6 " VJ | " c' v' x' e' t' k' w' u' " v' g' o' r' g' t' c' w' t' g' u' r' t' q' x' k' f' g' f' " d' { " c' " h' s' w' k' f' " p' k' t' q' i' g' p' " e' t' { q' u' v' c' l' o' }

Rnuo qpu' y' g' g' zek' g' f' " l' p' " c' m' l' u' c' o' r' n' g' u' " l' p' " y' j' g' t' g' w' p' e' { " t' c' p' i' g' " 3' / 5 " VJ | O' Vj g' t' g' u' q' p' c' p' v' h' e' c' w' t' g' u' " q' h' 4F " r' rnuo q' p' u' w' p' f' g' t' " y' j' g' i' t' c' v' p' i' " y' g' t' g' h' w' p' f' " c' u' " c' r' t' q' p' w' e' g' f' " o' k' p' o' w' o' " c' p' f' " c' p' " l' p' h' e' v' k' p' " r' q' l' p' v' k' p' " y' j' g' r' q' y' g' t' " c' p' f' " r' j' c' u' g' " u' r' g' e' v' t' c' . " t' g' u' r' g' e' v' k' g' n' f' " O' Vj g' r' qukkqp' qh' vj g' t' g' u' q' p' c' e' g' t' g' f' u' j' k' h' w' f' " y' k' j' " c' p' " l' p' e' t' g' c' u' g' " q' h' i' t' c' v' p' i' " r' g' t' k' f' " l' p' " c' p' " c' i' t' g' g' o' g' p' v' y' k' j' " y' j' g' q' t' { " ]6\_ : . " 32\_ " h' t' " g' z' c' o' r' n' g' . " y' j' g' r' rnuo q' p' u' y' g' t' g' zek' g' f' " c' v' 404 " c' p' f' " 306 " VJ | " l' p' " y' j' g' u' c' o' r' n' g' u' y' k' j' " i' t' c' v' p' i' " r' g' t' k' f' u' " q' h' 822 " c' p' f' " 3222 " p' o' . " t' g' u' r' g' e' v' k' g' n' f' " O' T' g' u' q' p' c' e' g' " h' e' c' w' t' g' u' " t' g' o' c' l' p' " x' k' u' k' i' d' r' g' " l' p' " d' q' y' " r' q' y' g' t' " c' p' f' " r' j' c' u' g' " u' r' g' e' v' t' c' " w' " v' q' " 442' M' " c' p' f' " 522' M' " h' t' " u' c' o' r' n' g' u' y' k' j' " y' j' g' u' c' o' g' i' t' c' v' p' i' " r' g' t' k' f' " q' h' 3222 " p' o' " d' w' f' " k' h' e' t' g' p' v' h' k' p' i' " h' e' v' t' " 72 " c' p' f' " : 2 " . " t' g' u' r' g' e' v' k' g' n' f' " O' O' q' t' g' x' g' t' . " y' k' j' " y' j' g' v' g' o' r' g' t' c' w' t' g' " l' p' e' t' g' c' u' g' . " 4F " r' rnuo q' p' " t' g' u' q' p' c' e' g' u' g' z' r' g' t' k' e' p' e' g' f' " y' j' g' t' g' f' / u' j' k' h' v' k' p' " y' j' g' t' c' p' u' o' k' u' k' p' " u' r' g' e' v' t' c' " q' h' " c' n' i' u' c' o' r' n' g' u' " 0' h' t' " c' " e' c' u' g' " q' h' : 2 " " h' k' n' i' p' i' " h' e' v' t' . " y' j' g' r' qukkqp' " e' j' c' p' i' g' f' " y' c' u' " r' c' t' i' g' u' v' " h' t' q' o " 306 : " VJ | " c' v' : 2' M' " v' q' " 305 " VJ | " c' v' 522 " M' O' " K' y' c' u' " p' q' w' e' g' f' " y' j' c' v' " y' j' g' " e' q' p' e' g' p' t' c' v' k' p' " q' h' " g' r' e' v' t' q' p' u' " c' v' t' q' q' o " v' g' o' r' g' t' c' w' t' g' " l' p' e' t' g' c' u' g' f' " w' " v' q' " 32 " " q' h' vj g' " n' y' / v' g' o' r' g' t' c' w' t' g' " x' c' n' w' g' " y' j' k' e' j' " l' p' " w' t' p' " u' j' q' w' f' " d' n' w' g' " u' j' k' h' vj g' t' g' u' q' p' c' e' g' r' " q' u' k' k' p' " 0' Vj wu . " y' j' g' r' j' g' p' q' o' g' p' q' p' " y' c' u' " v' t' w' k' d' w' e' g' f' " v' q' " v' j' g' t' g' p' q' t' o' c' r' i' k' c' v' k' p' " q' h' " g' r' e' v' t' q' p' " g' h' h' e' v' k' x' g' o' c' u' u . " y' j' k' e' j' " f' g' x' k' c' v' k' p' " u' n' c' t' u' " c' v' 356 M' " c' p' f' " c' v' 4 ; 7 M' " l' p' e' t' g' c' u' g' f' " w' " v' q' " 77 " " q' h' k' u' " p' q' o' k' e' c' n' i' x' c' n' w' g' . " h' t' m' y' k' i' " y' j' g' r' j' g' p' q' o' g' p' q' n' i' k' e' c' n' i' f' g' r' g' p' f' p' e' g' " q' h' " o' . " \*V' 4 " " o' g' ]3- " 203 \*V' B56-7\_ 0"

**Cempqy ngf i go gpv** Vj ku'y qtnly cu'lw r qtvgf 'd{ 'y g' T gugtej 'E qwpekri qh'Nkj wcpk "Nlgw xqu' b' qmm' t' c' t' { d' c' + w' p' f' g' t' " y' j' g' v' G' T' C' I' C' P' Y' K' G' o' R' t' q' l' g' e' v' \*1 t' c' p' v' p' Q' O' U' N' N' / 3 ; / 3\_ 4'

[3\_ "Y O' M' p' e' r . " X0' M' e' j' q' t' q' x' u' n' i' k' [ " O' F' g' p' i . " U' O' T' w' o { c' p' u' g' x . " L' O' S' O' N' w' " T' O' I' c' u' n' e . " O' U' U' j' w' . " I' O' U' o' k' p . " Z' O' J' w' " O' O' C' O' M' j' c' p . " E' O' C' O' U' c' { n' i' t . " N' E' O' D' t' w' p' g' n' o' p' q' p' t' g' u' q' p' c' p' v' f' g' v' e' v' k' p' " q' h' v' g' t' e' j' g' t' v' " t' e' f' k' c' v' k' p' " l' p' " h' g' r' f' / g' h' h' e' v' t' c' p' u' k' v' q' t' u' o' " l' q' w' p' e' r' i' q' h' C' r' r' i' d' g' f' " R' j' { u' l' e' u' ; 3\*33+ ; 568 " \*4224+ O' F' QK320285 B0868 : 479 "

[4\_ "Z' O' j' c' p' i . [ " O' Z' k' i . ' S' O' j' c' p' i . [ " O' I' w' [ " O' U' w' E' j' O' O' c' v' j' k' i' j' " u' r' g' g' f' " v' g' t' e' j' g' t' v' " o' q' f' w' r' c' v' t' ' d' c' u' g' f' " u' p' " v' j' g' l' u' p' i' n' e' j' e' j' c' p' p' g' i' C' n' i' c' P' I' I' c' P' ' j' k' i' j' " g' r' e' v' t' q' p' b' o' q' d' r' k' k' v' [ " t' c' p' u' k' v' q' t' o' " U' q' r' i' f' / U' c' v' g' " G' r' e' v' t' q' p' l' e' u' 368 . " ; / 34 " \*423 ; + O' F' QK320238 1100g4 23 : 060233 "

[5\_ "F' O' R' c' u' j' p' g' x . " V' O' M' e' r' r' e' u . " X' O' M' q' t' q' v' [ g' { g' x . " X' O' L' e' p' q' p' k' u . " C' O' W' d' e' c' p' y' k' e' l . " I' O' L' a' t' w' f' c' u' " c' p' f' " I' O' M' c' - c' n' f' p' c' u . " o' v' g' t' e' j' g' t' v' " v' k' o' g' / f' q' o' c' l' p' " u' r' g' e' v' t' q' u' e' q' r' { " q' h' v' y' q' / f' k' o' g' p' u' k' p' c' n' i' r' r' e' u' q' p' u' " l' p' " C' n' i' c' P' I' I' c' P' " j' g' v' g' t' q' u' v' w' e' w' t' g' u' o' " C' r' r' i' o' R' j' { u' N' g' w' 0339 . 273327 " \*4242+ 0 }

[6\_ "I' O' V' O' E' j' g' p' . " I' O' D' g' t' i' u' n' g' p' . " I' O' N' w' " G' O' L' e' p' ] 2 p . " O' O' Vj q' t' u' g' m' " N' O' J' w' n' o' c' p' . " P' O' T' q' u' o' c' p' . " c' p' f' " Q' O' M' q' t' f' l' o' c' . " o' C' I' c' P' / U' E' " j' { d' t' k' " o' c' v' g' t' k' e' i' r' h' t' " j' k' i' j' / h' t' g' s' w' p' e' { " c' p' f' " r' q' y' g' t' " g' r' e' v' t' q' p' l' e' u . " o' C' r' r' i' o' R' j' { u' N' g' w' 0335 . 263827 " \*423 ; + 0 }

[7\_ "P' O' F' { c' n' y' p' q' x' c . " R' O' H' e' n' g' t' o' g' l' e' t' . " F' O' D' O' D' w' " F' O' E' q' s' w' k' n' c' v' " U' O' F' O' I' c' p' l' e' j' g' x . " Y' O' M' p' e' r . " M' O' U' m' v' f' r' e' t' g' m' " c' p' f' " I' O' E' { y' k' p' u' n' k' " o' U' e' w' t' c' v' k' p' " q' h' i' t' j' q' v' q' t' g' u' r' q' u' g' " v' q' " l' p' e' p' u' g' " VJ | " t' e' f' k' c' v' k' p' " l' p' " C' n' i' c' P' I' I' c' P' " J' G' O' V' f' g' v' g' e' v' t' . " o' L' O' C' r' r' i' o' R' j' { u' 0342 . 386729 " \*4238+ 0 }

[8\_ "X' O' C' O' U' E' j' e' r' i' m' . " o' C' d' u' q' t' r' w' k' p' " c' p' f' " g' o' k' u' k' p' " q' h' " g' r' e' v' t' q' o' c' i' p' g' l' e' " y' c' x' g' u' d' [ " y' q' t' " l' o' g' p' u' k' p' c' n' i' r' r' e' u' q' p' u' . " o' U' m' t' h' O' U' e' l' O' T' g' r' O' r' . " 4 : ; 6557 " \*3 ; : 7\_ 4'

[32\_ "F' O' R' e' u' j' p' g' x . " X' O' X' O' M' q' t' q' v' [ g' { g' x . " I' O' L' a' t' w' f' c' u' " V' O' M' e' r' r' e' u . " X' O' L' e' p' q' p' k' u . " C' O' W' d' e' c' p' y' k' e' l . " c' p' f' " I' O' M' c' - c' n' f' p' c' u . " o' G' z' r' g' t' k' o' g' p' v' e' r' i' g' x' k' f' g' p' e' g' " q' h' v' g' o' r' g' t' c' w' t' g' u' " f' g' r' g' p' f' g' p' v' g' h' h' e' v' k' x' g' o' c' u' u' " l' p' " C' n' i' c' P' I' I' c' P' " j' g' v' g' t' q' u' v' w' e' w' t' g' u' q' d' u' g' t' x' g' f' " x' l' e' " VJ | " u' r' g' e' v' t' q' u' e' q' r' { " q' h' 4F " r' rnuo q' p' u' o' C' r' r' i' o' R' j' { u' N' g' w' 0339 . 384323 " \*4242+ 0 F' QK320285 F0244822T "

# GNGEVTKECN'EJ CTCEVGT KUVKEU'QHŠDWHHGT/HTGGÖ'CH cP II cP'' J GVGTQUVTWEVWTGU'

Lwukpcu'Iqtwf cu<sup>3</sup>. 'Ctv t''to wmqxk<sup>4</sup>. 'Ko cpwu'Mc-cn{pcu<sup>3</sup>

<sup>3</sup>Vgtcj gtv 'r j qvqpleu'rdqtcvt { 'Egpgt 'hqt 'Rj { ulecl'Uelgpegu'cpf 'Vgej pqm { '\*HVO E+ 'Nkj wcpk''

<sup>4</sup>Hwewwvq'p'tgugctej 'rdqtcvt { 'Egpgt 'hqt 'Rj { ulecl'Uelgpegu'cpf 'Vgej pqm { '\*HVO E+ 'Nkj wcpk''

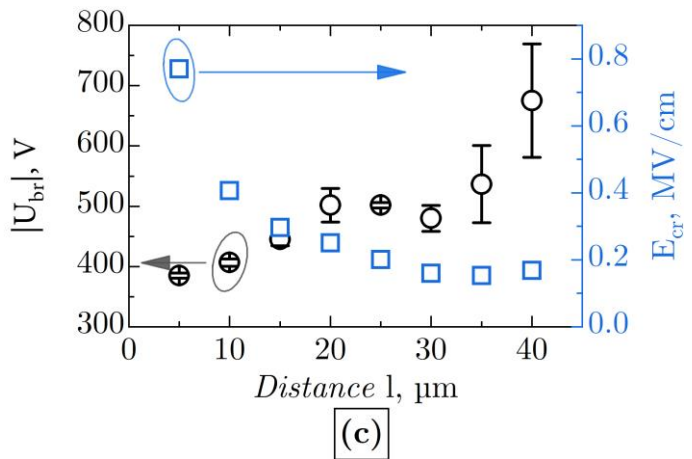
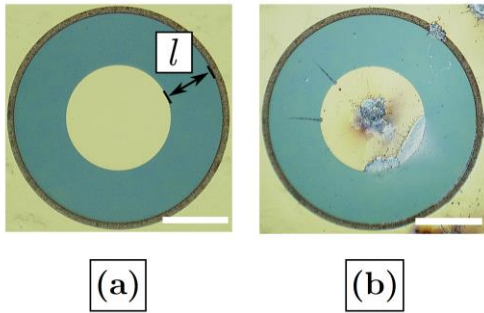
Lwukpcu'Iqtwf cuB ho eOw'

"

Vj g'Crñ cP II cP'' j ki j 'gngewq'p'o qdtkw' 't'cpukvqtu''\*J GO Vu''wug' 'lp'' j ki j 'r qy gt' 'cpf'' j ki j 'Itgs wpe { 'cr r rlecwqpu'' wuwcm' 'ctg'i tgy p' 'qp' 'ukdeqp' 'ectdkf' g''\*UE+ 'uwdutcvg' Vj g' 'eqo o qp' 'cr r tqcej 'vq' 'eqo r g'pucv' hqt 'v' g' 'r'wleg' 'o' kuo cvej 'cpf'' vq' 't'gf' w'eg' 'v' j g' 'f' kurecvq'p' 'f' g'puk' 'lp'' 'v' j g'ug' 'utwewtgu' 'ku' 'v' 'i' tgy 'v' j lenil' cP 'dwhgt' 'f' qr' gf' 'y' kj 'f' ggr' 'ceegr' 'vqtu' 'uwej' 'cu' 'Hg' 'qt'' E' 'y' j lej 'eqo r g'pucv' 't'guk' 'w'cl'f' qr' kpi 'qh' 'cp' 'p' / 'v' r' g' 'I' cP 'qp' 'v'qr' 'qh' 'v' j g'Crñ 'p'wengcvq'p' 'rc' { 'gt' '\*P N+0J' qy' g'xgt. 'v' j ku' 'cr r tqcej'' tgf' w'egu' 'v' j g' 'cf' xcpwci' g' 'qh' 'UE' 'j' ki j 'v' j gto' crieqpf' w'ekw' (O' Cnq. 'v' j g'ceegr' 'vqt' / 'v' r' g' 'ko r' w'kkgu' 'lp'' 'c' 'v' j lenil' cP 'dwhgt' 'lp'w'qf' w'eg'' v' j g' 'f' ggr' 'ej' cti' g' 'v' cr r kpi 'egpgtu' 't'g'uw'kpi 'lp'' 'v' j g' 'kpet' g'cug' 'qh' 'm'v' / 'Itgs wpe { 'pqkug' 'J3\_0'Vq' 'uq'w'g' 'v' j ku' 'c' 'p'gy' 'j' g'vgt' q'gr' kcz' { 'cr r tqcej' 'j' cu' 'dggp' 'f' g'xgnr' gf' 't'gegp'w'. 'y' j lej 'ku' 'dcug' 'qp' 'v' j g' 'j' q'v' y' cni' 'o' g'w'c'nti' c'p'le' 'x'cr' qt' 'f' gr' qukw'qp' '\*O QEXF' + 'cpf'' cmqy' u' 'v' 'i' tgy 'j' ki j 'utwewt' cni' s' w'ekw' 'Crñ cP II cP'' J GO V' utwewt' gu' y' kj' qw' 'v' j lenil' cP 'dwhgt' 'J4\_0'K' 'eqw'f' 'dg' 'gzr' g'ev'f'' v' j cv' 'v' j ku' 'vej' pqm { 'y' kmit' g'f' w'eg' 'gh' g'ew' 'qh' 'v' cr' u' 'Itqo' 'I' cP 'E' 'dwhgt'. 'dw' 'v' j leni' ceegr' 'vqt' 'f' qr' gf' 'I' cP 'dwhgt' 'ku' 'lo' r' qt' w'p'v' 'hqt'' tgf' w'ekw' 'qh' 'v' j g'cf' kpi 'f' kurecvq'p' 'f' g'puk' (0'

Kp' 'v' j ku' y' qtm' 'v' j g' 'ödwhgt' / 'Itggö' 'Crñ cP II cP'' j g'vgt' qut' wewt' g' y' cu' 'wug' 'v' q' 'f' g'xgnr' 'Uej' qwn' 'd'ctt' lgt' 'f' kqf' gu' '\*UDF' u' + 'cpf'' J GO Vu' 'uwf' { kpi 'v' j g' 'r' g' thqto' c'peg' 'qh' 't' g'cr' k'w' 'f' g'xlegu' 'w'p'f' gt' 'j' ki j 'F E' 'x'qnci' gu' 'cpf' 'lp'' 't'cf' k' 'Itgs wpe { '\*TH' 't'gi' lo' g'U'V' j g' 'x'qnci' g' 'ewt' g'p'v'. 'v' j g' 'p'qkug'. 'cpf'' 'v' j g' 'i' c'kp' 'ej' ctcevt' g' t'k'w' 'f' go' q'p'ut' cv'f' 'v' j g' 'ko r' t'q'x'g' 'v' j gto' cni' 'u'cd'k'w' { 'qh' 'ödwhgt' / 'Itggö' 'Crñ cP II cP'' j g'vgt' qut' wewt' g' 'lp'' 'eqo r' c' t'ku'p' 'v' q' 'c' 'u'w'c'p'f' c'f' 'Crñ cP II cP'' j g'vgt' qut' wewt' gu' 'dw' 'y' kj' 'v' j lenil' cP 'dwhgt' 'J3.5\_0'V' j g' 'UDF' u' 'f' go' q'p'ut' cv'f' 'v' j g' 'd' t'g'c'nf' qy' p' 'h'g'f' u' 'w' 'v' q' '20' 'O X' 'leo' '0J' cni' 'o' g'c'uw' t'go' g'p'w' 't'g'x'g'c'rf' 'v' j gto' cni' 'u'cd'g' 'v' y' q' / 'f' lo' g'p'uk' p'cni' 'g'ngew' t'q'p' 'i' cu' '\*4F' G' 'f' g'puk' 'P\_4F' G' 'i' '? '32<sup>35</sup>' 'eo' /<sup>4</sup> 'lp'' 'v' j g' 't'c'p' i' g' 'Itqo' 't'q'qo' 'v' go' r' g' t'c'w' t' g' '\*522' 'M' 'f' qy' p' 'v' q' 'r' s' w'f'' p'k' t'q' i' g'p' '\*99' 'M' 'y' kj' 'v' j g' 't'g'ur' g'ev'x'g' 'o' qdtkw' { 'x'c'w'gu' 'q' h' ' '? '30' 'ö' '2<sup>5</sup>' 'eo' /<sup>4</sup> 'IX' 'a' 'c'p'f'' ' '? '30' 'ö' '2<sup>6</sup>' 'eo' /<sup>4</sup> 'IX' 'a' 'O' g'c'p' y' j' k'g' 'v' j g' 'J GO Vu' 'f' go' q'p'ut' cv'f' 'c' 'o' c'z'ko' w'o' 'f' t'c'lp' 'ewt' g'p'v' 'c'p'f'' 'v' j g' 't'c'p'ue'q'p'f' w'ev'p'eg' 'x'c'w'gu' 'v' q' 'dg' 'cu' 'j' ki j 'cu' '20' 'C' 'lo' o' 'c'p'f'' 372' 'o' 'U'lo' o' 't'g'ur' g'ev'x'g' 'h' 't' 'v' j g' 't'c'p'uk'v'qtu' 'y' kj' 'v' j g' 'i' c'v'g' 'r'g'p' i' 'v' 'N' 'i' '? '7' 'o' '0'N'q' y' / 'Itgs wpe { 'p'qkug' 'ej' ctcevt' g' t'k'w' 'q' h' 'J GO Vu' 't'g'x'g'c'rf' 'v' j g' 'gh' g'ev'x'g' 't'cr' 'f' g'puk' { 'x'c'w'gu' 'v' q' 'dg' 'd'g'ny' '32<sup>3</sup>' 'eo' /<sup>5</sup> 'g'X' /<sup>30</sup> 'V' j g' 'c'p'c'nf' 'uku' 'qh' 't'c'p'uk'v'qtu' 'T' 'H'ej' ctcevt' g' t'k'w' 't'g'x'g'c'rf' 'h'v' 'c'p'f' 'h' 'cz' 'x'c'w'gu' 'v' q' 'dg' 'w' 'v' q' '30' 'I' 'J' | 'c'p'f' '80' 'I' 'J' | 't'g'ur' g'ev'x'g' 'f' go' q'p'ut' cv'p' i' 'v' j g' 'h' i' w'g' 'q' h' b' g' t' k'w' 'H'Q' O' ? 'h'v' 'N' i' 'v' q' 'dg' 'w' 'v' q' '80' 'I' 'J' | 'ö' 'b' 0'

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Hki 030Uej qwn' 'd'ctt' lgt' 'f' kqf' gu' '\*UDF' u' + 'h'cd' t'lec'v'f' 'Itqo' 'ödwhgt' / 'Itggö' 'Crñ cP'' J GO V0Qr' 'w'ec'ni' b' ket'que'qr' g' 'ko' ci' gu' 'qh' 'n' '62' 'o' 'eq'p'w'ev'ug'r' c'w'v'q'p' 'UDF' u' 'd'gh'q't'g' 'c' + 'c'p'f' 'c' h'g't' 't' d' + 'd' t'g'c'nf' qy' p0' 'e' + 'D' t'g'c'nf' qy' p' 'x'q'nci' g' 'W' d' 'c'p'f' 'e' t'k'k'ec'ni' h'g'f' 'G' e' t' 'f' g' r' g'p'f' g'p'eg' 'qp' 'eq'p'w'ev'ug'r' c'w'v'q'p' 'f' k'uc'p'eg' 'h' q' h' 'UDF' u' "

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**Cempqy rgi i go g'p'v' Vj g' y' qtm' y' cu' 'u'w' r' q' t'v' g'f' 'd' { 'v' j g' 'T'gugctej' 'Eq'w'pek' i' q' h' 'N'kj' w'c'p'k' '\*N'g'w'x'q' 'o' q'm'ny' 'v'ct' { 'dc' + 'w'p'f' gt' 'v' j g' 'ö'V'G' T' C' I' C' P' Y' K' T' G' ö' 'r' t'q' l' g' ev' '\*i' t'c'p'v' P' q' 0' U' / N' N' 3; / 3-0'**

[3]\_R0Uc'k'g'v'c'ni' 'ö'N'q' y' 'Itgs wpe { 'p'qkug' 'c'p'f' 't'cr' 'f' g'puk' 'lp'' 'I' cP 'I' Crñ cP 'h'g'f' 'gh' g'ev' 't'c'p'uk'v'qtu' 'ö' 'C'rr' i' 0' R' j' / 'u' 0' N' g' w' 0' 'x'q' n' 0' 337. 'p'q' 03. 'f' 03: 5723. 'Q'ew' 0423; 0' [4]\_L0V0Ej' g'p' 'g'v'c'ni' 'ö' C' I' cP 'ö' U' E' 'j' { 'd' t'k' 'o' c'v'g' t'k' r' h' q' t' 'j' ki j / 'Itgs wpe { 'c'p'f' 'r' qy' gt' 'g'ngew' t'q'p'leu' 'ö' 'C'rr' i' 0' R' j' / 'u' 0' N' g' w' 0' 'x'q' n' 0' 335. 'p'q' 06. 'r' 0263827. 'L'w' 0423; 0' [5]\_L0I'q' t'w'f' cu' 'g'v'c'ni' 'ö' C' I' cP 'II cP 'qp' 'U' E' 'f' g'x'legu' y' kj' q'w'c' 'I' cP 'D'whgt' 'N'c' { 'g' t' < 'G' r' g'ev' t'c'nf' 'c'p'f' 'P' q'kug' 'E' j' ctcevt' g' t'k'w' 'ö' 'O' ket' qo' c'ej' 'k'p'gu' 'x'q' n' 0' 33. 'p'q' 034. 'r' 03353. 'F' g' e' 042420

# TERAHERTZ EMISSION FROM ULTRATHIN BISMUTH LAYERS

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Terahertz (THz) frequency range measurement techniques have greatly improved over the last decades and are applied in many different application areas such as sensing, spectroscopy, imaging, and material characterization. THz emission spectroscopy (TES) is becoming popular technique for material characterization. THz pulses are generated on the material surface when it is photoexcited by femtosecond laser pulses. Laser pulses are inducing ultrafast changing photocurrents, which cause electrical dipoles radiating in the THz frequency range. THz pulse emission induced by femtosecond optical pulses has been observed in different semiconductors, gases and liquids. TES can be used to determine some parameters of the semiconductor band structure. These include direct band gap [1], subsidiary valley position [2] and conduction band offset position of heterojunctions [3].

In this work, we describe the effect of femtosecond optical pulse induced THz emission from thin bismuth layers. Thin bismuth (Bi) films are an interesting research object because of their rich variety of physical properties. Previously THz pulses were used for investigating bismuth only in two contributions [4,5]. In both works much thicker Bi samples were used.

Several Bi samples were grown on (111) oriented Si substrates using Molecular beam epitaxy system (MBE). The main difference in technological conditions between investigate samples was different substrate temperatures. It was equal to 100 °C for the layer VS001 and 20 °C for VS002.

The structure of the layers was studied by In-plane X-Ray diffraction (XRD) and their thickness by X-ray reflectivity (XRR). thickness of the both Bi films was approximately the same:  $7.7 \pm 0.5$  and  $8.8 \pm 0.5$  nm for VS001 and VS002 respectively. Measurements also showed that VS001 sample resembles polycrystalline film, while VS002 epitaxial layer is monocrystalline, with the hexagonal plane coinciding with sample's surface.

THz pulse emission from the Bi layers was investigated using femtosecond optical pulses from OPA Orpheus (Light Conversion). THz emission spectra (fig 1 a) shows It can be seen that THz emission sets-on when the photon energy becomes larger than  $\sim 0.45$  eV, which suggests that the energy band gap of these layers, and monotonously increases at higher photon energies. THz emission could be explained by photoexcited lateral currents in hexagonal crystals, such currents can be excited by optical beams polarized perpendicular to the main c axis. Both samples has an azimuthal angle dependence (fig 1 b), which is more pronounced in vs002 sample. This could be explained by shift current.

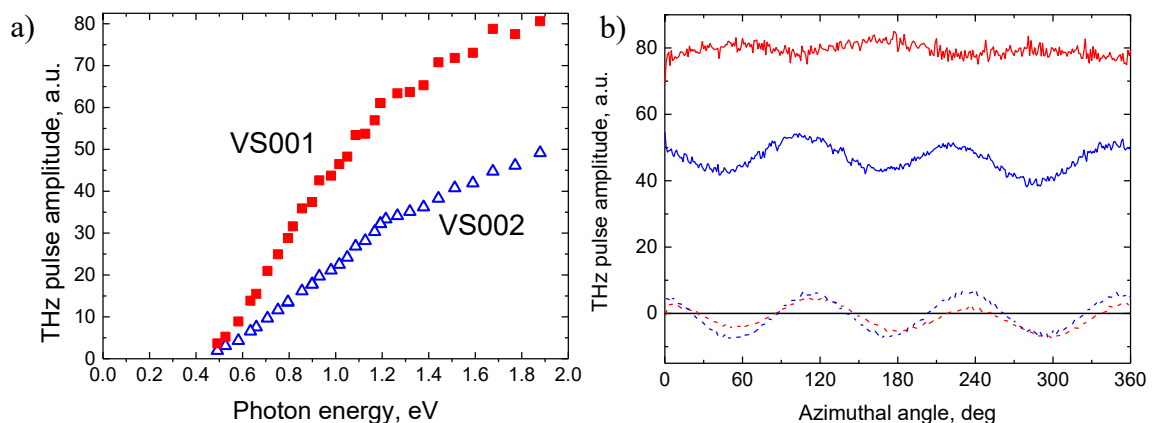


Fig. 1. a) THz emission spectra of thin Bi layers, b) Azimuthal angle dependence of those layers, while the incidence angle is 30 degrees (full line) and 0 degrees (dotted line)

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# PHOTOLUMINESCENCE STUDY OF GaAsBi/GaAs QUANTUM WELLS

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GaAsBi heterostructures are an attractive candidate to develop GaAs-based applications for long wavelength optoelectronics, such as infrared lasers, photodetectors, solar cells, terahertz devices [1], etc. This is mainly due to the large band gap reduction possible with incorporation of small amounts of Bi, relatively temperature insensitive band gap, high electron mobility, and large spin-orbit splitting. However, the exploitation of those GaAsBi heterostructures has been hampered by the practical difficulties of growing GaAsBi quantum wells with high emission at room temperature.

This work presents temperature- and excitation-dependent photoluminescence (PL) study of three GaAsBi/GaAs multi-quantum wells (MQW) structures grown by molecular beam epitaxy. All three MQW structures exhibits exceptionally high room temperature emission. Temperature-dependent PL measurements were used to explore optical interband transitions at temperature from 3 K to 300 K (see Fig. 1 a-c). PL peak position versus temperature (Fig. 1 d) were analysed using Varshni equation [2] or combined Varshni–Eliseev equations [3]. A broad PL emission band at room temperature together with S-shape character of PL peak position variation with temperature indicated effect of carrier localisation. As further matter, activation energies derived from PL measurements provided in-sight into thermal quenching processes of luminescence. Moreover, room temperature time-resolved photoluminescence spectroscopy (TRPL) was applied for study of carrier recombination in GaAsBi MQWs.

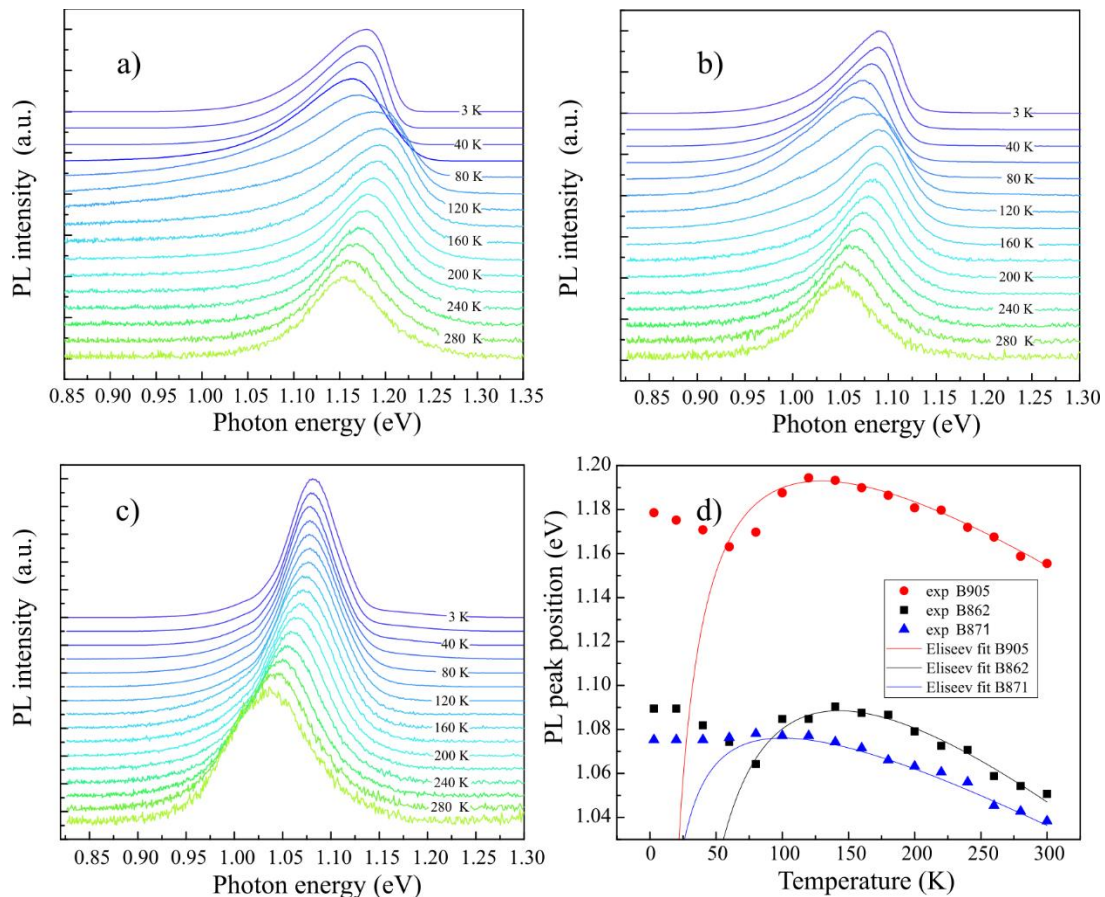


Fig. 1. Temperature – dependent PL spectra of GaAsBi/GaAs MQW PL measured for sample B905 with 3.9 % of Bi (a), sample B862 with 4.5% of Bi (b) and sample B871 with 4.6% of Bi (c). GaAsBi/GaAs MQW structures PL peak position at maximum intensity dependences on temperature (d).

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# IMPROVING SODIUM BATTERIES CATHODES: THERMAL NANOCRYSTALLIZATION OF GLASSY ALLUAUDITES

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Application of renewable power sources carries new challenges concerning energy storage. Wind and solar plants are susceptible to atmospheric conditions. For example – wind farms produce energy only when sufficiently strong wind blows. One of the remedies to stabilize their output is utilization of battery storage stations. In this field, sodium-ion batteries are expected to be sustainable and cheap alternative to lithium ones [1].

Alluaudites, which structure was first described by Fisher in 1955 [2], are among potential cathode materials.  $\text{Na}_x\text{MnFe}_2(\text{PO}_4)_3$  attracted much interest of Trad and co-workers, since its theoretical gravimetric capacity could be close to 170 mAh/g if reversibly cycled between  $x = 0$  and 3 [3]. Poor electrical conductivity ( $\sigma(275^\circ\text{C}) = 9.7 \cdot 10^{-7}$  S/cm [4]) is one of the main obstacles to their implementation.

Alluaudite structure can be adopted by various compounds. In our research, we were studying materials with nominal composition of  $\text{Na}_2\text{Fe}_3(\text{PO}_4)_3$ ,  $\text{Na}_2\text{Fe}_2\text{V}(\text{PO}_4)_3$  and  $\text{Na}_2\text{FeMnV}(\text{PO}_4)_3$ . Some of these compositions have been synthesized for the first time, as no such reports in the literature have been found. Thermal treatment of glassy samples led to nanocrystallization of alluaudite phase [5]. Previous studies on amorphous analogs of cathode materials for Li-ion batteries show significant increase of electrical conductivity as a result of their thermal nanocrystallization, due to occurring of preferable conditions for polaron hopping mechanism of conduction [6]. We have shown that similar procedure can be successfully applied to sodium compounds as well. In preliminary measurements, we observed a significant (5 orders of magnitude) and irreversible increase of conductivity, which resulted in receiving nanomaterial with  $\sigma(25^\circ\text{C}) \approx 10^{-3}$  S/cm (Fig. 1).

We observed some impurity phases in the samples, though. Therefore, in this work, we strived to elaborate optimal syntheses conditions to obtain alluaudite-like nanomaterials with maximum possible phase purity. The following parameters were taken into account: reagents used, presynthesis of the reagents, cooling rate, role of reducing atmosphere.

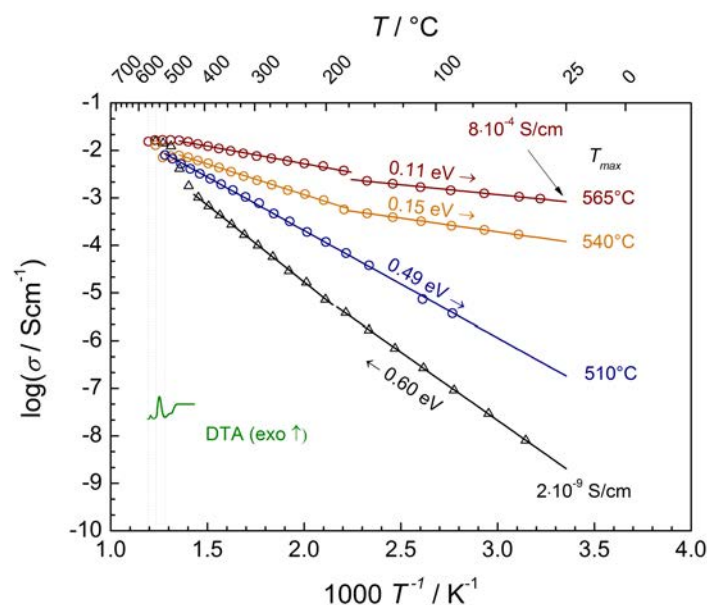


Fig. 1. Arrhenius plot for an as-prepared glassy  $\text{Na}_2\text{Fe}_2\text{V}(\text{PO}_4)_3$  sample (triangles) and heated to different maximum temperatures (circles) within 510–565°C range. DTA curve is given for comparison.

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**TGUGCTEJ 'QHKO RCEV'QH'RTGUGPEG'QH'XK/CO K'UD4.'D5.'CPF'E'QP''**  
**ECNEKWO 'QZCNCVG'O QJ QJ [ F TCVG'ET[ UVCNNK CVKQP''**  
**RTQEGUUGU'K'UKO WNCVGF'DQF [ 'HNWKF''**  
O ct{pc'Ft{ j ckm<sup>3</sup>. [ wrkk'Vctcpgw<sup>4</sup>

<sup>3</sup>Hcewn{ 'qh'Rj { uleu.'XOP'OMctc| kp'Mj ctnix'P cvkqpcn'Wpkxgtuks{.'Whtclpg''

<sup>4</sup>F gr ctvo gpv'qh'pqp/nkpgct'et { uvcn.'Kpukwag'hqt'Ukpi ng'Et { uvcn'qh'vj g'P cvkqpcn'Ceef go { 'qh'Uelgpegu'qh'Whtclpg.'  
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r tqr gpukkgu'hqt'tgpcn'ecrewk'qt'nfkpg{ 'uqpgu'hqto cvkqp'Vj g'tgxkgy gf'gzco r ng'qh'vj gug'et { uvcn'ku'ecrekwo 'qzcrvg''  
o qpqj { ftcvg'EcE4Q6 J 4Q''EQO +'j3\_0'P qy cf c{ u'vj g'et { uvcnk'cvkqp'qh'EEO 'wpf gt'kphwpeg'qh'xctkqu'eqo r qwpf u''  
vj cv'eqo g'v'j wo cp'qti cpluo 'y kj 'hqf'ku'pqv'hwnt'uwf lgf'cpf'cpcn| gf'U'Uelgpkwu'ctg'kpvgtgugf'kp'ko r cev'qp''  
et { uvcnk'cvkqp'EEO 'qh'co kpq'ceku.'hqf'uw r ngo gpw.'cpf'gur gekm'xkco kpu'j4\_0'

Vj g'o clp'r wtr qug'qh'vj ku'y qtm'ku'o qf gmkpi 'EQO 'et { uvcnk'cvkqp'r tqeguugu'kp'ulo wrcvg'dqf { 'hwwf'y kj 'r tgupeg''  
qh'y cvt/uqndrg'xkco kpu'D4.'D5.'cpf'E'cpf'gzco kpkpi 'vj gk'kphwpeg'qp'vj g'pwercvqp'r tqeguugu.'o qtr j qmji {.'cpf'uk'g''  
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Vj g'utwewt'g'cpf'vj g'r j cug'eqo r qukqp'qh'vj g'u'pj guk'gf'ecrekwo 'qzcrvg'r tgekr kcvu'y g'g'f gvgto kpgf'wukpi 'vj g''  
o gvj qf u'qh'Z/te{ 'r j cug'cpcn'uku'cpf'K'ur gev'qer {0'Vj g'o qtr j qmji { 'qh'vj g'et { uvcn'y cu'gzco kpgf'cr r n'kpi 'u'ecppkpi''  
gr'ev'qp'o let'qer {0'Vj g'et { uvcnk'cvkqp'nkpgku'hqt'vj g'o qf gn'EEO 'uqnwkp'u'y cu'uwf lgf'd { 'o gcuwtkpi 'vj g'uqnwkp''  
wtdkf kv{0'

"

[3\_'Tg| 0R0'Y j cvf'qgu'vj g'et { uvcn'j tcr j { 'qh'uqpgu'vgn'wu'cdqw'vj gk'hqto cvkqp'A'Wtqrkj kuku'67\*3+'33/3: ''4239+0'

[4\_'Vctcpgw| 0X0'gv'c'0'Gh'gev'qh'co kpq'ceku'c'p'f'D/i tqwr'xkco kpu'qp'pwercvqp'qh'ecrekwo 'qzcrvg'o qpqj { ftcvg'et { uvcn.'Lqwtpcn'qh'Et { uvcn'i tqy vj''  
753.'34758: ''4242+0'

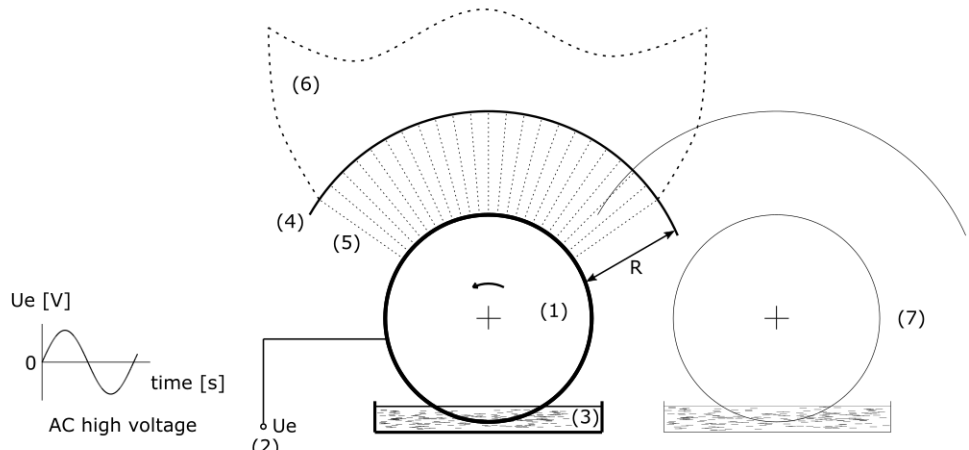
"

**HTGS WGPE [ 'EQPVTQNGF 'CE 'GNGETVQRKPPKI " "**  
**HQT'GPJ CPEGF 'PCPQHKGDT 'RTQF WEVKQP " "**  
**Opf tgl'Hkgf tlej<sup>3</sup>. 'Lcp'Xcngtc<sup>6</sup>"**

<sup>3</sup>F gr ct wo gpv'qh'Vgzvkg'O cej kpg'F guki p. 'Vgej pkeci'Wpkxgtukv' 'qh'Nkdgt ge. 'E| gej 'Tgr wdrie "  
 qpf tgl'ht'kgf tlej B wrte| "

P cpqhdgt "o cvgt kcu'ctg' ej ctcevt k'gf "d{ "j ki j "ur gekle" uwthegu. "cf xcpvci gqwu" hqt " cr r rkecvkpu" kp" vj g" hgrf "qh' hntcvkqp." xkuwg" gpi kpggt kpi. " gve' Vj gtg" ctg" ugxgtcni' o gy qf u" qh' r tgr ct kpi " r qn( o gt le" pcpqhdgtu" qw" qh' y j lej " grgevt qur kppkpi "ku' vj g" o quv' wugf " qpg' O' k' vj ku' vgej p qmji { . " hdt gu' ct g' hqt o gf " f wg' vq' grgevt le" hqtegu' et gc vgf " d{ " o gcpu' qh' grgevt le" r qvq' v' cni' f k' hgt gpeg" dgvy ggp" cp" grgevt qf g' cpf " c" eqmgevt o' Vkm' p qy . " y q' v' r gu' qh' grgevt qur kppkpi " j cxg' dggp" f gxgrnr gf < ur kppkpi " kp" vj g' eqpucpv' grgevt leci' hgrf " \$FE" grgevt qur kppkpi \$' cpf " ur kppkpi " kp" vj g' cngt pcvkpi " grgevt leci' hgrf " \$CE" grgevt qur kppkpi \$ " j3\_ O' Wpkrng" vj g' hku' v' p qg. " vj g' CE" grgevt qur kppkpi " f qgu' p qv' tgs vkt g' cp { " r j { uecn' eqmgevt " cpf " vj g' r nwo g' qh' pcpqhdgtu' ecp" dg' eqmgevt " d { " xct kqwu' o gcpu. " gG O' p q p/ eqpf vevkxg' t qv' v' kpi " eqt g' { ctp " j4\_ O' kpu' go kvgf " t qo " vj g' ur kppgt gv' hqt o " b' uq/ ecmgf " dxk' wcn' eqmgevt o' kp' ku' x' k' l' k' p' vj v' y q' t m' u' c' u' b' j " ki j n' " gh' h' k' e' g' p' v' eqmgevt " hqt " q' r r' q' u' k' n' " e' j' c' t' i' g' f " kpu' go kvgf " kp" vj g' p' g' z' v' r' g' t' k' q' f " j5\_ O' X' g' r' e' k' v' { " qh' h' k' d' t' u' f' t' c' y' p' d' { " grgevt le" hgrf " h' c' m' u' w' f' g' p' n' " c' h' g' t' " t' g' c' e' j' k' p' i' " vj g' c' t' g' e' " qh' vj g' " x' k' t' w' c' n' e' q' m' g' e' v' t' O' G' x' p' vj q' v' i' j' " u' q' o' g' u' w' f' k' g' u' j' c' x' g' d' g' g' p' e' c' t' t' k' e' f' " q' w' j' 6\_ " vj g' d' g' j' c' x' k' q' w' t' " qh' vj g' " x' k' t' w' c' n' e' q' m' g' e' v' t' " w' p' f' g' t' " f' k' h' g' t' g' p' v' k' p' r' w' u' k' i' p' c' n' e' q' p' f' k' k' a' p' u' c' p' f' " ku' l' p' h' w' g' p' e' g' " q' p' " h' k' d' t' u' r' t' q' f' v' e' v' k' x' v' " j' c' u' p' q' v' { " g' v' d' g' g' p' " h' w' n' " k' p' x' g' u' k' i' c' v' g' f' O' "

Vj ku' y qm' h' q' e' w' u' g' u' q' p' c' p' c' n' { u' k' u' q' h' h' k' d' t' g' x' g' r' e' k' v' { " kp' d' g' y' g' g' p' vj g' grgevt qf g' cpf " vj g' x' k' t' w' c' n' e' q' m' g' e' v' t' " w' p' f' g' t' " x' c' t' k' q' w' u' k' i' p' c' n' e' q' p' f' k' k' a' p' u' O' h' w' vj g' t' o' q' t' g' " vj g' c' k' o' " ku' v' q' " f' g' u' k' i' p' " c' " p' g' y' " grgevt qf g' e' c' r' c' d' r' g' " qh' h' c' v' p' c' p' q' h' d' t' q' w' u' o' c' v' g' t' k' e' n' i' r' t' q' f' v' e' v' k' a' p' " y' k' j' " c' r' r' t' q' r' t' k' e' v' g' u' k' i' p' c' n' e' c' t' c' o' g' v' g' t' u' r' r' k' e' f' " kp' q' t' f' g' t' " q' k' o' r' t' q' x' g' vj g' g' h' h' e' k' e' p' e' { " cpf " j' q' o' q' i' g' p' g' k' v' { O' h' q' t' vj ku' r' w' r' q' u' g' vj g' r' e' d' q' t' c' v' q' t' { " CE" grgevt qur kppkpi " f' g' x' l' e' g' y' c' u' d' w' k' n' O' K' " e' q' o' r' t' k' u' g' u' p' q' g' t' " u' g' x' t' c' n' i' vj kp' t' q' v' c' t' { " f' k' u' e' u' c' u' c' " ur kppkpi " grgevt qf g' " u' g' g' " h' k' i' " 30Vj g' " f' g' x' l' e' g' " g' p' c' d' r' u' g' vj g' u' g' v' k' p' i' " qh' l' p' r' w' " grgevt leci' u' k' i' p' c' n' i' " y' c' x' g' h' q' t' o' . " c' o' r' i' k' w' f' g' . " h' t' g' s' w' g' p' e' { " cpf " qh' u' g' v' : " y' j' k' g' t' g' e' q' t' f' k' p' i' " vj g' " h' k' d' t' u' o' q' x' g' o' g' p' v' d' { " j' ki j / ur g' g' f' " e' c' o' g' t' c' O' Vj g' g' h' h' e' v' " qh' x' c' t' k' q' w' u' k' i' p' c' n' i' r' c' t' c' o' g' v' g' t' u' r' w' r' q' p' " vj g' " e' q' m' g' e' v' t' " f' k' u' c' p' e' g' " T. " h' k' d' t' u' r' t' q' f' v' e' v' k' a' p' " cpf " o' q' t' r' j' q' m' j' { " y' c' u' o' g' e' u' w' t' g' f' " cpf " c' p' c' n' { u' g' f' O' "



Hki 030Uej go cvke' qh' vj g' r' t' q' e' g' u' u' qh' h' q' t' o' k' p' i' " p' c' p' q' h' d' t' q' w' u' o' c' v' g' t' k' e' n' " g' r' e' v' t' q' f' g' " vj g' kp' t' q' v' c' t' { " f' k' u' e' u' c' u' c' " + j' ki j " CE" x' q' n' c' i' g' " u' q' w' t' e' g' " 4+ . " r' q' n' ( o' g' t' l' e' " u' q' n' w' k' a' p' " 5+ . " x' k' t' w' c' n' e' q' m' g' e' v' t' " 6+ . " c' t' g' e' " qh' h' c' u' v' o' q' x' k' p' i' " h' k' d' t' u' " 7+ . " c' t' g' e' " qh' h' u' n' y' n' { " t' k' u' l' p' i' " p' c' p' q' h' d' t' q' w' u' o' c' v' g' t' k' e' n' " 8+ . " k' m' w' t' c' v' k' a' p' " qh' i' o' w' n' k' f' k' u' e' " e' q' p' h' i' w' t' c' v' k' a' p' " 9+ "

T guwuu' qh' e' c' t' t' k' e' f' " q' w' v' g' u' u' r' t' q' x' g' f' " e' q' u' p' k' t' c' d' r' g' " g' h' h' e' v' " qh' h' t' g' s' w' g' p' e' { . " c' o' r' i' k' w' f' g' " c' p' f' " y' c' x' g' h' q' t' o' " " i' k' p' g' " x' u' u' s' w' c' t' g' + " q' p' " vj g' " f' k' u' c' p' e' g' " T O' k' p' " c' o' w' n' k' f' k' u' e' " e' q' p' h' i' w' t' c' v' k' a' p' . " k' y' c' u' " q' d' u' g' t' x' g' f' " vj g' c' v' " ur kppkpi " w' p' f' g' t' " n' y' g' t' " h' t' g' s' w' g' p' e' k' u' " lo' r' t' q' x' g' u' " vj g' " k' p' v' g' t' e' q' p' p' g' e' v' k' a' p' " qh' i' p' c' p' q' h' d' t' q' u' l' t' h' q' o' " k' p' f' k' k' f' w' c' n' i' f' k' u' e' u' c' p' f' " g' p' c' d' r' u' g' t' q' f' v' e' v' k' a' p' " qh' i' c' " u' k' p' i' n' g' " h' c' v' p' c' p' q' h' d' t' q' w' u' l' u' t' w' e' w' t' g' O' C' e' s' w' k' t' g' f' " t' g' u' w' u' l' t' q' o' " u' k' p' i' n' g' b' o' w' n' k' f' k' u' e' " CE" grgevt qf gu' y' k' n' i' d' g' " h' w' t' vj g' t' " w' u' g' f' " h' q' t' " lo' r' t' q' x' g' o' g' p' v' qh' j' q' o' q' i' g' p' g' k' v' { " vj g' c' v' k' u' t' g' s' w' k' t' g' f' " h' q' t' " o' g' f' k' e' c' n' j' { i' k' p' g' t' " h' k' t' c' v' k' a' p' " c' r' r' i' k' e' c' v' k' a' p' O' "

Vj ku' r' w' r' i' k' e' c' v' k' a' p' " y' c' u' y' t' k' w' g' p' " c' v' vj g' " Vgej pkeci' Wpkxgtukv' ' qh' Nkdgt ge' cu' r' c' t' v' qh' vj g' r' t' q' l' g' e' v' y' k' j' " vj g' u' w' r' r' q' t' v' qh' vj g' " U' r' g' e' k' l' e' " W' p' k' x' g' t' u' k' v' " T' g' u' g' t' e' j' " T' t' c' p' v' 4243/724; . " c' u' r' t' q' x' k' f' g' f' " d' { " vj g' O' l' p' k' u' t' { " qh' G' f' w' e' c' v' k' a' p' . [ q' w' j' " c' p' f' " U' r' q' t' u' v' qh' vj g' E' | g' e' j' " T' g' r' w' d' r' i' e' " l' p' vj g' " { g' e' t' " 42430' "

[3]\_Demji j. 'Cwkr: 'Htneu' Deric' u' 'Xgtgem' I' ggtv' O' g' puej. 'L'w' i' g' p. 'D'q' t' d' c' u. 'G'p' l' n' i' q. 'P' c' i' . 'D' t' i' k' w' c. 'O' c' t' q' u' k' I' { 'q' t' i' . 'P' c' i' { . \ } u' q' o' d' q' t' 'M' k' u' v' qh' CE' c' p' f' " FE" grgevt qur kppkpi " qh' j' { f' t' q' z' { r' t' q' r' { m' g' y' { n' e' g' m' w' u' q' e' y' k' j' " r' q' n' g' y' { n' e' p' g' z' k' f' g' u' c' u' u' e' q' e' p' f' c' t' { " r' q' n' ( o' g' t' " h' q' t' " lo' r' t' q' x' g' f' " f' w' i' " f' k' u' u' q' w' k' a' p' O' k' p' v' g' t' p' e' v' k' a' p' c' n' i' " l' q' w' t' p' e' n' i' q' h' R' j' c' t' o' c' e' e' g' w' e' u' j' w' r' - l' i' f' z' o' f' q' l' q' t' i' B208238 l' l' O' r' j' c' t' o' 042380250246" "

[4]\_LOXcngtc. "VOMenqwu. "RORqntqpf. "QODcvmr. "O' O' D' k' r' g' m' " L' O' E' j' x' q' l' n' e. " R' O' k' n' g' u. " G' O' M' Q' u' c' m' q' x' c. " R' O' c' d' n' e. " L' O' Q' t' p' u' q' x' c. " L' O' D' g' t' e' p. " C' O' U' c' p' l' u' j' g' x' u' n' f' . " F' O' " N' w' n' e' u. " H' e' d' t' e' c' v' k' a' p' " qh' f' w' e' n' h' w' p' e' v' k' a' p' c' n' i' e' q' o' r' q' u' k' g' { " c' t' p' u' y' k' j' " c' " p' c' p' q' h' d' t' q' w' u' g' p' x' g' r' n' r' g' " w' u' k' i' " j' ki j " vj g' t' q' w' j' r' w' CE" p' g' g' f' n' g' u' u' c' p' f' " e' q' m' g' e' v' t' n' g' u' u' " g' r' e' v' t' q' u' r' k' p' p' k' p' i' . " U' e' k' O' T' g' r' O' ; " 423; +0f' qk32025: l' u' 637; ; /23; /5: 779/ /0' "

[5]\_RORqntqpf. "GOMquncmxc. "HUCpgetplm "ROR kngu. "LOEj xqlne. "VOMenqwu. "O' O' D' k' r' g' m' " M' O' R' g' l' e' j' c' t. " L' O' X' c' n' g' t' c. " F' O' N' w' n' e' u. " G' h' h' e' v' k' " CE" p' g' g' f' n' g' u' u' c' p' f' " e' q' m' g' e' v' t' n' g' u' u' " g' r' e' v' t' q' u' r' k' p' p' k' p' i' " h' q' t' { " c' t' p' r' t' q' f' v' e' v' k' a' p' . " 42360f' qk32025: l' e' 6er 26568f' O' "

[6]\_O' c' j' g' u' j' y' c' t' k' " U' k' f' j' c' t' vj g' O' 422; +0' C' u' g' o' d' n' { " qh' O' w' n' k' " U' t' c' p' f' g' f' " P' c' p' q' h' d' t' " Vj g' t' g' e' f' u' vj g' t' q' w' j' " CE" G' r' e' v' t' q' u' r' k' p' p' k' p' i' O' C' f' x' c' p' e' g' f' " O' c' v' g' t' k' e' n' i' / " C' F' X' C' P' " O' C' V' G' T' 043056; /5760f' q' l' q' t' i' B208224 k' f' o' c' 0422: 229440' "

**DNGPF 'GNGEVTQURKPPPI 'QHEQPVTQNNGF/TGNGCUG'FTW ''**  
**F GNKXGT[ 'U UVGO UY KJ 'O O R'KJ KDKQTU'**  
O ci f erpce'Detvrgy unc<sup>3,4</sup>. 'O cvgl'Dw i q<sup>4</sup>. 'Ckxc'Uko cksq<sup>4</sup>'

<sup>3</sup>Hcewn{ 'qh'Rj { uleu. 'Wpkxgtuks{ 'qh'Y ctucy . 'Reugwtc'7. '24/2; 5'Y ctucy . 'Rqncpf "  
<sup>4</sup>KpqEwtg'u00q0'T( F 'rcd. 'Rtwo { unx<sup>a</sup> '3; 82. '472': . 'Egn nqxlæg. 'E| gej 'Tgr wdrle "  
detvrgy unc o ci f erpceB i o ckrqo "

Dqpg'htcewtgu"cuuqekvqf "y kj "quvqr qtquku"ctg" c"ugtqwu"y qtrf y kf g"r tqdrgo . "gur gekm{ "co qpi "vj g"grf gtn{ 0'F gur ksg" uli plklecpv'cf xcegu'kp"vj g"vtgcvo gpv'qh'quvqr qtquku"qxgt"vj g"r cuv'hgy "f gecf gu. quvqr qtqve"htcewtgu"tgo clp" c"o clqt" erklecne'ej erpce g'kp"vj g"grf gtn{ 'r qr wrcvqp" f wg"vq"ko r cktgf "j gcrkpi 0"O cvtkz"o gvcnr tqvqpcugu"O O Ru+"ctg'c'ico kl "qh" j quv'f gtxgf "r tqvqnf vke"gp| {o gu'vj cv'r rc{ "c"ng{ "tqrq"kp"vkuuwg/f gwtq{ kpi "kphco o cvqt{ "f kugcugu"cpf "j cu'cnuq"uj qy p"vq" r rc{ "tqrq"kp"quvqr qtquku0Ej mtj gzkf kpg" \*EJ Z + "ku" c"eqo r qwpf "ecr cdrg'qh'kpi kdkkpi "O O R" d{ "dkpf kpi "ecr kwo "cpf " | kpe" kpu" pgeguact{ "hqt" r tqvqnf vke"cevkkv{ 0'Vq" cmjy "vj g"vkuuwg" vq" j gci' ghklekpvaf "kp" r cvkpvu"y kj "tgf weg" tgi gpgtcvkg" ecr cekv{ . "vj g"cevkg"o qrgewgu. "uwej "cu'e{ enj gzkf kpg. "ecp"dg" gpecr uwr vgf "kp"vj g'hdgtu"cpf "ko r rcpvf "kp"vj g'chgevgf "ukg0" Vj g"grgevtqr kppkpi "vej pls wg"j cu'dggp"y kf gn{ 'tgeqi pl gf "cu'cp"ghgevg"cpf "eqpxgplgpv'o gvj qf "qh'r tqf welpi " hmpcvkpcn'dkqo cvgtlcni'htqo "pcpqhdgtu0Grgvtq/ur wp"r qn{ o gt/egtco ke"eqo r qukgu'j cxg'i clpgf "kpvgtgu'cu'uechqrf kpi "kp" dqpg" gpi kpggtkpi "cr r necvqpu0Grgvtq/ur wp"hdgtu"j cxg"o cp{ "cf xcpvi gu'y j gp"kv'eqo gu"vq"vj gk" wug"cu'f twi "f grkxgt{ " u{ uvgo u" \*F F U+ "uwej "cu'dkqeqo r cvdkkx{ 0'Vwpcdrg'dkqf gi tcf cdkkv{ . "f twi 'tgrgcug' tcvg0" Vj g'tgugctej "clo gf "vq"etgcvg'hdgtu'uechqrf u'o cf g'qh'r qn{ gvj { rpgg"qz kf g" \*RGQ+"cpf "r qn{ ecr tqrcvqpg" \*REN+" qh'f khtgtpv" r tqf qt vqpu"y kj "vj g" gpecr uwr vqp" qh'ej mtj gzkf kpg" cu' O O R" o qf wrcvtu0'Vj g" vko gf "tgrgcug" qh'cevkg" o qrgewgu'ecp'rgcf "vq"hcugt"cpf "o qtg"eqo r rvg'j gcrkpi 0'Vq"eqpvtqn'vj g'tgrgcug' tcvg'qh'vj g'O O R" o qf wrcvtg. "vj g"co qwpv' qh'RGQ"kp"REN/RGQ"hdgtu'ecp"xctkgf 0'kp"vj ku'y qtm'y g'lpkxguki cvgf "vj g" kphwpeg"qh'vj g'REN-RGQ' tcvkqp"qp"vj g'tgrgcug" tcvg'qh'vj g"uo cni'o qrgewgu'htqo "grgevtqr wp"pcpqhdgtu0"

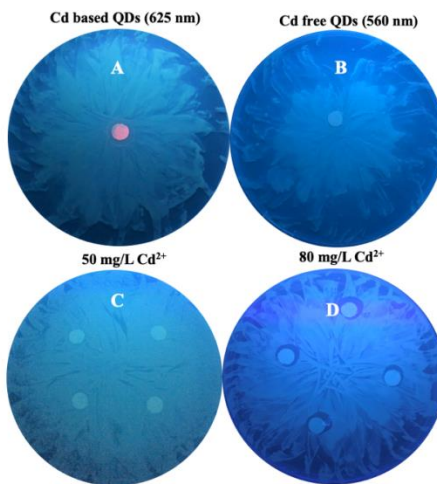
**GHHGE VU'QH'Ef 'DCUGF . 'Ef 'HTGG'S WCP VVO 'F QVU'CPF 'Ef<sup>4</sup> 'QP ''  
 KUQNCVGF 'I W'O KETQDKQVC'QH'Salmo trutta'HT[ '''**

Tgpcvc'Dwtlo kgp<sup>3</sup> . 'Xguc'Untqf gp {v / Ctdc kcwunkgp<sup>3</sup> . 'F cpi wqn 'O qpwx { f kgp<sup>3</sup> . 'fikxkn ''  
 Lxti gn p<sup>3</sup> . 'F crkwu'Dwncwunau<sup>3</sup> . 'P klqn 'Mc| rcwunkgp<sup>3</sup>

<sup>3</sup>P cwtg'Tgugctej 'Egptg.'Xkpkwu.'Nkj wcpkc  
[tgpcvc@wtlo kgpB i co ve0v](#)

Vj g" o quw' r tgcrcgpv" eqo o gtekn' pcpqo cvgtkn' r tqf wewu" ctg" y kf gn{ " tgrgcugf " kvq" yj g" gpvktqpo gpv' Uqo g" pcpqo cvgtkn' ctg" vqzle" vq" xctkqwu" cs wvle" qti cpluo u." dw" yj gk " kphwpgpeg" qp" yj g" cs wvle" qti cpluo au" i w" o letqdkqc" tgo clpu'wmpqy p"]3\_0'Qpg'qh'yj g" pcpqo cvgtkn' y j lej " ghgevu'qp" qti cpluo u'cpf "gpvktqpo gpv'ctg" s wcpwo "f qw" \*S F u'0' Eqpegpvcvqp" qh'S F u'lp" yj g" eqo r qwpf u'qh'cs wvle" gpvktqpo gpv'ku'ukni'wmpqy p"]4\_0'Vj g" geqvzleqmqi lecn'lo r cev'qh' S F u'qp" cs wvle" qti cpluo u'ku"cp" go gti kpi " r tqdrgo . " gur gekm{ " f wg" vq" yj gk " pcpq/ur gekle" r tqf gt vku. " r j { uleq/ej go lecn' vcpuhqto cvkqp" kp" yj g" gpvktqpo gpv'cpf " tgrgcugf" qh'vqzle" o gvcn. " uwej " cu'Ef . " htqo " S F u'wvewt g"]4\_0'Uwf kgu" j cxg'uj qy p" yj cv'o gvcn' gzc' quwt g" cngtu" yj g" eqo r qukskqp" cpf " o gvcdqle" r tqf hkg" qh' yj g" i w' o letqdkqc" cv' yj g" hwpevqpcn' r xgn" cpf " kp" wtp. " yj g" i w' o letqdkqc" cngtu" yj g" wr vng' cpf " o gvcdqle" qh' o gvcn' cpf " eqwf " ecwug' yj g" f { udkquk' ]5. " 6\_0'

Vj g" clo " qh" yj g" uwf { " y cu" vq" gzc' kpg" yj g" ghgevu' qh' eqo o gtekn{ " cxkcdng" ugo leqpf wvqtu" Ef " dcugf " S F u' \*Ef Ugλ pUEQQJ 06" pO +. 'Ef 'htgg' S F u' \*EwkpUλ pUEQQJ . '6" pO + l' pf " Ef<sup>4</sup> " \*72" cpf " : 2" o i IN" qp " kuqrcvgf 'i w'dcevgtk' qh' Ucm q' t' mwc' ht { " f r gpf kpi " qp" vgo r gtcwt g" cpf " vq" gxcnwcg' yj g" ej cpi gu' qh' o letqdkqc' 0'



Hki 030 Ghgevu' qh' 6" pO " eqpegpvcvqp" qh' Ef " dcugf " \*C" cpf " Ef " htgg" \*D" S F u' cpf " 72" \*E" + " cpf " : 2" o i IN" \*F + " eqpegpvcvqp" qh' Ef<sup>4</sup> " qp" i w'dcevgtk' qh' Ucm q' t' mwc' ht { 0'

Kuqrcvgu' yj g" g' kf gpvktqpo " d { " r qn { o gtcug' ej clp' tgcvcvqp" cpf " ugs wcpkpi " qh' 38U' tP C" 3722" p' 0' Ugs wcpkpi " qh' kuqrcvgu" CN35" cpf " CN42" emqun{ " tgrcvgf " vq" Cgtqo qpcu' ur 0' ucm qpkelf c" uwdur 0' ucm qpkelf c" \*uko kctkx{ " ; ; ' + " CN: " o" vq" Cgtqo qpcu' ur 0' \*uko kctkx{ " 322" +. " CN4" o" vq" Cgtqo qpcu' r q' qh' hkk" \*uko kctkx{ " ; ; ' + " cpf " CN3: " o" vq" Uj gy cpgm" r wv ghc' kpgu" \*uko kctkx{ " ; ; ' - 0' O kpo wo " kpj kdkqt { " eqpegpvcvqp" qh' Ef<sup>4</sup> " ci ckv' kuqrcvgf " Ucm q' t' mwc' ht { " i w'dcevgtk" yj g" g' f vgo kpgf " d { " ci ct " f lue" f k' wkwqp" o gvj qf 0' F khtg' gpv' eqpegpvcvqp" yj g" r tgr ct g' " cpf " f kur gpugf " cv' 32" Uri' lp" gcej " f lue" \*8" o o " f kco gvgt" qh' yj g' dcevgtkwo / uggf gf " t { r vqpg' uq { c" ci ct " r rcvg' cpf " yj g' g' lpewdcvgf " cv' 37a' E" cpf " 47a' E" hqt" 6: " j " cgtqdkcm { 0" "

Vj g" f cv" qd' cvkpgf " uj qy gf " yj cv' yj g" eqpegpvcvqp" qh' vguvf " S F u' cpf " 72" o i IN" Ef<sup>4</sup> " f kf " pqv' f ecwug' uvcvkwecm { " uki p' hkecpv' kpj kdkqt { " ghgevu' qp" kuqrcvgf " i w'dcevgtk' qh' Ucm q' t' mwc' ht { " cpf " yj ku" ghgevu' f kf " pqv' f gr gpf " qp" vgo r gtcwt g" ] Hki 0' 3" C = D = E\_0' O kpo wo " kpj kdkqt { " eqpegpvcvqp" \*O KE + xcnwg" qh' Ef<sup>4</sup> " y cu" cuuguuf " d { " f vgo kpgf " yj g" nqy guv' eqpegpvcvqp" qh' o gvcn' kqp" yj cv' ecwugf " i tqy yj " kpj kdkqt " qh' dcevgtk' 0' Vj g' O KE " xcnwg" hqt " kuqrcvgf " Cgtqo qpcu' ur 0' \*CN: + " Cgtqo qpcu' ur 0' ucm qpkelf c" uwdur 0' ucm qpkelf c" \*CN35. " CN42 +. " Cgtqo qpcu' r q' qh' hkk" \*CN4" cpf " Uj gy cpgm" r wv ghc' kpgu" \*CN3: + y cu: 2" o i IN" Ef<sup>4</sup> " eqpegpvcvqp" ] Hki 03' F\_0'

Vj ku' uwf { " qh' kuqrcvgf " i w' o letqdkqc" qh' Ucm q' t' mwc' ht { " chgt " Ef / dcugf " cpf " Ef / htgg" S F u' gzc' quwt g" kp" yj g" hwwt g" y kni' cmqy " r tgf lcvkpi " yj g' r qv' p' v' kni' j gcnj " tkun' vq" cs wvle" qti cpluo u' 0'

Vj ku' y qtni' cy' hwpf gf " d { " yj g' Tgugctej " Eqwpekn' qh' Nkj wcpkc. " Rtqlgev' P q' 0' U' O IR/42/440

[1] Y. Ma et al., Ugz' f' gr gpf gpv' ghgevu' qh' ukxgt' pcpq' ct' l' engu' qp" yj g' gdt' k' i' w' o letqdkqc. " Gpvktqpo gpv' cn' Uel' p' eg- P cpq, **5**, 740-751 (2018).  
 ]4\_ " V0N0T qej c' g' v' cn' Gpvktqpo gpv' cn' d' g' cxkqwt' cpf " geqvzleqmqi " qh' s' wcpwo " f' qv' cv' xctkqwu' t' q' j' le' r' xgn' < C' t' g' x' g' y . " Gpvktqpo gpv' k' p' v' t' p' cv' k' p' cn' ; : . " 3/39 " \*4239-0'  
 ]5\_ " J 0' F wcp' g' v' cn' I' w' o letqdkqc < C' v' ti' g' v' hqt' j' g' cx { " o' gvcn' vqzleqmqi " cpf " c' r' tqd' q' v' r' tq' v' g' v' x' g' u' t' cv' g' i . " Uel' p' eg' qh' Vj g' V' qv' cn' Gpvktqpo gpv' **964** \*32+ " 36264; " \*4242-0'  
 ]6\_ " Q0Cf co qxun' f' g' v' cn' Vj g' I' w' o letqdkqc g' cpf " Cs wvle" Vqzleqmqi { < C' p' Go gti kpi " Eqpegp' v' hqt " Gpvktqpo gpv' cn' J gcnj . " Gpvktqpo gpv' cn' Vqzleqmqi { " cpf " Ej go kn { . **59** \*33+; 497; /4997 " \*423: -0'

# CHARACTERIZATION OF CARBONACEOUS MATERIALS WITH CONTROLLED POROSITY AND MORPHOLOGY

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Carbonaceous materials that include metallic nanoparticles (NPs) have attracted extensive interest during the last decades, especially those of metals like Ni and NiO in core/ shell morphologies. However, in order to improve NiO properties for those applications, a correlated analysis of its microstructure and magnetic properties, should be done.

In particular, Nickel oxide is widely studied due to its importance in technological applications (i.e., catalysis, batteries, ceramics, etc). To achieve this purpose, we have prepared five samples of 2-methylimidazole Nickel (NIOF) nanoparticles with carbonization temperatures between 400°C and 600°C; characterized their crystal structure and microstructure by X-Ray diffraction (XRD) and high resolution transmission electron microscopy (HRTEM). Additionally, their magnetic properties were studied by SQUID magnetometer through ZFC-FC and M(H) curves.

The samples exhibit two crystallographic phases of Ni: face centered cubic-FCC and hexagonal compact phase-HCP. Additionally, at the lowest carbonization temperature Ni<sub>3</sub>C was also detected. XRD peaks become narrower and symmetrical as the carbonization temperature raises, suggesting that the Ni-NPs mean diameter increases. Inter planar distances were measured by analysing into detail HRTEM images. These studies corroborate XRD results and the existence of Ni<sub>3</sub>C phase on samples synthesized at the lowest carbonization temperature.

The analysis of M(H) curves recorded at room temperature, reveal that the saturation magnetization is low on samples that contain antiferromagnetic Ni<sub>3</sub>C or NiO phases. Besides, the saturation magnetization values (Ms) and mean blocking temperature values (TB) increases as the carbonization temperature rises because larger NPs are synthesized in those conditions.

From the magnetic analysis, we suggest that each NPs can be described as consisting of a metallic Ni core, surrounded by very thin shell of NiO.

**ƆP VGTHTGTGPEG'QH'CPVKRJ CUG/U PEJ TQP K GF'XQTVGZ'UJ GFF ƆPI "**  
**ƆP'HNQY 'RCUV'CP'ƆPNK'G'O KETQ/E[ NKƆFGT'CTTC[ "**

Lwukpc'Leugrk pckv "

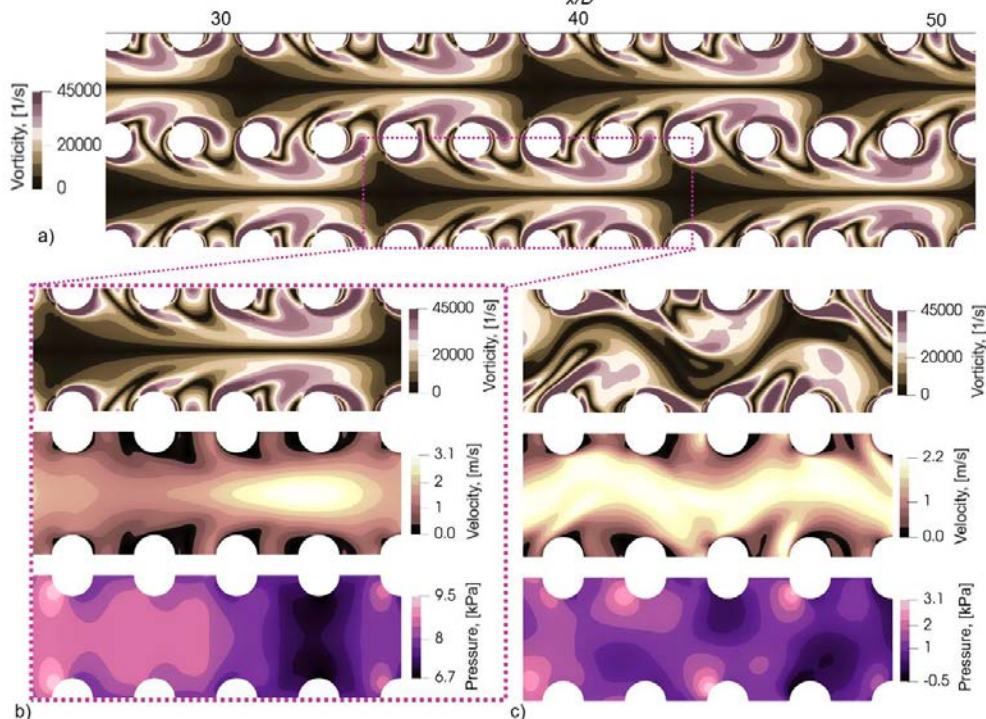
"Ncdqtcvqt { "qh'P wengct "Ɔpuvncvkqp"Uchgv{ . "Nkj wcpkcp'Gpgti { "Ɔpuvkwg. "Nkj wcpk "

Lwukpc'LeugrkpckvgB rgl0v'"

Wpungcf { "cpf"wtwdwgpv'hny "ctqwpf"cp"cttc{"qh'e{ rkpftu'ku'gpeqwpvgtgf "lp'o cp{"gpi kpggtkpi "cr r rkecvkpu."g0i 0" hngn'cpf "eqpvtqn'tqf u'lp'pwengct'tgcevqtu."qk'icpf'i cu'r k rkpogu."j ki j /tkug'dwkrf kpi u."j gcv'gzej cpi gtu'gve0'hny "qxgt'vy g" ekewrt"e{ rkpftu'lp" c" wcpf go . "uci i gtgf . "ukf g/d{/ukf g"cttcpi go gpw'ku'y gni'kpxguki cvgf "]3\_0P gxtg'v gguu."cu" y j g" pwo dgt'qh'qduwercu'kpetgcugu."hny "dgeqo gu'r tqi tguukgn{ "o qtg'eqo r rnz0Gzkvki "tgugtej "ku'iko ksf "vq" kpxguki cvkqp" qh'y cng'qh'y g'e{ rkpftg'cttc{"dw'f qgu'p'v'cpcn' ug'y g'i cr "hny "dgy ggp'y g'e{ rkpftu"]4\_0Vj g'eqw rkp' "gh'ge'v'dgy ggp" e{ rkpftu'lp'f weng' y cng'kpwgt'htg'ppeg."xqtvgz"u{pej tqpk cvkqp."dqwpf ct{"rc{ gt luj gct"rc{ gt ly cng'le{ rkpftg'lxqtvgz li cr "hny " kpwgt'cevkpu"]5\_ "y j lej "i ksg'tkug'vq" hny /kpf wegf "xkdtcvkqp"r j gpqo gpp"ecwvki "ugxgtg'ej cngpi gu'vq" y j g'f guki p"cpf" gZR rnkcvkqp"cu'c'tguwv'qh'qewt'gpeg'qh'iqcf u'cpf "rci g'co r rkwf gu0"

Ɔp"y ku'y qtm'eqo r wcvkpcn'hwk "f {pco leu'uko wcvkqp"qh'y j g" hny "lp'o letq/iej cppgn'ku'tgr qtvgf 0'P wo gtekn'4F" uko wcvkqp"y cu'r gthqto gf "wvki "Qr gpHQCO "uqhw ctg0'Xcrk cvkqp"y cu'r gthqto gf "ceeqt'kpi "vq" Tgphgt'gZR gto gpv"]6\_ " y j g'eqkpkf gpeg'qh'o qf gmkpi "cpf" gZR gto gpcn'f c'v'qp"cxgtci g"gzegf u"; 2" 0Vj g'hny "utwewt'g'ku'f gr gpf gpv'qp"i cr / ur celki "tcvkq" R<sub>NVIF</sub> . "y j gtg" R"ku'y j g"e{ rkpftg' "egpvtg/vq/egpvtg"ur celki "tcvkq."N'cpf "V"ctg"mqi kwf kpcn'cpf "t'cpuxgtug" ugr ctvkqp. "t'gur gevkg'gn."F"ku'y j g'f kco gvt'qh'c'e{ rkpftg. "lp'y ku'ecug"/"R<sub>NVIF</sub>"? "4."R<sub>VIF</sub>"? "50"

Kpxguki cvgf "eqphki wcvkqp"cv'egt'cvkqp" Tg{pqrf u'pwo dgtu" T<sub>gr</sub>" gZR gtlkpeg" kpwgt'htg'ppeg"qh'cpvr j cug/u{pej tqpk gf" r cwtg'qh'i cr "hny . "y j lej "ku'uj qy p"lp" Hki 030" j gtg" T<sub>gr</sub>?" "w<sub>0</sub> F l . "y j gtg" w<sub>0</sub> "ku'y j g'o gcp" xgmekf{ "qh'hwk "dgy ggp" y j g" e{ rkpftu'cpf "ku" "y j g'nikpgo cve'xkuequk{ "qh'hwk 0F w'vq" hny "R<sub>NVIF</sub>"tcvkq"cpf "j ki j gt" R<sub>VIF</sub>"tcvkq. "t'gekt'ewcvkqp" qpgu'iqug" y j g'k'utgpi y j "cpf" u'j g' cngt'pckpi "xqp" Mto cp'xqt'vlegu0Cu'y j g'r j cug'f khtg'ppeg'dgy ggp'gcej "i cr "hny "ku" . "k'tguwv'lp" cpvr j cug'u{pej tqpk gf "xqtvgz"uj gf f kpi . "y j gtg'y cng" qpgu'kpwgt'cevy kj "gcej "qy j gt'eqpvt'wvkg'gn" "hgg" Hki 03" d+0Vj ku" r j gpqo gpp"rgcf u'vq" f getgcugf "r t'guwv'g"cpf "j ki j gt" nkp'vke" gpgti { "cpf" "xqt'vlekf" | qpgu. "y j lej "j cxg'cdtw'v'i tcf kgrw0' 0 czko wo "ur g'gf "kp" y j g'ug" | qpgu'ku"62" "j ki j gt" y j cp" y j g'o czko wo "ur g'gf "cv'y j g" gpf "qh'ej cppgn" y j gtg" y j g"lp/r j cug" xqtvgz/uj gf f kpi "ku'qdugt'xgf" "hgg" Hki 03" e+0Vj g'kpwgt'htg'ppeg"i kxgu'tkug'vq"eqw r'gf "xqt'vlegu"cpf "kpuvdkk'kku"lp" y j g"i cr " hny "cpf" y cngu. "y j lej "ecp"rgcf "vq" c" utqpi "kpetgcug"qt" f getgcug'qh'f tci "cpf" rkn'hqtegu"cpf "Utqwj cni'pwo dgt"qh'y j g" qduwercu'0'Ɔ"cm'ecugu'xqtvgz'uj gf f kpi "rgcf u'vq" o qtg'qt'rguu'hwewcvkpi "hqtegu"qp" y j g'e{ rkpftu'cpf "ecp"ecwug'utwewt'cni' xkdtcvkpu. "t'guq'ppeg. "ceqwu'k'p'qkug. "y j lej "ecp"r tqxqng'hkwt'g'qh'utwewt'g0"



Hki "30T<sub>gr</sub>"? "3: 2. "v"? "20B"u. "c+xqt'vlekf" "eqpvtu."d'+cpf "e+xqt'vlekf" "xgmekf{ . "r t'guwv'g' hgrf u'utcvkpi "htqo "z'IF"?" "56" cpf "; 6. "t'gur gevkg'gn" "

[3\_] 0\ j qw( "0f000Cno . "Y cng'qh'y q'kpwgt'cevkpi "ekewrt"e{ rkpftu'c'tg'xly . "kpwgt'cevkpcn'lwtpcn'qh'J gcv'cpf "Hwk" hny "84."732/759"4238-0' ]4\_ "V0Vepi . "R0\ w"Z0Uj cp'g'v'cn'Qp'y j g'tcpuk'kqp'dgi cxkgt'qh'iro kpcn'hny "y tqwi j "cpf" c'b wnk'e{ rkpftg'cttc{ . "Rj { uleu'qh'Hwk u"54."235823"4242-0' ]5\_ "0f000Cno (" "L0R00 g'gt. "Vy q'kpwgt'cevkpi "e{ rkpftu'lp'etqu'hny . "Rj { uleu'c'tg'xly "; 6."278526"4233-0' ]6\_ "C0Tgphgt. "0'0M0Vly ctk"V0'Dtwpej y kgt"gv'cn'GZR gto gpcn'kpxguki cvkqp"lp'vq'xqtvgz'utwewt'g'cpf "r t'guwv'g'f tqr "cetqu"o letqec'k'kku"lp"5F" k'vgi t'cvgf "grgext'p'kleu."CZR gto gpw'lp'Hwk u"73."953/963"4233-0"



# KO RTQXGF 'HCMG'NGRVQP 'DCEMI TQWPF 'GUVKO CVKQP 'HQT 'VJ G' FTGNN/ CP 'F KHHGTGP VKCN'ETQUUGE VKQP 'O GCUWTGO GP V'WUR I " 4238'EGTP 'EO UF CVC"

O ctkwu'Co dtq[ cu."Cpf tkwu'Lxqf ci ctku"

Kpukwng'qh'Vj gqg'g'ceciRj { uleu'cpf 'Cwtqppqo { .H'ewm' {qh'Rj { uleu.'Xkpkwu'Wp'k'gtuk'f .N'kj wcpk' " o ctkwu'Co dtq[ cuB i o ctk'ego "

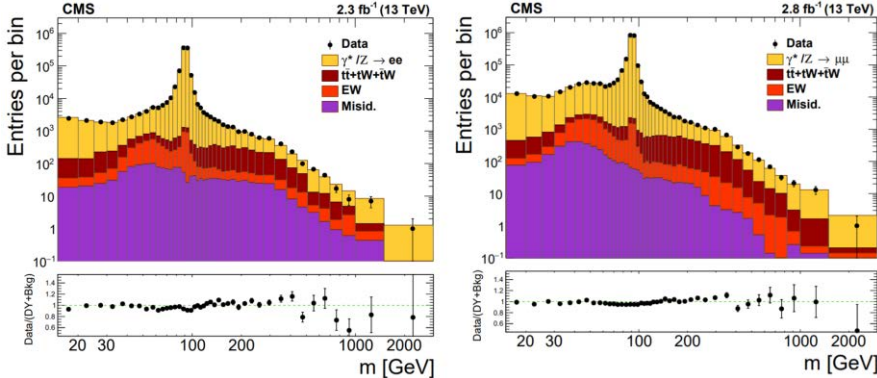
Vj g'Ncti g'J cf tqp"Eqm'k'gt"NJ E-"cv'EGTP "ceeg'gt'cvu'r tqv'pu'v'q"cm quv'v'g"ur ggf "qh'rk'j v'cpf "eqm'k'gu"v'g go " vqi gv'gt"y kj "35"VgX"eqm'k'k'qp" gp'gti {O'Uj qv'v'k'g'f "j gcx { "r ct'v'ergu"o c { "dg"r tqf wegf "f w'k'pi "uwej "eqm'k'k'pu."cpf " k'p'x'g'w'k' cv'k'p'qh'v'j g'ug'g'x'p'w'c'm'y u'r j { u'k'k'w'u'v'q"hw'v'g'gt"r w'uj "v'j g"ht'p'v'k'g't'qh'q'w'v'p'f'gt'w'c'p'f'k'pi "cd'q'w'v'j g"v'p'k'g't'ug'O' Eqm'k'k'p' "r tqv'pu'ec'p'd'g'f'guet'k'd'g'f'cu'v'y q'qr'r'q'k'g'f'hw'y u'q'h's'w'c't'n'i'c'p'f'f'w'q'p'u."ceeq't'f'k'pi "v'q'v'j g'r ct'v'p'o qf'gr'O'CP { "y q" \*qt"o q't'g"r ct'v'p'u"o c { "k'p'v'g't'ce'v'f'w'k'pi "v'j g"eqm'k'k'p."r tqf'w'k'pi "p'gy "r ct'v'ergu'O'Vj g't'g'ct'g" f'k'hh'g't'gp'v'r tq'd'cd'k'k'k'g'u"qh' f'k'hh'g't'gp'v'q'w'eqo'gu."y j'k'ej "k'p'k'k'c'm'f'f'g'r'g'p'f'q'p'v'j g'r ct'v'p'f'k'w'k'd'w'k'p'w'p'v'k'p'u"RF Hu'O'RF Hu'f'guet'k'd'g'f'rq'd'cd'k'k'k'g'u"qh' g'z'k'v'p'eg'c'p'f'gp'gti { "h'c'v'k'p'qh'ur'g'ek'h'e'r ct'v'p'u'k'p'uk'f'g'c'r tq'v'p'O'RF Hu'o w'u'd'g'o'g'cu'w't'g'f'v'k'y "j k'j "r t'g'ek'k'p'k'p'q't'f'g'v'q" o c'ng'e'q't't'g'ev'r'g'f'k'v'k'p'u'cd'q'w'r tq'v'p'k'p'v'g't'ce'v'k'p'u'O'

Vj g'F tgm[ cp'r tq'eguu'w'c'ngu'r'w'eg'f'w'k'pi "c'r tq'v'p'r tq'v'p'eqm'k'k'p."y j'gp" c's'w'c't'n'i'c'p'f'cp"cp'w's'w'c't'n'i'c'p'p'l'j'k'v'v'v'q" et'g'c'v'g" c \ "dq'v'p'q't" c'x't'w'c'n'r j'q'v'p"y j'k'ej "p'g'c't'n'f'k'p'u'c'p'v'v'f'g'ec { u'k'p'v'q" c'ej'c't'i'g'f "n'g'r'v'p'c'p'w'k'g'r'v'p"r'c'k'k'f'k'g'r'v'p"h'q't" u'j'q't'v'v'j]3\_OF k'g'r'v'p'eg'p'v'g't/q'h'o'cuu'r tq'r'g't'k'g'u'f'g'r'g'p'f'f'k'g'ev'v'q'p"hw'w'o'q'o'g'p'v'c'q'h'v'j g'c'p'p'l'j'k'v'v'v'q'p' "s'w'c't'm'o'v'j'g't'g'h't'g." r t'g'ek'k'g"o'g'cu'w't'g'o'g'p'u'q'h'F tgm[ cp'r tq'eguu'f'k'hh'g't'gp'v'k'n'i'et'qu'u'g'ev'k'p'u'ct'g" w'ug'f "v'q" eq'p'ut'c'p'v'j g' RF Hu" ]4\_O'Vj g'ug" o'g'cu'w't'g'o'g'p'u'c't'g'c'nu'g'w'ug'h'w'i'h'q't"v'g'w'k'p'i "v'j g'x'c'k'f'k'v' "qh"j k'j j'g't'q'f'g't'eq't't'g'ev'k'p'u'qh'v'j g'w'c'p'f'c't'f' "o'q'f'g'n'c'u'y'g'n'i'c'u'f'q't" c" p'w'o' d'g't'q'h'v'j'g't'z'r'g't'k'o'g'p'v'c'i'o'g'cu'w't'g'o'g'p'u'v'j'g't'g'v'j'g'F tgm[ cp'r tq'eguu'k'u'eq'p'uk'f'g't'g'f'c'd'c'emi tq'w'p'f' ]5/7\_O'

Ej'c't'i'g'f' "n'g'r'v'p'u'et'g'c'v'g'f'f'w'k'pi "v'j g'F tgm[ cp'r tq'eguu'w'w'c'm'f' "j'c'x'g" c"j k'j "o'q'o'g'p'w'o' "c'p'f' "r'g'c'x'g"v'c'c'emi'v'j'c'v'c't'g" y'g'm'ug'r'c't'c'v'g'f' "h't'q'o "v'c'c'emi'q'h'v'j'g't" r'ct'v'ergu'O'Vj k'u'v'f'r'g'q'h'v'g'r'v'p'u'k'u'w'w'c'm'f' "ec'ng'f' "o'r't'q'o'r'v'v'j'v'j'g't'g'c'nu'g'ct'g"q'v'j'g't" r tq'eguu'g'u'v'j'c'v'o'c'f' "r tq'f'w'eg"r tq'o'r'v'v'g'r'v'p"r'c'k'u'w'w'v'k'k'g'v'j'g'F tgm[ cp'r tq'eguu'O'Y'g't'g'h'g't'v'q'v'j'g'ug'r' tq'eguu'g'u'c'u'r tq'o'r'v' n'g'r'v'p'v'c'c'emi tq'w'p'f' u'O'Vj g't'g'k'u'c'nu'g'c"r'q'u'k'd'k'k'k'f' "v'j'c'v'c'r'q'q't'n'f' "k'u'q'v'v'g'f' "n'g'r'v'p'go'g't'i'k'p'i "h't'q'o'c'j'c'f' t'q'p'k'g'v'q't'g'x'g'p'v'j'g'g'v' k'ug'h'y'k'n'i'd'g'o'k'ut'g'eq'p'ut'w'ev'g'f'cu'c'r'q'o'r'v'v'g'r'v'p'O'Vj k'u'v'f'r'g'q'h'v'g'r'v'p'u'k'u'ec'ng'f' "o'h'c'ng'v'v'v'f'r'k'ec'n'i'h'c'ng'v'g'r'v'p'v'c'c'emi tq'w'p'f' u' ct'g'v'j'g'Y - I'g'w'v'q'p'g'v'g'r'v'p'k'u'r'q'o'r'v'c'p'f' "q'p'g'k'u'h'c'ng"cp'f' "v'j'g'S'EF"o'w'w'k'g'v'v'd'q'v'j' "n'g'r'v'p'u'c't'g'h'c'ng"r' tq'eguu'g'u'

H'c'ng'v'g'r'v'p'g'x'g'p'w'j'c'x'g'x'g't' "r'c't'i'g'et'qu'u'g'ev'k'p'u'c'p'f' "x'g't' "n'g'y "r tq'd'cd'k'k'k'g'u"v'q"dg'v'ug'ng'ev'g'f'cu'F tgm[ cp'g'x'g'p'v' ec'p'f'k'f'c'v'g'u'O'Vj g't'g'h't'g'f' "v'j'g'v'k'o'w'v'g'f' "h'c'ng'v'g'r'v'p'v'c'c'emi tq'w'p'f' "r'g'f'k'v'k'p'u'c't'g'w'w'c'm'f' "k'p'c'c'ee'w'c'v'g'O'f'c'v'f'k'x'g'p'v'g'ej'p'l's'v'g'u" ct'g'g'z'r'k'k'g'f'v'q"v'g'w'k'o'c'v'g'u'w'ej "v'c'c'emi tq'w'p'f' "f'k'g'f' u'O'Vj g'o'h'c'ng'v'c'v'g'o'o'g'v'j'q'f' "t'g'r'k'g'u'q'p"o'g'cu'w't'k'p'i "v'j'g'h'c'ng'v'g'r'v'p'v'ug'ng'ev'k'p'p' g'h'h'k'g'p'e { O'Vj g'o'g'cu'w't'g'f' "g'h'h'k'g'p'e { "k'u'c'r'r'k'g'f' "q'p" g'x'g'p'w'v'eq'p'c'k'p'k'p'i "h'c'ng'v'g'r'v'p'u'v'j'c'v'j'c'x'g'f'k'k'g'f' "v'j'g'v'ug'ng'ev'k'p'v'q" v'g'w'k'o'c'v'g'v'j'g'p'w'o' d'g't'q'h'v'g'x'g'p'w'v'j'c'v'j'c'x'g'f'c'w'g'f' "k'o'f'p'v'j'g'q't'f' "c'o'q't'g'v'q'r'j'k'w'k'c'v'g'f' "o'g'v'j'q'f' "k'u'v'j'g'o'o'c'v'k'z' "o'g'v'j'q'f' "o'y'j'k'ej " c'f'f'k'k'p'c'm'f' "o'g'cu'w't'g'u'v'j'g'r' tq'o'r'v'v'g'r'v'p'v'ug'ng'ev'k'p'p'g'h'h'k'g'p'e { O'D'q'v'j "o'g'v'j'q'f' u'y'k'n'i'd'g'r' t'g'ug'p'v'g'f' "c'p'f' "eq'o'r'c't'g'f' "k'p"v'j'g'v' eq'p'v'z'v'q'h'v'j'g'F tgm[ cp'f'k'hh'g't'gp'v'k'n'i'et'qu'u'g'ev'k'p'v'g'cu'w't'g'o'g'p'v'v'k'p'i "4238'EGTP 'EO UF c'v'c't'g'eq't'f'g'f'c'v'c'u'?" "35"VgX'O'

Eq'm'c'd'q't'c'v'k'p'v'k'y'k'j' "EGTP 'EO U'g'z'r'g't'k'o'g'p'v'k'u'w'r'q't'v'g'f' "d' "v'j'g'N'k'j'w'c'p'k'c'p' "C'ec'f'g'o' { "q'h'U'ek'p'p'eg'u'O'Vj k'u'y'q't'm'i'y'cu" c'nu'g'r'c't'v'c'm'f' "u'w'r'q't'v'g'f' "d' "c'v'ej'q'r'c't'uj'k' "h't'q'o' "X'k'p'k'w'u'W'p'k'g't'uk'f' "G'z'r'g't'k'o'g'p'v'c'i'P'w'eng'c't'c'p'f' "R'c't'v'erg'v'j' { u'leu' "E'g'p'v'g't'c'p'f' "f'q'p'g'k'p' "eq'm'c'd'q't'c'v'k'p'v'k'y'k'j' "u'ek'p'v'k'u" h't'q'o' "W'p'k'g't'uk'f' "r'k'd't'g'f'g' "D't'w'z'g'm'g'u." [ q'p'ug'k'W'p'k'g't'uk'f' "c'p'f' "v'j'g'W'p'k'g't'uk'f' "q'h' P'g'd't'c'w'n' "k'p'N'k'p'eq'p'o'



H'k'i'O'30'F'k'g'ev't'q'p' "v'g'h"cp'f' "f'k'o'v'q'p' "v'k'j'v'v'k'p'x'c't'k'c'p'v'o'cuu'f'k'w'k'd'w'k'p'u"o'g'cu'w't'g'f' "w'ul'p'i "4237'EGTP 'EO U'f'c'v' " ]4\_O' D'r'c'v'n'f'q'u'f'g'p'q'g'g'x'g'p'v'f'k'g'f' u'o'g'cu'w't'g'f' "y'k'j' "v'j'g'EO U'f'g'v'g'ev'q't'O' [ g'm'q'y "d'c't'u'o'c't'n'i'k'o'w'v'g'f' "F tgm[ cp'r tq'eguu'v'g'Y'v' o'c't'm'u'r'q'o'r'v'v'g'r'v'p'v'c'c'emi tq'w'p'f' u'O'v'v'o'k'k'f' (v'f'g'p'q'v'g'u'h'c'ng'v'g'r'v'p'v'c'c'emi tq'w'p'f' u'g'w'k'o'c'v'g'f' "w'ul'p'i "v'j'g'o'h'c'ng'v'c'v'g'o'o'g'v'j'q'f' O'

[3\_ "U'f'f' tgm'v'O'O' [ cp.'O'c'u'k'g'N'g'r'v'p' "R'c'k'R'q'f'w'v'k'p'k'p'J'c'f' t'q'p'J'c'f' t'q'p' "Eq'm'k'k'p'u'c'v'J' k'j' /G'p'g't'i' l'g'u.'R'j' { u'O'T'g'x'O'N'g'w'047.'538"3; 924'0'  
[4\_ "EO U'Eq'm'c'd'q't'c'v'k'p'v'k'p' "O'g'cu'w't'g'o'g'p'v'q'h'v'j'g'f'k'hh'g't'gp'v'k'n'i'F tgm[ cp'et'qu'u'g'ev'k'p'k'p'r' tq'v'p'r' tq'v'p' "eq'm'k'k'p'u'c'v'c' u'?" "35"VgX.'LJ' GR'34'27; "423; 4'0'  
[5\_ "CVNC U'Eq'm'c'd'q't'c'v'k'p'v'k'p' "u'g'c't'ej' "h'q't"v'j'g'f'k'o'v'q'p'f'g'ec' { "q'h'v'j'g'U'c'p'f'c't'f' "O'q'g'n'J' k'i' i' u'd'q'v'p"y'k'j' "v'j'g'CVNC U'f'g'v'g'ev'q't'O'R'j' { u'O'N'g'w'O'D': 34.'357; : 2' "4243-4'  
[6\_ "EO U'Eq'm'c'd'q't'c'v'k'p'v'k'p' "u'g'c't'ej' "h'q't"v'j'k'j' /o'cuu'f'g'u'p'c'p'eg'u'k'p'f'k'g'r'v'p' "h'p'c'n'i'v'c'v'g'u'k'p'r' tq'v'p'r' tq'v'p' "eq'm'k'k'p'u'c'v'c' u'?" "35"VgX'O'LJ' GR'28'342"423; 4'0'  
[7\_ "EO U'Eq'm'c'd'q't'c'v'k'p'v'k'p' "u'g'c't'ej' "h'q't"v'q'r' "u's'w'c't'n'i'c'k'r' r'q'f'w'v'k'p'w'ul'p'i "f'k'g'r'v'p' "h'p'c'n'i'v'c'v'g'u'k'p'r' "eq'm'k'k'p'f'c'v'c' "eq'ng'ev'g'f'c'v'c' u'?" "35"VgX'O'G'w'O'R'j' { u'O'LO'E' " : 3'5"4243-4'

# MULTI-HIGGS DOUBLET MODELS AND GROUP THEORY

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The Standard Model (SM) of particle physics has been extensively tested for a few decades and is the most successful description of Nature. Nearly all theoretical SM predictions have been experimentally verified and the last missing piece, the Higgs boson, was discovered in 2012 [1, 2]. This is undoubtedly a fascinating discovery in the field of particle physics and might be the final missing piece. Nevertheless, there is no experimental verification that it is the only Higgs boson, and it will be tested at the LHC and future colliders. It is widely accepted that the SM is an effective low-energy theory, which is capable of explaining physics at low energies,  $\mathcal{O}(100)$  GeV, but fails at high energies. While the SM of particle physics keeps on triumphing, there is a vast amount of both theoretical and experimental phenomena that cannot be resolved within the SM framework, some of which are: neutrino oscillations, asymmetry of matter-antimatter, the strong CP problem, *etc.* From the cosmological point of view the overall SM situation is daunting as it fails to describe not only gravity and dark energy, but also nearly 85% of the matter in the Universe, which is constituted by Dark Matter (DM). The multi-Higgs models could resolve some of the issues and are commonly invoked when models beyond the SM are constructed. Thus, we propose and are motivated that such extension could potentially solve several problems.

The SM uses the minimal Brout-Englert-Higgs mechanism [3, 4, 5], where a single complex SU(2) doublet is considered. The simplest extension of the SM electroweak sector is the Two-Higgs-Doublet Model (2HDM) [6, 7]. In the 2HDM a second SU(2) doublet is added to the SM-like doublet. Such extension predicts a rich scalar spectrum: two additional neutral states  $h_{(1,2)}$ , and a charged state  $h^\pm$ . The second SU(2) doublet can be further on constrained to result in a viable DM candidate [8]. There are many possibilities to extend the scalar sector by not only the SU(2) doublet but a general  $n$ -tuple, each with its own advantages. A non-minimal scalar sector is well motivated in both Supersymmetry and Grand Unified Theories, where extension of the scalar sector is inevitable.

With limitless possibilities to extend the scalar sector it is crucial not to oversaturate a model with an endless list of free parameters. Let us consider the most general NHDM model. The number of free real parameters is given by  $N_{\text{tot}} = N^2 (N^2 + 3) / 2$  [9]. With the number of additional SU(2) doublets, the total amount of free parameters grows rapidly, and a specific model loses predictiveness. Symmetries play an important role in controlling the number of free parameters, therefore increasing the predictability of such extensions. For example, the most general 3HDM scalar potential results in 54 free real parameters. However, if we impose a discrete  $S_3$  symmetry [10, 11, 12, 13] *ad hoc*, the number of free parameters decreases to up to ten. In the multi-Higgs extensions some of the problems of the SM, such as the need for new sources of CP violation, which are required to account for the observed baryon asymmetry, can be addressed. An important feature of multi-Higgs extensions of the SM is the possibility of having spontaneous CP violation. Imposing additional symmetries may eliminate the possibility of having spontaneous CP violation.

During the talk we shall cover the 2HDM and the 3HDM models. In particular, we shall present results of Ref. [14], where implications of a mass degeneracy among scalar states and possible symmetries of the 2HDM scalar potential were presented. Moreover, we shall discuss what happens to CP violation in the scalar sector when symmetries are imposed. Also, we introduce a basic principle of how to construct an  $S_3$ -symmetric 3HDM and how symmetries can lead to massless states [15, 16].

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# ENGINEERING TIME-SPACE CRYSTALLINE STRUCTURES

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Regular space crystals are described by a spatially periodic distribution of particles observed at a fixed moment of time. To form time crystals [1, 2], the roles between time and space are interchanged. In this case the periodicity is observed in time by fixing a position in space and measuring the periodic detection of particles during the experimental time frame. Time crystal behavior can emerge spontaneously in many-body systems and can also be engineered by suitable external time-periodic driving. This allows to realize a variety of condensed-matter phenomena in the time domain [3, 4].

In this presentation, we demonstrate the notion of time-space crystalline structures (TSCS) which merge the ideas of time and space crystals to form systems that are both temporally and spatially periodic [5]. Starting with a particle in a one-dimensional periodic potential, an external periodic and resonant driving can be used to engineer a crystalline time structure at each potential well of the spatial lattice thus effectively forming a two-dimensional TSCS. This allows us to construct a system where each spatially orthogonal one-dimensional periodic potential comes equipped with a periodic structure in time. For a three-dimensional lattice with a proper choice of driving this leads to a six-dimensional TSCS. Realization of a six-dimensional crystalline structure paves the way towards investigation of higher-dimensional condensed-matter phases.

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**O QF GNNKPI 'QHHP VGTCEVQP 'DGVY GGP 'RJ QVQU P VJ GVKE''  
RK O GP VU'WUKPI 'S WCP VWO 'EJ GO KVT[ 'O GVJ QF U''**

Mc| ko kgtcu'Vco qrk pcu<sup>3</sup>. 'Lgxi gpl'Ej o grkqx<sup>3,4</sup>. 'Cpf tkwu'I grflpk<sup>3,4</sup>

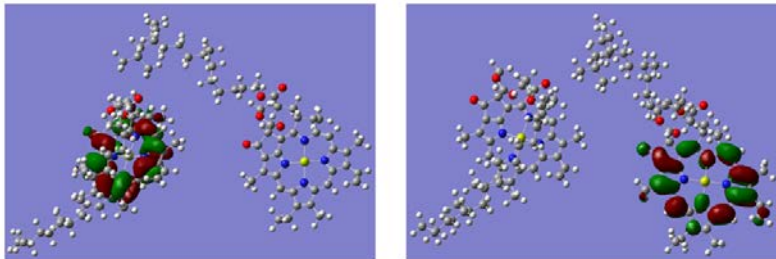
<sup>3</sup>Kpukwag'qh'Ej go kecn'Rj { uleu. 'Hcewn{ 'qh'Rj { uleu. 'Xkpkwu'Wpkxgtukf. 'Nkj wcpk"

<sup>4</sup>F gr ctvo gpv'qh'O qrgewrt'Ego r qwpf 'Rj { uleu. 'Egpyt'ht'Rj { ulecn'Uelgpegu'cpf 'Vgej pqm| . 'Nkj wcpk"  
ne| ko kgtcu'Vco qrkpcuB HfUwf Kwfn'

Rj qvqu'ugvo "RUKK:"qpg'qh'o cp{ "r ki o gpvr tqvklp'uw gteqo r rgzgu'rqecvqf "kpkf'g'y'j'g' { rncqkf "o go dtcpg'qh'y'j'g' r rcpwu' qti cpgng' ej nqtqr nuv." wngu' cp' ko r qtcvp' r ctv'lp" y'j' r j qvqu{ py gke "tgecvkppu'0'RUKK' r ctvkr cvgu'lp" y'j' g' rki j v' j ctxgukpi 'cu'y' gnicu'y' g'ej cti g'tcphgt'r tqeguug'y' j krg'cnuq'eqpvtkdwkpi 'v' y'j' g'r rcpwu'f ghgpkxg'b' gej cpluo u'j3\_0K'y' cu' tgeqi plugf "y'j' cv'y'j' g'NJ EKK'r tqvklp'eqo r rgz." y'j' lej "eqo r tkugu'y'j' g'RUKK'r tqvklp." ku'j' ki j n' "lpxqkxgf "lp" y'j' g'r tqegu'qh' pqr j qvqej go kecn's wpej kpi "P RS + 'o' "qpg'qh'y'j' g'o cklp' r rcpwu'f ghgpkxg'tguqwtegu'0'k'p'ecugu'y'j' gp' y'j' g'tcv'qh'r'j' qvqp" cduqtr vkpp'gzegf u'y'j' g'tcphgt'tcv'qy' ctf u'y'j' g'tgecvkpp'egpvtg. 'egt'cpl's wpej kpi 'uksu'cr r gct'y'j' kj' lp'y'j' g'NJ EKK'eqo r rgz." cmqy' kpi 'k'v'q'f'kuur cv'g'y'j' g'gzegu'gzekcvkpp'gpgti { 'cu'y'j' gcv'j4\_0'

K'ugctej 'ht' y'j' g'f'guetkr vkpp'qh'y'j' g'P RS 'r tqegu. 'c'uwf { 'lwi i guvgf 'y'j' cv'y'j' g'emug/n' kpi 'ej nqtqr j { m'Ej n'o qrgewru' ecp'ht'o 'y'j' g'ej cti g'tcphgt '\*E V+'ucvgu. 'y'j' lej 'ctg'cdng'v'q'cev'cu'y'j' g'gzekcvkpp'gpgti { 's wpej gtu'j5\_0O gcpy j krg. 'qy'j' gtu' cti wgf 'y'j' cv'y'j' g'EV'ucvgu'ctg'tgrvqf 'v' y'j' g'tgf /uj kngf 'ucv'g'922/942'po +y'j' kj' 'tgr gev'v'q' y'j' g'o cklp'ucv'g'8: 2'po + 'qh'y'j' g' NJ EKK'eqo r rgz'j6\_0Gxgp'y'j' qwi j 'y'j' g'o gej cpluo 'cpf' r tgeklug'rqecvqf'qh'y'j' g'P RS 'y'j' cu'p'qv'erct'kngf. 'y'j' g'uwf'ku'ko r n' 'y'j' g' r quukl'k'v' y'j' cv'y'j' g'EV'ucvgu'o ki j v'eqpvtkdwg'v' y'j' g'r tqegu'0Vj' g'emug/n' kpi 'Ej m832. 'Ej m833'cpf 'Ej m834'utwewt'gu' kpkf'g'y'j' g'NJ EKK'eqo r rgz'gzegnl'p'y'j' g'ny'j' guv'gzekgf /ucv'g'gpgti'ku'cu'y'j' g'ni'cu'y'j' g'j' ki j guv'k'p'v'et'cvkpp'gpgti'ku. 'y'j' lej 'ctg' y'j' g'lpj' gt'gp'v'ej'ctcevt'ku'cu'qh'y'j' g'EV'ucvgu'j7\_0Qp'y'j' ku'd'cuku. 'y'j' g't'kr ngv'y'j' cu'egpvt'cu'v' y'j' g'r tgu'gpv'lp'xguk' cvkpp'0'

J ki j 'tgu'nwkkp'NJ EKK'r tqvklp'utwewt'g'j8\_cpf' r rcpv' 'qh'gzr gto gpcn'f'c'v'j5. '6\_cmqy' gf 'v'g'ugctej 'ht' y'j' g'EV'ucvgu' wukpi 's wcpwo 'ej go kut { 'eqo r wcvkpp'cn'o g'y'j' qf u'0Vj' g'f'g'pukf' 'hwpev'kpp'cn'y'j' gqt { '\*F HV+'y'j' cu'cr r rkgf 'v'q'r' tgd'g'y'j' g'i' tqwpf /ucv'g'r' tqr gt'v'gu'y'j' krg'y'j' g'v'ko g'f' gr gpf'gpv'F HV'\*VF F HV+'h'qto' ckuo 'y'j' cu'wugf 'v'q'lp'xguk' cv'g'y'j' g'r' tqr gt'v'gu'qh'y'j' g'gzekgf /ucv'gu'0Eqw' d'c'w'p'w'cvkpi 'j' { dtkf "gzej cpi g'eqtt'grv'kpp'hwpev'kpp'cn' \*ECO /D5N[ R+'y'j' cu'ugr'gevgf 'y'j' kj' 'ee/r XF \ "d'cuku' ug'0Vj' g'utwewt'gu'y'j' g'r' lengf 'q'w'qh'y'j' g'NJ EKK'utwewt'g'cpf' 'qr v'ko kugf 'cv'y'j' g'F HVIECO /D5N[ R'rgxgn'qh'y'j' gqt { 0Vj' g' qr v'ko kugf "o q'p'qo' gtu'y'j' g't'cu'go dngf 'lp'v'q'f'ko' gtu'y'j' kj' 'tgr gev'v'q' y'j' g't'k' q'ki' l'p'cn'rqecv'kpp'cpf' 'c'p'wo' dgt'qh'gzekgf "ucv'gu'": 'ht' "o q'p'qo' g't'cpf' '38'ht'f'ko' g't'utwewt'gu'y'j' g't'g'ecr'w'v'g'f' cv'y'j' g'VF F HVIECO /D5N[ R'rgxgn'qh'y'j' gqt { 0'



Hki 030Vj' g'eqpvtkdwkpp'qh'y'j' g'o qrgewrt'qt'dkcn'f'cpuk'kpp'v'q' y'j' g'ugx'gp'y'j' g'gzekgf 'ucv'g'qh'y'j' g'Ej m8326Ej m833'f'ko' g't'0'

Vj' g'gzekgf /ucv'g'r' tqr gt'v'gu'y'j' g't'g'ugp'v'g'f' wukpi 'y'j' g'o qrgewrt'qt'dkcn'f'eqpvtkdwkpp'u'v'q' y'j' g'f' h'ngt'gp'v'gzekgf 'ucv'gu.' v'cpuk'kpp'gpgti'ku'cpf' 'f'kr'qrg' 'o' qo' g'p'u'0Vj' g'ecp'f'k'cv'g'EV'ucv'gu'ht' 'cn'y'j' g'f'ko' g't'utwewt'gu'y'j' g't'g'ht'wpf' 'v'q'ht'g'co' qpi 'y'j' g' j' ki j' g't'q'f' g't'gzekgf 'ucv'gu'0Vj' g' { 'y'j' g't'g'eqi' plugf 'cu'g'kx' g't'p'p'p'q'ecn'f'cpuk'kpp'u'qt' v'cpuk'kpp'u'y'j' kj' 'u'qo' g'r' tqr'qt'v'kpp'qh' g'z'ek'k'p'le'eqw' r'kpi' 0V'v'cpuk'kpp'f'kr'qrg' 'o' qo' g'p'u'ht'v'j' g't'x'c'k'f'cv'g'f' y'j' g'gz'k'ng'peg'qh'EV'ucv'gu'uj' qy' kpi 'ej' ctcevt'ku'le' | g't'q' "Hki 03+'qt'p'g'ctn'f' 'x'c'p'k'uj' kpi 'v'cpuk'kpp'f'kr'qrg' 'o' qo' g'p'v'0'

K'p'eqp'ewk'kpp.' y'j' g'eqo r wcvkpp'cn'uwf { 'cv'y'j' g' \*VF +F HVIECO /D5N[ R'rgxgn'qh'y'j' gqt { 'ku'cdng'v'q' tgr'q'f'weg' y'j' g' g'zr' gto' g'p'cn'f'gu'w'u'0Vj' ku'ko r r'ng'u'y'j' cv'ht'v'j' g't'o' qf' g'u'ecp'dg'v'g'ugf 'v'q'x'g't'k'f' y'j' cv'y'j' g'gz'k'ng'peg'qh'y'j' g'EV'ucv'gu'ku'c' t'g'cn' r'j' { ulecn'r'j' g'p'qo' g'p'q. 'lp'x'ct'k'p'v'qh'ej' qu'gp' "o' g'y'j' qf' qm| { 0H'ht'v'j' gto' q'tg. 'y'j' g'gp'x'k'q'p'o' g'p'cn'f'gh'g'ew. 'y'j' lej 'ctg' y'j' qwi j v'v'q' r' qu'gu'c'j' w' g'gh'g'ev'q'p' y'j' g'P RS 'o' gej' cpluo 'ecp'dg' l'p'eqtr'q'c'v'g'f' v'q'x'ct' { kpi 'f'gi' tgg'lp'q'f' g't'v'q'cej' k'g'x'g'c' "o' q'tg' t'g'erk'le' " r' k'ewt'g'0'

[3\_100 0Dgti . 'L0N0V{ o qe| nq. 'N0U' { g't. 'Dkqej go kut { . '7y' 'gf' k'k'p. 'Y' 0J 0H' g'go' cp'cpf' 'Eqo r cp{ . '42240'  
[4\_ 'C0X0T'wdep. 'P' q'p'r'j' q'v'qej go kecn'Ej nqtqr j { m'f'hw'qt'g'ue'g'p'eg' 'S' wpej kpi <O' gej' cpluo 'cpf' 'G'h'g'ew'x'g'p'gu'lp' 'R't'q'v'g'ek'p' 'R'rc'p'u'ht'qo' 'R'j' q'v'q' co' ci' g'0RR. " 392\*6+;\*4238+\*3; 2563; 380'  
[5\_1\_ 00 k'q'u'x'k'p'c. 'C'0Y' g'j' p'g't. 'R'J 0N'co' dt'g'. 'G'0Y' k'p'v'g'u. 'O' 0T'g'w. 'I' 0I' c'tcd. 'T'0E't'q'eg. 'C'0F'0J' q'ni' y'j' c'ty'j. 'H'ct' /g'f' 'h'w'qt'g'ue'g'p'eg' <c'f' k'g'ev'ur' g'ev't'que'q'r' k'e' " o' c'tng't' 'ht' 'NJ EKK'q'ri' qo' g't' h'q'to' cvkpp'lp'p'q'p'r'j' q'v'qej go kecn's wpej kpi . 'HGDUN'gw'07: 4\*47/48-\*422: +\*5847658530'  
[6\_ 'L0Ej o grkqx. 'C'0I' g'n' l'p'ku. 'G'0U'q'pi' c'kr. 'T'0C'w' w'ku. 'E'0F'0R'0F' w'h'h' . 'C'0X0T'wdep. '( 'N'0X'cm'w'p'cu. 'Vj' g'p'c'w'g'q'h' l'ug'h' /t'gi' w'v'k'p'lp' r'j' q'v'q' { py'j' g'ke' " rki j v'j' c'tx'g'uk'pi 'c'p'v'p'p'c'0P' c'w'g' 'R'rc'p'u. '4\*7+;\*4238+\*382670'  
[7\_ 'L0'Ej o grkqx. " \*4237+." 'G'z'ek'cv'k'p' g'x'q'w'k'p' c'p'f' 'u'g'h' /t'gi' w'v'k'p' c'd'k'k'f' { 'q'h' r'j' q'v'q' { py'j' g'ke' " rki j v'j' c'tx'g'uk'pi " u' { u'g'o' u. " f' q'ev'q't'c'f' k'ug't'v'k'p. " 'X'k'p'k'u' W'p'k'g't'uk'f' 0'  
[8\_1\_ 0W'o' g'p'c. 'M'0M'c'y' c'nc'o' k' 'L'0T'0'Uj' g'p. '( 'P' 0M'co' k'f'c. 'E't' { u'c'n'f'ut'w'ew'g'q'h' /q'z' { i' g'p' /g'x'q'k'p' 'r'j' q'v'q' u'g'o' 'K'k'c'v'c' 't'g'u'q'w'k'p' 'q'h'30' 'C'0P' c'w'g'. " 695\*9567+;\*4233+\*776820'

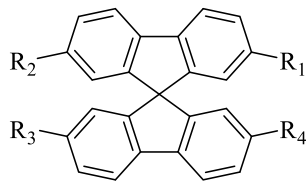
**GPCO KPG/FGTKGF 'URKT QDHNWQT GP GU'CU'J QNG'VT CP URQT VKPI "**  
**O CVGTKCNU'HQT 'RGT QXUMKG'UQNCT'E GGNU"**

F glo cpvg'Xckwnc'v<sup>3</sup>. 'Et knkpc' O qo dmpc<sup>4</sup>. 'Mcur ctu' T cmv' u<sup>3</sup>. 'Crdgt wu' Cf tkcp' Uwcpvq<sup>4</sup>. 'Dkp'  
 F kpi<sup>4</sup>. 'X{ i kpwu' Lcpn'wuncu<sup>5</sup>. 'Cn' vku' I twqf k<sup>5</sup>. 'Vcf cu' O crkpcwuncu<sup>3</sup>. 'Cdf wncj' 'O OCUkt<sup>6</sup>. 'RcwIL0'  
 F { uqp<sup>4</sup>. 'X{ vwu' I gcvwku<sup>3</sup>. 'O qj co o cf' 'Mj clc' P c| ggt w f k p<sup>4</sup>

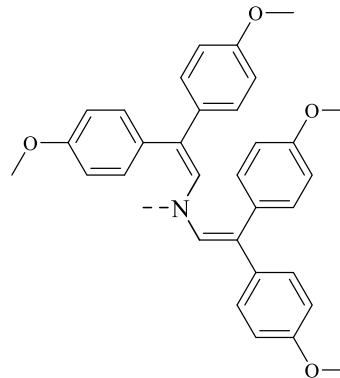
<sup>3</sup>F gr ctvo gpv'qh'Qti cple'Ej go knr { . 'Mwpcu' Wpkxgtuk' { 'qh'Vgej pqm' { . 'Nsj wcpk' "  
<sup>4</sup>'kpukwg'qh'Ej go kcrn'Uelgpegu'cpf' 'Gpi lpggtkpi . ' eqnr'Rqn' vgej pls wg' 'F f<sup>2</sup> tcrn' f g' Ncwucppg. 'Uy k| gtrcpf "  
<sup>5</sup>'kpukwg'qh'Ej go kcrn'Rj { uku. 'Xkrku' Wpkxgtuk' . 'Nsj wcpk' "  
<sup>6</sup>'Egpgt'qh'Gzegmpg' hqt' Cf xcpgef' 'O cvgtkcn' T gugctej . 'Mkpi' 'Cdf wr| k' 'Wpkxgtuk' . 'Ucw' k' C' tcdk' "  
 f glo cpvg'Xckwnc'vB nwn

Rgtqxunkg' uqrrt' egm' \*RUEu' tgs wkt g' j k j "ghlelgepe { "cpf "i qqf "npi / vgt o "ucdkk' "v' cv' o wuv' eqo g' cv' nqy "equu' vq' "  
 cej lxxg' vj g' eqo o gtelcn' xcdk' k' (0Eqwpvki "o qtg' vj cp' 42' { gctu. 'ur ktq/ QO gVCF "pqy "f qo lpcv' u' vj g' hgrf' qh' RUEu' cpf' "ku' "  
 vj g' j] qrg' v' t' cpur qt vki "o cvgtkcn' \*J VO + t' qw' lpgn' "go r nq' { gf' cu' j k j n' "ghlelgepv' t' ght' gpeg' "o cvgtkcn' hqt' vj g' t' gugctej' "lpvgt' gmu' "  
 f gur kg' ku' j k j "r' t' leg' \*472' &#x2122; +] 3\_0Cn' qwi j 'RUEu' j' cxg' t' gegp' v' "cej lxxg' f' egt' v' hgrf' r' qy' et' eqpxgtuk' q' ghlelgepe { "REG+ "  
 gzegf' kpi' 47' . "ppg' o clqt' d' qw' g' pgen' qh' ucdk' k' kpi' vj g' r' g' thqto' cpeg' ku' vj g' n' en' qh' ucdng' J VO u' y' j' lej' "gz' t' cev' r' qukkxg' "  
 ej' cti' gu' l' t' qo' vj g' v' c' v' xg' r' g' t' qxunkg' r' ki' j' v' c' du' q' t' d' g' t' "cpf' v' t' cpuo' k' vj' go' "v' vj' g' g' r' g' ev' t' q' f' g' j' 4\_0'

Kp' vj' ku' y' qtm' hqwt' J VO u' eqp' v' k' p' kpi' "y' gm' gu' c' d' k' u' j' g' f' "ur' k' t' q' d' h' w' q' t' g' p' g' "eqt' g' y' k' j' "k' p' t' q' f' w' e' g' f' "gpco' k' p' g' "cto' u' y' g' t' g' "  
 u' { p' v' j' gu' k' g' f' "d' { "uko' r' n' g' r' "cpf' "u' t' c' k' j' v' h' t' y' c' t' f' "eqp' f' g' p' u' c' v' k' q' p' "t' g' c' v' k' q' p' "v' j' c' v' k' p' "eqp' t' c' t' { "v' q' "ur' k' t' q' / QO g' VCF "f' q' gu' "p' q' v' t' g' s' w' k' t' g' "  
 g' z' r' g' p' u' k' x' g' r' c' m' c' f' k' w' o' 'e' c' v' n' l' u' u' ' c' p' f' "y' c' v' g' t' "ku' vj' g' q' p' n' l' "d' { / r' t' q' f' w' e' v' O' k' p' "c' f' k' k' q' p' . "uko' r' n' g' r' t' q' f' w' e' v' y' q' t' m' w' "c' p' f' "r' w' k' h' e' c' v' k' q' p' "o' c' { "  
 t' g' u' w' v' k' p' "u' k' i' p' k' h' e' c' p' v' l' "t' g' f' w' e' g' f' "u' { p' v' j' g' u' k' i' "equu' 0'



- V1305: R<sub>1</sub> = BDDE, R<sub>2</sub> = R<sub>3</sub> = R<sub>4</sub> = H
- V1306: R<sub>1</sub> = R<sub>3</sub> = BDDE, R<sub>2</sub> = R<sub>4</sub> = H
- V1307: R<sub>1</sub> = R<sub>2</sub> = R<sub>3</sub> = R<sub>4</sub> = BDDE
- V1308: R<sub>1</sub> = R<sub>2</sub> = BDDE, R<sub>3</sub> = R<sub>4</sub> = H



bisdimethoxydiphenylamine (BDDE) "

Hi 030Ut wewt gu' qh' gpco kpg/ dcugf "j qrg' t' cpur qt vki "o cvgtkcn' X3527. X3528. X3529' cpf' X352: 0'

Vq' l' p' x' g' u' k' i' c' v' g' r' j' q' v' g' r' g' e' v' t' k' e' c' n' r' t' q' r' g' t' v' g' u' q' h' u' { p' v' j' g' u' k' i' g' f' "J VO u' j' q' r' g' f' t' k' n' o' q' d' k' r' k' v' " \*U' " c' p' f' " k' p' k' v' k' q' p' r' q' v' g' p' v' c' n' i' \*K' + "  
 y' g' t' g' o' g' c' u' w' t' g' f' O' u' q' r' k' f' / u' v' c' v' g' " k' k' y' c' u' o' g' c' u' w' t' g' f' " w' u' k' p' i' " v' j' g' g' r' e' v' t' q' p' r' j' q' v' g' o' k' u' k' q' p' " k' p' v' j' g' c' k' " \*R' G' U' C' + " v' q' u' w' f' { " v' j' g' J' Q' O' Q' "  
 g' p' g' t' i' { " r' e' x' g' r' i' q' h' u' r' k' t' q' / g' p' c' o' k' p' g' J' VO u' O' k' p' k' v' k' q' p' r' q' v' g' p' v' c' n' i' x' c' n' w' u' q' h' X3527. X3528' vj' c' v' j' c' x' g' q' p' g' c' p' f' " v' y' q' g' p' c' o' k' p' g' c' t' o' u' "  
 t' g' u' r' g' e' v' k' x' g' n' . " v' g' t' c' / u' w' d' u' k' w' w' g' f' " X3529' " c' p' f' " t' c' p' u' / e' q' p' l' k' i' w' e' c' v' g' f' " X352: " y' g' t' g' h' q' w' p' f' " v' q' d' g' " 705. " 7059. " 7068. " c' p' f' " 7068" g' X' "  
 t' g' u' r' g' e' v' k' x' g' n' . " y' j' l' e' j' " k' u' u' k' i' p' k' h' e' c' p' v' l' " u' c' d' k' k' g' f' " e' q' o' r' c' t' k' p' i' " v' q' v' j' c' v' q' h' u' r' k' t' q' / QO g' VCF " \*7022' g' X+ 0' D' c' u' g' f' " q' p' v' j' g' u' q' r' k' f' / u' v' c' v' g' "  
 q' r' v' e' c' n' i' c' r' " c' p' f' " k' k' x' c' n' w' u' q' g' r' e' v' t' q' p' " c' h' i' k' p' k' k' u' y' g' t' g' e' c' r' e' w' r' v' e' g' f' " v' q' d' g' " 4065. " 4075. " 4085. " c' p' f' " 408: " g' X' h' q' t' " X3527. " X3528. " X3529' "  
 c' p' f' " X352: . " t' g' u' r' g' e' v' k' x' g' n' (0K' / k' u' l' o' r' q' t' c' p' v' v' j' c' v' v' j' g' g' r' e' v' t' q' p' " c' h' i' k' p' k' k' u' c' t' g' u' o' c' n' g' t' " e' q' o' r' c' t' k' p' i' " y' k' j' " v' j' g' e' q' p' f' w' e' v' k' q' p' " d' c' p' f' " \*E' D' + "  
 g' p' g' t' i' { " q' h' v' j' g' r' g' t' q' x' u' n' k' g' " \*60B2' g' X+ . " v' j' g' t' g' h' q' t' g' " g' h' e' v' k' x' g' " g' r' e' v' t' q' p' " d' m' e' n' k' p' i' " h' t' q' o' " v' j' g' r' g' t' q' x' u' n' k' g' " v' j' g' g' r' e' v' t' q' f' g' u' j' q' w' f' " d' g' "  
 g' p' u' w' t' g' f' O' Z' g' t' q' i' t' c' r' j' e' " v' o' g' q' h' l' r' k' i' j' v' \*Z' V' Q' H' " v' e' j' p' l' s' w' g' y' c' u' w' u' g' f' " v' q' f' v' g' t' o' k' p' g' v' j' g' e' j' c' t' i' g' o' q' d' k' r' k' v' " q' h' l' p' x' g' u' k' i' c' v' g' f' " J VO u' "  
 n' { g' t' u' O' X352: " c' p' f' " X3529' " g' z' j' k' d' k' g' f' " v' j' g' j' k' j' g' u' v' l' " g' t' q' / h' g' r' f' " U' 2' " c' o' q' p' i' " v' j' g' u' g' t' k' g' u' j' c' x' l' p' i' " v' j' g' x' c' n' w' u' q' h' i' ; 06" " 32' / 6' " c' p' f' " 806" "  
 32' / 6' " e' o' 4' I' X' u' . " t' g' u' r' g' e' v' k' x' g' n' . " d' q' v' j' " q' w' r' g' t' h' q' t' o' k' p' i' " v' j' c' v' q' h' u' r' k' t' q' / QO g' VCF " \*U' 2' ? " 305 " 32' / 6' " e' o' 4' I' X' u' 0'

p/kr' uqrrt' egm' y' g' t' g' h' d' t' e' c' v' g' f' " y' k' j' " v' j' g' f' g' l' e' g' " n' c' { q' w' / H' V' Q' k' e' / V' l' Q' 4' l' o' / V' k' Q' 4' l' U' p' Q' 4' l' r' g' t' q' x' u' n' k' g' l' J' VO I' C' w' v' q' " v' g' u' v' p' q' x' g' n' "  
 o' c' v' g' t' k' c' n' u' c' u' J VO u' O' v' j' g' o' q' u' v' g' h' l' e' g' p' v' f' g' x' l' e' g' u' e' q' p' v' c' l' p' k' p' i' " X3527. X3529' " c' p' f' " X352: " r' t' g' u' g' p' v' g' f' " u' k' o' k' r' c' t' r' q' y' g' t' " e' q' p' x' g' t' u' k' q' p' "  
 g' h' l' e' l' g' e' p' e' { " x' c' n' w' u' q' h' i' ; 02' ; 3; 04' c' p' f' " 3; 05' . " t' g' u' r' g' e' v' k' x' g' n' (0F' c' v' c' p' c' n' l' u' i' e' q' p' h' k' o' u' v' j' g' e' q' t' t' g' r' e' v' k' q' p' " d' g' y' g' g' p' j' q' r' g' f' t' k' n' o' q' d' k' r' k' v' "  
 c' p' f' " f' g' l' e' g' r' g' t' h' q' t' o' c' p' e' g' . " d' g' l' p' i' " o' q' u' v' g' h' l' e' g' p' v' j' g' f' g' l' e' g' u' e' q' p' v' c' l' p' k' p' i' " v' j' g' J VO " y' k' j' " j' k' j' g' t' j' q' r' g' o' q' d' k' r' k' v' " x' c' n' w' u' q' h' n' q' y' k' p' i' "  
 v' j' g' q' t' f' g' t' " X3528 X3527 X352: ? X35290' v' j' k' u' y' q' t' m' l' u' j' q' y' u' v' j' c' v' u' k' o' r' n' g' " g' p' c' o' k' p' g' e' q' p' f' g' p' u' c' v' k' q' p' r' t' q' v' e' q' n' e' q' w' f' " d' g' " w' u' g' f' "  
 c' u' v' p' k' x' g' t' u' c' i' n' r' r' t' q' e' j' " c' e' j' k' x' l' p' i' " J VO u' h' q' t' " j' k' j' n' l' " g' h' l' e' l' g' e' p' v' c' p' f' " u' c' d' n' g' " RUEu' 0'

[3\_ "M0' l' k' p' i' . " H' Y' w' . " I' 0' j' c' p' i' " g' v' c' i' n' l' " G' h' l' e' l' g' p' v' R' g' t' q' x' u' n' k' g' " U' q' r' t' " E' g' m' " D' c' u' g' f' " q' p' " F' q' r' c' p' v' H' g' g' " U' r' k' t' q' QO g' VCF " R' t' e' g' u' g' f' " Y' k' j' " J' c' n' j' g' p' H' g' g' " I' t' e' g' p' "  
 U' q' x' g' p' v' " U' q' r' t' " T' T' N' 5' . " 3; 22283' \*423; 40'

[4\_ "M0' T' c' m' u' v' u' . " O' O' U' c' r' i' d' c' . " R' O' I' c' q' " g' v' c' i' n' l' " J' k' i' j' n' l' " G' h' l' e' l' g' p' v' R' e' t' q' x' u' n' k' g' " U' q' r' t' " E' g' m' " G' o' r' n' q' { k' p' i' " c' p' " G' u' k' i' " C' w' l' e' p' c' d' n' g' " D' i' k' h' w' q' t' g' p' { r' k' f' g' p' g' D' c' u' g' f' " J' q' r' g' "  
 V' t' c' p' u' r' q' t' v' k' i' " O' c' v' g' t' k' c' n' i' " C' p' i' g' y' c' p' f' v' g' E' j' g' o' l' e' " k' p' v' g' t' c' p' v' c' n' i' G' i' k' k' q' p' " 77. " 9686/968: " \*423840'

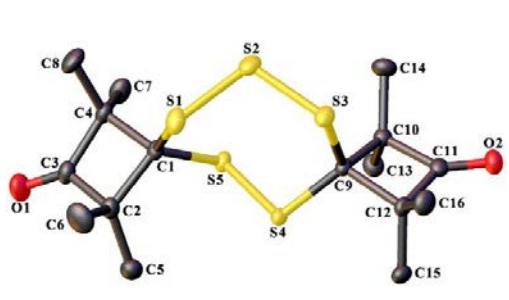
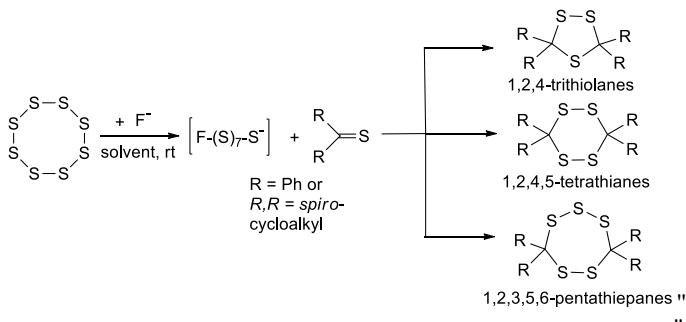
**VJ G'HNWQTĦ G'CPKQP 'E CVCN[ \ GF 'UWNHWTĶ CVKQP'''**  
**QH'VJ KQMGVQP GU'Y KŪJ 'GNGO GP VCN'UWNHWT'''**  
**NGCF ĶPI 'VQ'UWNHWT/TĶEJ 'J GVGTOE[ ENGU'**  
lcmwd'Y t e| {enk<sup>3</sup>. 'I t| gi qt| 'O mquq<sup>4</sup>. 'Mcvt| {pc'Wdcpknt. 'Fctkwu| 'O 0Dlgrk unk<sup>3</sup>

<sup>3</sup>"Ķpukwag'qh'Rqn| o gt'cpf 'F { g'Vgej pqrqi { . 'Ĥcewn| 'qh'Ej go knt { . 'Nqf| 'Wpkxgtuk| 'qh'Vgej pqrqi { . "'  
 34 B8 "Ughcpqy unki q'Utggv. ; 2/; 46. 'Nqf| . 'Rqrpf "

<sup>4</sup>F gr ctvo gpv'qh'Qti cple'cpf 'Crr rkgf 'Ej go knt { . 'Ĥcewn| 'qh'Ej go knt { . 'Wpkxgtuk| 'qh'Nqf| . "'  
 34 "Vco nē'Utggv. ; 3/625. 'Nqf| . 'Rqrpf "  
lcmwd'Y tgel {enk<sup>3</sup> fqm'0 ōqf| ō n'

Vj g'grgo gpcn'uwht'''U. +dcugf "qti cple"u{ pŷj guku"eqpukwgu"cp"kpvtgukpi "cpf "r tcevecm| "tgrgxcpv"vqr le"kp"y'j g' ewtgpv'qti cple"ej go knt { " ]3\_0'Wkkt' cvkqp'qh'uwht' "gzeguu. "o ckn| "o cpwħcewtf "cu"c"ukf g'r tqf wev'qh'y'j g'r gvtqrwo " kpf wnt { 'r tqeguugu. 'hqt' y'j g'r tqf wev'kp'qh'wughw|qti cple"qt' r qn| o gtle "o cvgtkcn'ku'qh'r tko ct { 'kpvtguk'v'uwuc'kp' y'j g'r tqf gt' e { erg'qh'uwht' "eqpxgtukp' ]4\_0'Ķ' qwt' "eqp'v'p'wau'uwf lgu'qp' p'wengr j kte'ectdgp'p' \*P J Eu+tgcevkpu'y' kj "grgo gpcn'uwht' " ctg'clo gf "cv'y'j g'u{ pŷj guku'qh'r tcevecm| "wughw' qp'gpqrk' cdr'ko kf c| qrg/4/y' kqpgu' ]5\_0"

Ķ'ku'y' gni'gucdrkj gf "y'j cv'uwht'k' cvkqp' "tgevekp'v'qh'y'j kqngvqpgu' uwej "cu'ct { n'j' gvt { n'qt' e { emqrk' j' cve' y'j kqngvqpgu' " \*T4E? U'y' kj "y'j g'wag'qh'U. "cwtcew'cwgp'kqp'qh't'gugtej' gtu'ulpeg'uwht'/tlej "j' gvtqe { ergu'ct'g'qh'kpvtguk'v' hqt' "o gf lekpci' ej go knt { . 'kp' hci' tpegu. "ci' tcej go knci' r tqf wev'kp. "gve0]6.7\_0'Ķ' y'j g'r cuv. "xctk'q'w'p'wengr j kte'ur' geku'j' cxg'dggp'crr' rkgf " hqt' y'j g'U. "cev'k'cvk'p'0J' qy' g'xgt. "qp'g'qh'y'j g'w'p'q'v' qf' qz' "crr' r tcej. "r' t'gug'v'gf' "kp' qwt' y' qtm'ku'y'j g'wuci' g'qh'g'cuk| "ceeg'auk'drg' " hwtk'f' g'c'pkqp' 'H' cu'c' l' q'v'p'v'cev'k'c'v'q'qh'grgo gpcn'uwht' " ]8\_0'V'g'p'v'k'x'gn. "y' g'r tqf qug' y'j cv'y'j g't'geve'k'g'uwht'k' lpi' "t'gei' g'pw' " hqto gf "y'j gtgd { "ctg'kp'ukw'i' g'p'g'v'gf. "p'wengr j kte' hwt'qr' qn' uwht'f' g'c'pkqp'u'HU\* : /z+0



Hki 030T lpi "ergxcxi g'qh'y'j g'U. "etqy p'lp' y'j g'r t'gugpeg'" " " " Hki 040Z/Tc { "l'weww'g'qh'cp' "3.4.5/7.8/"  
 qh'hw'qt'k'f' g'c'pkqp'cpf' "hw'y'j g'r t'cv'j y'c { "t'geve'k'p'u'" " " " r g'p'v'j' lgr' cp'g' \*T.T' " "ur' k'q/4.4.6.6/"  
 qh'y'j g'i' g'p'g'v'gf' "hw'qt'qr' qn' uwht'f' g'c'pkqp'u'y' kj "y'j kqngvqpgu' h'gcf' lpi' " " " vgtco' g'y' { rē { enq'dw'c'p'p'g' "

Ķ'qwt' qpi' qkpi' "t'gugtej. "y' g' "h'q'w'p'f' "y'j cv'y'j g'lp'ukw'i' g'p'g'v'gf' "hw'qt'qr' qn' uwht'f' g'c'pkqp'u'cev'cu' r' qy' g'hw'uwht'k' lpi' " t'gei' g'pw'q'h'e { emqrk' j' cve' l'p'f' "ug'ge'v'gf' "ct'qo' cve' y'j kqngvqpgu' h'gcf' lpi' "v' l'k'x'g't'ug'uwht'/tlej "j' gvtqe { ergu' \*Hki 030' O' q'g'x'g't. " f' gr' g'p'f' lpi' "qp' y'j g'o' q'nt' "t'cv'k' qh'y'j g'uw'c'k'p'i "o' cvgtkcn' "Ķ'0' y'j kqngvqpgu' ]U\_+ "h'qto' cvkqp'qh'uwht'/tlej "j' gvtqe { ergu' y' kj " xct'k'drg' t'kpi' "uk' g'y' cu'q'dugt'x'gf' 0C' p'q'x'gn' w'p'k' w'g'cpf' "g'h'le'k'p'v'o' g'y' qf' "hqt' y'j g'U' t'c'p'uh't' "v' y'j g'E' ? U'd'q'p'f' "x'k'cev'k'cvk'p'qh' U' "y' kj "hw'qt'k'f' g'c'pkqp'cu' y' g'ni'cu'o' g'ej' c'p'k'uo' u'qh'y'j g' h'qto' cvkqp'qh'uwht' "tlej /j' gvtqe { ergu' "l'pen'f' lpi' "f' kj' k't'c'p'g'u' g'z'k'uk'p'i' " l'p'c'p'g's' w'k'k'd't'k'wo' "y' kj' "y'j g't'k'p'i' /qr' g'p'gf' "ku'qo' g'tle' "ur' geku' \*f' k'c'f' k'c'n'l' y' k'w'g't'k'p'u'+cu'c' h'g { "kp'v'to' gf' k'c'v'g'u' y' k'n'i'd'g'f' k'ue'w'ug'f' 0

**Cempqy rfi i go gpv'<** Cwj qtu' cempqy rfi i g' "h'p'c'p'ek'n' uwr' r'qt'v' d { " y'j g'P' cvk'q'p'c'n' E'g'p'v'g' hqt' "T'gugtej' "cpf' "F' g'x'g'nr' o' g'p'v' \*Y' ctucy. "R'qr'p'f' +y' kj' l'p' y'j g'i' t'c'p'v' Ķ'v'g't' E'j go O' gf' \*Y' P'F' /R'Q'Y' T'0'5'0'4'0'2' /22' /R'24; B'38' /23+0'1' O' "cpf' "M'W' cempqy rfi i g' r' ct'w'c'n' uwr' r'qt'v' d { " y'j g'P' cvk'q'p'c'n' U'ek'p'eg' E'g'p'v'g' \*E' t'c'eqy' +y' kj' l'p' y'j g'I' t'c'p'v' D'g'g'j' q'x'g'p' /4' \*%4'238'4'5' II' IUV7'126337' h'nt'

[3] VODOP i w'gp. "T'ge'p'v'cf' x'c'p'egu'kp' q'ti' c'p'le' t'g'c'v'k'p'u' l'p'x'q'k'k'p'i' "grgo' g'p'c'n'uwht'. "C'f' x'c'p'eg'f' "U' { p'ŷj' guku' ( 'E'c'v'c'n' uku'57; '328863352' \*4239+0)  
 [4] Y' 010Ej' w'p'i. "L'0'0'1' t'lg'd'gn' "G'0'V'0'M'0' "g'v'c'n'0'V'j' g'w'ag'qh'grgo' g'p'c'n'uwht' "cu'c'p' c'n'g't'p'c'v'k'g' h'g'g'f' u'q'en' h'qt' r' qn| o' g'tle' "o' cvgtkcn'. "P' c'w't'g' E'j go knt { "7. " 73: 6746' \*4235+0"  
 [5] 'I' 0'0' m'quq. "O' 0'E'g'rg'f'c. "Y' 0'R'qr' g't. "O' 0'M'q'y' c'n'el' { m' 'M'0'1' c'ej' /l'c'p'el' c'm' 'C'0' l'ep'g'ene. "O' 0' l'c'uk' unk' "U' { p'ŷj' guku. "ug'ge'v'gf' "t'c'p'uh't'o' cvk'q'p'u' "cpf' "d'k'q'ni' k'ec'n' c'ev'k'k'f' "qh'c'm'q'z' { "c'p'c'ni' w'g'u' q'h' h'gr' k'f' k'ip'g'u' "C' "cpf' "E' 0'0' c'v'g't'k'c'n' 35. 'b'63; 2. \*4242+0'  
 [6] "T'0'J' w'ku' g'p. "l'0' T'err. "V'j' g' "eq'p'x'g't'uk'p' qh'y'j kqngvqpgu' v'q' "3.4.6.7/ v'g'v'c'j' k'c'p'g'u' "c'p'f' "ku'o' g'ej' c'p'k'uo. "J' gvtqe { ergu' 67. '729' /747' \*3; ; 9+ "  
 [7] "T'0'J' w'ku' g'p. "l'0' T'err. "L' J' 0'J' w'd'gt. "U'w'ht'k'f' cvk'q'p' qh'y'j kqpgu' <4.4.6.6/ v'g'tco' g'y' { n'5/ y'j' k'z'q'c' { enq'dw'c'p'p'g. "N'gd'k' u' "C'p'p'c'rg'p' II' g'ew'g'n' 9. "373963745" \*3; ; 9+0'  
 [8] XOC'0' R'g't'q'x. "Y' 0'0' ct'uj' c'm' "T'go' c'tn'd'rg' "g'h'g'ev'q'h'i' o' g'v'n' h'w'qt'k'f' g'c'v'c'n'f' u'v'q'p' t'g'c'v'k'p' qh'y'j g'z' c'h'w'qt'qr' t'qr' g'p'g. "uw'ht' "c'p'f' "x'lp' { n'g'y' g'tu' 0'Eq'p'x'g'p'k'p'v' u' { p'ŷj' guku' qh' "4.4/ d'k'r' \*t' h'w'qt'q'o' g'y' { n'6/ T/ y'j' k'c'v'c'p'g'u. "5.5/ d'k'r' \*t' h'w'qt'q'o' g'y' { n'7/ T/ 3.4/ f' k'j' k'q'c'p'g'u' "c'p'f' "4.4/ d'k'r' \*t' h'w'qt'q'o' g'y' { n'6/ T/ 3.5/ f' k'j' k'q'c'p'g'u' 0' l'q'w'p'c'n' qh' h'w'qt'k'p'g' E'j go knt { "353. '336663377' \*4232+0'

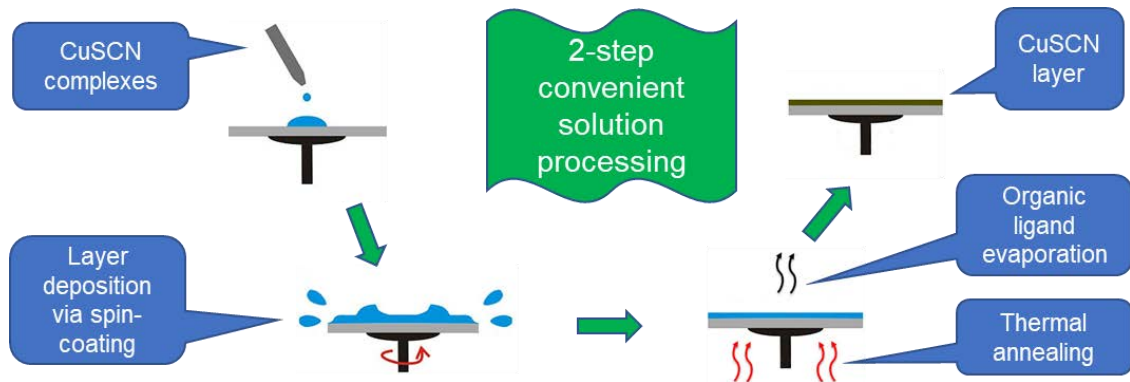
# U P V J G U K ' C P F ' K G U V K C V K Q P ' Q H ' Q T I C P Q O G V C N N K E ' R T G E W T U Q T U ' H Q T ' E Q P X G P K G P V ' E Q R R G T ' \* K ' V J K Q E [ C P C V G ' N C [ G T ' F G R Q U K V K Q P ' ' O c p v e u ' O c t k p u n e u . ' V c f c u ' O c r i k p c w u n e u "

Heewm{ "qh'Ej go lecnVgej pqmji { . 'Mwpcu'Wpkxgtukf{ "qh'Vgej pqmji { . 'Nkj wcpk' " o c p v e u o c t e k p u n e u B n w Q f w "

Qxgt 'vj g'ruv'f gecf g'r gtqxunkg'uqnt'egmu'RUEu+tgegkxgf 'rti g'co qwpv'qh'cwgpvkqp'rtqo 'uelgpkvu'cpf 'vj g'ghhelepe{ " qh'vj gug'f gxlegu'y cu'kpetgcugf "wr'vq'470" "j3\_0E qpugs wgpv{ . 'RUE'dgeco g'ppg'qh'vj g'o quv'r tqo kulpi 'hmwtg'r j qvqxncle" vgej pqmji kguOC'v'j ku'o qo gpv'rti g'ghqtv'ku'dgkpi 'o cf g'vqy ctf u'e'qo o gteknk'c'vkqp .d{ 'ko r tqxkpi 'vj g'rti /v'gto 'uvcdkks{ 'cpf " kpf kpi 'vj g'dcncpeg'dgy ggp'vj g'f gxleg'r gthqto cpeg'cpf 'q'xgtcm'o cpw'cewtkpi 'equuONcti g'r ctv'qh'e'quv'ghge'v'x'g'p'gu'lp'RUE" tgrku'qp'vj g'e'j cti g't'cpur qtvkpi 'o cvgtkcu.'vj g'tghqtg.'o cp{ 't'gugctej gtu'j cxg'hwewgf 'vj g't'cwgpvkqp'qp'f g'xgnr o gpv'qh'qr 'ko cni' j qng'v'cpur qtvkpi 'o cvgtkcu' \*j VO u+0"

k'p'qti cple'ugo leqpf vewqtu.'uwej "cu'v'cpukkp"o gvcn'q'z'k'f'gu.'eqr r g't'qt'plengr'f g't'k'v'k'x'g'u'q'h'gt'dgp'g'h'ekcni'r j { u'lecn'cpf " ej go lecn'r tqr g'v'guOC o qpi 'vj go . 'eqr r g't' \*K' 'vj k'e { c'p'v'g' \*E'w'UEP + 'e'c'p' 'd'g' 'j k i j v'g'f 'cu' 'p'p'g' 'q'h' 'v'j g' 'o' q'v' 'r' 't'q'o' k'ul'p'i ' 'J' 'V'O' u.' " d'g'ec'w'ug' 'q'h' 'k'u' 'h'q'y /e'quv.'rti g'd'c'p'f i c'r \*C'07'g'X+.'qr v'lecn'v'c'p'ur c't'g'p'e { 'c'p'f 't'g'r'v'k'x'g'n{ 'j k i j " j qng' 'o' q'd'k'k's{ ' \*w' 'v'q' '2'0' 'e'o '4X' /3'u'3-40 Hwt'v'j g'to q'tg. 'E'w'UEP "ku' 'u'q'n'w'k'q'p' 'r' t'q'eg'u'c'd'ng' 'c'p'f 'ku' 'r'c' { g't' 'e'c'p' 'd'g' 'f' g'r' q'u'k'x'g'f 'g'x'g'p' 'c'v' 'n'q'y ' 'x'g'o' r' g't'c'w't'g'u' 'V'j' g'ug' 'd'g'p'g'h'k'u' 'o' c'ng' " E'w'UEP "r' g't'ur' g'e'v'x'g' 'u'go' l'e'q'p'f' v'e'w'q't' "h'q't' 'c'r' r' n'ec'v'k'q'p' "p'q'v' 'q'n'f' "h'q't' "RUEu."dw'c'm'q' 'k'p' 'q'v'j' g't' 'q'r' v'q'g'r'g'e'v' 't'p'leu."g'f' '0'q'ti' c'p'le' "r'i' j' v' go k'w'k'p'i 'f' k'q'f' g'u' 'q't' 'E'f' 'V'g' 'u'q'n't' 'e'g'm'u' 'J' q'y' g'x'g't. 'E'w'UEP 'ku' 'l'p' 'u'q'n'w'k'q'p' 'o' q'u'v'q'h'y' k'f' g'n'f' 'w'ug'f' 'u'q'n'k'g'p'u.'vj g't'g'h'q't'g' 'e'w't'g'p'v' 'E'w'UEP " u'q'n'w'k'q'p' 'r' t'q'eg'u'k'p'i 'v'g'e'j' p'q'm'j' k'g'u' 'c't'g' 'h'o' k'g'f' 'v'q' 'q'n'f' 'c' 'h'y' 'u'q'n'k'g'p'u.'uwej 'cu' 'c'o' o' q'p'k' 'u'q'n'w'k'q'p' 'q't' 'f' k'g'y' { n' 'l'w'k'f' g' \*F' G'U' '0' 'D'q'j' " q'h' 'v'j' g'o' "e'c'p' 'f' 'c'o' c'i' g'r' g't'q'x'unk'g' 'r'c' { g't. "c'f' 'f' k'l'q'p'e'm' { "F' G'U'j' cu' 'u't'q'p'i 'g'o' g'v'k' 'g'h'g'ev.'u'q' 'ku' 'g'n'k'o' k'p'c'v'k'q'p' 'y' q'w'f' 'd'g' 'c'f' 'x'c'p'c'i' g'q'w'u." g'ur' g'e'k'm'f' 'k'p' 'r'c'ti' g't' 'u'ec'ng' 'c'r' r' n'ec'v'k'q'p' "j4/6\_0"

k'p' 'v'j' k'u' 't'g'ug'c'tej . "c' 'u'g't'k'g'u' 'q'h' 'f' k'h'g't'g'p'v' 'q'ti' c'p'q'o' g'v'c'n'k'e' "e'q'o' r' n'g'z'g'u' 'y' g't'g' 'u'f' 'p'v'j' g'uk' 'g'f' "cu' 'E'w'UEP "r' t'g'ew't'q'u't'u' 'v'q' 'k'o' r' t'q'x'g' 'k'u' " f'g'r' q'uk'k'q'p' "r' t'q'eg'f' v'g' '0' 'C' m' 'u'f' 'p'v'j' g'uk' 'g'f' "e'q'o' r' q'w'p'f' u' 'y' g't'g' 'q'd'v'k'p'g'f' "k'p' 'q'p'g' 'u'v'g'r' 'u'f' 'p'v'j' g'uk'u." r' w'k'h'k'g'f' "d' { 's' w'len' 'c'p'f' "k'p'g'z'r' g'p'uk'x'g' " o' g'y' q'f' u' 'c'p'f' "o' q'u'v' 'q'h' 'v'j' g'o' "c't'g' 'e'j' c't'ce'v'g't'k' 'g'f' "d' { 't'g'r'v'k'x'g'n' "n'q'y' "v'j' g't'o' c'n'f' 'g'eq'o' r' q'uk'k'q'p' "v'g'o' r' g't'c'w't'g'u' 'V'j' g'ug' "r' t'g'ew't'q'u't'u' 'v'j' g't'o' c'm'f' "f' g'eq'o' r' q'ug' 'v'q' 'h'q't'o' "E'w'UEP "c'p'f' "x'q'r'v'k'q'p' 'q'ti' c'p'le' "d' { r' t'q'f' v'ew'u' 'y' j' l'e'j' "g'x'c'r' q't'c'v'g'f' w'k'p'i 'v'j' g' 'r'c' { g't' "h'q't'o' c'v'k'q'p' 'u'v'g'r' ."cu' 'j' q'y' p' 'k'p' 'U'ej' g'o' g'30"



Uej go g'30Vj g'hqto c'vkqp'qh'E'w'UEP 'r'c' { g't' 'd' { 'ur' k'p' /e'q'c'v'k'p'i 'c'p'f' 'j' g'e'v'k'p'i "

Ncti g'r ctv'qh'u{p'v'j g'uk' g'f "E'w'UEP "e'q'o' r' n'g'z'g'u.'k'p'x'g'v'k'i'c'v'g'f "k'p' 'v'j' k'u' 'y' q't'm' 'c't'g' 'u'q'n'w'k'q'p' 'k'p' "f' k'o' g'y' { n' 'u'w'h'q'z'k'f' g' .y' j' l'e'j' "k'u' 'e'q'p'uk'f' g't'g'f' "cu' 'c' "i' t'g'g'p' 'u'q'n'k'g'p'v' 'c'p'f' "e'c'p' 'd'g' 'w'ug'f' "cu' 'c' "t'g'r' n'ego' g'p'v' 'h'q't' "F' G'U' '0' q't'g'q'x'g't. "u'g'x'g't'c'n'r' t'g'ew't'q'u't'u'j' c'x'g'f' g'o' q'p'unt'c'v'g'f' " u'q'n'w'k'k'k'f' 'k'p' 'q'v'j' g't' 'q'ti' c'p'le' 'u'q'n'k'g'p'v' 'u'w'ej' "cu' 'e'j' n'q't'q'h'q't'o' "c'p'f' 'v'g'w'c'j' { f' t'q'h'w'c'p. "j' g'p'eg' 'v'j' g't' 'w'uc'd'k'k'k'f' "e'c'p' 'd'g' 'g'z'r' c'p'f' g'f' "v'q' 'x'c't'k'q'w'u' " RUEu'c'tej' k'g'ew't'g'u.'cu' 'y' g'n'ic'u' 'q'v'j' g't' 'q'r' v'q'g'r'g'e'v' 't'p'leu'0"

[3]\_P TGN'uqnt'egmu'ghhelepe { 'e'j' c't'v'j' [vr'u-dly'y' \(ptgrf\)qx'lx'lcu'g'v'ur'f' h'ld'g'v't'g'ug'c'tej /e'gm'ghhelepe'k'g'u'24223260'f'f' "](#)  
 [4]\_P OTORcw'gn' ' '0'1' cp'0Cr r n'ec'v'k'q'p' 'q'h' 'e'q'r' r' g't' 'v'j' k'q'e { c'p'c'v'g' 'h'q't' 'j' k i j ' 'q'r' g'p' e'k't'w'k' 'x'q'n'c'i' g'u' 'q'h' 'E'f' 'V'g' 'u'q'n't' 'e'g'm'u' '0' 'R't'q'i' t'g'u' 'k'p' 'R'j' q'v'q'x'q'n'c'leu'46' \*3+; / 6/3230"   
 [5]\_P OY k'g'f' c'uk'p'i' j' g.'VOC'p'y' q'r' q'w'q'u'0'E'q'r' r' g't' \*K' 'v'j' k'q'e { c'p'c'v'g' \*E'w'UEP + 'c'c' 'j' q'r'g' 'v'c'p'ur' q't'v'o' c'v'g't'k'c'ni' 'h'q't' 'r'c'ti' g'c't'g'c' 'q'r' v'q'g'r'g'e'v' 't'p'leu'0'U'go' l'e'q'p'f' '0'U'e'k'0'V'g'e'j' p'q'f'0' 52."3262240"   
 [6]\_P OY k'g'f' c'uk'p'i' j' g.'C'0T'g'i' q'w'i' "g'0'c'n'0'E'q'r' r' g't' \*K' 'v'j' k'q'e { c'p'c'v'g' \*E'w'UEP + 'J' q'ng' /v'c'p'ur' q't'v' 'N'e' { g't'u' 'R't'q'eg'ung'f' "h'q't'o' "C's' w'g'q'w'u' 'R't'g'ew't'q'u't' 'U'q'n'w'k'q'p'u' 'c'p'f' "V'j' g't' " C'r' r' n'ec'v'k'q'p' 'k'p' 'v'j' k'p' /h'k'o' 'v'c'p'uk'q'q'u't'u' 'c'p'f' 'J' k i j n' { G'h'hele'p'v' 'Q'ti' c'p'le' 'c'p'f' 'Q'ti' c'p'q'o' g'v'c'n'J' c'r'k'f' g' 'R'g't'q'x'unk'g' 'U'q'n't' 'E'g'm'u' '0' 'c'f' 'x'0' 'H'p'ew'0' 'C'v'g't' 04239."3923: 3: 0"

# J K J /GPVTQR[ 'CNNQ[ U'CU'ECVCN[ UVU'HQT'UGNGE VKGI N[ EGTQN'' QZKF CVKQP'''

Kxc'Ci pg'Egej cpcxlekwg<sup>3</sup>. "Y qrih cpi "Uej wj o cpp<sup>4</sup>"

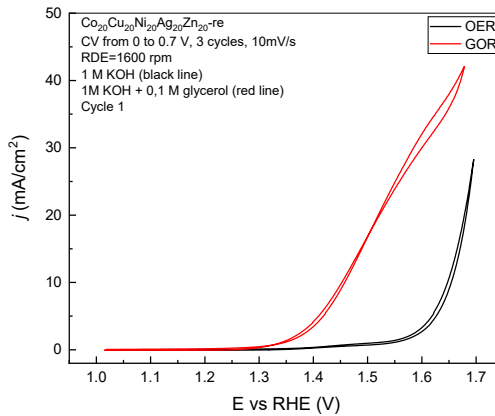
<sup>3</sup>Hcewm\ "qh'Ej go knt { "cpf "I gquekpegu. "Xkpkwu" Wpkxgtuk\ . "P cwi ctf wnt\ ut046. "Xkpkwu. "Nkj wcpk" "  
<sup>4</sup>"Cpcn\ vceh'Ej go knt { ô Egpvt\ hqt\ Grgextqej go lecn\ Uekpegu\*EGU: "Hcewm\ "qh'Ej go knt { "cpf "Dqej go knt { . "Tvj t" "  
Wpkxgtuk\ "Dqej wo . "Wpkxgtuk\@uutcuug"372. "669: 2"Dqej wo . "I gto cp { "  
lxccci pgB i o cktqo "

J { f tqi gp"u{pjv guku'yj tqwi j "y cvgt "grgextqf uku"ku"utqpi n\ "rko kqf "d { "y g" j ki j "qxtgr qvqpcnu"cuuqekvqf "y kj "y g" cpqf le"qz { i gp"gxqmwkqp"tgcevkqp" \*QGT +0Qpg'qh'yj g'cngt pcvkxgu"eqwaf "dg'tgr melpi "qz { i gp"gxqmwkqp"y kj "y g"qz kf cvkqp" qh"o qtg"tqcf kn\ "qz kf k gf "ur gelgu"knq"creqj qnu"j3\_0Vj tqwi j "tgegp" { gctu"lpetgcugf "r tqf wexqp"qh'dkqf kgugn'qh'y j lej " i n\ egtqnl'vj g'o clp'd { r tqf wev\*32'y v +lpetgcugf "i n\ egtqnl'cxckcdkrlk\ "cpf "o cf g'k'c't g'hevev'cpf kf cvg'hqt "y g'cngt pcvkxg" cpqf g'tgcevkqpu"vq'xcnwq/cf f gf "r tqf wevu"j4\_0"

J ki j /gpvtqr { "cmq { u"\*J GCu+"ctg"cmq { u'yj cv'ctg'hqto gf "d { "o kzkpi "eqo r ctcv'xgn\ "rti g'qt" gxgp"gs wcnr\ tqr qt vqpu'qh" wuwcn\ "h'xg"grgo gpv0F wg"vq"y j g'o wncvqo le"eqo r qukkqp" c"wpks wg"cmq { "ut wewt g. "y kj "xctkqwu"cevkxg"dkpf kpi "ukgu"cpf " ko r tqxgf "ecvnl\ vceh'r tqr gtvku"ecp"dg"cej lqxf "j5\_0Hqt"y ku'tgugtej "J GCu'y gtg"qdvkpgf "wulpi "egtquqndcugf "ur tc { kpi " u{pjv guku'tqwg"cpf "rko kqf "vq"o czko wo "qh'y q'pqdrg"o gcnu'lp"y j g'ut wewt g0Vq h'kp"y j g'dguv\ GC hqt "i n\ egtqnl'qz kf cvkqp" dqj "grgo gpv'neqo r qukkqp"cpf "grgo gpv'ncv'kq"lp"y j g'cmq { "y gtg"xctkqf "eqpukngpv"0"

J GC"uwkcdkrlk\ "hqt"i n\ egtqnl'grgextqz kf cvkqp"y cu"htuw\ "lpxguki cvqf "d { "gxcnw'v'kpi "ku"ecvnl\ vceh'r'cevkxk\ "0'k'y cu" f qpg'd { "r gthqto kpi "r qvqpcn'le { erkpi "dgw ggp"2'cpf "20'X. "32'o X lu. hqt "5'e { ergu'lp"3'O "MQJ "cpf "20'O "i n\ egtqnl'qz kf cvkqp" kp"3'O "MQJ "0Hqt"grgextqej go lecn'o gcuwtgo gpv. "c"y j tgg/grgextqf g"u'vgo "y j gtg"y j g'y qtnkpi "grgextqf g'y cu"o qf k'kqf " y kj "ecvnl\ u"uwur gpukqp"y cu" wugf "0'k"r vtg"grgextqnl\ vq"uqmwkqp. "qz { i gp"gxqmwkqp"tgcevkqp"y cu"o qpkqtf "cpf "r vq" eqo r ctf "vq"y j g'creqj qn'qz kf cvkqp"tgcevkqp"qewt tkpi "kp"y j g"i n\ egtqnl'qz kf cvkqp" d { "eqo r ctkpi "y j g"ewt gpv'f gpuk\ "cpf " qxtgr qvqpcn'xcnwq" \*Hki "03+0Vj ku'y c { "qxtg"62"ecvnl\ u"y j gtg"u'ecppgf "cpf "y j g't "ecvnl\ vceh'r'cevkxk\ "cuugugf "0"

Ecvn\ u"y j cv'f go qpvtcvqf "uw'helekpvn\ "j ki j "ewt gpv'f gpukku"cpf "uw'kcdrg"qxtgr qvqpcn'xcnwq"y j gtg"hw'v'j gt" wugf "vq" lpxguki cvqf "y j g't "ugr'ev'xk\ "hqt"i n\ egtqnl'qz kf cvkqp"0Vj ku'y cu" f qpg" wulpi "c"emugf "u'vgo "h'qy /y j tqwi j "egm'y j gtg"i n\ egtqnl\ cpf "3'O "MQJ "uqmwkqpu"y j gtg" wugf "hqt"y j g'ekew'v'kq"lp"o qf k'kqf "y kj "ecvnl\ u"y j qtnkpi "grgextqf g"cpf "eqwvgt"grgextqf g" eqo r cto gpv" uko wncpgqwu\ "0'Eqo r cto gpv" y gtg" ugr ctcv'f " wulpi " kq/gzej cpi g" o go dtcpg0' Uco r rgu" qh' qz kf k gf " i n\ egtqnl'qz kf cvkqp"y j gtg"vengp"cv'kz gf "vko g'lpv'x'cnu"y j tqwi j "y j g'vko g'ur cp"qh'6: "j "cpf "cpn\ | gf "wulpi "j ki j "r gthqto cpeg" rks w'f "ej tqo cvqj tcrj { " \*J RNE+0"



Hki 030Grgextqej go lecn'o gcuwtgo gpv'wulpi "Eq42Ew42P k42Ci 42\ p42"ecvnl\ u"v"

O wnk'rg'ugr'ev'xk\ "o gcuwtgo gpv'tgxcn'f "y j cv'v'j g'o clp'r tqf wevu'qhi n\ egtqnl'qz kf cvkqp"y j gtg'heve. "qzcnle. "ctvtqple. " hqto le. "cegvle. "i n\ eqrle"cpf "i n\ egtle"cekf u'0Vj g'lp'hw'p'eg'qh'f k'kqf gpv'grgo gpv'cpf "y j g't "cv'kq"vq"y j g'ugr'ev'xk\ "y j gtg"cmq" gxcnw'v'f "0'k'y cu"p'qygf "y j cv'xct { kpi "y j g'eqo r qukkqp"qh"J GCu"o c { "r'gcf "vq"o"j ki j gt "ugr'ev'xk\ "vqy ctf u'r c't v'w'w'c't r tqf wev" hqto cvkqp"0Vj ku"r'gcf u"o"r tqo kulpi "y c { "hqt"hw'w'g'tgugtej "y j gtg"eqp'xgtukqp"qh'egt'v'kq"o qrgew'gu"ecp"dg"gcukn\ "uj k'kqf" vqy ctf u"o"t gukt'cdrg'f k'g'ev'kqp"d { "gcug"o cplr w'v'kqp"qh"J GCu"

13\_ " O 0C0'Nklg" F w"l' 0Uwp. "D0l qw"J { dtk "y cvgt "grgextqf uku"tgr melpi "qz { i gp"gxqmwkqp"tgcevkqp" hqt "gpvti { /gh'helekp'v'j { f tqi gp"r tqf wev'kqp"cpf " dg { qpf. "O cvgtkcn\ Tgr qtuw" Gpgti { "322226" \*4242+0"  
14\_ " O 0T00 qp'v'kq. "EONOMwi gno g'g't. "T0UOR'p'j g'k'q. "g'v'c'f0' n\ egtqnl'qz kf cvkqp" d'kqf kgugn'r tqf wev'kqp"v'gej p'q'q'j lecn'r cvj u'hqt "uw'v'k'p'cd'k'rlk\ "T'gpgy c'ndg" cpf "Uw'v'k'p'cd'g'Gpgti { "T'g'x'k'y u. " : "32; /344" \*423: -0"  
15\_ " F'k'q. "J "0'U'cp'q'f q'p'q. "NLO"V'cpi. "\ 0'gv'c'f0'N'q'c'c'f'U'w'v'w'g'u'q'h"J ki j /G'p't'q'r { "C'mq { u"\*J GCu+"q" C'q'o le "U'c'ng'u" C'p" Q'x'g't'k'g'y. "89. "454364547" \*4237+ "



**CP'GHHKCPV'J GVGTOI GPQWU'ECTDQP/DCUGF 'RJ QVQECVCN[ UV'  
HQT'UGNGE VKXG'UWNHGF G'QZKF CVKQP 'VQ'UWNHQZKF GU'**

Cwi wukpc'Lq| grk pckv<sup>3</sup>. 'Gf xkpcu'Qtgpvcu<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Qti cple'Ej go knt{. 'Xkpkwu'Wpkxgtukv{. 'Nkj wcpkc"  
cwi wukpc'Qq| grkwpckvgB ej i hkw0n"

"

Qz kf cvkqp"qh'uwhkf gu'r r{ u'c"uki p hkecpv'tqng"lp"pwo gtqwu'hgrf u'uwej "cu"y cwyg cvgt"tgcvo gpv."ej go lecn'y cthctg"  
ci gpv'f kur qucn'hquukihwgn'f guwhwt k cvkqp"cpf "r tgr ctcvkqp"qh'xctkqwu'r j cto cegwlecnu0Vj gtghqtg."vj g'tgo gpf qwu'ghhqtv"  
j cu'dggp"o cf g'vq'f gxgnr "ej go qugrgevxg'tcpuhqto cvkqp"qh'uwhkf gu'vq'uwhqz kf gu'0O quv'eqo o qp'u{pvj gvk"cr r tqcej gu"  
tgn{"gkj gt"qp"j c| ctf qwu'qz kf k lpi "ci gpv'rnng"r gtqz kf gu'cpf "j { r gt xcrpv'kqf kpg'tgci gpw."tgs wkt g'gzi gpukxg"cpf "vqz le"  
vcpukxqp"o gvcn'cu"ecvn{usu"qt" r j qvugpukx gt u"uwej "cu" Tque" Dgpi cn" Gqukp" [ . " Dqf kr { . " gve0 P gxtg vj grguu." r qqt"  
ej go qugrgevxkx{ "cpf "ny "ecvn{vke'cevxkx{ "ukni'ko k'vj gkt"r tqur gevkg"cr r rkecvkqp"j3\_0

Xkudng/rki j v'o gf kvgf "o gvcn'ht gg"j gvgtoi gpqwu'ecvn{usu"j cxg'dggp"gzvpuvxgn{ "r vtuwgf "lp"j qr gu'qh'gpcdtkpi "o qtg"  
ghhkegpv'cpf "gpv'kqpo gpvcn{"uwvckpcdng"ej go lecn'vcpuhqto cvkqp0J gpeg."y g'r tqur qug"wpof hkegf "hwngt gpg"uqv'cpf "  
hwngt gpg" E82" pcpqf kur gtukqp" cu" c" ny /equv" j gvgtoi gpqwu" r j qvqecvn{usu" hqt" ej go qugrgevxg" uwhkf gu" qz kf cvkqp" vq"  
uwhqz kf gu"lp"gvj cpqn'y kj qw'hwv'j gt "qxtgqz kf cvkqp"vq'uwhqz gu'0Ukpeg"E82"ku'y gm'npqy p"i qqf "grgevtqp"ceegr vqt"cpf "ku"  
gcukn{"gzekgf "d{ "dnwg"rki j v."vj g'r j qvqz kf cvkqp"ecp"vng'r rneg"d{ "y q'f k hgtgpv'o gej cpluo u"<gkj gt"d{ "gzekgf "E82"ucvq"  
i gpgt cvkpi "ukpi rnv'qz { i gp"qt"d{ "cp"grgevtqp/vcpuhgt"o gej cpluo "go r ny { lpi "vkr rnv'qz { i gp0

Vj g'hwngt gpg"uqv'r quuguu"vj g"j wi g'cf xcpvci g"co qpi uv'qvj gt "tgwudng"ecvn{ uv'dgecvug"kw'ecp"dg"gcukn{ "tgeqxgtgf"  
d{ "uko r ng" hnt cvkqp"cpf "tgwugf "o cp{ "vko gu'y kj qw'nyukpi "ku"kv'kpkule"r tqur gt vku'0Cf f kkpvcn{. "k" f qgu'pqv'tgs wkt g"cp{ "  
o qf hkecvkqp"qt"ecvn{ uv'ko o qdtkk{ cvkqp"qpvq"j gvgtoi gpqwu'uvr r qt u'uwej "cu"t gulpu"qt" kpuqndng'r qn{ o gtu."k'ku'cxckcdng"  
htqo "o vnk r ng'uvr r rktu'cpf "ku'xgt { "ej gcr 0'k"cf f kkp. "rcti gt "uecng"tgcevkqpu'y gtg'ectt kfg "qwu'kp"gzegmrv{ kgrf u'wukpi "c"  
hny "tgecvq"y kj "c"pqp/ko o qdtkk{ gf "j gvgtoi gpqwu'hwngt gpg"uqv'0

Vj g'y kf gt "cr r rkecdkx{ "qh'hwngt gpg"pcp qf kur gtukqp"cu"j gvgtoi gpqwu" r j qvqecvn{ uv'y cu'uweeguuhwn{ "f go qpvt cvgf "  
kp'tcf lecn{er{ er{ cvkqp."dqtpke'cek "qz kf cvkqp"cpf "ko kpg'hqto cvkqp"tgcevkqpu"j4\_0

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[3\_ 'F0[ 0\ j gpi. "G0Z0Ej gp."E0T0[ g."Z0E0J wcpj. "J ki j /ghhkepe{ "r j qvq/qz kf cvkqp"qh'v'j kqgv'gtu'qxgt"E82B REP/444"wpf gt"ck."L0O cvgt0Ej go 0'  
C."9."442: 6/442; 3"423; #0

[4\_ 'C0q| grkwpckg."F0Xcrgencu."G0Q'gpcu."Hwngt gpg"uqv'cpf "c" hwngt gpg"pcp qf kur gtukqp"cu"tge{ encdng"j gvgtoi gpqwu'qh/v'j g/uj grh'r j qvqecvn{usu."  
TUE"Cf x."33."6326/6333"4243-0

"

**IP XGUVK CVKQP 'QH'KPKCN'I TQY VJ 'T'CVG'QH'F KNGEVT KECN'  
VJ K'HKNO U'F GRQVKGF 'D[ 'CVQO KEC'NC[ GT'F GRQVKQP "**

O cpwu'F tc| f {u<sup>3</sup>. 'F ctklc'Cu'c'wun{v<sup>3</sup>. 'Tco wku'F tc| f {u<sup>3</sup>"

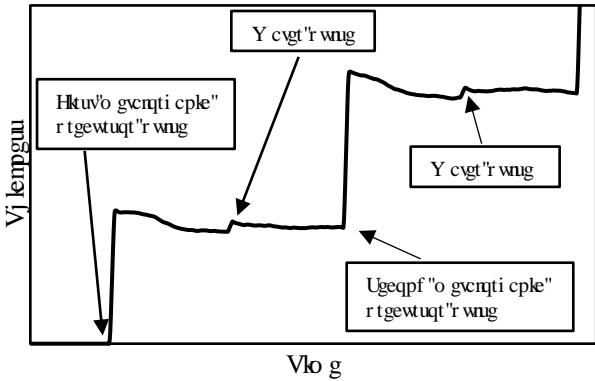
<sup>3</sup>O letqqr vce'ne'qo r qppgw'rdqtcvqt { . 'Egpygt'hqt' Rj { ulecn'Uekpegu'cpf 'Vgej pqmji { . 'Nkj wcpk' "  
o cpwu'f tc| f {uB hno e0h'

Eqp'kpwqwu'f g'xgnr o g'p'v'q'h'rcu'g'u'c'p'f'rcu'g't'v'gej pqmji k'g'u'et'g'c'v'g'j ki j g't'g's wkt go g'p'u'hqt'qr vce'ne'qo r qppgw'c'p'f'v'j k'p' h'k'o 'eq'c'v'k'p'i u'0'V'j k'p' h'k'o u'ec'p'd'g'f'g' r qu'k's'g'f' d { 'w'k'p'i 'x'c't'k'v' { 'q'h'o g'y q'f u'lp'ew'f'k'p'i 'r'j { u'le'c'n'x'c'r q'w't'f'g'r qu'k's'k'p' "RXF +: 'u'q'n' i g'n'v'g'ej p'k's w'g'u.'ur w'w'g't'k'p'i "c'p'f' "e'j go k'ec'n'x'c'r q'w't'f'g'r qu'k's'k'p'0'J q'y g'x'g't.'y k'j "v'j g'f'g'et'g'c'v'k'p'i "u'k' g'q'h'qr v'k'u'c'p'f' "k'p'et'g'c'v'k'p'i " f go c'p'f' "h'q't" 'e'q'o r r'g'z" 5'F" 'u'j c'r g' "q'r v'k'ec'n' u'w'd'u't'c'v'g'u" c'v'q'o k'e" r'c' { g't'f'g'r qu'k's'k'p' " \*CNF -" d'g'eco g' "q'p'g" q'h' 'v'j g' "r' t'q'o k'k'p'i " v'g'ej p'q'm'j k'g'u'v'j c'v'eq'w'f' "d'g'w'g'f' "h'q't'o c'p'w'h'c'ew't'k'p'i "q'h'qr v'k'ec'n'eq'c'v'k'p'i u'0'

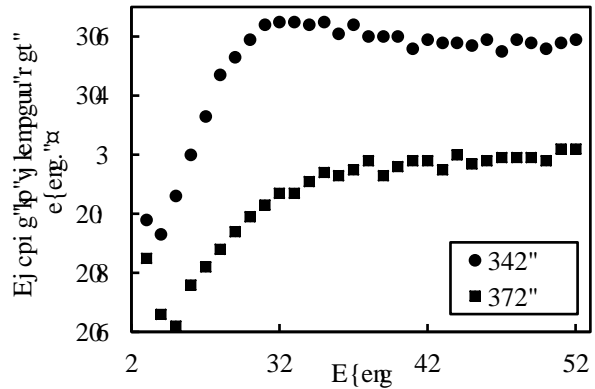
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V'j g'k'p'k'ec'n'i t'q'y v'j "t'c'v'g'q'h'rc' { g't' "k'u'c' "n'g' { "h'c'ev't' "k'p" o c'p'w'h'c'ew't'k'p'i "r' t'g'ek'ug'w'nt'c'y k'p' h'k'o u'y j q'ug'c'ee'w't'c'e { "f'g'h'k'p'g'v'j g' "e'j c't'c'ev't'k'k'ec'u'q'h'qr v'k'ec'n'eq'c'v'k'p'i u'0'K'j' c'u' "d'g'g'p' "u'j q'y p' "v'j c'v'f'g'r g'p'f'k'p'i "q'p'v'j g' "u'w'h'c'eg'ur g'ek'g'u' "q'p"y j k'ej "h'k'o "k'u'd'g'k'p'i " f'g'r qu'k's'g'f' . "v'j g'k'p'k'ec'n'i t'q'y v'j "t'c'v'g'o k'j j v'x'c't' { 0'V'j k'u'x'c't'k'v'k'p' "e'c'p' "d'g'q'd'ug't'x'g'f' "f' w't'k'p'i "v'j g' "h'k'u'v'32"v'q'52"e { e'rg'u' ]4\_0'V'j g'ug' "x'c't'k'v'k'p'u'q'h'i t'q'y v'j "t'c'v'g'f'q'p'q'v'j c'x'g'c' "u'k'i p'k'k'ec'p'v'k'o r c'ev'q'p'c'x'g't'c'i g'v'j k'emp'g'u'r' t'g'ek'k'p'q'h'v'j k'eng't' h'k'o u'0'J q'y g'x'g't.'y j k'rg' "f'g'r qu'k's'k'p' "w'nt'c'y k'p' h'k'o u. "v'j g' "x'c't'k'v'k'p' "q'h' k'p'k'ec'n'i t'q'y v'j "t'c'v'g' "e'c'p' "t'g'u'w'nt' "k'p" c'r c't'g'p'v'f' k'uet'g'r c'p'e { "q'h' h'k'ec'n'v'j k'emp'g'u' "r' t'g'ek'k'p'0'

K'p'v'j k'u'y q't'n'y g'k'p'x'g'u'k'i c'v'g'f' "v'j g'k'p'k'ec'n'i t'q'y v'j "q'h'J' h'Q4. "V'k'Q4. "V'c4Q7" c'p'f' "C'n'Q5" v'j k'p' h'k'o u'q'p'x'c't'k'q'w'u'w'nt'c'eg'ur g'ek'g'u' "d { 'w'k'p'i "CNF" v'j g't'o c'n'r' t'q'eg'u'u'c'p'f' "k'p' "u'k'w's'w'c't'v'j "e't { u'c'r'd'o l'et'q'd'c'r'p'eg' "S'EO +o q'p'k'q't'k'p'i 0'G'c'ej "CNF" "e { e'ng' "e'q'p'uk'v'g'f' "q'h' "h'q'w't' "u'v'g'r u'y j k'ej "y g't'g'c'u' "h'q'm'q'y u'c'o g'v'c'r't'i c'p'le" r' t'g'ew't'u'q't' "r' w'ng. "r' w'ti g. "y c'v'g't' "r' w'ng. "r' w'ti g' "H'k'i 03-0'H'q't' "v'j k'u'k'p'x'g'u'k'i c'v'k'p' "y g'w'g'f' "o g'v'c'r't'i c'p'le" r' t'g'ew't'u'q't' "c'p'f' "f'g'l'q'p'k'k'g'f' "y c'v'g't' "v'q'f'g'r qu'k's'k'p' h'k'o u'c'v'342" "c'p'f' "372" "0"



H'k'i 030S EO "o g'c'u'w't' go g'p'u'q'h'y q' "CNF" "e { e'rg'u'0'



H'k'i 040J h'Q4'i t'q'y v'j "q'p' "U'k'Q4'0'

G'z'r g't'k'o g'p'v'c'n'k'p'x'g'u'k'i c'v'k'p' "r'g'f' "v'q' "e'q'p'ew'k'k'p'u' "v'j c'v'k'p' "u'q'o g' "e'c'ug'u'v'j g' "k'p'k'ec'n'i t'q'y v'j "t'c'v'g' "e'c'p' "d'g' "o q't'g' "v'j c'p' "y k'eg' "n'y g't' "e'q'o r c't'g'f' "v'q' "v'j g' "u'c'd'r'g' "i t'q'y v'j "t'c'v'g' "H'k'i 0'4+0' Q'p' "v'j g' "e'q'p'v'c't' { . "y j g'p' "f'g'r qu'k's'k'p' "V'c4Q7. "C'n'Q5" u'w'd'r'c' { g't' "d'c't'g'n'f' "k'p'h'w'g'p'eg'u'v'j g' "k'p'k'ec'n'i t'q'y v'j "t'c'v'g'0'Y' g' "h'q'w'p'f' "v'j c'v'k'p' "o q'u'v' "e'c'ug'u' "h'k'p'g'c't' "i t'q'y v'j "q'h'v'j k'p' h'k'o u' "d'g'i k'p'u'c'h'v'g't' "32" "o" "37" "e { e'rg'u'0'

[3\_0' "J' 0" "V'k' p'c'f' q' "g'v'c'n'0' "V'k'Q4" c'p'f' "C'n'Q5" "w'nt'c'y k'p' "p'c'p'q'r'o k'p'c'v'g'u'i t'q'y v'j "d { "CNF" =k'p'w't'o g'p'v'c'w'q'o c'v'k'p' "c'p'f' "h'k'o u' "e'j c't'c'ev't'k'k'ec'u'q'h'qr v'k'ec'n'eq'c'v'k'p'i. "T'g'x'0'0' g'z'0'H'k'u'07: . " 67; /687 "4234-0' ]4\_0' "E'0'Y' 0'Y' k'g'i c'p'f' "g'v'c'n'0' "W'p'f' g't'u'c'p'f'k'p'i "v'j g'f' t'q'y v'j "o g'ej c'p'k'u'o u'q'h'o w'nt'c'y { g't'g'f' "u' { u'v'g'o u'k'p' "c'v'q'o k'e" r'c' { g't'f'g'r qu'k's'k'p' "r' t'q'eg'u'u' "E'j go 0'0' c'v'g't'0'52. "3; 93/ 3; 9; "423: -0'

O7-2

DID NOT PARTICIPATE

# RJ QVQRJ [ UE CN'RT QRGTVKGU'QHRJ T KO K P G/DCUGF 'VCF H' GO KVVGTU'

Mco kn 'Dctgkncv<sup>3</sup>. 'Tqncu'Unekui kku<sup>3</sup>. 'Lgrpc'F qf qpqxc<sup>4</sup>. 'Uki kcu'Vwo ngxk ku<sup>4</sup>. 'Ucwku'Lwt - pcu<sup>3</sup>"

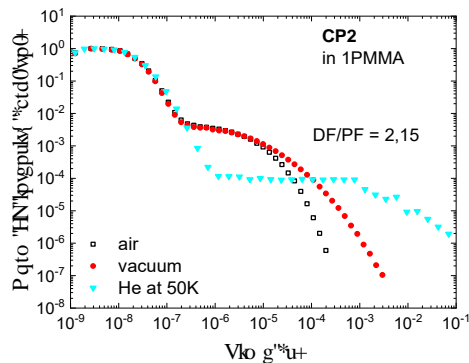
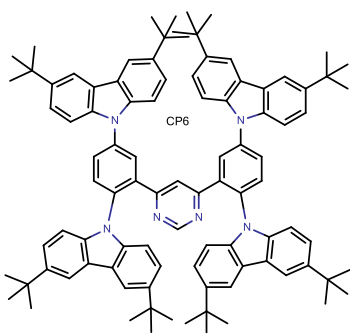
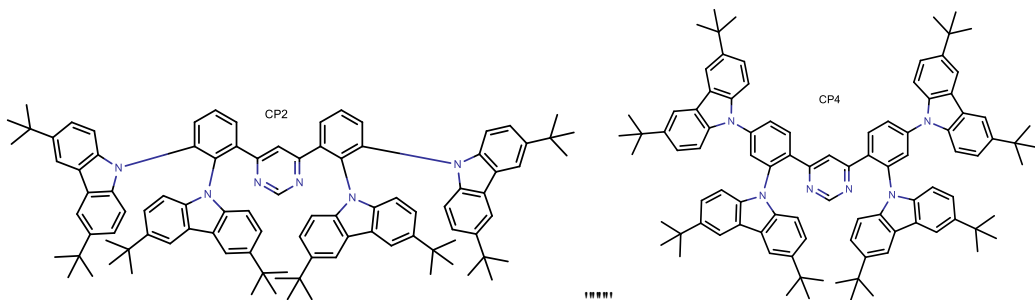
<sup>3</sup>kpukwg'qh'Rj qvpleu'cpf 'P cpqvej pqrj { . 'Hewm' 'qh'Rj { ueu 'Xkpkwu'Wpkxgtukv' . 'Nkj wepkc' "

<sup>4</sup>kpukwg'qh'Ej go kut { . 'Hewm' 'qh'Ej go kut { 'cpf 'I gqukgpegu 'Xkpkwu'Wpkxgtukv' . 'Nkj wepkc' "  
nc o kgQlctgkncvB Hfwwf 0xv0v"

Qti cple'ri j v'go kxpi 'f kqf gu'\*QNGF u'ctg'f gxlegu'qh'i tgcv'r qvqpcn'cpf 'lpvgtgu0J qy gxgt.'97' "qh'grgvtkecm' " kplgevgf'ej cti g'lp'y g'QNGF'gpf u'wr 'lp'pqp/go kuuxg'vtr ngv'ucvgu'Vtr ngv'ecp'dg'j ctxgugf'y tqwi j 'y g'o gej cpkuo 'qh' y gto cm' 'cevkxcvgf'f grc { gf 'hwtgugpeg' '\*VCF H: 'y j gtg'y gto cn'gpgti { 'ku'gzt rnkqgf 'v'w' eqpxgtv'vtr ngv'v'go kuuxg' ukpi ngv'ucvgo'Cu'c' tguwn: 'k'ku'r quukdg'v'cej lxxg'wr 'v'322' 'lpvgtpcn'ghhlegpe { . 'y kj qw'y g'wug'qh'cp { 'j gcx { 'o gvcu'cu' k'ku'wucn'lp'ghhlegpv'r j qur j qtgugpv'f gxlegu'j3\_0Vq'cej lxxg'ghhlegpv'VCF H'y g'gpgti { 'i cr 'dgvy ggp'y g'hy guv'ukpi ngv' cpf 'vtr ngv'ucvgu'\*Δ G<sub>UV</sub>'uj qwf 'dg'o lpo k gf . 'y j ku'wucm' 'tgcej gf 'd { 'ur cvecm' 'ugr ctevkpi 'y g'J QO Q'cpf 'NWO Q' ucvgu'lp'ej cti g'vcpuhgt'eqo r qwpf u'eqo r qugf 'qh'grgvtq'f qppt'cpf 'ceegr vqt'j4\_0'

Kp'y ku'y qtm'r j qqr j { uecn'r tqr gtvgu'qh'pgy 'r { tko k'lp/g'dcugf 'go kvgtu'y g'g'lp'xguki cvgf'/'c'r { tko k'lp'g'ceegr vqt' y kj 'c'vgtvdw'r'lectdc' qrg'f qppt'c'wej gf 'v'k'v'f'k'htg'pvr'uegu'\*hi 03+0U'c'p'ctf 'r j qqr j { uecn'r tqr gtvgu'c'p'cn' uku'y cu' eqpf vevgf'/'cduqtr vkp. 'go kuukp. 'vko g'tguqk'gf 'hwtgugpeg'g'zr g'ko gpw'/'lp'ck'qt'x'cewo 'cpf 'lp'tqo 'vgo r gtcwtg'cu' y gm'cu'72M'Vj g'qdvkpgf 'f'c'v'tg'x'g'rgf 'y'c'v'wej kpi 'f'q'p'q'c'v'f'k'htg'pvr'qukk'p'u'rgcf'v'q'go kuukp'y'cxg'g'pi'v' 'uj'kv' htqo '6: 5'po 'lp'eqo r qwpf 'ER4'v'659'po 'lp'eqo r qwpf 'ER800'qtg'x'g't. 'y g'o qrgewg'y kj 'f'q'p'q'c'v'v'g'q'v'q'cpf' 'o'g'v' r qukk'p'u'ER4+'uj qy u'y g'uo cmgu' Δ G<sub>UV</sub>'i cr '\*3570 gX+y j kg'hq'v'g'q'v'gt'eqo r qwpf u'ku'y cu'd'q'x'g'4720 gX0Vj ku'o c { ' dg'y g'tguwn'qh'vgtkecm' 'etqy f kpi 'qh'f'q'p'q'c'v'p'ku'rgcf'kpi 'v'q'rti'gt'v'y'ku'v'c'pi'ngv'c'p'f'lp'w'p'rti'gt'ugr'cte'vk'p'qh'J QO Q'6' NWO Q'qtdkscn'j5\_0Vj g'tgf wegf " Δ G<sub>UV</sub>'rgf 'v'ER4'j'cxkpi 'y'g'rti'gu'co'qwp'v'qh'f'grc { gf 'go kuukp'6'8: ' 'eqo r ctgf 'v'q' 7: ' 'cpf'42' 'hqt'eqo r qwpf u'ER6'cpf 'ER8. 't'g'ur'v'x'g'g'0'Vj g'q'k'lp'qh'f'grc { gf 'hwtgugpeg'y'cu'c'w'k'd'w'gf 'v'q'VCF H' go kuukp'f'v'g'v'q'd'g'kpi 's'w'p'g'gf 'lp'hy'v'go r gtcwtg'qh'72'M'hi '30f'g'ec { 'h'k'p'v'e-0'

Kp'eqpenukp. 'ectghwm' 'ugr'v'kpi 'y'g'r'q'k'p'v'qh'c'wej o'gpw'hq'f'q'p'q'c'v'p'ku'ecp'rgcf'v'q'uw'g'k'q't'VCF H'go kuukp' r tqr gtvgu'0'



Hi 03'R { tko k'lp'g'6'ectdc' qrg'VCF H'eqo r qwpf u'c'p'cn' | gf 'lp'y ku'y qtm'nc'p'f 'y'g'f'g'ec { 'h'k'p'v'k'p'v'qh'eqo r qwpf 'ER4'lp'3' y v' 'RO O C' hko u'c'v't'q'qo 'v'go r gtcwtg'lp'ck'cpf 'x'cewo 'co d'k'p'v'cpf 'c'v'72'M'v'go r gtcwtg'0'

j3\_MDI quwv k'MDI quj k'c'.MDU'v'q. 'E0'c'f'cej k'Qti cple'hi j v'go kxpi 'f kqf gu'go r m { kpi 'ghhlegpv'lxgtug'lpvgtu' u'ngo 'et'qukpi 'hqt'vtr ngv'v'ukpi ngv'ucvgo' eqpxgtukp. 'P'cw'g'Rj qvpleu'8. '475647: \*4234+0'

j4\_HDDOF'ku'v'v'c'f'0'Rj qqr j { ueu'qh'y gto cm' 'cevkxcvgf'f grc { gf 'hwtgugpeg'g'o qrgewgu'0'g'v'q'f'c'p'f 'Cr r'nc'v'q'p'u'lp' hwtgugpeg'7. '234223'4239+0' j5\_'V0'U'g'x'k'ku. 'T'0'U'nekui kku. 'L'0'F'q'f'qp'q'xc. 'N'0'L'ci'k'p'c'x'k'ku. 'L'0'D'w'g'x'k'ku. 'M'0'M'c'j'w'w'u'u. 'U'0'w'v'go r qwpf u'ku'y cu'd'q'x'g'4720 gX0Vj ku'o c { ' dg'y g'tguwn'qh'vgtkecm' 'etqy f kpi 'qh'f'q'p'q'c'v'p'ku'rgcf'kpi 'v'q'rti'gt'v'y'ku'v'c'pi'ngv'c'p'f'lp'w'p'rti'gt'ugr'cte'vk'p'qh'J QO Q'6' NWO Q'qtdkscn'j5\_0Vj g'tgf wegf " Δ G<sub>UV</sub>'rgf 'v'ER4'j'cxkpi 'y'g'rti'gu'co'qwp'v'qh'f'grc { gf 'go kuukp'6'8: ' 'eqo r ctgf 'v'q' 7: ' 'cpf'42' 'hqt'eqo r qwpf u'ER6'cpf 'ER8. 't'g'ur'v'x'g'g'0'Vj g'q'k'lp'qh'f'grc { gf 'hwtgugpeg'y'cu'c'w'k'd'w'gf 'v'q'VCF H' go kuukp'f'v'g'v'q'd'g'kpi 's'w'p'g'gf 'lp'hy'v'go r gtcwtg'qh'72'M'hi '30f'g'ec { 'h'k'p'v'e-0'

**QRVĒCN'O QF WNCVQP 'QH'O QPQ'CPF 'DKNC[ GT'I TCRJ GPG'**

Twup "Kc-ngxk k v /Rqkrcwunq<sup>3</sup>. 'F crkw'Ugrkw<sup>3</sup>. 'Cnguk' Rcf f wdunε {c<sup>4</sup>. 'F qo cu"  
 Lqmwdcwun<sup>3</sup>. 'Nkpcu'O kpnxk kw<sup>3</sup>. 'Cpf t| gl'Wdcpqy le|<sup>3</sup>. 'Kxc'O cwrcklq<sup>5</sup>. 'Nkpc'O knrk pckv<sup>5</sup>. "  
 I kvctcu'Xcnw-ku<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Qr vqgrvtpleu. 'Egpgt' hqt' Rj { ulecn'Uelqpegu'cpf 'Vgej pqm| { . 'Nkj wclk"  
<sup>4</sup>Kpukwg' hqt' P verget' Rtqdrgo u. 'Dgrt wulcp' Uevg' Wpkgtuk| . 'Dgrt wu"  
<sup>5</sup>F gr ctvo gpv'qh'Qti cple' Ej go km { . 'Egpgt' hqt' Rj { ulecn'Uelqpegu'cpf 'Vgej pqm| { . 'Nkj wclk"  
 twup(kxcunxkewgB ho e0h"

"

Vgtcj gtv "VJ | +kō ci kpi "u{vgo u'ctg'ewttgpw| "ppg'qh'v'j g'o quv'cwtcevkxg'vqr leu'kp'qr vqgrvtpleu0Cu'cm'u{vgo u'  
 cevkxg'grgo gpw'ctg'i gwłpi "uo cngt. 'r cuukxg'qr vlecneqo r ppgw'u'cu'y gml'tgs wkt gf "vq'dg'o qtg'eqo r ce0'k'v'j ku'ecug'qr vlecni'  
 r tqr gt'vku'cpf "eqo r cevgu'q'hi' tcr j gpg'o cngu'k'uwkcdrg' hqt' v'j ku'cr r dcevqap0'v'q'o cng'c' hwpvqpcn'f khtcevkxg'grgo gpv"  
 i tcr j gpg'tgs wktgu'v'q'cduqtd'VJ | 'tcf kvqap0'Uqpeg'k'ku'cm quv'eqo r rvgv| 't'cpur ctgpv'kp'v'j ku'htgs wgep{ 't'cpi g. 'i tcr j gpgai'  
 vcpuo kwcepg'ecp'dg'eqpvtmgf 'd{ "włpi "ej go lecn'grvtecln'qt'qr vlecni'f qr kpi "j3\_0

Kp'v'j ku'y qtm'qr vlecni'o qf wrcvqp'ku'ej qugp'cu'eqpvcv'gu'bo gj qf 0'

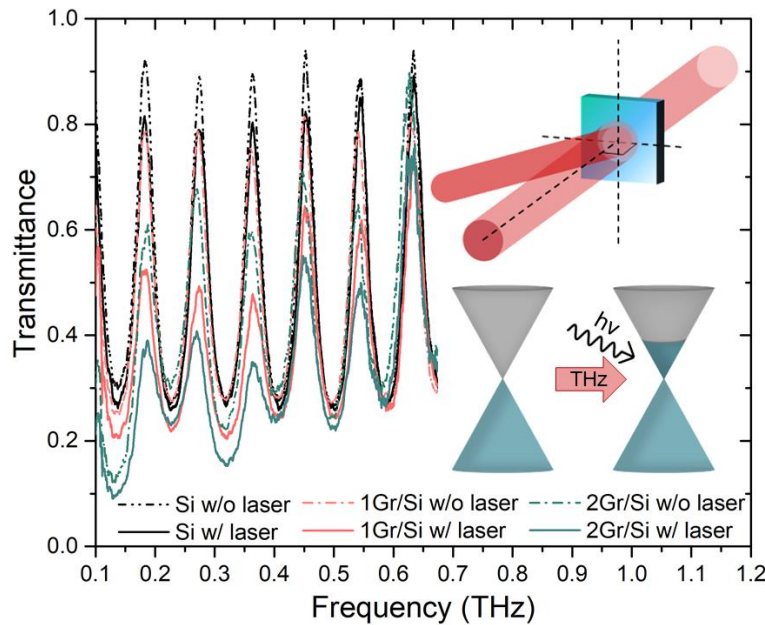
Vj tgg'v'f r gu'qh'uco r ngu'y g'g' hcdtlevgf "kp'qtf gt'v'q' kpxgunki cvg'qr vlecni'o qf wrcvqp'qh'o qpq'cpf "dk/rc{gt'i tcr j gpg0'  
 Cu'i tcr j gpg'ku'pqv'c'htgg'uepf kpi "o cvgtken'kv'y cu'vcpuhgtgf "qp'ukleqp" \*Uk+uwdustcvg. 'y j lej 'ku'vcpur ctgpv'kp'VJ | 't'cpi g0'  
 Vj gtghqtg. 'v'j g'htuv'uco r ng'ku'c'ukpi ng'i tcr j gpg'rc{gt'qp'Uk0Vj g'ugeqpf 'uco r ng'ku'y q' i tcr j gpg'rc{gtu'qp'Uk'y j lej 'y g'g'  
 vcpuhgtgf "qpg'd{ "qpg0Vj g'v'j kf 'uco r ng'ku'r wtg'Uky chgt'y j lej 'ugt'xgf "cu'c'tghgt'gpeg'v'q'v'j g'htuv'v'q'uco r ngu0"

Qr vlecni'o qf wrcvqp'y cu'cej lxxgf 'd{ "włpi "r wo r kpi "rcugt'v'q' i gpgtcvg'htgg'ectt'ktu'kp'Uk' uwdustcvg0' Ectt'ktu'ctg'  
 vcpuhgtgf "v'q' i tcr j gpg'rc{gt'cpf "f wg'v'q'ku'j ki j gt'ectt'kt' o qd'k'k'f. 'i tcr j gpgai'vcpuo kwcepg'qh'VJ | 'tcf kvqap'ku'tgf wvgf "  
 j4\_0

Kp'qtf gt'v'q' gxcnvcg" o qf wrcvqp' f gr v'j "qh'cm'v'j tgg' uco r ngu. "vcpuo kwcepg"ur gevte"y g'g'o cuwgtf "włpi "VJ | "  
 htgs wgep{/f qo clp'ur gevte' gvt0Ur gevte'ctg'f gr levgf "kp'Hki 030T guwmu'uj qy gf "v'j cvf wg'v'q'r j qvqgzekcvkqp. 'v'j g'bo qf wrcvqp"  
 f gr v'j "qh'dk/rc{gt'i tcr j gpg'i qgu'w'v'q'64' 0"

Rj qvq'o qf wrcvqp" hgcwt'gu' qh' i tcr j gpg/qp'ukleqp" r tgr ctgf " włpi " f khtg'gpv' vgej pqm| lecn' cr r tqcej gu" y km' dg"  
 f kuewugf "kp'f gvckn0"

"



Hki 030'vcpuo kwcepg'ur gevte' qh'Uk'cpf "f khtg'gpv'i tcr j gpg'rc{gtu'0'k'ugv'f gr leu'qr vlecni'o qf wrcvqp'uej go g'cpf "  
 i tcr j gpgai'f kce'eqpgu'dghqtg'cpf "chgt'r j qvqgzekcvkqp0"

"

j3\_ T0Dkpf gt. 'Qr vlecni' Rtqr gt'vku'q'hi' tcr j gpg' \*Wpkgtuk| 'qh' Ctk' qpc. "WUC. "4238-0"  
 j4\_ O 0Hw'Z0Y cpi. "U0Y cpi. \ 0Zlg. "U0H'epi. "Y 0Uwp. "l0| g. "R0J ep. "l 0| j cpi. "Gh'ekgpv'vgtcj gtv 'o qf wrcvqt'dcugf'qp'r j qvqgzekcv' i tcr j gpg. "Qr v0"  
 O cvgt088. "5: 3/5: 7" \*4239-0"

**EJ CTI G'ECTT'KT'V'TCPURQT'V'R'ENQUG'VQ'TGCN'Y QTM'KI " EQPF'K'QP'U'QH'QTI CP'KE'UQNCT'EGNNU"**

Tqneu'Leuk pcu<sup>3</sup>. 'Xkf o cpvcu'Le-kpuncu<sup>3</sup>. 'J wqkcp\' j cpi<sup>4</sup>. 'Hgp'i 'I cq<sup>4</sup>. 'Xkf o cpvcu'I wrdkpcu<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'O qrgewrt 'Eqo r qpwf 'Rj {uleu.'Egpgt 'hqt 'Rj {ulecn'Uekpgegu'cpf 'Vgej pqmji {.'.Ucwn vgnk'cx05.'NV/32479'Xkpkwu.'Nkj wcpke"

<sup>4</sup>F gr ctvo gpv'qh'Rj {uleu'Ej go kur { 'cpf 'Dkqmji { '\*HO + 'Nlponor kpi 'Wpkxgtukv. 'Nlponor kpi 'UG/7: 3: 5.'Uy gf gp" tqneu'leukwpcuB ho ehu'

"

Gxgt'ukpeg'qti cple'rj qvqxqncle'f gxlegu'j cxg'dggp'lpwtqf wegf 'vq'uelgpv'kle'eqo o wpkv' f gecf gu'ci q.'f gdcvgu'cdqw' wpf gtrc {kpi 'rj {uleu'qh'eji cti g'tcpur qtv'ki pkskf 'cpf 'eqpvpwg'vq'hwqwkuj 'vq'vj ku'f c{0Ej cti g'ectt'kgt'o qdkrkv' ku'qpg'qh'vj g' o clp'r ctco gvgu'f gvgto klpki "ectt'kgt'gz'vcv'kqp'cpf "tgego dlp'cv'kqp'0'Vj wa."pqv'wvtr tkukpi "vj cv'eqo r rgez "cpf "ukni'r qatn' " wpf gtuqqf 'k'dgego gu'vj g'egpgt'qh'f gdcvgo'

K'j cu'dggp'f go qputcvgf 'lp'ugxgtcn'r wdrckv'kpu'vj cv'eji cti g'ectt'kgt'o qdkrkv' "kp'cp'cev'xg'rc {gt'qh'vj g'qti cple'uqrc' egmf' getcguguy' kj "vko g'chgt'r j qvqi gpgt'cv'kqp'd { 'ugxgtcn'qtf gtu'qh'o ci pkskf g'j3/7\_0'Qp'vj g'qyj g't'j cpf. 'vj g'tg'ctg'cnuq' y qtm'uj qy kpi "vj cv'uv'gcf { /ucv'g'o qdkrkv' "cpnc'uku'ecp'dg'uuegu'uwmn' 'cr r'kgf'vq' qti cple'rj qvqxqncle'f gxlegu'8; \_0' Tgegpw'."k'y cu'cti wgf 'vj cv'ectt'kgt'o qdkrkv' "kp'qr g'tcv'kpi "uqrc' egmu'ku'lpf g'gf "eqpvc'p'p'cpf "vj cv'vc'puk'p'p'v'o g'vj qf u' uj qy kpi "vko g'f gr gpf g'v'ectt'kgt'o qdkrkv'. "uwej "cu'v'cpuk'p'p'v'rj qvqewt'gpv'y j g't'g'vj g'wco r ng'ku'gzek'kf d { 'c'uj qtv'meug' r wng. "ctg'kpcf gs wcv'g'dgecw'ectt'kgt'v'cr u't'go clp'cm qv'go r v' "j32\_0'Y j kg'w'pf g't'eqpvc'p'p'v'uqrc' kmwo k'p'cv'kqp'ectt'kgt' v'cr u'dgego g'r qr wcv'g'f. 'vj g'tg'q'g'o qdkrkv' "f qgu'pqv'f getcgug'y j kg'vj g'ectt'kgt'ku'f tk'mkpi 0'

K'j v'ku'y qtm'y g'j cxg'gz'r g'tlo g'p'vc'm' "kpxg'uki cvgf 'ectt'kgt'gz'vcv'kqp'f { pco leu'kp'VS 3-RE93DO.'. "qpg'qh'c'uc'p'f ctf " o qf gn' qh' r qn' o g't'hwngt'pgp' uqrc' egmu. "cpf " j ki j n' "gh'g'ev'xg'g' pqp/hwngt'pgp' cee'gr v'at' dcu'gf " RDF D/V-3" qti cple'rj qvqxqncle'f gxlegu'0'Y g'go r mj {gf "ugxgtcn'v'cpuk'p'v'o g'vj qf u'eq'xgt'kpi "vj g'y kf'g'vgo r q'rcn'ij k'p'qy "ht'go "r u'v'q'Uu."cpf " pwo g'tec'n'o qf gn'kpi "vq'cf'f t'gu'ectt'kgt'v'cpur qtv'k'p'em'q'g'v'q'tgc'n'ij qtm'kpi "eqpf k'k'p'u'qh'c'uc'p'f'egm'0'V'q'g'xcn'cv'g'vj g't'q'ng' qh'v'cr r gf "ectt'kgt'u"y g'eqo r c'g'f "ectt'kgt'gz'vcv'kqp'f { pco leu'w'p'f g't'gzek'cv'kqp'qh'uco r ngu'd { 'y g'cn'f'ru'g't' r wng'u'y j gp' v'cr "uc'v'gu'y g't'g'p'q'r qr wcv'g'f 'cpf 'y kj 'cf'f k'k'p'c'n'3'U'wp'kmwo k'p'cv'kqp'r'qr w'cv'kpi "vj g'v'cr "uc'v'gu'0'

Y g'uj qy gf "vj cv' o qdkrkv' "f gec { "f w'kpi "k'p'k'cn'ectt'kgt'f tk'h'ku'vj g'wco g'y j gp'ectt'kgt'u'ctg' g'k'j g't' eqp'v'p'w'w'w' i g'p'g'v'g'f "d { "uv'gcf { /ucv'g' kmwo k'p'cv'kqp'qt'd { "c'uj qtv'meug' r wng'0'P g'x'g'v'j g'guu. "uv'gcf { /ucv'g' kmwo k'p'cv'kqp'cng'u'ectt'kgt' v'cpur qtv'k'p' "Uu" vko gue'cn'g' f h'g't'gp'w'f. "f gr g'p'f kpi "qp'cev'xg'g'rc { g't' o cv't'k'cn'0' H'qt'hwngt'pgp'/dcu'gf "f gxleg. "eqp'v'p'w'w'w' kmwo k'p'cv'kqp't'gr g'cn'u' o qdkrkv' "f gec { "r t'g'ug'p'v'k'p'ec'ug'qh'r'g't'k'f'k' "gzek'cv'kqp'=j qy g'x'g't. "kp'j ki j n' "gh'g'ev'xg'g'pqp/hwngt'pgp' "f gxlegu'f w'g'v'q'gz'v'go gn' "h'y v'cr 'r qr w'cv'kqp'o qdkrkv' "f gec { "kp'Uu'vko gue'cn'g'ku' o cti k'p'cn'k'p'd'q'j 'ec'ug'u'0'

"

- [3\_F'g'x'k'f'ku.'C0#U'g'd'g'p'c.'C0#O g'g'tj q'j. 'M0#I g't'v'g'n 'F 0#I w'rd'k'p'cu.'X0W'it'c'w'F { pco leu'q'h'ectt'kgt'0' qdkrkv' "kp'c'Eq'p'w' cvgf 'Rq'n' o g't'Rt'q'd'g'f 'cv' O q'rg'ew'r't'c'p'f "O let'q'ue'q'r' le'Ng'p'i v'j 'U'ec'ig'u'0'R'j {u'0T'g'x'0'Ng'w'0422; .325\*\*4+;2496260"
- [4\_'L'c'u'k'w'p'cu.'T0# \ j c'p'i. 'J 0#I w'cp. 'L0# \ j q'w'Z0#S k'p.'F 0# \ q'w' [ 0#F' g'x'k'f'ku.'C0#U'w'm'm'u.'L0#I c'q.'H0#I w'rd'k'p'cu.'X0H'q' 'I g'p'g't'cv'kqp'v'q'G'z't'cv'kqp'<'C' Vlo g'T'g'u'k'g'f "k'p'x'g'u'k' cv'kqp'qh'R'j q'v'r'j {ulecn'Rt'q'eg'ug'u'k'p'p'p'q'p/Hwngt'pgp'Q'ti cple'Uqrc' 'Eg'm'0'LOR'j {u'0E'j go 0E'4242. "
- [5\_'O'g'r'ic'p'cu.'C0#R't'c'p'ew'ku.'X0#F' g'x'k'f'ku.'C0#I w'rd'k'p'cu.'X0#I'p'i c'p'@. 'Q0#M'go g't'k'p'm'0'0'F'k'ur g't'k'q'p'F'q'o k'p'c'v'g'f 'R'j q'v'q'ew't'g'p'v'k'p'R'q'n' o g't'hwngt'pgp'U'qrc' 'Eg'm'0'c'f.x'0'H'w'p'e'v'0'0'c'v'g't'04236.'46\*\*4; +'6729667360"
- [6\_'C'd'co c'x'k'k'w.'X0#C'0 c't'c'u'p'i j g'X'k'j c'p'c'i g.'F 0#F' g'x'k'f'ku.'C0#I'p'h'j'c'ug'p'i. 'I 0#D't'w'p'q.'C0#H'q'ug't.'U0#M'g'k'c'p'k'f'ku.'R'0G'0#C'd'co c'x'k'k'w.'F 0#P' g'n'q'p.'L0# [ c't'v'g'x.'C0#U'w'p'f'ut'3'o. 'X0#I w'rd'k'p'cu.'X0#E'c'tt'k'g't'0' q'v'k'p'k'p'Cu'U'r w'p'c'p'f 'C'p'p'g'c'g'f 'R5J V-REDO'D'rg'p'f u'T'g'x'c'g'f'f' d { "W'it'c'w'v'Q'r'v'c'n'i'G'g'ev't'e' 'H'g'r'f " R't'q'd'k'p'i 'c'p'f "O q'v'g'f'c'c'nt'q'U'o w'v'k'p'u'0'R'j {u'0E'j go 0E'j go 0R'j {u'04236.'38\*\*8+;48: 80"
- [7\_'C'w'i w'ku.'T0#F' g'x'k'f'ku.'C0#R'eg'm'u.'F 0#I w'rd'k'p'cu.'X0#J' g't'v'g'n 'F 0#O g'g'tj q'n. 'M0J' k'i j 'G'g'ev't'q'p'0' qdkrkv' "cpf 'Ku'T'q'ng'k'p'E'j cti g'ectt'kgt'I' g'p'g't'cv'kqp'k'p' O g't'q'e {c'p'l'p'g'H'wngt'pgp'D'rg'p'f u'0'LOR'j {u'0E'j go 0E'4237.'33; \*\*33+;7983679920"
- [8\_'O'k'j c'k'g'v'ej k'X0'F 0#Z'k'g.'J 0Z'0#f g'D'q'g't.'D'0#M'q'ug't.'N0'L0C'0#D'm'q'o.'R'0Y'0'0'0'E'j cti g'V't'c'p'ur q't'v'c'p'f 'R'j q'v'q'ew't'g'p'v'I' g'p'g't'cv'kqp'k'p'R'q'n' \*/ J g'z {n'j k'q'r j g'p'g'+0' g'v' c'p'q'hwngt'pgp'D'w'm'J' g'v'g't'l'w'p'v'k'p'U'qrc' 'Eg'm'0'c'f'x'0'H'w'p'e'v'0'0' c'v'g't'04228.'38\*\*7+;8; ; 692: 0"
- [9\_'D'c't'v'g'n.'L0C'0#N'co.'F 0#D'w'ng.'V0'0'0#U'y g'v'p'co. 'L0'0'0#O e'l g'j g'g.'O'0'F'0'E'j cti g'ectt'kgt'0' qdkrkv' "T'g's w'k'g'o g'p'u'v'q't' D'w'm'J' g'v'g't'l'w'p'v'k'p'U'qrc' "Eg'm'y' k'j "J' k'i j 'H'm'i'H'ev'q't'c'p'f "G'z'v'g't'p'c'i'S w'p'w'o "G'h'ie'k'p'e'f {"@ 2' 0'c'f'x'0'G'p'g'ti { 'O'c'v'g't'04237.'7\*\*37+;37227990"
- ]:'\_D'c't'v'g'u'c'i j k'F 0#R't'g'l. 'I0'f' g'n'E 0#M'p'k'r g't'v.'L0#T'q'nc'p'f. 'U0#V'm'd'k'g'l. 'O'0#P' g'j g't.'F 0#M'q'ug't.'N0'L0C'0'Eqo r g'v'k'k'p'v'g'y g'g'p'T'g'eqo d'lp'cv'kqp'c'p'f " G'z't'cv'kqp'qh'H'g'g'E'j cti g'u'F g'v'g'to l'p'g'u'vj g'H'm'i'H'ev'q't'q'h'Q'ti cple'U'qrc' 'Eg'm'0'P'c'v'0'Eqo o w'p'04237.'8\*\*3+;92: 50"
- ]:'\_R't'q'ev't.'E'0'0#N'q'x'g.'L0C'0#P'i w'g'p.'V0S'0'0' qdkrkv' "I w'k'f'g'r'k'p'u'v'q't' 'J' k'i j 'H'm'i'H'ev'q't'U'q'n'w'k'p'v'g'v'g'f'U'o c'm'i'0' q'rg'ew'g'U'qrc' 'Eg'm'0'c'f'x'0'0' c'v'g't'0 4236.'48\*\*56+;7; 7967; 830"
- [32\_'Ng'E'q'tt'g.'X'0'0'0#E'j c'v'k'c'0T'0#F'q'wo q'p.'P'0] 0#M'q'ug't.'N0'L0C'0'E'j cti g'ectt'kgt'G'z't'cv'kqp'k'p'Q'ti cple'U'qrc' 'Eg'm'I' q'x'g't'p'g'f'f' d { "U'g'cf { /U'c'v'g' O qdkrkv'g'0'c'f'x'0'G'p'g'ti { 'O'c'v'g't'04239.'9\*\*44+;392335: 0"



# CRYSTALLOGRAPHY-BASED MODELLING OF THE INTER-PIGMENT INTERACTION IN THE FUCOXANTHIN–CHLOROPHYLL PROTEIN COMPLEX

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Photosynthesis is undoubtedly one of the most important biochemical interactions in nature, which allows for the coexistence of countless life forms. Organisms, which carry out photosynthesis, have adapted to live in various ecological niches throughout the millions of years of evolution, which has resulted in roughly the same amount of net primary production executed on land and in water. Diatoms are a wide-spread species of algae, that performs approximately 20% of photosynthesis on Earth. Diatoms have a unique light-harvesting complex – fucoxanthin-chlorophyll protein (FCP), which has such chromophores as chlorophyll (Chl) *c* or fucoxanthin, that are not present in light-harvesting complexes in higher plants. These exceptional chromophores enable diatoms to survive in water, where penetrated light is mostly in the blue-green visible region. FCP complexes are not only responsible for light harvesting, but their chromophores also participate in the quenching of the photosystem in order to minimize the damage done by intensive light and therefore serves as an interesting research material due to systematic differences in their mechanisms from light harvesting complexes of higher plants.

Only in 2019 two crystallographic structures of FCP were determined from *Phaeodactylum triconutum* [1] and *Chaetoceros gracilis* [2]. In this work interaction energy by point dipole approximation was calculated for various Chl *a* and *c* pairs in FCP monomers and FCP-A tetramer from the determined crystallographic structures. Transition dipole moment was formed in the direction from N<sub>B</sub> to N<sub>D</sub> atom (representing direction of the Chl Q<sub>y</sub> transition) and the center of the dipole was chosen the Mg atom in the center of porphyrin ring of chlorophylls. Results of the study indicate that for chromophore pairs present in all monomers interaction energy is really similar (Fig. 1), however, differences occur, when additional pigments are present in some of the monomers. These additional pigments interact strongly with some chlorophylls in the system. Strong interactions between chlorophyll *c* and chlorophyll *a* align well with the results from spectroscopic data [3]: there is a fast energy transfer channel (50 fs) from Chl *c* to Chl *a*. Notwithstanding, that does not have an impact on Q<sub>y</sub> peak position in absorption spectra and differences in absorption strength can be explained by the amount of pigments present in the monomer. Currently the chromophores of FCP are being modelled using Density Functional Theory and it is hoped that these calculations will provide some new insights about the system in the near future.

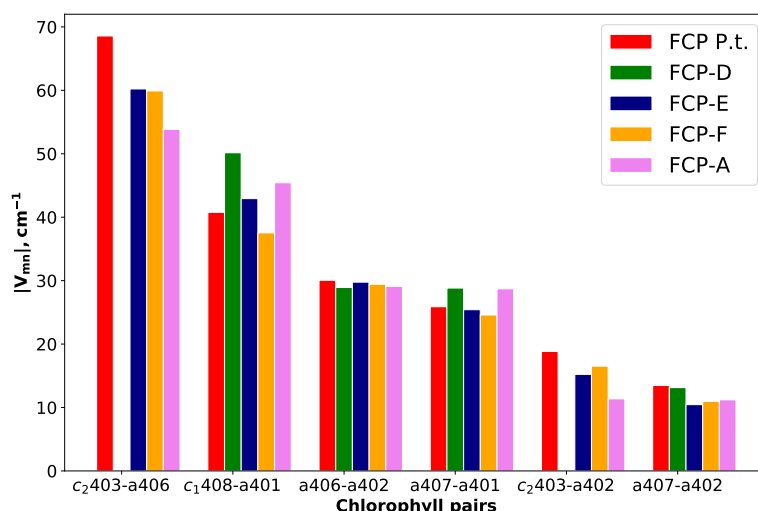


Fig. 1. Interaction energies comparison of some chlorophyll pairs in different FCP monomers

[1] W. Wang et al., Structural basis for blue-green light harvesting and energy dissipation in diatoms, *Science*, **363**, 1–8 (2019).

[2] X. Pi et al., The pigment-protein network of a diatom photosystem II–light-harvesting antenna supercomplex, *Science*, **365**, 1–10 (2019).

[3] A. Gelžinis et al., Confronting FCP structure with ultrafast spectroscopy data: Evidence for structural variations, *Physical Chemistry Chemical Physics*, **23**, 806-821, 2021.

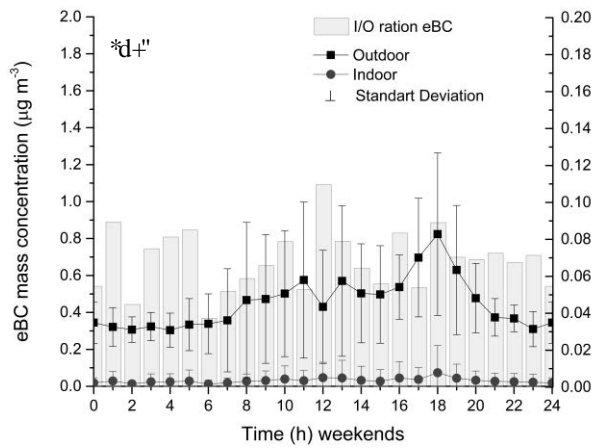
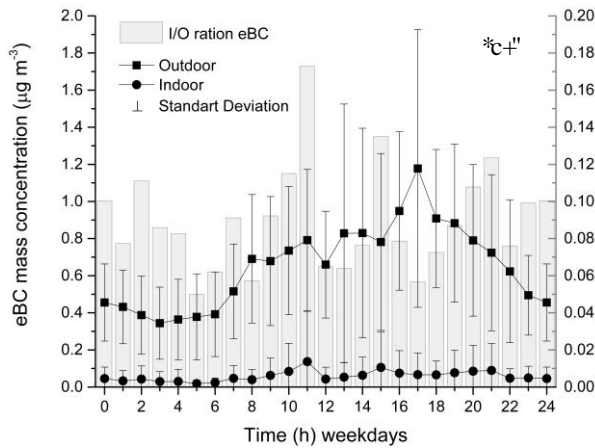


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Mkukpc'Rrcw-nckv. 'Kpi c'I ctdctkgr. 'Nkpc'F cxwtkgr. 'Ugki xkn 'D{ gpnkgr "

F gr cto gpv'qih'Gp xtkqpo gpvcn'T gugctej. 'Egpgvt'hqt'Rj { ulecn'Uelkpegu'cpf 'Vgej pqmri { . 'Xkpkwu. 'Nkj wcpkc''  
fctkc'cuj p gxcB ho e'w''

Drcemlectdqp"DE+ku'j g'o quv'utqpi n' hki j v'cduqtdkpi 'eqo r qppgv'qih' ct'vewrcvg'o cvgt"RO +y kj 'uj qtv'cvo qur j gtle" rhtgko g"\*qp" 'j g'qtf gt 'qh'c' hgy "f c { u'vq'y ggm+ 'cpf "j wu"DE"pqv'qpn' "j cu'ko r cew'qp"enlo cvg'ej cpi g'dw'cnuq"j cu'v'j g" r qv'p'vkn'vq'ch'gev'j wo cp'j gcnj '0Vj g'o clp' uq'wtegu'qh'DE'lp' wtdcp'gp xtkqpo gpw'eqo g'htqo 'lpeqo r r'gv'eqo dwuk'qp'qh' hquukih'wgn'cpf 'dlqo cu'dwt'pki '0F w'v'q'ku'uo cni'uk' g'rguu'v'j cp'40'' o + 'DE'ecp'dg'lpj crgf 'f ggr 'lpv'v'j g'hapi u'tgcej kpi " crxgqr'cpf 'r gpg'v'cv'g'dm'qf utgco "ecwulpi "ectf kqxcuewrt. "t'gur k'cvqt { "cpf "qv'j gt 'f kucugu"j3. "4. '0'k'v'j g'o qf gtp"y qtrf. " r gqr ng'ur gpf "; 2' "qh'v'j gk'v'ko g'lpf qqtu"j qo g. 'qh'legu'gve'0+y j g'g'gp'gti { / g'ht'ek'p'v'dw'k'f' lpi u'ecp'et'g'cv'g't'kumi'hqt'lpf qqt' ckt's wcrk'v' 'cpf 'j gcnj 'j5\_0Vj ku'uwf { "cko u'v'q'lp'xgunki cvg'lp'h'w'peg'qh'q'w'f qqt/v'q/ kpf qqt "gzej cpi g'v'q'lpf qqt 'h'x'g'ni'qh'DE'0' Eqp'v'p'w'qu't'gcn'v'ko g'o g'c'uwto gpw'qh'qr v'ec'n'c'duqtr v'k'p'd { "cgt'q'q'ni'r ct'v'eng'u'y g'g'lp'x'g'unki cvg'f "lp'v'j g'wtdcp't'gi k'p'p'qh' Xk'p'k'w'f w'k'p' 'j g'g'eq'f 'r g'k'qf "ht'qo 'Q'ev'q'dgt 'v'q'F g'ego dgt'4242+0G's w'k'c'rg'p'v'drcemlectdqp"DE+o cuu'eq'peg'p't'cv'k'p' 'y cu' o g'c'uw'gf "d { "cp" 'C'g'y c'no g'vgt "O ci gg" 'Uelk'p'v'k'le. "o qf gr'CG/53+0'Vj g'qr v'ec'n'v'c'puo k'uk'p'p'qh'ect'd'ap'ceg'q'wu' cgt'q'q'ni' r ct'v'eng'u'y cu' b' g'c'uw'gf "ugs w'p'v'k'ni' 'cv'9'y cx'g'g'pi v'j u' \* ? "592. '692. '742. '7; 2. '882. ': 2'cpf "; 72'po +. 'y j g'g'v'j g'g'DE' b' cuu' eq'peg'p't'cv'k'p' 'y cu' f' g'k'x'g'f 'ht'qo 'v'j g' hki j v'c'duqtr v'k'p' 'eq'g'ht'ek'p'v' \* cd+'cv'c' ': 2'po 'y cx'g'g'pi v'j 0'



Hki 030F ckn' 'e { erg'qh'q'w'f qqt'cpf 'lpf qqt'gDE' b' cuu'eq'peg'p't'cv'k'p' 'hqt' "c+y ggnf c { u'c'p' "d+y gng'p'f 0'

Vj g't'guw'u" "hki w'g'3" \*c. "d++'uj qy "c" o qf g'cv'g' "lp'h'w'peg'qh'q'w'f qqt'gDE" go k'uk'p'u'qp' 'y g'lpf qqt'gDE" r'x'g'ni'Vj g' y gng'p'f 'h'x'g'ni'qh'gDE" o cuu'eq'peg'p't'cv'k'p' 'y g'g'ny g't' 'v'j cp'lp' 'y ggnf c { u'0J q'w'ni' 'o g'cp' b' cuu'eq'peg'p't'cv'k'p'u'qh'gDE' 'hqt' y ggnf c { u'c'p' 'y gng'p'f u'lj qy u'f ckn' 'e { erg'u. 'v'j ku'ecp'dg'g'zr n'k'p'g'f 'd { 'r g'k'q'f l'ek'v' { 'qh'v'c'h'le'lp'v'p'uk'v' 'cpf 'j g'cv'k'pi 'c'v'x'k'k'g'u'0' Vj g'j ki j guv'q'w'f qqt'gDE' b' cuu'eq'peg'p't'cv'k'p'u' "304'µi 'b' /5+y g'g'q'd'ug't'x'g'f 'd'g'y g'gp'38-22'cpf '3: <2200 g'cp'lpf qqt' l'q'w'f qqt' " \*KQ+'t'c'v'ku'qh'v'j g'gDE" o cuu'eq'peg'p't'cv'k'p' 'hqt' 'v'j g'gp'v'k'g' o g'c'uw't'go gpv'r g'k'q'f " \*c'c'w'w'v'g'f "qp'c' 'u'co r ng'd { / u'co r ng'd'cuku' " y g'g'f' h'q'w'p'f "v'q' "dg'2084" \*u'c'p'f c'tf "f g'x'k'v'k'p' " /2048+0'

13\_ WLU'GRC. "0T'gr q't'v'q'Eq'pi 't'gu'q'p'Drcem'lectdqp.0'F gr 0'lp'v'gt'0'Gp'x'k'q'p'0'T g'rc'0'Ci g'p'ek'u'Cr r tq'r t'k'v'k'p'u'Cev'4232. "pq'0'O c'tej. "r 0'5: : . "4234. " J'Q'p'ri'p'g\_0'C'x'k'c'w'd'g'z'j w'r u'4'y y 5'q'r c'd q'x k'k's w'c'k's { d'rcem'lectdqp'4234'gr q't'v'hw'nt'gr q't'0'f'f'0'

14\_ U'W'M'R'c'p'k'U'0J '0'Y c'pi. "P'0J '0'N'k'p. "U'0'E'j c'p'v'c't. "E'0'V'g'N'g'g. "c'p'f 'F'0'V'j g'r p'w'c'p. "0'Drcem'lectdqp'q'x'g't'c'p'w't'd'c'p'c'v'o q'ur j g'g'lp'p'q't'v'j g't'p'r g'p'k'p'w'c't' " U'q'w'j g'cu'v' C'uk'z' E'j c't'c'v'g't'k'v'k'eu. " u'q'w't'eg' c'r r q't'v'k'p'o g'p'v' " c'p'f " c'u'q'ek'v'g'f " j g'cnj " t'kumi'0' G'p'x'k'q'p'0' R'q'm'w'0' x'q'ni'0' 47: . " Cr t'0' 4242. " f'q'k'z' 320'238'11'q'p'x'r q'ni'0'23; 0'35: 930'

15\_ G'0'E'j g'gm'X'0'I w'g't'ek'q. "E'0'U'j t'w'd'u'q'rg. "c'p'f "U'0'F'ko k't'q'w'r q'w'w'v'0'r'q't'v'c'd'g'c'k'r'w'k'ht'ec'v'k'p'z'g'x'k'g'y "q'h'lo r c'ew'q'p'lpf qqt'c'k's w'c'k's { 'c'p'f 'j g'cnj. "0'U'ek'0' V'4242"

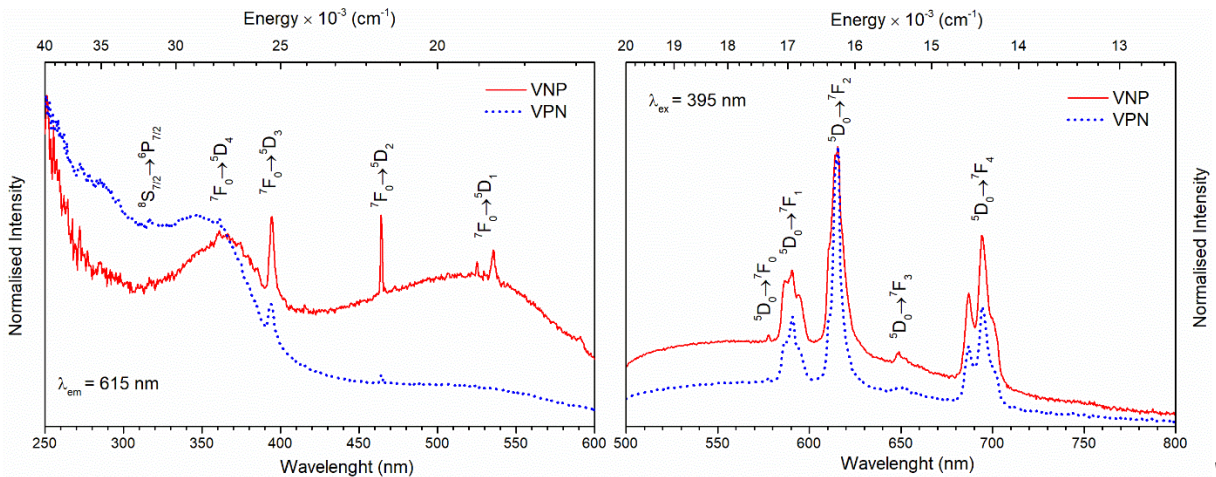
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o qpknc'lcwndf vB o d0kwn'

Y qqf "ku'qpg'qh'y'g"o qu'cdwfp epv'dwrf kpi "o cvgtknu'wugf "lp'tgukf gpv'kn'cpf "pqp/tgukf gpv'kn'dwrf kpi u.'hwtplkwtg"  
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 f go cpf "ku'kpetgcukpi "gxtg{"{gct"}j3\_0"

P gxtg'y grguu.'vj g'y qqf "wugf "lp'rkngf "lpf wnt'lg'u.'tgs vkt'g'j ki j "tguk'ncpeg'v'q"o gej cple'cn'cpf "ej go kcn'f co ci g'0'Qpg"  
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 xqrc'v'ku'y j lej "ctg'hqmy gf 'd' { 'ki p'k'kp'cpf 'hco g'ur t'gcf "cet'qu'v'j g'w'nt'ce'g'kpetgcukpi "vj g'tcv'q'h'j gcv'tc'pu'ht'v'q'f ggr gt"  
 n' { gtu'qh'y qqf '0'Uelg'p'v'ku'ctg'etgc'kpi "o cvgtknu'v'q'gpeq'w'v'gt "o k'p'at "ku'w'g'°'w'w'c'm' { "qti cple'eqo r qwpf u' "r'j qur j q'w/  
 dcugf . "r'j qur j q'w/pk'tqi gp. "r'j qur j q'w/j c'ngi gp'eqo r qwpf u' "ctg'wugf "v'q'lo r t'gi pc'v'v'j g'y qqf . "vj qwi j . "k'ecp' "r' tqf w'g"  
 v'zle' "xqrc'v'kg' "eqo r qwpf u' f w'kpi "r { tqn' u'k'0' I tqy kpi "cy ctg'p'gu'v'q'h'y'g'v'zlek' { "qh' u'w'j "eqo r qwpf u' r'gcf u' v'q' hwt'v'j gt"  
 kpx'g'ki cv'k'p'qh'p'gy "o cvgtknu' "u' { v'go u' c'p'f "o gv' qf u' y j lej "eqw'f "lo r tqx'g' y qqf "tguctf cpe{0'V'j ku'y q'nt'm' r'qr q'gu'c'p"  
 k'p'qi cple' "I f RQ6' "eqo r qwpf "r' tqf w'egf "d' { "lp' ukw'j { f tq'v'j gto c'n' u' { p'v'j g'uk' "lp' y qqf u' o cvtk' "cu'c' p'gy "cngt'p'cv'k'g' c'p'f "  
 k'p'p'x'cv'k'g' o gv'j qf "v'q' k'petgcug' t'guctf cpe { "j4/6\_0"

Uco r r'gu'qh'lu'q'h'y' qqf 'y' g'g'r' t'g'r' ct'gf 'd' { 'lp' ukw'j { f tq'v'j gto c'n' u' { p'v'j g'uk' "cv'332'Æ' l'p'k'k'c'm' { 'g'v'k'p'kpi 'y qqf 'lp'c'x'ce'wwo "  
 c'p'f 'h'v'gt' k'p'at'qf w'egf "v'q' r' t'g'ew'ut' u'q'nw'k'p'u'q'h' I f P Q5 8J 4 QIGwP Q5 8J 4 Q' \*XP R+ c'p'f 'P J 5J 4 RQ6' \*XRP +0' E'j ct'ce'v'gt'k'v'ku'  
 qh' u'co r r'gu'ch'gt' u' { p'v'j g'uk' y g'tg' q'dug't'x'g'f 'd' { 'u'c'p'p'kpi "grgext'q'p' o let'q'ue'qr { "UGO + "qr v'k'c'n'r' t'qr gt'v'ku' "Hk' 0'3' y g'tg' w'ugf "  
 v'q' f' g'v'g'to k'p'g' h'y' qqf "u'w'hc'g' e'q'p'v'k'p'u' v'j g' f' g'uk' g'f' e'g'tco leu. "vj gto qi t'cx'lo g't'le' \*VI + "c'p'c'n' u'k' y cu' r' g'ht'q'to gf "v'q' k'p'ur' g'ev'  
 I f RQ6' "lo r c'ev'q'p' y qqf u' t'guctf cpe { 0"



Hk' 030'Gzekc'v'k'p'c'p'f "go ku'k'p'ur' g'v'c'q'h'y' qqf u' o cvtk' "ch'gt'lp' ukw' I f RQ6-GwJ { f tq'v'j gto c'n' u' { p'v'j g'uk'0'

[3]\_T0E0Rgwtugp.'Vj g'Ej go kcn'Eqo r qu'k'kp'qh'Y qqf .Vj g'Ej go kut { "qh'Uq'nf "Y qqf "429.796348"°3; : 6-0'  
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 H'qt'039'35'°4233-0'  
 [5]\_"H'0'N'k'p'g'v'q'."T'0'F'g'nf'U'q'rg'."F'0'Ec'p'p'q'rg'w'c'."I'0'X'cu'c'r'q'ny'."c'p'f "C'0'O'c'h'g'j | q'rk"O'q'p'k'q't'k'p' "Y qqf "F'g'i'c'f'c'k'q'p'f'w'k'p'i "Y'g'c'v'j'g't'k'p'i "d' { "E'g'm'w'q'ue"  
 E't { u'c'n'p'k' { .O'cvgtknu'7.'32'3; 3263; 44'°4234-0'  
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 4'°4235-0'

**PQXGN'J [ DTK'QTI CPKE/KPQTI CPKE'RGTXUMKVG'Y KVJ "**  
**RTQVQP CVGF 'WPU O O GVTKECN'FKO GVJ [ NJ [ FTC\ KPG'δ"**  
**U PVJ GUK'CPF 'RJ [ UEQEJ GO KECN'EJ CTCEVGTK CVKQP "'**  
Lcp'Crldgtv\ kppnkgy le<sup>3</sup>. 'F qtqvc'Mqy cnum<sup>3</sup>. 'Mxvt| {pc'Hgf qtwnf.'O ctkw| 'Ughc unk<sup>3</sup>. 'Cf co "

<sup>3</sup>'Kpukwv'qh'Nqy "Vgo r gtcwtg'cpf "Utwewtg'Tgugctej . 'Rqrkuj "Cecf go { "qh'Uelgpegu."Qmnp'c'4'ut0'72/644'Y tqerxy . "

<sup>4</sup>'Kpukwv'qh'Rj {uleu.'Y tqe'ey "Wpkxgtukf { "qh'Vgej pqrqi { . 'Y {dt| g g'Y {ur kc unkgi q'49.'72/592'Y tqe'ey . 'Rqrmpf "

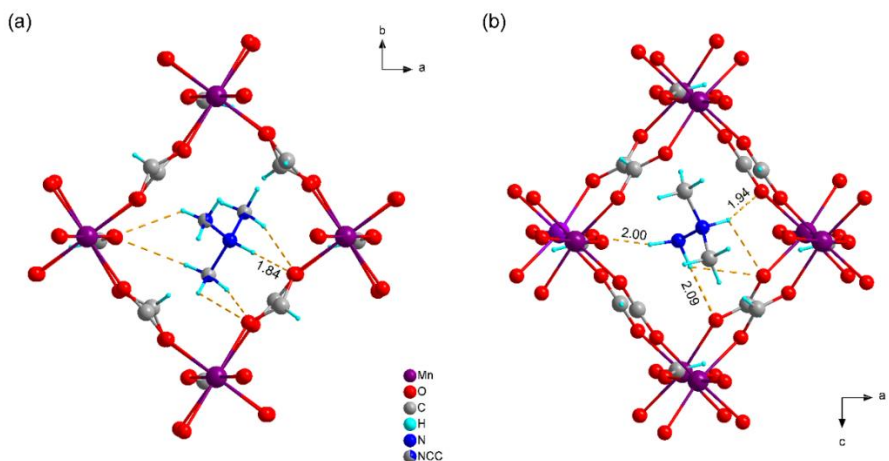
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Qpg'qh'v'j g'uwden'uugu'qh'o gcn'qti cple"ltco gy qtmu"\*O QHu+y kj "xgt { "kpvgtgukpi "r j {uleqej go kecn'r tqr gt'vku'ctg" o gcn'htqo cvgu'vgo r r'v'gf "d { "co o qpkwo "kpu0'Vj g { "ctg"ercuukhgf "cu"j { dtk' "qti cple/kpqi cple" r gtqxumkvgu"\*J QRu+ " dgecvug'o quv'qh'v'j go "cf qr v'r gtqxumkvg/rng'c'tej kgewtg.'f guetldgf "d { "i gpgtcr'htqo wr "CD\*J EQQ+s. 'y j gtg'ukgu"C'cpf " D'cpf "ctg'qeewr kgf "d { "cp'co o qpkwo "kpp'cpf "o gcn'kqp"\*Q00 p<sup>4</sup>. 'Eq<sup>4</sup>. 'Pk<sup>4</sup> "qt' \ p<sup>4</sup> +. 't'gur gev'xgn' "J3\_0

F gr gpf kpi "qp"v'j gk' "utwewtg" cpf "et { ucn' u' o o gt . "v'j gtg'ctg' npqy p" g'zco r r'gu'qh'htqo cvg"J QRu"v'j cv'gzj kdk' nwo kpguegpv'htgtqgru'le. 'htgtqgru'le. 'f kgru'le. 'o ci p'vle'qt' b' wnk'htgtqle' r' tqr gt'vku'0Qw' r' ct'vewr'c'v'w'p'v'p'v'j cu'ecwi j v' d { "co kpgu'y kj "xct { kpi "pwo dgt'qh'o gj { ni tqw u0"

Cp"ketgculpi "pwo dgt"qh'o gj { n'i tqw u' ch'geu'v'j g"u'wgtle"j kpf t'cpeg. "qtf gt"qh'j { f tqi gp"dqpf u' cpf "v'j wu"et { ucn' utwewtg'cpf "r j {uleqej go kecn'r ctco g'v'gu. 'uwej "cu"r j'cug'v'c'puk'k'p'u"RVu+ "vgo r gtcwtgu'qt'htgtqle'qtf gt'kpi 0Hqt'gzco r r'ng. " o cpi cpgug'\*Kk' { f tc| kpkwo 'htqo cvg. 'JJ { \_O p\*J EQQ+s. 'ku'c' b' wnk'htgtqle' b' cvgt'ken'y j lej "et { ucn'k' gu'lp'v'j g'q'v'j q'j qo dle" Rpc<sub>43</sub>'ur ceg'i tqw 0Cv577'M'k'w'p'f gti qgu'RV'v'q'v'j g'Rpo c'eg'p'tqu { o o g'v'le' r' j'cug' "J4\_0Vj g' b' o gj { nj { f tc| kpkwo 'cpcrqi wg. " JO J { \_O p\*J EQQ+s. 'gzr gt'k'p'egu'v'j q'RVu'w' r' q'p'eq'q'k'p'i. "k'g'0'cv'532'M'htqo "f { pco kecm' "f ku'q'f'gt'gf "j k'j /vgo r gtcwtg" \*J V+73e' r' j'cug'v'q'v'j g' r' ct'v'cm' "q'f'gt'gf "t'qo /vgo r gtcwtg"TV+htgtqgru'le"75e' r' j'cug'cpf "cv'446'M'v'q'v'j g'R3' r' j'cug'0Vj g" htgtqgru'le"pcwtg'qh'v'j g'TV' r' j'cug'v'j cu'eq'p'ht o gf "d { "r { tqgru'le" o g'cu'wt'go g'p'u"J5\_0'K'ku'y q'v'j "go r j'cug' k'p'i "v'j cv'v'j g" o gj { nj { f tc| kpkwo "ecv'k'p'v'j cu't'ge'p'w' "uj q'y p'v'q' dg'cp'k'p'v'gt'g'uk'p'i "ci g'p'v'j cv'ecp' dg'w'ug'f "cu'c'vgo r r'v'gf "ecv'k'p'qt'ur ceg' " k'p'f' g'uki p'qh'p'q'x'g'p'p'p'eg'p'tqu { o o g'v'le"5F "qt'4F "r'g'cf "j' c'rk' g' r' g'v'q'x'um'k'v'g"J6.7\_0"

Kp'x'k'gy "qh'v'j g'cd'x'g."v'j g'3.3/f ko gj { nj { f tc| kpkwo "ecv'k'p'ecwi j v'q'w"j w' g'cv'w'p'v'k'p'0'k'p' r' t'g'ug'p'v'f "y q'tm'u { p'v'j g'uku" cpf "r j {uleqej go kecn'r tqr gt'vku'qh'3.3/f ko gj { nj { f tc| kpkwo "cpcrqi wg. 'JFO J { \_O p\*J EQQ+s' \*Hk' 030: 'ctg'f guetldgf "cpf " eqo r ct'gf "v'j "t'gu'wu" qd'v'k'p'gf "ht"j { f tc| kpkwo "cpf " o gj { nj { f tc| kpkwo "cpcrqi wgu' Vj g' v'k'rg" eqo r q'w'p'f "j cu" d'g'gp" k'p'x'g'uki cv'gf "wuk'p'i " b' gj q'f u'qh'f k'ht'g'p'v'c'n'ue'c'p'k'p'i "ec'v'k'p' g'v' { "F UE+ "Tco cp. 'k'p'ht'ct'gf " \*K' +cpf "WX/XKU' r' g'v'q'ue'qr { . " r'q'y f'gt' "cpf " uk'p'i n'g'et { ucn'Z/Tc { "f k'ht'c'v'k'p' " \*ZTF + " o ci p'v'le" o g'cu'wt'go g'p'u"cpf " dt'q'cf' d'c'p'f "f k'gru'le"ur g'v'q'ue'qr { " \*DF U0"



Hk' 030'Vj g'f g'v'c'ku'qh'v'j g'et { ucn'utwewtg'qh'htqo "vgo r gtcwtg"\*c+ "cpf "nqy "vgo r gtcwtg"\*d+ r' j'cug'0Vj g'f cu'j gf "k'p'gu" f' g'uki p'cv'g'P dJ Q'j { f tqi gp"dqpf u' "ng'p'i v'j u'i k'x'gp'k'p' "α +"

"

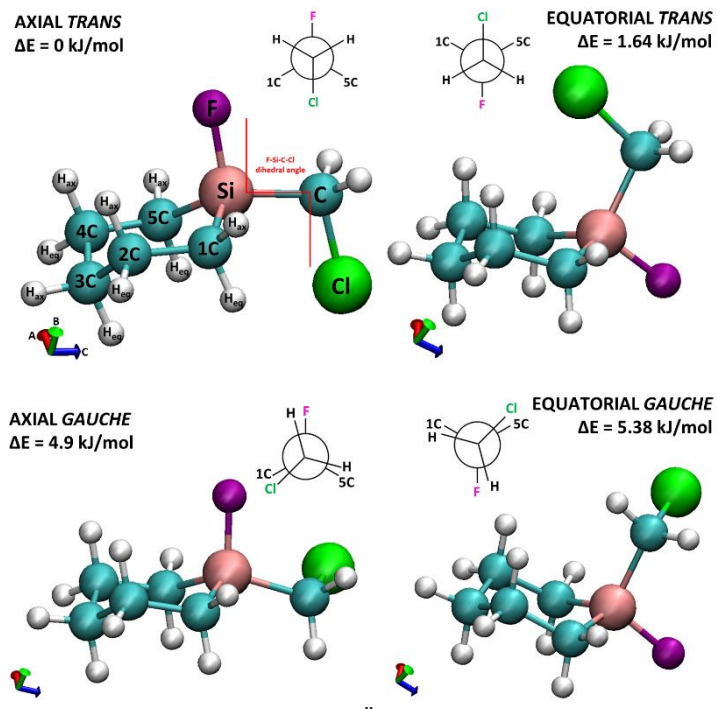
J3\_I (R0' P ci cdj wuj cpe." T0' Uj kxctco c'ej . " C0' P cxtqumf . " Vj gto qej go k'v' { " qh' " o wnk'htgtqle" qti cple/kpqi cple" j { dtk' " r gtqxumkvgu" ]\*EJ 54PJ 4\_0 \*J EQQ+s\_\*O "? "O p. 'Eq. 'Pk'cpf "\ p+ '10Co 0Ej go 0Uqe0359.'32573632578"\*4237-0'  
 J4\_'U0'ej gp.'T0'Uj cpi . "MN0J w'g'v'c'f0"]PJ 4PJ 5\_0 \*J EQQ+s\_\*O "? "O p<sup>4</sup>. 'p<sup>4</sup>. 'Eq<sup>4</sup> "cpf "O i<sup>4</sup> +<utwewtcr' r' j'cug'v'c'puk'k'p'u" r' tqo k'p'gp'v'f k'gru'le" cpqo c'k'gu'cpf "p'gi cv'k'g'v'j gto c'f'gzr'c'puk'p'p'p'f "o ci p'v'le'q'f'gt'k'p'i . "k'p'qti 0Ej go 0Hqt'p03. :. 56. : "4236+ "  
 J5\_'O'0'0' e' l'nc. "C0I i qt. "O'0'Rcm'g'v'c'f0" C0'Rj'cug' "V'c'puk'k'p'u"cpf "Eq'z'k'v'g'p'eg'qh'0' o ci p'v'le"cpf "G'gru'le"Q'f'gt'u'lp'v'j g'O gj { nj { f tc| kpkwo "O g'cn' H'qto cvg'H'co gy qtmu.'Ej go 00 cvgt04; . '448664497"\*4239+ "  
 J6\_'O'0'0' e' l'nc. "O'0'Rcm' C0I i qt. " g'v'c'f0" C0' O gj { nj { f tc| kpkwo " Ngcf " D'tqo k'f'g'<P p'q'eg'p'tqu { o o g'v'le" Vj tgg'F ko g'puk'p'c'ri' R'gt'qxumk'v'g" y kj " G'zegr v'k'p'cm' "N'cti g'H'co gy qtm'f'ku'q'v'k'p'cpf "I t'gg'p' R'j' q'v'q'no k'p'g'ue'p'eg. 'Ej go 00 cvgt054.'388963895"\*4242+ "  
 J7\_'O'0'0' e' l'nc. "C0I i qt. "L0M' \ ct' dc. 'g'v'c'f0" C0'Vj tgg'F ko g'puk'p'c'ri' R'gt'qxumk'v'g" O gj { nj { f tc| kpkwo " Ngcf " E'j n'q'f'k'g'y kj "Vy q' R'q'r' R'j' c'ug'u'cpf "W'p'w'c'ri' U'ge'q'p'f'J c'to q'p'le' I' g'p'g'v'k'p' D'k'nc'ld'k'k'f' "cd'x'g' T'q'qo "Vgo r gtcwtg.'Ej go 00 cvgt054.'6294662: 4"\*4242+ "

**EQO RWCVKQP CN'CPF 'GZRGTKO GP VCN'XKDT CVKQP CN'UVWF [ 'QH''  
 3/EJ NQTQO GVJ [ N/3/HNWQTQUKNC[ ENQJ GZCPG''  
 EQPHQTO CVKQPUCPF 'KWUTGCTTCPI GO GP VU''**

Lqcppe"Uqene<sup>3</sup>."Tcuc"Rrcvcm{ v <sup>3</sup>."Lwukpcu" gr qpmw<sup>3</sup>."Xcfcu"<sup>3</sup>"Edrkpuncu<sup>3</sup>."I co kiCOI vkti ku<sup>4</sup>."  
 Rcy g€Tqf| kgy kel<sup>5</sup>"

<sup>3</sup>Ej go lecnRj { uleu"Kpukswg."Xkpkwa"Wpkxgtukv{ ."Ucwn vgnkq"cr05."32479"Xkpkwa."Nkj wcpk"  
<sup>4</sup>F gr ctvo gpv'qh'Ej go kut { "cpf"DKqej go kut { ."Eqngi g"qh'Ej ctrguvq."Ej ctrguvq."UE"4; 646."WUC"  
<sup>5</sup>Kpukswg'qh'Ej go kut { ."Lcp"MQej cpqy unk"Wpkxgtukv{ ."37I " y k vqnt| { unu"U0"47/628."Mkgreg."Rqrpf"  
[lqcppeUqeneB i o ckrqo](#)

Qti cpqurlep"eqo r qwpf u"ctg"tcvj gt"cwtevkxg"lp"vj g"hgrr"qh'uwthceg'uekgpeg0E { erke"j { ftqectdqp'hko u"j cxg"i qgf"  
 uwthceg'cf j gukqp"r tqr gt vku'y j lej "ctg"o quvn{ "tgrvfg"vq"e" "grgevtqp"qtdkcn0Uwdukswkpi "qpg'ectdqp"cvqo "lp"vj g'tkpi "y kj"  
 c"ukrlep"cvqo "gpj cpegu'cf j gukqp"ukpeg"kv'cevu"cu"j { ftqn{ vccm{ "ugpukxg"egpvt"vj cv'ecp"tgcevy kj "kpqi cple"uwdutcvgu"  
 uwej "cu"i rcuu"vq"lqto "uxcdrg"eqxcrgpv"dqpf u"0'3/ej nqtgo gvj { n/3/hnwqtquknc { emj gzcpg"ku"e"pgy n{ "u{ pvj guk gf "e { erke"  
 qti cple"eqo r qwpf "y kj "wppqy p"utwewtcnr ctco gygtu'cpf"eqphqto cvkqpcif kxgtukv{ 0"



Hki 030Ut wewt gu'qh'hw"ny gu'gpgti { "eqphqto gu'qh'3/ej nqtgo gvj { n/3/hnwqtquknc { emj gzcpg"cpf "vj g'tgur gevkg"  
 F HVID5N[ R'tgrvkg"gpgti kgu0Vj g'H/UK/E/Enf kj gf tncpi ng'ej cpi g'ku'vj qy p"cu'P gy o cp'r tqlgvkap0K'vgtpcn'czgu'ctg"  
 o ctngf "cu"e"tfg + "D"i tggp + "E" \*dmg-0"

Ugxgten'f khtgpv'xkdtcvkqpcn'ur gewtueqr { "o gvj qf u"y gtg"go r nq { gf "vq"cpn{ | g"vj g"r tqr gt vku"qh"vj ku"o qrgewg0  
 Kphtctgf "cpf" Tco cp"ur gevte"y gtg"tgeqtf gf "hqt"vj g"uco r ng"kp"rks wkf "r j cu0' Cf f kkkqpcm{ ."Kf" cduqtr vkqp"ur gevte"y gtg"  
 tgi kngtgf "kp"i cuqquw'r j cuq'cpf "cu"ny "vgo r gtcwtg"uqrf "y kj "vj g"o qrgewgu"kuqrvfg "kp"cti qp"cpf "pktqi gp"o cvtlegu0Kp"  
 qtf gt"vq"eqpvtqn'vj gto qf { pco le'gs wktdtkwo "dgy ggp"vj g'eqphqto gu'j qv'pq | ng'gej pks wgy cu'wugf "f wtkpi "vj g'f gr qukqkp"  
 qh'vj g"i cuqquw'o cvtz"o kzwtg0F HV"ecrwr vkpu"y gtg"r gthqto gf "wkik kpi "D5N[ R'hwpevkqpcn'cpf "cwi o gpvfg "F wppkpi "  
 eqttgrvkap/eqpukrgpv"xcrgpeg" f qwdrg" | gvc"dcuku"ug0'Vj g'3/hnwqtq/3/ej nqtgo gvj { n'uknc { emj gzcpg"o qrgewg"ecp"tgxgcn'  
 vy grxg"eqphqto cvkqpu"qww'qh"y j lej "vj g'ej ckt/czken'vcpu'qpg"j cu"vj g"ny gu'gpgti { 0J qy gxgt."vj gtg'ctg"cuq"vj tgg"vy q"  
 o qtg'ej ckt "v{ r g'eqphqto gu'vj cv'ctg"ucdrg"gpqwi j "vq"r quukdn { "dg"qduqtxgf "kp"gzr gtko gpvcnr gevte0"

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 "

[3\_]J 0Dww"MI tch"O 0Mcr r n'Rj { uleu'cpf "Ej go kut { "qh'hwthcegu."Y krg{ ."4225"  
 [4\_]0Egr qpmu."X0Ucdrkpuncu."XCngmc."O Rwegvks."T(Rrcvcm{ v."E0Y 0f ggf."E(Eqvtg."I 0 vkti ku."Xkdtcvkqpcn'ur gewtueqr { " : 3."358/365."4237"

# O QF GNPI QHUVTWEVWT CN'CPF RJ QVQRJ [ UECN'RTQRGT VKGU' QHCP'QRVKCN'RTQDG'P CS WGQWUCPF 'O GO DTCPG' GPXKQPO GPVU'

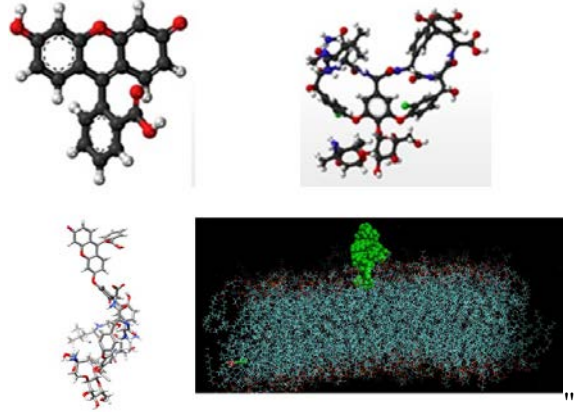
Utk j ct'J ctkj cter wtcp.'Ctwi'O wti w cp'P cvctclcp.'\ kxkpcu'Tkpnxleku.'Rcvkemi'P qto cp''

Hcewn{ "qh'O cyj go cvku'cpf 'P cwtci'Uekpgegu.'F gr ctwo gpv'qh'Rj { uleu.'Mwpcu'Wpkxgtuk{ "qh'Vgej pqm{ { .Uwf gpv " ut072.'NV/7358: 'Mwpcu.'Nkij wcpk. "'

F kxkq{ "qh'Vj gqtgkceci'Ej go kwt { 'cpf 'Dkqmi { . 'MVJ 'Tq { cni'kpkxwsg'qh'Vgej pqm{ { . 'Uqenj qm . 'Uy gf gp' "utllqB i o ckqgo "

**O qvkvcp<I** tco /pgi cvkxg"dcevgtk"ecwulpi "ej tqple"cpf "dkqkno "cuuqekvqf "kphgevkpu"j cxg"dgeqo g'tgukvcpv"vq" o wnk r g" f twi u" cpf "ku" c"eqpegt" cetquu" vj g" i rdg0'K'ku" qh' r ctco qwpv'ko r qtvcpv" vq" f gxgnr " f kci pqvke" ci gpw" cpf " ewt cvkxg" o qrgewgu" hqt" eqo dcvkpi "uwej "dcevgtkcn'kphgevkpu" **Rt qdgo** <Vq" f gxgnr "uwej "o qrgewgu'uwkcdrg" hqt" f kci pqvke" cpf " vj gtr c{ . "dcevgtkcn' go dtcpg" lpxgnr g'ugt'xgu"cu" c'uwkcdrg"vcti gv'cpf "ku'ku" ko r qtvcpv"vq" wpf gtucpf "vj g" kphgevkpu" qh' dcevgtkcn' gpxgnr gu" vq" uo cni' o qrgewgu"vq" f guki p" f twi u" cpf " vq" f gxgnr " o letqdkcn' eqv'kpi u' Vj gqtgkceci" cpf " gzt r gto gpv'cu'uwf lgu'kp" vj g" r cu'f gecf gu" j cxg" f lueqxt g" f cpf " cpcn' ug" vj g' utwewt g' qh' i tco /pgi cvkxg" dcevgtkcn' tguwmu" hqo "vj g" uwf lgu'rcf "vq" vj g' wpf gtucpf kpi "vj cv'vj g' uj cr g' cpf " utwewt g' qh' vj g' qvwt "o go dtcpg" j cu'c' uki p k h c e p v t a q g' k p " f twi " f guki p" vj cv'ecp" r gpgvcg" vj g" ko r gto gdcrg" o go dtcpg' J3\_ 'Cpqj gt "ng{ "vq" k' qh' t' g r x c p e g' k u' v q' f g u k i p' o q r g e w g u' uwkcdrg" hqt" dcevgtkcn' ko ci kpi 00 cp { "o qrgewr" r tqdgu' j cxg' dggp" f gxgnr gf "cpf "qr v'ecni' r tqdgu' ctg' qpg' qh' vj g' f kci pqvke" ci gpw" cpf "kp" vj ku' ko ci kpi "ku" f qpg" d{ "hwqtguegpv" tcegtu" vj cv' vcti gv' q' kmo kpcv" dcevgtkcn' **Qwt' cr r t qcej** <'kpxqkxgu" dkwf kpi " o go dtcpg" o qf gni" vq" cpcn' ug" uo cni' qti cple" o qrgewgu" kphgevkpu" y kj " I tco /pgi cvkxg" dcevgtkcn' egm' o go dtcpgu' Vj g' dculc" o go dtcpg" eqo r r g z " o qf gni' ctg' dkw' wulpi " EJ CTO O /I WKy gd/dcuqf " r n'vqto u' Dcuqf " qp" vj g" r t g x k q u' t g u g t e j " y q t m i' q p " i t c o / p g i c v k x g " d c e v g t k c n' " y g " f g x g n r g f " o g o d t c p g " u { u g o u " w u k p i " j g v g t q i g p g q u " r k k f " eqo dpcv'kpu" eqpukv'kpi "qh' RQRG" \*j qur j cvk { r g v c p q m o k p g + c p f " R Q R I " \*j q u r j c v k { i n i e g t q n' r k k f u' h q m y k p i " v j g " u y r u' k p " v j g' r n'vqto 0Hwt j gt "o qrgewr" f { pco leu'uko wv'kpu" y gtg' r gthqto gf 0Vj g' vclgevt kgu' hqo "vj g' r tqf wv'kpu" t w p " y g t g' w u g f " h q t " h w t v j g t " c p c n' u k u' P g z v' k u' v q' u w f { " v j g' u t w e w t g' q h' x c p e q o { e l p' c p f " h w q t g u e g l p' v c i i g f " x c p e q o { e l p' y k j k p " o g o d t c p g " c p f " v q' u w f { " v j g' r j q v r j { u l e u' q h' x c p e q o { e l p' c p f " h w q t g u e g l p' v c i i g f " x c p e q o { e l p' y j g p' v j g { " c t g' d q w p f " v q " o g o d t c p g " e q o r c t g f " v q' k p " c s w g q u " g p x k q p o g p v' 0Hwt j gt " c k o " k u' v q' u w f { " " e q p h q t o c v k p c n' f { p c o l e u' c p f " q r v e c n i' r t q r g t v g u' q h' h w q t g u e g l p' v c i i g f " x c p e q o { e l p' k p " y c v g t " c p f " k p " v j g " o g o d t c p g " g p x k q p o g p v' 0T g u w m u' F w t k p i " v j g " u k o w v k v p " q h' 322' p u' k o g' u e c n g. " v j g' h w q t g u e g l p' v c i i g f " x c p e q o { e l p' c d n g' v q' d l p f " v q' v j g " o g o d t c p g " c p f " i g' k p u g t v g f " u w i i g u k p i " v j c v' v j g' u w f k e f " x c p e q o { e l p' v c i i g f " h w q t g u e g l p' e c p " d g e q o g " c " r q v g v k e n' o q r g e w r " r t q d g' h q t " o g o d t c p g " k o c i k p i 0Hwt j gt. " u t w e w t c n i' r t q r g t v g u' q h' v j g' u' u g o u' u w e j " c u' c t g c' r g t' h r k f . " x q m o g . " f g p u k f . " g r e v t q p' f g p u k f " c p f " q v j g t " r t q r g t v g u' y g t g' c p c n' u g f 0' Y g' c n u q' c k o " v q' e c t t { " q w' S O I O O " e c r e w v k p u' c u' k o r n g o g p v g f " k p " X g m z e j g o ] 4\_ " h q t " v j g " r t q d g' k p " v j g' y c v g t' c p f " o g o d t c p g " g p x k q p o g p v' v q' u w f { " k u' q r v e c n i' r t q r g t v g u' }

Lipid type	System	Upper Leaflet	Lower Leaflet	Total number of Lipids
POPE:POPG	1:1	21:21	21:21	42:42
POPE:POPG	3:1	33:11	33:11	44:44
POPE:POPG	5:1	40:08	40:08	48:48
POPE:POPG		41:123	41:123	164:164



**Hli wt g03'C+Uwo** o ct{ "qh'f k h g t g p v o go dtcpg" u' ugo u' wulpi " j g v g t q i g p g q u' h r k f u' \*D+0Vqr " / " H w q t g u e g l p . " X c p e q o { e l p . " D q w q o < " H w q t g u e g l p " v c i i g f " x c p e q o { e l p . " R t q d g' d l p f k p i " v q' v j g' o go dtcpg' }

**Eqpenwukpu<Vj** tqwi j "wpf gtucpf kpi "vj g" r j qvqr j { uleu' "cduqtr vqpu. "hwqtguepeg" r tqr gt vgu' qh' q' r v'ecni' r tqdgu' k p " c " o go dtcpg' r k n g' g p x k q p o g p v' y g' e c p' q r v o k g' v j g o " k p " c' y c { " v j c v' v j g' { ' e c p' d g' w u g f " v q' r t q d g' o go dtcpg' u t w e w t g o " }

**Cempqy ngf i go gpw<Vj** g' y qmij cu' dggp' r ctvq' r gthqto gf "wpf gt" vj g' "Rtqlgev" J RE/GWTQRC5" \*P H' T' C' K / 4238/3/952 ; 9+ " y k j " v j g' u w r r q t v' q h' " v j g' G E " T g u g t e j " k p p x c v k p " C e v k p " w p f g t " v j g' J 4242 " R t q i t c o o g - v j g' " h t u v' c w j q t " i t c v g h w n i " c e m p q y n g f i g u' v j g' u w r r q t v' q h' " M V J " T q { c n i' k p u k x w g' q h' V g e j p q m i { . " F g r c t w o g p v' q h' V j g q t g k c e c i E j g o k w t { " c p f " D k q m i { " U / 328 " ; 3 " U q e n j q m . " U y g f g p " c p f " h q t " v j g' e q o r w g t " t g u w t e g u " c p f " g e j p l e c n i' u w r r q t v' r t q x k f g f " d { " R F E " e g p v g' h q t " J k j " R e t h q t o c p e g " E q o r w k p i " c v' M V J . " U y g f g p . " M w p c u' W p k x g t u k f " q h' V g e j p q m i { 0 V j g' U y g f k u j " P c v k p c n i' k p i c u t w e w t g " h q t " E q o r w k p i " \* U P k e + " U y g f g p . " P c v k p c n i' U w r g t e q o r w g t " E g p v g " \* P U E + c v' N k p n i' 4 k p i " W p k x g t u k f . " U y g f g p . " H w p f k p i " c i g p e k u' o' T g u g t e j " E q w p e k i' q h' N l s j w c p k e " \* N O V + " G w t q r g e p " U t w e w t c n i' H w p f u' T q x g t p o g p v' q h' v j g' T g r w d i t e " q h' N l s j w c p k e 0' "

**Eqttgurgpf gpeg' t f f t g u <**o wti wcpB vj ggej go 0nj 0g." ] kxkpcu'kpnxlekuB mwfhw' r cpqtB nj 0g "

[1] J ctkj cter wtcp "Ug'v'cnf' /p <O gf kccn'Rj { uleu' k' vj g' D'cnk' U'cvgu' T' ] g f " C f r d g p g . " F . " M V W R t g u i . " 423 ; " r 0324/326 " ] 4\_ " T k p n x l e k u " \ g v' c n i' Y K' G u' E q o r w c v k p c n i' O q r g e w r t " U e k p e g . " 32-g-3679. 4242

# HYPERSPECTRAL UNMIXING: ALGORITHMS REVIEW AND BENCHMARKING

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Hyperspectral imaging is an emerging technology used in remote sensing for acquiring images on hundreds of spectral bands at the same time. Often hyperspectral cameras have a small spatial resolution compared to RGB cameras, which often creates mixed pixels. Hyperspectral unmixing algorithms aim to estimate the pure spectral pixels and their abundances in hyperspectral imagery. Developed unmixing algorithms are used to solve three main steps of the spectral unmixing problem: 1) accurately estimating the possible endmembers in a hyperspectral image or dataset; 2) finding the spectral signatures in the extracted endmembers; 3) calculating the abundances of each endmember in all of the pixels of a hyperspectral image.

Many of the available spectral unmixing algorithms are not capable of performing all of the main unmixing steps or struggle to do so resulting in an inadequate unmixing accuracy. While using an algorithm capable of completing all three steps with high enough accuracy greatly reduces errors between steps, integration and development times. Many of the available algorithms fall into three main categories:

- Sparse regression models. E. g.: CLSUnSAL [1] an upgraded algorithm based on *alternating direction method of multipliers* that achieved a signal reconstruction error (SRE) score on synthetic data of 21.47 dB and 8.79 dB for 2 and 6 endmembers respectively (with signal-to-noise ratio (SNR) of 40 dB).
- Non-negative matrix factorization. E. g.: TV-RSNMF [2] a blind hyperspectral unmixing algorithm implemented with sparse and total variation regularizers. On synthetic dataset algorithm got spectral angle distance (SAD) of 0.0452 (SNR 10 dB) and 0.0060 (SNR 40 dB).
- Autoencoder networks. E. g.: DeepGUn [3] a network made from generative adversarial network and variational autoencoders to use spatial and spectral information of a hyperspectral cube. Reconstruction root mean squared error (RMSE) metric was used to test the performance of this algorithm and a value of 0.0448 was achieved on a synthetic dataset.

Many of these algorithms not only use different base methods to solve the unmixing problem but also these authors create different methodologies and datasets (e.g. synthetic data created from USGS spectral library [5]) to test their methods against each other, because a standardised experiments and universal datasets are not available. This creates a problem when trying to compare the algorithms against each other and trying select the best quality algorithms for any of the three steps. In turn selecting and improving the best available unmixing algorithm is difficult.

In this paper we review the most popular and newest hyperspectral unmixing algorithms, and create a standardised algorithm testing methodology to benchmark hyperspectral unmixing algorithms. To accurately compare them, the algorithms are tested using three different metrics and five different datasets to more accurately assess the performance of solving any of the three unmixing problems. Used datasets: 1) an artificially created dataset in a laboratory [4]; 2) synthetic dataset create from USGS spectral library [5]; 3) IEEE GRSS 2018 data fusion contest hyperspectral dataset; 4) USGS created Cuprite dataset; 5) USGS created Urban dataset. The metric that are used: RMSE; SAD; SRE. In this paper an experiment using this methodology is conducted to test the algorithm robustness to a change in a number of endmembers and the results of this experiment will be presented.

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**EJ CTCEVGTK CVKQP'QHDQTQP'PKTFF G'S WCP VWO 'F QVU  
U P VJ GUK GF 'D[ 'C'UKPI NG'UVGR'J [ FTQVJ GTO CN'O G VJ QF**

Twi kn 'Nwnc-gxk k v<sup>3,4</sup>. 'Ngpc'I qnwdgy c<sup>4,5</sup>. 'Tgpcw'Mctr ke<sup>4</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rj { uleu. 'Xkrpkw'Wpkxgtuks\ . 'Nkj wcpkc

<sup>4</sup>F gr ctvo gpv'qh'O qngewct 'Eqo r qwpf u'Rj { uleu. 'Egpgt 'hqt'Rj { ulecn'Uekgpegu'cpf 'Vgej pqrqi { . 'Nkj wcpkc

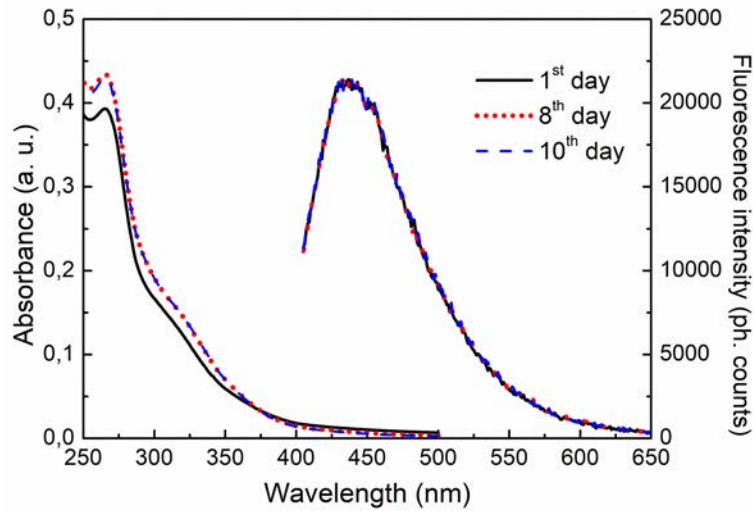
<sup>5</sup>F gr ctvo gpv'qh'P cpqgrgevtqo ci pgvku. 'Kpukwng'hqt'P verget'Rj { uleu'qh'DUW.'Dgrmtwu

twi kq0nwncugxlekwgB i o clrfqo.

S wcpwo "f qu"\*S F u"gzj kdk'gzvctqtf kpt { "qr vlecn'cpf "r j { ulecn'r tqr gtvku "cpf . "j wu . "j cxg'r tqxgp"j go ugrku'kp xctkqwa'kgrf u'qh'tgugctej 'kpenf kpi 'dlq/ko ci kpi . 'dlqmi kecn'rdgrkpi . 'f twi 'f grkxgt { . 'r j qvqecwn\ uw 'grgevtlecn'f gxleku'cpf ugpuqtu'j3\_0

Qpg'qh'j'g'o quv'r tqo kulpi "v\ r gu'qh'S F u"ctg"dqtq"p\kstk'g"s wcpwo "f qu"\*DP S F u: "cu'j g { "gzj kdk'j'g"wpks wg r j { ulecn'cpf "ej go kecn'r tqr gtvku"j4\_ . "kpenf kpi "gzegngpv'o gej cpkcn'utgpi vj . "j ki j "j'g'to cn'wcdkks\ . "nwo kpguegpv r tqr gtvku . "nti g'wv'w'ctg'ctg . "wv'gd'qz'kf cvkqp'tgukwpcg . "y j kej 'r tqxkf'g'gz'v'tgo gn\ "j ki j "f twi /mqf kpi 'ecr cek\ . "o cnkpi vj go "i qqf "ecpf kf cvgu"ht "xctkqwa"dlq/o gf kecn'cr r necvkpu'Vj g'tghqg . "uki plk'ecpv'cvgw'kqp"j cu'dggp"r ckl "tgeg'v'v\ vqy ctf u'j'g'u\{pvj guki'cpf 'hcdt'lecvkqp'qh'wcdng'pqp/vqz'le"DP S F u'y kj "eqpvtqmdng'cpf 'uecn'dng'r tqr gtvku0

Kp'j'ku'y qtm'DP S F u'y g'tg'u\{pvj guki'gf "xlc"j { f tqj'g'to cn'v'g'cvo gpv'qh'j'g'o k'w'g'qh'dqtle'cek'cpf "co o qpk uq'w'kqp"cv'422'g'ht"34'j'0Vj q/wgr 'r w'k'lecvkqp'y cu'r gthqto gf <\*k'j'g'nti g'v'cew'y g'tg'tgo qxgf "xlc"ht'w'kqp'j' tqw'j' 2.44 "Uo "o letqr qtqwa"o go dtcpg . "k'u'q'w'k'p'v'tgr'w'ego gpv'ht"y cvgt"y cu'r tqxkf'gf "xlc"gxcr qtcv'kqp"cv'TV'Vj g'h'p'cn uq'w'kqp'y cu'c'wcdng'v'cpur ctgpv'w'ur gpukqp'y kj qw'x'k'k'ldng'ci i mqo g'tcv'gu'0Vj g'ur gev'tueqr le'r tqr gtvku'qh'u\{pvj guki'gf DP S F u'uq'w'kqp'y g'tg'k'p'x'g'uki'cv'gf "d { "wulpi "w'v'gf { /w'v'g"cpf "Tco cp "ur gev'tueqr {0'Htqo "WX/xku"ur gev'two . "j g o czko wo "cd'v'q'r'v'kqp'y cxg'ng'pi vj "qh'DP S F u'y cu'ht'w'p'f "v'q'dg"487"po "cu'uj'qy p'k'p'Hk'030'Vj g'y'kf'g"go kuukqp'r gcm'ku mq'ec'v'gf "cv'652"po "w'p'f'gt"597"po "gzekc'v'kqp'0Hw'qt'g'ue'p'eg's wcpwo "{ kgrf "qh'DP S F u'y cu'ec'w'v'v'gf "wulpi "U'k'ld'g'p'g'642 cu'c't'gh'g't'g'p'eg'cpf "ku'cd'q'w'8' 0



Hk'030C duqtr v'kqp'cpf 'hw'qt'g'ue'p'eg'ur gev't'qh'j'g'DP S F u'y cvgt'w'k'p'v'v'0Gzekc'v'kqp'y cxg'ng'pi vj " g' "?597"po . go kuukqp'tcpi g" go "?5; 2/872"po 0

F w'g'v'q'ur gek'le'j'gzci qpcn'DP "cv'qo le'w'v'w'w'g . "cp'k'ec'p'eg't'f' twi u'qh'j'g's w'k'p'q'p'g'rk'ng'w'v'w'w'g'ctg'co qpi "j'g'o quv u'w'k'cdng"j'g'tcr gw'ke'ci gpw'j'cv'eq'w'f "dg"gh'g'e'v'x'gn' "f grkxgt'gf "k'p'uk'f'g"j'g'ec'p'eg't'egm'y kj "DP S F "d'ij'w'w'g'0'Vj wu . u\{pvj guki'gf "DP S F u"y km"dg"w'ugf "h'w'v'j'gt "ht "qr vlecn\ "i w'k'gf "f grkxgt { "qh"s w'k'p'q'p'g'f' twi u"cpf "j'g'k' "u'w'd'ugs'w'gpv eqpvtqmdng't'gr'c'ug'k'p'uk'f'g'y'g'ec'p'eg't'egm'0

[3\_]T'0'lg'tqo g . "Cuj qm'M'U'w'p'f'tco qqt'j { . "J { f tqj'g'to cn'U\{pvj guki'qh'Dqtq"p'k'k'f'g"S wcpwo "F qu'w'k'p'v'v'0'g'k'p'q'p'g'rk'ng'w'v'w'w'g'ctg'co qpi "j'g'o quv F g'g'e'v'k'p'qh'c'ue'q't'd'le'c'ek'f . '10'G'ev't'q'ej'go '0'U'q'e'0388 . 'D5239'\*423; +0

[4\_]E'0'f'g'p . "C'0'f' q'v'pi . 'k'0'o'g'le . 'E'0'N'gg'g'v'c'f'0'Dqtq"p'k'k'f'g"u'w'd'v'c'v'g'u'ht"j'ki j /s'w'c'k'v\ "i tcr j g'p'g'g'ev't'q'p'leu . "P'c'v'0'p'cp'q'g'ej'p'qr'0'7 . "944/948 \*4232+0

# GHHGE VU'QH'P GDWNK GF 'ECNEKWO 'P KVT'KVG'E QPE GP VT CVKQP 'QP 'C'' NCUGT/KP F WEGF 'RNCUO C'GO KUKQP 'CP F 'RCT CO GVG TU''

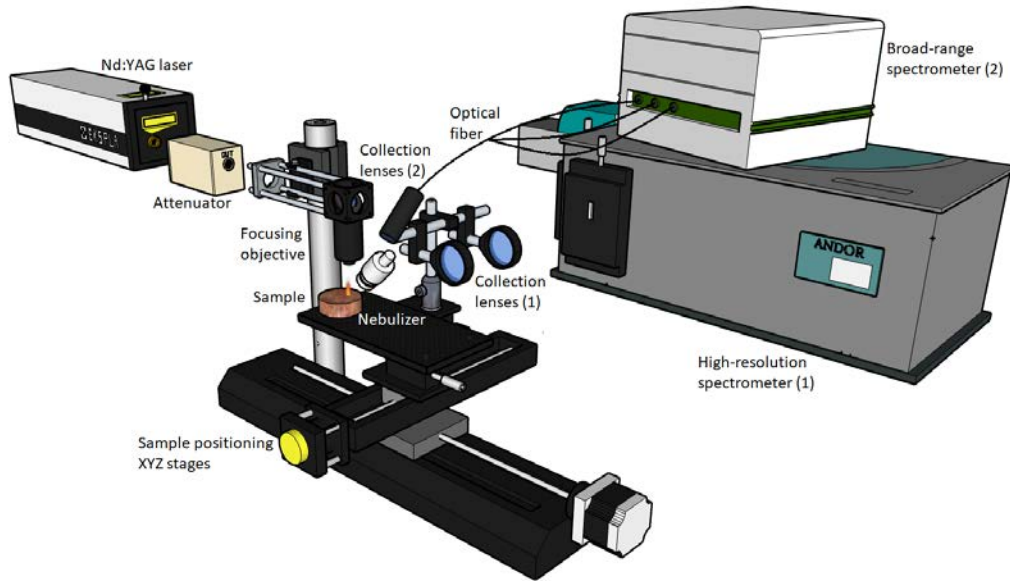
Etkukpc'O<sup>2</sup> pf gl /N»r gl<sup>3</sup>. 'Nwku' Lcxkg<sup>t</sup> 'Hgt<sup>a</sup> pf gl / O gp<sup>2</sup> pf gl<sup>3</sup>. 'Etkukpc' I qpl<sup>a</sup> rg<sup>l</sup> / I ci q<sup>3</sup>. 'Lqti' g''  
Rkuqpgtq<sup>3</sup>. 'P gtgc' Dqtf gn<sup>3</sup>'''

<sup>3</sup>F gr ctvo gpv'qh'Rj { uku. "Wpkxgtuk{ "qh'Qxkgf q. "Ur clp"  
o gpf gl etkukpcB wplqxkQu"

Vj g'f gyto kpcvqp'qh'j cmi g'pu'ku'c'ej cmgpi kpi 'vcunlp'Ncugt/Kpf wegf 'Dtgcnf qy p'Ur gevteqqr { "dgecwug'vj gug'ur gekgu"  
j cxg'ruy "gzekcvqp'ghhlekpekgu."y kj "vj gk't'o quv'kpvugp'go kuukqp'rkp'gu'dgkpi "kp'xcwwo /WX0'F khhgtgpv'utcvgi kgu'j cxg"  
dggp'f g'xgnr gf "k'p'etgcug'ugpukskxv' "qh'f gyvkvqp."gkj gt 'kpxqm'kpi "vj g'wug'qh'c'p'dqng'i cu'cvo qur j g'tg'qt'vj g'f gyvkvqp'qh'  
o qrgewrt'go kuukqp'itgo 'ur gekgu'vj cvt'geqo d'kpg'lp'vj g'r'ruo c''kQ0j cmi gp'cpf 'cp'cm'rkpg'gct'vj "o gvcn'OC'f ct'kewrt'ecug"  
y qwf "dg'vj g'f gyvkvqp'qh'hwqtkpg'xlc'go kuukqp'qh'EcH'J3\_0J qy gxgt. "vj ku'tgs wkt'gu'vj g'uco r'rg'vq'eqpvclp'vj g'cm'rkpg'gct'vj "  
o gvcn'lp'qtf gt "vq'uwr'cu'vj ku'ekewo ucpeg."c'pgdwlk cvkqp'o g'vj qf "y cu'f g'xgnr gf 0'Vj ku'o g'vj qf "k'p'v'qf wegu'ecrekwo "qp'c"  
H'eqpvclp'kpi 'uco r'rg'd'f "f'k'gev'kpi "c'Ec/eqpvclp'kpi "uqmwkqp'cgt'quq'v'qy ctf u'vj g'ruqta'l'p'ekf g'peg'ur qv'0]4\_0"

Vj g'r'j { ulecn'ghg'ew'qh'vj g'p'dgwlk cvkqp'eqo r'ppgw''kQ0C't'ect'lg'k. "wnt'cr wt'g'y cvt'bo c'k'k'. "Ec'p'k'k'g'uqmwkqp'+y g'tg"  
r'vgt "uwf l'gf "kp'c'ugs wgv'kcn'o c'p'p'gt'qp'c' "H'f'g'go qf gr'uc'co r'rg' "E'w' "qdugt'xkpi "c'ut'qpi "cngt'cvkqp'qh'vj g'r'ruo c'r'ruo g'  
uj cr g'cpf "go kuukqp'y j gp'vj g'cs'wgqu'Ec/uqmwkqp'y cu'k'p'v'qf wegf "J5\_0'Vj gug'uwf kgu'y g'tg'f'q'p'g'y kj "ur cvkq/vo r'qtcn'  
t'guqmwkqp'cm'ppi "vj g'x'gt'v'ec'n'cz'ku'qh'vj g'r'ruo c'0"

Kp'vj g'r' t'gug'p'v'y qtm'y kj "vj g'r' wtr'qug'q'lh'w'vj g't' "ej ct'cevt'k'g'vj g'p'ghg'ew'qp'vj g'r'ruo c'." c'f'qwdng/f gyvkvqp"  
g'zr'g'tko gpvcn'ug'vr "y cu'ko r'rgo gpv'g'f 0'Vj ku'y c'."c'j k'j /t'guqmwkqp'ur gev'qo g'vgt'y kj "dq'vj "f'k'hh'cev'kqp' "i' t'cvkpi u'cpf "c"  
o kt'qt'ku'wug'f' h'q't'r't'g'ekug'ur cvkq/vo r'qtcn'o g'cuwt'go gp'v'y j k'rg'vj g'q'x'g't'cm'go kuukqp''ur cvkcn'cpf "vgo r'qtcn'f'k'p'vgi' t'cv'gf "ku"  
eqm'ge'v'f'xlc'qr'v'ec'n'hd'kt'lp'v'q'c' "dt'qcf /t'cpi g''\*422/822"po +p'p'p/i' cvgf "ur gev'qo g'vgt'0'Vj ku'f'qwdng'u'f' ugo "ecp'dg'wug'f'v'q"  
o q'p'k'q't' "q'x'g't'cm' "ej c'pi gu'qp' "vj g'r'ruo c' "y j k'rg'c' "ur gek'k' "r'ct'co g'vgt' "ku'uwf l'gf 0'C' "uej go cvk'gf "x'k'gy "qh'vj g'eqo r'rg'v'g"  
g'zr'g'tko gpvcn'ug'vr "ku'uj qy p'lp'H'ki wt'g'30"



Hki 0300 clp'rgo gpv'qh'vj g'zr'g'tko gpvcn'ug'vr "

Vj g'uwf kgu'ect'lg'f "q'w'v'q' "ej ct'cevt'k'g'vj g'p'dgwlk cvkqp'ghg'ev'qp'vj g'r'ruo c'y g'tg'r' g'rh'qto gf "h'q't'f'k'hh'gt'gpv'Ec/uqmwkqp"  
eqpegp'v'cvk'p'u' \*t'cpi kpi "h'q'to '2' "v'q'37' "+cu'y g'n'ic'u'y kj q'w'p'dgwlk cvkqp.'cu't'gh'gt'g'peg'OC'u'c' h'ku'v'uv'rg'. "vj g'f'qwdng'u'f' ugo "  
y cu'wug'f'v'q' "q'd'v'clp'gzekcvqp'vgo r'g't'c'w'gu'it'qo "dq'vj "f' gyvkvqp' "u'f' ugo u'0'Q'p'g'qh'vj go "t'gs wkt'gu'o w'k'rg'ur gev'c'v' "eq'x'g't"  
cm'vj g'y cxg'g'pi vj "g'zr'quwt'gu'p'geguuct' {"v' "eqm'ge'v'cm'go kuukqp'rkp'gu."y j k'rg'vj g'q'vj g't'cm'qy u'h'q't'c' "h'w'n'ur gev'two "cv'g'cej "  
uj q'0'Ch'g'ty ctf u. "g'rg'ev't'p'ke'f'g'p'uk'k'gu'y g't'g'q'd'v'clp'g'f' "xlc' "U'ct'm'y k'f'g'p'kpi "qh'J /cm'j c'go kuukqp'rkp'g'y j k'rg'o q'p'k'q't'kpi "vj g"  
h'w'n'go kuukqp'0'Vj g't'gu'w'u'uj qy "c'f' get'cgug'qp'gzekcvqp'vgo r'g't'c'w'gu'vj cv'ku'f' gr'g'p'f'gpv'qp'vj g'k'p'et'g'cukpi "co q'wp'v'qh'Ec"  
cpf "cp'cngt'cvkqp'qh'vj g'g'rg'ev't'p'ke'f'g'p'uk'k' "lp'vj g'r'ruo c'."t'gi ctf kpi "dq'vj "ur cvkcn'f' k'w'k'd'w'k'qp'cpf "p'wo g't'k'ec'n'x'cn'w'gu'0"

J3\_E0'f' r'kct'gl /N'ro cu.'L0'R'kuqpgt'q'cpf 'P'0'D'q't'f' g'r'0'S w'ep'k'k'cvkqp'qh'hwqtkpg'x'cegu'lp'u'q'rk'f' "uco r'rg'u'v'ul'pi "Ec'H'o q'rg'ewrt'go kuukqp'd'c'p'f' u'lp'c'wo qur j g't'k' "  
ck' "ruq't'k'p'f' wegf "d't'g'c'nf' qy p'ur gev't'eqqr { 0'Ur gev't'eqj ko 0'C'ev'c'6' R'ct'v'D'<'C'0'Ur gev't'eqe'0'345\*4238+379/3840'  
J4\_E0'f' r'kct'gl /N'ro cu.'L0'R'kuqpgt'q'cpf 'P'0'D'q't'f' g'r'0'C' "p'q'x'g'n'ic'r' r'q'cej 'h'q't' 's' w'ep'k'c'v'k'g'N'ID'U'hwqtkpg'c'p'c'n'f' u'k'u'v'ul'pi "Ec'H'go kuukqp'k'p'ec'rekwo /h'gg'uco r'rg'u'0'  
I'0'C'p'c'n'0'U'Ur gev't'qo 05408\*4239+384/388"  
J5\_E'0'0'2'pf'gl /N»r'gl. "T'0'f' r'kct'gl /I' c't'e'p'c'."E'0'f' r'kct'gl /N'ro cu.'g'v'c'n'0'Ncugt' /K'p'f' wegf "r'ruo cu'c'v'f'k'hh'gt'gpv'p'dgwlk cvkqp'eqp'f'k'k'p'u'<'ur cvkq/vo r'qtcn'  
f'k'w'k'd'w'k'qp'qh'go kuukqp'uki'p'c'n'f'p'f' "gzekcvkqp'vgo r'g't'c'w'gu'0'Ur gev't'eqj ko 0'C'ev'c'6' R'ct'v'D'<'C'0'Ur gev't'eqe'0'392\*4242+327; 28"



# MEASURING THE VECTOR OF A MAGNETIC FIELD USING A DIAMOND CRYSTAL.

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In this work we are using nitrogen–vacancy (NV) centers (Fig. 1 Left) in diamond to measure the vector [1] (magnitude and direction) of a magnetic field.

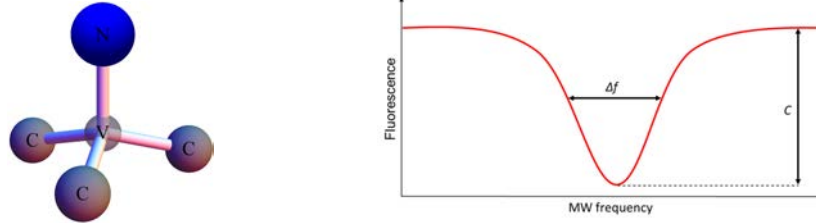


Fig. 1. Left: NV center, a  $C_{3v}$  symmetric structure in a diamond crystal carbon lattice consisting of a carbon atom substituting nitrogen atom and a lattice vacancy adjacent to it. Right: Continuous wave ODMR magnetic field measurement sensitivity.

The sensitivity of a magnetic field measurement [2] can be estimated by the following relation:

$$\eta_{\text{sensitivity}} \approx \frac{\Delta f}{C\sqrt{N_P}}. \quad (1)$$

The main parameters are  $\Delta f$  - the full width at half maximum (FWHM),  $C$  - the optically detected magnetic resonance (ODMR) contrast,  $N_P$  - the number of received photons per second (see Fig. 1 Right).

This work is focused on creating a compact magnetometer prototype device (with a magnetic field sensitivity on the order of  $100 \text{ pT/Hz}^{1/2}$ ) as a part of a feasibility study project with the European Space Agency (see Fig. 2).

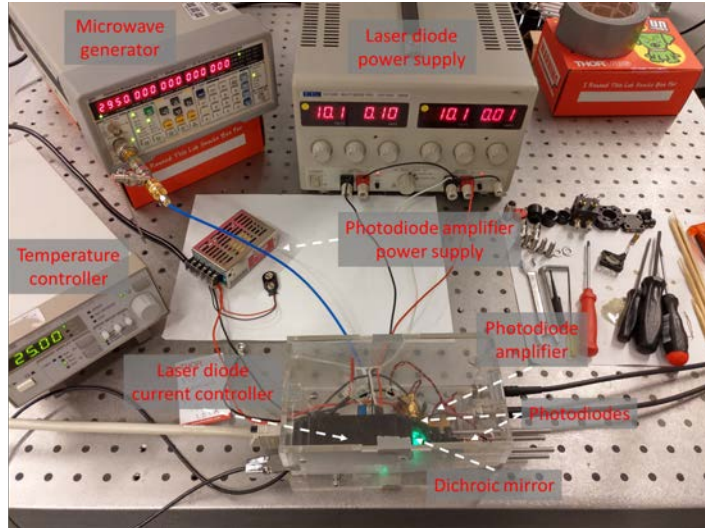


Fig. 2. Experimental setup showing a compact optical system design (laser excitation, fluorescence collection and microwave delivery) encased in a small volume.

## Acknowledgements

We acknowledge the financial support from the Base/Performance Funding Project Nr. ZD2010/AZ27, AAP2015/B013 of the University of Latvia. This activity is carried out under a programme of, and funded by, the European Space Agency, ESA Contract No. 4000129670/20/NL/SC, "Feasibility study of spacecraft magnetometers based on nitrogen-vacancy centres in diamond". The view expressed in this publications can in no way be taken to reflect the official opinion of the European Space Agency.

[1] Jennifer M. Schloss, John F. Barry, Matthew J. Turner, and Ronald L. Walsworth, Phys. Rev. Applied **10**, 034044 (2018).

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**J GRP/O P V'VQZRP/CPVKQZRP 'U UVGO 'CU'C'RTQRQUGF 'DCE VGT KCN' CVR'UGP UQT'**

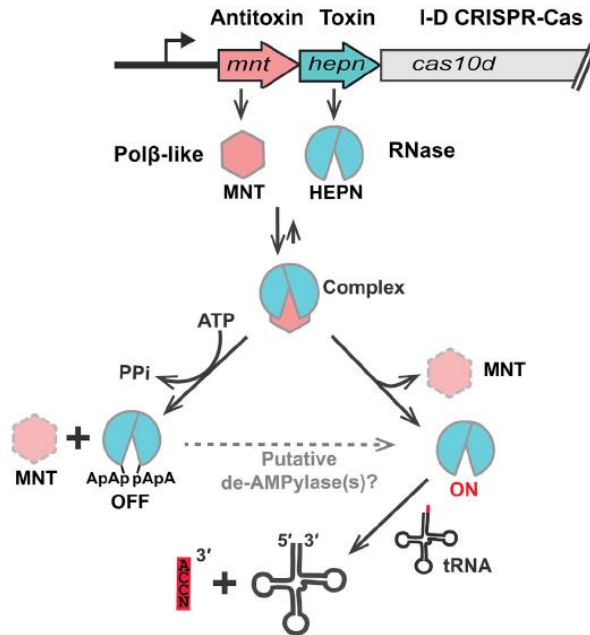
Uqpi cklepg "kpi c<sup>3</sup>. 'Lwq| cr ckku' Lqpcu<sup>3</sup>. 'Vco wrcklepg' I kgf tg<sup>3</sup>. 'Twmugpckg' Cwf tqpg<sup>3</sup>. 'Tm n kuu' Uki kcu<sup>4</sup>. 'Ucupcwunau' I kgf tkwu<sup>3</sup>. 'Xgpenqxcu' guqxcu<sup>3</sup>. 'Tm-p {u' Xki kplku<sup>3</sup>"

<sup>3</sup> "kpukswg'qh'Dkqvej pqmi { .Nkkg' Uelpegu' Egpvtg. 'Xkpkwu' Wpkxgtukf. 'Nkij wcpkc' "  
<sup>4</sup> "Ncdqtcvqt { "qh' Cni qmi { "cpf 'O letqdkri' Geqmi { .P cwtg' Tgugctej 'Egpvtg. 'Xkpkwu. 'Nkij wcpkc' "  
kpi c'Uqpi cklepgB d'k'w'w'"

Rtqnet { q'le'vqzlp/cpvkqzlp' u{ ugo u\*VC +ctg' eqo r qugf 'qh'c'vqzlp. 'ecr cdng' qh'kpvgthgtkpi 'y kj 'ng { 'egmwrct' r' t qeguugu. " cpf 'ku'pgwctck' kpi 'cpvk' qvg. 'y' g'cpvkqzlp0"

J gtg. "y' g' hqewu" qp" yj' g' J GRP/O P V' VC" u{ ugo " gpeqf gf" kp" yj' g' xlekpkl' " qh' c" KF" ETKURT/Ecu" u{ ugo " kp" e { cpqdcvgtkwo "Crj cpk'qo gpqp' hqu'cswc g0 P V' ucpf u' hqt' o' kpk' cni' pwegqvk { ntcpuhgtcug. "y' j' kg' J GRP" tgr' t' gupw' c" i' tqw' qh' j' ki' j' gt' gwmet { qv'u' cpf' r' tqnet { qv'u' d' lpf' kpi' f' qo' c' k' p' r' tqv' kpu. 'o' quv' h' p' qy' p' cu' ce' v' x' g' TP' cugu' ]3\_ ]4\_ OY' g' u' j' qy' gf" yj' cv' J GRP "vqzlp" ceu' cu' cp' TP' cug' y' kj' cp' w' p' w' u' c' n' c' t' i' g' v' r' g' e' k' k' e' k' { 'cpf' "ergcxgu' qh' '6' p' v' h' t' qo' "y' g' 5 / gpf' "kp' c' u' w' d' u' g' v' qh' v' TP' Cu. "y' j' g' t' g' d' { 'kp' v' g' t' h' g' t' k' p' i' "y' kj' "v' c' p' u' r' c' v' k' p' " ]5\_ 0"

O qtgqxt. "y' g' h' q' w' p' f' "y' j' cv' y' g' O P V' cpvkqzlp' kpi' k' l' k' u' J GRP "TP' cug' y' t' q' w' i' j' "gp| { o' c' v' e' t' g' c' e' v' k' p' 0' O P V' r' g' t' h' t' o' u' " eqxcngp' v' f' k' CO R { r' v' k' p' " \*f' k' e' f' g' p' { r' v' k' p' + "qh' c' " e' q' p' u' g' x' g' f' "v' t' q' u' k' p' g' [ 32; "t' g' u' l' f' w' g' "kp' y' j' g' c' e' v' x' g' " u' k' g' " h' q' r' " qh' J GRP "vqzlp' 0' H' w' t' v' j' g' t' o' q' t' g' "y' g' r' t' g' u' g' p' v' e' t' { u' c' m' i' t' e' r' j' k' e' " u' p' c' r' u' j' q' u' " qh' y' j' g' f' k' CO R { r' v' k' p' " t' g' c' e' v' k' p' " c' v' f' k' h' g' t' g' p' v' u' c' i' g' u' " y' j' cv' g' z' r' e' k' p' " y' j' g' " o' g' e' j' c' p' k' u' o' " qh' J GRP "TP' cug' k' p' c' e' v' x' c' v' k' p' 0' H' l' p' c' m' f' . "y' g' r' t' q' r' q' u' g' " y' j' cv' J GRP / O P V' u' { u' g' o' " h' w' p' e' v' k' p' u' " c' u' " c' r' t' k' o' k' k' x' g' " e' g' m' w' r' c' t' " CVR' u' g' p' u' q' t' " y' j' l' e' j' " o' q' p' k' a' t' u' CVR' j' q' o' g' q' u' c' u' k' i' " c' p' f' " c' v' h' y' ' CVR' h' g' x' g' n' i' t' g' r' g' c' u' g' u' " c' e' v' x' g' J GRP "vqzlp' ]5\_ 0"



**Hli '30Rt qr qugf 'b' gej cpluo 'qhl'evkqp' qh' A. flos-aquae' J GRP/O P V'vqzlp/cpvkqzlp' u' ugo 0' C' h' g' t' v' c' p' u' r' c' v' k' p' J GRP "** cpf 'O P V' h' t' o' 'c' v' q' z' l' p' / c' p' v' k' q' z' l' p' \*VC +eqo r r' g' z' 0' W' p' f' g' t' p' q' t' o' c' n' i' e' g' m' w' r' c' t' ' CVR' e' q' p' e' g' p' t' c' v' k' p' u' . O' P' V' c' p' v' k' q' z' l' p' f' k' CO R { r' v' g' u' " J GRP "kp' yj' g' eqo r r' g' z' t' g' u' w' k' p' i' "kp' TP' cug' k' p' c' e' v' x' c' v' k' p' " c' p' f' "VC" eqo r r' g' z' f' k' u' e' k' c' v' k' p' = t' g' r' g' c' u' g' f' t' g' r' v' x' g' n' i' " w' p' u' c' d' r' g' O' P' V' k' u' " r' k' n' g' n' f' "f' g' i' t' c' f' g' f' 0' C' v' h' y' " CVR' h' g' x' g' n' i' e' c' w' u' g' f' "d { "r' j' c' i' g' "k' p' h' e' v' k' p' " q' t' " q' y' j' g' t' " u' t' g' u' u' e' q' p' f' k' k' p' u' " y' j' cv' e' j' c' p' i' g' " CVR' j' q' o' g' q' u' c' u' k' i' " c' e' v' x' g' J GRP "TP' cug' t' g' o' c' k' p' u' w' p' o' q' f' k' h' g' f' " c' p' f' " o' c' { " g' u' e' c' r' g' h' t' q' o' " y' j' g' eqo r r' g' z' 0' T' g' u' w' n' c' p' v' e' r' g' e' x' c' i' g' qh' '6' p' v' h' t' q' o' " y' j' g' v' T' P' C' " 5 / gpf' " c' d' q' i' k' u' j' g' u' c' o' k' p' q' c' e' { r' v' k' p' " c' p' f' " f' k' u' w' r' u' i' t' c' p' u' r' c' v' k' p' 0' C' n' g' t' p' c' v' k' g' n' i' . " f' k' CO R { r' v' g' f' " J GRP "TP' cug' 0' c' { " d' g' t' g' c' e' v' x' c' v' g' f' " d { "cu" { g' v' w' p' n' p' q' y' p' " e' g' m' w' r' c' t' " f' g' CO R { r' v' g' \*u+0

[3\_ "X0C' p' e' p' j' e' t' c' o' e' p' . " M' U' O' c' n' e' t' q' x' c' . " C' O' 0' D' w' t' t' q' i' j' u' . " G' X' 0' M' i' q' p' l' p' . " N' 0' C' t' e' x' l' p' f' . " E' q' o' r' t' g' j' g' p' u' k' x' g' " c' p' c' n' i' u' k' i' qh' y' j' g' J GRP " u' w' g' t' h' o' k' i' f' " k' f' g' p' v' h' e' c' v' k' p' " qh' " p' a' x' g' i' t' a' n' g' u' k' p' l' p' t' c' / i' g' p' q' o' k' e' ' e' a' p' h' k' e' u' . " f' g' l' p' u' g' . " y' c' v' j' q' i' g' p' g' u' k' i' c' p' f' " T' P' C' r' t' a' e' q' u' k' p' i' 0' D' k' i' r' i' F' k' g' e' 0' 4' 2' 3' 5' L' w' p' ' 3' 7 = 3' 7 0' q' k' 3' 2' 0' 3' : 8' 1' 3' 9' 6' 7' / 8' 3' 7' 2' : / 1' 3' 7' 0' ] 4\_ " N' 0' C' t' e' x' l' p' f' . " G' X' 0' M' i' q' p' l' p' . " F' P' C' r' q' i' o' g' t' c' u' g' d' g' v' / r' i' n' g' " p' w' e' r' g' q' v' k' f' { n' t' c' p' u' h' g' t' c' u' g' " u' w' g' t' h' o' k' i' f' " k' f' g' p' v' h' e' c' v' k' p' " qh' y' j' t' g' g' p' s' y' " h' o' k' i' g' u' " e' n' c' u' k' k' e' c' v' k' p' " c' p' f' " g' x' q' u' w' k' a' p' c' t' { " j' k' a' a' t' { O' P' v' e' r' g' l' e' " C' e' k' i' u' T' g' u' 0' 3 ; ; . " C' r' t' ' 3' - 4' 9' + 3' 8' 2 ; / 3 : 0' f' q' k' 3' 2' 0' 2 ; 5' l' p' c' t' 1' 4' 9' 0' 0' 8' 2 ; 0' ] 5\_ " U' q' p' i' c' k' l' e' p' g' . " I' 0' L' w' q' | c' r' c' k' k' u' . " I' 0' v' c' o' w' r' c' k' l' e' p' g' . " C' O' f' w' m' u' g' p' c' k' g' . " 3' U' 0' U' w' e' l' s' u' . " I' 0' U' c' u' p' c' w' u' n' e' u' . " O' X' g' p' e' n' q' x' c' u' c' p' f' " X' 0' U' k' n' p' { u' . " J GRP / O' P' V' v' q' z' l' p' / C' p' v' k' q' z' l' p' " U' f' u' g' o' < " V' j' g' " J GRP " T' k' l' e' p' w' e' r' g' c' u' g' " K' u' " P' g' w' t' c' k' i' g' f' " d { " Q' r' i' q' C' O' R { r' v' k' p' 0' " O' q' i' n' " E' g' n' 0' " 4' 2' 4' 2' " F' g' e' " 3' 9 = 2' \* 8 + ; 7' / ; 9' 2' 0' 9' 0' f' q' k' 2' 3' 0' 2' 3' 8' 1' 1' 0' q' e' g' t' 2' 4' 2' 0' 3' 0' 2' 5' 6' 0

# ACTIVATION OF NUCLEAR FACTOR NF- $\kappa$ B RECOGNITION PROMOTER-CONTROLLED REPORTER GENE TRANSCRIPTION BY PULSED ELECTRIC FIELD TREATMENT IN VIABLE HEP-2C AND CHO-K1 CELLS

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A significant number of human disease phenotypes are linked to mutations in over 4000 genes (as per OMIM Gene Map Statistics, 2020). This has created a base for therapeutic strategies that can modify nucleic acids within disease-affected cells, eg., gene therapy, and many genes have been investigated as potential candidates for such strategies. However, effects of transgene medicinal agents depend on the dosage, therefore, both for laboratory and therapeutic applications, a regulated gene expression is a potential requirement. In this context, pulsed electric field technology could be a candidate for non-invasive, biophysical activator of the induction of gene expression.

The aim of this study is to examine the use of microsecond pulsed electric field ( $\mu$ sPEF) stimulation as a proof-of-concept for potential non-ligand physically triggered inducer of gene expression in viable mammalian cells. We report here the response and activation of heterologous transcription system, which consists of NF- $\kappa$ B controlled synthetic promoter and a reporter gene (pNF- $\kappa$ B-SEAP) in viable human cervix carcinoma cells (Hep-2c) and *Cricetulus griseus* ovarian tissue (CHO-K1) cells. The conditions for treatment were selected based on published data [1, 2]. The rectangular electric pulses with different amplitude, fixed pulse frequency (1 Hz) and pulse duration (100  $\mu$ s) was used. Results are reported in relative expression of SEAP in folds 24- and 48-hours post-pulsation. The cellular metabolic activity was assessed 24- and 48-hours post-pulsation and was expressed as a percentage relative to the untreated control cells.

pNF- $\kappa$ B-SEAP transfected Hep-2c cell line exposure to  $\mu$ sPEF of 0.25, 0.3 and 0.4 kV/cm resulted in increased levels of relative expression of SEAP (approximately 1.7-fold compared to the control) 24 hours post pulsation. However,  $\mu$ sPEF of 0.165 kV/cm showed the highest peak of relative expression of SEAP in Hep-2c cell line 24 hours post-pulsation – 2-fold in comparison to control. No gene expression activation was detected in Hep-2c cell line 48 hours post-pulsation. Conversely, no activation of gene expression was detected in all experimental setup in CHO-K1 cell line 24 hours post-pulsation, but  $\mu$ sPEF of 0.3 kV/cm resulted in increased levels of relative expression of SEAP (approximately 1.2-fold compared to the control) 48 hours post-pulsation. All experimental setup resulted in high viability of both cell lines.

We conclude the activation of NF- $\kappa$ B in Hep-2c cells is achieved by  $\mu$ sPEF treatment of cell suspension reaching the peak at 0.165 kV/cm 24 hours post-pulsation. The activation of CHO-K1 is achieved at lower levels at 0.3 kV/cm with a time delay and is detected 48 hours post-pulsation. Experimental setup of PEF application does not have a significant impact on viability of treated cells. To our knowledge, this is the first experimental study that demonstrates  $\mu$ sPEF can act as the inducer of target promoter.

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**P Q X G N ' C R R T Q C E J ' Q P ' C R R N E C V K Q P ' Q H ' C P ' G Z V T G O Q R J K N E ' T G F ' ' C N I ' C ' C Y A N I D I O S C H Y Z O N M E R O L A E ' K P ' R J [ V Q T G O G F K C V K Q P ' ' G y c ' D a t q y u n e <sup>3</sup> . ' O c v g w u l ' C d t c o <sup>4</sup> . ' L q c p p c ' M c t i w i <sup>4</sup> "**

<sup>3</sup> Vj g'Eqngi g'qh'Kpvt/Hcewm' Kpf kxf wcn'Uwf lgu'lp'O cyj go cvleu'cpf 'P cwtcn'Uelkpegu\*'O KUO cR+.'Wpkxgtukv' 'qh' Y ctucy . 'Rqrpf "

<sup>4</sup> Uqmt'Hwgn'Ncdqtcvt{ . 'Egpyt'qh'P gy 'Vgej pqrqi lgu.'Wpkxgtukv' 'qh'Y ctucy . 'Rqrpf " gldqtqy uncB dlqrw Qf wft n'gy cldqtqy unc: 8B i o chfgo "

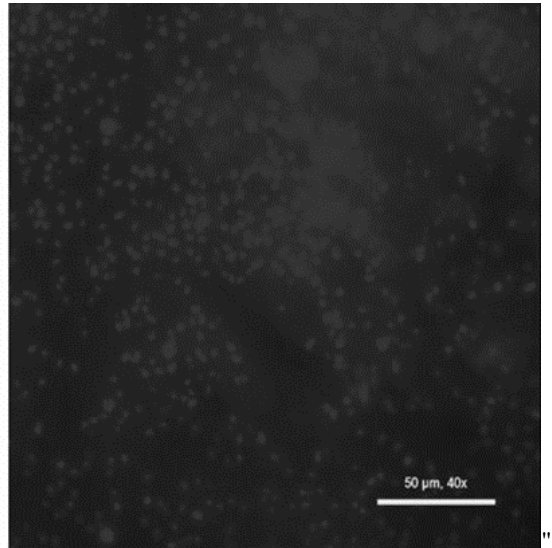
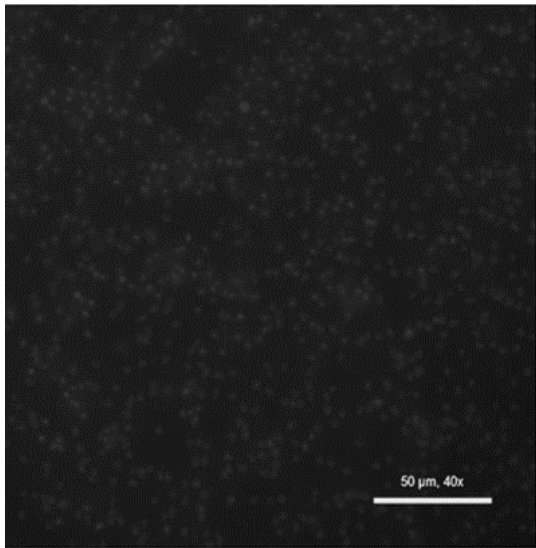
"

Kp'qwt'r tguv'v'y qtrf . 'y cvgt'r qmwkqp'cpf 'dlqtgo gf kcvkp'ctg'co qpi 'vj g'o quv'ko r qtcvp'kuwgu'hceki 'qwt'uqekv' " cpf "qwt" r nppg'U'Uelkpvku'ctg' gpf gcxqt'kpi "vq" f lueqxt' "pqxgn'o g'j qf u' hqt" tgo qxkpi "r qmwcpw" hqo "y cvgt" qt' ergcp " unxf i gu' hqt' uchgn' "tgwupi "eqpwo kpcv'f "y cvgtu'0O quv'qh'v'j g'ug'gp'xk'qpo gp'vri'j c| ctf u'ctg'etgcv'f "kp" vj g'j wo cp'ur j g'g' " uwe'j "cu'cekf "cpf "o gvcn'htgt'qwa'f tclpci g. "y j lej "cnuq'eqp'v'k'j" gcx { "o gvcn'0Cek'le" cpf "gwt'qr j le" y cvgtu'ecp'f g'vgt'o kpg' " hwt'j g't' f cpi g'qwa'eqpf k'k'qpu' hqt' "dkqf kxgtukv' "cu'cp' lpetgcug'qh'g'k'j g't' "dkqj gple" grgo gpw'qt' vj g'cekf k'v' "qh'i t'qwpf "cpf "ugc" " y cvgtu'0Qti cpluo u. "gur gekm' "vj qug'v'j cv'ecp" vj tkxg'lp'pcwcm' "r qmwgf" j cdkcvu. "i kxg'wu'c" i tgcvr' quukdkv' "vq" wug'v'j g'k' " hgcwt'gu' hqt' w'pf g'v'cp'f kpi . 'ergcpkpi . 't'cpuhqto kpi . 'cpf' tgo qxkpi "vzle" r t'qegu'gu' ]3\_0

Qpg'qh'v'j g'r quukdkv'gu' hqt' t'gf welpi "vzlekv' "qh'y cuvg'ku'v'q' cr r n' "o letqti cpluo u'lp' dlqtgo gf kcvkp'0Vj wu. "vj g'dguv' " q'r r q'w'p'k'v' "ku'v'q' wug' t'gr'x'cp'v'qti cpluo u'y k'j "c'y k'f g'ur gev'two "qh'cev'k'v' "cpf "cf cr cvkqp" v'j "cto hwt'eqpf k'k'qpu. "uwe'j "cu" " y k'j "gz'tgo q'r j k'gu'0

E{cpkf kqej {/qp"o gtqr'g"ku" c"tg" "o letqni cg. "ppg"qh'v'j g'o quv'r tko k'k'g'cni cg"lp' h'cev" y j lej "pcwcm' "gz'ku"lp' " uwr j cvg'tlej "j qv'ur t'kpi u'j cdkcv' "r J "30. "cv'67"o"78"AE+cuuqekv'f "y k'j "j k'j "j g'cx { "o gvcn'eqpegp'v'k'qpu" ]4. "5\_0" k'p'v'j k'p' " t'gug'ctej . 'y g'r t'gug'p'v'j g' h'ktu'v'gr u'v'q' cuuguu'v'j g' dlqtgo gf kcvkp' r q'v'p'v'cni'qh' E0b gtqr'g'0Y g'o g'cuwt'gf "egm'ut'x'k'cdk'k'v' " k'p' "v'j g' r t'gug'peg" qh' ugr'ev'g'f "j k'j " ucni' eqpegp'v'k'qpu" cv' v'q' i t'qy v'j "vgo r g'cwt'gu" \*64" AE" cpf "47" AE+0 K' ku' y q't'v'j " o gp'v'k'p'kpi "v'j cv'v'j ku' t'gug'ctej "k'p'v'q'f v'eg'u" c'pgy "egm'ut'c'k'p'qh' E{cpkf kqej {/qp"o gtqr'g"dcugf "qp" v'j g'P KGU/3554" ut'c'k'p' " \*O letq'cni' Ewmt'g' Eqng'ev'k'p' h'qo " v'j g'P cv'k'p'cni' K'p'v'k'w'g' h'qt' "Gp'x'k'qpo gp'v'ri' Uwf lgu' \*Vuv'w'w'c. "lcr cp++" y j lej "ku" " cf cr v'g' "v'q' xct'k'qwa' r J " cpf "ecr c'dng' qh' d'g'kpi "cp" g'ht'g'ev'k'g' i t'qy v'j "w'pf g't" r J " eqpf k'k'qpu" k'p' "v'j g' t'cpi g'qh' 40" v'q' 80'0 N'k'ngy k'ug. "k'v'ecp' dg'ew'k'x'cv'g'f "k'p' v'go r g'cwt'g' t'cpi gu'qh' 47" o' 87" AE. "cmj q'w'j "v'j g'qr'v'ko c'nt'cpi g'ku' 62" o' 64" AE'0

Qwt' t'gug'ctej "ko r rik'u" c'pgy "h'cev'v'q' eqr'g'y k'j "uwe'j "r gew'k'c't' r qmwkqp' y k'j "c'f k'ht'gp'v'r J " t'cpi g'0Vj ku' t'gug'ctej "ku" " dcugf "qp' R'cv'gp'v'p'q'w'k'ev'k'p' d' { "R'q'k'uj "R'cv'gp'v'Q'ht'eg<P q0R6548: 60



Hki 030Hwqt'g'uepeg'bo letqueqr { 'ko ci gu'qh'ej n'qtqr j { m'go ku'k'qpu' h'qo "E0b gtqr'g'egm'ewmt'gf "cv'f k'ht'gp'v'r J < \*c+40" \*d+@80

Y g'f lueqxt'g'f "ko r q'v'p'v'f k'ht'g'p'egu'dgy ggp'egm'lp'xct' { kpi "r J "eqpf k'k'qpu'uwe'j "cu'v'j g'k'uk' g'c'p'f "uj cr g'uj qy p'lp' " Hki 0'30'0 letqueqr le" c'p'cni' uku' y cu' r g'ht'qto gf "xlc" NU942" h'wqt'g'uepeg'bo letqueqr g' "G'c'm'wo c'v'c'v'62z" o ci p'ht'ev'k'p' "cpf " " ej n'qtqr j { m' "gz'ek'cv'k'p' " cv' 7: 2" o' 7: ; " po 0' 72" UO " uecrg'0' Dq'v'j " o letq' t'cr j u' "uj qy " v'j g' h'wqt'g'uepeg' " qh' l'p'f k'k'f w'cn' " ej n'qtqr r'cuu'lp' "E0b gtqr'g'egm'0Vj ku'uj qy u'v'j g'egm'x'k'cdk'k'v' "lp' d'q'v'j "ewmt'gu'0

Kp' uwo o cvk'p' " v'j ku' r t'gr'ko k'p'ct { " f'cv' " cpf " pgy " egm' ut'c'k'p' " qr gp' " hwt'j g't' r quukdkv'gu' qh' l'p'x'g'unk'v' cv'k'p' " hqt' " v'j g' " dlqtgo gf kcvkp' r q'v'p'v'cni'qh' E0b gtqr'g'0

[3\_]UOMI w'v'c0Crr'ne'cv'k'p'qh'0 letq'cni cg'lp'Y cuvg' cvgt' V'ig'c'w' g'p'v' "U' t'kpi g't. "Uy k'j g't'p'f. "423; #0  
 [4\_]VOM'at'q'ky c. "gv'cni'E{cpkf kqej {/qp"o gtqr'g'0C'P gy 'O qf g'it'G'w'nt {q'v' h'qt' E'gm'c'p'f 'Q'ti c'p'ng'g' D'k'q'qi { "U' t'kpi g't. "U'pi cr q'tg. "4239-#0  
 [5\_]ROF g'N'w'ec. "gv'cni'E{cpkf kqej {/qp"o gtqr'g'c'p'gy "cni c'qh'v'j g'to c'nt'c'k'le" g'p'x'k'qpo gpw'0 l'q'w'p'v'cni'q'h' R'ev'v'v'c'z'q'p'qo { "c'p'f I' g'qi t'cr j { "53" \*3; 9: #0

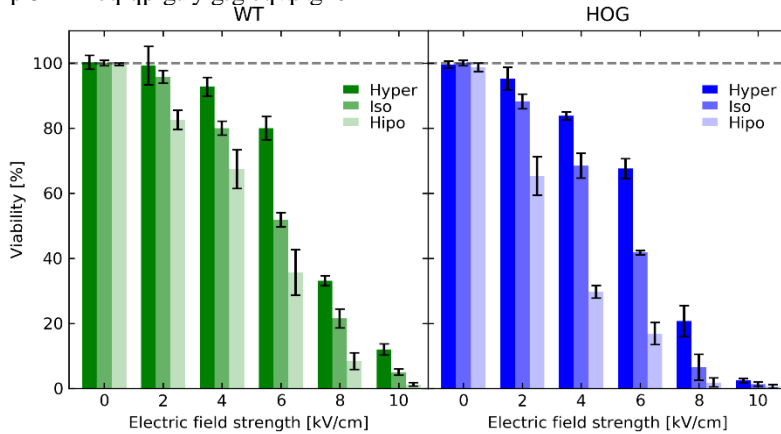
**IPXGUVK CVKQP'QH'QUO QVKE'UJ QEM'GHHGE VUQP'[ GCUV'E'GNN'  
TGURQP UGU'VQ'RWNUGF 'GNGE VT'KE 'HKNF 'VTGCVO GP V'**

I tgv'I cp {v<sup>3</sup>. 'Rqxkr'u' "k' qpk<sup>3</sup>. 'Ct pcu'Uktm<sup>3</sup>"

" "  
<sup>3</sup>Ncdqtcvt { "qh'Dkqrgvteku. ""  
 Egpvt' hqt' Rj { ulecn'Uelgpegu'cpf "Vgej pqm { ."  
 Ucvn vgnk' cr05. "Xkpkwu. 'Nkj wepk"  
 i tgv' cpe { vB i o ch'eqo. "

Uceej ctqo { egu'egt gxlk'g' { gcuu'ct g'ulpi ng/egmgf 'gwect { qve'hwpi wu'o letqati cpluo u0Upep'cpekp'vko gu'yj g { 'j cxg' dggp'wugf "kp'dcnkpi . 'y kngo cnkpi 'cpf 'dtgy kpi 0Vj g { 'cmu'j cxg'dggp'y kf gn' 'wugf 'cu'c'o qf gn'qti cpluo u'ht'c'pwo dgt'qh' tgcuppu'kpenf kpi 'uko kct 'kp'vtpcn'egm'cpf 'i gpg'ut wewtg'vq'j k j gt'gwmt { qvqu. 'hcu'f qwdkpi 'vko g'cpf 'ny 'o c'k'p'p'peg' tgs vkt go gpw'j3\_0F wtkpi 'vj g'eqwtug'qh'g'xqmwkqp' { gcuu'cf cr vgf 'vq'go r nq { 'vj g'J QI 'r cvj y c { 'vq'tgeqxtg' chgt'f cpi g'qwu' egm'ij cr g'o qf k'lec'v'p'p'cpf 'k'p'v'ceg'mwct 'y cvgt 'f'kud'c'p'eg'ec'wugf 'd { 'gp'x'k'q'p'o gp'v'c'q'uo qve' r' tguu'w'g'ej cpi gu'j4\_0Rwugf " grvete' h'grf "RGH'v'g'cvo gp'v'ku'hpqy p'v'q'ec'wug' r'ruo c'o go d'c'p'g' r' gto g'cd'k'k' c'v'k'p. 'cp'gh'ge'v'hpqy p'cu'gr'ge'v'qr q'c'v'k'p. " { g'v'c'v'j g'o qo gp'v'j g't'g'ku'p'q'k'p'q'to c'v'k'p'q'p'y j g'v'j g't' d'k'q'ej go k'c'nr' cvj y c { u't'g'ur q'p'uk'ng' h'qt' k'p'v'ceg'mwct 'quo qve' d'c'p'eg' j cxg'c't'q'ng'k'p' { gcuu't'g'ur p'p'ug'v'q'RGH'v'g'cvo gp'v'j5\_0

Kp'vj ku'uwf { 'y g'lp'x'g'uki cvgf 'h'quo qve' r' tguu'w'g'ej cpi g'j cu'cp { 'gh'ge'v'hp'egm'x'k'cd'k'k'v' 'cpf 'y j g'v'j g't'J QI 'r cvj y c { ' r n'c' 't'q'ng'k'p' t'geqxtg' { 'chgt'RGH'v'g'cvo gp'v'G'zr g'tko gp'w'y g't'g' r' g'ht'q'to g'f 'y k'j 'y k'f 'v' r'g' [ 22222' { gcuu'cpf 'c'o w'c'p'v' ut'cl'p'f g't'k'x'g'f 'ht'qo 'Y V. [ 24946. 'y k'j 'p'q'c'v'k'x'g'J QI 3'i g'p'g'0 [ gcuu'ht'qo 't'g'ur g'e'v'x'g'ut'c'k'p'u'y k'n'd'g' t'gh'g't'g'f 'cu'Y V'cpf " J QI 0'Egm'y g't'g'i t'qy p'w'p'k'i3'QF. 't'c'p'uh'g't'g'f 'v'q'gr'ge'v'qr q'c'v'k'p' d'w'ht'g' "42'o O 'VT'k'U. '3'O 'u'q't'd'k'q'n' r'J " ? '906+ " { gcuu' u'w'ur g'p'uk'p' 'y cu'g'z'r q'ug'f 'v'q'ul'pi ng'gr'ge'v'k'le' h'grf "r w'ug' 'y k'j 'f'v'c'v'k'p'q'h'372'U'u'cpf 'h'grf 'u't'g'p'i v'j 'q'h'w' 'v'q'32'n'X'leo 0' G'g'v'qr q'c'v'k'p' d'w'ht'g' 'y cu'w'ug'f 'cu'c' t'gh'g't'g'p'eg' r' q'k'p'v'q' t'g'r t'g'ug'p'v'lu'q'uo qve' e'q'p'f k'k'p'p'u'0'Chgt'RGH'v'g'cvo gp'v'egm'y g't'g' ko o g'f k'c'v'g'f 't'c'p'uh'g't'g'f 'v'q'j { r g't'q'uo qve' \*30'0 'u'q't'd'k'q'n: 'ku'q'uo qve' q't'j { r q'q'uo qve' \*20'0 'u'q't'd'k'q'n: 'ku'q'uw'k'p. 'k'p'ew'c'v'g'f " h'qt'7'o k'p'w'gu'c'p'f 'r' r'v'g'f 'q'p'c'i c't'k' [ RF 'o g'f k'c'0'U'y k'n'q'uo qve' r' t'g'u'w'g'ej cpi g'y k'n'd'g'f g'h'k'p'g'f 'cu'quo qve' 'ij q'em'0'Chgt' v'y q'f'c { u'q'h'k'p'ew'c'v'k'p' k'p'52'9'E'eq'm'p'k'g'u'y g't'g'eq'w'p'v'g'f 0



Hki 030 [ gcuu'x'k'cd'k'k'v' { f'gr g'p'f g'peg'q'p'quo qve' 'uj q'em'it'g'cvo gp'v'chgt'RGH'v'g'cvo 'ku'f'gr lev'g'f 'q'p'v'j g'gh'v'ul'f'g'k'p' i t'gg'p'eq'm'w't. J QI 'x'k'cd'k'k'v' 'ku'f'gr lev'g'f 'q'p'v'j g't'k'i j v'ul'f'g'k'p' d'w'g'eq'm'w't0Qr c'ek'v' { 'q'h'v'j g't'g'ur g'e'v'x'g'eq'm'w't'g'r t'g'ug'p'w' quo qve' 'uj q'em'it' r' r'g'f <f c't'ng'v'ht'j' { r g't'q'uo qve' . h'ki j v'g'u'ht'j' k'r q'q'uo qve'0

K'y cu'uj qy p'yj c'v'egm'u'x'k'cd'k'k'v' { f'get'g'cu'g'u'y k'j 'v'j g'k'p'et'g'c'g'q'h'gr'ge't'k'le' h'grf 'u't'g'p'i v'j 0'V't'c'p'uh'g't'q'h'RGH'v'g'c'v'g'f 'egm'u' v'q'ul'w'k'p'p'u'y k'j 'f' h'ht'g'p'v'q'uo qve' 'eqo r q'uk'k'p' 'u'ki p'k'k'ec'p'v' { 'k'p'hw'g'peg'f' { gcuu'egm'x'k'cd'k'k'v' "Hki 03000 q'u'w'p'q'v'c'w'g'x'k'cd'k'k'v' " ej cpi gu'y g't'g'ur q'w'g'f 'chgt'6'cpf '8'n'X'leo 0'Chgt'6'n'X'leo 'j { r g't'q'uo qve' 'uj q'em'it'g'c'v'g'f 'Y V'cpf 'J QI 'x'k'cd'k'k'v' 'd' { '35' " cpf '37' .j { r q'q'uo qve' 'o'f' get'g'c'g'f 'd' { '34' 'cpf '5; ' t'g'ur g'e'v'x'g'gn' 0'Chgt'8'n'X'leo 'j { r g't'q'uo qve' 'uj q'em'it'g'c'v'g'f 'Y V'cpf " J QI 'egm'x'k'cd'k'k'v' 'd' { '4: ' 'cpf '48' .j { r q'q'uo qve' 'o'f' get'g'c'g'f 'd' { '38' 'cpf '47' ' t'g'ur g'e'v'x'g'gn' . 't'g'r'v'x'g'v'q'p'q'ku'q'uo qve' + 'uj q'em'it'g'cvo gp'v'0'V'q' h'w'j g't'lp'x'g'uki cv'g'v'j g'k'p'hw'g'peg'q'h'quo qve' 'uj q'em'it'g'cvo gp'v'g'c'v'c'i g'q'h'k'p'v'ceg'mw't'eqo r q'w'p'f' u'y cu' g'x'c'w'c'v'g'f 0'c' d'q'at'd'v'k'p'c'v'y cy g'p'p'i v'j u'q'h'482'po 'cpf '4: 2'po 't'g'x'g'c'g'f 'v'j c'v'j g'co q'w'p'v'q'h'k'p'v'ceg'mw't'eqo r q'p'g'p'w'k'p'v'j g' o g'f k'c' 'f' get'g'c'g'f " chgt'j k'r g't'q'uo qve' 'uj q'em'it'g'c'v'g'f " chgt'j k'r q'q'uo qve' 'uj q'em'it'g'c'v'g'f " u'w'r r'q't'v'k'p'i 'v'j g'j { r q'v'j g'uku' 'v'j c'v' o g'ej c'p'k'c'nr'egm'ij cr g'c'ng't'c'v'k'p'k'p'hw'g'pegu'egm'u'g'c'v'k'p'v'q'RGH'v'g'c'v'g'f g'to q't'g'. 'u'c'v'k'c'nr'c'p'c'nr' u'ku'eq'p'k'to g'f 'v'j c'v'J QI " ut'cl'p'y cu'o q't'g'ug'p'uk'x'g'v'q'd'gh'g't'go gp'v'k'p'g'f 'v'g'cvo gp'w'uw'i i g'uk'p'i 'v'j c'v'J QI 'r cvj y c { 'ku'q'h't'g'ng'x'c'p'eg'v'q't'geqxtg' { 'chgt' gr'ge'v'qr q'c'v'k'p'0

Vq'lw'o o c't'k'ug. { gcuu'egm'x'k'cd'k'k'v' 'chgt'g'z'r q'uw'g'v'q'RGH'v'g'c'v'g'f 'd' { 'u'w'd'ugs w'g'p'v'ej cpi g'k'p'quo q'r'ct'k'v' { 'q'h'o g'f k'c'0 J QI 'r cvj y c { 'lp'x'q'k'go gp'v'y cu'k'p'ng'f 'v'q't'geqxtg' { 'chgt'gr'ge'v'qr q'c'v'k'p'0

[3\_0'R'c't'or q'w'k'c'0'X'c'uk'g'k'f'ku'c'0'U'0'c'g'p'f'c. 'cpf 'G0J' c'v' k'u'w'w'u. '0'U'ceej ctqo { egu'egt g'x'k'k'g'c'p'f 'ku'k'p'f w'nt'k'c'nr' r' d'ec'v'k'p'u'o. 'C'IO U'0' let'q'd'k'r0'8'3'< 3653'4242'+" [4\_'U'0J' qj o c'p'p. '0'E'q'p'v'q'n'q'h'j' k'i j 'quo q'r'ct'k'v' 'u'ki c'p'm'p'i 'lp'v'j g' { gcuu'U'ceej ctqo { egu'egt g'x'k'k'g'o. 'H'G'D'U'Ng'w'039'7: 5'46+6247/; . '\*422; +' [5\_'C'0'U'k'ng. 'T'0'E'g'k'g'k'w'g' I' g'to c'p'le'p'g. 'C'0' lo m'w'u. 'P'0' w'c'w'uk'p'g. 'R'0'U'o q'p'ku. 'C'0'F' g't'x'p'ku. 'C'0'T'c'o c'p'x'le'k'u. 'c'p'f 'U'0'D'c'ng'x'le'k'u. '0'v'j g'h'p'nd'g'y g'p'p' { gcuu'egm'y c'nr'q't'q'uk' { 'c'p'f 'r'ruo c'o go d'c'p'g' r' g'to g'cd'k'k'v' 'chgt'RGH'v'g'cvo gp'v'U'el'g'p'v'k'le'g'r q't'u'x'q'nd; .3'36953. '\*423; +'

# BIOSYNTHESIS OF RECOMBINANT ALLERGENS USING MAMMALIAN CELLS EXPRESSION SYSTEM

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IgE-mediated allergic reactions are the most common hypersensitivity disorders affecting up to 30% of the population worldwide and still rising. Due to the high prevalence of these diseases, accurate diagnosis is critical to ensure the most effective treatment. Immunological test systems for allergy diagnostics currently mostly involve allergen extracts, which are a heterogeneous mixture of various allergic and non-allergic components. Levels of the main allergen and the additional substances could vary among different batches of the product. In contrast, recombinant allergens can be produced as defined molecules with known immunologic and biological features [1]. The usage of purified recombinant allergens instead of allergen extracts could increase the accuracy of allergic reaction detection, as well as reduce cross-reactions. Recombinant proteins could be produced using various expression systems, including mammalian cells. The ability to perform post-translational modifications that are not present in proteins produced in prokaryotes makes mammalian cells expression system an advantageous production platform [2].

This study aimed to produce recombinant secreted maltose-binding protein (MBP) fused wasp's allergen Ves v 2 (rVes v 2-MBP) and cow's milk allergen Bos d 4 (rBos d 4-MBP) in mammalian cells. Synthetic DNA fragments coding these allergens were cloned to mammalian expression vector and transiently transfected into Chinese hamster ovary (CHO) cells. Secreted rBos d 4-MBP was purified using MBP affinity tag and confirmed using immunoblotting and indirect enzyme-linked immunosorbent assay using monoclonal antibodies against MBP. However, recombinant Ves v 2 allergen was not secreted into cells growth media but was detected in intracellular compartment of the cell. To determine if synthesized recombinant protein antigenicity is similar to natural allergen, blood serum samples from patients allergic to cow's milk were tested with rBos d 4-MBP. Also, blood serum samples were tested using the same recombinant allergen produced in *E. coli*.

Results show that serum samples with allergen-specific IgE recognizes rBos d 4-MBP antigen produced in CHO cells, suggesting that recombinant protein contains IgE-binding epitopes. Nevertheless, rBos d 4-MBP protein produced in *E. coli* was not recognized by specific IgE.

In conclusion, recombinant Bos d 4 fused with MBP expressed in mammalian cells is most likely to be similar to native protein as compared to the same recombinant allergen produced in *E. coli*. These results indicate that mammalian cells expression system is suitable for eukaryotic protein production and synthesized recombinant proteins could be used for improving molecular allergology tests *in vitro*.

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[2] M. Curin, V. Garib, R. Valenta, Single recombinant and purified major allergens and peptides How they are made and how they change allergy diagnosis and treatment, *Ann Allergy Asthma Immunol*, 119(3): 201–209 (2017).

**FGUK PPI 'C'XKUEQUK\ /UGP UK\KG'DQF RR\ 'HNWQTQRJ QTG'HQT'C' NKGE'EGNN'KO CI PPI "**

Mctqrkpc'O cpgenk<sup>3</sup>. 'Lgrpc'F qf qpqxc<sup>4</sup>. 'Ugr cu'Vqrkcwcu<sup>5</sup>. 'Twi kn 'fi kn pckv<sup>3,4</sup>. 'F flkwi cu' Lxti wku<sup>6</sup>. 'Xkcrklwu'Mctcdcpqxcu<sup>6,7</sup>. 'Uki kcu'Vwo ngxk kwu<sup>4</sup>. 'C wtko cu'X{-pkcwunεu<sup>3</sup> "

<sup>3</sup>Egpgvt'qh'Rj {ulecni'Uekgpegu'cpf'Vgej pqrj {.'Ucwn vgnk'cx05.'Xkpkwu.'NV/32479.'Nkj wcpkc0"

<sup>4</sup>'Kpukwng'qh'Ej go kut {.'Hcewn'qh'Ej go kut { 'cpf' I gquekpegu.'Xkpkwu'Wpkxgtuk\.'P cwi ctf wnj'ut046.'Xkpkwu.'NV/25447.'Nkj wcpkc"

<sup>5</sup>'Kpukwng'qh'Ej go lecn'Rj {uleu.'Hcewn'qh'Rj {uleu.'Xkpkwu'Wpkxgtuk\.'Ucwn vgnk'cx0; /KK'32444'Xkpkwu.'Nkj wcpkc"

<sup>6</sup>'Dkqo gf lecn'Rj {uleu'Ncdqtcvqt {.'P cvkpcn'Ecpegt'Kpukwng.'R0Dcwidrk'ut05d.'NV/2: 628'Xkpkwu.'Nkj wcpkc"

<sup>7</sup>'F gr ctvo gpv'qh'Ej go kut { 'cpf' 'Dkqgpi kpggtki {.'Xkpkwu' I gf ko kpcu'Vgej plecn'Wpkxgtuk\.'Ucwn vgnk'cx033.'NV/32445.'Xkpkwu.'Nkj wcpkc"

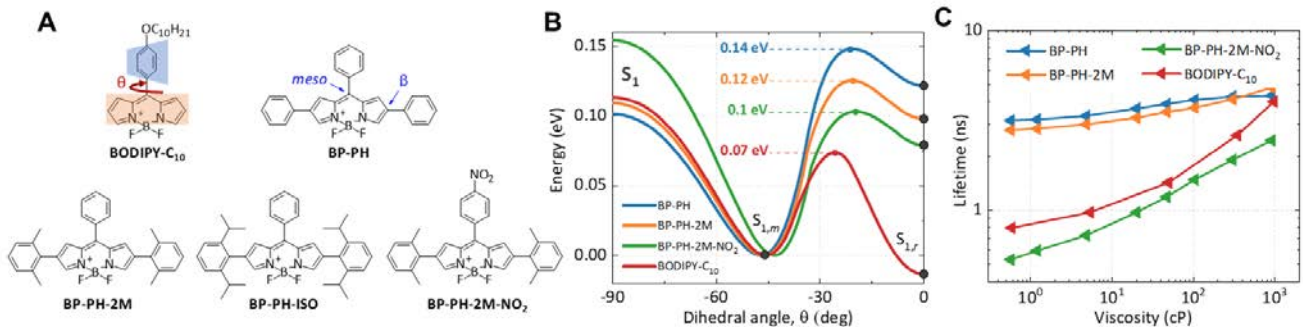
**netqrkpcO cpgenkB ho eOv'**

Xkuequk\ "ko ci kpi "cv" c" o letqeur le" uecrg" ecp" tngxci' kphqto cvkqp" cdqw" vj g" f khwukqp/eqpvtqmgf" r tgeguugu" kp" dkqu(ungo uO' F vgyto kplpi "c" o letqxkuequk\ "ej cpi g" ecp" kpf kecvg" vj g" f gxnqr o gpv' qh' cvj gtquerqtaku." f kcdgvgu." cpf" Cij j glo gtu'f kugcugQ3\_ "O qrgewrt'tqvtu'ctg'xkuequk\ /ugpukxg'hwqtqr j qtgu'vj cvr tqxf g'qpg'qh'vj g'gculgv'o gj qf u'vq" ko ci g"o letqxkuequk\ 0'Vj gug'hwqtqr j qtgu'j cxg'dggp" go r m' gf 'hqt'ko ci kpi "o letqxkuequk\ 'kp'r qn'o gtu.'hxlpi 'egmu'cpf" rkr kf'dkrc {gtuQ3\_ 'Vj g'eqpegr v'qh'o qrgewrt'tqvtu'o gej cpkuo 'ku'dcugf'qp'c'ej cpi kpi 'hwqtguegpeg'uki pcn'y j lej 'go gti gu' hqo 'vj g'eqo r g'v'kqp'dgvy ggp'kptco qrgewrt'tqcvkqp'cpf' go kwgf 'rj qvqpu0'Vj g'pcwtg'qh'vj g'grcvtqplecm\ 'gzekgf 'ucvg' ku'ej cpi gf 'd{ 'vj g'tqcvkqp'ecwukpi "c" hcvgt'pqp/tcf kcvkxg'tgrczvkqp0'Vj gtghqtg." c" rpi gt'hwqtguegpeg'rhgkvo g'qh'vj g" o qrgewrg'ku'dquxtxgf 'kp'c'j ki j 'xkuequk\ 'gpxkqpo gpvQ4\_ "

Qpg'qh'vj g" o quv'y kf gn\ wugf "o qrgewrt'tqvtu'ku' DQF RR\ /E<sub>32</sub>" \*Hk 0'3C-0'Vj ku'ucpf qw" o qrgewrg" f kur rε {u'vj g" o qpqzr qp'pvcn'hwqtguegpeg" f gec{. "y j lej "uko r rkhgu" vj g" f cvc" cpcn\ uku' Wphqtwpcevgn\." vj g" i tggp' cduqtdcpeg" cpf" hwqtguegpeg'y cxgrpi vj u'ctg'vj g'i tgcvgu'f tcy dcem'qh'vj g'DQF RR\ /E<sub>32</sub>0'K'ku'y gm'hpqy p.'vj cv'vj g'rpi gt'y cxgrpi vj u' ctg'f gultgf 'hqt'xkuequk\ "ko ci kpi "qh'vj g'dkqni lecn'uco r ng'0'K'ku'r quikdr'vq'cej kxg'mpi gt'y cxgrpi vj u'd{ 'kptqf welpi " eqplwi cvgf 'uudukwgpw'cpf'gzv'p' kpi 'vj g'eqplwi cvkqp'rpi vj 'y kj kp'vj g'hwqtqr j qtgQ5\_ 'J qy gxt. 'y g'j cxg'vq'gpwut'vj cv' vj g'pvy 'tgf/go kwpki 'DQF RR\ "o qrgewrg'tgo kpcu'xkuequk\ /ugpukxg0"

Vq'cxqkf "c"ko g'equwo kpi "u{pvj guku'qh'c'rti g'pwo dgt'qh'hwqtqr j qtgu'y kj "xctkqu"o qf kkecvkqu."y g'uj qy "j qy " f gpuk\ 'hwpevkpcn'vj ggt { \*F HV-'ecrewr'v'kpu'ecp'j gr 'vq'f vgyto kpg'xkuequk\ /ugpukxg'r' tqr g'v'ku'qh'vj g" o qrgewrg'dghqtg" ku'u'pvj guku'0'K'vj ku'y qtm"y g'kpxguki cvg'hqwt'rj gp {n'uudukwgf "DQF RR\ "o qrgewrt'tqvtu'"\*Hk 0'3C-<y kj qw'cp { cf f k'k'p'cni'o ql'v'ku'qp" /rj gp {n'\*DR/RJ +y kj 'y q'o gj {n'\*DR/RJ /40 +qt'kuqr tqr {n'\*DR/RJ /KQ+i tqwr u'qp'gcej " / rj gp {n'tkpi." cpf" o gj {n'uudukwgf" /rj gp {n'y kj "c'pkqtq/uudukwgf "o guq/rj gp {n'\*DR/RJ /40/P Q<sub>4</sub>+0'K'vj ku'ecug." cf f kpi " /rj gp {n' kpetcgugu" o qrgewrg'u' eqplwi cvkqp" cpf" tgf /uj kku' hwqtguegpeg" ur gev'tc" vq" dkqni kcm\ /htkpf n' "y cxgrpi vj uO"

Vj g' tgugetej "eqpuku" qh' s wcpwo "ej go lecn' ec'ewr'v'kpu." cduqtr v'kqp" cpf" hwqtguegpeg" ur gev'tc" o gcuw'tgo gpw" hwqtguegpeg'rhgkvo g'gxcn'cvkqp." cpf" r'kxg'egmu'ko ci kpi "wukpi "rkr kf" xgukrgu'F gr gpf gpeku'tgi ctf kpi "vj g" o qrgewrt' utwewtg."cev'x'cvkqp'gp'gti { "dcttktg." kpetgukpi "uqrxgpv'xkuequk\." r qrtk\." cpf" vgo r gtcwtg'y gt'g'kpxguki cvgf 0'S wcpwo " ej go lecn'ec'ewr'v'kpu'uj qy gf "vj cv'p'kpetcgug'kp'cp'cev'x'cvkqp'gp'gti { "dcttktg" \*Hk 0'3D+tgwuu'lp'tgf /uj kngf 'hwqtguegpeg" ur gev'tc0O qtgqxt. 'F HV/dcugf 'ecrewr'v'kpu'cmqy gf 'wu'vq'et'cv'c'tgf/go kwpki "r tqdg'd{ 'kptqf welpi "c'pkqt' i tqwr. 'y j lej " tgf wegu'vj g'dcttktg'cpf' kpetcgugu'xkuequk\ /ugpukxk\ 'qh'vj g" o qrgewrg" \*Hk 0'3E" :Q6\_ "



Hk 0'30'C+Vj g'utwewtg'qh'vj g" o qrgewrt'tqvtu'wugf 'kp'vj ku'y qtm'cpf' vj g'tqvt'o gej cpkuo 'uj qy gf "qp'DQF RR\ / E<sub>32</sub>0'VF /F HV'ecrewr'v'g'f' r qv'pvcn'gp'gti { "utw'ceg'ew'xgu'"\*D'cpf' xkuequk\ /f gr gpf gp'hwqtguegpeg'rhgkvo gu'"E+qh'DR/ RJ "dmx+ 'DR/RJ /40 " {gmjy + 'DR/RJ /40/P Q<sub>4</sub>" i tggp+ 'cpf' DQF RR\ /E<sub>32</sub>" tgf +0"

[3]\_O 0MDMwko qxc.'Rj {ulecni'Ej go kut { 'Ej go lecn'Rj {uleu.'4234.'36.'348936348: 80  
 [4]\_O 0C0J ckf gmgmt'cpf' GOC0Vj gqf qtcnku.'Qti cple'cpf' Dkqo qrgewrt'Ej go kut {.'4229.'7.'388; 6389: 0'  
 [5]\_F 0\ j cpi 'gv'cni'Rj {ulecni'Ej go kut { 'Ej go lecn'Rj {uleu.'4233.'35.'352486352550'  
 [6]\_U'Vqrkcwcu'gv'cni'Ej go kut { '6'C'Gwtqr gcp'Iqwp'cn'423; .47.'3256463256: 0'

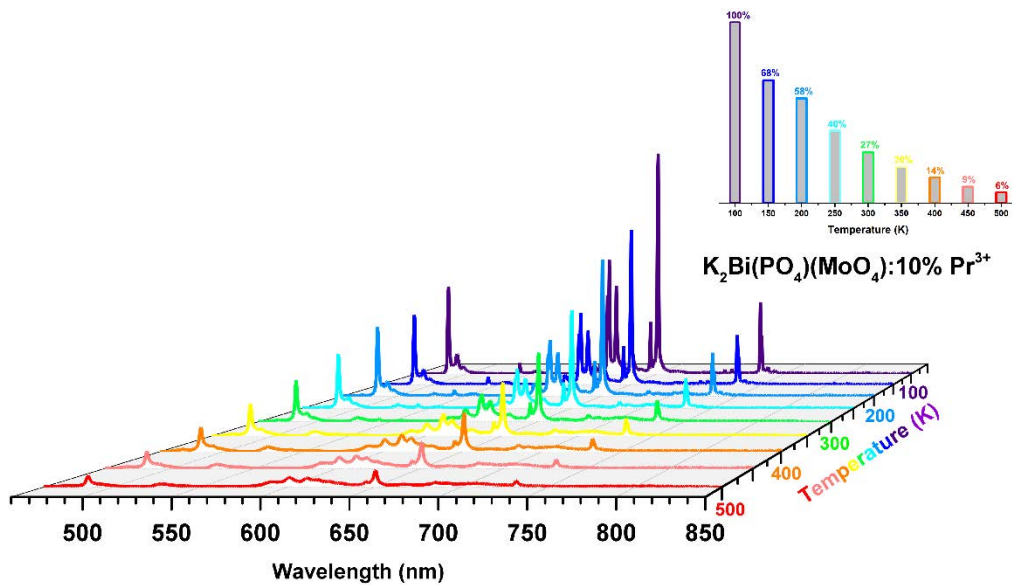
**QRVĖ CN'RTQRGT VĖGU'Ė XGUVĖ CVĖQP 'QH'DNWG/GZEK/CDNG''**  
**TGF/GO KVVĖPI 'M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+Rt<sup>5</sup>- 'RQY F GTU'**  
**Lwĭcĭ tki qtlgxckg<sup>3</sup>. 'Ctwtcu'Mcvgpknqxcu<sup>3</sup>**

<sup>3</sup>Kpukwwg"qh'Ej go knt { .F gr ctvo gpv'qh'Ej go knt { 'cpf 'I gquekpegu."Xkpkwu'Wpĭkgtukv { .Nkj wcpĭc "  
Lwĭcĭ tki qtlgxckgB ej ĩxvĭm'

Vj g'f ktgev'tcpukqpu'ĭtqo <sup>5</sup>R<sub>L</sub>\*L? "2."3."4+qt<sup>6</sup>F<sub>4</sub>"gzekgf 'ĭgxgn'vq'vj g'i tqwpf 'uvcvu<sup>8</sup>J<sub>L</sub>+tguwu'kp'ĭj ctr 'ĭkpgu'kp'vj g' Rt<sup>5</sup>- 'go kuukqp'ur gev'tcDgukf gu.'kp'ĭqo g'j quv'o cvtĕgu.'vj g'gpgti { 'o ki cvkqp'ĭtqo <sup>6</sup>R<sub>L</sub>'vq<sup>6</sup>F<sub>4</sub>'ĭgxgn'ĕcp'dg'qdugtxgf { 'ĭkrf ĭpi " gzenwukxgn' 't'gf "go kuukqp"j3\_0'ĭp'qwt'uwf ĭgf "j quv'o cvtĕz.'pco gn'."M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+."qpn' 'ĭpvtĕcpĭki vtcvĭkpcn'8h' "8h" vtcvĭkqpu'y g'tg'qdugtxgf OCnq.'ĕtquu'tgrzcvkqp'r tqeguug'ctg'xgt { "ĕqo o qp 'ĭp'ĭpqi cple'o cvgtĕni'f qr gf 'y kj "vtkxĕgpv' r tcugqf { o kwo "ĭqpu'cpf "vj ku'r tqegu'ku"tgr qpukdg'hqt"vj g'go kuukqp"s wpej ĭpi ."gur ĕekm' "cu" c" ĭwpevkqp"qh'f qr cpv' ĕqpegpvtcvkqp0Vj g'ĕtquu'tgrzcvkqp'r tqegu'ĕcp'dg'f ktgev' 'o gcuwtgf 'd { "gzco ĭkpi "vj g'ĭwqtgvegpeg'ĭvĭpukv' 'f ĕec { "ĕhgt "vj g'r wugf "gzekcvkqp0"

Hqt'vj g'ĕhqtgo gpvĭkpgf 'tgcūqpu.'Rt<sup>5</sup>- 'f qr gf 'M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+u' p'j guku'cpf 'qr vĕcni'o gcuwtgo gpv'u' g'tg'r gthqto gf 0' O qtgqxtg.'vj g'ĭwĭo ĭpĕuegpeg'r tqr gt vĕgu'qh'ĕtg/gctvj 'ĭqpu'ctg'f vĕgto ĭpĕgf 'd { 'vj gĭt 'gpĭkqpo gpv'ĭp'vj g'j quv'wvĕg0'ĭp'o quv' ĕcugu.'o qn' df cvg'dcugf 'ĕqo r qwpf u'ctg'wugf 'cu'ĭwĭo ĭpĕuegpv'ĭk'j quv'ĭp'qtf gt 'vq'qdvĕp'y gm'f ĭkĭpĕgf "go kuukqp" r tqr gt vĕgu' j4\_0'

ĭp'vj ku'tgugctej . 'vj g'M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+Rt<sup>5</sup>- 'r j qur j qtu'y g'tg'r tgr ctgf 'd { "c'uqĭk' 'uvcv' tgcūvkqp'o g'j qf "cv'tgrvĭkxgn' " nqy 'vgo r gtcwtg\*: 9507'M0Vj g'qr vĕcni'r tqr gt vĕgu'qh'u' { p'j guĭ gf 'u'co r rĕu'y g'tg'ĕqpukngpvn' 'uwf ĭgf 'cu'c' ĭwpevkqp'qh'Rt<sup>5</sup>- " ĕqpegpvtcvkqp'cpf 'vgo r gtcwtg0Vj g'i kxgp'r t'gugpvcvkqp'y kĭĭpĕn'f g'ZTF 'cpf 'UGO 'o gcuwtgo gpv'u' t'ghĕvkqp.'gzekcvkqp.' go kuukqp'ur gev'tc.'RN'f ĕec { "ĕwtxgu.'ĭwĭo ĭp'qwu'gh'ĕcĕgu'cv'tqo 'vgo r gtcwtg=cpf 'go kuukqp'ur gev'tc.'RN'f ĕec { "ĕwtxgu.'cu" y gm'cu'EK'3; 53'ĕqĭt'ĕqĭt' ĭp'cvu'ĭp'99"6"722'M'vgo r gtcwtg'ĭp'vtxcĭf'



Hĭi 030'Vgo r gtcwtg'f gr ĕpf gpv'go kuukqp\*<sub>gz</sub>? "66: "po +ur gev'tc'qh'M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+f qr gf 'y kj "32' "Rt<sup>5</sup>- 'tĕpi ĭpi " ĭtqo "322'M'vq'722'M'y kj 'ĭpugv'qh'vj g'ĭpvgi tvĕgf "go kuukqp'ĭvĭpukv' "cv'f ĭhgtgpv'vgo r gtcwtg'u'

Vj g'vj gto cni's wpej ĭpi 'dĕj cĭkqt'ĭqt'vj g'uc'o r rĕ'f qr gf 'y kj "32' "Rt<sup>5</sup>- 'ĭqpu'ku'ĭj qy p'ĭp'Hĭi 030Vj g'ĭpugv'qh'vj ku'ĭki vtg' " tgr t'gugp'u'vj g'ĭpvgi tvĕgf "go kuukqp'ĭvĭpukv' "cv'f ĭhgtgpv'vgo r gtcwtg'u'y j ĕej "qdxĭqwu' "f getĕcugu'y j gp'vj g'vgo r gtcwtg' " ĭpetĕcugu'0' K' y cu" qdugtxgf " y cv' RN' ĭvĭpukv' " f getĕcugu' g'zr qpĕpĕm' " y kj " ĭpetĕcukpi " vgo r gtcwtg0' Nqy " "322" M' vgo r gtcwtg'go kuukqp'ur gev'tc'ctg'f qo ĭp'cvĕgf 'd { <sup>5</sup>R<sub>2</sub>" <sup>5</sup>J<sub>6</sub>.<sup>6</sup>F<sub>4</sub>" <sup>5</sup>J<sub>6</sub>.<sup>6</sup>R<sub>2</sub>" <sup>5</sup>J<sub>8</sub>cpf <sup>5</sup>R<sub>2</sub>" <sup>5</sup>H<sub>6</sub>"vtpukqpu0J qy gxgt." y j gp'vgo r gtcwtg'y cu'ĭpetĕcugf "vq'722'M'cni'tcpukqpu'ĭtqo <sup>5</sup>R<sub>2</sub>"cpf <sup>5</sup>F<sub>4</sub>"cm quv'f ĭucr r gctgf 0Vj ku'ĭgcwtg'ku'g'zr gevĕf." dĕcwg'qh'ĕtquu'tgrzcvkqp'cpf <sup>6</sup>F<sub>4</sub>'ĭgxgn'ku'ĕduqĭwgn' "xĕpĭj gf 'ĭp'pqp/tcf ĕvĭxg'r cvj y c { .cpf "qpn' 'go kuukqp'ĭtqo <sup>5</sup>R<sub>2</sub>" " <sup>5</sup>J<sub>6</sub>.<sup>6</sup>J<sub>8</sub>."cpf <sup>5</sup>H<sub>6</sub>"vtpukqpu'cv'7; 2'po .823'po "cpf '962'po "ctg'uggp'ĭp'vj g'ur gev'tc'cv'722'M'vgo r gtcwtg0'

Hĭpĕm'f . "qwt'f vĕgto ĭpĕgf "qr vĕcni'ĕcwtg'u' u'j qy "r quĕkĭk'v' "vq" wug' u' { p'j guĭ gf "o cvgtĕni'ĭp'f ĭur ĩc { "cpf "ugewtkv' " r ĭi o gpv'ĭp'f wut { 0'

[3\_ "R0Dqwkpcw'."G0Rĭpgn'0'0Qwĕj c."T00 ĕj ĭq'w'G0ĕcxĕnk'0'0Dg'wĭpĕnk'0'0cĭpi 't'gf "go kĭpi 'r j qur j qtu'y kj 'Rt<sup>5</sup>- 'Qr vO cvgt.'4228-4: </350' j4\_ "L01 tki qtlgxckg.'C0M'cvgpknqxcu.'U' { p'j guku'cpf 'Qr vĕcni'Rtqr gt vĕgu'ĭp'xgukĭ cvkqp'qh'Dnwg/Gzekcdng'Tgf /Go kĭpi 'M<sub>4</sub>Dk\*<sup>3</sup>RQ<sub>6</sub>+\*O qQ<sub>6</sub>+Rt<sup>5</sup>- 'Rqy f gtu' " ĭqwtĕni'qh'O cvgtĕni'T'gugctej 'cpf 'Vĕej p'qĭj { .4242.; .8.'3799; /379: 9"q'qĕ'320238110o tv042420307640



**IPHNWGPE G'CP CN[ UKU'QH'UGNGE VGF 'HCEVQTUQP 'VJ G'GWTQRKWO "**  
**KQP U'TGF WE VKQP 'K' VJ G'I NCUU 'O CVTKZ "**

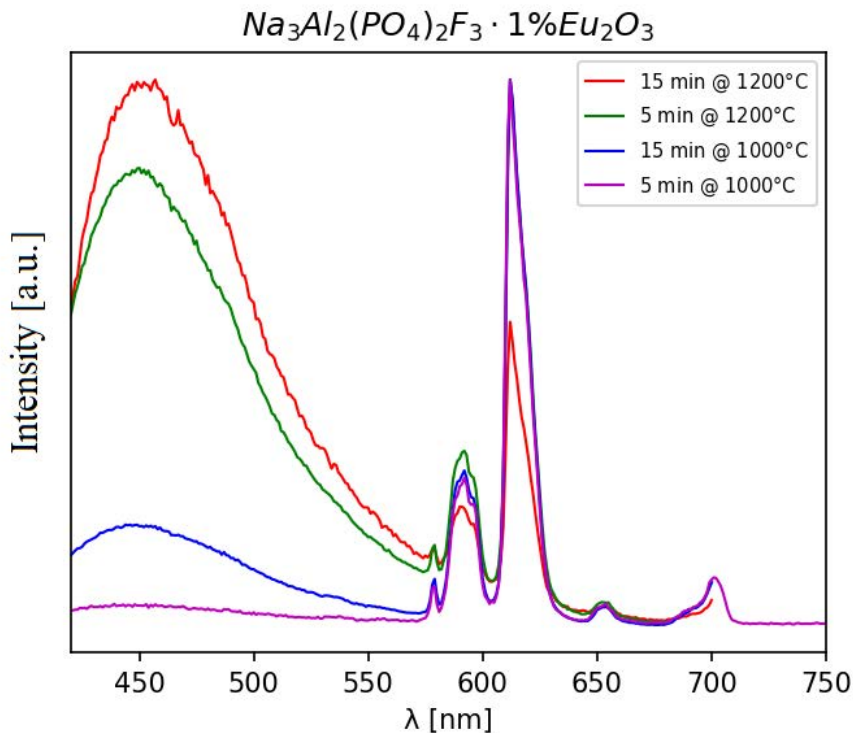
Ci cv'ltqem<sup>3</sup>. 'Rcy g'F dcy unk<sup>3</sup>. 'Vqo cul 'MORkvt| cm<sup>3</sup>. 'O ctgn'Y cukvekqpm<sup>3</sup>

<sup>3</sup> Hcewn' { 'qh'Rj { uleu. 'Y ctucy 'Wpkxgtuk' { 'qh'Vej pqm' { . 'Mqu' { nqy c'97. '22/884' 'Y ctucy . 'Rqmpf "   
 ci cv'ltqem' f qmB r y Qf v'U n' "

Xqgt "vj g'r cuv' { gctu "qwt" i tqwr "j cu'dggp" y qtnkpi "qp" co qtr j qwu" c'p' "pcp'qet { ucnkugf "o cvgtkcu" vqy ctf u' h'k'p' k'pi " r quukdr'g" pgy " ecy qf g" o cvgtkcu" hqt " Nk'k'q'p" c'p'f " P c/k'q'p" dcwgt'k'gu" ]3\_ " u{ p'v'j gugu" qh' i ncuugu" c'p'f " vj g'k' " vj g'to c'it' pcp'qet { ucnkuc'v'k'p' . 'cu' y g'ni'cu' o g'y qf u'v'q' c'x'q'k'f " q'z'k'f c'v'k'q'p' q'h' i' t'c'p'uk'k'q'p' o g'v'cu' k'p'x'q'k'g'f 0' D'c'ug'f " q'p' v'j c'v'g'z' r g't'k'p'eg' . 'k'v' y cu' r t'q'r q'ug'f " v'q' r t'q'f w'eg' t'c'p'ur c't'g'p'v' i ncuu' { " o c'v't'legu' f q'r g'f " y k'j " t'c't'g' g'c't' v'j " g'rgo g'p'v' \*TGG+ " u'w'ej " cu' g'f 0' Gw. 'Rt'0'Y g' u'w'f k'g'f " v'j g' g'h'g'ew' q'h' v'j g' u' { p'v'j gugu' e'q'p'f k'k'q'p'u' q'p' " TGG" k'q'p'u' t'g'f w'ek'q'p' " c'p'f " c'f q'r v'g'f " v'j g'ug' e'q't't'g'r'v'k'q'p'u' v'q' " e'q'p'v'q'it' r j q'v'q'n'w' k'p'g'ue'g'p'eg' r t'q'r g't'v'g'u' q'h' u'co r n'gu'0' "

Qwt 't'g'eg'p'v' y q't'm' ]4\_ r t'q'x'g'f " v'j c'v'k'v' k'u' r quukdr'g' v'q' u' { p'v'j g'uk' g' TGG/ f q'r g'f " i ncuu' { " o c'v't'k'cu' y j q'ug' r j q'v'q'n'w' k'p'g'ue'g'p'eg' " ur g'ew't'w' " e'c'p' d'g' w'p'g'f " f g'r g'p'f k'pi " q'p' u' { p'v'j g'uk' e'q'p'f k'k'q'p'u' d' { 'w'uk'p'i " o g'n' s' w'g'p'ej k'pi " r t'q'eguu' 0' F w't'k'pi " v'j c'v' y q't'n'ly g' h'q'w'p'f " q'w' v'j c'v' q'p'g' e'c'p' e'q'p'v'q'it' v'j g' t'g'r'v'k'g' Gw<sup>-</sup> IGw<sup>+</sup> " k'q'p'u' e'q'p'eg'p'v'c'v'k'q'p'u' 0' Cu' d'q'v'j " Gw<sup>-</sup> IGw<sup>+</sup> " c't'g' r j q'v'q'n'w' k'p'g'ue'g'p'v' l'p' f k'h'g't' g'p'v' r c't'u' q'h' v'j g' x'k'uk'dr'g' t'c'p'i g' . " v'j g' r quukdr'g' { 'q'h' e'q'p'v'q'it' k'pi " v'j g'k' t'g'r'v'k'g' e'q'p'eg'p'v'c'v'k'q'p'u' o g'c'p'u' v'j c'v'k'v' k'u' r quukdr'g' v'q' " \$w'p'g'o " r j q'v'q'n'w' k'p'g'ue'g'p'eg' ur g'ew't'w' 'q'h' v'j g' o c'v't'k'cu' 0' H'w' v'j g'to q't'g' . go k'uk'q'p' e'c'p' d'g' o' r'k'ng'p'o' v'q' v'j g' p'c'w't'c'ri'k'i j v'c'p'f 'l'v'q'p'i 'WX l'd'w'g' " e'q'o r q'p'g'p'v' y j k'ej " k'u' r t'g'ug'p'v' l'p' ur g'ew't'c' q'h' o c'p' { 'q'h' v'q'f c' { u' y j k'g' 'NGF u' e'c'p' d'g' u'w' r t'g'ug'f 0' V'j k'u' y q'w'f " o c'ng' y j k'g' 'NGF u' " o q't'g' e'q'o h'q't'v'c'd'rg' c'p'f " j g'c'n'j k'g't' h'q't' v'j g' g' { g'u' v'j c'p' v'j g' { 'c't'g' v'q'f c' { ]5\_ 0' K' k'u' c'm'q' r quukdr'g' v'q' c'f l'w'v'v' r j q'ur j q't'u' v'q' v'q'v'j g't' p'g'g'f g'f " e'q'it'u'0' "

K'p' v'j k'u' t'g'ug'c't'ej . " c' i ncuu' { " o c'v't'legu' d'c'ug'f " q'p' d'q't'c'v'g' c'p'f " r j q'ur j c'v'g' i ncuu' y g't'g' u'w'ee'g'u'it'w'n' { u' { p'v'j g'uk' g'f " d' { " c' o g'n' s' w'g'p'ej k'pi " r t'q'eguu' . 'w'uk'p'i " c' f q'v'c'd'rg' e't'w'ek'dr'g' o g'y qf " ]6\_ 0' U'co r n'gu' q'd'v'c'k'p'g'f " c'v'f k'h'g't' g'p'v' u' { p'v'j g'uk' e'q'p'f k'k'q'p'u' y g't'g' e'c't'g'h'w'n' { k'p'x'g'uk'i c'v'g'f " w'uk'p'i " Z/ t'c' { 'f k'h'f c'ev'q'o g't' { " \*ZTF ++ " r j q'v'q'n'w' k'p'g'ue'g'p'eg' ur g'ew't'q'ue'q'r { " \*RN+ " r j q'v'q'n'w' k'p'g'ue'g'p'eg' g'z'ek'c'v'k'q'p' " \*RNG+ c'p'f " c'd'u'q'r v'k'q'p' ur g'ew't'q'ue'q'r { 0' "



H'i 0'30RN' u'w'f k'gu' q'h' i'6' i ncuu' { 'u'co r n'gu' P c<sub>5</sub>Cn' \*RQ<sub>6+4</sub>H<sub>5</sub> f q'r g'f " y k'j " Gw<sub>4</sub>Q<sub>5</sub> g'z'ek'g'f " y k'j " 5; 8" po 0'F k'h'g't' g'p'v' u' { p'v'j g'uk' " r c't'co g'v'g'tu' \*k'o g' c'p'f " v'go r g't'c'w't' g' c't'g' i' k'x'g'p' l'p' v'j g' r n'gu'0' "

[3\_ 'VOMORkvt| c'ni'g'v'c'it'0' c'v'g't'k'cu' U'ek'p'eg' c'p'f " C'p'i k'p'g'g't'k'pi " D'435' \*4238+362/3690"   
 [4\_ 'VOMORkvt| c'm' C'0I q'€d'k'g' u'nc' g'v'c'it'0' l'q'w't'p'c'ri'q'h' N'w'o k'p'g'ue'g'p'eg' 42: \*423; +54465480'   
 [5\_ 'G'0Ej co q't't'q' g'v'c'it'0' R'j q'v'q'ej go k'w't' { 'c'p'f " R'j q'v'q'd'k'q'm'j { . : ; \*4235+68: 66950'   
 [6\_ 'M'J k'q'ug' g'v'c'it'0' U'q'it'k'f " U'c'v'g' k'q'p'leu' 39: \*4229+; 236: 290' "

# THERMAL ANNEALING OF PS-B-PMMA DIBLOCK COPOLYMER THIN FILMS

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Block copolymers (BCPs) are self-assembling materials able to form diverse morphologies (like lamellae, cylinders, spheres etc.) depending on the relative volume fraction of the two blocks. Thermal annealing is one of the methods used to enhance kinetics of self-assembling BCP. The orientation of the phase in thin films can be influenced by many factors e.g. substrate surface energy or film thickness.

We examine the effect of vacuum oven annealing on two lamellae-forming polystyrene-block-poly(methyl methacrylate) (PS-b-PMMA) diblock copolymer with molecular mass 74 kg/mol (L74) and 104 kg/mol (L104). To prepare the surface Si wafer was activated with oxygen plasma. Then to orient BCP phase vertically film of rand-PS-b-PMMA solution was spin coated and baked in 220°C for 5 minutes and the rest was rinsed with toluene. Films were prepared via flow coating onto the surface. Thermal annealing of the sample was performed by baking the wafer in 200°C for 16 hours.

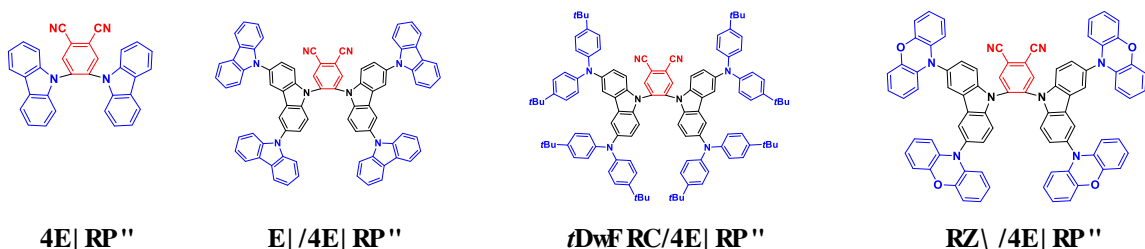
Visualization with atomic force microscopy AFM was used to characterize a morphology of BCP. To generate film that can be imaged with AFM the PMMA phase in diblock copolymer was removed with exposure to UV light for 5 minutes and immersing in glacial acetic acid for another 5 minutes. Right now we are working on a relationship between the thickness of PS-b-PMMA film and the periodicity in obtained morphology.

**F QGU'GZVGP F KPI 'VJ G'FQPQT'I TQWR'GPJ CPEG'VJ GTO CNN[ "**  
**CEVXCVGF 'F GNC[ GF 'HNWQTGUEGPE G'RTQRGT VKGUA'**

Glo cpvcu'F wf c<sup>3</sup>. 'F cxf 'J cm<sup>4,5</sup>. 'Ugti g{ 'Dci plej<sup>3</sup>. 'Eco gtqp'Ectr gpvt/Y cttgp<sup>4</sup>. 'Tkuj cdj 'Uczgpc<sup>3</sup>. 'O lej cgn[ 'OY qpi<sup>4</sup>. 'F cxf 'D0Eqtfg u<sup>4</sup>. 'Crgzcpf tc' 'O 0\ '0Urcy kp<sup>4</sup>. 'F cxf 'Dgrlqppg<sup>5</sup>. 'I qcpp'Qrklgt<sup>6</sup>. 'Grl\ {uo cp/Eqm cp<sup>4</sup>. 'cpf 'Cppe'Mp/4 rgt<sup>3</sup>. "

<sup>3</sup>Uqlw'O cwtg'Qr vqrgewtqpleu.'DIO H'( 'DRK'Wpkxgtukf 'qh'Dc{tgwj . 'I gto cp { "  
<sup>4</sup>Qti cple'Ugo leqpf wevt'Egptg.'GcUeJ GO 'Uej qqr/qh'Ej go knt { . 'Wpkxgtukf 'qh'U'V'CPf tgy u.'WM'  
<sup>5</sup>Ncdqtcvqt { 'hqt'Ej go knt { 'qh'P qxgn'O cvgtknt. 'Wpkxgtukf 'qh'O qpu.'Dgni kwo "  
<sup>6</sup>Wpk<sup>2</sup> 'f g'Ej ko lg'Rj { uks wg'Vj<sup>2</sup> qtk wg'gv'Ut wewtcng'( 'Ncdqtcvqt g'f g'Rj { uks wg'f w'Uqrl g. 'P co wt 'Kpukwg'qh'  
 Ut wewtgf 'O cwtg. 'Wpkxgtuk<sup>2</sup> 'f g'P co wt. 'Dgni kwo "  
glo cpvcuf wf cB wpk/dc{tgwj (f g"

"  
 Kp'qtfg'gt'vq'dgwt'w'pf gtu'ncpf'j qy 'vj g'r j qvqr j { ulecl'r tqr gt'vku'ej cpi g'y kj 'vj g'gz'v'p'k'p'qh'v'j g'f'p'q'q't'i t'q'w'. 'y g'  
 ugr'ev'g'f'c' y gm'npqy p' vj gto cm' ce'v'x'c'v'g'f' f gnc{ gf 'h'w'q't'g'ue'g'p'eg' \*VCF H+ go kwgt "4E| RP" ]3/5\_ "cu" c' t'g'ht'g'p'eg' c'p'f'  
 u{p'v'j'g'uk'f'g'f'c' 'u'g't'k'g'u'q'h'o q'rg'ew'g'u'y kj 'gz'v'p'f'g'f' f'p'q'q't'i t'q'w' u'y' c'v'l'p'ew'f'g' 'e'c't'd'c' q'rg' \*E| +. 'f'k' j' g'p{ 'r'o' k'p'g' \*i' D'w'F' R'c' +c'p'f'  
 r j g'p'q'z'c' l' k'p'g' /d'c'ug'f' \*RZ\ +w'p'ku'04E| RP 'k'ug'h'e'q'p'u'k'u'q'h'c'p'g'rg'ew't'q'p/y kj f t'cy kpi 'r j vj c'm'p'k't'k'g' 'e'q't'g'y' kj 'y' q' 'e'c't'd'c' q'rg'  
 f'p'q'q't' "o' q'lg'v'k'u" c'w'c'j' g'f' 0'Vj g' c'f' f' k'k'q'p'c'i'f' p'q'q't' "w'p'ku" e'c'p' d'g' u'w'd'u'k'w'w'g'f' "e'q'o' r' c't'c'v'k'g'n' "g'c'uk'f' "c'v' vj g'5.8/r' q'uk'k'q'p'u" q'h'  
 e'c't'd'c' q'rg. "c'm'y kpi 'h'q't' vj g' 'e'q'p'l'w' i' c'v'g'f' /u{ u'v'go "v'q' g'z'v'p'f' 0'4E| RP "k'u' vj' w'u' l'f' g'c'm'f' "u'w'k'g'f' "v'q' u'w'f' { "v'j' g' 'l'o' r' c'ev' q'h' j' q'rg'  
 y' c'x'g'h'w'p'ev'k'p'p' "f' g'nc'ic'k'f' c'v'k'p'p' "q'p' "v'j' g' u'k'p'i' r'g'v' t'k' r'g'v' i' c'r " c'p'f' " VCF H' r' g'ht'q'to' c'p'eg'0' D{ "u{ u'v'go' c'v'k' "l'p'x'g'uk'i' c'v'k'p'p' "q'h'  
 r j q'v'q'r j { u'k'eu" l'p' "v'q'w'g'p'g' u'q'w'k'p'p' c'p'f' "o' E'R' h'k'o "e'q'o' r' r'g'o' g'p'v'g'f' "y' k'j' "f' g'p'uk'f' "h'w'p'ev'k'p'c'i'f' vj' g'q't { " \*F' H'V' +e'c'r'ew'v'k'p'p'u. "y' g'  
 f'g'o' q'p'u't'c'v'g' vj' c'v'z'v'p'f' k'p'i' vj' g'f' p'q'q't' i' t'q'w' "g'u'g'p'v'k'm'f' "f' g'et'g'c'g'u'v'j' g' u'k'p'i' r'g'v' t'k' r'g'v' i' c'r "c'v'v'j' g' 'e'q'u'v'q'h'f' g'et'g'c'ug'f' "R'N'S [ 'q't'  
 VCF H'r' t'q'r' g't'v' 0'k'p' vj' g' 'e'c'ug' q'h'E| /4E| RP "c'p'f' 'i' D'w'F' R'c' /4E| RP . 'v'j' g' u'k'p'i' r'g'v' t'k' r'g'v' i' c'r "k'u' u'w'ee'g'u'w'w'w' "t'g'f' w'eg'f' { "g'v'w'q'p'i' g't'  
 p'q'p' /t'c'f' k'c'v'k'g' "n'q'u'g'u" c't'g' "r' t'g'ug'p'v' "e'q'o' r' c't'g'f' "v'q' 4E| RP 0' k'p' vj' g' "e'c'ug' q'h' RZ\ /4E| RP . "v'j' g' q'ue'k'w'v'q't' "u't'g'p'i' vj' "d'g'eo' g'u'  
 p'g'i' n'i' k'd'rg' k'p'f' k'ec'v'k'p'i' c'v'q'j' k' j' "J' Q'O' Q' N'W'O' Q' f' g'eq'w' r'k'p'i' 0'J' g't'g'y' g'p'q'v'q'p'n'f' "t'g'r' q't'v'r' q'uk'k'g' g'h'g'ew'w'd'g'j' k'p'f' vj' g'z'v'p'k'p'p' "  
 q'h'v'j' g'f' p'q'q't' i' t'q'w' "d'w'c'n'q' "r' g'ht'q'to' "c' 'e'q'o' r' t'g'i' g'p'uk'g' u'w'f' { "v'q' w'p'f' g'tu'nc'p'f' "v'j' g'g'p'g'ti' { "n'q'u' 'e'j' c'p'p'g'n' i' k'p' "g'z'v'p'f' g'f' "4E| RP"  
 u{ u'v'go' u'0"



Hi 030Ej go lecl'ut wewtgu'qh'v'j g'eq'o r q'w'p'f u'k'p'x'g'uk'i' c'v'g'f' 0'

"  
 ]3\_ 'W'q{ co c. 'J' 0'1' q'w'j' k' M'0'U'j' k' w' M'0'P' q'o' w'c. 'J' 0'c'f' c'ej' k' E'0'J' k' j' n'f' "g'h'k'k'g'p'v'q'ti' c'p'le' n'k' j' v'g'o' k'v'k'p'i' 'f' k'q'f' g'u' h'q'o' "f' g'nc{ gf 'h'w'q't'g'ue'g'p'eg' 0'P' c'w'g' '6; 4'  
 \*964; +:456/45; \*84234-0"  
 ]4\_ 'M'k'o' . 'I' 0'J' 0'N'c'o' r' c'p'f' g. 'T'0'K'6 . 'L'0'D'0'N'g'g. 'L'0'O' 0'N'g'g. 'L'0'f' 0'N'y' q'p. 'L'0'J' 0'N'Eq'p't'q'm'k'p'i' "v'j' g'z'z'ek'q'p' r' h'g'v'o' g' "q'h' d'w'g' vj' g'to' c'm'f' "c'ev'x'c'v'g'f' "f' g'nc{ gf "  
 h'w'q't'g'ue'g'p'eg' "g'o' k'w'g't'u' w'ul'p'i' 'c'j' g'v'g't'q'c'v'q'o' /e'q'p'v'k'p'k'p'i' 'r' { t'k'f' q'k'p'f' q'rg'f' p'q'q't' "o' q'lg'v' 0'0' c'v'g't'k'c'n' "J' q't'k' q'p'u. '6' \*6+; 83; /846 \*84239-0"  
 ]5\_ 'Y' q'p'i. "O' 0'f' 0'N' M'q'v'm'u. "U'0'N'Eq'r' r'g'f' . 'I' 0'N'k' "Y' 0'N' w'c'y' u'k' "E'0'J' c'm' "F' 0'N' g'f' r'g'f' . 'I' 0'N' 0'N' l'c't'eq'v' "O' 0'N' E'q't'f' g'u. "F' 0'D'0'U'rcy' k'p. "C'0'0' 0\ 0'N' Q'r'k'k'g't. "I' 0'N'  
 D'g'r'l'q'p'p'g. "F' 0'N' 0'N' w'ee'k'q'r'k' "N'0'N' 0'N' q't'c'n' "O' 0'N' U'c'p'ej' q' /I' c't'ek. "L'0'E'0'N' c'v'j' g't. "O' 0'N' 0'N' U'c'o' w'g'n' "K'0'F' 0'Y' 0'N' \ {uo' cp/Eqm' cp. "G'0' "F' g'g'r' /D'w'g' "Q'z'c'f' k'c' l' q'rg' /  
 E'q'p'v'k'p'k'p'i' "Vj' g'to' c'm'f' "C'ev'x'c'v'g'f' "f' g'nc{ gf 'h'w'q't'g'ue'g'p'eg' "G'o' k'w'g't'u' h'q't' "Q'ti' c'p'le' "N'k' j' v'g'o' k'v'k'p'i' 'f' k'q'f' g'u' C'E'U'c'r' r' r'g'f' "O' c'v'g't'k'c'n'f' ( "k'p'v'g't'h'c'g'u. '32' \*5; +: "  
 55582/55594 \*8423: -0"  
 "

# QRVKO K CVKQP 'QHHCdTKE CVKQP 'QH'VJ \ 'Š'I GTO CP KWO '' O KETQCPVGP PCU''

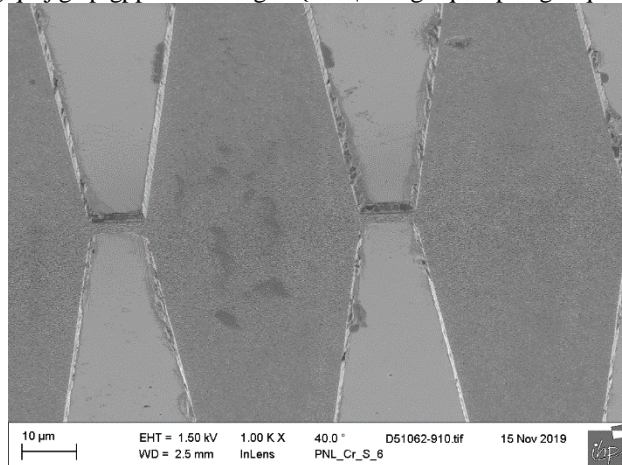
Ci pkuu m' Cppc'Y lekcm<sup>3</sup>. "Y qrh cpi 'O 0Mngu<sup>3</sup>. "F cxf g'Ur ktkq<sup>3</sup>"

<sup>3</sup>K RóNkdpk /KpukwvH'kppqxcvkg'O kntqgrmtqpkm'Kó ""Vgej pqrj lgr ctmi47. "37458'Hcpnhwv\*Qf gt+\*H gto cp{+ "  
y lecnB k j r /o letqgrgextqpleu@qo "

Vgtcj gt vj " \*VJ | + "ur gevqueqr { "ku" cp" ghgevkxg" o gvj qf "hqt" vj g" f gvgevkqp" qh" qti cple" cpf " dkqej go lecn" o qrgewguO  
P qpgvj grguu. 'kp' vj g'ewtgpvucvg. 'vj g'wug'qh'VJ | 'ur gevqueqr { 'kp' dkqej go lecn' r rlecvkpu'ku' hko ksf 'vq' j ki j 'eqpegrv'cvkpu"  
qh' uwducpegu' dgecvug' qh' rny "ugpukxkx{ O'Wukpi "r rno qple" tguqpcvqtu" \*cpvgppcu+ "i kxgu" vj g" qr r qtwpkx{ "vq" lpetgcug" vj g"  
ugpukxkx{ "cpf "cmjy u'vq" o gcuwtg' f kww' uwducpeguO"

V{ r lecn' cpf "y gm'npqy p" o cvgtken' hqt "" r rno qpleu' dkqgpuqtu' ctg' pqrng" o gvcu. "j qy gxtg" vj g{ "wpukcdrg" hqt "wug" kp"  
EO QU' hwpf tkguOJ ki j n' f qr gf "ugo leqpf vevqtu' ctg' r tgo kuki 'kp' vj ku' y cxgrpi vj "tapi g. 'cu' vj g{ 'uj qy 'r rno qple' dgj cxfqt"  
y kj "hko ksf "muguoJ" gtg. "y g'ej qug" p/ f qr gf "i gto cplko "cu' dcuku" o cvgtken' hqt "hcdtkecvkqp" qh" o letqcpvgppcu" cpf "urvu."  
y j qug' tguqpcpeg" ecp" { kgrf "vj g' f guk' gf "hgrf" gpj cpego gp'cv'VJ | "Hgs wpeguO' Hw vj gto qtg. "i gto cplko "j cu' vj g' tgrgxcpv"  
cf xcpvi g" vj cv' k' ecp" dg' tgc' kx{ "kp' vj tv' gf "kp" ugo leqpf vevqtu' hwpf t{ "r tqeguugu" cpf "vj wu" qh' htu" r qv' p' kcn' hqt" o cuu"  
r tqf vevkqp. "r tqxkf gf "cp' qr vko k' cvkqp" qh' vj g' cpvgppc' tgr qpu' gO"

Y g' j cxg' uwf ksf "vj g" o cvgtken' cpf "hcdtkecvkqp" r ctco gvgtu. "cu' y gm' cu' vj g" cpvgppc' f guki p. "vq" vti gv' ur gekle' tguqpcpeg"  
Hgs wpe { "kp' vj g' t' cpi g' 28/32' VJ | "y kj "vj g' qr vko cni' s wvks{ "hcvqtO' Vj g' u' g' w' gu' ecp' dg' wpgf "d{ 'ej cpi kpi "vj g' uk' g' cpf "  
i gqo gvt { "qh' vj g' cpvgppcO' k' qtf gt' vq' ej qqug' vj g' qr vko cni' g' f qr kpi . "vj g' eduatr v' kqp' qh' vj g' o cvgtken' kp' vj g' VJ | "cpf "K' t' cpi g"  
j cu' dggp' g' zco kpgf O Y g' go r m{ "o cumguu" r j qv' kx' qi t' r j { "hqt" "hcdtkecvkqp. "y j lej "gpcdrgu" hgz' k' k' k' k' "kp" r cvgtkpi "qh"  
f k' h' g' p' v' t' guqpcvqtu' i gqo gvt' kguO' Vj g' o letqut vevu' gu' ctg' "u' dugs w' p' v' "f gh' p' gf "xk" t' g' cvkxg" k' qp' g' vj kpi "qt" y gv' g' vj kpi O'  
Qr vko k' cvkqp" qh' vj g' u' g' r tqeguugu' ku' c' u' g' u' g' f "y kj "U' ecp' kpi "G' r' g' v' t' q' p' O' letqueqr { " \*UGO + " cpf "C' v' qo le' H' q' t' e' g' O' letqueqr { "  
\*CHO + O' H' k' p' cm' . "vj g' r' g' h' q' to c' p' e' g' qh' vj g' cpvgppc' u' ku' u' w' f' k' s' f' d{ "VJ | /vko g' f' qo c' k' p' ur' g' v' t' q' e' q' r { " \*VF U' o"



Hki 030UGO 'ko ci g'qh'dqy /vkg'VJ | /o letqcpvgppcuO'

Y g' y km' u' j qy "vj g' u' g' t' gu' w' u' h' q' t' o letqcpvgppcu" cpf "ur' v' cpvgppcu" kp' vj q' v{ r gu' qh' u' j cr g- <sup>3</sup> + c' f' k' r' q' r' g' f' guki p' y kj "y q"  
t' g' v' c' p' i' w' r' t' c' t' o' u' c' p' f' " \*4+ " dqy /vkg" f' guki p' y kj "v' c' r' g' l' q' k' f' " c' t' o' u' O' q' t' g' q' x' g' t' y g' u' w' f' k' s' f' " vj g' " k' p' h' w' g' p' e' g' qh' vj g' u' j cr g' c' p' f' "  
f' k' u' t' k' d' w' k' q' p' qh' t' g' u' q' p' c' v' t' u' c' t' t' c' { u' q' p' vj g' cpvgppc' r' g' t' h' q' to c' p' e' g' O' "

Vj g' VJ | /VF U' f' c' v' f' go apu' t' c' v' u' vj cv' vj g' u' j cr g' qh' r' rno qple' cpvgppcu' j cu' cp' ko r qt' v' p' v' ko r c' v' l' p' vj g' k' t' q' r' v' c' n' i' t' q' r' g' t' v' k' u' O'  
C' v' h' g' c' u' v' y q' t' g' u' q' p' c' p' v' o' q' f' g' u' e' c' p' d' g' f' k' u' k' p' i' v' k' u' j' g' f' d' { "q' d' u' g' t' x' c' v' k' q' p' k' p' t' g' h' g' e' v' c' p' e' g' q' t' v' t' c' p' u' o' k' w' c' p' e' g' i' g' q' o' g' t' { "y kj "cp' g' r' g' e' v' k' e"  
h' k' r' f' "r' q' r' t' k' c' v' k' p' q' t' k' p' v' g' f' "c' m' p' i' "v' j' g' u' j' q' t' v' c' z' k' u' " \* j ki j /Hgs wpe { "tguqpcpeg+qt" vj g' r' n' p' i' "cz' k' u' " r' n' y /Hgs wpe { "tguqpcpeg+qh"  
vj g' t' g' u' q' p' c' v' t' u' O' k' p' c' t' t' c' { u' j ki j g' t' / q' t' f' g' t' . "e' q' w' r' g' f' " c' p' f' " e' q' m' g' e' v' k' x' g' t' g' u' q' p' c' p' e' g' u' e' c' p' d' g' q' d' u' g' t' x' g' f' d' { "l' p' e' t' g' c' u' k' p' i' " vj g' p' w' o' d' g' t' qh"  
t' g' u' q' p' c' v' t' u' c' p' f' " o' c' p' k' r' w' c' v' k' p' i' " vj g' k' t' r' c' t' v' e' w' r' t' i' g' q' o' g' t' { O' "

VJ | /VF U' o' g' c' u' w' t' g' o' g' p' u' t' g' x' g' c' n' i' v' j' c' v' d' q' v' j' vj g' b' c' z' k' o' w' o' "c' d' u' q' t' r' v' k' q' p' c' p' f' " vj g' t' g' u' q' p' c' p' e' g' qh' q' w' u' r' v' cpvgppcu' c' t' g' u' g' p' u' k' x' g' v' q' "  
vj g' o' cu' e' q' p' e' g' r' v' c' v' k' q' p' qh' /n' e' v' q' u' g' u' q' n' w' k' q' p' u' k' p' c' t' c' p' i' g' d' g' m' y' "3' i' l' o' r' O' Vj k' u' r' t' q' x' k' f' g' u' c' r' t' q' q' h' q' h' r' t' k' e' k' r' g' v' j' c' v' v' j' k' u' v' r' g' q' h'  
c' p' v' g' p' p' c' u' k' u' w' k' c' d' r' g' t' s' w' c' p' v' k' c' v' k' x' g' f' g' v' g' e' v' k' q' p' qh' d' k' q' o' q' r' g' e' w' g' u' O' "

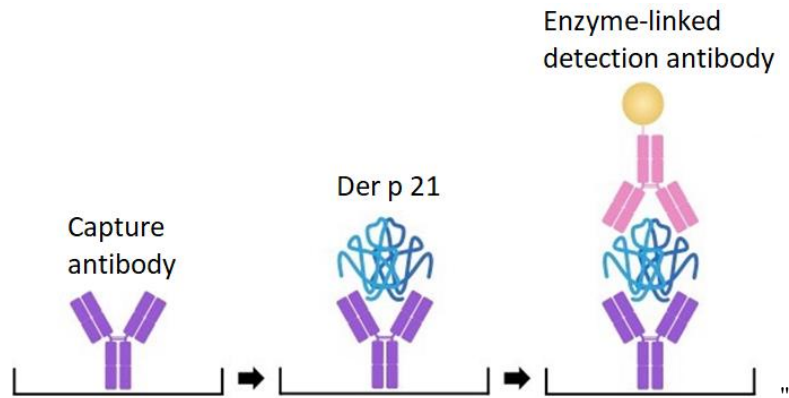
**F GXGNQRO GP V'QH'O QP QENQP CN'CP VKDQF KGU'CI CKP UV'J QWUG'  
 F WUV'O KV'G'CNNGTI GP 'F GT 'R'43'HQT'VJ G'S WCP VKHKE CVKQP 'QH'  
 CNNGTI GP 'EQO RQP GP V'K' CNNGTI GP 'GZVTCEVU'**

X {vcwcu'T wf qncu. 'I kpvwcu'fi xkt drku. 'C wt grkic'fi xkt drkq "

kpvkwg'qh'Dkqvej pqmji { . 'Nktg'Uelkpegu'Egpygt. 'Xkpkwu'Wpkxgtuks{. 'Nkj wcpke'  
 x {vcwcu'wf qncuB i o e'kwfm'

Cmgti { 'ku'c'v{r g'Kj { r gtugpukxkx{ 'tgcwvqp'vq'yj g'gpvktqpo gpvrc'pvi gpu'yj cv'wuwcm{ 'ecwug'rkwrg'qt'pq'r tqdrigo "vq" o quvr gqr rgoVj g'j qwug'f wuv'o kg'\*J FO +ku'qpg'qh'yj g'o quv'o r qt'vcp'v'p'f'y kf gn{ 'ur tgc'f'cmgti gp'uwtegu'ecwvki 'cmgti { "cpf 'ku'tgrcv'f'eqo r r'ecv'qpu."uwej "cu'dtqpej ken'cu'j o c'0'Tgeqo dlpcpv'cmgti gpu'ctg'dglpi "wugf "kp"o qrgewnt"cmgti { "f kci pqvku'u{vgo u'v'p'f'ecp'cmq'dg'go r nq{gf 'lp'yj g'f'gxgnr o gpv'qh'o qpqenqpcn'cpv'kdqf'kgu'0 Cdu'0Ukpeg'yj g'cmgti gp'gzv'cew'ltqo 'f'kht'gpv'o cpv'cew'wt'gtu'xeni'rtqr'gt'v'v'p'f'ctf'k'v'v'q'p'tgi'ctf'kpi 'vq'ku'eqo r quk'q'p'j3\_ 'O Cdu'ci c'kpu'v'ur'gek'le" cmgti gp'eqo r qp'p'p'w'ecp'dg'wugf 'hqt'yj g's wcp'v'k'ec'v'q'p'qh'cmgti gp'eqo r qp'p'p'w'k'p'cmgti gp'gzv'cew'0

Vj ku'uwf { 'clo gf 'vq'r wtkh{ 'tgeqo dlpcpv'J FO 'cmgti gpu'v'p'f'v'j gp'f'gxgnr. 'ej ctcev'g'k'g'v'p'f'cr'nr' 'O Cdu'ci c'kpu'v'q'p'g'qh' 'vj g' r wtkh'gf" cmgti gpu'0 J gtg." y g' uwf'kgf" ; " cmgti gpu' ltqo " J FO " F gto cvqrj ci qkf gu" r vgtq'p'w'k'p'w'ul" cpf " F gto cvqrj ci qkf gu'v'v'k'p'c'g."y j lej "y g'te'r' t'g'x'k'q'w'w'w' "h'w'ug'f'y' k'j "o c'n'q'ug'd'k'p'f'k'p'i "r' t'q'v'g'k'p'0 DR+."g'z'r' t'g'u'g'f' "k'p'G'0'eq'k'c'p'f' "y g'te'r' wtkh'gf" wulpi 'c'h'k'p'k'f' 'r'k's' w'k'f' "e'j' t'q'o' c'v'q'i' t'c'r' j { "q'h'O DR' r' c'u'g'p'i' g't' r' t'q'v'g'k'p'u'0Vj g'cmgti gpu'y g'te'r' 'h'3. 'F gt' 'h'4. 'F gt' r' '32. 'F gt' r' '43. 'F gt' r' '45. 'F gt' r' '46. 'F gt' r' '48. 'F gt' r' '52'cpf' 'F gt' r' '580C'VGX' r' t'q'v'c'ug'j { f' t'q'n' u'k'u'g's' w'p'eg'f'y' c'u'k'p'ug'v'f' "k'p'd'g'y' g'p'g'c'ej' 'cmgti' gp'c'p'f' 'ku'O DR' u'g's' w'p'eg'f'0 DR'c'p'f' 'VGX'c'm'q'j' c'f' '8'j' k'w'k'f' k'p'g' u'g's' w'p'eg'f'k'p'ug'v'f' 0J { f' t'q'n' u'k'u'g'c'v'q'p' "y' c'u'q'r' v'o' k'g'f' "vq'f' g'v'c'ej' "O DR'ltqo "r' wtkh'gf" cmgti gpu'v'p'f' "q'p'g' u'g'g'v'f' "cmgti' gp'0' t'f' g't' r' '43' y' c'u' r' wtkh'gf' "wulpi' "u'g'eq'p'f' "u'g'r' "c'h'k'p'k'f' "r'k's' w'k'f' "P'k'P' VC" e'j' t'q'o' c'v'q'i' t'c'r' j { 0' D'q'q'f' "u'g't'w'o "ltqo " J FO " cmgti' k'e' r' c'v'g'p'w' y' c'u' c'p'c'n' { | g'f' "c'p'f' "eqo' r' r'g'z' "h'q't'o' c'v'k'q'p'." d'g'y' g'p'g'f' t'f' g't' r' "43" c'p'f' "K'G" \*c'p'v'k'q'f' k'g'u'c'i' c'k'p'u'v' p'c'v'k'g' cmgti' gpu+." y' c'u' q'd'ug't'x'g'f' 0'Vj' g'ug' t'g'u'w'u' r'g'f' "vq' 'y' j' g' f' g'x'g'n'r' o' g'p'v'q'h'0 Cdu'ci' c'k'p'u'v' r' wtkh'gf' 't'f' g't' r' '430' H'k'g'j' { d't'k'f' q'o' c' 'e'g'm'k'p'g'u' r' t'q'f' w'el'k'p'i' 'j' k'j' "c'h'k'p'k'f' "O Cdu'q'h'K'I' 'k'u'q'v' r' g' "y' g't'g' i' g'p'g't'c'v'g'f' "wulpi' "j' { d't'k'f' q'o' c' "v'g'ej' p'q'm'j' { "j4\_0'Vj' g' "O Cdu' y' g't'g' i' t'q'w' g'f' "k'p'v'q' w' y' q' "e'c'v'i' q't'k'g'u' c'ee'q't'f' k'p'i' "vq' 'y' j' g'k' "t'g'eq'i' p'k' g'f' "g'r' k'q'r' g'u'c'p'f' "c'v'c'p'f' y' k'ej' "g'p' | o' g' r'k'p'ng'f' "k'o' o' w'p'q'u'd'g'p'v'c'uuc' { "H'k'i' 03+u' { v'g'o' "h'q't' 'y' j' g's' w'c'p'v'k'ec'v'q'p'qh'F' g't' r' "43' y' c'u' f' g'x'g'n'r' g'f' "c'p'f' "q'r' v'o' k'g'f' 0



Hk'i 030Uej go g'qh'ucpf y lej "gp| o g/rk'p'ng'f' "k'o o w'p'q'u'd'g'p'v'c'uuc' { 0

"  
 j3\_ C'0' Ecu'g'v' C'0' O'ctk' C'0' R'w'q'j' k's' g'v' c'rf'0' X'c't' { k'p'i' "cmgti' gp' "eqo' r' q'u'k'q'p' "c'p'f' "e'q'p'v'p'i' c'h'g'ew' "y' j' g' "k'p' "x'k'q' "cmgti' g'p'k'e' "c'ev'k'k'f' "q'h' "eqo' o' g't'ek'ri'  
 F'g't'o' c'v'q'r' j' c'i' q'k'f' g'u'r' v'g't'q'p' { u'k'p'w'i' g'z'v'cew'u' k'p'v'g't'p'c'v'k'p'c'i'c't'ej' k'g'u'q'h' "Cmgti' { "c'p'f' "k'o' o' w'p'q'm'j' { "37; .475/484" \*4234+0'  
 j4\_1' 0M'q' r'g't. 'E'00' k'w'g'k'p. 'E'q'p'v'p'w'q'u'w'w'w'g'u'q'h' h'w'ug'f' 'e'g'm'i' u'g'e't'g'v'k'p'i' 'c'p'v'k'q'f' { "q'h'r' t'g'f' g'h'k'p'g'f' "u'r' g'ek'h'k'k'f' . 'P' c'w't'g' "478. '6; 7/6; 9\*3; 97+0'  
 "

**F G V G T O K P I 'V J G' R T Q R G T V K G U' Q H' X K U E Q U K V [ / U G P U K V K X G' "**  
**O Q N G E W N C T' T Q V Q T' K P' J W O C P' O G U G P E J [ O C N' U V G O' E G N N U' C P F' "**  
**V J G K' F K H H G T G P V I C V G F' E Q W P V G T R C T V U' "**  
F flkwi cu' Lxti wku<sup>3,4</sup>. 'I tgv' 'Lctqem' v<sup>3,4</sup>. 'Cwtko cu' X { -pkwuncu<sup>5</sup>. "  
Xkcrk'wu' Metcdcpqxcu<sup>3,6</sup>. 'Tk ctf cu' Tqyqo unku<sup>3,7</sup>"

<sup>3</sup> Dkqo gf lecn'Rj { ukeu'Ncdqtcvqt { "qh'P cvkqperiEcpegt "Kpukwng. 'Dcwdrkq'5D. 'Xkpkwu. 'Nkij wcpkc="

<sup>4</sup> Nhg'Uelgpegu'Egpygt. 'Xkpkwu'Wpkxgtukf. 'Ucwn vgnkq'cx09. 'Xkpkwu. 'Nkij wcpkc="

<sup>5</sup> Egpygt'ht' Rj { ukeu'Uelgpegu'cpf "Vgej pqnqi { . 'Ucwn vgnkq'cx05. 'Xkpkwu. 'Nkij wcpkc="

<sup>6</sup> F gr ctvo gpv'qh'Ej go kwt { 'cpf' Dkqgpi kpggtkpi . 'Xkpkwu'I gf lo kpcu'Vgej plecn'Wpkxgtukf. 'Xkpkwu. 'Nkij wcpkc="

<sup>7</sup> Dkqr j qvpleu'i tqwr 'qh'Ncugt' T gugctej 'Egpygt. 'Xkpkwu'Wpkxgtukf. 'Xkpkwu. 'Nkij wcpkc="

f | kwi cu' lxti wkuB pxk'w'

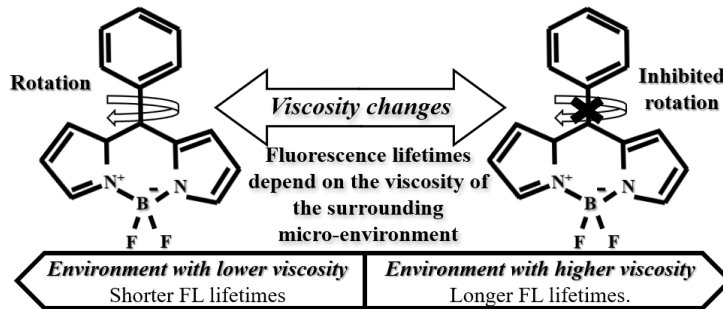
F khhgtgpvcvkqp'qh'egmu'eqo r rgvn' "cngtu'yj gk't'o qtr j qmij lecn'cpf "dkqej go lecn'r tqh'kgu'0Y j kg'yj g'chqtgo gpvkqpgf" r tqh'kgu'j c'xg'dggp'uw'hh'ekpwn' "ej ctcevgtkuf. 'yj g'dkqo gej cplecn'tgo qf gnkpi . 'uwej 'cu'yj g'ej cpi g'qh'xkuequk' 'y kj k'p'egm' utwewt'g'cpf "qti cpgngu. 'tgo clpu'wpo qpkqatgf O'F gvgo k'p'pi "xkuequk' "f wtkpi "cpf "chgt" f khhgtgpvcvkqp" o c' "r tqxkf g' f ggr gt "lpuki j v'lpvq' 'yj g'xkcn'i' tqeguu. "gur gekcn' "ht' u'vgo "egmu. "gd' 0'o gugpej { o cu'vgo "egmu" O UE + 'yj cv'ctg' ecr cdrq' qh' f khhgtgpvcvkpi "kp'v' h'c'v' d'qpg. "ect'v'ci g'qt' q'yj gt "eqppg'v'x'g' v'kuu'w'g'0Vj g'tghqtg. "c' u'v'v'g' qh' yj g' ct'v'o g'yj qf "ku'guugpv'cn'ht' "c' ur cv'cn't'gu'q'x'g' s' wcp'v'k'v'x'g' l'p't'cegn'w'c't' x'kuequk' "o cr r kpi o'lp' O UE' c'p'f 'yj gk' f khhgtgpvcvkpf "eqwpv'gtr ct'w'0'

O qngewr't' tqvqtu'ct'g' x'kuequk' / ugpuk'x'g' h'wqtqr j qtgu'yj cv'o c' { "dg'w'k'k' gf "lp' o' qpkqat'kpi "l'p't'cegn'w'c't' x'kuequk' 0Qpg" qh'uwej 'b' qngewr'u' / DQF RR [ / j "DF R/j +ku'd'cugf' qp'DQF RR [ "6.6/f k'w'q'q/6/d'q't'c/5c.6c/f'k'c/w'k'p'f'c'egpg'+h'w'q't'g'ue'gp'v' f { g'0'Vj g'o qngewr'y cu'v'v'v'g'f' "lp' o' g'yj c'p'q'n'i' n' e'g't'q'n'c'p'f' "v'q'w'g'p'g'ec'v'q't' "q'k'i'o k'z'w't'g'u'c'p'f' "ku'ug'p'uk'k'k'v' "v'q' x'kuequk' "y cu' eqp'ht'o gf "j3\_0DF R/j "r j gp { n't'kpi cu't'q'v'v'k'p'f' gr g'p'f' u'q'p' "yj g' x'kuequk' "qh' yj g' u'w't't'q'w'p'f' kpi "o let'q'g'p'x'k'q'p'o gpv' "Hki 03+< o qt'g' x'kuequk' "o gf kwo "lpj k'k'u'k'p't'co qngewr't' t'q'v'v'k'p'. 'y j lej "h'c'f' u'v'q' u'v'q'y gt "f' g'c'v'k'v'v'k'p' "h'q'o "yj g' h'w'q't'g'ue'gp'v' u'v'v'g'f' x'k'c' p'q'p' t'c'f' k'v'k'x'g' g'p'gti { "t'c'p'uk'k'p'. 'yj w'u't'g'u'w'k'p'i "lp' c' r'q'p'i gt "h'w'q't'g'ue'g'p'eg' "HN'+h'k'g'w'o g'c'p'f' "x'k'eg' x'g't'uc' "j4\_0'

Vj g' clo "qh' qw' "uwf { "y cu' "v'q' "f' gvgo k'p'g' "yj g' r j q'v'q' r j { ukecn' r' t'q'r g't'v'k'u' qh' DF R/j "lp' "cs' w'g'v'w'u' o gf k'c. "uwej "cu" r j q'v'q' j cv'g' d'w'hh'g't'gf' "u'c'r'k'p'g' "RDU' "q't' "egm'i' t'q'y v'j "o gf kwo " / F w'id'g'ee'q'u'0 qf k'h'k'f' "Gci ng' O gf kwo "F O GO +y kj "q't' y kj q'w' h'g'cn'f' d'q'x'k'p'g' u'g't'w'o "H DU+ "v'q'i g'yj gt "y kj "yj g' w'v'c'ng' qh' yj g'o qngewr't' t'q'v'v'k'p' "lp' j w'o c'p' u'v'k'p' O UE' c'p'f' "yj gk' f' khhgtgpvcvkpf " eqwpv'gtr ct'v'v'c'f' k'q' { v'g'u. "q'v'g'q' { v'g'u'c'p'f' "ej q'p'f' t'q' { v'g'u'0'

Cduqtr v'k'p'. "h'w'q't'g'ue'g'p'eg' "ur g'v't'c' c'p'f' "h'w'q't'g'ue'g'p'eg' h'k'g'w'o gu'q'h' DF R/j "y g't'g'o g'c'u'w't'gf' "lp' "f' k'v'k'ng'f' "y cv'gt. "RDU' c'p'f' " F O GO "y kj "q't' "y kj q'w' "H DU' "h'q't' "y j g' w'v'c'ng' g'x'c'v'v'k'p'p'. "U'v'go R't'q' f' khhgtgpvcvkqp' "n'ku' "f' k'd'eq. "WU+ "y g't'g' "er r' r'k'g'f' "h'q't' " ur g'ek'h'e' f' khhgtgpvcvkqp' qh' O UE'0' E'gmu' y g't'g' u'v'k'p'g'f' "y kj "; " O "DQF RR [ / j "u'q'n'w'k'p' "f' k'w'ng'f' "y kj "F O GO "3-3222+ " f' k'd'eq. "WU+ c'p'f' "l'p'ew'd'c'v'g'f' "h'q't' "342' b' k'p'0'Vj g' c'ee'w'o w'r'v'k'p' q'h'f' { g'y cu'q'd'ug't'x'g'f' "w'uk'p'i "P k'n'q'p' "G'er'k' u'g' "V'g'4222/ U'eq'p'h'q'ec'n' o let'q'ue'q'r g' "P k'n'q'p'. "L'cr c'p'0'

Qw' h'k'p'f' kpi u'k'p'f' k'c'v'g'f' yj cv'o qngewr't' t'q'v'v'k'p' DF R/j "lp'v'g't'c'eu'y kj "u'g't'w'o "r' t'q'v'k'p'u. 'y j lej 't'g'u'w'u' "lp' c' u'v'k'i j v't'gf' "h'j k'h'q'h' d'q'y "DF R/j "cduqtr v'k'p' c'p'f' "h'w'q't'g'ue'g'p'eg' "ur g'v't'c' d' { "8' "p'o "c'p'f' "6' "p'o . 't'gur g'ek'x'g'n'f' O'k'p'ew'uk'p' qh' r' t'q'v'k'p' "o qngewr'u' c'nu'q' " t'g'u'w'u' "lp' r'q'p'i gt "h'w'q't'g'ue'g'p'eg' h'k'g'w'o gu. 'y j lej "l'p'et'g'c'ugu' h'q'o "2044' "p'u'v'q' "60' "p'u'0' DF R/j "w'v'c'ng' g'x'c'v'v'k'p'p' "t'g'x'g'c'ng'f' "y cv' f { g' "c'ee'w'o w'r'v'g'u' d'q'y "lp' "h'z'g'f' "c'p'f' "r'k'x'g' O UE'0' Vj g' o qngewr't' t'q'v'v'k'p' "f' k'h'w'ug'u' "y t'q'w' j " y j g' o go d't'c'p'g' "c'p'f' "u'v'k'p'u" o go d't'c'p'g' d'q'w'p'f' "q'ti c'p'g'ng'u'y kj q'w'r' c'u'k'p'i "y j g' p'w'erg't' "o go d't'c'p'g'0'k'p' f' khhgtgpvcvkpf "O UE' "y j g' l'p't'cegn'w'c't' "f' k'w't'k'd'w'k'p' " ku'f' khhgtgpvcvk'p' c'f' k'q' { v'g'u' DF R/j "c'ee'w'o w'r'v'g'u' "lp' "h'r' k'f' "f' t'q'r ng'u. 'y j k'g' "lp' "ej q'p'f' t'q' { v'g'u'c'p'f' "q'v'g'q' { v'g'u' yj g'f' { g'g'z' j k'd'ku' e' { v'q'u'q't'e' u'v'k'p'k'p'i 0'



Hki 030Vj g'o gej cpluo "qh'o qngewr't' t'q'v'v'k'p' f' go q'p'ut'c'v'g'f' y kj "DF R/j 0'

j3\_ "V'q'k'ew'u. "U'lg'v'c'f'0Gj c'p'ek'p'i "y j g' x'kuequk' / Ugpuk'x'g' T'epi g'q'h'c' DQF RR [ "O qngewr't' T'q'v'v'k'p' d' { "Vy q' Q'f' g't'u'q'h'0' c'i p'k'w'f' g'0Ej go kwt { "6' C' G'w't'q' g'c'p' " Iq'w't'p'c'i'47. "3256463256; "8423; +0' "j4\_ "M'w'o q'x'c. "O 0M00 cr r kpi "x'kuequk' "lp' "egm'i' w'uk'p'i "o qngewr't' t'q'v'v'k'p' { u'0Ej go 0Ej go 0Rj { u036. "348936348; 8 "4234+0'

# A FLEXIBLE MATHEMATICAL SYSTEM TO MODEL EPIDEMICS AND SOME PREDICTIONS FOR ITALIAN COVID-19 PANDEMIC

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Our study consists of a theoretical model that allows predictions of epidemic evolution. It has high flexibility to adapt to a wide range of circumstances via a calibration process made with real data. In this paper, we study the Italian COVID-19 pandemic. Employing data from the first half of 2020, we got a forecast for the second half of that year.

The model presented consists of a mix of established and acknowledged epidemic evolution modelling, of which [1] is a clear and engaging introduction, and our personal view of the subject. We have opted for a complex model with a fair amount of rates to enhance flexibility at the cost of simplicity.

Every person of the whole population gets classified into one of four types: susceptible (S), infected (I), recovered (R) and asymptomatic (A). S can contract the illness by getting in contact with I or A, turning himself I or R depending on his resistance to the disease. I can recover entirely becoming R, or overcome the disease while still spreading it, becoming A in this case. R can lose immunity going back to I. A can lose the capacity to transmit the illness, finally achieving R. Every one of these transitions is controlled by an evolution rate, which needs calibration with real data.

To calibrate these rates, we have used real data from the first wave of Italian COVID-19 pandemic. From there, we have used numerical integration of the differential equations model to predict the impact of easing containment measures, ultimately leading to the second wave, as seen in Fig. 1.

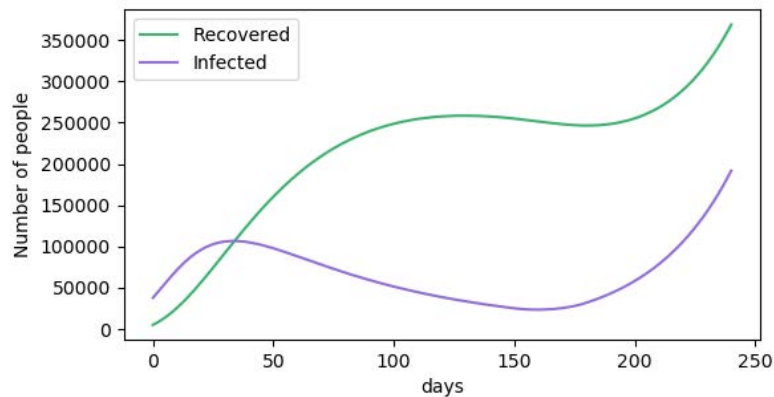


Fig. 1. Temporal evolution of the number of recovered and infected people.

The most concerning issue when mathematically modelling an epidemic is its periodic behaviour (the so-called waves). We have considered a manual tweak of the rates to solve this problem, taking into account government decisions and population reaction to them.

However, this need for a precise selection of the parameters can be a double-edged sword. In our case, it was simple to choose rates that would fit reality because we knew the results beforehand, though it could get tricky to select adequate parameters to achieve real predictions of the future of an epidemic.

Nowadays, with the new possibilities granted by technology, we have reached a clear conclusion. The complex epidemiological models are the best way to transform existing data into predictions of the future. Its only disadvantage is the accuracy required in its parameters.

Nevertheless, neural networks with deep learning methods could accomplish this fine-tuning by intense training of this artificial intelligence. Now, with the COVID-19 pandemic at its peak, we are collecting a large amount of useful data every day. It is mandatory to take this opportunity to create a strong understanding of the evolution of epidemics, as well as a capacity to predict and contain them.

[1] E. C. Pliego, A. Fraguera, *Modelos Epidemiológicos de Enfermedades Virales Infecciosas* (Epidemiological Models of Infectious Viral Diseases), Meritorious Autonomous University of Puebla. Undergraduate thesis, 2017.

# THE OLIGOMANOSE N-GLYCANS 3D ARCHITECTURE AND ITS RESPONSE TO THE FC $\gamma$ RIIIA STRUCTURAL LANDSCAPE.

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Oligomannoses are evolutionarily the oldest class of N-glycans, where the arms of the common pentasaccharide unit, i.e.  $\text{Man}\alpha(1-6)-[\text{Man}\alpha(1-3)]-\text{Man}\beta(1-4)-\text{GlcNAc}\beta(1-4)-\text{GlcNAc}\beta(1-Asn)$ , are functionalized exclusively with branched arrangements of mannose (Man) monosaccharide units. In mammalian species oligomannose N-glycans can have up to 9 Man, meanwhile structures can grow to over 200 units in yeast mannan. The highly dynamic nature, branching complexity and 3D structure of oligomannoses have been recently highlighted for their roles in immune escape and infectivity of enveloped viruses, such as SARS-CoV2 and HIV-1. The architectural features that allow these N-glycans to perform their functions is yet unclear, due to their intrinsically disordered nature that hinders their structural characterization. In this work we will discuss the results of over 54  $\mu\text{s}$  of cumulative sampling by molecular dynamics (MD) simulations of differently processed, unlinked oligomannose N-glycans common in vertebrates. We then discuss the effects of a complex protein surface on their structural equilibria based on over 4  $\mu\text{s}$  cumulative MD sampling of the fully glycosylated CD16a Fc gamma receptor (Fc $\gamma$ RIIIa), where the type of glycosylation is known to modulate its binding affinity for IgG1s, regulating the antibody-dependent cellular cytotoxicity (ADCC). Our results show that the protein's structural constraints shift the oligomannoses conformational ensemble to promote conformers that satisfy the steric requirements and hydrogen bonding networks demanded by the protein's surface landscape. More importantly, we find that the protein does not actively distort the N-glycans into structures not populated in the unlinked forms in solution. Ultimately, the highly populated conformations of the Man5 linked glycans support experimental evidence of high levels of hybrid complex forms at N45 and show a specific presentation of the arms at N162, which may be involved in mediating binding affinity to the IgG1 Fc.

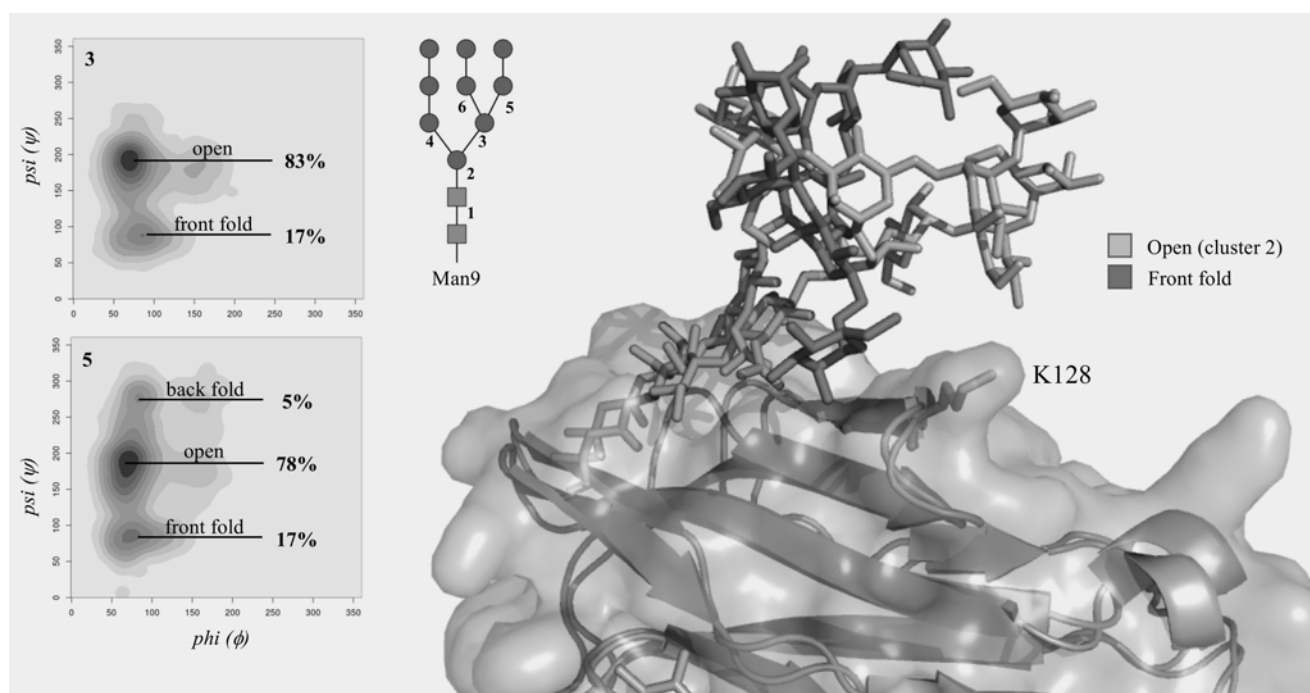


Fig. 1. Conformational analysis of the (1-6) arm and (1-6) branch of the N157-linked Man9 in terms of phi ( $\phi$ ) and psi ( $\psi$ ) torsion angles, obtained from the 2  $\mu\text{s}$  of cumulative MD sampling of the Man9 glycosylated Fc $\gamma$ RIIIa. Heat maps are labelled on the top-left corner according to the Man9 numbering in the sketch. The two dominant conformations of the N157-linked Man9 are shown on the right-hand side, with the protein represented by the solvent accessible surface and underlying cartons in grey and the mannose residues with different shades of green as described in the legend. Heat maps were made with RStudio ([www.rstudio.com](http://www.rstudio.com)) and structure rendered with pyMol ([www.pymol.org](http://www.pymol.org)). N-glycan coloured according to the SNFG convention. (adapted to grey-scale).



**VJ KTF 6J CTO QP KE'I GP GT CVKQP 'O KETQUEQR| 'QHEQNNCI GP 'KP''  
DKNQI KE CN'VKUWGU'UVCKP GF 'Y KVJ 'J GO CVQZ| NKP 'CPF 'GQUR''**

O { nqruc'O c kwkub. "Xknqtcu'O cflgknc. "O ctv\ pcu'Tlkwnc. "Nwncu'Mqpvqpkub. "F cpww 'Dwqvkgp 3.5."  
Xkcrklwu'Mctedcpqxcu<sup>3.5.6.</sup> "Gf xctf cu'fi wtcwuncu<sup>7.</sup> "Xkti kpkwu'Dct| f c<sup>3.8.9</sup>"

<sup>3</sup>Ncugt'Tgugctej 'Egptg.'Hewm\ 'qh'Rj { uku.'Xkrpkwu'Wpkxgtuk\.'Ucwn vgnk\ 'Cyg032.'NV632445.'Xkrpkwu.'Nkj wcpk"

<sup>4</sup>Nki j vEqpxgtukp.'4D'Mgtco km 'u0'NV632455.'Xkrpkwu.'Nkj wcpk"

<sup>5</sup>Dkqo gf kecn'Rj { uku.'Ncdqtcvqt\.'P cvkqpcn'Ecpegt'Kpukwng.'R0Dcwdrkq'u05d.'NV62: 628.'Xkrpkwu.'Nkj wcpk"

<sup>6</sup>F gr ctwo gpv'qh'Ej go kw\ { 'cpf 'Dkqgpi lpggtkpi . 'Xkrpkwu'I gf ko kpcu'Vej plecn'Wpkxgtuk\.'Ucwn vgnk\ 'Cyg033.'NV632445.'  
Xkrpkwu.'Nkj wcpk"

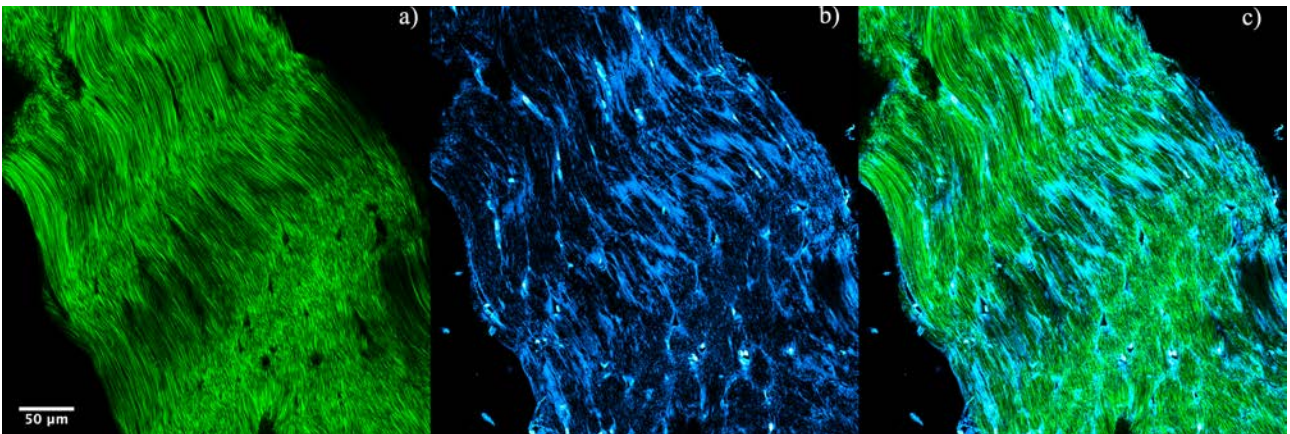
<sup>7</sup>F gr ctwo gpv'qh'Rcvj qm\ { .'Hqtgpule'O gf kelpg'cpf 'Rj cto ceqm\ { .'Hewm\ 'qh'O gf kelpg.'Xkrpkwu'Wpkxgtuk\.'O (M)  
kwtrkplq'u043149.'NV625323.'Xkrpkwu.'Nkj wcpk"

<sup>8</sup>F gr ctwo gpv'qh'Rj { uku.'Wpkxgtuk\ 'qh'Vqtqpvq.'82'U0I gqti gu'u0'Vqtqpvq.'QP 'O 7U'3C9.'Ecpfc c"

<sup>9</sup>F gr ctwo gpv'qh'Ej go kecn'cpf 'Rj { ulecn'Uelgpegu.'Wpkxgtuk\ 'qh'Vqtqpvq'O kuukucwi c.'557; 'O kuukucwi c'Tf 0P 0"  
O kuukucwi c'N7N'3E8.'QP .'Ecpfc c"

o { nqruc'0 ckwkub Hnwf kw0w'

O wko qf cn'pqrkpgct'rcugt0uecpkpi "o letqueqr { "ku" c' r qy gthw\ 'vej pls wg' hqt "pqp\pxcukxg" dlqni kecn'ko ci kpi "]3\_0'  
Uxgtcn'pqrkpgct'uki pcn'ecp'dg'i gpgtcvqf 'uko wncpgqwan\ 'cv'j g'hqewu'qh'c'o letqueqr g'qdlgevxg.'kpenw kpi 'o wnk' j qvq"  
gzekcvkq'hwqtguepeg.'ugeqpf 6j cto qple'i gpgtcvqpp '\*U I +'cpf 'y kf 6j cto qple'i gpgtcvqpp '\*VJ I +0E qmci gp.'y g'o clp"  
eqpukwgpv'qh'gzvcegnwrt'o cvkz'lp'j g'dlqni kecn'kuuwg'ecp'dg'xkuwrk\ gf 'y kj 'U I "o letqueqr { 'y j lej 'ecp'dg'wugf"  
hqt'ecpegt'f kci pquku"j4\_0'Ej cpi gu'lp'j g'eqmci gp'utwewtg'ctg'qduxtxgf "lp"j go cvqz { rkp0cpf 6gqulp0ucvkgf '\*J ( G6  
ucvkgf +' j kvqni { "ugevqpu." y j lej "eqpvcuv' egm' pwegk' hqo " y j g' e { vq r cuo " cpf " gzvcegnwrt' utwewtgu' cpf " ctg"  
eqpukf gtf "cu'y j g'i qf "ucvkgf hqt"j kvqni kecn'lp'xgukv cvkpu"j5\_0' Cnj qwi j "eqmci gp'hkdtu'ctg'xkuwrk\ gf 'y kj 'U I "  
o letqueqr { "lp' j ku' y qtn' VJ I " ku' wugf " hqt" eqmci gp' xkuwrk\ cvkqpp' cpf " ej ctcevgtk\ cvkqpp' Vj g' r qvqpcn' hqt" ecpegt"  
f kci pquku' wulpi "VJ I " hqo " J ( G6ucvkgf "uco r ngu'ku'cnuq'lp'xgukv cvqf 0'Hki 0\*c+'xkuwrk\ gu'eqmci gp'hkdtu'lp'U I ."  
y j kw'VJ I " \*Hki 0\*d++'uj qy u'gpf qvqpf lpgwo " y j lej 'y tr u'lpf kxk\ wcn'hcuelegu'0E qmci gp'hkdtu'ctg'cnuq'hc'kw' 'xkukdg'lp"  
y j g'VJ I "ko ci g0k'cf f kkp'egm'pwegk'qh'vqpf qe { vgu'ctg'j ki j rki j vqf "lp'VJ I 0Vj g'eqo dlpqf 'ko ci g' \*Hki 0\*e++'uj qy u'y j g'  
eqmceik\ cvkqpp'dgy ggp'eqmci gp'hkdtu'gpf qvqpf lpgwo "cpf 'vqpf qe { vgu'0O wko qf cn'pqrkpgct'o letqueqr { "ko ci kpi 'ecp"  
dg' lpeqtr qtcvqf " lp'vq' j g' 'kuuwg' j kvqni { " lp'xgukv cvkpu" y kj qw' cf f kkp'pcn' o qf hkecvkpu' qh' y j g' J ( G6ucvkgf "  
j kvq' cvj qm\ { 'uco r ngu'0O wko qf cn'ko ci kpi 'ecp'dg'cr r rkgf 'hqt'lp'xgukv cvkqpp'qh'utwewt'cej cpi gu'lp'eqppgevxg'kuuwg"  
f vq'vq'xctkvw'f kugcugu'cpf 'cnuq'ku'dgpghelecn'lp'qduxtkpi 'gzvcegnwrt'o cvkz'cpf 'egm'pwegk'lp'ecpegt'f kci pquku'0



Hki 0300 wkeqpv'cu'pqrkpgct'qr vkecn'0 letqueqr { "ko ci gu'qh'tcv'ckn'vqpf qp'j kvqni { "ugevqpp'ucvkgf 'y kj 'j go cvqz { rkp"  
cpf 'gqulp '\*J ( G'ucvkgf +0c+'U I "ko ci g'qh'eqmci gp'kuuwg.'d+'VJ I "ko ci g'hqo 'y j g'uco g'uco r ng'ctg'cpf 'e+'eqo dlpqf "  
ko ci g'qh'dqj 0'

Cempy ngf i go gpw'v'j g'y qtniy cu'lw r qt vqf 'd { "i tcpvP q03040NO VM93: /24/22380

aa  
j3\_'T0'Ecttkgu.'F 0P 0'Uej chgt.'M'GO'Uj ggv\.'L0'LO'Hlgr.'T0'Ekgm'X0'Dct| f c.'cpf "L0'Us vkgf."0k6 ko kpi "vej pls vgu'hqt"j cto qple'cpf "o wnk' j qvq"  
cdqtr vqpp'hwqtguepeg'o letqueqr { .0'Tgx0'Uek0'pustwo 0: 2.'2: 3323'\*422; +0'  
j4\_'C0I qnctek'N0Mqpvqku.'T0'Ekgm'F 0'Vqnet|. 'U0'LO'F qpg.'DO'E0Y kuq.'cpf 'X0'Dct| f c.'0Ej cpi gu'qh'eqmci gp'wnt'cvt'wewt'g'lp'dtgcuv'ecpegt'kuuwg"  
f gvtg' lpgf 'd { 'ugeqpf /j cto qple'i gpgtcvqpp'f qvqdg'U'qngv'0 wngt'f qnctg' gule'o letqueqr { .0'Dkqo gf 0Qr v0Czr tgu'9\*32+'62766628: '\*4238+0'  
j5\_'L0C0Mkt'p'p.'J kvqni kecn'cpf 'J kvqj go kecn'0 gy qf u.'Stf 'gf 0'Dwgt y qv'j 'J g'pgo cpp.'Y qdwt.'O C '\*3; ; +0

O12-6

DID NOT PARTICIPATE

**'O KETQO CEJ KPI 'QH'VT CP URCT GP V'DKQEQO RCVKDNG'  
RQN[ O GTU'CCRNGF 'K' O GF KE KPI 'DWTUVU'QH'HGO VQUGE QP F'  
NCUGT 'RWNUGU''**

Gxcrf cu'Mcflwncwncu<sup>3</sup>. 'Uko cu'Dwmwu<sup>3,5</sup>. 'Rkqt 'Vqncetunk<sup>4</sup>. 'X{vcwcu'Lwncp<sup>3</sup>. 'Ectmqu'X{vcwcu'  
F kco qpf 'O cplncu<sup>3</sup>. 'O ctv{pcu'Dctncwncu<sup>5</sup>'cpf 'Xcrf cu'Uktwncwncu<sup>3</sup>'"

<sup>3</sup>Ncugt'Tgugctej 'Egpygt. 'Hecwnc'qh'Rj {ukeu. 'Xkpkwu'Wpkxgtukv{. 'Ucwn vgnkq'Cxg032. 'NV/32445'Xkpkwu.'Nkj wcpkc"

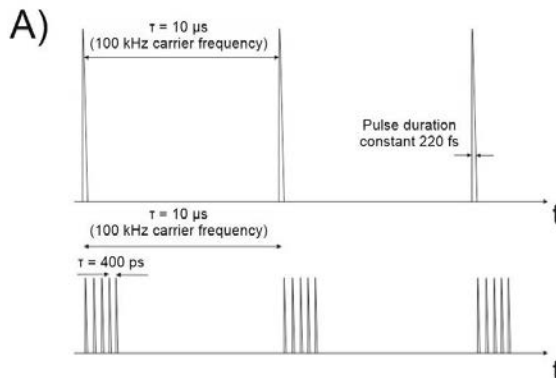
<sup>4</sup>O un'O gf 'Ugtxlegu'Nvf 0'Tqf qw8. 'Vtgo kj qwoc. 'Rcr j qu': 492. 'E{rtwu"

<sup>5</sup>Nki j v'Eqpxgtukp. 'Mgtco km '4d. 'NV/32455'Xkpkwu.'Nkj wcpkc"

gxcrf cu'nc| wncwncuB Hkxwnc

"Dkqeqo r ckdng' r rncwncu'ctg' wugf "hqt" o cp{ "f khtgtpv' r wtr qugu" \*ecvj gvgtu." ctv'kncn' j gctv' eqo r qppgw. "f gpkwnc{ " r tqf wewu." gve0]3\_0CP' ko r qtcvpv' hkrf "hqt" vj g'wug'qh'dkqeqo r ckdng' r qnc' o gtu'ku'vj g'r tqf wewq'qh'xkukq' ko r rcpw'hpqy p" cu'lpvtcqwnc' r'gpugu' \*kp'uj qtv'0' 'KQNu'qt' ewuqo /uj cr g'eqpcev' r'gpugu'0' Ceeqtf kpi "v'uncwncu." cdqw'72" "qh'Co gtlccpu" j cxg'f gxnqr gf "ecvctcew'd{ "vj g'ci g'97/9; "j4\_ "c'eqpf kkp'vj cv'ku'ewctdng'd{ "uwti kcm{ "tgr rckpi "vj g'qt ki kpcn'g{ g'rgpu" y kj "cp'ct'kncn'rgpu'0"

Qpg'qh'vj g'o qu'lxqctcdng' o cvgtknc'kp' "KQNu" o cpwncwncu'ku'j {f tqr j knc'cet{ rnc'0'c' uqhw' dkqeqo r ckdng' r qnc' o gtu' V{r kcm{. "ewtxgf' uwtncwncu'ctg' o cpwncwncu' d{ "o gej cplccn' o gpcu'uwej "cu' o kncpi. "wtpkpi "qt'ncvj g'ewwncu' 0P qy cf c{ u' 40F' qdlgeu' uwtncwncu' ecp'cnq' dg' o cpwncwncu' d{ "o gpcu'qh'ncwncu' o letqo cej kpi. "vj cv'ctg' o qtg'xgtucwnc' ]5\_0J qy gxgt." f wnc'vj g' rki j v o cvgt' kpcwncwncu' o gej cplkuo u. "vj g' uwtncwncu' qh'vj g' o letqo cej kpi qdlgeu' cr r gtu' tqwi j "0'3' Uo "Tc' cpi" ecppqvtgcej "qr wncn' i tcf g' uwpf ctf u'0Vj g' uwtncwncu' o c{ "dg' r qnkj gf "xlc' o gej cplccn' o gvj qf u'j qy gxgt. "vj g' r tgegu' o c{ " wnc'w' "v'c' "hgy "f c{ u' ]6\_ "y j knc' o cncu' vj g' r tgegu' geqqo kcm{ "ej cncpi kpi. "gur geknc{ "y j gp' wncn' kpi "cdqw' ewuqo / uj cr g' r'gpugu'0Vj ur ggf "w' vj ku' r tgegu. "cncgpcwnc' y c{ u' v' r qnkj "KQNu' ctg' qp' vj g'ugctej 0"



Hki 030Hgo vqugeqpf 'rcugt' r wngu' f kxf gf 'kpq' dwtu' u'wej go cve' \*C=ewtxgf' uwtncwncu' r qnkj gf 'wukpi' dwtu' qh' hgo vqugeqpf 'rcugt' r wngu'

Vj g' cko "qh'vj ku'uwf { "ku'vj g' lpxguki cvkq' qh'vj g' r qnkj kpi "ecr cdkkku' qh' tqwi j "20" / "5" Uo "Tc+" {f tqr j knc' cet{ rnc' " uwtncwncu' wukpi "dwtu' qh' hgo vqugeqpf "rcugt' r wngu' "rcugt' o Ectdkf g0+. "c' tgi ko g' "y j g' g' uki ng' r wngu' ctg' f kxf gf "kpq' c" ugs wpeg' qh' uwd/ r wngu' y kj "c' ko g' ugr ctevkq' qh' 622' r u'0' ugg' Hki wtg' 3' \*C+0Hgo vqugeqpf 'rcugt' r wngu' y g' g' f kxf gf "kpq' dwtu' r cengw' qh' 4. "7. "32. "47' uwd/ r wngu. "vj g' kpf kxf wnc' co r rkwf gu' y g' g' r' g' xgnr gf "v' cp' gttq' qh' cr r tqzko cvnc' "32" 0' Cdrwncu' qh' vj g' uwtncwncu' y cu' ectt' g' f "q' w' q' p' j {f tqr j knc' cet{ rnc' \*E q' p' v' c' e' EQP VCHNGZ "48" WX/ KQNu' \*T++ u' c' o r' ngu' k' p' c' " y q/ ugr ' r tgegu' c' d' r' wncu' vj g' f guk' gf "uj cr g' cpi' f' uwdugs wgpv' r qnkj kpi "wukpi" f khtgtpv' dwtu' v' qf gu'0' k' vj g' h' t' u' l' u' r. "pwo dgt" qh' u' c' o r' ngu' y g' g' r' tgr ctg' "j c' kpi "f khtgtpv' uwtncwncu' tqwi j pgu' x' c' wncu' t' cpi kpi "htqo "20" v' q' 5' Uo "Tc'0' k' vj g' ugeqpf "uwr. "c" ugt' kku' qh' uwtncwncu' r qnkj kpi "zr' g' tko g' p' u' y g' g' e' q' p' f' w' e' v' f' wukpi "dwtu' qh' hgo vqugeqpf 'rcugt' r wngu. "y j knc' o q' p' k' q' t' kpi "vj g' vgo r g' t' c' w' t' g' qh' vj g' uwtncwncu' y kj "cp' K' eco g' t' c' 0' D' { "ej cpi kpi "f khtgtpv' r' c' t' c' o' g' v' g' t' u. "k' y' cu' r' qu' k' d' r' g' v' r' t' q' f' w' e' g' q' r' w' e' c' n' s' w' r' k' f' " uwtncwncu' uwtncwncu' tqwi j pgu' > "42" po "Tc+0' k' v' c' f' f' k' k' p' f. "k' y' cu' r' q' w' p' f. "vj cv' vj g' t' g' u' w' n' k' p' i "Tc' t' q' w' i j p' g' u' qh' vj g' uwtncwncu' chgt' r' qnkj kpi "j cu' c' er' g' t' e' q' t' g' r' w' k' p' y' kj "vj g' uwtncwncu' vgo r g' t' c' w' t' g' f' w' k' p' i "o letqo cej kpi 0' Wukpi "vj g' y' q/ ugr "cr r t' q' e' j. " k' y' cu' r' qu' k' d' r' g' v' r' t' q' f' w' e' g' q' r' w' e' c' n' e' q' o' r' q' p' p' w' u' w' e' j "cu' c' e' q' p' e' c' x' g' r' g' p' u' t' q' o "vj g' u' w' f' k' g' f' j {f tqr j knc' o cvgtknc' cu' u' j qy p' k' p' " Hki wtg' 3' \*D+0" "

[3] "Dcwt. "U0' Uej o wnc' "R0' xq' p' f' g' t' O' ctm' "M0' Rctm' "L0' Gpi kpgtkpi "dkqeqo r ckdng' ko r rcpw' uwtncwncu' "Rctv' K' O' cvgtknc' cpi' "uwtncwncu' R' t' q' i' 0' O' cvgt' 0' U' k' 0' 4235. '7: . '48365480

[4] "Eqpi f qp. "P0' R' t' x' c' r' p' e' g' qh' E' c' v' t' c' e' v' e' p' f' "R' u' g' w' q' r' j' c' n' k' i' C' r' j' c' n' k' "co qpi "C' f' w' n' u' l' p' vj g' W' p' k' g' f' "U' c' y' u' 0' C' t' e' j' 0' Q' r' j' vj c' w' q' 0' 4226. '344. '6: 966; 60

[5] "Mcflwncwncu." G0' D' w' n' u' . "U0' V' q' n' e' t' u' n' k' "R0' L' w' n' p' c' . "X0' D' e' t' n' e' w' u' n' c' u' . "O' 0' U' t' w' n' e' k' k' u' . "X0' O' l' e' t' q' o' c' e' j' k' p' i' "q' h' V' t' c' p' u' r' c' t' p' v' D' k' q' e' q' o' r' c' k' d' n' g' "R' q' n' [ o' g' t' u' "C' r' r' n' g' f' "p' O' g' f' k' e' l' p' g' "W' u' k' p' i' "D' w' t' u' v' q' h' h' g' o' v' q' u' g' e' q' p' f' "N' c' u' g' t' "R' w' n' u' g' u' 0' l' e' t' q' o' c' e' j' k' p' i' 4242. '33. '32; 50

[6] "Xcng. "O' 0' l' co' c' f' c' . "C' 0' l' co' g' u' . "T' 0' k' v' t' c' q' e' w' n' t' "N' g' p' u' V' w' o' d' r' p' i' "R' t' q' e' g' u' u' W' u' k' p' i' "E' q' c' v' f' "D' g' c' f' u' 0' W' L' O' R' e' v' p' v' 7. ; 83.592. '7' Q' e' v' d' g' t' '3; ; ; 0'

# TOWARDS 50 FS SWIR PULSES BY TRANSIENT STIMULATED RAMAN CHIRPED-PULSE AMPLIFICATION WITH SPECTRUM SYNTHESIS

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Expanding the coverage of laser sources spectral range is one of the most urgent scientific problems. Near infrared (NIR) lasers (0.7 – 1.1  $\mu\text{m}$ ) are well developed to provide high pulse energy, short pulse duration and high repetition rate. However, the wavelength conversion of ultrashort pulses in short-wave infrared (SWIR) spectral region ( $> 1.1 \mu\text{m}$ ) with good efficiency has not yet been exhaustively studied. Picosecond and femtosecond pulse width SWIR laser sources are required for a wide range of applications, ranging from spectroscopy, biomedicine to material processing and metrology. In strong field physics, high peak power SWIR laser pulses allow to generate high harmonics and reach attosecond pulse width. In this case, increasing the fundamental wavelength makes it possible to achieve higher photon energy [1]. Also, recent studies have shown that with the increase in the wavelength of the laser source for excitation of THz radiation, the conversion efficiency grows by an one order of magnitude [2].

Stimulated Raman scattering (SRS) is a promising wavelength conversion method that also has advantages for pulse compression and its inherent phase matching in gas, liquid or crystalline media, eliminating the need for parametric crystals. However, stimulated Raman scattering with picosecond and femtosecond laser pulses suffers from lower energy conversion efficiency and nonlinear phenomena caused by the optical Kerr effect. The use of broadband supercontinuum pulses as a seed can improve efficiency and stability of SRS-conversion, maintaining beam quality.

The goal of this study was to investigate transient stimulated Raman chirped-pulse amplification (TSRCPA) and to determine the optimal conditions for broadband spectrum synthesis which allows to achieve a pulse width of 50 fs.

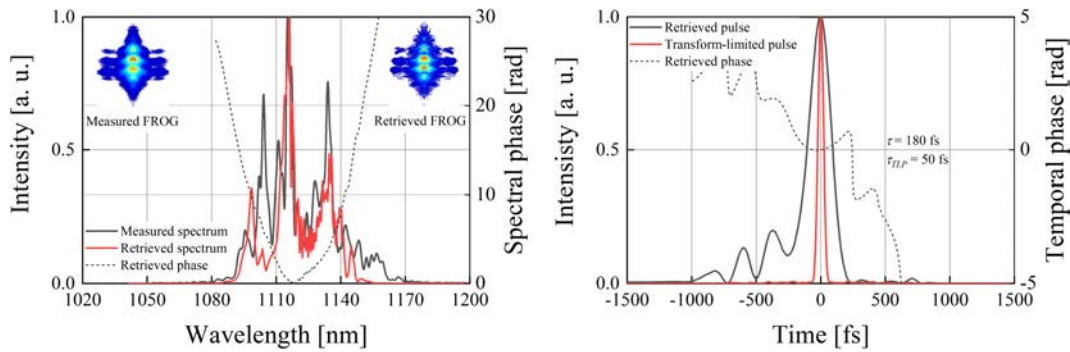


Fig. 1. Left – the measured and retrieved spectrum and spectral phase of the amplified pulse before compression, inset: measured and retrieved FROG traces. Right – retrieved temporal profile of the compressed pulse compared to transform-limited pulse calculated from the spectrum width and retrieved temporal phase.

We report a two-stage TSRCPA system based on KGW crystals seeded with supercontinuum and pumped by 1.2 ps pulses at 1030 nm wavelength [3]. The anisotropic nature of KGW crystal allows several spontaneous Raman scattering modes, which depend on the pump polarization with respect to the crystal axis. This was achieved by rotating KGW crystal about  $N_p$  optical axis and controlling pump and seed electric field vectors  $E$  parallel to the crystal axes  $N_g$  or  $N_m$  with Stokes shifts of  $767 \text{ cm}^{-1}$  and  $901 \text{ cm}^{-1}$ , respectively. This made it possible to amplify the separate Raman scattering modes and synthesize a common broadband spectrum. In the first amplifier stage, the pump-to-signal conversion efficiency for the  $901 \text{ cm}^{-1}$  Stokes shift under optimal conditions reached 7 %. The second amplification stage operated in the  $768 \text{ cm}^{-1}$  Stokes mode and achieved a conversion efficiency of 35 %. Thus, this method of spectrum synthesis made it possible to achieve amplified pulse energy of  $460 \mu\text{J}$  and expand the spectral bandwidth to 35 nm at a central wavelength of 1120 nm, see 1 fig. left. Amplified pulse bandwidth was about 22 times the pump bandwidth. Eventually, the FROG measurement of the TSRCPA-amplified broadband pulses indicate linear phase modulation, which was partially compensated by N-SF11 prism pair compressor, providing pulse width of up to 180 fs (1 fig. right).

**Acknowledgement:** This research was partially funded by the European Social Fund under the No 09.3.3.-LMT-K-712-22-0123 Development of Competences of Scientists, other Researchers and Students through Practical Research Activities measure.

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 [2] A.D. Koulouklidis, C. Gollner, V. Shumakova, V.Y. Fedorov, A. Pugžlys, A. Baltuška, and S. Tzortzakakis, Observation of extremely efficient terahertz generation from mid-infrared two-color laser filaments, *Nat. Commun.* **11**(1), 1–8 (2020).  
 [3] P. Mackonis, A. Petrulėnas, A.M. Rodin, V. Girdauskas, and A. Michailovas, Two-stage transient stimulated Raman chirped-pulse amplification in  $\text{KGd}(\text{WO}_4)_2$  with compression to 145 fs, *Opt. Lett.* **45**(24), 6627–6630 (2020).

**QRVKO K CVKQP 'QHI cKpCuII cCu'S WCP VVO 'Y GNN'VGEJ PQNQI [ 'HQT' 'CRRNIE CVKQP U'K' P GCT 'KPH CT GF 'XGT VRE CN/GZ VGT P CN/ECXK\ [ ' UWHCEG/GO KVKPI 'NCUGTU'**

Cpf tgc\ grkqrk<sup>3</sup>. 'Cri kf cu' Lcukpuncu<sup>4</sup>. 'Cfc' I clewuncv<sup>4</sup>. 'Uko qpc' R mkgp<sup>4</sup>. 'Nwncu' Lq kqpla<sup>4</sup>. ' Gxgrkpc' F wf wkgp<sup>4</sup>. 'Dtqpkmxcu' gej cxx kwu<sup>4</sup> 'cpf' Tgpcw' Dwnnw<sup>4,5</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rj { uleu. 'Wpkxgtuk\ 'qh'O qf gpc. 'Kcrk'

<sup>4</sup>Egpygt' hqt' Rj { ulecn' Uelgpegu' cpf 'Vgej pqmji { . 'Xkpkwu' Nkj wcpkc'

<sup>5</sup>'Kpukwag'qh'Rj qvqpleu' cpf 'P cpqvej pqmji { . 'Hewm\ 'qh'Rj { uleu. 'Xkpkwu' Wpkxgtuk\ . 'Nkj wcpkc'

3; 277: B uwf gpv'kwplo qtgkv'

"

Vqf c { 'rcugt' u'ctg' wugf 'kp' o cp { 'hgrf u. 'r ctvewrtn\ 'kp' qr vlecn' hgdg' eqo o wplecvkp. 'qr vlecn' ki kcn' tgeqt' f' kpi . 'o cvgtkcn' r tqegukpi . ' dmqmji { " cpf " o gf lkp. " ur gextqueqr { . " ko ci kpi . " gpv' tckpo gpv. " cpf " o cp { " qj gtu' k' p' etgcukpi " f go cpf " qh' gzeqr vqpcn' kpxgukv cvkp " eqpf k' k' qpu' uwf { kpi " xctk' qvu' o cvgtkcn' tgs wkt' g' wpls wg' ugv' qh' rcugt' r ctco gvtu' / " go k' ukqp " y cxgrgpi vj . " ku' wpcdkk\ . " dgco " s wcrk\ . " qr gtcv' k' vgo r gtcw' g. " qr vlecn' qwr w' r qy gt' J gt y kj . " eqpxgplgp' o gvj qf " qh' rcugt' g' zekcvkp. " r qy gt' eqpuwo r v' k' p. " j ki j / ur g' g' f' o qf wrcv' k' p' cpf " f' gxleg' uk\ g' dgego g' xgt { " ko r qt' v' p' h' cev' qtu' }

Xgt vlecn' g' z' v' t' p' cn' / ecxk\ " uwthceg / go k' v' k' pi " rcugtu' \*XGEUGN+ . " cmq' ecngf " qr vlecn' " r wo r gf " ugo leqpf wev' t' rcugtu' qt " ugo leqpf wev' t' f kmi' rcugt' d' g' r' p' i " v' q' t' g' r' v' k' g' n' " pgy " rcugt' h' co k' k' " vj cv' eqo d' k' p' u' o cp { " qh' vj g' f' g' u' k' t' cdrg' r t' q' r' g' t' v' k' u' o' k' p' " eqo r ct' k' u' p' v' q' d' q' v' r' g' u' qh' g' r' g' e' t' vlecn' " r wo r gf . " xgt vlecn' / ecxk\ " uwthceg / go k' v' k' pi " rcugtu' \*XGEUGN+ go k' v' k' pi " n' y' r' qy gt' " ekewr' t' h' w' p' f' co gpv' cn' t' cp' u' x' g' t' u' g' o' qf g' dgco " cpf " gf i g' go k' v' k' pi " rcugtu' \*Hcdt { / Rgt' v' cp' f' F HD+ t' g' e' j' k' pi " j ki j " qwr w' r' qy gt' " dw' g' z' j' k' k' k' pi " cu { o o g' t' k' dgco " y kj " ut' q' pi " c' pi w' r' t' f' k' x' g' t' i' g' p' e' g' . " XGEUGN' u' ct' g' e' c' r' cdrg' v' q' i' g' p' g' t' c' v' j' ki j " qr vlecn' r' qy gt' " dgco " n' g' r' k' pi " j ki j " ekewr' t' s' w' r' k' v' { " J3/5\_0'

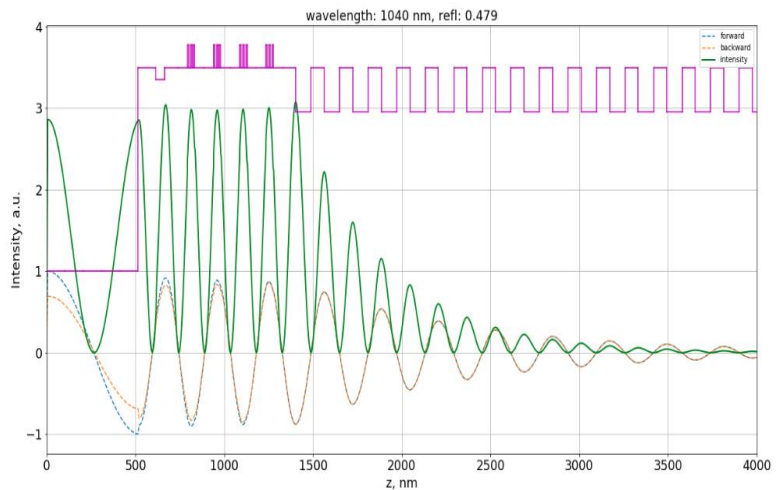
Kp' vj ku' y qtni' vj g' d' g' j' c' x' k' q' w' t' " qh' vj g' " go k' u' k' q' p' y' c' x' g' r' g' p' i' vj " y' cu' uwf' k' e' f' " k' p' t' g' r' v' k' q' p' " v' q' vj g' f' g' u' k' i' p' r' ctco g' v' t' u' qh' vj g' " XGEUGN' " e' j' k' o'

O qf g' n' g' f' " XGEUGN' " ut' w' e' w' t' g' " ku' " f' go q' p' u' t' c' v' g' f' " k' p' Hki 030' Vq' q' d' v' k' p' r' u' k' p' i " k' v' k' u' " p' g' e' g' u' c' t' { " v' q' f' g' u' k' i' p' vj g' " D' t' c' i' i " o' k' t' q' t' . " i' c' l' p' " t' g' i' k' q' p' " c' p' f' " uwthceg' " d' c' t' t' l' g' t' " r' { g' t' " \*y' k' p' f' q' y' + " f' g' r' g' p' f' k' pi " q' p' vj g' v' e' t' i' g' v' y' c' x' g' r' g' p' i' vj " qh' vj g' " rcugt' 0' Vj g' " i' c' l' p' " t' g' i' k' q' p' " ku' w' u' w' c' m' { " eqo r' q' u' g' f' " h' t' q' o " s' w' c' p' w' o " y' g' m' i' ut' w' e' w' t' g' " e' c' r' e' w' r' v' g' f' " v' q' " o' c' v' e' j' " vj g' " rcugt' " q' r' vlecn' u' c' p' f' k' pi " y' c' x' g' " c' p' v' k' p' q' f' g' u' c' u' l' j' q' y' p' k' p' Hki 03' v' i' t' g' g' p' e' w' x' g' +0'

O w' n' k' r' g' k' p' i' c' Cull cCu' s' w' c' p' w' o " y' g' m' i' " \*O S Y u' t' c' p' f' " C' r' Cull cCu' F' k' u' t' k' d' w' g' f' " D' t' c' i' i " t' g' h' g' e' v' q' t' " \*F DT+ " y' g' t' g' " w' u' g' f' " h' q' t' " XGEUGN' " c' t' e' j' k' g' e' w' t' g' 0' Vj g' " u' g' r' c' t' c' v' g' " r' { g' t' u' " c' p' f' " XGEUGN' ut' w' e' w' t' g' u' y' g' t' g' i' t' q' y' p' v' u' k' p' i " u' q' i' k' f' / u' q' w' e' g' " O DG' u' { u' g' o " \*Xg' g' e' q' " I GP z' r' r' q' t' " T ( " F + " g' s' w' k' r' g' f' " y' k' j' " u' e' p' f' c' t' f' " e' g' m' i' h' q' t' " o' g' v' e' n' k' e' " Cn' I' c' c' p' f' " w' p' l' s' w' g' " Cu' f' g' u' k' i' p' u' q' w' e' g' "

i' g' p' g' t' c' v' k' p' i " r' w' t' g' " c' t' u' g' l' e' " f' k' o' g' t' u' " h' w' z' 0' Vj g' " ut' w' e' w' t' g' " y' cu' i' t' q' y' p' " q' p' " u' g' o' k' l' p' u' w' r' v' k' p' i " I' c' Cu' u' d' u' t' c' v' g' " q' t' l' g' p' v' g' f' " k' p' " \*223+ " e' t' { u' c' n' k' p' g' r' r' c' p' g' 0' Vq' d' c' r' c' p' e' g' ut' c' l' p' qh' S Y ' k' p' vj g' r' u' g' t' ut' w' e' w' t' g' . ' S Y ' y' k' f' vj " f' " c' p' f' " k' p' " e' q' p' v' g' p' v' y' cu' x' c' t' k' e' f' 0' k' p' " e' q' p' v' g' p' v' k' p' vj g' " S Y ' y' cu' e' j' c' p' i' g' f' " h' t' q' o' " 7' " v' q' " 52' . " vj k' e' n' p' g' u' i' qh' S Y ' y' cu' t' c' p' i' g' f' " d' g' y' g' g' p' " 5' p' o' " c' p' f' " : " p' o' 0' Vj g' " go k' u' k' q' p' y' c' x' g' r' g' p' i' vj " qh' " i' t' q' y' p' " o' w' n' k' r' g' s' w' c' p' w' o " y' g' m' i' c' p' f' " XGEUGN' ut' w' e' w' t' g' u' y' cu' o' g' e' u' w' t' g' f' " w' u' k' p' i " r' j' q' v' q' n' w' o' k' p' g' e' g' p' e' g' " ur' g' e' t' q' u' e' q' r' { " c' v' y' k' f' g' " v' g' o' r' g' t' c' w' t' g' " t' c' p' i' g' qh' " 522' M' / " 6' M' 0' Vj g' " s' w' r' k' v' { " qh' " F DT' " k' p' " ur' g' e' t' c' n' i' t' c' p' i' g' " h' t' q' o' " : " 22' p' o' " v' q' " 3722' " p' o' " y' cu' v' g' u' g' f' " w' u' k' p' i " " g' n' k' u' q' o' g' v' g' t' 0'

Chgt' f' g' v' k' e' g' f' " uwf { " qh' k' p' " e' q' p' v' g' p' v' c' p' f' " S Y ' vj k' e' n' p' g' u' i' l' p' h' w' g' p' e' g' v' q' vj g' q' r' vlecn' r' q' r' g' t' v' k' u' qh' O S Y . " vj g' eqo r' n' g' v' e' j' k' r' " y' cu' h' c' d' t' e' c' v' g' f' . " clo k' pi " c' v' vj g' r' t' q' f' w' e' v' k' p' qh' c' " XGEUGN' f' go q' p' u' t' c' v' k' p' i " go k' u' k' q' p' y' c' x' g' r' g' p' i' vj " qh' " ; 98' p' o' 0' Vj g' t' g' h' g' e' v' c' p' e' g' " qh' F DT' y' cu' o' qf g' n' g' f' " h' q' t' " 47/52' I' c' Cu' c' p' f' " C' r' C' u' r' g' t' k' q' f' u' q' " q' d' v' k' p' j' ki j' g' t' vj cp' ; 9' " c' v' e' g' p' t' c' n' F DT' y' c' x' g' r' g' p' i' vj " qh' ; 98' " p' o' 0' Vj g' p' w' o' d' g' t' qh' k' p' i' c' Cu' O S Y u' y' cu' q' r' v' o' k' g' f' " v' q' " 340' Vj g' c' e' v' k' x' g' c' t' c' o' qh' ut' w' e' w' t' g' y' cu' e' q' x' g' t' g' f' d' { " 387' p' o' " vj k' e' m' C' r' C' u' " y' k' p' f' q' y' " c' p' f' " 7' " p' o' " I' c' Cu' e' c' r' r' k' pi " r' { g' t' 0' Vj g' " t' g' u' w' u' " qh' " T' g' h' g' e' v' c' p' e' g' " c' p' f' " Rj q' v' q' n' w' o' k' p' g' e' g' p' e' g' " o' g' e' u' w' t' g' o' g' p' u' " c' p' f' " e' j' c' t' c' e' v' t' k' v' k' p' d' { " C' v' q' o' l' e' " H' q' t' e' g' " O' l' e' t' q' u' e' q' r' { " qh' i' t' q' y' p' r' { g' t' u' c' p' f' " XGEUGN' ut' w' e' w' t' g' u' y' k' n' i' r' t' g' u' g' p' y' g' f' 0'



Hki 030' G' p' g' t' i' { " h' g' x' g' u' i' qh' o' qf g' n' g' f' " XGEUGN' ut' w' e' w' t' g' 0'

J3\_0' c' n' i' m' w' p' g' u' q' x' . " XGEUGN' u' g' o' l' e' q' p' f' w' e' v' q' t' " N' c' u' g' t' u' < C' R' e' j' " v' q' " j' ki j / R' q' y' g' t' . " S' w' r' k' v' { " D' g' c' o' " c' p' f' " W' X' v' q' " k' f' " Y' c' x' g' r' g' p' i' vj " d' { " F' g' u' k' i' p' . " U' g' o' l' e' q' p' f' w' e' v' q' t' " F' k' u' m' i' " N' c' u' g' t' u' 0' R' j' { u' l' e' u' c' p' f' " V' g' e' j' p' q' m' j' i' { 0' G' f' k' e' g' f' " d' { " Q' r' i' g' i' " I' 0' Q' n' j' q' v' p' k' u' x' . " 4232 . " Y' K' N' G' l' / X' E' J' " X' g' t' r' e' i' " I' o' d' j' ( " E' q' 0' M' i' c' c' . " Y' g' l' p' j' g' l' o' " J4\_0' F' 0' R' e' v' n' e' " U' g' o' l' e' q' p' f' w' e' v' q' t' " h' u' g' t' " f' k' q' f' g' z' g' e' j' p' q' m' j' i' { " c' p' f' " c' r' r' i' e' c' v' k' p' u' . " k' p' v' e' j' " \*4234+ r' r' 0439/43; 0' J5\_0' 01' w' p' c' g' v' c' i' 0' l' q' w' p' c' i' qh' Rj { u' l' e' u' F' < C' r' r' i' g' f' " Rj { u' l' e' u' 72' \*4239+0'

O13-4

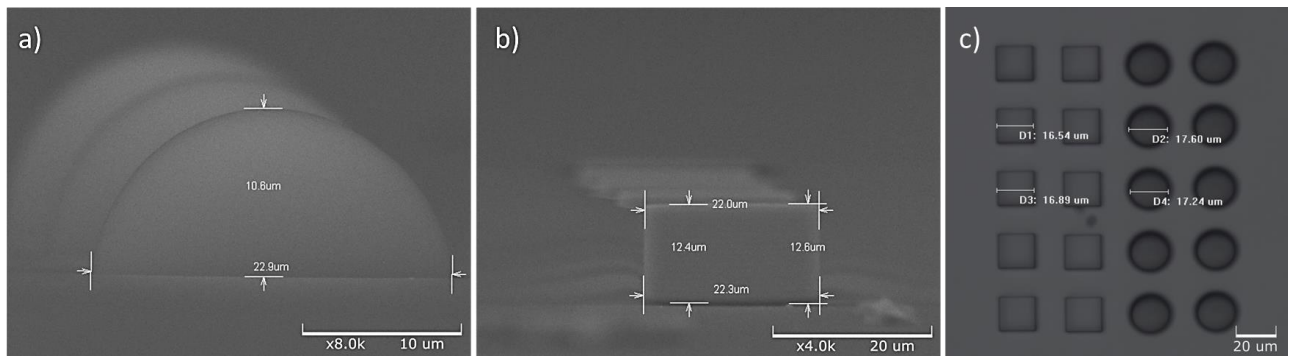
DID NOT PARTICIPATE

**HCDTKECVKQP'QH'VJ TGG/F KO GP UKQP CN'O KET QGNGO GP VU''**  
**D[ 'VY Q/RJ QVQP'NKVJ QI TCRJ [ ''**  
**HQT'TGHTCEVKG'KPF GZ'O GCUWTGO GP VU'**  
F kpc'I qpl crgl /J gtpcpf gl. "Uko qpcu'Xctcr plenu. 'O cpi kf cu'O crikpcwntu"

Ncugt'Tgugctej 'Egpygt. 'Hewm' 'qh'Rj { uleu. 'Xkpkwu'Wpkxgtuks'. 'Nkj wcpke"  
rwtcG qpl crgl B Hfwwf Kwth'

Vy q/r j qvqp' rky qi tcr j { '\*VRN+' vgej plks wg' j cu'uj qy p' 'y g' xgtucvks' 'qh' etgcvkqp' qh' vtwg' y j tgg/f ko gpukqpcn' \*5F +' o letqutwewtgu' hqt' qr vceci' r r hcevkqp' 'lp' y g' tgegpv' { gctu00 quv' qh' y j g' 5F ' i gqo gvtkgu' ctg' c' eqo dkpcvkqp' qh' dcuke' 'uj cr gu' uwej 'cu' r npp' lwt hcegu. 'ewtxgf' lwt hcegu. 'cpf' 'uj ctr gf' 'gf' i gu' 0Hqt' 'y' ku' tgcucp. 'y' g' hqewugf' 'y' ku' y qtnlkp' 'y' g' f' guki p' 'qh' ur j g' tkeci' rpgugu' 'cpf' 'tgevcpi' wxt' r' tkuo u' y j' kej' 'hwtkn' uwe' j' 'eqpf' kkpqu' 0F' khtg' gp' v' cr r' tqcej' gu' j' cxg' dggp' 'f' qpg' hqt' 'y' g' hcdtkecvkqp' 'qh' ewtxgf' lwt hcegu' t' guw' kpi' 'lp' f' khtg' gp' v' lwt hceg' s' wcrk' 0Y' tkkpi' 'd' { 'uwdtgi' kpcn' ur' l' kpi' 'J3\_ ' c' p' f' 'gs' wcn' c' t' e' ur' l' kpi' 'J4\_ ' o' g' y' q' f' u' j' cxg' 'uj' qy p' 'cp' 'ko' r' tqxgo' gp' v' 'lp' 'y' g' qr' vceci' s' wcrk' 'qh' y' g' 'utwewtgu. 'dw' y' g' 'eqo' r' r' g' z' k' v' 'qh' y' g' 'ko' r' ngo' gp' v' k' p' 'ko' ku' y' g' hcdtkecvkqp' r' tqeguu' 0Vj' g' VRN' ku' dcugf' 'qp' r' qkp' v' d' { / r' qkp' v' r' tqeguu' cmqy' kpi' 'qxg' t' r' r' kpi' 'qh' x' z' g' n' f' w' kpi' 'hcdtkecvkqp' y' j' kej' " f' g' v' g' to' k' p' u' y' g' r' p' u' s' wcrk' 'cpf' " uwt hceg' uo' q' q' y' p' g' u' 0' Y' g' " ko' r' ngo' gp' v' g' f' " c' " ur' k' c' n' ur' j' g' t' g' " y' tkkpi' " o' g' y' q' f' " dcugf' " lp' " y' g' " r' c' t' c' o' g' v' k' k' v' k' p' " k' p' " Ect' v' k' u' c' p' t' g' r' t' g' u' g' p' v' k' k' p' " qh' y' g' " y' q' f' ko' gpukqpcn' Cte' j' ko' g' f' g' c' p' " ur' k' c' n' ur' k' p' " r' q' r' t' " eq' q' t' f' k' p' c' v' u' " hqt' " y' g' " y' tkkpi' 'qh' eq' p' e' g' p' v' k' e' 'uj' g' m' i' v' q' h' q' to' 'h' p' u' g' u' J5\_ 0"

Vq' q' r' v' k' g' y' g' " ko' ci' k' p' kpi' " r' g' th' q' to' c' p' e' g' " qh' " o' let' q' / r' v' c' e' c' i' r' g' r' o' g' p' u' " f' g' v' k' k' g' f' " n' p' q' y' n' g' i' g' " qh' f' k' u' r' g' t' u' k' p' " ku' t' g' s' v' k' t' g' f' 0' F' khtg' gp' v' o' g' y' q' f' u' hqt' " t' g' h' t' c' e' v' k' g' " k' p' f' g' z' " e' j' c' t' c' e' v' g' t' k' v' k' p' " y' c' x' g' " d' g' g' p' " w' u' g' f' " u' w' e' j' " cu' l' p' v' g' t' h' q' to' g' v' t' { " J6\_ " g' n' k' u' o' g' v' t' { " J7\_ " e' q' w' r' g' t' " r' t' k' u' o' " o' / n' p' g' u' " J8\_ " c' p' f' " e' t' k' l' e' c' i' n' c' p' i' n' g' " d' { " v' c' n' i' p' v' g' t' p' c' n' i' t' g' h' g' e' v' k' p' " J9\_ 0' J' q' y' g' x' g' t' " y' g' u' g' " v' e' j' p' l' k' s' w' g' u' " e' c' p' " d' g' " c' r' r' i' d' e' g' " q' p' n' f' " y' k' j' " y' q' f' ko' gpukqpcn' ur' g' e' k' o' g' p' u' 0' Y' g' " r' t' q' r' q' u' g' " c' " t' g' h' t' c' e' v' k' g' " k' p' f' g' z' " o' g' c' u' w' t' g' o' g' p' v' " v' e' j' p' l' k' s' w' g' " d' c' u' g' f' " q' p' " y' g' " k' p' f' g' z' / o' c' v' e' j' k' p' i' " q' k' u' b' g' y' q' f' " J: " 0Vj' g' x' g' t' u' c' v' k' s' ' qh' y' g' r' t' q' r' q' u' g' f' " b' g' y' q' f' " e' q' w' f' " h' g' c' f' " v' q' c' e' e' w' t' c' v' g' " o' g' c' u' w' t' g' o' g' p' u' i' q' h' t' g' h' t' c' e' v' k' g' " k' p' f' g' z' " qh' " e' q' o' r' r' g' z' " y' j' t' g' g' / f' ko' gpukqpcn' ur' w' e' w' t' g' u' " c' p' f' " p' q' v' q' p' n' f' " y' q' f' ko' gpukqpcn' ur' v' u' t' w' e' w' t' g' u' 0' Vq' " r' g' t' h' q' to' " u' w' e' j' " o' g' c' u' w' t' g' o' g' p' u' " y' g' f' g' u' k' i' p' g' f' " c' p' " c' t' t' c' { " qh' " ur' j' g' t' k' e' c' i' n' r' p' g' u' " c' p' f' " t' g' e' v' c' p' i' w' x' t' " r' t' k' u' o' u' y' k' j' " u' c' o' g' i' g' q' o' g' v' t' k' e' c' i' n' e' j' c' t' c' e' v' g' t' k' v' k' e' u' " d' c' u' g' f' " k' p' " y' g' " r' t' q' r' q' u' g' f' " y' tkkpi' " o' g' y' q' f' 0"



Hki 030UGO 'ko ci g'qh'c+'32'wo 'tcf ksu'ur j gtlecni' rpgugu' 'cpf' 'd+' t' g' e' v' c' p' i' w' x' t' r' t' k' u' o' u' qh' 34' wo 'j' g' k' i' j' v' c' p' f' f' q' w' d' r' g' r' p' i' v' j' 0' e+' Qr' v' c' e' c' i' n' o' let' q' u' e' q' r' g' 'ko' ci' g' qh' c' t' t' c' { 'qh' g' r' o' g' p' u' y' k' j' " u' c' o' g' i' g' q' o' g' v' t' k' e' c' i' n' r' c' t' c' o' g' v' g' t' u' 0'

Y g' l' w' e' e' g' u' u' h' w' m' f' hcdtkecvkf' 'cttc' { u' qh' g' r' o' g' p' u' d' { 'VRN' u' { u' g' o' " w' u' k' p' i' " c' 737' p' o' " d' g' c' o' " y' k' j' " : 2' h' u' r' w' u' g' f' w' t' c' v' k' p' 98' 0' J | " t' g' r' g' v' k' k' p' " t' c' v' g' 0' k' z' w' t' g' " qh' " U 42: 2' y' k' j' " 3' y' g' k' i' j' v' r' g' t' e' g' p' v' qh' " r' j' q' v' k' p' k' k' e' v' k' t' " y' c' u' w' u' g' f' " cu' r' t' g' r' q' n' o' g' t' " u' q' n' w' k' p' 0' W' u' k' p' i' " y' g' " r' t' q' r' q' u' g' f' " ur' k' c' n' ur' j' g' t' g' y' tkkpi' " o' g' y' q' f' . " y' g' hcdtkecvkf' " ur' j' g' t' k' e' c' i' n' r' p' g' u' " c' p' f' " r' i' p' g' c' t' " u' e' c' p' p' k' p' i' " y' tkkpi' " o' g' y' q' f' " hqt' " r' c' { g' t' / d' / r' c' { g' t' " hcdtkecvkqp' qh' t' g' e' v' c' p' i' w' x' t' " r' t' k' u' o' u' 0' Y' g' " c' e' j' l' e' x' g' f' " j' k' i' j' " t' g' r' g' v' c' d' k' k' v' " qh' " u' t' w' e' w' t' g' u' " c' p' f' " g' t' t' q' t' " k' p' " f' ko' gpukqpcn' ur' d' g' n' y' " y' g' " t' g' s' w' k' t' g' f' " hqt' " y' g' " c' r' r' h' c' e' v' k' p' " qh' l' p' v' g' t' g' u' 0'

J3\_ " U0J 0'Rctm' U0J 0'Ngg. 'F 0[ 0[ cpi. 'J 0'LOMqpi. 'M0U0Ngg. "Uwdtgi kpcn' ur' l' kpi' " o' g' y' q' f' " v' q' l' p' e' t' g' c' u' g' " y' t' g' g' / f' ko' gpukqpcn' ur' c' p' q' hcdtkecvkqp' " g' h' h' k' e' p' e' { " k' p' " y' q' / r' j' q' v' q' p' " r' q' n' o' g' t' k' v' k' p' . " C' r' r' i' d' e' j' { u' 0' N' g' w' 0: 9\*37+\*365\*4227+0'  
 J4\_ " F 0Y w' U0\ 0Y w' N0I 0P kw' S 0F 0Ej gp. 'T 0Y cpi. 'L 0H 0Uapi. 'J 0J 0Hepi. 'J 0D 0Uwp 0' J k' i' j' " p' w' o' g' t' k' e' c' i' n' r' g' t' w' t' g' o' let' q' r' g' u' " c' t' t' c' { u' qh' " e' m' u' g' r' " c' e' n' k' p' i' . " C' r' r' i' d' e' j' { u' 0' N' g' w' 0; 9\*5+\*4232+0'  
 J5\_ " E 0J Awki. 'M 0Ugo o' g' t' 0' Vj g' u' r' k' c' n' i' t' k' f' <C' " p' g' y' " c' r' r' t' q' c' e' j' " v' q' " f' k' u' e' t' g' v' k' g' " y' g' " u' r' j' g' t' g' " c' p' f' " k' u' " c' r' r' h' c' e' v' k' p' " v' q' " o' c' p' v' g' " e' q' p' x' g' e' v' k' p' . " I' g' q' e' j' g' o' 0I' g' q' r' j' { u' 0' I' g' u' u' { u' 0; \*4+\*422: +0'  
 J6\_ " C 0 f' i' w' e' w' u' n' e' u' " K' 0' O' c' w' r' e' k' k' e' p' g' . " F 0' R' c' l' r' w' c' u' . " I' 0' P' k' e' w' t' c' . " O' 0' O' c' r' i' p' c' w' u' n' e' u' " T 0' I' c' f' q' p' c' u' 0' " V' v' l' p' i' " y' g' " t' g' h' t' c' e' v' k' g' " k' p' f' g' z' " k' p' 5F " f' k' t' g' e' v' r' u' g' t' " y' tkkpi' " r' k' j' q' i' t' e' r' j' { <" V' q' y' c' t' f' u' I' T' R' " o' let' q' q' r' v' e' u' . " N' c' u' g' t' " R' j' q' v' q' p' l' e' u' T' g' x' 0; \*8+\*9286934\*4237+0'  
 J7\_ [ 0' N' k' " U' 0' R' c' t' m' " 0' 0' o' e' N' c' o' d' . " O' 0' N' c' v' . " U' 0' U' e' j' t' 3' e' j' g' . " F 0' E' j' k' f' g' t' u' . " I' 0' F' 0' C' i' i' c' y' c' n' " 0' 0' M' 0' R' q' w' q' u' . " I' 0' D' q' t' g' o' c' p' . " V' 0' J' q' h' o' c' p' p' 0' " W' X' " v' q' " P' K' f' " q' r' v' c' e' c' i' n' r' t' q' r' g' t' v' u' q' h' " R' / F' k' . " R' / N' . " c' p' f' " R' / U' c' h' n' g' t' " y' q' / r' j' q' v' q' p' " r' q' n' o' g' t' k' v' k' p' " f' g' v' g' t' o' k' p' g' f' " d' { " u' r' g' e' w' t' q' u' e' r' k' e' " g' n' k' u' o' g' v' t' { . " Q' r' v' 0' G' z' r' t' g' u' i' ; \*33+\*653: \*423; +0'  
 J8\_ " U' 0' O' q' p' p' g' t' g' v' " R' 0' J' w' i' v' g' v' E' j' c' p' v' b' o' g' . " H' 0' " H' q' t' { 0' " o' / N' p' g' u' " v' e' j' p' l' k' s' w' g' <" R' t' k' u' " e' q' w' r' i' p' i' " o' g' c' u' w' t' g' o' g' p' v' c' p' f' " f' k' u' e' w' u' k' p' " qh' " c' e' e' w' t' c' e' l' " h' q' t' " j' o' q' i' p' g' p' q' w' i' " y' c' x' g' i' w' k' f' g' u' " L' 0' Q' r' v' 04' \*5+\*3: : 63; 7\*4222+06\_ ""  
 J9\_ " V' 0I' k' u' k' d' n' " U' 0Y' c' i' p' g' t' . " L' 0U' { n' a' q' t' e' . " O' 0' U' e' j' o' k' f' . " J' 0I' k' e' u' g' u' p' 0' T' g' h' t' c' e' v' k' g' " k' p' f' g' z' " o' g' c' u' w' t' g' o' g' p' u' i' q' h' t' j' q' v' q' / t' g' u' k' u' " h' q' t' " y' j' t' g' g' / f' ko' gpukqpcn' ur' k' g' v' e' i' v' e' u' g' t' " y' tkkpi' . " Q' r' v' 0G' z' r' t' g' u' i' 9+\*44; 5\*4239+0'  
 J: " T' 0I' 0P' w' u' d' c' w' o' g' t' . " O' 0J' c' n' g' t' . " V' 0V' g' t' x' q' q' t' v' . " Y' 0T' 0E' c' u' g' t' k' " R' 0L' o' k' j' 0' C' " u' b' o' r' n' g' b' o' g' y' q' f' " h' q' t' " y' g' f' g' v' g' t' o' k' p' c' v' k' p' " qh' h' t' g' h' t' c' e' v' k' g' " k' p' f' l' e' g' u' " qh' " t' q' w' i' j' + " v' c' p' u' r' c' t' g' p' v' u' q' n' f' u' " L' 0O' c' v' g' t' 0' U' e' k' 62\*5+\*79767: 4\*4227+0'

**P NTR5'KPHNCO O CUQO G'CEVXCVKQP 'D[ 'XKT'CN/NKMG'RCTVÆNGU'K' "**  
**O CETQRJ CI GU'**

Mtkukpc'O c-crckv <sup>3</sup>. 'Cuuc'Nw k pckv <sup>3</sup>. 'Kpf t 'F cni f lgp <sup>3</sup>'Cwtgrkic'fi xkt drkqp <sup>3</sup>'''

<sup>3</sup>'Kpukwag'qh'Dkqvej pqrqi { . 'Nkg'Uelgpegu'Egpygt. 'Xkpkwu'Wpkxgtuk{ . 'Xkpkwu. 'Nkij wcpkc' "  
mtkukpc'ob cucrckgB i o ckrkqo "

"  
Kphro o cuqo gu'ctg"kp'tcegmrwt'r tqvklp'eqo r ngzgu'cpf "ko r qt wcpv'eqo r qpgpw'qh'yj g'kppcvg"ko o wpg'u'f ugo 0'Vj g' dguw' f guetkdgf " kphro o cuqo g' ku" P NTR5." y j lej " eqvckpu" yj tgg" o clqt" eqo r qpgpw' / " pwegqvkf g/dlpf lpi " cpf " qriki qo gt k' cvkqp" f qo clp/rkng" tgegr vqt. "cf cr vgt" r tqvklp" cr qr vquku/cuqekvcgf "ur gen/rkng" r tqvklp "CUE-" cpf " r tqecur sug/3" ]3\_0'P NTR5" kphro o cuqo g'cevxcvkqp" tguwuu"kp" ergxcxi g" cpf "cevxcvkqp" qh' kphro o cvqt { "e { vqnrkpu. "rkng"KV/3 . "cpf " kpf welpi " kphro o cvqt { "egm' f gcj " o" r { tqv vquku" ]4\_0' Cevxcvkqp" qh' P NTR5" kphro o cuqo g' ku" cuqekvcgf " y kj " xctkqwu" f kugcugu. "kpenf lpi " cudguvaku. " i qw. 'C n j glo gt ai' f kugcug" cpf " cwq/ kphro o cvqt { " f kugcugu 0' k' qw" r t g x k w u' t g u g t e j " y g " u j q y g f " y c v P N T R 5 " k p h r o o c u q o g ' k u ' c e v x c v k q p " d { " u q n w d r g " c o { n k f / d g v " r t q v k l p " q r i k i q o g t u ' c p f " r t q v k l p " ] 5\_0' V j g " c l o " q h ' y j k u ' u w f { " y c u ' v q " g z v g p f " y j g ' n w g t " t g u g t e j " c p f " f g v g t o l p g " y j g y g t " q r i k i q o g t k e " r t q v k l p " q h ' f k h g t g p v ' u t w e w t g ' c e v x c v g " P N T R 5 " k p h r o o c u q o g ' k p " o c e t q r j c i g u 0'

J wo cp" o qppe { ve " egm' r k p g " V J R / 3 . " f k h g t g p v k v g f " v q " o c e t q r j c i g u ' y g t g " u g r g e v g f " c u " e g m ' e w n w t g " o q f g n ' h q t " y j k u " u w f { 0 E g m ' y g t g ' t g c v g f " y k j " x c t k q w u ' x k t c n ' q r i k i q o g t k e " r t q v k l p " k h r o g p w ' h q t o l p i " o g c u r g u ' c p f " o w o r u ' x k t c n ' r t q v k l p " ] 6 . " 7 \_ " u r j g t k e c n ' x k t c n ' r k n g " r c t v l e r g u " \* X N R u + " q h ' y j g u g " r q n f q o c x k t w u g u " o " M c t q r k p u n e " k p u k w w g v " r q n f q o c x k t w u " \* R { X + . " O g t n g i ' e g m ' R { X " ] 8 . " L a j p " E w p p l p i j c o " R { X " ] 9\_0' O E E ; 7 2 " y c u " w u g f " v q " k p j k d k s " P N T R 5 " k p h r o o c u q o g ' c e v x c v k q p 0' P N T R 5 " c e v x c v k q p " y c u ' u w f k g f " d { " g x c n c v k p i " e g m ' x k c d k k s { " d { " N F J " f g v g e v k q p " c u u c { . " K V / 3 " c p f " V P H " e { v q n k p g " t g r g c u g " d { " G N R U C . " c e v x g " e c u r c u g / 3 " f g v g e v k q p " w u l p i " h w q t g u e g p v ' r t q d g " H N E C . " y j k j " d l p f u " v q " y j g " c e v x c v g f " e c u r c u g / 3 . " c p f " C U E " u r g e n i f g v g e v k q p " w u l p i " V J R / 3 " o c e t q r j c i g u " g z r t g u u l p i " C U E " r t q v k l p " h w u g f " v q " i t g g p " h w q t g u e g p v ' r t q v k l p 0'

K' y cu' hqwpf " yj cv' hro gpv/rkng" pwegqecr ukf " r tqvklp' qh' o gcurgu" cpf " o wo ru' xktwugu" f kf " pqv' ecwug" cp { " kphro o cvqt { " t g u r q p u g " k p " o c e t q r j c i g u 0' k p " e q p v c u v " u r j g t k e c n ' X N R u " q h ' r q n f q o c x k t w u g u " v k i i g t g f " e g m ' f g c j . " k p f w e g f " K V / 3 " u g e t g v k q p " c p f " C U E " u r g e n i h q t o c v k q p " k p " j w c p " e g m ' o q f g n ' k p f l e c v k p i " P N T R 5 " k p h r o o c u q o g ' c e v x c v k q p 0' k p " c f f k k q p . " k v " y c u ' f o g q p u t c v g f " y j c v ' e c v j g r u l p u ' c t g " k p x q n g f " k p " P N T R 5 " c e v x c v k q p " k p f w e g f " d { " r q n f q o c x k t w u " X N R u 0' V q " e q p e n f g . " q w " t g u w u " f g o q p u t c v g " y j c v ' x k t c n ' r t q v k l p " e c p " c e v x c v g " k p h r o o c u q o g ' f g r g p f l p i " q p " y j g k " u t w e w t c n ' r t q r g t v g u 0'

Hwpf lpi <

Vj g'uwf { "y cu'hwf gf "d { "T g u g t e j " E q w p e k i q h ' N k j w c p k c " \* N O V N V + . " r t q l g e v p q 0 U / U G P / 4 2 / 3 3 0

"  
"

- 13\_ " Y cnij 'U . 'O w w x g ' F C . ' R q y g t ' E 0' k p h r o o c u q o g u ' l p ' y j g ' E P U 0 P c v T g x k w g y u ' P g w t q u e l 0 3 7 \* 4 + < : 6 6 ; 9 \* 4 2 3 6 + 0
- 14\_ " G n k q w ' G K ' U w w g y c r e ' H U 0' k p k c v k q p ' c p f ' r g t r g w c v k q p ' q h ' P N T R 5 ' k p h r o o c u q o g ' c e v x c v k q p ' c p f ' c u o g o d n 0' k o o w p q n T g x 0 4 8 7 < 5 7 6 7 4 \* 4 2 3 7 + 0
- 15\_ " N w k p c k v ' C . ' O e O c p w u ' T O . ' L c p m w p g e ' O . ' T a e l ' K F c p u q n j q ' E . ' F c n i f l g p " K ' g v ' e n 0' U q n w d r g ' C " q r i k i q o g t u ' c p f " r t q v k l p " k p f w e g " P N T R 5 " k p h r o o c u q o g ' c e v x c v k q p " k p " o l e t q i r k 0 L P g w t q e j g o 0 \* Q e v q d g t 4 2 3 ; + < 3 6 3 4 \* 4 2 3 ; + 0
- 16\_ " U r d l p u n e u ' T . " x k t d r k p g ' C . ' I g f x k r c k g ' C . ' U c o w g n i F . ' L p ' N . ' D g c t f ' U . " g v ' e n 0' U { p v j g u k u ' q h ' o w o r u ' x k t w u ' p w e g q e c r u k f " r t q v k l p " k p " { g c u v R l e j k e " r c u q t k u 0 L D i q v e j p q r i 0 3 2 5 \* 3 + < 6 5 6 6 ; \* 4 2 2 5 + 0
- 17\_ " U c o w g n i F . ' U c u p c w u n e u ' M ' L p ' N . ' I g f x k r c k g ' C . ' U r d l p u n e u ' T . ' D g c t f ' U . " g v ' e n 0' F g x g n r o g p v ' q h ' c ' o g c u r g u ' u r g e k t i e ' K O ' G N R U C ' h q t ' w u g ' y k j " u g t w o " c p f " q t c n ' h w f ' u c o r n g u ' w u l p i " t g e o d l p c p v ' o g c u r g u ' p w e g q r t q v k l p " r t q f w e g f " k p " U c e e j c t q o { e g u ' e g t g x k u l c g 0 L E n p ' X k t q n 0 4 : \* 4 + < 3 4 3 6 3 4 ; " \* 4 2 2 5 + 0
- 18\_ " P q t n k p g ' O . ' U q p { v g ' L \ k j i k p g ' F . ' O c l g k n g ' G . ' U c u p c w u n e u ' M ' I g f x k r c k g ' C 0 R t q f w e v k q p ' q h ' t g e q o d l p c p v ' X R 3 / f g t k x g f " x k t w u / r k n g " r c t v l e r g u " h t q o ' p q x g n j w o c p ' r q n f q o c x k t w u g u ' l p " { g c u v 0 D O E ' D i q v e j p q r i 0 3 7 \* 3 + < 3 6 3 6 \* 4 2 3 7 + 0
- 19\_ " U c u p c w u n e u ' M ' D w r x c k g ' C . ' J c n g ' C . ' L p ' N . ' M p q y n g u ' Y C . ' I g f x k r c k g ' C . " g v ' e n 0' I g p g t e v k q p ' q h ' t g e q o d l p c p v ' X k t w u / N k n g ' R c t v l e r g u ' q h ' J w o c p " c p f " P q p / J w o c p ' R q n f q o c x k t w u g u ' l p " { g c u v ' U c e e j c t q o { e g u ' e g t g x k u l c g 0' k p v g t x k t q n j i { 0 6 7 \* 6 6 8 + < 5 2 : 6 5 3 9 \* 4 2 2 4 + 0
- "
- "



# INVESTIGATION OF A NEW ORGANIC CONTROL MEASURE AGAINST INVASIVE SLUGS

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The Spanish slug, *Arion vulgaris* Moquin-Tandon, 1855, is a serious pest in agriculture and private gardens around the world [1]. Saponins, which are secondary metabolites of plants, have previously been shown to have strong molluscicidal effect [2]. The use of saponins-rich plant extracts is gaining importance as are safe (as saponins residues) in agriculture products [3]. However, despite of the proven safety in food, they still do not have a widespread application due to their liquid form and absence of more accurate knowledge of effects on other organisms. White worm, *Enchytraeus albidus* Henle, 1837, is an important model of decomposer organisms in the terrestrial ecosystem [4]. We investigated which doses of saponins are lethal to the slug, *A. vulgaris*, and to the non-target organism, *E. albidus*. An aqueous solution with different concentrations of saponins extract from the bark of the soap tree, *Quillaja saponaria* Mol., was used in repeated treatments. Slugs were tested in filter paper contact tests as they are naturally exposed to soil contact while crawling. Worms were tested in soil contact tests as they live below ground. It was found that lethality of saponins depends on the slugs' age group and environmental temperature. The median lethal concentration (LC<sub>50</sub>, at 15°C) on adults was 68.5 g/l, and on juveniles, 96.9 g/l. The slugs were significantly more sensitive at 2 and -1°C compared to 15°C. The LC<sub>50</sub> (at 6°C) on *E. albidus* was 2.7 g/l (or 0.5 g/kg dry weight of soil), far below those in *A. vulgaris* (at 15°C and lower). The LC<sub>50</sub> for worms at -1°C was also significantly lower than at 6°C (Table 1) [5].

Table 1. Dose-response parameters of *Quillaja* aqueous extract for slugs and worms in g/l (average ± standard error). LC<sub>50</sub> – median lethal concentration,  $\chi^2$  – goodness of fit of probit lines.

Species	Life stage	Temperature (°C)	LC <sub>50</sub>	$\chi^2$ (df, P)
<i>A. vulgaris</i>	Adult	+15	68.52 ± 8.38	15.68 (27, 0.9588)
<i>A. vulgaris</i>	Juvenile	+15	96.94 ± 13.84	16.731 (17, 0.4727)
<i>A. vulgaris</i>	Adult	+2	33.52 ± 7.49	29.077 (30, 0.5135)
<i>A. vulgaris</i>	Adult	-1	18.38 ± 3.64	20.986 (31, 0.9123)
<i>E. albidus</i>	Adult	+6	2.72 ± 0.09	22.792 (29, 0.7857)
<i>E. albidus</i>	Adult	-1	2.07 ± 0.11	51.252 (46, 0.2753)

Therefore, we can conclude: 1) that *Q. saponaria* saponins may be a successful slug control tool used during the colder time of the year, but its concentration should be selected according to the age group of *A. vulgaris*; 2) this measure was more toxic than expected to white worms, therefore, more research should be done with other groups as well.

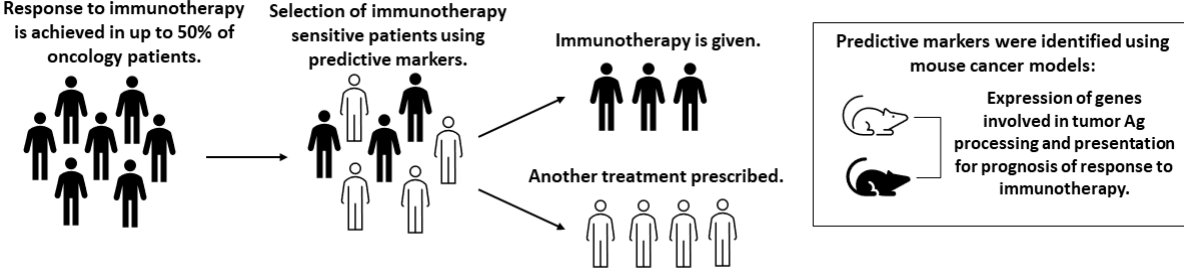
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 [5] M. Adomaitis, G. Skujienė, Lethal doses of saponins from *Quillaja saponaria* for invasive slug *Arion vulgaris* and non-target organism *Enchytraeus albidus* (Olygochaeta: Enchytraeidae), *Insects* **11**, 1-11 (2020).

# O QNGEWNCT'DKQO CMGTU'QH'O QWUG'VVO QT'KO O WPQI GPKEKV[ ' ' CP F 'RT GF KE VKQP 'QHT GURQPUG'VQ'F GP F TKVKE 'EGNN'XCEEKPGU' CP F 'CP VKRF /3'VTGCVO GP V'

Mctqkpc \ ktkq { vg<sup>3,4</sup>. 'Wl pg'Dci f | gxlekwxg<sup>5</sup>. 'Gncp'Wtduvckg<sup>4</sup>. 'Ci cv'On f pun<sup>3</sup>. 'Go krlk' Rcdgtcrg<sup>3</sup>.  
P gtlpi c 'F qdtqxqnnkpgg<sup>3</sup>. 'Xkc' Rcuwnqkpgg<sup>3</sup>'

<sup>3</sup>P cvkqpcnEcepgt "Kukwkwg."Xlkpkwu."Nkj wcpk"  
<sup>4</sup>Xlkpkwu'Wpkxgtukf. 'Xlkpkwu."Nkj wcpk"  
<sup>5</sup>Xlkpkwu'I gf ko kpcu'Vej plecn'Wpkxgtukf. 'Xlkpkwu."Nkj wcpk"  
nctqkpc0 ktkq { vgB pxkth

Ko o wpyj gter { "ku"r tqo kulpi "eceptg" tgcvo gpv'v'j cv'uko wrcyru' r cvkqpv'u'ko o wpg'u' ugo "vq"hi j v'ci cklpuv'wo qt' J qy gxgt. 'y' g'tgur qpug'v'q'eceptg'ko o wpyj gter { "ku'qpr' "cej lgxgf "kp" c'uo cni'uwdugv'qh'r cvkqpv'u' "Hki 0/3+0T gegpv'uwf lgu" uj qy gf "v'j cv'wpgs wcn't gur qpug'v'q'ko o wpyj gter { "o ki j v'dg'i qxgtpgf "d' "wo qt'ko o wpg'ej ctcevgt'ku'leu'OEruukhkecvkqp'qh' r cvkqpv'u'd { "wo qt'ko o wpg'r' tqr gt'vku'lp'qt'f gt'v'q'lpf kxkf wcrk'g'ko o wpyj gter { "ku'pq'v'y kf gn' "wugf" lp'v'y g'enkpleu."dculecm' " f wv"q'v'j g'nem'qh'r' tqr gt'o' qrgewar't'o ctngtu'0Vj g'clo "qh'q'w'u'w'f { "y'cu'v'q' h'kp'v'y q'ko o wpyq'i kec'nf " f k'wkpve'o wtkpg' wo qt' "o qf'gnu'cpf "o qrgewar't'o ctngtu'hqt'v'j g't'v'c'w'le'cvkqp'cpf' r' tgf'levkqp'qh't'gur qpug'v'q' tgcvo gpv'y kj "f'gpf' tkle'egm' xceekpgu'cpf' 'cpv'k'RF/30



Hki Ø0Rtlpekr cnkf gc'qh'v'j ku't'gugctej 0'

E79DN18'u'f pi gpgle'i rko c'I N483'cpf "napi"ectekppo c'NNE3'egmu'y gte'ej qugv' hqt'eqo r' t'g'j gpukxg'lp'xguk'i c'vkqp' qh' ko o wpyq'i kecn'r' tqr gt'vku'0I N483'cpf "NNE3"egmu'y gte'cuuguugf "d' "v'j g't' cdkr'k'f { "v'q'r' t'qegu'u'cpf' r' t'gugpv'wo qt' cp'ki' g'pu' "Ci +cpf "v'j g'i g'p'gt'ci'p'c'w'g'qh'f' g'x'gn'r' kpi "cp'v'k'wo qt'ko o wpg't'gur qpug'0Hqt'v'j ku't'gcuqp'0J E'K'cpf "RF/N3" g'zr' t'g'ukqp'y' cu'o' gcuw'gf "qp" I N483'cpf "NNE3"egmu'uw'h'ceg'0Cnuq'lp'eq'ng'e'v'f "r' t'ko ct { "wo qt'uco' r'gu'ko o wpg'egm' k'ph'nt'cvkqp."g'zr' t'g'ukqp'qh'ko o wpg' t'g'rc'v'f "i' g'p'gu'cpf' i' g'p'gu'lp'x'q'x'g'f "lp'Ci' r' t'qegu'kpi "cpf' r' t'gugpv'cvkqp'y' g'g'g'x'cn'w'v'f 0' Vj' g'ug'uwf' lgu'y' g'g' h'm'q'y' g'f "d' { "o' wtkpg'f' g'p'f' tkle'egm'x'ceekpgu' "F EX'+cpf' "cp'v'k'RF/3" g'h'ke'e { "cp'cn'f' u'ki'lp'v'j' g' t'g'cvo' gp'v' qh'o' leg'y' kj "u'dew'w'c'p'g'q'u'u'f "lp'f' w'v'g'f' I N483'qt' "NNE3"wo qtu'0F EX'y' g'g't'g' i' g'p'gt'c'v'f "t'qo' "o' wtkpg'd'qpg'o' c'tt'q'y' "egm' d' { " f'k'h't'g'p'v'k'v'kpi "y' kj "I O/EUH'- "KN/6"e { v'm'k'p'gu' hqt'9'f' c' { u'j'3\_ "cpf' "o' c'w'w'kpi "y' kj "NNE3"qt' I N483'egm'h' uc'v'g'cpf' "Gle'q'rk' r'k' q'r' q'nf' u'cee'j' c't'k'f' g'0O' leg't'gur' qpug'v'q' F EX'cpf' "cp'v'k'RF/3" tgcvo' gpv'y' cu'cuuguugf "d' { "wo qt'uk' g."ej' cpi' gu'lp'ko o wpg' egm' k'ph'nt'cvkqp' "cpf' "g'zr' t'g'ukqp' qh' ko o wpg' t'g'rc'v'f "i' g'p'gu' C'm' g'zr' g't'ko' g'p'v'cn' r' t'q'v'eq'm' y' g'g' "crr' t'q'x'g'f' "d' { "v'j' g' "r'q'ec'n' k'p'uk'w'w'k'p'c'n' C'p'ko' cn'Ect'g'Eqo' o' kw'gg'0'

Qwt'uwf' { "uj' qy' gf "v'j' cv' I N483'cpf "NNE3"wo qtu'r' qu'gu'u' f'k'h't'g'p'v'ko o wpg'r' tqr gt'vku'0Vj g' r'cti' gu'f' k'h't'g'p'eg'ug' dgw' g'p'v'j' g'ug'wo qtu'y' g'g' q'dug't'x'g'f' "y' j' g'p'cu'gu'ukpi "v'j' g't' cdkr'k'f' "v'q'r' t'qegu'u'cpf' r' t'gugpv'wo qt' Ci' 0'Ui' p'k'h'c'p'v'f' get'g'c'ug' lp'v'j' g'zr' t'g'ukqp'qh'i' g'p'gu'lp'x'q'x'g'f' "lp'v'j' ku'r' t'qegu'u'uw'ej' cu'Vcr3. 'Vcr4. 'Ruo d. :. 'Ruo d. :. 'Ruo d32. 'Gtcr3. 'Khl'+y' g'g' q'dug't'x'g'f' "lp'NNE3"wo qtu'0K' r' c'kt'gf' "Ci' r' t'qegu'kpi "cpf' r' t'gugpv'cvkqp'o' ge'j' c'p'ku'o' "lp'NNE3'egm'u' t'gu'w'ng'f' "lp'v'j' g'ug'wo qt' ko o wpyq'i' g'p'le'k'f'. "ng'cf' kpi "v'q'v'j' g' "cdug'peg'qh' g'h'g'v'k'g' cp'v'k'ce'pgt'ko o wpg't'gur qpug'0D { "eq'p'c'u'v'lp' I N483'egm'Ci' r' t'qegu'kpi "cpf' r' t'gugpv'cvkqp'o' ge'j' c'p'ku'o' "y' cu'p'q'v'c'ng't'g'f. "o' c'nkpi "v'j' go' ko o wpyq'i' g'p'le'cpf' t'gu'w'kpi "lp'h'q'to' c'v'k'qp'qh'cp'v'k'wo qt'ko o wpg't'g'ce'v'k'p'0F k'h't'g'p'eg'ug'y' g'g'c'nu'q'ug'g'v'j' g'p'v'g'c'v'kpi "wo qtu'y' kj "F EX'qt'cp'v'k'RF/3. "v'j' g'g'v'j' g' "g'h'g'v'k'g'g'nf' u'q'y' g'f' I N483'f' g'x'gn'r' o' gp'v'cpf' "c'm' q'u'v'j' cf' "pq' g'h'g'v' hqt' NNE3'wo qtu'0'

Ej' cpi' gu'lp'Ci' r' t'qegu'kpi "cpf' r' t'gugpv'cvkqp'o' ge'j' c'p'ku'o' "o' ki' j' v' t'gu'w'v'lp'wo qt' k'p'ug'p'uk'k'k'f' "v'q' f' g'p'f' tkle'egm' x'ceekpgu'cpf' "cp'v'k'RF/3'v'j' g'g' { 0'Vj' g'g'h'q'g' "g'zr' t'g'ukqp'g'x'cn'w'v'k'p'qh'i' g'p'gu'lp'x'q'x'g'f' "lp'Ci' r' t'qegu'kpi "cpf' r' t'gugpv'cvkqp' r' c'v'j' y' c { "Ruo d. :. 'Ruo d. :. 'Ruo d32. 'Ver3. 'Ver4. 'Gtcr3. 'Khl'+o' ki' j' v'j' g'n' "v'q' u't'c'v'k'h' r' t'ko ct { "w'p't'g'c'v'f' "o' wtkpg'wo qtu'cpf' r' t'gf'lev'v'j' g't' t'gur qpug'v'q' f' g'p'f' tkle'egm'x'ceekpgu'cpf' "cp'v'k'RF/3' tgcvo' gp'v'o'

[3\_Nw] "OD'g'v'cn'0Cp'cf' x'ce'p'g'f' e'w'w't'g' o' g'y' qf' hqt'i' g'p'gt'c'v'kpi "r'cti' g's' w'c'p'v'k'k'g'u'q'h'i' ki' j' n'f' "r' w'g'f' g'p'f' tkle'egm' h'q'o' "o' q'u'w'g'd'qpg'o' c'tt'q'y' 0L'k'o' o' w'p'q'n' O' g'y' qf' u03; ; : 'Hgd'3=445\*3+99/; 40f' q'k'32Ø238 h'2244/397; \* : : 422426/z0'

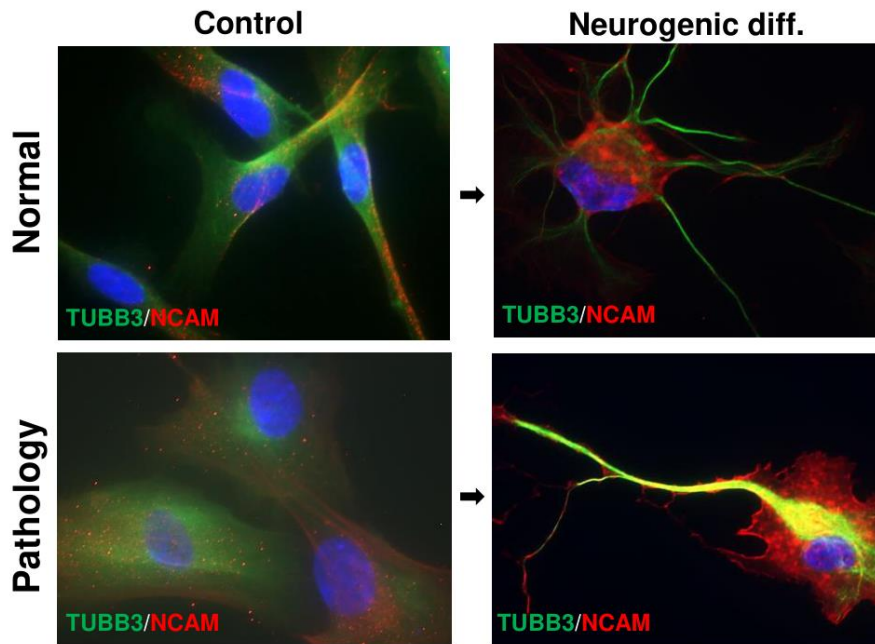
**P GWTQI GP KE 'F KHGT GP VKVQP 'QH'J WO CP 'CO P KQVKE 'HNWKF 'UVGO ' EGNNU'HTQO 'J GCNVJ [ 'CP F 'HGVWU'CHHGE VGF 'RTGI P CPE KGU'**

Ckuv \ gpvgnf v. "Gnk cdgvDgtflcpumf v."I kgf t "Xcrkwxkp .T vc"P excnæwunxkp "

F gr ctwo gpv'qh'O qngewrt 'Egm'Dkqmi { .Nkhg'Uelpegu'Egpvt. "Xkpkwu'Wpkxgtukf .Nkj wepkc "  
ckuv0 gpvgnf vB dej kxw0u'

J wo cp'co plqvle'hwkf "uvg" "egm"\*CHUE-"ctg"e"xtg {" r tqo kulpi "uqwtg"qh'uvg" "egm"lqt"vj gtr gwle"cr r rlecwkp" Dgecwug"qh'vj gk "dtqcf "f khgtgpvcwqp"r qvvpkcn'cpf "j ki j "r tqnhtgcvkqp"ecr cdhkkku"CHUEu"ctg'y kf gn "tgugctej gf 0Dw'lp" qtf gt"v"go r m {" CHUEu'lp'erikplecn'ugwki u."vj g'f khgtgpegu'qh'uvg" "egm'r tqr gt vku'qh'egm'kuqrcvf "Itqo "j gcnj {"cpf 'hgwu" chhgev f 'r tgi pcpelgu'pggf u'v'dg'gnwef cvgf 0Qw'uwf {"y cu'hqewugf "qp'cf f tguakpi 'o gxcdqrlc.'pgwtqi gpke'cpf 'pgwtqqr j le" r qvvpkcn'cpf "f khgtgpegu'qh'CHUEu'qdvkpgf "Itqo "pqto cni gucvkqpu'cpf "i gucvkqpu'chhgev f "y kj "r qn {" f tco plqu'0

Ugo 'egm'y gtg'kuqrcvf "Itqo "co plqegpvuku'uco r ngu'wulpi "y q/uci g'kuqrcwqp'r tqvqerlc'p' "gxr cpf gf "lp'o qppqc {"gt" ewwtg"lp"xat q0'kuqrcvf "egm"y gtg"ej ctcevgtk gf "cpf "uj qy gf "uko krt "ngxgn"qh'r ntkr qvpe {"i gpg"\*UQZA."PCPQI ." NKP4: C."gve0"gzr tguakqp"cpf "o guppej {"o cni'ug" "egm'uwthceg"o ctngt"\*EF 66."EF 368."EF 388+"gzr tguakqp."dw"j ki j gt" gzr tguakqp'ngxgn'qh'EF 35."EF 95."EF ; 2"cpf "EF 327"y gtg'f gvevf "lp'CHUEu'ltqo "j gcnj {" r tgi pcpelgu'0Cnuq."uvg" "egm" qh'0P qto cni'cpf "0Rcvj qmi {"0'i tqw u'y gtg'hqwpf "v'dg'f khgtgpvlp"vgo u'qh'qz kf cvkxg'r j qur j qt {"rvkqp'tcvg."r tqf wevqp'qh" CVR"cpf "tgecvkxg"qz {"i gp"ur geku'0CHUEu'ltqo "dqj "uqwtg"y gtg'lpf wegf "v" f khgtgpvcw"vqy ctf u'pgwtqi gpke"rkgci g" wulpi "hqw" f khgtgpvcwqp"o gf kcu'eqo r qugf "qh'eqo o gtekn'uw r ngo gpv'P 4."pgwtqqr j lpu"\*DF P H "PI H"cpf "uki pcrkpi " o qngewru"\*eCOR."KDOZ."MEN"tgwkpqle"cekf +0'f khgtgpvcwqp"qh'CHUEu"y cu'eqphko gf "d {" o qtr j qmi kcn'ej cpi gu" e {"vqungrcnltgati cplk cvkqp'cpf 'pgwtcni'o ctngt'gzr tguakqp"\*Hi wtg"3+0



Hi 030% o wpqhnwtgwegpeg"cpnc'uku'qh'CHUEu'lj qy lpi "r qukkxg'egm'lqt"pgwtcni'o ctngt "VWDD5"r tqvklp"xi tggp+"cu" y gni'cu'pgwtcni'o ctngt "PECO" \*tgf +0P wengky gtg'eqwvgtuclp'gf "y kj "F CRK"dmw+0

P gwtqi gpke" f khgtgpvcwqp"y cu' cnuq"eqphko gf "d {" wr tgi wrcvf "gzr tguakqp" qh' f khgtgpvcwqp" cuuqekcvf "i gpgu" \*PECO 3."XKO."Pgwqf 3."UR."OCR4."I HCR."UB22D."PVTM3."gve0'Vj g'ugetgkqp'ngxgn'qh'pgwtqqr j le'hcevqtu'DF P H" cpf "XGI H"lp" f khgtgpvcw" CHUEu"y gtg"wr tgi wrcvf "cu"y gm"y kj "j ki j gt"wr tgi wrcwqp"tcvq"lp" P qto cni'uco r ngu'0 Hwvj gto qtg."CHUEu'ltqo "r qn {" f tco plqu'uco r ngu'y gtg'f kulpi wkuj gf "d {" ugetgkqp'qh'r tq/lphco o cvqt {"e {"vqmkpg"VP H" y j lej "ugetgkqp'ngxgn"y gtg'uki plhcepv" f qy ptgi wrcvf "chgt" f khgtgpvcwqp'0

Qxgtem"qwt'tguwuu'wi i guv'y cv'CHUEu'kuqrcvf "Itqo "j gcnj {" r tgi pcpelgu'f khgtgpvcw"vqy ctf u'pgwtqi gpke"rkgci g" o qtg"ghhlegpv"eqo r ctgf "v"CHUEu'ltqo "r qn {" f tco plqu'uco r ngu'0'Vj gug"qdugtxcwkp'u'r tqxkf g'pgy "lpuki j w'lpv"vj g" r tqr gt vku'cpf 'pgwtqi gpke" f khgtgpvcwqp"r qvvpkcn'qh'CHUEu'qdvkpgf "Itqo "hgwu'wpc'hhgev f "cpf 'hgwu'chhgev f "i gucvkqpu" cnj qwi j "o qtg'f gvckrgf "uwf lku'ctg'tgs wktgf "hqt"dtlpi lpi "vj gug"egm'equgt "v"erikplecn'cr r rlecwkp"0

**URGEKGU'QH'VJ G'I GPWU'ANTOCHA'QUVGP'UCEMGP'3: 82'F KRVGTC'<  
NKO QP KKF CG+K' UKEJ WCP '\*EJ K C+'**

Tcf xkn 'O ctngxk k v "

"

P cwtg'Tgugctej "Egptg."Cnrf go kqu'ut04.'NV/2: 634'Xkpkwu.'Nkj wpcle"

tcf xkn'0 ctnB i o cktēqo "

"

I gpwu" Cpvejc" Quvgp" Ucengp."3: 82" y kj " y tgg" uwdi gpgtc" Cpvejc" \*u' ut0" Quvgp" Ucengp"3: 82." Rtcpcvejc" Cngzcpf gt."3: 3; "cpf "Qtko cti wr" O km"3: : 5" kpenwf gu"37: "ur gelgu."hqw" uwdur gelgu"j3\_cpf "ceeqtf kpi "vq" Ecwnci wg'qh'vj g" Etcpghgu"qh'vj g"Y qtrf "y ku'i gpwu"ku'tgeqtf gf "htqo "cm" qqi qqi tcr j le'tgi kqpu"j4\_0Vj g'uwdi gpwu"Cpvejc" \*u' ut0"ku'vj g" o qu'ur gelgu/tlej "uwdi gpwu'qh'vj g"i gpwu"Cpvejc."y kj "334"xcrkf "ur gelgu"cpf "y q" uwdur gelgu."kpenwf kpi "39"ur gelgu"cpf " y q" uwdur gelgu"tgeqtf gf "htqo "Ulej wcp"\*Ej kpc+0Cf wmu"qh'vj g"i gpwu"Cpvejc"ctg"uo cm"\*5"o o +"vq"o gf kwo /uk' gf "\*"33" o o +"etcpq"htgu."y j lej "ctg"hwqpf "pgct"utgco u"qt"tkxgtu"j3\_0Y kpi u"qh'vj gug"kpugeu"ctg"y kf g"y kj "rcti g."pgctn' "tki j v cpi ngf "cpcn'cpi ng"j3\_0'

Vj g"vczqqo { "qh'vj g"i gpwu'tgo cku'wpergct="ugxgctn'ur gelgu"ctg"npqy p"qpn' "htqo "y g"wpks wg'hgo cng"j qm'v' r gu'cpf " pq'r j { nqi gpgve"cpn' uku'qh' Cpvejc"j cu'dggp"wpf gt vengp0F wg'vq"ncem'qh'kphqto c'vqrp. 'k'ku'f khtkewu'v'kf gpv'ht' "ur gelgu'qh' vj ku'i gpwu."y wu'vj ku'i tqwr "qh'kpugeu'ku'pqv'y gmi'npqy p0"

Vj ku'tgugctej "y cu'ectk'gf "qw'lp"Ulej wcp"r tqxk'pge"\*Ej kpc+0Qpg"ur gelgu"y cu'f guetk'dgf "cu'pgy "vq"uelgpeg"\*Hki 0'3+0' Kpugeu'qh'vj g"pgy "ur gelgu"j cxg'uengt'q'kf gf "cpf "y kngf "kpq"ur k'cn'i gpkcn'ut wewtgu'o"r ctco gtgu."y j lej "ctg" f khtg'gpv'lp" qvj gt "ur gelgu"j3\_0"

"



"

Hki 030Cf wu'kpugev'qh'vj g'i gpwu"Cpvejc 0'

Vczqqo { "ku'hwqpf c'vqpcn'vq"Dkqmi { 0'k'i'vj g"uelg'p'v'k'le"pco g"cpf "u{ ugo c'vle"qh'cp{ "rktg"htqo "ku'wpergct."k'y kni'dg" ko r quukdng"vq" tgr gc'v'cp" g'zr g'tko gpv."y j g" tguwmu"y kni'dg" l'peqo r ctcdng."cpf "j { r qvj gugu"y kni'dg" w'p'v'g'v'f 0'Vj gtghq'g." uelg'p'v'k'le"y qtmu'uwej "cu'vj ku'r tqxk'f g'hwqpf c'vqpcn'vq"ht'q'vj gt "uelg'p'v'k'le"y qtmu'0"

"

j3\_"T0O ctngxk k v ."U'Rqf gpcu."C0'Uc'f c'kku."T0'Dgt'p'q'v'gp ."C"pgy "ur gelgu'qh' Cpvejc" Quvgp" Ucengp."3: 82" F kr v'gtc'<'Nko q'p'k'f cg+'htqo "Ulej wcp." Ej kpc." q'q'v'z'c'6883."33: /354"\*423; +0'

j4\_"R0Q'v'g't'q'g'm'Ecwnci wg'qh'vj g'Etcpg'htgu'qh'vj g"Y qtrf "\*EY +0C'x'k'c'x'dng'htqo <'j wr <l'p'n'l'k'g'v'0'w'c'p'n'l'ee'y l'p'f g'z'0'j r "

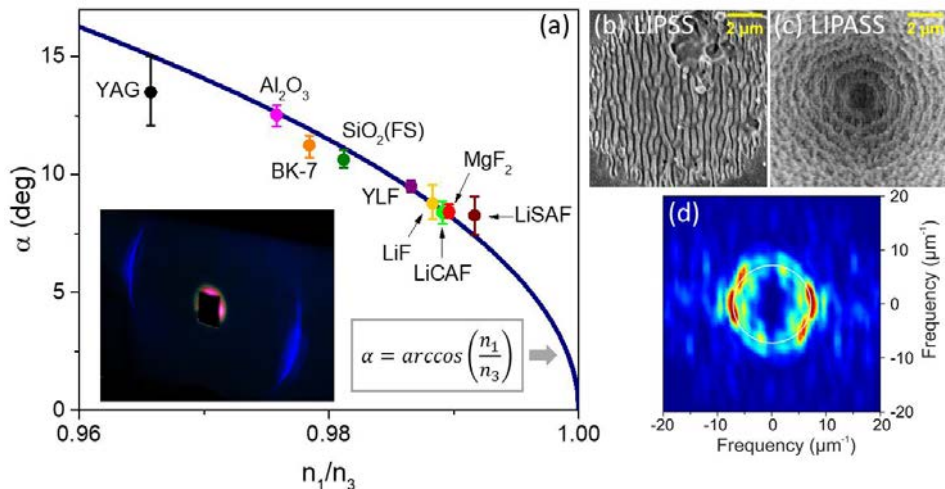
"

**EQP KECN'VJ KTF 'J CTO QPKE'I GP GT CVKQP 'HT'QO 'HGO VQUGE QPF "**  
**NCUGT'KPF WEGF 'PCPQI TCVKPI 'K'VTC PURCTGP V'O CVGT KCNU'**  
**F WT KPI 'HNCO GP VC VKQP 'CV'J K J 'TGRGVK VQP 'TCV GU'**  
Tqdg tvcu' tki wku<sup>3</sup>. 'X{ vwcw' Lwmpc<sup>3</sup>. 'O ctkwu' P cxlenu<sup>3</sup>. 'I kvctcu' Vco q-cwntcu<sup>3</sup>. 'M uwku'  
Ucrk pcu<sup>3,4</sup>. 'C wf tkwu' F wdkvku<sup>3</sup>"

<sup>3</sup>Ncugt 'T gugctej 'Egpgvt. 'Xkpkwu' Wpkxgtuk\ . 'Ucwn vgnk' Cxgpgw'32. 'NV/32445' Xkpkwu. 'Nkj wcpk' "  
<sup>4</sup>Kpukwelo 'Ecvncpc' f g' Tgegtec' k'Guwf ku' Cxcp+cu' \*KETGC+. 'Rcuuki' f g' Nnw' u' Ego r cp { u. '45. '2: 232. 'Detegmpc. "  
 Ecvcnplc. 'Ur clp "  
tqdg tvcu' tki wkuB hXwdu'

Ncugt/kpf wegf "r gtkqf le" uwthceg' utwewtgu' \*NRUU+ctg'c" wpkxgtucn' r j { ulecn' r j gpqo gpqp. "y j lej "qewtu' qp" o cp { " o cvgtkcn' \*o gvcn. " ugo leqpf wexqtu. " f kngctvku' y kj kp' hqecn' ur qv' qh' y g' rkpctn' " r qm' tk' gf " rucgt' tcf kcvkp" ]3\_ cpf " hkp' " o cp { " cr r' n' c' v' k' p' u' " l' p' " r' n' u' o' q' p' l' e' u' " r' j' q' v' q' p' l' e' u' " c' p' f' " o' l' e' t' q' h' n' k' f' l' e' u' " ]4\_ O' I' t' c' f' w' c' n' v' c' p' u' k' k' p' " h' t' q' o' " N' R' U' U' " v' q' " c' " r' q' m' t' k' c' v' k' p' / k' p' f' g' r' g' p' f' g' p' v' n' y' " u' r' c' v' k' n' i' t' g' s' w' p' e' { " u' t' w' e' w' t' g' u' " e' c' n' g' f' " r' u' c' g' t' / k' p' f' w' e' g' f' " r' g' t' k' q' f' l' e' " c' p' p' w' r' t' " u' w' t' h' e' g' " u' t' w' e' w' t' g' u' " \* N' R' C' U' U' " l' p' " y' g' " e' g' p' v' t' " q' h' " y' g' " f' c' o' c' i' g' " e' t' c' v' g' t' " y' c' u' " q' d' u' g' t' x' g' f' " ]5\_ " c' p' f' " o' q' t' g' " k' o' r' q' t' v' c' p' w' t' . " y' g' " h' q' t' o' c' v' k' p' " q' h' " p' c' p' q' i' t' c' v' k' p' i' u' " l' p' " y' g' " x' q' n' o' g' " q' h' " x' c' t' k' q' u' " o' c' v' g' t' k' c' n' " y' c' u' " l' p' x' g' u' k' i' c' v' g' f' " ]6\_ O' o' q' t' g' " t' g' e' g' p' w' t' . " e' q' p' l' e' c' n' " y' k' t' f' " j' c' t' o' q' p' l' e' " \* V' J' + " i' g' p' g' t' c' v' k' p' " h' t' q' o' " l' p' / d' w' m' i' q' r' v' e' c' n' " f' c' o' c' i' g' y' c' u' t' g' r' q' t' v' g' f' " c' p' f' " k' u' " e' q' t' t' g' r' v' k' p' " y' k' j' " g' z' v' p' e' v' k' p' " q' h' " u' r' g' t' e' q' p' v' p' w' o' " t' c' f' k' e' v' k' p' " y' c' u' " w' p' x' g' k' g' f' " ]7\_ O'

Kp' y' ku' Uwf { " y' g' f' go qputcv' y' cv' hkrco gpvcvkp' qh' hgo vqugeqpf " rucgt' r wngu' cv' j' k' j' " tgr gvkkp' " tcv' k' p' u' e' t' k' d' u' c' " p' c' p' q' i' t' c' v' k' p' i' " l' p' " y' g' " x' q' n' o' g' " q' h' " v' c' p' u' r' c' t' g' p' v' p' q' p' k' p' g' c' t' " o' c' v' g' t' k' c' n' " y' c' v' j' " c' u' " c' " e' g' t' v' k' p' " u' r' g' e' t' w' o' " q' h' " r' g' t' k' q' f' u' " c' p' f' " e' q' t' t' g' u' r' q' p' f' k' p' i' " r' w' l' e' g' " x' g' e' v' t' u' " p' g' e' g' u' c' t' { " v' q' " h' w' t' h' k' i' " y' g' " r' j' c' u' g' / o' c' v' e' j' k' p' i' " e' q' p' f' k' k' q' p' " h' q' t' " e' q' p' l' e' c' n' " V' J' " i' g' p' g' t' c' v' k' p' o' V' j' g' u' g' " h' k' p' f' k' p' i' u' " c' t' g' " u' w' r' q' t' v' g' f' " d' { " y' g' " o' g' c' u' w' t' g' o' g' p' w' " q' h' " V' J' " e' q' p' g' " c' p' i' r' g' u' " l' p' u' k' f' g' " q' h' " x' c' t' k' q' u' " p' q' p' k' p' g' c' t' " e' t' { " u' c' m' " c' p' f' " i' " r' u' u' g' u' < [ " C' I' . " u' c' r' r' j' k' g' . " [ " N' H' " N' H' " O' i' H' . " N' K' U' C' H' " N' E' C' H' " h' w' u' g' f' " u' k' l' e' c' " c' p' f' " D' M' 9' " i' r' u' u' . " r' g' t' h' q' t' o' g' f' " y' k' j' " c' p' " c' o' r' i' k' k' e' f' [ " d' e' M' I' Y' " r' u' c' g' t' " y' c' v' f' g' r' k' x' g' t' u' " 3: 2' " h' u' " 3257' " p' o' " r' w' n' u' g' " c' v' / 422' " n' i' | " t' g' r' g' v' k' k' p' " t' c' v' g' . " u' g' g' " H' k' i' 03' \* c' + O' Y' g' " c' n' u' g' " l' p' x' g' u' k' i' c' v' g' f' " N' R' U' U' " c' p' f' " N' R' C' U' U' " o' q' t' r' j' q' m' i' { " \* H' k' i' 03' \* d' + c' p' f' " \* e' + t' g' u' r' g' e' v' k' x' g' n' f' + c' p' f' " y' g' " e' q' t' t' g' u' r' q' p' f' k' p' i' " u' r' g' e' w' t' " q' h' " p' c' p' q' i' t' c' v' k' p' i' " r' g' t' k' q' f' u' t' g' t' k' x' g' f' " d' { " 4F " H' q' w' t' k' e' t' " t' c' p' u' h' q' t' o' " \* H' k' i' 03' \* f' + O' Q' w' t' " t' g' u' w' u' " u' j' q' y' " y' c' v' " e' q' p' l' e' c' n' " V' J' " i' g' p' g' t' c' v' k' p' " q' e' e' w' t' u' " c' u' " c' " p' a' q' e' q' n' l' p' g' c' t' " h' q' w' t' / y' c' x' g' " o' l' z' k' p' i' " r' t' q' e' g' u' . " y' j' g' t' g' " y' g' " V' J' " e' q' p' g' " c' p' i' r' g' " k' u' " f' g' h' k' p' f' " d' { " y' g' " r' u' p' i' k' w' f' k' p' c' n' r' j' c' u' g' / o' c' v' e' j' k' p' i' " u' g' v' d' { " y' g' " o' c' v' g' t' k' c' n' f' k' u' r' g' t' u' k' p' . " y' j' k' g' " y' g' " t' c' p' u' x' g' t' u' g' " r' j' c' u' g' / o' c' v' e' j' k' p' i' " l' p' x' q' x' g' u' " y' g' " t' g' e' k' r' t' q' e' c' n' i' r' w' l' e' g' " x' g' e' v' t' " q' h' " p' c' p' q' i' t' c' v' k' p' i' . " y' j' k' e' j' " k' u' " r' t' q' f' w' e' g' f' " d' { " j' k' i' j' " t' g' r' g' v' k' k' p' " t' c' v' g' " h' k' r' o' g' p' v' c' v' k' p' " q' h' h' g' o' v' q' u' e' g' e' q' p' f' " r' u' c' g' t' " r' w' n' u' g' o' "



Hki 030\*c+O gcuwtgf "VJ "eqpg'cpi rgu'lp'xctkqwu'o cvgtkcn'Vj g'lpugv'ij qy u'c'uetggpuj qv'qh'eqplecn'VJ "go kuukp'lp' ur r j ktg0\*d+UGO 'ko ci g'qh'NRUU'cpf '\*e+NRCCUU'qp' y'g'uwthceg'qh'ucr r j ktg0\*f+4F 'Hqwtket' t'c'p'uh'q'to 'ur g'et'w'o 'qh' NRCCUU.'y j gtg'y j kg'ekterg'lpf'kecvu'y'j'p'c'p'q'i' t'c'v'k'p'i' r'g't'k'q'f' 't'g's'w'k'g'f' 'v'q' r'j' c'ug'o' c'v'ej' "eqplecn'VJ "i' g'p'g't'c'v'k'p'o'

Y g' dngkxg' y' cv' qwt' uwf { " r' t' q' x' k' f' g' u' " c' " f' g' g' r' g' t' " w' p' f' g' t' u' c' p' f' k' p' i' " c' d' q' w' " y' g' " p' c' w' t' g' " q' h' " e' q' p' l' e' c' n' " V' J' " i' g' p' g' t' c' v' k' p' " c' p' f' " k' u' " t' g' r' v' k' p' " y' k' j' " g' x' q' x' k' p' i' " l' p' / d' w' m' i' q' r' v' e' c' n' f' c' o' c' i' g' " f' w' t' k' p' i' " h' g' o' v' q' u' e' g' e' q' p' f' " h' k' r' o' g' p' v' c' v' k' p' " c' p' f' " u' w' r' g' t' e' q' p' v' p' w' o' " i' g' p' g' t' c' v' k' p' " l' p' / d' w' m' i' o' c' v' g' t' k' c' n' " c' v' j' k' i' j' " t' g' r' g' v' k' k' p' " t' c' v' g' u' o' "

[3\_ 'L' O' D' q' p' u' g' . ' L' O' M' A' i' g' t' . ' U' O' J' 3/4 o . " c' p' f' " C' O' T' q' u' e' p' h' e' r' f' . " S' H' g' o' v' q' u' e' g' e' q' p' f' " r' u' c' g' t' / k' p' f' w' e' g' f' " r' g' t' k' q' f' l' e' " u' w' t' h' e' g' " u' t' w' e' w' t' g' u' s' . ' L' O' N' c' u' g' t' " C' r' r' i' o' 46. ' 264228' \* 4234-0'  
 [4\_ " T' O' D' w' k' k' f' c' u' . " O' O' O' k' n' w' u' . " c' p' f' " U' U' L' v' q' f' n' e' | k' u' . " S' U' w' t' h' e' g' " c' p' f' " d' w' m' i' u' t' w' e' w' t' l' p' i' " q' h' " o' c' v' g' t' k' c' n' " d' { " t' l' r' r' n' u' " y' k' j' " r' u' p' i' " c' p' f' " u' j' q' t' v' r' u' c' g' t' " r' w' n' u' g' . " T' g' e' g' p' v' c' f' x' c' e' p' e' g' u' s' . " R' t' q' i' O' S' w' c' p' w' o' " G' i' g' e' v' q' p' O' 5 . " : 33 ; 6378' \* 4236-0'  
 [5\_ [ " O' N' w' [ " O' D' t' g' r' e' v' \ . " O' J' g' . " N' O' [ " w' " D' O' H' q' t' g' u' w' g' t' . [ " O' F' g' p' . " J' O' l' l' e' p' i' . " c' p' f' " C' O' J' q' w' c' t' f' . " S' N' c' u' g' t' / k' p' f' w' e' g' f' " r' g' t' k' q' f' l' e' " c' p' p' w' r' t' " u' w' t' h' e' g' " u' t' w' e' w' t' g' u' " q' p' " h' w' u' g' f' " u' k' l' e' c' " u' w' t' h' e' g' s' . " C' r' r' i' o' R' j' { " u' O' N' g' w' 0324. ' 473325' \* 4235-0'  
 [6\_ " C' O' T' w' f' g' p' n' u' . " L' O' R' O' E' q' i' o' d' l' e' t' . " U' O' J' 3/4 o . " C' O' T' q' u' e' p' h' e' r' f' . " L' O' M' A' i' g' t' . ' L' O' D' q' u' e' p' u' g' . " c' p' f' " V' O' G' O' K' l' p' c' . " o' l' u' r' q' p' v' c' p' q' w' u' r' g' t' k' q' f' l' e' " q' t' f' g' t' k' p' i' " q' p' " y' g' " u' w' t' h' e' g' " c' p' f' " l' p' " y' g' " d' w' m' i' q' h' f' k' n' g' e' v' t' u' k' t' e' f' l' e' v' g' f' " d' { " w' n' t' c' h' u' v' r' u' c' g' t' - c' t' u' j' c' t' g' f' " g' n' e' v' t' o' c' i' p' g' v' l' e' " q' t' i' k' p' o' . " U' e' k' O' T' g' r' 09. ' 34528' \* 4239-0'  
 [7\_ " T' O' I' t' k' i' w' k' u' . " I' O' V' c' o' q' - c' w' n' t' u' . " X' O' L' w' n' p' c' . " C' O' T' k' u' q' u' . " c' p' f' " C' O' F' w' d' k' v' k' u' . " S' U' w' r' g' t' e' q' p' v' p' w' o' " i' g' p' g' t' c' v' k' p' " c' p' f' " q' r' v' e' c' n' f' c' o' c' i' g' " q' h' " u' c' r' r' j' k' g' " c' p' f' [ " C' I' " c' v' j' k' i' j' " t' g' r' g' v' k' k' p' " t' c' v' g' u' s' . " Q' r' v' O' N' g' w' 067. ' 672966732' \* 4242-0'

# CZKU O O GVTKE 'F KHT CE VKG' TGHNGE VQT 'HQT 'DGCO 'UWRGT/ EQNKO CVKQP "

Kpf tg' O gungrksg<sup>3</sup>. 'F ctkwu' I ckgxlekw<sup>3,4</sup>. 'O ctv' pcu' Rgemw<sup>3</sup>. 'Nkpc' I tkgxlekw<sup>3,5</sup>. 'T wurp' CO' N{ o ctgpm<sup>6</sup>. 'Xlevt' D0' Vctcpgrnq<sup>6</sup>. 'Mguwku' Ucrkxpcu<sup>3,7,8</sup>"

<sup>3</sup>Xkpkwu' Wpkgtukv' 'Ncugt' Tgugctej 'Egpgvt. '32' Ucwrgvgnq' cxgpgw. 'NV/32445. 'Xkpkwu. 'Nkj wcpk' "  
<sup>4</sup>oHgo vkrö. '37' Ucwrgvgnq' cxgpgw. 'NV/32446. 'Xkpkwu. 'Nkj wcpk' "

<sup>5</sup>Egpgvt 'hqt' Rj { ucln' Uelgpegu' c'pf 'Vgej pqrni { . '453' Ucxcpqtkw' cxgpgw. 'NV/32446. 'Xkpkwu. 'Nkj wcpk' "

<sup>6</sup>Kpvtpcvqpcrlepgvt' öKpukwng' qh' Cr r rkgf 'Qr vkuö' P CU' qh' Wntckpg. 'Mwf t { cxunc { c' Ut032I . '26275. 'Mf kx. 'Wntckpg' "

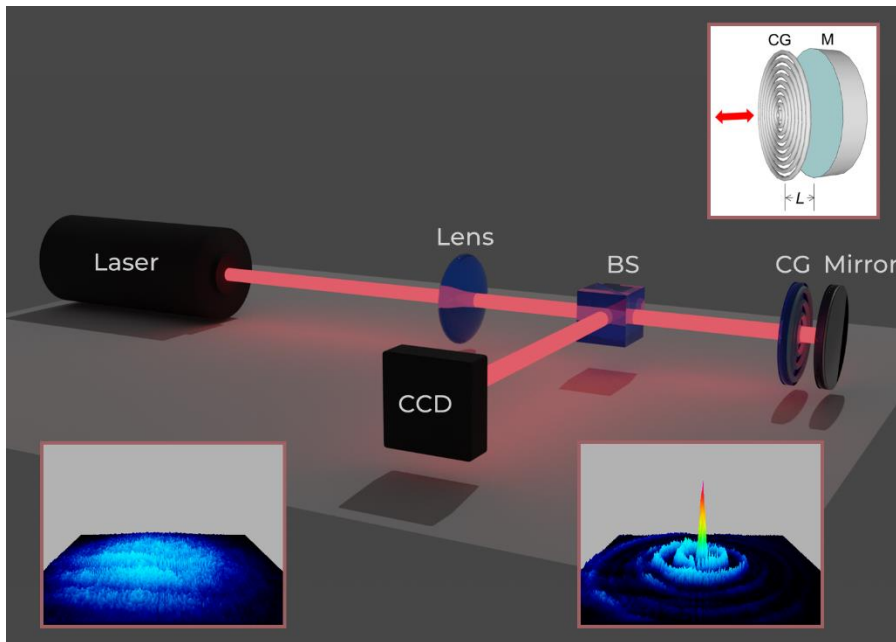
<sup>7</sup>Kpukwelo' 'Ecvncpc' f g' Tgegtec' k' Guwf ku' Cxcpecu' \*KETGC+ 'Rcuugli' 'Nnw' u' Ego r cp { u' 45. '2: 232. 'Dctegrupc. 'Ur clp' "

<sup>8</sup>Wpkgtukcv' Rqrk<sup>3</sup> eplec' f g' Ecvncp { c' \*WRE+ 'Tco dr' Ucpv' P gdtkf k' 44. '2: 444. 'Vgttcuac' \*Dctegrupc+ 'Ur clp' "

[kpf tg' O gungrksgB Hñwfw Öwñw](#)

Tgegpwñ. "k'j cu'dggp'r tqr qugf "v" wug" cp" czku{ o o gvtke" 5F "r j qvqple" et { ucln' lpukf g' vj g' ecxkw{ "qh' c" y kf g' cr gtwt g" o letqej kr 'rcugt' kp' qtf gt' vq' kpetgcug' vj g' dtki j vpguu' c'pf "vj g' ur cvkcn's wrkvw{ "qh' ku' go kuukqp" j3\_OJ qy gxgt. "vj g' hcdtkecvkqp' qh' uej '5F' utwewtgu' vgej pqrni kecmñ 'ku' c' xgt { 'ej cmgpi kpi 'vun0Vj gtghqtg. "vj g' kf gc' vq' eqo dkgp' vj g' r tqr gt vku' qh' 5F 'r j qvqple" et { ucln' j4\_ c'pf "vj g' o cpwkecwtkpi 'cf xcpvcu' gu' qh' hrcv' qv' vku' d { "vj g' wug' qh' c" 4F' utwewtgu' r qukkqp' gf' emug' c'pf 'r ctcmgn' vq' vj g' utwkecg' qh' c" o ktqt' j' cu' dggp' uwi i gungf 0"

J gtg' y g' vj g' qtgvecmñ "gzr rclp' c'pf "gzr g' tko gpvcuñ { r tqxg' vj g' hct' hgrf' ghgevu' qh' vj g' czku{ o o gvtke' f khtcevxg' tghngevt' "ó' c' vj kp' tcpuo kuukxg' eqpegvte' f khtcevkqp' i tcvkpi 'r megf' cv' c' f kucpeg' qh' ugxg' tcr' o letqo gvtu' kp' htqpv' qh' c' hrcv' o ktqt0' Vj ku' eqphk' wcvkqp' r tqxkf gu' vj g' ghgevu' qh' uwr gt/ eqmko cvkqp' y j lej 'ku' f ghkpgf' d { "cp' gpj cpego gpv' qh' czkcn' eqo r qpgpv' qh' I cwukcp' hrcugt' dgco 'tghngevf' htqo 'uej' utwewtgu' Vj g' kpvtg' tgcvkqp' qh' vj ku' ghgevu' ku' dcugf' qp' vj g' czku{ o o gvtke' f khtcevkqp' qh' vj g' tcf kcvkqp' f wtkpi 'vj g' r tqeguu' qh' f khtcevkqp' kp' vj ki j gt' f khtcevkqp' qtf gtu' c'pf "vj gp' dcen' vq' vj g' gtq/ qtf gt' f khtcevkqp0"



Hki 030Gzr g' tko gpvcuñ uej go g' y kj 'c' uej go g' qh' czku{ o o gvtke' f khtcevxg' tghngevt' \*qvr' tki j v' c'pf "o gcuwgf' " hct' hgrf' r tqhkgu' qh' lpekf' gpv' I cwukcp' \*dqwqo 'rghv' c'pf "f qwdrg/ f khtcevgf' \*dqwqo 'tki j v' hrcugt' dgco 0"

Vj g' r tqvq' r g' qh' vj g' eqpegvte' f khtcevkqp' i tcvkpi "j cxkpi "c' s wcu' ukpwuqkf' cnr' tqhkg' c'pf "c' r g' tkqf' qh' 4" o letqo gvtu' y cu' hcdtkecvgf' wukpi 'grgevtq' dgco 'hki q' i tcr j { 0Cp' gzr g' tko gpvcuñ kpxguki cvkqp' qh' vj g' r tqr ci cvkqp' qh' c' f kxgti kpi 'I cwukcp' dgco "vj tqw' i "vj g' i tcvkpi / o ktqt' c'pf go "Hki 03+ vj qy gf' "cp' kpetgcug' kp' czkcn' kp' vgpukv{ "qh' vj g' tghngevf' dgco "d { "vr' vq' 9" vko gu0Vj g' qdvc' kpgf' t' guwn' s wrkcvkxgn' c'pf "s wcpkcvkxgn' "ci tgguy' kj "vj g' vj g' qtgvecmñ r tgf' kcvkqp' qh' vj g' uwr gt/ eqmko cvkqp' ghgevt0"

Uwej "czku{ o o gvtke' f khtcevxg' tghngevtu' wugf' "cu' qpg' \*qt' dqj + "ecxkw{ "o ktqtu' kp' o letqrcugt' eqwf' "dg' gur gekcmñ " wughwñhqt' vj g' lo r tqxgo gpv' qh' vj g' ur cvkcn's wrkvw{ "qh' vj g' kt' tcf kcvkqp0"

<sup>j3\_</sup>F 0I ckgxlekw. 'X0Mq' rcf' gpmñ. 'X0Rvtn' u. 'O 0Rgemw. 'X0Vctcpgrnq. 'c'pf 'M0Ucrkxpcu. 'Rj qvqple' Et { ucln' O letqej kr 'Ncugt. 'Uel0T gr 08. '56395' \*4238-0' <sup>j4\_</sup>X0Rvtn' u. 'N00 cki { vg. 'F 0I ckgxk kwu. 'O 0Rgemw. 'T0I cf qpcu. 'c'pf 'M0Ucrkxpcu. 'Uwr gt/ eqmko cvkqp' d { "czku{ o o gvtke' r j qvqple' et { ucln. 'Crr r0Rj { u0' Ngw0326. '44332: \*4236-0'

**J [ DT'KF 'NKS WK'ET[ UVCN'O KETQECXK[ 'CUC'RJ QVQP'K'F GX'KG' VQ'EQPVTQN'U P VJ GV'K'QRV'K'CN'URK/PQTDK'K'P VGTCEVKQP'U**

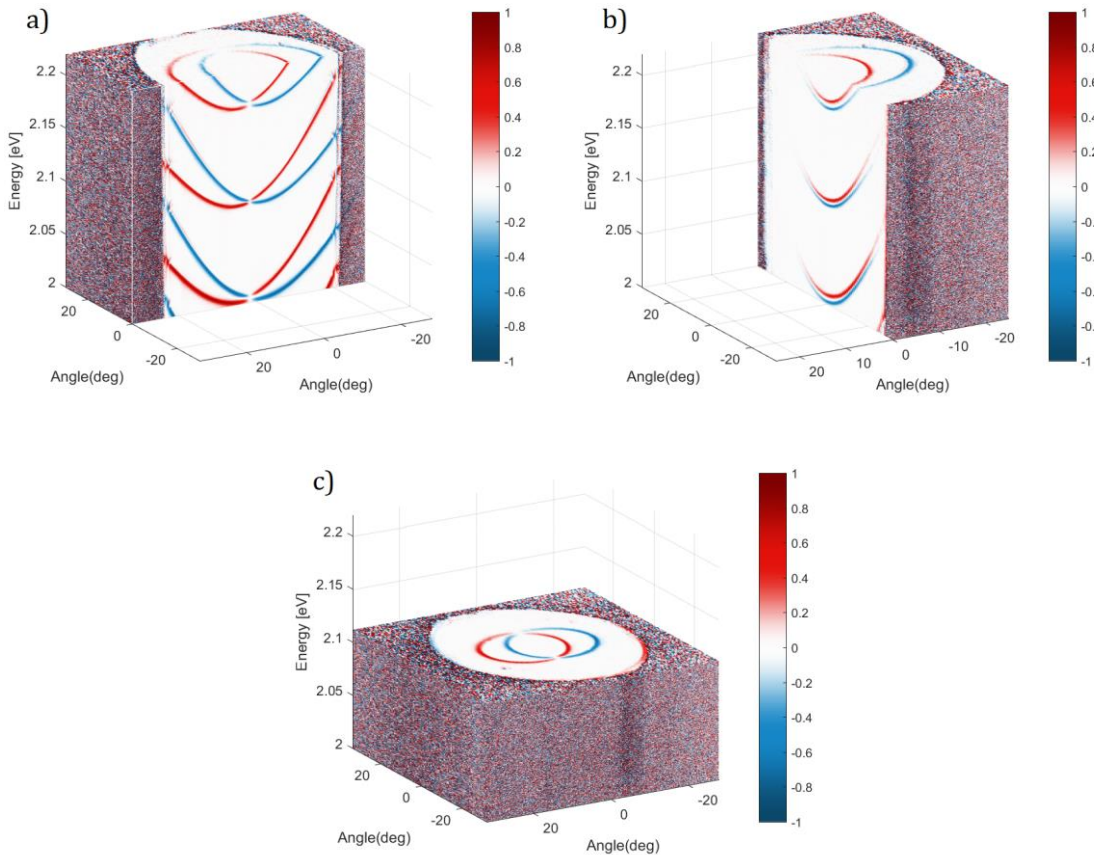
Uctc'Rkqtqy um<sup>3</sup>. 'O cygwu| 'Mt»n<sup>3</sup>. 'Mwct| {pc'Tgej ek um<sup>3</sup>. 'Tchc-EO ktgm<sup>3</sup>. 'Tchc-EO c| wt<sup>4</sup>. " Rt| go {u€y 'O qtcy knf. 'Rt| go {u€y 'Mw<sup>4</sup>. 'Y kmqt 'Rkgegn<sup>4</sup>. 'Dctdct'Rk vr<sup>3</sup>. 'LcegnU e| {vny<sup>3</sup>. ""

<sup>3</sup>Kpukwng'qh'Gzr gtko gpcnRj {uleu.'Hcwm| 'qh'Rj {uleu.'Wpkxgtuk| 'qh'Y ctucy . 'Rqrcpf "   
<sup>4</sup>Kpukwng'qh'Cr r rkgf 'Rj {uleu.'O krctct { 'Wpkxgtuk| 'qh'Vgej pqm| { . 'Y ctucy . 'Rqrcpf "   
 :LcegnU e| {vnyB hwy Qf wt n' "

O letqecxk| "ku'cp'qr v€cn'tguqpcvqt. "eqpukukpi "wuwcm| "qh'y q'r ctcmgri'F kutkdwgf "Dcti i "Tghrgevqtu" 'F DT -0Uvej " utwewtg'cmjy u'vq'vcr "rki j v'kp" c" hqto "qh'c'ucpf kpi "y cxg0'Vj gtg'ctg"uqo g'ur gekkle'grgevtle'hgrf "f kutkdwkqpu'ecmgf " tguqpcvqt"o qf gu. "y j lej "ctg"qdvcckpgf "f vq"vq"vj g"eqpf kkp"vj cv"vj g"tguqpcvqt"ngpi vj "ku'cp'kpgi tcn'o wnk'ng"qh'j ch'j g" y cxgrpi vj 0Rj qvqple"o qf gu'kp"o letqecxkkgu'ecp"eqw ng'y kj "gzekqpu"go gti kpi "kp" c's wcpwo "y gm'qt" f khtgtpv'v' r g'qh' go kwgt \*g0 0' cp" qti cple" f {g+." y j lej "ngcf u"vq" y gcn'qt" utqpi "eqw rki . " dqvj " dgkpi " c" uqwteg" qh' xgt { " kpvgtgukpi " r j gpqo gpc0' "

D{ " gpenqkpi "c" pgo cv€ "nks wk' "et {ucmkpg" \*NE -d' dkhtkpi gpv' o gf kwo "kukf g" c" o letqecxk| " \*O E+." kp" y j lej "NE" cpkukvqr { "ecp'dg'eqpvtqmgf "d { "cr r n' kpi "cp"gzvtpcn'grgevtle'hgrf . "y g'ctg'cdng"vq"ur gevcm| "wpg'cpf "eqw ng'uwdugs wgpv' ecxk| "o qf gu0' ]3\_ "Tgegpv| . "y g"j cxg" f go qpwtcvgf "c" Tcuj dc/F tguugn cwu/rkng" ur kp" qtdk' eqw rki " \*QE+ " kp" uvej " utwewtg. "y j gp'o qf gu'qh'f khtgtpv' r ctk| "y g'gt' dtqvi j v'kpq" c" tguqpcpeg0' ]4\_ ""

Kp"vj ku'y qtm"y g" kpxguki cvg" r qnctkucvqp/tguqngf "f kur gtukqp"qh'ur kp/qtdk'eqw ngf "o qf gu'kp" c" o letqecxk| . "vj cv" qr gtcvku'kp"y gcm'eqw rki "tgi ko g. "y kj "qti cple" f {g" r {ttqo gvj gpg/7: 2+ lpeqtr qtevgf "y kj kp"NE"rc {gt0'Y g'ctg'cmjy gf " vq" vtecg" ecxk| "o qf gu" d { "f ggevkpi "r j qvqpu"go kwgf "htqo "vj g"pqptguqpcpv| "gzekgf "uco r ng0'Y g" r gthqto gf "cpi ng/ tguqngf "vqo qi tcr j { "vq' hwm| "o cr "f kur gtukqp"tgrvqp"qh'vj g" ecxk| "o qf gu'ht"cm'f kgevkpu'qh'kp/r rpg' y cxg'xgevqt"qh' vj g" ecxk| "r j qvqpu' Rqmtkucvqp/tguqngf "gpgti { /o qo gpwo "vqo qi tcr j kgu'ht"cm' o clqt" tgi ko gu'kp"NE" O E" y gtg" kpenf gf "kp"tguqcte| <tguqpcpeg"qh'vj g"o qf gu'y kj "qr r qukg"r ctk|. "y j gp'vj g { "ctg'eqw ngf "d { "Tcuj dc/F tguugn cwu'ur kp/ qtdk' eqw rki " vto " \*Hi 0' 3+ "cpf " tguqpcpeg" qh' vj g" o qf gu' qh' vj g" uco g" r ctk| 0' O gcuwtgo gpw" y gtg' gzgewgf " hqt" nwo kpguepeg'cpf "tghrgevcpeg"htqo "vj g'uco r ng0' "



Hki 030Vj g'vj kf "Uqngu'r ctko gvt'qdvcckpgf "hqt"vj g'tghrgevcpeg"m'ur ceg'ur gevte'hqt"vj g'Tcuj dc/F tguugn cwu' eqw rki "tgi ko g'urkgf "y kj "r rpgpu'cv'c+hm" ? "2. "d+hm" ? "2. "e+vj g"gpgti { "4034" gX0 "

[3\_ 'MDNngpvc'gv'cn0'Vwpcdn'qr v€cn'ur kp"J cm'ghrgevp'k'c'ns wk' "et {ucn'io letqecxk| 0Ni j v'UelOC'r r r09. '96" \*423: -0'   
 [4\_ 'MOTgej ek um'gv'cn0'Gpi kpggtkpi "ur kp/qtdk'u| pvj g'ke"J ko knqkpcpu'kp'ns wk' "et {ucn'iq' v€cn'ecxkkgu'0'Uelgpeg'588. '949" \*423: +"

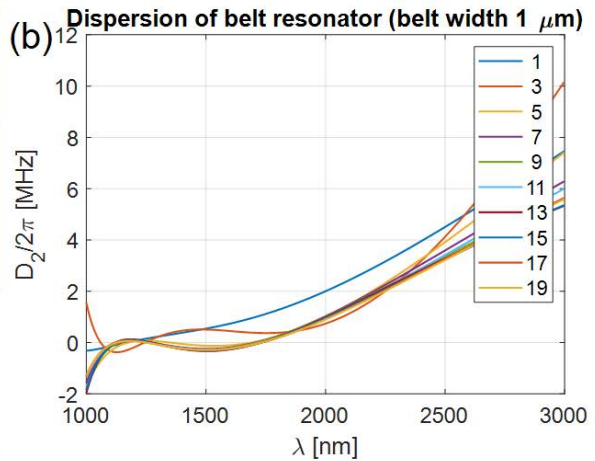
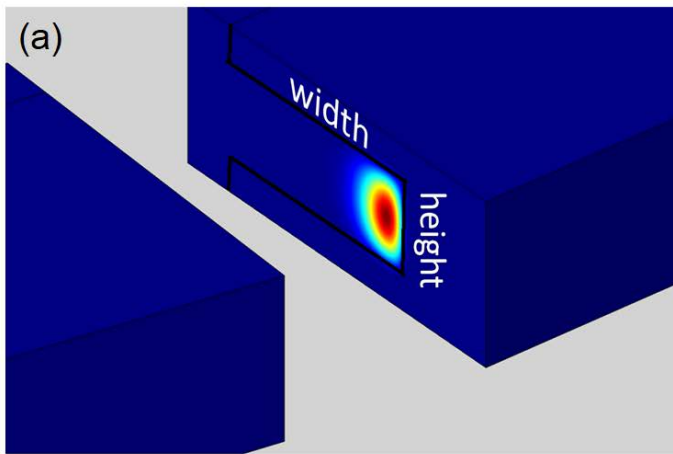
**F KURGTUKQP 'GPI KP GGT KPI 'QHY J KURGT KPI 'I CNNGT[ 'O QF G'  
 TGUQP CVQTUHQ T'HTGS WGPE[ 'EQO D'I GP GT CVKQP 'CPF "  
 VGNGEQO O WP KECVKQP 'CRRNE CVKQP U'  
 Mtkukpu'F tci wpu<sup>3,4</sup>. 'Kpi c'Dtle<sup>3</sup>. 'Vqo u'Ucni cnu<sup>4,5</sup>. 'Lcpku' Cpk<sup>3</sup>"**

<sup>3</sup>Kpukwag'qh' C'vqo le'Rj { uleu'cpf 'Ur gev'queqr { . 'Wp'k'gtuk'f 'qh'N'cxlc. '5' Lgri cxcu'Ut'ggv.'3226. 'Tki c.'N'cxlc"  
<sup>4</sup>CHQE'U'q'w'k'p'u'N'f 0'39' C'p'f t'g'q'x'c'u'ut'ggv.'3267' T'ki c.'N'cxlc"

<sup>5</sup>Kpukwag'qh'Vgrgeqo o wplecvkqp'u'qh'v'j g'Tki c'Vgej p'le'cni'Wp'k'gtuk'f . '34'C| g'p'g'u'Ut'ggv.'326: . 'Tki c.'N'cxlc"  
 ntkukpu'f tci wpuB n'w'k"

Y j kur gtupi "i cngt { "o qf g" tguqpcvqtu" \*Y I O Tu" ctg" qr vlecn'f gxlegu'y kj "czkcn'uko gv { . "y j gtg" rki j v'ku' eqphkpgf "  
 y kj lp'vj g'tguqpcvqt' f'wg'vq'v'q'w'c'rl'p'v'gt'pc'n'l't'gh'g'ev'k'p'0'Y I O Tu'j' c'x'g'c'v'f' r'le'c'n'uk' g'q'h'v'g'u'v'q'j' w'p'f't'g'f'u'q'h'o' l'et'q'o' g'v'g'tu' "c'p'f "  
 g'z'r'g't'k'p'eg' "u't'q'p'i "rki j v'o' c'w'g't'k'p'v'g't'c'v'k'p'p'f' w'g'v'q' "n'q'y "n'q'u'g'u'c'p'f "j ki j "o qf g'f' g'p'uk'v' { 0'Y I O Tu' "e'c'p' "d'g' "w'ug'f' "v'q' "i' g'p'g't'c'v'g' "  
 M'g't't' "H't'g's' w'g'p'e { "e'q'o' d'u' "l'p'f' w'eg'f' "d { "h'q'w't' "y' c'x'g' "o' k'z'k'p'i 0'V'j' g' "h't'g's' w'g'p'e { "e'q'o' d'u' "c't'g' "i' g'p'g't'c'v'g'f' "c'v'c'p'q'o' c'r'q'w'u'f' k'ur' g't'uk'q'p' "c'p'f "  
 k' "k'u'f' g'ul'g't'c'd'n'g' "v'q' "j' c'x'g' "c' "h'c'v'f' k'ur' g't'uk'q'p' "r' t'q'h'k'g' "h'q't' "d'g'u'v' "t'g'u'w'u" ]3\_0'V'j' w'u'k' "k'u' "k'o' r'q't'c'p'v' "v'q' "k'p'i' g'p'g't' "v'j' g' "t'g'u'q'p'c'v'q't' "v'q' "  
 c'ej' k'g'x'g' "v'j' g' "f' k'ur' g't'uk'q'p' "t'g's' w'k'f'g' 0"

H'q't' "v'g'r'g'e'q'o' w'p'le'c'v'k'q'p' "c'r' r' "l'c'c'w'k'q'p'u' "v'j' g' "f' g'ul't'g'f' "h't'g'g' "u'r' g'e'v't'e'n' "t'c'p'i' g' "k'u' "c't'q'w'p'f' "322" "I J | . "y' k'ej' "v'c'p'ur'c'v'g'u' "k'p'v'q' "c' "  
 Y I O T' "t'c'f' k'w'u' "q'h' "554" "μo " ]4\_0' C'p' "k'p'v'g't'g'u'k'p'i "i' g'q'o' g'v't' { "k'u' "d'g'm' "v'f' r'g' "Y I O T' . "y' j' g't'g' "v'j' g' "f' k'ur' g't'uk'q'p' "r' t'q'h'k'g' "e'c'p' "d'g' "  
 c'ej' k'g'x'g'f' "s' w'k'g' "h'c'v' " ]5\_0' V'j' g' "d'g'm' "t'g'u'q'p'c'v'q'tu' "c't'g' "e { "n'k'p'f' "l'c'c'n'l' "u't' w'e'w't'g'u' "y' k'j' "c'p' "g'z' w'g'p'uk'q'p' "y' k'j' "k'u' "u'k' "g' "e'j' "c't'c'v'g't' k'ug'f' "d { "  
 y' k'f' "v'j' "c'p'f' "j' g'k'i' j' v' "h'k' 030c' +0"



H'k'i 030°c +V'j' g'g'r'g'e'v't'le' "h'g'r'f' "f' k'ur'k'd'w'k'q'p' "k'p'uk'f' g'c' "d'g'm' "v'f' r'g' "h'w'ug'f' "u'k'r'le'c' "Y I O T' "c'v'3; 3"VJ | = "d' "e'c'r'e'w'r'c'v'g'f' "u'g'e'q'p'f' /q't'f' g't' "  
 f' k'ur' g't'uk'q'p' "h'q't' "c' "d'g'm' "t'g'u'q'p'c'v'q't' "y' k'j' "v'j' g' "d'g'm' "y' k'f' "v'j' "q'h' "3 μm and various belt heights shown in the legend in μm0"

E'q'o' r' w'g't' "u'k'o' w'r'c'v'k'q'p'u' "c't'g' "o' c'f' g' "l'p' "E'Q'O' U'Q'N' "O' w'n'k'r' j' { u'le'u' "v'q' "f' g'v'g't'o' k'p'g' "v'j' g' "f' k'ur' g't'uk'q'p' 0'V'j' k'u' "y' c' { "y' g' "e'c'p' "n'p'q'y' "c'v' "  
 y' j' c'v'f' k'o' g'p'uk'q'p'u' "y' g' "p'g'g'f' "v'q' "o' c'ng' "q'w't' "Y I O Tu' "h'q't' "g'z'r' g't'k'o' g'p'u' 0' H'q't' "v'g'r'g'e'q'o' o' w'p'le'c'v'k'q'p'u' "v'j' g' "t' w' r' "l'p'i' "r'c'ug't' "l'j' q'w'f' "d'g' "  
 c't'q'w'p'f' "3772" "p'o' "6' "c'v' "v'j' g' "o' k'f' f' n'g' "q'h'E/ "d'c'p'f' "t'g'i' k'q'p' "3752" "p'o' "6' "3787" "p'o' " +0"

]3\_ "U'W'H'w'k' " "V'0'V'c'p'c'd'g' "F' k'ur' g't'uk'q'p' "g'p'i' k'p'g't'k'p'i' "c'p'f' "o' g'c'u'w't'g'o' g'p'v'q'h' "y' j' k'ur' g't'uk'q'p' "i' c'ng't' { "o' q'f' g' "o' l'et'q't'g'u'q'p'c'v'q't' "h'q't' "M'g't't' "h't'g's' w'g'p'e { "e'q'o' d' "i' g'p'g't'c'v'k'q'p' . "  
 P'c'p'q'r' j' q'v'p'le'u' . "32: 963326" \*4242+0  
 ]4\_ "G'0'C'0'C'p'c'uj' n'k'p'c' . "O' (R'0'0' e't'k'q'x'c' . "C'0'X'0'C'p'f' t'le'p'q'x' . "T'0'C'0'C'n'j' o' g'f' | j' c'p'q'x' . "T'0'0' w'p'k'm'u' . "O' (F' 0'V'q'n'o' c'p' . "N'0'U'm'e'f' q'x'c' . "K'0'X'0'Q'w'e'f' { u'j' n'k'p' . "V'0'U'c'ni' c'nu' "K'0' "  
 N { c'uj' w'm' "C'0'U'q't'q'n'k'p' . "U'U'U' r'q'r'k'u' "I' 0'N'g'e'j' u' "X'0'D'q'd't'q'x'u' "O' l'et'q'ur' j' g't'g' /d'c'ug'f' "q'r' vle'c'n'l' "h't'g's' w'g'p'e { "e'q'o' d' "i' g'p'g't'c'v'q't' "h'q't' "422" "I J | "u'r' c'e'g'f' "Y F O "f'c'v' "  
 v'c'p'u'o' k'u'k'q'p' "u'f' u'g'o' . "R'j' q'v'q'p'le'u' 09" \*4242+0  
 ]5\_ "K'0'U'0'1' t'w'f' l'p'l'p' . "P' 0' | w' "F' k'ur' g't'uk'q'p' "g'p'i' k'p'g't'k'p'i' "q'h'l'et' { u'c'n'l'p'g' "t'g'u'q'p'c'v'q'tu' "x'k'c' "o' l'et'q'u't'w'e'w't'l'p'i' . "Q'r' vle'c' "4\*5+ "443/446" \*4237+0"



# COMPARATIVE NONLINEAR DYNAMICS OF HIGH-POWER FEMTOSECOND LASER PULSES IN KERR MEDIA DEPENDING ON THEIR TOPOLOGICAL CHARGE

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In present work we compare conditions of spatio-temporal localization of terawatt femtosecond vortex (doughnut) and vortex-less (Gaussian) laser pulsed beams in Kerr media and formation of light bullets. Due to dozens of different applications of light bullets (LB) such as remote sensing of atmosphere, lightning control, high harmonic generation, astronomy, material processing, lithography and so on this activity field draw attention of researchers. As is known, in Kerr media the filamentation makes possible the spatial and temporal compression of pulses. The filament is a self-organized structure formed through the competition of underlying processes such as, for example, diffraction, Kerr nonlinearity, plasma photoinduced via multiphoton absorption or tunnel mechanisms, etc. Under anomalous group velocity dispersion (GVD) one of filamentation regimes may be realized, i.e. LB generation. As shown in experiment [1], the stability of the LB is due to their polychromatic Bessel-like structure consisting of a sharply localized high-intensity core and a weak, delocalized low-intensity periphery, which balances energy losses in the central core.

The system of nonlinear Schrödinger equation for the complex envelope of the electric field and kinetic equation for the electron plasma density is exploited. The Hamiltonian deduced on the base of this equation in approximation of negligible dissipation allowed us to obtain a potential function (Fig. 1). In the frame of two-scale variation approach the system of motion equations for both temporal  $T(z)$  and spatial  $R(z)$  beam radii was found. The solution of this system allowed to define the stability regions for LB. Solutions of the above equation system have been analyzed in broad spectral range of the anomalous GVD for fused silica and other Kerr solids at different values for topological charge  $m$  (0,1,2,3,4) and various ratios of input pulse power to critical one for self-focusing  $\alpha > 10$ . Under suggestion that the multi-photon ionization mechanism is dominated, we deduced the expressions for stationary values  $T_0$  and  $R_0$  corresponding to the minimum of the potential function  $V(R, T)$  and estimated their values in dependence on medium and radiation parameters. The stability is originated from the complete balance of all underlying processes accompanying the pulsed beam spreading. For vortex beams the following threshold dependence of their possible input power on  $m$  is revealed:  $\alpha > 2m/0.093$ . Only pulsed beams obeying this condition may propagate in vortex LB regime. The Gaussian-type LBs are free of such conditions.

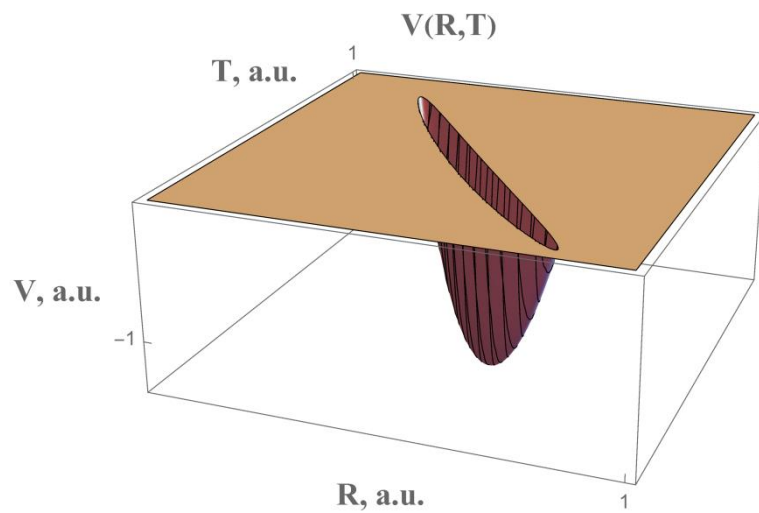


Fig. 1. Potential function  $V(R, T)$  for vortex pulsed beam with  $m=1$ .

We show for the case of the initial spatial radius and duration of the pulsed beam are detuned from their stationary values  $R_0$  and  $T_0$ , the possible scenarios of their behavior under the LB propagation obey the dynamics of two coupled oscillators. So, the LB propagation is accompanied by oscillations of spatial and temporal radii. Furthermore, they may oscillate in phase or in antiphase. The frequency of the “in-phase” oscillations is less than for the antiphase oscillation frequency.

[1] D. Majus, G. Tamošauskas, I. Gražulevičiūtė, et al., Nature of Spatiotemporal Light Bullets in Bulk Kerr Media, Phys. Rev. Lett. **112**, 193901-1-5 (2014).

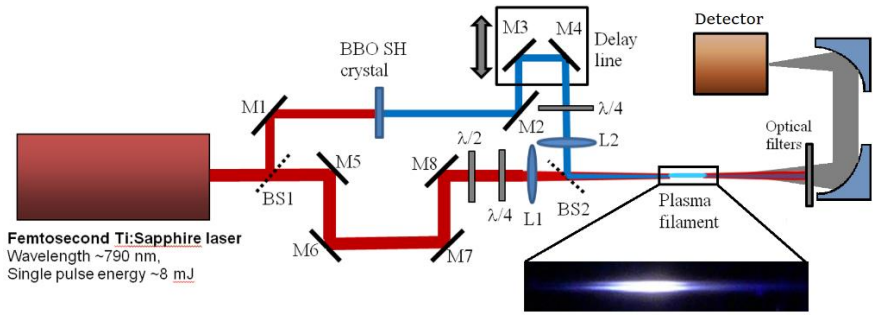
**VGTCJ GT\ 'Y CXG'I GPGT CVKQP 'K' 'CKT' RNCUO C'QRVKO KUCVKQP "**  
**WUKPI 'DREJ TQO CVKE 'HGO VQUGE QP F 'NCUGT 'RWNUGU'**

F cpcu'Dwqflku. 'I kfg tkwu'Dcn cu. 'Xkmqtklc'Vco wkgp "

Xkpkwu'Wpklxtukv{ . 'Ncugt 'T gugctej 'Egpgvt. 'Ucwn vgnk'cxgpgw'32. 'NV/32445'Xkpkwu. 'Nkj wcpkc "  
f cpcu'Uwq| kuB HfxwM"

Kp'vj g'tgegpv{ gctu'vgtcj gtv \*VJ | +y cxg'vj cvtgr tguwpv'grgestqo ci pgle'tcf kcvkp'vj cvt'cpi gu'kp'htgswgpe { 'htqo "2.3" VJ | "vq"32"VJ | "j cu'f tcy p" c" ur gekcn'cwpgvkp'f wg'vq'ku'wpls wg'r tqr gt vku" j3\_ "cpf "c"y kf g"cr r rkecdkxv{ "kp'ctgcu"qh' ur gestqueqr { . 'dkmqi kecnko ci kpi . 'f gvevkp'qh'j c| ctf qwu'o cvgtkcu. 'ugewtkv{ 'uetggpki . 'gve0C"j ki j "f go cpf "hqt'vgtcj gtv " tcf kcvkp'go kvkpi "f gxlegu'kpetgcugf "vj g'f gxgnr o gpv'qh'pgy "ghhlekpv'uqwtegu0Y g'r tguwpv'o gvj qf "qh'VJ | 'htgswgpe { " tcf kcvkp'i gpgtcvkp'htqo "ck"r nu c"kp'f vefg "wukpi "dlej tqo cve'ngo vqugeqpf "ruugt"r wngu0'Wukpi "vj ku'o gvj qf "vj g'qtf g" qh'o ci pkwf g'qh'i gpgtcvkp'ghhlekpe { "ku'qpn{ "10<sup>-5</sup>"dw'qp'vj g'qvj g"j" cpf "k'ku'ko r quukrg'vq'f co ci g'qwt'uqwtg'o gf kwo " ukpeg"co dlpgv'ck'ku'wugf "uq'ruugt"r wo r "r qy g"ku'p'qv'vj g'rko kapi "hcvqt0'K'vj ku'tgugctej "y g'hqewugf "qp"qr vko kucvkp'qh' VJ | "i gpgtcvkp'ghhlekpe { "d { "xct { kpi "vj g'tgrvkg"r wo r "r wug"vko kpi . "r wug"gpgti { "cpf "r qnctkucvkpu"qh'vj g"r wo r " y cxgu0

Kp'qwt"gzr gtko gpv'y g'wugf "c"Vklcr r j ktg'ruugt"u'wgo "Ngi gpf "grkg"fvq"J G- . "Eqj gtpgv'Kpe0"fgnkgtkpi "65"hu" r wngu'y kj "tgr gvkkp'tcvg'qh'3"m | . 'egpvcn'y cxgpgpi vj "qh'9; 7"po "cpf "o czko cn'r wug"gpgti { "qh": "o L0'Hktu.v"vj g'ruugt" dgco "y cu'ur rkv'y kj "vj g'j gm "qh'c'vj kp'dgco "ur rkwgt0'K'ppg'qh'vj g'vq'dgco u'c'ugeqpf "j cto qple"U " +y cu'i gpgtcvgf "kp"c" DDQ"et { ucn'y j kng'cpqj g'truugt"dgco "y cu'ngn'cu'hwpf co gpcn'j cto qple"HI +0S wctvt/y cxg'r r wngu'y g'tg'wugf "qp'dqv" dgco u'ht'vcpuqto kpi "r wo r "y cxg'r qnctk cvkpu'vq'ektewr"kp'qtf g"vq'kpetgcug"VJ | "i gpgtcvkp'ghhlekpe { "j4\_0"U " tcf kcvkp'y cu'hngt'f "qwtqo "vj g'HI "cpf "r cuugf "qp'vq"vj g'hqewukpi "ngpu'vj tqw j "f kngvte"o ktqtu'qh'f gr { "kpg0'Vy q" f khtg'gpv'ngpu"y g'tg'wugf "vq'hqewu'dqv"r wo r "dgco u'dgecwug"qh'vj gk" f khtg'gpv'y cxgpgpi vj u'cpf "r wug"gpgti kgu" \*o czko cn'r wug"gpgti kgu"y g'tg"2(6"cpf "3(6"o L'hqt"vj g"U "cpf "HI . "tgr gevkgf +0'Vj gp"dqj "hqwugf"dgco u'y g'tg" eqpepvtkecn{ "xqgtrr r gf "kp"vko g'cpf "ur ceg"wkpi "vj g'f gr { "kpg"cpf "c"flkj tqle"dgco "ur rkwgt0'Vj gp"cv'r tqr g"r wo r " r wug"gpgti kgu"vq"2(8"o L+; y g'j cxg'f gvevgf "VJ | "tcf kcvkp'vj cv'ku'go kvgf "htqo "r nu c'hko gpv'htqo gf "kp'ck0'VJ | " tcf kcvkp'y cu'hngt'f "qwtqo "xkudrg'hi j v'cpf "r wo r "wkpi "ukieq'hnktu'cpf "vj gp'wkpi "r ctcdqke"o ktqtu'f kvegf "vq" kqj g"r { "tqrgvte" f gvevt'qt "c"o ketqdqno gtle"vj gto cnleco gtc0



Hki 0'30'Gzr gtko gpcn'ugwr 0'O 3/O : <f kngvte"o ktqtu="N3. "N4<"hqwukpi "ngpu=" 16. " 14<"s wctvt/y cxg'cpf "j cnh' y cxg'r r wngu="DU3. "DU4<dgco "ur rkwgtu. "U "cpf "HI "dgco u'ct'g'uj qy p'd { "dwg'cpf "t'gf /r kpnleqmwu. 'tgr gevkgf 0'

Ky'cu'hqwpf "vj cv'kpetgukpi "r qy g"qh'U "dgco "f getgcugu"vj g"qr vko cn'tgrvkg"fvq"gr { "xcwg"qh'U "r wngu'y kj " tgr gev'vq"HI "r wngu0'Qp"vj g'qvj g"j" cpf . "y j gp"HI "r qy g"y cu'kpetgcugf "c"uko krt"r tqegu"qewt'f "dw'k'y cu'o wej " y gcnr" f wg'vq"ny g"HI "r wug"gpgti { 0'Uwej "f gr gpf gpeg"qh'f gr { "xcwgu"eqwf "dg"gzr rkp'f "d { "vj g'hcv'vj cv'f v'kpi " r tqr ci cvkq. "vckkpi "r ctv'qh'vj g'r wug'ku'uecwtg'f "o qte'kp'vj g'r nu c'etgcvgf "d { "vj g'htqpcn'r ctv'qh'vj g'uco g'r wng0'Vj wu. " hqwugf "r wo r "r wngu'qh'vj g'j ki j g'gpgti { "kp'ck"o qxgu'hcvgt "vj cp'vj g'g'qh'ny g"gpgti { 0'Vj g'ghq'g. "vj g'o qu'ghhlekpv' i gpgtcvkp'qh'VJ | "tcf kcvkp'y cu'qdugt'xg'f "y j gp'vj g'tgrvkg"vko kpi "qh'vq"r wo r "r wngu'y cu'cf lwngf "ceeqtf kpi "vq"vj g" gpgti kgu'qh'vj g'g'r wngu0"

Vj g'r tguwpv'f "tguwu"eqwf "dg"ughw'kp'qr vko k kpi "pqrkpgct"qr vkn'r tqegu"uwej "cu'i gpgtcvkp'qh'vgtcj gtv " tcf kcvkp"j5\_ "cu'y gm'cu'r ctco gtle"hw/y cxg'o kzkpi "cpf "i gpgtcvkp"j6\_ "gve0"y j gpgxg'vj g'dkej tqo cve"r wo r "dgco u" ctg'wugf 0'

j3\_1 0U0Ngg. 'Rtlpek ng'qh'vgtcj gtv 'Uekpeg'cpf 'Vgej pqm { \*Ur tpi g. 'WUC. '422: +"  
j4\_ "E0'Vckmgl . 'C0'Uc'vj qr vqu. 'U0'Uw'r kp. 'F 0'Dwqflku. 'I0'Dcdwuj nlp. 'X0'Xck kku. 'N0'Dgti 2. 'Vgtcj gtv "r wng'i gpgtcvkp"d { "y q/eqr"t'ruugt'kgr u'y kj " ektewr"r qnctk cvkq. 'P gy 'L0'Rj { u'0P gy 'Lqwtpcn'qh'Rj { uleu044032525: 03202: : B589/4852 kdd: 850"4242+ "  
j5\_ "F 0L0E'qnm'cpf "T00 0J qej utcuugt. 'b'k'v'pug'vgtcj gtv "r wngu'd { "hw/y cxg'f gvev'k'cvk'kp'ck. '0'Qr v'Ngw047. "343263434"4222+0 "  
j6\_ "G0I ck wnuu. 'F 0'Rgpv'ctu. 'V0'Ghj ko kqr qwqu. 'cpf "X0'Xckckku. 'Rtdkpi "grgestqple"eqj g'tpegu'd { "eqo dlpgf "y q' /cpf "qp'g/r j qwp'gzekcvk'kp" cxqo le'xcr qtu. 'Qr v'Ngw05: . "346"4235-0"

**PHNWGP EG'QH J 'QP'UY GNNKI 'RTQRGT VKGUQH'CNi K CVG'  
J [ FTQI GN'CU' RQVGP VKCN'O CVGT KCN'HQT'FTW 'FGNKGT[ "  
U UVGO "**

O ci f crgpc'DO' cdqy unc<sup>3</sup>. 'Kcdgrc'O lej crnt. 'Lgt| { 'F gv| pc<sup>3</sup>'

<sup>3</sup>F gr ctwo gpv'qh'O gej cpleu.'O cvgtkcn'cpf 'Dkqo gf lecn'Gpi kpggtkpi . 'Hewm' 'qh'O gej cplecn'Gpi kpggtkpi . Y tqe'€y " Wpkxgtuk' 'qh'Uelgpeg'cpf 'Vgej pqm| { . 'Y tqe'€y . 'Rqmpf "

<sup>4</sup>F gr ctwo gpv'qh'CF xcpegf 'O cvgtkcn'Vgej pqm| kgu. 'Hewm' 'qh'Ej go kut { . 'Y tqe'€y 'Wpkxgtuk' 'qh'Uelgpeg'cpf " Vgej pqm| { . 'Y tqe'€y . 'Rqmpf " "  
o ci f crgpc'rdqy uncB r y t'qf w' n'

"

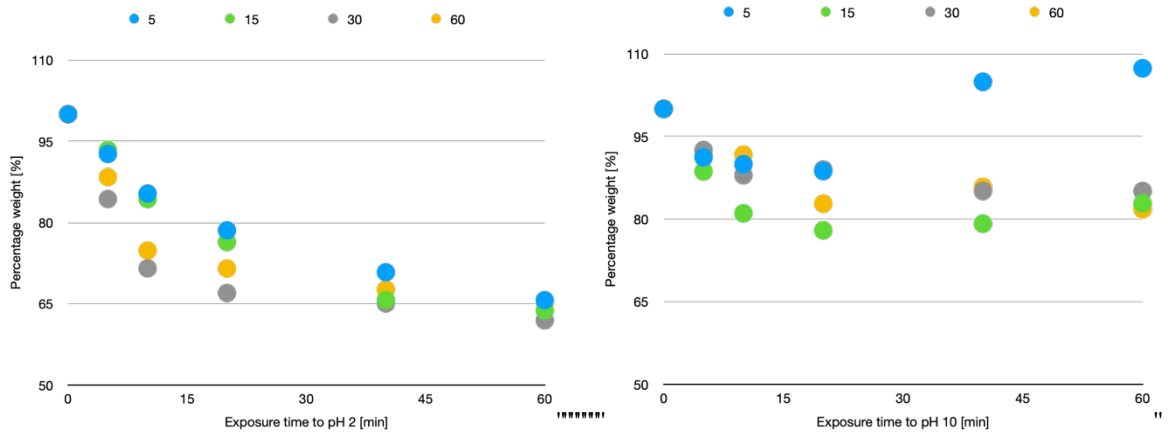
Cni kpcvg'ku'c"pcwctm' " qeewttkpi " r qn'uceej ctk'g" qdvclopf " Htqo " egn'y cmu' qh' dtqy p' ugcy ggf uO' K' eqpuku' qh' tgr gcvpi " /F/o cppwtqple'cefk " \*O +cpf " /N/i wmtqple'cefk " \*I +t'guk' wgu'rkpnf " cu'j qo qr qn' o gtle'dm'em'qt'tcpf qo n'O K'ku'cdng'vq'htqo " j { f tqi gn'lp' 'y g'r t'gugpeg'qh'y cvgtO'K'p' t'gur qpug'vq' f kxcrgpv'ecv'qpu' \*g'f 0'Ec<sup>4</sup> . 'Dc<sup>4</sup> . 'Hg<sup>4</sup> . 'O i<sup>4</sup> " cpf " Cn' +cni kpcvg'etquu'rkpmO'Vj g'co qwpv'qh'y g'ug'ecv'qpu'f gvgtO' kpu'v'j g'o gej cplecn'r tqr gt'vku'cpf " y' g'o czko wo " y cvgt " cduqtr v'kq'ecr cekl " j3\_0'

Cni kpcvg'j { f tqi gn'ku'q'hwg'wug'f "lp'v'j g'dkqo gf lecn'kgrf . 'f wg'vq'ku'dkqni lecn'ce'v'x'k'f . 'dkqeo r cvd'k'k'f 'y kj "vkuu'gu. " dkqf gi tcf cdk'k'f " cpf " r'em'q'h'v'z'k'k'f {O'Vj g'ghq'g. "y' ku'v' r g'q'h'j { f tqi gn'ku'gz'eg'ng'p'v'ht' " cr r r'ecv'qpu'lp'v'kuu'g'gpi kpggtkpi . " y qwpf " t'g'co gpv' cpf " t'gi g'p'g'c'v'x'g' " o gf k'k'p'g' j4\_0' Hw'v'j gto qt'g. " y' ku' u'q'h'v' o cvgtkcn' r quugu'gu' v'j g' cdk'k'f " vq' " wpf gti q' j { f tqi gn'ku'f gr g'p'f kpi " qp' r J . " v'ko g'cpf " v'go r g'c'w'g'0'Vj g'uy g'ni'kpi " r tqr gt'v' " q'h'j { f tqi gn'c'p'f " quo q'v'k' r t'guu'g'g' i t'cf k'p'v'c't'g' ko r q't'c'p'v'f'c'v'q't'u'f' v'k'p' i " y' g'f' g'uk' p' q'h'f' t'w' i " f' g'rx'g't { " u' { u'go u' " F'F' Uu' +h'q' " v'j g'eq'p't'q'm'g'f " t'g'rc'g'ug' q'h'c'p' " c'v'x'g' " u'w'd'c'p'eg'0' Vj g'ug'f' gvgtO' k'p'c'p'u'f' k'g'ev' " l'p'h'w'g'peg'v'j g'f' k'h'm'uk'q'p' q'h'f' t'w' i u'ht'qo " y' g'f' gn'v'q'v'j g'v'w't'q'w'p'f kpi " g'p'x'k'q'p'o gpv' j5\_6\_0'

C'f' t'w' i " e'c't't'k'g't " c'f' o k'p'k'v'g't'f " q't'c'm' { " y' q'w'f " g'p'eq'w'p'v'g't " x'c't'k'q'u' " g'p'x'k'q'p'o gpw'f' v'k'p' i " ku' " v'c'p'uk' " k'p'em'f kpi " u'q'o c'ej . " y' j' k'ej " j' cu' " c'ek'f' k' " e'q'p'f' k'k'q'u' " r' J " c'd'q'w' " 3/4-0' O' qu' " q'h'v'j g' " u'w'd'c'p'eg'ug' " c't'g'f' k' i' g'ug'f " c'v'v'j' ku' " r'g'x'g'n'O' J' q'y' g'x'g't . " k'h'v'j g'f' t'w' i " f' g'rx'g't { " u' { u'go " ku'f' g'uk'f' " v'q' " d' { r' cu' " v'j g' " u'q'o c'ej " c'p'f " f' g'rx'g't " v'j g'f' t'w' i " k'p'v'q'v'j g' " u'o c'n'k'p'v'g'uk'p'g . " y' j' g't'g'v'j g' " g'p'x'k'q'p'o gpv'ku' " c'm'k'k'p'g . " c'ni k'p'c'v'g' " ku'v'j g' " d'g'u'v'o cvgtkcn'ht' " v'j' ku' " cr r' r'ecv'q'p'O' c'ni k'p'c'v'g' " k'p'v'j g' " c'ek'f' k' " g'p'x'k'q'p'o gpv'f' q'g'u'p'q'v'uy g'n'O'Vj g'ghq'g . " v'q' " g'x'c'w'c'v'g' " v'j g' " g'h'g'ev' " q'h'f' k'h'g't'gp'v'o gf k' " \*c's' w'g'q'u' " u'q'n'w'k'q'p' " y' k'j " j { f' t'q'ej' n'q'le' " c'ek'f' " c'v'v'j' J' " 4' " c'p'f " c's' w'g'q'u' " u'q'n'w'k'q'p' " y' k'j " u'q'f' k'wo " j { f' t'q'z'k'f' g' " c'v'v'j' J' " 32+ " q'p' " v'j g' " u'y' g'm'c'd'k'k'f' " q'h'c'ni k'p'c'v'g' " j { f' t'q' i' g'ri'c' " e'q'o r' c't'c'v'x'g' " u'w'f' { " y' cu' " e'c't't'k'g't'f' " q'w' " j5\_6\_0'

Cni kpcvg'j { f tqi gn' \*cni kpcvg. " Uki o c/C'f' t'lej . " Ucl'p'v' N'q'w'u' " WUC-+ " y' cu' r tgr c't'g'f " d { " etquu' r'k'p'k'p' i " y' k'j " e'c're'k'wo " e'j' n'q'k'f' g' " \*E'c'En . " C'x'c'p'v'q't' " R'g'h'q'to c'p'eg' " O' cvgtkcn' " R'q'c'p'f " UC0' " I' r'ky' k'eg . " R'q'c'p'f " +c'v' " e'q'p'eg'p't'c'v'q'p'u' " q'h' " 2'0'0 . " 2'0'0 " c'p'f " 3'0 . " c'v'f' k'h'g't'gp'v'k'o gu' \*7' " o' k'p . " 3'7' " o' k'p . " 5'2' " o' k'p " c'p'f " 8'2' " o' k'p " 0'Vj g' " u'co r' n'g'u' " y' g't'g' " lo o' g't'ug'f' " k'p'f' k'h'g't'gp'v' " u'q'n'w'k'q'p'u' " r' J' " 4' " c'p'f " r' J' " 32+ " c'v' " 43.9 " E " c'p'f " v'j' g't' " y' g'k'j " v'y' cu' " c'p'c'n' | gf " c'h'g't' " c' " u' r' g'ek'h'e' " v'ko g' " \*cu' " u'j' q'y' p' " k'p' " H'k' i' w't'g' " 3+0' "

"



Hki 030E'q'tt'g'r'v'k'q'p' q'h'y' g'k'j' v'ej' c'p'i' gu' q'h'4' " c'ni k'p'c'v'g' " j { f' t'q' i' g'ri'et'quu' r'k'p'ng'f' " c'v'f' k'h'g't'gp'v'k'o g'd { 'E'c'En " \*2'0'0 " e'q'p'eg'p't'c'v'q'p' +k'p' t'g'r'v'k'q'p' " v'q' u'q'n'k'p' i " v'ko g'k'p' r' J' " 4' " r'gh' +c'p'f' " r' J' " 3'2' " o' g'f' k' " \*k' i' j' v'0'

Vj g'c'k'o " q'h'v'j g'r' t'g'ug'p'v'j q't'm'ku'v'q' " e'q'o r' c't'g' " c'p'f " u'g'rg'ev'v'j g' " cr r' t'qr' t'k'c'v'g' " e'q'p'eg'p't'c'v'q'p' " q'h' " e't'quu' r'k'p'k'p' i " c'i' g'p'v' " h'q't' " c'ni k'p'c'v'g' " cu' " c' " h'w'w't'g'f' t'w' i " e'c't't'k'g't " o' cvgtkcn'0'Vj g' " u'g'rg'ev'k'q'p' " q'h'v'j g'ug' " r' c't'c'o g'v'g'tu' " e'q'p'eg'p't'c'v'q'p' " q'h' " e't'quu' r'k'p'ng't' " c'p'f " f' w't'c'v'k'q'p' " q'h' " e't'quu' r'k'p'k'p' i " +k' " lo r' q't'c'p'v'v'q' " q'r' v'ko k' g' " v'j g' " c'v'x'g' " u'w'd'c'p'eg' " t'g'rc'g'ug' " c'v'c' " u'r' g'ek'h'e' " n'q'ec'v'k'q'p' " k'p' " v'j g' " i' c'v't'k'p'v'g'uk'p'c'n' " v'c'ev'0' " E'q'p'f' v'ev'g'f' " t'g'ug'c't'ej " g'p'c'd'rg'u' " v'q' " f' g'v'g'to k'p'g' " v'j g' " g'h'g'ev' " q'h' " v'j g' " e't'quu' r'k'p'k'p' i " " h'c'ev't' " q'p' " u'y' g'ni'k'p' i " r' t'qr' g't'v'ku' " q'h' " c'ni k'p'c'v'g' " j { f' t'q' i' g'n'lp' " f' k'h'g't'gp'v' r' J' " q'h'o' g'f' k'c . " v'j g't'g'd { " k'v'j' q'w'f' " d'g' " d'g'p'g'h'e'k'c'n'k'p' " q't'c'n' F'F' U'f' g'uk' p' " h'q't' " e'q'p't'q'm'g'f' " f' t'w' i " t'g'rc'g'ug'0'

j3\_M0j\_0Ngg.'F 0L0O qppg{ . 'C'ni k'p'c'v'g' " R't'qr' g't'v'ku' " c'p'f " d'k'q'o gf lecn'c'r r' r'ecv'q'p'u'0'Rt'q' i' t'guu'lp' " R'q'c'p'f " o' g't' " U'el'g'peg' " 59\*3+328/348 . " 42340 " j4\_ " C'0'M'c'e' | o' c't'g'n' " R'cy' g'n'unc . 'C'ni k'p'c'v'g' / d'c'ug'f' " j { f' t'q' i' g'n'lp' " t'g'i' g'p'g't'c'v'x'g' " o' g'f' k'k'p'g . " k'p' " d'q'q'm' " C'ni k'p'c'v'g' / " T'g'eg'p'v' " W'ug'u' " q'h' " v'j' k'p' " P'w'c'n' " R'q'c'p'f " o' g't . " g'f' < " N'0' " R'et'g'k'c . " k'p'v'g'ej " Q'r' g'p' . " 423 ; 0' " j5\_ " L' / E'j' w'c'p'i . " j / " j' w'c'p'i . " U' / j' " N'q . " g'v'c'n'0' " G'h'g'ew' " q'h' r' J' " q'p' " v'j g' " u'j' c'r' g' " q'h'c'ni k'p'c'v'g' " r' c't'v'k'ng'u' " c'p'f " ku' " t'g'rc'g'ug' " d'g'j' c'x'k'q't'0' " k'p'v'g't'c'v'k'q'p'c'n' " l'q'w'p'c'n' " q'h' " R'q'c'p'f " o' g't " U'el'g'peg' " 4239\*3+3 ; . " k'f' " 5 ; 24926 . " 42390 " j6\_ " j' O'j' O'v'ap'p'g'ug' . " L'0'M'c't'm'g'p . 'C'ni k'p'c'v'g' " k'p' " f' t'w' i " f' g'rx'g't { " u' { u'go u'0'f' t'w' i " f' g'x'g'n'r' o' gpv'c'p'f " k'p'f' w'w't'k'n' " R'j' c't'o' c'e' { . " 4 : \*8+843/852 . " 42240' "

**CP VHWPI CN'CEVKKV[ 'QH'HNWEQPC\ QNG'KPEQTRQTCVGF 'KP VQ"  
J [ FTQI GNU'O QF KHKGF 'Y KJ 'PCPQJ [ FTQZ[ CRCVKV'G"**

Lxuv[pc" Tgy cm/Uqtqel {punc<sup>3</sup>. "Rcwkp"Udqkgtclum<sup>3</sup>. "TchenLO'Y ki mu<sup>3</sup>"

" <sup>3</sup>Kpukwng'qh'Nqy "Vgo r gtcwtg'cpf "Utwewtg" Tgugctej . "Rqikuj "Ceef go { "qh'Uelgpegu. "Qnuprc"4. "72/644"Y tqermy . " Rqrpf "

lQgy cnB kpxdu0 n'

"

Hwpi cni'kphgcvkpu. "Htgs wgpw[ "ecwugf "d { "qr r qtwpknle" r cyj qi gpu. "ctg" ugtkqwu" o gf lecn' r tqdrgo . "gur gekm[ "co qpi " ko o wpeqo r tqo kugf "r cwkpwu'Vj gug'chhvevkupecp" dg "f kxk gf "f gr gpf kpi "qp" yj g" uksg" qh' qeewt gpeg" j gpeg" uwr gthlekn" ewcpggwu. "uawdewcpggwu" cpf "u[ uvgu ke" o { equgu" ecp" dg "f khtgpkvcvgf " ]3\_0Ej tqple" y qwpf u" ctg" j ki j n[ "r tqpg" vq" hwpi cni' kphgcvkpu" cpf "yj g" j ki j guv' r tgcxngpeg" ku' tgr qtvgf " hqt "Ecpf kf c" ur gekgu" \*E0cndkcpu. "E0i ndtcv. "E0tqrkecrk" ]4\_0"

Hweqpc[ qrg' yj g' o dg dt "qh' c[ qrg' i tqwr "ku' apg' qh' yj g' o quv' Htgs wgpw[ "ej qugp" f twi "hqt" hwpi cni' kphgcvkpu" tgcvo gpw' Ku" cevksk[ "ku' dcugf" qp" yj g' kpi kdkkqp" qh' gti quvgt qndkqu[ pyj guku' yj lej "ecwugu" ko r ckt o gpw' kp" hwpi cni' r cuo c' o go dtcpgu" ]5\_0"

Vj g' kf gc" qh' wukpi " j { f tqi gn' hqcf gf " y kj " f twi u' y cu' tgr qtvgf " r tgcxkwun[ " ]6\_0J qy gxgt" j { f tqz { cr cvkg" cu' c' hkngt" cpf " f twi " ectlgt" ku' c' pgy " cr r tqcej " r tqr qugf " d { " qw" vgo 0J { f tqi gn' ecp" r tqxk gf " i tcf wcnf twi " tgrcug" vq ctf u' yj g' kphgcvkpu" uksg" cpf " gpj cpeg" y qwpf " j gcrkpi " d { " o qkuwtg" tgcxkpi 0' O qtgxgt. " j { f tqz { cr cvkg" \*Ec \*RQ + \*QJ + \*J Cr ++ pcwcm[ " qeewu" kp" j wo cp' dqf { " cu' c' eqo r qpgpv' qh' vggj " cpf " dqpg" kuwgu" ku' j ki j n[ " dkqcevksg" cpf " dkqeqo r cvkrg' 0' Ku' cnuq" npqy " p" hqt " ku' tgi gpgtcvksg" r tqr gtvku' cpf " y qwpf " j gcrkpi " ceegrtcvkpu" ]7\_0"

Vj g' cpw' hwpi cni' cevksk[ " qh' r wtg' hweqpc[ qrg' y cu' cuugugf " wukpi " E0cndkcpu. " E0i ndtcv. " E0tqrkecrk. " Et { r vqeqeewi" ppglqto cpu. " Et { r vqeqeewi" i cwk" Tj qf qwtw" o wckv i kpguc" cpf " Tj qf qwtw" t wdt c' t' ghtgpeg" cpf " erikplecni' kuqrvgu' Vj g' dkqhkro " r tqf wvkuq" cdllk[ " et { ucni' xkrgv' uvcxkpi + qh' yj gug' utckpu" y cu' vuguf " cv' 4: " cpf " 59° E " vq' ugrge' vj g' o quv' cr r tqr tkcvg" eqpf kkpau' hqt " hwt' vj gt' g' zr gtko gpw' 0J { f tqz { cr cvkg' y cu' u[ pyj guk' gf " d { " yj g' r tgekr kcvkpu" o gvj qf " cpf " j gcv' tgcvgf " cv' 672° E" hqt " 5" j qwu' 0J { f tqi gn' \*8/ cpj { f tq/ / N/ i cmev/ ô F/ i cmevcp + y gtr' r tgr ctgf " kp" hqt " f khtg' gpv' hqto u' r wtg' j { f tqi gn' j { f tqi gn' hknf " y kj " J Cr. " j { f tqi gn' hknf " y kj " hweqpc[ qrg" cpf " j { f tqi gn' hknf " y kj " dqy " J Cr " cpf " hweqpc[ qrg' 0' Cni' o cvgtkcm' y gtg' h' q' r j kxk gf " cpf " r j { ukeqej go lecn' lej ctcevtgk' cvkpu" y cu' r gthqto gf " vq' cuuguu' yj gk' r tqr gtvku' Vj g' uco r ngu' y gtg' ew' kp' q' gxgp" r kgegu' cpf " kpewdcvgf " y kj " hwpi cni' ewnwgu' vq' gxcncvsg" j qy " yj g' { " kphwpeg" yj g' i tqy yj " cpf " dkqhkro " hqto cvkpu" \*eqphqecni' rugt" o letqueqr { " y kj " NKXGIF GCF " uvcxkpi + qh' ugrgevgf " utckpu" 0"

Hweqpc[ qrg' hqcf gf " o cvgtkcm' cm quv' eqo r rgnv[ " kpi kdkgf " hwpi cni' i tqy yj " qh' cm' vuguf " utckpu. " j qy gxgt " kxkpi " egmu" y gtg' ur qwgf " qp" yj g' uwt' hceg" qh' cm' vuguf " o cvgtkcm' 0' K' ecp" cnuq" dg " uggp" yj cv' hweqpc[ qrg' cf f kxkg" ej cpi gf " yj g' dkqhkro " o qtr j qni { " kpetgcukpi " yj g' egmi' ci i tgi cvkpu" cpf " enwugtu' hqto cvkpu" y j kuw' pcpqj { f tqz { cr cvkg' tgcxgtugf " yj cv' ghge' 0' Vj g' cv' qdugt' cvkpu" uwi i guv' yj g' r qv' p' kcn' cpv' kdkqhkro " cevksk[ " qh' J Cr " yj lej " r tqgevgf " hqto " hwn[ " i tqy p' dkqhkro " hqto cvkpu" cpf " uwi i guv' ku' d' gpg' hlecn' ghge' v' cu' f twi / hknf " j { f tqi gn' cf f kxkg' 0"

"

Hkpcpekn' uwr r qtv' qh' yj g' P cvkpcni' Uelgpeg" Egpwtg" kp" yj g' eqwtug" qh' tgcik' cvkpu" qh' yj g' Rtlqgeu' o' Gredqtcvkuq" cpf " ej ctcevtk' k' u' qh' dkqeqo r quksu' y kj " cpv' xk' wgpv' cpf " cpv' dcevtk' ni' r tqr gtvku' ci ckpu" Rugwf go qpcu' c' gtwi kpguc" \*pq0' WO Q/423843 IDIP \ 8123379+ " cpf " o' Rtgr ctcvkpu" cpf " ej ctcevtk' cvkpu" qh' dkqeqo r quksu' dcugf " qp" pcpqcr cvkpu" hqt " yj g' t' cpqu' u' o' \*pq0' WO Q/4237B; IDIUV7123552+0"

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[3\_ "Mqj cxcfg. " T00# Mwc. " O0 0# Xcnpf. " C0 0# Rcpj cnk " O0 0' Ecpf kf c " vqrkecrk " Ku' r tgcxngpeg. " r cyj qi gpkel[ " cpf " kpetgcukpi " t' gukncpeg" vq" hweqpc/ qrg' 0' 00 gf 00 letqdkr04232. " 7; . : 956: . 2. " Fqk32082; ; llo o 0235449/20"

[4\_ "Fqy f. " U00# F gnqj " J cpuqp. " 10# Tgg. " G0# Y qreqw. " T0F 0# kiej cw " C00 0# Uwp. " 1 0# Y j kg. " 10# Uo kj . " F0 0# Mppgf . " 10# Lqpgu. " E0G0Uw' xgf " qh' hwpi k' cpf " f' gcw' kp' r qf o letqdkr' kphgcvkpu' kp' ej tqple" y qwpf u' 0' 10' Y qwpf " Ectg " 4233. " 42. " 62669. " Fqk32084; 8: lly e0423304208620"

[5\_ " 0 qtu' j @ugt. " 10' vj gf gxgr o gpv' qh' hweqpc/ qrg' t' gukncpeg' kp' Ecpf kf c' ndkcpu' o' ep' g' zco r rg' qh' o letqdkr' wkp' qh' c' hwpi cni' cyj qi gp' 0' 00 letqdkr' 0' 4238. " 76. " 3; 46423. " Fqk3208229 h34497/238/784: /60"

[6\_ " J co gf k' J 0# O qtc' k' U0# J wf uqp. " U0 0# Vqpgnk " C0G0Ej kqucp' dcugf " j { f tqi gn' cpf " yj gk' cr r nekcvkpu' hqt " f twi " f gixkgt { " kp" y qwpf " f t' gukpi u' c' t' g' xkgy 0' Ectdaj { f t' 0' Rqf o 0423: . " 3; ; . " 6676682. " Fqk3208238 llo' c' tdr qn' 0423: 0808360"

[7\_ " Dtwi i ku' gt. " T0Dcevtk' ni' cpf " hwpi cni' duqtr' vkuq' r tqr gtvku' qh' c' j { f tqi gn' f' t' gukpi " y kj " c' uwr g' t' duqtr' dgpv' r qf o gt " eqt g' 0' 10' Y qwpf " Ectg " 4227. " 36. " 65: 6664. " Fqk32084; 8: lly e042270860 048: 5; 0"

**O QF WNCVKQP 'UKTV/3'CEVKKV[ 'KP'KO O WPG'E'GNNU'WPF GT''  
QZKF CVKKG'UVTGUU<E'GNN'F GCVJ 'CPF 'UWTXKCN''**

Xcuf n'Xgnf mf k<sup>2</sup>. 'O ctkc'Uwr ej wnt. 'Vcv{ cpc'Xq| pgugpunc { c<sup>4</sup>'

<sup>3</sup>F gr ctvo gpv'qh'K6 o wpqmi { . 'Vctcu'Uj gxej gpmq'P cvkqpcn'Wpkxgtukv' 'qh'M'lx. 'Wntckpg'  
<sup>4</sup>F gr ctvo gpv'qh'K6 o wpqr j { ukqmi { . 'Dqi qo qrv' 'Kpukwv'qh'Rj { ukqmi { 'qh'P CUW. 'Wntckpg'  
xcuf mxgnf mf lanpwuj B qwrqnteqo .''

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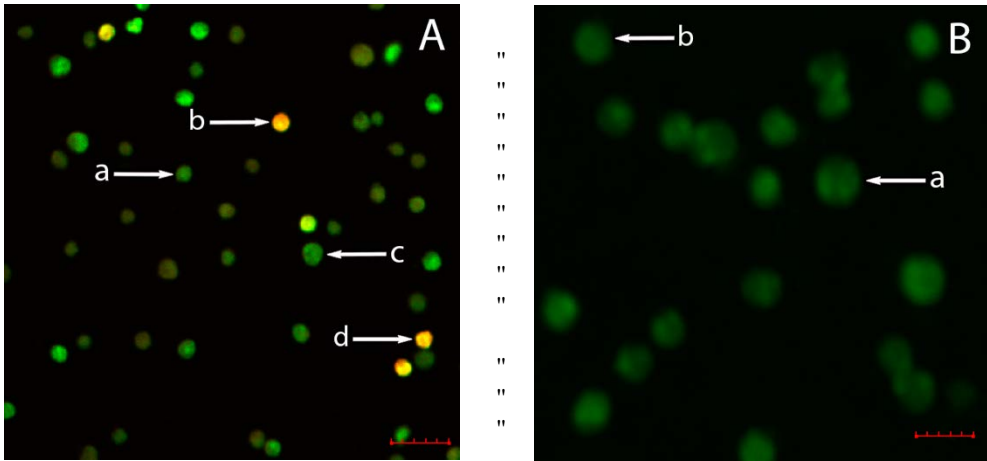
P wergt'Ukwlp/3'qt'UKTV/3'ku'c'o go dgt'qh'y' g'ho kf 'qh'P CF - 'f gr gpf gpv'r tqvlp'f gcegv' rug0'Rt gxlqwu'uwf lgu'  
j cxg'uj qy gf 'y' cv'UKTV/3'ku'lxqkxgf 'kp'r tqeguugu'tgrv' 'v' r tqi tco gf 'egmf' gcv' 'o' gej cpluo u. 'egm'ci kpi . 'kv'cuq'ecp'  
cevkxcv'wo qt' uwr' r tguqt' i' gpgu. 'o' cklv'cp' gpgti { 'o' gcvdqle'j go quvcuku. 'cpf' 'ecp' 'tgxgtug' 'kppcv' 'cpf' 'cf' 'cr' 'v' 'xg' 'ko' 'o' 'wpg'  
vqrgtcepg" ]3.4\_0' Ncu' t'gugtej' gu' r' q'lp'v'f' " qw' r' g'ur' ge'v'x'gu' v' UKTV/3'kp' cr' r' n'ec'v'q'p' v' v' gcv' r' t'q'p' / o' g'f' k'v'f'  
pgwtqf' gi' gpgt'cv'k'p. 'ecpegt. 'qd'gukv' / cuuqekv'f' 'o' g'v'cd'q'le'f' get'g'c'ug. 'ect'f' k'ce'ci' kpi 'cpf' 'ut'gu' ]5\_0'0' q't'g'x'g't. 'kv' r' m' { u' t'q'rg'  
kp' 'egm'w'c' t' u'g'p'g'ue'p'eg. 'k'p' h'c'o' o' c'v'q't' { 'u'ki' p'c'r'k'p' i' 'kp' t'g'ur' q'p'ug' v' " g'p'x'k'q'p'o' g'p'v'c'n' ut'guu. 'f' g'x'g'r'q' o' g'p'v' 'c'p'f' " r' n'ec'g'p'v'c'n' 'egm'  
uwtxkcn' ]5\_0'

Vj ku'tgugtej' 'clo' gf' 'v' 'q' 'l'p'x'g'u'ki' c'v'g' v' j' g' t'q'rg' qh'UKTV/3'kp' v' j' g' o' q'f' w'v'v'k'p' qh'lo' o' w'p'g' 'egm'f' g'c'v' j' 'c'p'f' 'uwtxkcn' 0'Y' g'  
gzco' k'p'g'f' 'd'k'q'mi' k'ec'n' g'h'g'ew' q'p' 'D' / 'c'p'f' 'V' 'egm'f' g'c'v' j' 'v' r' g' 'c'p'f' 'c'w'q'r' j' c' i' { 'c'h'g't' 'c'ev'k'c'v'k'p' q't' 'l'p'j' k'k'k'q'p' qh'UKTV/3'kp' x'k't'q'  
w'p'f' g't' 'q'z'k'f' c'v'k'g' u't'guu'0'

Hqt'gzco' k'p'c'v'k'p' g'h'g'ew' q'p' 'egm'f' g'c'v' j' 'c'p'f' 'uwtxkcn' y' g' l'q'v'v'g'f' 'ko' o' w'p'g' 'egm'f' t'q'o' 'y' g' v' j' { o' w' u' 'c'p'f' 'k'p' i' w'p'c'r'n' { o' r' j' }  
p'q'f' g'u' qh' 'C'n'l'k'p'q' r'k'p'g' o' l'eg. 'c'f' w'v' h'g'o' c'rg'u' y' g' l'j' v' 3: / 42' i' 0' D' / 'c'p'f' 'V' 'egm'f' 'ew'v'k'c'v'g'f' y' k'j' "42" μO' t'g'x'g't'c't'q'n' i' 'ur' g'ek'h'e'  
cevkxcv' qh'UKTV/3'qt' 7' b' O' p'le'q'v'k'p'c'o' k'f' g' w'p'ur' g'ek'h'e' l'p'j' k'k'k'q'p' qh'UKTV/3'kp' TRO' Ko' g'f' k'c' y' k'j' "322" μO' J' 4' Q'4' "q'z'k'f' c'v'k'g'  
u't'guu' h'c'v'q't' + f' w' l'p' i' "3" j' q'w' 'c'v' 49' A' E' l'p' v' j' g' p'c'w't'c'r'i'c'v'o' q'ur' j' g't'g'0' H'q't' f' g'v'g'v'k'p' qh' h'x'g. 'p'g'et'q'v'e' 'c'p'f' "c'r' q'r' v'q'v'e' 'egm'f' y' g't'g' w'ug'f' "c' 'e'q'o' d'k'p'c'v'k'p' qh'  
j' q'w' 'c'v' 49' A' E' l'p' c' p'c'w't'c'r'i'c'v'o' q'ur' j' g't'g'0' H'q't' f' g'v'g'v'k'p' qh' h'x'g. 'p'g'et'q'v'e' 'c'p'f' "c'r' q'r' v'q'v'e' 'egm'f' y' g't'g' w'ug'f' "c' 'e'q'o' d'k'p'c'v'k'p' qh'  
R't'q'r' k'f' k'w'o' "k'q'f' k'f' g' 'c'p'f' "J' Q'G'E'J' U'V'f' { g'u' u'q'n'w'k'p' } 'c'p'f' "h'w'q't'g'ue'g'p'v' o' l'et'q'ue'q'r' { "k'o' c'i' k'p'i' " \*H'i' 0'30' " r' l'e'0' H'q't' f' g'v'g'v'k'p'  
c'w'q'r' j' c' i' { \*H'i' 0'30' r' l'e'0' +, y' g' w'ug'f' 'O' q'p'q'f' c'p'u' n'ec'f' c'x'g't'k'p'g'f' { g' u'q'n'w'k'p' } 'c'p'f' "h'w'q't'g'ue'g'p'v' o' l'et'q'ue'q'r' { "k'o' c'i' k'p'i' 0'  
"

"

""



H'i' 0'30' r' l'e'0' k'w'g't'g'0' 'e'q'p'h'q'ec'n'lo' c'i' k'p'i' 'q'h'V' 'egm'f' R't'q'r' k'f' k'w'o' 'k'q'f' k'f' g' 'c'p'f' "J' Q'G'E'J' U'V'f' { g'u' 'e'q'o' d'k'p'c'v'k'p. 'u'ec'rg'd'c't' "? 42" μO' 0'  
c'0' i'k'x'k'p'i' 'egm'f' d'0' p'g'et'q'v'e' 'egm'f' o' c'r' q'r' v'q'v'e' 'egm'f' "0' p'g'et'q'r' v'q'v'e' 'egm'f' D' r' l'e'w't'g'0' 'e'q'p'h'q'ec'n'lo' c'i' k'p'i' 'q'h'V' 'egm'f' .  
O' q'p'q'f' c'p'u' n'ec'f' c'x'g't'k'p'g'f' { g' u'ec'rg'd'c't' "? 32" μO' 0'c'0' v' 'egm'f' k'j' 'c'w'q'r' j' c' i' { . d'0' v' 'egm'f' k'j' q'w'c'w'q'r' j' c' i' { 0'  
"

"

Y' g' v' j' q' y' g'f' "k'p' q'w' t'g'ugtej' 'y' c'v' UKTV/3' cevkxcv'k'p' d' { t'g'x'g't'c't'q'n' r'g'c'f' u' v' q' k'p'et'g'c'ul'p'i' "k'o' o' w'p'g' 'egm'f' t'g'uk'v'c'p'eg' v' q'  
q'z'k'f' c'v'k'g' u't'guu' c'p'f' r' t'q'o' q'v'g'u' c'w'q'r' j' c' i' { 0' H'q't' D' / 'egm'f' u't'x'k'c'n'c'v'g' 32.5' } 'k'p'et'g'c'ug' c'p'f' 'h'q't' V' / 'egm'f' 35.3' } 'k'p'et'g'c'ug' 0' k'p' v' j' g'ug'  
i' t'q'w' u'c'm'q' y' c'u' q'd'ug't'x'g'f' 'k'p'et'g'c'ug' q'h'c'w'q'r' j' c' i' { 'h'q't' D' / 'egm'f' v' r' v'q' : .4' } 'c'p'f' "V' / 'egm'f' v' r' v'q' ; ' O'P' g'et'q'u'k'u' t'c'v'g' k'u'f' g'et'g'c'ug'f' 'h'q't'  
D' / 'egm'f' c'p'f' 'h'q't' V' / 'egm'f' v' r' v'q' 36.4' } 'c'p'f' "33.7' } 'k'p' c'ee'q't'f' c'p'eg'0' C'r' q'r' v'q'u'k'u' t'c'v'g' u' j' c'x'g' c' u' g'p'f' "v' q' k'p'et'g'c'ug' "h'q't' D' / 'c'p'f' "V' / 'egm'f' 0'  
k'p'j' k'k'k'q'p' qh'UKTV/3' d' { 'p'le'q'v'k'p'c'o' k'f' g' r'g'c'f' u' v' q' i' g'u' u't'x'k'c'n'c'v'g' q'h'lo' o' w'p'g' 'egm'f' c'p'f' r' t'q'o' q'v'g'u' k'p'et'g'c'ul'p'i' 'q'h'c'r' q'r' v'q'u'k'u'0'  
H'q't' D' / 'egm'f' u't'x'k'c'n'c'v'g'f' g'et'g'c'ug'f' v' r' v'q' 7.4' } 'c'p'f' 'h'q't' V' / 'egm'f' g'et'g'c'ug'f' v' r' v'q' 8. : ' O' C'r' q'r' v'q'u'k'u' t'c'v'g' k'u' k'p'et'g'c'ug'f' 'h'q't' D' / 'egm'f'  
c'p'f' 'h'q't' V' / 'egm'f' v' r' v'q' 5.5' } 'c'p'f' "6. : : ' k'p' c'ee'q't'f' c'p'eg'0'P' g'et'q'u'k'u' t'c'v'g' h'q't' D' / 'egm'f' k'p'et'g'c'ug'f' v' r' v'q' 5.7' } O' C'n'q' k'p' v' j' k'u' i' t'q'w' f' g'et'g'c'ug'  
c'w'q'r' j' c' i' { 't'c'v'g' h'q't' D' / 'egm'f' v' r' v'q' 5.9' } 'c'p'f' "V' / 'egm'f' v' r' v'q' 8.4' } O'Y' g' w'ug'f' "U'w'f' g'p'v'v'v' v' g'v'v'v' h'q't' u'w'c'v'k'c'c'v'k'p' c'p'f' u'k'u' . r' > 2.270"

E'q'p'ew'k'p' < UKTV/3' cevkxcv'k'p' k'p'et'g'c'ug' 'egm'f' g'uk'v'c'p'eg' v' q'z'k'f' c'v'k'g' u't'guu' k'p' lo' o' w'p'g' 'egm'f' W'uk'p'i' t'g'ug't'c't'q'n' r'g'c'f' u' v' q' i'  
k'p'et'g'c'ul'p'i' "k'o' o' w'p'g' 'egm'f' u't'x'k'c'n'c'p'f' 't'c'v'g' q'h'c'w'q'r' j' c' i' { . c'v'j' g' u'c'o' g' l'k'o' g' l'k'f' t'x'g'u' v' q' f' g'et'g'c'ul'p'i' "p'g'et'q'u'k'u' t'c'v'g' 0' k'p'j' k'k'k'q'p'  
q'h'UKTV/3' d' { 'p'le'q'v'k'p'c'o' k'f' g' r'g'c'f' u' v' q' i' g'u' u't'x'k'c'n'c'v'g' q'h'lo' o' w'p'g' 'egm'f' c'p'f' r' t'q'o' q'v'g'u' k'p'et'g'c'ul'p'i' "q'h'c'r' q'r' v'q'u'k'u' c'p'f'  
f' g'et'g'c'ul'p'i' 'q'h'c'w'q'r' j' c' i' { 0' ""

"

[3\_ C'0'P'0'0' c't'v'p. 'O'0' C'ng'z'c'p'f' g't' / O' k'ng't. 'D'0'M'0' ] q' l' c' . g'v'c'r'n' U't'w'lp'3' V'c't'i' g'v'k'p'i' 'T'g'x'g't'ug'u' k'p'p'c'v'g' c'p'f' 'C'f' c'r' v'x'g' k'o' o' w'p'g' v'q'rg't'c'p'eg' k'p' U'g'r' v'e' 'O' l'eg. "  
l'q'w't'p'c'r'n' q'h'K6 o' wpqmi { 'T'g'ugtej' .423: .35. \*423: 40'  
[4\_ 'O'0'F'0'0' q'm. 'I'0'F' g'u'k'g. 'I'0' C'n'c'w' g'v'c'r'n' J' g'r' c'v'q'eg'm'w'c't' 'G'z'r' t'g'u'k'p' q'h'UKTV/3' c'p'f' 'K'u' G'h'g'ev'q'p' J' g'r' c'v'q'eg'm'w'c't' 'E'c't'el'p'q'o' c' R't'q'i' t'g'u'k'p' < C' "  
H'w'w't'g' v'j' g't'c'r' g'w'k'e' R'g't'ur' g'ev'k'g'. 'K'p'g't'p'c'v'k'q'p'c'n'l'q'w't'p'c'r'n' q'h'J' g'r' c'v'q'mi { .4242: .32. \*4242: 40'  
[5\_ 'U'0' T'c'j' o' c'p. 'T'0'K'ur'co. 'O' c'o' o' c'r'k'p' U't'v'3' l'p'k'i' j' w'q'p' k'u' d'k'q'mi' k'ec'n' h'w'p'ev'k'p. 'E'g'm'f' e'q'o' o' w'p'le'c'v'k'p' c'p'f' 'U'k'i' p'c'r'k'p'i' ; . \*4233: 40'

**GXCNCVQKP 'QH'RQNNWGF 'UQKN/KP F WEGF 'QZKF CVKG'UVTGUU'**  
**WURPI 'VICIA FABA'EJ NQTQRJ [ NN'O QTRJ QUGU'CUC'O QF GN'**  
**U UVGO'''**

X 1 p "Rwngr{v<sup>3</sup>."Tclo qpf cu"<sup>T</sup>"kwm-vc<sup>3,4</sup>."Vclpc" upkgr<sup>3</sup>"

<sup>3</sup> Kpukwq'qh'Dkuekpgegu."Nkhg'Uekpgegu'Egptv.g."Xlpxk'Wpkkgtukf. "Ucwn vgnk' Cxg09."NV/32479'Xlpxk'w.'Nkj wcpk"

<sup>4</sup> DqvcplecniI ctf gp'qh'Xlpxk'Wpkkgtukf. 'Mclt pck'Ut065.'NV/3245; . 'Xlpxk'w.'Nkj wcpk0'  
xglwpg0' wngr{vB i o e0rwf 0x0n'

" Uqknt qmwkqp'ku'vzle'v'dqyj 'vj g'gpxktqpo gpv'cpf 'vq'vj g'gti cpkuo u'vj cvtkxg'kp'k0k'Gwtqr g'vj g'vqkiku'wuwcmf 'b quvf "  
 r qmwgf "d{ "j gcx{ "o gvcni"}J3\_0J gcx{ "o gvcni"kp"ny "eqpegpvcvkpu"ctg"guugpvcni'htq"rkklpi "qti cpkuo u."dw'gzegukxg"  
 co qwpv'qh'vj go 'ecp'dgego g'i gpqvzle'cpf 'ecwgf'co ci g'vq'vj gk'F P C"J4\_ 'vj wu'k'u'ko r qtvcpv'vq'uwf { "vj g'ghgev'j gcx{ "  
 o gvcni'j cxxg'qp'rkklpi 'qti cpkuo u0"

Kp' vj ku'y qtm' vj g'i gpqvzle' ghgev' qh' uqkl' kp" emugf "Xlpxk'u" ekf{ "r rcpw' \$I t fivcl\$ " cpf " \$Tko gf c\$ " \$I TF + " y cu"  
 kpxgvki cvgf 'wukpi 'vj g'Xlck' 'hdc' ej mtqr j { mbo qtr j quku'gv'u'vgo 'wpg'gt'eqdcm'vutguu' "Hk 03+0Vj g'j gcx{ 'b gvcni'lpf wegf "  
 qzkl cvxg' utguu'ngxn'y cu'kpxgvki cvgf "d{ "gxcn'cvlpi "vj g'xctk'vqpp'kp"dlkej go kccn' o ctngtu'"ej mtqr j { mu."ectq'vppkf u."  
 r tqikpg."j { f tqi gp' r gtqzkl g. "h'xc'pkl u." r qn'r j gpxm. "cpf "cuetdile'cekf + "cu'y gm'cu'vj g'r qvcpvcni' o qf wv'kpi "ghgev'qh'  
 ucnie{ nle'cekf'qp'vj g'co qwpv'qh'vj gug'o ctngtu'kp' r rcpw'OHwpev'kpcn'EF R'ci u'y gtg'wugf "vq'kpxgvki cvg'vqkni' gpqvzle'kx{ 0"

Tgugetej 'j cu'lj qy p'vj cv'vj g'vqknu'kp'vj g'htgo gt'hcev'qtkgu'ol t fivcl'ocpf "otko gf co'j cxxg'i gpqvzle'ghgev'ap'X0hdc "  
 r rcpw'd{ 'kpf'wepi 'r qn' o qtr j luo 'kp'EF R'r tqh'kvu'0k'y cu'cnuq'hqwpf 'vj cv'i tqy kpi 'r rcpw'kp'I TF 'uqkne'epvco kpcv'gf 'y ksj "  
 j gcx{ "o gvcni'uki ph'kcpv'kf 'kpetgcug'vj g'co qwpv'qh'J 4Q4"r ">2027+"cpf "t'gf wegu'vj g'eqpegpvcvkp'qh'cp'vzkl cpw'/"It gg"  
 r tqikpg"r ">2027+"cpf "cuetdile'cekf "r ">2027+"kp' r rcpv'gcv'gu'0k'cf f kklqpp. 'Eq'kpf wegu'Xlck' 'hdc' ej mtqr j { mbo qtr j qugu "  
 y j lej "ctg"o ctngf "d{ "c'uki ph'kcpv'kf getgcug'kp'ej mtqr j { m'c'pf "ectq'vppkf "ngxn'y'cpf "cp'kpetgcug'kp'rk'kf "r gtqzkl cvkpp "  
 ngxn'y'kp'cmir j gpxq' r le'i tqw u'wpej cpi gf . 'kpvgo gf kv'w'cpf "{ gmjy +kp'r ">2027"eqo r ctgf "vq'eqpvt'qm0"



Hk "30Rj gpqvf r gu'qh"Eq'kpf wegf 'ej mtqr j { mbo qtr j qugu'qh'Xlck' 'hdc"

J3\_ "oRti tqi' tguu' kp" o cpki go gpv' qh' eqpvco kpcv'gf "ukgu" o " Gwtqr gcp" Gpxktqpo gpv' Ci gpe { .o" Lcp0' 39." 423; 0' j wr u'ly y y (ggc'gwtqr c'gwf' c'/cpf/  
 o cr ul'kpf'kcv'qtur' tqi' tguu'/kp' o cpki go gpv'qh'eqpvco kpcv'gf /ukgu'5 kcu'gu' gpv' "ceegugf "qp'4243'24'32+"  
 J4\_ "X0" r r' c'ne'w'ne'u. "C'w' cn "gn'q'k' kqm'j kcc0'k'w'pcu'<Nwww . 42280"

**RTGUGPEG'QHUCTU/EqX/4'VTCPUETRVU'K'VJ G'EJ QTQK' 'RNGZWU'  
QHO U'CPF'PQP/O URCVKG VU'Y K'J 'EQXK/3; "**

Xkf o cpvg'Hwej u<sup>3</sup>. 'O lej cgn'Mw' c<sup>4</sup>. 'Uxgp'Y kuj pgy unk<sup>4</sup>. 'P knqrwu'F gki gpf guej<sup>5</sup>. 'Nwe'Nw' <sup>3</sup>. 'Nckr'  
Mwuxg ci gp<sup>3</sup>. 'I gtf c'Tkengp<sup>6</sup>. 'Nw' y ki 'Mr r qu'. 'Cngzcpf ct'V| cpmx<sup>5</sup>. 'Uko qp'J co gypg<sup>6</sup>. 'Uvr j cp'  
Htcm<sup>5</sup>. 'Nwecu'Uej k to gt<sup>4,7,8</sup>. 'Cpgg/Mcvtkp'Rt<sup>3</sup>/dug<sup>3</sup>."

<sup>3</sup>F gr ctwo gpv'qh'Dkqo gf lekpg. 'Wpkxgtuk{ 'J qur kcr'cpf 'Wpkxgtuk{ 'qh'Dcugn'Dcugn'Uy k| gtrcpf "

<sup>4</sup>F gr ctwo gpv'qh'P gwtqmi { . 'O gf lecn'Hcewn' 'O cppj glo . 'J gkf gndgti 'Wpkxgtuk{ . 'O cppj glo . 'I gto cp{ "

<sup>5</sup>Kpukswg'qh'O gf lecn'I gpgv'eu'cpf 'Rcvj qmi { . 'Wpkxgtuk{ 'J qur kcr'Dcugn'Wpkxgtuk{ 'qh'Dcugn'Dcugn'Uy k| gtrcpf "

<sup>6</sup>F gr ctwo gpv'qh'P gwtqmi { . 'F kxkukp'qh'P gwtqr cvj qmi { 'cpf 'P gwtqej go kwt { . 'O gf lecn'Wpkxgtuk{ 'qh'Xlppc. 'Xlppc. "  
Cwutk "

<sup>7</sup>O cppj glo 'Egpgvt'htq'Vtcurv'kpcr'P gwtquekpeg'cpf 'Kpukswg'htq'Kpucv'K o wpquekpeg. 'O gf lecn'Hcewn' 'O cppj glo . "  
J gkf gndgti 'Wpkxgtuk{ . 'O cppj glo . 'I gto cp{ "

<sup>8</sup>Kpvtgf k'ekr'k'pct { 'Egpgvt'htq'P gwtquekpegu. 'J gkf gndgti 'Wpkxgtuk{ . 'J gkf gndgti . 'I gto cp{ "

· Vj gug'cwj qtu'eapv'kdwgf "gs wcm' "

Cpgg/Mcvtkp(RtgdugrB wud@j "

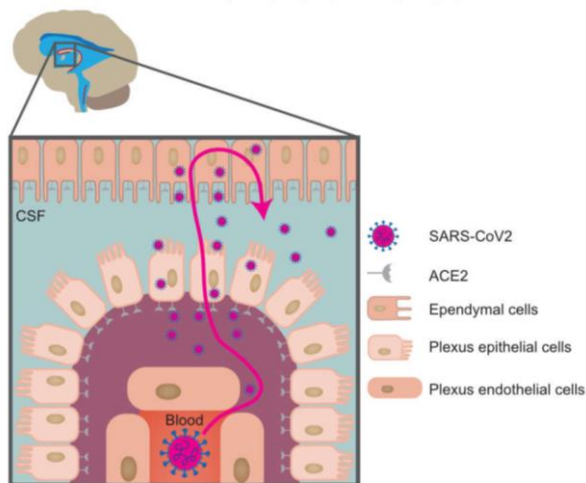
Cmj qwi j "r tlo ctk' "cti gwpi "y j g"tgr kcvqt { "u{ ugo . "eqtpcxk'wu'f kugcug"423; "EQXK/3; "cnuq"o cpl'guu"y kj "  
egp'tcrl'p'gt'x'q'wu'f' ugo "EP U'/'tgr'v'f' 'u{ o r'vqo u'lp'w' 'vq': 2' "qh'y' g'r' cvk'p'u'0'N'k'w'g'ku'hp'q'y p'p'q'v'q'p'n' 'cd'q'w'U'CTU/EqX/  
4'p'g'w't'q'r' cvj' q'ni { . 'd'w'c'nuq'cd'q'w'v'y' g'ek'p'le'c'n'e'q'w't'ug'q'h'i'r' t'g'z'k'w'p'i 'EP U'c'w'q'l'o o w'p'g'f' k'ug'c'ug' 'c'p'f' 'e'q'p'w't'g'p'v'U'CTU/EqX/  
4'k'p'h'g'e'v'k'p'0' O w'nr' ng' 'u'erg't'q'uku' \*O U'+' ku' 'y j g' o qu'v' H't'g's'w'g'p'v' c'w'q'l'o o w'p'g' f' k'ug'c'ug' 'q'h' 'y j g' EP U' y' k'j " k'p'h'co o cvqt { "  
f go { g'ri'p'c'v'k'p' 'c'p'f' 'd'ni'q'f' /d't'c'k'p' /d'c't't'k'g't' "DDD'+f' k'ut'w' v'k'p' /d'g'k'p'i 'v' r' lecn'r' cvj' q'ni' lecn'r'j' c'm'o' c't'm'u'0'Y' j' g'y' g't' 'b' w'nr' ng' 'u'erg't'q'uku' "  
\*O U'+'t'g'p'f' g'tu' r' c'v'k'p'w' o' q't'g' 'u'w'eg'r' v'd'ng' 'v'q' EP U' 'l'p'x'q'x'ng'o' g'p'v' f' w'k'p'i "U'CTU/EqX/4' 'k'p'h'g'e'v'k'p' . 'c'p'f' 'y j g' 'k'o' r' c'ev'q'h' 'U'CTU/  
EqX/4' 'k'p'h'g'e'v'k'p' 'q'p' 'O U'f' k'ug'c'ug' 'c'ev'k'k'v' { 't'g'o' c'k'p' 'g'w'uk'x'g'0' "

J g't'g' 'y' g' 'c'uu'g'ug'f' 'y' j' g'y' g't' 'c'p' 'k'o' r' c'k't'g'f' 'd'ni'q'f' /d't'c'k'p' /d'c't't'k'g't' 'k'p' 'O U' 'h'c'ek'k'c'v'g'u' 'x'k't'c'n' EP U' 'g'p'v' { . 'c'p'f' 'y' j' g'y' g't' 'EQXK/3; "  
"k'p'h'g'e'v'k'p' 'ku' 'c'uu'q'ek'cv'g'f' 'y' k'j "O U'f' k'ug'c'ug' 'g'z'c'eg't'd'c'v'k'p'0'Y' g' 'e'q'o' d'lp'g'f' "c'p' 'k'p' /f' g'r' 'y j' "j' k'w'q'r' cvj' q'ni' lecn'r' 'c'uu'g'uo' g'p'v' 'y' k'j "  
ur' c'v'k'n' 'v't'c'p'ue't'k'r' 'v'q'o' le' 'c'p'c'n'f' 'u'k'u' 'w'ul'p'i "o' w'nr' ng'z' "k'p' 'u'k'w'j' { d't'k'k' c'v'k'p' 'c'p'c'n'f' 'u'k'u' 'h'q't' "U'CTU/EqX/4' 'c'p'f' "CEG4' 'v't'c'p'ue't'k'r' 'w' 'k'p' "  
c'w'q'r' v'e' "d't'c'k'p' 'k'u'w'g' 'q'h' 'c'p' 'O U' r' c'v'k'p'v' 'y' j' q'f' l'g'f' "H'q'o' "EQXK/3; /c'uu'q'ek'cv'g'f' 't'g'r' k'c'v'q't' { 'r'c'k'w'g' 'e'q'o' r' c't'g'f' 'v'q' 'q'y' g't' 'p'q'p' /  
O U'EQXK/3; "ec'ug'u' 'c'p'f' 'k'p'h'co o' cvqt { 'e'q'p'v'q'ni'0' "

F gur k'g' 'c' 'i' g'p'g't'c'ri'b' l'et'q'i' r'c' 'c'ev'k'c'v'k'p' 'k'p' 'O U' 'c'p'f' 'p'q'p' /O U'EQXK/3; "d't'c'k'p' r' c't'g'p'ej { o' c' 'c'p'f' 'b' 'k'p'q't' 'DDD' 'r'g'c'n'c'i' g' 'k'p' "  
O U'EQXK/3; "d't'c'k'p' . 'y' g' 'h'q'w'p'f' 'p'g'k'j' g't' 'g'x'k'f' g'p'eg' 'h'q't' 'c'ev'k'x'g'f' g' go { g'ri'p'c'v'k'p' 'p'q't' 'r' t'g'ug'p'eg' 'q'h' 'U'CTU/EqX/4' 'v't'c'p'ue't'k'r' 'w' 'k'p' "  
O U' 'g'uk'p'u'0'U'CTU/EqX/4' 'c'p'f' "CEG4' 'v't'c'p'ue't'k'r' 'w' 'y' g't'g' 'e'q'p'uk'g'p'v'w'f' 'f' g'y'g'v'g'f' 'k'p' 'g'r' k'j' g'r'k'n'c'ig'm'i' 'q'h' 'y j' g' 'e'j' q't'q'k'f' 'r' ng'z'w' 'ER' "  
c'p'f' 'g'r' g'p'f' { o' c'n'c'ig'm'i' 'q'h' 'y j' g' 'E'U' 'd't'c'k'p' 'k'p'v't'h'c'eg' 'k'p' 'd'q'y' 'O U' 'c'p'f' 'p'q'p' /O U'EQXK/3; "ec'ug'u'0' "

Qw' "h'k'p'f' 'k'p'i' u' r' t'q'x'k'f' g' 'p'g'k'j' g't' 'g'x'k'f' g'p'eg' 'h'q't' 'e'k'p'le'c'n' 'q't' 'p'g'w't'q'r' cvj' q'ni' lecn'r' 'u'k'i' pu' 'q'h' 'O U'f' k'ug'c'ug' 'g'z'c'eg't'd'c'v'k'p' "p'q't' "  
r' t'g'ug'p'eg' 'q'h' 'x'k't'c'n' 'v't'c'p'ue't'k'r' 'w' 'k'p' 'p'g'w't'q'p'c'n' 'c'p'f' 'i' r'c'n'c'ig'm'i'0'P' q'c'v'd'q'f' . 'r' t'g'ug'p'eg' 'q'h' 'x'k't'c'n' 'v't'c'p'ue't'k'r' 'w' 'k'p' 'y j' g' 'ER' 'u'w'i' i' g'u'w' 'y j' g' 'ER' "  
d'g'k'p'i' 'c' 'ng'f' 't'g'ut'c'k'p'v' 'q'h' 'U'CTU/EqX/4' 'g'p'v' { 'k'p'v' 'y j' g' 'EP U' 'H'i' 03-0'H'w'w't'g' 'u'w'f' k'g'u' 'y' k'n'p'g'g'f' 'v'q' 'u'j' g'f' 'h'i' j' 'v'q'p' 'U'CTU/EqX/  
4' /c'uu'q'ek'cv'g'f' 'r' cvj' q'ni' k'g'u' 'k'p' 'EQXK/3; 'r' c'v'k'p'v' 'y' k'j' 'c' 'o' q't'g'f' 'c'ev'k'x'g' 'O U' 'e'q'w't'ug' 'c'p'f' 'q'y' g't' 'c'w'q'l'o' o' w'p'g' 'e'q'o' q't'd'k'f' k'k'g'u'0' "

**Choroid Plexus**



H'i 030Cpv'k'c'v'g'f' 'U'CTU/EqX/4' 'g'p'v' { 't'q'w'g' 'k'p'v' 'y j' g' 'EP U' 'y' q'w'i' j' 'y j' g' 'e'j' q't'q'k'f' 'r' ng'z'w' 'c'f' c'r'v'g'f' 'H'q'o' "  
Hwej u'g'v'c'ri'0'J3\_0'

J3\_Hwej u'X. 'Mw' c'O . 'Y kuj pgy unkU' 'g'v'c'r'0'Rt'gugpeg'q'h'U'CTU/EqX/4' 'V't'c'p'ue't'k'r' 'w' 'k'p' 'y j' g' 'E'j' q't'q'k'f' 'R'ng'z'w' 'q'h' 'O U' 'c'p'f' 'P' q'p' /O U' 'R'c'v'k'p'w' 'Y' k'j' 'EQXK/3; '0'P' g'w't'q'ni' { 'P' g'w't'q'l'o' o' w'p'q'ni' { 'P' g'w't'q'l'p'h'co o' c'v'k'p' '4243=; g; 790'

VJ G'E QO RCT KUQP 'QHF KHHGT GP V'O QF GNUHQ T'K F WEK P I "
GZRGTKO GP VCN'RGT KVQP GCN'CF J GUKQP U'K P 'T CVU'
Cpcucuk{c'Mcpwppknqxc<sup>3,4</sup>. 'P cwnk' O grj cxgu<sup>3</sup>. 'Ctvo 'I qrkux<sup>5</sup>. 'Ctkpc' O co cxqxc<sup>5</sup>. '[ wkl{c'
Rtquo {wuc{c<sup>3</sup>. 'F cpkklNcr r q<sup>3</sup>. '[ wt { 'Nkppkn<sup>4</sup>

3Ej go kut { 'F gr ctwo gpv.' Dgrctwukp'Ucv'Wpkxgtuk{ . 'O kpum'442252. 'Dgrctwu'
4Vj g'Tgr wdrcep'Uelgpkhe'cpf 'RtcevknE gpygt' hqt' Rgf kctle'Uwti gt { . 'O kpum'442235. 'Dgrctwu'
5Dgni qtqf 'Ucv'P cwkpcnT gugctej 'Wpkxgtuk{ . 'Dgni qtqf . '52: 237. 'T wukc'
c0ncrpwppknqxcB i o cklqo "

"

Vj g'hqto cvkqp'qh'r quqr gtcvkg'cf j gukpu'ku'c'uki pkkcpv'enkpcn'r tqdngo 'hqt' 'y j g'r t gupv' f c { 'uwti gt { 'j gpeg' 'y j gtg'
ctg'c' f kxgtuk{ 'qh'xctkcpw'j qy 'vq'uko wrcv'g'r gtkappcn'cf j gukpu'lp'c'f khhgtgpv'o qf gnu'y j lej 'r tqxkf gu'tgr tqf wkdrg'cpf "
tgr t gupv'cvkg'hgrf 'hqt' pgy 't gugctej gu0Cv'j ku'o qo gpv. lpxgukl cvkpu'lp'j g'r gtkappcn'cf j gukpu'dtcepej 'ctg'xgt { 'gzkki "
hgrf 'hqt'o cnkpi 'cp'kf gcn'o qf gnu'v'j wu'j g'co qwpv'qh'j g'r v'kpu'j qy 'vq'r gthqto 'cmf' go cpf u'ctg'gpqto qwu'cpf 'gxp'p'qy "
y g'j cxg'c' m'v'qh'o gjv qf u'v'q'lpf weg'v'j g'cf j gukqp'hqto cvkqp'r t qegu'lp'c'tcv'o qf gnu' qy g'xgt. 'pqy' kpi 'eqwf' 'dg'kf gcn'cpf "
cnl'v'j g'o qf gnu'j cxg'uqo g'kuwgu.'y j lej 'o gcpu'v'j cv'r t qegu'qh'lxp'g'v'kpu'ku'u'kn'i qkpi 'qp'j3\_0'

Ncu'f gct' y g'lp'xgpv'c'tcv'o qf gnu'qhr quqr gtcvkg'r gtkappcn'cf j gukpu'cpf 'k'v'j qy u'i ntk'qwu't guwu'g'xgp'chgt'c' { gct'
qh'tgugctej gu'kh'v'eqo r ctg'k'v'y kj 'tgegpv'o qf gnu'k'v'j qy u'j cv'qwt'o qf gnu'ku'ucdrg'cpf 'f wcdrg'hqt' 'ko g'f gur kg'qy' gt "
lp'xgpv'kpu'j4\_0Vj ku'f gct' y g'j cxg'cp'cn' { gf 'cpf 'eqo r ctg'f 'qwt'pgetquku'o qf gnu'y kj 'hk'cvkqp'j4\_0'y kj 'v'j tgg'eqo o qpn' 'wugf "
cf j gukqp'o qf gnu'pgetquku'o qf gnu'y kj qw'hk'cvkqp'j5\_0' cdtcukxg'o qf gnu'cpf 'f ku'gevkqp'o qf gnu'j3\_0'

Hqt 'f g'xgmr kpi "o qf gnu'lp'v'j ku'y qtm'y g'wugf'6: "o crg'Y knct'tcv'qh'v'j g'uco g'ci g'cpf"o gcp'y g'ki j v\*472/522'i +-
y j lej 'y g'tg'ur nk'lp'v'j 'h'xg'i t qwr u'qh'g'ki j v'tcu'lp'gcej 'i t qwr 0Rtkqt'v'j g'r g'qr gtcvkg'p. 'cm'tcv'y g'tg's wctcvkpgf 'hqt'5'f c { u'
lp'v'j g'xkxctkwo 'cpf 'ngr v'lp'c'34-34/j 'nki j v'f ct'nle { erg' y kj 'h'qf' 'cpf' 'y cvgt'cxk'cdrg'cf 'n'k'kwo 0Vj gp'v'j g'tcu'y g'tg'
cpguy g'kf gf 'd { 'lp'tco wuewrt 'kpl'gevkqp'qh'2027'o nlni 'qh'Z { n'k'p'g'cpf'207'o i lni 'qh'ö' q'g'v'v'i72ö.'y g't'ej gu'v'j ckt'y g'tg'
tgo qxgf 'd { 'uj cxkpi 'cpf' 'v'j g'un'kp'y cu'uetwddgf 'y kj 'g'v'j cp'q'0Vq'ceegu'v'j g'cdf qo kpcn'ecxk{ 'c'5/0' 'n'r ctqvo { 'y cu'
r gthqto gf 0K'v'j g'öpgetquku'y kj 'hk'cvkqp'o i t qwr . 'y g'egewo 'y cu'f g'xg'gt' 'cpf' 'ku'y cnl'y cu'kplwt'gf 'd { '3/o kpwg'cr r n'ecv'kqp'
qh'c'eqwqp'r cf 'u'qcn'gf 'lp'3P 'P cQJ 'cpf' 'v'j gp'v'j g'egewo 'y cnl'y cu'k'z'gf 'v'q'v'j g'cdf qo kpcn'y cml' { 'c'bpq/cduqtdcdrg'uwwt'g'
v'q'iqecr'k'g'cf j gukqp'ukgu'0K'v'j g'öpgetquku'y kj qw'hk'cvkqp'o i t qwr . 'y g'egewo 'y cu'f g'xg'gt' 'cpf' 'ku'y cnl'y cu'kplwt'gf 'd { "
3'o kpwg'cr r n'ecv'kqp'qh'c'eqwqp'r cf 'u'qcn'gf 'lp'3P 'P cQJ 0Chgt'v'j g'r t qegf w'g. 'y g'c'm'k'p'g'u'q'w'k'p'p'y cu'y cu'j gf 'q'w'
eqo r n'g'v'n' 'y kj 'u'c'k'p'g'v'j g'öcdtcukxg'o i t qwr . 'y g'egewo 'y cnl'y cu'kplwt'gf 'd { 'tgr g'c'v'pi 't'wddkpi 'y kj 'v'j g'j' gnr 'qh'
v'j g'öcdtcukxg'o cvgt'k'c'0K'v'j g'öf ku'gevkqp'o i t qwr . 'f ku'gevkqp'qh'v'j g'v'j tgg'r g'tkappcn'y cnl'ukgu'\*7 4'o o 'r'qr r qukg'v'j g'egewo "
y g'tg'r tgr ctg'f 0K'v'j g'eqpvt'qni t qwr . 'qpn' 'v'j g'5/0' 'n'r ctqvo { 'y cu'r gthqto gf 0Vj g'y qwp' 'y cu'emugf' 'd { 'y q'w' { 'g'u'q'q'
eqp'v'k'p'w'w'w'w'gu'0Rtqr j { n'v'le'cp'v'k'v'le'72'o i lni 'V { n'k'p'p'v'j cu'kpl'gevg'f 'q'peg'f c'k' { 'hqt'7'f c { u'chgt'v'j g'uw'ti gt { 0Cv'f c { "
9'chgt'uw'ti gt { . 'y g'cp'ko cu'l'y g'tg'gw'j cp'k' gf 'cpf' 'v'j g'cdf qo kpcn'ecxk{ 'y cu'qr g'p'g'f 'x'k'c'W/uj cr gf 'k'p'ek'k'p'0'

Cf j gukqp'hqto cvkqp'y cu'g'x'c'w'v'g'f 'd { 'c' o cetqueqr le'lpur gevkqp'ceeqt'f kpi 'v'q'v'j g'cf j gukqp'tcvkpi 'uecr'g'hqto '2'v'q'7"
r tqr qugf 'd { 'Q'p'eg'n'g'v'c'0'j6\_0I tcf g'2'<p'q'cf j gukpu'v'j tcf g'3'<'m'q'ug' h'k'm { 'cf j gukpu'v'j cv'ecp' 'dg'ugr ct'cv'gf 'd { 'd'w'p'v'
f ku'gevkqp'v'j tcf g'4'<cf j gukpu't'g's v'k'k'pi '>72' 'qh'v'j ctr 'f ku'gevkqp'hqt'ugr ct'cv'kqp'v'j tcf g'5'<cf j gukpu't'g's v'k'k'pi '@/2' 'qh'
v'j ctr 'f ku'gevkqp'hqt'ugr ct'cv'kqp'v'j tcf g'6'<hgt'qucn'lp'wt' { . 'i t cf g'7'<'h'w'v'j k'p'ng'w'lp'wt' { 0'

Chgt'v'j g'lo r ngo g'p'cvkqp'qh'c'n'r t'q'eg'f w'g'u'ugx'gt'g'f 'i t cf g'q'h'cf j gukqp'hqt'v'j g'öpgetquku'y kj 'hk'cvkqp'o i t qwr 'y cu'4'0"
cpf 'cnl'y g'f' j gukqp'ukgu'y g'tg'ut'le'v'f 'm'ecr'k' gf 'd'gy' g'p'v'j g'egewo 'cpf' 'v'j g'cdf qo kpcn'y cml'0K'v'j g'öpgetquku'y kj qw'
hk'cvkqp'o i t qwr 'cnl'y g'tcu'j cu'4/i tcf g'cf j gukpu'0K'v'j g'öcdtcukxg'o i t qwr . 'y tgg'tcu'j cf '4/i tcf g'cf j gukpu.'h'w'tcu'j cf "
pq'cf j gukpu'cpf 'q'p'g'tcv'f k'g'f 'd'gh'q't'g'w'j cp'k' kpi 'r t'q'egu'0K'v'j g'öf ku'gevkqp'o i t qwr . 'h'w'tcu'j cf '3'i tcf g'cf j gukpu.'q'p'g'
tc'v'j cf 'p'q'cf j gukpu'cpf 'v'j tgg'tcu'f k'g'f 'd'gh'q't'g'w'j cp'k' kpi 'r t'q'egu'0K'v'j g'eqpvt'qni t qwr . 'h'xg'tcu'j cf '3/i tcf g'cf j gukpu'
cpf 'v'j tgg'tcu'j cf 'p'q'cf j gukpu'0Cf j gukqp'ukgu'lp'c'm'v'j g'i t qwr u'g'zegr v'j g'öpgetquku'y kj 'hk'cvkqp'o i t qwr 'y g'tg'm'ecr'k' gf "
ur q'p'v'p'g'q'w'w'w'w' { 'd'gy' g'p'v'j g'egewo 'cpf' 'v'j g'q'v'j g't'ctw'q'h'v'j g'cdf qo kpcn'ecxk{ 0'

Ht'qo 'cnl'y ku'f cv. 'y g'ecp'o cng'c'f g'tk'cvkqp'v'j cv'o qf gnu'y kj 'cdt'cukqp'cpf 'f ku'gevkqp'ct'g'p'q'v'v'q'eqp'g'p'k'p'v'd'g'ecw'ug'
v'j g'f 'f q'p'w'uc'v'k'v'h' 'v'j g'f go cpf u'lp'tgr tqf w'kd'k'k'k'k'0P g'x'g't'v'j g'g'u'u. 'p'getquku'o qf gnu'y kj qw'cv'cej o gpv'ecp'dg'wugf 'k'h'qwt'
o c'k'p'c'k'o 'ctg'cf j gukpu'cpf 'p'q'v'v'q'ko r q't'cv'p'v'y g'tg'v'j g' { 'y k'nl'd'g'0C'ng'q. 'p'getquku'o qf gnu'y kj 'cv'cej o gpv'ecp'dg'wugf 'k'p'lu'qo g'
uk'w'cv'k'p'u'v'q'q. 'd'g'ecw'ug'f gur kg'v'j g'j v'g'v'c'w'o c't'k'uni'y ku'o qf gnu'ku'eq'p'g'p'k'p'v'k'h'y g'y cp'v'cf j gukpu'lp'f'g'v'to k'p'gf 'uwt'f'ce'g'
qt'r n'eg'0C'm'g'zr g'tko g'p'u'y g'tg'ect'k'g'f 'lp'eqo r r'k'ep'eg'y kj 'v'j g't'geqo o g'p'f cv'k'p'u'qh'v'j g'G'w'qr g'c'p' 'E'q'p'x'g'p'v'k'p'q'p'J wo c'p'g'
Vt'g'co g'p'v'q'h'N'cd'q't'c'wt { 'C'p'ko cni'j7\_0'

[3]...M'cgo gt. 'D0'g'v'c'0'U'c'p'f'ct'f'k'ug'f "o qf gnu'hqt'lpf v'elpi "g'zr g'tko g'p'v'c'n'r g'tk'ap'g'cn'cf j gukpu'lp'g'o cng'tcu'ID0M'cgo gt'j'g'v'c'0'II'D'k'go gf 'T'g'u'0'k'p'0'6'
423606'X'q'0'4236'0'R03/: 0'
[4]...'R'q'm't'x'um'f. 'X'0'g'v'c'0'V'j g'p'q'x'g'n'g'zr g'tko g'p'v'c'n'tcv'o qf gnu'qhr quqr gtcvkg'r gtkappcn'cf j gukpu'0Qr gp'T'g'cf kpi u'4242'85pf "k'p'v't'p'cv'k'p'c'n'E'q'p'h'g'p'eg'
hqt'U'w'f g'p'u'q'h'R'j { u'ku'c'p'f 'P'c'w'c'n'U'el'k'p'eg'u. 'X'k'p'k'u. 'N'j'v'c'p'k'. 'R076: "
[5]...'Q' g'nk'0'0'g'v'c'0'E'qo r c'tk'up'q'h'c'ej { o c'ug'lp'j k'k'q't'c'p'f'j { c'n'w'q'p'le'c'ek'f l'c'ct'dqz { o g'v'j { r'eg'm'w'q'ug'U'g'r t'c'h'ko -#lp'c'p'q'x'g'r'g'r g'tk'ap'g'cn'cf j gukpu'o qf g'nu'
lp'tcu'0R'N'q'U'Q'p'g'0423; 0X'q'0'36. " 3'0'R0'g'24335; 30'
[6]...'Q'p'eg'n'0'0'g'v'c'0'E'qo r c'tk'up'q'h'c'p'q'x'g'n'is'v'k'f' "C'f'eq'p'RI -#c'p'f'c' "u'q'f'k'wo "j { c'n'w'q'p'ev'g'c'p'f' "ect'dqz { o g'v'j { r'eg'm'w'q'ug'0' go d'tc'p'g' "U'g'r t'c'h'ko VO -#lp'
r q'u'w'ti l'ec'n'cf j gukpu'hqto cvkqp'lp'c'o w'k'p'o qf g'nu'f ku'0E'q'q'p'T'g'ewo '68. '3: 963; 3''4225-0'
[7]...'G'w'qr g'c'p' 'E'q'p'x'g'p'v'k'p'q'p'J g'r t'q'v'g'v'k'p'q'h'x'g't'g'd't'c'v'g'c'p'ko cni'wugf 'hqt'g'zr g'tko g'p'v'c'n'c'p'f' 'q'v'j g't'ue'k'p'v'k'k'e' r w'r q'u'g'u'0'U't'c'ud'q'w'ti <G'w'qr 0V't'g'c'v' 'U'g't'k'g'u'
3; : 80' 3450R06: 0'



**WVVTCHCUV'NQECNK GF 'UWTHCEG'RNCUO QP 'TGNCZCVKQP "**  
**F[ P CO KEU'QHRNCUO QP KE 'O GVCN'P CP QRCTVKENGUD[ 'O GCP U'QH'**  
**VTCP UKGP V'CDUQTRVIQP 'URGE VTQUE QR[ "**

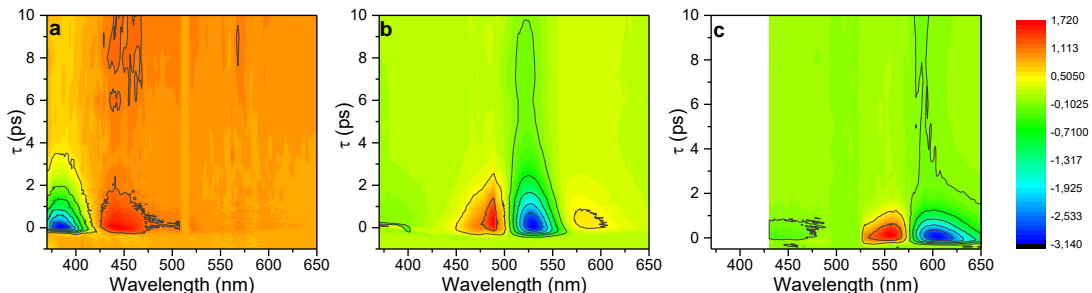
I gtf c'Mko cky<sup>3</sup>. 'F qo cpvcu'Rgemwu<sup>4</sup>. 'Vqo cu'Vco wrgxlekuw<sup>3,4</sup>. 'Lcwpkuw'O { nqrckku<sup>4</sup>. 'O kpf cwi cu'  
 Lxqf pcu<sup>4</sup>. 'Cucv'Vco wrgxk kgp <sup>3,4</sup>. 'Cni ktf cu'Nc| cwunru<sup>4</sup>. 'Uki kcu'Vco wrgxk kuw<sup>3,4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rj { uku. 'Mcwpcu'Wpkxgtukf 'qh'Vgej pqnqi { . 'Uwf gpv 'U072. 'NV/7358: 'Mcwpcu. 'Nkj wcpkc"  
<sup>4</sup>Kpukwng'qh'O cvgtkcu'Uelgpeg. 'Mcwpcu'Wpkxgtukf 'qh'Vgej pqnqi { . 'MDDct-cwunq'U07; . 'NV/73645' 'Mcwpcu. 'Nkj wcpkc"  
i gtf c'0mko ckgB mwqfw"

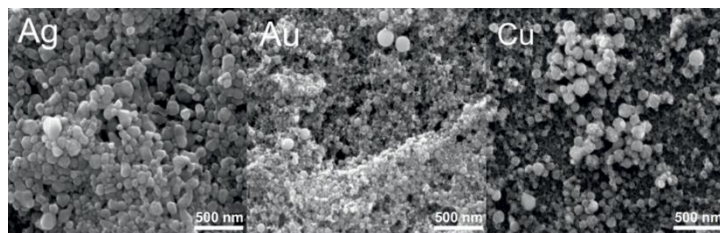
Tgegpw. 'pqdn'g'o gcn'pcpqr ctvlegu'P Ru'j' cxg'dggp'xgt { 'kpvtgukpi 'hqt'vj g'uelgpw'le'eqo o wpkf 'dgecwug'qh'vj gkt"  
 grgetqr vlcni'r tqr gtvku'vj cv'cr r gct'dgecwug'qh'rqecrk gf "uwt'hecg'r ruo qp'tguqpcpeg" \*NURT+' ]3\_0'F w'v'vj gkt "NURT"  
 hgcwtgu'r ruo qple'o gcn'P Ru'ecp'dg'wugf 'lp'xctkqwa'grgetqqr vlcni'cr r rlcwvqpu'rkng'uqrc't'egmu. 'r j qvqecvni'uku. 'ugpukpi. "  
 o gf lekpg'cpf "uq'qp"]3\_0"

Y g'lxgukki cvgf 'Ci. 'Cw'cpf 'Ew'P Ru'lp'qwt'tgugctej 'dgecwug'vj gug'pcpqr ctvlegu'j' cxg'y gmf ghkpgf "NURT"r tqr gtvku'  
 cpf "uj qy u'i tgcv'r tqo kugu'ht'hwmtg'grgetqqr vlcni'cr r rlcwvqpu']3\_00 quv'o gcn'P Ru'y g'g'u{pvj guk gf 'ej go kecmf "uq'htc"  
 dw'y kj 'vj g'f gxnqr o gpv'qh'wntc/uj qv'r wng'ruugu. 'pgy "o gvj qf u'qh'u{pvj guku'qh'P Ru'j' cxg'go gti gf "rkng'ruugt'cdrcwvqp"  
 kp'hs wlf u'\*NCN+0Vj g'lo r qtwpv'cf xcpvci g'qh'NCN'ku'c'uko r ng'cpf 'hcu'u'pvj guku'r tqegu0Vq'gxcwv'vj g'uk'gu. 'wtwewtci'  
 cpf 'qr vlcni' tqr gtvku'qh'P Ru'r tgr ctgf 'd{ 'vj g'NCN'o gvj qf 'vj gkt'r tqr gtvku'uj qwf 'dg'zr nqtgf 'lp'f gvc'k0Vj g'o gvj qf u'rkng"  
 uecplpi 'grgetqp'o letqueqr { . 'Z/tc { 'f'khtcewvqp. 'hpgct'cpf 'pqp'p'gct'qr vlcni'o gcuwt go gpw'ecp'i'kxg'xcwv'vj'kphqto cvkqp"  
 cdqw'hgcwtgu'qh'vj gug'P Ru'lp'qwt'tgugctej. "y g'y g'tg'hwewkpi "qp"vj g'wntchcu'NURT"tgrzcwvqp" f { pco leu'qh'P Ru'  
 u{pvj guk gf 'htqo "vj tgg'r ruo qple'o gcn'vcti g'u'd{ 'vj g'NCN'v'gej pls w'g0"

Vj g'f { pco le'ruo qple'r tqr gtvku'qh'pqdn'g'o gcn'pcpqr ctvlegu'y g'tg'zr nqtgf "d{ "wntchcu'wcpukgp'v'cdutr v'kqp"  
 ur getqueqr { "VCU+o gvj qf 'zr nqkpi [ d-MI Y 'hgo vqgeqpf 'ruugt'cpf 'pqp'p'gct'r ctco g'ule'co r r'kht0Vj g'r tqr gtvku'qh'  
 wntchcu'NURT' tgrzcwvqp' f { pco leu'lp'r ruo qple'P Ru'r tgr ctgf 'd{ 'vj g'NCN'o gvj qf 'y g'tg'eqo r ctgf 'y kj 'vj g'qppu'r tgr ctgf "  
 d{ 'ej go kecnif'pvj guku']4\_0Vj g'VCU'o gcuwt go gpw'tguwru'qh'Ci. 'Cw'cpf 'Ew'P Ru'ctg'uj qy p'lp'Hki 030Vj g'uk'gu'cpf 'lj cr gu'  
 qh'lxgukki cvgf 'r ruo qple'o gcn'P Ru'y g'tg'o gcuwtgf 'y kj "UGO"cpf 'ecrew'cvgf 'y kj "K ci g'Luqhy ctg'"Hki 04+0"



Hki 030'Vtcpukgp'v'cdutr v'kqp'ur gestqueqr { 'f'cv'eqpvq'w'r'rwu'qh'Ci 'P Ru'\*c+. 'Cw'P Ru'\*d+cpf 'Ew'P Ru'\*e+0



Hki 040Ci. 'Cw'P Ru'UGO' 'ko ci gu'

j g'VCU'tguwru'f kur m{ 'vj cv'vj g'f { pco le'r tqr gtvku'NURT'qh'NCN'P Ru'ctg's wkg'uko kct'vq'P Ru'r tgr ctgf 'd{ 'vj g'y gv'  
 ej go kecnif'pvj guku'o gvj qf 'uwi i gukpi 'vj cv'vj gkt's wcrk'ku'cnuq'eqo r ctcdng']4\_0Cnj qwi j. 'vj g'tgrzcwvqp' f { pco leu'qh'P Ru'  
 r tgr ctgf 'd{ 'y gv'ej go knt { 'cpf 'NCN'ku's wkg'uko kct'vj g'uk'gu'f knt'kdwkqp'ku'o wej 'hty gt'ht'P Ru'r tgr ctgf 'd{ 'y gv'ej go knt { "  
 o gvj qf u'\*Hki 04+']4\_0Vj g'r tgrko kpc' { 'tguwru'lpf'lec'g'vj cv'vj g'NCN'u{pvj guku'qh'P Ru'eqw'f 'dg'c'r g'ur ge'v'g'o gvj qf 'htq"  
 vj g'r tgr ctv'kqp'qh'j' ki j /s wcrk' { 'r ruo qple'P Ru'ht'xctkqwa'grgetqqr vlcni'cr r rlcwvqpu'"

**Cenpqy ngf i go gpw**< Vj ku'tgugctej "y cu'hw'pf gf "d{ "y g'Gwtqr gcp"Uqekci'hw'pf "w'pf gt "y g'P q02; 05/NO V/M/934"  
 0F g'xg'qr o gpv'qh'E'qo r g'v'gegu'qh'Uelg'p'kuu. "qj gt "T'gugctej gtu'cpf "Uwf gpw"vj tqwi j "Rtcw'keci'T'gugctej "Cev'k'k'ku'o"  
 o gcuwtg. 'i tcpv'p q02; 05/NO V/M/934/44/24340

[3\_1 0X0J ctw'pf. 'Qr vlcni'Uwf'ku'qh'F { pco leu'lp'P qdn'g'o gcn'P cpqut'wewtgu. 'Ej go 0Tgx0333. '5: 7: 65: : 9"\*4233+0'  
 [4\_1 'F 0Rgemu'gv'cni'J qv'G'ge'q'p'Go kuu'q'p'Ec'p'Ng'cf "v'f'Co r lpi 'qh'Qr vqo ge'j cpleci'Q qf gu'lp'Eq'tg Uj gni'Ci B V'kQ4'P cpqewdgu'0Rj { u0Ej go 0E."  
 343.'4637; /46389"\*4239+0

\ pQ'VGVT CRQF UO QTRJ QNQi [ 'CPF 'UVT WE VWT G'RP HNWGPE G'QP''  
**GNGEVTQEJ GO KECN'RTQRGT VIGU'**

Kxc'Uc-ckf v<sup>3</sup>. 'Cpf tkw'Xkmwuncu<sup>3</sup>. 'Ci p "Tm k v<sup>3,4</sup>. 'Uko cu'Tc nwwuncu<sup>4</sup>""

<sup>3</sup>F gr ctvo gpv'qh'Rj { ulecn'cpf 'kqti cple'Ej go knt { . Hcwm' "qh'Ej go lecn'Vgej pqm { . 'Mcwpcu'Wpkxgtuk' "qh'  
 Vgej pqm { . 'Tcf xkrgpwr' rnpvcu<sup>3</sup>; . 'Mcwpcu'NV/72476"

<sup>4</sup>F gr ctvo gpv'qh'Rj { uleu. 'Hcwm' "qh'O cyj go ckleu'cpf 'P cwtcn'Uelgpegu. 'Mcwpcu'Wpkxgtuk' "qh'Vgej pqm { . 'Uwf gpv 'u0'  
 72. 'NV/7358; . 'Mcwpcu. 'Nkj wcpk"

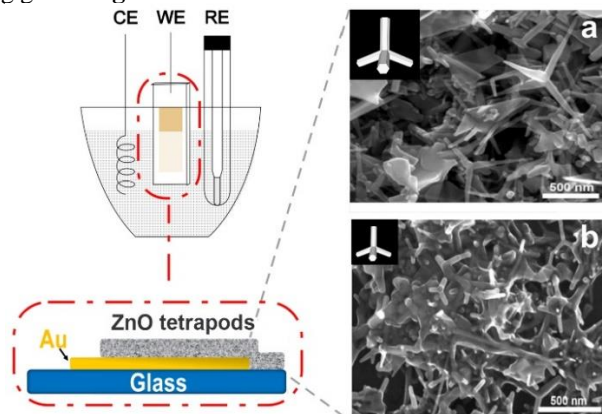
.ci pgUwkwgB mw0n'

" Kp'yj g'ruv'f gecf g'kpvgt gu'lp' pQ'o ctngr n' tgewt'cpf 'kpetgcug0'Vj ku'qwwucpf kpi 'r qr wrctk' "ku'f wg'vq' pQ'o wnk/  
 hwevqpcrk' . 'uwxcdng' hqt' xctkqwu' cr r rlecwqpu' ]3\_0F gr gpf kpi 'qp'yj g'o gyj qf 'qh'u' { pyj guku. 'yj g'ut wewtg'cpf 'o qtr j qm { "  
 ecp'dg'i tgcw'f "o qf kkgf . 'tguwnkpi 'lp'ej cpi gu'lp'r j { ulecn'cpf 'ej go lecn'r tqr gt vgu0'

Qw'clo 'y cu'vq' lpxguki cvg' pQ'o qtr j qm { ' \*uk' g. 'uj cr g. 'r qtquk' +qp'grgextqej go lecn'r tqr gt vgu0'

**Gzrgtko gpvclrt qcej** 0Vgtr qf u'y g'g'u' { pyj guk' g' wulpi 'eqo dwukp'o gyj qf " ]4\_ 'cpf 'ugr ctcvg' 'd' { 'egpvtkwi cvkqp'  
 kpq'4'uk' g' hcewqpu' rcti g'vgtcr qf u'0'3222'TRO . 'pco gf 'NV=uo cni'vgtcr qf u'0'5222'TRO . 'pco gf 'UV=0'

Grgextqej go lecn' r tqr gt vgu' \*cevxg' uwt hceg' ctgc' C. " grgextqp' vcpuhg' tcvg' ΔG<sub>r</sub>+ y g'g' gxcnwcvg' " wulpi " e { erke'  
 xqncu o g'v' "o gcuwt go gpw'qh'322"uo "M<sub>6</sub>]Hg\*EP<sub>8</sub> f kuuxrgf "lp'208"O "MEn'uqnwkp0 Y qtnkpi "grgextqf g'\*Y G<i rcu"  
 uwdutcvg' →322"po "Cw" →\ pQ'vgtcr qf u'0'Ci Ci En'tghgt gpeg'grgextqf g'\*TG+qh'4"o o "lp'f kco gvt'cpf "cpf "Rv'eqwvgt'  
 grgextqf g'\*EG+qh'20"o o "lp'f kco gvt' **Hki wt g'30'**



Hki 030Uko r nkgf 'xgtukp'qh'gzr tklo gpvclugv'w' hqt'grgextqej go lecn'o gcuwt go gpw'c'0'3222'TRO 'rcti g'vgtcr qf u'

\*NV=d'0'5222'TRO 'uo cni'vgtcr qf u'\*UV=

Vgej plk wgu'wugf <t'gukncpeg'o gcuwt go gpv'Uecpplkpi 'cpf 'Vtcpuo kuukp'grgextqp'o ketqueqr lgu'\*UGO 'cpf 'VGO + 'Z/  
 tc' 'r qy f gt'f khtcewqpu' \*ZTF + 'WX/Xku'ur gextqueqr { 0'

**Utwewtg'c'pf 'b' qtr j qm {** 0K'y cu'p'q'v'g' 'dqj 'NV'cpf 'UV'vgtcr qf u'hqto 'c'v'f r lecn'vgtcr qf 'utwewtg'eqpukukpi 'qh'6'  
 eqppgevg' 'pcpqtqf u<

E' uo cni'vgtcr qf u'\*UV+f kco gvt'7"po . 'rpi yj '72"po =

E' rcti g'vgtcr qf u'\*NV+f kco gvt'42"po . 'rpi yj '372"po =

O qtqaxgt. "k'y cu' hqwpf "yj cv'pcpqtqf u' \*rpi u'ctg'y gmf ghkpgf "kpvthgt gpeg'ht kpi gu'eqt gur qpf kpi "vq" \ pQ"\*3212"  
 r rpgu0'

**Grgextqej go lecn'r tqr gt vgu0'** K'y cu'f kuki wkuj gf "yj cv' yj g'grgextqej go lecn'tgcewqpu'qh' \ pQ'pcpqt wewtg'ctg'  
 kphwpegf 'd' { "y q'uko wncpgqu'w'o gej cpluo u<"

E' \ pQ'pcpqt wewtg'w'pf gt'f khtgpv'r qv'p'kcn'

E' hgttle { cpl'g'lp'yj g' \ pQ'grgextqf g0'

K'y cu'eqpenf gf "yj cv'f wg'vq' yj g'q'p'f ko gpukpcn'hi 'cttepi go gpv'vgtcr qf u'lj qy gf 'i tgc'v'grgextqej go lecn'r tqr gt vgu0'

Vj g'gh'ev'ku' o qtg' r tqp'wpegf "hqt' rpi gt' rpi "vgtcr qf u' \*NV+ . "rcf kpi "vq" r gni'ugr ctcwqpu' ΔG<sub>r</sub> . "cr r tqcej kpi "yj g'  
 yj g'gtg'lecn'xcnw0'Vj qwi j . "NV'yj cv'j cu'yj g'dki i guv'cevxg' uwt hceg' \*20; 7"eo <sup>4</sup>+ 'cpf "ku'r tcewlecn'ΔG<sub>r</sub> 'xcnw'qh'830"o X. "  
 y j lej 'ku'emqu'g'v' yj g'gtg'lecn'7; "o X0'

Vj gug't guwu'ctg'uki p'k'ecp'v'ht' yj g'w' eqo kpi \ pQ'vgtcr qf u'cr r rlecwqpu'lp'grgextqej go knt { . 'y j g'g'v'g'o qtr j qm { "  
 kphwpeg'qp' yj g'r tqr gt vgu'uj qwf 'dg'eqpuk'gtgf " ]5\_0'

[3\_C00 qgl | k'C00 00 eF qpci j . 'O 00Eqt'v'g. \ lpe'qz'k' g't ctv'ngu'U' { pyj guku. 'r tqr gt vgu'cpf 'cr r rlecwqpu. 'Ej go lecn'Gpi lpggt kpi 'Lqvt'pcn'44.'3: 7/3: 8"  
 \*42344)

[4\_ 'U0T'cennwuncu'Q0Mko qxc. 'J 0lkpi . 'g'v'0'Vj g'Lqvt'pcn'qh'Rj { ulecn'Ej go knt { 'E. '4237. '4: . '38588/38595' \*42370"

[5\_ 'C0Uwkwg. 'MOP k'j ko wtc. 'G0I k'j v'g'p. 'g'v'0'Vj g'Lqvt'pcn'qh'Rj { ulecn'Ej go knt { 'E. '4. "3694/36: 4' \*4243+ "

**CRRNĒCVĪQP'QH'Ō CI PĠVĒ'I QNF/EQCVGF'PCPQRCTVĒNGU'HQT'  
VJ G'F GVGTO ĶPCVĪQP'QH'J WO CP'I TQY VJ 'J QTO QP'G'**

Go c'Derk pckv<sup>3</sup>. 'Cm ktc'Tco cpcxk kgp<sup>3</sup>

<sup>3</sup>P cpqVgej pcu'Ō'Egpygt'qh'P cpqvej pami { "cpf 'O cvgtkcm'Uelgpeg. 'Hcewm' 'qh'Ej go kut { 'cpf 'I gquelpegu. 'Xkpkwu' 'Wpkxgtukf. 'Nkj wpcle' go c'ŌlcrkwpcksgB ej i h'wfw ŌwŌh' }

Ķ"tgegpv' { gctu. "i qif "pcpqr ctveng'u y gte" wuf "kp" c"xctkqv' "qh'hkgr u. "kpenw' kpi "ecvcl' uku. "grgetvpleu. "r j qvqpleu. "cu" y gmi'cu'pcpgo gf kelpg. "cpf "ej go lecl'cpf "dkqmi lecl'ugpuki Ō'Vj gk'ty kf g'tcpi g'qh'cr r rēcvkqpu'eqo gu'ht qo "vj gk'wpls wg" qr vēcŋ " grgetqo ci pgle. " cpf " eqpf vėxkg" r tqr gtvėgu. " kp" cf f'kxkp" vq" vj gk" i qaf " dkqeo r cvdkrkv' " cpf " gcug" qh' hwpvėkpcik' cvkqp" cpf "o qf hlecvkqp" y kj "dkqo qngewgu' Vj g'wug" qh' o ci pgle "i qif /eqcvgf "pcpqr ctveng'u \*O /CwP Ru+ "ku" cf xcpvc' gquw' dgecvug' qh' vj g' eqo dlpgf "cdqxs/ o gpv'kppgf "i qif "pcpqr ctveng" r tqr gtvėgu. "cmppi "y kj "vj g'cdkxk' "vq" wug" o ci pglu'vq' eqpv'qni'v' g' r ctveng'u' r qukkqp' kp' ur ceg' Vj ku' r tqr gtv' "ku' gur gekm' "wughw' hqt" vj g' eqmgevkqp' qh' r ctveng'u' chgt" gcej "vgr "qh' o qf hlecvkqp" ]3/5\_0"

J wo cp' i tqy vj 'j qto qpg' \*j I J +. "cmq' hpqy p' cu' uqo cvq' tqr kp. "ku' c' r gr vėf g' j qto qpg' y j lej "ku' ugetv' g' d' { 'vj g' cvgtkqt" r kwkct { 'i rpf Ōj I J "ku' guugpv' kci' hqt' p' qto cni' wo cp' i tqy vj 'cpf 'f g' xgrqr o gpv' 'cpf 'ku' lpxqrk' g' kp' uvej "dkqmi lecl' r tgeguugu" cu' rēcvkqpu. "uqo cvqi gpguku. "cpf "cev' xcvkqp' qh' o letqr j ci gu' ŌC p' ko dcmpeg' qh' j I J "ecwugu' xctkqu' f kugcugu. "vj wu' ugpukxg" f gvgto kpcvkqp' qh' vj g' j qto qpg' ku' guugpv' kci' ]6\_0"

Vj g' o clp' cko "qh' vj ku' uwf { "y cu' vq' f g' xgrqr "cp" ko o wpqcuuc { "hqt" vj g' f gvgto kpcvkqp' qh' j I J "wukpi "O /CwP Ru' Ō { p' vj gw' gf "O /CwP Ru' y gte' ej ctcevgtk' gf "ur gev' tveqr lecl' "cpf "wukpi "v' tcpuo kuukqp' grgetv' o letv' eqr { Ō' Ķ' vj ku' y qtm" o qpqem' p' c' p' v' d' qf l' gu' ci clp' v' j wo cp' i tqy vj 'j qto qpg' \*o /cp' v' j I J + y gte' eqxcrppv' "ko o qdkrk' gf "qpv' vj g' uwh' ceg' qh' O /CwP Ru' wukpi "c" ugr' h' cuugo drgf "o qpqr { gt' Ō' Chgt" o /cp' v' j I J "kp' vgt' cev' kqp" y kj "j I J . "r qn' em' p' c' i' p' v' d' qf l' gu' ci clp' v' j wo cp' i tqy vj 'j qto qpg' r' d' g' n' g' f "y kj "dk' v' k' \*r /cp' v' j I J /D+ "cpf "ut' gr v' x' k' f' kp' r' d' g' n' g' f "j qtugt' cf k' i' j "r gtqz' k' f' g' cu' c" u' w' d' u' t' v' g' "hqt" vj g' y gte' cf f' gf Ō' Vj gp' c" o k' w' t' g' qh' 5.5 .7.7 /v' g' t' c' o' g' v' j { n' d' g' p' l' k' p' g' \*VO D+ "cpf "j { f' t' q' i' gp' r' gtqz' k' f' g' cu' c" u' w' d' u' t' v' g' "hqt" vj g' gp' { o c' v' k' t' g' c' v' k' p' y cu' c' f' f' g' f. "cpf "vj g' c' d' u' q' t' d' c' p' e' g' qh' u' q' n' w' k' p' chgt' vj g' c' f' f' k' k' p' qh' u' w' h' w' k' e' c' e' k' f' y cu' t' g' i' k' u' g' t' g' f' Ō' "

**Cempq' r' g' i' go' gpw''**

Vj ku' r' t' q' l' g' e' v' j' cu' t' g' e' g' k' x' g' f' h' w' p' f' k' p' i' h' t' q' o' 'G' w' t' q' r' g' c' p' 'U' e' k' e' n' i' H' w' p' f' "r' t' q' l' g' e' v' P' q' 2; Ō' Ō' Ō' N' O' V' / M' 934/44/2393 + w' p' f' g' t' i' t' c' p' v' ci t' g' g' o' g' p' v' y' k' j' "v' j' T' g' u' g' t' e' j' 'E' q' w' p' e' k' i' qh' N' k' j' w' c' p' l' e' \*NO VNV+ Ō' "

[3\_1 ŌNk' J ŌUej n' w' g' u' e' p' g' t' . ( " Ō Ō Z' w' ' I qif "pcpqr ctveng/ dcugf 'dkqugpuqtu. 'I qif 'Dwngv' k' p' 65\*3+; 4; 663\*4232+ Ō)  
[4\_1 ŌNgg. 'J ŌEj q. 'J ŌEj q' k' g' v' c' r' Ō' C' r' r' i' t' e' c' v' k' p' qh' I qif "P cpqqr ctveng' vq' R' r' e' u' o' q' p' l' e' D' k' u' g' p' u' q' t' u. "Ķ' v' g' t' p' c' v' k' p' c' i' l' a' w' t' p' c' i' qh' Ō' q' r' e' w' e' r' t' 'U' e' l' g' e' p' e' g' u' 3; \*9+; 4243" \*423; + Ō)  
[5\_1 NŌY epi . 'J ŌRctm' ŌŌNko 'g' v' c' r' Ō' E' q' t' g' B' u' j' g' n' i' p' c' p' q' o' c' v' g' t' k' c' m' d' q' i' f' / e' q' c' v' g' f' ' Ō' c' i' p' g' l' e' ' q' z' k' f' g' p' c' p' q' r' c' t' v' e' n' g' u. 'I' a' w' t' p' c' i' qh' Ō' c' v' g' t' k' c' m' E' j' g' o' k' u' t' { '3; \*45+; 484; Ō 4857\*422; + Ō)  
[6\_1 CŌM' w' u' c' k' s' g' / Ō' k' p' m' i' v' Ō' k' e' p' g' . 'C' Ō' T' c' o' c' p' c' x' l' e' k' w' u. 'I' Ō' T' w' m' p' c' k' s' g' ' g' v' c' r' Ō' C' ' u' w' h' c' e' g' t' r' e' u' o' q' p' ' t' g' u' a' p' c' e' p' e' g' ' l' o' o' w' p' q' u' g' p' u' q' t' ' h' t' ' j' w' o' c' p' i' t' q' y' v' j' ' j' q' t' o' q' p' g' ' d' c' u' g' f' ' q' p' ' h' t' c' i' o' g' p' v' g' f' ' c' p' v' d' q' f' l' e' u. 'C' p' c' n' v' l' e' c' i' Ō' g' y' q' f' u' 7\*3; +; 697966985\*4235+ Ō)

# DEPOSITION OF THIN FILMS ON STRUCTURED SURFACES

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Miniaturisation of laser systems along with still holding high requirements for optical elements, raises demand for novel elements, with 2D or even 3D spatial refractive index modulation, as photonic crystals [1]. Possibilities of state-of-the-art fabrication technologies of such structures are limited due to restricted control over the formation at nanoscale. An alternative fabrication method is based on the deposition of multilayer optical coatings on modulated surfaces employing physical vapor deposition (PVD) technologies. Deposition of multilayer interference coating creates the modulation of the effective refractive index modulation in vertical direction, while pre-structured substrate surface introduces modulation in horizontal direction as well (fig. 1 A). In order to fabricate thin film based periodic structure, precise control of layers deposition is required, which leads to investigating the possibilities of conventional physical vapour deposition technologies to form such nanostructured elements.

This work presents primary experimental and theoretical results of conformal deposition of multilayer structure and formation of periodically organized microstructures on modulated surfaces. Experimental part was performed employing energetically diverse PVD technologies based on sputtering and evaporation processes. Energetic thin film deposition technology as Ion Beam Sputtering (IBS) is well-established and stands out for its highly controlled, densely packed optical coatings fabrication. On the other hand, deposition of low-energy particles potentially may help to form periodically organized microstructures with controlled porosity. In such case evaporation of thin film together with GLancing Angle Deposition (GLAD) method is required. GLAD allows to form the so called sculptured thin films by directing vapor flux towards the substrate at oblique angle. In case of periodic grating several variables appear: structured substrate relative orientation during the deposition process and the angle subtended between the substrate normal and the incident vapour flux. Considering many variables, it is important to evaluate the dependence of final structure on these values. Primary numerical simulations were performed employing NANO SCALE Modeling (NASCAM) software based on kinetic Monte Carlo algorithm [2]. This software does not take into account the vibrational movement of atoms, hence allows to investigate time evolution of relatively large systems containing millions of atoms. As both experimental and simulation results showed, film growth mode heavily depends on energy of incoming flux as well as on substrate orientation. As a result, main arising problems have been identified as modulation extinction after several layers (Fig. 1 B) and cracks formation (Fig. 1 C).

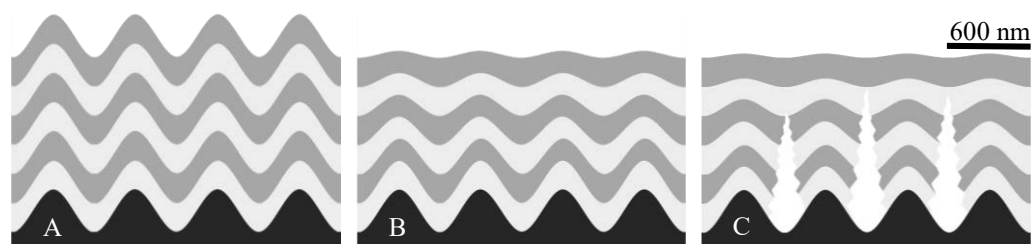


Fig. 1 Schematic representation of (A) an ideal conformally deposited multi-layer coating on periodically corrugated surface; (B) Planarization of surface modulation with increase of deposited coating thickness; (C) Planarization effect along with cracks formation.

The aim of this research is to evaluate the growth mechanism of multilayer optical coatings on modulated surfaces and compare theoretical results with experimental measurements. Experimental part was performed with different PVD technologies, as IBS and electron beam evaporation with GLAD method. The possibility to control the coating formation in both ways: conformally cover modulated surface and periodic microstructure deposition, will be presented during the conference.

[1] L. Grinevičiūtė, C. Babayigit, D. Gailevičius, E. Bor, M. Turdjev, V. Purlys, T. Tolenis, H. Kurt, and K. Staliūnas. "Angular filtering by Bragg photonic microstructures fabricated by physical vapour deposition." *Appl Surf Sci.*, 481, pp. 353 – 359 (2019)

[2] Moskovkin, P., & Lucas, S. Computer simulations of the early-stage growth of Ge clusters at elevated temperatures on patterned Si substrate using the kinetic Monte Carlo method. *Thin solid films*, 536, 313 – 317 (2013)

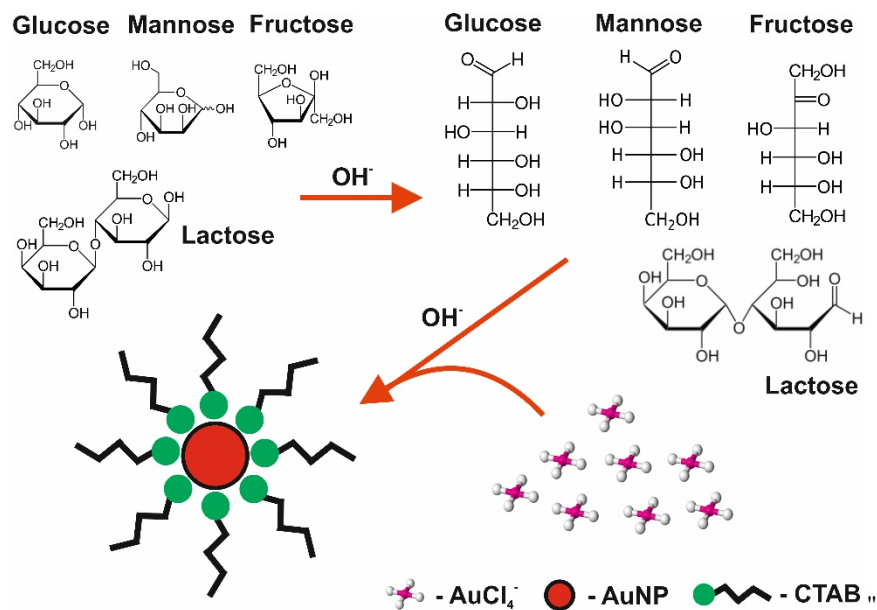
**VJ G'GXCNWCVKQP 'QHMKP GVKE 'QRVKE CN'TGF WEKPI 'UWI CT'UGPUQT''  
DCUGF 'QP'I QNF 'P CP QRCT VKE NG'HQTO CVKQP''**

Dpggf kmcu'Dtcukwpcu<sup>3</sup>. 'Cpvqp'Rqr qx<sup>3</sup>. 'Cmo ktc'Tco cpcxlekgp<sup>3</sup>

<sup>3</sup>P cpqVgej pcu'ó'Egpvt'qh'P cpqvej pqmji { 'cpf 'O cvgtkcu'Uelgpeg. 'Kpukwg'qh'Ej go knt { 'Hewm' 'qh'Ej go knt { 'cpf' I gquekpegu. 'Xkpkwu'Wpkxgtukf. 'P cwi ctf wmq'uv046. 'NV/25447. 'Xkpkwu. 'Nkj wpcleO' dpggf kmcu'0itcukwpcuB ej i hXw0h'

Tgf welpi 'uwi ctu'ctg'hqwpf 'kp'cdwfp cpeg'kp'yj g'hqf 'yj cv'y g'gcv'gxgt { 'f c { 'U'U'peg'qxgteqpuwo r v'kqp'qh'uiw ctu'ecp'dg' tgrcvf 'v'xctkqu'f kugcugu'wej 'cu'f kcdgvgu. 'qdgukf. 'j gctv'f kugcug. 'cpf 'xctkqu'q'v'j gt 'f kuqtf gtu. 'yj g'b qpkqtkpi 'qh'tgf welpi' uwi ct'rgxgru'kp'hqf' 'cpf 'q'v'j gt' o gf kwo u'ku'cp'ko r q'tcvp'v'cun'j3\_0C'u'wej. 'uwi ct'f g'vekqp'o gj qf u'ctg'dgkpi 'eqpuwcv'v' ko r tqxgf 'uggnkpi 'uko r rgt. 'ej gcr gt. 'cpf 'o q'tg'ceew'cv'g'f g'vekqp'0'Ewtg'p'v' 'pcp'qo cvgtkcu'r m { 'cpf 'ko r q'tcvp'v'tq'rg'ht' tgf welpi 'uwi ct'f g'vekqp'cev'kpi 'cu'cpcn'f v'ecn'uki pcn'r tqxkf gtu'qt' dgkpi 'wugf 'hqt' cpcn'f v'ecn'uki pcn'co r nk'k'ecv'kqp. 'hqt' gzco r rg. 'kp' qtf gt' v'q'ko r tqxg' g'rg'ev'qp' v'cpuhgt' m'p'g'v'eu. 'kpet'g'culpi 'ugpu'k'k'x'k'v'. 'tgr tqf veldk'k'v'. 'cpf' 'u'cd'k'k'v' 'qh' 'yj g' ugpuqtu'j4\_0' I qrf 'dcugf' 'pcp'qo cvgtkcu' \*CwP R+' c'tg' 'yj g' o quv' y gm'npqy p. 'w'p'f' gtu'q'q'f. 'cpf' 'wugf' 'qr' v'ecm'f 'cev'x'g' pcp'qo cvgtkcu'0T gi ctf lpi 'yj g'k'v'p'k' w'g'r'j { u'lec'n'c'p'f 'q'r' v'ec'n'r' t'q'r' g't'v'g'u'c'w'p' R'u'j' c'x'g' d'g'g'p' g'z'v'p'k'x'g' n'f 'g'o r m { g'f 'k'p'f' k'ht'g'p'v' cpcn'f v'ecn'u'f' u'go u'v'q' u't'g'p'i 'yj g'p' g'z'k'k'p'i 'uki pcn. 'qt' 'cu'c' u'g'r' c't'c'v'g' u'ki pcn'k'p' k'ug'h'j4. '5\_0'H'qt' g'z'co r rg. 'yj g' h'q'to' c'v'k'q'p' q'h' CwP Ru. 'k'p'f' w'eg'f' d' { 't'g'f' w'el'p'i' 'u'w'i' c't'u' 'e'c'p' d'g' w'ug'f' 'c'u' c'p' c'p'c'n'f' v'ec'n'r' u'ki' p'c'n'j6\_0' U'g'p'u'q't'u' 'y' c'v' w'ug'f' 'y' g' h'q'to' c'v'k'q'p' q'h' pcp'qo cvgtkcu'cu'uki pcn'ecp'j' c'x'g' w'p'k' w'g'c'p'c'n'f' v'ec'n'r' c't'c'o' g'v'g't'u'k'p'eg' 'y' g'c'p'c'n'f' v'ec'n'r' u'ki' p'c'n'k'u'i' q'x'g't'p'g'f' d' { 'p'c'p'q'o' c'v'g't'k'c'u' u' { p'v'j' g'uk'v' m'p'g'v'eu'c'm'y' k'p'i' h'q't' u'q'r' j' k'k'ec'v'g'f' 'c'p'c'n'f' u'k'u'q'h' u'k'o' k'c't' 'c'p'c'n'f' v'g'o' k'z'w't'g'u'0F' w'g'v'q' C'w'P' R'q'r' v'ec'n'r' t'q'r' g't'v'g'u' u'k'o' r' r'g' f' g'vekqp'o' g'j' q'f' u'w'ej' 'c'u' W'X' x'k'u' r' g'ew'q'ue'q'r' { 'e'c'p' d'g' g'o' r' m { g'f' 'v'q' b' q'p'k'q't' C'w'P' R'u' h'q'to' c'v'k'q'p' t'g'u'w'k'p'i' 'k'p'c' h'c'u'v'c'p'f' 'p'q'p' f' g'u't' w'e'v'x'g'f' g'vekqp'0

Kp'yj ku'y qtn'yj g'hqto c'v'k'q'p' q'h' CwP R' t'g'u'w'k'p'i' 'h'q'to' 'c'p' q'z'k'f' c'v'k'q'p' / t'g'f' w'el'p'i' t'g'c'v'k'q'p' q'h' J CwEn' k'p' 'y' j' r' t'g'ug'peg' q'h' t'g'f' w'el'p'i' 'u'w'i' c't'u' y' c'u' w'ug'f' h'q't' 'y' j' g'f' g'x'g'r' o' g'p'v'q'h' 'c'p' q'r' v'ec'n' u'g'p'u'q't' 0Q'r' v'k'o' c'n'q'z'k'f' c'v'k'q'p' / t'g'f' w'el'p'i' t'g'c'v'k'q'p' 'e'q'p'f' k'k'q'p'u'y' g't'g' f' g'v'g'to' k'p'g'f' 0V'j' g'f' g'x'g'r' g'f' 'c'p'c'n'f' v'ec'n'u'f' u'go 'y' c'u' g'x'c'm'ev'g'f' 'y' k'j' 'b' o' q'f' g'n'f'c'o' r' r'g'u' q'h'i' n'w'eq'ug. 'h'w'ev'q'ug. 'i' c'n'ev'q'ug. 'r'ev'q'ug. 'cpf' 'o' c'p'p'q'ug' c'u' y' g'm'c'u' t'g'f' w'el'p'i' 'u'w'i' c't' 'o' k'z'w't'g'u'0V'j' g'k'o' r' c'ev' q'h' CwP R' h'q'to' c'v'k'q'p' m'p'g'v'eu' q'p' 'y' j' g' c'p'c'n'f' v'ec'n'r' c't'c'o' g'v'g't'u' y' c'u' g'u'c'd'k'ij' g'f' 0C'f'f' k'k'q'p'c'm'. 'y' j' g'f' g'x'g'r' g'f' u'f' u'go 'y' c'u' v'g'ug'f' 'y' k'j' 't'g'c'n'f'c'o' r' r'g'u'0



Hki 030Qz'k'f' c'v'k'q'p' / t'g'f' w'el'p'i' t'g'c'v'k'q'p' 'c'p'f' 'i' q'rf' 'p'c'p'q'r' c't'v'eng' u'f' p'v'j' g'uk'u'w'ej' g'o' g'0

[3]\_I 0C0Dtc { 'U0L0P' k'gn'p. 'D0O 0'R'q'r' m'p. 'E'q'p'w'o' r' v'k'p' q'h'f' k'i' j' / h'w'ev'q'ug' 'e'q't'p' u'f' t'w'r' 'k'p' d'g'x'g't'c'i' g'u'o' c' { 'r' n' { 'c' 'l'q'rg' 'k'p' 'y' j' g' r' k'f' g'o' k'e' q'h' q'd'g'uk'f'. 'C'o' 0'1'U' E'rk'p'0P' w't'09; \*6+; '759/765' \*4226+0' ]  
 [4]\_C'0T'co' c'p'c'x'le'k'w'u. 'P'0'1' g't'o' c'p. 'C'0T'co' c'p'c'x'le'k'p'p. 'G'x'c'n'c'v'k'q'p' q'h' g'ng'ev'q'p' v'c'p'uh'g't' 'k'p' g'ng'ev'q'ej' g'o' k'ec'n'f'u'f' u'go 'd'c'ug'f' 'q'p' 'k'o' o' q'd'k'k'f' g'f' 'i' q'rf' 'p'c'p'q'r' c't'v'eng'u' c'p'f' 'i' n'w'eq'ug' q'z'k'f' c'ug. 'G'rg'ev'q'ej' g'o' 0'U'q'e'0386\*6+ 'I' 67//I' 6; \*4239+0' ]  
 [5]\_C'0T'co' c'p'c'x'le'k'p'p. 'U'0X'q't'q'p'q'x'le. 'C'0R'q'r' q'x' g'v'0'c'n'0' k'p'x'g'uk'i' c'v'k'q'p' q'h' d'k'ec'v'n'f' v'ec'n'g'p'r'c't'i' g'o' g'p'v'q'h'i' q'rf' 'p'c'p'q'r' c't'v'eng'u' w'uk'p'i' 'f' { 'p'c'o' k'e' 'h'i' j' v'ue'c'v'g't'k'p'i' 'c'p'f' c'v'q'o' k'e' 'h'q't' g'o' k'et'q'ue'q'r' { 'E'q'm'k'f' u' 'U'w'f'0C' 'R'j' { 'u'le'q'ej' g'o' 0C'p'i' 0C'ur' 0732. '3: 563: ; \*4238+0' ]  
 [6]\_D'0'D'0'c'uk'w'p'c'u. 'C'0'R'q'r' q'x. 'C'0T'co' c'p'c'x'le'k'w'u. 'C'0T'co' c'p'c'x'le'k'p'p. 'I' q'rf' 'p'c'p'q'r' c't'v'eng' d'c'ug'f' 'e'q'm'k'f'o' g'v'k'e' u'g'p'uk'p'i' 'u't'c'v'g'i' { 'h'q't' 'y' j' g'f' g'v'g'to' k'p'c'v'k'q'p' q'h' t'g'f' w'el'p'i' 'u'w'i' c't'u'. 'H'q'f' 'E'j' g'o' k'nt { . '34; 45: . \*4243+0' ]

# LEAD HALIDE PEROVSKITE NANO- AND MICROLASERS FOR GAS SENSING APPLICATIONS

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Over the last 5 years, lead halide perovskite nano- and microstructures have emerged as promising laser medium exhibiting low generation threshold and high quality factor ( $Q$ ) modes. Among these lasers, external cavity-free single-crystal nanowires and microplates are the most available. They possess high optical gain, well-shaped reflective end facets, and can be grown by cost-effective and large-scale wet chemical approaches at moderate temperature (50–80 °C). One of the possible applications for such lasers could be optical sensing of volatile substances: various organic solvents and hydrogen halides. However, detecting of volatile organic molecules at low concentrations cannot be realized for isolated perovskite nanowire or microplate laser on an ordinary substrate since optical eigenmodes in high refractive index perovskite ( $n \approx 2.3$ ) do not interact effectively with the surrounding low refractive index medium. To address this issue, a perovskite laser needs to be coupled with a whispering gallery mode (WGM) polymer cavity [1] or should be deposited on a nanoporous substrate capable of changing its refractive index owing to the gas sorption process. On the contrary, detecting hydrogen halides vapors with perovskite lasers does not require the change of the refractive index of the surrounding medium because the vapor modifies the surficial chemical composition of the perovskite resonator due to halide exchange reaction [2, 3]. As a result, the change in the complex refractive index for the surface could invoke a small spectral shift of laser modes.

Herein we report on  $\text{CsPbBr}_3$  nanowires and microplates deposited on a nanostructured indium tin oxide (ITO) substrate (Fig. 1) consisting of ITO whiskers and similar substrate consisting of  $\text{ITO}/\text{Al}_2\text{O}_3$  whiskers by using a simple wet chemical approach. Perovskite crystals were synthesized on an amorphous  $\text{SiO}_2/\text{Al}_2\text{O}_3$  substrate with island-like surface morphology. Thereafter, they were suspended in non-polar solvent via ultrasonication and deposited on the nanostructured substrates. The obtained perovskite cavities show room-temperature laser generation and high- $Q$  laser modes owing to low refractive index ( $n \approx 1.15$ ) of the substrates. Optical sensing of acetone and hydrogen iodide vapors at different concentrations is discussed.

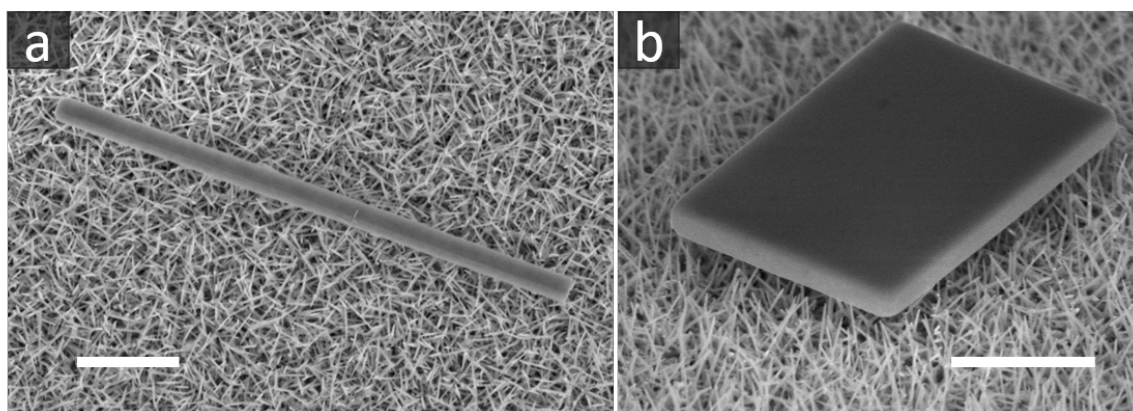


Fig. 1. (a,b) SEM images of  $\text{CsPbBr}_3$  nanowire and microplate on nanostructured ITO substrate (scale bars are 1  $\mu\text{m}$ ).

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**P/F QRGF 'TGF WEGF 'I TCRJ GP G'QZKF G'CU'GNGEVTQF G'O CVGT KCN'  
HQT'J [ FTQI GP 'RGTQZKF G'GNGEVTQEJ GO KCN'UGPUQT "**

Lwukpc'I ckl wngxk<sup>3</sup>. "T cuc"Rcwkwnekv<sup>3"</sup>

<sup>3</sup>F gr ctvo gpv'qih'P cpqgpi kpggtkpi . 'Egpvt' hqt' Rj { ulecn'Uekpegu'cpf 'Vgej pqmji { . 'Ucxcpqtkw'Cxg0453. 'NV/24522'  
Xkrkku. 'Nkj wpcik"

lwukpc'i ckl wngxk B ho e0n'

"

J { f tqi gp'r gtqz kf g'ku'y g'o quw'ucdr'g'cpf 'cdwfp cpv't gcevkxg'qz { i gp'ur geku'kp'cp'qti cpluo 'cpf 'r t gupv'kp'o cp { " dlqmqi kecn'r t qeguugu' ]3\_0K'ku'c'i gpgtcrn'gp] { o ckle'r tqf wev'qh'qz kf cugu'cpf 'c'uwduw'cv'gh'r gtqz kf cugu. 'y j lej 'ct g'lo r qt vcpv' kp'dkqmqi kecn'r t qeguugu'cpf 'dlquguquu'0J\_4Q4'ku'cnuq'cp'guugpvcn'io gf kwqt'kp'hqdf . 'r j cto cegwkecn'ekplecn'kp'wnt kn'cpf " gp'xkt qpo gpvcn'pcn'uku' ]4\_0' S wcpkcvkxg' f gvevkp' qh' J\_4Q4' j cu' ko r qt vcpv' uelgpv'kle" uki pklecpeg" hqt' wpf gt ucpcp' kpi " kptcegmwrt' uki pcn'itcpuf wevkp'cpf 't gcrk' kpi " y j g'pqto cni'hwpevkp'qh'egm'0Vj g'f g'xgrqr o gpv'qh'ny " equv. " j k j / ur ggf . " wpeqo r rkecvf . " j k j n' " ugrvevkxg. " cpf 'ugpukxg' J\_4Q4' ugpqu'ct g' guugpvcn'io

Chgt' f' kueqxtg' kpi " y j g'gzkuvgpeg' qh'i tcr j gpg' d { " C0I glo " cpf " MOP qxqurqx. " y j ku'pgy " o cvgt kn'ku'qpg' qh' y j g'o quw' egrgdtcvf " f' kueqxtg' kpi " r t gupv' " kp' y j g' hgrf " qh' o cvgt kn' uelpege " ]5\_0' U' Xgxt crn' wpls wv' r tqr gt vgu' qh' i tcr j gpg' o cng' k' c" ecr cdr' eqpvpf gt 'vq' dg' wugf " cu'c' ugpqu'0Vj g' eqplwi cvgf " ut wewt g' qh' i tcr j gpg' ecp' hcekrkcv' y j g' g' r' g' r' g' t' cp' u' h' t' d' g' y g' p' y j g' dlq' t' g' e' g' r' q' t' p' f' t' cp' u' f' w' e' g' t' . " y j lej ' e' c' p' i' g' p' g' t' c' v' g' j k j ' u' k' i' p' c' n' i' u' g' p' u' k' x' k' v' l' h' q' t' g' r' e' v' t' q' e' j' g' o' k' e' c' n' i' u' g' p' u' q' t' u' 0' V' j' g' l' p' e' q' t' r' t' q' t' c' v' k' p' " qh' i tcr j gpg' cpf 'ku' t' g' w' v' f' p' c' p' q' o' c' v' g' t' k' e' n' i' p' " \* d' k' u' g' p' u' q' t' ' v' e' j' p' q' m' i' k' u' j' c' x' g' u' j' q' y' p' i' t' g' e' v' r' t' q' o' k' u' g' f' w' g' v' q' k' u' j' k j ' u' w' t' h' e' g' " c' t' g' c' " \* 4852 " o " 4 " i " / 3 + " g' r' e' v' t' q' e' j' o' q' d' k' r' k' v' l' c' v' t' q' q' o' ' v' g' o' r' g' t' c' w' t' g' " \* w' " v' q' 422222 " e' o " 4 " X " / 3 " u " / 3 + " e' j' g' o' k' e' c' n' i' u' d' k' r' k' v' l' c' p' f' k' u' e' c' r' c' e' k' v' l' " v' q' k' o' o' q' d' k' r' k' v' l' g' c' x' c' t' k' g' v' l' q' h' f' k' h' g' t' g' p' v' d' k' q' o' q' r' e' w' e' g' u' o' 0' o' q' t' g' x' g' t' . " e' j' g' o' k' e' c' n' i' f' q' r' k' p' i' q' h' i tcr j gpg' d' c' u' g' f' ' b' o' c' v' g' t' k' e' n' i' u' g' p' u' q' t' u' 0' V' j' g' l' p' e' q' t' r' t' q' t' c' v' k' p' " g' h' g' e' v' k' x' g' o' g' y' q' f' v' q' b' o' q' f' k' h' l' ' o' c' v' g' t' k' e' n' i' p' o' t' k' p' u' e' c' m' f' . " c' k' r' k' v' l' g' r' e' v' t' q' e' j' p' l' e' r' t' q' r' g' t' v' g' u' . " b' o' c' p' k' r' w' e' v' g' u' w' t' h' e' g' e' j' g' o' k' u' t' { . " c' p' f' r' t' q' f' w' e' g' " m' e' c' n' i' e' j' c' p' i' g' u' v' q' y' j' g' g' r' o' g' p' v' c' n' i' e' q' o' r' q' u' k' k' p' q' h' j' q' u' v' o' c' v' g' t' k' e' n' i' ] 5\_0'

Vj g'clo " qh'y ku'y qnily cu'v'q'r tqf weg'P / f qr gf 't' gf wegf 'i tcr j gpg' qz kf g' \* t I Q + cpf 'v' q' kpxguki cvg'ku'ugpukxk'v' 'kp' y j g' pqp/gp] { o ckle'f gvevkp'qh'j } { f tqi gp'r gtqz kf g'0"

I Q' y cu' r tgr ctgf " h' t' q' o' p' c' w' t' c' n' i' t' c' r' j' k' g' " w' u' k' p' i' " y' j' g' u' p' v' j' g' u' k' i' r' t' q' v' e' q' n' t' g' r' q' t' v' g' f' d { " [ c' p' " g' v' c' i' o' ] 6\_0' k' p' c' " v' r' k' e' c' n' i' g' z' r' g' t' k' o' g' p' v' i' t' c' r' j' k' g' r' q' y' f' g' t' y' c' u' t' g' c' v' g' f' y' k' j' e' q' p' e' g' p' v' t' c' v' g' f' " J\_4UQ6. " M' u' U' Q. " c' p' f' " R\_4Q\_7\_0Vj g' q' d' v' c' l' p' g' f' r' t' g' / q' z' k' f' k' g' f' i' t' c' r' j' k' g' " y' c' u' u' w' d' l' e' g' e' v' f' v' q' q' z' k' f' c' v' k' p' d' { " J\_7\_0Vj g' y' j' g' t' o' c' n' i' l' i' Q' y' c' u' l' t' q' f' w' e' g' f' " h' t' q' o' " I\_4Q\_7\_0Vj g' y' j' g' t' o' c' n' i' l' i' q' e' m' b' o' g' y' q' f' 0Vj g' f' t' k' e' f' " I\_4Q\_7\_0Vj g' y' j' g' t' o' c' u' s' w' e' m' f' " k' p' u' g' t' v' g' f' " k' p' v' c' r' t' g' j' c' v' g' f' " w' d' w' r' t' " h' m' t' p' e' g' c' v' c' " v' g' o' r' g' t' c' w' t' g' q' h' i' e' d' q' w' : " 22\_0' k' p' C' t' c' v' o' q' u' r' j' g' t' g' 0Vj k' p' t' q' f' w' e' g' P / h' w' p' e' v' k' p' e' r' k' k' e' u' . " y' j' g' t' i' Q' u' w' t' h' e' g' y' c' u' b' o' q' f' k' h' e' f' " y' k' j' i' c' u' g' q' u' w' " c' o' o' q' p' k' c' v' ; " 72\_0' k' h' t' : " j' q' t' y' k' j' b' g' r' o' k' p' g' v' 922\_0' k' h' t' ' 3' j' ] 8\_9\_0Vj g' q' d' v' c' l' p' g' f' o' c' v' g' t' k' e' n' i' u' g' t' g' e' j' c' t' c' e' v' t' k' g' f' d { " f' k' h' g' t' g' p' v' " o' g' y' q' f' u' " \* g' r' o' g' p' v' c' n' i' c' p' c' n' i' u' k' i' . " D' G' V' " o' g' c' u' w' t' g' o' g' p' v' . " U' G' O' " k' p' x' g' u' k' i' c' v' k' p' u' . " T' c' o' c' p' " u' r' g' e' v' t' q' e' j' q' e' r' { +0' " G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' o' g' c' u' w' t' g' o' g' p' u' . " k' p' r' c' t' w' e' w' r' t' . " e' { e' r' k' e' " x' q' n' c' o' o' g' t' { " c' p' f' " g' r' e' v' t' q' e' j' g' o' k' e' c' n' i' o' r' g' f' c' p' e' g' u' r' g' e' v' t' q' e' q' r' { " y' g' t' g' w' u' g' f' v' q' g' x' c' n' o' v' g' y' j' g' " q' d' v' c' l' p' g' f' " u' c' o' r' n' g' u' u' g' p' u' k' x' k' v' l' " v' q' y' c' t' f' j' " { f' t' q' i' g' p' r' g' t' q' z' k' f' g' f' g' v' e' v' k' p' o' "

Vj g' t' guwuu' f go quutcvf' y j cv'chgt' y j g' t' g' f' wevkp' qh' I Q. " c' e' j' c' t' c' e' v' t' k' u' k' e' " o' q' t' r' j' q' m' i' { " q' h' i' Q' c' p' f' " P / f' q' r' g' f' " t' i' Q' " q' e' e' w' t' u' l' p' f' g' r' g' p' v' q' p' y' j' g' h' w' p' e' v' k' p' e' r' k' k' e' v' k' p' r' t' q' v' e' q' n' o' q' t' g' x' g' t' . " k' y' c' u' q' d' u' g' t' x' g' f' . " y' j' c' v' x' c' t' k' q' u' a' p' k' t' q' i' g' p' u' r' g' e' k' u' l' p' e' n' f' k' p' i' " r' { t' k' f' k' p' l' e' / P . " r' { t' t' q' i' k' e' / P " c' p' f' " s' w' c' v' t' p' c' t' / P " y' j' g' t' g' f' g' v' e' g' v' f' " k' p' y' j' g' P / f' q' r' g' f' " t' i' Q' 0' D' G' V' " o' g' c' u' w' t' g' o' g' p' v' t' g' u' w' u' r' t' q' x' g' y' j' c' v' c' n' i' r' t' g' r' c' t' g' f' " u' c' o' r' n' g' u' y' g' t' g' o' g' u' q' / " c' p' f' " b' o' c' e' t' q' r' q' t' q' u' w' i' p' c' w' t' g' 0' k' p' c' f' f' k' k' q' p' . " c' h' g' t' y' j' g' t' o' o' q' p' k' e' / t' g' e' v' o' g' p' v' c' v' j' k' j' " v' g' o' r' g' t' c' w' t' g' u' . " d' q' j' " D' G' V' u' w' t' h' e' g' c' t' g' c' " c' p' f' " r' q' t' g' x' q' n' o' g' " q' h' i' y' j' g' u' c' o' r' n' g' u' u' k' p' e' t' g' e' c' u' g' f' " e' q' o' r' c' t' g' f' " v' q' y' j' g' r' t' k' u' k' p' g' " I\_4Q\_7\_0Vj g' t' i' Q' 0' H' k' p' c' m' f' . " y' j' g' e' q' p' f' w' e' g' f' " g' r' e' v' t' q' e' j' g' o' k' e' c' n' i' o' g' c' u' w' t' g' o' g' p' u' j' k' j' n' i' j' v' g' f' " y' j' c' v' P / f' q' r' g' f' " t' i' Q' " e' q' w' r' f' " d' g' c' r' t' q' o' k' u' p' i' " g' r' e' v' t' q' e' j' g' o' c' v' g' t' k' e' n' i' h' t' " y' j' g' f' g' v' e' v' k' p' q' h' j' } { f' t' q' i' g' p' r' g' t' q' z' k' f' g' 0' "

**CEMPQY NGFI O GPVUUVj ku'r tqlgev'j cu'tgegkxgf' hwpf kpi " h' t' q' o' " G' w' t' q' r' g' c' p' " U' q' e' k' n' i' H' w' p' f' " r' t' q' l' g' e' v' P' q' 2; 65/NO V/M/ 934/3; /2272+ w' p' f' g' t' i' t' c' p' v' c' i' g' g' o' g' p' v' y' k' j' " y' j' g' T' g' u' g' c' t' e' j' " E' q' w' p' e' k' i' q' h' N' k' j' w' c' p' k' e' " \* NO VNV+0'**

[3]\_X0M'no ct. "TMDI w' c. "TMDI w' p' f' c' o' r' c' k' " F' O' M' U' l' p' i' j' . " U' O' q' i' c' p' . " U' j' 0' j' c' u' p' . " O' 0' O' c' n' k' k' c' . " G' p' i' c' p' e' g' f' " g' r' e' v' t' q' e' j' " t' c' p' u' h' t' " o' g' f' k' e' v' g' f' " f' g' v' e' v' k' p' q' h' j' { f' t' q' i' g' p' r' g' t' q' z' k' f' g' w' u' k' p' i' " c' " u' k' x' g' t' " p' e' p' q' r' c' t' k' e' g' o' t' g' f' w' e' g' f' " i' t' c' r' j' g' p' g' z' k' f' g' o' r' q' n' c' p' k' i' p' g' " h' e' d' t' e' c' k' e' v' g' f' " g' r' e' v' t' q' e' j' g' o' k' e' c' n' i' u' g' p' u' q' t' . " T' U' E' " C' f' x' e' p' e' g' u' : " \* 83; / 853 " \* 423: -0'

[4]\_J 0'Uj co nj erkej gpcr. "L0Y 0'Ej qk" T' g' x' l' y' o' P' q' p' / G' p' ] { o' c' v' k' e' " J\_4Q\_7\_0Vj { f' t' q' i' g' p' r' g' t' q' z' k' f' g' " G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' u' g' p' u' q' t' u' " D' c' u' g' f' " q' p' " T' g' f' w' e' g' f' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' " L' q' w' t' p' c' n' i' q' h' V' j' g' G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' u' q' e' l' g' v' f' " 389. " 259753 " \* 4242+0'

[5]\_Y 0'f w' "NOUuk' l' 0'j ckl ep. "NOUkg. "R' t' q' i' t' g' u' u' k' p' y' j' g' h' w' p' e' v' k' p' e' r' o' q' f' h' e' c' k' e' v' k' p' q' h' i' t' c' r' j' g' p' g' l' i' t' c' r' j' g' p' g' z' k' f' g' c' z' t' g' x' l' y' . " T' U' E' " C' f' x' e' p' e' g' u' 32. " 3754: / 37567 " \* 4242+0'

[4]\_Z' 0' [ c' p' . " I' 0' E' j' g' p' . " I' 0' [ c' p' i' . " S' 0' Z' w' g' . " R' 0' O' k' e' g' . " H' e' d' t' e' c' k' e' v' k' p' " q' h' i' H' i' g' g' / U' c' p' f' k' p' i' . " G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' " C' e' v' k' x' g' . " c' p' f' " D' i' k' e' q' o' r' c' e' k' d' r' i' g' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' R' q' n' c' p' k' i' p' g' c' p' f' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' R' q' n' c' p' k' i' p' g' J\_4Q\_7\_0Vj { d' t' k' f' " R' e' r' g' u' " C' r' r' 0' O' c' v' g' t' 0; . " 4743-474; " \* 4232+0'

[7]\_Y 0'Uj wo o gtu. "T0G0Qhgo cp. "R' t' g' r' c' t' e' v' k' p' q' h' i' t' c' r' j' k' e' " Q' z' k' f' g' . " I' 0' C' o' 0' E' j' g' o' 0' U' q' e' 0; " 2. " 355; " \* 3; " 7: -0'

[8]\_L0Nqpi . "Z0Zlg. "L0Zw' S' 0' i' w' N0Ej gp. "Z0Y' epi . "P' k' t' q' i' g' p' / F' q' r' g' f' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' P' c' p' q' u' j' g' g' u' c' u' o' g' v' c' n' H' i' g' g' / E' c' v' n' f' u' w' i' h' t' " C' g' t' q' d' l' e' " U' g' r' e' v' k' x' g' / Q' z' k' f' c' v' k' p' " q' h' D' e' p' ] { i' t' e' " C' r' e' q' i' q' u' . " C' E' U' E' c' v' n' f' u' k' i' " 4. " 844/853 " \* 4234+0'

[9]\_ \ 0'j 0'Uj gpi . "NOUj cq. "L0L0Ej gp. "Y' 0L0Dc q. "H0D0Y' epi . "Z0J 0Zlc. "E' c' v' n' f' u' w' H' i' g' g' / U' p' v' j' g' u' k' i' q' h' P' k' t' q' i' g' p' / F' q' r' g' f' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' " I\_4Q\_7\_0Vj g' p' g' z' k' f' g' y' j' k' j' " O' g' r' o' k' p' g' c' p' f' " K' u' / C' z' e' g' m' p' v' G' r' e' v' t' q' e' c' v' n' f' u' k' i' . " C' E' U' P' c' p' q' 7. " 6572/657: " \* 4233+0'

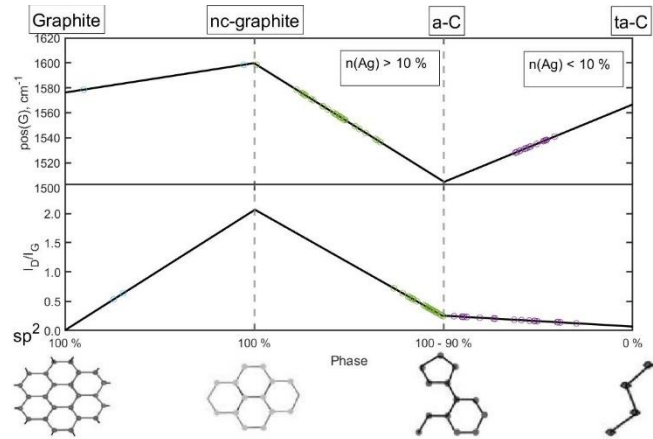
**CO QTRJ QWUF KCO QPF /NKMG'ECTDQP 'CU'C'O CVTKZ 'HQT''  
 P CPQE QO RQUK'G'RNCUO QP KE 'NK J V'CDUQTDKPI '''  
 CP VKTGHNGE VKXG'E QCVKPI U''**

Rcwkwu'F qm cpvcu<sup>3,4</sup>. 'Cw-tpk 'Lwtngxk k v<sup>3,4</sup>. 'Cuc'Vco wrgxk kgp<sup>3,4</sup>. 'Cpf tkwu'Xcukrcwuncu<sup>4</sup>.  
 T'et pcu'O g-nlpu<sup>4</sup>. 'Vqo cu'Vco wrgxk kwu<sup>3,4</sup>'

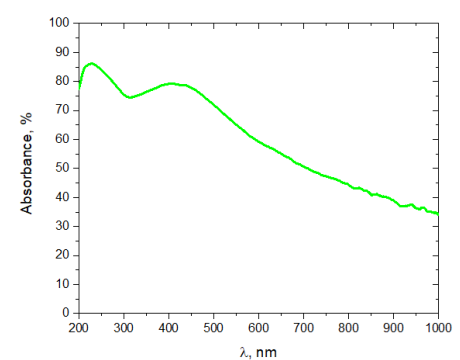
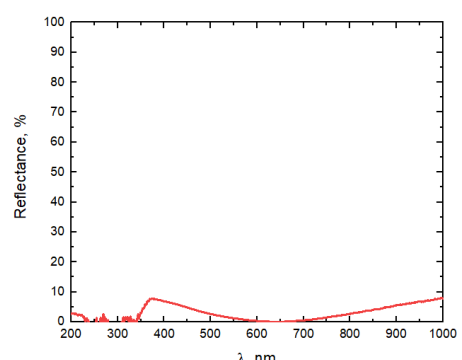
<sup>3</sup> Kpukwng'qh'O cvgtkcu'Uelgpeg'qh'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmqi { .MODct-cwunq'U07; .NV/73645'Mcwpcu.'Nkj wcpk'  
<sup>4</sup> F gr ctwo gpv'qh'Rj { uku.'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmqi { .Uwv gpv 'U072.'NV/7358: 'Mcwpcu.'Nkj wcpk'  
Rcwkwu'F qm cpvcuB mwqf w'

Cf xcpegu'lp'wvf gtucpf lpi "cpf 'cr r rlecwqpu'qh'r rno qpleu'j cu'ngf "vq'dgi kppkpi "qh'f gxgnr o gpv'qh'wpeqpxgpvkpcn'  
 cpw'tghngexg'eqcvkpi u'CTEU+lp'y j lej "cduqtdkpi 'rc' {gtu'ctg'cnuq'wugf 0J gtg.'y g'tgf wexkq'qh'tghngewpeg'qtiki kpcvgu'pqv'  
 qpn' 'Itqo 'r j cug'eqpxcu'w'cpf 'f gnt wexkq'lpvgtgtgpeg'rkng'lp'o wnkrc' {gt'CTEU.'dw'cnuq'f w'v'q'j' ki j "gz'wexkq'lp'eqcvkpi "  
 o cvgtkcu' \*j gpeg." cduqtdkpi "CTEU+0' Wukpi "r rno qpleu' uecwgtkpi "d { "pcpqr ctvrgu." y j g'tghngexk' "eqwrf "dg"tgf wrgf "  
 uki plklecpw' "J3\_0'Uvej "ut wewtgu'eqwrf "dg"lct" y j kppgt' y j cp'eqpxgpvkpcn'o wnkrc' {gt'CTEU'0Co qtr j qwu'f lco qpf /rkng'  
 ectdqp' \*FNE-'ku'cp'cwtcew'g'o cvgtkcu'v'wug'cu'o cvtkz'ht' 'Ci "pcpqr ctvrgu'0'Vj ku'ku'r tko ctkn' "f w'v'q'j' ki j "j ctg'pguu."  
 ej go kecnlpgt'pguu.'cpf 'tqy 'ht'wexkq'eqgh'elg'p'v'14\_0'

Kp'y g'r tgu'p'y qtm'y g'lp'xguki cvgf "c'ugtku'qh'wntc/vj kp" FNE-Ci 'hko u'qh'y kempgu'g'w'cp' kpi 'Itqo '72'v'522'po "  
 cpf "eqpvc'kpi "f khtg'gpv' co qwpw' qh' ukxgt'0' Pcpqeqo r qukg' hko u' y gtg' f gr qukg'f "wukpi "ewwqo "dwkrf "FE"tgcew'xg'  
 o ci pgw'q'ur wwtg'kpi "u' ugo "lp'cev'f' rpg'g'i cu'cwo qur j gtg'0' Tco cp'epcn'uku." UGO." GFZ." cduw'kq' y j g'uj qif "cpf "WX/xku"  
 ur ge'w'c'ej ctcew'g'k' cvkpu'y gtg'ect'k'g'f "qw'0' Cp'lo r qtpv'ej ctcew'g'k'w'qh'FNE'o cvtkz'ku'ku'ur<sup>5</sup> lur<sup>4</sup> d'qpf kpi 'tgr tgu'p'kpi "  
 y j g'f lco qpf "cpf "i tcr j k'g'r j cug'eqp'v'p'lp' y j g'hko u'0'Cu'uggp'ltqo "Hki 0'30'o quw'uco r ngu'hcml'k'p'v'pe/i tcr j k'g'v'c/E"  
 \*co qtr j qwu'ectdqp+'qt'c/E'v'q'c/E' \*v'gtc'j' gf tcr'c/E+'ecv'gi qt {0Uco r ngu'y kj 'tqy 'Ci "eqp'v'p'v' \*32'c'w0 -+lj' qy 'j ki j 'ur<sup>5</sup> lur<sup>4</sup>  
 d'qpf 't'v'k'eqo r ctg'f "v'uco r ngu'y kj "j ki j 'Ci "eqp'v'p'v' \*32'c'w0 -0Hki 040Uj qy u'tghngewpeg'cpf "cduqtdcpeg'ur ge'w'c'qh'  
 FNE-Ci 'y kj "'40' c'w0 'Ci 0'



Hki 030Ercu'k'w'k'w'q'qh'f gr qukg'f 'FNE-Ci 'pcp'qeqo r qukg' hko u'cee'q'f kpi "v'q'Hgttct'k'y jgg'w'ci g'o qf gn'15\_



Hki 040Tghngewpeg'ur ge'w'c'w'qh'FNE-Ci 'hko "'qp'et { ucn'k'p'g'Uk'uw'dut'cv'g'c+'cpf "cduqtdcpeg'ur ge'w'c'qh'k'f gp'w'ec'n'hko "  
 qp'hw'ug'f 'uk'k'ec'uw'dut'cv'g'c+'d+'"

[3\_] O 0M0J gf c'c'k'ep'f 'O 0Gndc'j tk'0'CPvt'ghngexg'eqcvkpi u'Eqpxgpvkpcn'w'ncn'p' 'rc' {gtu'c'p'f 'wnt'c'v'j'lp'r' rno qple' b' g'cw'w'ht'eg'u'c' 'o k'p'k'  
 t'g'x'k'y .0' 'O c'v'g'k'c'u' 'D'c'ug'n'0'x'q'f'0; . 'p'q'08."4238. 'f' qk'3205; 2 b c; 2826; 90'  
 [4\_] D00 gf pl'k'et'q'x'g'v'c'n'l'0'Qr' v'k'ec'n'f' t'q'r' g't'v'g'u'q'h'f' l'co' q'p'f' /r'k'ng'ect'd'q'p' 'c'p'f' 'p'c'p'q'et' {u'cn'k'p'g'f' l'co' q'p'f' 'h'k'o' u'0' 'L'0'Q'r'v'j'g'g'ew'p'p'0'c'f'x'0'0'c'v'g'0'x'q'f'0'90"  
 [5\_] l0T'q'd'g't'w'q'p' .0'F' l'co' q'p'f' /r'k'ng'co' q'tr' j' q'w'u'ect'd'q'p' .0' 'O c'v'g'k'c'u'0'G'p'i'0'T' 'T'g'r'q't'u'w' .x'q'f'059. 'p'q'0668. 'r' r'034; 64; 3. 'O c' { '4224. 'f' qk'3205238'1L2; 49/  
 9; 8Z \*24+22227/20'



**GXCNCVKQP 'QH'CP VEDQF KGU'KO O QDKNK CVKQP 'QP '''**  
**I QNF/EQCVGF 'O CI PGVKE 'P CP QRCTVKE NGU'**

Glo cpvcu'Dweo {u<sup>3</sup>. 'Xkmqt klc'Nku{ vg<sup>3</sup>. 'Cpvcpp'Rqr qx<sup>3</sup>'''

<sup>3</sup>P cpqvej pcu'o'Egpyt'qh'P cpqvej pami { 'cpf 'O cvgtkni'Uekpeg. 'Hewm' 'qh'Ej go knt { 'cpf 'I gquekpegu. 'Xkpkwu'  
Wpkxgtukv. 'Nkj wpcle"  
glo cpvcu'dweo {uB ej i hnwfw'kw'w"

I qnf/eqcvgf 'o ci pgve'pcpqr ctveng' "o CwP R+hmpvcvkpcrk gf 'y kj 'cpvkdqf lgu'ctg'cp'lpvgtgukpi 'ctgc'qh'tgugetej 'Ob CwP R' cr r necvkqp "kp"dlqcpn'uku'cmqy u'vq"ko r tqxg'yj g"cpn'vlecn'ej ctcevgtkne'u'qh'ko o wpqugpuqtu"wpf gt'f gxgnr o gpw'Vj gk" o ci pgve'r tqr gtvku'ctg'wghwihqt'ugr ctvkvqp'qh'yj g'cpn'v'htqo 'c'eqo r ngz'ob cvtz'wulpi 'c'ob ci pgve'kgrf "]3\_0Vj g'i qrf 'rc { gt" r tqxkf gu'dlqeqo r cvdkkx'f. 'wpls wq'qr vlecn'r tqr gtvku. 'cpf 'cmqy u'vq'wug'xctkqwu'o gjv qf u'ht'ko o qdkk'cvkqp'qh'cpvkdqf lgu'qp" yj g'uwthceg'qh'r ctveng'u]4\_0Vj g'qtkgpvcvkqp'cpf 'mcf lpi 'f gpukv' 'qh'ko o qdkk'gf 'cpvkdqf lgu'j cu'c'uki ptkc'p'v'k'p'w'p'eg'qp'yj g" cpn'vlecn'r gthqto cpeg'qh'yj g'ko o wpqugpuqt. 'y j gtgk'cpvki gp/dlpf lpi 'ecr cek' 'eqttgrv'gu'y kj 'yj g'pwo dgt'qh'ceegukdr' "Hcd" f qo cku'j]5\_0Vj g'tghqtg. 'yj gtg'ku'cp'ppi qlpi "ghqtv'k'p'ugetej 'qh'cp'qr vko cn'ko o qdkk'cvkqp'r tqvqer'k'p'v'j ku'y qtm'f khtg'p'v' o gjv qf u'qh'cpvkdqf { 'ko o qdkk'cvkqp'yj g'gxcncwv'f'OC'itgcf { 'gzk'k'p' 'lphqto cvkqp'cdq'w'ob CwP R'cpf 'yj gk'ob qf khtc'v'k'p'yj kj " cpvkdqf lgu'y cu' u'ugvo cvk'gf "cpf "qr vko cn' o gjv qf u' y gtg'ugr'ev'f'0'Vq'cej k'x'g" yj ku. "uwthceg" r nuo qpu' tgu'p'c'peg' "URT+" ur gev'queqr { . 'y j lej 'ku'j ki j n' 'ugpuk'x'g'cpf 'tgr'k'cd'g'ht' yj g'uwf { 'qh'dlqo qngewg'lpvgt'cvk'p'p'u'y cu'wugf '0'C'f'f'k'k'p'cm'f. 'wulpi " c'ob qf kht'f "Dtc'f'ht'f "cuuc { "j6\_ 'cpf "WX/xku'ur gev'queqr { 'yj g'co qwp'v'qh'ko o qdkk'gf 'cpvkdqf lgu'y cu'gxcncwv'f'0'

Vj g'o ckp'clo "qh'yj ku'uwf { 'y cu'vq' cr r n' 'f khtg'p'v'cpn'vlecn' o gjv qf u'ht' yj g'gxcncwv'k'p'qh'yj g'mcf lpi 'f gpukv' 'cpf " qtkgpvcvkqp'qh'cpvkdqf lgu'ko o qdkk'gf 'qp'v'yj g'uwthceg'qh'ob CwP R'0J qtug'cf kuj 'r gtqz'k'cug' "J TR+'cpf 'cpvkdqf lgu'ci cku'p'J TR" y gtg'wugf "ht" yj g'f guki p'qh'yj g' o qf gn'u'ugvo '0'Vj g'pwo dgt'qh'cpvkdqf lgu'ko o qdkk'gf "qp'yj g'uwthceg'qh'ob CwP Ru'y cu' f g'v'gto k'p'gf "wulpi "yj g'tg'cvk'p'p'd'gyv ggp"J TR. "J 4Q4. "cpf "5.5)7.7)vg'tco gjv { rldgp| k'k'p'g' "VO D+. "y j lej 'tgu'w'w'k'p'c'ej cpi g'qh' uq'nw'k'p' "eqm't'0'Vj g'eq'p'eg'p'v'cvk'p'qh'cpvkdqf lgu'yj cv'y gtg'p'q'v'ko o qdkk'gf 'y cu'f g'v'gto k'p'gf "wulpi "c'ob qf kht'f "Dtc'f'ht'f "cuuc { '0' URT'ob gcu'w'go gpw'yj gtg'wugf "ht" yj g'gxcncwv'k'p'qh'yj g'lpvgt'cvk'p'p'qh'yj g'ko o qdkk'gf 'cpvkdqf lgu'yj kj "J TR'0'

**Cempqy ngf i go gpw'**

Vj ku' r tq'lg'ev' j cu' tge'g'k'g'f "hmpf lpi "htqo "Gwtqr gcp" Uqelcn' Hw'p'f "r tq'lg'ev' P q'0' 2; 050/NO V/M034/44/238: + "wpf gt' i t'cp'v' ci t'ggo gp'v'y kj "yj g'T'gugetej 'Eqw'pek'qh'Nkj wpcle" "NO VNV+0'

30 Ngqpi . "U'U'U' 'Cj o cf. \ '0'Nqy . "U'U'U' 'Eco cej q. 'L'0' 'Hctcw'q. 'L'0' ( 'Nko . 'L'0' 'W'p'k'k'g' 'X'k'g' 'qh' 'O ci pgve' 'P cpqr ctveng' 'Ugr ctvkvqp' wpf gt' 'O ci pgv'qr j qt'guk'0' 'Ncpi o wkt. "58\*4: +": 2556; 277\*4242+0'  
40 Nk'j '0' 'U'ej 'ngug'p'gt. 'J '0' 'L'0' ( 'Z'w' 'U'0' 'I qrf 'pcpqr ctveng' /dcug'f 'dlq'ug'puqtu'0' 'I qrf 'D'w'ng'v'p. '65\*3+ '4; 663\*4232+0'  
50 T'w'k' . "I '0' 'V'k'r cvj k' 'M'0' 'Qm'f go . "U'0' ( 'F' t'k'ng'm 'L'0' 'F'0' 'r 'J " 'K'6 r ceu' 'y j g' 'Q' t'k'g'p'v'cvk'p'qh' 'C'p'v'kdqf { " 'C'f' u'q't'd'g'f 'q'p'v'q' 'I qrf " 'P' cpqr ctveng' '0' 'D'k'q'eq'p'lw' cvg' 'Ej go knt { . "52\*6+ '33: 4633; 3\*423: -0'  
60 V'k'r cvj k' 'M'0' ( 'F' t'k'ng'm 'L'0' 'F'0' 'S' w'c'p'v'k'k' lpi 'D'q'w'p'f 'cpf 'C'ev'x'g' 'C'p'v'kdqf lgu' 'E'q'p'lw' cvg'f 'v'q' 'I qrf " 'P' cpqr ctveng' 'C' 'E'q'o r t'g'j gpuk'x'g' 'cpf " 'T'q'd'w'w' 'C'r r t'q'cej " 'V'q' 'G'xc'nc'w'v' 'K'o o qdkk'cvk'p' 'Ej go knt { '0' 'C' 'E' 'U' 'Q'o gi c. "5\*9+ :. 4756: 47; \*423: -0'

**VJ G'VGO RGT CVWT G'P HNWGP EG'QP 'WNVTC/J K J 'O QNGE WNCT''  
Y GK J V'RQN[ GVJ [ NGP G'UVTWE VWT CN'RTQRGT VKGU'**

Newt {pcu"Vwo\_pcu<sup>3</sup>."Unkto cpwu"P qtmwu<sup>4,5</sup>."Dtki kc"Cdcngxk lgp <sup>3,6</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rj { uleu."Mcwpcu"Wpklxgtukf "qh"Vgej pqmji { ."Uwf gpv "ut072."NV/7358: "Mcwpcu."Nkj wcpkc"

<sup>4</sup>Qt vj q "Dcmlc."Vckmqu"cxg0353C."NV/73346"Mcwpcu."Nkj wcpkc"

<sup>5</sup>Egpgvt "hqt" Rj { ulecn"Uelgpegu"cpf "Vgej pqmji { ."Ucwn vgnkq"cxg05."NV/32479"Xkpkwu."Nkj wcpkc"

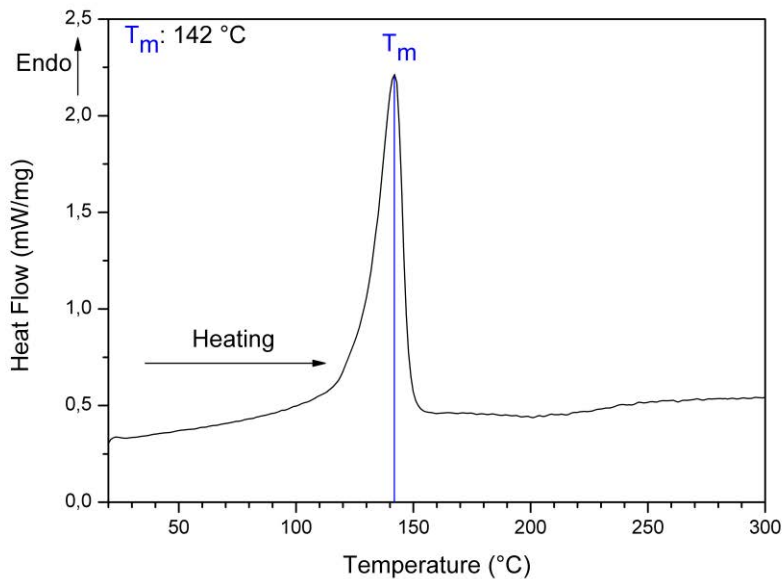
<sup>6</sup>Kpukwng"qh'O cvgtkcu"Uelgpeg."Mcwpcu"Wpklxgtukf "qh"Vgej pqmji { ."MODct-cwunq"ut07; ."NV/7358: "Mcwpcu."Nkj wcpkc"  
rwv {pcu0wo\_gpcuB\_mw0f w"

"

O gf lecn'f gxlegu"uwej "cu"ko r rcpwu"o wu'dg"dlqeqo r cvdkrg."j cto ngu"vq"rkxkpi "qti cpluo u."o wuv'pqv'ecwug"cmgti le" tgcevkpu"cpf "f q'p'qv'ej cpi g'vj gk'r tqr gt vku'q'xg"t'ko g'j3\_0Qpg'uwej "u'wduvpeg'ku'wntc/j ki j 'o qngewct'y gki j vt qn' g'v { rpgg" \*WJ O Y RG+y j lej ."ikng"qvj gt'qt vj qr gf le'ko r rcpv'o cvgtkcu'ctg'ej ctcevtk' gf "d{ 'j ki j 'dlqeqo r cvdkrkf."h'vy "eqgfhlekpv'qh' h'le'vkp."cpf "ej go lecn'f g'kucvpeg"j4\_0Ceeqtf lpi "vq"KQ"ucv'p'ctf "3; 449"sk'o r rcpwu'hqt'uwti gt { "o"Engcprkpguu'qh'qt vj qr gf le" ko r rcpwu"o"l gpgtcn'tgs wktgo g'p'v'o"ppg"qh'vj g"o clp'tgs wktgo g'p'v'u"vq"gpwug'r tqr gt "quugqk'p'v'gi tcvk'p'qh'uwti lecn'ko r rcpwu" cpf "tgf weg"cm'r quukdr'g"tkumi"qh'k'p'hev'k'p"ku"c"y cuj lpi k'ergcplki "r tqeguu."dw'engcplki "o g'v' qf u"o wuv'pqv'k'p'v'gtcev'y kj " o cvgtkcu"cpf "f co ci g'qt"qvj gty kug'ch'gev'vj gk'r tqr gt vku'cpf "utwewtg"j5\_0

Kp"vj ku"uwf { ."o gf lecn'i tcf g" WJ O Y RG"y cu" wugf 0'Vq" f g'v'gto kpg"vj g" utwewtg"qh' WJ O Y RG"r qn' o gt "ch'gt" vj g" uwgtk'k' cvk'p"cv'f k'ht'gpv'v'go r gtcw'w'gu."vj g" utwewtcn'r tqr gt vku'qh'vj g"o cvgtkcu'y g'g"cp'cn' | gf 0'Vj g"ej go lecn'dqpf u"qh' uco r ngu" y g'g" k'f g'p'w'k'g" d{ " Hqwtk'gt" v'cp'uh'qto " l'p'ht'ct'gf" ur gev't'queqr { " \*HV/KT+" vj gto cni' o cvgtkcu' r tqr gt vku" y g'g" ej ctcevtk' gf "d{ "f k'ht'gpv'uecpplki "ecm't'ko g't { " \*FUE+"uwf { ."cpf "vj g" utwewtg"qh'vj g"o cvgtkcu'y cu"cp'cn' | gf "d{ "Z/tc{ " f k'ht'cev'k'p"cp'cn' uki" \*ZTF +0'

Vj g't'guwmu'qh'vj g'FUE"uwf { "uwr r qt'v'vj g't'g'ic'd'k'k'v' "qh'vj g'ZTF "cpf "HV/KT" t'guwmu."y j g'g'cu'v'j g'FUE"t'guwmu"uj qy gf " vj cv'vj g" WJ O Y RG"r qn' o gt "utwewtg"ku"q'pn' "ch'gev'g"cv'364"ae" \*o g'nk'pi "vgo r gtcw'w'g+0'Vj g'g'ht'g."y g'ecp"uc { "vj cv'vj g" vj gto cni'g'zr quwt'g"qh'vj g"uco r ngu'cv'd'qvj "82"ae"cpf "322"ae" f q'gu"p'q'v'ch'gev'o cvgtkcu'r j { ulecn'ej go lecn'utwewtcn"cpf " vj gto cni'r tqr gt vku'0'



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**Hki 030F k'ht'gpv'uecpplki "ecm't'ko g't { 'j g'cv'k'pi "ewtxg0'**

"

j3\_ F 00 k' g'cu."C0X0Xerkwku"C0"q-qm"cpf "L0I tk-ngxk ksu."o'k'o r rcpv "k"cw'f'lpk "tgi gpgtc'k'k'qu'hetn'cu "o gf filci "c'p'cn'k' .o'42370  
j4\_ P 0C0Rc'v'n' L0P lvi v'p'c'p'f "D0M'ep'f cuwdtco c'p'k'p."o'WJ O Y RG"ht' "dlqo gf lecn'r r r'ecv'k'p'u-<R'g'ht'qto c'peg'cpf "h'w'p'v'k'p'c'k'k' cvk'p."o'G'w'f'0' R'q'n' o OLO"x'q'f'0347."j'p'q'0Q'ev'q'd'g't"423; "4242."f' q'k'3208238 l'lg'w'r q'n' o l'q'242082; 74; 0'  
j5\_ o'R VGT'P CVI'QP CN'UVCP FCTF "k'o r rcpwu'ht'uwti gt { "o "Engcprkpguu'qh'qt vj qr gf le'ko r rcpwu"o "l gpgtcn'tgs wktgo g'p'v'u"x'q'f'0423: 0'

"

**F GXGNQRO GP V'QH'GNCUVKE 'RGF QV<RU/DCUGF 'GNGE VTQEJ T QO KE''  
EQO RQUK'GU'HQT 'UVTGVEJ CDNG'GNGE VTQP KE U'CRRNKE CVKQP U''**

Lw gh'Mvekpunk<sup>3</sup>. 'O kpf cwi cu'I legxleku<sup>4</sup>. 'Nkpc'O knqkwpckg<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rj { ulecn'Ej go knt { .Hcewn' qh'Ej go knt { 'cpf 'I gquelpegu. 'Xkpkwu'Wpkxgtuk { . 'Nkj wcpk'

<sup>4</sup>F gr ctvo gpv'qh'Rj { uleu. 'Wpkxgtuk { qh'Eco dtkf i g. 'Wpkgf 'Mpi f qo "

Lw gh'mvekpunkB i o cktqo "

"

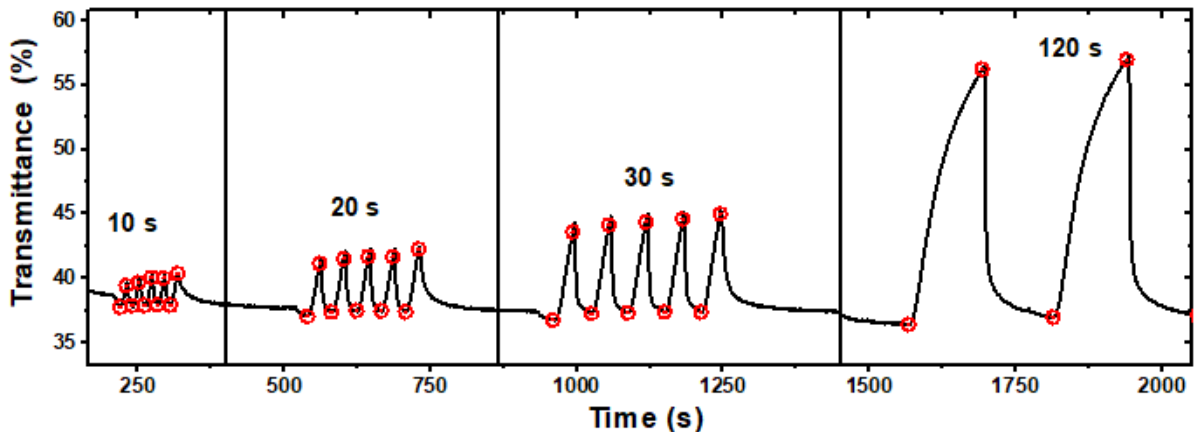
Utgej cdng' grgevtqpleu' tghgt "vq' grgevtqple" f gxlegu" cpf " o cvgtkcu" vj cv' j cxg" j ki j " grvulek { . " utgej cdkk { . " cpf " f ghqto cdkk { (0'Wprikng' vj gk' eqpxgpvkpcrleqwpvgr ctva. 'utgej cdng' grgevtqpleu' f gxlegu' ecp' wuwcm { 'dg' grmipi cvgf 'd { 'cv'rgcu' 32' " y kj qw'pqlegcdng' rquu' kp' eqpf vwxk { 'cpf 'qvj gt' hmpvkvpcrnr' tqr gt vku' ]3\_0' F gxgnr o gpv'qh' utgej cdng' cpf " grvulek " grgevtqej tgo ke' b cvgtkcu' ecp' dg' wugf 'cu' c' r tqqh' qh' eqpegr v'gej pqrqi { 'hqt' y gctcdng' f kur re { u0' hqt' g'zco r ng. 'uo cni' utggpu' o cf g' hqo " vj qwucpf u' qh' r kzgm' dwkn' d { " ucenkpi " ugxgtcn' re { gtu. " ecp' f kur re { " vgz' v' qt' " gxgp' ko ci gu' Hwtv jto qtg. " d { " eqo dlpki " f khtgtpv' grgevtqej tgo ke' b cvgtkcu' qh' tgf. 'i tggp. 'cpf " dnwg' eqmqtu' kv' ku' r quukdng' vq' b cng' b wneqmt' f kur re { " ]4\_0' "

Vj g' cko " qh' vj ku' tgugetej " y cu' vq' f gxgnr " c' utgej cdng' grgevtqej tgo ke' eqo r qukg' dcugf " qp' grvulo gt' o cvgtkcu' cpf " eqpf vwxkpi " r qn' o gt' r qn' \*5.6/ g' y { rpgpf kqz { vj kqr j gpg' r qn' ut' tggp' uwhqpcv' \*RGF QV<RU+ 'cpf ' kpxguki cvg' ku' hmpvkvpcrnr' r tqr gt vku' 0' Grgevtqej tgo ke' utgej cdng' hko u' y gtg' r tgr ctgf " d { " o kzkpi " eqpf vwxkpi " r qn' o gt' " RGF QV<RU " y kj " cs wqwu' grvulo gt' f kur gtukqp' vq' qdvclp' c' j qo qi g' p' qwu' eqo r qukg' 0' hmpvkvpcrnr' grvulo gtle' hko u' y gtg' hqto gf " d { " uq' nkwqp' ecuvkpi " kp' c' b qn' hknf' y kj " hkgf " co qwpv' qh' c' b kzwtg' cpf " f tkgf " cv' 82° E 0' F kwwkqp' d { " f gkpk' gf " y cvgt' y cu' wugf " vq' cej kxg' vj kempgu' " eqpvtq' 0' C m' grgevtqej go kecn' b gcuwtgo gpv' y gtg' r gthqto gf " kp' c' ewuqo " b cf g' vj tgg' grgevtqf g' u' ugo " y j gtg' Ci Ci En' c' p' r r' v' k' p' w' y k' g' y gtg' wugf " cu' t' g' h' g' t' p' e' g' " cpf " eqwvgt' grgevtqf gu' t' gur gev' x' gn' . " y j k' g' grgevtqej tgo ke' utgej cdng' hko u' hkgf " qp' c' i r' cu' u' w' d' u' t' cv' g' y gtg' wugf " cu' y q' n' k' pi " grgevtqf gu' "

Vq' gxcn' cvg' " grgevtqej tgo ke' " r tqr gt vku' qh' vj g' " qdvclp' gf " eqo r qukgf " ej tqpqco r g' t' qo g' tle' " o gcuwtgo gpv' y gtg' r gthqto gf 0' Vj g' f w' cvkqp' qh' c' " ukpi ng' uy ke' j kpi " e { eng' y cu' 82' ugeqpf u. " cpf " vj g' grgevtqej go kecn' r qv' g' p' v' k' n' y cu' uy ke' j gf " dgw ggp' /4 " X " cpf " - 3 " X " xu' Ci Ci En' 0' F w' k' pi " ej tqpqco r g' t' qo g' tle' " v' gu' v' t' cp' u' k' v' e' g' " v' " + " cv' o czko wo " cduqtr v' k' p' y cxg' g' pi vj " 7; 2' po " y cu' tgeqtf gf 0' Wukpi " ces v' k' t' gf " f cv' " cduq' n' w' g' f k' h' g' t' p' e' g' " dgw ggp' p' g' ki j d' q' t' k' pi " r gcn' x' cn' w' gu' y cu' ec' r' e' w' v' g' f " vq' qdvclp' " V' 0' "

Vj g' qr' v' k' o k' cvkqp' qh' e' j go kecn' eqo r qukg' qp. " vj kempgu' qh' vj g' hko u. " c' r' r' k' g' f " grgevtqej go kecn' r qv' g' p' v' k' n' y cpf " r wug' f w' cvkqp' \* Hki 0' 30: " cpf " vgo r g' t' cvwtg' t' g' c' v' o gpv' y gtg' ectt' k' g' f " qw' vq' cej kxg' vj g' i t' g' cvgu' v' e' j c' pi g' " kp' qr' v' k' n' y t' cp' u' k' v' e' g' 0' Utgej cdkk { . [ qwpi u' b qf wwu' cpf " vj kempgu' qh' vj g' GO " y gtg' guko cvgf " dcugf " qp' vj g' q' t' g' v' k' n' y ec' r' e' w' v' k' p' u' "

"



Hki 030Ej cpi g'lp' v' t' cp' u' k' v' e' g' " cv' 7; 2' po " qh' RGF QV<RU/ dcugf " utgej cdng' grgevtqej tgo ke' eqo r qukg' v' p' f' g' t' f k' h' g' t' p' e' g' v' grgevtqej go kecn' r wug' f w' cvkqp' u' "

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# CF UQTRVQIP 'QHf KENQHGP CE 'HTQO 'CS WGQWU'O GF KWO 'QP "

## EJ GO KECNN[ 'O QF KHGF 'UVCTEJ "

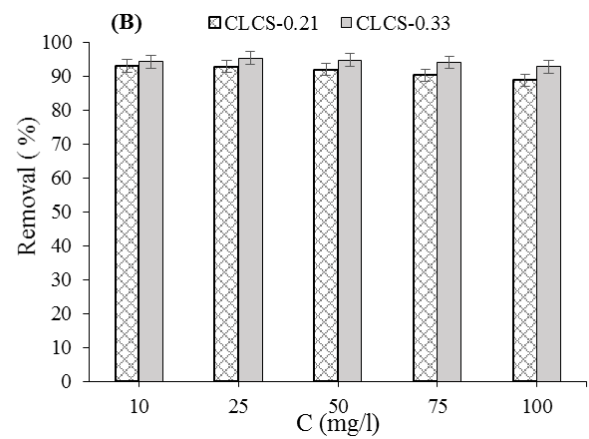
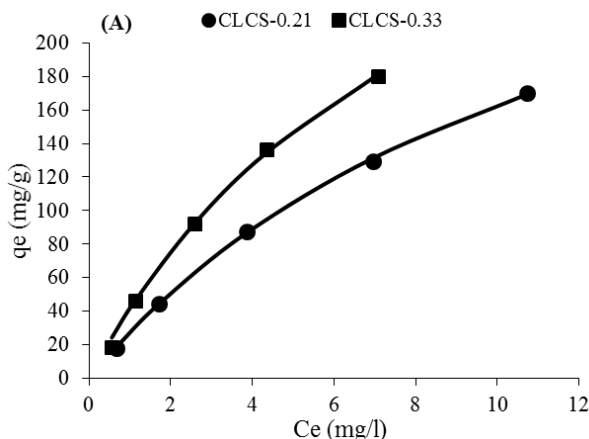
RcwlpC'P'f tkwpc'g<sup>3</sup>. 'Xguv'P c'xk'k'g/Upk c'k'g'p'g<sup>3</sup>. 'Tco wpg'T wnc'k'g<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rqn(o gt'Ej go kut { 'cpf 'Vgej pqm{ { . 'Mcwpcu'Wpkxgtukv{ 'qh'Vgej pqm{ { . 'Mcwpcu. 'Nkj wcpk' r cwlpC'P'f tkwpc'gB mw'f w' "

F k'nh'g'p'ce'ku'cp'cp'k'p'hr'o o cvqt { 'f twi 'y kj 'y j' g' j' ki j guv'cewg'v'z'k'v{ 'co qpi 'y g'p'p'p'w'g't'q'k'f'c'n'c'p'k'p'hr'o o cvqt { 'f twi u'0'F w'g'v'q'ku'g'z'v'p'k'x'g'eq'pu'wo r v'k'p. 'f k'nh'g'p'ce'j' cu'd'g'g'p'f'g'v'g'v'g'f'k'p'y'g'uc'o r'g'u'q'h'w'w'c'g'e'y' cvgt'uw'ej'cu't'k'x'g'tu'cu' y'g'n'cu'y'c'v'g'y'cvgt'v'g'c'vo'g'p'v'r'p'w'u'J'g'p'eg. 'y'g'w'ug'q'h'v'c'f'k'k'q'p'c'n' o'g'ej'c'p'k'c'n'c'p'f' d'k'q'm'i'k'c'n'y'c'v'g'y'cvgt'v'g'c'vo'g'p'v' v'g'ej'p'q'm'i'k'g'u't'g'u'w'u'k'p'k'p'u'w'h'h'k'g'p'v't'g'o'q'x'c'n'q'h'y'k'u'v'r'g'q'h'eq'p'w'o'k'p'c'p'v'J'3'0'V'j'g'c'k'o'q'h'y'k'u'y'q't'n'y'cu'v'q'uw'f' { 'y'g' c'f' u'q't'r'v'k'p'q'h'f'k'nh'g'p'ce'ht'q'o' 'y'cvgt'q'p'et'q'u'w'k'p'ng'f'ec'v'k'p'le'w'ct'ej'0' "

Et'q'u'u'k'p'ng'f'ec'v'k'p'le'w'ct'ej' \*ENEU'f'o'k'et'q'i't'c'p'w'c't'w'q't'd'g'p'v'y'cu'q'd'v'c'k'p'g'f'd' { 'y'g'o'g'c'p'u'q'h'ej'g'o'k'c'n'f'o'q'f'k'h'ec'v'k'p'q'h' r'q'v'c'v'w'w'ct'ej'0'ENEU' 'y'cu'q'd'v'c'k'p'g'f'd' { 'et'q'u'u'k'p'ng'f'ec'v'k'p'le'w'ct'ej' 'y'k'j' '20' 'o'q'n'l'c'I'W' \*c'p'j' { 'f't'q'i'm'eq'u'k'f'g'w'p'k'v'q'h' gr'k'ej'm'q't'q'j' { 'f't'k'p'c'p'f'ec'v'k'p'k'f'c'v'k'p'y'k'j' '4.5/gr'q'z' { 'r't'q'r' { 'n't'k'o'g'y' { 'c'o'o'q'p'k'w'o' 'e'j'm'q't'k'f'g'd' { 'x'c't' { 'k'p'i' 'o'q'r'c't' 't'c'v'k'q'u'q'h'f't'g'c'i'g'p'u'0' V'j'g'w'ct'ej' 'f'g't'k'c'v'k'g'u'y'k'j' 'y'g'f'g'i't'g'g'q'h'u'd'u'k'w'k'p'q'h'f'w'c'v'g't'p'c't' { 'c'o'o'q'p'k'w'o' 'i't'q'w'u'q'h'2043'c'p'f'205'y'g't'g'u' { 'p'y'g'u'k'g'f'0' U'q't'd'g'p'w'i' 't'c'p'w'g'u'y'g't'g' 'e'j'c't'c'v'g't'k'f'g'f'd' { 'u'ec'p'p'k'p'i' 'g'r'g'v'q'p' 'o'k'et'q'ue'q'r' { . 'H'q'w'k'g't'v'c'p'u'h'q't'o' 'k'p'h't'c't'g'f' 'u'r'g'v't'q'ue'q'r' { 'c'p'f' 'y'g't'o'q'i't'c'x'l'o'g't'k'e'c'p'c'n'f'k'u'0' "

V'j'g'c'f' u'q't'r'v'k'p'q'h'f'k'nh'g'p'ce'q'p'v'q'ENEU'f'o'k'et'q'i't'c'p'w'g'u'y'cu'k'p'x'g'u'k'i'c'v'g'f'd' { 'g'o'r'q' { 'k'p'i' 'y'g'g's'w'k'k'd't'k'w'o' 'c'f' u'q't'r'v'k'p' 'o'g'y'q'f'0'V'j'g'q'd'v'c'k'p'g'f'k'u'q'y'g't'o'u'q'h'f'k'nh'g'p'ce'c'f' u'q't'r'v'k'p'q'p'ENEU'c'v'42'AE'c'p'f'f'k'nh'g'p'ce't'g'o'q'x'c'n'g'h'h'k'g'p'e' { 'ht'q'o' 'y'cvgt' 'f'k'c'i't'c'o' 'c't'g'r't'g'u'g'p'v'g'f'k'p' 'H'k'i'03C'c'p'f' 'H'k'i'03D. 't'g'u'r'g'v'k'x'g'n'0' "



H'k'i'030C'f' u'q't'r'v'k'p'k'u'q'y'g't'o'u'q'h'f'k'nh'g'p'ce'q'p'ENEU'c'v'42'AE' \*C'c'p'f' 't'g'o'q'x'c'n'g'h'h'k'g'p'e' { 'q'h'f'k'nh'g'p'ce'ht'q'o' 'y'cvgt' '\*D+' "

V'j'g'N'c'p'i'o'w'k't.'H'g'w'p'f'r'k'ej' 'c'p'f' 'F'w'd'l'p'k'p'o' 'T'c'f'w'uj'ng'x'k'ej' 'c'f' u'q't'r'v'k'p' 'o'q'f'g'u'y'g't'g'w'g'f' 'v'q'f'g'u'et'k'd'g'y'g'c'f' u'q't'r'v'k'p' k'u'q'y'g't'o'u'0'c'ee'q't'f'k'p'i' 'v'q'y'g'N'c'p'i'o'w'k't'c'f' u'q't'r'v'k'p' 'o'q'f'g'n'y'g'f'k'nh'g'p'ce' 'o'q'r'g'w'g'u'y'g't'g'c'f' u'q't'd'g'f' 'q'p'y'g'c'v'k'x'g'eg'p'v'g't'u' k'g'0's'w'c'v'g't'p'c't' { 'c'o'o'q'p'k'w'o' 'i't'q'w'u'q'h'ENEU'0'V'j'g'N'c'p'i'o'w'k't'u'q't'r'v'k'p'ec'r'c'ek'k'g'u'y'g't'g'628'c'p'f'587' 'o' 'i' 'l'i' 'y'j'g'p'f'k'nh'g'p'ce' 'y'cu'c'f' u'q't'd'g'f' 'q'p'v'q'ENEU/205'c'p'f' 'ENEU/2043. 't'g'u'r'g'v'k'x'g'n' \*V'c'd'g'r'3'0'V'j'g'x'c'n'w'g'u'q'h'H'g'w'p'f'r'k'ej' 'e'q'p'u'c'p'v'p'p' 'c'p'f' 'F'w'd'l'p'k'p'o' 'T'c'f'w'uj'ng'x'k'ej' 'c'f' u'q't'r'v'k'p'g'p'g't'i' { 'G'f'r'k'p'f'k'ec'v'g'f' 'y'c'v'e'q'p'f'k'k'q'p'u' 'h'q't'f'k'nh'g'p'ce'c'f' u'q't'r'v'k'p'q'p'v'q'ENEU'y'g't'g'w'p'h'c'x'q't'c'd'g' 'c'p'f' 'y'g'k'p'g'z'ej'c'p'i'g'o'g'ej'c'p'k'u'o' 'y'cu'r't'g'f'q'o'k'p'c'p'v'f'w'k'p'i' 'c'f' u'q't'r'v'k'p'0' "

V'c'd'g'r'30C'f' u'q't'r'v'k'p' 'o'q'f'g'n'r'c't'c'o'g'v'g't'u' 'h'q't'c'f' u'q't'r'v'k'p'q'h'f'k'nh'g'p'ce'q'p'v'q'ENEU'c'v'42'AE' "

U'q't'd'g'p'v'	N'c'p'i'o'w'k't'b'q'f'g'r'i'		H'g'w'p'f'r'k'ej'b'q'f'g'r'i'		F'w'd'l'p'k'p'/T'c'f'w'uj'ng'x'k'ej' 'o'q'f'g'r'i'	
	Q <sub>L</sub> (mg/g)	R <sup>2</sup>	n <sub>F</sub>	R <sup>2</sup>	E <sub>DR</sub> (kJ/mol)	R <sup>2</sup>
ENEU/205"	628"	20 ; 94"	305"	20 ; 5; "	320"	20 ; 8; "
ENEU/2043"	587"	20 ; 92"	308"	20 ; 69"	; 0"	20 ; 97"

C'u'ec'p'd'g'ug'g'p'ht'q'o' 'H'k'i'3D'y'g't'g'o'q'x'c'n'q'h'f'k'nh'g'p'ce'x'c't'k'g'f'ht'q'o' ; 5'v'q' ; 6' 'c'p'f' : ; 'v'q' ; 5' 'y'j'g'p'w'k'p'i' 'f'k'h'g't'g'p'v' e'q'p'eg'p'v'c'v'k'p'u'q'h'ENEU/205'c'p'f' 'ENEU/2043' 'u'q't'd'g'p'w'u' 't'g'u'r'g'v'k'x'g'n'0'V'j'g'q'd'v'c'k'p'g'f' 't'g'u'w'u' 'e'q'p'h'k'o'g'f' 'y'c'v'ENEU'ku' r't'q'o'k'k'p'i' 'u'q't'd'g'p'v' 'h'q't'y'g't'g'o'q'x'c'n'q'h'f'j'c't'o'c'eg'w'k'c'n'eq'p'w'o'k'p'c'p'v'eq'p'v'c'k'p'k'p'i' 'c'p'k'p'k'le'i't'q'w'u'ht'q'o' 'c's'w'g'q'w'u'o'g'f'k'w'o'0' "

**C'emp'q'y'ng'f'i'o'g'p'w'0'V'j'k'u't'g'ug'c't'ej' 'y'cu'w'w'r'q't'v'g'f'd' { 'y'g'g'g'g'g'c't'ej' . 'F'g'x'g'm'r' 'o'g'p'v'c'p'f' 'k'p'p'q'x'c'v'k'p' 'H'w'p'f' 'q'h' 'M'c'w'p'cu' 'W'p'k'x'g't'uk'v' 'q'h'V'g'ej'p'q'm'i' { 'r' 't'q'l'g'ev'i' 't'c'p'v'P'q'0'RR' ; 3F' B ; +0' "**

J3\_'F'g'H'c'p'eq.'0'0'0'0'0'g'v'c'w'0'F'k'nh'g'p'ce'T'g'o'q'x'c'n'ht'q'o' 'Y'cvgt'd' { 'C'f' u'q't'r'v'k'p'W'k'p'i' 'C'ev'k'c'v'g'f' 'E'c't'd'q'p'k'p' 'D'ev'ej' 'O'q'f'g'c'p'f' 'H'z'g'f' /D'g'f' 'E'q'w'o'p'z' k'k'q'y'g't'o'u' 'V'j'g't'o'q'f' { 'p'c'o'k'e'U'w'f' { 'c'p'f' 'D't'g'c'm'y' 't'q'w'i'j' 'E'w't'x'g'u'0'q'f'g'r'i'p'i' <L'q'w'p'c'n'E'g'c'p'g'R'q'f'w'v'k'p'3: 3.'367/376'423: +

# I TCPWNCVQP'QH'K'F WUVTKCN'Y CUVG'CPF 'CP CN[ UKU'QH'VJ G' QDVCKP GF 'I TCPWNGU'

Mkukpc'Dwpgxk kgp <sup>3</sup>. 'O gf c'Re-xgpunekv <sup>4</sup>.'''

<sup>3</sup>Kpukwag'qh'Ci tlewnwtg.'Nkj wcpkcp'Tgugctej'Egpyt'g'ht'Ci tlewnwtg'cpf'Hqt gum {'.Nkj wcpkc''

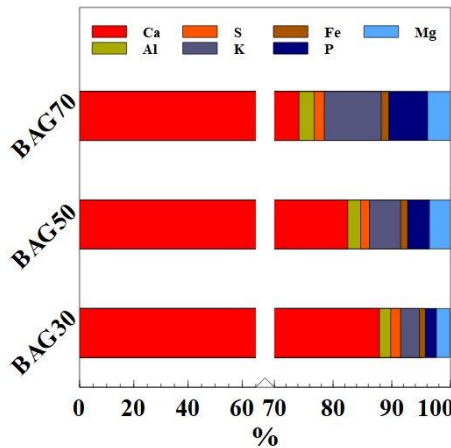
<sup>4</sup>Hcewn'qh'O gf lelpqg.'Mcpwu'Wpkxgtukv'qh'Cr r nkgf'Uelkpegu.'Nkj wcpkc''  
o gf c'f c; 968B i q'f'w'w'q'w'

Dkqhwn'cuj '\*DC+'cpf'rko g'nkcp'f wuv'\*NMF+'ctg'lpf wutkcn'y cuvg'DC'ku'c'eqo r rgg'cpf'j gvtqi gpgqu'o kzwg'qh' kpti cple'et { ucnkpg'cpf'co qtr j qwu'o kptcni'y kj 'qti cple'o cwgt'j3\_0'DC'wuwcm'eqpvkpu'o clpn' 'M'R'Ec'cpf'O i.' y j lej 'ctg'guugpvkni'o cetqrgo gpw'ht'r rpv'i tqy vj 'j4\_0Cuj 'r tqegulpi '\*i tcpwvkvq+'wugu'uko krc'o gy qf u.'y j lej 'ctg' cnuq'wugf 'v'q'r tqf weg'o kptcni'ht'krk'gtuOI tcpwvkvq'ku'yj g'tcpur qtv'q'v'qh'kpg'r qy f gt gf 'o cvgt kcu'kpv'i tcpwvkvq'kp'kpvgtcvkvp'y kj 'v'g'rks wkf'r j cuvg'OI tcpwvkvq'w'o cvgt kcu'ctg'v'j qug'y kj 'c'r ctveng'f lco gvt '@0''o o 0'Vj g'i tcpwvkvq'ht'krk'gt'r tqf wevu'o wuv'dg'o gej cplecm'utqpi 'uq'v'v'g'f'ecp'dg'gculk'v'tcpur qtv'g'f'cpf'ur tgc'f'kp'v'g'k'grf u'dw'v'v'g' uco g'wo g'ecr cdng'qh'gculk'f'geqo r qukpi 'kp'v'g'u'k'Xctkqu'u'p'v'g'v'q't'pcwvkvq'cvgt kcu'ecp'dg'wugf'cu'dkpf'gtu'kp'v'g' i tcpwvkvq'r tqegu. lpenm'kpi 'NMF'j5\_0Cv'j wo k'kf. 'DC'tgcew'y kj 'NMF'v'q'ht'o 'eqo r qwpf u'y kj 'dkpf'kpi 'r tqr g'v'kuO'

Kp'v'k'u'uwf {.dkqhwn'cuj 'i tcpwvkvq'y g'g'r tqf weg' <DCI 52.'DCI 72'cpf' 'DCI 92'eqpvkplpi '52.'72'cpf' '92' 'cuj 0' Vj g'q'v'g't' r ctv'eqpvkvq'f' qh' rko g'nkcp'f wuv:'92.'72'cpf' '52' . 'tgr ge'v'k'gn'0'NMF' 'cpf' 'DR'y g'g't'y gli j gf' 'cpf' 'o k'z'gf' v'j qtqwi j n' 'wukpi 'c'j qo go cf g'tkddq' dmf'g'ci kcvqt'0'Y j k'g'ci kcvkpi 'v'j g'o kzwg.'c'uo cni'co qwpv'qh'y cvgt '\*c'34' -'y'cu' cf f gf 'v'j g'f t { 'o cvgt kcu' w'v'k'u'uo cni'ci i tgi cvgu' uctv'g'f 'v'j'ht'o 'c'r cuvg'0' Vj g'r cuvg' y cu' i tcpwvkvq'f' wukpi 'c'f k'ue' r gmg'k'gt'0'C'ht'g'i tcpwvkvq'.'v'j g'i tcpwvkvq'y g'g'f' t'k'g'f'cv'tqqo 'vgo r g'c'w'v'g'k'p'c'rdq'cv'q't' 'h'wo g'j' q'f' 'ht'46'j' q'w'u'j6\_0'

Vj g'uco r rgu'y g'g'i tqwpf. 'ukxg'f. 'gz'v'ce'v'g'f' y kj 'c's'w'v'g'i'k'c'cee'q'f'kpi 'v'j'NUV'GP' 'KUQ'35872-42280'C'v'qo k' Cduqtr v'kvq'Ur gestv'eq'f' '\*CCU+'y cu'wug'f'v'j'k'p'f'v'j g'eq'peg'p't'v'kvq'q'v'Ec' 'cpf' 'O i.' 'h'xo g'r j q'v'qo gvt '\*HR+'q'h'M'WX/ XRU'ur gestv'q' j q'v'qo gvt'q'h'R' 'cpf' 'k'p'f'v'v'k'gn' 'eq'v'rg'f' 'r'ruo c'o cuu'ur gestv'qo g't' '\*ER/O U+'q'h'j' g'c'x' { 'o g'c'ni'j6\_0'Vj g'Z/ t'c' { 'f'k'ht'cev'q' '\*ZTF+'f'c'v' y g'g'eq'ng'ev'g'f' y kj 'c'F TQP/8'r qy f' g't'Z/ t'c' { 'f'k'ht'cev'qo gvt' y kj 'Dt'ci i /Dt'g'p'cv'q'i' g'qo g't' { 'wukpi 'P'k'ht'ng't'f' 'E'w'M' 't'c'f'k'v'kvq'j7\_0'Vj g'r ctv'eng'uk' g'f'k'ut'k'v'kvq' y cu'f' g'v'g'to k'p'gf' 'wukpi 'v'j g'f'k'k'ci'g'g'ev'qo ci p'g'v'k' ukx'g' u'j'cng't' 'H'k'c' 'X'k'd'cev'q' 'HVN/2422' 'cpf' 'v'j g'ut'g'p'i v'j 'q'h' v'j g' i tcpwvkvq' y cu' f'g'v'g'to k'p'gf' 'wukpi 'ut'g'p'i v'j 'i tcpwvkvq' o g'cu'v't'g't' 'RI /30' 'kp'v'g'o g'cu'v't'kpi 't'c'p'i g'd'g'y ggp'7'v'q'422'P'j6\_0'

Vj g'c'p'cn'uku'qh'ej go k'cni' 'cpf' 'r'j { u'k'eq'ej go k'cni's'w'v'k'f' 'k'p'f'k'ev'q'tu'q'h'cuj 'i tcpwvkvq't'g'x'g'c'rg'f' 'v'j cv'v'j g'ug' 'u'dw'v'p'egu' eqpvk'v'o clpn' 'qh'ej go k'cni'eqo r qwpf u'eqpvk'plpi 'Ec'4' 'kpu'v'k'i'0'



Hki 030Ej go k'cni'eqo r qukvq'q'h'v'j g'o clqt'p'w'v't'g'p'u'k'p'i tcpwvkvq'

Vj g'ut'g'p'i v'j 'q'h'v'j g' i tcpwvkvq'eq'tt'g'r'v'g'u'y kj 'v'j g'co qwpv'q'h'cuj 'c'f'f'gf' 'v'j g' o kzwg.'k'0'g'0'v'j g'ut'g'p'i v'j 'k'p'et'g'c'ug'u' y kj 'k'p'et'g'c'ulpi 'cuj 'eq'p'g'p'v'k'p'v'j g'i tcpwvkvq' y j lej 'y g'c'ng'p'u'v'j g't'g'rc'ug'q'h'p'w'v't'g'p'u'ht'qo 'v'j g'i tcpwvkvq'0'Vj g'ut'g'p'i g'v'v'DCI' y g'g'k'p'v'j g'o kzwg' y kj '92' 'cuj 0J k'j g't' ut'g'p'i v'j 'i tcpwvkvq'ct'g'g'c'ulkt'v'q'v'tcpur qtv.'rgu'r'j { u'k'cm' 'x'w'p'g'cd'ng.'d'w'j'c'x'g' c'p'g'i cv'x'g'c'ur gev'v'v'j g'f' 'u'v' { 'q'p'v'j g'u'k'v'ht'ce'g'ng'p'i g't' 'cpf' 'f'q'p'v't'g'rc'ug'p'w'v't'g'p'u.'u'q'v'j g'o qu'v'q'r v'ko cni'DCI' 'j'c'x'g'v'j g' r'q'y g'v'v'cuj 'eq'p'g'p'v'k'p'v'j g'o kzwg.'k'0'g'0'52' 0'

- 13. UOX0Xcuukgx.'F0Dc'v'g't.'NOMDC'p'f'g'u'g'p.'E0I 0'Xcuuk'g'x'c.'Cp'q'x'g't'x'k'y 'q'h'v'j g'eqo r qukvq' 'cpf' 'c'r r' r'ec'v'kvq'q'h'i'd'k'qo cuu'cuj 0'Rctv30Rj cu/ o k'p'tcni' 'cpf' 'ej go k'cni'eqo r qukvq' 'cpf' 'erc'uk'ht'ec'v'kvq'. Hw'gn'327' \*4235+62698.'j' w' u'd'f' q'k'ht'i B20238' l'0'w'g'v'0'2340; 02630
- 14. O 0'H'g't'g.'J 0'N'q'g'u.'NOC0E0'v'ct'g'q.'E't'k'k'c'ni'c'ur gev'v'q'h'i'd'k'qo cuu'cuj g'u'w'v'k'k' v'kvq'k'p'u'k'u'Eqo r qukvq'.'t'g'ej c'd'k'k'f'.'RCJ' 'cpf' 'REF F IH' Y'cu'g'0'c'p'ci 068' \*4237+5266537.'j' w' u'd'f' q'k'ht'i B20238' l'0; cuo c'p'0'2370; 02580'
- 15. C0C't'w'v't'c'j.'C0O'q'j'c'o' o'c'f'k'p'k'c.'C0F'c'Co'k'eq.'U0J' q't'r'k'd'w'n'w'm'E'go g'p'v'v'k'p'f'v'w'v'c'p'f' 'h'q' 'cuj' 'd'ig'p'f' u'c'u'c'p' 'c'ng't'p'ev'k'g'd'k'p'f'g't' 'ht'v'j g' u'c'd'k'k'k' v'kvq'q'h'f' go q'k'k'v'q'c'i i t'g'i'c'v'gu.'E'q'p'v't'0'D'v'k'f'0O'c'v'g't'0367' \*4239+43: 6447.'j' w' u'd'f' q'k'ht'i B20238' l'0'c'p'd'w'k'f' o'c'v'0'239'026'0290'
- 16. MOD'w'p'x'le'k'p'g.'F0F' t'c'r'c'p'c'w'v'k'g.'T0O'c'j' g'k'nc.'X0V'v'k'k'k'p'g.'I0D'c'nt'w'k'k'u.'I' tcpwvkvq'f' 'dk'q'h'wn'cuj 'cu'c' 'u'w'v'k'p'c'd'ng' 'u'q'v'g'q'h'f' r'p'v' p'w't'k'p'u.'Y'cu'g'0'c'p'ci 0T'g'u'0'4242+.'j' w' u'd'f' q'k'ht'i B20399' l'0'2956464Z42; 6: ; 740'
- 17. MOD'c'nc'f' u.'C0'f'k'p'c.'C0D'c'p'c'w'v'k'g.'Vj g'to c'nr' t'q'r' g't'v'gu' 'cpf' 'c'r r' r'ec'v'kvq'q'h' 'u'k'k'c'f' g'ri'y'cu'g'eq'p'v'co' l'p'c'v'g'f' y'kj' 'H' 'k'p'u'ht'q' 'E/U'J' ' u'f'p'v'j'g'u.'L0'Vj g'to 0C'p'c'i0'Ec'm't'0' \*4237+3676376.'j' w' u'd'f' q'k'ht'i B20229' l'032; 95/237/6885/60'

# J GCVKPI 'DGJ CXKQWT'KP XGUVH CVKQP 'QH'CI IRC'DCUGF 'MP KVVGF'' HCDTKEU'

O f 0T gcl w f f k p Tgr qp<sup>3</sup>. 'F ckxc'O kmw kqpkp<sup>4</sup>"

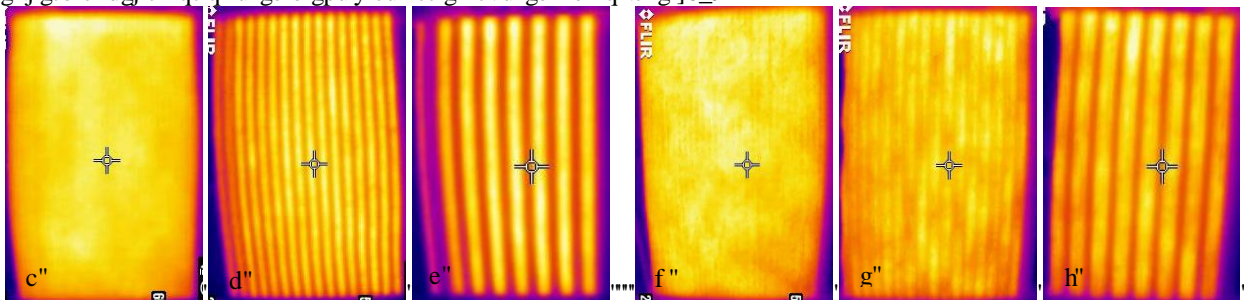
3.4 "F gr ctvo gpv'qh'Rtqf wevkp"Gpi kpggtkpi . 'Hcewn' "qh'O gej cplecniGpi kpggtkpi "cpf 'F guli p. 'Mcwpcu'Wpkxgtuk' "qh'  
Vgej pqm' { . 'Nkj wcpk"  
tgc/o duw0gB i o ck0qo "

"

Vgzvrgu'hgcwtgf "y kj "grgvtqple"hwpevkp"ctg"dgeqo kpi "qpg"qh'yj g'o clqt"i tqy vj "ugevqtu"lp"yj g'o wmkf ko gpukpccr  
cr r rncvqkq"ctgc0Dcugf "qp"kvgtcevkxg"vgej pqm' { . 'yj g'y gctcdrg"grgvtqple"vgzvrgu'hqto "c"pgy "o ctngv'ugi o gpv'tguwvki pi "  
htqo " yj g'o kpkwtk cvkqp" qh" grgvtqpleu." cpf " kppqxcvqkq" hqt" dqyj " grgvtqple" cpf " vgzvrgu" kpf wvrtkgu" ]3." 4\_0' Grgvtq/  
eqpf wevkxg"vgzvrgu"ecp'dg"wugf "lp"j gcvkpi "r wtr qug"r ctvewctn' "lp"o gf lecn'cr r rncvqkq" ]5\_0Vj g'c'ko "qh'yj ku'y qtniy cu'vq"  
kpxgvki cvg"j gcvkpi "dgj cxkqt"qh'hcdtkecvgf "mpkxgf "hcdtkeu" f guli pgf "hqt"qt vj qr gf le"uwr r qtv0'Vgo r gtcwtg"hgcvklkx' "y cu'  
gzr nqtgf "dcugf "qp"xqno g"qh'eqpf wevkxg" { ctp" wugf "lp" yj g"mpkxkpi "r cvgtp0'Vj g"ghge'v'qh" { ctp"rkpgct" f gpuk' "qp" yj g"  
yj gto crldgj cxkqt" wugf "lp" yj g'utwewtg"y cu'cnuq"eqpukf gtgf "cpf "eqo r ctgf 0'

C'hw'v'f qwdrg'pggf rg/dgf "mpkxkpi "o cej kpg"y cu'wugf "vq"mpk'Ci "eqcvgf "r qn' co kf g" { ctp" yj kj "grcvqo gtle"kp'c' / { ctp"  
kp" yj ku'uwf { 0'Vj g'hwng"783"J XCERtq"lphctgf "yj gto qo gvg"cpf "HNK"FO 4: 7"yj gto cn'ko ci gt"y g'g'wugf "vq"o gcuwtg"  
yj g'uwthceg"vgo r gtcwtg"cpf "yj gto cn'ko ci kpi "qh'yj g"ur geko g'p'Vj q"eqr r gt"r r'v'gu"qh'ceewtcvg" f ko gpukp. "grgvtqf g"  
r r'v'gu"y g'g'r r'v'egf "qp" yj g"qr r qukg"gf i gu"qh'yj g"ur geko gp"cpf "eqppgevgf "y kj "FE"r qy gt0'Vj g"cr r r'kgf "xqnci g"y cu'  
r tqi tguukgn' "kpetgcugf "cpf "qdugt xgf "yj g'eqt gur qpf kpi "xcwgu"qh'ewtgpv'cetqu' yj g'hcdtke"y g'g'pqvgf "htqo "co o gvgt0'  
Uk"ur geko g'p' yj g'o cpw'cewtf "f gr gpf kpi "qp" yj g'co qwpv'qh'eqpf wevkxg" { ctp" wugf "lp" yj g"mpkxkpi "utwewtg"cpf "y q"  
xctkcpw'qh'rkpgct" f gpuk' "qh'Ci "eqcvgf " { ctp0'

Vj g' uwthceg" vgo r gtcwtg" y cu' o gcuwtgf "cv' f k'htgtpv' vko g" kvgtxcni' cv' h'zgf "xqnci g" cr r r'kgf 0' Vj g" i gpgtcvgf "  
vgo r gtcwtg" yj qy gf "yj cv' yj g'vgo r gtcwtg" t'kg' y cu' h'w'p'f "vq" dg' t'grcvgf "vq" yj g'vko g'cpf "cr r r'kgf "xqnci g" 0T guwv'eqphk' o gf "  
yj cv' yj g'ugrgevgf "grgvtq/eqpf wevkxg" hcdtke" j gcu'w' s'wem' "cv' h'ktu'v' y q' o kpwgu'cpf "yj g'p'xgt { "urqy n' 0H'kpcm' . 'yj ku' tkkpi "  
ku' r'gxngf "qh'cv'c" r ctvewct" vgo r gtcwtg0'F gr gpf kpi "qp" yj g"mpkxkpi "utwewtg"cpf "yj g'co qwpv'qh'eqpf wevkxg" { ctp" wugf . "  
yj g' yj gto crldgj cxkqt" qh'ur geko g'p' yj cu'xctk'f "cv'ur gekle" xqnci g" ]6\_0'



\*c/e+hcdtkeu'mpkxgf "y kj "88"vgz" \*34' h'ko gpw' { ctp" ..... "f/h' hcdtkeu'mpkxgf "y kj "457"vgz" \*56' h'ko gpw' { ctp"  
Hki 030Vj gto cn'ko ci gu'qh'mpkxgf "ur geko g'p' hcdtkecvgf "f gr gpf kpi "qp" eqpf wevkxg" { ctp" co qwpv'cpf "rkpgct" f gpuk' "wugf "lp"  
mpkxkpi "r cvgtp0'

Vj g' kphwpeg" qh' yj g' eqpf wevkxg" { ctp" f' kutkdwkq" lp" yj g' mpkxkpi "r cvgtp" ku' erngctn' "gzj kdkgf "lp" hki wtg" 3. "y j gtg"  
{ gmty "eqmt" kpf kecvgu" yj g' j ki j guv' vgo r gtcwtg" \*62/67AE+ "y j kg" yj g' d'wng" eqmt. "ceeqtf kpi n' . "yj g' nqy guv' vgo r gtcwtg"  
\*48AE-0'

"

13. "O 0Q) c j qp { . 'W0G0Dtc f qem'Erctng. "Vgej pq"vgzvrgu"4-t'gxqmwkqpc' { "hcdtkeu'ht' "w'uj kq"cpf "f guli p" \*8Vj co gu'cpf "J w' uq. "Nqpf qp. "4227-0'  
14. "E0T0Eqtm"Eqpf wevkxg" hcdtkeu'ht' "grgvtqple"vgzvrgu" < p' q'xgt'xky . "Grgevtqple"Vgzvrgu" \*Y q'qf j gcf "Rvdrkuj kpi . "Nqpf qp. "4237-0'  
15. "O 0Uqr r c. "E0C'rgu'cpf tq. "Y gctcdrg"grgvtqpleu'cpf "uo ctv'vgzvrgu" < c'etk'lecn'f'gxky . "Ug'puqtu" 36. "33; 79/33; ; 4" \*4236-"  
16. "O 0T gr qp. "F 0'O kmw kqpkp . "K'Den'kpc" gv'cn' "Ci "Eqcvgf "RC/Dcugf "Grgevtq/eqpf wevkxg" Mp'kxgf "Hcdtkeu'ht" "J gev'I gpgtcvqkq" lp" Eqo r tguukp"  
Uwr r qtv0' Cwz' Tgugct ej "Lqwt'pcn" 3 \*cj gcf /qh' r t'kp. "4243-0'

**RGE WNKCTKVKGUQH'RQVCVQ.'EQTP'CPF'Y J GCV'UVCTEJ GU''  
ETQUUNKPKPI ''**

**Mctqrkpc'Crn qpckv'vg.'Lqpcp'Dgpf qtckkpgg.'I tgv'Ekl cwunckg.'F kpcp'O cukwkap {vg.'F qxkrg'  
Nkxf xkpcxlekwg.'Tco wpg'Twnckg''**

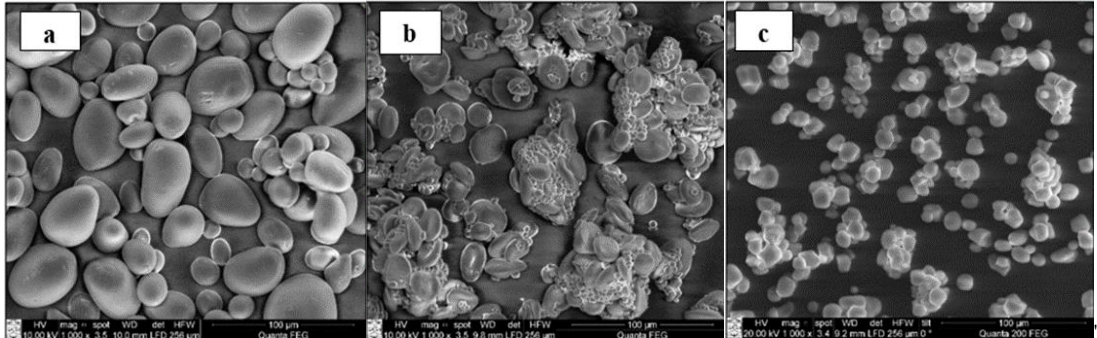
F gr ctwo gpv'qh'Rqn{o gt'Ej go knt { 'cpf "Vgej pqmri { . "Mcwpcu'Wpkxgtukv{ "qh"Vgej pqmri { . "Nksj wpcpk"  
**netqrkpc'Crn qpckv'vgB mwth'**

''

Uctej "ku"pcwctn'ectdqj { f tcv'g'dcugf 'r qn{o gt.'y j kej "ku'y kf gn{ "cxckrdrg"htqo "xctkqwu'pcwctn'uwtegu'kpenwf kpi '' r qvcvq.'y j gcv'cpf "eqtp'0Vj g'i tcv'wgu'qeeewt'kp'cmli'j cr gu'cpf'uk'g'gu.'kq'0ur j gt'gu.'gnkr uqkf u.'r qn{i qpu.'r r'vrgu'v'cpf'kt'gi wct'' wd'wrgu'0Vj gkt'f'kco gvg't'ku'tcpi kpi "htqo "ctqwpf'203'vq'422'o ketqo g'v'gu'f'gr gpf kpi "qp'dqvcplecni'qt'ki kp'j3\_0'Etquu/rkpnkpi '' qeeewt'u'y j gp'kpygo qngewct'dtkf i gu'ctg'k'pvt'qf wegf "dgy ggp'r qn'uceej ctkf g'o cetqo qngewrgu'0'Etquu/rkpnkpi "u'ctej gu'ctg'' t'guk'ncp'v'q'j'ki j "vgo r gtcw'g.'m'y 'r J . "cpf'j'ki j gt'uj gct.'cpf'v'j g'xkuequk'v'cpf "vgz'wctn'r' tqr g'v'gu'ctg'ej cpi gf "eqo r ctg'' v'q'pcv'xg"u'ctej "g'f'0'v'j g'j { f tqi gp'dqpf u'lp'etquu/rkpnkpi '' i tcv'wct' "u'ctej "ctg'ut'qpi gt'cpf "r t'g'x'g'p'k'pi "uy gnkpi "qh'v'j g'' i tcv'wrgu'f'w'k'pi "r'cuk'pi 0Vj g'r'w'r qug'qh'v'j ku'y qtn'ly cu'v'q'g'x'c'nc'v'g'v'j g'u'ctej "etquu/rkpnkpi "y kj "gr'kej m'qt'j { f t'kp'r t'q'g'uu'' v'cnkpi "k'p'v'g'ceeq'v'v'v'j g'd'q'v'c'p'le'c'ni'q't'ki kp.'' i tcv'wrg'uk'g'cpf "u'w'r g'p'uk'q'p' "eq'p'ep'v'c'v'k'q'p' "qh'u'ctej "k'p'q't'f'g'v'q'qr'v'o k'g'cpf'' r t'g'f'lev'v'j g'et'quu/rkpnkpi "r t'q'g'uu'0'

Rqvcvq.'y j gcv'qt'eqtp'u'ctej "y cu'o k'z'gf "y kj "c'uf'k'wo "j { f tqz'kf g'v'q'w'k'q'p' "cpf "et'quu'r'k'p'k'pi "ci gp'v'gr'kej m'qt'j { f t'kp'' \*GRK'c'v'j g'o q'w'r' t'c'v'q'q'h'v'j g'CI W'<GRK'<P cQJ "2J 4Q'y cu'3'<2022762023+<20247620234+<320Vj g't'g'ce'v'k'q'p' "b'k'z'w't'g'' y cu'o c'k'p'c'k'p'g'f' "c'v'j g'v'go r gtcw'g'qh'67AE'ht'46'j "cpf 'r J "320''

Cu'v'j g'uk'g'qh'v'j g'i tcv'wrgu'ku'qh'i t'g'cv'ko r q'v'c'p'eg'k'p' "u'ctej "b' qf' h'k'ec'v'k'q'p' "t'g'ce'v'k'q'p'u.'v'j g'r' c't'v'k'g'u'y g't'g' h'k'u'v'j c't'ce'v'g'k' gf'' d{ "u'ec'p'k'pi "gr'g'v'q'p' "b' let'q'ue'qr { \*UGO +\*ugg'Hki 03+'cpf "h'c'ug't'f' h'k'c'v'k'q'p' "v'g'ej p'k's'v'gu'0'



Hki 030Uecp'k'pi "gr'g'v'q'p' "b' let'q'ue'qr { \*UGO +k'ci gu'qh'u'ctej "i tcv'wrgu'<c' "o'r q'v'c'v'q'="d' "o'y j gcv'="e' "o' "eqtp'0'  
O ci p'h'ec'v'k'q'p' "z'32220'

Cu'k'ku'hpqy p'htqo "h'k'g'c'w'g'f'c'v'"j4\_ "u'ctej "b' q'ng'ew'rgu'ct'g'j'ki j n{ "u'q'w'd'rg'k'p'3'O 'MQJ "c's'v'g'q'w'u'q'w'k'q'p' "v'j g't'g'ht'g'' v'j ku'v'q'w'g'p'v'y cu'w'ug'f "v'q'k'p'x'g'uk'i c'v'g'u' { p'v'j g'uk' gf "et'quu/rkpnkpi "u'ctej "f' g't'k'c'v'k'x'g'u'0'D { "k'p'et'g'c'uk'pi "GRK'eq'p'ep'v'c'v'k'q'p' "k'p' "v'j g'' o qf' h'k'ec'v'k'q'p' "o k'z'w't'g.'' v'j g' "u'q'w'd'k'k'v' { "qh' "v'j g' "q'd'v'c'k'p'g'f' "u'co r'ng'u' "f' g'et'g'c'ug'f' "f' w'g' "v'q' "v'j g' "h'q'to gf'' et'quu/rkpnkpi "d'gy ggp'' o cetqo q'ng'ew'rgu'0'k'v' cu'd'g'g'p'q'd'ug't'x'g'f "v'j c'v'g'x'g'p'x'g't { "uo c'm'ico q'w'p'u'q'h'et'quu/rkpnkpi "ci gp'v'j c'x'g't'g'f' wegf "v'j g' "u'q'w'd'k'k'v' { "qh' "p'c'v'k'x'g' "u'ctej "d { "37/52'' . "ko r n{ k'pi "v'j c'v'p'q'v'q'p'n { "i t'c'h'k'pi "t'g'ce'v'k'q'p'u'd'w'c'nu'q'et'quu/rkpnkpi "qh'o cetqo q'ng'ew'rgu'ku'v'cnkpi '' r'nc'eg'0'Vj g' "x'k'ue'q'uk'v' { "ej cpi gu'qh'v'j g' "u'w'r g'p'uk'q'p'u' "qh' "u'ctej "f' g't'k'c'v'k'x'g'u' "y g't'g' "f' g'v'go k'p'g'f' "d { "w'uk'pi "x'k'ue'q'co { m'j t'c'r j { " v'g'ej p'k's'v'g'0'Vj g' "m'y g't' "x'k'ue'q'uk'v' { "y cu' "ej c't'ce'v'g't'k'v'le' "qh' "v'j g' "u'w'r g'p'uk'q'p'u' "qh' "y j gcv' "cpf "eqtp' "u'ctej gu' "eqo r qu'g'f' "qh' "u'o c'm' i tcv'wrgu.'o g'c'p'y j k'rg.'v'j g'r' g'c'n'x'k'ue'q'uk'v'g'u' "qh' "v'j g' "u'w'r t'k'g'u' "qh' "r' q'v'c'v'q' "u'ctej /dcug'f "u'co r'ng'u' "eqo r qu'g'f' "qh' "i'c'ti g'i tcv'wrgu' "y g't'g' "o w'ej "j'ki j g't'0'D { "u'g'v'k'pi "v'c'k'q't'g'f' "u'ctej gu' "cpf "co q'w'p'u' "qh' "et'quu/rkpnkpi "ci gp'v' "v'j g' "o c'v'g't'k'c'u' "y kj "r' g't'h'g'v'v'j l'eng'p'k'pi '' r t'qr g't'v'gu' "ec'p'd'g' "q'd'v'c'k'p'g'f' 0O g'c'p'y j k'rg.'et'quu/rkpnkpi "u'ctej gu' "q'd'v'c'k'p'g'f' "d { "w'uk'pi "203' "b' q'n'q'h'et'quu/rkpnkpi "ci gp'v' "gt' "3' "b' q'n' q'h' "u'ctej "f' q' "p'q'v' "h'q'to "i' g'u' "f' w'k'pi "r'c'uk'pi "cpf "t'go c'k'p' "k'p' "y c'v'g't' "k'p' "v'j g' "h'q'to "q'h'o let'q'r c't'v'k'g'u'0'Vj g't'g'ht'g.' "u'w'ej "f' g't'k'c'v'k'x'g'u' eq'w'f "d'g'c'nu'q' "r' q'v'g'p'k'c'm' { "w'ug'f' "cu' "u'q't'd'g'p'u'0'

[3\_ "UOR'et'g'j . "G'0'D'g't'v'q'h' "Vj g'o q'ng'ew'rt' "u't'w'ew't'g'u' "qh' "u'ctej "eqo r q'p'g'p'u' "cpf v'j g'k' "eq'p'v'k'd'w'k'q'p' "v'q' "v'j g' "c't'ej k'g'ew't'g' "qh' "u'ctej i tcv'wrgu'<C' "eqo r t'g'j g'p'uk'x'g' t'g'x'lg'y 0'U'ctej . "84. "5. ; 6642" \*4232-#

[4\_ "Mo . "J 0U'W'J w'dgt . "TOME'0C'm'nr'p'g'F'ku'q'w'k'q'p' "qh' "u'ctej "H'ek'k'c'v'g'f' "d { "O let'q'y c'x'g' "J g'cv'k'pi "h'q't' "C'p'c'n' "u'ku' "d { "U'k' "g' / "G'z'en'w'k'q'p' "Ej t'qo c'v'q'i t'c'r j { 0L'0' Ci t'le'0'H'q'f' "Ej go 076. ; 886 ; 88 ; " \*4228-#

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# URGEVTQUEQRÆ'EJ CTCEVGTKUCVKQP'QH'DQF RR[ /DCUGF'PGY'' HNWQTGUEGPV'XKUEQUKV[ 'UGPUQTU''

Twi kn 'fi kn pckv<sup>3,4</sup>. 'Mctqrkpc'O crgenekv<sup>4</sup>. 'Lgrgpc'F qf qpqxc<sup>3</sup>. 'Uki kcu'Vwo ngxk kwu<sup>3</sup>. 'Cwtlo cu' X{-pkwunū<sup>4</sup>

<sup>3</sup>'kpukwæ'qh'Ej go kut { . 'Hcewm'qh'Ej go kut { "cpf 'I gquelpegu. 'Xkpkwu'Wpkxgtuks { . 'P cwi ctf wnt'um046. 'Xkpkwu. 'Nkj wcpkc"

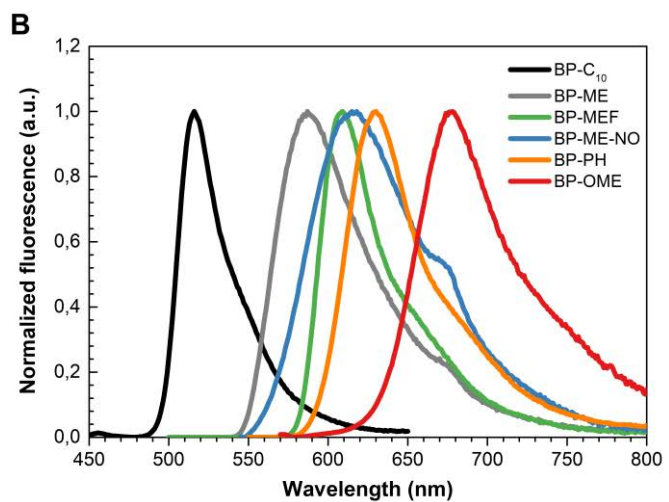
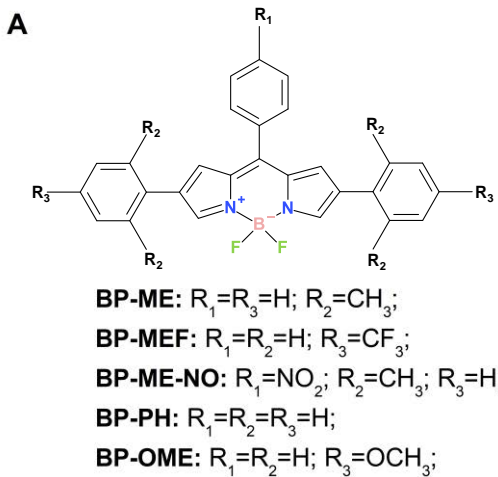
<sup>4</sup>Egpgvt'hqt'Rj { ulecn'Uelqpegu'cpf 'Vgej pqrqi { . 'Ucwrgvknq'cx05. 'Xkpkwu. 'Nkj wcpkc"  
twi kq0 krgpckvB ej i hmwf 0kw0v''

Xkuequkv { 'cpf 'vgo r gtcwtg'r m { "c"o clqt'tqrg'qp"o ketqueqr le'ngxgni'lp'dkqu { vngo u0Vj gug'r ctco gvgtu'ecp'f gvgto kpg" f kthwukqp'tcvg'cpf 'r tqeguugu'kpkf'g'egm0'Ej cpi gu'lp"o'egm'ecp"j cr r gp'f wtksi "pcwtcn'r tqeguugu. 'cu'y gni'cu'f wtksi "y g" f gxgnr o gpv'qhf'kugcugu'qt'r cy qmī kgu"]3.4. Hmwqtguegpv'o qrgewrt'tqvtu'HO Tu+ctg'y g'i tqr 'qh'qti cple'hmwqtqr j qtgu." yj g'nxo kpguepeg'qh'y j lej "ku'ugpukxg'vq"o gf kwo ō'r j { ulecn'r tqr gtvku. 'uwej "cu'xkuequkv { 'qt'vgo r gtcwtg0'Chgt'HO T" gzekcvkp'kptco qrgewrt'tqvcvkp'qeevto0'Hmwqtguepeg'kpvgpuk { 'f gr gpf u'lp'y g'vko g'o qrgewr'ur gpf u'lp'y g'gzekgf 'uvcvg" dghgtg'y g"tqvcvkp0'kptco qrgewrt'tqvcvkp'ku'lcuv'lp'my 'xkuequkv { 'uqrgpvu. 'y j lej "rgcf u'vq'cp"lpetgcugf "ppqctf kvkxg" tgrzcvkp0'kptco qrgewrt'tqvcvkp'ku'lcuv'lp'my "cpf "c'hmwqtguepeg'kpvgpuk { 'lpetgcugu0'Dgukf gu'y g" hmwqtguepeg'kpvgpuk { . 'c's wcpwo 'ghlekpe { "cpf "c'f gec { 'vko g'cnq'lpetgcugu"]5\_0"

Dqtqp/f lr { ttqo gj gpg' \*DQF RR[ + 'dcugf " HO Tu" ctg' y kf gn { " wugf " cu' xkuequkv { " ugpuqtu0' kptco dgy ggp' yj go .'' DQF RR[ /E32'cpf 'qy gt'ku'f gtlkvxgu'ctg'y g'o quv'r qrwrt'o qrgewrt'tqvtu0Vj gk'o clp'cf xcpvci gu'ctg'o qrp/gzr qpgrvkn' f gec { 'cpf 'tgrvkvgn' j ki j "o qrt'gzvkvkp'eqghlekpv"]6\_0J qy gxtg. 'y gk'o clp'f tcy dcmiku'cdutr vkp'cpf 'hmwqtguepeg' y cxgrpi yj u0Vj g'o quv'qh'y g'DQF RR[ "dcugf"r tqdgu'go kv'r j qvpu'lp"o"i tggp'ur gevtn'tgi kq. 'cnj qwi j "y j krg'y qtnkpi " y kj "dkmqi lecn'kuu'wgu'tg'qt'pget/kphtctgf 'hki j vku'o qtg'f guktcdrg"]7\_0"

Vj g'o clp'hwew'qh'y ku'tgugctej "y cu'v'uj kn'cp"go kukqp'ur gev'tv'q'mpi gt'y cxgrpi yj u'd { "lpetgcukpi "eqplwi cvgf" u { vngo 0Cduqr vkp'cpf 'hmwqtguepeg'go kukqp'ur gev'tc. 'cu'y gni'cu'hmwqtguepeg'f gec { u'j cxg'dggp'tgeqt'f gf 'vq'ej ctcevt'k g' ur gev'tqueqr le'r tqr gtvku'qh'y g'vco r rgu0F gr gpf gpegu'qp'uqrgpvu'r qrtkv { . 'xkuequkv { . 'cpf 'vgo r gtcwtg'y g'g'o gcuw'gf 0"

Vj g'qdckp'f "tguwu'uj qy "y cv'gzv'p'f kpi "y g'eqplwi cvgf"u { vngo "tguwu'lp"o"dcy qej tqo le'uj kn'qh'hmwqtguepeg' ur gev'tc'Hi 03. 'D+00 gcuw'go gpv'uj qy gf "y cvDR/QO G'ecp'dg'cr r rkgf 'hqt'ugpuki 'r qrtkv { 'kpv'gcf 'qh'xkuequkv { 0DR/O G/P Q'uj qy gf "cr r tqzko cvgn' "6"vko gu'mpi gt'hmwqtguepeg'f gec { "vko g'lp'xkuequkv'pqp/r qrt'ecuv't'qk'f'vku'gpv'lp'eqp'tcv'vq" pqp'xkuequkv'pqp/r qrt'vknv'p'p'vku'gpv'0Vj gtghgt. 'kv'eqw'f "dg'wugf "cu'c'xkuequkv { 'ugpuqt0"



Hi 030'C+'Vj g'o qrgewrt'twtwewtg'qh'gzco kpgf 'HO Tu0'D+'Hmwqtguepeg'ur gev'tc'qh'DR/O G'i tg { + 'DR/O GH'i tggp+-  
DR/O GH/P Q'dmg+- 'DR/RJ "qtcpī g+- 'DR/QO G'i'gf +0DR/E32' \*dmem+hmwqtguepeg'ur gev'tc'ku'wugf "cu'c'tghgt'ppeg0"

13\_ O 0Uj kpkj nř . 'O go dtepg'hwkf kř 'lp'o cni pepe { 'Cf xgtuevkv'cpf 'tgevr gtcvkv. 'DDC'/'Tgx0Ecepgt095: \*3; : 6+47364830"  
 14\_ QOP cf kx. 'O 0Uj kpkj nř . 'J 00 cpw'F 0J gej v'E0M0T qdgtu. 'F 0NgT qkj . 'I 0. lem'Gngxcvg' 'r tqv'lp'v' tqukp'g' r qur j cvcug'cevkxkř { 'cpf 'lpetgcugf " o go dtepg'xkuequkv { 'ctg'cuuqekcvf 'y kj 'ko r cktgf 'cevkxkvp'qh'y g'lpu'wlp'tgegr vqt'nkp'cug'lp'qrf 'tcu. 'Dkqj go 0L04; : \*3; : 6+66566720"  
 15\_ C0X {-pkwunū. 'O 0M0Mko qxc. 'C'y kvgf 'cvrg<O gcuw'kpi 'xkuequkv { 'cpf 'vgo r gtcwtg'qh'o ketqgp'kqpo gpv'wulpi 'o qrgewrt'tqvtu. 'kpv0Tgx0' Rj { u0Ej go 059\*423; +47; 64: 70"  
 16\_ U0Vqrcwcu. 'L0F qf qpqxc. 'C0fi xkdru. 'K0' lr nř u. 'C0Rqřkc. 'C0F gxlku. 'U0Vwo ngxk kwu. 'L0'Wnuwu. 'C0X {-pkwunū. 'Gpj cpekpi 'y g'Xkuequkv / Ugpukxg'Tepi g'qhc'DQF RR[ 'O qrgewrt'Tqvt'f' 'Vy q'Qt'f'gtu'qh'0 ci pkwf g. 'Ej go 0Gw0L047\*423; +3256463256; 0"  
 17\_ U0E0Ngg. 'L0J gq. 'J 0E0Y qq. 'L0C0Ngg. 'I 0 0Ugq. 'E0N0Ngg. 'U0Mko . 'Q0R0M'yp. 'Hmwqtguegpv'O qrgewrt'Tqvtu'hqt'Xkuequkv { 'Ugpuqtu " Ej go 0Gw0L046\*423; +3592863593: 0"



# ENCAPSULATION OF ANTHOCYANINS AND CINNAMALDEHYDE IN STARCH OCTENYLSUCCINATE

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The anthocyanins and essential oils are derived from plants and are denoted by antioxidant, antibacterial, anti-cancer and anti-inflammatory properties. They are widely used in cosmetics, pharmaceuticals and food industry because of their active properties. However, anthocyanins are unstable compounds. In order to increase their stability, anthocyanins are immobilized into various carriers which not only protect their molecules from physical and chemical factors, but also maintain their activity [1, 2]. The aim of this work is to encapsulate anthocyanins and cinnamaldehyde in hydrophobically modified starch by using spray drying method.

In this study anthocyanins (AC) from bilberry extract (*Vaccinium myrtillus L.*) and cinnamaldehyde (CA) were encapsulated in starch octenylsuccinate (OSAS) by using spray drying method. Firstly, aqueous emulsion containing 20 % of starch octenylsuccinate, 0.05 % anthocyanins and 5 % cinnamaldehyde was prepared. The droplet size of emulsion ( $271\pm 5$  nm) was measured and antioxidant activity ( $78\pm 4$  %) was determined. The dry capsules of starch octenylsuccinate with entrapped active compounds were obtained by spray drying the emulsion with *Nano Spray Dryer B-90* (Buchi). The obtained OSAS-AC-CA capsules (Fig. 1 C) were characterized by using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy studies.

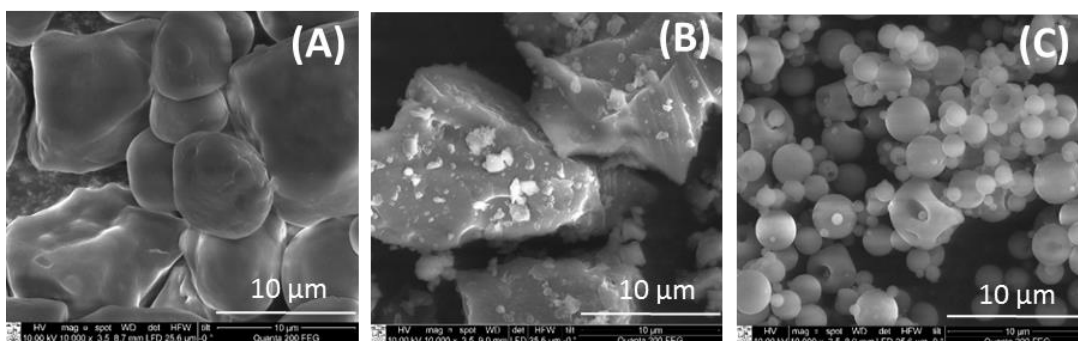


Fig. 1. SEM micrographs of OSAS (A), anthocyanins (B) powders and OSAS-AC-CA capsules (C). The magnification is  $\times 10000$

The tablets containing various amounts of OSAS-AC-CA capsules and microcrystalline cellulose were prepared and their antioxidant activity was examined (Fig. 2). The antioxidant efficiency varied from  $23\pm 1$  to  $90\pm 5$  % depending on OSAS-AC-CA content in the tablet. Consequently, OSAS-AC-CA capsules could be potentially used as antioxidant component in food supplements.

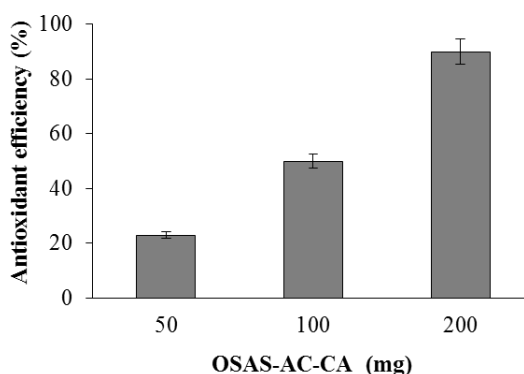


Fig. 2. Dependence of tablet antioxidant efficacy on the amount of OSAS-AC-CA capsules in the tablet. Total weight of the tablet was equal to 500 mg

[1] Tarone A.G. et al., Anthocyanins: New techniques and challenges in microencapsulation: *Food Research International* **133**, 109092 (2020)  
[2] Sharifi-Rad, J. et al., Biological Activities of Essential Oils: From Plant Chemoecology to Traditional Healing Systems: *Molecules* **22(1)**, 70 (2017)



# METAL IONS SENSING FOR BIOLOGICAL APPLICATIONS BASED ON ORGANIC SEMICONDUCTORS

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Metal ions have vital importance for living organisms. Ions play an important role in the life cycle of a cell, starting with reproduction and ending with programmed cell death (apoptosis). Moreover, metal ions are responsible for enzyme production and generally control all chemical reactions that are happening in a living cell. Naturally, high concentration as well as low concentration of metal ions in a living organism can have a negative impact. One of many metal ions which has both negative and positive effects on a living organism is silver ( $Ag^+$ ). Small concentrations of silver ions have antibacterial properties that can kill pathogenic bacteria, however, high concentration can even lead to liver cirrhosis [1]. Other metal ions such as  $Zn^{+2}$ ,  $Cu^{+2}$  and  $Ca^{+2}$  can accumulate in the human body and cause neurodegenerative diseases (e.g. Wilson disease) [2].

Thus, it is important to detect and monitor metal ions in living organisms for that purpose metal ion detectors are being developed. Fluorescence detectors get a great deal of attention because they exhibit high sensitivity, low production cost and short response time. One of many kinds of organic fluorescence detectors are purin-based organic compounds [3].

In this work we researched photophysical properties of a purin-based donor-acceptor molecule, its interaction with different metal ions in different protic solvents. The investigated compound (DaC-60) comprises of 2,6-bis-(1,2,3-triazol-1-yl)purine acceptor and two asymmetrically located 4-methoxyphenyl donors.

The results revealed that in methanol solution the organic molecule reacted with  $Zn^{+2}$ ,  $Ca^{+2}$ ,  $Ag^+$  or  $Fe^{+2}$  ions producing a new fluorescence emission peak at 409 nm wavelength. Similar effect was observed in ethanol, however, only with  $Ag^+$  ions. During complexation a new peak in the fluorescence spectrum with a shorter wavelength gradually grows while the old one diminishes. Though the exact cause of this shift is debatable, a photoinduced electron transfer between donor branches is supposed [4].

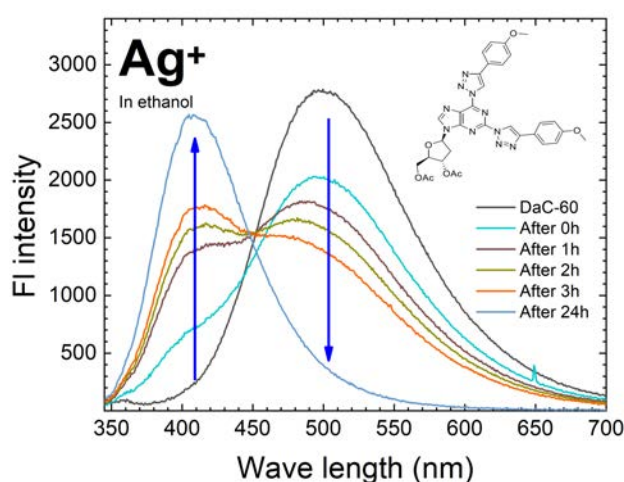


Fig. 1. Fluorescence spectrum of DaC-60 with silver ions in ethanol showing how complexation changes spectrum over time.

Furthermore, during our research we noticed that complexation was not an immediate process, therefore, time-dependent measurements (up to 24h after introduction of metal ions) were carried out (Fig. 1). It was shown that the concentration of metal ions and viscosity of solvent plays an important role in complexation suggesting it is a diffusion-induced process.

Overall this compound can be used to detect  $Ag^+$  and  $Zn^{+2}$  ions in methanol and ethanol solutions.

- [1] J. Jia, F. Li, H. Zhou, Y. Bai, S. Liu, Y. Jiang, G. Jiang, B. Yan, Oral exposure to silver nanoparticles or silver ions may aggravate fatty liver disease in overweight mice, *Environmental Science Technology* **51**(16), 9334–9343, PMID: 28723108 (2017).
- [2] P. Dusek, T. Litwin, A. Czlonkowska, Wilson disease and other neurodegenerations with metal accumulations, *Neurologic Clinics* **33**(1), 175–204, *Movement Disorders* (2015)
- [3] H. Xu, W. Chen, W. Zhang, L. Ju, H. Lu, A selective purine-based fluorescent chemosensor for the “naked-eye” detection of zinc ions ( $Zn^{2+}$ ): applications in live cell imaging and test strips, *New Journal of Chemistry* **44**(35), 15195–15201 (2020).
- [4] J. Jovaisaite, D. Cirule, A. Jeminejs, I. Novosjolova, M. Turks, P. Baronas, R. Komskis, S. Tumkevicius, G. Jonusauskas, S. Jursenas, Proof of principle of a purine d–a–d ligand based ratiometric chemical sensor harnessing complexation induced intermolecular pi-pi, *Phys. Chem. Chem. Phys.* **22**, 26502–26508 (2020).



# QTI CPKE'F[ GUY KVJ 'HWPEVKQPCN'CO O QP KWO 'I TQWRUHQT'VJ G' 4F 'RGTQXUMKVGU'

Xkrku'Uco vqrku. "X { vwcu'I gvcwku. 'Ct vko 'O ci qo gf qx"

F gr ctvo gpv'qh'Qti cple'Ej go knt { . 'Mcwpcu'Wpkxgtukv{ 'qh'Vgej pqm { . 'Nksj wpcle"  
xkrku'Uco vqrkuB mwqf w'

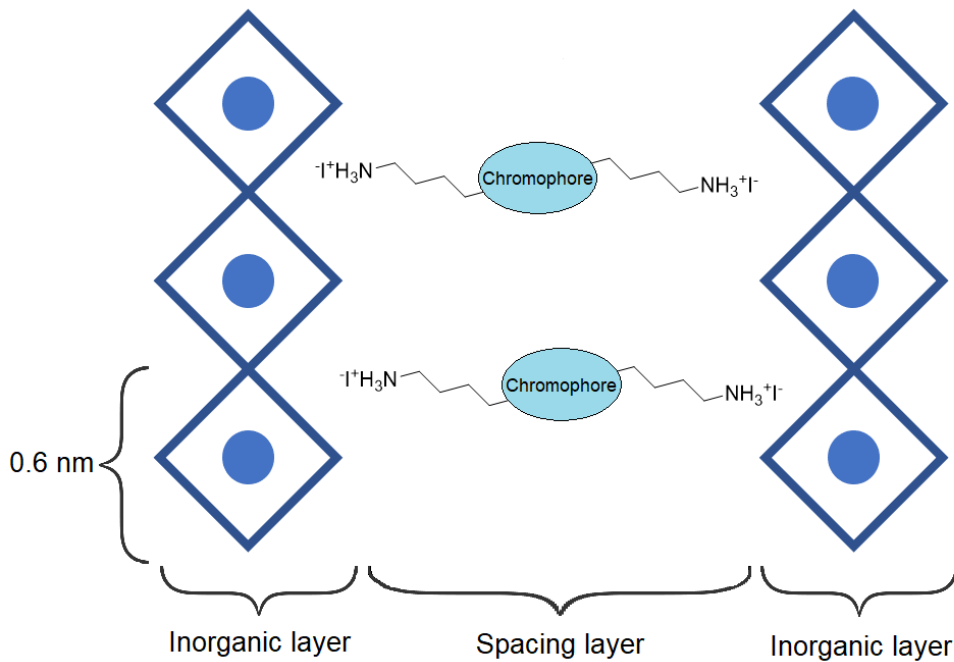
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Vj g" et { uvcn' ut vewt g" qh' vj g" dwni' r gtqxunkg" ku" wuwnm{ " tghgtgf " vq" cu" 5F 0' Kp" vj g" v' r lecn' qti cple lkpqi cple" r gtqxunkg. "uwej "cu'o gjy { nco o qpkwo "rgcf "vkkqf kf g. "uo cni'qti cple"ecvqpu'y kj "hwpevkqpcn'co o qpkwo "i tqwr u'ctg'hwkpi " vj g"ur ceg'dgy ggp'kpqi cple"ecvqpu'0'Vq"o cng'k'4F. "rci gt'qti cple"ecvqpu"o wu'dg'kpugt'v'f "lpvq"vj g"5F "rcwleg0'Cu'vj g" tguwn. "gcej "kpqi cple"r gtqxunkg"uj ggv'dgeqo gu'ugr ctv'gf "h'qo "qpg'cpq'vj gt'd { "vj g"uq/ecngf "ur celki "rc { gt' "Hki 03+0'J3\_"

Vj g" o clqt k{ "qh'vj g"4F RMu" et { uvcn' ut vewt gu"ecp'dg'ercu'hw'f "lpvq"y q" o clqt "ercu'gu" < T wf f r'guf gp/Rqr r gt' r gt' cpf " F kqp/Lceqduq'0'Vj g'gzcev'et { uvcn' j cug'f gr gpf u'qp"qti cple"ecvqpu'vj cv'ctg'wugf "lp'vj g"ur celki "rc { gt'0'0' qpqecvqpu'hwto " vj g" T wf f r'guf gp/Rqr r gt' r j cug. "y j kq'f lecvqpu'hwto " vj g" F kqp/Lceqduq' r j cug'0'F w'g" vj g" cdugpeg'qh'vj g"lpvgt'ceg" dgw' ggp"y q'ugr ctv'g"qti cple"o qrgewgu'k'ku"gzr gev'f. "vj cv'4F RMu"y kj "F kqp/Lceqduq' r j cug"ur ceg'y kn'j cxg'dgw'gt' g'g'v'lecn'r tqr gt'v'gu. "lp'eqo r ctv'q'v'vj cv'qh'y kj "vj g" T wf f r'guf gp/Rqr r gt' r j cug'0'J4\_"

"



Hki 0304F RM'y kj "rci gt'qti cple" f lecvqpu'lp'vj g'ur celki "rc { gt'0'

Hqt "vj ku'y qtm"ugxgtcn'eqo o gtekm{ "cxckrdng"qti cple"ej tqo qr j qtgu"j cxg"dgpp"ugrgev'f "hqt'hw'vj gt"o qf k'lecvqpu." dcugf "qp"vj g"y kf vj "qh'vj g"o qrgewgu'cpf "vj gkt"qr v'lecn'r tqr gt'v'gu' Vj g" etquw/ugev'q'qh'vj g"ej tqo qr j qtg"uj qwf "pqv' gzeggf "20'po. "qvj gty kug. 'k'o ki j v'dg'pqv'r quukdr'v'hwto "c"et { uvcn'kp'g'ut vewt g'0'

Cni' u{ pvj guku' lp' vj ku' y qtni' y kn' dg' ecctk'gf "qww' lp" c" hgy " uko r ng" ugr u. "k'0' ej tqo qr j qtg" tgcev'q'p" y kj " P / \*6/ dtqo qdww' nr j j cko kf g. "h'qmy gf "d { "I cdtk'gr' u{ pvj guku. "cpf "h'pcm{ "vtg'cv'pi "vj g"lpvgt'o gf k'ev'eqo r qwpf "y kj "j { f tqi gp" kqf kf g'0"

F wtkpi "vj g"hw'vj gt" uvcn' gu' qh' vj ku"tgugctej. "k'ku"gzr gev'f "pqv' qpn{ "vq" u{ pvj guku' g' cpf "lp'xgunki cvg" pgy "qti cple" f lecvqpu'dw'cnuq'v'hw'f "cp"gcuk'gt'cpf "ej gcr gt" y c { "vq" u{ pvj guku' vj go. "tcv' gt" vj cp'v'q' m'qni'hw' ur g'ek'ke"u{ pvj guku' r cv' u'0' Vj ku'y qwf "cm'y "wu'v'd'atq'cf gp'vj g'gzr nqt'gf "ur ceg'qh'v' cvgtk'cn'cpf "hw'vj gt" cf xcpeg'vj ku'hgrf 0'

"

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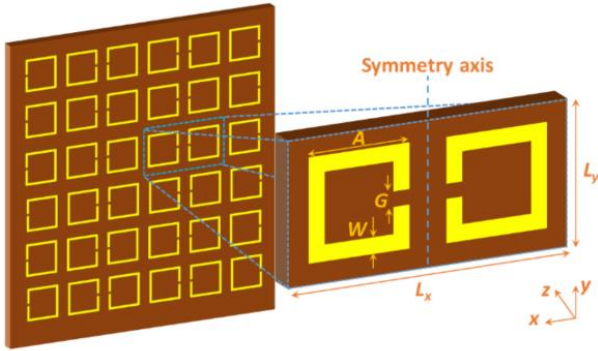
"

# O WNVKRNĠHCPQ'TGUQPCEGUĠP'C'O KTTQTGF'CTTC[ 'QHURNK/ TRPI 'TGUQPCVQTU'

Cpf tkwu'Mco ctcwuncu<sup>3</sup>. 'I gf ko kpcu'Ygnu<sup>3</sup>. 'F crkwu'Ugrkwc<sup>3</sup>. 'fi kxkpcu'Mcpergtku<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rj { ukecn'Vgej pqmji lgu.'Egpvgt'hqt'Rj { ukecn'Uelgpegu'cpf 'Vgej pqmji { . 'Nkj wcpkc' cpf tkwu'ncu ctcwuncuB ho ehn'

Tgegpvnl'o gvcuwthcegu'ctg'i cklpki 'uvcgf { 'cwgpvkqp'ltqo 'yj g'tgugctej 'eqo o wpk{0'Vj ku'j cr r gpu'o quwn{ 'f wg'vq'vj g' r gtur gevkg'vq'etgevg'c'pgy 'v' r g'qhi'ncv'o cvgtkcu'khwkpi 'ur gekkle'r tqr gt vku'qhf'khtgtgpv'cr r nkcwkpup'Qpg'qh'vj g'r quukdrg' tgcrl' cvkqpu'qh'vj gug'j qr gu'o ki j v'dg'o gvcuwthcegu'f go qputcvkpi 'j ki j 'S 'hcevt'Hpq'tguqpcpegu'j3\_ 'y j lej 'ctg'pqy 'dglpi' ' y kf gnl' kpxgunki cvgf 0'



Hki 030Uej go cvku'qh'vj g'o kttqgf'cttc{ 'qh'UTTu'cpf gprcti gf 'ukpi rg'wpk'egm'Vj g'vj kempgu'qh'vj g'uidutcvg'ku 347' o . 'ku'f krgextle'equpcvp'v' \* "? 40+ 'f ko gpukqpu'qh tguqpcvqtu'C' "? 722' o . 'Y' "? 'I' "? '72' o 0'

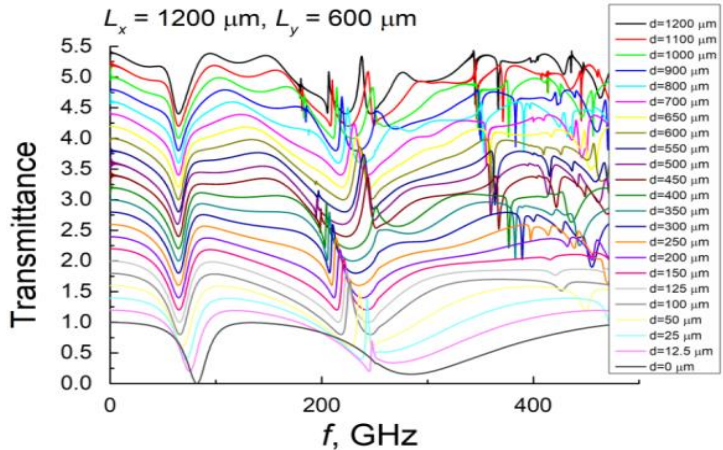
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Ecrewrvgf'tcpuo kwcepg'ur gevte'ctg'lj qy p'lp' Hki 0' 40' Hqt' ucneg' qh' emtkv{ . " yj g' ur gextc' ctg' kpvkqpcmf' 'uj kxgf 'lp'vj g'xgt'kcn'czku'Vj g'hku'v' o kpo wo 'ctqwpf' ; 2'I J | "o qf g'p' "? 3+'cr r gctkpi " lp'vj g'ur gevte'wo 'ku'cwt'kwgf 'v'vj g'hku'v' r'uo qple' o qf g'gzekgf 'lp'UTTu'0'K'ku'y qt'vj 'o gpv'kqkpi 'vj cv' f wg'vq'vj g'cu{o o g'vte'q'lgpv'cvkqp'qh'vj g'grgextle' hgrf 'lp'tgur gev'qh'vj g'i cr 'qh'UTTu.'qpn{ 'yj g'qf f' o qf gu'lp'vj g'o gvcuwthceg'ctg'gzekgf 0'K'ku'uggp' yj cv'y kj 'kpetgculpi 'vj g'vj kempgu'qh'vj g'uidutcvg' yj g'hts wpe { 'qh'o qf g'p' "? 3'uj kku'v'vj g'my gt' hts wpe { 'dgcwug'qh'vj g'kpetgcug'qh'vj g'gh'gevkx'g' f krgextle'equpcvp'qh'vj g'ut wewt'g'Vj g'r r'uo qple' o qf g'p' "? 5'ku'tgur qpukdrg'hqt'vj g'ugeqpf "y kf g' o kpo wo 'lp'vj g'v'cpuo kwcepg'ur gevte'wo 'cv'f' "? 2' ctqwpf "4: 2'I J | 0'K'ku'uggp'vj cv'y kj 'kpetgculpi " yj g' yj kempgu' qh' yj g' uidutcvg' yj g' Hcpq' v' r g' tguqpcpeg'cr r gctu'cv'vj ku'hts wpe { 0'Cu'crtgcf { " o gpv'kqpgf . 'ku'cr r gctu'f wg'vq'vj g'kpv'gtcvkqp'qh'vj kf g'r r'uo qple' o qf g'y kj 'pcttqy 'rwleg'o qf g'gzekgf 'lp'vj g'r g'rtkqf'le' utwewt'g'14\_0Hwt'j gt'kpetgcug'qh'vj g'vj kempgu'qh'vj g'uidutcvg'rgcf u'v'vj g'f'qwdrg'cpf 'gxgp'v'kr rg'Hpq'tguqpcpegu.'y j lej " engctn{ 'o cpl'guu'kuugn'lp'vj g'v'cpuo kwcepg'ur gevte'v'q' Hki 04-0'

Qwt'kpxgunki cvkqpu'f go qputcvg'vj cv'gzekcvkqp'qh'vj g'f krgextle'y cxgi wkf g'o qf gu'lp'vj g'uidutcvg'ku'gu'gpv'kcn'lp'vj g' ecug'qh'vj kenu'uidutcvg'00 wnr rg'bo qf gu'kpv'gtcv'vj kj 'vj g'r r'uo qple' o qf g'p' "? 5.'cpf 'y ku'ku'tgur qpukdrg'hqt'vj g'cr r gctcpeg' qh'vj g'o wnr rg' Hcpq'tguqpcpegu'lp'vj g'o gvcuwthceg'eqo r qugf "qh'c'o kttqgf'cttc{ 'qh' UT Tu'0'Y g' dgr'kxg'vj cv'vj ku' r j gpqo gpqp'o ki j v'kpf'cr r nkcwkp'lp'ugpukpi 'f gxlegu'0Cp'g'zr g'tko gpv'cn'kpxgunki cvkqpu'ku'wpf gt' r tgr ctcwkp'0'

Tgegpvnl'j ki j "S 'hcevt'Hpq'tguqpcpeg'y cu'f kxqxtg'gf " lp'c'o gvcuwthceg'o cf g'ltqo "c'o kttqgf'cttc{ 'qh'ur rsk'tkpi " tguqpcvqtu' \*UTTu+ " 14\_0' Vj g' xlgx " qh' yj g' kpxgunki cvgf " o gvcuwthceg'ku'uj qy p'lp' Hki 030K'ecp'dg'uggp'vj cv'k'ku'o cf g' ltqo "c' uko r rg' r r'pct'cttc{ 'qh'ur rsk'tkpi " tguqpcvqtu' g'xgt { " ugeqpf 'eqmwo p'qh'y j lej 'ku'tqvcv'gd' { 3: 2°0'K'uwaj 'c'y c { . 'c' r g'rtkqf' qh' yj g'cttc{ 'lp' yj g' z/f k'gevkqp'ku'kpetgcugf " yj k'eg. " y j g'gtcu'vj g'r g'rtkqf 'lp'vj g' // f k'gevkqp'tgo c'kpu'vj g'uco g'0'Cu' uj qy p'lp' 14\_ " f kxqxtg'gf " tguqpcpeg'f go qputcvg'u'j ki j "S " hcevt'cpf 'cr r gctu'f wg'vq'vj g'f k'gevkqp'vtcvkqp'qh'r r'uo qple' o qf g'y kj 'rwleg'o qf g'0'Vj g'g'htg'g' y j gp'vj g'r g'rtkqf 'qh'vj g' cttc{ 'ku'kpetgcugf . 'y j g'tguqpcpeg'uj kku'v'c'ny gt' hts wpe { 0' K'vj g'r t'gugp'v' r cr gt. " y g'pwo g'k'ecm{ " kpxgunki cvg' o kttqgf " UT Tu'f gr qukxgf 'qp'c'vj lengt'uidutcvg'cpf 'kpf' o wnr rg'Hpq' tguqpcpegu'0'

Y g' kpxgunki cvg' yj g' utwewt'g' yj qy p' lp' Hki 0' 30' Vj g' k'p'kf'gpv'y cxg'hmu'r gtr g'p'kewctn{ 'v'q'vj g'utw'cepg'qh'UTT'



Hki 040Ecrewrvgf'tcpuo kwcepg'ur gevte'qh'bo gvcuwthceg'eqo r qugf qh'c'o kttqgf'cttc{ 'qh'ur rsk'tkpi 'tguqpcvqtu'qp'c'f khtgtgpv'vj kempgu'qh yj g'uidutcvg' \* "? 40+0'uidutcvg'vj kempgu'ku'f gpv'qf 'lp'vj g'hki wtg' U' r gevte'ctg'lj kxgf 'lp'vj g'q'f k'pcv'czku'

<sup>1</sup>J3\_ 'Y 0'Y cpi 3. 'N0' j gpi . 'gv'cn'0'Cr r r'g'f 'Rj { ukeu.'Gzr t'guu'Gzr t'guu'J ki j 'S' hcevt' o wnr rg'Hpq'tguqpcpegu'hqt'j ki j /ugpuk'k'k'f' ugpukpi 'lp'cm'f krgextle' pcpq'e'f'kpf gt'f'lo gt'o g'vco cvgtkcu'0'Xq034.'P q'9.'r r 0297224/317'423; +0f qk'320'789B: : 4/29: 8 kcd428c=" 14\_ 'F 0'Ugrkwc.'gv'cn'0'Qr v'ku'Ngv'gu.'Hpq'tguqpcpeg'ctk'k'pi 'f wg'vq'f k'gevkqp'vtcvkqp'qh'r r'uo qple'cpf 'rwleg'o qf gu'lp'c'o kttqgf'cttc{ 'qh'ur rsk'tkpi " tguqpcvqtu'Xq066.'P q'6.'r r 097; /984'423; +0f qk'320'586IQN6602297; ="







**J K J N [ 'GHHKGPV'GO KUKQP 'QHEJ CTI G'VTCPUHGT'UVCVGRP''**  
**ECTDC\ QNG/'R[ TFKP'G'O QNGEWNCT'U UVGO UHQ'T'VCFH'**  
**CRRNECVKQP U'**

O kkc" Wfi kt v<sup>3</sup>. Rqkrcu' Cf qo pcu<sup>4</sup>. Qpc' Cf qo plgp<sup>4</sup>. Tgi ko cpvcu' Mqo unki<sup>3</sup>. Ucwkwu"  
 Lwt- pcu<sup>3</sup>"

<sup>3</sup>Kpukwng'qh'Rj qvpleu'cpf 'P cpqvej pqrqi { .Xkpkwu'Wpksxtukv{ "  
<sup>4</sup>Hcewm{ "qh'Ej go kut { .Xkpkwu'Wpksxtukv{ "  
o kkcW i k { vB HxwWn"

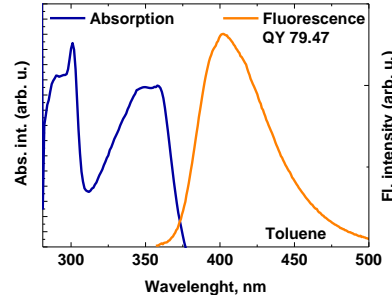
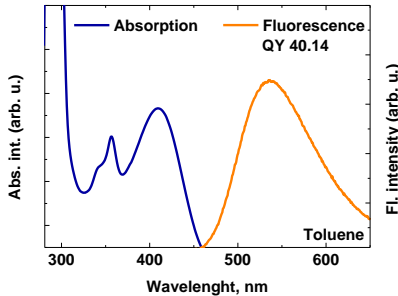
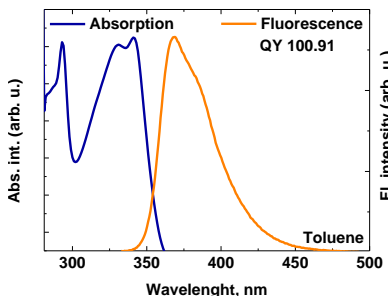
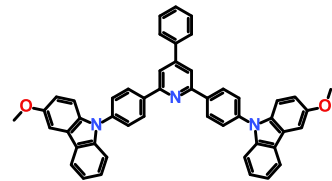
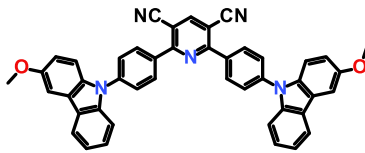
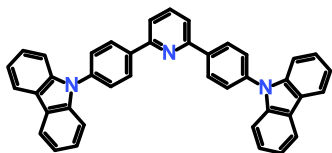
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 \*VCF H'r t qegu. "y j gp" f ctn' tkr nvy' ucvgu' ctg" j" ctvguf "vq" go kuukg' ulpi nvy' ucvgu' 0Vj ku' r t qegu. cmqj u' vq' cej kxg' w' vq"  
 322' "qh' k' pvt pcr' s wcpwo " ghlekpe{ "qh' vj g" go kvgt 0J qy gxgt. "VCF H' r t qegu" ku' f kr qng' hqtdkf f gp" cpf "ku' r ctvcm{ "  
 f gvto kpgf "d{ "mj "hwtgugpeg" s wcpwo " { kgrf "qh' ej cti g" tcpuht' ucvgu' \*E V+ cu" c" eqpug' wpg" qh' y cni' quekrcvq"  
 utgpi vj "qh' vj g" tcpuht' 0Vj wu. "cp" qxgtcm' hwtgugpeg' r hgwko g' ku' uduwcpvcm{ "gzvpgf gf" cpf "QNGF " uwhgtu' ht qo "  
 s wcpwo "ghlekpe{ "tqm/qlh"

J gtg. "y g' r' t gupv' c" j ki j n{ "ghlekpv' ectdc| qng" /" r { t k l p g " E V " go kvgtu' cpf " f go qpvt cvg' vj g' r quukkrk{ "vq' eqpvt qn' c"  
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 o qf kh{ kpi " f qpqt k " r tqr gt vku' qh' ectdc| qng" cpf " ceegr vt k l e " r tqr gt vku' qh' r { t k l p g 0Vj g" ej cti g" tcpuht' xlc" o qrgewrct "  
 dcendqpg' y cu' eqpvt qmgf " d{ " kpvt qf wki " o gy qz { " i tqw u' q" ectdc| qng" cpf " pktkrk' uduwkwg' vq' r { t k l p g " t k pi 0E V " ucvg"  
 r qr wcvkp' y cu' cpcn{ | gf " d{ " ucvgf { " ucvg' cduqr vqp" cpf " hwtgugpeg" ur gevteqr { " vj g' pls vgu' 0"

Cduqr vqp' dcpf "qh' o qf gn' f qqt " o " ceegr vt " ectdc| qng" o " r { t k l p g " \*O 7+ o qrgewru' ku' kp' vj g' wntcxkqngv' y cxgrpi vj "  
 tcpi g' cv' 472/583" po " \*Hki " 3+ 0C duqr vqp" ur gevte " j cu' c" erget " xkdtqple" utwewtg. " y j kej " kpf kecvgu' c" f qo kpcvqp' qh'  
 mrcm{ " gzekgf " \*NG+ ucvgu' 0Vj g' hwtgugpeg" go kuukp' ku' kp' 55: " o' 688" po . " y kj " c' uo cni' Uqngulij kn0C" j ki j n{ " g' r t g u g f "  
 NG' tgrzcvkqp" gpdcrgu' c' xgt { " j ki j " s wcpwo " { kgrf " o' 322" 0J qy gxgt. " y kj " pq' r tqo kpgpv' E V " ucvg' go kuukp. " vj g' VCF H' "  
 r t qegu. ku' kp' ghlekpv' 0"

F tcvk" ej cpi gu' kp" cduqr vqp" cpf " go kuukp" r tqr gt vku' ctg" qdugt xgf " y j gp" f qpqt k " r tqr gt v{ " qh' ectdc| qng" ku'  
 gpj cpegf " d{ " o gy qz { " uduwkwg' wu' cpf " r { t k l p g " ceegr vt " ku' o qf k h g f " y kj " p k t k r k " h t c i o g p w u' \*Hki 0' 400C " vj t g g / y c x g "  
 cduqr vqp' dcpf " ku' qdugt xgf " kp' wntcxkqngv' tcpi g. " r gcnkpi " cv' 522" po . " 578" po " cpf " 62; " po . " y j kej " kpf kecvgu' y q' mrcm{ "  
 gzekgf " ucvgu' \*NG+ " cpf " g' r t g u g f " E V " ucvgu' 0C eeqt f k pi n{ . " hwtgugpeg" ur gevte " ku' t g f u j k h g f . " kp' tcpi g' qh' 679' o' 964' po . "  
 y kj " gpj cpegf " E V " ucvg' go kuukp' 0Vj wu. " c' s wcpwo " { kgrf " f getcgcu' d{ " j cni' vq' 62" 0J qy gxgt. " vj g' qxgtcm' E V " eqpvpv' ku'  
 j ki j . " cpf " vj g' r h g v k o g' qh' qxgtcm' go kuukp' ku' uduwcpvcm{ "gzvpgf gf 0"

Y j gp" ceegr vt k l e " r tqr gt v{ " qh' r { t k l p g " t k pi " ku' t g f w e g f " y kj " c' r j g p { n' t k pi " \*Hki 0' 5+ " vj g' eqo r qwpf " f go qpvt cvg' cp"  
 g' r t g u g f " xkdtqple " ugt lgu' qh' NG' ucvgu. " kp' wntcxkqngv' y cxgrpi vj " tcpi g' qh' 472' o' 598' po 0Vj g' hwtgugpeg' ku' qdugt xgf " kp'  
 582' o' 772' po " tcpi g. " y kj " c' t g f " u j q w r f g t . " q t k i k p c v k p i " h t q o " u o c n i' r c t v' q h' E V " ucvg' t g r z c v k q p 0 S w c p w o " { k g r f " k u ' j k i j " o "  
 9; " 0Vj wu. " c' E V " ucvg' t g r z c v k q p " r c v j y c { " h t " g h l e k p v' V C F H ' r t q e g u . " o c k p c k p i " j k i j n { " g h l e k p v' h w t g u g p e g " k u '  
 cej kxgf 0"



Hki 0' 30' Cduqr vqp" cpf " hwtgugpeg"  
 ur gevte " qh' o qf gn' ectdc| qng" o " r { t k l p g "  
 o qrgewrct" u' ugo 0' Hwtgugpeg"  
 s wcpwo " { kgrf " kp' vqngpg" ku' cniq "  
 kpf kecvgf 0"

Hki 0' 40' Cduqr vqp" cpf " hwtgugpeg"  
 ur gevte " qh' ectdc| qng" o " r { t k l p g "  
 o qrgewrct" u' ugo . " uduwkwgf " y kj "  
 o gy qz { " cpf " p k t k r k " h t c i o g p w u'  
 Hwtgugpeg" s wcpwo " { kgrf " kp' "  
 vqngpg' ku' cniq " kpf kecvgf 0"

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 o qrgewrct" u' ugo . " uduwkwgf " y kj "  
 o gy qz { " cpf " r j g p { n' h t c i o g p w u'  
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# UVKO WNCVGF 'I TGGP 'GO KUUKQP 'P 'NGCF 'DTQO K' G'RGTQXUMKVGU'

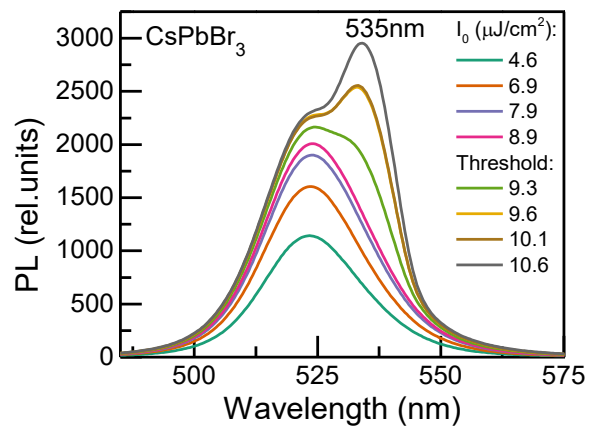
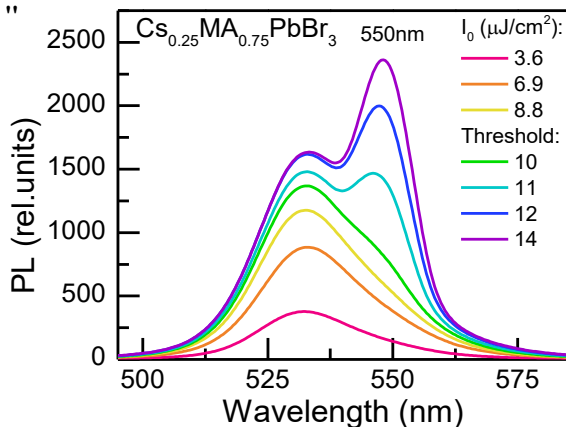
Uco cpvc 'Nkr ngxk k v<sup>3</sup>. 'F flkwi cu 'Nkxkpcu<sup>3</sup>. 'Tgi ko cpvcu 'Mqo unku<sup>3</sup>. 'Ucwksu 'Lxt - pcu<sup>3</sup>

<sup>3</sup>kpukswg'qh'Rj qvqpleu'cpf 'P cpqvej pqmji { . 'Xkpkwu 'Wpkxgtuks { . 'Nksj wcpkc  
uco cpvc'0kr ngxlekwgB Hfhwf 0xw0h'

Ncugt" go kwgtu" rnc { "cp" ko r qtwcpv" tqrq" lp" o qf gtp" uelgpeg=" j y gxgt. " rcti g" f ko gpukqpu. " eqo r rnz" o cpwkcwtkpi " vzej pqmji kgu'cpf 'mry "ghhlekpe { " tgf wegu" yj g' cxckrcdkkx { "qh'uwej " f gxlegu' O gcnj' cirk g' r' gtqxunkgu' ctg' cp" go gti kpi " encuu" qh'ugo keqpf wevtu" j qrf kpi " r tgo kulpi " r qvqpcn' lp" hmt yj gt " cf xcpelkpi " yj g' ncugt" vzej pqmji { " yj lej " o ki j v' qxgteqo g" yj gug" r tqdrgo u' y kj " yj gk' " gcu" r tqf wevkqp" cpf " uo cni' f ko gpukqpu' J qy gxgt. " r gtqxunkg" o cvgtkcu' g' zj kdk' j ki j " yj tguj qrf u' hqt" co r rkhgf " ur qpvcpgqu" go kuukqp" \*CUG+0' O qtg" ko r qtwcpv { . " yj g' CUG" ur gevte" r gcnl' r qukskqp" j ki j n' " f gr gpf u' qp" yj g' eqo r quksq' qh' r' gtqxunkg' ut wewtg. " cpf " c' t' gugctej " qp" yj g' kphwvpeg' qh' f khhgtgpv' cplkpu' cpf " ecvku' lp" r' gtqxunkg' r' wleg' vq" yj g' ur gevte qer ke' ej ctcevgtkku' qh' CUG' ku' t go gpf qwu' 0' k' yj ku' uwf { . " yj g' hqewu' qp" c' r' gcf " dtqo k' f g' r' gtqxunkg' hco k' f " yj kj " o k' zgf " qti cple" o g' yj { rco o qpkwo " cpf " k' p' qti cple " egukwo " cplkpu' / " Eu<sub>2</sub>O C<sub>3/2</sub> RdDt<sub>5</sub> \* O C - " ? " EJ<sub>5</sub> / P J<sub>4</sub> - 0' Y g' ugrgevkgn' " uwdukswg" egukwo " cplkqp" y kj " f khhgtgpv' o qrcr " r ctw' qh' o g' yj { rco o qpkwo " lp" Eu<sub>2</sub>O C<sub>3/2</sub> RdDt<sub>5</sub> " r' wleg" cpf " k' p' xguki cvg" ur gevte qer ke' ej ctcevgtkku' qh' CUG' d { " go r m { kpi " k' o g' t' guixgf " r j qvqno k' p' uegpeg \* VTRN+ " ur gevte qer { 0'

Eu<sub>2</sub>O C<sub>3/2</sub> RdDt<sub>5</sub> " r' gtqxunkg" r { gtu" y g' g' f gr quksqf " htgo " c' uqnwkp" qp" ergepgf " i r' u' uwdutcvgu" xlc" ur lp" eqcvkpi " o g' yj qf 0' O qrcr " t' cvku' qh' egukwo " cpf " o g' yj { rco o qpkwo " lp" yj g' r' gtqxunkg' uqnwkp" y g' g' o k' zgf " lp" yj g' k' p' v' t' xrci' ? " J2.47-3\_ " d { " cngt kpi " yj g' o cuugu' qh' f t { " r' t' gewtuqtu" egukwo " dtqo k' f g' \* EuDt + " cpf " o g' yj { rco o qpkwo " dtqo k' f g' \* O C Dt + 0' Vj gug" y q" r' t' gewtuqtu" vqi g' y g' t' y kj " r' gcf " dtqo k' f g' \* RdDt<sub>4</sub> + y g' g' f kuukxgf " lp" f ko g' yj { n' w' h' q' z' k' f g' \* F O UQ + 0' Rgtqxunkg" r { gtu" y g' g' r' cuukxcvgf " y kj " c" r { g' t' qh' r qn { o g' yj { m g' yj cet { r' w' g' \* RO O C + " r' qn { o g' t' htgo " qz { i gp" cpf " y cvgt " xcr qt " vq" r' t' gxgpv' f gi t' cf cvkp' 0' D { " ej cpi kpi " yj g' cpi wrt " x' g' r' q' k' f " qh' yj g' ur lp" eqcvkpi " r' tqeguu. " r' gtqxunkg" r { gtu" hqt" cp" ghhlekpv' CUG' y g' g' r' q' r' w' k' gf " cu' yj k' p' p' g' t' cpf " uo q' q' yj g' t' r' c' gtu" y g' g' ces w' k' gf " y kj " j ki j g' t' x' g' r' q' k' f k' g' u' 0'

Ur gevte r' eqo r qukskqp" qh' uco r r' g' go kuukqp" y cu" yj q' t' q' w' j n' " k' p' x' g' u' k' i cvg' f " wulpi " k' o g' t' guixgf " r j qvqno k' p' uegpeg" \* VTRN+ " ur gevte qer { " cv' c' f khhgtgpv' g' zekcvkqp' h' w' g' peg " Hk 03 + 0C v' c' uo cni' q' r' w' cni' g' zekcvkqp' h' w' g' peg. " c' r j qvqno k' p' uegpeg" r' gcnl' ctw' go gti kpi " cu' c' eqpugs wpeg' qh' ur qpvcpgqu" go kuukqp " lp" Eu<sub>2</sub>O<sub>7</sub> O C<sub>2</sub>O<sub>7</sub> RdDt<sub>5</sub> uco r r' g' cv' 752' po " cpf " cv' 747' po " lp" ukpi r' g' ecvku' qp" EuRdDt<sub>5</sub> uco r r' g' 0' C v' c' j ki j " q' r' w' cni' g' zekcvkqp. " cni' r' gtqxunkg" r { gtu" f go q' p' utcv' f w' cni' d' c' p' f " go kuukqp. " y kj " cf f k' k' qp' cni' d' c' p' f " go gti kpi " cv' 772' po " lp" Eu<sub>2</sub>O<sub>7</sub> O C<sub>2</sub>O<sub>7</sub> RdDt<sub>5</sub> " cpf " cv' 757' po " lp" EuRdDt<sub>5</sub> " r { gtu" 0' Y g' cuuqekcv' cf f k' k' qp' cni' go kuukqp' d' c' p' f u' y kj " cp" CUG' r' tqeguu. " cu' c' f t' q' yj " qh' l' p' v' p' u' k' f " qh' ch' q' t' go g' p' v' k' p' g' f " d' c' p' f " ku' s' w' c' f " t' c' v' e' 0' W' i' n' t' c' h' e' u' v' h' w' q' t' g' u' e' g' p' e' g' " f' g' e' c' f " e' q' p' h' t' o u' yj g' p' c' w' t' g' u' e' g' p' f " r' j qvqno k' p' uegpeg" d' c' p' f " cu' cp" CUG' 0' Y g' y g' g' t' g' c' d' n' g' v' q' c' e' j k' g' x' g' c' " u' c' u' k' h' e' c' v' t' { " yj t' g' u' j q' r' f " h' q' t' " CUG' d' g' n' y " 32 " U' L' e' o " 4' qh' q' r' w' cni' g' zekcvkqp' h' w' g' peg' 0' C " v' g' p' f g' p' e { " qh' co r r' khgf " ur qpvcpgqu" go kuukqp" r' gcnl' u' j k' h' k' p' i " v' y c' t' f " : i t' g' g' p' g' t' : " \* 772' po + y c' x' g' r' p' i v' yj g' p' v' j g' o qrcr " r' ctw' qh' o g' yj { rco o qpkwo " lp" yj g' r' gtqxunkg' ku' l' p' e' t' g' c' u' g' f " y cu" q' d' u' g' t' x' g' f 0'



Hk 030VTRN' o gcuwt go gpvt guwmu' hqt " y q' r' gtqxunkg' uco r r' g' u' cv' c' f khhgtgpv' g' zekcvkqp' h' w' g' peg " K' 0' H' q' o " r' g' h' v' q' t' k' i j v' " Eu<sub>2</sub>O<sub>7</sub> O C<sub>2</sub>O<sub>7</sub> RdDt<sub>5</sub> uco r r' g' k' p' v' g' i t' c' v' g' f " ur gevte = EuRdDt<sub>5</sub> uco r r' g' k' p' v' g' i t' c' v' g' f " ur gevte 0' ""

Vj g' o c' k' p' t' guwmu' qh' yj ku' uwf { < yj k' p' p' g' t' " uo q' q' yj g' t' r' gtqxunkg" r { gtu" q' d' v' k' p' g' f " y kj " c' j ki j g' t' c' p' i wrt " x' g' r' q' k' f " qh' yj g' " ur lp" eqcvgt " ctg" o qtg' u' w' k' c' d' n' g' h' q' t' " ghhlekpv' uko w' r' v' g' f " go kuukqp" i g' p' g' t' c' v' k' p' 0' O qt' g' q' x' g' t. " yj g' ur gevte cni' qukskqp" qh' yj g' r' gcnl' qh' co r r' khgf " ur qpvcpgqu" go kuukqp" e' c' p' d' g' g' c' u' k' f " e' q' p' v' t' q' m' g' f " d { " ej cpi kpi " yj g' eqo r qukskqp" qh' Eu<sub>2</sub>O C<sub>3/2</sub> RdDt<sub>5</sub> = f getg' c' u' k' p' i " o qrcr " r' ctw' qh' o g' yj { rco o qpkwo " r' gcf u' v' q' co r r' khgf " ur qpvcpgqu" go kuukqp" r' gcnl' u' j k' h' k' p' i " htgo " 772' po " vq " 757' po 0'

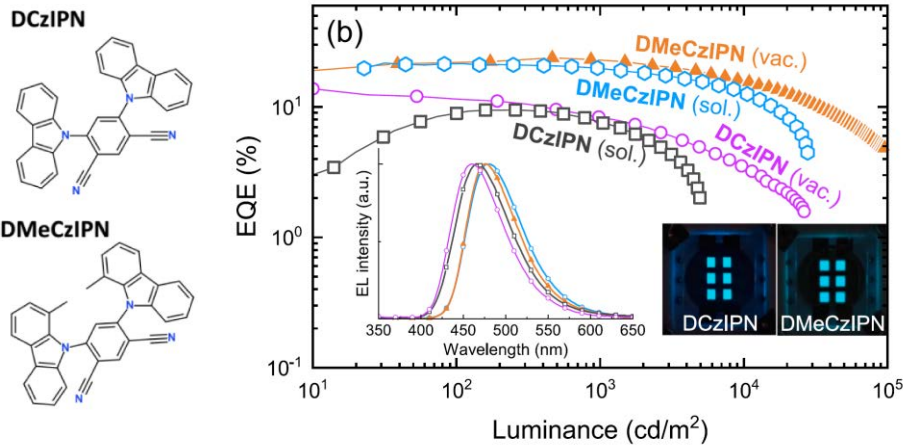
**UWUVCP VCN'VCF H'QNGF 'RGTHQT O CPEG'KO RTQXGO GPV'D[ " UKO RRG'GO K/VGT 'UVT WE VWT G'O QF KHE CVKQP "**

**Fqx{f cu'Dcpgxk kw<sup>3</sup>. 'I gf ko kpcu'Mtggk c<sup>3</sup>. 'F qo cpvcu'Dgtgpk<sup>3</sup>. 'Vqo cu'Lcxqtunk<sup>4</sup>. 'Gf xlpcu'Qtgpcu<sup>4</sup>. 'Ucwkku' Cpvcpcu' Lxt - pcu<sup>3</sup>. 'Mctqrku' Mc| rcwncu<sup>3</sup>**

<sup>3</sup>kpukswg'qh'Rj qvqpleu'cpf 'P cpqvej pqm| { . 'Xkpkku'Wpkxgtuk{ . 'Nkj wpcle'  
<sup>4</sup>F gr ctvo gpv'qh'Qti cple'Ej go kwt { . 'Xkpkku'Wpkxgtuk{ . 'Nkj wpcle'  
 fqx{f cu'lcpgxlekuB hfkw'v'

Vj gto cm| "cevkxcvgf "f gr { gf "hmqtguegpeg" \*VCF H" eqo r qwpf u'j cxg "tgegxgf "i tgcv'cwgpvkq "hqt "j gk "r qvqpleu'vq" wkkk g'dqj "ukpi rnv'cpf "vkr rnv'gzekqpu'lp'QNGF u'hqto gf "f wtkpi "ej cti g'ecttktg'lp'gevkq0]3\_ "Tcvkqpcno cvgtkcnf guki p'j cu" gpcdnrf "VCF H'QNGF "f gxlegu" y kj "wr "vq" 322" "kpvtpcn' s wcpwo "ghhlegpeku" o clpn "f wg" vq "cp" ghhlegpv' tngxgtug" kpvgtu{ ungo "etquukpi " \*T KUE + "j cv'cmqy u'eqpxgtukq "qh'f ctm'vkr rnv'gzekqpu'lp'vq" go kuukxg' ukpi rnv'ucvq0]4\_ "Y j krg "T KUE" ku" wuwcm| "c" unqy "r tqeguu. "VCF H'QNGF u'uwhtg "h qo " gctn| "ghhlegpe { "tqm/qhh' cuqekcvgf "y kj "j ki j "mpj / rdxgf "vkr rnv' gzekqpp' r qr wcvkq0Vj g'ghqg. "VCF H'go kvgtu'y kj "rcti g't KUE "tcvg' hcekxvpi "vkr rnv'wr / eqpxgtukq "ctg'tgs wkt gf 0]5\_ "

Kp "j ku" y qtm' d| "kpvqf welpi "c" uwdvq" o qf htecvkq "vq" y q "ectdc| qn' n' eqpxvklpi "kuqj j vj cmjpktkrg/ dcugf "VCF H" go kvgt. "y g'f go qpuctvg' c'j wi g' ko r cev'qp' ku' VCF H' r qv'vku'0Vq' dg" o qtg' r tgekug. "j g' lpetgucgf "f kj gf tcn'cpi rnv'dgy ggp" F "cpf "C" vpkku' ku' hqwpf "vq" uki pkkcpv' "t gf weg" GUN. "t guwvki "lp' uwdvcp' kcn' d' qqu' v' qh' T KUE "tcvg' cpf "uj qtvgkpi "qh' VCF H' r h'vko g'0Y g' hcdtkcvgf "xcevwo "cpf "uqnvkq" r tqegu'gf "VCF H'QNGF u'go r m| { kpi "9" "kuqj j vj cmjpktkrg/ f qr gf "go kuukxg" r { g'0F gxlegu' g'zj kdkgf "dnvg' vq' um| / dnvg' go kuukq. "gzvtpcn' s wcpwo "ghhlegpe { "GS G' qh'wr "vq" 450 " cpf "j ki j "dtki j vpguu" \*wr "vq" ; 7222' ef lo 4'00 quvko r qtvcv'v. "f wg" vq' j g' h'cti g't KUE "tcvgu. "VCF H'QNGF u'f go qpuctvgf "gzvgo gn' hqy "ghhlegpe { "tqm/qhh'0'QNGF u' dcugf "qp" o qf h'vqf "eqo r qwpf " \*F O gE| KRP + " g'zj kdkgf "uki pkkcpv' r g' h'qto cpeg' ko r tqxgo gpv' qh' vq" vko gu' lp' v' gto u' qh' GS G'0' H' 03' "uj qy u'ej go kcn' utwewtgu' qh' wpo qf h'vqf "F E| KRP" cpf "o qf h'vqf "F O gE| KRP" eqo r qwpf u' cpf "j g' GS G' ej ctcevgtkcn' u' qh' vj g' r tqf weg' "f gxlegu' vqi g'v' gt' y kj "j gk "grgextqno kpguegpeg" \*GN' ur gev'c'0Vj g' qd'v'k'p'gf " tguwv' f go qpuctvg' vj g' r qvqpleu' qh' kuqj j vj cmjpktkrg/ dcugf "VCF H' go kvgtu' h'q' j ki j / dtki j vpguu' QNGF " cr r necv'k'pu0



Hki 030Ej go kcn' utwewtgu' qh' lpxgu'ki cvgf "eqo r qwpf u'cpf "j g'GS G'ej ctcevgtkcn' u' qh' vj g' VCF H'QNGF u' hcdtkcvgf " go r m| { kpi "j g'v'kuqj j vj cmjpktkrg/ dcugf "go kvgtu. "cpf "GN' ur gev'c' vqi g'v' gt' y kj "r kcw'v'gu' qh' vj g'v' f gxlegu0

[3\_] cpi .\ 00 cq. \ 0Zlg. [ 0\ j cpi . 'UONkw' L0\ j cq. 'L0Z w' \ 0Ej k' O (R0C'rf tgf. "Tgegpv'cf xcpegu'lp' qti cple' vj gto cm| "cevkxcvgf "f gr { gf "hmqtguegpeg" o cvgtkcn' .Ej go 0'Uqe0Tgx068. " ; 37/3238\*4239-0  
 [4\_] J 0Wq{ co c. 'M0I quw' k' M0Uj k' w' J 0P qo wtc. 'cpf 'E0Cf cej k' J ki j n' "ghhlegpv' qti cple' h' j vgo k'vpi 'F kqf gu' h'qo 'F gr { gf "hmqtguegpeg. 'P cwtg' 6; 4. " 456\*4234-0  
 [5\_] O'0'M' G'j g' t'kpi vq. "L0I kduq. "J 0' H'0J ki i k'pdqj co. " gv'cn0 "Tgxgc'kpi "j g' ur l'pox'kdtqple" eqwr n'kpi "o gej c'pkuo "qh' vj gto cm| "cevkxcvgf "f gr { gf " hmqtguegpeg. 'P cv0E qo o wp09. "358: 2\*4238-0

**VGUVPI QHEO T/D/UECNCT UGPUQTUWUPI O KETQUGEQPFU  
FWTCVQP J K J RWNUGF O CI PGVKE HGRNFU**

O qf gucu gkncwuncu<sup>3</sup>. Xqkgej Ucpngxk<sup>3,4</sup>

<sup>3</sup> Fgr ctwo gpvqhHwpevkqpcnO cvgtkcu cpf Grgextqpleu. Egpvt hqt Rj { ulecnUekpegu cpf Vgej pqrni { . Ucwv vgnkq cxg05.  
NV/32479 Xkpkwu. Nksj wcpkc

<sup>4</sup> Hcewv qhGrgextqpleu. Xkpkwu I gf ko kpcu Vgej plecnWpkxgtuks{ . P cwi ctf wntj 63. NV/25449. Xkpkwu. Nksj wcpkc  
o qf gucu gkncwuncuB ho e0v

F wtkpi vj g r wv f gecf gu. kv y cu f go qpwtcvgf vj cv o ci pgvke hgrf ugpuqtu dcugf qp pcpwtwewtgf rcpvj cpwo o cpi cplkg hro u g z j k k k k p i vj g eqmucno ci p g v t g u k n e p e g \*E O T + r j g p q o g p q p e q w f d g w u g f h q t j k j r w n u g f o c i p g v k e h g r f o g c u w t g o g p v k p x g t { u o c m x q n w o g u \*32/4 o o <sup>5</sup>+ ]3\_0 Vj g u g u g p u q t u c t g e c r c d r g q h o g c u w t k p i v j g o c i p g v k e h g r f o c i p k w f g k p f g r g p f g p v q h v j g o c i p g v k e h g r f f k t g e v k q p \*E O T / D / u e c n c t u g p u q t u + ]4\_0 Vj g { y g t g w u g f h q t v j g o g c u w t g o g p v q h o c i p g v k e h g r f f k u t k d w k q p ]5\_ c p f f k h w k q p r t q e g u u g k p t c k i w p u ]6\_0 K v y c u u j q y g f v j c v v j g { c t g c u w k c d r g k p u t w o g p v h q t o g c u w t k p i v j g h g r f y k j j k j t g u q n w k q p k p d q v j v o g c p f u r c e g 0 k p c m v j g u g g z r g t k o g p v u v j g r w n u g f w t c v q p q h o c i p g v k e h g r f y c u 3 / 3 2 2 o k r k u g e q p f u 0

J qy gxgt. kp uqo g r t q e g u u g v j g u k i p k h e c p n l u j q t v t o c i p g v k e r w n u g y k j j k j c o r r k w f g u j q w f d g o g c u w t g o g p v 0 O c i p g v k e R w n u g Y g r f k p i \*O R Y + k u q p g q h v j k u r t q e g u 0 V j g O R Y k u c e q n k u k q p y g r f k p i r t q e g u u . y j k e j w u g u c j k i j x g n e k s { k o r c e v v q l q k p y q o g v c u v j c v c t g c e e g r t c v g f d { u j q t v \*c d q w 4 2 o 5 2 u + u t q p i \*c 3 2 V + o c i p g v k e h g r f 0 V j g o g c u w t g o g p v q h v j g k p v p u k s { c p f f { p c o k e u q h v j g o c i p g v k e h g r f c v f k h g t g p v r q u k k a p u f w t k p i v j g g r e x t q o c i p g v k e h q t o k p i q t y g r f k p i r t q e g u u k u p q v q p n l t g s w k t g f h q t v j g e c r e w r c v k q p q h v j g o c i p g v k e r t g u u w t g . y j k e j k p h w g p e g u v j g c e e g r t c v k q p . d w e c p c n u q r t q x k f g c f f k k q p c n k p h q t o c v k q p c d q w v j g r t q e g u u g v j c v c n g r r e g f w t k p i v j g O R Y 0 V j g t g h q t g . v j g o c i p g v k e h g r f u g p u q t u . y j k e j c t g e c r c d r g v q o g c u w t g v j g u g h g r f u . u j q w f d g f g u k i p g f c p f v g u g f 0

Uj q t v r w n u g f j k j o c i p g v k e h g r f i g p g t c v k q p u { u g o h q t g r e x t q o c i p g v k e y g r f k p i c p f h q t o k p i y c u f g u k i p g f h q t v g u k p i v j g E O T / D / u e c n c t u g p u q t u 0 K e q p u k u g f q h e c r c e k q t d c p m u r c t n i c r u y k e j c p f c D k w g t e q k n 0 C 7 2 U H e c r c e k q t e j c t i g f w r v q ; m X y c u f k u e j c t i g f v j q w i j q w 7 y k p f k p i D k w g t e q k n c p f v j g o c i p g v k e r w n u g q h c d q w 4 7 U u y k j c o r r k w f g q h 7 V y c u i g p g t c v g f k p u k f g v j g e q k n 0 V j g v g u g f u g p u q t y c u r q u k k a p p g f k p u k f g q h v j g e q k n \* q t k p v j g h g r f u j c r g t + c p f v j g q w r w u k i p e n y c u t g e q t f g f d { c o g c u w t k p i o q f w g 0 K v y c u h q w p f v j c v v j k u m k p q h u g p u q t k u g e u k p u v c n g f v q v j g o g c u w t k p i r q u k k a p . d g e c w u g f w g v q f k o k p k u j g f c p k u q t q r { v j g E O T / D / u e c n c t u g p u q t f q g u p q v t g s w k t g c p g z c e v q t k e p v c v k q p y k j t g u r g e v v q v j g o c i p g v k e h g r f f k t g e v k q p 0 O q t g x g t . k v k u x g t { u o c m c p f v j w u e c p d g c r r k e g f h q t o g c u w t k p i v j g o c i p g v k e h g r f m e c n l 0 k p c f f k k q p . v j g o g c u w t g o g p v o q f w g q h v j g u { u g o j c u c u w t k e g p v v o g t g u q n w k q p v q o g c u w t g h c u v o c i p g v k e h g r f e j c p i g u 0 J q y g x g t . u q o g r t q d r g o u e q p e g t p k p i v j g o n q r o g h e v \* k p f w e g f r c t c u k l e u k i p c n f w g v q g r e x t q o q v k x g h q t e g u + c p f g r e x t q o c i p g v k e p q k u g u u j q w f d g t g u q n g f v q q d v c l p q w r w u k i p c n q h u g p u q t y k j j k j g t c e e w t c e { 0 V j g r q u k k k r k s { v q w u g v j g u g u g p u q t u h q t v j g o g c u w t g o g p v q h o c i p g v k e h g r f f { p c o k e u f w t k p i o c i p g v k e r w n u g h q t o k p i q h o g v c n w d g y k m d g f g o q p u t c v g f 0

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[4\_ V0Ucpngxk . N0O gf k-cwuncu gvcrf) Rwnugf o ci pgvke hgrf o gcuwtgo gpvu{uggo dcugf qp eqmucno ci p g v t g u k n e p e g / D / u e c n c t u g p u q t u h q t t c k i w p k p x g u n k c v k q p 0 T g x 0 U e l 0 k p u t w o 0 : 7 . 266926 \*4236+0

[5\_ Q0Nngdhtlgr . O0Uej pgkf gt gvcrf) O gcuwtgo gpvqh vj g o ci pgvke hgrf f k u t k d w k q p k p t c k i w p u l p i E O T / D / u e c n c t u g p u q t u 0 C e v 0 R j { u 0 R q n 0 C . 337 . 334763349 \*422; +0

[6\_ V0N0J ctep. T0D0J qlito cp. U0G0Ncpg. F k e i p q u k e e c r c d k i s k u h q t g r e x t q o c i p g v k e t c k i w p u 0 I G G G V t c p u 0 R r ع o c U e k 0 6 3 . 3748 o 3754 \*4235+0

**IP XGUVH CVIQP 'QH'QRVKE CN'RTQRGT VIGU'QHEcCiDQ<sub>5</sub>H<sub>4</sub>I NCUU ''**  
**O CVTKZ'FQRGF 'Y KVJ 'GWTQRKW 'CP F 'UCO CTKW 'KQP U''**

Ci cv'Ictqem<sup>3</sup>. 'F qo lpkne"Y u<sup>3</sup>. 'Lcmvd'R€ej v<sup>4</sup>. 'Vqo cu| 'MORlgt| cm<sup>3</sup>

<sup>3</sup>Hcewn{ 'qh'Rj { uleu."Y ctucy "Wpkxgtukv{ 'qh'Vej pqmi { ."Mqul { nqy c'97."22/884"Y ctucy ."Rqrcpf "

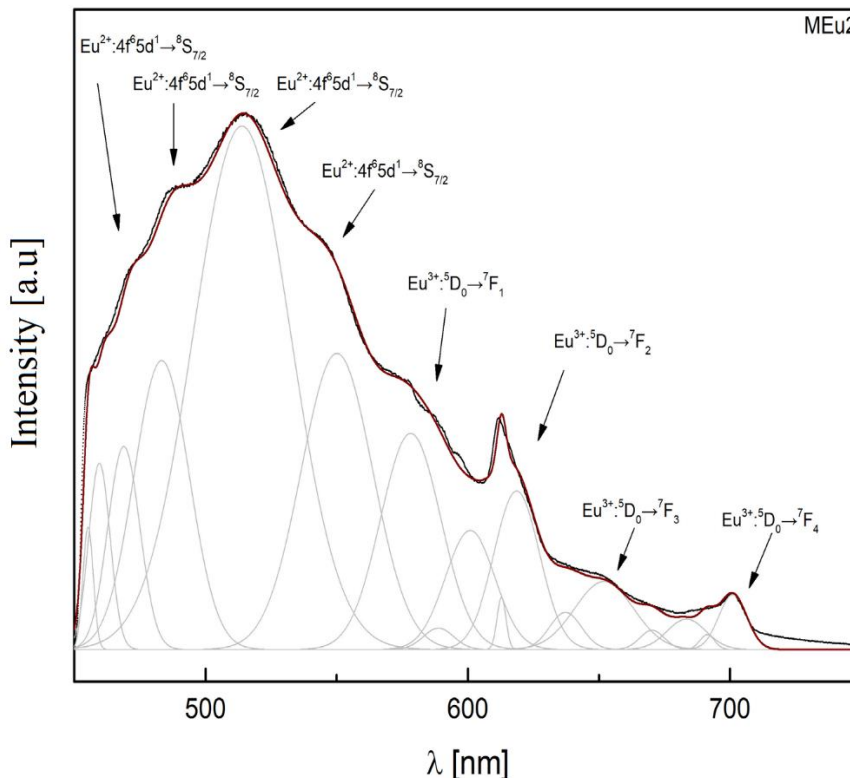
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Vj g'cvqo ke'utveww'g'qh'rcpvj cplf gu"i tqw "vj cv'lp'ncm' gu'eqpukf gtgf "Uo ."Gw"ku'ej ctcev'gtk kf "d{ "wphkngf "6//uj gmi'cpf " gzv'gt'pcn'uj gmi"vj cv'uetggp "6//uj gmi'htqo "vj g'lp'hwgpeg"htqo "qwuuf g'0Vj ku'hcwv'g"ku"t'gur qpukng"htq"tgo ctncdng"qr v'ecni' r tqr gt'v'gu'qh'rcpvj cplf gu'0Qr v'ecni'ur gev'tc"qh"vj qug'grgo gpv'gzj kdk'uj ctr "rk'p'u'ej ctcev'gt'ku'v'htq"t'c'puk'kpp"y kj kp"vj g'6// uj gm"npqy p"cu"htdkf f gp"t'c'puk'kppu'0K'p't'gen'v'gto u'k'o gcpu"vj cv'vj g{ "o c{ "q'eev't."dw'y kj "ny "r tqdcdk'k'v'."ceeq'f kpi "vq" Lxf f /Qhgn'Vj gqt { 0Chtqgo gp'v'k'p'gf "uet'g'p'kpi "qh'6//uj gmi'd { "q'w'gt'uj gmi't'guwmu"lp"r tqv'ev'kpp"qh'qr v'ecni' "cv'k'g"grg'v't'qpu" htqo "vj g'lp'hwgpeg"qh'et { ucn'ih'grf "cpf "cu"v"t'guwmu"TGg"kp'au'ur gev'two "lp"v"u'q'rk' "ecp"dg'uko k'ct"vq"vj cv'qh'c"htg'kpp" ur gev'two j4\_0

Vj g'tgugctej "ectt'kgf "q'w"xgt { "t'g'gpv'v' "lp"q'w"i tqw "j cu'uj qy p"vj cv'k'ku"r quukdng"vq"r tgr ctg"TGg/f qr gf "i rcuuf " o cv'gt'k'm'y kj "vj cv'ctg'ej ctcev'gtk kf "d{ "ut'qpi "t'cf k'ni'v'c'puk'kppu"j5\_0Vj gtghqg."k'ku'y q'v'j "vq"lp'xguk' cv'f k'htg'gpv'i rcuuf " o cv'legu"lp"qt'f gt "vq"hp'f "vj qug'qh'vj g'dgu'v'o gev'c'plec'nc'pf "ej go k'c'ni't'guk'nc'p'eg'0K'p'q'w"u'w'v' l'gu."EcCnDQ<sub>5</sub>H<sub>4</sub>i rcuuf "o cv'legu" f q' r gf "y kj "3"y v' "Gw"Q<sub>5</sub>"c'p'f "Uo 4Q<sub>5</sub>"y gtg'u'we'eg'uu'hw'v' "r tgr ctg'f "d{ "c'v' g'ni's'wg'p'ej kpi "o gv'j q'f 0Uw'du'v'c'v'gu'y gtg'o grw'gf "htq" 37"o lp"cv'3522"AE0"



Hk 030Rj qvqno lpguegpeg'ur gev'two "htq"uco r ng'EcCnDQ<sub>5</sub>H<sub>4</sub>f q' r gf "y kj "gwt'qr kwo "k'p'u."gzek'xgf "y kj "547"po "rcu'gt'0

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 Hq't'v'g'0G't'leg'k'cn'."U'r' t'p'i'gt."4227"  
 [5]\_"VOM'Rl'gt| cm"COI q€dl'gy un'c."L'0'R€ej v."O'0'lt'c'le| gy un'k"l'0'T { n"O'0'Y'cu'v'k'ep'gm"l'0G'0I'ct'd'c'le| { m²Rj qvqno lpguegpeg"qh'r'ct'v'k'm' "t'gf'w'egf"  
 Gw' IGw' "v'ev'k'g'eg'p'v't'lp"v" PcH6CuQ<sub>5</sub>0R<sub>4</sub>Q<sub>7</sub>i rcuuf "o cv'k'v' y kj "w'p'c'd'ng"uo q'q'v' "ur' gev't'c'0L'q'w'p'c'ni'q'hi'N'wo lpguegpeg."42: "423; +54465480

P1-30

DID NOT PARTICIPATE

# CARBAZOLE - PYRIMIDINE MOLECULAR SYSTEMS FOR TADF APPLICATIONS

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Currently, the most efficient organic light emitting diodes (OLEDs) are fabricated using a thermally activated delayed fluorescence (TADF) emitters, where dark triplet states are turned to radiative states using the reverse intersystem crossing process. The internal quantum efficiency in such emitters can be up to 100%. However, the application of such emitters in OLED devices is limited by the long emission lifetime and the wide emission band. Also there is a lack of efficient emitters in the 400 nm - 500 nm range.

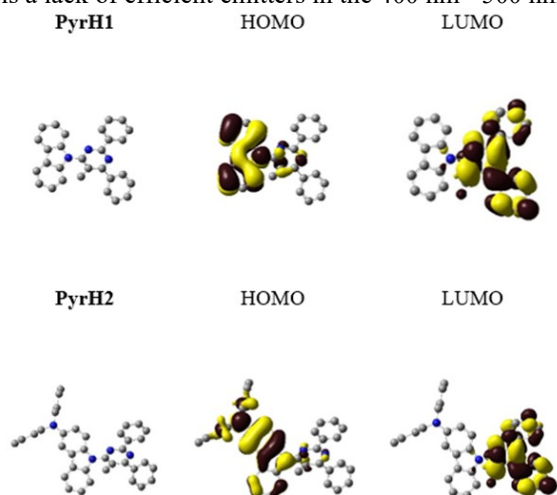


Fig 1. Optimized molecular geometry of donor - acceptor carbazole - pyrimidine systems, distribution of HOMO and LUMO orbitals.

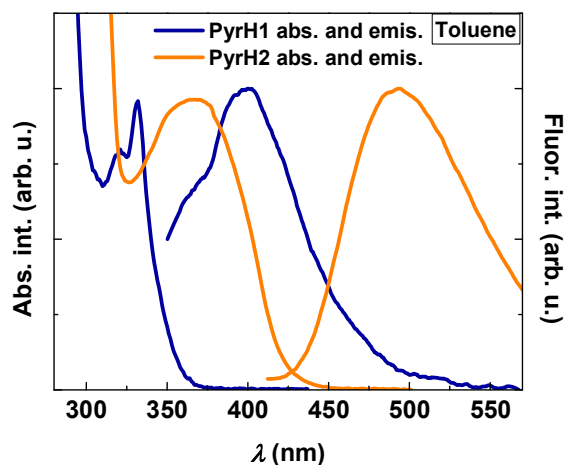


Fig 2. Absorption and fluorescence spectra of donor - acceptor carbazole - pyrimidine systems (top) and fluorescence lifetime characteristics (bottom).

In this research we focus on carbazole - pyrimidine molecular system to evaluate the properties of charge transfer and TADF in a single molecule by employing a subtle modification of a molecular backbone. We investigate the donor - acceptor carbazole - pyrimidine molecular system, where the donoric properties of carbazole were further enhanced by an alkylamine moiety. By using various steady state spectroscopy techniques and computational modeling, we investigated the distribution of excited states and evaluated the possibility of TADF process. Carbazole - pyrimidine molecules exhibited a twisted molecular geometry, where the carbazole moiety is rotated at an angle of 52 degrees relative to the pyrimidine ring. The highest occupied molecular orbital (HOMO) is localized on the carbazole moiety and the lowest unoccupied molecular orbital is located on the acceptor pyrimidine moiety (Fig. 1). In the PyrH1 compound, the lowest singlet excitation is the charge transfer state (CT), with an extremely low transition oscillator strength ( $f = 0.05$ ). The energy gap between the singlet and triplet levels is quite high - 260 meV. Meanwhile, in the PyrH2 compound, part of the HOMO is distributed at the introduced alkylamine moiety. This results singlet excitation energy decrease (from 3.44 eV to 2.66 eV) and an even lower oscillator strength ( $f = 0.012$ ). On the other hand, the energy difference between the lowest singlet and triplet excitations is as low as 66 meV, which is a crucial requirement for an efficient TADF process.

Carbazole - pyrimidine molecular system PyrH1 demonstrated absorption in the ultraviolet wavelength range (from 280 nm to 360 nm), with a pronounced vibronic structure associated with locally excited state from the donoric carbazole moiety (Fig. 2). The fluorescence at 400 nm and with somewhat expressed vibronic series was also observed. After enhancing the donoric properties of carbazole with an alkylamine moiety in the PyrH2 compound, the absorption band redshifts significantly, peaking at 375 nm. The fluorescence peak exhibits redshift to 500 nm, followed by a large Stokes shift (150 nm). Interestingly, both absorption and emission bands are structureless and in combination with a large Stokes shift indicates enhanced charge transfer (CT) character (Fig. 2).

The existence of TADF process was observed in PyrH2 compound. An exponential fluorescence decay with the time constant of 10.02 ns was observed. After removal of oxygen, the decay time constant was enhanced up to 1.4 times (time constant - 14.28 ns), indicating expressed TADF process.

# COMPARISON OF SOLID-PHASE EXTRACTION SORBENTS FOR THE DETERMINATION OF SEDATIVE-HYPNOTICS DRUGS IN BIOLOGICAL SPECIMENS

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Sedative-hypnotics drugs represent a pharmacologically diverse group of compounds, such as benzodiazepines, barbiturates, and other newest agents (e.g. zaleplon and zopiclone), that are used clinically [1]. Currently, there is no scientifically precise or universally accepted classification scheme for these drugs. Sedative-hypnotics drugs are often prescribed in primary care for insomnia.

Zaleplon and zopiclone are sedative-hypnotic drugs, which are used to induce sleep in the short-term treatment of insomnia. These newest medications are less safe than other benzodiazepines and have a tendency to induce physical dependence [1,2]. Currently, these drugs are the most commonly prescribed sedative-hypnotics agents in the United States of America and the European Union.

Although these drugs are widely prescribed for patients the certain side-effects were identified. It should be noted an adverse cognitive (such as, memory loss) and psychomotor (such as, road traffic crashes) effects, daytime fatigue, addiction, and excess of mortalities with no significant difference from the side-effects of typical benzodiazepines [2-5]. However, with increased use of zaleplon or zopiclone drugs, reports of misuse and possible dependence began to appear in the literature, particularly considering people with a history of drugs and/or narcotics misuse and comorbid psychiatric illness [1,2,4]. For this reason, it is essential to develop a fast and sensitive method for the determination of both analytes in biological matrices.

When developing a fast gas chromatography with negative-ion chemical ionization mass spectrometry (GC/NICI-MS) method matrix effects are a major issue. The effect of co-eluting compounds arising from the matrix (blood, urine) can result in a signal enhancement or suppression [6,7]. During method development, much attention should be paid to diminish matrix effects as much as possible.

The main aim of my study was to develop a new sensitive and specific method based on a fast GC/NICI-MS using solid-phase extraction (SPE) for the quantification of zaleplon and zopiclone at trace level in low-volume blood and urine samples. To the best of my knowledge, this method has been used for the first time for the optimization of sample preparation at different pH values (pH 1.0 - 10.0). Comparison of two SPE sorbents for the determination of both analytes in blood and urine were investigated. The analytes were well retained on Oasis MCX and Oasis HLB sorbents, also sufficient extraction efficiency was achieved at pH 9.0. For further study, a hydrophilic-lipophilic (polymeric) sorbent Oasis HLB was selected due to the polarity of sorbent surface and its large surface area ( $830 \text{ m}^2 \text{ g}^{-1}$ ) in order to achieve efficient extraction of the analytes in a single step. The surface area is one of the most important factors for extracting the analytes from blood or urine samples by SPE. Special attention was paid to the selection of washing and eluting solvent in the SPE procedure, resulting in very pure and free from moisture extract, which can successfully be applied for gas chromatography-mass spectrometry. Different solvents or mixtures of solvents for elution of the adsorbed analytes, washing step-eliminating interferences in the sorbent were tested.

The developed method provides significant advantages in comparison with other previously published methods [6,8-10]. It shows higher sensitivity (the limit of detection  $\leq 0.60 \text{ ng mL}^{-1}$  and the limit of quantification  $\leq 2.00 \text{ ng mL}^{-1}$ ) in blood and urine samples. The mean extraction efficiency was higher than 90.1 % for zaleplon and 82.9 % for zopiclone. The precision for zaleplon and zopiclone was between 3.04 – 10.58 % and 4.08 – 9.52 %, respectively. Whereas the accuracy (Bias value) was in the range from -5.73 to 6.00 % and from -7.00 to 6.32 % for zaleplon and zopiclone, respectively. The results have shown that the developed method is accurate, selective, precise, very fast with excellent recovery, low limits of detection and quantification. Finally, it was demonstrated that this method is applicable for the determination of trace concentrations of zaleplon and zopiclone in whole blood and urine samples. The developed method can be applied in routine toxicological analysis during the investigation of both clinical and forensic cases.

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*The author has declared no conflict of interest*

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**HQTO CVKQP 'QH'UQNK' 'UQNWWKQP 'P' 'ZCP VJ QP G'F GTKXCVKXG' U UVGO U'GZJ KDKKPI 'NWO KPGUEGPEG'RTQRGT VKGU'**

Mkuvr u'Uct- pu'. 'Crgmglu' Mct| k kpu'. 'Mcur ctu' Ngf wuntcuw'. 'Ci tku' D t| k -'. 'Vqo u' Tg k'

<sup>c</sup> Hcew{ 'qh' Ej go knt { . 'Wpkxgtuks{ 'qh' Ncxlc. 'Lgri cxcu' lgr' 3. 'Tki c. 'Ncxlc

<sup>d</sup> Ncxlc{ 'kpu' kwg' qh' Qti cple' U{ 'pyj' guku. 'Ck' ntcwmg' lgr' 43. 'Tki c. 'Ncxlc

ntkuvr u' UctwpuB nwt

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Uqrf "uqnwqpu" \*U' ctg' o wneqo r qpgpv' r j cugu' hqt' y j lej 'y' g' eqo r qpgpv' tcvku' ecp' dg' xctkgf 'kp' eqpvkpwwo 0' Vj gug' r j cugu' eqpukv' qh' f khtg' p' v' o qrgewrt' eqpukwgpv' u' tcpf qo n{ "qeww { kpi " et { ucnrqi tcr j le' ukgu' ] 3\_0' Vj g' ej cpi gu' kp' eqo r qukq' p' ctg' qh' r' p' ceeqo r cplgf "d { "c' eqpvkpwqwu' ej cpi g' kp' uqo g' r j { ulecn' c' p' lqt' "ej go lecn' r' tqr gt vku' \*g' 0' f' gpukv' . " uqndk' k' v' . " ucdk' k' v' . " c' p' f' " o q' t' g' " eqo r r' g' z' " r' t' q' r' g' t' v' k' u' " uwe' j' " cu' p' q' p' / r' k' p' g' c' t' " q' r' v' k' e' c' n' r' t' q' r' g' t' v' k' u' . " uqrf / u' c' v' g' " nwo k' p' g' u' e' g' p' e' g' " c' p' f' " r' j' q' u' r' j' q' t' g' u' e' g' p' e' g' " r' t' q' r' g' t' v' k' u' " ] 3\_4\_0'

Ugxg' t' c' n' z' c' p' y' q' p' g' " \*Z' C' P' V+ " f' g' t' k' c' v' k' x' g' u' " \*H' i' w' t' g' " 3+ " y' g' t' g' " u' g' r' e' v' g' f' " cu' o' q' f' g' n' i' e' q' o' r' q' w' p' u' f' d' g' e' c' w' a' g' " q' h' ' y' g' k' t' " r' j' { u' l' e' q' / e' j' g' o' k' e' c' n' r' t' q' r' g' t' v' k' u' " c' p' f' " e' j' g' o' k' e' c' n' r' " u' l' o' k' r' t' " u' t' w' e' w' t' g' u' . " k' p' " y' j' l' e' j' " y' g' f' k' h' t' g' p' v' c' v' o' " \*Z' " c' p' f' " T+ " o' c' { " p' q' v' u' k' i' p' h' e' c' p' w' " c' h' g' e' v' " y' g' f' q' o' k' o' c' p' v' k' p' v' g' t' o' q' r' g' e' w' r' t' " k' p' v' t' c' e' v' k' p' u' " ] 4\_0'

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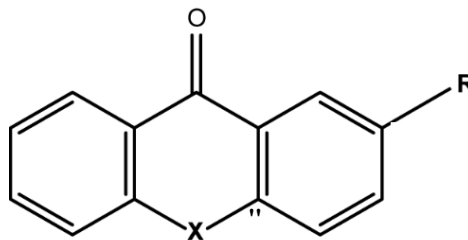
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Z' ? " Q " \* Z' C' P' V+ " q' t' " U " \* V' Z' C' P' V+ " T' ? " J " \* Z' C' P' V+ " c' p' f' " V' Z' C' P' V+ " " E' n' \* V' Z' C' P' V+ " E' n' " q' t' " K " \* V' Z' C' P' V+ " K' "

**Hli wt g' 300** qrgewrt' utwewt g' qh' zcpjy qpg' f' g' t' k' c' v' k' x' g' u' 0'

Vj g' d' l' p' c' t' { " u { u' g' o' u' q' h' z' c' p' y' q' p' g' f' g' t' k' c' v' k' x' g' u' " \* Z' C' P' V " < " V' Z' C' P' V " c' p' f' " V' Z' C' P' V / E' n' " < " V' Z' C' P' V / K' " j' c' x' g' " d' g' g' p' " g' z' r' n' t' g' f' " u' j' q' y' k' p' i' " y' c' v' h' q' w' " f' k' h' t' g' p' v' u' q' r' k' " u' q' n' w' k' p' u' " \* h' q' t' o' g' f' " d' c' u' g' f' " q' p' " r' c' t' g' p' v' u' t' w' e' w' t' g' u' " q' h' z' c' p' y' q' p' g' f' g' t' k' c' v' k' x' g' u' . " t' g' u' r' g' e' v' k' g' n' { " + " e' c' p' " d' g' " h' q' t' o' g' f' 0' V' j' g' " q' d' v' k' p' g' f' " e' t { u' c' n' k' p' g' " r' j' c' u' g' u' " y' g' t' g' " e' j' c' t' c' e' v' g' t' k' g' f' " w' u' k' p' i' " r' q' y' f' g' t' " Z / t' c' { " f' k' h' t' c' e' v' k' p' " \* R' Z' T' F " + " c' p' f' " f' k' h' t' g' p' v' k' c' n' " u' e' c' p' p' k' p' i' " e' c' m' t' k' o' g' t' { " \* F' U' E " + " o' g' y' q' f' u' k' p' " q' t' f' g' t' " v' q' " e' q' p' u' t' w' e' v' t' g' u' r' g' e' v' k' x' g' " r' j' c' u' g' " f' k' c' i' t' c' o' u' 0' H' w' t' y' g' t' o' q' t' g' . " r' j' q' v' q' n' w' o' k' p' g' u' e' g' p' e' g' " u' r' g' e' v' c' " q' h' c' n' i' e' t { u' c' n' k' p' g' " r' j' c' u' g' u' " k' p' " r' q' y' f' g' t' " h' q' t' o' " y' g' t' g' " t' g' e' q' t' f' g' f' " v' q' " u' g' g' " j' q' y' " y' j' g' { " e' j' c' p' i' g' " y' k' i' j' " t' g' u' r' g' e' v' v' q' " y' j' q' u' e' " q' h' ' y' j' g' " r' w' t' g' " u' d' u' c' p' e' g' u' " n' p' q' y' p' " h' q' t' o' " y' j' g' " r' k' g' t' c' w' t' g' " ] 5\_0'

**Cempqy rgi go gpw'**

Vj ku' y' q' t' n' i' j' cu' d' g' g' p' u' w' r' q' t' v' g' f' " d { " y' j' g' " Ncxlc{ " E' q' w' p' e' k' i' " q' h' " U' e' k' p' e' g' . " r' t' q' l' g' e' v' o' E' t { u' c' n' i' g' p' i' k' o' g' g' t' k' p' i' " q' h' " r' j' c' t' o' c' e' g' w' k' e' c' n' i' o' w' n' e' q' o' r' q' p' g' p' v' i' j' c' u' g' u' " h' q' t' o' q' t' g' " g' h' h' e' k' p' v' e' t { u' c' n' k' p' g' " r' j' c' u' g' " f' g' u' k' i' p' o' . " i' t' q' l' g' e' v' P' q' 0' i' j' r' / 423: 13/2534 " c' p' f' " W' p' k' x' g' t' u' k' s { " q' h' " N' c' x' l' c " h' q' w' p' f' c' v' k' p' " y' j' t' q' w' j' " o' 0' k' n' t' q' v' m' u' o' " f' q' e' v' q' t' c' i' l' u' e' j' q' r' c' t' u' j' k' r' " k' p' " y' j' g' " h' g' r' f' " q' h' " p' c' w' t' c' n' i' c' p' f' " o' g' f' k' e' c' n' i' u' e' k' p' e' g' u' 0'

[3\_ Nwuk' O 0' Gpi kpgt' kpi 'Et { ucn' R' t' q' r' g' t' v' k' u' ' y' j' t' q' w' j' " U' q' r' k' " U' q' n' w' k' p' u' 0' E' t { u' c' n' i' t' q' y' y' j' " ' F' g' u' k' i' p' . " 423: . " 3: \* 8+5926/59340  
 [4\_ Uct- pu. 'M' D' t' k' - . 'C' O' T' g' k' u' " V' 0' U' q' r' k' " U' q' n' w' k' p' u' " k' p' " Z' c' p' y' q' p' g' " o' " V' j' k' z' c' p' y' q' p' g' " D' l' p' c' t' { " u { u' g' o' < " J' q' y' " y' g' n' i' c' t' g' " U' o' k' r' t' " O' q' r' g' e' w' r' t' " F' k' u' e' t' l' o' k' p' c' g' f' " k' p' " y' j' g' " U' q' r' k' " U' e' v' g' " E' t { u' c' n' i' t' q' y' y' j' " ' F' g' u' k' i' p' . " 4242: " 42 \* 34+9; ; 9/: 2260  
 [5\_ Y' gp. " [ 0 " Nw " J 0 " \ j' c' p' i' . " U' 0 " I' c' q' . " [ 0 " [ c' p' . " [ 0 " [ c' p' i' . " D' 0' Q' p' g' / F' l' o' g' p' u' k' p' c' n' i' / " U' c' e' n' k' p' i' " k' o' f' w' e' g' u' " J' k' i' j' n' " G' h' h' e' k' p' v' " R' w' t' g' " Q' t' i' c' p' l' e' " T' q' q' o' / V' g' o' r' g' t' c' w' t' g' " R' j' q' u' r' j' q' t' g' u' e' g' p' e' g' " c' p' f' " V' g' t' p' c' t' { / G' o' k' u' k' p' " U' k' p' i' n' g' / O' q' r' g' e' w' t' " Y' j' k' g' " N' k' i' j' v' 0 " L' 0' 0' c' v' g' t' 0' E' j' g' o' 0' E' . " 423; . " 9: " 34724/3472: 0'

**P CRJ VJ [ T F R G'CPF 'ECTDC\ QNG'F GTK CVKXGU'CU'  
GNGEVTQCEVKG'O CVGTRCNU'**

Nwneu'F x { n u. 'T cuc' Mgt wenkgpg. 'Lwq| cu'Xkf cu'I tc| wngxlekwu'

F gr ctwo gpv'qh'Rqn{ o gt'Ej go kut { 'cpf 'Vgej pqm{ { . 'Mwpcu'Wpkxgtuk{ 'qh'Vgej pqm{ { . 'Nkj wcpk' "  
nwneu'f x { n uB mwqf w'

"

J ki j /r gthqto cpeg" qti cple" nki j vgo kwkpi "f kqf gu" \*QNGF u+" j cxg" dggp" c" uwdlgev' qh' gz vgpukg" tgugetej "dqyj "kp" ceef go le" cpf "lp'lpf wut{ "hqt" yj g'ruv'y q" f gecf gu" ]3\_0'Rwtg" qti cple" yj gto cm{ "cevkxcvgf "f grc{ gf "hwqtguegpeg" \*VCF H" o cvgtkcu" j cxg" cwtcevgf "y qtrf /y kf g" cwgpvkqp" kp" ceef go le" cpf "lpf wutkcu" eqo o wpkkgu" f wq" vq" yj gk" j ki j "gzekqp" wkkk' cvkqp" ghhekgpe{ "cpf "mqy "equv" ]4\_0'Qti cple" o cvgtkcu" y j lej "r quuguu" VCF H" ej ctcevgtkukcu" ctg" j ki j n{ "r tqo kulpi " qy kpi "vq" yj gk" uo cm' ukpi rgv'vtr rgv'gpgti { "f khtgtpg" \* GUV+ "y j lej "hcekkxcvgu" ghhekgpv' t gxtug" kpvtu{ vgo "etquulpi " \*TKUE+0F wq" vq" yj g'wutqpi "ur kpdtqtdk'eqwr nki "ghhegv'lp" yj g'r j qur j qtguegpv' o cvgtkcu. "yj g'qr vcecn'cf kvkqp" cwgpwcvkqp" qh' yj g'vtr rgv'gzekqp" dgeqo g' r quukng. "cpf "yj g'lpvgtpci's wcpwo "ghhekgpe{ "qh' qti cple" grgev'qno kpguegpeg" dcugf "qp" yj g' r j qur j qtguegpv' o cvgtkcu" ecp" yj g'qtg'v'ecm{ "tgcej "322" 0'Vq" f guki p" c" pqxgr' VCF H" o qngewrg. "y q" r tkpek' ngu'uj qwf "dg" hmqy gf 0' Hktuv{. " yj g' qxgr' " dgy ggp" yj g' j ki j guv' qeew kqf " o qngewrt" qtdkcu" \*J QO Q+" cpf "mqy guv' wq' qeew kqf " o qngewrt" qtdkcu" \*NWO Q+" yj qwf "dg" ugr ctcevgf "d{ "kv'qf velpi "rci g" yv ku'cpi ngu'qt "vgtk' j kpf gtcpeg" vq" qd'v'kp" c" uo cm' GUV'0'Ugeqpf n{. "yj g' J QO Q" cpf "NWO Q" pggf "vq" j cxg" r ctv'cn' qxgr' "vq" i wctcpvg" j ki j "r j qv'qno kpguegpeg" s wcpwo " { kgrf " \*RNS [ +] 5\_0'

Kp" yj ku' y qtn'ly q" pcr j yj { tkf kpg' cpf "ectdc| qrg" eqo r qwpf u' y kj "f khtgtpv' cm{ n' uwdukwgpw" j cxg" dggp" u{ pyj guk' gf. " y j gtg' pcr j yj { tkf kpg' ceu' cu' cp' grgev' qp' ceegr v' t' cpf "ectdc| qrg" o' cu' cp' grgev' qp' f qpqt0Vj gk' yj gto cn' r j qv'qj { ukcu' cpf " grgev' qej go lecu' r' q' r' v' ku' y ku' d' g' t' gr qt' v' gf 0'

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[3\_ "V0] gj . '10Ngg. 'NOEj gp. 'VOEj cwgtlgg. 'Y 0J wpi . 'cpf 'M0Y qpi . 'P gy 'pcr j yj { tkf kpg/ dcugf "dlr qm' j qu'v' o cvgtkcu' hqt' yj gto cm{ "cevkxcvgf " f grc{ gf "hwqtguegpv' qti cple" hi j vgo kwkpi "f kqf gu" Qti cple' Grgev' qpleu' 92" \*423; +776840  
[4\_ "Z0\ j qw' J 0] cpi . \ 0Ej gp. 'U0I qpi . \ 0Nw' cpf 'E0I' cpi . 'P cr j yj { tkf kpg/ dcugf "go kvgtu' uko wncpgqwn' "gzj kdkkpi " yj gto cm{ "cevkxcvgf " f grc{ gf " hwqtguegpeg" cpf "ci i tgi cvkqp/ lpf wegf " go kulqp' hqt' j ki j n{ "ghhekgpv' pqp/ f qr gf "hwqtguegpv' QNGF u. '100 cvgt0Ej go 0E. '423; . '9. '88290  
[5\_ "E0Ej gp. 'J 0Nw' \ 0Y cpi . 'O 0Nk' \ 0Uj gp. 'cpf 'E0H0Ej gp. 'P cr j yj { tkf kpg/ dcugf " yj gto cm{ "cevkxcvgf " f grc{ gf "hwqtguegpeg" go kvgtu' hqt' o wnk' eqm' qti cple" hi j vgo kwkpi "f kqf gu' y kj "huy "ghhekgpe{ "tqm/ qh' '100 cvgt0Ej go 0E. '423; . '9. '68950'

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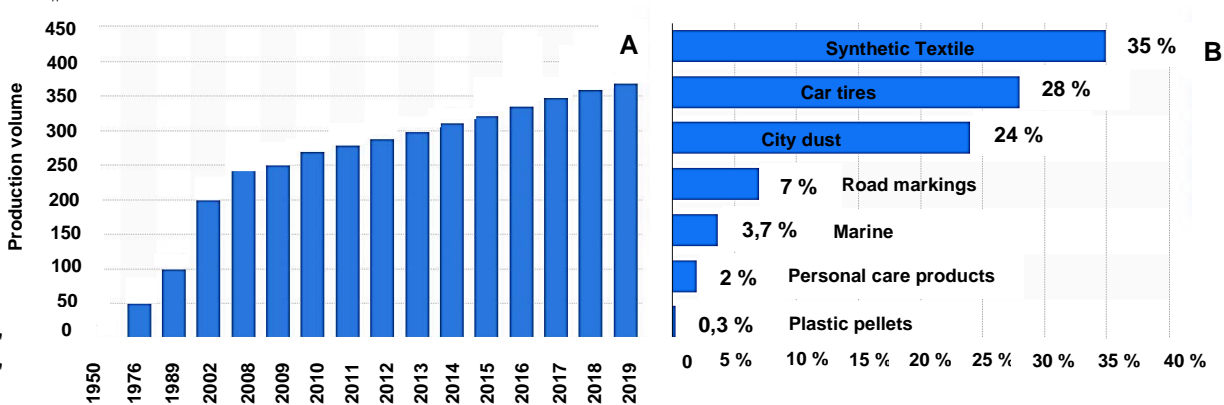
# KP XGUVH CVKQP 'QH'O KETQRNCUVKE 'EQP VCO KP CVKQP 'K' " Y CUVGY CVGT 'UCO RŅGU"

Uqpcvc'Rņgunf v<sup>3</sup>. 'Kģxc'Wqj kpv<sup>4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Ej go kurt { . 'Xlķpkwa'Wpķxgtukf . 'Nķj wcpķc "'

<sup>4</sup>F gr ctvo gpv'qh'Gp xktqpo gpvcn'Uelķpeg. 'Egpvgt 'Hqt 'Rj { ulecn'Uelķpegu' Cp f "Vgej pqtqi { . 'Nķj wcpķc "'  
uqpcvc'Rņgunf vģB ej i Hōwfw (xwōh)"

Vj g'eqpvc lpcvkqp'qh'o ctkpg'cpf "Ht guj y cvgt "gequ{ ugo u'y kj "r űvķe. "cpf "gur gekm{ "y kj "o letqr űvķe "O R+ "ku" c" i űdcn'geqmqi ķecnr tqdrgo "qh'ķpet gculpi "uelķpvķķe'eqpegtpO'Rūvķeu'ctg'wgf 'kp'c'y kf g'xctķgv "qh'ķgo u'cpf "j cxg'f kur űvegf " qv j gt "ko r qtvcpv'o cvgtķcu' űvej "cu'o gvcn" i űcu. "cpf "y qaf O'O letqr űvķeu'ctg' hqto gf "Ht qo " r qnf gvgtu. " r qnf xlp { űkf gpg" ej űķķf g. " r qnf ectd qpcvķu. "cpf "o cp { "qv j gt " qti cplē " r qnf o gtu' hqt "wug'kp'c" j w i g' cpf " i tqy ķpi " tēpi g'qh' cr r űecvķqpu' Vj g" dķi i guv'co qwpv'qh'r űvķe "y cu' cr r űķf "cv'r cenci ķpi . "dķwf ķpi . "eqpwt vķvķp. "cpf "cwwqo qvķxg'ķpf wut { " \*Hķi O'3+ " j3 \_O' Gxg { " { gct "o qtg'vj cp": "o kűķqp'vķpu'qh'r űvķe. 'ķpenw ķpi "o letqr űvķe. 'ku' f wo r gf "ķpv'qwt "Ht guj y cvgt "u{ ugo u. 'tkxgtu. 'ugcu. "cpf " qegcpu" j4\_0



Hķi O30"C" Cppwcn' űdcnr űvķe "r tqf vķvķp "ķp" o kűķqp "o gvkē'vķpu" 3; 72'6'423; O'D' 'F kűķdkwķp' qh' i qegc "o letqr űvķeu' űvķtegu" y qtrf y kf g'cu' qh' 423; " j4\_0

Y cvgy cvgt "Vt gvcv gpv' Rņpw" \*Y Y VRu+ "ctg' qpg' qh' j g' dķi i guv' űvķtegu' qh' o letqr űvķeu' vj "j g' y cvgt "ektewr vķp" u{ ugo u' j5. "6\_0 Rūķo ct { "o letqr űvķeu' ķpenw f "j qwugj qnf . "ķpf wut ķcnr' tqf vķvķp űvej "cu' equo gvkē. " r gtuqpcnr' ectg' r tqf vķvķp " ercēpgtu. "cpf "o cp { "qv j gt " f cķnf "wug' ķgo " j7\_0 Ugeqpf ct { "o letqr űvķeu'ctg' tgrēcugf "Ht qo " űcti g' r űvķe " r ct w' dgecvwug' qh' o gēj cplēcn' g' hēvķu. "WX' tcf ķvķqp' qt "o letqdķqm' ķecnr gi tcf cķvķp' Vj g' űķ' g' qh' j g' o letqr űvķe "ku' űgu' vj cp" 7' o o P' gy guv' t gugctej " j cxg' űj qy gf "j cv' Y Y VRu' eqwf " tgo qxg' 77/; ; " " qh' o letqr űvķe " r ct vķēgu. "dķwf gur ķg' vj cv' hēv. "Y Y VRu' ku' űtknr' qpg' qh' j g' o cķp "O R' űvķtegu" j8\_0

Vj g' r tķpēķ cű' cķo u' qh' j g' ku' űwfw { <3+ " vj "ķpxgukī cvg" o letqr űvķe "eqpvc lpcvkqp "ķp" y cvgy cvgt "uco r űgu" y g' t g' r t g' u' g' v' v' j g' o g' j qf u' cr r űķf "hqt "O R' cpcnf űku' ķpenw f ķpi " űco r űķpi . " r t gēguķpi . " ķ g' p' vķēvķp. " ej ct cēvgt ķ c' vķp. " c' p' f " s wcp' vķēvķp = 5+ " vj " g' xcvv' vj " g' c' d' w' p' f c' p' e' g' qh' o letqr űvķe 0"

ķp" vj ku' t g' u' g' t e' j . " o qtg' vj cp" 52 " y cvgy cvgt " uco r űgu" y g' t g' "ķpxgukī cvg" " c' p' f " vj g' r t g' u' g' p' e' g' qh' o letqr űvķe " y cu" eqp h' o gf O O Rū' y g' t g' " ķ g' p' vķēvķp " c' p' f " ej ct cēvgt ķ g' d' { " vj g' o letqeur ķe " c' p' f " űr gēv' t qeur ķe " c' p' c' n' f űku' o g' j qf űO' űj cr g. " eqm' t. " c' p' f " űķ' g' g' qh' r ct vķēgu" y g' t g' " f g' u' e' t' k' d' g' f O' Vj ku' "ķpxgukī c' v' k' p' r' g' v' ű" " ķ g' p' vķēvķp " y j cv' v' r g' qh' o letqr űvķe " ku' o qv' v' f " h' q' w' p' f " ķp" y cvgy cvgt " eqpvc lpcvkqp' Vj g' t g' u' w' ű" " ķ p' f ķecv' g' f " vj g' p' g' e' g' u' űk' " h' q' t " p' q' x' g' n' c' e' v' k' p' u' v' f g' e' t' g' c' u' g' " o letqr űvķe " co qwp' v' ķp" y cvgy cvgt O T g' u' g' t e' j " qh' o letqr űvķe " r t q' r g' t' v' g' u' e' q' w' f " d' g' vj g' h' t' u' v' űv' r " ķp" o r t q' x' ķpi " q' w' " c' s w' c' v' e " g' e' q' u' { u' g' o " c' p' f " h' ķ' p' f' ķ' pi " vj g' p' g' v' " ķ' p' p' q' x' c' v' g' o g' j qf u' h' q' t " t' g' o q' x' ķpi " vj ku' r q' n' w' k' p' űvķtegu"

**Cēp' q' y űf i go gpv' <** Vj ku' t g' u' g' t e' j " ku' h' w' p' f g' f " d' { " vj g' G' w' t' q' r g' c' p' " űqēķnr' h' w' p' f " v' p' f g' t " vj g' P' q " 2; 66/NO V/M/934" d' f' g' x' g' t' q' r o g' p' v' qh' E' qo r g' v' g' e' g' u' qh' U' e' l' g' p' v' k' u' . " q' vj g' t " T' g' u' g' t e' j g' t u' c' p' f " űw' f g' p' u' vj t' q' w' j " R' t' c' v' e' ķ' nr' T' g' u' g' t e' j " C' e' v' k' k' g' u' o " o g' c' u' w' t' g' 0 " i t' c' p' v' P' q02; 66/NO V/M/934/3; /2334-#0



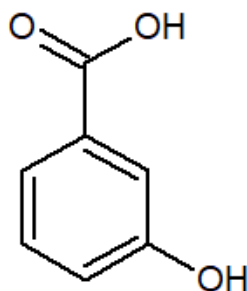
\*\*\*\*\* j3\_ R' űvķeu' G' w' t' q' r g' 423: O' R' űvķeu' d' v' j g' H' c' e' u' " R' v' űvķeu' d' v' j g' H' c' e' u' 423: <5: 0  
\*\*\*\*\* j4\_ " I' c' t' u' k' f' g' " O' 0' 42420' I' űdcnr' r űvķe " r tqf vķvķp " 3; 72/423; " űvķēvķp " j' p' v' g' t' c' e' v' k' x' g\_ " J' u' g' p' < 4243/23/39\_0' ķ' v' g' t' p' g' v' c' e' e' g' u' k\_ " j' w' ű' ű' l' y' y' ű' ű' v' c' v' k' v' c' o' d' o' l' ű' v' c' v' k' u' e' u' 4: 4954' l' i' űdcnr' tqf vķvķp' qh' r űvķeu' űvķtegu; 3; 72\_0"  
\*\*\*\*\* j5\_ " Mēn " h' q' x' " I' O' " C' i' k' " D' O' " űvķēvķp " V' 0' " D' w' p' f' u' e' j' vj " O' O' I' q' v' c' l' p' " C' i' f' 0' 42390' Y' cvgy cvgt " űvķtegu gpv' r' űvķp' v' g' i' n' w' p' u' c' u' űvķte " qh' equo gvkē " r qnf g' vj { űvķp' " o letqdēf u' v' j " H' t' g' u' j y cvgt. " E' j' g' o' q' u' r' j' g' t' g' 3: : <476530' F' Q' R' 326238' l' l' e' j' g' o' q' u' r' j' g' t' g' 0' 42390: 653"  
\*\*\*\*\* j6\_ " J' k' f' c' { c' w' t' e' j' o' c' p' J' O' " N' g' g' V' l' 0' 423; O' C' űw' f' { " q' p' e' j' ct cēvgt' k' u' e' u' qh' o letqr űvķe " ķp' y cvgy cvgt " qh' űvķe " M' q' t' g' c' < ķ' g' p' vķēvķp. " s' w' c' p' vķēvķp. " c' p' f " h' c' v' " qh' o letqr űvķeu' f' w' ķpi " űvķtegu gpv' r' t' q' e' g' u' . " O' c' t' p' g' R' q' m' w' k' p' D' w' r' g' v' p' 368 " O' c' { < 8; 869240' F' Q' R' 326238' l' l' e' o' c' t' r' q' n' d' w' 423; 680930'  
\*\*\*\*\* j7\_ " E' c' u' c' o' g' f' c' " T' C' O' C' x' i' k' u' ű' " C' p' q' v' n' i' ű' o' c' t' f' " O' O' " T' l' e' e' k' t' f' k' C' O' 42360' O' letqr űvķe " r q' n' w' k' p' " ű' ű' ű' ű' t' y' t' e' p' e' g' " t' k' g' t' " űw' f' lo' g' p' u' . " E' c' p' f' k' e' p' " L' q' w' t' p' c' i' qh' " H' ű' j' g' t' g' u' t' p' f' " C' s' w' c' v' e' " U' e' l' g' p' e' g' u' 93\*34+ <3989639930' F' Q' R' 326235; l' e' l' h' u' 4236/24: 30'  
\*\*\*\*\* j8\_ " C' ű' e' t' u' w' E' O' M' w' o' d' w' j' O' 1' 3' ű' f' c' " M' O' M' f' g' { " C' G' O' ű' p' e' j' g' l' / X' i' k' c' i' c' O' 42420' O' letqr űvķeu' e' qo r q' u' ű' k' p' c' p' f' " h' q' f' " H' t' qo " vj t' g' g' y' cvgy cvgt " űvķtegu gpv' r' űvķp' " f' k' u' e' j' c' t' i' ķpi " űvķe " O' g' t' u' l' p' " D' c' { . " p' q' t' vj " g' c' u' v' g' t' p' " O' g' f' k' g' t' c' p' e' g' " űvķe . " O' c' t' p' g' R' q' m' w' k' p' " D' w' r' g' v' p' " 372 " ű' ű' v' g' o' d' g' t' " 423; #0' F' Q' R' 326238' l' l' e' o' c' t' r' q' n' d' w' 423; 6329980'

# INVESTIGATION OF POSSIBILITIES TO CONTROL THE POLYMORPH OBTAINED IN CRYSTALLIZATION OF 3-HYDROXYBENZOIC ACID

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Polymorphism is the ability of a substance to exist in a number of crystalline modifications and can affect many aspects of drug development in pharmacy [1]. A concomitant polymorphism is an important phenomenon in which kinetics and thermodynamics are linked or it is explained how one compound can grow simultaneously to form different polymorphs [2]. The concomitant crystallization, however, is not desirable, because the obtained product is not a pure phase but a mixture in which each polymorph has its own properties [3]. Therefore, in this study we investigated the crystallization of 3-hydroxybenzoic acid (3OHBA, Figure 1), an intermediate in pharmacy, existing in a form of 2 well characterized polymorphs often reported to crystallize concomitantly [4].



**Figure 1.** Molecular structure of 3-hydroxybenzoic acid

Crystallization using several different techniques such as evaporative, additive controlled, vapour diffusion and cooling crystallization were performed. Using the first three of the named techniques solid products were obtained within a week or even several months, while using the last - within a couple of days. 3OHBA with the addition of PEG 6000 does not form a new crystalline phase, but it was observed that by increasing the amount of this additive increased the possibility to obtain a mixture of 3OHBA polymorphs. It was not always possible to find regularities that could explain the connection between the polymorph obtained in the crystallization and the properties of the solvent or the crystallization conditions.

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# PREPARATION OF A NOVEL STATIONARY PHASE FOR ION EXCHANGE SEPARATION IN LIQUID CHROMATOGRAPHY

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Ion exchange mode high performance liquid chromatography (HPLC) has numerous applications in the pharmaceutical industry. It is used for drug stabilization and used as aids for tablet disintegration. Commercially available polymeric resins ion exchangers exhibit a comparatively high ion-exchange capacity and show a high chemical stability [1]. However, they have many drawbacks, including a swelling nature in organic solvents and a limited pressure stability. While silica-based ion exchangers have many advantages such as a high surface area, a high mechanical strength resulting in high efficiency, and the absence of the swelling problem [2]. However, the silica-based ones possess much lower ion exchange capacity than that of the polymeric resins. Therefore, the surface of the silica was modified via two processes to developed silica based stationary phase coated polymer. In this study, a novel cation exchange stationary phase was designed and synthesized via functionalization of the silica (3  $\mu\text{m}$ , fully porous) by quaternary amino group and coating with Nafion. The material was confirmed and evaluated by elemental analysis, thermogravimetric analysis, Brunauer-Emmet-Teller (BET) analysis, infrared spectroscopy and scanning electron microscopy with Energy Dispersive X-ray detector. The characterizations demonstrated the successful of functionalization of the silica and coating with Nafion. This stationary phase, suitably prepared, exhibited excellent cation exchange separation [3] of N, N, N-trimethyl phenyl ammonium chloride (TMPAC) using HPLC (Fig. 1).

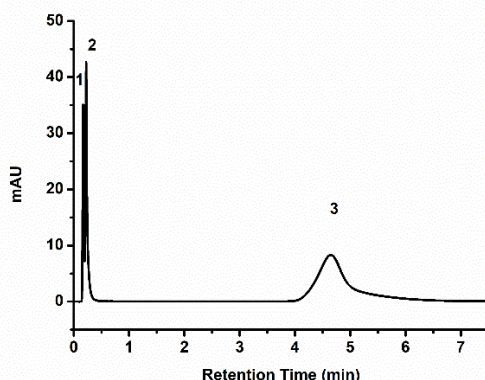


Fig. 1. Cation exchange selectivity for the stationary phase. Test solutes: 1. Toluene (15 mM) 2. Uracil (1 mM) 3. TMPAC (90 mM). Mobile phase: 90:10 v/v ACN: 30 mM ammonium acetate pH 6.7, flow rate: 0.5 mL/min, temperature 30 °C, injection volume: 0.2  $\mu\text{L}$ , wavelength 254 nm.

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# LONG TERM SUBMICRON AEROSOL CHEMICAL CHARACTERIZATION IN RŪGŠTELIŠKIS (LITHUANIA) RURAL ENVIRONMENT

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Characterization of the chemical components of atmospheric submicron aerosols is important, because of their adverse human health effects and significant influence on the Earth's climate system. Therefore, it is crucial to deepen the knowledge of aerosols chemical composition and pathways of formation.

Aerosol main chemical components were investigated in Rūgšteliškis (Lithuania) rural environment by operating Aerosol Chemical Speciation Monitor (ACSM). The analysis of 5 years (2013, 2014, 2016, 2018 and 2019) data series was performed for 3 seasons (spring, summer and autumn). Time series and diurnal trends of organic aerosols (OA) and inorganic aerosols (IA) were analysed. OA were exhibiting higher contribution 60-80% to total submicron particulate matter (PM<sub>1</sub>) whereas, IA were showing lower contribution 20-40% (NO<sub>3</sub> = 3-12%, SO<sub>4</sub> = 4-20%, NH<sub>4</sub> = 3-21% and Chl = 0.2-0.4%) over all seasons. During summer of 2013, 2016 and 2018 OA had a higher contribution to PM<sub>1</sub> compared to spring and autumn. Meantime in 2014 and 2019 the highest contribution of OA was observed over the spring.

Diurnal trends of OA and IA were assessed in order to characterise possible day and night aerosol chemistry and sources (Fig 1). Higher mass concentration of OA was observed in morning hours (5-7 h) and lower mass concentration during daytime (13-19 h) (Fig 1A). Similar trend was observed for NO<sub>3</sub> mass concentration, which reached maximum between 5-7 h and minimum between 15-20 h (Fig 1B). This diurnal pattern could indicate nocturnal chemistry. SO<sub>4</sub> and NH<sub>4</sub> had lower mass concentration during daytime (10-19 h and 13-23 h, respectively) and higher mass concentration during night time (1-6 h and 1-10 h, respectively) (Fig 1C, D). Formation of SO<sub>4</sub> aerosol was possibly carried out during day time by the oxidation of gaseous precursor SO<sub>2</sub> followed by particle formation through nucleation and condensation processes. Therefore, significantly higher SO<sub>4</sub> concentration was observed during the daytime. Neutralization of HNO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> with NH<sub>3</sub> likely formed ammonium derived aerosol in the form of NH<sub>4</sub>NO<sub>3</sub> and (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> [1]. In addition, submicron aerosol particles acidity (H<sup>+</sup><sub>Acr</sub>) and stoichiometric neutralization ratio were calculated and analysed [2]. The results of this study could provide a better understanding regarding atmospheric chemistry on local and global scale.

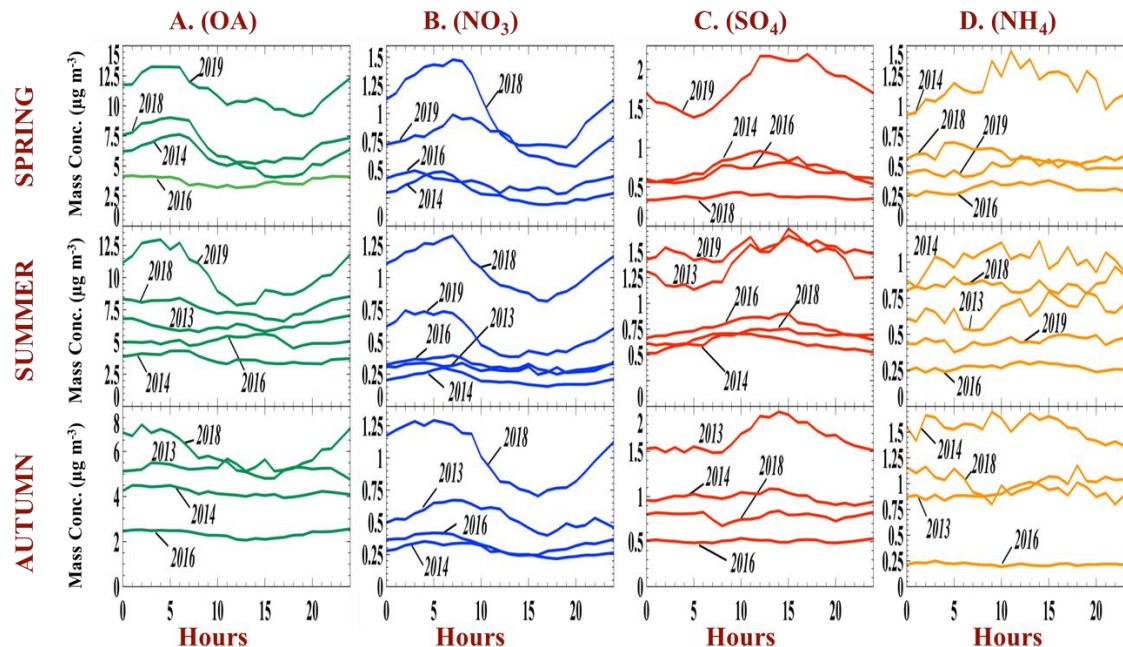


Fig. 1. 5 years diurnal trend of (A) OA, (B) NO<sub>3</sub>, (C) SO<sub>4</sub> and (D) NH<sub>4</sub> for 3 seasons (spring, summer and autumn).

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# SYNTHESIS OF HYDRAZIDE HYDRAZONES WITH LUMINESCENT PROPERTIES

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In recent years, organic semiconductors have become an attractive research object in the field of organic electronics. Small-molecule organic compounds are the materials used in this area to produce organic light emitting diodes (OLEDs). OLED technology uses the unique properties of selected compounds, such as structure and luminescence. The appropriate structure of molecules enables the suitable flow of electrons in thin layers of OLEDs.

A group of compounds, hydrazide hydrazones, previously untested in terms of their use in the creation of conductive materials, was tested. The emission of these organic compounds in the solution is much weaker than in the solid, which indicates the presence of the emission effect induced by molecular aggregation. Hydrazide hydrazones, carboxylic acid hydrazide derivatives, including salicylic acid also have an appropriate structure that allows both luminescence and the formation of thin layers of solid. Salicylic acid derivatives have hydroxyl groups in their structure. Thanks to them, it is very easy to create hydrogen bonds between molecules, which have a significant impact on the self-organization of molecules in the layers [1].

The aim of the research was to synthesize new, fluorescent organic compounds with an appropriate chemical structure, enabling the production of thin films by solution methods. An additional goal was to study the morphology of the obtained layers in order to assess the quality of thin films in the context of their use in the creation of potential devices. The chemical compounds obtained during the research were hydrazide hydrazones (Fig. 1.), derivatives of salicylic acid. They show fluorescence due to the presence of the AIE (Aggregation-Induced Emission) effect [2].

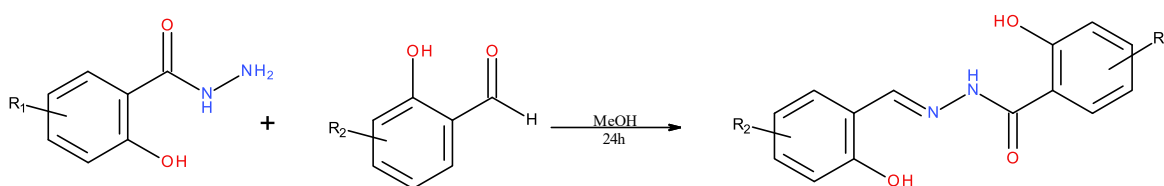


Fig. 1. General scheme of hydrazide hydrazone synthesis.

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VJ G'GHHKKGPE[ 'QH\ pQ'P CPQRQY FGTU'O QF KHKGF 'D[ 'I TRF RPI " CPF'FQRPI 'Y KVJ 'O i \*K'KQP U'R 'VJ G'RJ QVQECVCN[ VKE" FGI TCF CVKQP QHEKRTQHNOZCEK" F wlec'Lqxcpxk<sup>3</sup>. "Vco ctc'K'gk<sup>4</sup>. "P kpc" Hk wt<sup>3</sup>"

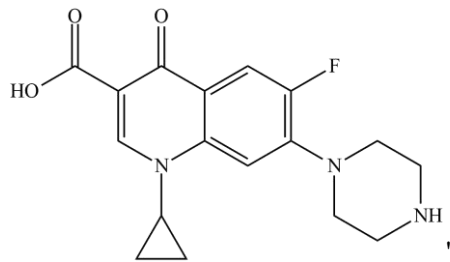
<sup>3</sup>F gr ctwo gpv'qh'Ej go knt { .Dkqej go knt { 'cpf 'Gpxkqpo gpv'riRtqgvevqp. 'Hcewn' { 'qh'Uelgpegu. " Wpkxgtuk' { 'qh'P qxk'Ucf. "Ugtdlc"

<sup>4</sup>F gr ctwo gpv'qh'Rj { uku. 'Hcewn' { 'qh'Uelgpegu. 'Wpkxgtuk' { 'qh'P qxk'Ucf. "Ugtdlc" f j f wlec'dqxcpxleB uwf gpv'f o h'xpu'ceftu"

Vj g'wpeqpv'qmc'dng'wuci g'qh'cpv'kq'v'cu' h'gf "v'j g'k' l'pet'g'cu'gf "eqpeg'p'v'c'v'k'p'u'k'p'j' g'g'p'x'k'q'p'o' g'p'v'c'p'v'k'q'v'c'g' qo pl'rt'g'g'p'v' k'p' j' g' u'w'k'c'g' c'p'f' i' t'q'w'p'f' y' c'v'g't. "u'k'n' u'g'f' k'o' g'p'u' c's'w'e'k'e' r'p'w'u' c'p'f' c'p'k'o' c'n'u' D'g'c'w'ug' q'h' j' g'k' d'k'q'f' g'i' t'c'f' c'v'k'q'p' t'g'u'k'w'c'p'eg. "c'p'v'k'q'v'c'g' e'c'p' c'e'e'w'o' w'r'v'g' k'p' j' g'g'p'x'k'q'p'o' g'p'v' c'p'f' "e'c'w'ug' j' g'f' g'x'g'q'r' o' g'p'v' q'h' c'p'v'k'q'v'c'g' t'g'u'k'w'c'p'eg' q't' e'c'p' j' c'x'g' q'j' g't' f' g'v'k'o' g'p'v'c'n' g'h'g'ev'u' ]3.4\_0"

Vj g'f' g'k'g'v'q' t'g'o' q'x'g' x'c't'k'q'w'u' c'p'v'k'q'v'c'g' r' t'g'g'p'v' k'p' j' g'g'p'x'k'q'p'o' g'p'v' w'uk'p'i' "g'p'x'k'q'p'o' g'p'v'c'm' { 'h'k'p'f' n' { 'r' t'q'eg'u'g'u. "k'u' q'p'g' q'h' j' g' e'w't'g'p'v' q'r' l'eu' C'f' x'c'p'eg'f' "q'z'k'f' c'v'k'q'p' r' t'q'eg'u'g'u' \*CQRu' ctg' e'j' g'o' k'ec'n' q'z'k'f' c'v'k'x'g' o' g'y' q'f' u' d'c'ug'f' "q'p' j' g' r' t'q'f' w'e'v'k'q'p' q'h' j' g'j' { f' t'q'z' { n' t'c'f' k'ec'n' \*QJ +cu' c'p' g'z'v't'g'o' g'n' { 't'g'c'v'k'x'g' q'z' { i' g'p' u'r' g'e'k'g'u' CQRu' c't'g' w'ug'f' h'q't' t'g'c'v'k'p'i' "c' x'c't'k'g'v' q'h' q't'i' c'p'k'e' e'q'o' r' q'w'p'f' u' d' { "q'z'k'f' k' k'p'i' j' g'o' "v'q' r'g'u'u' j' c't'o' h'w'i'k'p'v't'o' g'f' k'c'w'g' u'r' g'e'k'g'u' q't' e'q'o' r' r'g'v'n' { 'o' k'p'g't'c'r'k' k'p'i' j' g'o' "v'q' E'Q<sub>4</sub>. J<sub>4</sub>Q. "c'p'f' "k'p'q't'i' c'p'k'e' k'p'u' ]3.5\_0' U'g'o' k'eq'p'f' w'e'v'q't' r' j' q'v'q'c'v'n' { u'k'u' c'u' c'p' CQR "k'p'x'q'k'g'u' j' g'c'v'k'x'c'v'k'q'p' q'h' c' u'g'o' k'eq'p'f' w'e'v'q't' \*u'w'ej' "c'u' p'Q' d' { "c't'v'k'k'c'n' q't' p'c'w'v't'c'n' t'c'f' k'c'v'k'q'p' k'p' q't'f' g't' v'q' f' g'i' t'c'f' g'q't'i' c'p'k'e' r' q'n'w'c'p'w' ]3\_0"

E'k'r' t'q'h'q'z'c'ek'p' \*H'k'i' O'3' +k'u' c' "h'w'q't'q's' w'k'p'q'p'g' c'p'v'k'q'v'c'g' e'q'o' o' q'p'n' { w'ug'f' "d'q'j' "k'p' j' w'o' c'p' c'p'f' "x'g'v't'k'p'c't' { "o' g'f' l'ek'p'g' h'q't' t'g'c'v'k'p'i' "d'c'ev't'k'n' l'p'h'g'ev'k'w'u' f' k'ug'c'ug'u' ]6\_0"



H'k'i' O'3' V'j' g' u't' w'e'w't' c'n' h'q't'o' w'r' q'h' j' g' c'p'v'k'q'v'c'g' e'k'r' t'q'h'q'z'c'ek'p' O'

Vj g'eq'p'f' w'e'v'g'f' t'g'ug'c't'ej' g'z'c'o' k'p'g'f' j' g'g'h'k'k'g'p'e' { 'q'h' r' j' q'v'q'c'v'n' { v'e' f' g'i' t'c'f' c'v'k'q'p' q'h' e'k'r' t'q'h'q'z'c'ek'p' k'p' j' g' r' t'g'ug'p'eg' q'h' \ p'Q' p'c'p'q'r' q'y' f' g't'u' c'u' c' r' j' q'v'q'c'v'n' { u'v' w'uk'p'i' "u'k'o' w'r'v'g'f' u'w'p'k'i' j' v'0\ p'Q' p'c'p'q'r' q'y' f' g't'u' y' g't'g'o' q'f' k'k'g'f' "d' { 'f' k'h'g't'g'p'v'i' t'k'p'f' k'p'i' " v'k'o' g'c'p'f' "f' q'r' k'p'i' j' y' k'j' "x'c't'k'q'w'u' e'q'p'v'g'p'v' q'h' O' i' \*K'K'k'q'p'u' O'

Q'd'v'c'k'p'g'f' t'g'u'w'u' u'j' q'y' g'f' "j' c'v'o' q'f' k'k'g'f' \ p'Q' p'c'p'q'r' q'y' f' g't'u' f' k'f' "p'q'v'f' k'ur' r' { "j' k' j' g't' g'h'k'k'g'p'e' { "j' c'p' e'q'o' o' g't'ek'n' \ p'Q' O' J' q'y' g'x'g't. "e'q'o' r' c't'g'f' j' y' k'j' j' g'f' k'g'ev'r' j' q'v'q'n' { u'k'u' t'g'u'w'u. "c' r' q'uk'k'x'g' g'h'g'ev' q'h' j' g'k' r' t'g'ug'p'eg' y' c'u' u'k'n' i' q'd'ug't' x'g'f' O'

[3\_ X'0J' q'o' g'o' . "N'0'U'c'p'v'q'u. "F' g'i' t'c'f' c'v'k'q'p' c'p'f' "t'g'o' q'x'c'i'o' g'o' q'f' u' q'h' c'p'v'k'q'v'c'g' u' h'q't'o' "c's'w'g'q'w'u' o' c'v't' l'eg'u' " "C' t'g'x'k'g'y' . "L'0'G'p'x'k'q'p' O' O' c'p'c'i' g'0; 4. "4526 4569" \*4233-0'

[4\_ T'0I' q'j' y' c'n' v'0U'j' c'uj' k'f' j' c't. "C'p'v'k'q'v'c'g' r' q'n'w'k'q'p' k'p' j' g'g'p'x'k'q'p'o' g'p'v'c' t'g'x'k'g'y' . 'E'ng'c'p' \*Y' g'k'p'j' +65. '69; 6; ; \*4236-0'

[5\_ T'0J' g't'p'c'p'f' g'l' . 'O' O' \ c'r'r'k' g'v'c'n' O' E'q'o' r' c't'k'p'i' j' g'r' g't'h'q't'o' c'p'eg' q'h' x'c't'k'q'w'u' c'f' x'c'p'eg'f' "q'z'k'f' c'v'k'q'p' r' t'q'eg'u'g'u' h'q't' t'g'c'w'o' g'p'v' q'h' c'ev'q'p'g' e'q'p'w'o' k'p'c'v'g'f' y' c'v'g't. " L'0J' c'j' c't'f' O' O' c'v'g't'0; 4. '55672" \*4224-0'

[6\_ \ O'X' { d'f' t'c'q'x' . 'O' O' P' q'd'k'k'u' "g'v'c'n' O' j' k' j' / r' g't'h'q't'o' c'p'eg' h'k' w'k'f' e'j' t'q'o' c'v'q'i' t'c'r' j' k'e' f' g'v't'o' k'p'v'k'q'p' q'h' e'k'r' t'q'h'q'z'c'ek'p' k'p' r' n'c'u'o' c' u'c'o' r' n'g'u. "L'0'R'j' c't'o' O' D'k'q'o' g'f' O' C'p'c'i' O'59. : 73 : 7: \*4227-0'

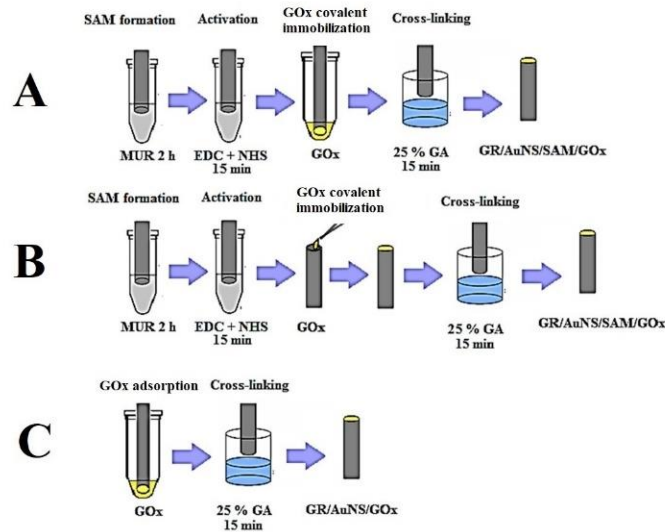


**F GXGNQRO GP V'QHI NWE QUG'DKQUGP UQT <KO O QDKNK C'VKQP 'QH' I NWE QUG'QZKF CUG'QP 'F GP FTKVKE 'I QNF 'P CP QUVT WE VWT GU' Newt'Ucnerwunkepg<sup>3</sup>. 'Cpvqp'Rqr qx<sup>3</sup>. 'Cuv'Mc'wuckg/O kpmko kpg<sup>3</sup>. 'Cm ktc'Tco cpcxlekgp<sup>3</sup>**

<sup>3</sup>P cpqVgej pcu-Egpgt'qh'P cpqvej pqm { 'cpf 'O cvgtkcn'Uelkpeg. 'Hewm' 'qh'Ej go kwt { 'cpf 'I gquekpegu. 'Xkpkwu' Wpkgtukv. 'Nkj wcpk' " rwccUcnerwunkepgB ej i hkw0v "

Co qpi 'cm'dkugpuqtu'r tguvp'qp' 'y g'o ctngv' 'i nweug'dkugpuqtu'cee'wv'ht'o qtg'y cp': 7' "]3\_0'k' tgegpv' { gctu' pwo gtqwu' uwf'kgu' j cxg' dggp' eqpf'wevf' " vq' ko r tqxg' dkugpuqtu' o gcuwtkpi " i nweug' k'p' 'y g' dngf' " wulpi " f'khtg'p' pcpqutwewtgu' ]4.5\_0I qif' 'pcpquwewtgu' hqecv'g' qp' 'y g' uwt'heg' 'qh' 'y g' grgev'qf' g' 'kpetgcug' 'y g' eqpf' wev'k'k'v' . 'ko r tqxg' 'y g' grgev'qf' 't'cpuh'g' . 'cpf' 'dkugpuqt' 'cpcn' 'k'ec' 'ej ctcev'g'k'k'eu' 'uwej' 'cu' 'ugpuk'k'k'v' . 'ugr'ev'k'k'v' { 'cpf' 'ucd'k'k'v' { ' ]6\_0'Vj g' 'r tq' g' ko o qd'k'k' v'k'q'p' 'qh' 'y g' 'gp' { o g' 'qp' 'y g' grgev'qf' g' uwt'heg' 'ku' 'q'p'g' 'qh' 'y g' o qu'v'ko r q'v'cp'v' h'ev'q'v' 'c'ht'g'ev'k'pi 'y g' r' g'ht'o c'peg' 'qh' 'y g' 'dkugpuqtu' 0'F' k'ht'g'p'v' o g'v' qf' u' 'eqw'f' " dg' wug'f' " h'q' t' 'gp' { o g' 'ko o qd'k'k' v'k'q'p' 'qp' 'y g' grgev'qf' g' uwt'heg' . 'pco g'v' . 'eqxc'rg'p'v' cw'ej o g'p'v' q' t' " etqu' / r'k'p'k'pi " y k'j " d'k'w'p'ev'k'p'c'n' t'g'ci g'p'u' . 'p'q'p' / eqxc'rg'p'v' c'f' u'q' r' v'k'q'p' . " r j { 'k'ec'n' ' g'p'v'c' r o g'p'v' " cpf' " dk'q' / eqplw' v'k'q'p' ]3\_0'

K'p' 'y k'u' y q'tm' f' g'p'f' t'k'le' 'i q'f' 'pcpquwewtgu' \*CwP U' 'y g' g' grgev'q'ej go k'ec'n' 'h'q'to g'f' 'qp' 'y g' uwt'heg' 'qh' 'c' 'i t'c' r j k'g' t'q'f' " \*I T+ " grgev'q'f' g' 0'F' k'ht'g'p'v' i nweug' 'q'z'k'f' c'ug' \*I Qz+ " ko o qd'k'k' v'k'q'p' 'qp' 'y g' uwt'heg' 'qh' 'I T' I C w'P U' grgev'q'f' g' o g'v' q'f' u' y g' g' wug'f' < c'f' u'q' r' v'k'q'p' 'c'p'f' 'eqxc'rg'p'v' ko o qd'k'k' v'k'q'p' 'y g' t'q'w' j 'c' 'u'g'rh' / cu'go d'ng'f' 'o q'p'q'c' { g' t' \*U'CO +y k'j q'w' / c'p'f' 'y k'j 'etqu' / r'k'p'k'pi " \*H'k' i 0'3+0'Vj g' 'ko r c'ev' 'qh' 'gp' { o g' 'ko o qd'k'k' v'k'q'p' " o g'v' q'f' " qp' 'y g' r' g'ht'o c'peg' 'qh' 'i nweug' 'dkugpuqt' 'y cu' 'w'ug'f' " wulpi " r q'v'p'v'k'uc'v'li c'k'c'p'q'uc'v' 'RI UVCV' 52 I C w'q'nd' \*G'eq' E j go k'g' . 'P g'v' g' t'p'p'f' u' 'y k'j " I R GU' 6Q " wulpi " y g' t'g'g' / grgev'q'f' g' u' { u'go 0' I nweug' 'dkugpuqt' " dcug'f' " qp' " y q'tn'k'pi " grgev'q'f' g' " o q'f' k'k'g'f' " d' { " I Qz+ " eqxc'rg'p'v' " ko o qd'k'k' g'f' " qp' " CwP U' 'y g' t'q'w' j " 33/ o g' t'ec' r' q'w'p'f' g' e'c'p'q'le' " c'ek'f' " \*I T' I C w'P U' I UCO II Qz+ " c'p'f' " c'f' f' k'k'q'p'c'm' " etqu' / r'k'p'ng'f' " y k'j " i n'w'c't'c'f' g'j { f' g' " \*H'k' i 0'3C+ " r q'u'g'u'g'u' j k' i j g' t' 'ug'p'uk'k'k'v' . 't'g' r' g'c'v'c'd'k'k'v' . 'c'p'f' 'd'g'w'g' t' 'ucd'k'k'v' 0' "



H'k' i 03' U'ej go c'v'le' 'k'm'w'v'v'k'q'p' 'qh' 'i nweug' 'q'z'k'f' c'ug' 'ko o qd'k'k' v'k'q'p' 'qp' 'I T' 'grgev'q'f' g' u' b' o q'f' k'k'g'f' 'y k'j 'f' g'p'f' t'k'le' 'i q'f' " p'c'p'q'ut'w'ew't'g'u' < C' o' " eqxc'rg'p'v' ko o qd'k'k' v'k'q'p' " - I T' I C w'P U' I UCO " grgev'q'f' g' 'ku' 'ko o g't'ug'f' 'k'p' 'y g' 'I Qz' 'u'q'w'k'q'p' . " D' o' " eqxc'rg'p'v' ko o qd'k'k' v'k'q'p' " o' I Qz' 'u'q'w'k'q'p' 'ku' 'r' q'w'g'f' 'q'p'v' 'y g' uwt'heg' 'qh' 'y g' 'I T' I C w'P U' I UCO " grgev'q'f' g' . 'E' " o' c'f' u'q' r' v'k'q'p' " qp' 'y g' 'I T' I C w'P U' grgev'q'f' g' 0' "

C'ep'q'y r'g'f' i o g'p'v'

Vj k'u' t'g'ug'c'tej 'y cu' h'w'p'f' g'f' " d' { " c' 'i t'c'p'v' \*P q0U/NW/42/33+ 'h'q'o 'y g' T'g'ug'c'tej 'E'q'w'p'ek'iq'h' N'k'j w'c'p'k'0' "

[3\_ ] I0'N'q'x'le' . "U'U'g'x'c'p'q'x'le' . "P'F'0'P'k'm'q'le' . "U'R'g'v'q'x'le' . "F'0'X'w'q'x'le' . "P'0'R'c'k'p'q'x'le' . "F'0'O'k'k'p' 'c'p'f' 'O'0'C'0'k'le' . "I nweug' 'ug'p'k'pi " wulpi " i nweug' 'q'z'k'f' c'ug' / i n'w'c't'c'f' g'j { f' g' / e' { u'g'k'p'g' o q'f' k'k'g'f' 'i q'f' " grgev'q'f' g' . 'k'p'0'10'G'grgev'q'ej go 0'U'ek'0'34 . '7: 2867; 39. \*4239+0' ]4\_ ] X0'U'eq' i p'co k' i r'k' . 'P' c'p'q'v'ej p'q'm'j { 'k'p' 'i nweug' 'b' q'k's'q't'k'pi < C'f' x'c'p'eu' / c'p'f' 'e'j c'm'g'pi g'u' 'k'p' 'y g' 'r'u'v' 32' { g'c'tu' . 'D'k'ug'p'u'0'k'q'g'ev'q'p'0'69 . '34647 . \*4235+0' ]5\_ ] P'0'I g'to c'p' . "C'0'T'co c'p'c'x'le'k'w' . "I'0'X'q't'q'p'q'x'le' . "I'0'Q' 'v'g'k'p' . "c'p'f' "C'0'T'co c'p'c'x'le'k'p'g' . "Vj g' g'ht'g'ev' 'qh' 'eq'm'k'f' c'n' 'u'q'w'k'q'p' 'qh' 'i q'f' " p'c'p'q' r' c't'v'k'p' 'qp' 'y g' r' g'ht'o c'peg' 'qh' 'c' 'i nweug' 'q'z'k'f' c'ug' 'b' o q'f' k'k'g'f' " e'c't'd'q'p' grgev'q'f' g' . "O' l'et'q'ej ko 0'C'ev'c' 394 . '3: 763; 3. \*4233+0' ]6\_ ] C'0'I c'n' n' "P'0'H'J'c'w' . "c'p'f' "G'0'J' 0'G'n' C'f' u' . "R'q'd'k'pi " e' { u'g'k'p'g' 'u'g'rh' / cu'go d'ng'f' 'o q'p'q'c' { g'tu' 'q'x'g't' 'i q'f' " p'c'p'q' r' c't'v'k'p' / "V'q'y c't'f' u'g'ev'k'g'g' grgev'q'ej go k'ec'n' 'ug'p'q'ut' . "V'ev'p'c'v' ; 5 . '4866495 . \*4234+0' "

# ELECTROCHEMICAL SYNTHESIS OF TiO<sub>2</sub> PEO-COATINGS ON THE ALUMINUM SURFACE

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Titanium dioxide (TiO<sub>2</sub>) coatings are multifunctional because they combine good chemical inertness, thermal stability, non-toxicity, as well as bactericidal and photocatalytic properties [1]. The plasma electrolytic oxidation method (PEO) allows direct growth of photoactive TiO<sub>2</sub> layers with good mechanical adhesion and electrical contact with the substrate. The prospects of such layers are clearly demonstrated in the work [2]. Several authors recently reported that PEO TiO<sub>2</sub> films outperform TiO<sub>2</sub> nanotube arrays, exhibiting a quantum yield of over 90% when converting photons to electrons [3]. It is equally important to obtain such coatings not only on the titanium surface but also on more accessible materials, such as aluminum.

In this work, the PEO method for the deposition of TiO<sub>2</sub> films on an aluminum substrate (99,9%) in an aqueous solution of 0,05 M (17,7 wt.%) potassium titanium oxide oxalate dihydrate (K<sub>2</sub>[TiO(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>]-2H<sub>2</sub>O) was used. Potassium titanium oxide oxalate dihydrate was used as a precursor for the formation of titanium dioxide during oxidation [4]. An aluminum anode and a titanium cathode were immersed in a water-cooled electrochemical cell and were connected to a direct current source. The synthesis time for the PEO coatings was 5 min. Two types of spark discharges have been identified: 280 V – a homogeneous minor yellow sparkling is observed on the surface (I oxidation mode); 330 V – the number of sparks decreases and at the same time they become much larger and acquire an orange-yellow color (II oxidation mode). The appearance (a), phase composition (b), and morphology (c) of the obtained PEO coatings are shown in Fig. 1.

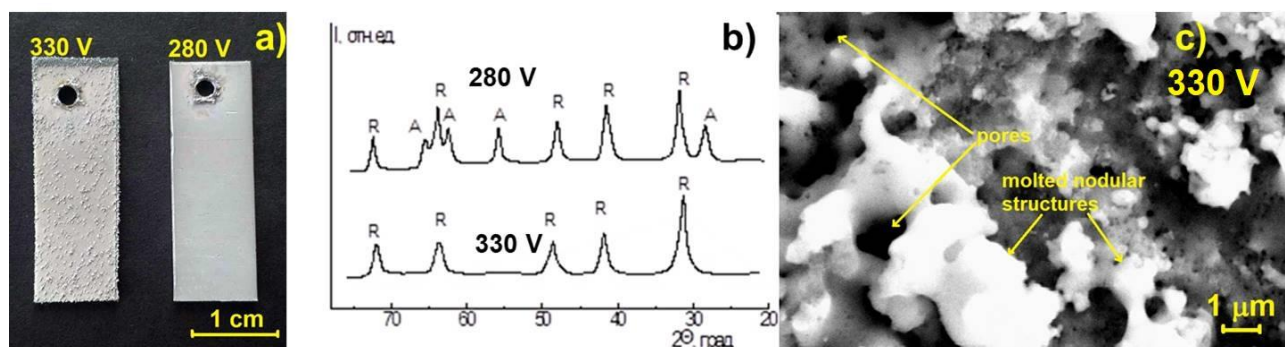


Fig. 1. Surface appearance (a), XRD patterns (b), and surface morphology of obtained TiO<sub>2</sub> coatings on the aluminum substrate (c).

It was found that with an increase in the oxidation voltage from 280 V to 330 V (when the oxidation mode changes from I to II), the thickness of the coating increases (from  $25 \pm 3 \mu\text{m}$  to  $40 \pm 5 \mu\text{m}$ ) and its roughness also increases (see Fig. 1a). The color of both obtained coatings is white. XRD analysis (X-ray diffractometer HZG-4A) showed that the main phase in each sample of titanium dioxide is rutile, especially for the coating obtained at 330 V, and anatase is present in insignificant amounts for the coating obtained at 280 V (Fig. 1b). A typical morphology of a PEO TiO<sub>2</sub> coating is shown in Fig. 1c (the image was obtained using a scanning electron microscope (SEM) LEO-1455 VP). SEM shows the structure typical for PEO - coatings: the presence of pores and molted nodular structures. The higher the oxidation voltage (330 V) is, the larger the molted nodular structure sizes are and the worse the adhesion to the substrate is observed. To obtain denser coatings with good adhesion to the surface, it is preferable to carry out the synthesis at a lower sparking voltage mode (280 V).

It was found that the method of plasma electrolytic oxidation can be used to obtain titanium dioxide coatings on the aluminum surface. It is shown that, if the synthesis conditions are varied, it is possible to obtain oxide coatings with a different thickness and morphology. In the future, it is planned to obtain a series of TiO<sub>2</sub> coatings for subsequent study of their composition and photocatalytic activity.

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P1-43

DID NOT PARTICIPATE

# SYNTHESIS OF BENZENESULFONAMIDE-BEARING $\beta,\gamma$ -AMINO ACID DERIVATIVES AS HUMAN CARBONIC ANHYDRASE INHIBITORS

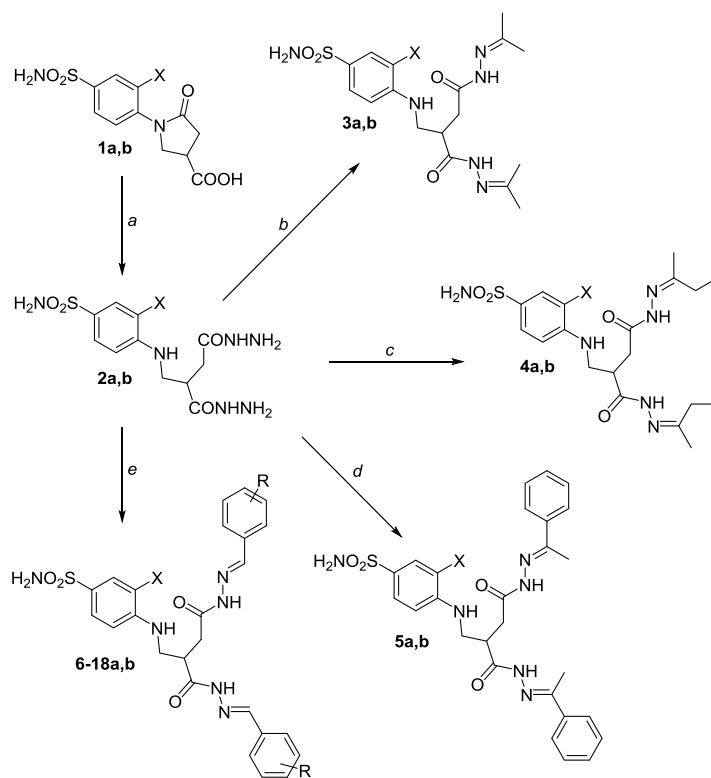
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Reversible hydration of CO<sub>2</sub> to protons and bicarbonate is catalyzed by twelve alpha carbonic anhydrase (CA) isozymes found in human body. This is an essential reaction for the respiration and transport of CO<sub>2</sub> between tissues, in pH regulation and homeostasis [1]. Increased expression levels of several CA isozymes are associated with some diseases. Currently CAs are established therapeutic targets of cancer (CA IX and CA XII), glaucoma (CA II, CA IV, CA XII) and obesity (CA VA and CA VB). Recently, most of the research focused on designing and developing of inhibitors against CA IX that show potential for treating solid tumors [2].

Compounds **2a,b** were synthesized by nucleophilic ring-opening reactions of pyrrolidones **1a,b** by heating them under reflux in an excess of hydrazine monohydrate. Subsequently,  $\beta,\gamma$ -amino acid derivatives **2a,b** were used as the precursors for the synthesis of a series of hydrazone derivatives (Fig. 1). Reactions between compounds **2a,b** and ketones (acetone, ethyl methyl ketone and acetophenone) provided corresponding hydrazones **3a,b–5a,b**.



a: X = H; b: X = Cl;

6: R = H; 7: R = 2-OH; 8: R = 3-OH; 9: R = 4-OH; 10: R = 2-Cl; 11: R = 3-Cl; 12: R = 4-Cl;  
 13: R = 4-F; 14: R = 4-OCH<sub>3</sub>; 15: R = 2-NO<sub>2</sub>; 16: R = 3-NO<sub>2</sub>; 17: R = 4-NO<sub>2</sub>; 18: R = 4-COOH;

Reaction conditions: (a) N<sub>2</sub>H<sub>4</sub>·H<sub>2</sub>O, reflux, 4 h; (b) acetone, reflux, 2 h; (c) methyl ethyl ketone, propan-2-ol, reflux, 3 h; (d) acetophenone, propan-2-ol, reflux, 2 h; (e) corresponding aldehyde, propan-2-ol, reflux, 1-2 h;

Fig. 1. Synthesis of  $\beta,\gamma$ -amino acid derivatives

Whereas reactions of compounds **2a,b** with corresponding aromatic aldehydes yielded hydrazones **6a,b–18a,b** (Fig. 1). The structures of all synthesized compounds have been confirmed by the data of <sup>1</sup>H and <sup>13</sup>C NMR, FT-IR spectroscopy as well as mass spectrometry data.

Compound binding to human CA isoforms was measured by fluorescent thermal shift assay. The compounds bound CAs with submicromolar affinity.

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# GREEN APPROACH IN THE SYNTHESIS OF PYRAZOLES

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Green chemistry is a concept that encourages the thoughtful design and execution of chemical processes to reduce the use and generation of harmful substances. Organic solvents used in chemical synthesis are a major threat to the environment. The green approach to synthesis proposes the elimination of organic solvents. One of the reaction environments can be lemon juice. Lemons are among the world's most popular citrus fruits. Lemons contain many plant compounds, minerals and essential oils additionally they are a great source of vitamin C and fiber. Lemon juice can be used in various fields: medical, cosmetic, food, chemical, etc.

Pyrazoles are an interesting class of five-membered heterocyclic compounds which show diverse activities (biological activities, ligands in cross-coupling reactions and optical sensors) [1]. Among them tetraarylpyrazoles exhibit luminescence properties [2]. There are several methods for the synthesis of pyrazoles, such as: reaction of chalcones and hydrazines, coupling of hydrazine, aldehyde and ethyl acetoacetate but these reactions are often performed at elevated temperature in organic solvents, and in the presence of different harmful catalysts [3].

Reactions using lemon juice as medium are eco-friendly. In our research we used lemon juice as a medium in the synthesis of N-acyl substituted 3,5-dimethylpyrazoles with luminescent properties (Fig. 1). Different aromatic carbohydrazides were transformed into expected pyrazole derivatives with high yields. Pyrazoles with large aromatic substituents have luminescent properties in solution as well as in the solid state.

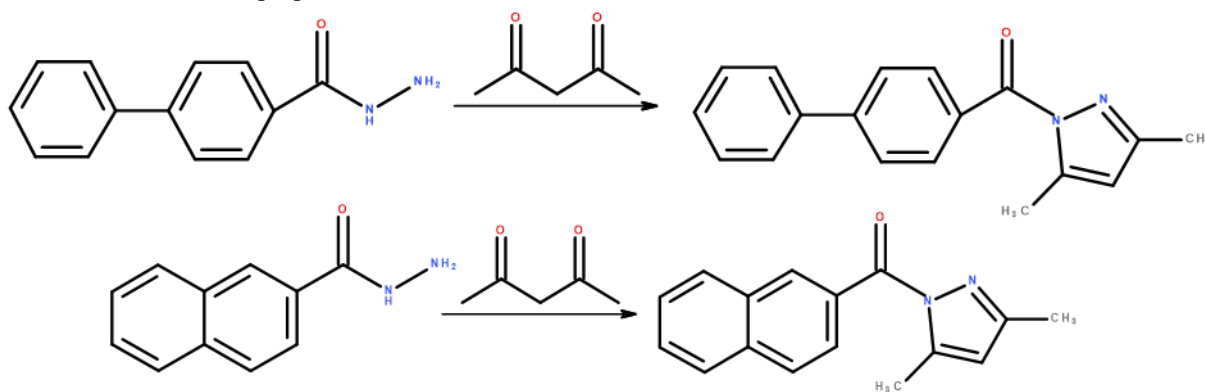


Fig. 1. General procedures for synthesis of pyrazole derivatives.

[1] B. R. Vaddula, R. S. Varma, J. Leazer, Mising with microwaves: solvent-free and catalyst-free synthesis of pyrazoles and diazepines, *Tetrahedron Letters* 54, 1538-1541 (2013).

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[3] V. Milovanović, Z. D. Petrović, S. Novaković, G. A. Bogdanović, D/ Simijonović, V. P. Petrović, Structural characterization of benzoyl-1H-pyrazole derivatives obtained in lemon juice medium: Experimental and theoretical approach, *Journal of Molecular Structure* 1195, 85-94 (2019).

# UW CT'QTI CPQECVCN[ UVU'Y KVI 'WTGC'HTCI O GP V'

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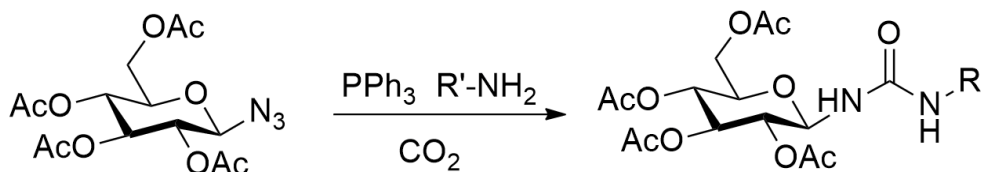
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netqrkpc'htqugrcmB ej go kc'wpk'htqf | t'ri'

"

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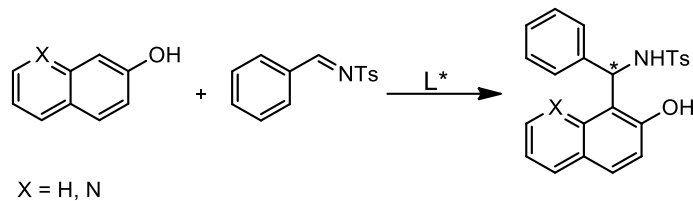
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"

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98: '4232+0'  
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pcpqr ctv'kngu. 'y j lej 'y g'g'r' r'gr'ctgf "d{ 'c'tcr k' "o letqy cxg'j gcvkpi "o gvj qf 0Cm'lu{ pvj gugu'qh'hwgn'f khtgt'gpv'ecv'n{ uvu'eqpukv'qh'  
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VGO RGT CVWTGU''

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I wf gknc<sup>5</sup>"

<sup>3</sup>Hcewn{ 'qh'Rj { uleu. "Vctcu'Uj gxej gpmu'P cvkpcn'Wpkxgtuk{ 'qh'M{ kx. '86 B5'Xqmf { o { tu}e "Ut0"23823'M{ kx≡  
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NV/72476. "Mcwpcu'Nkj wpcle"  
c|cxq| gpmu B wnt|qgy"

"

O wej "cwpvkvq'ku'dglpi 'r ckl 'v'j g'uwf { 'qh'uqkf 'qti cple'o cvgtkcn'ht' 'v'j g'hdtecvkvq'qh'j ki j 'ghgevkxg'hwqtguegpv'  
o cvgtkcn'j3\_0|k'qwt' r tglxkwa'kpxguki cvkpu. 'v'j g'r tqr gt vku'qh'v'j kp'eqo r quksq'kro u'hdtecvkvf "qp'v'j g'dcuku'qh'v'j g'dtqp/  
eqpvcklpi 'f { gu'y gtg'uwf kcf "j4\_00 quvko r qtcvvtqrg'kp'eqo r quksq'o cvgtkcn'ghhkepe { "dgmipi u'v'j g'f qr cpv'o qrgewgu'  
Guugpvkcn'ej ctcevtkuke'qh'v'j g'o cvgtkcn'ku'hwpevkvpcik{ 'vgo r gtcwtg0'Vj gthqg. "v'j g'kphwpeg'qh'v'j g'vgo r gtcwtg'qp'v'j g'  
hwqtguepeg'ur gevte'qh'f { gu'o qrgewgu'y cu'kpxguki cvgf 0'

Kp'qtf gt "v'j ur gevtecm{ 'ej ctcevtk g'v'j g'u{pvj guk gf "dtqp/eqpvcklpi 'u'wduvpegu'cpf "v'j hwv'j gt "eqpht'o 'v'j g'grgevtqp/  
xldtecvkpcn'pcwtg'qh'v'j g'dcpf u'kp'v'j gk'hwqtguepeg'ur gevte. "y g'j cxg'tgeqtf gf "cduqtr kvq. "hwqtguepeg'gzekcvkvq'cpf "  
hwqtguepeg'go kuukqp'ur gevte'qh'v'j g'eqo r qwpf u' uqnvkvqpu'kp'cegvpktrg'cv' rks wkl "pktqi gp"vgo r gtcwtg'99"M'cpf "  
eqo r ctgf "v'j go "v'j qug'cv'tqgo 'vgo r gtcwtg'4; 5'M0'

Ego r ctgpi "v'j g'hwqtguepeg'ur gevte'qh'uqnvkvqpu'cv'4; 5'M'cpf "99'M"v'j g'uki phtecpv'ej cpi gu'kp'v'j g'uj cr g'qh'v'j g'  
dcpf u'qh'v'j g'f { g'ur gevte'j cu'dggp'hwqpf 0'Cv'tqgo 'vgo r gtcwtg. "v'j g'hwqtguepeg'ur gevte'qh'f { gu'K'cpf "K'r quugu'y q'  
dcpf u. "y j krg'v'j g'f { gu'K'cpf "K"o cplkgu'qpn{ "qpg'dcpf ≡'cv'v'j g'uco g'vko g. "cm'v'j g'f { gu'r quugu'y q'dcpf u'kp'v'j g'  
cduqtr kvq'ur gevte0' Vj g' hwqtguepeg' kvvpuks{ "qh'v'j g'dcpf u'kp'v'j g'ur gevte' kpetgcugu'uki phtecpv'w' wpf gt' rny gt'  
vgo r gtcwtg. "y j lej "ecp'dg'gzr r kpgf "d{ "v'j g'tgutevkvq'qh'v'j g'f { g'o qrgewgu'o qvkvq'kp'v'j g'tki kf "o gf kwo 0'Cv'v'j g'uco g'  
vko g. "v'j g'hwqtguepeg'ur gevte'ht' 'v'j g'ug'f { gu'ctg' u{o o g'vke'kp'eqo r ctkuqp' y kj "v'j g'cduqtr kvq'ur gevte. "cpf "v'j g'  
hwqtguepeg'gzekcvkvq'ur gevte'ctg'uko kxt "v'j g'cduqtr kvq'ur gevte0'hwqtguepeg'gzekcvkvq'cpluqtqr { "ur gevte'y gtg'  
tgeqtf gf "ht'kpvtg'cvkvq'qh'v'j g'ej cpi gu'kp'v'j g'cduqtr kvq'cpf "hwqtguepeg'ur gevte'w'pf gt' rks wkl "pktqi gp"vgo r gtcwtg0'  
Vj g'ug' ur gevte' cnuq' r qlpv' v'j g' grgevtqp/xldtecvkpcn' pcwtg' qh' v'j g' tgeqtf gf "dcpf u' kp' v'j g' hwqtguepeg' ur gevte0'  
Rj qur j qtguepeg'qh'v'j g'ug'f { gu'y cu'cnuq'kpxguki cvgf 0'

"

Cempqy r gfi go gpv'v'j ku'r tqg'ev'j cu'tgegkxgf "hwqf kpi 'ht'go "v'j g'Tgugcte'j "Eqwpek'qh'Nkj wpcle"NO VNV+ "ci tggo gpv'P q"  
JUNW/42/5\_0'

"

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j3\_'L0'Nk'L0'Np. 'I 0J wpi "gv'cn'Qti cple'hwqtguegpv'f { gu'ur r qtvgf "qp'cevkvkvf "dtqp'pktkf g<C'r tqo kulpi "dmg'iki j v'gzekgf "r j qur j qtu'ht'j ki j /  
r gthqto cpeg'y j kg'iki j v'go kvkpi 'T'kf gu. 'UeKOT gr 0'4237-0'  
j4\_'Q00'P cxq| gpmu. 'X00'0| cuj ej wm| w0R0Rk { cvkpunk'gv'cn'Wnt0L0Rj { u087. 'P'5. '3; 8/426'4242-0'

# SINGLE-PARTICLE MOTION IN A WOBBLING NUCLEUS - A CASE-STUDY FOR ODD-MASS ISOTOPES

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The wobbling phenomenon in nuclei, which implies a precession of the total angular momentum combined with an oscillation of its projection onto the rotation axis, is analyzed within the Particle Rotor Model for odd-mass nuclei. Triaxial nuclei are objects with all three moments of inertia associated with the principal axes different in magnitude, making it possible for rotation to occur around all three axes. This results in a rich rotational spectrum with a collective character. Interpretation of the wobbling motion in odd-mass nuclei is usually done through a particle-rotor coupling, where an even-even triaxial is coupled to an odd- $j$  nucleon which is said to be moving in a deformed quadrupole mean-field generated by the core itself. The strength of that potential is crucial in the description of the wobbling spectrum of a nucleus. In the present work, an analysis of the potential strength that characterizes the coupling between the core and the odd-nucleon is made, with the help of a deformed Nilsson potential in the total Hamiltonian of the system. A study of the coupling term is performed for different isotopes in which wobbling motion is known to occur.

**GZVTGO GN[ 'J GCX[ 'TCKP'CPF'XGT[ 'UVTQPI 'US WCNNU'QXGT''  
 NKVJ WCPKC'KP'3; 83/4242'RGTKQF <CP CN[ UK'CPF 'ENKO CVQNQI [ ''  
 Kqrf c'O ctekpqkpgp ''**

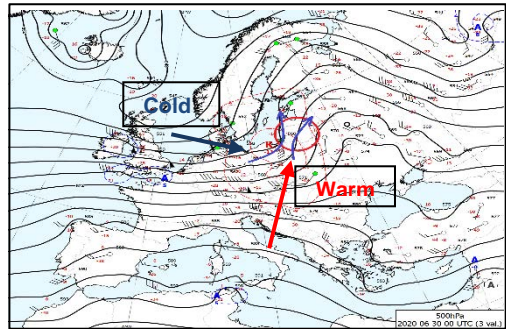
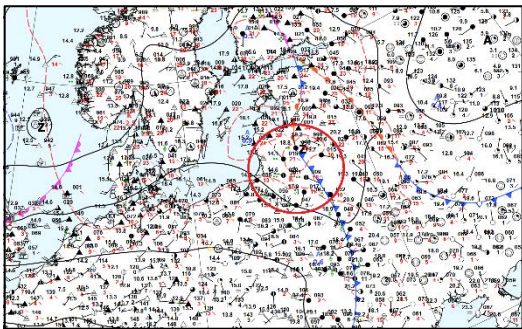
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 k qrf cO ctekpqkpgpB ej i tO vOw"

C'dt lgh'qxgtxkgy 'qh'ugxgtg'y gcvj gt'rj gpqo gpc'uwej 'cu'xgt { 'j gcx { 'tckp'cpf'xgt { 'utqpi 'us wcmu'qxgt 'Nkj wcpkc'kp'y g' r'uv'82' { gctu'\*3; 8364242+'ku'r t'gugpvf 0U { pqr v'e'cpf 'erko cvqmi lecn'cpcn' ugu'qh'43: 'ecugu'y kj 'tckp'\*72'o o B4'j '+cpf'' 5: 'ecugu'qh'utqpi 'us wcmu'\*y kpf 'ur ggf '\*4: 'o lu+'tqo 'Cr tki'v'Ugr vgo dgt 'hqt'us wcmu'+cpf 'v'P qxgo dgt 'hqt'tckp'+y g'g' g'zco kpgf 0Cm'f cv'wugf 'hqt't'gugtej 'ctg'vcnpg'htqo 'Nkj wcpkc'p'J { f'tqo gvgqtqmi lecn'Ugt'xleg '\*NJ O U+'ctej kxgu'

Gzvtgo gn { 'j gcx { 'tckp'cpf 'r'qy g'hwilus wcmu'o clpn { 'f'gxgnr 'kp'y cto 'ugcuq'0Vj g'u' pqr v'e'ukwcvkp 'hcxqwtcdrg'y g'g' ugxgtg'y gcvj gt'rj gpqo gpc'v'q'qewt'ku'htqo gf 'wuwcm' { 'd' { 'lphwpeg'qh'y g'P q'v'j 'C'wv'v'e'Qegcp. 'O gf kgtt'cpgcp'Ugc'cpf'' Drcni'Ugc'0Ht'uv'f. 'y g'C'wv'v'e'qr g'pu'r cv'j u'htq'y gv'cpf 'b'kf' c'kto cuu. 'y j'lej 'b'gti gu'y kj 'f't { 'cpf 'y cto 'eqpv'kpg'w'ic'kto cuu' cpf 'f'wg'v'q'dki 'vgo r'gtcwtg'cpf'j' wo kf'kf' 'eqpv'cuu'et'gcvu'k'puc'dk'k'k' { 'kp'y g'y j'qrg'eqnw p'qh'y g'c'vo qur j'g'g'qxgt'y g' eqwvt { 0C'vo qur j'g'g'eqpx'g'v'k'p'dgeqo gu'gur gekm' { 'ce'v'x'g'y j'gp'c'y cto 'w'r'gt'k'f'i'g'qxgt'y g'p'q'v'j'g'p'r'ct'v'qh'W'ntck'p'g' qt'y g'ugtp'r'ct'v'qh'T'wauk. 'ku't'gr'w'egf'd { 'eqrf'v'q'w'i'j' 'o'q'x'k'p'i'htqo 'Y'IP'Y'G'w'qr'g'qt'U'ec'p'f'k'p'c'x'k'c'p'f'r'w'uj'k'p'i' 'y'g'j'g'c'v' gc'uy c'tf '\*Hi 03+0'

Cu'c't'g'uwm'k'v'y cu'f'g'v'to kpgf 'y'cv'3'15'qh'j' gcx { 'tckp'ecugu'htqo gf 'd' { 'r'cuuci'g'qh'eqn' c'kto cuu'eqn'qt'ugeqpf'ct { 'eqrf'htqpw'\*39'' 'qh'ecugu'+cpf'eqn' 'y'cx { 'c'vo qur j'g'g'htqpw'\*37'' 'qh'ecugu'+0T'gur'g'v'k'g'n'f. 'u' { pqr v'e'cn'ukwcvkp'ig'cf'k'p'i' v'q'y g'f'gxgnr' o'gp'v'q'h'us wcmu'k'p'Nkj wcpkc'ku'htqmi'k'p'i' <UIUG'v'q'w'i'j' u'htqo 'U'ec'p'f'k'p'c'x'k'c'p'f'e' { em'p'g'u'\*5; '' -'cpf'eqn' 'y'cx'k'p'i' htqpw'\*38'' +0'

Ugeqpf'nf. 'y'g't'g'uwm'qh'c'p'cn'f'uku'qh'y'g'u'q'w'j'g't'p'w'q'w'j'g'c'v'g't'p'htqy 'cv'722'j' Rc'j' g'k'i'j'v'htqo 'O'gf'k'g'tt'c'p'g'c'p'f'Drcni'Ugc'uj'qy 'y'cv'v'q'r'lecn'c'kto cuu'f'qo'k'p'cv'g'k'p'49'' 'qh'ecugu'y'kj' 'j'g'cx { 'tckp'cpf'38'' 'qh'ecugu'y'kj' 'us'w'cmu.'y'cto 'cpf'' qeem'f'gf'c'vo'qur'j'g'g'htqpw'r't'g'x'c'k'k'p'45'' 'qh'tckp' { 'ecugu'0'



C+ ..... d+

Hk'030'Ugxgtg'y gcvj gt'ecug'cv'22'WVE'qp'52'v'qh'Lxpg.'4242'z'u { pqr v'e'c'p'cn'f'uku'c'+=htqy 'cpf'f'k'x'g'ti'g'peg'cv'722'j' Rc'' i'g'qr'q'v'p'ek'n'j'g'k'i'j'v'v'd+''

Uj'qt'v't'c'p'i'g'j'g'cx { ''tckp''\*5''j'+ 'cpf''us'w'cmu'cuu'q'ek'v'g'f''y'kj''h'k'p'g'u'qh'eqpx'g'ti'g'peg'k'p''v'q'r'lecn'c'kto'cuu'cpf''ct'g'' r't'g'f'qo'k'p'c'p'v'c'v'f'c'f' { 'cpf'g'x'g'p'k'p'i' =htq'i' r'uv'k'p'i' 'tckp'\*33634'j' '+cuu'q'ek'v'g'f''y'kj''y'cto 'cpf'q'eeem'f'gf'htqpw'ct'g'o'q't'g'q'h'w'p'c'v' p'k'i'j'v'c'p'f' 'o'q't'p'k'p'i' 0''

Tckp'y'kj' '72687'o' o' 'ku'r't'g'x'c'k'k'p'i' '\*96'' 'qh'r'w'eg'u'y'kj' 'tckp'+ 'us'w'cmu'y'kj' 'y'k'p'f'i'w'uu'4: 654'o' lu'r't'g'f'qo'k'p'cv'g'k'p'' : 8'' 'qh'c'm't'g'i'k'w'g't'f'r'w'eg'u'y'kj' 'us'w'cmu'0'

K'p'hev'qp'cp'cx'g't'c'i'g'6'j' g'cx { 'tckp'g'x'g'p'u'r'gt' { g'ct. 'cpf' '3'us'w'cmi'r'gt'4' { g'ctu't'g'i'k'w'g't'f'k'p'Nkj'w'cp'kc'0E'q'p'uk'f'g't'k'p'i' 'v'q'' us'w'cmu'ht'ec'k'k'f'. 'y'g't'g'c'n'p'wo' d'g't'qh'q'ee'w't'g'p'eg'u'ku'j' k'j'g't'k'v'ku'v'q'd'g'u'w'r'q'ug'f'p'g'c't'v'q'466'x'g't' { 'ut'q'p'i' 'us'w'cmu'r'gt' { g'ct'0''

Vj'g'ct'g'cu'qh'f'k'ut'k'd'w'k'p'qh'd'q'v'j' r'j'gpqo'gpc'k'p'Nkj'w'cp'kc'ct'g'f'k'ht'g'p'v'j'g'cx { 'tckp'ku'o'q't'g'q'h'w'p'r'j'gpqo'g'p'q'p'k'p'y'g'v' P'Y' 't'g'i'k'p'u'ut'q'p'i' 'us'w'cmu'o'k'p'y'g'UY' 'c'p'f' 'P'G'r'c't'v'0'k'ku'j'c't'f' 'v'q'c'x'q'k'f' 'u'w'd'l'g'v'k'k'k'f' 'k'p'us'w'cmu'q'd'ug't'x'c'v'k'p'u'0'Q'd'x'k'q'w'um'. '' k'v'ku'c''i'q'q'f' 'eq'tt'g'w'k'p' 'd'g'v'g'p'f'g'p'uk'f' 'qh'r'q'r'w'v'k'p' 'c'p'f' 'p'wo' d'g't'qh'us'w'cmu'o'v'j'g'o'q't'g'r'g'q'r'g'w'ug'v'g'ej'p'k'eu''\*o'q'd'k'g'' r'j'q'p'g'u'eco'g't'cu'g'v'e'0: 'v'j'g'o'q't'g'g'x'g'p'u'v'j'g'f' 't'g'r'q't'v'q'NJ' O'U'q't' 'o'gf'k'c'0'

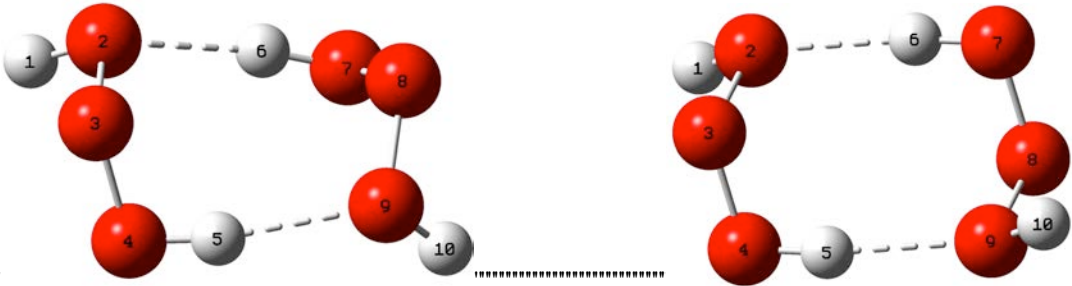
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VJ GQTGVÆCN'CP CN[ UKU'QH'VJ G'E QPHQTO CVKQP U'CPF 'KT'URGEVTC''  
 QH'VJ G'J [ FTQI GP'VTKQZKF G'\*J QQQJ +F KO GTU'

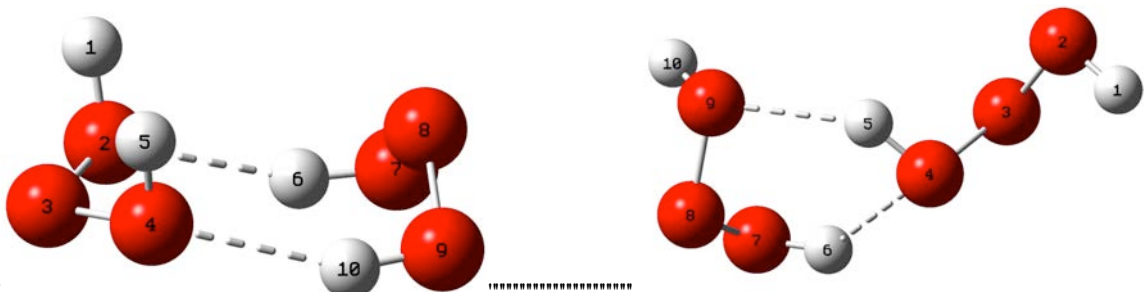
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 Xcrf cu'Ucdkpnuc<sup>4</sup>

<sup>3</sup>Dgrct wukcp'Ucvg'Wpkxgtukv{. 'O kpum'Dgrctwu"  
<sup>4</sup>Xkpkwu'Wpkxgtukv{. 'Xkpkwu.'Nkj wpc{k"  
 mkwtkpcf cuj cB i o ckræqo "

J { f tqi gp'vklqz kf g'\*J QQQJ +o qrgewrg'r r{ u'cp'ko r qt vcpv'tqrg'kp'f khtgtpv'cvo qur j gtle'r j gpqo gpc'}3/5\_'cu'y gni'cu' kp''hwpvklqkpi "qh'dkqni kecn'u{ vngo u"}6.7\_0J qy gxgt."vj g'guxcdkuj o gpv'qh'ku'ur gev'tcn'cpf "utwew'tcn'ej ctcevgtkruku'ku' rti gn{ 'j co r gtgf "d{ 'vj g'cdkxv{ 'qh'vj ku'o qrgewrg'vq'htqo "cuuqekvgo'Vq'f cvg."r tcevæcm{ "pqvj kpi "ku'npqy p'cdqw'vj g' ur gev'tcn'cpf "utwew'tcn'ej ctcevgtkruku'qh'enwvgtu'qh'vj g'j { f tqi gp'vklqz kf g'o qrgewrg.'kpenxf kpi "ku'uko r rguv'cuuqekv'g."c" f ko gt0Vj gtghqtg."y g'o cf g'ghqtu'vq'ugctej "hqt'vj g'eqphqto cvkqpcnf kxgtukv{ 'qh'f ko gtu'qh'j { f tqi gp'vklqz kf g'o qrgewrgu." cu'y gni'cu'vj gk'ur gev'tcn'ej ctcevgtkruku'Y g'qr vko k gf "vj g'i gqo gvt { "qh'vj g'f ko gtu'vctv'kpi "htqo "f khtgtpv'kpkcn'r qkpw' wukpi "D5N[ Rlee/r XV\ " rxxgn' qh' vj gqt { 0' C'v' rxcuv' hqwt" gs wkrkdkwo "i gqo gvtkgu" qh' vj g' f ko gtu' y gtg' hqwpf 0' " Vj g' eqphki wcvkqpu'qh' vj tgg' qh' vj g' hqwpf "eqphqto gtu'dgnqpi "vq' vj g'r qkpw' u{ o o gvt { "i tqwr u'E4."E\_k" cpf "E\_u' Vj g' hqwt vj " eqphqto gt "ku'ej ctcevgtk gf "d{ 'vj g'cdugpeg'qh'u{ o o gvt { "rgo gpv0Y g'y knlf gpqvg'vj g'eqttgur qpf kpi "eqphqto gtu'qh'vj g' j { f tqi gp'vklqz kf g'o qrgewrg'f ko gt'cu'hqmqy u'F 4. 'F\_k' 'F\_u' cpf "F\_3'0Gs wkrkdkwo "eqphki wcvkqpu'qh' vj g'ug'eqphqto gtu'ctg' tgr tguqvgf "qp'Hki 0.40'



Hki 0'30'Gs wkrkdkwo "eqphki wcvkqpu'qh' vj g'F 4 '\*rghv'+cpf 'F\_k' \*tki j v+eqphqto gtu'qh' vj g'f ko gtu'qh' vj g'j { f tqi gp'vklqz kf g' o qrgewrgu0'



Hki 0'40'Gs wkrkdkwo "eqphki wcvkqpu'qh' vj g'F\_u '\*rghv'+cpf 'F\_3' \*tki j v+eqphqto gtu'qh' vj g'f ko gtu'qh' vj g'j { f tqi gp'vklqz kf g' o qrgewrgu0'

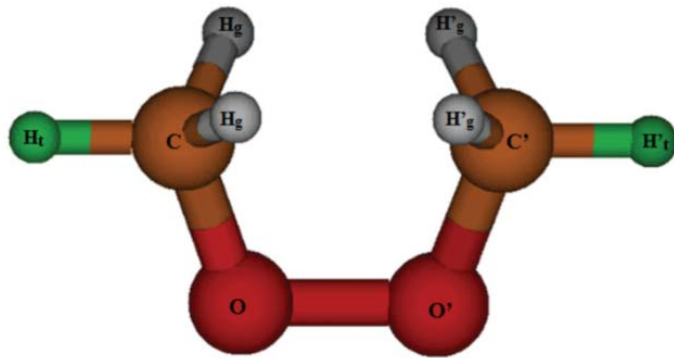
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"j3\_ F 0Ecppqp.'V0Vwmg.'L0Mqmg.'D0Rgupk ct.'Eqo r 0Vj gqt(Ej go 03232\*4235+3; "  
 "j4\_ E00 wte{.'GN0F gttq.'V0F 0Ugej ngt.'O 0Nngut.'Cee(Ej go 0F gu064\*422; +63; "  
 "j5\_ Y 0' j gpi.'F 0Lgy kv.'T0Mekugt.'Rj {uEj go (Ej go 0Rj {u0; \*4229+4778"  
 "j6\_ R0Y gpy qtvj 'L10'N0Lqpu.'C0Y gpy qtvj.'.Z0' j w'P 0Nctugp.'R0Y kuqp.'Z0Z w'Uekpeg'4; 5\*4223+3: 28"  
 "j7\_ Z0' j w'R0Y gpy qtvj 'L10'C0Y gpy qtvj.'.C0Guej gpo qugt.'P 0Nctugp.'Rtqe(P cvfCecf (Uek0WUC'323\*4226+4469"  
 "j8\_ I 0Rkugxlej.'.C00 cngxlej.'.W0Ucr guj nrc.'Ej go 0Rj {u0'752\*4242+332855"

VJ G'VTCPUKVKQP 'HI QO 'PQP 'GS WKF KUVCP V'VQ'GS WKF KUVCP V'I TKF''  
 HQT'VJ G'VQTUKQP 'EQQTF K CVG'QH'VJ G'EJ 5'I TQWR'Y J GP''  
 ECNE WNCVPI 'O WNVK KO GP UKQP CN'RQVGP VKCN'GPGTI [ 'UWTHCEGU'  
 Cpvqp'Ugtm<sup>3</sup>. 'RcxgrlRgtgtvj k<sup>3</sup>. 'Crgz 'O cngxlej<sup>3</sup>. 'I ggti g'Rkugxlej<sup>3</sup>. 'F o kt { 'Uj gpf gt<sup>3</sup>. 'F ct { c'  
 Mkwrt { pc<sup>3</sup>. 'Xkcu'Dcngxlekwa<sup>4</sup>'

<sup>3</sup>Dgretwukp'Ucvg'Wpkxgtukv{. 'O kpum'Dgretwu"  
<sup>4</sup>Xkpkwa'Wpkxgtukv{. 'Xkpkwa.'Nkj wpc{k"  
nkuwtkpcf cuj cB i o ckrleqo "

Rqvpvcn'gpgti { "uwthceg"ku'cp"ko r qtvcpv'ej ctcevtkwe"qh'o qrgewgu"cpf "enwvgtu0'Vq"dg"cdng"vq"vng"kpq"ceeqwpv'  
 u{o o gvt { " r tqr gtvku" qh' eqpukf gtgf " o qrgewgu" kv' ku' ko r qtvcpv' vq' ecrewrvg" gpgti { " xcnwgu" cv' yj g" paf gu" qh' yj g"  
 o wnkf ko gpvkpcn'gs wkf kuvcpv'i tkf 0'Wuwcm' yj gte"ku'pq'r tqdngo "y kj "yj ku'cur gev'y kj "xcngpeg"cpf "dgpf kpi "eqqtf kpcvgu0'  
 J qy gxgt.'yj ku'r tqdngo "ctkugu'gxgt { "ko g'y j gp'qpg'qh'yj g'vqr u'qp'kpvgtpcn'tqcvkqp"czku'eqpvckpu'o qtg'yj cp'qpg'cvqo 0'Qpg'  
 qh'uwej "vqr u'ku'EJ 5"o gjv { n'i tqwr "cpf "f ko gjv { n'r gtqz kf g'o qrgewg"cu'gzco r ng.'ugg'Hki (B+'eqpvckpu'y q'qh'yj gug'vqr u0'



Hki (BOP qv'gs wkrtdtkwo "eqphki wcvkqp"qh'yj g'f ko gjv { n'r gtqz kf g'o qrgewg0'

"K'ku'engct"vj cv'yj g"kvgtpcn'tqcvkqp"qh'yj g'EJ 5"i tqwr u"kp"f ko gjv { n'r gtqz kf g'o qrgewg"ctqwpf "E/Q"dqpf u'ku"qpg"  
 f ko gpukpcn'xkdtcvkpcn'cum0'Ukpeg'ectdqp"cvqo u'ctg'eqppgevgf "y kj "yj tgg"j { f tqi gp'cvqo u."vtukpcn'eqqtf kpcvgu"γ<sub>1</sub>"cpf "  
 γ<sub>2</sub>"o wuv'dg'f gvgtto kpgf "cu'yj g'cxgtci g'qh'yj g'uvo "qh'yj tgg'f kj gf tcn'cpi ngu'<

$$\gamma_1 = (\angle H_t C O O' + \angle H_g^1 C O O' + \angle H_g^2 C O O') : 3$$

K'ku'y gni'npqy p"vj cv'EJ 5"i tqwr "nqgu"ku'E<sub>5x</sub>"nqeci'u{o o gvt { 0'K'o gcpu'vj cv'yj g'f kj gf tcn'cpi ngu'∠H<sub>t</sub>CH<sub>g</sub>O"ctg"pqv'  
 gs wcn'vq"342<sup>2</sup>"cpf "ecp'ej cpi g'f wtkpi "kvgtpcn'tqcvkqp0'Qpg'ecp'ugg'vj cv'yj g'xcnwg"qh'"γ<sub>1</sub> = 60° ecp'dg'qdvckpgf "d { 'o cp { "  
 f khtgtgpv'y c { u"ugg"3+0'Vj wa."yj cv'ugxgtcn'xcnwgu"qh'r qvvpvcn'gpgti { "cpf "nkpgo cvle"eqghlekpu'y kn'eqttgur qpf "vq"qpg"  
 xcnwgu"qh'yj g'vtukqp"cp i ng0'Vq"cxqkf "yj ku'r tqdngo "qpn { "qpg"f kj gf tcn'cpi ng"igt"gzco r ng ∠H<sub>t</sub>COO'+"ku'ht q| gp"y j kg"yj g"  
 xcnwgu"qh'y q"qvj gt"f kj gf tcn'cpi ngu'ctg'f gvgtto kpgf "f wtkpi "qr vko k'cvkqp"r tqeguu0'J qy gxgt."yj g'tguwtkpi "xcnwg"qh'yj g"  
 vtukpcn'eqqtf kpcvg'y kn'unki j vq { f khtgt'ht qo "yj g'f gukt gf "qpg0'"

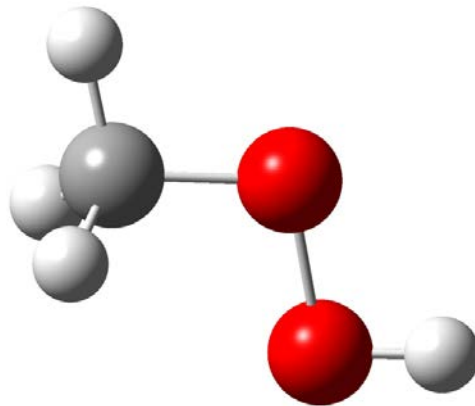
Kp'vj ku'y qtm'y g'kvqf wegf "y q"o gjv qf u'qh'yj g'vcpukvqp'ht qo "pqp"gs wkf kuvcpv'vq"gs wkf kuvcpv'i tkf "hqt"yj g'vtukqp"  
 eqqtf kpcvg"qh'yj g'EJ 5"i tqwr "y j gp"ecrewrvkpi "o wnkf ko gpukpcn'r qvvpvcn'gpgti { "uwthcegu0'Vj g'hku'v'qpg'ku'dcugf "qp"  
 kvgtqr vkvqp"d { 'ewdke"ur nkpgu0'Y j kg"yj g'ugeqpf "qpg'ku'dcugf "qp'uqrvkpi "c"u { uvgo "qh'kpgct"gs wcvkpu'wukpi "rgcuv'us wctgu"  
 o gjv qf u0'T guwuu'qh'dqjv "o gjv qf u'ctg'eqo r ctgf 0'

**J [ FTQZ[ N'CPF'O GVI [ NI TQWRU'VWP PGNPI 'RTQDCDKK[ 'K''  
 VJ G'J QQEJ 5'O QNGE WNG'E CNE WNCVGF 'CV'O R4lee/r XS \ 'NGXGN'QH'  
 VJ GQT[ 'VCMPI 'K'VQ'CEEQWP V\ RXG''**

Wrcf | lo k'Nc | lenk<sup>3</sup>. 'Gi qt'O qmncpqx<sup>3</sup>. 'Crgz'O crgxlej<sup>3</sup>. 'I gqti g'Rkugxlej<sup>3</sup>. 'Qri c'Uqtqnc<sup>3</sup>.  
 Crgmcpf t'Uj cuvkp<sup>3</sup>. 'F ct { c'Mkwt { pc<sup>3</sup>. 'Xkcu'Dcrgxlekwu<sup>4</sup>

<sup>3</sup>Dgrctwukp'Ucv'g'Wpkxgtukf. 'O kpum'Dgrctwu"  
<sup>4</sup>Xkpkwu'Wpkxgtukf. 'Xkpkwu.'Nkj wcpk"  
nkuwtkpcf cuj cB i o cklqo "

Gctrlgt'y g"j cxg"tgr qtvgf "qwt"fcv"qp"vqtukpcn'Kt"ur gevwo "qh'yj g"o gj { nj { f tqr gtqz kf g"j QQEJ 5+"o qrgewrg"  
 ecrcwrcvgf'cv'O R4lee/r XS \ 'rgxgn'qh'yj gqt { "j3\_0Vj g'o gj qf 'wugf 'hqt'ecrcwrcv'ku'f guetkdgf 'kp"j4/8\_0Vj ku'o qrgewrg"ugg"  
 Hki B+j cu'y q'kpvgtpcn'vqr u'<yj g'j { f tqz { ni tqwr "QJ +y j lej "ecp'tqvcg'ctqwpf 'y g'Q/Q'dqpf 'cpf 'y g'o gj { ni tqwr "EJ 5+"  
 y j lej "ecp'tqvcg'ctqwpf 'y g'E/Q'dqpf 0"



Hki 030Vj g'gs wkrtdtkwo 'utwewtg'qh'yj g"o gj { nj { f tqr gtqz kf g'o qrgewrg0'

Ceeqtf kpi "v"j3\_'ecrcwrcvgf 'xcnwg'qh'yj g'j { f tqz { ni tqwr "wppgrkpi 'htgs wgepe { 'qh'yj g"o gj { nj { f tqr gtqz kf g"o qrgewrg"  
 kp"y g"i tqwpf "ucv'g'ku'gs wcn'vq"3; 045"eo /3\_0J qy gxt. "y g'g'zr g'tko gpvcn'xcnwg'qh'yj g'j { f tqz { ni tqwr "wppgrkpi 'htgs wgepe { "  
 ceeqtf kpi "v"j9\_'ku'gs wcn'vq"360 9'eo /3\_0Y g'cuuwo gf 'y cv'y ku'f kuci tgggo gpv'dgy ggp'yj gqt { 'cpf 'g'zr g'tko gpv'kp'yj g'j { f tqz { ni  
 i tqwr "wppgrkpi 'htgs wgepe { 'qh'yj g"o gj { nj { f tqr gtqz kf g"o qrgewrg'qeeuw'f w'v'q'yj g'h'kw'g'v'q'v'cng'kp'v'q'cee'qwpv' | g'tq'r q'kp'v'  
 xkdcv'kpcn'gp'gti { "RXG+0U'p'eg'cwj qtu'qh'yj g'j: \_j cxg'v'q'ni'kp'v'q'cee'qwpv' \ RXG'qh'yj g"o gj { nj { f tqr gtqz kf g"o qrgewrg"  
 kp'yj g'j cto qple'cr r tqzko cvkqp.'y g'f gekf gf "v'ecrcwrcvg'yj ku'gp'gti { 'kp'cpj cto qple'cr r tqzko cvkqp'0Dgecvw'g'ecrcwrcv'k'p'qh'  
 yj g'Kt"ur gevwo "kp'cpj cto qple'cr r tqzko cvkqp"vcngu'c"m'v'qh'v'ko g'y g'ecttkgf "q'w'yj ku'y qtn'iwukpi "O R4lee/r XV \ 'rgxgn'qh'  
 yj gqt { 0C'htg' \ RXG'y cu'ecrcwrcvgf 'k'y cu'cf f gf "v"4F 'r qv'gp'v'k'ri'gp'gti { "utw'ecg'c'p'f 'y ku'v'v'c'ri'gp'gti { 'y cu'w'ugf 'v'q'ecrcwrcvg'  
 wppgrkpi "htgs wgepe { "hqt'yj g'j { f tqz { ni tqwr 0'k'p'yj ku'ecug. "k'w'w'p'gf "q'w'v'q'd'g'gs wcn'vq"35025"eo /3\_0Q'pg'ecp'ugg'yj cv'yj ku'  
 tguwn'ku'o wej "em'ugt'v'q'yj g'g'zr g'tko gpvcn'q'p'g'0"

[3\_'Wrcf | lo k'Nc | lenk'Vqtukpcn'ur gevwo "qh'yj g"o gj { nj { f tqr gtqz kf g"o qrgewrg'ecrcwrcvgf'cv'O R4lee/r XS \ "Wrcf | lo k'Nc | lenk' \ rcv'Ngr gpnqxc."  
 F ct { c'Mkwt { pc. 'Crgz'O crgxlej. 'I gqti g'Rkugxlej. 'Xkcu'Dcrgxlekwu'If'Qr gp'T gcf kpi u'4242<85pf 'Uelq'v'kle 'Eq'p'ht'g'peg'hqt'Uw'f gp'w'qh'Rj { uku'c'p'f "  
 P cwtcn'Uelq'pegu'z'rtqi tco o g'c'p'f 'cdut'ceul'Xkpkwu'Wpkxgtukf =6'Xkpkwu. '424206'R622"  
 [4\_'I 0Rkugxlej. 'C00 crgxlej. 'X0Ucr guj nq. 'L0 qn'U' gev0'582"423; +53/5: 0'  
 [5\_'I 0Rkugxlej. 'C00 crgxlej. 'X0Ucr guj nq. 'Ej go Rj { u0'752"4242+3328550'  
 [6\_'I 0Rkugxlej. 'C00 crgxlej. 'H00 ctn'q'xlej 'W0Ucr guj ne. 'O qn'Rj { u0'33: "4242+"g3968647"  
 [7\_'I 0Rkugxlej. 'C00 crgxlej. 'F 0Mkwt { pc. 'C0Xcuk'rgxumf. 'C0Xcuk'rgxlej. 'W0Ucr guj ne. 'C0M'eo p'gx. 'Ur gev'qej lo 0C'evc. 'Rct'v'c. '45; "4242+33: 42; 0'  
 [8\_'I 0Rkugxlej. 'C00 crgxlej. 'F 0Mkwt { pc. 'C0Q'uv' c'n'q'x. 'W0Ucr guj ne. 'L0Rj { u'ej go 0'C. '346"4242+: 955/: 9650'  
 [9\_'O 0V' { d'ngy un'k'V0M'0J c. 'T00 g'f'gt. 'C0D'cw'f'gt. 'E0D'rqo. 'L'ej go Rj { u0'; 9"3; ; 4+838: /83: 20'  
 ]: \_U'W'f'c'nd'q'v'j c. 'O 0U'g'p'p'v. 'P 0M'qo l'j c. 'L'ej go Rj { u0'364"4237+2965260'

**T GHT CE VKXG'K P F GZ 'UGP UQT 'HQT 'NKS WKF UDCUGF 'QP 'F KHHT CE VKQP ''  
GHHKEKPE [ 'O GCUWTGO GP V''**

Vqo cu'Mrkpxk kwu<sup>3</sup>. 'O kpf cwi cu'Lxqf pcu<sup>3</sup>. 'Cpf tkwu'fi wewcu<sup>3,4</sup>. 'Vqo cu'Vco wrgxk kwu<sup>3,4</sup>"

<sup>3</sup>Kpukwag'qh'O cvgtkcn'Uelkpeg. 'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmri { . 'Nkj wpcle''

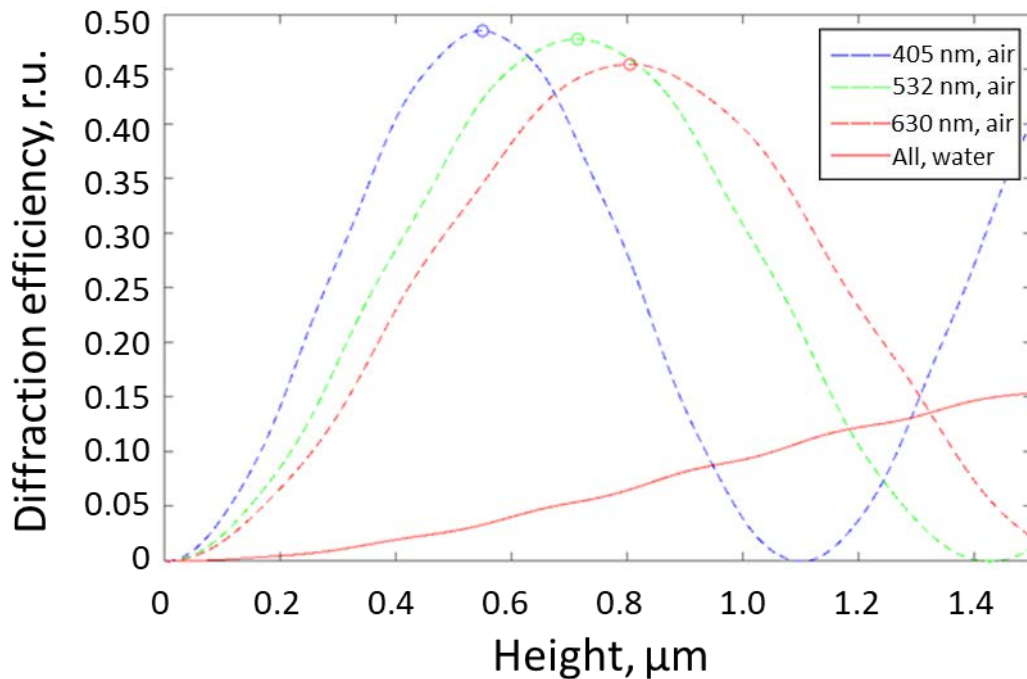
<sup>4</sup>F gr ctvo gpv'qh'Rj { ukeu. 'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmri { . 'Nkj wpcle''

vqo cu'mrkpxk kwuB mw@f w''

"

Vj g'tghtcevxg'kpf gz'qh'c'o cvgtkcn'ku'c'f lo gpukqrguu's wcpkxv' 'vj cv'f ghtkpgu'c'c'v'kq'qh'r j'cug'xgnqekv' 'qh'rki j'v'lp'c'' xcewwo "cpf "vj cv'o cvgtkcn'j3\_0'Tghtcevxg'kpf gz'ugpuqtu'qh'ns wkf u'ctg'lo r qt wcpv'ht'ej go kecn'cpcn'uku."cpf "vj gtg'ctg'' o cp{ 'f khtgtpv'eaputwepku'qh'vj gug'ugpuqtu'r tqr qugf "j4/6\_0J Qy gxgt."vj gug'uqmwkqpu'v'gp'v'q'pqv'dg'cko gf 'cv'uo cni' uco r rgu'qh'ns wkf 0''

Kp'vj ku'y qtm'y g'r tqr qug'c'f guki p'cpf "y qtnkpi "r tlpek rg'ht'c'o letqhwkf le'tghtcevxg'kpf gz'ugpuqt'dcugf "qp'' f khtcevxg'kpf ghhkekp{ "o gcuwtgo gp'0'k'y qtmu'd{ "o gcuwtkpi "vj g'ej cpi gu'qh'f khtcevxg'kpf ghhkekp{ "cv'uqo g'y cxgrpi vj'' dghqg'cpf "chgt'ns wkf "kpcng."cu'vj g'ej cpi g'qh'vj g'f khtcevxg'kpf i'cvkpi "uwr gtutcv'g'kphwgegu'ksu'f khtcevxg'kpf ghhkekp{ 0' Vj g'ej cpi g'lp'f khtcevxg'kpf ghhkekp{ "ku'tgrv'g'v'q'vj g'tghtcevxg'kpf gz'qh'ns wkf u'd{ "wukpi "vj g'Tki qtqwu'Eqr rgf "Y cxg'' Cpcn'uku'o gj qf "j7\_v'q'o qf gric'f khtcevxg'kpf i'cvkpi "w'pf gt'f khtgtpv'eapf kkp'u'tghtcevxg'kpf gz'gu'qh'uwr gtutcv'g'0'V{ r kecn' ukwepku'qh'f khtcevxg'kpf ghhkekp{ "f gr gpf p'ep'qp'i'cvkpi "j gli j'v'ht'f khtgtpv'uwr gtutcv'g'ku'f gr kegf "lp'Hki 030''



"

Hki 030E qpegr v'qh'ugpuqt'y qtnkpi "r tlpek rg'o'rk j'v'tcpuo kuukp'ej cpi gu'htqo "j ki j' "o letqhwkf le'htkrgf'y kj "ck'+v'q'' ngy "o letqhwkf le'htkrgf'y kj "y cvgt'+cv'c'egt'wkp'i'cvkpi "j gli j'v'0'k'ecug'qh'y cvgt.'ghhkekp'elgu'qh'cni'y cxgrpi vj u'y gtg'' kf gpvkecn'

"

j3\_G0J gej. 'Qr vku. 'Rctup. 'KDP"; 9: /2/543/3: : 9: /8. "4238-0'  
j4\_"V0'Vco wrgxk kwu."gv'cn'0'Tghtcevxg'kpf gz'ugpuqt'dcugf "qp'vj g'f lco qpf "hng'ectdqp'f khtcevxg'kpf i'cvkpi. "Vj lp'Uqrf "Hko u'73; . '62: 4/62: 8"4233-0'  
j5\_"V0'Vco wrgxk kwu."gv'cn'0'P wo gtlecn'cpf "g'zr gtlo gpv'cn'cpcn'uku'qh'qr v'ecni'tgur apug'qh'uwd/y cxgrpi vj "r g'kqf "utwewt'g'lp'ectdqp'cegqu' "Hko "ht'' ghtcevxg'kpf gz'ugpuqtu'. 'Qr vku'G'zr tguu'44."49684/49697"4236-0'  
j6\_"T0'Ugrcu/Ci wkt. 'gv'cn'0'P qpeq'p'cev'Qr v'ecni'hdgt'Ugpuqt'ht'0'gcuwtkpi "vj g'Tghtcevxg'kpf gz'qh'ns wkf u.'Lqwt'pcn'qh'Ugpuqtu'4238."3/8"4238-0'  
j7\_"O 0I 0'O qj etco. 'g'cn'0'Uedng'lo r ngo gpv'ekp'qh'vj g'tki qtqwu'eqwr rgf /y cxg'cpcn'uku'ht'uw'ceg't'gr'gh'i'cvkpi u'g'pj c'ep'f "v'cpuo kwep'g'o cvtkz'' crr tqcej. 'Lqwt'pcn'qh'vj g'Qr v'ecni'Uqelgv' 'qh'Co g'lecc'34."3299/32: 8"3; ; 7-0'



# IDENTIFICATION OF NUMBER, FREQUENCY, AND POWER OF SOURCES OF ELECTROMAGNETIC RADIATION IN THE HUMAN LIVING AREA

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Current electronic devices and systems developed for remote communication (e.g. wireless/radio communication, electric power transfer, smartphones, tablets, and laptops, etc.) become sources of electromagnetic pollution. Although the harm to living organisms caused by electromagnetic pollution is still open to question, the electromagnetic pollution classified as potentially carcinogenic. The sources of extremely low frequency electromagnetic fields (< 300 Hz), intermediate electric fields (300 Hz – 100 kHz), radio frequency electric field (100 kHz – 300 GHz) are classified as sources of the electromagnetic pollution that influence living organisms making harm to their reproductive system [1], memory performance [2], oxidative stress [3], blood parameters and myocardium [4] etc. For these reasons, it is very important to understand the impact of electromagnetic pollution on living organisms, stay safe and protected from the potentially harmful effects and/or to leave as soon as possible unsafe of high power radiation environment.

The effect of electronic device's radiation on living organisms increases with increasing frequency [5] and decreasing distance to the source of radiation since the most efficient absorption of the radiant by radiation strongly absorbing bodies happens to be at  $\lambda$ -depth (here  $\lambda$  is the wavelength of the electromagnetic wave). Therefore, the most dangerous for living organisms are radiation sources that come into direct contact with their body (e.g. smartphones, wireless headphones, Bluetooth devices) or appear to be located nearby (e.g. Wi-Fi routers, computer screens, microwave ovens, etc.) [6]. However, living in urban areas quite often we have no enough information about radiation sources (i.e. their exact location and radiation power) and therefore getting exposed to radiated electromagnetic waves.

We propose a method for detection of a location of an “unknown” radiation source of GHz frequency signals and demonstrate that it works well in the case of human living room if the source of radiation is located outside the living area. The radiation source (blue triangle in Fig. 1) set to radiate signals of fixed frequency ranging from 0 to 6 GHz. The power of radiation we measured by a detector (yellow circle) through moving it from one fixed position (blue circles) to another when the signals receiving antenna of the detector is located at different heights from the laboratory ground ranging from 0.4 m to 1.2 m. (Fig.1).

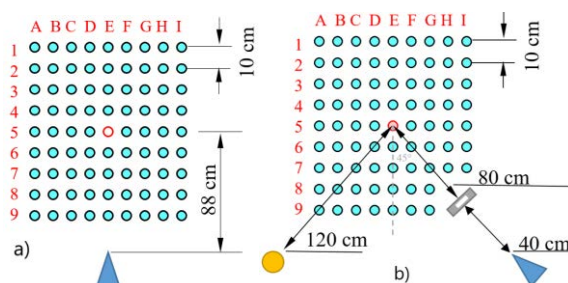


Fig. 1. The 0° (a) and 45° (b) setups we used for identification of the objects (located in a coordinate E5) reflected radiation power from the radiation source (blue triangle imitating an “unknown” source, radiating fixed frequency in the range of 0-6 GHz). For radiation power detection, we used an 8GHz detector, and for the radiation beam adjustments a diaphragm shown by grey rectangular shown in (b).

The experimentally measured radiation power verified through results of our calculations of the power rate using inverse distance square law helped us to recognize the presence of the “unknown” source of radiation, to determine its exact position (distance, height) in a room, and to estimate the magnitude of radiated power at various fixed positions in the room. The precision of the method depends on the signal-to-noise ratio and magnitude of the signals reflected from random surfaces of laboratory stuff and reaches the maximal value at the highest signal-to-noise ratio in the case when both the signals radiating antenna and the detector are located in an echo-free chamber.

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# CHARACTERIZATION AND SPECTRAL PROPERTIES OF THERMOGRAPHIC PHOSPHORS FOR OPTICAL THERMOMETRY APPLICATIONS

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Measurement of the surface temperature is a crucial factor in many industrial processes and their optimization. To fulfill the strict requirements and yield accurate temperature measurements, many kinds of sensing devices have been employed, e.g. thermocouples or infrared thermometer. Surface contact temperature sensors, like thermocouple, can sometimes result in poorly characterized results, as a consequence, non-contact thermometers are more preferred for temperature sensing.[1] Although IR thermometer provides the non-contact measurements, its signal may be affected by the background radiation. A revolutionary alternative to the above approaches is phosphor thermometry that implies observation of change in radiation intensity of luminescent phosphor materials in respect to the variations of temperature.[1] Optical temperature sensing relies on the temperature dependent properties of rare-Earth luminescent materials, i.e. phosphors that emit visible, IR or UV radiation upon excitation. The temperature variation is reflected by the change in fluorescence intensity.[1, 2] Studies of phosphor thermometer technology are well documented.

In this study, the spectral properties of two synthesized phosphors prepared by a high temperature solid state reaction [3] -  $\text{Lu}_3\text{Al}_5\text{O}_{12} : 0.5\% \text{Ce}^{3+}$  (LuAG) and  $\text{Eu}_2\text{Mo}_4\text{O}_{15}$  (EMO) - were analyzed and their applicability for optical thermometry was investigated. The samples of each phosphor were prepared by mixing 15 wt% with silicone and letting them to solidify in 2 mm deep molds as shown in Fig. 1(a).

Data collection was performed with a standard technique involving the use of integrating sphere and measurement of phosphors spectra in A, B and C configurations. The spectral properties such as Photoluminescence (PL), PL efficiency, and PL dependence on the temperature were measured. PL quantum efficiency was determined in line with the analysis described by de Mello (1997). [4] Excitation sources used for LuAG were 450 nm and 468 nm, while in EMO case, a 463 nm source was included. The results have shown that EMO is strongly dependent on the ambient temperature, whereas LuAG was found to be more stable with the changes in temperature.

During the presentation, results of temperature dependence of LuAG and EMO PL spectra as well as fluorescence intensity ratio for temperature determination will be demonstrated.

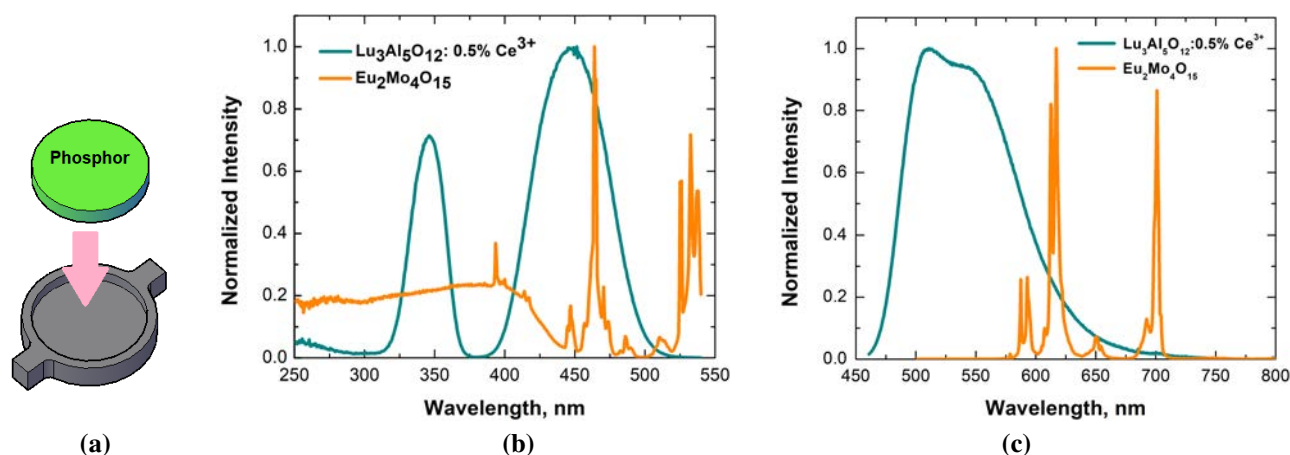


Fig. 1. Methodology and experimental results: figure (a) is an illustration of used mold for sample production, (b) and (c) are excitation and photoluminescence spectra of both  $\text{Lu}_3\text{Al}_5\text{O}_{12} : 0.5\% \text{Ce}^{3+}$  and  $\text{Eu}_2\text{Mo}_4\text{O}_{15}$ , respectively.

[1] X. Wang, Q. Liu, C.-S. Liu, Y. Bu, Optical temperature sensing of rare-earth ion doped phosphors, RSC Adv **105**, 86219–86236 (2015).

[2] Y. Zhao, X. Wang, Y. Zhang, Y. Li, Optical temperature sensing of up-conversion luminescent materials: Fundamentals and progress. J. Alloy. Compd. **817**, (2020) 152691.

[3] M. Janulevicius, J. Grigorjevaite, G. Merkininkaitė, S. Sakirzanovas, A. Katelnikovas, Luminescence and luminescence quenching of  $\text{Eu}_2\text{Mo}_4\text{O}_{15}$ , J. Lumin. **179**, 35-39 (2016).

[4] J. C. de Mello, H. F. Wittmann, R. H. Friend, An Improved Experimental Determination of External Photoluminescence Quantum Efficiency, Adv. Mater. **9**, 230-232 (1997).

**UVWF [ 'QHUCO 'Y KJ 'KO KFC \ QNG'HWPEVKQP CN'I TQWR'D [ ''  
 UWT HCEG'CPF 'UJ GNN/KUQNCVGF 'P CP QRCTVKENG'GP J CPEGF ''  
 TCO CP 'URGEVTQUEQR [ ''**

F qo cpvcu'F wplcxcu<sup>3</sup>. 'Ci p \ f cplcwunkp<sup>4</sup>. 'O ctv{pcu'Vercnkku<sup>4</sup>. 'Tkc'Ucf | gxk kgp<sup>4</sup>.  
 I gf ko kpcu'P kwtc<sup>4</sup>"

<sup>3</sup>Kpukwng'qh'Ej go lecn'Rj { uleu. 'Hcewn' 'qh'Rj { uleu. 'Xkpkwa'Wpkxgtukv. 'Nkj wcpkc"

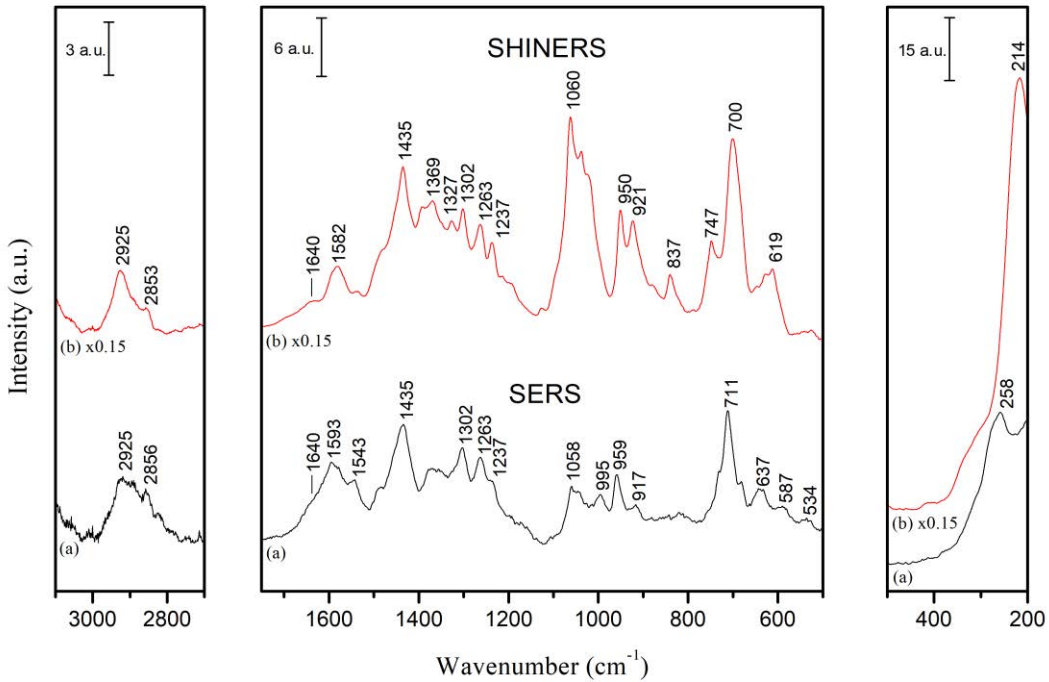
<sup>4</sup>F gr ctvo gpv'qh'Qti cple'Ej go knt { . 'Egpygt 'hqt' Rj { ulecn'Uekppegu'cpf 'Vgej pqrqi { . 'Nkj wcpkc"  
 f qo cpvcuf wplcxcuB Hfufw'kwf"

"

J knkf kpg'ku'cp'co kpq'cekf "y kj "c"wpks wg'utwewtg'yj cv'cmqy u'k'vq'vcng'r ctv'kp'xctkqwa'o qrgewrt "kpvgtcevkqpu0Vj g"  
 hqewu'ku'qp"vj g"ukf g"ej clp"qh'j knkf kpg"o"vj g"ko kf c| qrg'tkpi . "y j lej "eqqtf kpcvgu'o cp { "o gvcn'kqpu0Dgecwng"j knkf kpg"  
 kpvgtcevu'kp'o wnkrg'y c { u'y kj "qy gt'co kpq'cekf u'cpf "o gvcn'kqpu'j3\_ 'hwtvj gt'gugctej "ku'tgs wkt gf "v'dgwtg'wfp gtuwcpf "vj g"  
 tqrg'qh'j knkf kpg'kp'r tqvqk'kpvgtcevkqpu0"

Qpg"qh'j g"o quv'kphqto cwxg"cpf "pqróf gntwewxg"o gj qf u'wugf "vq" f gvgto kpg"vj g" utwewtg" cpf "r tqr gtvku"qh"  
 o cvgtkcu"qp"co qrgewrt "uecrg"ku'uwthceg/gpj cpegf "Tco cp"ur gevqueqr { "UGTU"4\_0'Wphqt wpcvgn. "vj g"o gj qf "j cu"  
 uqo g'f qy pulf gu'6'qpn' "c'uo cmipwo dgt'qh'o gvcn'ctg'UGTU'cewxg. 'cpf "c'o gvcn'uwduwcvg"o wv'dg'pcpquwewtgf. "y j lej "  
 tgp'gtu"vj g"o gj qf "wugruu'hqt"u'ugo u'qp"uo qqj "uwthcegu'k'4232"o pgj "o gj qf "qh'gpj cpeki "Tco cp"uki pcn'y cu"  
 kvtqf wegf. "y j lej "uwi i gungf "wukpi "Cw"qt "Ci "pcpqr ctveng"y kj "c"vj kp'kpgt'v'uj gm'j5\_0'Vj g"o gj qf "qh'uj gm'kuqrvf"  
 pcpqr ctveng/gpj cpegf "Tco cp"ur gevqueqr { "UJ RGTU"uwkcdng"y kj "cp { "uwduwcvg. 'cpf "vj g"vj kp'uj gm'f qgu"pq'cmqy "  
 vj g"UGTU'cewxg'eqtgu'vq'kpvgtcevy kj "gcej "qy gt'cpf "y kj "vj g'r tqdgtf "o qrgewru0"

Vj g"o clp"clo "qh'vj ku'uwf { "y cu"vq'kf gpvkh { "vj g"o qrgewrt "utwewtg"qh'vj g"ugrhócuugo drgf "o qppr { gt "UCO +"  
 hqto gf "tqo 'P/\*4/\*3J /ko kf c| qn'6/ { n'8/o gtecr vqj gzcpcp kf g"KO J C+ 'kp'cs wqqu'uqmwkq'cr r n'kpi "UGTU'cpf "  
 UJ RGTU"o gj qf u'0'ht"vj g"UGTU"o gj qf. "vj g"UCO "y cu"cf uqtdgtf "qp"o "tqwi j gpgf "Cw'grgestqf g. "y j krg"ht"vj g"  
 UJ RGTU"o gj qf "6'qp"o'uo qqj "Cw'grgestqf g0O qtqgxt. 'UJ RGTU"o gj qf "go r m { kpi 'Ci B UQ4'pcpqr ctveng0"



Hki 030UGTU'ur gevte'qh'KO J C'cf uqtdgtf "qp"qp"o'c'qwi j gpgf "Cw'grgestqf g"o'cpf "UJ RGTU'ur gevte'qh'KO J C"  
 cf uqtdgtf "qp"o'uo qqj "Cw'grgestqf g"kp'cp'cs wqqu'uqmwkq'uwkq'p'd-0Gzekwq'p'y cxngpi vj "ku'9: 7'po 0"

"

F wtkpi "vj ku'uwf { . "k'y cu'hqwpf "vj cv'vj g"u { o o gtlc'utgewj kpi "xkdtcvkq'qh"o gj { rpgg"i tqwr u'ku'cv'urki j w' "mqy gt"  
 y cxgpwo dgtu'kp"vj g"UJ RGTU'ur gevte "4: 75"eo<sup>3</sup> "eqo r ctgf "y kj "vj g"UGTU'ur gevte 0'Vj ku'tguwa'ku'tgo ctmedn'  
 tgrcvf "vq"o'j ki j gt'rgxgr'qh'qtf gkpi "hqt"UCO "r tgr ctgf "qp"o'uo qqj "Cw'uwduwcvg0"

"

[3\_]UO O'Nkq. "S 0UOF w'LO\ 0O gpi .\ 0Y 0Rcpi . 'cpf "T0D0J wpi . "Vj g"o wnkrg'tqrgu'qh'j knkf kpg'kp'r tqvqk'kpvgtcevkqpu. 'Ej go knt { 'Egpycti'iqwpcn'  
 9. "; 633"4235-0"

[4\_]I 0P kwtc. 'Rcxk-ko k'uwk'k'p'c' "Tco cpq'ur gntqunqr klc. "Rcxk-ko k'uw'qr'kp 'ur gnt qunqr klc. "3356372"422: 40

[5\_]LOHNN'g'v'c'Uj gm'kuqrvf "pcpqr ctveng/gpj cpegf "Tco cp"ur gevqueqr { . 'P cwtg'686. '5; 465; 7"4232-0"

"

**UVWF [ 'QHRCVJ QI GPÆ 'DCEVGT'K'CPF 'HWPI KD[ 'O GCP U'QH'HVKT' " CVT'URGEVTQUEQR[ "**

**I gtf c'O lem pckv<sup>3</sup> . 'Ckf c'Mco ctewunigp<sup>4</sup> . 'Lwukpcu" gr qpmw<sup>3</sup> . 'Gi n 'Neucwunigp<sup>4</sup> . 'Tko cpv " Dcpf | gxx k v<sup>3</sup>**

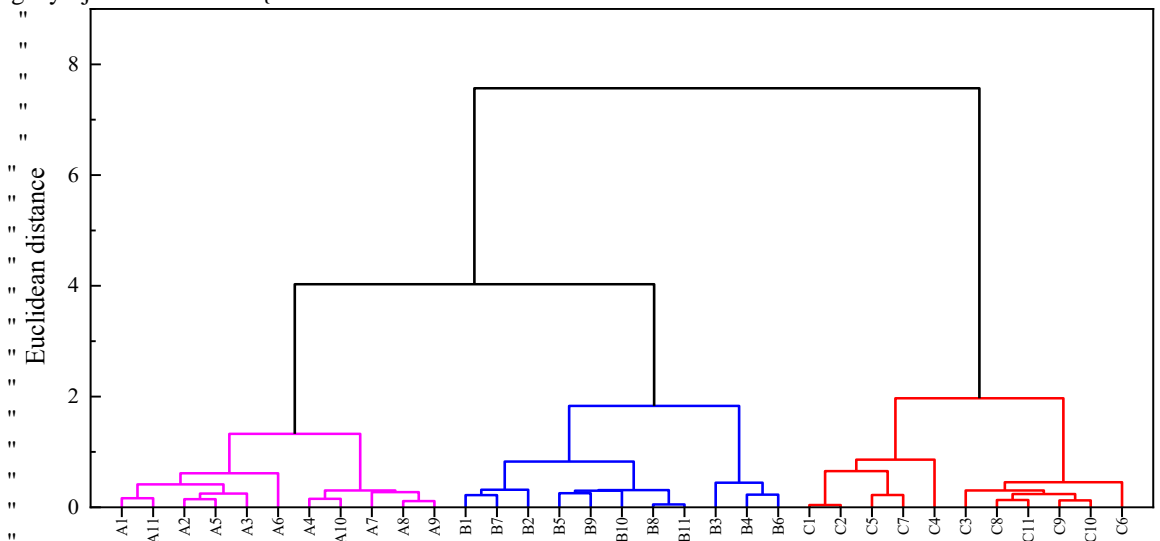
<sup>3</sup>Ej go lecnRj { uleu'kpukwg. 'Hcewn' qh'Rj { uleu. 'Xkpkwu'Wpkxgtukv. 'Ucwn vgnk' Cx05. 'NV/32479'Xkpkwu. 'Nkj wcpk' "  
<sup>4</sup>kpukwg'qh'Dlquelpegu. 'Nhg'Uelpegu'Egpgvt. 'Xkpkwu'Wpkxgtukv. 'Ucwn vgnk' Cx09. 'NV/32479'Xkpkwu. 'Nkj wcpk' "  
**i gtf cO lempckgB HkxwO'**

Rcvj qi gple"o letqati cpkuo u"uwej "cu"dcevtk"qt"hwpi k"ecp"ecwug"lphgevkwu"fgucugu0'Ewtgpnv. "o gf lecvkpu"ctg" wuwcn' "r tguetkdgf "v"ewt g"r cvkpwu"qh"lphgevkwu"fgucugu0'CPvdkvku"ctg" wugf "hqt"vj g"v'gco gpv'qh"dcevtkcn'lphgevkpu" cpf "cpv'hwpi cnu'hqt"vj g" { gcu'ecwugf "lphgevkpu0'K'ku"mpqy p"vj cv'dcevtk"ecp"fgxgqr "cpvdkvku"tgukwpeg"y j kg"hwpi k' ctg"pqv'ugpukxg'hqt"vj g"v'gco gpv'd {"cpvdkvku"cpf "xleg'xgtuc0'K'o kzgf "lphgevkpu."qpn' "qpg"fo clp'qh'r cvj qm' lecn' o letqati cpkuo "gwnct { qvg"qt"r tqect { qvg"ecp"dg"mngf "y j kg"cmqy kpi "cpqj gt"v"ur tgc' "gxgp"t'cugt0'Hqt"vj ku'tgcuqp. "k' ku"ko r qtwcpv"v"kf gpv'h' "vj g"ur geku"qh'o letqati cpkuo u"gctn' "v"ceewtcvgn' "r tguetkdg"vj g"v'gco gpv'K' "vj g"ecug'qh'hwpi cni' lphgevkpu. "k'ku"ko r qtwcpv"v"kf gpv'h' "vj g"v'f r g"qh'vj g"egm'f gcj <cr qr vuku"qt"pgetuku0'K'ku"mpqy p"vj cv'f wtkpi "pgetvku" y c { "qh'egm'f gcj "vj g" TQU. "fo ci gf "r tqvku. "vz'kpu"cpf "ge"ctg'trgcugf "v"vj g"uwttqwpf kpi "gpv'kqpo gpv'cpf "ecp"ecwug" ugeqpf ct { "lphco o cvkpv0'Vj gthqtg. "cr qr vku"r cvj y c { "ku"pq'ecwukpi "vj g"lphco o cvqt { "ghgev."qr r qukg. "vj g"eqo r qwpf u" trgcugf "htqo "vj g" cr qr vku" egm' ecp" dg" wugf "d {"vj g" j quv' gr kj grkwo "egm' hqt"vj g" tgi gpv'ekvp0' Ewtgpnv. "vj g" kf gpv'lecvkpu"qh'dcevtk"cpf "hwpi k'ecp"v'cng"vr "v"vj g"tgg'f c { u'cpf "vj g"ceewtce { "qh'vj g'kf gpv'lecvkpu"tapi gu'htqo "62" "v" 322" . "y j kg" wukpi "HVKT'CVT"ur gev'queqr { . "kf gpv'lecvkpu"ecp"dg"ectk'gf "qws'wem' "cpf" o qtg'ceewtcvgn' "J3/4\_0

K'vj ku'y qtm'vj g'o gvj qf "qh'cp"cvgpwcvgf "vq'cn'tghgevkp"qh'k'htctgf "tcf kcvkpp"CVT"K' "ur gev'queqr { "y cu'cr r rkgf " hqt"vj g"cp'cn'uku0'CVT"K'"cduqtr vkpp"ur gev'tc"qh"; 7"uco r ngu"qh'f k'htg'gpv'dcevtk"\*54"uco r ngu. "; "f k'htg'gpv'ur geku"cpf " hwpi k' \*85"uco r ngu. "5" f k'htg'gpv'ur geku"y gtg"cp'cn'ugf 0'Vj g'o clp' f k'htg'gpegu"dgw ggp" dcevtk" cpf "hwpi k' CVT" K'" cduqtr vkpp"ur gev'tc"y gtg'qdugtxgf "k'vj g"3: 22"eo /3"6"972"eo /3"tgi kq0'K'qtf gt"v"fgvto kpg"j qy "ceewtcvgn' "dcevtk"cpf " hwpi k' CVT" K'"cduqtr vkpp"ur gev'tc"ecp"dg"kf gpv'k'gf. "j k'gtctej lecn'envugt"cp'cn'uku" \*J EC"y cu' r gthqto gf 0'J EC"y cu' r gthqto gf "wukpi "Y ctf "Cni qtkj o . "ugrevkpi "vj g"3: 22"eo /3"6"972"eo /3"ur gev'tc'tgi kq0'CVT"K'"cduqtr vkpp"ur gev'tc"qh' hwpi k'cpf "dcevtk"y gtg'ugr ctcvgf "k'vq"y q'envugtuy kj "322" "ceewtce { 0

K'qtf gt"v"fgvto kpg"Ecpf k'c "mukcplc" g'hwpi k'f gcj "o gej cpkuo u"J EC"y cu' r gthqto gf 0'J EC"y cu' r gthqto gf " wukpi "Y ctf "Cni qtkj o . "ugrevkpi "vj g"3946"eo /3"6"3757"eo /3"ur gev'tc'tgi kq0'Vj ku'ur gev'tc'tgi kq"y cu'ugrevk' "dcewug" vj g'uj k'v'qh'Co kf g'Kur gev'tc'dcpf "cv'3859"eo /3"y cu'qdugtxgf "k'vj g"CVT"K'"cduqtr vkpp"ur gev'tc"qh'f co ci gf "d {"vj gto cni' uj qeni'E0mukcplc" g'hwpi k'0J EC"uj qy gf "vj cv'CVT"K'"cduqtr vkpp"ur gev'tc"qh'w'pf co ci gf. "f co ci gf "d {"vj gto cni'uj qeni'cpf " WX"tcf kcvkpp"E0mukcplc" g'ecp"dg"i tqw gf "k'vq" f k'htg'gpv'envugtuy kj "322" "ceewtce { \*Hk 0300"

Ur gev'tc'f k'htg'gpegu"dgw ggp"CVT"K'"cduqtr vkpp"ur gev'tc"qh'f k'htg'gpv'w'ckpu"qh'I ggdcekmul"ur 0'y gtg'qdugtxgf "k' vj g"33: 5"eo /3"6"; 52"eo /3"ur gev'tc'tapi g"y j gtg"vj g"l'p'v'puk'f {"qh'vj g"ur gev'tc'dcpf u"cv'3499"eo /3"\*r tqvku. "35: 4"eo /3" \*ectdaj { f tcvu. "35: : "eo /3"\*k'w' "cpf "co k'p' c'ek' u. "3662"eo /3"\*k' k' u. "3675"eo /3"\*cm'p'gu"cpf "ce { erke"eqo r qwpf u" f k'htg'0J EC"y cu' r gthqto gf "hqt"vj g"CVT"K'"cduqtr vkpp"ur gev'tc" wukpi "Y ctf "Cni qtkj o . "ugrevkpi "vj g"3396"eo /3"6"3386" eo /3"ur gev'tc'tgi kq0'CVT"K'"cduqtr vkpp"ur gev'tc"qh'I ggdcekmul"ur 0834"cpf "I ggdcekmul"ur 0; 7"y gtg'ugr ctcvgf "k'vq"y q' envugtuy kj "322" "ceewtce { 0"



Hk'0' 30' J EC" qh' CVT" K'"cduqtr vkpp"ur gev'tc"qh' w'pf co ci gf. "f co ci gf "d {"vj gto cni'uj qeni'cpf " WX"tcf kcvkpp" E0mukcplc" g'hwpi k'0Ngwt"C'tghgtu"v"CVT"K'"ur gev'tc"qh'w'pf co ci gf. "D"6"fo ci gf "d {"WX"tcf kcvkpp. "E"6"fo ci gf " d {"vj gto cni'uj qeni'E0mukcplc" g'hwpi k'0Vj g'pwo dgt'hmny kpi "vj g'hwgt'lpf k'cvu"vj g'uco r ng'pwo dgt0

[3\_0 ORk' €y unk 'k'v'LO'G'pxktq0T'gu0'Rvdrk'j' gcnj "38."699"\*423; +  
 [4\_0 0J ct| "g'v'cn'0'E { vqo gt { "97C."326/335"\*422; +

**URGEVTQUEQRKE 'GNNRUQO GVT[ 'P XGUVK CVKQP 'QH'WP KHQTO KV[ ''  
 QHF KCO QP F/NKMG'ECTDQP 'CP F 'UKXGT'P CP QE QO RQUK/G'VJ K''  
 HKNO ''**

Cw-tpk "Lwtngxk k v<sup>3,4,5</sup>. "Rcwku'F qm cpvcu<sup>3,4</sup>. "Vqo cu'Vco wngxk kw<sup>3,4</sup>. "Lwtku'Rtkmwku<sup>5</sup>"

<sup>3</sup>"Kpukwng'qh'O cvgtkcu'Uelgpeg'qh'Mcwpcu'Wpkxgtuks' { 'qh'Veje pqmji { . 'MDDct-cwumq'w07; . 'NV/73645. 'Mwpcu. 'Nksj wpcle"

<sup>4</sup>F gr ctvo gpv'qh'Rj { uleu. 'Hcewn' { 'qh'O cvj go ckleu'cpf 'P cwtcn'Uelgpegu. 'Mwpcu'Wpkxgtuks' { 'qh'Veje pqmji { . "

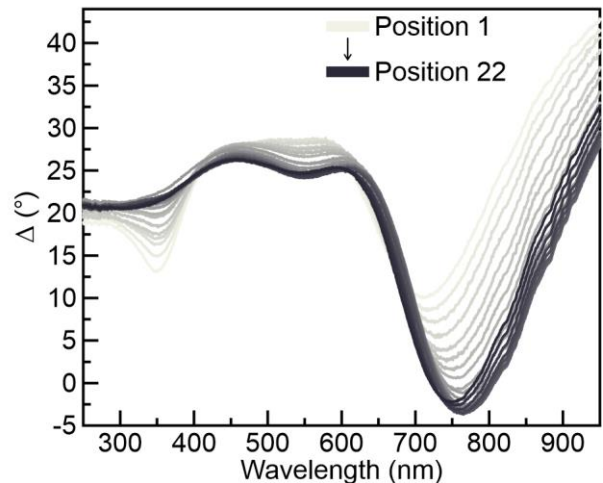
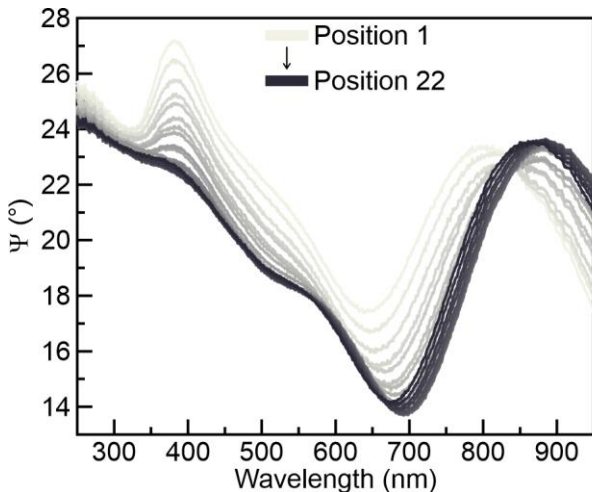
Uwf gpv 'w072. 'NV/7358: . 'Mwpcu. 'Nksj wpcle"

<sup>5</sup>Kpukwng'qh'Ej go lecn'Rj { uleu. 'Wpkxgtuks' { 'qh'Ncxlc. 'Lgri cxcu'w03. 'NX/3226. 'Tli c. 'Ncxlc"

, cwut'kg0wngxlekwgB mw0w'

Hqt'o cp { 'cr r nccvqpu. 'wplkqto kv' { 'qh'vj kp' hko u'ku'co qpi 'vj g'o quvf guktgf 'r tqr gt vku0Vj g'vj kp' hko 'o wuv'j cxg'vj g' uco g'r tqr gt vku'lp'vj g'nti g'ctgc0Hqt' r nco qple 'cr r nccvqpu' \*g0' 0qr vlecn'ugpuqtu+ 'qr vlecn' r tqr gt vku'qh'vj kp' hko 'uj qwf' 'pqv'ej cpi g'y kj lp'vj g'y j qrg' hko 0'kp' pcpqeqo r quks'g'o cvgtkcu. 'qr vlecn' r tqr gt vku'f gr gpf' 'qp'nc { gt'vj lempgu. 'qr vlecn' eqpuwcpv'qh'eqpuwkgpv'o cvgtkcu. 'eqpegpvc'vqpu'qh'eqpuwkgpv'o cvgtkcu. 'pcpqr ct vkgu'uk' g'f kut'kwkqpu. 'gve0Cm'vj ku' j cu'v'q'xct { 'cu'hwng'cu' r qukdng0'

Kp'vj ku'y qtm'f kco qpf/rkng'ectdqp' pcpqeqo r quks'g'y kj 'ukxgt' pcpqr ct vkgu' \*F NE-Ci + 'qp' ukleqp' uwdutcvg'y cu' kpxguki cvgf 0'Uco r ng'y cu' r tgr ctgf 'lp' wpcrcpegf 'o ci pgstqp' ur wwtgkpi 'u' ugo 'lp' f l' tgeve'wttgpv'o qf g'y kj 'ukxgt' vti gv' kp' r meg0Vj g'ewttgpv'y cu'208'C. 'vj g'xqnci g'y cu'588'X. 'vj g'r tguuwtg'y cu'90 " 32'<sup>5</sup>o dct. 'cti qp' hmq' 'tcvg'y cu': 2'ueeo. " cegv' rpgg' hmq' 'tcvg'y cu'390'ueeo. . 'i tqy vj 'wko g'y cu'3354'w0Vq'vj g'pcngf' 'g'g' 'vj g' uco r ng' cr r gctgf' 's wkg' wplkqto. " gzeqr v' ctqwpf' 'vj g' gf i gu0' Vj qtqwi j " cpcn'uku' qh' wplkqto kv' 'y cu' ectlkgf' 'qww' go r mq' lpi " I GU7/G' \*Ugo krcd+' tqvcvpi " eqo r gpuwqt' ur gev' queqr le' gnr uqo gvtg' 'lp' vj g' tgh'gev'kqp' o qf g0' kpekf gpeg' cpi ng'y cu'ugv' v'97'Å'cpf' 'vj g' ur gev'c'y cu' tgeqtgf' d' { 'EEF' f' gvgvqt' 'ltqo' 472'po 'vq'; 72'po 0'Vj g'uwthceg'qh'vj g' uco r ng'y cu' uecppgf' 'cv'44' r quks'kqp'lp' qpg' hkg. " y kj' 207'o o 'f' kwcpeg' dgvy ggp' gcej' 'r quks'kqp'0T guw'kpi 'gnr uqo gvtle' r ctco gvtu' ur gev'c'ctg' f' gr levgf' 'lp' Hki 030



Hki 030Gnr uqo gvtle' r ctco gvtu' " \*ghv'cpf " " \*tki j v'f gr gpf gpeg'qp'vj g'r quks'kqp'qp' F NE-Ci 'uco r ng0F kwcpeg' dgvy ggp' gcej' 'r quks'kqp'ku'207'o o 0'

Cu'k'ecp'dg'uggp'ltqo 'Hki 03. 'vj g'gnr uqo gvtle' r ctco gvtu' " cpf " 'ctgcf { 'lpf' lecvg'vj g'f' khtg'pegu'lp'vj g'vj kp' hko 0' Vj g'r gcn'cv'ctqwpf'5: 2'po "lp" "ur gev'c'cu'y gni'cu'vj g'o kpkc'c'cv'ctqwpf'572'po "lp" "ur gev'c'dgeqo g'uo cmgt'cpf" g'xgpwcm' "eqo r ngv'nf' f' kucrr gct. "y j gp' i qkpi "ltqo 'vj g'vqr' r ctv'qh'vj g' uco r ng'v'vj g'dqwqo 0'Vj g'o kpkc'c' r qkpv'qh' gzvtgo c'cv'872'po "lp" "ur gev'c'cpf'cv'942'po "lp" "ur gev'c'uj kh'vqy ctf u'mpi gt'y cxg'gpi vj u'y kj' 'vj g'ej cpi g'qh'vj g' r quks'kqp'0'Vj ku'lpf' lecvgu'vj g'i tcf wcn'ej cpi g'qh'vj g'vj kp' hko "r tqr gt vku'0'Vj ku'eqwrf' hko r n' 'vj cv'vj g' uco r ng'y cu'urki j v' " v'ngf' f' wt'kpi "vj g'f' gr quks'kqp'0'hw'vj gt'cpcn'uku' \*o qf gnrkpi 'qh'gnr uqo gvtle' f'cv'cv'gxgt { "r quks'kqp'+y kni't'gxgn'vj g'cewcn' t'gcuqp'ltq'vj g'ug'f' khtg'pegu'k'eqwrf' g'k'j gt'dg'vj lempgu. "t'ght'cev'kg'lpf'gz'cpf' "gz'v'p'v'kqp'eqgh'lel'g'p'v'qt' ukxgt' "eqpv'g'p'v' pqp/wplkqto kv' 0'

**F G V G E V K Q P ' Q H ' O C N K P C P V ' J W O C P ' D N C F F G T ' V K U W G ' D I ' O G C P U ' Q H ' H K D G T ' D C U G F ' C V T ' K T ' U R G E V T Q U E Q R I ' ' "**

Tlo cpv "Dcpf | gxk k v<sup>3</sup>. "I gf lo kpcu'Rrcvngxk kwu<sup>4</sup>. "Lwukpcu" gr qpmw<sup>3</sup>. "I gtf c'O kem pckv<sup>3</sup>. "Crdgtcu" gnɛwunɛu<sup>4</sup>. "Ct pcu'fi grx { u<sup>4</sup>. "Xcrf cu"<sup>1</sup>ɛdɪkpuɛu<sup>3</sup>"

<sup>3</sup>"kpukwg'qh'Ej go lecn'Rj { uleu. "Hcewn' { qh'Rj { uleu. "Xkpkwu'Wpksgtukv. "Ucwn vgnkq'Cx05. "NV/32479"Xkpkwu. "Nkj wcpk"  
<sup>4</sup>"kpukwg'qh'Eriplecn'O gf lekp. "Hcewn' { qh'O gf lekp. "Xkpkwu'Wpksgtukv. "Ucpwtknk "Ut04. "NV/2: 883. "Xkpkwu."

Nkj wcpk"

tlo cpv|dcpf | gxlekwgB H0xw0v"

"

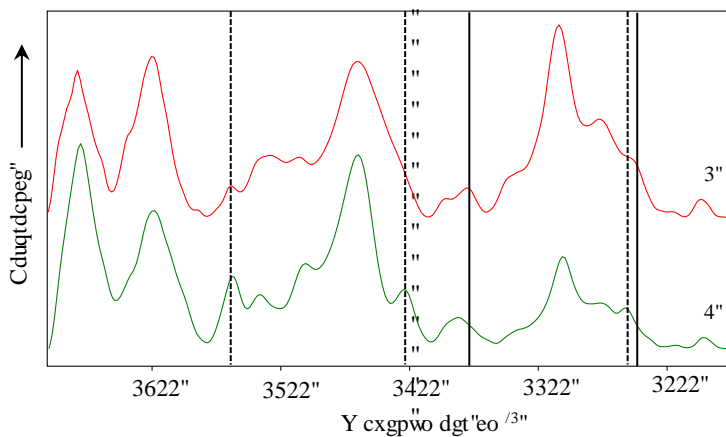
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F wtkpi "wo qt "h'q'to c'v'k'p' . "v'j g'o g'v'cd'q'ruo "qh'eg'mi'ej c'pi gu. "v'j g't'g'ht'g. "k'c'h'g'ev'v'j g'ej go lecn'eqo r qu'k'k'p'qh'v'j g'kuu'w'g'0 X'k'd'c'v'k'p'c'n'ur g'ev't'que'q'r { "ku'g'p'uk'x'g'o g'y q'f "h'q't'v'j g's w'k'c'v'k'x'g'c'p'f "s w'c'p'v'k'c'v'k'x'g'ej go lecn'c'p'c'n' u'ku. "v'j w'le'j go lecn'ej c'pi gu' qh'v'j g'kuu'w'g'v'j q'w'f "d'g'q'd'ug't'x'c'd'g' "k'p'v'j g'x'k'd'c'v'k'p'c'n'ur g'ev't'c'0k'p'v'j k'u'w'w'f { "h'k'd'g't' "d'c'ug'f "c'w'g'p'w'c'v'g'f "v'q'v'c'n't'g'h'g'ev'v'k'p' "k'p'ht'c't'g'f " \*C'V'T' "K'T' "ur g'ev't'que'q'r { "y cu'c'r r r'g'f "h'q't'v'j g'kuu'w'g'g'zco k'p'c'v'k'p'0U' r g'ev't'c'eq'w'f "d'g'o g'cu'w'g'f "y kj k'p' "h'g'y "o k'p'w'g'u'y kj q'w' c'mo qu'v'c'p' { "ur g'ek'n'ico r r'g'r' t'gr c'tc'v'k'p'0C'r r r'ec'v'k'p'qh'v'j h'k'd'g't' r t'q'd'g'p'c'd'g'u'v'q'f "q'v'q' b' g'cu'w'g'o g'p'u'k'p' "k'w'q't' "k'p' "x'k'q' "eq'p'f k'k'p'u. " v'j c'v'k'u'ko r q'tc'v'p'v'f wtkpi "v'j g'lwiti gt { 0"

F wtkpi "v'j g'lwiti { . "uco r r'g'u'q'h'p'q'to c'n'c'p'f "wo q't'q'w'u'j wo c'p' "d'rcf fgt "kuu'w'g'qh'6; "r c'v'k'p'v'u'y g't'g'zco k'p'gf . "k'p'ew'f k'pi " ecugu'qh'wtq'v'j gricn'ectekp'qo c. "p'q'p'ur g'ek'he' "e' { u'k'ku' "c'p'f "r c'r k'm'c' { "w't'q'v'j gricn'p'g'q'r n'uo "qh' "m'y "o c'iki p'c'p'v'r q'v'g'p'v'c'n'0Vj g' v'g'ej p'ls w'g'y cu'c'r r r'g'f "h'q't'v'j g'kuu'w'g'u't'go q'x'g'f "c'h'g't'v'j g'lwiti gt { 0Vj g'c'v't' "K'T' "c'd'ug't'r v'k'p' "ur g'ev't'c'qh'p'q'to c'n'c'p'f "wo q't'q'w'u' v'kuu'w'g'c't'g't'g'r t'g'ug'p'v'g'f "k'p' "H'k'i 030Vj g'f g'et'g'c'ug'f "k'p'v'p'uk'v' "qh'ur g'ev't'c'n'd'c'p'f u'q'h'eq'm'c'i g'p' "h'ec'v'g'f "c'v'355; "eo /<sup>3</sup>. "3427"eo /<sup>3</sup>"c'p'f " 3255"eo /<sup>3</sup>"ku'q'd'ug't'x'g'f "k'p'v'j g'c'v't' "K'T' "c'd'ug't'r v'k'p' "ur g'ev't'c'qh'wtq'v'j gricn'ectekp'qo c' "kuu'w'g'0K'ku' "t'g'v'g'f "v'q'v'j g'f g'et'g'c'ug'f " co q'w'p'v'q'h'eq'm'c'i g'p' "k'p'v'j g'kuu'w'g'0Vj g'd'rcf fgt "k'u'g'v'c'v'le' "q'ti c'p'v'j c'v'ec'p'f "k'v'g'y j g'p' "v'j g'd'rcf fgt "k'u' "h'w'n'c'p'f "u'j t'k'p'ni'y j g'p' "k'v'ku' go r v'g'f . "eq'm'c'i g'p' r t'q'x'k'f g'u'v'j g'g'v'c'v'k'v'k'v' 0F wtkpi "v'j g'r t'q'eg'uu'qh'wo qt "f'g'x'g'g'ur o g'p'v' "kuu'w'g' "h'ug'u'ku' "h'w'p'v'k'p' . "v'j g't'g'ht'g. "k'v' eq'w'f "r'g'c'f "v'q' "f' g'et'g'c'ug'f "r'g'x'g'ni'qh'eq'm'c'i g'p'0C'nuq. "v'j g'k'p'et'g'c'ug'f "k'p'v'p'uk'v' "qh'v'j g'ur g'ev't'c'n'd'c'p'f u' "h'ec'v'g'f "c'v'3377"eo /<sup>3</sup>"c'p'f " 3248"eo /<sup>3</sup>"ku'q'd'ug't'x'g'f . "k'v'ku' "t'g'v'g'f "v'q' "k'p'et'g'c'ug'f "r'g'x'g'ni'qh'v'j n'eq'i g'p'0C'p' "k'p'et'g'c'ug'f "co q'w'p'v'q'h'v'j n'eq'i g'p' "k'p'v'j g'e' { v'q'u'q'n'ku'c' " ej c't'c'ev'g't'k'v'le' "h'g'c'w't'g' "h'q't' "u'q'o g'v'f r g'u'q'h' "ec'p'eg't'0I n'eq'i g'p' "k'u'ce'ewo w'v'v'g'f "c'p'f "w'g'f "cu'v'j g' "u'q'w'eg'qh'g'p'g'ti { "u'k'p'eg' "ec'p'eg't'q'w'u' eg'm'i'f w'g'v'q'v'j k'j "r' t'q'k'ht'c'v'k'p' "c'v'g'p'g'g'f "o q't'g' "g'p'g'ti { "v'j c'p' "p'q'to c'n'c'p'p'u0"

"

"



H'k'i 030C'V'T' "K'T' "c'd'ug't'r v'k'p' "ur g'ev't'c'qh' "ec'p'eg't'q'w'u' "w't'q'v'j gricn'ectekp'qo c' +\*3+ "c'p'f "p'q'to c'n'c'p'f "d'rcf fgt "kuu'w'g'0F cu'j g'f " r'k'p'u'k'p'f k'ev'g' "ur g'ev't'c'n'd'c'p'f u' "cu'ki p'g'f "v'q' "eq'm'c'i g'p' . "u'q'k'f "h'k'p'u'o "cu'ki p'g'f "v'q' "i n'eq'i g'p'0"

"

[3]\_MDUci k'p'c'n' . "C'0D'c't'ug'w'm' "I'0U'0C' "n'w' "R'0T'c'y n' . "U'0C'0R'ef' c'n' . "C'0D'c't'ug'w'm' "G'r'k'f' go k'q'ni { "q'h' "D'rcf fgt "E'c'p'eg't' . "O' g'f "U'ek' "D'c'ug'ni' : "4242+ "  
 [4]\_U'U'j c'to c' . "R'0M'j g'g't'uci c't' . "R'0U'j c'to c' . "F'k'ci p'qu'k'c'p'f "v'g'co g'p'v'q'h'd'rcf fgt "ec'p'eg't' . "C'o "H'ko "R'j { u'lek'p' : "2. "939/45 "422; + "

P2-13

DID NOT PARTICIPATE

**NKDTCT[ 'QH'TGF'RK O GPV'TCO CP'URGEVTC'CPF'RK O GPV'  
 KF GPVHKECVKQP 'KP'RCKP VGF 'Y QTMU'QH'CTV''**

O qtc'Ucf wñ v . 'Tcuc'Rrcvcm{ v . 'Lwukpcu' gr qpmw'

Kpukwng'qh'Ej go lecn'Rj { uku.'Hcwm' qh'Rj { uku.'Xkpkwu'Wpkkgtuk{ . 'Xkpkwu'  
o qtc'Ucf wñ v B Hñwñf kvñw'

"

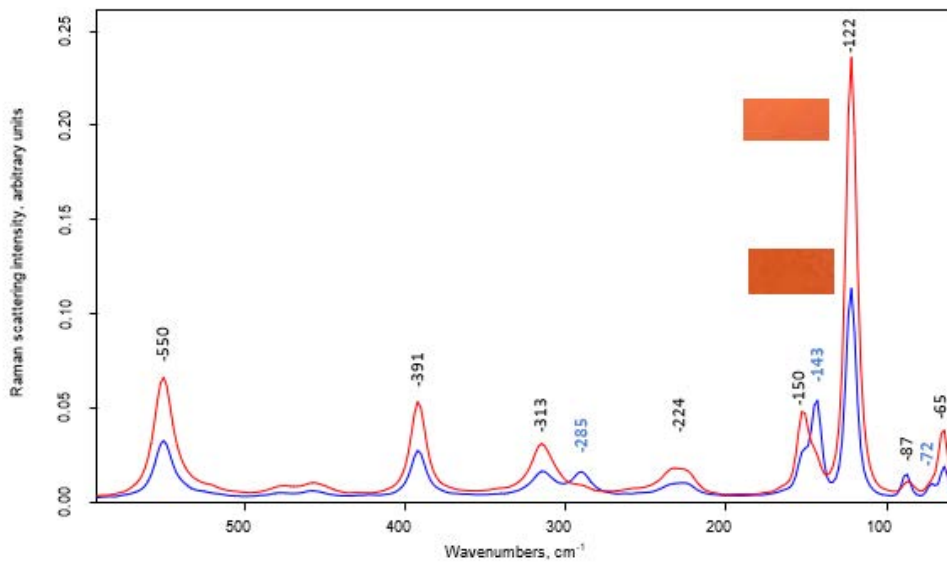
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F k'ht'gpv'uc'p'f'ctf't'gf'r ki o gpv'uco r ngu'ht'qo "Xkpkwu'Rtc'p'cu'I wñ { p'cu't'guvtcvkp'eg'p'vt'y gte'o gcuwt'gf'0'F wtkpi 'yj g' u'w'f { "qh'yj g'ug'r ki o gpw.'p'g'ct'k'p'ht'ct'gf'hc'ugt'3286'po +y cu'go r m{ gf 'kp'q'f'g'v'q't'gf'w'eg'yj g't'k'um'qh'hw'qt'g'ue'p'eg'0'Vj g'q'p'g' eqo r r'kecvkp'yj cv'q'hw'p'ct'q'ug'y j krg'o gcuwt'kpi 'f'k'ht'gpv'uco r ngu'y cu'yj g'p'gg'f'v'q'cf'lw'v'hc'ugt'r qy gt'cpf 'uec'p'kpi "ko g'kp' q'f'g'v'q'q'd'v'cl'p'ur gev't'c'y k'j "dg'v'uki p'cn'v'q'p'q'k'ug't'c'v'k'cpf "cx'q'k' 'uco r r'g'j' g'cv'kpi "cpf "f'co ci g'0'Tco cp'ur gev'tueqr { "y cu' wugf 'v'k'f gpv'kh{ "ur gek'he'd'c'p'f' u'q'h'q'x'g't'g'p't'gf'r ki o gpw'0'k'c'f'f'k'k'p'.'yj g'ur gev't'c'r t'q'x'g'f'w'ug'hw'y j krg'hw'ny kpi 'f'gi t'cf'cv'k'p' qh'c'r ki o gpv'0'k'p'hi w'g'3.'y q'ur gev't'c'qh'yj g'uco g'r ki o gpv'0'g'f' 'r'g'c'f'+'h'qo "f'k'ht'gpv'uc'p'f'ctf't'gf'r ki o gpv' c'p'f "U'q'x'lg'v'r ki o gpv'ct'g'r t'g'ug'p'v'f'0'k'ku'r qukk'ng'v'q'q'd'ug't'x'g'yj cv'yj g'hc'wgt'r ki o gpv'j' cu'f'gi t'cf'gf' 'h'qo "Rd5Q6'v'q'RdQ'ht'qo " yj g't'g'v'x'g'k'p'v'p'uk'ku'qh'yj g'ur gev't'c'nd'c'p'f' u'kp'yj g'542/4: 2'eo /3'cpf "382/352'eo /3't'gi k'p'u'j4\_0'

U'qo g'uco r ngu'qh'q't'ki p'cn'cp'f't'guvt'gf' 'H'gueqgu'ht'qo "Xkpkwu'Wpkkgtuk{ "N'w'ng't'c'd'q'q'm'v'q't'g'y gte'o gcuwt'gf'cu'y g'nd' Vj g't'gf'r ki o gpv'wugf 'kp'q'p'g'qh'yj g'ht'gueqgu'cpf 'o cvgtkcn'wugf 'kp'f'k'ht'gpv'r'nc'ugt'hc' { gtu'w'p'f'g't'v'j g'ht'gueqgu'y gte'kf gpv'kh'f' " cu'j' go cv'kg.'ec'ek'wo 'ect'd'q'p'cv'g'cpf "uk'ke'q'p'f'k'z'k'f'g'0'

"

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 [4] "D'wti l'q.'N'w'el'c'≡E'nc'm't'Q'd'k'p'1'0'J 0'H'ñ'v'j . 'U'g'x'p'0'T'co cp'ur gev'tueqr { "cu'c' 'o g'c'p'u'ht' 'y j g'f' gpv'kecvkp'qh'r'nc'wp'gt'k'g' "RdQ4+'q'h'ig'c'f'r ki o gpw'cp'f' " q'h'yj g'k'f'gi t'cf'cv'k'p'rt'q'f'w'ewi"4223-40'



**TGNCVKQP UJ KR'QHURCVKN'CP F'MKPGVKE''**  
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**S WCP VWO 'Y GNNU''**

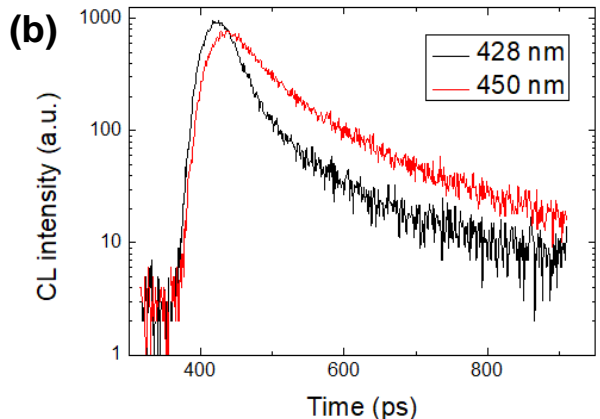
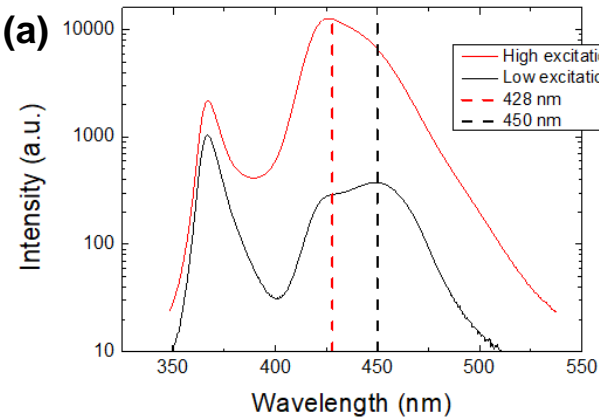
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**I NCUUGU'**

Mcurctcu'F t f lcu<sup>3</sup>. 'Ncwtc'Vcwtckv<sup>3</sup>. 'Cpvcpcu'Wdcu<sup>3,4</sup>. 'Ugti glwu'Qtmxcu<sup>3</sup>

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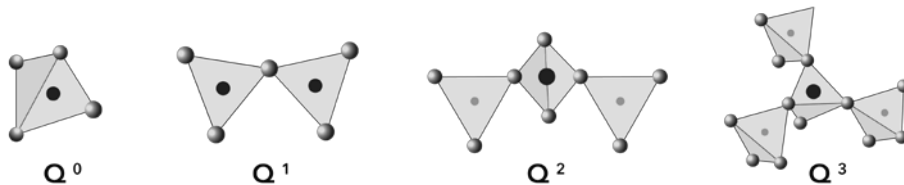
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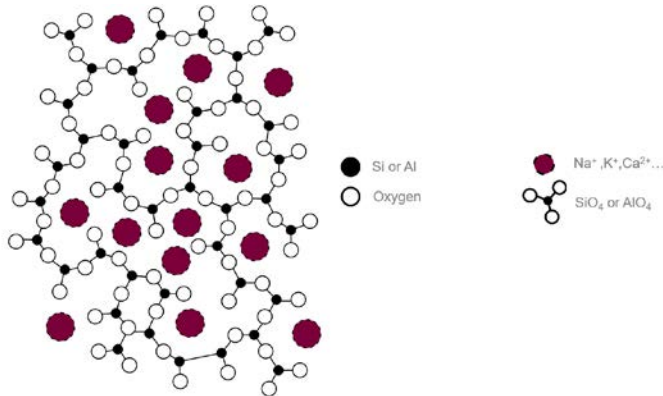
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I ctpci c/Dwft 'I ckrpc<sup>6</sup>

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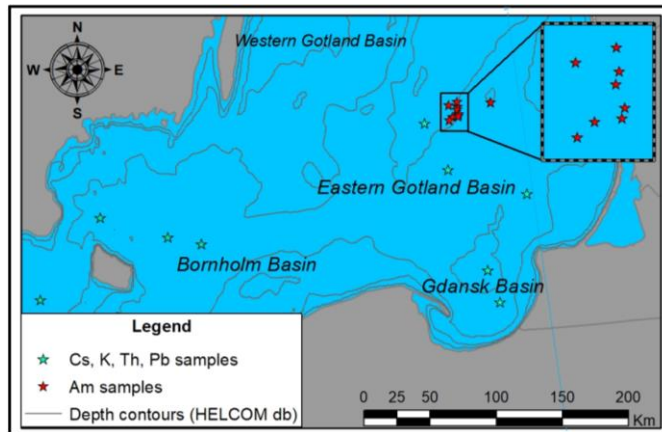
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Vj g'Dcnle"Ugc"j cu'dggp'eqpwo kpcvfg'y kj "cpvj tqr qi gpke'tcf kqpwrf gu'qxgt'c'itpi 'j kwqt {"qh'pwergct'gppti {"wug'0  
Pqy cf c{u' 'y j g' Dcnle" Ugc" eqpwpwgu" vq" dg" eqpwo kpcvfg" y kj " cpvj tqr qi gpke" tcf kqpwrf gu" f wg" vq" y j g' kphny" qh'  
tcf kqpwrf gu'itqo "tkxgtu'y kj "c"vqcn'ecvej o gpv'tcgc"qh'cdqw"4032<sup>8</sup>mo "0'Hqt"gzco r ng."y j g'Xlwur"Tkxgt'dtkpi u'cdqw'  
308'I Ds l' "qh"<sup>463</sup>Rw'y kj "ku'y cvgtu"j3\_00 qtqgxt."y j g'kpi tqy p'cevkkv' "eqpegpvcvqpu'qh"<sup>463</sup>Co "ctg'y j g'tguwn'qh'qpi qlpi " "  
tcf kqcevkxg'f gec {"qh"<sup>463</sup>Rw'0Vj g'cevkkv' {"qh"<sup>463</sup>Rw'lp"y j g'Dcnle"Ugc" f wg"vq"i mdcn'hmjw'cpf "y j g'Ej gtpqd' n'P RR'ceekf gpv'  
ctg'guwo cvgf"cv'5; VDs "f c'c"j4\_ "ctg"eqttgevgf "hqt"4243+0Vj g'kpetgucg'lp"y j g'cevkkv' "eqpegpvcvqpu'qh"<sup>463</sup>Co "y kn'itgej " "  
c'o czko wo "qh'60VDs "lp"e"69" { gctu0"

Rctveng/tgcevkg'tcf kqpwrf gu'j cxg'qxgt"y j g' { gctu'dggp" c" wughwi'vqni'hqt" uwf { lpi "y j g'tgf kwtkdwkp"qh"xctkqwu"  
r qmwpwu'lp"y j g'o ctkpg'gpxktqpo gpv'0'ku'npqy p'y j cv'o cp {"vzle"qti cple"uuducpegu."r ctvewrctn' "ej nqtkpg/eqpvcvqpi " "  
qpgu."gculn' "dlpf "ugf ko gpw' cpf" ctg" vcpur qtvgf "itqo " rnpf "vq"y j g'o ctkpg'gpxktqpo gpv' d {"tkxgtu" cpf " eqcucn' i cvgtu0'  
Mpqy rgi g'cdqw'y j g'uqwtegu'qh'tcf kqpwrf gu'cpf "wpf gtucpf lpi "qh'y j g'k' dgj cxkqt"ctg"guugpvcn'itqo"y j g'k' cr r necvqp'lp"  
vcegt"uwf lgu'Vj " clo "qh'y j ku" uwf {"ku"vq" g'zr cpf "npqy rgi g'cdqw"y j g' f kwtkdwkp"qh"<sup>463</sup>Co "cpf "<sup>359</sup>Eu"lp" dqwqo " "  
ugf ko gpw'qh'y j g'Dcnle"Ugc" hqt"y j g'k' hwwt g'cr r necvqpu'lp"vcegt"uwf lgu'0"

Vj g'dqwqo "ugf ko gpv'uco r ngu" \*Hki 03+ y gtg'vcnpg" d {"y j g'Gpxktqpo gpvniRtqvevqp'Ci gpe {"Mckr f c."Nkj wcpkc+"  
cpf "d {"RRUJ ktuj qx "kpkswg'qh'Qegcpqmi { "TCU" \*O queqy ."Twuuk+0Uco r npi "f gr y j u'y cu'tpci gf "itqo "65"vq"342"o 0C"  
Xcp'Xegp'I tcd'Uco r rgt'y cu'wugf "hqt'vcnpi "uco r ngu'0"

"Ugf ko gpv'uco r ngu'y gtg'cu'j gf "cv"772dE."y j gp'f ki gungf "wulpi "utqpi "cekf u0Co "y cu'gz'vcevgf "y kj "VQRQ le { emj gzcpq." "  
hmqy gf "d {"tcf kqej go kecnr' wtklecwqp"y kj "VTW'cpf "VGXC"t gulpu"\*322/372"o o +0465Co "y cu'wugf "cu'c" { kgrf "lpf kecvq"  
lp"y j g'ugr ctecvq' r tqegf wg" \*CGC"Vgej pqmji {"WM"kuqtem" S UC"Co gtuj co "kpvtpcvqpcn" CVR32242+0Vj g'r wtkhgf "Co " "  
y cu'grgevtq r vef "qpvq" uclpngu' uggri' f kum'0Vj g' cr j c/ur gevqo gt {"u' ugo "y kj "r cuukcvgf" lo r rnpvgf "r rnpct" ukdeq"  
\*RRU+f gvevqtu "672"o o "cevkkv'ctgc" \*CO GVGm"QcmT'kf i g."Vgpp."WUC+y cu'wugf "hqt"y j g'f gvevqpu'0Vj g'cevkkv'gu'qh'  
y j g'i co o c'ko wgtu'y gtg'o gcuwgf "d {"J RI g'f gvevqtu" \*tguqnwkp"30 "hgX" \*HY J O +cv'305'0 gX'cpf "gh'kegpe {"64' +0"  
"



Hki 030Vj g'uco r npi "ctgc"

Vj g'f c'c' qdvcvqgf "f wtkpi "y ku'uwf {"uj qy gf "y j cv'lp"y j g'dqwqo "ugf ko gpw'qh'y j g'I qv'v'p'F ggr."<sup>463</sup>Co "ku'f kwtkdwgf "  
wpqxpni' "lp"y j g'tpci g"qh"2087/20453"Ds "I"o <sup>50</sup>Ceeqtf lpi "q'r tgrko kpc {"f c'v."y j gtg'y cu'c"i gpgtcr'v'gpf "hqt"y j g"<sup>463</sup>Co " "  
cevkkv' "vq" kpetgucg"y kj "f gr y j 0Vj g'cevkkv' "eqpegpvcvqpu'qh"<sup>659</sup>Eu "<sup>436</sup>Rd"cpf "<sup>62</sup>M'lp"uwf lgf "uco r ngu'tpci gf "itqo "84"vq"  
442"Ds lni ."itqo "5208"vq": 204"Ds lni "cpf "itqo " : 49"vq"32; 5"Ds lni ."tgr gevkg'n(0Vj g'qdvclpgf "tguwn'y j kni'dg" wugf "vq"  
uwf {"ugf ko gpv'vcpur qt'v'lp"y j g'Dcnle"Ugc'0"

J3\_ "F 0'U'Utwo k une/Rctwune."Xgt vlcni'f kwtkdwkp"qh'463Rw'lp"y j g'uqwj gtp"Denle"Ugc"ugf ko gpw."\*O ct'0'Rqm'w'0'Dwn'0"xq'0": ; "pq0364."r r 034637."

F ge04236+0

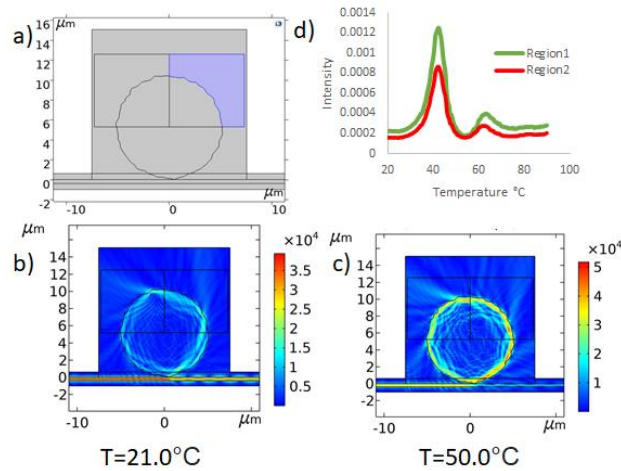
J4\_ "G0J qno ."6Rnwqplwo "lp"y j g'Dcnle"Ugc."0"Cr r n'0T'cf ke'0'k'q'0"xq'0'68."pq033."r r 034476344; .P qx03; ; 7+0

# RO O C'Y I O 'O KETQ'TGUQP CVQT'O QF G'HCO KN[ " CPCN[ UKU'WUP I 'URQV'K VGP UKV[ 'EJ CPI GU'HTQO 'KO CI G' RTQEGUUP I O'

Tqdgwu'Dgtntku<sup>3</sup>. 'Kpi c'Dtleq<sup>3</sup>. 'Mkukcpu'F tci wpu<sup>3</sup>. 'Cki ctu'Cwctu<sup>3</sup>. 'Rcwu'Mtku'v u'T gkpu<sup>3</sup>. 'M trku' I twpf uvgkpu<sup>3</sup>. 'Lcpku'Cpku<sup>3</sup>"

<sup>3</sup>Wp'kxgtukv{ 'qh'Ncxlc". 'Kpukwvg'qh'cvqo ke'r j { uleu"cpf'ur gev'queqr { .S wcpwo 'qr vleu'rdqtcvt { " [Tqdgwu'0igtntkuB n0x](#)"

Vj g'y j kur gtlpi "i cmgt { "o qf gu"\*Y I O +o letq'tguqpcvqtu'ctg'dcugf "qp'gnrk uqkf cn'qdlgevu."y j lej "ecp'dg"o cf g'htqo " qr vlecm{ 't'cpur ctgpv'o cvgtkcm."y cv'ecp'gpcdrng'qr vlecn'y c'xg'ekteww'kpi 'kpu'f g'y j g'gnrk ug'wukpi 'v'q'w'k'p'v'g't'p'c'nt'gh'ge'v'k'p'0'K'i' y j g't'ku'c'o qp'qej tqo c'vle'hi j v'uq'w'eg'y kj "eq'p'uc'p'v'k'p'g'p'ukv{ 'v'q'j'g'gnrk ug'eq'p'ut'w'k'x'g'k'p'v'g't'ht'g'p'eg'o c { "dg'q'dug't'x'g'f"j3." 4\_0'Rq' "o gj { n'o gj cet { n'v'g'cet { n'e"RO O C'+Y I O 'o letq'tguqpcvqtu'ctg'eqo o gtelem{ 'cx'k'c'dr'ng'y kj "v'f'r'k'c'n'q'r'v'le'c'n' s'w'k'v'k'f' 'h'c'v'q't'q'h'32<sup>5</sup>/32<sup>6</sup>]5\_0'Vj gug'eq'w'f' 'h'o k'r' t'q'd'r'g'o u'y kj "Y I O 'o letq'tguqpcvqt'g'z'r'g'p'uk'x'g'o c'p'w'k'c'w'w'k'p'i' 0'D'g'c'w'g' " qh'cf'x'c'p'eg'u'k'p'j' k'j "t'g'u'q'w'k'p'k'o' c'g'r' t'q'g'u'k'p'i' .t'g'c'f' /q'w'u'w'k'p'i' 'ur' g'v't'q'ue'q'r { "u'k'p'i' n'g'r' j' q'q'f' g'v'g'v'q't'+e'q'w'f' 'd'g't'r' n'e'g'f' " y kj "k'o' c'g'r' t'q'g'u'k'p'i' 0'K'o' c'g'r' t'q'g'u'k'p'i' "60'U'o' l'r'z'+c'm'q'y' u'v'q'ur' r'k'v'g'n'r'k'v'le'c'n'Y I O 'o letq'tguqpcvqt'k'p' "t'g'i' k'p'u'c'p'f' " c'p'c'n{ | g'ug'r' c't'c'v'g' 'u'g'v'q'tu'q'h'v'j' g'gnrk ug'j]6\_."y j lej "ecp'w'ug'f' 'cu'c' "t'r' t'g'g'p'c'v'k'p'q'h' 'u'w'h'c'g'f' k't'g'i' w'r'c't'k'f' ]7\_ "k'p'v'g't'c'v'k'p'y' k'j " j k'j g't'q't'f' g't'ur' g'k'c'n'o' q'f' g'i' t'q'w' u'0"



Hki 030EQO UQN'4F' i gqo gvt { 'y kj '32'U'o 'f'k'o g'v't'RO O C'Y I O 'o letq'tguqpcvqt'y kj 't'c'p'f' q'o n'f' g'ht'q'o g'f' 'u'w'h'c'g' " eq'w'r' n'g'f' 'v'q'206'U'o 'f'k'o g'v't' 'c'r' g't'g'f' 'h'd'g't' 'y' c'k'v't'g'i' k'p'u'c'p'f' 'y' j' g'v'g'v'g'f' 't'g'i' k'p'u'c'v'y' j' k'j 'y' j' g'c'x'g't'c'i' g'k'i' j' v'k'p'v'g'p'uk'v' 'k'u'd'g'l'p'i' " o' g'c'u'w't'g'f' 0'd'+G'g'v'g't'k'e' 'h'g'r'f' 'f' k'v't'k'd'w'k'p'q'p'32'U'o 'f'k'o g'v't'RO O C'Y I O 'o letq'tguqpcvqt.'y j' k'j 'k'u'eq'w'r' n'g'f' 'v'q'206'U'o " f'k'o g'v't' 'c'r' g't'g'f' 'h'd'g't' 'y' c'k'v't'g'i' k'p'u'y' k'j '982'p'o 'h'i' j' v't' t'q'r' c'i' c'v'k'p'i' 'k'p'u'f' g'y' j' g'h'd'g't' 'c'v'43<sup>2</sup>E'0e'+G'g'v'g't'k'e' 'h'g'r'f' 'f' k'v't'k'd'w'k'p'q'p' " 32'U'o 'RO O C'Y I O 'o letq'tguqpcvqt.'y j' k'j 'k'u'eq'w'r' n'g'f' 'v'q'206'U'o 'c'r' g't'g'f' 'h'd'g't' 'y' c'k'v't'g'i' k'p'u'y' k'j '982'p'o 'h'i' j' v't' t'q'r' c'i' c'v'k'p'i' " k'p'u'f' g'y' j' g'h'd'g't' 'c'v'72<sup>2</sup>E'0f' +C'x'g't'c'i' g'k'p'v'g'p'uk'v' 'f' k'v't'k'd'w'k'p'c'v'f' k'h'g't'g'p'v'g'o' r' g't'c'w't'g'u' 'h'q't' 'y' q' 'u'g'r' c't'c'v'g't'g'i' k'p'u'q'h'Y I O " RO O C' 'o letq'tguqpcvqt'0'

Kp'v'j' g'r' t'g'g'p'v'y' q't'n'p'g'y' 'v'f'r' g'q'h'k'o' c'i' g't' t'q'g'u'k'p'i' 'h'q't' 'b' letq'tguqpcvqtu'y' g't'g'f' g'x'g'm'r' g'f' . 'v'q'c'p'c'n{ | g'k'p'v'g'p'uk'v' 'f' k'v't'k'd'w'k'p' " k'p' 'u'g'r' c't'c'v'g't'g'i' k'p'u' 'h'q't' "RO O C'Y I O 'o letq'tguqpcvqtu'k'p'f'k'o' g'v't' 't'c'p'i' g'q'h'62/: 7"U'o . "y' c'v'y' g't'g'eq'w'r' n'g'f' 'y' k'j 'c'r' g't'g'f' " h'd'g't' 'y' c'k'v't'g'i' k'p'u'c'p'f' 'h'z'g'f' 'y' c'x'g'g'p'i' v'j' 'h'c'ug't'982'p'o +0'V'g'o' r' g't'c'w't'g'y' c'u'e'j' c'p'i' g'f' 'h'q'q'o '42/: 2'E'y' j' k'j 'g'h'g'v'v'j' g'RO O C' " t'g'h't'c'v'k'x'g'k'p'f' g'z' " + 'h'q't'982'p'o 'f'p'f'V' " 3054x32<sup>6</sup>h<sup>2</sup>E<sup>3</sup>4'c'p'f' 'y' j' g't'o' c'f'g'z'r' c'p'uk'p' " + 'y' j' k'j 'k'u'4082x32<sup>6</sup>h<sup>2</sup>E<sup>3</sup>4'0'Eq'o' d'k'p'i' " v'j' g'h'q'm'y' k'p'i' "r' j { u'k'c'i' 'e'j' c'p'i' g'u' . 'v'q'w'c'i' 'e'j' c'p'i' g'u' " - " + 'Y I O 'RO O C' 'o letq'tguqpcvqt' 'o' q'f' g'o' c'r' r' k'p'i' "y' c'u'q'd'c'k'p'g'f' 0'V'j' g' " h'q'm'y' k'p'i' "y' q't'n'q'h't'g'u'p'g'y' 'v'f'r' g'q'h'k'p'v'g'p'uk'v' 'r' t'q'g'u'k'p'i' "o' g'y' q'f' u' 'h'q't' "o' g'c'u'w't'k'p'i' 'c'r' r' n'c'c'v'k'p'u'w'k'p'i' "RO O C'Y I O 'o letq't " t'g'u'q'p'c'v'tu'c'p'f' 'k'p'v'g't'c'v'k'p' 'h'q'q'o' "j' k'j' g't'q't'f' g't' 'q'r' v'le'c'n'o' q'f' g'u'c'p'f' 'u'w'h'c'g'f' g'h'q't'o' c'v'k'p'u'q'p' 'o' letq'tguqpcvqt' 'u'w'h'c'g'f'0'

Vj' k'u' t'g'ug't'c'j' "y' c'u' 'h'w'p'f' g'f' " d { " 'y' j' g' 'N'c'w'k'c'p' " 'E'q'w'p'ek'i' q'h' 'U'ek'p'eg' " r' t'q'l'g'v' " P'q'0' n' r /423: B/2732" c'p'f' " GTF'H' 30807B; IC 1225'i' t'c'p'w'0'

- 13\_ " [ 0\ j gpi . " 0'Y w' 'R0'Rkpi 'Uj wo .\ \ 0'Z w' 'I 0'M'g'k'ug't' . 'I 0'J wo d'g't'v' 'I 0' j' c'p'i' . "U'0' g'p'i' . "c'p'f' "Z'0'S w'g'p'f' 'F'k'p'j' . "U'g'p'uk'p'i' "c'p'f' "N'c'ul'p'i' "C'r'r' n'c'c'v'k'p'u'q'h' " Y j' k'j' g't'k'p'i' 'I' c'm'g't' { 'O' q'f' g' 'O' letq'tguqpcvqtu' . 'Q'r' v'q' /G'g'v'g't'q'p'l'e' 'C'f' x'03 . '3: 223723' " "423: -0'
- 14\_ " 0'0'0'H'q't'g'o' c'p' . 'I'0'F'0'U'y' c'l'o' . 'c'p'f' 'H'D'X'q'm'o' g't' . 'Y' j' k'j' g't'k'p'i' 'I' c'm'g't' { 'O' q'f' g' 'U'g'p'u'q't'u'c'G'g't'c'w'o' . 'C'f' x'0'Q'r' '0'R'j' q'v'q'p'l'e'u'9 . '854' " "4237' -0'
- 15\_ " 'T'0'D'g't'k'u' 'L'0'C'p'l'k'u' 'C'0'C'w'c't'u' 'I'0'D't'leg' . 'M'0'F' t'c'i' w'p'u' . 'c'p'f' 'M'0'I' t'w'p'f' u'v'g'k'p'u' . 'S' w'k'v'k'f' 'H'c'v'q't' 'O' g'c'u'w't'g'o' g'p'u' 'h'q't' 'RO O C'Y I O 'o letq'r' j' g't'g' 't'g'u'q'p'c'v'tu' " 'W'k'p'i' 'H'z'g'f' 'Y' c'x'g'g'p'i' v'j' 'N'c'ug't' 'c'p'f' 'V'g'o' r' g't'c'w't'g' 'E'j' c'p'i' g'u' . 'R't'q'e'0423; 'I'G'G'G'; v'j' 'k'p'0'E'q'h'0'P' c'p'q'o' c'v'g't'0'C'r'r' r'0'R't'q'r'0'P'0423; " ; " "423; -0'
- 16\_ " 'C'0'D'0'R'g'g't'o' c'p'p' . 'V'0'J' k'f' g'd'c'p'f' v' 'W'0'0' q't'i' p'g't' . 'D'0'Y' 0'T'q'j' . 'c'p'f' "O'0'O' g'k'p'j' c't'f' v'Y' q'm'y' g'd'g't' . 'R'q'r' n' o' g't' 'D'c'ug'f' 'Y' j' k'j' g't'k'p'i' 'I' c'm'g't' { 'O' q'f' g' "J' wo k'f' k'f' " 'U'g'p'u'q't' . 'U'g'p'u'q't'u' 'U'y' k'j' g't'r'c'p'f' #3: . '3' " "423: -0'
- 17\_ " 'T'0'R'q'r' q'x' . 'I' 0'M'0'U'j' c'p'n'c' . 'E'0'x'q'p' 'D'q'l'p'l'e'l'e' /M'p'l'p'u'k' 'R'0'D'c't'w'e' . 'F' 0'O' c'w'g'u' . 'H'0'D't'g'k'r'k'p'i' . 'c'p'f' "C'0'P' g'ug't'q'x' /O' w'ng'm't' . 'U'q'ej' c'w'k'e' 'F' g'r' k'v'q'k'p'q'h' 'C'o' k'p'q' " 'C'ek' u'k'p'q' 'O' letq'c'v'k'x'k'g'u' 'x'k' 'O' letq'r' c't'v'k'g'u' 'U'ek'0'T' g'0; . '3' " "423; -0'

# HOLDER FOR IMPEDANCE SPECTROSCOPY MEASUREMENTS OF MIXED CONDUCTORS IN INERT GAS ATMOSPHERE

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Thermal nanocrystallisation of glasses is a method of obtaining highly conductive nanomaterials by means of appropriately selected heat treatment. Experiments carried out at our faculty have shown that this method can lead to a huge increase in electrical conductivity of selected glassy analogues of cathode materials for lithium-ion batteries, even by 9-10 orders of magnitude [1, 2]. Recent studies of the glassy analogues of cathode materials for sodium batteries from NASICON family [3] and alluaudites [4] did not confirm this observation. It is believed that sodium ion conductors may react differently to the heating in air than lithium conductors. Hence the need to investigate the change of conductivity of these materials during thermal nanocrystallization.

During this work we adapted existing systems to measure impedance as a function of temperature, in the flow of inert gas (argon). We constructed the hermetic measuring holder with a gas inlet and then carried out impedance measurements as a function of temperature. The schematic of the holder is shown in Fig. 1. Test measurements were performed to check the effect of an inert atmosphere on the nanocrystallization process of the materials. Those measurements also confirmed that the designed device works properly. The obtained Arrhenius curves (which show how conductivity of studied sample depends on temperature) were compared with the same curves obtained for samples which were nanocrystallized in air.

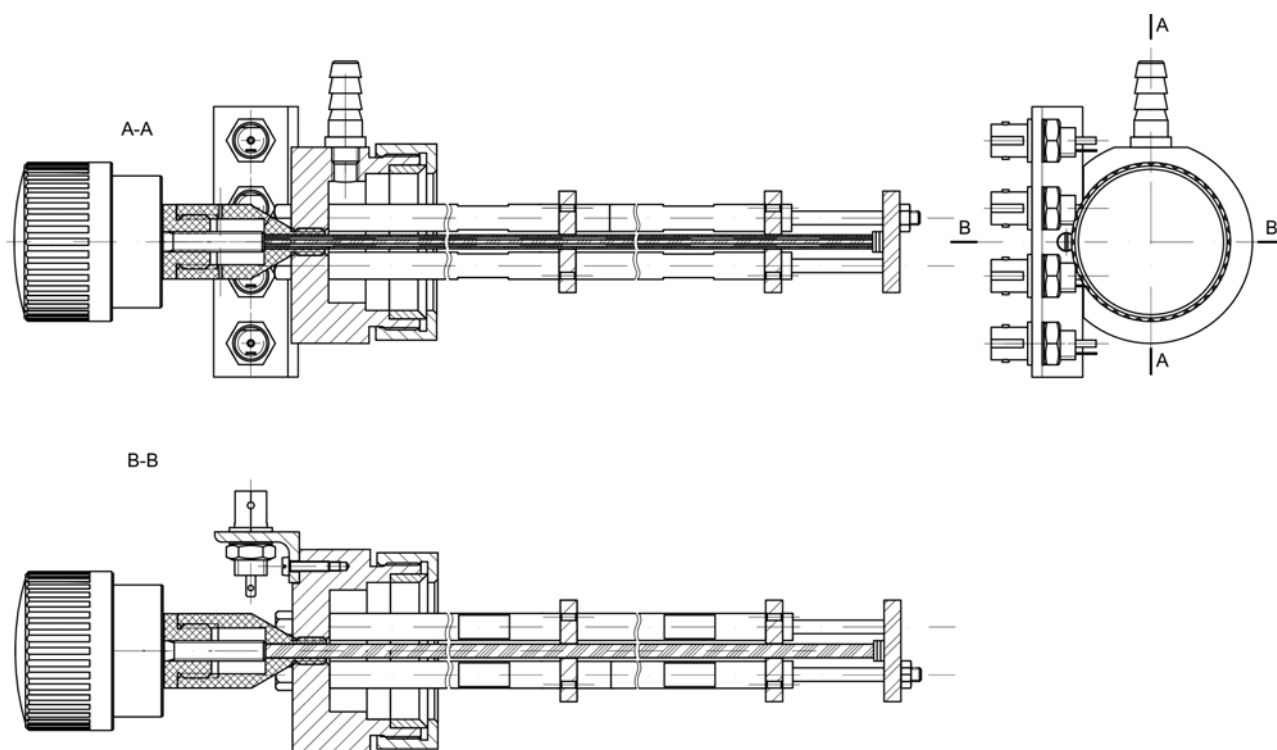


Fig. 1. The designed impedance measurement holder.

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- [2] J.E. Frackiewicz, T.K. Pietrzak, M. Wasiucione, J.E. Garbarczyk: Synthesis and Characterization of Highly-Conducting Nanocrystallized  $\text{Li}(\text{Fe}_{1-x}\text{Mn}_x)_{0.88}\text{V}_{0.08}\text{PO}_4$  Cathode Materials ( $x = 0.25, 0.5, 0.75$ ). *ECS Transactions* 80 (2017) 325-330.
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# ENHANCED DETECTION OF UV-INDUCED FREE-CARRIERS BY MULTIPLE PROBE BEAM PASSES INSIDE A CO-DOPED GAGG CRYSTAL

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In this work, we have investigated the advantages of increasing the 1064nm CW<sup>1</sup> probe interaction length in a  $\text{Gd}_3\text{Al}_2\text{Ga}_3\text{O}_{12}$  (GAGG:Ce,Mg) crystal by multiple internal reflections off two gold-coated parallel faces with entry/exit 0.75mm windows (Fig. 1). Modelling of such geometry enabled a more comprehensive experimental approach in terms of achieved results and time consumption by acquiring incidence angles of interest. Signal enhancement thus is achieved by maximizing free carrier absorption of the probe beam through increasing the path travelled inside the sample. A 266nm pulsed pump of  $4.2\mu\text{J}$  inducing  $1.6 \times 10^{15}\text{cm}^{-3}$  free carriers – two orders of magnitude lower than the previous results – in a cubic GAGG sample ( $5 \times 5 \times 5\text{mm}^3$ ) yielded a 1% signal change using an InGaAs detector. Higher energy pulses of 0.29mJ showed a signal change up to 65%.

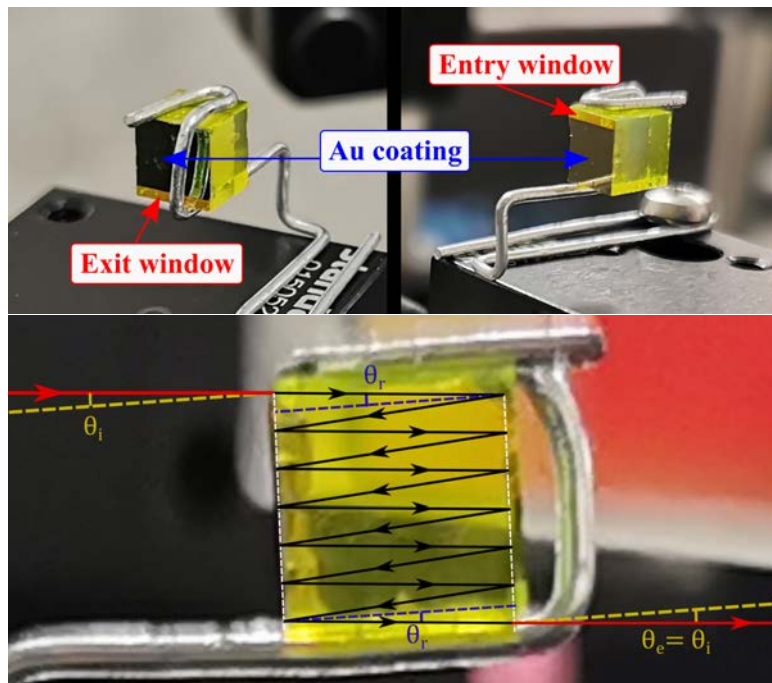


Fig. 1. (Top Right) Entry window, (Top Left) Exit window, (Bottom) Multiple reflections of the probe inside a cubic sample.

<sup>1</sup>Continuous Wave.

# METAL GRATING DEPOSITION, CHARACTERIZATION AND IMPACT ON OPTICAL RESPONSE OF GaAs/AlGaAs NANOSTRUCTURES

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Metal grating (MG) is a critical technique to study the optical properties of quantum structures in epitaxially grown samples [1]. It allows to change the direction of electric field of incident electromagnetic wave that it can couple with the confined electrons in the quantum system. As a result, one can optically measure the electronic structure of the quantum levels in simple experiment geometry [2]. In this work, the MG were deposited on the AlGaAs/GaAs samples and THz range optical response of the samples with MGs are studied. Two samples were used in the experiment. One consists of epitaxially grown AlGaAs on GaAs substrate, the other contains a superlattice of 35 pairs of GaAs/AlGaAs layers on GaAs substrate with GaAs/AlAs buffer.

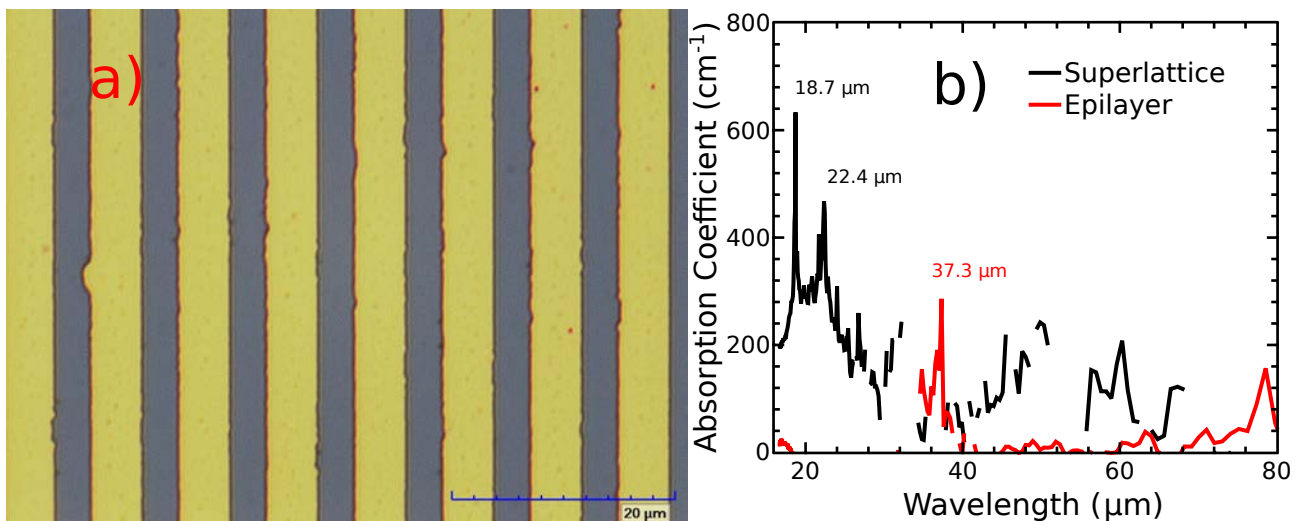


Fig. 1. Image of the MG on the sample surface under the optical microscope. Absorption spectrum of the AlGaAs/GaAs sample with MG in respect to GaAs spectrum (as reference). The red arrows indicate the measured resonance absorption peaks and blue arrows indicate the expected position of the resonance peaks defined by the grating period.

The MG was fabricated using photolithography and thin metal film sputtering techniques. First, the surface of the samples was rinsed using acetone, isopropanol and deionized water. Next, the samples were covered with photoresist and a Mask Aligner SUSS MA/BA6 Gen 4 was used to form the negative photoresist pattern by exposing the samples to UV light through the mask. Then, metalization of 20 nm/180 nm Ti/Au were deposited in vacuum by a E-Beam TFDS-870 equipment. Finally, the samples were immersed in the DMSO to remove remaining photoresist and washed in deionized water. The optical absorption spectra were measured using Fourier transform spectrometer Nicolet 8700 (Thermo Fisher Scientific, U.S.A.).

Fig. 1a shows the MG on the sample surface under the optical microscope. One can see perfectly aligned metal stripes although the edges of the stripes are slightly uneven. The filling factor of the grating is around 0.6 and the period of the grating is  $8 \mu\text{m}$ . The measured optical absorption coefficient spectrum reveals the strong resonance absorption lines at  $18.7 \mu\text{m}$  and  $22.4 \mu\text{m}$  for superlattice sample, as one can see in Fig. 1b. The reference sample with AlGaAs epilayer shows the single absorption resonance line at  $37.3 \mu\text{m}$

For conclusions, the high-quality MGs were fabricated using photolithography and thin metal film sputtering. The absorption coefficient spectra of the samples show well defined resonance lines. The peaks of superlattice sample at 16 THz and 13.4 THz frequencies may tentatively be attributed to THz radiation coupling with the electrons in the quantum system, whereas the peak of AlGaAs epilayer sample at 8 THz – to the THz radiation coupling with the phonons system.

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[2] M. Karaliūnas, J. Pagalys, V. Jakštas, R. Norkus, A. Urbanowicz, J. Devenson, R. Butkutė, A. Udal, and G. Valušis, Spectral properties of incoherent terahertz torch based on parabolic Ga(As,Bi)/AlGaAs quantum wells, *Proc. of SPIE* **11124**, 1112409 (2019)

# QDUVTWEVXG'UNGGR'CRPGC'RTGXGPVPI 'CPF'VTGCVPI 'DGF''

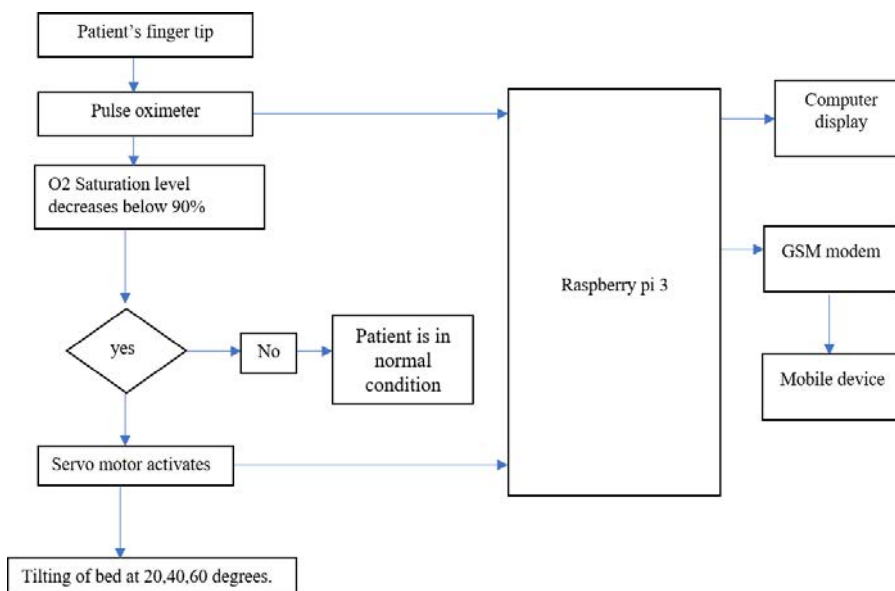
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[uwpcfct' Ctwo wi co B mwQfw'](#)

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Vj g'o clp"o qv'xg'qh'yj ku'r tql'gev'ku'v'q'r t'q'x'kf g'cp"cn'gt'p'cv'xg'o g'yj qf "v'q'uw'iti lecn'v'g'cvo gpw'0'k'p'uw'iti lecn'o g'yj qf u." f qev'qtu'wugf 'v'q'tgo q'xg'yj g'v'qpi w'g'd'cug'yj kj 'y'j g'j gm 'qh'v'ug'v'g'cvo gp'0'Vj ku'y kn'let'g'c'v'f lue'qo hqt'v'v'q'yj g'r cvl'gpv'0'Rt'gugpv' r tql'gev'ku'v'q'cm' 'c'p'qp/k'p'cx'k'xg'cr r t'q'cej . 'y j lej 'y kn'p'gx'gt 'ecw'ug'cp { 'f lue'qo hqt'v'v'q'yj g'r cvl'gpv'0'Vj g'r tql'gev'eqo r t'k'ug'v' qh'r w'ug'q'z'ko g'v'gt. 'ugt'x'qo q'v'qt. 'uwur gp'uk'qp"dgf 'k'p'v'g't'h'c'egf "v'q'yj g'T'cur d'gtt { "RK5"o let'q'ep'v't'q'm'gt"j3\_0'k'p'ku'r t'q'i t'co o g'f " wul'kpi 'r { y'j qp'0'Rw'ug'q'z'ko g'v'gt 'f g'v'ge'u'yj g'r w'ug't'c'v'g'cp'f "q'z { i gp'uc'w't'c'v'k'qp'rg'x'gn'qh'yj g'r cvl'gpv'0'U'gt'x'qo q'v'qt 'ku'c'w'cej g'f " w'p'f g't'yj g'r cvl'gpv'w'd'gf 0'Rw'ug'q'z'ko g'v'gt 'ku'k'p'ug't'v'g'f "v'q'yj g'h'k'p'i g't'v'k'v' qh'yj g'r cvl'gpv'0'P q'to c'n'l'q'z { i gp'uc'w't'c'v'k'qp'rg'x'gn'ku'; 2'v'q' ; 7' 0'Y j gp'yj g'q'z { i gp'uc'w't'c'v'k'qp'rg'x'gn'f g'et'g'c'ug'u'd'gm'y " ; 2' . 'y'j g'r w'ug'q'z'ko g'v'gt 'ug'p'f u'yj g'uki p'cn'v'q'yj g'ugt'x'qo q'v'qt 'v'q' v'k'v'yj g'd'gf 'c'v'yj t'gg'f k'h'g't'gp'v'c'pi ngu'p'co gn' '42. '62. '82'f g'i t'gg'u'0'Vj ku'v'k'p'i 'qh'd'gf 'dt'k'p'i u'yj g'q'z { i gp'uc'w't'c'v'k'qp'rg'x'gn'd'c'cn' v'q'p'q'to c'n'l'c'p'f 'y'j w'r t'gx'gpw'dt'g'c'v'j ngu'p'guu'k'p'r cvl'gpv'0'k'p'c'f f k'k'q'v'q'yj ku'T'cur d'gtt { 'r k'5'o let'q'ep'v't'q'm'gt'y'kj 'y'j g'j gm " qh'I UO "o qf w'g'ug'p'f u'c'p'c'ng't'v'o gu'uci g'k'p'yj g'h'q'to 'qh'UO U'v'q'yj g'f q'ev'qt'au'o q'd'k'rg'r j q'p'g'j4\_0'Vj g't'gd { . 'y'j ku'r t'gx'gpw'v'yj g' r cvl'gpv'w'ht'qo 'qdwtwev'xg'unggr 'cr pgc'0'



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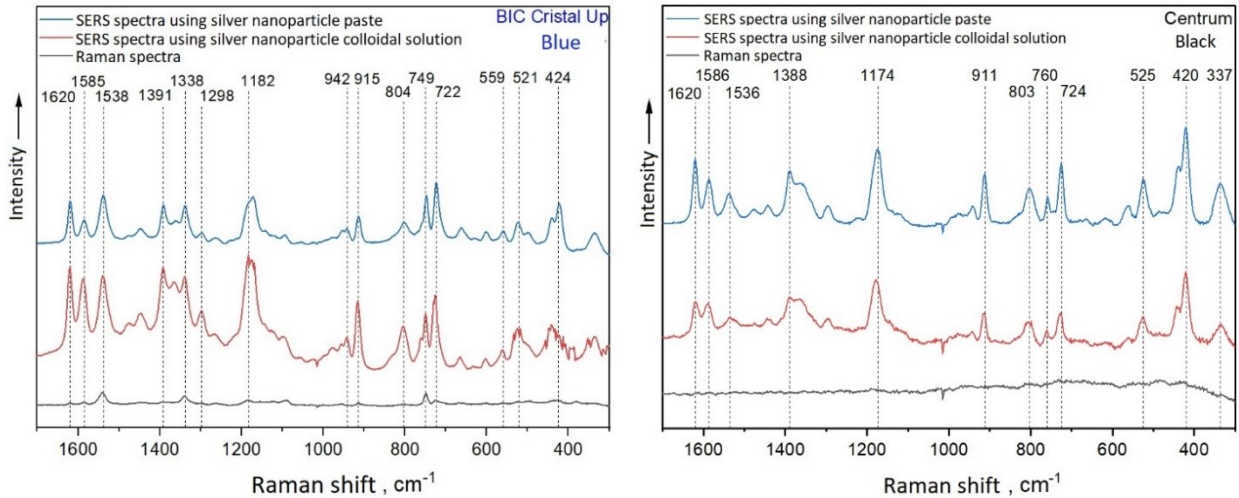
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 GP J CPEGF 'TCO CP 'URGEVTQUEQR[ "  
 F ckcpc'Chcpqxckv <sup>3</sup>. 'O ctv{ pcu'Xgrk m<sup>3</sup>"**

<sup>3</sup>Kpukwng'qh'Ej go kecn'Rj { uku.'Hcewn{ 'qh'Rj { uku.'Xkpkwu'Wpkkgtuk{ . 'Nksj wpcpk  
 f ckcpc'Chcpqxckv B Hhwwf kwwh''

Gxgp'y kj 'gxqkxkpi 'vgej pqrqi { . 'f qewo gpv'htqti gt { 'eqpvpwgu'vq'dg'c'o clqt'r tqdrigo . 'ecwukpi 'f co ci g'vq'pqr'qpn' ' kpf kxk wcu.'dw'cuq' qti cpk cvkpu.'dcpmu.'cpf 'gxgp'y j g'geapqo { "qh'y j qng'eqwvtkgu" ]3\_0'Hqti gt { "f wtkpi "hgtgpule" cpcn[uku'ku'f gvgtto kpgf "d{ "f gvgtto kpkpi "v j g'eqpvgpu'qh'y j g'f qewo gpv'lp's wguvkqp.'ur gekkhecnf "v j g'ej go kecn'eqo r qukkqp" qh'y j g'eqpukwgpwu.'cpf 'eqo r ctkpi "v j g'f khtgt pgegu'dgy ggp 'ugevku'lp'v j g'f qewo gpv']4\_0"

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Hki 030Uwt'heg/gpj cpegf 'Tco cp'uecwtkpi "ur gev'c'qh'dw'g'v'ghw' "cpf "d'v'cni't'ki j v' "kpmu'eqm'gev'g' "wukpi "uk'kg't' p'p'qr ct'v'erg'r cug'c'p'f "eqm'kf cni'uc'v'k'k'p'w'0"

aa " ]3\_0'U'0Dcgej ngt.'F qewo gpv'H'cwf '<Y kni' [ qw' "kf gpv'k' { "Dg'U'ge'wg'lp'v j g'V'v' gpv' /H'ku'v'E'gp'wt { A'G'wt'qr gcp'Lv'wt'p'cni'q'p'Et'ko k'p'cni'R'q'ite { "cpf "T'gug'ctej ." 48\*5+;59; 65; : \*4242-0' ]4\_0'0'Dtc { ."0'0'N'qr gl /N'qr gl ."E'0'I cte'ik' /T'w'k . "Tco cp'ur gev'queqr { "hqt' hgt'gpule' cpcn[uku'qh'kpmu'lp's wguvkp'g'f "f qewo gpv.'H'gt'gpule' "U'ek'p'eg' "k'p'v'gt'p'c'v'k'p'cni'45\*5+;4286434\*4235-0' ]5\_0'0'E'c'v'gt'tcf c.'E'0'I cte'ic' /T'w'k . 'C'p'cni'uku'qh's wguvkp'g'f "f qewo gpv'<C'v'g'x'g'y . 'C'p'cni'v'ec' 'Ej lo lec' 'C'ev.'. 75\*3+;3656388\*4237-0'

**VJ G'EJ QQUG'QH'QRVKO CN'E QPF KVKQP UHQ'T'VJ G'F GXGNQRO GP V''  
 QHI NWEQUG'DKQNQI KE CN'UGP UQT'DCUGF 'QP' K'P UQNWDNG''  
 GNGEVTQP'VTCPUHGT'O GF KCVQT''**

Gt kn' Rwkpegxckg<sup>3</sup>. 'P cvnk'c'I gto cp<sup>4</sup>

<sup>3</sup>F gr ctwo gpv'qh'Ej go knt { 'cpf "Dkqppi kpggtkpi . 'Hewm' 'qh'Hw'pf co gpvcn'Uelgpegu. 'Xkpkwu'I gf ko kpcu'Vgej pkecn' Wpkxgtuks' 'Xkpkwu'Vgej . 'Ucvngvknq'cxg(83. 'NV/32445. 'Xkpkwu. 'Nkj wpc'k'

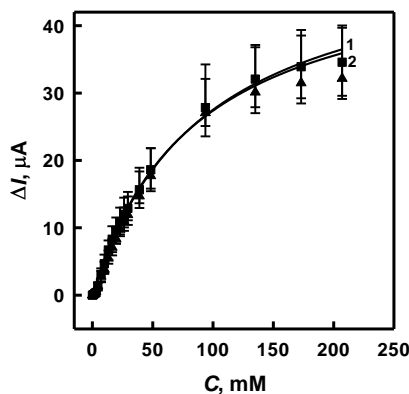
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gt kn' O wkpexckgB uwf Oki wfn'

"

Dkqmi lecn'ugpuqtu' hcmi' y kj lp' yj g' k'p'v'g't' k'ek'r' r'p'ct { ' hgrf. ' y j lej ' ku' qpg' qh' yj g' o quv' cev'x'g' t'gugctej ' ctgcu' kp' cpcn' v'ec'n'ej go knt { "j3\_0'Xctk'qwu'egmu. 'dcevg'k'c. 'cp'v'k'd'q'f' l'gu. 'cp'v'k' i' g'pu. 'gp' { o gu'cpf "o wnk'egm'w'ct' r'k'k'k'p' i' q'ti' c'p'k'u' u'ct'g' wugf " v'q' f' g'x'g'nr' "ur' g'ek'h'e" cpf "ugr'ge'v'k'g' d'k'q'ug'p'u'q'tu' ]3.4\_0'Ncu' f' g'ec'f' g' yj g' "eqo d'k'p'c'v'k'q'p' qh' g'p' { o c'v'k'e' d'k'q'ug'p'u'q'tu' cpf " g'g'ev't'q'ej go lecn' o g'v'j' q'f' u' f' w'g' yj g'k' "ugr'ge'v'k'k'v' " d'geco' g' x'g't' { " r'q'r' w'ct' " cpf " h'q'w'p'f' yj g' " cr' r' r'k'ec'v'k'q'p' h'q't' f' k'ci' p'q'u'k'e' " cpf " o q'p'k'q't'k'p'i " k'p' f' k'h'g't' g'p'v'c't'g'c' q'h' l'p'f' w'w' { . "o gf k'elp'g' 'cpf " r'j' c't'o' c'e'q'm'j' { "j5\_0'c'd'q'w': 7' " qh'yj g'v'c'n'i'd'k'q'ug'p'u'q'tu' o' c't'ng'v'c't'g' " i' n'w'e'q'ug' d'k'q'ug'p'u'q'tu' ]6\_0'G'g'ev't'q'ej go lecn' g'p' { o g' " d'k'q'ug'p'u'q'tu' d'c'ug'f' " q'p' " i' n'w'e'q'ug' " q'z'k'f' c'ug' " r' r'c' { " c' " u'k'i' p'h'k'ec'p'v' t'q'ng' " h't'q'o' " u'k'o' r' n'g' " g'cu' { /v'q' w'ug' d'm'q'f' " i' n'w'e'q'ug' " v'g'u'u' w'p'v'k'i' e'q'p'v'p'w'q'w'u' i' n'w'e'q'ug' o' q'p'k'q't'k'p'i " ]3.4\_0'Xctk'q'w'u' o' g'v'c'n' p'c'p'q'f' g't'k'c'v'k'g'u. " u'w'ej " cu' " p'c'p'q'r' c't'v'eng'u' " cpf " p'c'p'q'u't' w'ew't'g'u. " c't'g' " w'ug'f' " v'q' " k'p'et'g'c'ug' " yj g' " g'g'ev't'q'f' g' " u'w'h'c'eg' " c't'g'c' " cpf " " k'o' r' t'q'x'g' " yj g' " g'g'ev't'lecn' e'q'p'f' w'ev'k'k'v' " ]6.7.8\_0' D'k'q'ug'p'u'q'tu' " yj k'j " k'o' o' q'd'k'k' g'f " g'p' { o' g'u' " c'p'f' " o' g'v'c'n' p'c'p'q'f' g't'k'c'v'k'g'u' " c't'g' " e'j' c't'c'e'v'g't'k' g'f " d' { " j' k' i' j' " u'g'r'ge'v'k'k'v' . 'u'g'p'u'k'k'k'v' . 't'c'r' k'f' k'v' . 't'g'x't' u'k'd'k'k'v' . 't'g'r' t'q'f' w'ek'd'k'k'v' . 'r' t'c'e'v'k'ec'n' r' r'k'ec'v'k'q'p' 'c'p'f' " y' g'm'le'c'v'c'n' v'k'e' 'c'e'v'k'k'k'g'u' ]6.7\_0'

Vj g' c'k'o' " q'h' yj g' t'gugctej " y cu' v'q' " u'g'r'ge'v' " q'r' v'k'o' c'n' e'q'p'f' k'k'q'p'u' h'q't' " yj g' f' g'x'g'nr' o' g'p'v' q'h' i' n'w'e'q'ug' d'k'q'ug'p'u'q't' d'c'ug'f' " q'p' " k'p'u'q'w'd'ng' " o' g'f' k'c'v'q't' " - "3.32/r'j' g'p'c'p'v'j' t'q'n'k'p'g/7.8/f' k'q'p'g' " c'p'f' " x'c't'k'q'w'u' v'f' r' g'u' q'h' i' q'n'f' " c'p'f' " r' r'v'k'p'w'o' " p'c'p'q'f' g't'k'c'v'k'g'u' O' h'q't' " yj k'u' " r' w'r' q'ug' . " i' t'c'r' j' k'g' " g'g'ev't'q'f' g' " y cu' " w'ug'f' " cu' " y q't'n'k'p'i " g'g'ev't'q'f' g' . " e'j' t'q'p'q'c'o' r' g't'q'o' g'v't' { " c'p'f' " e' { e'k'le' " x'q'n'c'o' o' g'v't' { " - " cu' " g'g'ev't'q'ej go lecn' o' g'v'j' q'f' u' " h'q't' " yj g' " t'g'i' k'u't'c'v'k'q'p' " q'h' " c'p'c'n' v'k'e'c'n' u'k'i' p'c'n' c'p'f' " yj g' " g'x'c'n'w'c'v'k'q'p' " q'h' " yj g' " g'g'ev't'q'ej go lecn' r' t'q'eg'u' " t'g'x't' u'k'd'k'k'v' O' k'v' y' cu' l'p'x'g'u'k'i' c'v'g'f' " yj c'v' " g'g'ev't'q'ej go lecn' { " u' { p'v'j' g'u'k' g'f' " i' q'n'f' " c'p'f' " r' r'v'k'p'w'o' " p'c'p'q'u't' w'ew't'g'u' k'p' " c' " e'q'o' d'k'p'c'v'k'q'p' " y k'j " i' n'w'e'q'ug' " q'z'k'f' c'ug' " q'h' h'g't' g'f' " u'q'o' g' " c'f' x'c'p'v'c'i' g'u' " yj g' " f'c'e'l'k'k'c'v'k'q'p' " q'h' l'p'f' k' t'g'ev' " g'g'ev't'q'p' " t'c'p'u'h'g't' . " j' k' j' g't' " u'w'h'c'eg' " c't'g'c' " c'p'f' " yj g' " r' q'u'k'k'g' " g'h'g'ev' " q'p' " yj g' " c'p'c'n' v'k'e'c'n' u'k'i' p'c'n' " h'q't' " yj g' " f' g'u'k'i' p' " q'h' i' n'w'e'q'ug' d'k'q'ug'p'u'q'tu' O' k'v' y' cu' l'p'x'g'u'k'i' c'v'g'f' " yj c'v' " u'w'ej " e'q'o' r' q'w'p'f' " cu' " e'j' k'q'uc'p' " o' k'z'g'f' " y k'j " i' n'w'e'q'ug' " q'z'k'f' c'ug' " c'p'f' " k'o' o' q'd'k'k' g'f " q'p' " yj g' " e'q'x'g't' g'f " d' { " i' q'n'f' " q't' " r' r'v'k'p'w'o' " p'c'p'q'f' g't'k'c'v'k'g'u' " u'w'h'c'eg' " q'h' " i' t'c'r' j' k'g' " g'g'ev't'q'f' g' " f' q'g'u' " p'q'v'j' c'x'g' " u'k'i' p'h'k'ec'p'v' " g'h'g'ev' " v'q' " yj g' " u'g'r'ge'v'k'k'v' " q'h' i' n'w'e'q'ug' d'k'q'ug'p'u'q't' O' k'v' y' cu' " f' g'v'g'ev'g'f' " yj c'v' " o' q't'g' " u'w'k'c'd'ng' " k'u' " d'k'q'ug'p'u'q't' " k'o' o' q'd'k'k' g'f " d' { " q'p'g' " r'c' { g't' " q'h' " g'c'ej' " e'q'o' r' q'w'p'f' u' " k'p' " yj g' " r' " t'g'ug'p'eg' " q'h' r' r'v'k'p'w'o' " f' w'g' " yj g' " j' k' j' " c'p'c'n' v'k'e'c'n' u'k'i' p'c'n' c'p'f' " i' q'q'f' " t'g'r' g'c'v'd'k'k'v' O' v'j' g' " q'r' v'k'o' c'n' " k'o' o' q'd'k'k' c'v'k'q'p' " u'q'w'k'q'p' " h'q't' " r' r'v'k'p'w'o' " p'c'p'q'u't' w'ew't'g'u' " h'q't'o' c'v'k'q'p' " c'p'f' " yj g'k' " e'q'x'g't' g'f " e'q'p'f' k'k'q'p'u' " y g't'g' " l'p'x'g'u'k'i' c'v'g'f' . " yj g'p' " yj g' " d'c'u'k'e' " c'p'c'n' v'k'e'c'n' e'j' c't'c'e'v'g't'k'u'v'e'u' " y g't'g' " g'x'c'n'w'c'v'g'f' O' h'w'v'j' g't'o' q't'g' . " yj g' " f' g'x'g'nr' g'f' " d'k'q'ug'p'u'q't' " c'n'q' " q'h' h'g't' u' " yj g' " r' q'u'k'd'k'k'v' " q'h' i' w'k'p'i " w'w't'c'o' k'et'q'g'g'ev't'q'f' g'f' g'u'k'i' p'k'p'i " h'q't' " k'p' " x'k'x'q' " o' g'c'u'w't'g'o' g'p'w'o'



Hki (80'Ecn'k'd't'c'v'k'q'p' r' q'w'u' q'h' i' n'w'e'q'ug' d'k'q'ug'p'u'q'tu' w'k'p'i " e'j' t'q'p'q'c'o' r' g't'q'o' g'v't' { " \*3- " c'p'f' " e' { e'k'le' " x'q'n'c'o' o' g'v't' { " \*4- " o' g'v'j' q'f' u' " h'q't' " yj g' " k'o' o' q'd'k'k' c'v'k'q'p' " q'h' i' r'v'k'p'w'o' " p'c'p'q'u't' w'ew't'g'u' " q'p' " yj g' " u'w'h'c'eg' " q'h' i' t'c'r' j' k'g' " t'q'f' " g'g'ev't'q'f' g'o'

j3\_1\_0'Tgdqmt/Rgtgl. 'L0'Eco r qu/Vgtcp. 'P'0'Qtpgru/Uqy. 'C'0'O' gpf gl /Cndtgu. 'G'0'Vqttgu. 'D'k'q'ug'p'u'q'tu' d'c'ug'f' " q'p' " q'z'k'f' c'v'k'g' " g'p' { o' g'u' " h'q't' " f' g'v'g'ev'k'q'p' " q'h' g'p'x'k'q'p'o' g'p'v'c'n'f' q'm'w'c'p'u. 'D'k'q'ec'v'n'f' u'k'i' 3. '33: /34; \*4237-4'  
 j4\_1\_0'Nkw. 'J'0'Nk' 'S'0'j' c'q. 'T'0'j' w'f' l' O'j' c'p'i. 'S'0'Le. 'D'0'Dlcp. 'N'0'j' v'q. 'I' n'w'e'q'ug' u'g'p'u'k'k'g' e'q'm'k't'o' g'y'k'e' u'g'p'u'q't' d'c'ug'f' " q'p' " r' g't'q'z'k'f' c'ug' " o' k'o' l'eu' 'c'e'v'k'k'v' { " q'h' r' q't'r' j' { t'p' / H'g' Q'6' " p'c'p'q'eq'o' r' q'u'k'g'u. 'O' c'v'g't'k'c'n'i' U'el'g'p'eg' 'c'p'f' " G'p'i' k'p'g'g't'k'p'i " E' '63. '364/373 \*4236-4'  
 j5\_1\_0'Nek' [ l' O'j' k' 'R'0'j' j' w' " l'0'U'j' g'p. 'M'0'Y' w' " N'0'j' c'p'i. 'L'0'Nkw. 'R'q'n' c'p'k'k'p'g' d'c'ug'f' " i' n'w'e'q'ug' d'k'q'ug'p'u'q't' " C' " t'g'x'g'y. ' " l'q'w't' p'c'n' q'h' " G'g'ev't'q'c'p'c'n' v'k'e'c'n' E'j' go k'nt { " 9: 4. '35: /375 \*4238-4'  
 j6\_1\_0'Y' c'p'i. 'G'g'ev't'q'ej go lecn'f' n'w'e'q'ug' d'k'q'ug'p'u'q'tu. 'E'j' go lecn'f' t'g'x'g'y' u' 32: .: 36: /47 \*422: -4'  
 j7\_1\_0'P'0'1' g't'o' c'p. 'C'0'T'c'o' c'p'c'x'k'k'v. 'C'0'T'c'o' c'p'c'x'k'k'p'g. 'C'o' r' g't'q'o' g'y'k'e' " i' n'w'e'q'ug' d'k'q'ug'p'u'q't' d'c'ug'f' " q'p' " g'g'ev't'q'ej go lecn'f' { " f' r' q'u'k'g'f' " i' q'n'f' " p'c'p'q'r' c't'v'eng'u' " e'q'x'g't' g'f' " d' { " t' q'n'f' { t' t'q'ng. 'G'g'ev't'q'c'p'c'n' u'k'i' 4: . '3489/3499 \*4239-4'  
 j8\_1\_0'P'0'1' g't'o' c'p. 'C'0'M'w'uck'g' / O' k'p'm'k'o' k'p'g. 'C'0'T'c'o' c'p'c'x'k'k'v. 'V'0'U'g'o' c'u'j' n'q. 'T'0'0' k'j' c'k'x'c. 'C'0'T'c'o' c'p'c'x'k'k'p'g. 'V'j' g' " w'ug' " q'h' f' k'h'g't' g'p'v' i' n'w'e'q'ug' " q'z'k'f' c'ug'u' " h'q't' " yj g' " f' g'x'g'nr' o' g'p'v' q'h' c'p' " c'o' r' g't'q'o' g'y'k'e' " t'g'c'i' g'p'v'g'u' i' n'w'e'q'ug' d'k'q'ug'p'u'q't' d'c'ug'f' " q'p' " i' q'n'f' " p'c'p'q'r' c't'v'eng'u' e'q'x'g't' g'f' " d' { " r' q'n'f' { t' t'q'ng. 'G'g'ev't'q'ej go lecn'f' 'C'ev'c' 38: . " 548/555 \*4237-4'

**VJ G'GP\ [ O G/CUUKVGF 'U\ P VJ GUK'QHRQN[ O GTĒE''  
P CPQE QO RQUKVGUCPF 'VJ GKT'RP XGUVK CVKQPU'**

T wi krg'Ej o kercwunckg<sup>3</sup>. P cverlc'I gto cp<sup>4</sup>

<sup>3</sup>F gr ctwo gpv'qh'Ej go knt { 'cpf 'Dkqgpi kpggtkpi . 'Hcewn\ 'qh'Hw'pf co gpv'cn'Uelkpegu.'Xkpkwu'I gf ko kpcu'Vgej pkecn'  
Wpkxgtuk\ 'Xkpkwu'Vgej . 'Ucwngvntk'cxgŮ3. 'NV/32445.'Xkpkwu.'Nkj wcpk"

<sup>4</sup>F kxkukqp'qh'kō o wpmj { . 'Ucvg'Tgugctej 'kpkwkwg'Egpygt'ht'kppqxcvkg'O go lekpg.'Ucpvtkunk 'i 07.'NV/2: 628.'  
Xkpkwu.'Nkj wcpk"

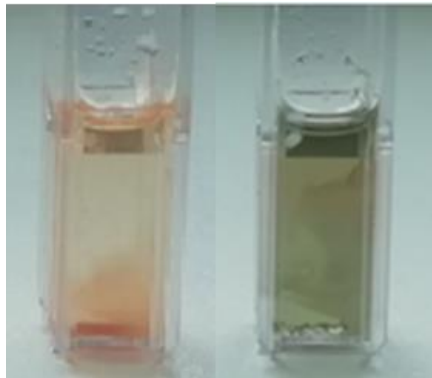
t wi krg'ej o kercwunckgB uwf Ůki wŮw'

"

Ncu' f gecf gu' y g' kpygt guv' qh' pcpq/ " cpf " dkq'gej pqmj { Ů' cr r nkecvkp " kp " y g' f kci pquveu' cpf " y g' o qpkqt kpi " qh' eqo r qwpf u' kpet gcugf " tcr kf n\ " ]3.4\_0' Grgevtqej go kecn' gp| { o cvle' dkqgpuqtu' ctg' y g' o quv' r qr wrc' cpf " y kf gn\ " wugf " kp' erpklecn' cpcn\ uku. 'r j cto cegwkecu. 'hqqf 'r tgeguiki 'kp' wut'kgu' cpf " gp'xktqpo gpv'cn' o qpkqt kpi " f w' v' q' y g' k' ur ge' h' k' k' " cpf " ugpukxkx\ " kp' eqo r r'gz " u\ ugo u' ]4\_0' F kcdgvgu' o gnkwa " - " y g' o quv' eqo o qp' gpf qet kpg' f kuqtf gt " qh' ectdqj { f tcv' o g' vcdq'kuo " cpf " ku' eqpukf gtgf " c' ej tqple " f kugcug' ecwugf " d { " lo r tqr gt " tgi wrcv'kp' qh' i n'weqg' kp' y g' drqf " ]4.5\_0' Wuwcm\ " j ki j " ugpukxkx\ " cpf " ugrge'v'xkx\ . " y g' tcr kf k\ " cpf " y g' t' g' x' g' t' u' d' k' k' . " y g' cr r nkecvkp' cpf " y g' g' z' e' g' n' p' v' e' c' n' \ " v' e' c' v' k' k' g' u' c' t' g' ej ctcevtk\ gf " hqt " grgevtqej go kecn' dkqgpuqtu' ko o qdkk\ gf " d { " gp| { o g' cpf " r qn\ o gtu' ]4.6.7\_0'

Vj g' o clp' cko " qh' y j ku' t' g' u' g' c' t' e' j " y cu' v' u\ { p' y' g' u' k' g' r' qn\ o g' t' k' e' p' c' p' q' e' o' r' q' u' k' k' p' u' \* R' P' E' + y' k' j " go dgf f gf " i n'weqg' qz' k' f' c' u' g' " cpf " v' f' g' x' g' n' r " i n'weqg' dkqgpuqtu' ko o qdkk\ gf " d { " uwe' j " R' P' E' " y' k' j " h' q' m' y' k' p' i " c' f' f' k' k' p' g' " qh' gp| { o g' V' q' c' e' j' k' x' g' " grgevtq' v' t' c' p' u' h' t' " d' g' y' g' p' y' g' u' q' n' w' k' q' p' " cpf " i' t' c' r' j' k' g' t' q' f' " g' r' e' v' t' q' f' g' u' q' n' d' r' g' o' g' f' k' c' v' q' t' " - " r' j' g' p' c' l' k' p' g' o' g' y' q' u' w' t' c' v' g' \* R' O' U' + y' cu' wugf O' K' y' cu' r' t' g' f' k' e' v' g' " y' c' v' h' q' t' o' g' f' " d { " gp| { o g' cuukv' g' f' r' qn\ o g' t' k' e' c' v' k' p' r' qn\ c' p' k' k' p' g' " cpf " r' qn\ r' { t' t' q' r' g' " p' c' p' q' e' o' r' q' u' k' k' p' g' " c' t' g' " c' d' r' g' " v' q' " h' e' k' k' c' v' g' " k' p' f' k' t' g' e' v' " g' r' e' v' t' q' p' " v' t' c' p' u' h' t' " cpf " j' cu' v' j' g' r' q' u' k' k' x' g' " g' h' g' e' v' " q' p' " y' g' u' g' p' u' k' k' x' k' \ " cpf " u' g' r' e' v' x' k' x' \ " qh' f' g' x' g' n' r' g' f' " u\ ugo " ]4.6.7\_0' Vj g' o quv' uwkcdrg' ko o qdkk\ cvkq' o g' y' qf " d { " R' P' E' " cpf " y' g' n' k' p' f " qh' r' qn\ o g' t' y' g' t' g' " e' j' q' u' g' p' " k' p' " q' t' f' g' t' " v' q' " ko r t' q' x' g' " c' p' c' n' \ " v' e' c' n' e' j' c' t' c' e' v' t' k' u' k' e' u' " qh' i' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' " f' w' t' k' p' i " t' g' u' g' c' t' e' j' 0' E' { e' i' n' e' " x' q' n' c' o' o' g' v' { " y' cu' wugf " v' q' " k' p' x' g' u' k' i' c' v' g' " y' g' " t' g' x' g' t' u' d' k' k' x' \ " qh' " g' r' e' v' t' q' e' j' go kecn' t' g' c' e' v' k' p' " cpf " y' g' " u' w' k' c' d' k' k' \ " qh' " f' g' x' g' n' r' g' f' " i' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' 0' O' g' c' p' y' j' k' r' g' . " c' p' q' y' g' t' " g' r' e' v' t' q' e' j' go kecn' o' g' y' qf " uwe' j' " cu' e' j' t' q' p' q' c' o' r' g' t' q' o' g' v' { " y' cu' wugf " h' q' t' " y' g' " k' p' x' g' u' k' i' c' v' k' p' u' " qh' " c' p' c' n' \ " v' e' c' n' e' j' c' t' c' e' v' t' k' u' k' e' u' " cpf " y' g' " u' e' d' k' k' x' \ " qh' " y' g' " f' g' x' g' n' r' g' f' " u\ ugo 0' K' y' cu' g' x' c' n' e' v' g' f' . " y' c' v' y' g' " c' f' f' k' k' p' g' " qh' " R' O' U' " k' u' " p' g' e' g' u' a' c' t' { . " d' g' e' c' w' u' g' " k' p' " y' g' " c' d' u' g' p' e' g' " qh' " o' g' f' k' c' v' q' t' " p' q' " g' r' e' v' t' q' p' " v' t' c' p' u' h' t' " k' u' " c' d' r' g' 0' C' n' j' q' w' i' j' " y' g' r' " t' g' u' g' p' e' g' " qh' r' qn\ r' { t' t' q' r' g' " p' c' p' e' q' o' r' q' u' k' k' p' g' " y' g' " u' w' t' h' e' g' " qh' y' q' t' n' k' p' i " g' r' e' v' t' q' f' g' " g' p' j' c' p' e' g' f' " y' g' " i' n' w' e' q' u' g' " c' p' c' n' \ " v' e' c' n' e' j' c' t' c' e' v' t' k' u' k' e' u' " p' c' n' y' g' o' q' u' v' . " j' q' y' g' x' g' t' " y' g' " m' y' g' t' " r' k' o' k' " qh' f' g' v' e' v' k' p' " y' cu' " q' d' v' c' l' o' g' f' " k' p' " y' g' " r' t' g' u' g' p' e' g' " qh' r' qn\ c' p' k' k' p' g' " p' c' p' q' e' o' r' q' u' k' k' p' u' 0' G' p' l' { o' g' / cuukv' g' f' " R' P' E' " e' q' w' f' " d' g' " c' r' r' n' \ " k' p' " y' g' " e' q' p' u' t' v' e' v' k' p' " qh' " g' r' e' v' t' q' e' j' go kecn' i' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' u' " cpf " e' q' w' f' " d' g' " w' u' g' " k' p' " f' k' h' g' t' g' p' v' f' k' e' i' p' q' u' k' e' " c' r' r' n' e' c' v' k' p' u' 0'

"



Hki ŮOHqto gf " d { " gp| { o g' cuukv' g' f' r' qn\ o g' t' k' e' c' v' k' p' r' qn\ c' p' k' k' p' g' " q' p' " y' g' " h' g' h' w' + " c' p' f' " r' qn\ r' { t' t' q' r' g' " q' p' " y' g' " t' k' i' j' v' u' q' n' w' k' k' p' u' 0'

"

[3\_ " H' O' Y' c' p' i . " U' O' J' w' " G' r' e' v' t' q' e' j' go kecn' l' u' g' p' u' q' t' u' " d' c' u' g' f' " q' p' " o' g' v' c' n' c' p' f' " u' g' o' l' e' q' p' f' v' e' q' t' " p' c' p' q' r' c' t' v' e' r' g' u' . " O' l' e' t' q' e' j' k' o' " C' e' w' " 387. " 3/44 " \* 422; #0'  
[4\_ " L' O' N' c' k' \ " I' 0' l' k' " R' O' \ " j' w' " L' O' U' j' g' p' . " M' O' Y' w' " N' O' \ " j' c' p' i . " L' O' N' k' w' . " R' a' n' \ c' p' k' k' p' g' / d' c' u' g' f' " i' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' u' " c' t' g' x' l' e' y' . " L' q' w' t' p' e' n' q' h' " G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' E' j' go k' n' t' { " 9: 4' " 35: / 375 " \* 4238-0'  
[5\_ " G' J' 0' l' q' q' . " U' O' J' 0' N' g' g' . " I' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' u' " c' p' " q' x' g' t' x' l' e' y' " qh' w' u' g' " k' p' " e' r' i' p' l' e' c' n' i' r' t' c' e' v' e' g' . " U' g' p' u' q' t' u' " 32-677: / 6798 " \* 4232-0'  
[6\_ " P' 0' I' g' t' o' c' p' . " C' O' T' c' o' c' p' c' x' l' e' k' p' g' . " C' O' T' c' o' c' p' c' x' l' e' k' u' . " H' j' t' o' c' v' k' p' " c' p' f' " g' r' e' v' t' q' e' j' go kecn' g' x' c' n' e' v' k' p' " qh' r' qn\ c' p' k' k' p' g' " c' p' f' " r' qn\ r' { t' t' q' r' g' " p' c' p' q' e' o' r' q' u' k' k' p' g' " d' c' u' g' f' " q' p' " i' n' w' e' q' u' g' " q' z' k' f' c' u' g' " c' p' f' " i' q' n' f' / p' c' p' q' u' t' v' e' w' t' g' u' . " R' a' n' \ o' g' t' u' " 34. " 5248 " \* 4242-0'  
[7\_ " P' 0' I' g' t' o' c' p' . " C' O' T' c' o' c' p' c' x' l' e' k' u' . " C' O' T' c' o' c' p' c' x' l' e' k' p' g' . " C' o' r' g' t' q' o' g' t' k' e' " i' n' w' e' q' u' g' " d' k' q' u' g' p' u' q' t' u' " d' c' u' g' f' " q' p' " g' r' e' v' t' q' e' j' go kecn' { " f' g' r' q' u' k' x' g' f' " i' q' n' f' " p' c' p' q' r' c' t' v' e' r' g' u' " e' q' x' g' t' g' f' " d { " r' qn\ r' { t' t' q' r' g' . " G' r' e' v' t' q' e' j' g' o' k' e' c' n' i' u' " 4; " 3489/3499 " \* 4239-0'

**GHHGE V'QH'DGVVWNP KE'CEKF 'RP'VJ G'RQN[ O GTKE'UJ GNN'QH'  
GPE CRUWNCVGF 'S WCP VWO 'F QVUQP 'VJ GKT 'RP VGTCEVKQP 'Y KVJ ''  
EGNNU'**

Crlcmcpf tc'Tcf ej cpm<sup>3</sup>. 'Xctxctc'J t{dqwu<sup>4</sup>{c<sup>4</sup>. 'Vc<sup>4</sup>kcpc'Vgtr kpunc{c<sup>5</sup>"

<sup>3</sup>Kpukwag'ht'Rj {ulecni'Ej go lecnTgugctej .Dgrntwulcp'Ucvg'Wpkxgtukf .Dgrntwu'

<sup>4</sup>Dgrntwulcp'Ucvg'Wpkxgtukf .Ej go knt { 'F gr ctvo gpv.Dgrntwu'

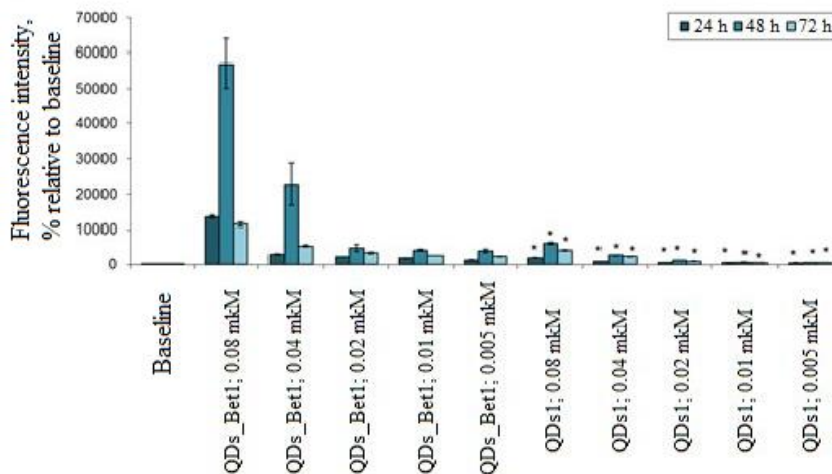
<sup>5</sup>Kpukwag'qh'Rj {ukqmi { 'qh'vj g'P cvkqpcni'Cecf go { 'qh'Uekppegu'qh'Dgrntwu .O kpum'Dgrntwu'  
crgmcpf tctcf ej gpm<sup>3</sup>2B i o ckt<sup>4</sup>qo .

Dgwruple'cekf 'ku'qpg'qh'vj g'o qu'uwf kgf "eqo r qwpf u'htqo 'vj g'emuu'qh'r gpvce { erke'tkgr gpqkf u'y kj 'j ki j 'dkqmi lecn'  
cevkxk{0'Dgwruple'cekf "j cu"cp" cp'kr tqk'gtcvkxg"cpf "r tqcr qr vqle" ghgewu"qp" o ctki pcpv'egmu." vj gtghqtg." k'ku'wpf gt"  
eqpukf gtvkqp'cu'c'dcuku'ht'j ki j n' "cevkxg"cp'kwo qt'ci gpu0J qy gxgt." nqy "uqwdkxk{ 'cpf 'r qqt'dkqcxkcdkxk{ 'pgi cvkxgn'  
chgeven'lecn'ghhece { 'cpf 'rko k'vj g'wug'qh'uwej "eqo r qwpf u' 'vj cv'ku'y j { 'k'p'ggf u'v'q'f gxgnr 'utcvgi kgu'ht'f grkxgt { 'v'egmu"  
uwej "ej go lecnOC'r tqo kulpi "crr tqcej "v'q'uxkxg'vj ku'r tqdngo "ku'eqplwi cvkqp'qh'vj gug'eqo r qwpf u'y kj 'pcpqcettkgtu"j3."4\_0'  
Dcugf "qp'vj ku'k'ku'qh'kpvtgug'v'uwf { 'vj g'ghgev'qh'dkqmi lecn' "cevkxg'eqo r qwpf u'lp'vj g'eqo r qukxqp'qh'pcpqr ct'vengu'qp"  
vj g'kpvtcev'kp'qh'vj g'tguwupi 'j { dtkf 'pcpqt wewtgu'y kj 'egmu0'

Vj g'clo "qh'vj ku'y qtniy cu'v'uwf { 'vj g'r tqeguu'qh'dkpf kpi "qh'S F u'o'dgwruple'cekf "eqplwi cvgu'v'wo qt'egmu'cpf "v'  
f gvtgto kpg'j qy "vj ku'eqo r qwpf "lp'vj g'S F u'o'uj gmi'chgeu'kpvtcev'kp'y kj 'egmu0'ht'vj ku'g'zr g'klo gp'v'y g'wugf "hwtgug'ep'  
ugo keqpf wvqt'pcpqr ct'vengu'wcpwwo "f qu'o'S F u'cpf "S F u'eqplwi cvgf 'y kj "dgwruple'cekf "f g'kxkxg0'

Gzr g'klo gpw'y g'g'ecttkgf "qww'y kj "Ef Ug<sup>1</sup> pU'eqtge/uj gmi'S F u'g'p'ecr uw'v'v'g'f 'y kj "cp'co r j kr j k'le'r qn' o gt'dcugf "qp"  
r qn' \*o c'ngle"cpj { f tkf g+0Vj g'r qn' o gt'ej cti g'y cu'w'p'gf "d { "k'p'qt'f w'epki "c"eqpvtqngf "co qwp'v'qh's w'v'gt'pct { "co o q'p'kwo "  
i tqw u'lp'v'vj g'r qn' o gt'0Y gcmf 'r qukxkxg'cpf "utqpi n' "r qukxkxg'ej cti g'qh'vj g'S F u'lp'xgtukf cvgf 'y cu'ej qugp'dcugf "qp'q'w"  
r t'g'x'k'w'uwf lgu'j5\_0'Dg'v' w'uple'cekf "y cu'eqplwi cvgf "v'q'r qn' o g'le'uj gmi'qh'S F u'd { 'w'epf ctf "ectdqf k'lo k'f g'r tqv'eqr0'Vj g"  
eqplwi cvgu'y g'g'ej ctcev'gt'k'gf "d { " /r qv'p'v'cn'qh' - ; "cpf - 42'o X0T'ghgt'p'eg'S F u'vj kj qw'dkqo q'g'ew'gu'lp'vj g'uj gm'j' cf "  
/r qv'p'v'cn' - 6'cpf - 37'o X't'g'ur ge'v'x'gn'0Vj g'j { f tqf { pco le'uk' g'qh'cm'r ct'vengu'y cu'lp'vj g't'cpi g'htqo "37"v'44"po =vj wu."  
vj g'uk' g'ghgev'dgwy ggp'vj g't'ghgt'p'eg'S F u'cpf "vj g'eqplwi cvgu'y cu'p'v'eqpukf g'g'f 0'

Vj g't'guwuu'htqo "h'qy "e{ v'qo g'v { 'uj qy u'vj cv'vj g'S F u'o'dgwruple'cekf "eqplwi cvgu'qh' - ; "o X" /r qv'p'v'cn'\*S F u'aDg'v'3+  
dkpf "v'egmu'dg'w'gt'vj cp'vj g't'ghgt'p'eg'q'p'gu\* - 6'o X."S F u'3+0Vj g'uwf { "qh'S F u'o'dgwruple'cekf "eqplwi cvgu'qh' - 42'o X" /  
r qv'p'v'cn't'g'x'g'c'gf "vj g'qr r quk'g'ghgev'uwej "vj cv'vj g't'ghgt'p'eg'S F u'dkpf "v'egmu'o qt'g'ghgev'x'g'vj cp'q'p'gu'y kj "d'g'v' w'uple'  
cekf "lp'vj g'uj gm0'



Hi 030T guwuu'qh'h'ny "e{ v'qo g'v { 'ht'kpvtcev'kp'dgwy ggp'S F u'aDg'v'3'cpf 'S F u'3'cpf 'E8'i r'ko c'egmu=" , r ">2027"  
eqo r ctkpi 'S F u'aDg'v'3'y kj 'S F u'3'

Vj g'eqplwi cvkqp'qh'S F u'y kj "dgwruple'cekf "f g'kxkxg'ej cpi gu'vj g'kp'v'p'ukf { 'qh'vj g'kpvtcev'kp'qh'pcpqr ct'vengu'y kj "  
egmu0'Vj g'f'k'ge'v'kp'qh'ej cpi gu'lp'vj g'kpvtcev'kp'pcpqr ct'veng'o'egmu'f'gr'gp'f'u'qp'vj g'x'c'w'g'qh'uw'h'ceg'ej cti g'qh'S F u'  
eqplwi cvgu'y kj " /r qv'p'v'cn'le'ng'v'q'p'g'w'c'n'dkpf "v'egmu'o qt'g'kp'v'p'uk'gn' .cpf "eqplwi cvgu'y kj "c'j ki j 'r qukxkxg' /r qv'p'v'cn'  
o'ng'u'kp'v'p'ug' "vj cp'vj g'kp'k'cn'pcpqr ct'vengu0' Vj g'g'z'v'p'v'qh'vj g'q'd'ug'x'g'f "ghg'ewu" f'gr'gp'f'u'qp'vj g'eq'p'eg'p'v'cev'kp'qh'  
pcpqr ct'vengu0'

j3\_C0U'epglc'g'v'c'f0'Vj g'cr g'wle'c'r r'nc'v'k'p'u'qh'd'g'w'uple'cekf 'pcp'q'ht'o w'v'k'p'u.'C'p'p'P'j 'C'ecf 'U'ek03.'7/3: \*423: +'  
j4\_Q0C0X'qt'q'd'g'x'c.'g'v'c'f0'D'g'w'uple'f'g'k'x'k'x'g'u'd'k'q'ni lecn'ce'v'k'x'k'f 'cpf 'k'p'et'g'culpi 'u'q'w'd'k'x'k'f .Ej go knt { 'qh'r'rc'p'v't'cy 'o cv'g'k'cn'6.'629'o'652'\*423: +'  
j5\_G0R'g'w'q'xc'g'v'c'f0'N'wo k'p'g'ue'p'v's'w'p'w'o "f qu'g'p'ecr uw'v'v'g'f "d { "j' y k'w'g'k'p'le'co r j kr j k'le'r qn' o gt'v'uw'h'ceg'ej cti g'f'gr'gp'f'p'v'p'v'cev'kp'y kj 'egmu."  
I'q'w'p'c'n'q'h'vj g'Dgrntwulcp'Ucvg'Wpkxgtukf0'Ej go knt { '3.'5/35'\*423: +'

**TGUGCTEJ 'CPF 'F GXGNQRO GP V'QH'P QXCVXG'HWPEVKQP CN''  
P CP QO GO DTC PGU'K'DKQGI KPGGTPI ''**

Wv 'Eki cp<sup>3</sup>. 'CtX {f cu'Rergxk kw<sup>3</sup>

<sup>3</sup>F gr ctwo gpv'qh'O gej cplecn'Gpi kpggtkpi . 'Hewm' 'qh'O gej cplecn'Gpi kpggtkpi "cpf 'F guki p. 'Mwpcu'Wpkxgtuk' 'qh'  
Vgej pqmji { . 'Nkj wcpk'  
wv'eki cpgB mw0v"

P cpqo go dtepgu'tgegkxg'o wej "cwgpv'q'f wg'v'q'j gk 'ur gekn'r tqr gt'v'gu'j3. '4\_0P cpqo go dtepg'ku'c'utwewtg'y kj "c"  
vj lempgu'qh'3/322'po . 'y j kg'q'v'j g't'f'ko gpukpu'ecp'dg'v'j g'uk'g'qh'pcpq lo letq lo cetq'uecrg'j5\_00 gej cplecn'utgpi vj 'ku'qpg'  
qh'v'j g'ng' 'r ctco gvtu'v'j cv'f gvtgto kpg'v'j g'cr r necv'k'p'qh'pcpqo go dtepg'lp'xctkqwu'hkrf u'j6\_0'

J qy gxgt."o cp {"pcpqo go dtepgu'ecppqv'dg'wugf "lp'dkqgpi kpggtkpi "dgecwug"o cp {"pcpqo go dtepgu'f'q'pqv'j cxg"  
uw'heleppv'o gej cplecn'utgpi vj "cpf "dkqeqo r cv'dk'k'k'{"j7\_0'ku'npqy p'v'j cv'o gej cplecn'utgpi vj "f gr gp'f u'q'p'v'j g'r qt'q'uk' 'qh'  
vj g'o cvgt'k'c'eeqtf kpi "v'q'v'j g'r qt'q'uk' 'qh'pcpqo go dtepgu."o gej cplecn'utgpi vj "f get'g'c'ug'zr qppv'k'cm' 'y kj "k'pet'g'culpi "  
r qt'q'uk' {"j8\_0'0'qt'g'x'gt."v'j g'dk'q'eqo r cv'dk'k'k'k' "cpf "v'q'z'k'k'k' "qh'pcpqo go dtepgu'j cxg'pqv'j { g'v'dggp'hw' {"k'px'g'uk'k' cv'g'0'k'ku'  
ko r qt'v'p'v'j cv'pcpqo go dtepgu'y qwf "dg'uko k'ct'v'q'p'ew'c'ri'o cvgt'k'c'0'k'k'v'o g'epu'v'j cv'pcpqo go dtepg'uj qwf "dg'o cf g'qh'  
dk'q'eqo r cv'drg"o cvgt'k'c'k' "j cxg"y gm'q'tf'gt'f "r qt'gu." cpf "j cxg"v'j g' tgs'v'k'gf "o gej cplecn'utgpi vj 0'Hqt' "gzco r rg."o cp {"  
k'p'q'ti cple'pcpqo go dtepgu'j cxg'i q'q'f "o gej cplecn'r tqr gt'v'gu'dgecwug'v'j gk'r qt'gu'ct'g'y gm'q'tf'gt'f . 'y j kg'v'j g'cf x'c'p'c'v'ci gu'  
qh'q'ti cple'pcpqo go dtepgu'ct'g't'g'v'k'x'g'k' "r'y "equ'v'cpf 'i q'q'f 'dk'q'eqo r cv'dk'k'k'k' {"j9\_0'

C'y k'f'g'k' "wugf'g'g'v'et'q'ej go lecn'c'dt'k'ec'v'k'p'o g'v'j q'f 'ku'c'p'q'f'k' k'pi "] : \_0C'p'q'f'k' k'pi 'ecp'dg'wugf 'v'q'f'g'x'g'nr 'cp'k'p'p'q'x'c'v'k'g'  
pcpqo go dtepg'0'v'j g'o clp'cf x'c'p'c'v'ci gu'qh'c'p'q'f'k' k'pi "ct'g'cp'q'tf'gt'f 'r qt'g'ut'wewtg.'v'j g'c'dk'k'k'k' "v'q'eq'p'v'q'n'v'j g'r qt'g'f'k'co g'v'g'."  
cpf "t'g'v'k'x'g'k' "r'y "r'q'f'v'ek'p'equ'u'"]; \_0'

Cp'c'p'c'n'f'uku'qh'v'j g'ue'k'p'v'k'k'k' "r'k'g't'c'w't'g'j' cu'uj q'y p'v'j cv'v'j g't'g'ku'c' "r'y'qh't'gug'ctej . "dw'v'j g'dgu'v'k'p'p'q'x'c'v'k'g'hw'p'v'k'p'c'c'i'  
pcpqo go dtepgu'j cxg'pqv'j { g'v'dggp'f'g'x'g'nr'gf'0'k'ku'v'j g't'g'ht'g'p'ge'gu'ct' {"v'q'f'g'x'g'nr' "pgy "v'ej'pqmji'k'gu'cpf "gzr'cpf "v'j g'  
r'qu'k'd'k'k'k'k'ku'qh'pcpqo go dtepgu'cr r necv'k'p'0'v'j g'k'p'p'q'x'c'v'k'g'hw'p'v'k'p'c'c'i'pcpqo go dtepg'y k'm'd'g'f'g'x'g'nr'gf "k'p'ug'x'g't'c'i'  
u'ci gu'0'Hk'uw'k' . "c'p'gy "cp'q'f'k'c'awo k'p'wo "q'z'k'f'g'CCQ+"o go dtepg'c'dt'k'ec'v'k'p'v'ej'pqmji {"y kj "eq'p'v'q'ng'f'pc'p'q'r'q't'g'ctt'c' {"u'  
y k'm'd'g'f'g'x'g'nr'gf'0'v'j gp.'v'j g'et'g'cv'f'f'g'go g'v' {"y k'm'd'g'c'p'uh'g't'g'f'v'q'c' 'dk'q'eqo cvgt'k'c'v'j cv'e'q'w'f' "dg'cr r'ng'f'k'p' 'dk'q'g'pi k'p'g'gt'k'pi 0'  
k'p'v'j g't'g'x'g'c'rf' "ecug."v'j g't'g' "d'geqo gu'c' "t'g'c'n'r'qu'k'd'k'k'k'k' "v'q'et'g'cv'g'cp'k'p'p'q'x'c'v'k'g'pcpqo go dtepg'y kj "v'j g't'g'v'k'gf "

o gej cplecn'utgpi vj "cpf "dk'q'eqo r cv'dk'k'k'k'k' {"0'v'j g'f'g'x'g'nr'gf'pcpqo go dtepg'ecp'dg'wugf'pq'v'q'p'n'k'p'o g'f'lecn'ect'g'ht'j'w'cp"  
j'g'c'n'j "dw'c'm'q'k'p'ct'g'cu'w'ej'cu'dk'q'ug'pu'q'tu'wugf'v'q'f'g'v'g'v'd'k'q'm'j'lecn'ej go lecn'v'j t'g'cu'q't'o let'q'ej k'u'wugf'v'q'v'g'u'v'j g'v'z'k'k'k'k' "  
qh'g'z'r'g't'ko g'p'w'c'n'f'w'iu'0'

- j3\_ "S 0I wq." 0Fk"0 0I 0Nei cm' "gv'c'ri'U'ut'clp'gpi kpggtkpi "cpf "o gej cplecn'cu'go d'nf "qh'uk'leq'li gto cpl'wo "pcpqo go dtepgu."O cvgt'k'c'U'le'k'peg'cpf "  
Gpi kpggtkpi <T<Tgr'qt'w'34: "3/53"423: #0"
- j4\_ 'H00 c. 'D0Z w'U0Y w'g'v'c'n'Vj gto c'n'eq'p'v'q'ng'f' 't'g'g'culpi 'cpf 'cu'go d'ripi 'qh'hw'p'v'k'p'c'c'i'pcpqo go dtepgu'v'j tq'w'j 'r'q'n'o g't'r' { tq'n'uku'P'cp'q'v'ej'pqmji {"  
52.'576223"423; #0"
- j5\_ 'I 0J w'epi . 'I 00 gk'Cu'go d'nf "cpf "U'gr'h'Cu'go d'nf "qh'P'cpqo go dtepg'0'cvgt'k'c'U'hw'q' "4F'v'q'5F. 'Uo c'm'36.'3/45"423: #0
- j6\_ 'D0D0Uj cto c.'C0R'ct'ej'ct.'O gej cplecn'utgpi vj "qh'c'pc'p'q'r'q't'q'w'u'd'let' { u'c'n'k'p'g'j' /DP'pcpqo go dtepg'lp'c'y cvgt'w'w'do g'ti g'f' "u'v'g.'Rj { u'le'c'n'E'ej go k'ut' {"  
Ej go lecn'Rj { u'le'u'44.'42675"4242#0"
- j7\_ 'E0T0'Dw'j t. "P 0Y k'guo c'p'p'g' "T0E0'v'c'p'p'g't'g'v'c'ri'Vj g'E'j q't'k'c'm'p'v'k'le'0 go dtepg'Cu'c' {"k'p'P'cp'q'v'z'le'q'm'j'lecn'U'g'ug'ctej' /C'p' "C'ng't'p'c'v'k'g'ht' "k'p'X'k'q'"  
G'z'r'g't'ko g'p'w'v'k'p'p'cpqo cvgt'k'c'32.'454: "4242#0"
- j8\_ 'R0P 0Ej t'k'k'k'k'k' "U0M0'D'c'uj c."X0U0M'w'o c't'k'g'v'c'ri'0'k'q'r'q'n' o g't'le'pc'p'q'eqo r'q'uk'g'ue'c'ht'q'f' u'ht' "d'q'p'g'v'ku'w'g'g'pi k'p'g'gt'k'pi "cr r' necv'k'p'u'c' "t'g'x'k'g'y . 'L'q'w'p'c'c'i'  
qh'F'w' "F'g'x'g'k'f' {"U'le'k'peg'cpf "V'ej'pqmji {"77.'323674"4242#0"
- j9\_ 'U0C'f'k'c.'E0L'p.'N0E'w'k'k'u'g'v'c'ri'0'P'p'q'r'q't'q'w'u'o go dtepgu'ht' "o g'f'lecn'c'p' "d'k'q'm'j'lecn'r' r' necv'k'p'u.'Y'K'Gu'P'cp'qo g'f'le'k'p'g'cpf'pc'p'q'd'k'q'v'ej'pqmji {"  
3.'78: /7: 3"422; #0"
- j: 'I 0C'd'uc'p'p' . 'U0D'c't'g'c't.'O 00 q't'c'f'k'g'v'c'ri'0'H'c'd't'le'c'v'k'p' 'C'n'Q's'p'c'p'q'r'q't'g'u'c'tt'c' {"d'f' 'cp'w'nt'c'j'k'j' 'x'q'nc'i'g'y'q'w'g'r' 'cp'q'f'k'c'v'k'p'v'ej'p'k's'w'g'k'p'x'g'uk'k'k'k'k'v'k'p'i "  
v'j g'g'ht'g'ev'q'h'x'q'nc'i'g'v'c'g'cpf "C'n'h'k'k'k'k'v'j lempgu'q'p'i g'go g'v' {"cpf "q't'f'g't'k'pi "qh'v'j g'c'tt'c' {"O'cvgt'k'c'U'ej go k'ut' {"cpf "Rj { u'le'u'3; ; . '487/493"4239#0"
- j: 'I 0R'ev'g'n'I 0L'c'p'w'cu."C0R'c'rg'x'k'kw'g'v'c'ri'0'F'g'x'g'nr' o gp'v'qh'P'cp'q'r'q't'q'w'u'CCQ'0 go dtepg'ht' "P'cp'q' "H'k'nt'c'v'k'p' "W'uk'p'i "v'j g'c'eq'w'w'q'r'j'q't'g'uk'0'g'v'j q'f' "  
U'g'p'q'u'tu'42.'5: 55"4242#0"

VQY CTF U'URGE VTQUE QRÆ 'GNNRUQO GVT[ 'DCUGF 'DKQUGP UQT<'  
GXCNCWVKQP 'QH'J WO CP'UGTWO 'CNDWO KP'CFUQTRVKQP 'VQ'  
RQTQWUCNWO KP KWO 'QZKF G'

Xlpegpvcu'O cekwku<sup>3</sup>. "Ukrklc'Lwekwg<sup>4</sup>. "Wf ku'O cirkpxunku<sup>5</sup>. "F qpcw'Gt w<sup>5</sup>. "Ctwpcu'Tco cpcxlekwu<sup>3,4</sup>. "  
Cm ktc'Tco cpcxlekgp<sup>4</sup>. "Ucwku'Dergxlekwu<sup>3</sup>. "Kgc'Rrkmwukpg<sup>3,4</sup>"

<sup>3</sup>Nedqtcvqt { "qh'P cpqvej pqmji { . "Ucvg'Tgugctej "Kpukwg'EGpvtg'ht'Rj { ulecn'Uelgpegu'cpf "Vgej pqmji { . "Ucwrgvntq"  
cxg05. "Xlrpkwu. "Nkj wcpkc="

<sup>4</sup>Kpukwg'qh'Ej go knt { . "Hewm'qh'Ej go knt { "cpf 'I gquekgpegu. "Xlrpkwu'Wpkxgtukf. "P cwi ctf wny'46. "Xlrpkwu"  
Nkj wcpkc="

<sup>5</sup>Kpukwg'qh'Ej go lecn'Rj { uleu. "Wpkxgtukf "qh'Ncwlc. "NX/37: 8'Tki c. "Ncwlc=" "  
xlpegpvcuO cekwkuB hwo eOn"

"

Kpxguki cvkpi "r tqvlp'cf uqtr vkqp" cpf "f guqtr vkqp" Itqo "pcpqr qtqwu" o cvgtkcu'ku'cp" ko r qtvcpv'wunif wg"vq"vj g'y kf g"  
cr r rkecvkp" qh' pcpquwewtgf " o cvgtkcu'kp" r tqvlp' ugr ctecvkp. "r wtklecvcqp. "cpf "dkqugpuqt" f gxgnr o gpv'P cpqr qtqwu"  
o cvgtkcu'cdkksf "vq'cf uqtd'nti g'o qrgewgu'y kj kp'vj g'r qtgu. "eqo gu'htqo "vj g'r qtg'uk g'cpf "ku'uki plklecpw" f gr gpf gpv'qp"  
vj g'j { f tqr j qdle'qt" j { f tqr j kke' r tqr gt vgu'qh'vj g'o cvgtkcu'Dkqugpuqtu'dcugf "qp'pcpqo cvgtkcu'eqcvkpi u'cwtcev'uki plklecpv"  
cvgpvkqp. "gur gekm' "vj qug'vj cvct'g'j ki j n' "ugpukxg'vq'c'ur gekle' r tqvlp'qt" o qrgewg' ]3\_0P cpqr qtqwu' o gvcn'qzkf g'eqcvkpi u"  
ecp'dg'wugf "kp'vj g'f gxgnr o gpv'qh'uwej "dkqugpuqtu'f wg"vq"vj g'r j { ulecn'cpf "ej go lecn'r tqr gt vgu'vj cv'vj g' { 'r quuguu'0

Ratqwu'cpqf le'cnwo kpwo "qzkf g'"r CCQ'+eqcvkpi . 'y j lej "ku'htqo gf 'd { "grgevtqej go lecn'cpqf k' cvkqp'qh'cnwo kpwo "kp"  
cp'cekf le'grgevtqej vg. "ku'qpg'qh'vj g'v' r lecn'ugr'qti cplugf "hpg'utwewtgu'y kj "pcpqj qrg'cttc { u0Vj g'r qtg'f lco gvt'ecp'dg"  
ej cpi gf "d { "xct { kpi "vj g'eqpepvtcvkqp" cpf "eqo r quksqp'qh'vj g'cekf le'grgevtqej vg'cu'y gmi'cu'vj g'xqnci g'qh'cpqf k' cvkqp" ]4\_0  
r CCQ" g'zj kdku" uwej " r tqr gt vgu'cu" dkqeqo r cvdkksf. " j ki j n' " qtf gtgf " ugrh'cuugo drgf " j ppf { eqo d' r qtg' utwewt. " j ki j "  
o gej cplecn'cpf "vj gto cilncdkksf. "cpf "ej go lecn'gukcpegO'Xctkqwu'dkqugpuki ' r r'vqto u'dcugf "qp'r qtqwu'cnwo kpwo "qzkf g"  
j cxg'dggp'cr r rkgf "kp'qr vcecn'cpf "grgevtqej go lecn'dkqugpuqtu" ]5\_0

Ur gewtqejr le'gnrk uqo gvt { "UG'+ecp'dg'uweegutwm' "wugf "ht'qr vcecn'dkqugpuki "dgecvwg'kv'ts wkt gu'pq'rcdgnkpi "cpf "  
vj g'ki j v'wugf "ht'vj g'o gcuwt go gpv'f qgu'pqv'clhgev'tf gvtqf { "vj g'uco r ngu'0Hwt vj gto qtg. "vj ku'o gvj qf "o cngu'k'r quakdg'vq"  
r gthqto "uko wncpgqwu'b gcuwtgo gpv'qh'ldqv' u'c'p'f 'r' qrtkcvkqp. "vj wu'qdvcklpi 'c'dgwtg'ci tgggo gpv'dgvy ggp'vj g'g'zr gtko gpv'  
cpf "o qf gn'f cv' ]6\_0

Kp'vj ku'y qtm'vj g'lp'xguki cvkqp'qh'j wo cp'ugt'wo 'cnlwo kp'J UC'+cf uqtr vkqp'qp'vj g'r CCQ'eqcvkpi 'y cu'cpcn'ugf "wukpi "  
UG"o gvj qf 0Vj g'vj kempgu'qh'vj g'htqo gf "r CCQ'rc { gt'f gvtgo kpgf "htqo "UG'tguwu'y cu'54407'0'2084'po 0Vj g'guno cvgf "  
tcf kuu'qh'vj g'pcpqr qtgu'y cu'5; '07'po 'c'p'f "vj g'f kuvpeg'dgvy ggp'pcpqr qtgu'y cu'329'08'po 0Vj g'qdvckpgf 'tguwu'uj qy gf "  
vj cv'vj g'r tqvlp'eqpepvtcvkqp" kpu'f g'vj g'pcpqr cpgnu'y cu'ugxgtcn'j wpf tgf "vko gu'j ki j gt'vj cp'kp'vj g'dwhgt' uqnwkwq="vj g"  
kp'kcn'r j cug'qh'vj g'cf uqtr vkqp' r tqeguu'y cu'umy "5045"o i eo " o kp "3" "kp'eqo r ctkuqp'y kj "vj g'r tqvlp'f guqtr vkqp'tcvg"  
\*430' o i eo " o kp "3" "d { "o gcpu'qh'r CCQ'rc { gt'y kuj kpi "eqp'xgp'vcpny kuj kpi 'y kj "RDU' uqnwkwq" cpf "f gkppk' gf 'y cvgt "  
f qgu'pqv'eqo r rvgnt' "tgo qxg'J UC"o qrgewgu'htqo "r CCQ' r qtgu'cpf. "vj gt ghtg. "vj g'J UC" eqpepvtcvkqp" kpu'f g'pcpqr qtgu'  
chgt'38"j "qh'y kuj kpi "vknit'go kpu'cm quv'322'vko gu'j ki j gt'vj cp'vj cv'r tgu'p'v'kp'RDU' uqnwkwq0"

"

Cempqy rgi go gpv<

Vj ku'y qtm'ku'r ctv'qh'c" r tq'ge'v'vj cv'j cu't'ge'g'x'g'f "hwpf kpi "htqo "vj g'Gwtqr gcp" Wpkapw'J qtk qp"4242"t'gugctej "cpf "  
lp'p'x'cvkqp' r tqi tco "w'p'f gt'vj g'j tcv'ci tgggo gpv'P q099: 379' EcpDkqUg0"

"

[3\_ " X0'O cekwku'gv'cl'0'0'Rqtqwu'cnwo kpwo "qzkf g'eqcvkpi "ht'vj g'f gxgnr o gpv'qh'ur gewtqejr le'gnrk uqo gvt { "dcugf "dkqugpuqt'<Gxcncwkvkqp'qh'j wo cp"  
ugt'wo "cnlwo kp'cf uqtr vkqp.0'Eqcvkpi u.'xqf032. 'pq033. 'r r 03632. '4242. 'f qk'3265; 2 kecvkpi u3233323: 0

[4\_ " J 0O cuw'c'cpf 'O 0Ucvaj. "0'Edtkecvkqp'qh'j qf "pcpqf qv'cttc { "wukpi "cpqf le' r qtqwu'cnwo kpc'cu'cp'g'xcr qtcvkwq'bo cum0'Lrcrpgug'LOCrriDRj { uleu "  
Rctv'4'Ngm'0'xqf057. 'pq03'D. '3; ; 8. 'f qk'320365 llcr 0708480

[5\_ " H0UJ 0M'kuo cuw'k'J 0Dc { cv'P 0J 0Xqrgent. 'cpf "J 0Uej 3/4j gtt. "0T gcn'vko g'O qpsqtkpi "qh'Ne { gt/d { /Nc { gt "Rqn'grgevtqej vg'F gr quksqp" cpf "  
Dcevtkcu' Gp { o g' "F g'v'cvkqp" kp' "P cpqr qtqwu' Cpqf k' gf " Cnwo kpwo " Qzkf g.0' " Cpcn'0' Ej go 0" xqf0 : 9. " pq0' 9. " r r 0' 5: 7865: 85. " 4237. " f qk' "  
320243 kee726848o 0

[6\_ " C0J cpu. "0Gnr uqo gvt { "qp'vj kp'qti cple'rc { gtu'qh'ldqmi lecn'kp'vgtug'2ej ctcevtg'k' cvkqp'cpf "cr r rkecvkpu.0'vj kp'Uqnf' Hko u.'xqf0599659: . 'r r 06: 0  
78. "4222. 'f qk'320238 IU2262/82; 2\*22+235: 7/90

"

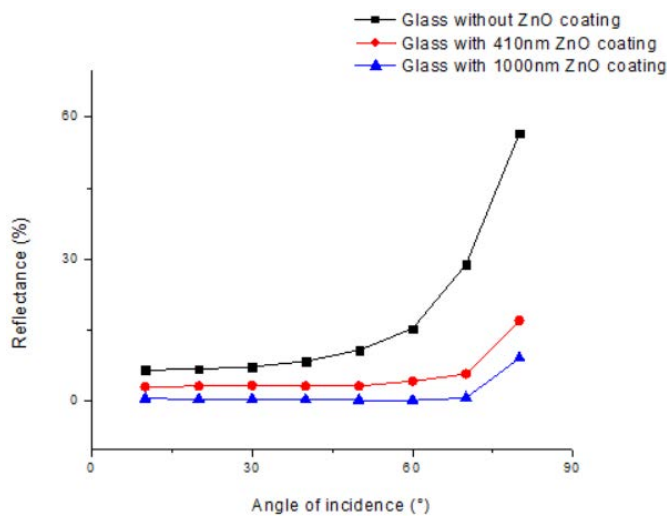
"

**\ P Q'P C P Q R C T V K E N G U H Q T ' C P V K T G H N G E V K X G ' C R R N K E C V I Q P U'**  
Rcwrksu'Nwtkm pcu<sup>4</sup>. 'O kpf cwi cu'kknru<sup>3.4</sup>'Vqo cu'Vco wrgxk kw<sup>3.4</sup>. 'Uko cu'Tc nruwu<sup>3.4</sup>'

<sup>3</sup>Kpukwag'qh'O cvgtkcm'Uelgpeg. 'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmji {.'Nkj wcpkc=" }  
<sup>4</sup>F gr ctwo gpv'qh'Rj { uleu. 'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmji {.'Nkj wcpkc' }  
r cwksu'cvtknqpcuB mw0f w'

\ pQ" pcpr ctvengu" j cxg" cwtcevgf " i tgcv' kpvtguv' f wg" vq" vj gk" gzeqr vkpcn' r tqr gtvku" uwev " cu" f ghgev'lpf wegf " hgttqo ci pvguo . 'WX'ugpukpi 'cpf'tgxtukdng'vtcpukvqp'htqo "j {ftqrj qdlek'v'q'j {ftqrj kklek' 'j3\_'j4\_0\ pQ'pcpqvgtcr qf u" u{pvj guk' gf 'd{ 'eqo dwukv'p'o gjj qf u'j5\_'ctg'qpg'qh'xctkqu'w'o qtrj qmji kgu'qh' pQ'y j lej 'ctg'wugf 'hqt'qr vqrgv'qplecrl'cpf " r j qvqxqncle'cr r kccv'kpu'vq'tgf weg'vj g'tghgev'kqp'qh'hki j v'htqo 'uwtceg0Vj gug'v'r g'qh'eqcv'kpi u'ctg'ecmgf "cpv'k'tghgev'kxg" j6\_0

Kp'vj ku'y qtm'c'uko r rg'o gjj qf 'qh'ur tc{ lpi 'y cu'wugf 'vq'f gr quks'cpv'k'tghgev'kxg'eqcv'kpi 'qh'\ pQ'pcpr ctvengu'qp'i rnuu' uwdut'cvg0Vj g'vj kempguu'qh'eqcv'kpi 'y cu'o gcuwtgf "d{ 'ewuqo 'WX'vtcpuo kwcpeg'o gvt0T'ghgev'cpeg. "vtcpuo kwcpeg"cpf " qvj gt'qr v'ecnr' r tqr gtvku'y g'g'kpxguk'i cvgf "d{ 'ur gekn'qr v'ecnr'ugwr . 'y j lej 'kpen'f gu'ur gevto gvt0O'wv'k'wpev'kpcn'pcwtg" qh'\ pQ'pcpr ctvengu'cpv'k'tghgev'kqp'eqcv'kpi u'y cu'qdugt'xgf <uwej 'eqcv'kpi u'ctg'o qtg'pgw'cn'v'q'hki j v'r qm'k'c'v'k'p'cpf 'tghgev' rguu'k'p'ekf gpv'hki j v'0O qtgq'xg. 'ej ctcevg'k'v'le'qh'WX'dm'qen'kpi 'y cu'qdugt'xgf 'kp'tghgev'cpeg'cpf "vtcpuo kwcpeg'pgct'vj g'gf i g' qh'WX'c" \*622po #0



Hki 030Nki j vt ghgev'kqp'f gr gpf gpeg'qp'cpi ng'qh'k'p'ekf gpeg'\*? '8540 po #0

- [3\_] [ 0MDO kjt'cpf "T0Cf gmipi . "o\ pQ'vgtcr qf "o cvgtkcm'ht'wpev'kpcn'cr r kccv'kpu.ö"O cvgt0Vqf c/.'xqf043.'pq08.'r r 08536873.'423: . 'f qk' 320238 ll0 cvqf 042390830250
- [4\_] ZOHgpi . 'NOHgi . 'O 0Lp. 'l0\ j ck'NOLLcpi . 'cpf 'F0\ j w'0T'gxtukdng'Uwr gt/j {ftqrj qdlek'v'q'Uwr gt/j {ftqrj kklek' "Vtcpukvqp'qh'Crki pgf " \ pQ'P cpqtqf 'Hko u.ö'LOCo OEj go 0Uqe0'xqf0348.'pq03.'r r 084685.'4226.'f qk'320243 llc25: 858q0
- [5\_] UOTcenuwu'u'v'c'n0'0C'pqxgn'lo gjj qf 'hqt'eqv'kpwqu'u'l'pvj guk'qh' pQ'vgtcr qf u.ö'LORj {uOEj go OE.'xqf033; . 'pq04: . 'r r 038588638595.' 4237.'f qk'320243 lcu0r ee0d259240
- [6\_] J 0MOTew'X0C0I cpguj . 'C0UOP'ck. 'cpf 'UOTco cntkij pc.'öC'p'v'k'tghgev'kxg'eqcv'kpi u'c'et'k'le'cn'lp/f gr vj 't'g'x'ly .ö'Gp'gti / 'Gp'xt'qp'0'le'k0'xqf0' 6.'pq032.'r r 0599; 65: 26.'4233.'f qk'32025; l3gg234; 9g0

**EQPVTQN'QH'VJ G'UVCKP'NGUU'UVGGN'Y GVVCDKWK[ 'XK'XCT[ KPI "**  
**HGO VQUGE QPF 'NCUGT'RCTCO GVGU'WUGF 'HQT'KO RQUKPI 'NCUGT/**  
**KPF WEGF 'RGTQF KE 'UWTHCE G'UVT WE VWTGU"**

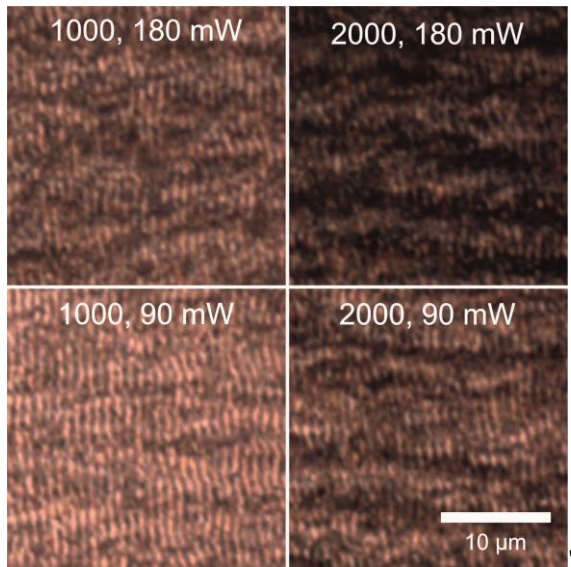
O cpwu'O kncmxxk kwu<sup>3</sup>. 'O kpf cwi cu'Lwqf pcu<sup>3</sup>. 'Vqo cu'Vco wgxk kwu<sup>3,4</sup>"  
Cuc'Vco wgxk kcp<sup>3,4</sup>"

<sup>3</sup>Kpukwag'qh'O cvgtkcn'Uekpeg'qh'Mcwpcu'Wpkxgtuk'qh'Vgej pqm { . 'M0Det-cwunq'Ut07; . 'NV/73645. 'Mcwpcu. 'Nkj wcpk "

<sup>4</sup>F gr ctvo gpv'qh'Rj { ukeu'qh'Mcwpcu'Wpkxgtuk'qh'Vgej pqm { . 'Uwf gpv 'Ut072. 'NV/7358; . 'Mcwpcu. 'Nkj wcpk "

o cpwuO kncmxxk kwuB nwtm

Y gwcdkxk'ku'c'xgt { "ko r qtvcv'uwthceg"r tqr gtv' "hqt"tcpi g'qh'vqnu. "ko r rpwu'cpf "f gxlegu"qr gtvkpi "kp"cy cvgt { "gpuxtqpo gpv0Rtqeguukpi "qh'uqrf u'pgct"vj gk "cdmxxk"vj tguj qif "d { "j ki j "kpvukxk' "r qmktk gf "rcugt"ktcf kxkq"o c { "rgcf "vq" yj g'f gxgr o gpv'qh'tgi wct "pcpquecrg'utwewtgu'hpqy p'cu'Ncugt/kpf wegf "Rgtkqf le'Uwthceg'Ut wewtgu"NRUU:0Cr r n' kpi "NRUU"vq"u'uwthceg"ecp"rgcf "vq"pwo gtqwu'cr r rkecvkpu'qh'uwthceg'hwpevkpcrk cvkqp'kpenf kpi "dw'pqv'ko ksf "vq"ko r tqxgf "y gwkpi "r gthqto cpeg"J3\_ "cpwkdcevtkcn'cevxxk' "J4\_ "ny "qr vceci' tghgecpeg"J5\_0' Qp"vq "qh"vj cv"y gwcdkxk' "ecp"dg" eqpvqmgf "d { "xct { kpi "rcugt"rctco gvgu'ctqwpf "tgs wktgf "NRUU" f gxgr kpi "eqpf kxkq"u'v' ku'j cu'c"j wi g'ko r cev'qp'r tqegu" qr vko k cvkqp'cpf "utwewtkpi "vko g. 'y j lej 'ku'xgt { "ko r qtvcv'v'ht"rcti g'uecrg'bo cpwkwewtkpi 0K'y cu'tgr qtvgf "vj cvy gwcdkxk" r tqr gtv'ku'qh'vj g'NRUU'utwewtgu'ku'r tqpg'ht"ci kpi "dgeo g'gxgp"o qtg"j { f tqr j qdke "chgt"gzr quw'g'vq'cvo qur j gtg"J6\_0" Kp'vj ku'y qtm"vj g'hwf co gpv'clj cto qple"3252"po +qh'c'rkpgctn' "r qmktk gf "l d-MI Y "hgo vqugeqpf "rcugt"dgco "y cu" uecpgf "go r nq { kpi "c"i cixquecpgt"cpf "c"i'vj gvc'ngpu'qxtg'vj g'uwthceg'qh'c'uwkprguu'uvgn'o ktqt"y j krg'xct { kpi "vj g'r wug" gpgti { . 'r wug'f gpukx' . 'cpf "rcugt"ur qv'qxtgr 0Vy q'r wug'gpgti { "f gpukx' "xcnwgu'y gtg'wugf "445'cpf "669"o Leo "cu'y gm'cu" r wug'f gpukx' "qh'3222"cpf "4222"r wugu"r gt"o krio gvt"y j krg"vj g'r wug"tgr gwkkq"tcvg"y cu"ngr v'cv'422"hf | 0'Vj g" y gwcdkxk' "qh'vj g'uwthceg"y cu'gxcwcvgf "wukpi "vj g'ugukrg" f tqr "o g'v'qf "y j gtg"3"Uhxqno g'f tqr rgu'qh'y cvgt"y gtg" f kur gpugf "qp"vj g'r tkwkp'cpf "f khtgpw" "tgcvgf "uwthceg"0Qr vceci'no letqueqr g"ko ci gu'qh'vj g'r rugt/vtgcvgf "uco r rgu'ctg" f gr levgf "kp'Hki 030"



Hki 030Qr vceci'no letqueqr g'bo letqi tcr j u'qh'uwkprguu'uvgn'uwthceg'chgt"vj g'r rugt"vtgcvo gpv0P wo dgtu'lpf levg'r wug" f gpukx' "cpf "cxgtci g'rcugt"r qy gt"wugf "hqt"vtgcvo gpv0Uecrg"dct"32" o 0"

Ncugt"vtgcvo gpv'xct { kpi "gpgti { "f gpukx' "gpdrfg"eqpvqn'qh'vj g'y gwkpi "cpi ng'hqt"y cvgt "kp"cy kf g'tcpi g'ur cpplkpi "htqo " ; 9'vq'353'Ahqt'f glkpk' gf "y cvgt0Vj g'eqpcev'cpi ng'y cu'kpetgcugf "d { : 9'vq' r ctgf "vq'r tkwkp'uwthceg0Vj g'j ki j guv" y cvgt"eqpcev'cpi ng'xcnwgu'y gtg'qdvkpgf "chgt"36"fc { u'qh'rcugt"r tqeguukpi 0Hcugt"r tqeguukpi "ku'qdvkpgf "wukpi "3222" r wugu'r gt"o krio gvt"y kj "vj g'r tleg'qh'3: A'uo cmgt"y cvgt"eqpcev'cpi ng'0"

J3\_ "Xcp" f tgn "J 0'0"Ukr g. "L0'G0"cpf "l qvpi . "L0'HD" Ncugt/ kpf wegf "r g'kqf le'uwthceg'utwewtgu'q' uqrf u'c'wpkxgtucn'r j gpqo gpqp. "Rj { ukeci' Tgxley " Ngwgtu'6; \*48+; 3; 7763; 7: \*3; : 4-0j wr u-1lf qkqti B208325 IRj { uTgxNgw6; 0; 77"

J4\_ "Nwg { . "C0J 0'I go kpk'NO" Tqo qrk'NO'Nej | kpk'I 0'Hwq. "HD" Hweqp. "O 0"cpf "Mkpi . "T0"Vqy ctf u'rcugt/vgzwtgf "cpwkdcevtkcn'uwthceg. "Uekp'wke" Tgr qtu' : \*3+ "3632" \*423: -0j wr u-1lf qkqti B20825: h637; : /23: /4: 676/4""

J5\_ "C0F quxcmx. "M0Dtqplmxx. "C0Mwej o k j cm" J kgtc'ej leci'cpw' tghgecvg'rcugt/ kpf wegf "r g'kqf le'uwthceg'utwewtgu"NRUUu'q'p'co qtr j qvu'UK' hko u'ht'ugpukpi "cr r rkecvkpu. "P cppquecrg"34\*47+; 4242. "F QK'320825; IF 2P T243: 4D"

J6\_ "Xctico qxc. "Q0"J qglpqt. "M0" Tcv'ng. "O 0'gv'cr'0 qf hkecvkq'qh'uwthceg' r tqr gtv'ku'qh'uqrf u'd { "hgo vqugeqpf "NRUU"y tkkpi <eqo r ctecvkx'uwf lgu'q'p" ukieq'cpf "uwkprguu'uvgn'0Cr r r0Rj { u0C"345. '947" \*4239-0j wr u-1lf qkqti B208229 h2255; /239/3584/ { "



# GHHGE V'QH'UWDUVT CVG'P CVWT G'QP 'EGNN'O QTRJ QNQI [ 'QH'VJ K'P'' CP QF KE 'CNWO KPC'HKNO U'HQTO GF 'K'P'VJ G'UWNHWT KE 'CEKF'' UQNWKQP''

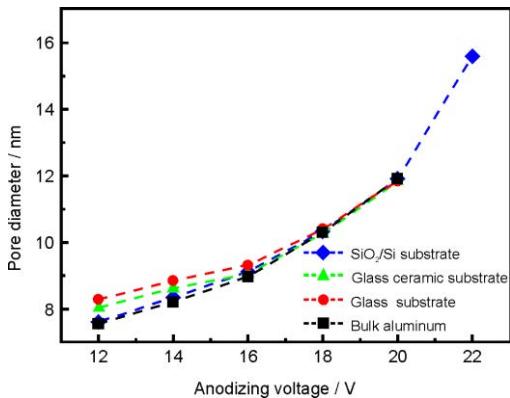
Mvukct { pc'Ej ctpkcnqxc<sup>3</sup>. 'Ct wpcu'Lei o kpcu<sup>3</sup>. 'Kqt 'Xtwdngxun{<sup>4</sup>

<sup>3</sup>F gr ctwo gpv'qh'Grgextqej go lecn'O cvgtkcn'Uelgpeg. 'Egpygt'htq'Rj { uqecni'Uelgpeg'cpf 'Vj gepqmi { . 'Nkj wpc'k''

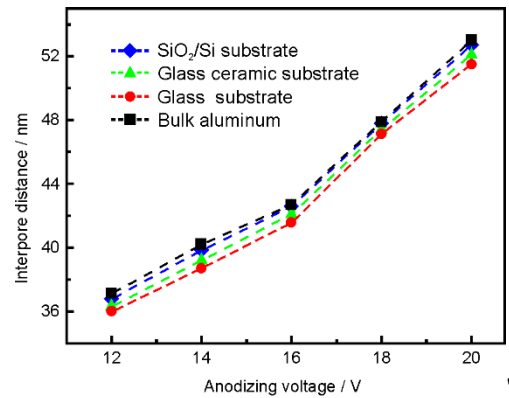
<sup>4</sup>F gr ctwo gpv'qh'O letq/'cpf 'P cpqgrgextqpleu. 'Dgrnt wukp'Ucvg'Wpkxgtukv' 'qh'Kphqto c'keu'cpf 'Tcf kqgrgextqpleu. 'Dgrnt wu' nvukct { pc'ej ctpkcnqxcB ho eOv''

Uwthceg'ob qtr j qmi { 'qh'vj g'r qtqwu'cpqf le'cnwo kpc'kno 'ku'f gygto kpgf 'd { 'dq'vj 'c'r qtg'f kco gygt 'f<sub>rqtg</sub>+cpf 'cp'kpvtr qtg' f kucpeg 'f<sub>kpvt</sub>+0'K'J3\_ 'k'y cu'uj qy p' 'vj cv'htq' r qtqwu'cpqf le'cnwo kpc' 'vj g'f gr gpf cpeg'qh'f<sub>kpvt</sub> 'qp'cpqf k' kpi 'xqnci g' 'Wc'+ y cu'htp'gct. 'j qy g'xgt. 'vj g'f gr gpf cpeg'qh'f<sub>rqtg</sub> 'qp'Wc'y cu'bpq/nkpgct0Vj g'ob c'k'p' r ctco gygtu'vj cv'htg'ev'vj g'uwthceg'ob qtr j qmi { "qh'vj g'kno u'ctg'cpqf k' kpi 'xqnci g'cpf 'grgextqf'vg' 'go r gtcwt g'0'K' 'cf f k'k'q'p. 'vj g'o qtr j qmi { 'qh'r qtqwu'cpqf le'cnwo kpc' kno u'ecp'dg'cnuq'kphw'gpeg' 'd { 'pqp/grgextqej go lecn'r ctco gygtu'uwej 'cu'pcwtg'qh'uwdutcvg'0Vj g'tghq'g. 'kp'vj ku'y qtm'y g' clo gf 'v'uwf { 'cpf 'cpcn' | g'vj g'gh'gev'qh'grgextqf'vg' 'go r gtcwt g'cpf 'cpqf k' kpi 'xqnci g'qp'egm'o qtr j qmi { 'qh'vj k'p'kno u' qh'uwhwt le'cek' 'cpqf le'cnwo kpc'htqto gf 'qp'f k'htg'gpv'uwdutcvg'0'ht' 'vj cv' 'vj k'p'cnwo k'pwo 'kno u'qh'cdq'w'322-po 'vj kem'y g'tg' qd'v'k'p'gf 'd { 'f gr qu'k'k'q'p'qh'cnwo k'pwo 'qp'vj g'uk'le'q'p'uwdutcvg'y k'j 'c' 'vj k'p'uk'le'q'p'f k'z'k'f g'kno ' 'UK<sub>4</sub>IUK'y chgtu+ 'qp' 'i' r'uu/ egtco le' 'cpf' 'i' r'uu'uwdutcvg'u'vj tqwi j 'vj gto cni'g'x'c' r'q'v'k'q'p' 'k'p'c'x'ce'w'w' 'cpf' 'qp' 'r' q'rk'uj gf 'cnwo k'pwo 'uwdutcvg'u' '208 o o ' 'vj kem' 'cpf' 'vj gp'cpqf k' gf 'k'p' 'y q/grgextqf g'egm' 'R'v'y cu'c'eq'w'p'v'g't'grgextqf g+'k'p'c'30 -O 'cs w'g'q'w'u'q'nw'k'q'p'qh'uwhwt le'cek' 'cv' eq'p'uc'p'v'x'q'nci g'k'p' 'vj g't'c'p'i g'qh'34642-XO'

Vj g'f cv'q'd'v'k'p'gf 'f go q'p'ut'cv'g'f 'f<sub>rqtg</sub> 'f gr gpf gf 'qp' 'vj g'vj gto c'ri'eq'p'f w'v'x'k'v' { 'qh'vj g'uwdutcvg' 'k'p' 'vj g'x'q'nci g't'c'p'i g'qh' 34636-XO'F gr gpf k'p'i 'qp' 'vj g'uwdutcvg'v' r g.'f<sub>rqtg</sub> 'k'p'et'g'c'ug'f 'k'p' 'vj g' 'h'q'ny k'p'i 'q't'f g't-'i' r'uu' '@'i' r'uu' 'egtco le' '@'UK<sub>4</sub>IUK' '@' cnwo k'pwo 0'K'y cu'ht'w'p'f 'vj cv'vj g'cpqf k' kpi 'xqnci g'qh'38-X' y cu'c'w'p'k'p'i 'r' q'k'p'v'ht' 'cpqf le'kno u'q'd'v'k'p'gf 'k'p' 'uwhwt le'cek' " chgt' 'y j ke'j 'vj g' 'u'q'r g'qh'vj g'r q'w'u'ht'q'f<sub>rqtg</sub> 'x'u'Wc' 'cpf' 'f<sub>kpvt</sub> 'x'u'Wc' 'ej c'p'i gf ' 'H'k'i 03+0Vj ku'y cu'g'z'r w'k'p'gf 'd { 'vj g'r t'q'eg'uu'qh' qz { i gp' 'g'x'q'nw'k'q'p'0'K'y cu'uj qy p' 'vj cv'vj j gp' 'vj g'cpqf g'r q'v'g'p'v'c'n't'g'c'ej gu'x'c'w'gu'g'z'eg'gf k'p'i 'vj g' 'g's' w'k'k'v'k'w'o 'r' q'v'g'p'v'c'n'qh' qz { i gp' 'grgextqf g.'q'z'k'f c'v'k'q'p'qh'vj cv'g't'ob q'rg'ew'gu'd'gi k'p'u'y k'j 'vj g't'g'rg'c'ug'qh'qz { i gp'ht'q'o 'vj g'u'q'nw'k'q'p'0Y g'cu'w'o gf 'vj cv'vj g' qz { i gp' 'g'x'q'nw'k'q'p' 't'g'c'v'k'q'p' 'qp' 'cnwo k'pwo 'q'z'k'f g'uwthceg'cv' 'vj g'r q't'g' 'd'q'w'q'o 'cv' Wc' '@'38-X' 't'g'uw'nu' 'k'p' 'cp' 'k'p'et'g'c'ug' 'k'p' 'cek' 'f' eq'p'eg'p'v'c'v'k'q'p' 'k'p' 'vj g'u'q'nw'k'q'p' 'cpf' . 'eq'p'ugs w'g'p'v'v' . 'k'p' 'j' k'j g't'grgextqf'vg' 'ej go lecn'c'v'x'k'v' { 'cpf' 'k'p'et'g'c'ug' 'k'p' 'vj g'f k'uu'q'nw'k'q'p' 't'cv'g' qh'vj g'q'z'k'f g'r'c' { g't'qh'r q't'g'y' c'm'u'0'



\*c+''



\*d+''

H'k'i 030G'x'q'nw'k'q'p'qh'r q't'g'f k'co gygt 'c'+ 'cpf' 'k'p'v'g'r q't'g'f k'uc'p'eg' 'd'+ 'cu'c' 'h'w'p'v'k'q'p'qh'vj g'cpqf k' k'p'i 'x'q'nci g'ht' 'r' qt'q'wu' cpqf le'cnwo kpc'kno u'htqto gf 'qp'cnwo k'pwo 'uwdutcvg.'UK<sub>4</sub>IUK'uwdutcvg.'i' r'uu' 'egtco le' 'uwdutcvg' 'cpf' 'i' r'uu' 'k'p'c'30 -O ' 'uwhwt le'cek' 0'

[3\_ 'Y 0'N'gg. 'U'U'0'ctm'R'qt'q'w'u'cpqf le'cnwo k'pwo 'q'z'k'f g'c'cpqf k' c'v'k'q'p' 'cpf' 'v'go r 'w'v'g'f 'u' { p'v'j g'uk'v'qh' 'h'w'p'v'k'q'p'c'n'p'c'p'q'ut w'ew'w'g'u. 'Ej go 0T'gx'0336'96: 969778' \*4236-0''

**U P VJ GUKU'QHI QNF 6'UKXGT'P CP QRCTVÆNGU'WUKPI ''  
P CP QUGE QPF 'NCUGT'CP F 'VJ K' O GVCNNÆ 'HKNO U''**

Xkc'Rgtkncly . 'Gxcnf cu'Ucprngxk kw"

" F gr ctvo gpv'qh'Ncugt "Vgej pqmji lgu. 'Egprgt'qh'Rj { ulecn'Uekppegu'cpf "Vgej pqmji { . 'Nksj wpcle"  
xkcR gvkncqgB ho eOv"

"

I qrf "cpf "ukxgt"pcpqr ctvængu"ctg"er r rlgf "lp" c"xctlgv{ "qh"vgej pqmji lgu. "lpenwf lpi "cf xcpegf "ecvnc{uu."UGTU."cpf " eqo r qpgpvu" qh'qr vœcn' cpf " grgevtqple" f gxlegu" y j qug" r tqr gtvægu" f gr gpf " qp" r ræuo qple" xkdtcvæqpu'OI qrf " cpf " ukxgt" pcpqr ctvængu"j cxg"lpvpgug"eqmju."j ki j "uwtæceg"ctgc"vq"xqno g"tcvæq."j ki j "grgevtæcn'eqpf vœvækw{."ej go læcn'ucdtkw{." ecvnc{ vœ" hœpevæqpu." gveQ3\_"Vj g" qr vœcn' r tqr gtvægu" qh'o gvcn' pcpqr ctvængu" f gr gpf " qp" vj g" ræcnc{ gf " uwtæceg" r ræuo qp" tguqpcpeg"\*NURT+0'

Vj g'ej qlæg'qh'vj g'o gjv qf "hqt"vj g'u{pvj guku'qh'r tgelqwu'o gvcn'pcpqr ctvængu"ku'pq'rguu'ko r qt vcp'cu'kv'f gvto lpgu'vj g" o qtr j qmji { . 'ucdtkw{.'cpf 'rj { uleqej go læcn'r tqr gtvægu"j4\_0Vj g'b ckp'r tqdrgo "gpeqwpvgf gf 'f wtkpi "u{pvj guku'ku'vj g'wpkqto " cpf 'tgr gvkxg'f gr qukwq'qh'pcpqr ctvængu0Vj g'wug'qh'c'æcugt'j gr u'vq"uqnxg'vj ku'r tqdrgo 0Wprikng'tcf kkpæcn'o gjv qf u.'vj ku' r tqeguu'f qgu'pqv'tgs vktg'ej go læcn'tgci gpvu'cpf "f gr qukwq'qh'pcpqr ctvængu"lp'uqnvæqpu'0Vj gto cni'j gvæpki "qh'c'vj lp'o gvcn' eqcvæpi "y kj "c"pcpqugeqpf "r wugf "æcugt"æcp"dg"r gthqto gf "ko o gf kvægn{ "qp"vj g'f guktgf "uwtæceg0Vj ku'o gjv qf "j cu'vj g" cf xcpvci gu'qh'æewtce{ . 'gcu{ "æcugt"r ctco gvgtu'æqpvæqn" c'mjy 'ko r cæv'qp'vj g'uwttqwpf lpi "ctgcu."cpf 'vj g'uwttæceg'kuægn0Y kj " vj ku'o gjv qf . 'pcpqr ctvængu'æcp"dg'f gr qukwg'f f ktgevn{ 'cpf 'hæcn{ 'gxgn{ "qp"xctkqwu'uwduæcvægu'cpf "æcp"dg'gcvækn{ 'tgr ræcvægf 0'

J gtg."vj g'i gpgtcvæqp'qh'i qrf "cpf "ukxgt"pcpqr ctvængu"qp" c"i ræuu'uwttæceg"htqo "vj g'o gvcn'hæno u'wukpi "c"pcpqugeqpf " ræcugt"cpf "vj g"lpæxgukvæ cvæqp'qh'vj g"o qtr j qmji { "cpf "r ræuo qple" r tqr gtvægu"qh'vj g" r ctvængu"y kn'dg"r tgugpvægf 0Cnuq."vj g" f khtgtgpeg'dgwy ggp'vj g'i gpgtcvægf "pcpqr ctvængu"læ g."f kur gtukap."cpf "qr vœcn'r tqr gtvægu'qh'f khtgtgpv'o gvcn'y knidg'æqo r ctgf " cpf "cpcn{ | gf 0'

"

[3\_]I 0E0I gj . 'D0Egtcpc.'X00 0Tqvænu."I qrf "pcpqr ctvængu"r tgr ctvæqp."r tqr gtvægu"cpf "cr r ræcvæqpu'lp'dkæpcpvæj pqmji { . 'Pcpquæcng'6\*8+."3: 936 3: : 2"\*4234+0'

[4\_]X0Rctggm'C0Dj cti cxc.'T0I wæc'."P 0Læp.'L0Rcpcy ct.'U{pvj guku'cpf "Cr r ræcvæqpu'qh'P qdng'O gvcn'P cpqr ctvængu"æC'Tgxlgv . 'Cf xcpegf "Uækppeg" Gpi lpggtlpi "cpf "O gf lælpg"\*; +:7496766"\*4239+0'

"

# DEVELOPMENT OF NANOCOMPOSITES BASED ON CLAY, GRAPHENE OXIDE AND MAGNETITE/MAGHEMITE

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The dynamically developing industrial sector, as one of the significant anthropogenic factors, is a source of a huge number of pollutants – organic, inorganic and biological, which negatively affect ecological integrity [1]. Despite the huge variety of methods suitable for removing pollutants from various wastes, there is still a shortage of highly efficient, eco-friendly materials. Adsorption methods have great potential for applications in the field of environmental protection [2, 3]. Therefore, it is promising to search for cost-efficient and biocompatible adsorbents possessing high adsorption capacity.

Currently, one of the most prospective adsorbents is clay minerals, which are not inferior in efficiency to commercial adsorbents, and in some cases even surpass them. Clays are being actively modified in order to increase their efficiency and selectivity towards specific pollutants. Another advantage of using clays is their possible combining with other potential adsorbents, that can increase the effectiveness of the composite due to a synergistic effect, while the most important is the ability of clays to minimize the toxic effect of other components in the composite, for example, graphene oxide [4], as well as various other modifiers [5].

The main challenges in this research area are possible additional pollution after the use of these adsorbents, the toxicity aspect of modified clays that are not fully understood, and that the data obtained *in vitro* and *in vivo* are contradictory.

The aim of this study was to develop composites of Clay-Graphene Oxide (GO)-Magnetite (MG)/Maghemite (MGH).

The first step of preparation of composites includes synthesis of all components. GO was obtained by the Hammers method, MG/MGH by a co-precipitation reaction of ferrous and ferric ions. Triassic clay (Šaltiškiai in North Lithuania) was used in this study. The clay was treated with 0.5 M HCl solution while for synthesis both treated and untreated clays were used. The synthesis of the composite included dispersing GO and MG/MGH in an ultrasonic bath for 2 h, followed by the addition to acid-treated (ATC) or untreated clay (UTC) to the solution, keeping the mixture under constant stirring in a flow of argon for 1.5 hours, at 60 °C. Then this mixture is centrifuged, the resulting composite is taken and dried in vacuum for 24 hours.

Thus, four composites were obtained based on acid-treated and untreated clay with different weight ratio (%) - ATC (43.48)-GO (13.04)-MG/MGH (43.48); ATC (66.67)-GO (16.67)-MG/MGH (27.78); UTC (43.48)-GO (13.04)-MG/MGH (43.48); UTC (66.67)-GO (16.67)-MG/MGH (27.78). These composites were characterized using X-ray diffraction analysis (XRD), X-ray fluorescence analysis (XRF), scanning electron microscope (SEM), transmission electron microscope (TEM) and FTIR spectroscopy (FTIR). The obtained composites were applied to remove heavy metals from aqueous solutions. Preliminary results of studying the adsorption of copper on composites showed the adsorption efficiency from 90 to 99%.

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[1] M. Hill, *Understanding Environmental Pollution* (4th ed.) (Cambridge: Cambridge University Press, 2020).

[2] B. Mu, A. Wang, Adsorption of dyes onto palygorskite and its composites: a review. *Journal of Environmental Chemical Engineering* **4**, 1274-1294 (2016).

[3] H. Han, M. Rafiq et al., A critical review of clay-based composites with enhanced adsorption performance for metal and organic pollutants, *Journal of hazardous materials* **369**, 780-796 (2019).

[4] M. Kryuchkova, R. Fakhrullin, Kaolin alleviates graphene oxide toxicity, *Environmental Science & Technology Letters* **5**, 295-300 (2018).

[5] K. Kansara, A. Kumar et al., Combination of humic acid and clay reduce the ecotoxic effect of TiO<sub>2</sub> NPs: A combined physico-chemical and genetic study using zebrafish embryo, *Science of the Total Environment* **698**, 134133 (2020).

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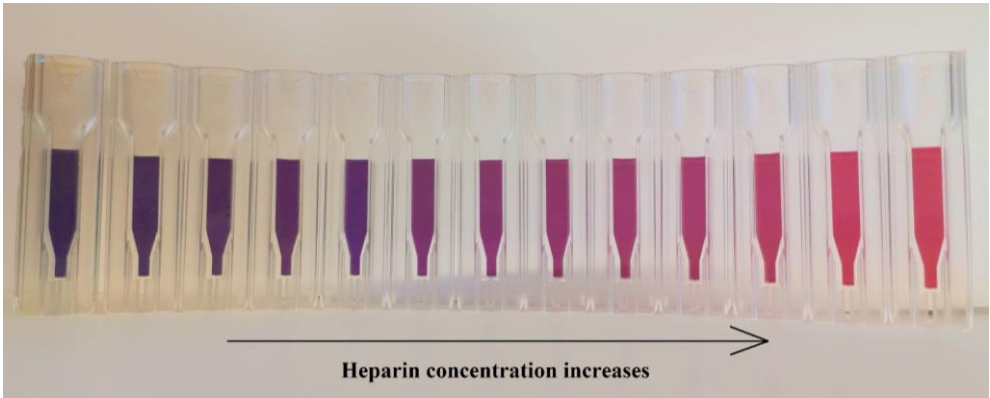
DID NOT PARTICIPATE

**VJ G'KO RCEV'QHI QNF 'P CPQRCTVÆNG'UK G'QP "**  
**URGEVTQRJ QVQO GVTKE 'F GVGGEVKQP 'QHJ GRCTK "**  
Gtpguc'Nwdkpckg<sup>3</sup>, .Dgpgf kmcu'Dtcukwpcu<sup>3</sup>. 'Cpvqp'Rqr qx<sup>3</sup>. 'Cuc'Mc wuckg/O kpmuko kpgg<sup>3</sup>. "  
 Iqpcu'Ncdwku<sup>3</sup>. 'Cmo kc'Tco cpxlekpgg<sup>3</sup>"

P cpqVgej pcu"ó'Egpgvt'qh'P cpqvej pqrqi { "cpf 'O cvgtkcu'Uelgpeg. 'Kpukwag'qh'Ej go kut { .Hewm'qh'Ej go kut { "cpf "  
 I gquelgpegu.'P cwi ctf wmq'ut046.'Xkpkwu.'Nkj wcpk "  
gtpguc'NwdkpckgB ej i hñw'f'kwñ"

J gr ctłp'ku'c'r'j cto cegwlecn'f'twi "vj cv'ku'wugf "vq'r tggp'v'j g'hqto cvkqp'qh'dmqf "emw"]3\_0'Ukpeg'f kugcugu'vj cv'ecp"  
 chge'v'vj g'ektewcvqt { "u{ ugo "ctg'y kf gur tge'f "pqy cf c{u."k'ku'ko r qtwcpv'vq'ghge'v'xgn{ "o qpkqt'dmqf "eqci wcvkqp."  
 gur gekm'f'włpi "uwti gt{0'O gvj qf u'vj cv'ctg'ewtgpwł "wugf "hqt"j gr ctłp'f'gvge'v'kqp"j cxg'c'hgy "f tcy dcemu'0'Hktumł."vj gug"  
 o gvj qf u'ctg'pq'v'ur gekle'hqt"j gr ctłp'cpf "vj gtg'ctg'mcf u'qh'cpcnł vlecni'kpvgthtgpegu'0'Ugeqpf nł."vj gł "ctg'wko g'eqpuwo kpi "  
 ]4\_0'Vj gug'f tcy dcemu'rgf "vq'c'pggf "hqt"c'pgy "cpcnł vlecni'f' ugo "vj cv'ku'ur gekle'hqt"j gr ctłp'0'Ukpeg'k'ku'c'j ki j nł "pgi cvkxgnł "  
 ej cti gf "r qnł uceej ctkf g."j gr ctłp'ecp'dg'gcukł "cf cr wgf "vq'vj g'cpcnł vlecni'f' ugo "y j gtg'pgi cvkxgnł "ej cti gf "eqmqk' cnił qrf "  
 pcpqr ctłerg"i P R'+'uqmwkqp'ku'wugf "tguwłkpi 'łp'ci i tgi cvkqp"]5\_0'

Kp'vj ku'y qtm'y g'eqo r ctgf "j qy "vj g'f'htg'peg'łp'I P Ru'ukł g'35'po "cpf '50'po "+chge'v'cpcnł vlecni'f' ctco gvgtu'uwej "cu"  
 ugpukxkł "cpf "tgr tqf wkdłkł "qh'vj g'u' ugo "wugf "hqt"j gr ctłp'f'gvge'v'kqp'0'Vj g'u' ugo "kugri'tgri'gu'qp"vj g'eqci wcvkqp'qh"  
 pgi cvkxgnł "ej cti gf "eqmqk' cnił P R'+'uqmwkqp'łp'vj g'r tgupeg'qh'r qukxgnł "ej cti gf "r qnł o gt "r qnł /N/nł ukpg"RNN+0'Ucdrg"  
 I P R'+'uqmwkqp'ku'tgf "f w'v'vj g'ne'cn'uwłhreg'r r'euo qp'tguqpcpeg"RURT+"cpf "vj g'r genłku'tgi kvg'gf "cv'c'y cxgrppi vj "qh"  
 742'po 0'Vj g'cf f kłqp'qh'RNN'v'q'I P R'+'uqmwkqp'tguwłkpi'p'cpqr ctłerg'ci i tgi cvkqp'0'Xkukdrg'eqmłt'ej cpi g'ecp'dg'qdu'g'xgf "  
 chgt'vj g'ci i tgi cvkqp'y kłj "I P R'+'uqmwkqp'włpłpi "dnw'cpf "RURT"r genłuj kłkpi "vq'c'y cxgrppi vj "qh'872'po 0'Qp'vj g'q'vj gt "  
 j cpf."j gr ctłp'łucdłkł gu'I P R'+'uqmwkqp'd'f' r tggp'v'kpi "vj g'RRN'łpf w'egf "ci i tgi cvkqp.'tguwłkpi 'łp'c'I P R'+'uqmwkqp'qh'ur gekle "  
 eqmłt'dcugf "qp"j gr ctłp'eqpegp'cvkqp'cmjy kpi "hqt"vj g'et'gcvkqp'qh'c'j gr ctłp'ugpuqt "Hki 03+0'



Hki 030'Vj g'eqmłt'ej cpi g'qh'I P R'+'uqmwkqp'łpet'g'cukpi "eqpegp'cvkqp'qh'j gr ctłp'0'

aa  
 ]3\_ ROGOO cntku."óNqy "o qrgewct'y gli j v'j gr ctłp.ó'Cte'j 0'J gm'00 gf 0'xqñ038."pq06.'r r 054; 6554."3; ; 0'  
 ]4\_ O 0C'0'Uo { vj g.'l'0'Ri'k' kqr.'R'0'R'0'F qdguj."F 0'Y k'vj."C'0'Ewngt."cpf "C'0'M'0'Y kwnjy unł."ół w'kf c'peg'hqt"vj g'r tce'v'ecni'f' c'pci go gp'v'qh'vj g'j gr ctłp"  
 cp'v'eqci w'epwł'łp'vj g't'g'cvo gp'v'qh'x'gp'qwu'vj tqo d'qgo d'qñkuo.ó'LOVj t'qo d'0'Vj t'qo d'qñ'uku."xqñ063."pq03.'r r 038763; 8."42380'  
 ]5\_ Z'0'O c."Z'0'M'q'w'f' 0'Z'w.'F'0'f' cpi."cpf "R'0'O k'q."óE'q'q'itko g'v'le'ug'p'ulpi "ut'cvgi { "hqt"j gr ctłp'cuuc { "dcugf "qp"R'F'F'C'łpf w'egf "ci i tgi cvkqp'qh'f' qrf "  
 pcpqr ctłergu.ó'P'cp'q'w'c'rg'f'x'0'xqñ03."pq04.'r r 06; 866; ; .423; 0'

# UPCONVERTING NANOPARTICLES - SYNTHESIS AND CHARACTERIZATION

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Nowadays one of the most challenging issues in medical sciences is the early detection of cancer. There are thousands of chemical and biological methods, but more and more popular become using also physical methods, such as quantum effects from novel nanomaterials. One of the widely explore fields, which shows potential applications in medical sciences, is the upconversion phenomena. The main goal was to obtain gadolinium oxide nanoparticles doped with selected metals to investigate energy transfer between erbium ( $\text{Er}^{3+}$ ) and ytterbium ( $\text{Yb}^{3+}$ ) ions and enhance of the efficiency of upconversion by doping structures with magnesium ions ( $\text{Mg}^{2+}$ ).

The examined nanoparticles were synthesized by a homogeneous precipitation method for 2 hours at a temperature of 85°C. The crystal structure arrangement was obtained by calcining at a temperature of 990°C for 3 hours. Additionally, nanoparticles were characterized with several methods. The atomic composition of the nanoparticles was analyzed via energy-dispersive X-ray spectroscopy (EDS). The size were determined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The crystal structure was characterized by X-ray diffraction (XRD). Optical properties were investigated by using photoluminescence measurements. Finally, nanoparticles were incubated with mouse mammary carcinoma (4T1) cells for 24h to examine their suitability for use in biology as luminescent markers.

As result of research, nanoparticles show luminescence in green emission region - maxima occur at a wavelength of 565 nm ( $^4\text{S}_{3/2} \Rightarrow ^4\text{I}_{15/2}$ ,  $^2\text{H}_{11/2} \Rightarrow ^4\text{I}_{15/2}$ ) – and in red emission region - maxima occur at a wavelength of 663 nm ( $^4\text{F}_{9/2} \Rightarrow ^4\text{I}_{15/2}$ ). The optical properties were examined by excitation with a semiconductor laser with a wavelength of 980 nm (continuous wave). An increase in the effectiveness of the upconversion process was observed - an 8-fold increase in red luminescence efficiency was obtained for nanoparticles doped with 2.5%  $\text{Mg}^{2+}$  compared with non-doped nanoparticles ( $\text{Gd}_2\text{O}_3$ : 1%  $\text{Er}^{3+}$ , 18%  $\text{Yb}^{3+}$ ). The measurements were carried out at a laser power density of 12  $\text{W}\cdot\text{cm}^{-2}$ . The nanoparticles were dissolved in a dimethyl sulfoxide solution. The nanoparticles diameter was 380 nm, 282 nm, and 260 nm (before calcining). The diameters of the obtained nanoparticles - are  $302 \pm 37$  nm and  $278 \pm 36$  nm (after a calcining) respectively. Obtained upconverting nanostructures show beneficial properties, which make them appropriate material to be used in bioimaging.

# INVESTIGATION OF INGAN/GAN QUANTUM WELLS PHOTOLUMINESCENCE AND SURFACE TOPOGRAPHY

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InGaN is a direct bandgap semiconductor material made with a mix of GaN and InN. By varying the amount of indium present in the alloy, we can change the bandgap of the material (usually from 0.69 eV to 3.4 eV)[1]. In this research we investigated the effects of the indium percentage difference in the InGaN multiple quantum wells (MQW) grown using metal organic chemical vapor deposition (MOCVD) method by Cheyenne Lynsky's team at University of California, Santa Barbara.

We studied four InGaN MQW samples having varying amounts of In (9 %, 12 %, 17 %, 20 %). They were excited with a 405 nm wavelength laser diode through a high numerical aperture (NA = 0.55) objective. Three measuring techniques were used. Confocal microscope – for the photoluminescence (PL) spatial distribution, atomic force microscope (AFM) – for the topography and using scanning near – field optical microscope (SNOM) technique enabled us to link the surface topography of the samples and its effects on the photoluminescence. Indium percentage and subsequent PL spectrum peaks were: 12 % - 431 nm, 17 % - 485 nm, 20 % - 535 nm (Figure 1). All samples showed highly inhomogeneous spatial distribution of PL intensity and peak position. Statistical analysis of PL maps revealed a positive correlation between PL intensity and peak position, i.e. PL intensity is more intense in areas that emit at longer wavelengths. This is due to carrier localization in the areas of higher indium content. The topography analysis revealed that surface roughness increases with average indium content in the samples. Moreover, SNOM measurements showed that PL intensity drops in the lower parts of the surface. We showed that the topography of the samples correlates with the photoluminescence intensity.

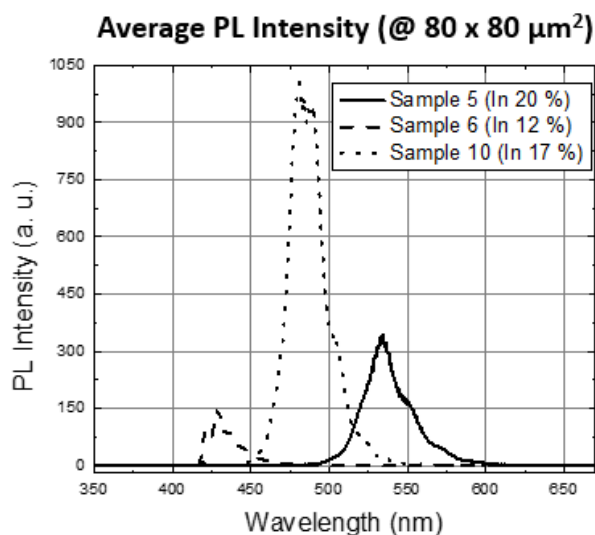


Fig. 1. Spatially averaged PL spectra of InGaN MQW

[1] G. Linti, "The Group 13 Metals Aluminium, Gallium, Indium and Thallium. Chemical Patterns and Peculiarities. Edited by Simon Aldridge and Anthony J. Downs.," *Angew. Chemie Int. Ed.*, vol. 50, no. 49, pp. 11569–11569, Dec. 2011, doi: 10.1002/anie.201105633.

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DID NOT PARTICIPATE



**F GXGNQRO GP V'QH'C'RQTQWU'UKNEQP'DCUGF'I WKF'G'O QF'G'  
T GUQP CVQT'CU'C'VGO RNCVG'HQT'UGTU/CRRNKE CVKQP "**  
P cf | g { c 'Mj kpgxlej <sup>16</sup>. 'Lxqf pcu'O kpf cwi cu<sup>3</sup>. 'Vqo cu'Vco wgxk kwu<sup>3,4</sup>. 'Uki kcu'Vco wgxk kwu<sup>3,4</sup>"

<sup>3</sup>"Kpurkwwg'qh'O cvgtkcm'Uelgpeg'qh'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmji { . 'Mcwpcu' 'Nkj wcpkc'"  
<sup>4</sup>"F gr ct vo gpv'qh'Rj { uku. 'Mcwpcu'Wpkxgtukv' 'qh'Vgej pqmji { . 'Mcwpcu' 'Nkj wcpkc'"  
pcf | g { c'0hj kpgxlej B mw0f w'

"  
Uwthceg"gpj cpegf "Tco cp"uecwtkpi " \*UGTU+"ur gestqueqr { "ku'y gm'npqy p"cu"cp" ghlekgpv'o g'jy qf "qh'o qngewgu" f gvevkap0Tqwi j "o gvcnie'lwthcegu'qt'emugn' 'r cengf "o gvcnie'pcpqr ctvgeru'cttc{ u'ctg'y'j g'o clp'cwt'kdwgu'wugf "vq'cej kxg" Tco cp'uki pcrngpj cpego gpv'3\_0'Vj g'uki pcrngpj cpego gpv'ku'qdugtxgf 'y j gp'v'j g'uwf kcf "o qngewg'ku'hw'w'f'pgz'v'v'q'y'j g'o gvcni' lwthceg'y'j cv'ku'ej ctcevgtk' gf "d { 'lwqpi "grgevtqo ci pgve'kgrf "cr r gctkpi 'w'pf gt 'y'j g'z'v'gt'pcni'gzekcvkap0Vj ku'gh'ge'v'ku'hpqy p" cu'Nqecik' gf "Uwthceg'Rruo qp" Tguqpcpeg" \*NURT +0"

Vj g'r tqo kulpi "wug'qh'c'i wkf g'o qf g'tguqpcvqt " \*I O T + "hqt'cf f ksqpcn'co r r hlecvkap'qh'UGTU/uki pcrnj cu'dggp'uj qy p" kp'tgegpv'tgr qt w' | 4\_0'Vj g'I O T "ku'tgi ctf gf "cu" c' f khtcevkp" i' tvkpi "y kj "uwy cxgrpi vj "f ko gpukpu"qp" c' f kgrgevtke" vgo r r v'g'0'Vj g'gzekcvkap'y cxg'v'g'p'f u'v'q'v'cxgricnpi 'y j g'lwthceg'kp'v'g'cevkpi 'y kj "y'j g'o cvgtkrc'p'f' hqny gf "d { 'v'cpuo kwkpi " qt "tgh'ge'v'kpi " r t'qegu'g'0'Vj g'tkug'kp"UGTU/cev'kxk' 'qh'I O T lo gvcnie'pcpqu'wewt gu'ku'qdugtxgf "f w'g'v'q'lwqpi "eqw r kpi " dg'y ggp'y'j g'ug'v'y q'lw'wewt gu'cp'f' ecp'dg'eqpvt'qngf "d { 'v'ck'v'kpi "y'j g'j' g'k'j' v'cp'f' r' g'k'q'f' k'k'v' 'qh'y'j g'hw'c'f' g'f' kgrgevtke'i' tvkpi "0"

P cpqu'wewt gf "ukleqp"ku'eqpuk' gf gf "v'q'dg'cp" ghlekgpv' uwdutcv'g' hqt "UGTU/cev'kxg' u'g'puqtu" f g'x'g'nr o gp'0'Rqtqwu" ukleqp "RU+ku'qpg'qh'y'j g'ukleqp'pcpqu'wewt gu'v' r' g'v' cu'ku'y' k'f' gn' 'wug' 'cu'c'v'go r r v'g' hqt' f' gr qu'k'v'q'p'qh'xct { kpi "o gvcnie" hqt o u'w'ej "cu'ukxg'ct'cp'f' i' qif "pcpqr ctvgeru. "f' g'p'f' t'kgu. "s' w'cu'k'eqp'v'p'w'q'w' h'ko u' | 5\_ "g'v'0'hw'v'j g'to q'g. "k'ku'g'r' q'v'g'f' 'y'j cv'RU" ecp'v'cng'r' ctv'lp' "Tco cp'uki pcrngpj cpego gpv'y'j k'g'd'g'kpi "o gcuwt gf " | 6\_ "y'j k'ej "t'ck'ug'v'p'v'g'v'lp'ku'wug'cu" c' uwdutcv'g' hqt " UGTU/cev'kxg' u'g'puqtu' h'cd'lecvkap0"

Kp'kw'y' q'ntly g'r' tqr qu'g'c'p'gy "cr r tqcej 'qh'co r r hlecvkap'qh'y'j g'c'rt'g'c'f { 'lwqpi "h'qec'nh'kgrf "y'j cv'cr r g'ct'u'd'g'y ggp'uk'x'g't' pcpqr ctvgeru" h'qec'v'g'f' "cv'ug'x'g't'c'p'p'qo g'v'g'u' "h'qo "g'cej "q'y'j g't. "wukpi "r' q'v'w'ukleqp" r' g'k'q'f' k'v' "lw'wewt gu'cu" y'j g'I O T "hqt" UGTU/cr r hlecvkap0C'ceq'f' kpi "v'q'v'j'ku'cr r tqcej "y'j g'pcpqu'wewt g'qh'I O T r' q'v'w'ukleqp" uk'x'g't' pcpqr ctvgeru" j' cu'dggp" h'cd'lecv'g'f' "kp'ug'x'g't'c'p'p'qo u'0'c'v'ht'v'v'j g'r' g'k'q'f' k'v' i' tvkpi u'j' cxg'dggp' h'qto gf "q'p'c'ukleqp" y' ch'g't { "f' k'g'v'v'c'ug't' k'p'v'g't'g'p'eg" r' cv'g't'kpi "wukpi "Hgo v'q'v'rd' y' q'm'v'v'k'p'gs' w'k'r' g'f' 'y' kj "I d-MI Y "hgo v'q'ge'q'p'f' "v'c'ug't' Rj' ct'qu'0'Vj g'y' cxgrpi vj u'qh'737"po " cpf'62'hw' | "h'g'w'g'p'e { 'y' g't'g'v'g'v'p'v'j g'uge'q'p'f' j' c'to q'p'k'v'q'ue'k'v'v'q't'0'Vj g'v'c'ug't' r' q'y' g't'cp'f' 'x'c'v'g'u'q'v'v'w'g'u'y' g't'g'c'p'i kpi "h'qo " 38'o Y "v'q'382'o Y "cp'f' "h'qo "3222'r' w'ng'u'v'q'47222. "t'g'v'g'v'x'g'g'f' "h'q't'ug'c't'ej kpi "y'j g'lwthceg'qh'y'j g'ukleqp" i' tvkpi "em'ug'v'q" y'j g'hw'v'q'p'g'kp'q'f' g't'v'q'cx'q'k'f' c'f'f' k'k'q'p'c'n'k'i j' v'uecwtkpi "d { "k't'g'i' w'v'v'k'k'g'u'0'Vj g'p. "y'j g'h'cd'lecv'g'f' "I O T" j' cu'dggp' r' q'v'q'k'k'g'f' " d { "gr'ge'v't'q'ej go k'ec'v'g'ej kpi "kp'c's'w'g'q'w'v' d'c'ug'f' "gr'ge'v't'q'v'g'v'p'ew'f' kpi "32" j' { f' t'q'hw'v'q't'k'v' c'ek'f' "c'v'v'ew't'g'p'v'f' g'p'uk'v' { "362'o C'leo 40" C'p'f' "h'k'p'cm'f' "y'j g'uk'x'g't' pcpqr ctvgeru" j' cxg'dggp' f' gr' qu'k'v'g'f' "q'p" I O T r' q'v'w'ukleqp" d { "ko o g't'uk'q'p' f' gr' qu'k'v'g'f' "h'qo "5" o " uk'x'g't' "v'c'n'v'q'v'w'k'q'p' h'q't' "cp'j' q'w'0"

Vj g'o qtr j' qmji { "cpf "qr' v'ec'n'r' tqr g't'v'g'u'qh'y'j g'pcpqu'wewt gu'r' t'q'f' w'eg'f' "j' cxg'dggp' u'w'f' k'g'f' 0'Vj g'cr r r hlecvkap'qh'y'j g' lw'wewt g'v'q'UGTU/ur' gestqueqr { "j' cxg'dggp' k'p'x'g'v'k'i' cv'g'f' "wukpi "Tj' q'f' co' k'p'g'8I "cu'c'v'cti' g'v'o qngewg'cp'f' "v'c'ug't' y' cxgrpi vj " 754"po 0'K'j' cu'dggp' g'v'c'd'k'v'j' gf "y'j cv'I O T IRU'uk'x'g't' pcpqr ctvgeru" u' { u'go "g'z'j' k'd'ku" j' k'j' g't'UGTU/cev'kxk'v' { "kp'eqo r' ct'ku'q'p" y' kj "RU'uk'x'g't' pcpqr ctvgeru" lw'wewt g'0"

Vj g'g'z'r' g't'ko g'p'v'c'n't'g'u'w'u'c't'g'w'r' r' q'v'g'f' "d { "y'j g'o q'f' g'm'kpi "t'g'u'w'u'g'p'c'd'k'p'i "w'u'v'q'q'v'g't' "y' c { "qh'r' t'q'f' v'ek'v'p'qh'UGTU/cev'kxg' r' q'v'w'ukleqp" d'c'ug'f' "u'w'd'ut'cv'g'u'0'Y g'f' go q'p'v'v'c'v'g'v'j' cv'y'j g'o q'v'v'g'h'g'v'k'x'g' u'g'puqt' y' kj "r' t'q'r' g't'v'g'u'k'p'f' k'k'f' w'c'm'f' "u'g'r'g'v'g'f' " h'q't' "y'j g'w'ug'f' "v'c'ug't' y' cxgrpi vj "lp" y'j g'UGTU/o g'cuwt'go g'p'w'o c { "dg" r' t'q'f' w'eg'f' "d { "xct { kpi "y'j g'r' k'ej "qh'I O T. "r' q'v'q'k'v'f' "qh' ukleqp" cp'f' "uj' cr' g'qh'p'c'p'qr' ctvgeru"0'"

13\_ O 0H'p. 'I (H)U'0'c'p'f' t'c'f' g.'C'0'0'v'q'q'v'c'v'g'x'g'y' "q'p'v'j' g'h'cd'lecvkap'qh'lw'wewt'cv'g'u' h'q't' lw'wewt'g'p'j' c'p'eg'f' "Tco cp'ur' gestqueqr { "cp'f' "y'j g'k'v'cr r r hlecvkap'p' c'p'c'n'f' v'ec'v'ej go k'v' { . "C'p'c'n'f' v'ec'v'ej ko lec'v'c'v'c'0'8; 5. '9647" \*4233-0"

14\_ [ 0Uj' g'p. "Z'0'ej' g'p'i. "I O'N'k'v'0'v'j' w'v' 0'ej' k'v'0'Y' c'p'i. "E'0'0'p. "J' k'j' n' "u'g'p'k'x'g'c'p'f' "v'p'k'v'q'to "lw'wewt'g'p'j' c'p'eg'f' "Tco cp'ur' gestqueqr { "h'qo "i' tvkpi / k'p'v'g'i' t'c'v'g'f' "r' r'v'c'u' q'p'le'p'c'p'q'i' t'c'u'u' "P'c'p'q'ue'c'g' "J' q't'k' q'p'u'3. "4; 264; 9" \*4238-0"

15\_ "J' 0'X'0'0'c'p'f' c't'g'p'ne. "M'0'X'0'1' k'g'n' "U'0'0' c'x'c'v'w'k' "C'0'R'c'p'c't'k'p. "U'P'0'V'g't'g'n'j' q'x. "R'q'i' t'g'u'v'k'p'v'j' g'f' g'x'g'nr o gp'v'q'v'UGTU/cev'kxg' u'w'd'ut'cv'g'u' d'c'ug'f' "q'p" o g'v'c'n' e'q'v'g'f' "r' q'v'w'ukleqp. "O'c'v'g't'k'c'n'0'33. "3642" \*423: -0"

16\_ "K'0'0'0'v'j' q'f' c'v'g'x'k'ej. "M'0'X'0'1' k'g'n' "J' 0'X'0'0'c'p'f' c't'g'p'ne. "X'0'R'0'D'q'p'f' c't'g'p'q'v'j' "U'P'0'V'g't'g'n'j' q'x. "C'Q' 0'R'c'p'c't'k'p. "H'q'to' c'v'k'q'p' "T'g'i' w'v'v'k'k'g'u'q'v'v'w'g'u' q'p'le' "U'k'x'g't" P'c'p'q'v'v'w'w'g'u'q'p' "R'q't'q'w'u' "U'k'leqp' h'q't' "G'h'g'v'k'x'g' "U'w't'h'c'eg' / G'p'j' c'p'eg'f' "Tco cp' "U'ec'w'g't'k'p'i. "P'c'p'q'ue'c'g' "T'g'ug'c't'ej "N'g'v'g'u'0'33. " \*4238-0"

# EFFECTS OF GRAPHENE OXIDE NANOSTRUCTURES AND METAL MIXTURES ON *LEPIDIUM SATIVUM*

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Graphene nanomaterials (GMs), such as graphene oxide (GO) due to unique structure and properties have been widely used in various fields [1]. Thus, the rapid increase in production and application, probably will lead to the inevitable release of GMs into water and soil environments with increment of potential health and ecosystem risks [2]. There are only some works on the ability of GO to adsorb heavy metals from aqueous solutions [3]. However, so far, only a few studies have been conducted regarding the effects of GO on plants. Also, the information related to the ability of GO to reduce the toxicity of heavy metals on plants by adsorption is still limited.

Therefore, the aim of the study was to examine the phytotoxicity of GO using garden-cress (*Lepidium sativum* L.) as a test-organism and to evaluate the ability of GO to modify the uptake of metals by plants exposed to metal mixture.

The metal ion mixture (MIX) (Ni(II) 0.034 mg/L, Zn(II) 0.1 mg/L, Cr(III) 0.01 mg/L and Cu(II) 0.01 mg/L) was prepared according to the maximum-permissible-concentrations (MPC) accepted for the inland waters in the European Union. The mixtures MIX20, MIX40 and MIX80 were prepared by increasing the MPC of every single metal ion by 20, 40 and 80 times, respectively. The GO concentrations (1, 20, 40, and 80 mg/L) were chosen in accordance with the previous study [4] concerning the ability of GO to adsorb heavy metals. In addition, the phytotoxicity of mixtures where GO was combined with MIX was evaluated.

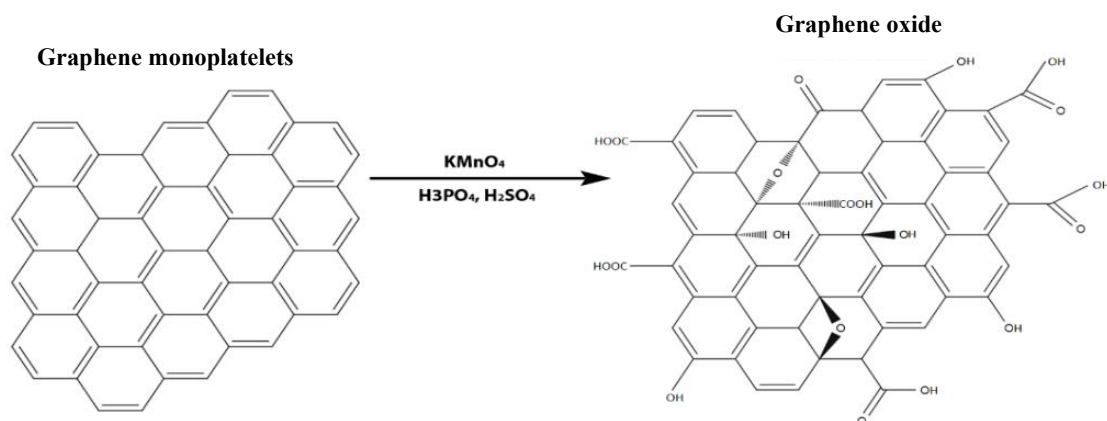


Fig. 1. Scheme of graphene oxide synthesis [4].

Obtained data showed that tested concentrations of MIX, GO and MIX+GO in the most cases did not affect seed germination, root growth and biomass of roots as well as above-ground parts of plants but influenced photosynthesis, increased the production of carotenoids and H<sub>2</sub>O<sub>2</sub> with further activation of lipid peroxidation. In addition, statistical analysis showed that in some cases the effect of metals on plants exposed to combined exposure to GO and MIX decreased. This study revealed that GO are promising and advanced adsorbents of metals.

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[4] S. Šemčuk, Application of graphene oxide based nanocomposites and Šaltiškiai clay for radionuclides removal from contaminated solutions. Summary of doctoral dissertation (Vilnius University Publishing, Lithuania, 2018).

# I TCRJ GP G'QZKF G'TEJ KVQUCP 'TEQRRGT 'P CP QE QO RQUKVGU'HQT'' CP VWDCE VGT KCN'UVWF KGU'

\*\*\*\*\*Gf kj 'Hqt c' Lqgn'. 'I cnkpc'Nwlcplgpg'. 'Ucpf tc'Ucplkqp{ v<sup>3</sup>. 'Nqtgvc'Ngxlpuncv<sup>4</sup>"

<sup>3</sup>UTKE gptg'qh'Rj {ulecni'Uelgpegu'cpf 'Vgej pqmji {.'Nkj wcpk"

<sup>4</sup>UTKP cwtg'Tgugctej 'Egptg.'Xkpkwu.'Nkj wcpk"

gf kj lqgnB hno ehn"

C"i gpgvle"o wcvkqp"lp"dcevgtkn'utckpu'ecwulpi "tgukwpeg"vq"enpklecn'f twi u'cpf "dkqekf gu'ecp"dg"hzgf"d{ "etgcvkpi "cpvkdcevgtkn'pcpqqeo r quksu0Vj g'r tqi tguu'cuuqekv'gf"y kj "o gvcn'pcpqqeo r quksu'f go qpwtcvgu'vj gk"i tqy yj "r qvpgvkn'lp"vj g"eqvtqn'qh'dcevgtkn'lp'hgevkpu"cpf "vj g"f go cpf "vq"r t'gxp'v'dkqkno "hqtto cvkqp0Eqr r gt"cpf "ku"qz'kf gu."cu'y gni'cu" r r'v'k'pwo "pcpqr ct'v'ergu."r quuguu'cpvkdcevgtkn'r tqr gt'v'ku0I tcr j gpg'Qz'kf g'Ej kqucp"pcpqqeo r quksu'ctg'uwks'cdrg'hqt"vj g"etgcvkqp"qh'cpvkdcevgtkn'o cvgtkcn"j3\_0'Vj g"eqo d'k'p'gf "ej ctcevgtkn'ku'eu"qh'c"j k j "uwt'heg/vq/xq'no g"t'cvkq"qh'I tcr j gpg'Qz'kf g"i Q+"j4\_"cpf "vj g"pcwt'cn'cpvkdcevgtkn'r tqr gt'v'ku'qh'Ej kqucp"iE VU"j5\_"cev'cu'gh'ge'v'k'g"o gcpu'vq"l'pet'g'cug"vj g"gh'ge'v'k'g'p'guu"qh'cp'v'k'o let'q'd'k'cn'o cvgtkcn0Eqr r gt"j6\_"cpf "Rr'v'k'pwo "pcpqr ct'v'ergu"r tqj kdk'hw'v'j gt"dcevgtkn'r tq'rh'gt'cvkqp"j7\_0'Vj g"cf'f'k'k'qp"qh'Rr'v'k'pwo "cpf "Eqr r gt"pcpqr ct'v'ergu"lp"eqo d'k'p'cvkqp"y kj "c"dk'qr qn'o gt"u'we'j "cu'I QIE VU"qh'htu"c" r tqo kulpi "cr r tq'cej "vq"q'd'v'k'p"e'p'gegu'uct { 'o cvgtkcn'vj tq'wi j "t'gug'ctej "cpf "eqo r ct'ku'qp"y kj "q'v'j gt"gz'k'v'k'pi "q'p'gu0O qt'g'q'x'gt." I QIE VU"pcpqqeo r quksu'j cxg"e"y k'f g"t'cpi g"qh'cpvkdcevgtkn'ej ctcevgtkn'ku'eu"cpf "ctg"u'w'gf "vq"ko r tq'x'g"vj g"cp'v'k'ugr v'le" r tqr gt'v'ku"qh'o gvcn'pcpqr ct'v'ergu0' Vj ku"y qtn'i'c'k'o gf "vq"u{pvj g'k'g"pcpqr ct'v'ergu"qh'Ew."EwQ."EwQ."Rv"cpf "vj gk" I tcr j gpg'Qz'kf g'Ej kqucp"eqo r quksu.'cu'y gni'cu'vq"v'gu'v'j gk"cp'v'k'o let'q'd'k'cn'ce'v'k'k'v'0

P'cpqr ct'v'ergu"qh'Ew."EwQ."EwQ"cpf "Rv"y gtg"r tgr ct'gf"d{ "ej go lecn't'gf wcvkqp"ht'qo "EwUQ60J 4Q"cpf "u'w'gf "vq"u{pvj g'k'g"eqo r quksu'qh'I QIE VUIRv'Ew."I QIE VUIRv'EwQ"cpf "I QIE VUIRv'EwQ0I QIE VUIRv'Ew."I QIE VUIRv'EwQ."eqo r quksu'y gtg"u{pvj g'k'g'gf "hqt"vj g'h'k'uv'k'o g0Ej ctcevgtk'cvkqp"qh'q'd'v'k'p'gf "o cvgtkcn'y cu'r gth'qto gf "wulpi "Z/Tc{ "F k'h'ce'v'k'p"iZTF +0'G'q'k'k'Guej gt'k'ej k'eq'k'k'CVEE"47; 44"y cu'w'w'gf "vq"v'gu'v'j g"cpvkdcevgtkn'gh'ge'v'qh'vj g"o cvgtkcn0Vj g"46/j qwt'ew'w'w'g"y cu'w'w'ur g'p'gf gf "lp"u'v'g'k'g'uc'k'p'g"cpf "u'c'p'f'c't'f'k'gf "vq"wt'd'k'k'v'qh'32: "EHW"t'o n'wulpi "c"ur gev'tqr j q'v'qo g'v'gt "cv'822"po 0322"U'n'q'h'vj g'w'w'ur g'p'k'q'p"y cu'cr r r'k'g'f "vq"R'g'v'k'f'k'uj gu'eq'v'k'p'k'pi "O w'ng't/J k'p'v'p"ci ct0Vj g"v'gu'v'o cvgtkcn"322"U'i +y gtg'r r'ne'gf "qp"l'p'q'ew'v'v'gf "r r'v'gu'cpf "l'p'ew'd'cv'gf "hqt"46"j "cv'57"AE0'Vj g"z'r gt'k'o g'p'v'y cu'ect't'k'gf "q'w'w'lp"v'k' r'ec'v'g0G'x'cn'w'v'k'p"qh'vj g'dcevgtk'k'f'cn'gh'ge'v'y cu'ect't'k'gf "q'w'w'd{ "o gcu'w'k'pi "vj g'f'k'co g'v'gt"qh'vj g"l'q'p'g'qh'k'p'j k'k'k'k'p" hqtto gf "ct'q'w'p'f "vj g"o cvgtkcn'cpf "vj g'p"ec'w'w'v'k'pi "vj g"o g'cp"cu'y gni'cu'vj g"u'c'p'f'c't'f "f'g'x'k'v'k'p0Rt'g'k'o k'p'ct { "t'gu'w'w"qh'cpvkdcevgtkn'v'guu"l'p'f'k'ec'v'gf "j k'j gt"ce'v'k'k'v' { 'ci c'k'p'uv'G0E'q'k'h'qt"Ew."EwQ"cpf "EwQ"pcpqr ct'v'ergu'cu'y gni'cu'hqt"vj g'I Q1 E VUIRv'EwQ"eqo r quksu0'Eq'p'k'f'gt'k'pi "vj g"r q'v'p'v'k'cn'cr r r'ec'v'k'p'u"lp" h'q'q'f "r c'c'nc'i'k'pi ."o gf lecn'f'g'x'k'g'u."v'z'v'k'g'u"cpf "r j cto ceg'w'k'cn'cpf "y cvgt"v'g'c'w'o g'p'v'y k'n'f' cxg'w'uci g'ht'qo "eq'r r gt"dc'ug'f"pcp'q'eqo r quksu0

"

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j3\_J 0[ wcp'Nqpi /I wg-Rctm"Uqq/Lp=C"tgxky <u{pvj g'k'g"cpf "cr r r'ec'v'k'p'u"qh'i tcr j gpg'k'ej kqucp"pcpqqeo r quksu."Ect'd'q'p"Ngw0"xqr039."pq03."r r 0'3339."42380"

4\_U0[ g'g'v'cn'0'cp'v'k'k'cn'ce'v'k'k'v' { 'qh'I tcr j gpg'Qz'kf g'J qy "Uj c't'r "G'f' i g'f "U't'w'ew'g"cpf "Ej c'ti g'O'c'w'gt."CEU'Cr r r'0'c'v'gt0( "l'p'v'g'h'c'egu."xqr09."pq05: ."Ugr 042370"

j5\_J 0'N'lo ."P 0'J w'c'p'i ."cp' "E0'N'q'q."H'c'k'g'r t'gr ct'v'k'p'qh'i tcr j gpg'g'c'ug'f "ej kqucp"l'k'm u'z'G'p'j c'p'eg'f "vj g'to c'n"o g'ej c'p'le'cn'cpf "cpvkdcevgtkn'r tqr gt'v'ku" Iq'w't'p'cn'q'h'P q'p'Et { u'c'ni'p'g'U'q'k'f' u.'xqr057: ."pq050'G'ng'x'k'g't."r r 0747752."23/Hgd/42340"

j6\_"W0'D'q'i f'c'p'q'x'k'X0'N'c'j k'X0'X'q'f'p'k'm"O 0'D'w'f'k'o k'." 0'O'c't'n'q'x'k"cpf "U0'f'k'o k'k'k'g'x'k"Eqr r gt"pcpqr ct'v'ergu"y kj "j k'j "cp'v'k'o let'q'd'k'cn'ce'v'k'k'v' { ."xqr0'w'p'f'g'h'p'g'f."pq0w'p'f'g'h'p'g'f 0"

j7\_"M0'D0C0Cj o g'f."V0'T'c'o c'p."cpf "X0C'p'd'c'j c'p."Rr'v'k'pwo "pcpqr ct'v'ergu"l'p'j k'k'k'd'cevgtk'k'r tq'rh'gt'cvkqp"cpf "t'g'ue'w'g'j g'd't'c'h'k'uj "ht'qo "dcevgtkn'lp'hge'v'k'p."TUE'f'c'f'x0'xqr08."pq072."r r 06663766646."O c{ "42380"

P2-42

DID NOT PARTICIPATE

# URIP GN'V[ RG' pEq<sub>4</sub>Q<sub>6</sub>'EQCVPI UHQTO CVKQP'CPF'' GNGE VTQEJ GO IECN'RGTHQTO CPEG''

O qpkne'Rw' gt {v.'Cw-tc'Uko cpeklgp . 'P gknc'fio wkl | kpcxk lgp . 'Uko qpc'Quvej cxk k v . 'F qxkn ''  
Ukpnxk k v . 'Ci p ''Mn k v . ''

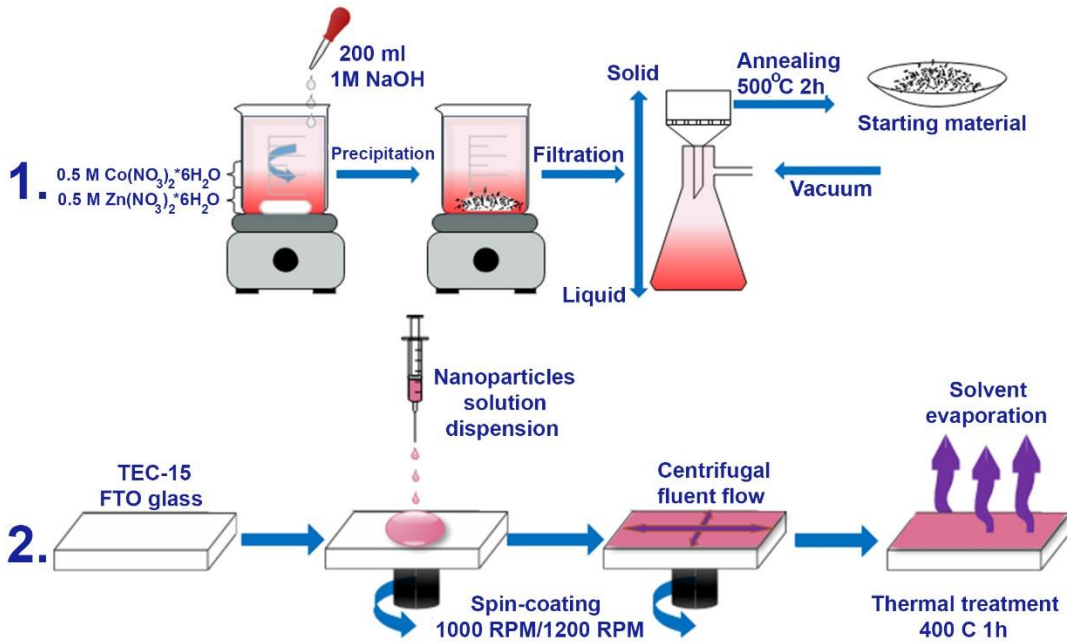
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Vvej pqm { . 'Tcf xknpw'r ngpcu'3; . 'Mcwpcu'NV/72476''  
ci pgUwewkgB mwOn''

Rj qvqgrgestqej go lecn'RGE+y cvgt'ur rkwpi 'j cu'dggp'y kf gn' 'eqpukf gtgf 'cu'qpg'qh'y'g'o quvr' tgo kulpi 'vej pqm lgu'lp' ercep.'i tggp.'cpf'tgpgy cdrg'gpgti { 'r tqf vevkqp''j3\_0'0 qtqaxgt.'pwo gtqwu'uwf lgu'wi i guv'yj cv'xctkqwa'tcpuklqp'o gvcn' qzkl gu'ctg'y'g'o quvr' tgo kulpi 'ecpf kf cvgu'cu'rj qvqcpqf gu'ht'RGE'o cvgtkcu.'gur gekm' 'y'j gp'wugf 'lp'eqplwpev'kqp''

Qwt' cko "y cu'vq" u{p'v'j guk'g' r op'j gvtqutwewt'g' qh'ur kpgn'v'r g'\ pEq<sub>4</sub>Q<sub>6</sub>'eqcvpi u' kpxguki cvg' y'g' kphwpeg' qh' o qtrj qm { "qp'ku'rj qvqgrgestqej go lecn'r tqf gt'v'gu'cpf'v'gu'v'j go 'cu'r tqur gev'x'g'o cvgtkcu'v'q'ecvnc' | g'qz { i gp'gxqk'kpi '' tgcw'kqp''QGT+0'

Ur kpgn'v'r g'\ pEq<sub>4</sub>Q<sub>6</sub>'eqcvpi u'y gt'g'u{p'v'j guk'g'f' wulpi 'y q'uvgr 'r tqegui''Hi B+<

- ej go lecn'r tgekr kcvkqp'' p-Eq'tcvkq'3-4'cpf'3-3'+cpf' 'y gto cnf'geqo r quklqp'cv'722'' hqt'4'j'.'
- ur lp'eqcvpi 'vej pls wg''y'j g'tqcvkqp'ur ggf' 'qh'3222'cpf'3422'TRO+''



Hi 030Uko r rklgf 'xgtukqp'qh'y q'uvgr 'u{p'v'j guk'g' r tqegui''

Ego r quklqp.'utwewt'g'cpf' o qtrj qm { 'y gt'g'kpxguki cvgf' wulpi 'xctkqwa'vej pls wgu'uwej 'cu'uecp'kpi 'grgestqp' o letqueqr { ''\*UGO+' cf uqtr v'kqp' I' f guqtr v'kqp' o gcuwtgo gpwu.'Z/tc{ ''gpgti { ''f kur gtukqp' ur gestqueqr { ''\*GF U+''Z/tc{ '' f kht'cev'kqp' \*ZTF+'' P 4'' cf uqtr v'kqp' I' f guqtr v'kqp' o gcuwtgo gpwu' cpf' ur gek'le' uwt'heg' ctgc'' ecrew'v'kqpu' y gt'g' wugf 0'' I c'kcpqu'v'le' ej cti g'f'k'uej cti g' o gcuwtgo gpv' cpf' ''kpgct'' uy ggr '' xqnc'o o gt { '' y gt'g' wugf '' kp' qtf gt'' vq'' kpxguki cvg'' rj qvqgrgestqej go lecn'r tqf gt'v'gu'cpf' 'eqcvpi u'ecr'cek'cpeg0''

Tcvk'ej cpi g'htqo '3-3'qh' p-Eq'v'q'3-4'rgf'v'q'htqo cvkqp'qh'f kht'g'p'v'utwewt'g'o qtrj qm { 'cpf' r tqf gt'v'gu'<

E' Vj g'qd'v'kpgf' \ p-Eq'3-3'eqcvpi u'y gt'g'o qt'g'tqwi j . 'i t'cpw'rt'cpf' 'y' lengt''884'po =y kj 'r qt'g'uk'g'3: 64'po 'cpf' 207''eo 5'li ''xqno g.'cu'y gmi'cu''790 4''o 4'li ''ur gek'le' uwt'heg'ctgc'cpf' 'cev'x'g' uwt'heg'ctgc'C? 206''eo 4''cv'G? 20 7''X''xu0' Ci .Ci EnME'n'v'v'Vj gug'eqcvpi u'f go qput'cv'gf' 'y'j g'k'pek' gpv'v'q' rj qvq'g'ht'ek'pe { ''REG+''qh'4406'' 'cpf' ''the applied bias photon-to-current (CDRG+508: ' =''

E' \ p-Eq'3-4'eqcvpi u'htqo gf' 'wpl'k'hto . ''664'po 'y' leni.'xgt'v'kcm' . 'j' qtk' qpvc'm' { 'c'ri' pgf' r' qt'qwu' r'co g'nc't' uwt'ewt'g'' r qt'g'uk'g'390 9'po 'cpf' 206''eo 5'li ''xqno g.'46063'o 4'li ''ur gek'le' uwt'heg'ctgc'cev'x'g' uwt'heg'ctgc'C? 2048''eo 4''cv'G? 20 7'' X''xu0'Ci .Ci EnME'n'v'v'KREG'59' =CDRG'70 3' 0'

F wg' vq''i tgcv' rj qvqgrgestqej go lecn'r g'htqo cpeg' y' g' cp'v'ek' cvg' y' cv' y' g' eqo r t'g'j gpuk'x'g' cpcn' { uku' qh' uwe'j '' r op' j gvtqutwewt'g' \ pEq<sub>4</sub>Q<sub>6</sub>'y kn'd'g'lo r qt'v'p'v'ht' h'w'wt'g'cr r r'ecv'k'p'u'lp'QGT0'

[3\_''S 0 j cq.' \ Q cp.'E0Ej gp.'l0Ej gp.'Ur kpgn'z'Eqpvtqngf' 'Rtgr'ctev'kqp.'Qz { i gp''Tgf vev'kqp'IGxqmw'kqp''Tgcw'kqp'Cr r r'ecv'k'p.'cpf' ''Dg { qpf.'Ej go lecn' Tgx'ky u.'37.'32343/32433''4239-0'

**F GRQUKVQP 'O GVIJ QF 'PHNWGPEG'QP 'O QTRJ QNQi [ 'CPF' 'RJ QVQNGEVTQEJ GO KECN'RTQRGT VKGU'QH\ pQ'HKNO U'**

**Lqxkc'I tki qp{v . 'Uko qpc'Qucej cxx k v . 'F qxkn 'Ukpmgxx k v . 'P gtkc'fio wkf | kpcxx kgp . "**  
**Cni kf cu'<sup>TM</sup>An kwu . 'Ci p <sup>TM</sup>An k v . '"**

F gr ctwo gpv'qhiRj { ulecn'cpf 'kqti cple'Ej go kw{ . Hcewm{ 'qhiEj go lecn'Vgej pqm{ { . 'Mcwpcu'Wpkxgtuk{ 'qh'  
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. ci pgUwkwgB mwOn'

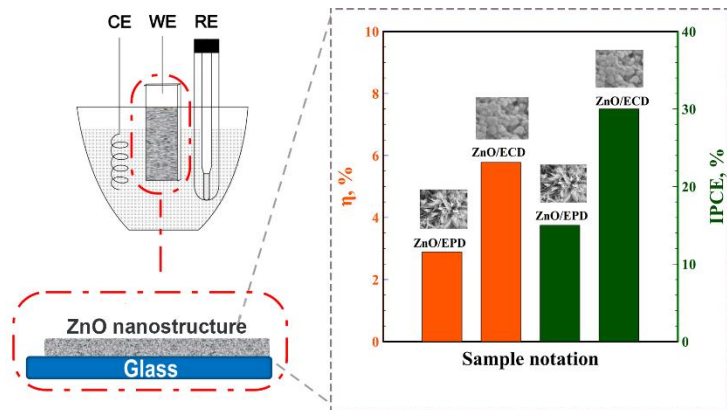
\ kpe"qzlf g'ku'cp'ko r qtcpv'ugo leqpf wevpi "o cvgtkn'y j lej "ku'y kf gn{ 'wugf "lp'ecvncf uku . r j qvqxqncleu . cpf "r ki o gpv'  
 kpf wnt { "j3\_0Vj g'cr r nccvqpf'qh\ pQ'pcpqr ctvengu'f gr gpf u'qp'yj gk 'utwewtg'cpf "o qtr j qm{ { . 'y j lej "ecp'dg'xctkfg'd { "  
 ej cpi kpi 'hko 'hqtocvqpf'o gj qf uO"

Vj g' clo "qh' y ku' y qtm' ku' vq' eqo r ctg' r tqr gtvku' qh\ pQ' eqcvkpi u' f gr qukvf " qp' C KUK 526' uclp'rguu' uvggn' d { "  
 grgvtqej go lecn'f gr qukvf "GEF '+cpf 'grgvtqr j qtgve'f gr qukvf "GRF +0Grgvtqej go lecn'bcuwt go gpw'y gtg'r gthqto gf "  
 d { "c'eqo r wgt 'eqpvtqmgf "Cwqncd'RI UVCV34' "Geqej go kg . "Vj g'P gj gtrcpf u'r qvqpvkncf cixcpqucv'wulpi "c'ucp'f ctf "  
 y tgg'grgvtqf g'egm' "xqmo g'322'o N+0Cni'y g'r qvqpvkncf'ctg'tghgtgf "v'y g'Ci . "Ci EnME<sub>ncv</sub>'tghgtgpeg'grgvtqf g'0Vj g' "  
 uwtceg'b qtr j qm{ { "cpf "y g'eqo r qukvf'qh\ pQ'r qy f gt'y g'g'lxgwk cvgf 'y kj "c'S wpc'c'HI "422' "HGK'j ki j 'tguqmwkqpf "  
 uecp'kpi "grgvtqf "o letqueqr g' "UGO '+v'y cv'y cu'gs wkr r gf "y kj "c'Dtwngt "Z Hrcuj <sup>®</sup> 6252'f gvgvqt "Dtwngt "CZ U+hq'j ki j "  
 tguqmwkqpf'gp'gti { "f'kr g'ukxg'Z/tc { "ur g'vq'ueqr { "GF Z+0Z/tc { "r qy f gt'f'khtcevkqpf "ZTF '+f'cv'y g'tg'eqmgevgf "y kj "c' "  
 FTQP /8' "Dqwtgxg'wupkni'kpeO' "T wucl'+r qy f gt'f'khtcevkqpf g'vgt "gs wkr r gf "y kj "Dci i oDtgpwcpq"i ggo gwt { "cpf "wulpi "P k' "  
 hkr'gtgf 'EwM 'tcf kcvkqpf'cpf "c'i tcr j kg'o qpqej tqo cvqt0Vj g't j qvqgrgvtqej go lecn'bcv'k'q'qh'y g'r tgr ctgf 'grgvtqf g'u'y cu' "  
 kpxgwk cvgf "d { "go r m{ { kpi 'r j qvqxqncf o gwt { "o gcuwt go gpv'o gj qf uOC' r j qvqgrgvtqej go lecn'bcv'k'q'qh'y g'r tgr ctgf 'grgvtqf g'u'y cu' "  
 C'I g'p'gt'cni'Grgvte' "H Y IDND' rco r " \* o cz ? 588' po . "r qy g't'f'gpuk{ "30 "o Y ceo <sup>64</sup> "y cu'r m'egf "cv'c'f'k'w'c'peg'qh'4'eo "Itqo "  
 yj g' pQ'grgvtqf g'cpf "y cu'wugf "cu'cp'WX'tcf kcvkqpf'uqwtg"j4\_0"

Grgvtqej go lecn'f "f gr qukvf " kpe"qzlf g'eqcvkpi u'y g'tg'r tqf wegf "wulpi "urki j v{ 'cekf k' kpe' "K'cegv'g'uqmwkqpf'wp'f g't "  
 i cixcpqucv'k'eqpf k'k'p'u' "y g'ewt'gpv'f'gpuk{ "y cu'30' "o C ceo <sup>64</sup> "cpf "f'w'cvkqpf'ko g' "32' "o k'p'0J qo qi g'p'g'w'u'w'ur'gpukqpf "4 "  
 i "qh'y g' pQ'r qy f gt'f'kr g'ugf "lp'322'o N'qh'o gj cpqnc' y cu'wugf "hqt' yj g'grgvtqej j qtgve'f gr qukvf'qh\ pQ'eqcvkpi u'cpf "  
 yj g'r qvqpvkncf'qh'52'X' y cu'cr r n'kf "hqt'42' "o k'p'w'g'u'0'k'p' qtf f'v'q'cej l'x'g'd'g'w'g't'cf j g'ukqpf'qh\ pQ'r ctvengu'qp' uclp'rguu' uvggn' "  
 f gr qukvf "d { "GEF "cpf "GRF "y g'tg'c'p'p'g'c'rf "cv'622' "AE' hqt'3'j "lp' yj g'c'w' qur j g'te' "ck'0"

ZTF 'r cvgt'p'qh'GEF "cpf "GRF \ pQ' hko u'ij qy gf "f'khtcevkqpf' r g'cu'cv'40' "gs wcn'v'q'530: A'56066A'cpf "58046A' y j lej "  
 eqttgur qpf "v'y g'y gm'et { ucn'k' gf "y w'v' kg'v'f' r g' pQ' "RF H26/226/6342+0J qy g'xgt . yj g'w'w'ceg'qh\ pQ'eqcvkpi u'r tgr ctgf "  
 d { "GEF "cpf "GRF "f'kht'g'u'0'UGO "ko ci g'u't'g'x'g'c'rf "y cv'GEF \ pQ' hko 'uwtceg'ku'i t'cp'w'rt'eqo r qugf "qh'i t'cl'p'u'y kj "f'kco g'vgt "  
 qh'52-332'po . 'y j g't'g'cu' hko u'r tgr ctgf "d { "GRF "ku' hny g't' n'kg' utwewtg'o c'k'p'n' "eqo r qugf "qh'tqf uO"

Rj qvqgrgvtqej go lecn'd'g'j c'x'k'q' "qh'y g' pQ'grgvtqf g'y cu'f'v'g'to k'p'gf "Itqo "y g'ewt'gpv'r qvqpvkncf'ewt'x'g'u'q'd'v'k'p'gf "lp' "  
 20' "O "P c4UQ6' "uqmwkqpu' d'qj "lp' yj g'f'ctm' c'p'f "wp'f g't "WX" k'tcf kcvkqpf'0'Uki p'k'he'c'p'v' c'p'q'f k'e' ewt'gpv' k'p'et'g'c'g'p' wp'f g't "WX" "  
 k'tcf kcvkqpf'ij qy u'p'v'f' r g'ugo leqpf wevpi 't' qtr g't'v'g'u'0'Vj g'ec'w'w'v'g'f "x'c'w'g'u'q'h'k'p'k'f' g'p'v'r j qvq'p'v'q'ewt'gpv'g'h'k'p'g'e' { "REG+ "  
 c'p'f "cr r n'kf "dku' r j qvq'p'v'q'ewt'gpv' eqp'x'g't'uk'q'p' g'h'k'p'g'e' { " \* 7+ "hqt' "y j g' 20' "X" r qvq'p'v'kncf' ctg' u'j qy p' "lp' "H'i w't g' "30 "  
 Grgvtqej go lecn'f "f gr qukvf \ pQ' hko u'qp' uclp'rguu' uvggn' u'ij qy gf "y j g'd'g'u'v' r g'th'q'to c'p'eg' "cu'c' "r j qvq'grgvtqf g'lp' "20' "O "  
 P c4UQ6' grgvtqf' v'g'0'



H'i 030Vj g'lp'ekf gpv'r j qvq'p'v'q'ewt'gpv'g'h'k'p'g'e' { "REG'+cpf "cr r n'kf "dku' r j qvq'p'v'q'ewt'gpv'eqp'x'g't'uk'q'p' "  
 "g'h'k'p'g'e' { " \* 7+ "x'c'w'g'u' hqt' \ pQ' hko u'lp' 20' "O "P c4UQ6' grgvtqf' v'g' "

j3\_ "C'0'0' qgl | k' "C'0'0' eF' q'c' j . "O'0'0' E'q't'k'g' "Ej go 0'Gpi 0'10' \ kpe"qzlf g' r ctvengu' "U{ p'v'j g'uku' r tqr g't'v'g'u' c'p'f "cr r n'ccv'k'p'u' "Ej go lecn'Gpi k'p'g't'k'p'i "  
 l'qwt'pcn'44.'3: 7/3: 8' "4234+0' "

j4\_ "G'0'0' R'U'g'k'p'o k'ngt . 'MLUEj qk 'Rj q'q'ej go lecn'f gr qukvf'qh'eqd'cn'd'cu'gf "qz' i { gp'g'x'q'k'k'p' "ecvncf' u'q'p'c' 'ugo leqpf wevqt' r j qvq'c'p'q'f g' hqt' "u'q'rt' "qz' i { gp' "  
 r tqf wev'k'p' . 'Rt'q'eg'g'f' k'p'i u'q'h'y g'P' c'v'k'p'c'ni'Ce'cf go { "qh'U'k'p'eg'u' .6; .42855/42858' "422; +0'

# STAR CLUSTERS IN THE ANDROMEDA GALAXY

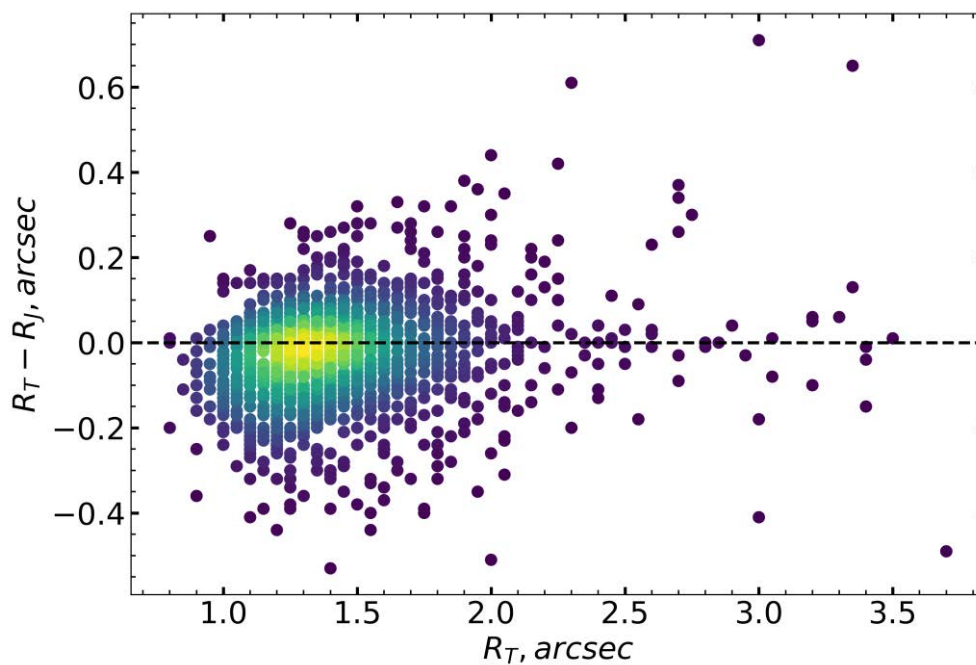
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The Panchromatic Hubble Andromeda Treasury (PHAT) survey is a *Hubble Space Telescope (HST)* multi-cycle program which obtained images of one third of the Andromeda (M31) disk in six passbands, ranging from near-ultraviolet to near-infrared wavelengths. High spatial resolution of *HST* has allowed users to identify hundreds of new clusters that were previously inaccessible with existing ground-based surveys. All of the detected clusters were sorted out into three catalogues: star cluster, galaxy, and ancillary [1].

The aim of this study is to perform an aperture photometry of the M31 star clusters in a colour-consistent way. For this purpose, we analysed the sample of 1471 cluster. New centre coordinates, apertures, and background levels are determined. We use a two-aperture approach: “total” and “colour” apertures in order to perform cluster photometry. The “colour” aperture is used to obtain an accurate cluster colour indices by avoiding bright field stars, the “total” aperture measures a total cluster magnitude. In Fig.1 “total” aperture sizes are compared with ones applied in [1]. Negative values indicate that we reduced aperture in order to exclude contaminating stars; positive values show that we increased aperture for star clusters in dense regions, globular clusters, and stellar associations. New centre coordinates are determined for 90% of star clusters. Our study demonstrates that by applying a new method of cluster photometry, we improve photometric accuracy of the Andromeda star cluster measurements.



**Fig. 1.** Differences of aperture size selected in this study ( $R_T$ ) and in [1] ( $R_j$ ) vs. aperture size selected in this study. Total number of objects – 1468. Three clusters were discarded, since they are double clusters.

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[1] L. C. Johnson, A. C. Seth, J. J. Dalcanton et al., PHAT stellar cluster survey II. Andromeda Project cluster catalog, *The Astrophysical Journal*, 802:127 (22pp), 2015.

# MODELLING CIRCUMSTELLAR MOLECULAR LINE VARIABILITY IN IRC +10216

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IRC +10216 (CW Leo) is a red giant carbon star in the asymptotic giant branch (AGB) phase of evolution. The star changes brightness with period of 630 days and is losing its outer layers due to the stellar wind driven by the radiation pressure on dust grains. Intense mass loss of  $2 \cdot 10^{-5} M_{\odot}/\text{yr}$  has created an extended nebula around the star - circumstellar envelope (CSE), expanding with the velocity of 14.5 km/s in which over 80 molecules have been detected. Relatively small distance to CW Leo (130 pc) and high brightness in the infrared are the main reasons why it is regarded as the archetypal C-rich AGB star.

Molecular emission lines are a powerful tool for studying various physical and chemical processes in the CSE. Most poorly understood region of the CSE is the innermost part close to the stellar surface, which is probed by the high energy rotational and rovibrational lines in the submillimeter and infrared light.

The star shows periodic variability in all photometric bands. Recently, millimeter line variability for IRC +10216 was revealed by HSO (Herschel Space Observatory) HIFI instrument spectra [1] and has attracted increasing interest since then. Variability of the highly excited molecular lines has a potential to probe how mass loss rate is dependent on the pulsation phase.

In this study we explore possibility for variation of SiO emission lines observed by Herschel/HIFI and try to model SiO and SiS line variation observed with Atacama Large Millimeter/submillimeter Array (ALMA) in IRC +10216. For our analysis we use approach presented in the analysis of ammonia lines for the same star [2]. For the numerical solution of the multilevel radiative transfer in spherically symmetric expanding envelope we use code MOLEXCSE [2].

For the analysis of the sensitivity of the periodically varying radiation field on the excitation of SiO we have chosen rotational transitions in the ground vibrational state ( $v=0$ ) ranging from  $J=12-11$  (520.881 GHz) to  $J=23-22$  (997.297 GHz). Calculations were performed at three different pulsation phases (minimum, mean and maximum brightness) by changing stellar and dust radiation fields. In result, only minuscule changes in line intensities are observed and it is seen that variation is more pronounced in lower  $J$  transitions. Observed and computed profiles for  $J=12-11$  line is shown in Fig. 1. Due to high levels of noise in HIFI spectra, it is not possible to test whether modelled variations in line intensity match observations. Observations of  $^{30}\text{SiO}$   $J=6-5$  line with ALMA [3][4] show 10% variation in line intensity. Approximately, only half of the variation amplitude seems to be reproduced by our calculations.

For SiS we model  $v=0$ ,  $v=1$  and  $v=2$   $J=14-13$  lines. Observations of these lines show significant (even 25%) variation in intensity over time. Our calculations suggest that the contribution of the variation from the radiation is definitely insufficient to explain observations. Also, the formation of the line shape is poorly understood.

In summary, for SiO lines in the spectral range of HIFI no noticeable variation is expected. The main cause for SiO line variability might be the changes in radiation field due to stellar pulsation, however this is not the case for SiS. Discrepancies between observed and calculated profiles suggest that our model of the CSE needs to be improved.

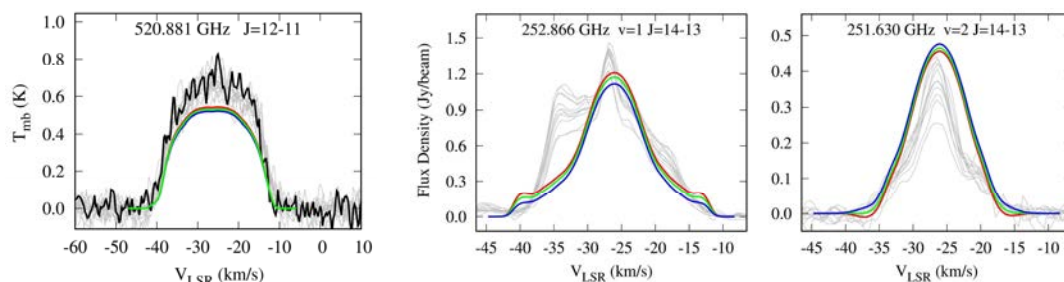


Fig. 1. Left: observed and modelled SiO  $v=0$ ,  $J=12-11$  line for IRC +10216. Black and grey lines – HSO HIFI observations for different epochs, blue, green and red – our calculation corresponding to minimum, mean and maximum brightness phases, respectively. Right: the same for SiS  $v=1$ ,  $J=14-13$  and  $v=2$ ,  $J=14-13$  profiles with grey lines depicting ALMA observations.

[1] J. Cernicharo et al., Discovery of Time Variation of the Intensity of Molecular Lines in IRC+10216 in the Submillimeter and Far-Infrared Domains, *The Astrophysical Journal Letters*, **796**, 21 (2014).

[2] M. R. Schmidt et al., Herschel/HIFI observations of the circumstellar ammonia lines in IRC+10216, *Astronomy & Astrophysics* **592**, 131 (2016).

[3] J. H. He, Dinh-V-Trung, and T. I. Hasegawa, Monitor Variability of Millimeter Lines in IRC+10216, *The Astrophysical Journal* **845**, 38 (2017).

[4] J. H. He et al., ALMA Monitoring of Millimeter Line Variation in IRC +10216. I. Overview of Millimeter Variability, *The Astrophysical Journal* **883**, 165 (2019)



**CDWPF CPEG'QH\ KTEQP KWQ 'K' VJ G'CVQ QURJ GTGU'QHTGF 'I KCPVU'  
K' I CNCEVRE' I NQDWNCT'ENWUVGT'69'VVE''**

**Gf i cteu'Mqmqo kgecu<sup>3</sup>. 'Xkf cu'F qdtqxqnume<sup>3</sup>. 'Ct pcu'Mw kpunu<sup>3</sup>'**

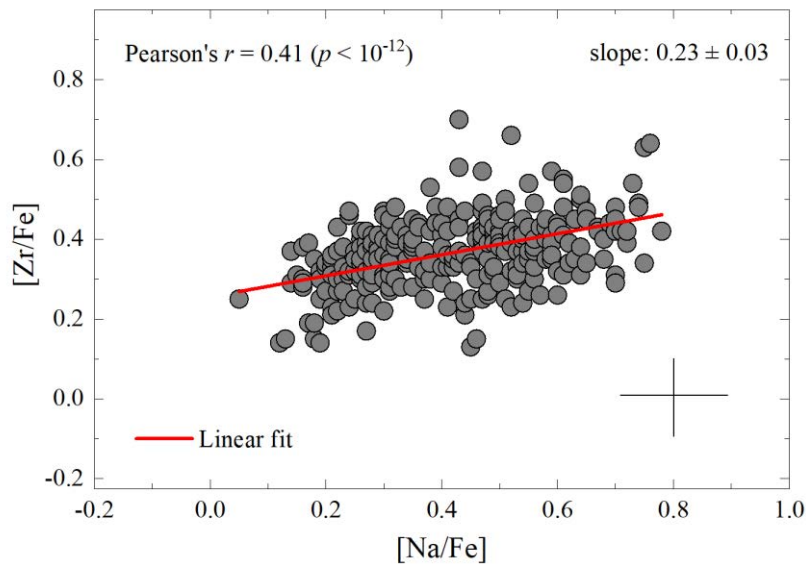
<sup>3</sup>Kpukwng'qh'Vj gqgtvleclRj { uleu'cpf 'Cuntppqo { . 'Hcewm\ 'qh'Rj { uleu. 'Xkpkw'Wpkxgtukf. 'Nkj wcpk'  
gf i cteu'Mqmqo kgecuB HfXvOw'

K'j cu'dggp'mpi 'j grf 'vj cv'I cneve'i mdwrt'enuvgtu' I Eu+'ctg'j qo qi gpgqu'qdlgeu'eqpukvpi 'qh'uvtu'yj cv'j cxg' vj g'uco g'ci g'cpf 'ej go kecl'eqo r qukqp0J qy gxgt. 'tgugtej 'f qpg'f wtkpi 'vj g'r cuv'f gecf g'j cu'uj qy p'vj cv'uvtu'lp'vj g' I I Eu'f q'pqv'uj ctg'vj g'uco g'ej go kecl'eqo r qukqp'cpf 'o c' { 'j cxg'htqo gf 'f wtkpi 'f khtg'p'v'uct'htqo cvkqp'gr kuqf gu'ugg. " g0 0'j3\_0Vj ku'awi i guw'vj cv'I I Eu'o c' { 'eqpukv'qh'vy q'ht'q'o qtg+'i gpgtcv'kpu'qh'uvtu.'y kj 'vj g'ugeqpf 'i gpgtcv'kqp'dqtp' htqo 'vj g'o cvgt'kcl'gptlej gf "d' { 'vj g'glgevc'qh'htuv'i gpgtcv'kqp'uvtu.'y kj 'vj g'o quv'r r'wukdng'ecpf kf cvgu'dglpi 'htuv'tqcv'kpi " o cuukxg'uvtu"j4\_ "cpf "cu{ o r vqve"i kcpv' dtcpej " \*CI D+'uvtu"j5\_ "vj g' uq/ecngf " r qmwgtu0' Wphtwpcvgnf. " qwt' ewttgpv' npqy r'gf i g'cdqvw'vj g'I I Eu'f qgu'pqv'cmqy 'wu'v'q'f kuetko kpcvg'dgy ggp'vj g'r quukdng'r qmwkqp'uegpctku0'

K'qtf gt'v'q'f vgtgo kpg'y j lej 'r qmwgtu'y g'g'o quv'r'ngn' 'v'g'g'tlej 'vj g'lpv'cenuvgt'o gf kwo 'f wtkpi 'vj g'gctn' 'uci gu'qh' I I E'htqo cvkqp. "qpg'o c' { 'mqm'cv'vj g'cdw'pf cpegu'qh'u'r tqeguu'grgo g'p'w'Ukpeg'vj g'rki j v' \*r gcm'ctqwpf "U. [ . \ t+'cpf " j gcx { " \*r gcm'ctqwpf " Dc. " Nc+ " u'r tqeguu'grgo g'p'w' ctg' r tqf wegf " kp' f khtg'p'v' v' r gu' qh' qdlgeu. " eqttgrv'kpu' dgy ggp' cdw'pf cpegu'qh'htj j vj gcx { 'u'r tqeguu'grgo g'p'w'cpf 'vj qug'qh'htj j v'grgo g'p'w' \*P. 'P c+'o c' { 'cmqy 'wu'v'q' r w'vki j vgt'eqpvt'kpu' qp'vj g'r quukdng'r qmwgtu0'Qpg'gctn'gt'uwf { 'j cu'awi i guv'f "c'v'pvc'v'xg'gz'k'v'peg'qh'c'eqttgrv'kqp'dgy ggp'vj g'cdw'pf cpegu' qh'P c'cpf "Dc'kp'vj g'i mdwrt'enuvgt'69'Vve"pqv'vj cv'Dc'ku'c'j gcx { 'u'r tqeguu'grgo g'p'w'cpf "ku'u' p'v'j guk' gf "f wtkpi "vj g' o clp' u'r tqeguu.'y j lej "o quv' { 'c'ng'u'r r'eg'lp'iqy /o cu'CI D'uvtu'+j6\_0Vq'ej gen'k'ht'uej "c'eqttgrv'kqp'o c' { 'cnuq'gz'kuv'kp' vj g'ecug'qh' \ t. "y j lej "ku'c' rki j v' u'r tqeguu'grgo g'p'w'cpf "ku'u' p'v'j guk' gf "f wtkpi "vj g'y gcm' u'r tqeguu.'y g'f vgtgo kpgf " \ t' cdw'pf cpeg'lp'4: 5'TI D'uvtu'lp'69'Vve0'K r qt'cv'v'v'. 'vj g'uwf kgu'qh' \ t'cdw'pf cpeg'lp'vj g'I I Eu'j cxg'dggp'xgt { 'uecteg' w'v'k'ip'qy "cpf 'vj g't'guw'u'y g'tg'k'p'eq'p'w'ukxg. 'k'g0'p'q'v'q'p'n' 'ht'vj ku'dw'cnuq'ht'q'vj g't' I I Eu0'

Cdw'pf cpeg'c'p'cn' uku'y cu'dcu'gf "qp'vj g'cte'j k'cn'r' g'ev'c'qh'TI D'uvtu'lp'69'Vve'vj cv'y g'tg'q'v'cl'p'gf "y kj "I K'CHHG" ur g'ev't'q' t'c'j "o q'w'p'gf "qp'vj g'XNV'W4'v'g'ueq'r g'\*GUQ. 'Ej k'g-0Vj t'gg'ur g'ev't'c'n'k'p'gu'qh'p'g'w'c'n' \ t'y g'tg'w'gf. 'y kj "vj g'k' e'g'p't'c'n'y cxg'r'p'ij v' u'iq'ec'v'gf "cv'8340697'po. "835067: 7'po "cpf "83606474'po 0'N'lp'g's w'x'c'r'p'v'y k'f v'j u'y g'tg'o g'cu'w'gf " w'k'pi "K'CH" r c'ev't' g. "d' { 'ht'k'pi "I c'w'u'k'p' r tq'ht'gu'v'q' vj g' q'dug't'x'gf "ur g'ev't'c'n' k'p'gu'U'g'm'c't' o q'f g'n' c'vo qur j g'tgu'y g'tg' eqo r w'gf "w'k'pi "vj g'CVNCU; "eq'f g'cpf "y g'tg'ht'v'j g't'go r m'q'gf "v'q'f g't'k'x'g'3F "NVG" \ t'cdw'pf cpegu'y kj "vj g'Y K'F VJ ; " r c'ev't' g0'

Vj g'o g'cp' \ t'v'q'Hg'cdw'pf cpeg't'cv'q'vj cv'y g'q'v'cl'p'gf "lp'c'uco r ng'qh'4: 5'TI D'uvtu'lp'69'Vve'ku' \ t' Hg\_ " ? - 2069'0' 20; " \*vj g'gtt'qt "ku'uc'p'f'ctf "f g'x'k'v'k'p'f'v'g'v'q' u'v'ct/v'q' u'v'ct'cdw'pf cpeg'x'c't'k'v'k'p'+0'Vj ku'ku' u'q'ht'vj g'rt'i guv'uco r ng'qh'TI D' u'v'ct'u'c'p'cn' \ gf "kp'vj ku'enuvgt'ht' \ t'cdw'pf cpeg'c'p'cn' uku'qh' \ t'cpf "P c'cdw'pf cpegu'uj qy u'c'y gcm'dw'uc'v'k'ecm' \ uki p'k'k'c'p'v'eq'tt'grv'k'p' \*Hki 03+0'V'c'ng'p'v'q'i g'y g't' y kj "vj g'j'Dc' Hg\_ 't'cv'q'u'f v'g'tgo k'p'gf "d' { "j6\_ "qwt' t'guw'u'awi i guv'vj cv'lp'vj ku' I I E'd'q'vj 'grgo g'p'w'y g't'g'u' p'v'j guk' gf "lp'o cuukxg'CI D'uvtu0'



Hki 030Cdw'pf cpeg'qh' \ t'lp'vj g'TI D'uvtu'qh'69'Vve'r'iq'w'gf 'ci cl'p'v'vj g'u'q'f kwo /v'q'k'q'p'cdw'pf cpeg't'cv'q'0'

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j5\_X'gp'w'c' 'R0'F 'C'p'v'c'p' 'H0'O c' | k'gn'k'10'I t'cw'q'p. 'T0'4223. 'CrL'772. 'N870'  
j6\_T' t'cw'q'p. 'T01 0' 'N'w'ec'v'g'q'p. 'U0'U'q'm' c. 'C0'E'c't'g'w'c. 'G0'D'c'i c'i r'c. 'C0'O qo c'p' { . [ 0'F'Q't'c' k'X0'E'cu'uk'U0'R'k'v'p'ht'g't'p'k'C0'( 'U'c'r't'ku' O04235. '  
C( C. '76; . 'C630'

# CHARACTERIZATION OF THE VARIABLE STAR EPIC 246257206 DISCOVERED WITH OBSERVATIONS OF THE K2-C12-FOV TAKEN BY THE KEPLER SPACE TELESCOPE

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Variable stars are stars of variable brightness. This means that their brightness doesn't remain constant throughout time. Eclipsing variables are binary stars where two stars orbit periodically around their common center of mass [1]. When one of them is situated in front of the other relative to the observer, the total brightness of the system decreases. These brightness variations depend only on geometric factors. There are three types of eclipsing variables: EA (well defined eclipses with constant brightness outside the eclipses), EB (well defined eclipses with brightness variations outside the eclipses) and EW (the eclipses are not noticeable).

Throughout this investigation an unregistered variable star has been found through observations taken by the Kepler Space Telescope. With this data, and with data from other land and space observatories its period, amplitude and distance to the Earth was calculated in order to find out the cause of variability of the star and to register it in the Variable Star Index. Besides the Kepler Space Telescope, observations from the Minor Planet Center (MPC) L94 observatory, MPC J38 observatory, the PanSTARRS telescope in Hawaii and the European Space Agency's Gaia space observatory have been used. Photometric observations were taken from the Kepler Space Telescope, from the Minor Planet Center (MPC) L94 observatory and from the MPC J38 observatory. Astrometric observations were taken from the Gaia space telescope. The PanSTARRS telescope was used to validate Kepler's K2 data.

The star found is EPIC 246257206. Analyzing the photometric data using the Lomb-Scargle periodogram, the period  $0.2198 \pm 0.0004$  days was obtained. Analyzing its phased light curve, shown in figure (??) and the value of the period, it can be concluded that the star is an EA type eclipsing variable. Using the parallax method and the observations taken by GAIA, it has been calculated that the EA variable star EPIC 246257206 is  $7.0832 \pm 0.0002$  light years away from Earth.

The most peculiar aspect of the star is its amplitude, of only 0,5 magnitudes (astronomical unit referring to the brightness of the star). This is probably due to the fact that the eclipses produced are *grazing eclipses*: in the plane that both stars are observed, they are not overlapping totally but partially. This, therefore reduces the total brightness change of the system. To confirm this, spectroscopic observations of the system are suggested. With these type of observations, joint with the already conducted photometric observations, the system could be modeled and its orbit can be calculated. With this information, it is possible to figure out the nature of the eclipses. Its small amplitude also suggests the possibility of a third body in the system that also blocks part of the light. To confirm this an investigation searching for transit-timing variation is also recommended.

In summary, to characterize the EPIC 246257206 star, its distance to the Earth, its amplitude and its period had to be determined. These values allowed to conclude that the star EPIC 246257206, located at  $(7,0832 \pm 0,0002) \cdot 10^2$  light years away from the Earth, presents a variability of 0,05 magnitudes periodically every  $0,2198 \pm 0,0004$  days due to the eclipses formed by the two stars that constitute the binary system. This can be viewed at its webpage at the International Star Index site: <https://www.aavso.org/vsx/index.php?view=detail.top&oid=1540324>.

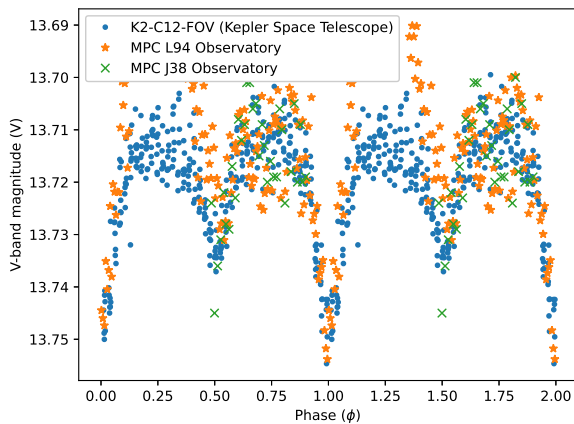


Fig. 1. EPIC 246257206 phased lightcurve. The amplitude of the light curve is 0.05 magnitudes and the period is  $0.2198 \pm 0.0004$  days.

[1] D. Gonzalez. *Curvas de luz y modelos de las estrellas binarias eclipsantes*. (2003).

[http://www.grupoastrofomicosilos.org/variables/analisis\\_binarias\\_eclipsantes.html](http://www.grupoastrofomicosilos.org/variables/analisis_binarias_eclipsantes.html) [Accessed 7. Feb. 2020.]

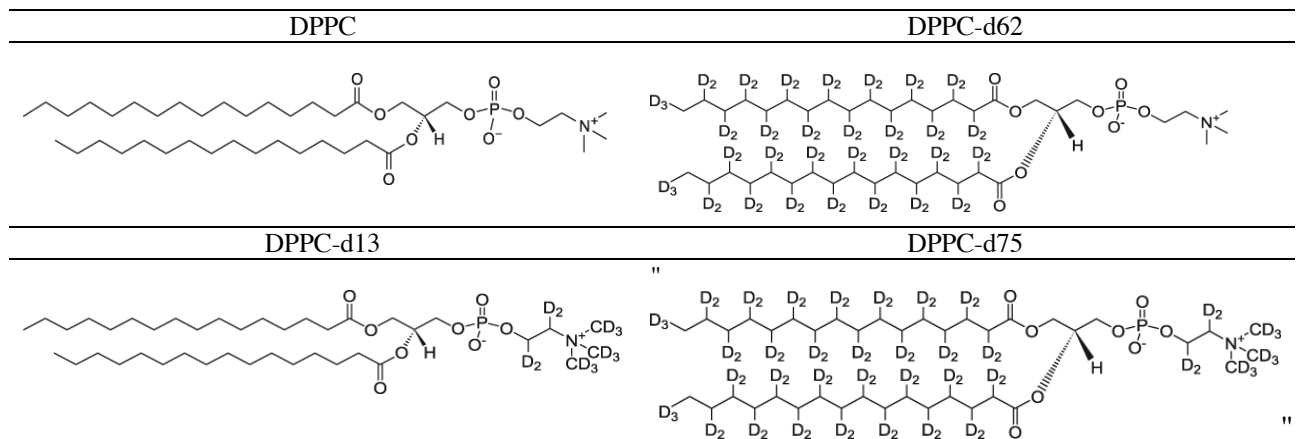
**E Q O R C T K U Q P ' Q H F K H H G T G P V ' F G W W G T C V G F ' F R C N O K V Q [ N ' R J Q U R J C V K F [ N E J Q N P G ' O Q P Q N C [ G T U W U K P I ' U W O / H I G S W G P E [ " I G P G T C V K Q P ' U R G E V T Q U E Q R [ " G f x l p c u P e x c n e w u n e u <sup>3</sup> c p f " U k o q p c " U t c | f c k v <sup>3</sup> "**

<sup>3</sup>Egpygt'qh'Rj {ulecn|Uelkpegu'cpf'Vgej pqmji {. 'F gr ctvo gpv'qh'Qti cple'Ej go kvt{.'Ucwn vgnku'cxg05.'NW/32479'Xlprkwi' Gf x l p c u P e x c n e w u n e u B h o e h n'"

Vj g'hg{ 'eqo r qpgpv'qhc'egmb go dtcpg'kut'j qur j qrk kf u'eqpukukpi 'qh'v'q'j { f t q r j q d l e ' c k n i t q w u ' c p f ' e ' j } { f t q r j k r l e ' j g c f ' i t q w ' h p n g f ' v i g y g t ' x l c ' v j g ' g u x g t ' i t q w ' O C ' r j q u r j q r k k f ' o q p q r c { g t ' k u ' q h g p ' w u g f ' g z r g t k o g p v c m f ' v q ' o l o k e ' v j g ' g ' q w g t ' n g c h g v ' q h ' v j g ' e g m b g o d t c p g ' k p ' q t f g t ' v q ' l p x g u n i c v g ' v j g ' r g r v f g / r k k f ' l p v g t c e v k q p ' c v ' v j g ' i r k k f / y c v g t ' l p v g t h c e g u 0 v j g ' f k u t w r v k p p ' q h ' r j q u r j q r k k f ' o q p q r c { g t ' e c p ' d g ' g x c n e w g f ' d { ' r t q d l p i ' e g t v e k p ' x k d t c v k p u < h t q o ' v j g ' E / J ' t g i k a p . ' v j g ' e j c p i g u ' l p ' r e v g t c n ' r c e n k p i ' q t f g t ' c u ' y g m ' c u ' v j g ' e q p h q t o c v k q p ' q h ' v j g ' j } { f t q e c t d q p ' e j c k p u . ' e c p ' d g ' f g v g t o l p g f ' j 3 = v j g ' e c t d q p { n i t q w r ' t g i k a p ' j c u ' c ' u t q p i ' f g r g p f g p e g ' q p ' r c e n k p i ' q h ' v j g ' r k k f ' c m f ' n ' e j c k p u ' c p f ' j g c f i t q w r ' u ' c u ' y g m ' c u ' v j g ' j } { f t c v k q p ' u e v g ' q h ' v j g ' j g c f i t q w r ' u ' j 4 = c p f ' v j g ' r j q u r j q r k k f ' t q w r ' t g i k a p ' k u ' v j g ' o q u v ' u g p u k x g ' v q ' v j g ' e j c p i g u ' l p ' v j g ' j } { f t c v k q p ' j 5 \_ 0

J qy g x g t . ' l p ' c ' o w n k e q o r q p g p v ' u { u v g o . ' y j l e j ' e q p u k u ' q h ' g 0 0 ' r k k f u . ' e j q r g u v g t q n ' c p f ' r t q v k p ' o k z w t g . ' v j g ' E / J ' t g i k a p ' r t q f w e g u ' c p ' q x g t c m ' d c p f ' r t q h k g ' v j c v ' t g h g e w ' v j g ' y g l i j v g f ' e q p v k d w k p u ' q h ' c m ' e q o r q p g p u ' l p ' v j g ' o k z w t g 0 V j g t g h t g . l p h t o c v k q p ' e q p e g t p l p i ' l p f k k f w n l e q o r q p g p u ' k u ' h u u 0 v j g ' o g y q f ' v j c v l e t e w o x g p u ' v j k u ' r t q d r g o ' t r k g u ' q p ' v j g ' k u q y r l e ' u w d u k w k p ' q h ' 4 J ' h q t ' 13 ' l p ' v j g ' r j q u r j q r k k f u ' j 3 . 4 . ' y j l e j ' t g u w u ' l p ' c ' u j k h ' v j g ' E / F ' u t g e j l p i ' o q f g u ' v j ' h y g t ' h t g s w g p e k u 0 P e x g t v g r u u ' v j g t g ' k u ' u k n ' c ' r e n ' q h ' u w f l g u ' v j c v ' u j q y . ' j q y ' v j g ' o q p q r c { g t a i ' h t o c v k q p . ' u e c d k k f . ' c p f ' ' e j c t c e v g t k u k e u ' c t g ' c l h g e v g f ' d { ' x c t k q w ' r k k f a i ' f g w g t c v k q p ' r e x g n u 0 H q t ' v j k u ' r w r q u g ' y g ' w u g f ' x k d t c v k p c n ' u w o / h t g s w g p e { ' i g p g t c v k q p \* X U H I ' + u r g e v t q e q r { ' v e j p l s w g ' v j c v g p c d r g u ' f g v g e v k q p ' q h ' c ' u k p i n g ' o q p q r c { g t ' h q t o g f ' c v ' y c v g t ' u w t h c e g 0

Vj k u ' t c r g t ' u g g n u ' v q ' w f g t u c p f ' c p f ' e q o r c t g ' v j g ' o c l q t ' f k h h g t g p e g u ' d g y g g p ' o q p q r c { g t u ' b c f g ' q h ' h p q p / f g w g t c v g f ' 3 . 4 / f k r c m k q { n ' u p / i n ' e g t q n / 5 / r j q u r j q e j q r k p g ' \* F R R E + ' e j q r k p g ' i t q w r ' f g w g t c v g f ' \* F R R E / f 3 5 + ' c m f ' n ' i t q w r ' f g w g t c v g f ' \* F R R E / f 8 4 + ' c p f ' d q v j ' i t q w r ' u ' f g w g t c v g f ' \* F R R E / f 9 7 + ' r k k f u 0 l p ' q t f g t ' v q ' q d u g t x g ' e j c p i g u ' l p ' o q p q r c { g t u 0 ' h t o c v k q p . ' u e c d k k f . ' c p f ' j } { f t c v k q p . ' f k h h g t g p v r j c u g ' o q p q r c { g t u ' y g t g ' h t o g f ' q p ' v j g ' F 4 Q ' c p f ' J 4 Q ' u w t h c e g u 0 Y g ' h q w p f ' v j c v ' o q p q r c { g t ' o c f g ' q h ' F R R E / f 8 4 ' e t g ' u e c d r g ' h q t ' w r ' v q ' . ' f c { u 0 C v j k i j ' u w t h c e g ' r t g u u t g u ' \* 5 2 ' o P l o + q p n ' x k d t c v k p u ' q h ' v j g ' o g y { n i t q w r ' y g t g ' t g i k u g t g f ' l p ' v j g ' E J ' t g i k a p ' h q t ' c m ' u w f l g f ' o q p q r c { g t u . ' y j l e j ' l o r i n g f ' v j c v ' c m f ' n ' e j c k p u ' c f q r v g f ' c p ' c m ' t c p u ' e q p h q t o c v k q p 0 v j g ' e c t d q p { n i g u v g t ' i t q w r ' c e v ' u k o k r c t ' h q t ' c m i b q p q r c { g t u . ' w r q p ' l p e t g c u l p i ' v j g ' c o q w p v ' q h ' h k k f ' q p ' v j g ' u w t h c e g . ' v j g ' u t g p i v j ' q h ' f k r q n g / f k r q n g ' l p v g t c e v k q p ' d g y g g p ' v j g ' e c t d q p { n i t q w r ' u ' l p e t g c u g u 0 0 g c p y j k g . ' v j g ' f g w g t c v k q p ' q h ' v j g ' i r k k f a i ' e j q r k p g ' i t q w r ' j c u ' v j g ' u t q p i g u v l o r c e v ' q p ' v j g ' x k d t c v k p u ' q h ' v j g ' r j q u r j q e j c v g ' i t q w r ' 0 v j g ' c d u g p e g ' q h ' c ' R Q 4 ' x k d t c v k p c n ' d c p f ' ' h q t ' o q p q r c { g t u ' h t o g f ' q h ' F R R E / f 3 5 ' c p f ' F R R E / f 9 7 ' h g c f u ' v j g ' e q p e n u k q p ' v j c v ' f g w g t c v k q p ' q h ' v j g ' e j q r k p g ' i t q w r ' l o r c e v u ' v j g ' q t l p g p c v k q p ' q h ' v j g ' i r k k f a i ' j g c f i t q w r ' l p ' t g u r g e v ' v j g ' u w t h c e g ' p q t o c r f 0 0 q t g x g t . ' y g ' w u g f ' e c r e k w o ' e j r k l f g ' v q ' g x c n e w g ' v h e i n t e r a c t i o n b e t w e e n p h o s p h o l i p i d m o n o l a y e r a n d i o n s , w h i c h p l a y a m a j o r r o l e i n m a n y b i o l o g i c a l p r o c e s s e s . W e o b s e r v e d f r e q u e n c y s h i f t s o f P O 2 - a n d C = O v i b r a t i o n a l b a n d s i n d u c e d b y i n c r e a s e d d e h y d r a t i o n o f t h e m o n o l a y e r a n d a d d i t i o n a l i n t e r a c t i o n w i t h C a 2 + i o n , w h i c h i n t h e c a s e o f c a r b o n y l g r o u p a l s o a f f e c t t h e s t r e n g t h o f d i p o l e - d i p o l e i n t e r a c t i o n .



Hk wt g'300 qngewct'utwewt'qh'F RRE'\*3.4/f k r c m k q { n'up/i n'eg tq n/5/r j q u r j q e j q r k p g + y k j ' f k h h g t g p v r e x g n u ' q h ' f g w g t c v k q p "

[3]\_F 0 F 0 D e r f { i c . ' T O C 0 F n j . { ' Q p ' v j g ' w u g ' q h ' f g w g t c v g f ' r j q u r j q r k k f u ' h q t ' l p h t c t g f ' u r g e v t q e q r l e ' u w f l g u ' q h ' o q p q o q n g e w r t ' h k o u < e ' j g t o q f { p c o l e ' c p c n { u k u ' q h ' u k p i n g ' c p f ' d l p c t { ' e q o r q p g p v r j q u r j q r k k f ' o q p q r c { g t . ' E j g o k u t { ' c p f ' R j { u k e u ' q h ' N k r k f u ' ; 8 . : 3 / ; 9 \* 3 ; : : 4 0 } [4]\_J 0 J 0 0 c p w e j . ' T O P 0 0 e G i j c p g f . ' R j q u r j q r k k f ' R j c u g ' v t c p u k q p u ' l p ' o q f g n i c p f ' D k m j i k e c n i o g o d t c p g u ' c u ' u w f l g f ' d { ' l p h t c t g f ' U r g e v t q e q r { 0 } E j g o k u t { ' c p f ' R j { u k e u ' q h ' N k r k f u ' 7 9 . ' 4 3 5 4 4 8 ' \* 3 ; ; 3 - 0 } [5]\_I 0 0 c . ' J 0 E 0 C m g p . ' F R R E ' N e p i o w k ' O q p q r c { g t ' c v ' v j g ' C k / Y c v g t ' l p v g t h c e g < R t q d l p i ' v j g ' v c k l c p f ' J g c f ' I t q w r ' u ' d { ' X k d t c v k p c n ' U w o ' H i g s w g p e { ' I g p g t c v k q p ' u r g e v t q e q r { . ' N e p i o w k ' 4 4 . ' 7 5 6 3 / 7 5 6 ; \* 4 2 2 8 - 0 } [6]\_T 0 0 g p f g n u j p . ' U 0 U w p f g t . ' J 0 D g t p u n g k p . ' F g w g t c v g f ' h e w f ' c e k f ' u ' c u ' T c o c p ' u r g e v t q e q r l e ' r t q d g u ' q h ' o g o d t c p g ' u w e w t g u 0 D i k e j k o l e c ' g v ' D i k r j { u l e c ' C e v ' 6 6 5 . ' 8 3 5 / 8 3 9 ' \* 3 ; 9 8 - 0 } [7]\_T 0 0 g p f g n u j p . ' E 0 M q e j . ' F g w g t c v g f ' r j q u r j q r k k f u ' c u ' T c o c p ' u r g e v t q e q r l e ' r t q d g u ' q h ' o g o d t c p g ' u w e w t g < R j c u g ' f k i t c o u ' q h ' v j g ' f k r c m k q { n i ' r j q u r j q e j c v k f { n e j q r k p g ' c p f ' k u ' f s ' f g t k c v k g e f f k r c m k q { n i ' r j q u r j q e j c v k f { n e j c p q n e o l p g ' u ' u g o . ' D i k e j k o l e c ' g v ' D i k r j { u l e c ' C e v ' 7 ; : . ' 4 8 2 / 4 9 3 ' \* 3 ; : 2 - 0 }

# PLASMA-INDUCED MODIFICATION OF ZnO-BASED CATALYSTS DOPED WITH Ag PLASMON NANOPARTICLES FOR PHOTODEGRADATION OF PHARMACOLOGICAL WASTE

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Water purification from pollutants containing various organic substances and their compounds, including medical waste (MW), is one of the main problems facing the world community. According to the World Health Organization, 15% of MW are considered hazardous materials that can be toxic, infectious or radioactive, and harm human health and the environment [1]. Existing methods have serious drawbacks, which makes it necessary to develop new solutions.

Heterogeneous photocatalysis using nanocatalysts is considered as a promising method for cleaning aqueous media from waste from the pharmaceutical industry, but the effectiveness of known photocatalysts is insufficient for use in industrial applications. In previous studies, it was shown that plasma treatment and impregnation of a ZnO-based catalyst with silver nanoparticles leads to an increase in its activity [2].

In this paper, photocatalysts were executed, which were impregnated with silver nanoparticles during the synthesis process. Such an injection mechanism should lead to a change in the morphology of the catalysts and an increase in their activity [2].

ZnO nanoparticles were prepared by dropwise addition of 25 mL of NaOH 0.4 mol/L into 25 mL of ZnSO<sub>4</sub> 0.2 mol/L at an approximate addition rate of 5 mL/min. After stirring with a magnetic stirrer SOLOR SCUID IKAMAG WHITE (IKA, Germany) at a speed of 150 rpm for 60 min, the solution was kept at 60°C for 2 h. Ag-ZnO composite nanoparticles were prepared by adding 6 mL of ascorbic acid 0.01 mol/L and 13 mL of AgNO<sub>3</sub> 0.01 mol/L into the solution of NaOH and ZnSO<sub>4</sub>, while stirring under the same condition as in the first experiment, and again the solution was kept at 70°C for 2 h. The catalysts synthesized by this method should have a size equal to 50-60 nm [3].

The photocatalytic activity of the obtained catalysts was researched in a model decomposition reaction of caffeine simulating pharmacological waste under the action of ultraviolet radiation in aqueous suspensions of synthesized samples. During the experiments for the preparation of the suspension, a 40 mg catalyst was mixed with 20 ml of an aqueous solution of caffeine sodium benzoate with a concentration of 300 mg/l. The mortars are prepared based on distilled water.

The selected concentration of caffeine for the model reaction is in the range of concentrations contained in wastewater. Suspensions of catalysts in aqueous solutions of model substances were exposed to UV radiation. As a source of ultraviolet radiation, a mercury-quartz lamp DRT-240 (power 240 W) was used. During the irradiation, the change in the concentration of caffeine in the solution was monitored using a SOLAR PB 2201 spectrophotometer (SOLAR, Belarus). The irradiation was carried out under constant stirring of the suspension in a magnetic stirrer SOLOR SCUID IKAMAG WHITE (IKA, Germany) at a speed of 200 rpm.

The reaction rate constant was determined by the slope of the graph of the dependence of the logarithm of the concentration of the decomposed substance on time. The relative concentration of the model substance  $C_r$  was determined by measuring the optical density at the absorption maximum:

$$C_r = \frac{C(t)}{C_0} \cdot 100\% = \frac{A_t}{A_0} \cdot 100\%, \quad (1)$$

where  $C_0$  is the initial concentration of the model substance,  $C(t)$  is the concentration of model substances after irradiation of the UV radiation at time  $t$ ,  $A_0$  and  $A_t$  the optical density of the solution of the model substance in the absorption maximum ( $\lambda=452$  nm) before irradiation and at time  $t$  after the start of irradiation of the samples, respectively.

To compare the photocatalytic activity of different samples, it was assumed that the photodegradation reaction can be described by a first-order equation, therefore, the kinetic equation has the form:

$$\frac{dc}{dt} = -kC \quad (2)$$

Here  $C$  – the concentration of the decomposed substance,  $k$ - the reaction constant. The solution of equation (2) can be represented as follows:

$$C(t) = C_0 e^{-kt} \quad (3)$$

Thus, by constructing a time dependence  $\ln \frac{C(t)}{C_0}$ , the values of the reaction rate constant can be easily found on the graph.

$$\ln \frac{C(t)}{C_0} = -kt \quad (4)$$

The activity of the synthesized samples was compared with the activity of commercially available ZnO (ECOS-1, Russia) with a particle size ranges from 100 nm to 1  $\mu$ m [2].

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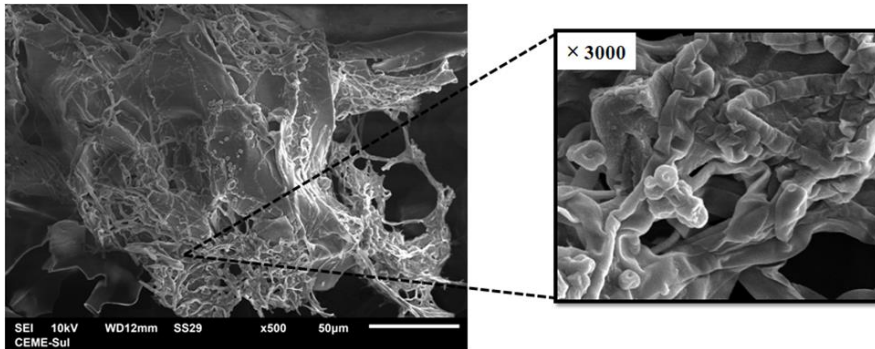
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**F GXGNQRO GP V'QHEJ KVQUCP 'URQPI G'O QF KHGF 'Y KVJ 'ECTDQP "**  
**PCPQVWDGU'HQT'RJ GP QN'CFUQTRVKQP "**

F cplgrg'Equc'f c'Ukrk'Crkgu<sup>3,4</sup>. Nwk 'CpV/plq'f g'cm gkf c'Rkpq<sup>4</sup>. 'Vksq'Tqdgvtq'UcpwCpcc'  
 Ecf cxclLwplqt<sup>4</sup>. 'Ecto gn'Dgtpcf gwg'Dt gurk<sup>3</sup>, "

" <sup>3</sup>F gr ctwo gpv'qh'Ej go km { . 'O c { pqqj 'Wpkxgtukf . 'O c { pqqj . 'Eq0Mkf ctg. 'Kgrpf "  
<sup>4</sup>Uej qqr'qh'Ej go km { 'cpf 'Hqf. 'Hgf gcn'Wpkxgtukf 'qh'Tkq'I tcpf g. 'Tkq'I tcpf g. 'TU. 'Dtc| kn'  
f cplgrg'Equc'f c'Ukrk'Crkgu@243B o wo chrkg"

Rj gpqn'ku'y kf gn' 'hqw'f 'lp'ghnwgpw'i gpgtevgf 'd{ 'ugxgcn'ej go lecnl'p'f wut'kgu'cpf 'k'ku'eqpukf g'gf 'qpg'qh'y g'r tkqt'k'f " eqpco kpcpw'f w'g'v'ku'j ki j "vzlek'f 'cv'ny "eqpegpvc'kpu'0'Vj ku'o cngu'k'pgeguuct { "v' tgo q'xg'r j gpqn'htqo "lpf wut'kcn' ghnwgpw'dghqt'g'k'ku'f k'ej cti gf "lpv'v'j g'gpxkqpo gp'0'Vj g'go gti p'peg'qh'p'cpq'v'ej p'q'ni { "j cu'gpcdrf "v' g'f guki p'qh'p'gy " cpf "r tqo kulpi "cf uqtdgpv'o cvt'kcu'j3\_0'k'p' r ct'kw'w'ct. "ectdqp'p'cpq'wdgu" \*EP Vu"j cxg'r tq'xg'f "v' dg'c'r tqo kulpi "uq'w'k'p' hqt "y cvgt' r w'k'k'ec'v'p'v'j tq'wi j "v' g'cf uqtr v'k'p'qr g'c'v'k'p'. "cu'v'j g' { "j cxg'cp'g'zegngp'v'cf uqtr v'k'p'c'k'k'p'k'f "hqt'x'ct'k'q'w'q'ti c'p'le" r qm'w'c'p'w'j4\_0'J ky g'x'g't. "k'ku'f k'h'le'w'v'q' t'go q'x'g'c'p'f "u'gr c't'v'g'EP Vu'htqo "y cvgt' ch'gt'v'j g'cf uqtr v'k'p'qr g'c'v'k'p'0'k'p'q'tf g't "v' q'x'g't'eqo g' "v' j ku' d'ct'k'g't. "cp"lp'v'g't'g'w'k'p' "cng't'p'c'v'k'g' "ku'v'j g' "f g'x'g'nr o gp'v'q'h'j { d'k'f "EP Vu"cf uqtdgpw'0'Vj g'd'k'q' q'nf o g't " ej k'q'uc'p'ku'c'w't'c'v'k'p' "eq'p'k'f g't'c'd'rg"lp'v'g't'g'w'v'cu'c"o c'v'k'z" hqt "EP Vu" f w'g'v'q'v'j g'r t'g'ug'p'eg'q'h'j { f tqz { n'i tq'w' u' \*QJ "cpf " r t'k'o c't { "co k'p'gu" \*PJ 4+ "v' c'v'c'v'cu'c'v'k'g'c'f uqtr v'k'p' "uk'g'u. "o c'n'k'p' "k'p' "g'h'le'k'p'v'cf uqtdgpv'j5\_0'Vj g't'g'ht'g' "c"ur q'p'i g' " eqo r q'ug'f "qh'ej k'q'uc'p'EP V" y cu'f g'x'g'nr g'f . "ej c't'c'v'g't'k'f g'f "d { "uec'p'k'p'i "g'ng'v'q'p" o k'et'q'ue'q' { " \*UGO + "cpf " cr r'k'g'f "v' " r j gpqn'cf uqtr v'k'p'lp'cs w'g'q'w'u'q'w'k'p'0'Vj g'm'p'g'v'k' "dg'j c'x'k't'q' y cu'g'x'c'w'c'v'g'f "w'k'p'i "f k'h'g't'g'p'v'w'k't'k'p'i "t'c'v'g'u" \*72. "322"cpf " 372"tr o +0'Vj g't'g'w'w'u'uj q'y "v' j c'v'v'j g'cf uqtdgpv'r t'g'ug'p'v'g'f "c"t'q'w'j "cpf "k't'g'i w'ct "u'w'h'c'g' "cu'uj q'y p'lp' "Hki 0'3. "y j k'ej " k'p'f l'ec'v'u"i q'q'f "c'ee'g'u'k'k'k'k'f "qh'r j gpqn'q'p'v'j g'w'w'h'c'g'q'h'v'j g'cf uqtdgpv'0'Ce'eq't'f k'p'i "v' "V'c'd'rg"3. "v' j g'r u'g'w'f q'uge'q'p'f/q't'f g't " \*RUQ + "y cu'o q't'g'c'f g's w'c'v'g'v'j cp'r u'g'w'f q'k'k'v'q't'f g't " \*RHQ + "m'p'g'v'k' "o q'f gn'v'q' t'g'r t'g'ug'p'v'j g'cf uqtr v'k'p' r j gpqo gp'p'c'v'c'm' t'q'v'k'p'u. "cpf "v' j g'o c'z'k'o w'o "cf uqtr v'k'p' "ec'r c'ek'k'f "y cu'44: 0 "o i "i /3"cv'372"tr o 0'Vj g't'g'ht'g' "v' j ku'w'w'f { "f go q'p'w't'c'v'g'f "v' j g' f g'x'g'nr o gp'v'q'h'c'r tqo kulpi "cf uqtdgpv'y k'j "j ki j "cf uqtr v'k'p' "ec'r c'ek'k'f. "ny "eq'u'c'p'f "lp'v'g't'g'w'k'p' "o g'ej c'p'k'c'n'r t'q'r g't'v'g'u' hqt " v' j g't'go q'x'c'n'q'h'r j gpqn'htqo "cs w'g'q'w'u'q'w'k'p'0' "



Hki 030UGO 'ko ci g'qh'ej k'q'uc'p'EP V'ur q'p'i g'0

V'c'd'rg'30'M'p'g'v'k' r c't'co g'y't'u' hqt' r j gpqn'cf uqtr v'k'p'q'p'v'q'ej k'q'uc'p'EP V'ur q'p'i g'lp'f k'h'g't'g'p'v'w'k't'k'p'i "t'c'v'g'u'0'

U'k't'k'p'i "t'c'v'g' "tr o +"	72"	322"	372"
RHQ"	"	"	"
$s_3^{*o} i^{1/3+}$	3840 "	3; 808"	43208"
$m_3^{*o} k^{3+}$	20824"	20862"	20889"
T "	20 : 9"	20 : 4"	20 : 9"
CTG <sup>o</sup> +"	707"	709"	608"
RUQ"	"	"	"
$s_4^{*o} i^{1/3+}$	3: 607"	43808"	44: 0"
$m_4^{*1} o i^{1/3} o k^{3+}$	20229"	2022; "	20232"
T "	20 ; 5"	20 ; 6"	20 ; 5"
CTG <sup>o</sup> +"	609"	407"	408"

[1] F'0'Crkgu. 'L0'I q'p'c'rkgu. "D0'E'q'ug'i r'k'g'v'c'f'0'f' uqtr v'k'p'q'h'r j gpqn'q'p'v'q'ej k'q'uc'p'j { f tqi gn'uecl'ht'q'f "o q'f k'h'g'f "y k'j "ectdqp'p'cpq'wdgu. "l'q'w't'p'c'n'q'h' G'p'x'k'q'p'o gp'v'c'n'Ej go l'ec'n'G'p'i l'p'g'g't'k'p'i "9. "325682" \*423; +0

[2] F'0' T'cy v'p'k' "P'0' M'j c'v'k' "U'0' V { c'i k' "g'v' c'f'0' "P' c'p'q'v'ej p'q'ni { /dcug'f "t'g'eg'p' c'rr t'q'ej gu' hqt "u'g'p'k'p'i " cpf "t'go g'f k'v'k'p' q'h' r g'u'k'k'f gu. "l'q'w't'p'c'n' q'h' G'p'x'k'q'p'o gp'v'c'n'0' c'p'ci go gp'v'428. "96; /984" \*423; +0

j5\_1 0F'v'q'v. "N0'R'p'v'q. "C'f uqtr v'k'p'q'h' h'q'f "f { g'u'q'p'v'q'ej k'q'uc'p' <Q'r v'k'o k' c'v'k'p' r t'q'eg'u'c'p'f "m'p'g'v'k'0'E'c't'd'q'j { f t' "R'q'f o g't": 6. "453/45: " \*4233+0

# VJ G'WUG'QH'O CEJ KP'NGCTP KPI 'KP'QTVJ QVTQRK'E'O CVGTKNU' ENCUKHKE CVKQP 'XK' O QF CN'CP CN[ UKU''

O qi co gf 'Cdf gmef gt<sup>3,4,5</sup>"

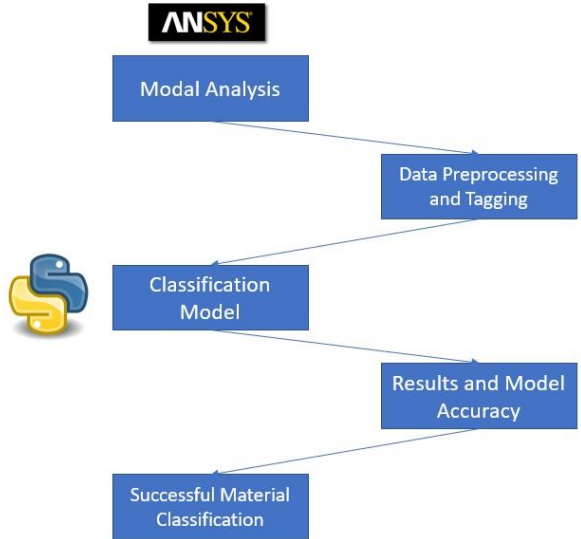
<sup>3</sup>F gr ctwo gpv'qh'O gei cpleu'cpf "O cvgtknu'Gpi kpggtkpi . 'Xkpkwu'I gf lo kpcu'Veji pleci'Wpkxgtukv{ . 'Xkpkwu.'Nkj wcpk'  
<sup>4</sup>F gr ctwo gpv'qh'r tgr ctokq'p'cpf "cpcn'uku'qh'pccquu'vewt'gu. 'Kpukwg'hqt'P cpqo cvgtknu.'Cf xcpgef "Vgei pqmi lgu'cpf "  
 Kppqxcvqkq. "Vgei pleci'Wpkxgtukv{ 'qh'Nldtge. 'Nldtge. 'Ei gei "Tgr wdike"

<sup>5</sup>F gr ctwo gpv'qh'P cpqgpi kpggtkpi . 'Ucvg'tgugteji 'kpukwg'E gpvt'ht'Rj { ukcni'Uekpegu'cpf "Vgei pqmi { "  
 Uxcpcqtk "cxg0453.'NV/24522'Xkpkwu.'Nkj wcpk'  
 o qi co gf 0cy | f B ho e0w'

O qf cni'cpcn'uku'ku'c" r qy gthwi'vqri'vq' gpuw'g'vj g' uchgv 'qh'o cvgtknu'cpf "qpg'qh'vj g'pqp/f guvwekxg'o cvgtknu'  
 ej ctcevtk'v'kqp'o gvi qf u."yj g'uwwf { "uj qy u'cr n'kpi "o cej kpg'ngctpki "v'j' cxg'c'ercukhkecvkqp'uej go g'qh'o cvgtknu'Vj g'  
 eqpegr v'qh'ercukhkecvkqp'vj tqwi j "vj g'uwwf { "ku'xcikf cvgf "hqt"kuvtqr le"cpf "qtvj qvtqr le"o cvgtknu'tgcej kpi "w"v'c"322' "  
 ceewtce{ "y j gp'f gr m{ kpi "vj g'o cej kpg'ngctpki "cr r tqcej "y kj "vj g'etgcvgf "kpvtgrv'kqp"xctkdrgu'dgvy ggp"vj g'o qf g'  
 pwo dgt" cpf "vj g'cuqekcvgf "htgs wpe{."CPU' U' y cu' wugf "v' uko wcvgf "o qf cni'cpcn'uku' Vj ku' uwwf { "uj qy u'c" pgy "  
 ercukhkecvkqp'o gvi qf "f gr gpf kpi "qpn' "qp'vj g'npqy rgi i g'qh'tguqpcpeg'htgs wpe{ "qpn' "qh'vj g'o cvgtknu'

Vj g' uwwf { " f go qpuvcvu' vj g'cdkxk' " vj g' ercukh' " vj g' gpi kpggtkpi " o cvgtknu' kpenf kpi " kuvtqr le" cpf " qtvj qvtqr le"  
 o cvgtknu'd { "cr n'kpi "ON"\*O cej kpg'Ngctpki "+cni qtkj o u'qp'vj g'o qf cni'cpcn'uku'tguwu."vj g'r tqr qugf "ON'cr r tqcej gu'  
 eqwv' "tgcej "cp'ceewtce{ "qh'322' " y j gp'kpvtgrv'kqp'u'ctg'etgcvgf "dgvy ggp" vj g'kpr wu" vj g'O N'cni qtkj o u' \*vj g'  
 eqo dlp'gf "nkpgt" tgi tguukq'cr r tqcej "kp'v'ku' uwwf { "Mgtcu" o qf gni' y cup'w' uwxcdrg' hqt' vj ku' uwwf { "cu'k'uj qy gf "72' "  
 ceewtce{ "y j gp'eqo r ctgf "v' vj g'O N'cr r tqcej gu' Vj g' uwwf { "xcikf cvgf" vj g' ercukhkecvkqp' cr r rcdkxk' "dcugf" qp' vj g'  
 tguqpcpeg'htgs wpe'kpi'kph'cto cvkqp' qpn' "y j lej "dtqcf g'pu' vj g' "j qtk qpu'qh' hwt'v'gt" cr r rkecvkqp'u' rkn'g' c' f gxleg' vj cv' ecp"  
 ercukh' " vj g'o cvgtknu' dcugf "qp' vj g'k' " o qf cni'cpcn'uku' Rqvp'v'kni' hww'g' uwwf lgu' ecp" uwwf { "qvj gt" F N' "F ggr "Ngctpki "  
 cr r tqcej gu'cpf "vj g'f gr m{ o gpv'qh'p'gw'v'v'p'gy qtnu'vj cv'ecp'cej kxg'r tqo kulpi "ercukhkecvkqp' uwwf lgu' Hwt'v'gt "gz v'puk'qpu'  
 cpf "t'gr'v'kqp'u' ecp' dg'guv'ckri'g'f "hqt' f'gvck'gf "o cvgtknu'r tqr gt'v'k'k' gp'v'k'kecvkqp' vj tqwi j "f gr m{ kpi "vj g'eqpegr v'qh'ON'cpf "  
 F N'kp'v' vj g'hgr' "qh'o gei cplecni'gpi kpggtkpi "y j lej "rtqxg'u'vj g'o qf gtp'eqpegr v'qh'uekpegi'k'v'gi t'cv'kqp'Vj g't'guwu'qh'vj ku'  
 uwwf { "ecp'd'qqu'v' vj g'pqp/f guvwekxg'o cvgtknu'ej ctcevtk'v'kqp'u'lp'i g'p'tcni'cpf "cpcn'uku' o gvi qf u'p'qv'lwu'vj g'zr'v'gt'f "  
 o qf cni'cpcn'uku'gzco r rg'cu'ON'cpf "F N'f g'v'no' ckni' "y kj "f c'v' t'gi ctf r'gu'qh'v'j g'ces'v'k'kpi "o gvi qf 0"

0'''  
"



Hki 030'Qxg'tcni'wuo o ct { "cpf "r tqefg'w'gu'qh'wulpi "ON'cpf "F N'k'gpi kpggtkpi "o cvgtknu'ercukhkecvkqp'

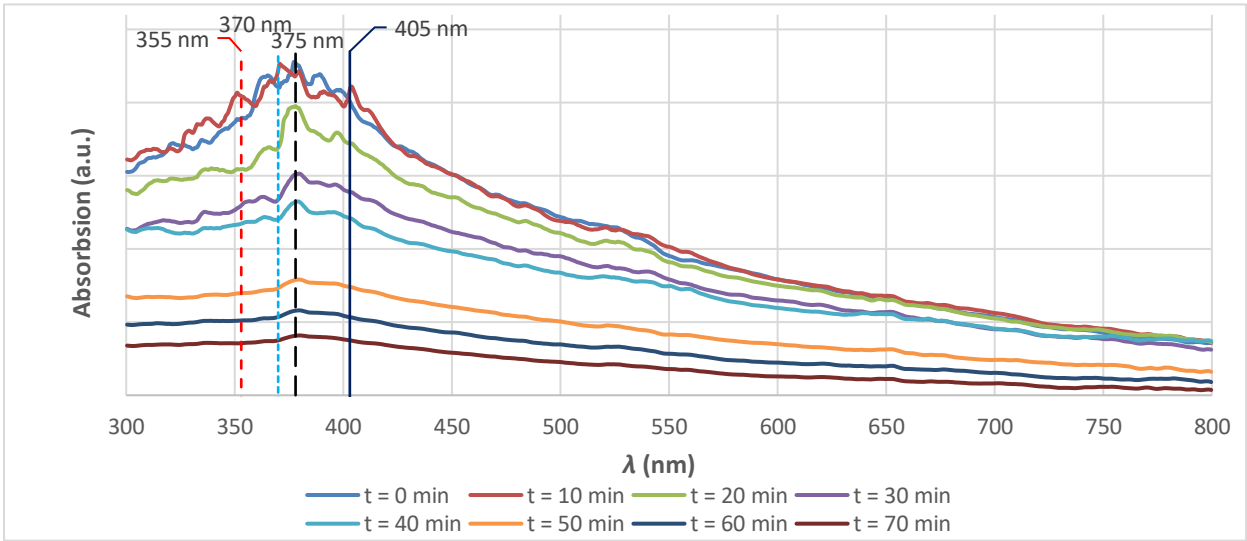
U P V J G U K U C P F ' K P X G U V H C V K Q P ' Q H H W P E V K Q P C N ' R T Q R G T V K U ' Q H \ K P E ' Q Z K F G ' P C P Q R Q Y F G T U "

O k p f c w i c u ' k l e n e u <sup>3,4</sup>. ' U k o c u ' T c n e w u n e u <sup>3,4</sup>. ' c p f ' D t k i k c ' C d c n g x k k p <sup>3,4</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rj { uleu.'Mcwpcu'Wpkxgtuks\ 'qh'Vgej pqmqi { . 'Nkj weple' }  
<sup>4</sup>'Kpukxwg'qh'O cvgtkcn\ 'Uelkpeg.'Mcwpcu'Wpkxgtuks\ 'qh'Vgej pqmqi { . 'Nkj weple' }  
o k p f c w i c u k l e n e u B m w Q f w

Vj g'y qtn'hwewugu'qp'vj g'u'p'vj guku'qh' kpe'qz'kf'g' pQ+'pcpqr ct v'ergu'cpf' 'y' g'u'w'f { 'qh'vj g'hwpevkqpcn'r tqr gt v'gu'qh' yj gug'r ct v'ergu' pQ'j cu'c' wpls w'g'eqo d'lc'p'v'k'p'qh'qr v'ec'n'r k'g' q'g'g'ev'te. "o ci p'g'le. "cpf' "ugpuqt { "r tqr gt v'gu'vj ku'ku'cp' ko r q't'v'cp'v'cur gev'lp'vj g'f' g'x'g'nr o gp'v'qh'x'ct'k'q'u'u'ugpuqtu'0'Vj g'cd'k'k'k' { 'qh' pQ'v'q'c'du'q't'd'w'nt'c'x'k'q'g'v'iki j v'32/622'po '+ku' cr r'k'g'f'lp'vj g'r t'q'f'v'ek'q'p'qh'lu'q'ic't'eg'm'i'eq'c'v'k'p'i u'c'p'f'w'nt'c'x'k'q'g'v'ugpuqtu'j3\_0D { 'k'w'o k'p'c'v'k'p'i 'y' g'w'w'f'c'eg'q'h'vj g' pQ'eq'c'v'k'p'i " y'kj "w'nt'c'x'k'q'g'v'iki j v'k's'k'u'r'q'u'k'k'q'g'v'q'et'g'c'g'f'g'x'c'c'p'k'g'u'q'h'vj g'q'z { i'g'p'c'v'q'o . 'y' j'k'ej 'ej'c'p'i'g'u'v'j'g'k'p'v'g't'p'c'n'r t'q'r'g't'v'gu'q'h' yj g'o'c'v'g't'k'c'n'w'ej'cu'k'p'et'g'c'v'k'p'i 'y' g'p'v'f'r'g'eq'p'f'v'ek'k'k' { 'c'p'f' 'y' g'v'k'p'i 'y' g'o'c'v'g't'k'c'n' k'p'e'q'z'k'f'g'ku'c'p'k'p'q't'i'c'p'le'eq'o r'q'w'p'f' h'q'w'p'f'lp'vj g'h'q'to'q'h'c'y'j'k'g'r'q'y'f'g't.'c'm'o'q'u'v'k'p'u'q'w'd'g'v'lp'y'c'v'g't'0\ pQ'ku'c't'g'v'k'x'g'v'q'u'h'v'o'c'v'g't'k'c'n'y'k'j'c'O'q'j'u'j'c't'f'p'g'u'q'h' c'607'j4\_0J'k'i'j'j'g'c'v'ec'r'c'ek'k' { 'c'p'f' 'e'q'p'f'v'ek'k'k' { 'c'p'f' 'j'k'i'j' 'o'g'u'k'p'i' 'r'q'k'p'v'c't'g'r'c't'v'w'w'r't'n'f' 'k'o'r'q't'v'cp'v'k'p'eg't'c'o'le'u'j5\_0\ pQ'j'cu' c'y'k'f'g't'c'p'i'g'q'h'hw'p'v'k'q'pc'n'r t'q'r'g't'v'gu'y'j'g'p'c'r'r'k'g'f'lp'qr'v'q'g'g'ev't'q'p'leu.'ur'k'p't'q'p'leu.'c'p'f' 'r'k'g'f'q'g'g'ev't'e'v't'c'p'uf'v'eg't'u'0\ pQ'ku' c'v'g'o'k'eq'p'f'v'eq't.'h'q'o' 'y'g'r'q'k'p'v'q'h'x'k'g'y'q'h'p'c'p'q'/'c'p'f' 'o'k'et'q'u't'w'w't'g'u'k'v'k'u'c'x'g't' { 'g'z'v'c'q't'f'k'p'c't' { 'o'c'v'g't'k'c'n'y'k'j'c'y'k'f'g'd'c'p'f' " i'c'r'6'G'?'569'g'X'j6\_0V'j'k'u'b'c'v'g't'k'c'n'k'u'r'j' { 'u'k'c'm'f'x'g't' { 'u't'q'p'i' . 'k'u'L'w'p'i' a'u'b'q'f'w'w'u't'g'c'ej'g'u'372'I' R'c'c'p'f' 'k'u't'g'v'k'x'g'v'q'u'c'd'g' " w'r'v'q'j'k'i'j' 'v'g'o'r'g't'c'w't'g'u'3: 22'v'E+0\ pQ'j'cu'c't'g'v'k'x'g'v'j'k'i'j' 'p'v'v'g'c't'd'k'p'f'k'p'i' 'g'p'g't'i' { '\*82'o'g'X'+u'q' \ pQ'uj'q'y'u'r'q'v'p'v'k'n'r' h'q't'w'nt'c'x'k'q'g'v'WX+q'r'v'q'g'g'ev't'q'p'leu'c'r'r'k'ec'v'k'p'u'j7\_0V'j'k'u'w'p'k'v'g'v'g't'c'r'q'f' 'u't'w'w'w't'g'eq'p'k'u'u'q'h'hw'w'j'g'z'c'i'q'p'c'n't'q'f'u.'c'm'q' ec'm'g'f' 'o'g'i' u'o. 'y'j'k'ej' 'c't'g'eq'p'p'g'ev'g'f'v'q'g'c'ej' 'q'y'g't'v'j'q'w'i'j' 'y'g'eg'p't'c'n'eq't'g'c'v'c'p'c'p'i'g'q'h'327'v'v'q'332'v'v'j7\_0'

Vj g'u'p'vj guku'qh' pQ'ut'w'w'w't'g'u'k'u'r'g't'q'to'g'f'd' { 'eq'p'v'k'w'q'w'u'f'p'vj'guku'eq'o'd'w'w'k'p'+'r'q'eg'u'u'j8\_0WX/Xku'ur'g'ev't'c'n' c'p'c'n'f'uku.'u'ec'p'p'k'p'i' 'g'g'ev't'q'p' 'o'k'et'q'ue'q'r' { '\*UGO '+'c'p'f' 'Z'/'t'c' { 'f'k'h't'c'ek'v'k'p' '\*ZTF '+'o'g'v'j'q'f'u'y'g't'g'w'g'f' 'k'p'v'j'k'u'y'q't'n'0'D'c'ug'f'q'p' w'nt'c'x'k'q'g'v'/'x'k'k'k'g'v'iki'j'v'ur'g'ev't'o'g't' { 'c'p'f' 'u'ec'p'p'k'p'i' 'g'g'ev't'q'p' 'o'k'et'q'ue'q'r' { . ' | 'k'p'e'q'z'k'f'g'r'c't'v'ergu'q'h'f'k'h't'g'p'v'uj'c'r'g'u'/' " v'g't'c'r'q'f'u'p'c'p'q'r'c't'v'ergu.'c'p'f' 'x'c't'k'q'w'3F'c'p'f' '5F'p'c'p'q'u't'w'w'w't'g'u'/'y'g't'g'h'q'to'g'f' 'f'w'l'k'p'i' 'y'g'u'p'vj'guku'WX/Xku'ur'g'ev't'o'g't' { ' " u'j'q'y'g'f' 'y'c'v'c'u'v'j'g'eq'm'q'w'q'h'v'j'g'f'w'o'g'k'p'v'j'g'd'w't'p'g't'ej'c'p'i'g'f' 'h'q'o' 'd'w'k'v'j' 'v'q'j'g'g'p'k'j' . 'y'g'r'c't'v'erg'uk'g'k'p'et'g'c'ug'f' '\*7: /86' po '+'c'p'f' 'y'g'r'c't'v'erg'uk'g'f'g'et'g'c'ug'f' '\*85/74'po '+'y'k'j' 'k'p'et'g'c'v'k'p'i' 'eg'p't'k'w'i'c'v'k'p'ur'g'g'f' 'k'p'v'j'g't'c'p'i'g'q'h'3222'/'32222't'r'o'0' Vj'k'u'j'q'y'u'v'j'g'r'q'v'p'v'k'n'q'h' pQ'p'c'p'q'r'c't'v'ergu'q'c'r'r'k'ec'v'k'p'lp'qr'v'q'g'g'ev't'q'p'le'f'g'x'k'g'eu'0'



H'i'0'30'WX/Xku'c'du'q't'r'v'k'p'ur'g'ev't'c'u'q'h'x'c't'k'q'w'u' pQ'ut'w'w'w't'g'u'0'Vj'g't'g'f' 'f'c'uj'g'f' 'h'k'p'g' '\*? '577'po '+'eq't't'g'ur'q'p'f'u'v'q' " p'c'p'q'r'c't'v'ergu.'y'g'd'w'w'g'f'q'w'g'f' 'h'k'p'g' '\*? '592'po '+'eq't't'g'ur'q'p'f'u'v'q'p'c'p'q'y'k'g'u' 'y'g'd'w'w'w't'f'c'uj'g'f' 'h'k'p'g' '\*? '597'po '+' eq't't'g'ur'q'p'f'u'v'q'v'g't'c'r'q'f'u.'c'p'f' 'y'g'd'w'w'g'f'c'uj'g'f' 'h'k'p'g' '\*? '627'po '+'k'u'f'w'g'v'q'v'k'i'j'v'v'j'k'w'v'q'v'j'g'd'w'w'g'f'g'i'k'p'v'j'c'v't'g'u'w'u'f'q'o' " y'j'g's'w'c'p'w'o' 'eq't'g'/'u'j'g'n'l' pQ'eq'm'q'w't'g'0'

Vj'k'u't'g'ug'c't'ej' 'k'u'hw'p'f'g'f'd' { 'y'g'g'w't'q'r'g'c'p' 'T'g'i'k'q'p'c'n'f'g'x'g'nr'o'gp'v'hw'p'f' 'c'ee'q't'f'k'p'i' 'v'q'v'j'g'u'w'r'q't'v'g'f' 'c'ev'v'k'k'f' 'o'c'w't'c'ev'k'p'i' 'u'ek'p'k'u'u' h'q'o' 'c'd't'q'c'f' 'v'q'ec't't' { 'q'w't'g'ug'c't'ej' . 'r'q'l'g'ev'P'q023040/NO'V/M'93: /24/22330'

- 13\_ 'I'ce'q'd'u.'E'j't'k'u'r'j'g't'D'g'v'c'f'0'WX/c'ev'k'c'v'g'f' \ pQ'h'k'o' u'q'p'c't' 'h'g'z'k'd'g'v'w'ud'w't'c'v'g'q'at' 't'q'q'o' 'v'g'o'r'g't'c'w't'g'Q+'c'p'f' 'J' '4'Q'v'g'p'ul'p'i' 0'U'ek'p'k'w'k' 'T'g'r'q't'u.'9\*3+ ' 8275.'42390
- 14\_ 'C'0J'g't'p'p'f'g'l' 'D'c'w'g'l' 'g'v'c'n'0'E'w'Q.' \ t'Q+'c'p'f' \ pQ'p'c'p'q'r'c't'v'ergu'c'u'c'p'v'k'y'g'et'c'f'f'k'k'x'g'k'p'q'k'i'h'w'd't'k'c'p'u'0'G'w'g'x'k'g't.'487\*5/6+'644664: . '422: 0'
- 15\_ 'I'0F'c'u.'g'v'c'f'0't'c'o'c'p'c'p'f' 'Z'R'U'w'w'f'k'g'u'q'h'v'w'g' \ pQ'eg't'c'o'k'eu'0'R'j' { 'u'k'c' 'D'z'Eq'p'f'g'p'ug'f' 'O'c'w'g't' '627\*32+'46; 4646; 9.'42320
- 16\_ 'X'0C'0'E'q'g'o'c'p.'c'p'f' 'E'0'L'c'i'c'f'k'ij'0'D'c'u'k' 'R't'q'r'g't'v'gu'c'p'f' 'C'r'r'k'ec'v'k'p'u'q'h' \ pQ'0\ k'p'e'Q'z'k'f'g'D'w'm' 'V'j'k'p' 'H'k'o' u'c'p'f' 'P'c'p'q'u't'w'w'w't'g'u.'3642.'42280
- 17\_ [ '00'k'ij'tc.'g'v'c'f'0\ pQ'v'g't'c'r'q'f' 'o'c'v'g't'k'c'n'f'q't' 'h'w'p'v'k'q'p'c'n'r'r'k'ec'v'k'p'u'0'c'v'g't'k'c'u'v'q'f'c'f' '43\*8+'8536873.'423: 0'
- 18\_ 'U'0T'c'e'n'e'w'u'w'u.'g'v'c'f'0'C'P'q'x'g'n'0'g'y'q'f' 'h'q't' 'E'q'p'v'k'w'q'w'u'f'p'vj'guku'qh' \ pQ'v'g't'c'r'q'f'u'0'Vj'g' 'L'q'w't'p'c'n'q'h'R'j' { 'u'k'c'n'f' 'E'j'g'o'k'w't' { 'E.' '33; \*4: '+'38588638595.' ' 42370

# UVGI CPQI TCRJ KE'KP VGI TCVKQP'QHEQO O WP KE CVKQP 'UEJ GO GU' KP'O CRU'

Cxwuj nu "Mtkm/Xcnpvlpqxlej . Ucf qx Xcukf "Ugti ggxlej "

F gr ctvo gpv'qh'kp'vgnki gpv'Uf'ungo . Hcewn'f'qh'Tcf'kqr j { uleu'cpf "Eqo r wgt "Vgej pqni lgu . Dgrntwukp "Ucv'g'Wp'kxgtukf . "

Tgr wdike'qh'Dgrntwu"

[te'Ucxwuj nu B duwli](#) "

Ceeqtf'kpi "vq'yj g'WP "F gr ctvo gpv'qh'Geppqo le'cpf "Uqeken'Ch'cku'htq"423: . "wtdep'r qr wv'kqpu'cetquu'Gwtqr g'ctg" i tqy kpi . 'y j kq'twctnr qr wv'kqpu'ctg'hcnpki 0Vj g'r tqdrgo 'qh'wtdep'k' cvkqp'ku' i tqy kpi 0Vqf'c' . 'y j gp'dwrf'kpi . 'b qf'gtpk'kpi " qt'tgugctej kpi "c'rcpf 'r' m'v'k'ku'p'geguuct { "vq'qdv'k'c'xct'k'v' "qh'r' r'pu . 'f'kci tco u . "cpf "f' tcy kpi u0Uqo g'qh'y' g'ug'r' r'pu'ctg" ercu'k'k'f' k'phqto cvkqp . 'uwej "cu'yj g'u'f'ungo 'qh'y' cvgt' u'w' r' n'f' 't'q'w'gu'0Vq' u'ko r' r'k'f' 'y' g'j' cpf' r'kpi "qh'cmf'kci tco u'cpf' 'b' cr' u . " { qw' ecp'ung' cpqi tcr j "y' g' h'ecv'k'p'qh'gpi k'p'ggt'kpi "eqo o w'p'lec'v'k'p'u'f'kci tco u'k'p'v'ect'v'qi tcr j le' b' cvgt'k'cn'0Vj cv'y' k'nt'gf' weg'y' g' co q'wp'v'qh'w'qt'gf' "f'cvc . 'dw'cv'yj g' u'co g'v'ko g'r' t'g'ug'x'g'yj g' u'get'ge { "qh'k'phqto cvkqp'0

Vj g'k'p'k'c'f'eq'p'v'k'p'g'u'htq" go dgf'f'kpi "k'phqto cvkqp"lp'yj ku'y' q'nt'f'ctg' u'cv'gn'k'g'ko ci gu'k'p'yj g'I g'q'V'k'k'f'htqto cv'0Vj g' uej go g'qh'eq'p'f'k'k'p'c'n'gpi k'p'ggt'kpi "eqo o w'p'lec'v'k'p'u'ku'c'ur' g'ek'c'k'f' g'f' "v'qr'qi tcr j le'cpf' "i' g'q'f'g'v'le' r' r'cp'0Y j gp'f' g'uet'k'k'p' " w'k'k'f' "p'gy' q't'm'lp'yj g'v'qr'qi tcr j le'cpf' "i' g'q'f'g'v'le' r' r'cp . "dqj "w'p'f'g'ti t'q'w'p'f' "cpf' "i' t'q'w'p'f' "p'gy' q't'm'ctg'v'c'ng'p'k'p'v'q'ce'eq'w'p'v' " y' g'k' 'd't'k'g'h'ej ct'cv'gt'k'k'eu . 'eq'p'v'q'n'r' q'k'p'u'ct'g' t'go q'x'g'f' 0Vj g'z'r' r'cp'v'qt { 'r' ct'v'eq'p'v'k'p'u'k'phqto cvkqp'cd'q'w'yj g'ug'eq'p'v'q'n'r' q'k'p'u' " cpf' 'cf'f'k'k'p'c'n'k'phqto cvkqp'<eq'q'f'k'p'c'v'g'u'cpf' 'j' g'k'j' v'q'q'h'r' q'k'p'u'q'h'g'ht'g'p'eg'cpf' "c'ri po gp'v'p'gy' q't'm'htq'yj g'ct'g'c'qh'v'c'emu' " eq'q'f'k'p'c'v'g'u'q'h'yj g'w'ct'v'r' q'k'p'v'q'h'v'c'emu'cpf' "gp'f' r' q'k'p'v'q'h'v'c'emu' . 'y' g'v'qr' u'q'h'yj g'k' 'w'p'k'p'i "c'p'i r'gu . "cpf' 'y' g'r'g'p'i yj "qh'w'ct'k'i j' v' u'g'v'k'p'u' "

Eq'p'v'q'n'r' q'k'p'u'k'phqto cvkqp"ku'w'qt'gf' "k'p'c'v'z'v'h'k'g"\*0z'v'cpf' "j' cu'yj g' h'q'm'y kpi "h'qto cv'z'r' q'k'p'v'q't'f'g' "I'p'q't'yj "r'v'k'w'f'g' " eq'q'f'k'p'c'v'g' "I'g'cu'v' r'p'i k'w'f'g'eq'q'f'k'p'c'v'g' "I'f'k'nc'p'eg' "I'q'go "r' t'g'x'k'w'u' r' q'k'p'v' "I'c'k'w'f'g' "I'c'j' k'o w'j' "I'q'go "r' t'g'x'k'w'u' r' q'k'p'v'0Vj g' go dgf'f'kpi "w'gu'k'phqto cvkqp'cd'q'w'h'k'g'eq'p'v'q'n'r' q'k'p'u' . 'y' g'w'ct'v'r' \*U'cpf' "gp'f' "G+r' q'k'p'u'0Gz'co r' g'q'h'k'phqto cvkqp'w'ug'f' <

U"176072399"1490 9; 9; : "12 B: 6 12= G"176072737: 2"1490 : 7: 38"13804"13: : "1: 80: 5=3"176073623"1490 : 4255"1 3; : 0 3"13: 5"169036=4"176074447"1490 : 5853"13590 8"13: 4"169053: =5"17607473: "1490 : 63: 9"16904"13: 4"1730658= 6"176073934"1490 : 72: 8"132604: "13: 8"136702; 8=7"176072737: 9"1490 : 7782"1580 6"13: 9"1337047: "



Hki 0' 30Vj g' qtki k'p'c'n' eq'p'v'k'p'g't' \*qr" r'ghw: " yj g' qtki k'p'c'n'" eq'p'v'k'p'g't' y' k'j' "c'w'w' g't'ko r' q'ug'f' "eqo o w'p'lec'v'k'p'uej go g' \*qr " t'k'i j' v' : 'y' g' h'k'ng'f' "u'gi cp'q'eq'p'v'k'p'g't' \*dq'w'qo +0

Vq'ko r' r'go gp'v'yj g'go dgf'f'kpi "qh'c'v'z'v'h'k'g'k'p'v'q'yj g'eq'p'v'k'p'g't'w'p'f'g't'k'p'x'g'u'ki cvkqp . 'y' g'y' k'w'w'g'c't'g'c'f' { /o cf' g'w'q'h'y' ctg' " u'q'w'k'p'htq' "u'gi cp'qi tcr j { "k'o ci g'Ur { gt' "I 40Vj g'c'w'j' q't'u'ko r' r'go gp'v'k'p'q'h'yj g'NUD'c'n' q't'k'j' o "ku'w'ug'f'htq" go dgf'f'kpi 0' J' k'f'kpi "o gu'ci g'd'ku'q'ee'w'u'lp'yj g'w'c'u'v'k'i p'k'k'ec'p'v'd'ku'q'h'yj g'eq'p'v'k'p'g't' "13\_0Vj ku'go dgf'f'kpi "ku'f'k'h'k'w'w'htq"j' wo cp'x'k'k'p'p' "14\_5\_0'k'p'cf'f'k'k'p'p'v'q'yj g'h'c'v'yj cv'yj g'ko ci g'k'ug'h'ku'f'k'h'k'w'w'v'q'u'w'ur' g'v'k'p'yj g'r' t'g'ug'p'eg'q'h'c'p' { "y' k'f' /r' ct'v'f' "k'phqto cvkqp'k'p' " k'v'yj g'r' t'qi tco "r' t'q'g'w'v'yj g'go dgf'f'g'f' "h'k'g'y' k'j' "q'p'g'q'h'62'w'q'p'i "et { r' v'q'c'n' q't'k'j' o u'0Vj g'w'ug'q'h'et { r' v'q'c'n' q't'k'j' o u'p'q'v'q'n'r' " r' t'q'x'k'f' g'u'c'p'cf'f'k'k'p'c'n'k'p'g'q'h'r' t'q'g'v'k'p' . 'd'w'c'v'q'g'r' t'g'ug'p'v'yj g'go dgf'f'g'f' "k'phqto cvkqp'cu'w'c'v'k'k'ec'n'p'q'k'g' . 'y' j' k'j' "r' t'q'x'k'f' g'u' " r' t'q'g'v'k'p' "ci c'k'p'u'v'c'v'k'k'ec'n'c'w'c'emu'q'p' "y' g'eq'p'v'k'p'g't' "16\_0'

H'k'g'u'y' g't'g'go dgf'f'g'f' "y' k'j' "k'phqto cvkqp'cd'q'w'7'f' h'k'g't'gp'v'eq't'p'g't' r' q'k'p'u'cpf' "322.2220Vq'g'x'c'v'c'v'g'yj g't'g'w'w'u' . 'y' g'w'ug'f' " c'r' k'z'g'n'd { /r' k'z'g'n'eqo r' c't'k'p'p'q'h'eq'p'v'k'p'g'tu' . 'cu'y' g'n'cu'cp'cu'gu'uo gp'v'd' { "y' g'RUP T"et'k'g't'k'p'0P'q'v'g'yj cv'c'x'g't'c'i g'RUP T" x'c'w'g'u'htq" c'i q'q'f' "s'w'k'w'f' "go r' v'f' "eq'p'v'k'p'g't'ct'g'k'p'yj g'57/67'f' D't'c'p'i g'0H'q't'322.222'eq't'p'g't' r' q'k'p'u' . 'y' g't'g'y' g't'g'3496'r' k'z'g'n' f'k'h'g't'g'p'eg'u' . 'cpf' "y' g'RUP T"r'g'x'g'n't'g'c'ej' g'f' "5: "f' D' . 'y' j' k'j' "ku'v'f' r' k'ec'n'htq" c'i q'q'f' "s'w'k'w'f' "go r' v'f' "eq'p'v'k'p'g't' "15\_0'

D'cu'g'f' "q'p' "y' g'f'c'v' "q'v'c'k'p'g'f' . "k'v' ecp' "dg' "eq'p'w'f' g'f' "y' cv'k'k' "cu'f' x'k'uc'd'ng' "v'q' go dgf' "eqo o w'p'lec'v'k'p'uej go gu'k'p'v'q' " ect'v'qi tcr j le' "o cvgt'k'cn'0C'v'yj g' u'co g'v'ko g' . "uo c'm'f' k'w'q't'v'k'p'u'q'h'yj g'q't'k'i k'p'c'n'eq'p'v'k'p'g't'ct'g'ce'j' k'x'g'f' "y' j' k'g'w'q't'k'p'i "g'x'g'p'c' " r'ct'i g' u'co r' g'q'h'eq't'p'g't' r' q'k'p'u'0

13\_ "F'k'i k'c'n'f'ng'i cp'qi tcr j { 0X0 0I t'k'd'w'p'k' . "K'P'0Q'ng'x . "K'X'0'v'w'k'p'v'g'x'0' "O' 0'U'Q'N'Q'P' "R'G'U'U'422; " / "494u0  
15\_ "Eqo r' wgt "v'gej pqni lgu'cpf' "f'c'v'c'p'c'n'f' u'k'z'c'v'gt'k'cn'q'h'yj g' "K'k'p'g't'p'0'ue'k'p'w'k'k' / r'c'v'k'ec'n'Eq'p'f'0' "O' k'p'm' "Cr' t'k'i 45/46 . "4242" "f'g' k'q't'k'c'i'd'q'c't'f' < "X'0'X'0'  
U'nc'w'p' "g'f' k'q't' /p' /ej' k'g'h' "j'c'p'f' "q'y' g't'u'0' "O' k'p'm' "D'U'W' "42420'42: " / "433"  
14\_ " "c'k'ug'x' "X'0'0' "I' w'k' "X'0'0' "f' w'q'x'k'm' "C'0'K' "0' "E'q'ng'v'k'p'q'h'ue'k'p'w'k'k' / r' c't'g'u' "S'k'p'g'n'ki gp'v'ug'p'q't' { "cpf' "b' g'ej' cv'q'p'le' "u'f'ungo u' / "4242\$0' "DP' V'W' "O' k'p'm' / " 42420' "65/660  
16\_ "Ucf'qx' "X'0'U'Eqo r' wgt' "u'gi cp'qi tcr j { < "g'ew'g'p'q'v'g'u' "D'U'W' "42320R04540'



**'KPPQXCVKKG'VGEJ PQNQI KGUHQ'T'VJ G'HQTO CVKQP 'QH'  
O KETQUVTWEVWTGU'K'HWPEVKQPCN'O CVGTICNU'**

Lwucw'Ek cpeu<sup>3</sup>. 'I kfg tkwu'Lcpw-cu<sup>3</sup>"

<sup>3</sup>F gr ctwo gpv'qh'O gej cplecni'Gpi kpggtkpi . 'Heww' 'qh'O gej cplecni'Gpi kpggtkpi "cpf 'F guki p. 'Mwpcu'Wpkxgtuk' 'qh'  
Vgej pqm' { . 'Nkj wpc' "  
Lwucw'Ek cpeuB mw'w"

O letqutwewtgu'ctg'utwewtgu'y j gtg'yj g'bo clp'f ko gpukqp'ku'bo letq/o gygt'uecrg'j3\_0Vj g'hqto cvkqp'qh'bo letqutwewtgu'  
j cu'bo cp { 'vgej plecti'ej cmgpi gu'k'q'q'f gt'v'q'q'dvckp'yj g'j ki j 's wcrk' 'o letqutwewtgu. 'k'ku'pgeguuct { 'v'f ghkg'cpf 'ugrgev'yj g'  
cr r tqr tkv'g' hqto kpi " o gyj qf " cpf " o cvgtknu' O qtqgxg. " k' ku' pgeguuct { " v' f gyvto kpg' cpf " wug' qr vko cil' r tqf wevkqp"  
ej ctcevgtkrku'j4\_0

Vj gtg'ctg'hqw"o clp'r tqf wevkqp"o gyj qf u'r j qvkrkj qi tcr j { . 'uwo r kpi . 'o cvgtkni't go xcn'cpf " f gr qukkqp"j5\_0Vj gug'  
hqw'r tqf wevkqp"o gyj qf u'i tqwr u'ctg'eqo o qpn' "wugf "kp"o letqutwewtgu'hqto cvkqp"tugctej O'k'cf f kkkp"v"jy gug. "qy gt"  
o cpw'cewtkpi "o gyj qf u'wej "cu'5F 'r tkp'kpi "qt'y g'v'wco r kpi "ucpf "q'w'd' { 'y gk' kppqxcvkg'hqto cvkpi "o gyj qf u'j6\_0"

O cvgtkni'cnuq'chge'v'yj g's wcrk' 'qh'bo letqutwewtgu'0Vj gtg'ctg'hqw"i tqwr u'qh'bo cvgtkni'y kf gn' "wugf "cpf "uwf kfg "kp"  
tugctej <ukleqp. 'r qn' o gtu. 'o gvcu. 'cpf 'i nuu'j7\_0Vj gtg'ctg'cnuq'xctkqwu'bo gvcniqz'kf gu'qt'ectdkf gu. 'dw'v'yj g' 'ctg'tctgn' "wugf "  
kp" yj g' r tqf wevkqp" qh' o letqutwewtgu'0'Ukrleqp"ku' yj g' o quv' eqo o qpn' "wugf " o cvgtkni' v'q" o cmg" o letqutwewtgu'0'K'j cu"  
ugo keqpf wevqt' r tqf gt'v'gu'cpf "i qqf "o gej cplecni'r tqf gt'v'gu. "y j lej "cmqy u'yj gug"o cvgtkni'v'q"dg" wugf "kp" f gxkgu'uwej "cu"  
o letqr wo r u. 'r tguuw'g'ugpuqtu'qt'ceegrtqo gyvto'j8\_0Rqn' o gtu'ctg'f kgrgevt'leu'y kj "y g' hgcuv'bo gej cplecni'utgpi yj "cpf "hgy "  
o gnkpi 'r qkp'0F v'g'v'q'q'pi qkpi 'tugctej . 'y g'ku'v'qh'xctkqwu'r qn' o gtle'bo cvgtkni'wugf "kp"o letqu'ungo u'ku'eqpuv'p'v'w' f cvgf "  
j9\_0O gvcu'j cxg'i qqf "o gej cplecni'r tqf gt'v'gu. "grgevt'leu'eqpf wev'k'k'f. "cpf "j ki j "o gnkpi 'r qkp'0Vj g' 'ctg"o quv'eqo o qpn' "  
wugf "hqt"o letqu'ungo "eqp'cev'hqto cvkqp"j: \_0I nuu'ucpf u'q'w'hqto "qy gt"o cvgtkni'f v'g"v'q"ku'r ct'v'w'ctn' "i qqf "qr v'ecni'  
r tqf gt'v'gu'0I nuu'ku'cnuq'ej ctcevgtk'gf 'd' { "j ki j "yj gto cil'cpf "o gej cplecni't guk'ncpeg"j; \_0

J qy gxgt. "y g'ej qleg"qh'yj g'tki j v'o cvgtkni'cpf "r tqf wevkqp" o gyj qf "f qgu'p'qv'i wctcpvgg'yj g'f gukt'gf "s wcrk' 'qh'yj g"  
o letqutwewtgu'0E'g'v'clp'r j gpqo gpc'f v'kpi "y g'r tqf wevkqp'qh'bo letqutwewtgu'ctg'xgt { "eqo r ngz"cpf "pggf "v'dg'eqp'v'qngf "  
cpf "kpxguki cvgf 0'Vj gt'ghqg. "k'ku'pgeguuct { "v' f gxgnr "c" pgy "cf cr v'kg" v'gej pqm' { "y cv'cmqy "y g'ceewt'cv'g. "huv'cpf "  
kpgzr gpukxg'hqto cvkqp'qh'bo letqutwewtgu'kp'xctkqwu'hwpevkqpcni'bo cvgtkni'0

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j3\_Y 0P cy tqv'M00 cnej c. 'Cf f kkg'bo cpw'cewtkpi 't'gxqmwkqp'kp'egtc'le'bo letqu'ungo u. 'O letqgrgevt'p'leu'k'p'v'gt'p'v'k'p'cni'59. '9; /: 7\*4242-0'  
j4\_Q0U' c'j p. 'O 0Uggj co dcn 'O QGO U'0'letq/Qrvq/Grgevt'q/O gej cplecni'U'ungo u' \*KUDP <; 9: 2: 3; 672432. '4227-0'  
j5\_I 0E0Mko . 'L0J 0M'cpi . 'O letqhwk'le'dlqo gej cplecni'f gxleg'hq'eqo r tguukxg'egm'lnko w'v'kqp'cpf "h'uku. 'U'g'puqtu'cpf 'C'ewcvqtu'D'<Ej go lecni'34: . '32: /  
338\*4229-0'  
j6\_X0C0Eco ctgpc/Ej 'xgl . 'T0Ecutq/D'gmt' p. 'Q00 00 gf kpc/E' | ctgu 'k' r ngo gpv'kqp'cpf "cu'guuo gpv'qh'c'ny /equ'5F 'r'ugt' r'nv'qto "eqp'v'qngf "d' "  
qr gp'v'q'hy ctg'hq' r' tkp'kpi 'r qn' o gtle'bo letq/utwewtgu. 'Lqwt'p'cni'q'hi'0 letqo gej cpleu'cpf 'O letqgpi kpggtkpi . '52. '5\*4242-0'  
j7\_N00 qw'Z0L'cpi . 'O cvgtkni'ht'0 letqhwk'le'k' o v'p'q'cu' { u'<'C' T'gxly . 'Cf x'c'pegf "J genj ectg'0 cvgtkni'8. '4: 544739\*4239-0'  
j8\_L0I 0L'wpi . 'M'0Ngg. 'G'ht'gev'qh'ht'cr kf "y gto cil'c'pp'g'c'kpi "qp'd'v'm'ilo letq/f ghgevu'cpf "r nuwle'f ghqto cvkqp'kp'ukleqp'f v'kpi "j ki j "vgo r gtcw'g'r tqegukpi . "  
O cvgtkni'U'ek'peg'kp'U'go keqpf wevqt' Rtqegu'kpi " : 7. : 5. : "423: -0'  
j9\_R00 2'f. 'L0I idqj . 'O letq' kpl'gev'kqp"o qf kpi "qh'yj gto qr nuwle' r qn' o gtu'<Rtqr qucni'q'hi'c'eqp'uk'w'k'g'rcy "cu'hwpevkqp'qh'yj g'cur'gev't'cv'ku. 'Lqwt'p'cni'q'hi'  
Cr r r'kgf "Rqn' o gt'U'ek'peg'357. '6\*4239-0'  
j: \_J 0M'cti ct/Rkj d'k'ctk'U'0L0J quag'k'p'q'w. 'C' p'q'x'gn' o gyj qf "hqt"o cpw'cewtkpi "o letq'ej c'pp'gn'qh'bo gvcni'le'dk' q'rt' r'v'g'hw'gr'egm'd' { "y g'j qv'bo gvcni' cu"  
h'qto kpi 'r tqeguu. 'Lqwt'p'cni'q'hi'0 cpw'cewtkpi 'Rtqegu'gu'77. '48: /497\*4242-0'  
j: \_P 0X'cp'V'qcp. 'O 0V'q'f c. 'k'pxguki cvkqp'qh'rt'qegu'gu'ht'1 nuu'0 letqo cej k'kpi . 'O letqo cej k'p'gu'9. '73\*4238-0'

**KO RTQXGO GP V'QHNCO G'TGVCTF CPE[ 'CPF 'GXCNCVKQP 'QH'  
RJ [ UKCN'RTQRGT VKGU'QHLWGW'HCDTKE 'WUKPI 'EQO DLP GF 'EJ GO KECN''**

O qj clo kpwriS wc{ wo <sup>3</sup>. 'O f 0Tgc| wf f lp'T gr qp<sup>3,4</sup>"

<sup>3</sup>F gr ctwo gpv'qh'Rtqf wewqp'Gpi kpggtkpi . 'Hewm{ "qh'O gej cplecni'Gpi kpggtkpi 'cpf 'F guki p.'Mcwpcu'Wpkxgtuk{ "qh'Vej pqrqi { ." Uwf gpw78.'NV/73646.'Mcwpcu.'Nkj wcpk"

<sup>4</sup>\ T'Tgugctej 'Kpukwag'hqt'Cf xcpegf "O cvgtkcu.'Uj gtr wt/4322.'Dcpi rcf guj " , Go ckn<sup>o</sup> qj clo kpwriS wc{ wo B mw@f w'

F gxnqr o gpv'qh'r tqvevkg'emqj 'r ctvewctn{ 'hco g/tgvctf cpv'cr r ctgn'ku'c'dki "ej emgpi g'hqt'vzvkq'lpf wutkgu'pqy cf c{ u" ]3\_0Wwcm{ . 'kpi gtgpv'hco g/tgvctf cpv'ku'o qtg'zr gpukg.'uq'o cni'pi "pcwtcn'hkdt'cu'c'hco g/tgvctf cpv'o cvgtkcn'ku'ej gcr "cpf " geqhtkpf n{ "cngt'pcvkgu'0Lwg'ku'c'pcwtcn'hkdt'cu'y gni'cu'dkqf gi tcf cdrg'o cvgtkcn'j cu'cngp'o qtg'cvgpkqp"vq'f gxnqr "hco g/ tgvctf cpv'emqj kpi "j4.5\_0Ej go kuqtr vkp'qh'eqo dlpgf "hco g'tgvctf cpv'kpenw'kpi "dqtcz'cpf "F CR."dqtcz'cpf "Vj kq/wtgc.'F CR" cpf "Vj kq/wtgc'y kj "f hktgpv'eqpegpvcvku'pu'y gtg'eqpf wewgf "qp'wv'gcvgf'cpf "j { f tqi gp'r gtqz'kf g'v'gcvgf "vdd{ "y gcv'g'lw'g' hcdtke"lp'r cff kpi /"ft{ "ewt'g'o gy qf "lp'y ku'uwf { 0Vj g'hco o cdkk{ . 'y gli j v'i clp"\* + "dtgcnkpi "mqf'r gtegpvcu'gu'cpf "y cuj " f wcdkklv{ "qh'y'g'v'gcvgf "ur geko gpu'y gtg'lp'xguk'cvgf "cpf "eqo r ctgf "y'g'qweqo gu'v'q'qr v'o k'g'y'g'ej go kcn'eqpegpvcvku'p' Vj ku'uwf { "gzj kdku'j ki j g'to r tqxgo gpv'qh'hco g/tgvctf cpe{ 'y kj "y'g'kpetgcug'qh'ej go kcn'eqpegpvcvku'p' hqt'dqv "wv'gcvgf " cpf "j { f tqi gp'r gtqz'kf g'v'gcvgf "lw'g'hcdtke'0Y gli j v'i clp'r gtegpvcu'g'ku'kpetgcug' hqt'dqv "y'g'ur geko gp'dw'gur gekm{ "dqtcz " cpf "Vj kq/wtgc'eqo dlpgf "ej go kcn'uj qy u'y'g'j ki j g'tguw'0K'ep'pvcu.'dtgcnkpi "mqf'r gtegpvcu'g'ku'f getgcug' hqt"j { f tqi gp' r gtqz'kf g'v'gcvgf "lw'g'hcdtke'y kj "y'g'eqo r ctuqp'qh'wv'gcvgf "lw'g'hcdtke'0T guw'u'tg'xgeng' "y'cv'dqtcz'cpf "F CR'eqo dlp'cvkqp" ej go kcn'y kj "8" "eqpegpvcvku'p'uj qy u'y'g'dgwgt'y cuj "f wcdkklv{ "hqt"j { f tqi gp'r gtqz'kf g'v'gcvgf "lw'g'hcdtke'y qwi j "y cuj " f wcdkklv{ "f getgcug' hqt'cni'eqo dlp'cvkqp'0O qtg'xgt."dqtcz'cpf "f lco o qpkwo "r j qur j cvg'\*F CR+uj qy gf "y'g'dgwgt'r gthqto cpeg" hqt'cni'zr g'klo gp'0Cm'lico r ngu'f gxnqr gf "lp'y ku'uwf { "ecp'dg'wug' hqt'hco g/tgvctf cpv'o cvgtkcn'0



Hk (B0Lwg'c+r rcpv.'d+hkdtg.'e+){ ctp'cpf 'f'+hcdtke"

"  
"

[3\_0T'J qttqemu'cpf 'UE'Cpcpf. "J cpf dqmqh'Vej plect'Vgzvkgu."\*Y qqf j gcf 'Rwdkuj kpi 'Nf. 'Eco dtkf i g.'WM.'4222-0'  
j4\_'Rer cur { tkf gu.'E0F 0'Rexrkf qw.'U'X' "Xqwf'kqwe.'UOP 0F gxnqr o gpv'qh'cf xcpegf "vzvkq'o cvgtkcu'P cwtcn'hkdtg'eqo r quksu'cp'w'o letqdken'cpf 'hco g/ tgvctf cpv'hcdtke'0Rtqeggf kpi u'qh'y g'k'pukwv'kp'qh'O gej cplecni'Gpi kpggtu.'Ret'N'Q'wtpen'qh'O cvgtkcu'F guki p'cpf "Cr r necv'kpu.'445\*4+.; 36324\*422; -0'  
j5\_'CMM'Uco cpcv.'MODj cwcej ct{c.'Uko wncpgqu'f { gkpi 'cpf "h'g/tgvctf cpv'hkpi kpi "qh'lw'g'hcdtke'wukpi "cp'ckf "f { g'cpf "ugvev'g'H/T'hkpi kpi "ej go kcn'0' Vgzvkgu'Nki j v'lpf wa.'Uek'0V'gej pqr'63723.'4526/; 643\*4237-0'

**ƆP XGU VƆ CVKQP 'QH P c<sub>6</sub>Hg<sub>5</sub>\*RQ<sub>6+4</sub>\*R<sub>4</sub>Q<sub>9+</sub>+ 'CU'ECVJ QF G'HQT 'CS WGQWU' P c/KQP 'DCVVGTKGU'**

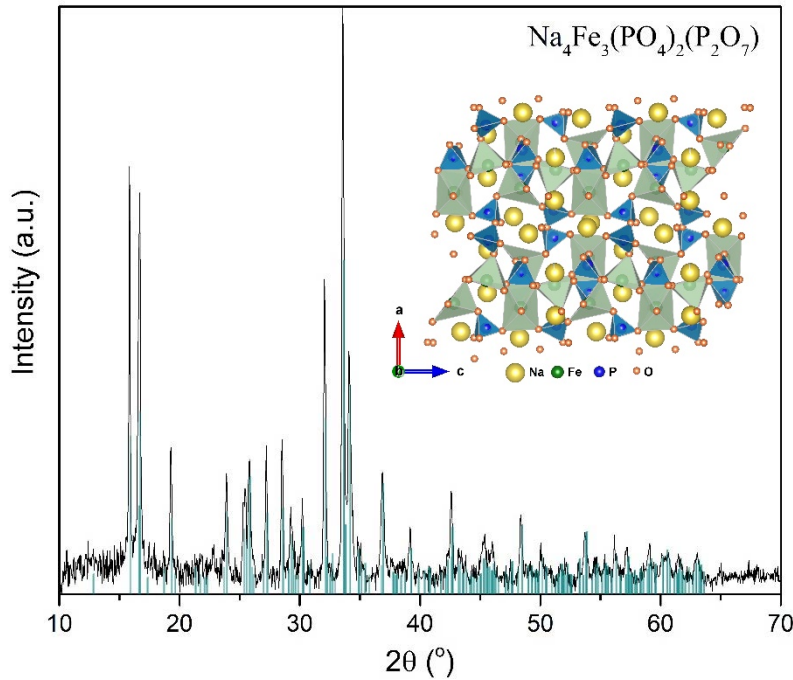
I kpvt 'Rng nck/v<sup>3</sup>. 'Lwti ku'Rkkr cxx kw<sup>3</sup>. 'Lwti c'Lwqf mē | { v<sup>3</sup>. 'Nkpcu'Xkn kwunū<sup>3</sup>"

<sup>3</sup>Egpyt 'hqt'Rj { ulecl'Uelgpegu'cpf 'Vgej pqrj { \*HVO E+ 'Ucwn vnkq'cī05. 'NV/32479'Xkpkw. 'Nkj wpcle' i kpvtgŃ ngenck/vgB hwo e0y"

"

Cs wqwu'P c/kqp'dcwtgku'j cxx'tgegkxgf 'r ctvewct'cwgpvkp'qh'tgugctej gt'u'cu'qpg'qh'yj g'o clp'cngtpevkgu'q'Nk/kqp' dcwtgku'hqt'uwwclpcdr'g'i tkf/uecng'gpgti { 'uqtci g'0Vj g'wug'qh'cs wqwu'grgevtqn'v'g'kpuv'gf'qh'qti cpeu'gpuwt'gu'yj g'uchgv'." nqy 'r'tleg'cpf'gp'xktqpo gpvcl'lkpf'rkpgu'qh'uwej 'u'usgo u'0Gzr'ntcvkqp'cpf 'f'gxgr o'gpv'qh'uwkcdng'r'qukkxg'cpf'pgi'cvkxg' grgevtqf'g'o'cvgtkcn'ctg'etk'k'ecm'f'ko'r'qt'wv'v'ht'j'ki'j'r'gthqto'cpeg'qh'P c/kqp'dcwtgku'0C'i'tgc'v'xct'k'v'f'qh'r'qn'cpkqple'qt' o'kzgf/r'qn'cplqp'eqo'r'qwpf'u'j'c'xg'dggp'kpxgwki'cvf'cu'ecy'qf'gu'ht'uwej'dcwtgku'0J'qy'gxg't'cm'quv'cm'qh'yj'go'u'wknl'ce'g' f'khtg'gpv'ej'cngpi'gu'uwej'cu'r'qqt'ucd'k'k'f'."nqy'gpgti { 'f'gpuk'f'qt'xqnci'g'j'3\_0Co'qpi'f'khtg'gpv'Hg/dcugf'r'j'q'r'j'cvu' \*P c<sub>4</sub>Hg<sub>4</sub>Q<sub>9</sub>. 'P c<sub>5</sub>Hg<sub>4</sub>\*RQ<sub>6+5</sub>'cpf'gve'0: 'y'g'b'kzgf/r'qn'cplqple'P c<sub>6</sub>Hg<sub>5</sub>\*RQ<sub>6+4</sub>\*R<sub>4</sub>Q<sub>9+</sub>'tgr'tgugpw'c'bo'qt'g'cvt'cevkxg'qr'v'kqp'ukpeg' kv'r'quugu'gu'y'g'j'ki'j'gu'f'k'uej'cti'g'xqnci'g'\*5B'X'xu'P c'IP c+'f'cxqtdcng'y'g'at'g'v'ec'ecr'cek'f'\*34; o'Cj' i<sup>3+</sup>'cpf'uwkcdng' 5F'ut'wewt'g'y'kj'nqy'xqnxo'g'ej'cpi'g'f'wkpi'uf'k'wo'k'pugt'v'kqp'14.'5\_0'

Ɔp'j'ku'y'qtm'y'g'r'tgr'ctgf'r'wtg'r'j'cug'P c<sub>6</sub>Hg<sub>5</sub>\*RQ<sub>6+4</sub>\*R<sub>4</sub>Q<sub>9+</sub>'xlc'uqnf/ucv'g'cpf'uqri'gn'u'f'pvj'guku'o'gy'qf'u'wukpi' f'khtg'gpv'Hg/dcugf'r'tgewt'qtu'Hg'EJ<sub>3</sub>EQQ<sub>4</sub>. 'HgE<sub>4</sub>Q<sub>6</sub>4J<sub>4</sub>Q'cpf'E<sub>6</sub>J<sub>4</sub>HgQ<sub>6</sub>0Vj'g'ut'wewt'g'cpf'bo'qtr'j'qni { 'qh'r'tgr'ctgf' o'cvgtkcn'y'gt'ej'ctcevt'k'gf'd'f'Z/tc { 'f'kht'cevkqp'\*Hk'03+'uecp'lp'i'grgevt'q'bo'let'que'r { 'cpf'y'gto'qi'tcxlo'gt'le'c'pcn'uku'0 Vj'g'grgevt'q'ej'go'lecl'r'tqr'gt'v'ku'qh'r'tgr'ctgf'grgevt'q'f'gu'y'gt'g'kpxgwki'cvf'd { 'e'erle'xqnci'o'gt'f'."ej'cti'gf'k'uej'cti'g' i'c'x'c'p'q'v'c'k'e'f'er'k'p'i'cpf'ko'r'gf'c'peg'ur'gest'que'r {0'



Hk' 030Z/tc { 'f'kht'cevkqp'r'cwgt'p'qh'P c<sub>6</sub>Hg<sub>5</sub>\*RQ<sub>6+4</sub>\*R<sub>4</sub>Q<sub>9+</sub>'u'f'pvj'guk'gf'xlc'uqri'gn'o'gy'qf'0'

"

**Cempqy ngf i go gpw<'"**

Vj'ku'r'tqlgev'j'cu'tgegkxgf'hw'pf'k'p'i'ht'qo'y'g'Gwt'qr'gcp'T'gi'kqpcn'F'gxgr' o'gpv'Hw'pf' \*Rt'qlgev'P q0230404/NO V/M93: /24/ 2227+'w'pf'gt'i'tcpv'ci'tggo'gpv'y'kj'y'g'T'gugctej'E'q'w'pek'qh'N'kj'w'pcle' \*NO VNV'0'

"

[3\_1\_0]Hpi'.\ 0Ej'gp.'NOZ'k'c'q'g'v'c'f'0'T'ge'gpv'R'q'i't'g'u'lp'K'q'p'D'c'ug'f'G'g'ew'q'f'g'O'cvgt'k'cn'f'ht'I't'k'f/U'ec'ng'U'q'f'k'wo/K'q'p'D'c'w'g't'k'g'u.'U'o'c'm'36'423: '+' [4\_0\_0]Ej'gp.'Y'0J'w'c.'10Z'k'c'q'g'v'c'f'0'P'CU'EQ'P/v'f'g'c'k't'ue'd'ng'c'p'f'c'm'er'ko'c'v'g'ec'y'q'f'g'ht'uf'k'wo/k'q'p'd'c'w'g't'k'g'u'y'k'j'nqy'eq'v'c'p'f'j'ki'j'r'qy'gt'f'gpuk'f'." P'c'w'g'eq'o'o'w'p'le'c'v'k'q'u.'32.'36: 2'423; +0' [5\_0\_0]Y'cpi.'U'0T'q'f'.'S'0U'j'k'g'v'c'f'0'R'q'i't'g'u'lp'c'p'f'c'r'r'f'k'c'v'k'p'r't'q'r'g'ew'q'f'c'f'x'c'p'eg'f'c'p'f'eq'w'g'f'g'v'x'g'k'q'p' \*H'g'/d'c'ug'f'ec'y'q'f'g'o'cvgt'k'cn'f'ht'uf'k'wo/k'q'p'd'c'w'g't'k'g'u.'I'q'w'p'c'n'q'h'0'cvgt'k'cn'E'j'go'k'w' { 'C.'; .3; 5: /3; 8; \*4243+0'

**U P VJ GU U'CPF 'RTQRGT VKGU'QH'O G VJ QZ[ RJ GP[ N'QT''  
O G VJ [ NVJ KQRJ GP[ N'UWDUVK\WGF 'ECTDC\ QNG'F GTKCVGU'CU''  
J QNG/VTCPURQTVKPI 'O CVGTKNU''**

**Gf wctf cu'Rg kwku.'L tcv "Uko qmckkcp . 'Lxq| cu'Xkf cu'I tcfhwgkxk kwu''**

F gr ctwo gpv'qh'Rqn(o gt'Ej go kwt { 'cpf "Vgej pqm| { . 'Mwpcu'Wpkxgtuk| 'qh'Vgej pqm| { . 'Mwpcu.'Nkj wep|c"  
gf wctf cu'f gekwkuB mw0w''

Gpato qwu'ghhqt'v'y qtrf y kf g'ku'dgkpi 'r wlpwq'bo cnkpi 'qti cple'ugo leqpf wevqtu.'y j lej 'eqwf'dg'f kulkpi wkuj gf 'y kj 'y g'  
o qu'cf xcpnci gqwu'ej cti g/vtcur qt'v'ucdkrk| "cpf" r tqeguucdkrk| "r tqr gt vgu'0'k'p'v'j g'u{pyj guku'qh'qti cple"j qng/vtcur qt'v'pi "  
o cvgtknu''J VO u+'v'zle'kpqti cple'eqo r qwpf u'wej 'cu'i cnkwo . 'ecf o kwo 'ctg'pqv'wugf 0'k'p'cf f kxqp.'qti cple"J VO u'ecp'dg"  
o qtg'equv'ghhlepvlp'eqo r ctuqap'y kj 'y gk'kpqti cple'eqwv'gtr ctu'0'Vj gtghqtg.'k'ku'ko r qt'v'v'v'q'eqv'v'w'v'g'y g'f g'x'g'nr o gp'v'  
qh'J VO u'v'q'kpetgcug'y'g'q'x'g'c'n'r'g'h'qto cpeg'qh'f g'x'legu'qh'qti cple'qr v'q'ng'ev'q'pleu'cpf'eqv'v'k'd'w'g'v'q'y'g'f g'x'g'nr o gp'v'qh'  
t'g'p'gy c'd'rg'r'q'y'g't'v'q'w'g'eu'0'

Tgegpw|.'o cp { "t'gug'ctej'gtu'ctg"l'p'x'q'rk'gf "k'p'v'j'g'u{pyj guku'cpf"u'w'f'k'gu'qh'qti cple"J VO u'ht' r'gt'q'x'unk'g'u'q'nc't'eg'mu'  
\*RUE+0'V'j'g't'g's'w'k'go'gp'u't'c'k'ug'f"l'q't'qti cple"J VO u'k'p'v'p'f'gf"l'q't"RUE"ctg-<j'k'j'j'q'ng'f't'k'h'o'q'd'k'k'k'g'u."n'y "k'p'k'c'v'k'p'  
r'q'v'p'v'k'nu."i'nu'u'ht'o'k'pi "r'q'r'gt'v'gu."o'q't'r'j'q'm'i'k'ec'n'l'uc'd'k'rk'| "qh'o'q'ng'ew'r't"i'nu'ugu."i'q'q'f"u'q'w'd'k'rk'| "k'p'q'ti cple"u'q'rk'gp'u."  
i'q'q'f"r't'q'egu'c'd'k'rk'| "cpf"t'g'r't'q'f'w'ek'd'k'rk'| "qh'v'j'g'ej'ct'ce'v'g't'k'v'k'eu'0'J VO u'k'p'RUE"ku'et'w'ek'n'l'q't"j'k'j'q'r'gp'ek't'ew'k'x'q'nc'i'g'cpf"  
j'k'j'q'y'g't'eq'p'x'g't'uk'q'p'ghh'k'g'p'e{0''

G'ng'ev't'q'p'l'ej'j'g'v'g't'q'e{e'rk'e'u{u'go' u'wej'cu'ectdc| q'ng'u'ct'g'y'k'f'g'n'f'w'k'k'k'gf'k'p'v'j'g'u{pyj guku'qh'J VO u'j'3\_0'k'p'v'j'k'u'y'q't'm"  
v'q'f'g'et'g'c'ug'k'p'k'c'v'k'p'r'q'v'p'v'k'nc'ng'ev't'q'p/f'q'p'c'v'k'pi "r/f'k'o'g'y'q'z{f'k'r'j'g'p{r'o'k'p'g'c'p'f"r/f'k'o'g'y'j'k'f'k'j'g'p{r'o'k'p'g'i't'q'w'u'  
ct'g'k'p'q'f'w'eg'f"l'p'v'q'v'j'g'o'q'ng'ew'r't'ut'w'ew't'gu'qh'J VO u'0'E'ct'dc| q'ng'f'g't'k'c'v'k'g'u'y'g't'g'ej'q'ug'p'ht'v'j'g'u{pyj guku'f'w'g'v'q'v'j'g'k't"  
g'z'eg'ng'p'v't'j'j'k'ec'n'l'c'p'f'ej'go'k'ec'n'l'r'q'r'gt'v'gu.'u'we'j'cu'j'k'j'v'uc'd'k'rk'|.f'k'g'g't'ug'r'q'u'k'd'k'k'k'g'u'qh'h'w'p'v'k'p'c'rk'c'v'k'p'c'p'f'c'r'r'q'r't'k'c'v'g'  
r'j'q'v'q'q'nc'le"ej'ct'ce'v'g't'k'v'k'eu'0'V'j'g'eq'o'r'q'w'p'f'u'y'g't'g'u{pyj guk'gf"u'w'k'p'i "f'k'h'g't'g'p'v'u{pyj guku"o'g'y'q'f'u."r't'k'o'c't'k'k'"W'm'o'c'p"  
eq'w'r'k'pi "cpf'D'we'j'y'c'f'f'J'c't'y'k'i'bo'g'y'q'f'u'0''

K'p'v'j'k'u'r't'g'ug'p'v'k'q'p'r'j'j'k'ec'n'l'v'j'g't'o'c'n"q'r'v'k'ec'n'l'c'p'f"ng'ev't'q'ej'go'k'ec'n'l'r'q'r'gt'v'gu'qh'v'j'g'u{pyj guk'gf'f'g't'k'c'v'g'u'y'k'm'd'g"  
r't'g'ug'p'v'g'f'0'V'j'g'r'q'r'gt'v'gu'qh'o'g'y'q'z{r'j'g'p{r'q't'bo'g'y'j'k'f'k'r'j'g'p{r'nu'w'k'k'w'w'g'f'ectdc| q'ng'f'g't'k'c'v'k'g'u'y'k'm'd'g'eq'o'r'c't'g'f'0'

V'j'k'u'r't'q'l'g'ev'j'cu't'g'eg'k'x'g'f'h'w'p'f'k'pi'ht'q'o'v'j'g'T'gug'ctej'E'q'w'p'ek'i'q'h'N'kj'w'ep'lc''NO VNV+.ci'g'g'o'gp'v'P'q'U/O'R/42/640'  
"

l3\_N0I'c'q.'V0J'0'U'ej'ng'o'g't.'H0\j'c'p'i.'Z'0'E'j'g'p.'E'0'Z'k'q.'M0\j'w.'C'0'U'g'n'p'i'g't'0'E'c't'd'c|q'ng'D'c'ug'f"J'q'ng'V'ic'p'ur'q't'v'0'c'v'g't'k'ec'n'l'q't"J'k'j'j'G'h'h'k'g'p'e{c'p'f"  
U'c'd'rg'R'g't'q'x'unk'g'U'q'r't'E'g'm'0'CEU'Cr'r'f'0'G'p'g't'i'{'O'c'v'g't'05'7+'66; 4/66; : '74242+'

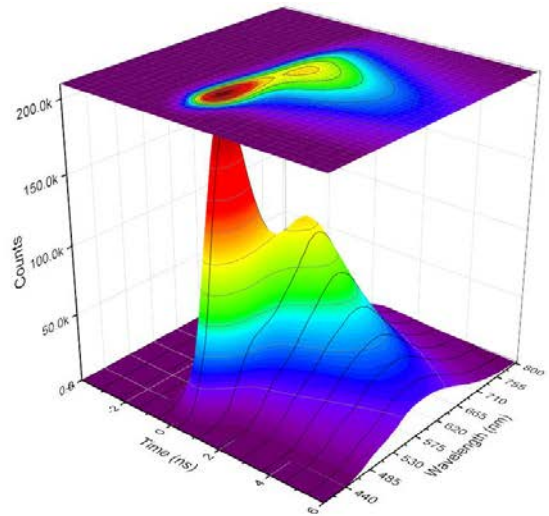
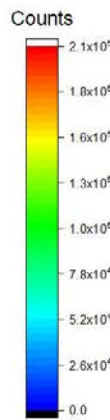
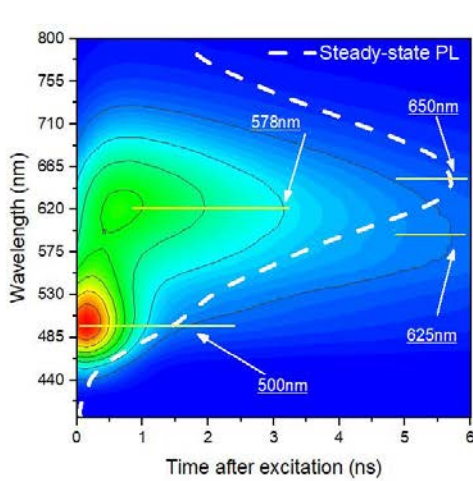
VCF HDGJ CXKQWT'QHECTDC\ QNG'CPF 'RJ GPQVJ KC\ KP'G'  
 UWDUVK\WGF 'R\ TKF KP GU'VQY CTF U'QNGF 'CRNKE CVKQP U'  
 Mctqrku\Ngkqpcu<sup>3</sup>. 'F o { vq'Xqn\ pkm<sup>3</sup>. 'Xkmqtkc' Cpf twgxlekgp<sup>3</sup>. 'Rcxgn' Ctugp { cp. <sup>4</sup>'Dtki kc'  
 Xki cpvg. <sup>4</sup>'Lxq\ cu'Xkf cu'I tc\ wgxlekw<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'Rqn\ o gt 'Ej go kut { 'cpf 'Vgej pqm\ { . 'Mwpcu' Wpkxgtuk\ 'qh'Vgej pqm\ { . 'M0Dctucwun\ 'i 07; . 'NV/'73645.'  
 Mcwpcu. 'Nkj wcpk'

<sup>4</sup>Ncxkcp 'Kpukwng'qh'Qti cplc 'U { pyj guku. 'Ck\ mtcwng'43. 'NX/3228. 'Tki c. 'Ncxk0'  
mctqrku0gkqpcuB mwQf w'

Qti cplc "eqo r qwpf u" g'zj kdkkpi "v'j gto cm\ 'cevxvcvg' f gr\ cf 'Hwqtguegpeg" \*VCF H"lp" tgegpv\ { gctu'j cxg'cwtcevgf "  
 uli pklcepv'kpvtgu'lp" v'j g' hkgf "qh'qti cplc" qr vqgrgestqpleu'0]3\_ "Qti cplc" rki j v'go kvkpi "f kqf gu" \*QNGF u" ecp" t'gcej "322" "  
 kpvtgpcn's wcpwo "ghlekgpe { \*KS G" v'j gp "VCF H" eqo r qwpf u" ctg" wugf "cu" go kvgtu" f w'g" v'j j ctgxukpi "qh'v'kr ngv'gzekqpu"  
 v'j tqwi j " v'j g' t'gxtug" kpvtu\ uvgu " etqukpi " \*TRKE +0' Upege" v'j g' hku' r wdrcekvqp" qp" cr r rkecvkp" qh' VCF H" o cvgtkcn" lp"  
 QNGF u" o wnr ng/ f qpqt" cr r tqcej "ku" y kf gn\ "wugf" lp" v'j g' f guki p" qh' ghlekgpv' VCF H" go kvgtu'0]4\_ "J ki j "gzvgtgpcn's wcpwo "  
 ghlekgpe { \*GS Gu+qh' VCF H' dcugf "QNGF u" ku' f kgevn\ ' t'grvcf "vq" go kuukxg' v'kr ngv' j ctgxukpi "xk" V<sub>3</sub> U<sub>3</sub> TRKE" r tqegu'lp"  
 r wtgn\ "qti cplc" eqo r qwpf u" y kj "uo cm\ ukpi ngv'v'kr ngv' gpgti { "ur rkvkpi " \* Guv" cpf "j ki j "r j qvqno kpguegpeg" s wcpwo "  
 { kgrf u" \*RNS [ u" lp" v'j g' uqrf "ucv'0]5\_ Uqo g' b' wnr ng/ f qpqt/ ceegr vt "VCF H" go kvgtu' y kj "uo cm\ Guv" cpf "j ki j "RNS [ u" lp"  
 v'j g' uqrf /ucv' y gt' r t'gxlqun\ ' f g' xgnr gf "cpf" u'j qy gf "ghlekgpv' cpf" t'grv'xgn\ ' u'cdng' g' rgestqno kpguegpeg'0]6\_ "

J gtg' y g' t'gr qt'v'qp" c' r ckt' qh' o wnr ng' f qpqt' u'wdukwgf "f le { cpqr { tkf kpgu' y kj "v'j tgg' f qpqtu' qh' qp'g/ v' r g" \*ectdc\ qrg"  
 qt' qh' v' q' v' r gu" \*ectdc\ qrg" cpf "r j gpqy k\ kpg+lp" v'j gk' o qrgewr' utwewt gu'0]7\_ "Vj g' eqo r qwpf u" y gtg' ej ctcevt k\ gf "d { "  
 ghlekgpv' eqpxgpv' kpcn' i tggp" cpf "f wcn' qtcpi g' VCF H" y j lej "t'guwmu' h' qo" t'geqo d' kpcv' qp" qh' qp'g" qt" y q' k' p' t'co qrgewr' "  
 ej cti g' wcpuhg' u'cv'gu. t'gur gev'xgn\ '0' QNGF u' dcugf "qp" v'j g' r j gpqy k\ kpg' cpf "ectdc\ qrg" eqp'v' kpi "go kvgt' g'zj kdkkpi "f wcn'  
 VCF H" \*Hki 0'3+ "uj qy gf "m' y "f g' xleg' r'kg/ v'ko gu' cpf "m' y" o czlo wo "gzvgtgpcn' ghlekgpe { "qh' 50" \*hqt" v'j g' pqp/ f q' r gf "f g' xleg"  
 cpf "qh' 7" " \*hqt" v'j g' f q' r gf "f g' xleg+0' QNGF u' dcugf "qp" v'j g' ectdc\ qn\ i' o wnr ng' u'wdukwgf "f le { cpqr { tkf kpg' g'zj kdkkpi "  
 pqto cni' VCF H' u'j qy gf "t'grv'xgn\ " j ki j "f g' xleg' r'kg/ v'ko gu' cpf "j ki j "o czlo wo "gzvgtgpcn' ghlekgpe { "qh' : 0" \*hqt" pqp/ f q' r gf "  
 f g' xleg" cpf "qh' 47" " \*hqt" f q' r gf "qpg+0' Uwe j "f g' xleg' u'cdkx\ " cpf "ghlekgpe { "ghgeu" ctg" r ctv\ "t'grvcf "vq" wmt/ m' ppi "  
 go kuukp' f gec' { \*w' vq' o k' n'ugeqpf u+ y j lej "ecp" gpj cpeg' r tqdcdkx\ "qh' g'zekap/ g'zekap" cpf "g'zekap/ r q' r' t' q' p' p' k' k' v' k' p' u'  
 wpf gt' g' rgest' kcn' g'zekv' k' p' 0'



Hki 030Uvcf { /ucv'g' f cuj gf "y j kg' h'kp+ cpf" v'ko g' t'guukxgf "t'geqtf gf "lp" 2/7" pu' t'cpi g' chgt' g'zekv' k' p' go kuukp"  
 ur gev'c' qh' ectdc\ qrg" cpf "r j gpqy k\ kpg" f qpqtu' eqp'v' kpi "f le { cpqr { tkf kpg' Eqp'v' w' r m' v' r' h' w' cpf "5F" r m' v' t' ki j v' qh"  
 32/6" o i lo n' q' n' w' g' p' u' q' n' w' k' p' 0'

Cempqy ngf i go gpv' Vj ku' y qtm' y cu' uwr r qt' v'g' "d { "v'j g' r t'qlgev' qh' uelgpv' hle" eq/ q' r g' t'cv' k' p' r t'qi t'co "dgy ggp" Ncxk. "  
 Nkj wcpk' cpf "Vck' cp" o' Rqn\ o gtle" Go kvgtu' y kj "Eqp' t' qm' dng" Vj gto cm\ "Cevxvcvg' "F gr\ cf "Hwqtguegpeg" hqt' "Uq' n' w' k' p' /  
 r tqegu' cdng' QNGF u" \*i t'cpv' P q' 0' U/ NNV/3; /6+0'

[3\_] I ONkw' E0Nk\ 0Tgp. 'U0\ cp. 'O 0T0Dt { eg. 'P cv0T gx00 cvgt03: 242' \*423: +3/420"  
 [4\_] J 0Wq { co c. 'M0I q' w' j k' 'M0Uj k' w' J 0P qo wtc. 'E0Cf cej k' 'P cwtg' 4234. '6; 4. '456645: "  
 [5\_] 'M0U' v'q. 'M0Uj k' w' 'M0I' q' u' j lo wtc. 'C0M' y cf c. 'J 00 k\ c\ cnk' 'E0Cf cej k' 'Rj' / u0Tgx0Ngn0' 4235. '332. '4696230  
 [6\_] 'U0M0Lgqp. 'J 0N0Ngg. 'M0U0\ q' qm' 'L0\ 0Ngg' 'Cf' x' 0' cvgt' 0423; '53. '3: 25746"  
 [7\_] 'R0Ctugp { cp0D0Xki cpvg. 'M0N' gkqpcu. 'F 0Xqn\ p' k' w' m' X0C' p' f twgxlekgp. 'N0U' h' k' v' r' f\ g. 'U0D' gn\ c' n' q' x. 'L0X0I' tc\ w' g' x' l' e' k' w'. 'L00' cvgt' 0Ej go 0E. '4243'  
 \*Cee' g' v' g' f' +'

**TGCN/VKO G'RI QVQTJ GQO GVT[ 'UVWF[ 'QH'F WCN'RJ QVQE WTKPI "**  
**MPGVKEU'QHDKQ/DCUGF 'O QP QO GTU"**

I tgvC' O qvknckv/ vg . 'Cwmug'P cxcctwenkpgg. 'Lqrksc' Qutcwunckg"

F gr ctvo gpv'qh'Rqn(o gt'Ej go km { "cpf "Vgej pqm { . 'Mcwpcu'Wpkxgtuk{ 'qh'Vgej pqm { . 'Tcf xknpgwTf 03; . "\*\*\*\*\*"  
NV/72476'Mcwpcu. 'Nkj wpcle"  
i tgvC' O qvknckv/ vGB mwQf w"

"

C'f wcn'ewtkpi 'r tgegu'ku'f ghlpgf "cu'c'eqo dlpckv'qh'v' q'ewtkpi 'tgecvkpu'cnkpi 'r nceg'uko wncpgqwu' 'qt'ugs wgvkcm{ 0K'ku' c'o gj qf "q'eqo dlpq'vy q'vy gty kug'f kulpev' qn{o gt'pgy qtm0Vj g'tguwnkpi 'kpvtr gpgvckpi 'r qn{o gt'pgy qtmzj klsu'lw' g'kq' r tqr g'vku' eqo r ctgf " vq " ku" kpf kskf wcn' r ctu" ]3\_0' Kp" vj ku" uwf { . " c" eqo dlpckv'qh' v' y q" uo wncpgqwu" cpf " ugs wgvkcn' r j qvqr qn{o gt'k' cvkqp' r tgeguugu'y cu'kpxguki cvgf 0'Rj qvqpkckv' r qn{o gt'k' cvkqp' j c'xg"vj g'cf xcpvc' gu'qh'tcr kf "ewg. "ny " gpgti { "eqpuwo r vkp. " j j "ghkelgpe { . "ny "xqrvkrg" qti cple'eqo r qwpf "go kuuq. "cpf "vj g'rti g'pwo dgt'qh'cr r rkecvkpu'kp" pqv'qpn{ "eqxgpv'kpcrict'gcu'wej "cu'eqcvkpi u' kpmu. "cpf "cf j gukxgu. "d'w'cnuq'kp" j j / vgej 'f qo c'ku. 'wej "cu' b' ketqrgv'qpleu. " qr vqrgv'qpleu. "rugt'ko ci kpi . "vngt'garkj qi tcr j { . "cpf "pcpvqgej pqm { " ]4\_0Vj g'tgr nceg' gpv'qh'r g'vqrgwo /dcugf 'o cvgtkcu" d { "o cvgtkcu'f g'kxgf 'tqo 't'pgy cdng'tguwtegu'kp'wej "vgej pqm { kgu'y qwf "i kxg"vj g'geqmi kcn'cpf "geqppo ke'dgpg'ku0"

Kp" vj ku" y qtm" y q" r tgeguugu" qh'htgg" tcf kcn'cpf "ecv'kple" r j qvqetquw' r'kpnkpi "qh' d'kqdcugf " o qpqo gtu" ectt'kfg " qw" uo wncpgqwu' "cpf "ugs wgvkcm{ "y g'g'kpxguki cvgf "d { "vj g'tgen'vko g'r j qvqtj gqo g'v { 0Vj ku" b' gj qf "r t'q'kf gu'vj g'y kf g'tcpi g" kphqto cvkqp' q'v' r kcn'lj gqmi kcn'r tqr g'vku'wej "cu'xkuequk{ "cpf "uqtc' g'o qf wnu'I . "hquu' b' qf wnu'I . "hquu' h'evq' 'cp . " cpf "eqo r r'z'x'kuequk{ " , "y j krg'c' b' cvgtkcn'ku' k' tcf k'v'g'f "y kj "WX IXK' h'ki j v0K' g'pcdr'gu'v'q' t'ceni'v' g'qeewt' g'peg' qh'ut' wewt'cu" r j gpqo gpc. "wej "cu' i' g'v'k'p'cpf "x'k'k'k'ecv'k'p. "kpf k'cvkpi "vj g'o qo gpv' y j gp'vj g'ut' wewt'cn'ej cpi gu'j c'xg' u'ct'v'g' " ]5\_0"

Vj g'f wcn' j qvqewtkpi "qh'x'ct'k'q'w'cet { r'v'g'f "cpf "gr qz'k' k' g'f "x'c'p'k'k'p'cpf "i n'eg'q'n' /dcugf " o qpqo gtu' y cu'k'p'x'g'uki cvgf "kp" vj ku" uwf { 0'U'g'x'g'c'n' h'gg" tcf kcn'cpf "ecv'kple" r j qvqpkckv'q'v' y g'g' wug'f 0' Vj g'k'p'h'v'g'peg" qh' vj g'k'p'k'c'n' t'gecvkqp" o k'z'w'g' eqo r quk'k'p' vq" vj g' r j qvqewtkpi "nkpg'v'eu. "tj gqmi kcn'r tqr g'vku. "tki k'k'f "cpf "uj t'k'p'nei g' qh' vj g' t'guwnkpi "et'quw' r'kpn'g'f " r qn{o gtu' y cu'k'p'x'g'uki cvgf 0'

K'v' cu'f g'v'g'to k'p'g'f "vj cv'vj g'j ki j guv'x'cn'gu' qh' u'q'tci g' o qf wnu'I . "cpf "vj wu' vj g'j ki j guv'tki k'k'f "y g'g'ce'j k'g'x'g'f "wukpi " ugs wgvkcn'f wcn' j qvqewtkpi "r tgegu0Vj g'i gnr' q'k'p'v' qh' vj g' o quv'f wcn' r j qvq'ewtkpi "u { u'go u' y cu'j ki j g' vj cp' vj cv'qh'r w'g' cet { r'v'g'u' d'w' h'qy g't' vj cp' vj cv'qh'r w'g' f ki n'ekf { n'g'v' gtu0Vj g'uj t'k'p'nei g' qh' vj g' u'co r r'gu' qh' vj g' o quv'f wcn' j qvqewtkpi "u { u'go u" y cu' h'qy g't' vj cp' vj cv'qh' vj g'r w'g' cet { r'v'g' u'co r r'gu' d'w' j ki j g't' vj cp' vj cv'qh'r w'g' f ki n'ekf { n'g'v' g't' u'co r r'gu' 0'

**Cempqy rgi go gpv0Vj ku'tgugctej 'y cu'hw'pf gf "d { "vj g'Tgugctej 'Eqwpekn'qh'Nkj wpcle" \*r tql'gev'pq0U/O KR/42/39-0'**

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[3\_ Q0M'p'w'c { . 'Z0H'g't'p'c'p'f g' / H'c'p'eu. 'Z0T'co ku. 'C0U'g't'tc. 'U'c'v'g' qh'c't'v'k'p' f wcn'ewtkpi 'cet { r'v'g' u { u'go u. 'R'qn { o gtu' 32. '39: \*423: -0'  
[4\_ ] 0[ ci ek' u'0'q'cm'uej =P 0'0'v'w'ttq. 'Rj qvqpkckv'g'f 'R'qn { o g'k' cvkqp' <C'f x'c'p'eg' u. 'Ej c'ng'pi gu. 'cpf " 'Qr r q'v'p'k'k'g' u. 'O' cet'qo q'rg'ew'gu' 65. '8467/8482" \*4232-0'  
[5\_ 'NG0'U'ej o k'f v'F 0'U'ej o @ = [ 0'N'g'v't't'g't' = L'G00 °pu'q. 'Vko g' / k'p'v'p'uk' { 't'c'p'uh'q'to cvkqp'cpf 'k'p'v't'p'c'n' u'g'u'kp' 'WX' / ewt'cdng'j { r g'td'c'p'ej g'f "cet { r'v'g'u. " Tj g'qr'0'c'ev' 68. '8; 5/923 \*4229-0'

**VJ G'EQPVTQN'QHVIJ GTO CN'DGJ CXKQT'EQKI'O KZGF'I NCU'HKDGT''  
URWT'I GCT'F WTKPI 'O GUJ KPI 'RTQEGUU\*J CPF/NC[ WR'O GVIJ QF +'**

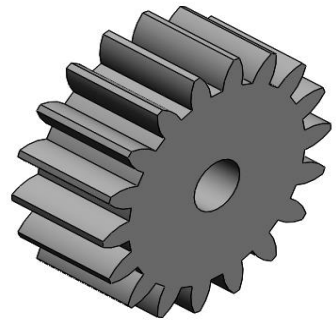
Ucplf guj 'O {uqtg'Ucvj {ctcl}^3.'J ctuj c'F {cpguj ^4.'Xggtctci j cexp'Tclci qr crmp^5.'''

<sup>3</sup>F gr ctvo gpv'qh'Grgextlecl'cpf 'Grgextqpleu'Gpi kpggtkpi ..'Mcwpcu'Wpkkxtukv{ 'qh'Vgej pqrqi { .'Nkj cwplc''

<sup>4,5</sup>F gr ctvo gpv'qh'O gej cplecl'Gpi kpggtkpi 'cpf 'F guki p.'Mcwpcu'Wpkkxtukv{ 'qh'Vgej pqrqi { .'Nkj cwplc''

Ucplf guj @ {uqtgB mWQf w.'xggtctci j cexp@clci qr crmpB mWQf w.'j ctuj c@grxclB mWQf w@''

Vj g' r tguv' y qtnl' f guetkdu' yj g' f gxgnr o gpv' cpf " o gej cplecl' ej ctcevtk' cvkqp" qh' pgy " r qn' o gt" eqo r quksu' eqpukv' qh' tglphqtego gpv' qh' G/i r uuu' hkdgt." gr qz { " tguip." cpf " j ctf gpgt." pcwtn' hkdgt " \*eqlt" hkdgt+0 Vj g' o gej cplecl' r tqr gt'vku'qh'vj g' pgy n' f' f gxgnr gf "eqo r quksu'ctg'ej ctcevtk' gf 0f' qtf gt "v' h'kf' yj g' uki p' h'lecpv' k'ph'w'p'eg' qh' pcwtn' hkdgt " \*eqlt+" q' yj g' o gej cplecl' ej ctcevtk' ku'eu' qh' i' r uuu' hkdgt " tglphqtego gpv' eqo r quksu. " g'zr g' tko gpw' uwe'j " cu' j ctf p'guu' v'g'uv. " v'pukg' v'g'uv. " eqo r tguakqp' v'g'uv. " ko r cev' v'g'uv' yj g' g' ectt' k'gf " q'w'0C' uki p' h'lecpv' er'cuu' qh' o cvgtkcn' c'xcl' r' d'rg " v'q' o c'p' n' k'p'f " ctg' eqo r quksu' 0f' " o cvgtkcn' uel' p'eg. " o g'v' n' m' t' i { ." ej go k'ut { ." u'q' n' k'f " o gej cpleu' cpf " g'pi kpggtkpi " cr r r'ec' v'k'p' u. " u'w'f' k'g' u' qh' uwe'j " eqo r quksu' r' n' c' " x'gt { " ko r q' t' v' p' v' t' q' n' 0' F' w' g' " v'q' " k' u' d' p' g' h' k' u. " uwe'j " cu' n' y' " equv' p' q' k' u' g' " eqp' v' t' q' n' " n' y' " y' g' k' i' j' v' c' p' f' " g' c' u' g' " qh' r' t' q' e' g' u' k' p' i. " yj g' G/i r uuu' hkdgt 3 " tglphqtegf " r' qn' o gt " eqo r quksu' k' u' o' q' t' g' y' k' f' g' n' " w' u' g' f' " k' p' " yj g' c' w' q' o' q' v' k' g' " k' p' f' w' u' t' { " c' p' f' " q' y' g' t' " k' p' f' w' u' t' k' n' " cr r' r' e' c' v' k' p' u' 0' E' j' g' c' r " c' p' f' " g' p' x' k' t' q' p' o' g' p' v' e' m' { " h' t' l' e' p' f' n' " o' c' v' g' t' k' c' n' " c' t' g' " p' c' w' t' n' " h' k' d' g' t' u' " ] 3\_ 0' E' q' o' r' q' u' k' s' u' " c' t' g' " c' " p' g' y' " f' g' x' g' n' r' o' g' p' v' l' p' " yj g' h' k' g' f' " qh' o' c' v' g' t' k' c' n' u' e' l' p' e' g' 0' C' k' e' t' c' h' v' k' p' f' w' u' t' k' u' v' q' f' c' { " p' g' g' f' " o' c' v' g' t' k' c' n' c' v' n' y' " e' q' u' v' " r' g' u' y' " g' k' i' j' v' " d' w' l' u' j' " q' w' f' " j' c' x' g' j' k' i' j' " u' t' g' p' i' yj " v'q' " k' p' e' t' g' c' u' g' " yj g' g' h' h' e' l' g' p' e' { " qh' " c' k' e' t' c' h' v' " c' p' f' " g' x' g' p' " k' p' " yj g' c' w' q' o' q' v' k' g' " k' p' f' w' u' t' { 0' Vj g' " c' d' q' x' g' " u' q' n' w' k' p' u' " c' t' g' " q' n' k' " eqo r quksu' " o' c' v' g' t' k' c' n' 0' P' c' w' t' n' " h' k' d' g' t' " eqo r quksu' " e' c' p' " c' n' u' q' " d' g' " x' g' t' { " e' q' u' v' " g' h' h' e' v' k' x' g' " o' c' v' g' t' k' c' n' " h' q' t' " cr r' r' e' c' v' k' p' " k' p' " eqp' u' t' v' e' k' q' p' " c' p' f' " eqp' u' t' v' e' k' q' p' " c' t' g' c' u. " u' q' t' c' i' g' " f' g' x' l' e' g' u. " h' m' t' p' k' w' t' g. " g' r' g' e' v' t' p' k' e' " f' g' x' l' e' g' u. " k' p' v' g' t' k' t' " r' c' t' u' v' " qh' " e' c' t' u' " c' p' f' " t' c' k' n' y' c' { " e' q' e' j' g' u. " g' v' e' 0' Vj k' u' r' c' r' g' t' " r' t' q' x' k' f' g' u' " yj g' o' c' p' w' h' c' e' w' t' g' " c' p' f' " k' p' x' g' u' k' i' c' v' k' p' " qh' j' go r " c' p' f' " d' c' i' c' u' u' g' " h' k' d' g' t' " t' g' l' p' h' q' t' e' g' f' " y' k' j' " g' r' q' z' { " j' { d' t' k' " eqo r quksu' " o' gej cplecl' r' tqr gt' v'ku' 0' Vj g' r' t' q' f' v' e' k' q' p' " k' u' r' g' t' h' q' t' o' g' f' " d' { " j' c' p' f' / r' c' { w' " v' g' e' j' p' l' s' w' g' y' k' j' " t' c' p' f' q' o' " q' t' l' e' p' v' e' k' q' p' " qh' j' go r " c' p' f' " d' c' i' c' u' u' g' " h' k' d' g' t' u' " k' p' " yj k' u' o' g' v' j' q' f' 0' J' g' t' g. " c' " h' r' z' g' w' t' c' n' " v' g' u' v' k' u' r' g' t' h' q' t' o' g' f' " c' e' e' q' t' f' k' p' i' " v' q' " C' U' V' O' " u' x' c' p' f' c' t' f' u' d' { " e' j' c' p' i' k' p' i' " yj g' " x' q' n' w' o' g' " h' t' c' e' v' k' q' p' " qh' " yj g' " h' k' d' g' t' u' " v' q' " 32 " r' g' t' e' g' p' v' ( " 42 " r' g' t' e' g' p' v' " eqo r quksu' " r' o' k' p' c' v' g' u' " c' p' f' " v' g' u' g' f' " h' q' t' " k' u' " o' gej cplecl' r' tqr gt' v'ku' uwe'j " cu' v' g' p' u' k' g' 0' C' p' f' " yj g' j' c' t' f' p' g' u' u' v' g' u' v' k' u' c' n' u' q' " e' c' t' t' k' e' f' " q' w' h' q' t' " d' q' yj " yj g' r' o' k' p' c' v' g' " x' q' n' w' o' g' " h' t' c' e' v' k' q' p' u' " ] 4\_ 0' "



Hki 030%+I r uuu' hkdgt \*d+Eqk' hkdgt \*e+Ur wt' I gct'''

C'ulpi ng'ur wt' i' gct' ku' v' r' k' e' c' m' { " u' g' r' e' v' g' f' " v' q' j' c' x' g' " c' " t' c' v' k' " t' c' p' i' g' " qh' d' g' y' g' p' " 3-3' c' p' f' " 3-8' y' k' j' " c' r' k' e' j' " h' k' p' " x' g' n' e' k' v' " w' " v' q' " 47' o' l' u' 0' Vj g' " u' r' w' t' " i' g' c' t' " j' c' u' " c' p' " q' r' g' t' c' v' k' p' i' " g' h' h' e' l' g' p' e' { " qh' : ; ; " r' g' t' e' g' p' v' 0' Vj " j' c' x' g' " yj g' o' c' z' k' o' w' o' " p' w' o' d' g' t' " qh' " v' g' g' y' . " eqp' u' k' v' g' p' v' " y' k' j' " c' p' " c' e' e' g' r' v' c' d' r' g' " u' c' h' g' v' { " o' c' t' i' k' p' " k' p' " u' t' g' p' i' yj " c' p' f' " y' g' c' t' . " c' i' " g' c' t' " r' c' k' " u' j' " q' w' f' " d' g' " e' j' " q' u' g' p' 0' Q' p' " c' i' " g' c' t' " y' k' j' " c' p' " q' t' o' c' i' l' r' " t' g' u' u' w' t' g' " c' p' i' n' g' " qh' " 42 " f' g' i' t' g' g' u. " yj g' o' k' p' o' w' o' " p' w' o' d' g' t' " qh' " v' g' g' y' " k' u' " 3: 0' Vj g' " h' k' p' c' n' " e' q' o' r' q' u' k' s' u' " k' u' r' t' q' f' w' e' g' f' " h' t' q' o' " 82 " r' g' t' e' g' p' v' " h' k' d' g' t' " eqo r quksu' " c' u' " c' " d' g' w' g' t' " u' t' g' p' i' yj " eqo r c' t' g' f' " v' q' " 62 " r' g' t' e' g' p' v' " eqo r quksu' " c' p' f' " yj g' " h' k' p' c' n' " o' c' p' w' h' c' e' w' t' g' " qh' i' g' c' t' " k' u' " o' c' f' g' " h' t' q' o' " 82 " r' g' t' e' g' p' v' " g' r' q' z' { " eqo r quksu' " c' u' " c' " d' g' w' g' t' " u' t' g' p' i' yj 0' G' r' q' z' { " t' g' u' k' p' u' " c' t' g' " r' t' g' r' q' n' o' g' t' u' " qh' " t' g' r' v' k' g' n' " n' y' " o' q' r' g' e' w' t' " y' g' k' i' j' v' " e' c' r' c' d' r' g' " qh' " d' g' k' p' i' " r' t' q' e' g' u' g' f' " w' p' f' g' t' " c' " x' c' t' k' g' v' { " qh' " e' q' p' f' " k' k' q' u' p' u' 0' Vj g' u' g' " j' c' x' g' " y' q' " u' k' i' p' h' l' e' c' p' v' " c' f' " x' c' p' v' c' i' g' u' " q' x' g' t' " w' p' u' c' w' t' c' v' g' f' " r' q' n' k' g' u' g' t' " t' g' u' k' p' u' < h' t' u' v' " yj g' { " e' c' p' " d' g' " r' c' t' v' e' c' m' " e' w' t' g' f' " c' p' f' " u' q' t' g' f' " k' p' " yj c' v' u' c' v' g' . " c' p' f' " u' g' e' q' p' f' . " f' w' t' k' p' i' " e' w' t' g' " yj g' { " g' z' j' k' d' k' " n' y' " u' j' t' k' p' n' e' i' g' 0' ] 4\_ 0' C' r' r' t' q' z' k' o' c' v' g' n' " 67 " r' g' t' e' g' p' v' " qh' " yj g' " v' q' v' e' n' " c' o' q' w' p' v' " qh' " g' r' q' z' { " t' g' u' k' p' u' r' t' q' f' w' e' g' f' " k' u' " w' u' g' f' " k' p' " r' t' q' v' e' k' x' g' " e' q' c' v' k' p' i' u' " y' j' k' r' g' " yj g' " t' g' u' v' " k' u' " w' u' g' f' " k' p' " u' t' w' e' w' t' c' n' " c' r' r' r' e' c' v' k' p' u' " u' w' e' j' " c' u' " n' o' k' p' c' v' g' u' " c' p' f' " eqo r quksu. " v' q' n' k' p' i' . " o' q' r' f' k' p' i' . " e' c' u' k' p' i' . " eqp' u' t' v' e' k' q' p' . " c' f' j' g' u' k' x' g' u. " g' v' e' 0' Vj g' " u' t' g' p' i' yj " l' y' g' k' i' j' v' " t' c' v' k' u' " qh' i' r' uuu' hkdgt " eqo r quksu' " c' t' g' " j' k' i' j' g' t' " yj c' p' " yj q' u' g' " qh' o' q' u' v' " q' y' g' t' " o' c' v' g' t' k' c' n' " c' p' f' " c' t' g' " r' j' g' p' q' o' g' p' c' n' " k' p' " yj g' k' " k' o' r' c' e' v' " t' g' u' k' u' c' p' e' g' 0' Vj g' { " c' n' u' q' " j' c' x' g' " i' q' q' f' " g' r' g' e' v' t' l' e' c' l' r' " t' q' r' g' t' v' k' u' " o' q' l' u' w' t' g' " c' p' f' " q' w' f' q' q' t' " y' g' c' v' j' g' t' " t' g' u' k' u' c' p' e' g' . " c' p' f' " j' g' c' v' " c' p' f' " e' j' g' o' k' e' c' i' t' " g' u' k' u' c' p' e' g' 0' U' w' e' j' " r' t' q' r' g' t' v' k' u' " c' t' g' " eqo d' l' p' g' f' " y' k' j' " g' c' u' g' " qh' o' c' p' w' h' c' e' w' t' k' p' i' 0' "

]3\_Ucplf j { c' " T' c' p' k' " D' q' t' w' n' e' v' k' " k' p' v' e' t' p' e' v' k' p' e' c' n' " E' q' p' h' q' t' e' p' e' g' " qh' " V' t' g' p' f' u' " k' p' " k' p' h' q' t' o' c' v' k' q' p' . " O' c' p' c' i' g' o' g' p' v' " G' p' i' k' p' g' g' t' k' p' i' " c' p' f' " U' e' l' g' p' e' g' u' " \*E' V' I' O' G' U' + " X' q' n' w' o' g' " 7. " U' r' g' e' l' c' n' " K' u' w' g' " 24. " H' e' d' 0' 423: . " 6' F' g' u' k' i' p' " c' p' f' " e' j' c' t' c' e' v' t' k' c' v' k' q' p' " qh' G/ I' r' uuu' hkdgt " T' g' l' p' h' q' t' e' g' f' " E' q' o' r' q' u' k' s' u' " O' c' v' g' t' k' c' n' y' k' j' " w' u' g' " qh' " E' q' k' " H' k' d' g' t' o' " ] 4\_ " [ c' u' j' c' u' " I' q' y' f' c' . " V' I' 0' + " U' e' k' p' l' c' { . " O' 0' f' 0' + " U' w' d' t' e' j' o' c' p' { c' " D' j' c' v' " M' 6' 0' c' f' j' w' " R' 0' + " U' g' p' y' c' o' c' t' e' k' n' e' p' p' e' p' . " R' 0' + " [ q' i' g' u' j' c' . " D' 0' " U' U' R' q' n' o' g' t' " o' c' v' t' k' / p' c' w' t' n' " h' k' d' g' t' " eqo r quksu: C' p' " q' x' g' t' x' l' e' y' 0' E' q' i' g' p' 0' G' p' i' 0423: . " 7. " 36688890 ] E' t' q' u' i' f' g' h' . "

# PRODUCTION OF VARIOUS SIZE ORGANIC PHOTOVOLTAIC CELLS WITH P3HT:PC61BM AS AN ACTIVE LAYER

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Developing effective renewable energy sources is essential due to the world's efforts for carbon-neutrality. Organic photovoltaics (OPV) provide unique possibilities. They are much cheaper than silicon cells and moreover, can be deposited on flexible substrates, which opens the potential for new niches such as wearable electronics and building incorporated panels.

Although promising, OPV suffers from relatively low efficiencies (c.a. 5 – 7% ) which is currently the main obstacle in the way for commercialization. The two major reasons behind this behavior are short exciton diffusion lengths and very low carrier mobility in an active layer.

Here, we present organic solar cell structures with P3HT:PC61BM mixture in weight ratio 1:0.6 as an active layer. P3HT (Poly(3-hexylthiophene-2,5-diyl)) is a conductive polymer with absorption edge in the visible region working as an electron donor. PC61BM is a C<sub>60</sub> fullerene derivative working as an acceptor. During research, we focus on the optimization of the deposition parameters, i.e. the active layer annealing temperature, spin coating rotation speed and used solvents. Also, to test our method at a larger scale we prepare the cells onto indium-tin oxide substrates with two, substantially different sizes: 3 cm<sup>2</sup> and 25 cm<sup>2</sup>.

As the result, we present absorption spectra of the P3HT and PC61BM. Regarding solar cells, I-V characteristics, photocurrent and external quantum efficiency measurements will be discussed.



**XCP KNNP 'CET[ NCVG/DCUGF 'RQN[ O GTU<P HNWGPEG'QH'TGUP' "**  
**EQO RQUVKQP 'VQ'RJ QVQE WTPI 'MKGVEUCPF 'RTQRGT VKGU'QH' "**  
**VJ G'TGUVNVI 'RQN[ O GTU' "**

Cwmug'P cxctwenkpg<sup>3</sup>. 'F cpi wqrg'Dtkf | kwkpgg<sup>4</sup>. 'Xkc'Tcwf qpkpgg<sup>4</sup>. 'Lqrkc'Quwtcwunekg<sup>3</sup>"

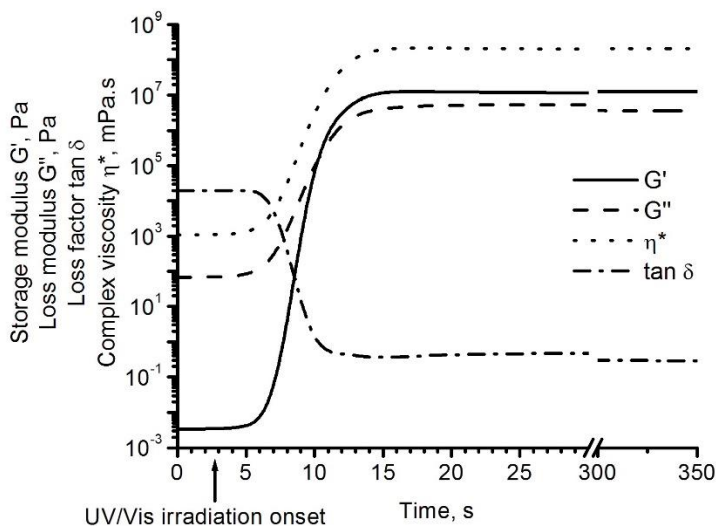
<sup>3</sup>F gr ctvo gpv'qh'Rqn[o gt'Ej go kwt {"cpf "Vgej pqmji {".'Mwpcu'Wpkxgtukv'qh'Vgej pqmji {".'Tcf xkpgpwTf03; . 'NV/72476'Mwpcu.'Nkj wcpkc0'

<sup>4</sup>Dkqf gvgtkqtcvkqp'Tgugctej 'Ncdqtcvqt{.'P cwtg'Tgugctej 'Egpygt.'Cnrf go kqu'Ut04.'NV/2: 634'Xkpkwu.'Nkj wcpkc0'  
cwmug'PcxctwenkpgB mw0n'

"

Cff kxg'o cpwrcwtkpi "ku'i gwłpi "r qr wct'kp"vj g'o cpwrcwtkpi "eqo r cplgu."dgecwug'kv'ku"e'ej gcr "cpf "hcu'y c {"vq" r tqf weg"pgy "r tqf weu'kp"eqo r ngz "uj cr gu"]3\_0'Cff kxg'o cpwrcwtkpi "r tqxkf gu"uwej "dgpghku"cu'nyj gt"o cvgtkcr'nyuu."tgf weg'f'r tqf wev'y gli j v'cpf'r quakdkv'vq'r tlpv'ur ctg'r ctu'y kj qw'wukpi "Hkwtgu'qt"o qrf u"]4.5\_0'

Kp"vj ku"uwf {".'etquu'rkpngf "r qn{o gtu'y gtg'qdvclpgf "d {"r j qvqr qn{o gtk cvkp"qh'xcprknp" f kct {"rvg" cpf "xcprknp" f lo gj cet {"rvg"y kj "3"qt "20"o qn0 "qh'30/dgp| gpgf kj kqn" wukpi "r j gp {"ndku\*4.6.8/vtko gj {"rdgp| q {"nr j qur j kpg"qz kf g" \*DCRQ"cu"r j qvqpkvctvt0'Rj qvtj gqo gvt {"y cu" wugf "vq"o qpkqt"vj g" gxqnwkp"qh'r j qvqetquu'rkpnpki "r tqeguu'Vj g" WXIXku'tgcn'vko g'r j qvtj gqo gvt {"'ewtkpi "vguu'y gtg'r gthqto gf "qp"o'ET524'tj gqo gvt'htqo "Cpvpq'Rcct'gs wkr r gf 'y kj "vj g'r rvgr rvg"o gcuwtkpi "u'uygo 0'F gr gpf gpekgu'qh'lvqtci g'o qf wnu'I a'nyuu'o qf wnu'I o.'nyuu'hcevt'vcp ".cpf "eqo r ngz "xkuequkv" , "qh'r wtg"xcprknp" f kct {"rvg/dcugf "tgulp"y kj "5"o qn0 "qh'DCRQ"qp'ktcf kvkp"vko g'ku'r tgugpvgf "kp'Hki wtg'30' K'y cu" f gvgto kpgf "vj cv'vj g"cf f kxkp"qh'uqrgpv'kpv"vj g"tgulp"uny gf "f qy p"vj g"r j qvqewtkpi "r tqeguu'cpf "nyuu'tki kf " r qn{o gtu'y gtg'qdvclpgf 0'Vj g'cf f kxkp"qh'vj kqn'kpetgcugf "vj g"r j qvqewtkpi "tcvg'dw'tgf weg'f"vj g'tki kf kv'qh'vj g'tguwnkpi " r qn{o gtu0'



Hki 030F gr gpf gpekgu'qh'lvqtci g'o qf wnu'I a'nyuu'o qf wnu'I o.'nyuu'hcevt'vcp ".cpf "eqo r ngz "xkuequkv" , "qh'r wtg" xcprknp" f kct {"rvg/dcugf "tgulp"y kj "5"o qn0 "qh'DCRQ"qp'ktcf kvkp"vko g.'cv'47'Æ0'

Xcprknp/dcugf "r qn{o gtu'uj qy gf "uki pkhcepv'cpvdcvgtkcr'cevkvkv"ci clpvu' Guej gtejkc "eqrk" cpf "Ucrj wrqeqewu" cwt gwu'kp" f kgeveqpvcev'cpf "qp"o gf kwo 0'Vqzlekv"vq"o letqueqr k'hwpi wu'Cur gti kmu'pki gt"cpf "Cur gti kmu'vgtt gwu'y cu" nyuu'r tqpwpegf 0'

**Cenpqy ngf i go gpv0'** Vj ku"tgugctej "y cu"hwf gf "d {"vj g"GW'GTFH"vj tqwi j "vj g"R'VGTTGI "DUT"Rtqi tco o g." \*GEQNCDP'GV"r tqlgv'v%T299+ "vj g'Gwtqr gcp"Uqekcr'hwf pf "vfp gt"vj g'o gcuwtg'pq02; 05/NO V/M034"0F gxgnyr o gpv'qh' Eqo r gvgpegu'qh'Uekgpvkuu."qj gt "Tgugctej gtu"cpf "Uwf gpw"vj tqwi j "Rtcevkcr'Tgugctej "Cevkvkkuo."cpf "vj g"tgugctej " Eqwpekri'qh'Nkj wcpkc"r tqlgv'pq0U/O RR/42/39+0'

"

[3\_0'OMDP kcnk'UOC0Vqtcdk'HDP qpkpq.'Y j {"o cpwrcwtkpi'cf qr'v'cf f kxg'o cpwrcwtkpi "vgej pqmji kgu'vj g'tqrg'qh'hwunckpcdkkv'.'10Engcp0Rtqf 0' 444.'5: 3/5; 4'\*423; +0'

[4\_0'FD3/enp.'C00 0Vkm cp.'Gpxtkqpo gpv'cuuguo gpv'qh'cf f kxg'o cpwrcwtkpi "kp"vj g'cwqo qkvxg'lpf wnt {".'10Engcp0Rtqf 0448.'; 99/; : 9'\*423; +0'

[5\_0'COEj gti w'0J cf l/J co qw'HDXi pcv.'Rtqf wvqpv'uej gf wkpki "cpf "pkułpi "kp'cf f kxg'o cpwrcwtkpi ".Eqo r w0'kpf 0Cpi 0348.'4; 4/523'\*423: +0'

"

**U P V J G U K U C P F ' R P X G U V K C V K Q P ' Q H V T K F G E [ N ' O G V J C E T [ N C V G /  
D C U G F ' R J Q V Q E T Q U U / N P M G F ' R Q N [ O G T U ]**

**Lwukpcu'Lctcu . 'Cwmg'P cxcwtwngpg. 'Lqksc'Quwewwng**

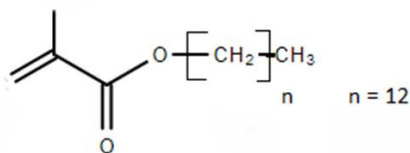
F gr ctvo gpv'qh'Rqn{o gt'Ej go kwt { "cpf "Vgej pqmji { . 'Mwpcu'Wpksgtuk\ 'qh'Vgej pqmji { . 'Tcf xkngpwTf03; . "\*\*\*\*\*  
NV/72476'Mwpcu.'Nkj wpc\k"

Lwukpcu'LctcuB mwqf w'

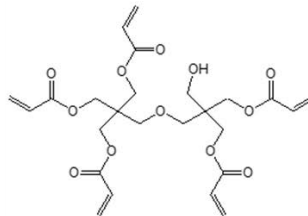
"

Kp'tgegpv\{ gctu'pcwtcn'qknu'j cxg'dgeqo g'vj g'egpvt'qh'cwtcewqp'htq'vj gk'r qvppkcn'wug'cu'uctwkp' "o cvgtkcn'htq'vj g' r tgr ctwkqp'qh'r qn{o gtu0Vj g'wug'qh'r j qvqpkkcvf 'r qn{o gtlk cvkqp'ku'eqpvkpwqun\ 'i tcy kpi 'kp'kpf wut { "cu'tghgevgf "d{ 'vj g' rti g'pwo dgt'qh'cr r nekcvkpu'kp'pqv'qpn\ 'eqpxgpwqpcn'ctgcu'uwej "cu'eqcvkpi u.'kpmu."cpf "cf j gukxgu'dw'cnuq'kp'j ki j /vgej " f qo ckpu." uwej "cu'qr vjgrgevtqkcu." rugt"ko ci kpi ." uvtgqkij qi tcr j { ." cpf "pcpqvej pqmji { " ]3\_0'Vj g" wug'qh'o cvgtkcn' f gtlxgf "htqo " tpggy cdng" tcy " o cvgtkcn' htq" vj g" r tqf wewqp" qh' r qn{o gtu" gzej kdkkpi " r tqr gt vku" uko kcti" vq" vj qug" qh' eqpxgpwqpcn'r gwtqngwo /f gtlxgf 'r qn{o gtu'cpf "cdng'vq" f geqo r qug'kp'vq" j cto nguu'wduwcpogu'chwgt'wug'cpf "tgrgcug'kp'vq'vj g' gpv'kqpo gpv'ku'qh'kpetgcugf "kpvgtguv'qh'dqvj "tgugctej "cpf "kpf wut { 0'Co qpi "cm'tgpgy cdng'tguqwtegu."pcwtcn'xgi g'cdng' qknu'ctg" eqpukf gtf "vq" dg" qpg" qh' vj g" o quv'ko r qt wcpv'ercuugu'qh'tgpgy cdng' uqwtegu" dgecwug' qh' vj g" y kf g' xctkqv " qh' r quukdkkku'htq'ej go kcn'v'cpcuqto cvkqp."wpxgtucn'cxkrcdkk\ ."cpf "mij "r tleg"]4\_0'Vt\k ge{ n'o gj cet { rvg'y cu'ej qugp'cu" c'dkqdcugf "o qppo gt 'f gtlxgf 'htqo 'pcwtcn'qknl'p'vj ku'uwf { 0'

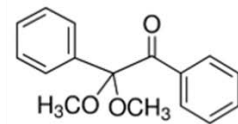
Vj g'clo "qh'vj ku'y qtn'y cu'vq'kpxguki cvg'vj g'kphwvpeg'qh'vj g'co qwpv'qh'vj g'etquu'rkpnkpi "ci gpv'fkr gpwct { vj tkqn' r gpv'cct { rvg'vq'vj g'r j qvr qn{o gtlk cvkqp'nikp'gku'qh'v'k ge{ n'o gj cet { rvg'cpf "r tqr gt vku'qh'vj g'tguwv'kpi "r qn{o gtu04.4 F lo gj qz { 4 r j gp { rvegvqr j gpqpg'y cu'wugf "cu'r j qvqpkkcvqto'Ej go kcn'v'weww'g'qh'vj g'wugf "eqo r qwpf u'ku'r tguv'v'f "kp'Hi wt g'30"



a



b



c

Hi 030Ej go kcn'v'weww'g'qh'v'k ge{ n'o gj cet { rvg'k+c+'fkr gpwct { vj tkqn'r gpv'cct { rvg'k+d+'cpf "4.4 f lo gj qz { 4 r j gp { rvegvqr j gpqpg'k'e+"

Rj qvqetquu'rkpnkpi " nikp'gku' y cu" o qpkqtf " d{ " vj g' tgn'vko g" r j qvtj gqo gvt { " y j lej " r tqxkf gu" vj g' y kf g' tci pi g' kphqto cvkqp"qp'v\ r kcn'tj gqmi kcn'r tqr gt vku'uwej "cu'xkuequk\ "cpf "uj gct"o qf wuu'y j krg"co cvgtkcn'ku'ktcf kcvf "y kj " WX IX KU'hi j v0 Vj g'ej go kcn'v'weww'g'qh'vj g'etquu'rkpngf "r qn{o gtu'y cu'eqpht'o gf "d{ "HV/KT"ur gwtqueqr { 0'Vj g'f kgrf "qh' vj g' kpuqndng"htcewqp"qh' vj g'etquu'rkpngf "r qn{o gtu" y cu" f gvto kpgf "chwgt"Uqzj ngv'gzv'cewqp" y kj "cegvqpg"htq"46"j 0' O gej cplecnej ctcevtkku'v' y gtf gvto kpgf "d{ "vgpukg kdpf kpi leqo r tguukxg'v'guu0'Vj gto cnr tqr gt vku'y g'g'kpxguki cvf " d{ "f khtgtpv'kcn'uecpkpi "ecmtko gvt { "cpf "vj gto qi tcxlo gtlk'cpcn'uku0

K'y cu'f gvto kpgf "vj cv'vj g'tj gqmi kcn'vj gto cn"o gej cplecnej tqr gt vku."cpf "uy gmki "qh'vj g'u{ pvj gu{ | gf "r qn{o gtu" kp'r qnt'cpf "pqr qnt' uqrxgpw'v'utqpi n\ "f gr gpf gf "qp'vj g'co qwpv'qh'vj g'etquu'rkpnkpi "ci gpv'v'ci o gpw'kp'vj g'r qn{o gt'cpf" vj g'f gpuk\ "qh'vj g'pgy qtn0'

"

**Cempqy rgi go gpv0** Vj ku'tgugctej " y cu'hwf gf "d{ " vj g'GW'GTFH" vj tqwi j " vj g'kP VGTTGI "DUT" Rtqi tco o g." \*GEQNCDP GV'r tqigev%Γ299+'cpf "vj g'Tgugctej "Eqwpeki'qh'Nkj wpc\k"r tqigev'pq0U/O RR/42/39-0'

"

[3\_1\_0] ci ek'U0Lqemuej =P(0Vvttq.'Rj qvqpkkcvf 'Rqn{o gtlk cvkqp<Cf xcpogu.'Ej emepi gu.'cpf "Qr r qtwpkku."O cetqo qrgewgu'65.'8467/8482" \*4232-0'

[4\_E0\ j cpi . 'VHDI cttkuqp.'UC00 cf dqwn\ . 'O 0f0Mguugt. . 'Rtqi 0Rqn{o 0Uek093. ; 3/365"4239-0'

# HELICITY INDUCED SPIN-ORBIT COUPLING FOR ULTRAFAST ISC IN ALKYNE BRIDGED BIFLUORENES

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Compounds with strong spin-orbit coupling (SOC) and fast intersystem crossing (ISC) are important for organic light emitting diodes and photosensitizers used for photo-dynamic therapy [1]. However, achieving a high ISC rate usually requires heavy atoms, such as Pt or Ru, thus making materials of this kind not cost-efficient. Here, we propose a concept to enhance SOC in carbon-only structures by taking advantage of helical molecular orbitals (Hel-MOs). Intersystem crossing dynamics in bifluorenes were investigated by means of pump-probe measurements, which indicated that minor modifications of the molecule (extended alkyne bridge) cause considerable photophysical differences (Fig. 1). Furthermore, theoretical calculations were performed to confirm the helical shape of the MO in the dialkyne bridge unit. Formation of helical molecular orbitals results in enhanced SOC leading to an increased ICS rate.

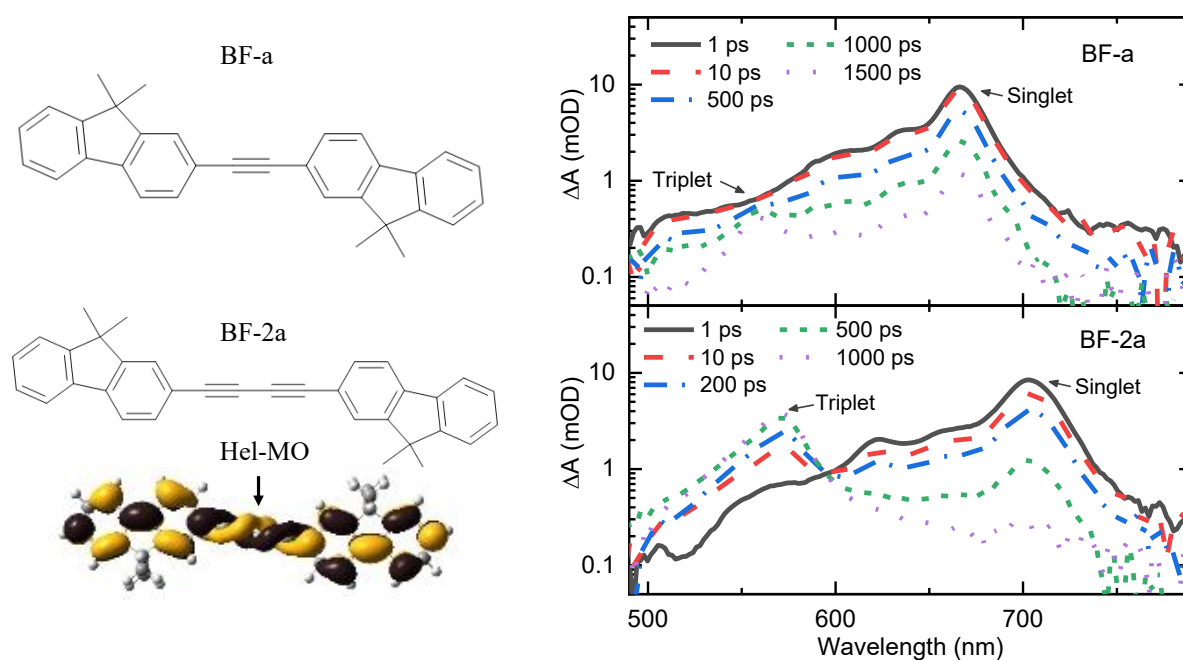


Fig. 1. Bifluorene molecules and their transient absorption spectra

[1] D. Sasikumar, A. T. John, J. Sunny, M. Hariharan, Chem. Soc. Rev. 2020, 49, 6122.

**F GXGNQRO GP V'QH'O GF ĶE CN'RNC P V'FT[ ĶPI 'O G VJ QF 'DCUGF 'QP''  
VJ G'E QPVTQN'QH'T GNCVĶG'J WO Ķ ĶV[ '''**

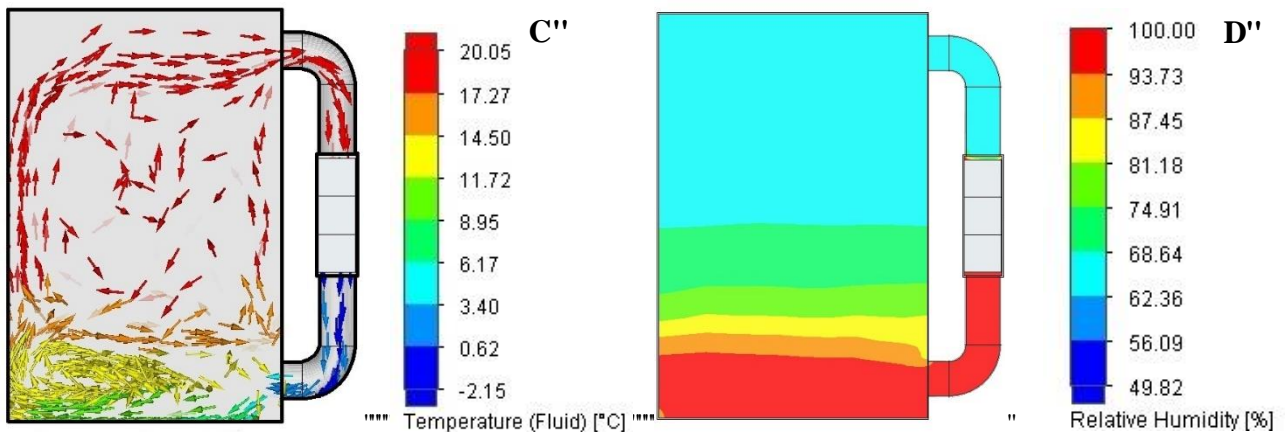
O { m{ v' Mqxcrgpnq<sup>3</sup>. F cplgrc "Ugpngrxk<sup>3</sup>. Mctqrkpc "Ner nēwunēkv<sup>3</sup>. Cpf tkw'F | gf | lenk<sup>3</sup>. "X { vwcu"  
Dw kōpunc<sup>3</sup>'''

<sup>3</sup>F gr ctwo gpv'qh'O gej cxtqpleu. Tqdq'vku'cpf 'F ki kcni'O cpw'hcw'wt kpi. "Xkpkw'I gf ko kpcu'Vgej plecti'Wpkxgtuk{ "  
o { m{ v' Mqxcrgpnq<sup>3</sup> B xkpkw'gej Qn''

F t { kpi "ku'qpg"qh'y'g'o quv'r qr wct "cpf "guagpvkn'qr gtcv'kpu'kp"y'g'r quv'j ctxgukpi "r tqeguukpi "qh'o gf lecn'r ncpw"qt"  
hqf "r tqf wew'OF wtkpi "f t { kpi . "y'g'o qkuwtg'htqo "kpkf'g'y'g'r tqf wew'o qxgu'vqy ctf u'ku'uw'hc'eg. "y'j g'tg'k'v'cpuhqto u'v'c"  
i cugqwu'ucv'g\* "y'cvtg'xcr qt + "cpf "y'j gp'v'cpuhqtu'v'q' "y'g'uw'wtqwpf kpi "ck' "kp'v'gto u'qh'j gcv'qt' "o cuu'v'cpuhq' "J3\_0E qpvgo r qtct { "  
hqf "kpf wut { "o quw' "wugu'f t { kpi "o gy' qf u'v'j cv'cr r n'j "j gcv'v'q' kpf w'eg' "y'g't'j cug'ej cpi g'qh'y' cvgt' "htqo "h'k' w'k' "v'q' i cugqwu'ucv'g"  
J3. "4\_0J qy g'xgt. "f g'j { f' tcv'kqp'cv'j' k'j "v'go r gtcw'wtg'u'o c' { "kph'w'gej "y'g'cr r gtc'peg. "wtwew'g. "cpf "dk'qej go lecn'eqo r qwpf "  
qh'f' t'kgf "ur geko gp' "J5\_0'

Qwt "uwi i gungf "o gy' qf "qh'f t { kpi "f qgu'pqv'kpxq'ng' "y'g'w'ug' "qh'j gcv'ht' "f g'j wo k'f' k'lec'v'kqp' "qh'f t { kpi "ck' "o' "y'g'r tqegu'  
kpk'cm' "qeev'u'cv'tqgo "v'go r gtcw'wtg'OCp' "qr gtcv'kpi "r t'k'p'k' r'g' "qh'c' "etg'cv'g' "u'v'go "ku'dcugf "qp' "y'j g'f gr gpf gpeg' "qh' t'g'v'k'g'  
j wo k'f' k' " "TJ " + "qh'ck' "htqo "ku'w'go r gtcw'wtg'Vj g'ck' "htqo "y'j g'f t { kpi "ej co dgt "ku'dm'qy p' "y'j tqwi j "c"j gcv'kpn'y'j k'ej "ku'kp"  
y'j gto c'rie'q'p'cv'v'j k'j "c' "eqf' "u'w'hc'eg' "qh'c' "y'j gto q'rg'ev'te' "eq'q'rg' " "VGE + OCp' "ko o gf k'c'v'g'f g'et'g'c'v'q' "qh'ck' "htqy' "v'go r gtcw'wtg' "cv'  
y'j ku' "o qo gpv' "k'pet'g'c'gu' "ku' "TJ " = "y' cvgt' "xcr qt "kp' "y'j g'ck' "t'gej gu' "ucw'v'k'v'k'p' "r q'kp'v. "cpf "eq'v'k'w'g'u' "v'q' "y'j g' "htqo c'v'k'p' "qh'  
eq'p'f g'p'uc'v'g. "y'j cv'v'j q'w'f "dg' "eq'ng'ev'g' "cpf "t'go q'x'g'f 0'

Vj g' "y' q'nt'ed'k'k'v' "qh'c' "r t'qr qu'g'f "o gy' qf "y' cu' "v'gungf " wukpi "eqo r w'cv'k'p'cn' h'w'k' "f { p'co leu' "EHF " + "u'q'hy' ctg' 0' Vj g'  
uko w'cv'k'p' "y' cu' r' g'htqo gf "cv' "h'q'ny' kpi "k'p'k'cn'r' c'tco g'v'gtu' "v'go r gtcw'wtg' "qh' "y'j g'ck' "ku'42.27' "AE. "TJ "ku'87' . "y'j g'ck' "r t'gu'wtg' "  
ku'323547' "Rc. "j g'cv'k'pn'v'go r gtcw'wtg' "ku'4.37' "AE. "y'j g'x'q'n'w'o g' "qh'c' "f t { kpi "ej co dgt "ku'2.2; 8' "o' . "v'q'v'cn'lu'ko w'cv'k'p' "v'ko g' "y' cu'32' "  
o k'p' "y' k'j "c' "u'gr /w' "qh'3' "o k'p'0'Vj g' "uko w'cv'k'p' "t'gu'w'u' "k'p' "y'j g' "htqo "qh'ew'r' "q'w'r' "t'gu'p'v'g'f "cv' "h'ki w'g'30'



Hki 030Rctco g'v'gtu' "qh'f t { kpi "ck' "kp'c' "ej co dgt "C' "o' "v'go r gtcw'wtg' "ej cpi g' "D' "o' "t'g'v'k'g' "j wo k'f' k'v' "ej cpi g'0'

Eq'nt'g'v'k'p' "qh' "TJ " "cpf "v'go r gtcw'wtg' "r' "q'w' "h'ki 03 + "f go q'p'ut'cv'gu' "y'j cv'v'j g' "TJ " "qh'ck' "ko o gf k'c'v'g' "t'gej gu'ku' "o czko wo "  
x'c'w'g' "y'j gp' "k'r' cu'gu' "y'j tqwi j "c' "eqf' "j g'cv'k'pn'ic'p' "u'v' { u'cv'v'j cv' "r'g'x'gr' "wp'v'v'v' "v'go r gtcw'wtg' "k'pet'g'c'gu' "v'q' "cr r tqzko c'v'g' "33' "AE'0'  
N'cv'gt. "k'i tcf w'cm' "f g'et'g'c'gu' "cu'v'go r gtcw'wtg' "t'k'gu' "OK' "o g'p'u' "y'j cv'v'j g' "r' "p'v'v'v' "o r ng' "v'q' "dg'f' t'kgf "uj q'w'f "dg' "h'q'cv'g'f "kp' "cp' "qr v'ko c'n'  
r q'uk'v'k'p' "d'gy' g'p' "c' "o k'p'o c'n' "TJ " "cpf "o czko c'n' "v'go r gtcw'wtg' "j p'p'g'0'

C'f'f' k'k'q'p'cm' . "k' "ku' "gu'g'p'v'kn' "v'q' "pq'v' "y'j cv' "TJ " "ej cpi g' "kp' "y'j g'ck' "u'w'g'co . "r cu'k'pi "y'j tqwi j "y'j g' "eqf' "j g'cv'k'pn'ic' "h'g'ew' "ku"  
v'go r gtcw'wtg' "Ej cpi g' "qh' "y'j g' "j g'cv'k'pn'v'go r gtcw'wtg' . "t'gs w'k'g'f "v'q' "k'p'f w'eg' "o q'ku'wtg' "eq'p'f g'p'uc'v'k'p' "o' "y'j g'f gy' r q'kp'v. "eq'w'f "ec'w'g'  
c'f' g'et'g'c'gu' "qh' "y'j g'f t { kpi "u'v'go "g'h'le'k'p'e { "0J k'j g' "t' "v'go r gtcw'wtg' "u'ny' u'f qy p' "y'j g' "eq'p'f g'p'uc'v'k'p' "r tqegu' . "v'q' "h'qy' "v'go r gtcw'wtg' "  
o c' { "r'g'cf "v'q' "k'eg' "htqo c'v'k'p' "qp' "y'j g' "j g'cv'k'pn'0' "O c'k'p'g'c'p'eg' "qh' "j k'j g' "u'v'go "g'h'le'k'p'e { "t'gs w'k'g' "r t'g'ek'g' "eq'p'v'q'n' "qh' "y'j g' "  
j g'cv'k'pn'v'go r gtcw'wtg' "cpf "ku' "u'gr q'kp'v'cf "lw'wo g'p'u' "c'ee'q'f k'pi "v'q' "q'v'j g' "u'v'go "r c'tco g'v'gtu' "OF g'h'p'k'k'p' "qh' "y'j g' "qr v'ko c'n' "t'cv'ku'  
d'gy' g'p' "r c'tco g'v'gtu' "c'h'g'ev'k'pi "u'v'go u' "g'h'le'k'p'e { "y' k'n'd'ge'qo g' "y'j g' "o c'k'p' "c'ko "h'q't' "h'w'v'j g' "t'g'ug'c'ej 0'

**Cempqy ngf i go gpv'**

Vj ku'r' t'ql'gev'j cu' "t'ge'g'k'x'g'f "h'w'p'f kpi "htqo "y'j g' "G'w'qr g'cp' "U'q'ek'n' "H'w'p'f "r' t'ql'gev' "p' q"2; 050NO V/M/934/44/24; 7 + "w'p'f g't"  
c'i t'cp'v'ci t'ggo gp'v'j k'j "y'j g' "T'g'ug'c'ej "E'q'w'p'ek'i' "qh' "N'k'j w'c'p'k' " "NO VNV-0'

J3\_Mgtt. "Y 0N0\*4235-0Hqf'f' t { kpi "cpf "G'x'cr q'v'k'p' "Rt'qeguukpi "Qr gtcv'k'p'u'0' "k'p' "J c'p'f "dq'q'ni' "h'k'c' "o . "F c'k' { "c'p'f "H'q'q' "O'c'ej k'p'g' { "G'pi k'p'g'g'k'pi "U'ge'q'p'f "  
G'f' k'k'p' "0j w'r u' "d'lf' q'k'q'ti B20238 ID: 9: /2/34/5: 7: : 3/: 02234/6"  
J4\_U'cd'ct'g'j . "J 0V0\*4237-0O q'f g'n'k'pi "qh'f t { kpi "r tqegu'gu' "h'q'f "h'q'f "o c'v'g't'k'n' "0'k'p' "O q'f g'k'p' "H'q'q' "Rt'qeguukpi "Qr gtcv'k'p'u'0'j w'r u' "d'lf' q'k'q'ti B20238 ID: 9: /  
3/9: 464/4: 6/802226/2"  
J5\_0\_Angt. "L0' " "J g'k'p'f n' "C0\*4229-0F t { kpi "qh' "O g'f le'k'p'cn' "R'c'p'u'0' "k'p' "O g'f le'k'p'cn'ic'p'f "C'tqo c'v'k' "R'c'p'u'0'j w'r u' "d'lf' q'k'q'ti B20229 B/6242/766; /3a39"

# RTQEGU'RCTCO GVG'T'KPHNWPEG'QP'UWTHCEG'TQWM J P GUU'QH' CFF KXGN' 'O CPWHCEVWTGF'UVCKP'NGUU'UVGGN'RCTVU'

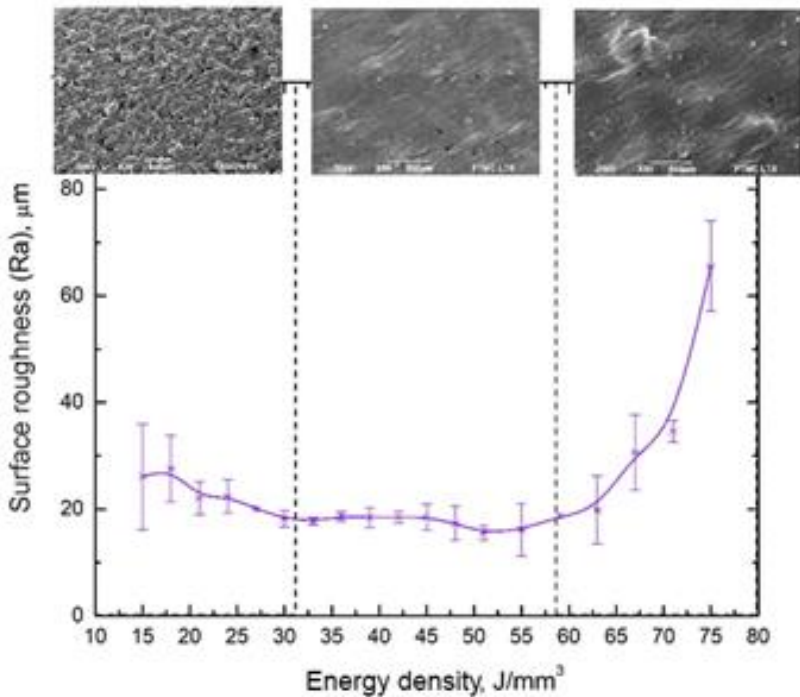
Cf c'Ugr qpcxk k v. 'Mctqrku'Utcxkpmæu. 'Cw-tc'Ugnukgp . 'I gptkmiO qtf cu'

F gr ctvo gpv'qh'Ncugt 'Vgej pqrqi kgu. 'Egpyt 'hqt 'Rj { ulecn'Uelgpegu'cpf "Vgej pqrqi { . 'Nkj wcpkc"  
cf c'Ugr qpcxk k w g B h o e h v'

Cf f kxg"o cpwhcewtkpi " \*CO + "ku" c" o cpwhcewtkpi " vgej pqrqi { " wugf " hqt " 5F " qdlgev" r tqf wevkqp" y j kej " qr gpu" c" r cvj y c { "vq" hcdtlecvg" eqo r rnz " r ctvu" f wv" vq" vj g" j ki j " i gqo gvtlecn' hgz kdkkx { "qh" vj g" vgej pqrqi { " j3\_0'F kt gev" O gvcn' Ncugt " Ukpvtkpi " \*FO NU+ "ku" qpg" qh" vj g" o quv" y kf gn { "cr r rkgf " o gvcn' CO " vgej pqrqi kgu. " y j gtg. " kp" c" r { gt/ d / r { gt " hcu j kqp. " d wmi" r ctvu" ctg" etgcvgf " d { " ugrgevkxg" ukpvtkpi " cpf " eqpuqnf cvkqp" qh" vj kp" r qy f gt" r { gt u" wukpi " c" r cugt " dgco " j4\_0'F O NU" ecp" dg" wugf " hqt " r ctv" hcdtlecvg" wukpi " f khtgtpv" o gvcn' cpf " vj gk" cmq { uO' Cnj qwi j " kqp" cpf " ku" cmq { u" j cxg" dggp" wugf " kp" eqpxgp vkp cn' o cpwhcewtkpi " hqt" c" r rpi " vko g" cpf " vj g" o quv' cf xcpvi gu" cpf " f kucf xcpvi gu" qh" vj g" o cvgtkcu" ctg" y gmi" npqy p. " wukpi " vj go " kp" cf f kxg" o cpwhcewtkpi " vq" cej kxg" j ki j " s wrkx { " ukn' ecp" dg" r tqdrgo cvkeO' kp" FO NU. " vj g" o clp" ej cmppi g" ku" vq" wpf gtucpf " vj g" kphwpege" qh" gpgti { " f gpukx { " qp" r qtqukx { . " o letqutwewt g" cpf " o gej cplecn' r tqf gt vku" qh" c" o cpwhcewtgf " r ctv' }

Kp" vj ku" uwf { . " vgu" ur geko gpu" y gtg" r tqf wegf " hqt" o " 39/6RJ " uckprguu" uvgn' wukpi " f khtgtpv" ugv" qh' d wkf " r ctco gvgtu" qp" vj g" GQUK V" O 4: 2" o cej kpg" kp" qtf gt" vq" f vgtgo kpg" vj g" kphwpege" qh" f khtgtpv" r tqegu" r ctco gvgtu" cpf " ur geko gp" r qukkqplkpi " qp" ur geko gp" uwthceg" s wrkx { O' C" uv' nuu" r tqhktg" y cu" wugf " kp" vj g" uwf { " vq" f vgtgo kpg" vj g" tgrvkqp" dgw ggp" ur geko gp" r qukkqplkpi " qp" vj g" d wkf " r r vhtqto " f wtkpi " vj g" r tkvki " r tqegu" cpf " vj g" uwthceg" tqwi j pguu" qh' r tkpvgf " qdlgevuO' Vq" dgwgt " wpf gtucpf " y j cv' ecwugu" f khtgtpv" uwthceg" tqwi j pguu" kp" ur geko gpu" r tqf wegf " y kj " xctkqu" xqno gtle" gpgti { " f gpukx { " xcnwgu. " etqu/ ugevkp cn' o letqutwewt g" qh" vj g" o cpwhcewtgf " ur geko gpu" y cu" kpxguki cvgf " wukpi " uecpplkpi " grgevtqp" o letqueqr { " \*UGO + " cpf " qr vlecn' o letqueqr { " cpf " f ghgevu" xkukdrg" kp" etqu/ ugevkp u" y gtg" gxcnwcvgf " y kj " j gn" qh" ko ci g" r tqeguulpi " uqhwy ctgO' }

Tguwuu" j cxg" uj qy p" vj cv' vj g" dguv' uwthceg" s wrkx { " ecp" dg" cej kxg" f " y j gp" vj g" gpgti { " f gpukx { " xcnwgu" f wtkpi " vj g" o cpwhcewtkpi " r tqegu" ctg" hqt" o " 6: " vq" 87" Lko o 5OJ gy gxt. " qpn { " cr r n' kpi " egtvclp" gpgti { " f gpukx { " ku" pqv' uwthcekgp" v' cpf " uwthceg" s wrkx { " f khtgu" f gr gpf kpi " qp" vj g" uwthcegau" r qukkqplkpi " qp" vj g" d wkf kpi " r r vhtqto 0



Hki 0'30' kphwpege" qh' xqno gtle" gpgti { " f gpukx { " qp" ur geko gp" uwthceg" tqwi j pguu" }

j3\_ "NOJ kj rgt. " O O' O gtmgr' gv' crf" C" Tgxkgy " qh" O gvcn' Hcdtlecvg" y kj " Ncugt/ " cpf " Rqy f gt/ Dgf " Dcugf " Cf f kxg" O cpwhcewtkpi " Vgej pls wgu- <Rt qegu" P qo gpe: wtg " O cvgtkcu. " Cej kxg" edng" Rtqr gt vku" cpf " ku" Wkik cvkqp" kp" vj g" O gf lecn' Ugevqt. " Cf xcpgef " Gpi kpggtkpi " O cvgtkcu" Xqno g" 42. " Kuw g" 7" \*423: 40

j4\_ "D0' Uqpi . " UOF qpi " gv' crf" O letqutwewt g" cpf " vgpukg" r tqf gt vku" qh' kqp" r ctvu" hcdtlecvg" d { " ugrgevkxg" r cugt " o gmi kpi . " Qr vleu" ( " Ncugt" Vgej pqrqi { " 78. " 673/682" \*4236-40

# EXPERIMENTAL RESEARCH OF FORCE/PRESSURE SENSOR STATIC AND DYNAMIC ACCURACY AND REPEATABILITY

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The progress observed in 'soft robotics' brought some promising research in flexible tactile, pressure and force sensors, which can be based on polymeric composite materials. Therefore, in this paper, we intend to evaluate the characteristics of a force-sensitive material – polyethylene-carbon composite (Velostat®) by implementing this material into the design of the flexible tactile sensor [1].

Velostat® is a composite polymer material consisting of carbon-impregnated polyethylene. Entrapped carbon powder turns initially dielectric polyethylene into electrically conducting composite material which belongs to the group of piezoresistive materials. Simply speaking by applying force or pressure on this material, its resistance is changed.

The main problem is an insufficiency of research of Velostat®, in order to successfully predict its reaction to particular mechanical irritation and therefore implement it as a reliable sensor in a mechatronic system.

During the research, the velostat® film was placed between two conductive copper electrodes which allowed to measure the resistance of the material in respect of time and evaluate sensors' dynamic response.

Dynamic load acting on the sensor's upper surface was created using a motor carrying an eccentric load (Fig. 1). By changing the mass and adjusting the loading fixture offset from motor shaft different magnitude mechanical loads were exerted. The loading frequency was controlled by the stepper motor's varying rotation speed.

From the Fig. 1 you can observe a velostat® film (1) being placed between two conductive strips (2), to connect it to measuring device, placed between a lower (3) and upper (4) plates to hold it in place. The upper plate is represented transparent, in order to show the interconnection between the elements. The upper plate is firmly connected to the motor (5), which is going to create an eccentric load for force-sensitive material. On the shaft of the motor a pulley (6) with slots is mounted, in order to allow attachment and adjustment of different weights making testing device more versatile also an accelerometer (7) is joined with the upper plate to monitor the magnitude of excited force and create a closed-loop system.

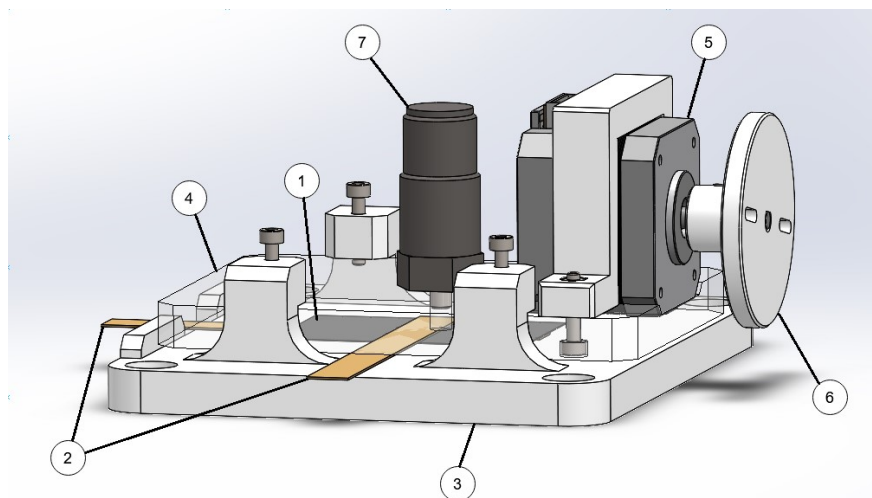


Fig. 1. Testing device scheme: 1 - Velostat® film, 2 - conductive strip, 3 – bottom plate, 4 – upper plate, 5 – electric motor, 6 – pulley, 7 - accelerometer

When the experiment is carried out, data is obtained and saved on the memory device. Correlation between frequency and amplitude of applied dynamic load and change in resistance of velostat® defines how precisely sensor can react to varying load. Obtained data allows defining the sensor's main dynamic characteristics such as response time and bandwidth.

After result evaluation, precise velostat® reaction is established, promoting the further implementation of force-sensitive material into "soft robotics" applications.

## Acknowledgement

This project has received funding from the European Social Fund (project No 09.3.3.-LMT-K-712-22-0328) under a grant agreement with the Research Council of Lithuania (LMTLT).

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# OPTICALLY 3D PRINTED SCAFFOLDS: BIOCOMPATIBILITY EVALUATION AND IMPROVEMENT

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The manipulation of biological tissues, including their growth or regeneration is a very promising field. However, most of the current researches are *in vivo* or based on the biological tissue or organ sample donations that in most cases causes a discomfort for the patient. Therefore the development of micro/nano bioscaffolds is a successful alternative for the manipulation and growth of the biological samples *in vitro*.

In this study we analyse two types of commercial stereolithography 3D printers: Ember (Autodesk) and Asiga PICO 2 UV DLP and their abilities for printing bioscaffolds. The concept is based on the articles by Grigalevičiūtė [1] and Hart [2]. The authors of these articles present studies of the biocompatibility of printed structures with cells in the case of various widely used resins. It is also well known that bio-based resin can be used in 3D printing [3, 4] so there is a possibility to print any wanted biocompatible 3D geometry with a resolution of a few nanometers and this leads to accurate organs engineering. Methods for increasing biocompatibility in the following ways are also discussed: treatment with IPA (isopropyl alcohol), UV, thermal baking, autoclaving and coating with another material. All these steps are shown in Fig. 1

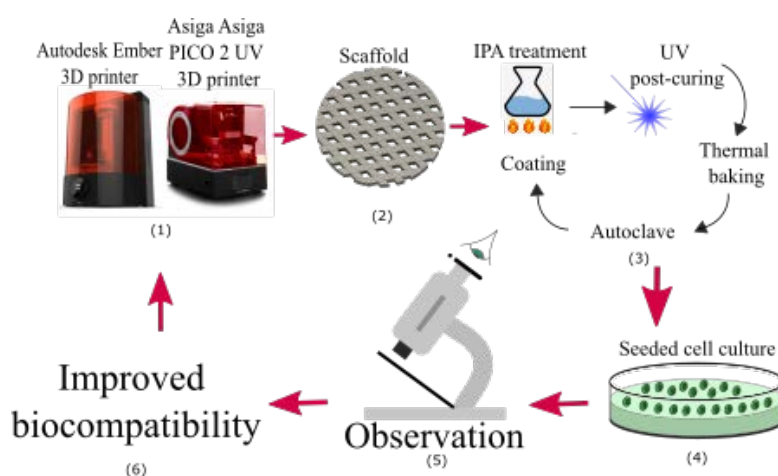


Fig. 1. Iteration steps of the proposed experiment: (1) Asiga PICO 2 UV digital light processing (DLP) 3D printer and Ember (Autodesk) 3D printer. (2) Scaffold, that can be printed from many commercial and bio-based resins. (3) Scaffold post-processing stages. (4) Samples, seeded with adult-organism derived stem cells and tested for biocompatibility (cell adhesion (integration), cell proliferation and differentiation capabilities). (5) Discussion of the results and conclusions. Knowing what went wrong and which parts of the experiment succeeded, we repeat the experiment again with new ideas

Based on the results obtained in previously mentioned articles it can be seen that Formlabs Clear and Flexible resins showed the best biocompatibility results. Taking into account the results obtained by Grigalevičiūtė, it is promising to achieve even better compatibility by changing the geometrical parameters of the scaffold (pore size, shape and porosity). Since cells die mostly in the middle of the scaffolds due to the pure leaching of monomers, changing of their geometry (making it with a higher resolution or creating a different geometric structures in the middle compared to the edges of the scaffold) might lead to even more biocompatible scaffolds. Various post-processing methods have also shown that the use of PDMS coating alone has greatly increased a biocompatibility. It would also be useful to try coating with other materials or even with several of them.

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# IPHNWGP EG'QH HOGT'E QP VGP V'QP 'VJ G'DGP F KPI 'UVKHP GUU'QH' HWP EVKQPCN'VGZVKNGU'

P qtkpc'Cuhepf. "Xkti kpkc'F cwnepvkpp "

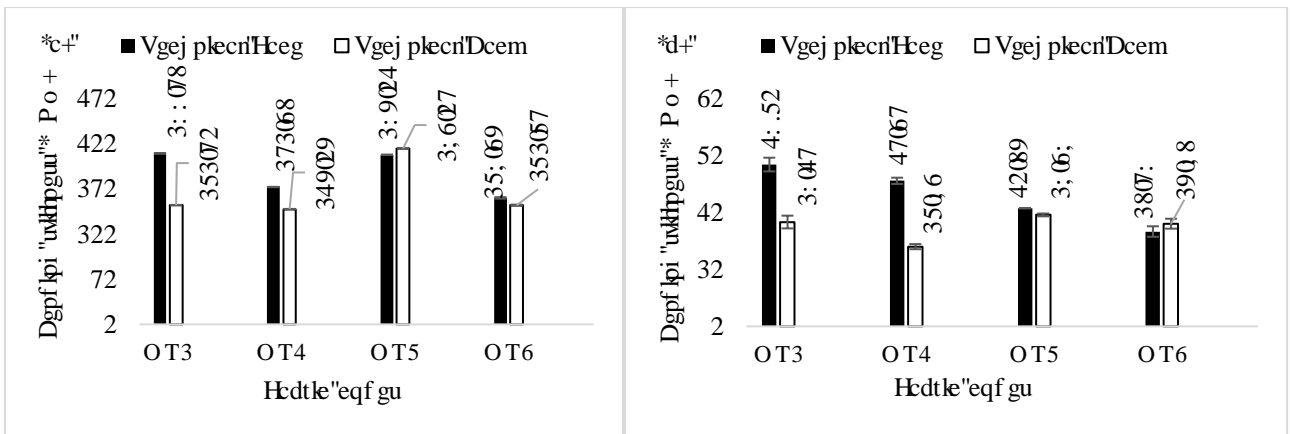
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[pqtkpc@uhepf B mwqf w'](#)

Mpkwgf 'hcdtleu'ctg'r tghgtgf 'hqt'eqv'j kpi 'f wg'v'j gk'q'wuxcpf kpi 'eqo hqt'0Mpkwgf 'hcdtleu'hgcwtkpi 'y kj 'y g'cpvkucvle " r tqr gtv'gu'ctg'lpetgculpi n' "wugf "hqt'uo ctv'vz'vkg"cr r decv'kpu'f wg'v'j gk'hzkdng'pcwtg"]3\_0P qy cf c{ u'npkwgf "hcdtleu" ctg'cuq'y kf gn' "wugf "hqt'eqo r quks'go cvgtkcu'cr r rkgf "lp'cwqo qv'xg'gpi kpggtkpi . 'lp'ekxki'gpi kpggtkpi . 'gve0]4\_00 gej cplecni' r tqr gtv'gu'qh'npkwgf 'hcdtleu'ctg'j ki j n' "lo r qt'v'p'v'j gp'ej qqukpi "o quv' "uwxkdng'qpg'hqt'c'r ct'v'w'ct'cr r decv'kpp0"

3 3'tld'npkwgf 'hcdtleu'y g'g'f g'x'g'g'f "d{ "wukpi "y g" {ctpu'qh'hq'w'f k'htg'gpv'dngpf 'tcv'qu'qh'eqw'p'hcdtleu'cpf "cpvkucvle" hcdtleu' b cf g'htqo 'f qn' g'v'gt'eqp'v'k'p'pi 'ectd'q'p'f ct'v'eng'0'hcdtleu'dngpf 'tcv'qu'p'v'j g'wugf " {ctpu'y g'g'v'j g'ug-> ; 2" "eqw'qp'132" " cpvkucvle" r qn' g'v'gt." : 2" "eqw'qp'142" "cpvkucvle" r qn' g'v'gt." 92" "eqw'qp'152" "cpvkucvle" r qn' g'v'gt." cpf " 87" "eqw'qp'157" "cpvkucvle" r qn' g'v'gt'0C"hm'f "cwqo cvle" h'c'v'npkwkpi "o cej kpg"0 CVUW C/O 322"y kj "36"i cwi g'y cu" wugf "hqt'uco r ng'f g'x'g'g'g' o gp'0'Vj k'ep'gu'qh'cm'j' g'lp'x'g'uki cv'gf "hcdtleu'tcpi g'f "y kj k'p'v'j g'iko ku'qh'30 9-30 2"o o . 'y crg" f gp'ukv{ "-3608-370 "eo /3 . 'cpf "eqw'ug'f gp'ukv{ "-3208-3308"eo /30'Vj g'ug'v'w'w'w'g'ej ct'ce'v'gt'k'v'k'eu'y g'g'f g'v'gt'o k'p'gf "ceeq'tf k'p' " v'j g'v'cpf ctf u'NUV'KUQ"72: 6"cpf "NUV'GP"36; 93. "t'gur g'v'x'gn'0'Ctgc'f gp'ukv{ "y "qh'v'j g'v'g'v'gf "hcdtleu'y cu'f g'v'gt'o k'p'gf " ceeq'tf k'p' "v'j g'v'cpf ctf "NUV'GP"343490'Vj g'ctgc'f gp'ukv'g'v'j g'lp'x'g'uki cv'gf "vgz'v'kg'u'y g'g'7; : 'i b 4"ht'0 T3'hcdtle." 79: 'i b 4"ht'0 T4'hcdtle."788'i b 4"ht'0 T5'hcdtle."cpf "733'i b 4"ht'0 T6'hcdtle'0'Dgp'f k'p' "r'g'pi v'j u'N'qh'72x372"o o " t'ge'v'pi w'ct"ur g'eko gp'u'ew'htqo "y g'lp'x'g'uki cv'gf "npkwgf "hcdtleu'y g'g'o g'cu'w'g'f "cr r n' k'p' "c"ecp'v'k'x'g't"o g'v'j q'f "y kj "y g' HCUV/4"dgp'f k'p' "o g'v'gt'0'hcdtle"dgp'f k'p' "u'k'ht'p'guu'D'y cu'ec'v'w'v'g'f "d{ "wukpi "Gs 0\*3+<

D?y "e<sup>5</sup> "; 0 3 32,6"" " " " " \*3+ "

y j g'g'D'o'dgp'f k'p' "u'k'ht'p'guu." P o =y "o'ctgc'f gp'ukv{ . 'i b 4"=e"o'j c'ht'q'h'dgp'f k'p' "r'g'pi v'j "N'qh'v'j g'v'g'v'gf "ur g'eko gp."o o 0'



Hki 030Dgp'f k'p' "u'k'ht'p'guu'qh'3 3'tld'npkwgf 'hcdtleu'lp'y crg'f k'g'v'k'p' \*c+'cpf "eqw'ug'f k'g'v'k'p' \*d+0'

Dgp'f k'p' "u'k'ht'p'guu'qh'3 3'tld'npkwgf 'hcdtleu'y cu'ht'wp'f "uki p'k'hec'p'v' "j ki j g't'lp'hcdtle'y crg'f k'g'v'k'p' \*Hki 03. 'c+'v'j cp'lp' " eqw'ug'f k'g'v'k'p' \*Hki 03. 'd+ : 'u'w' r qu'g' n' . 'f wg'v'j g'j ki j g't' hcdtle'f gp'ukv{ 'lp'y crg'f k'g'v'k'p' 'lp'hw'g'p'k'pi "ku'j ki j g't'ec' r cdk'v' " v'j y kj u'cp'f "y g'v'w'g'0'C" f g'et'g'c'ulpi "v'g'p'f g'p' { "qh'v'j g'dgp'f k'p' "u'k'ht'p'guu'qh'v'j g'lp'x'g'uki cv'gf "3 3'tld'npkwgf 'hcdtleu'y cu' t'g'v'gf "y kj "y g'f g'et'g'c'ug'lp'v'j g't'ctgc'f gp'ukv'g'j5 "cu'y g'm'cu'y kj "y g'lp'et'g'c'ug'lp'v'j g'cpvkucvle" r qn' g'v'gt' r g'teg'p'v'ci g'lp' " hcdtle'v'w'w'g'g'ur g'ek'm' "hqt'0 T5'cp'f "0 T6'npkwgf 'hcdtleu'j6\_0'

Y j gp' "u'w'o c'tk' k'p' "w' "y g't'g'ug'ctej "t'g'u'w'u "k' "ecp" dg'ug'gp' "v'j cv'v'j g'dgp'f k'p' "u'k'ht'p'guu'qh'npkwgf "hcdtle"ku'j ki j n' " f gr gp'f gp'v'q' "y g'hcdtle'f k'g'v'k'p'0'Ctgc'f gp'ukv{ "qh'v'j g'lp'x'g'uki cv'gf "npkwgf "hcdtleu"o c'ng'u'uki p'k'hec'p'v'lp'hw'g'peg"cu'y g'n0' J ki j g't' r g'teg'p'v'ci g'qh'v'j g'cpvkucvle" r qn' g'v'gt' "hcdtleu'lp'hcdtle'v'w'w'g'lp'hw'g'pegu"ku'ht'y g't' "u'k'ht'p'guu'0'

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 [6\_] C0'V'g'ni'k'c'p'f "P 0' | f k'n'G'ht'g'v'q'ht'g'e {eng'f "RGV'hcdtleu'q'p'v'j g't'g'ht'q'o c'p'eg'r t'qr g't'v'gu'qh'npkwgf 'hcdtleu' . 'L'q'w't'p'c'ni'qh'G'pi k'p'g'g't'f "hcdtleu'cp'f "hcdtleu'32. " 69682" \*4237+0'



P3-21

DID NOT PARTICIPATE

**5F 'RTK VGF 'J [ FTQZ[ CRCVK'G'6'RTQRGT VKGU'CPF 'CRRNKE CVKQP U'  
CU'UECHQNF 'O CVGT KCN'HQT'DQP G'TGI GP GT CVKQP "**

**Unto cpvcu'P qtmw<sup>3.5</sup>. 'Quxcrf cu'I twd {u<sup>4.5</sup>. 'Uko qpc'Tewi crckv<sup>4.5</sup>. 'Dtli kc'Cdcngxk lgp<sup>4</sup>. "  
Tco pcu'Xcrkqncu<sup>3</sup>"**

<sup>3</sup>Egpgt'hqt'Rj {ulecn'Uelpegu'cpf'Vgej pqrqi {.'Ucwn vgnk'cxg05.'NV/32479.'Xkpkwu.'Nkj wcpk'''

<sup>4</sup>F gr ctvo gpv'qh'Rj {uleu.'Mcwpcu'Wpkxgtuk'qh'Vgej pqrqi {.'Uwf gpv.'ut072.'NV/7358:.'Mcwpcu.'Nkj wcpk'''

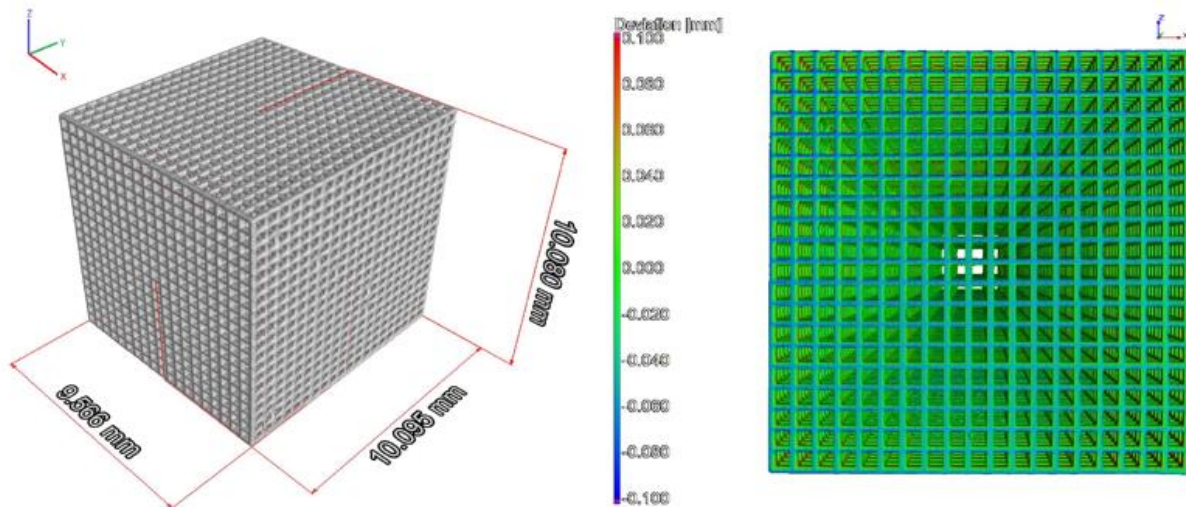
<sup>5</sup>Qtvj q'Denke.'Vcknu'cxg0353C.'NV/73346.'Mcwpcu.'Nkj wcpk'''

**unto cpvcu'pqtmb hxo ehu'**

"

Tgegpw' dppg'i tchu'j cxg'dggp' lpetgculpi n' wugf 'ctqwpf 'y g'y qtrf 0'Dppg'i tchm'pi 'htgs wpe { 'ku'lpf ggf 'y g'ugeqpf '' o quv'htgs wgpv'vkuw'g' t'cpur'ncv'kqp'y qtrf y kf g.'eqo kpi 'tli j v'chgt' dmqf "t'cpuhwukpp"]3\_0'Qxgt'y q" o knkqp' uwti kecn' uwti g'kgu'ctg'r gthqto gf 'r gt '{ gct'v'v'gcvd'ppg'vkuw'g'f ghgeu']3/4\_0'Dppg'vkuw'g'f ghgeu'ht'gt 'y' cp'6/8'eo 'ctg'etk'lecn'cpf'' u'j qwf "dg'v'gcvf' y kj "dppg'i tchu"]4\_0'Etk'lecn'uk'gf "f ghgeu'ecp'dg'eqpi gpkcn'qt' hqto gf "f w'g'v'q' t'cwo c." wo qwtu." kphge'v'kpu.'cpf'f'kugcugu'uwej'cu'quv'qr'qt'quku.'pget'quku.'qt'dppg'cvt'qr'j {"j3\_0'Hqwt'o c'k'p'v'r'gu'qh'dppg'i tchm'pi 'ctg'wugf 'v'g' v'gc'v'dppg'vkuw'g'f ghgeu'c'w'qrqi'qwu.'cmqi'g'p'gle."z'g'p'qi'g'p'gle.'cmqr'ruwe'0C'w'qrqi'qwu'dppg'ku'ewt'gpw'f'eqp'kf'gt'gf' 'y' g' o'i' qif'0'uc'p'f'ctf' hqt'v'gcv'kpi 'dppg'vkuw'g'f ghgeu']3.5\_0J'qy'g'x'gt.'o' q'g'c'p'f'v'q' o'q'g'c'w'g'p'v'k'p'ku'r'ck'f'v'q'c'mqr'ruwe'v'dppg'i' tch'v' o'cv'g't'k'cu.'cu'y'g'w'ug'qh'y'g'ug'dppg'i tchu'eqwf'uko'r'nh'f'qr'g'c'v'k'p'u'c'p'f'c'x'q'k'f'v'g'v'g'v'q'u'v'eqo'o'q'p'eqo'r'k'ec'v'k'p'u']3.5\_0V'j'g' o'cl'q't'c'f'x'c'p'v'ci'gu'qh'cmqr'ruwe'o'cv'g't'k'cu'k'p'en'f'g'y'g't'j'k'j'c'd'w'p'f'c'p'eg't'g'c'v'k'g'v'q'p'c'w'c'ri'o'cv'g't'k'cu.'p'q't'k'ni'q'h'f'k'ug'c'ug'v'c'p'uo'k'u'k'p'c'p'f'v'g'x'gt'f' {h'qy'c'p'v'k'g'p'le'k'f'0V'j'g'f'c'p'v'd'g'o'c'f'g'c'x'c'k'c'd'ng'p'v'd'q'v'j'g'u'g'q't'd'c'd'ng'c'p'f'p'p'p'g'u'g'q't'd'c'd'ng' h'qto'u.'c'p'f' e'c'p'd'g'ew'v'q'o'k'gf' 'y' kj 'x'c't'f'k'p'i' h'g'x'g'u'q'h'r'q't'q'u'k'f'c'p'f'v'q't'g'v'k'g'g'u']6\_0

Vj g'o c'k'p'q'd'l'g'e'v'k'g'q'h'y'k'u'uwf' { "y'cu'v'q'r' t'k'p'v'j' { f't'z' { c'r'c'v'k'g'\*J' C+'uech'q'f'u'q'h'eqo'r'ngz'i'g'q'o'g't' { "y'cv'eqwf'' r'q'v'p'v'k'm'f' "dg'wugf'v'q'h'k'i'd'ppg'f'ghgeu'0'Q'p'g'q'h'y'g'y'qtrf'u'r'v'g'u'5F'egtco'le'r' t'k'p'v'k'p'i'v'gej'pqrqi'k'g'u'NO'E"\*N'k'j'q'i't'c'r'j'// d'c'ug'f' "egtco'le'o'c'p'w'v'ew't'g+'y'cu'wugf'hqt'r' t'k'p'v'k'p'i' "j' { f't'z' { c'r'c'v'k'g'uech'q'f'u'0'W'uk'p'i' "y'k'u'v'gej'pqrqi' { "y'g'r'q'f'w'e'v'k'p'q'h' r' t'k'p'v'g'f' "j' { f't'z' { c'r'c'v'k'g'uech'q'f'u'g'u'g'p'v'k'm'f' "eq'p'uk'u'q'h'y'q'o'c'k'p'r'c't'w'5F'r' t'k'p'v'k'p'i' "c'p'f' "j'g'c'v'v'g'c'w'o'g'p'v'0'V'j'g'i'g'q'o'g't' { "q'h' y'g'r' t'k'p'v'g'f' "J' C'g'z'r'g't'k'o'g'p'v'c'n'l'r'g'el'o'g'p'u'v'g'g'f'k'i' 03+'uech'q'f'u'r'q't'q'u'k'f'.uech'q'f'u'r'q't'g'v'k'g'c'p'f'v'q'c'v'g't'k'c'n'f'g'p'u'k'f' h'm'w'e'v'k'p'u' y'g't'g'c'p'c'n'f'ug'f'w'uk'p'i'lp'f'w'ut'k'c'n'f'eqo'r'w'g'f'v'q'o'q'i't'c'r'j' { "\*"UE'V+0'k'p'q't'f'g'v'q'c'p'c'n'f'ug'v'j'g'v'w'w'e'v'c'n'l'r'q'r'g'v'k'g'u'q'h'J' C'v'c'o'r'ng'u' u'w'f'k'g'u'y'g't'g'r'g't'h'q't'o'g'f'w'uk'p'i'Z/tc'f'f'k'h't'c'e'v'k'p' "\*"Z' T'F+'c'p'c'n'f'uk'u'c'p'f' "H'q'w'k'g't'v'c'p'uh'q't'o' "k'p'h't'c't'g'f' "ur'g'e'v'q'ue'q'r' { "\*"H'V'K'v' "c'p'c'n'f'uk'u'0'V'j'g'v'w'w'k'c'g'v'q'r'q'i't'c'r'j' { "c'p'f' "t'q'w'i'j'g'u'v'q'h'J' C'v'c'o'r'ng'u'y'g't'g'c'p'c'n'f'ug'f'w'uk'p'i' "q'r'v'c'e'n'l'r'q'h'k'q'o'g't' { 0"



Hki 0300 letq'eqo'r'w'g'f'v'q'o'q'i't'c'r'j' { "\*"UE'V+'v'g'c'w'v'g'o'g'p'v'0'V'j'g'eq'ni'q'v'u'o'c'r' "lj'q'y'v'j'g'f'g'x'k'v'k'p'q'h'y'g'r' t'k'p'v'g'f' "J' C'uech'q'f'u' h'qto'v'j'g'f'g'u'k'i'p'g'f' "UVN'o'q'f'g'r'0

Dcugf' "qp'v'j'g'c'p'c'n'f'uk'u'q'h'y'g't'g'u'w'u'c'p'f' "eqo'r'c't'k'p'p'q'h'y'g'q'd'v'c'k'p'g'f' "t'g'u'w'u'y'k'j' "y'g'x'c'm'g'u'q'w'p'f' "k'p'v'j'g'v'el'g'p'v'k'k'e' "r'k'g't'c'w't'g'cu'y'g'm'ic'u'v'j'g't'gs'w't'g'o'g'p'u'hqt'dppg'i' tchu'lp'o'gf'k'el'k'p'g.'k'v'ec'p'dg'uc'v'g'f'v'j'c'v'r' t'k'p'v'g'f' "J' C'uech'q'f'u'j'cx'g'c'i'v'g'c'v' r'q'v'p'v'k'c'n'v'q'dg'wugf'cu'v'f'p'j'g'v'e'd'ppg'i' tchu'lp'v'j'g'p'g'c't'h'm'w'w'g'o'

- j3\_Eco r'c'p'c.'X0'O'k'p'p'q.'I'0'R'c'i'c'p'q.'G0'D'c't'd'c.'O'0'E'k'el'p'p'g.'E'0'U'c'n'p'p'c.'I'0'y' "N'q'i't'q'ue'p'q.'I'0\*4236-0'D'p'p'g'u'd'w'v'k'w'w'g'u'k'p'q't'v'j'q'r'c'g'f'k'e'v'w't'i'g't' {<h'q'o' " d'c'ule'v'el'k'p'eg'v'q'er'k'p'c'n'l'r'c'e'v'k'g'0'l'q'w'p'c'n'l'q'h'0'c'v'g't'k'c'n'l'U'el'k'p'eg'g'0'c'v'g't'k'c'n'l'k'p'0'g'f'k'el'k'p'g.'47\*32+.'4667646830f'q'k'320B229'k'32:78/236/7462/4"
- j4\_J'k'z'q'p.'M0T0'G'd'g't'k'p.'E'0V0'M'c'f'c'k'c'k.'R0W0'O'e'D't'k'g'I'c'i' {k'U'0J'0'l'c'p.'G0'y' "U'g'm'U'0C'0\*4238-0C' "eqo'r'c't'k'p'p'q'h'et'q'i'g'r'v'el'c'h'q'f'u'v'q'k'f'g'p'v'k'f' "c'p'c'r'r'q'r'k'c'v'g' "u't'v'ew't'g' "h'q'i' "r'q'o'q'v'k'p'i' "d'p'p'g' "t'g'i'g'p'g't'c'v'k'p'0'D'k'q'o'g'f'k'c'n'l'R'j' {uleu' ( "G'p'i'k'p'g'g't'k'p'i' "G'z'r't'g'u'u' "4\*5+ "2572360'f'q'k'320B2: :4279/3;98445I257236"
- j5\_J'g'p'n'g' "l0'Y'q'q'f't'w'h'0'0C0'G'r'c't'k'F'0T0'U'g'em'T0'I'c'w'X'0'F'k'en'p'u'q.'k0E'0'y' "J'w'o'c'ej'g't.'F'0Y'0\*4235-0'D'p'p'g'G't'g'i'g'p'g't'c'v'k'p'p'D'c'ug'f' "q'p'v'k'w'w'g' "G'p'i'k'p'g'g't'k'p'i' "E'q'p'eg'r'v'k'p'u'0' "C'43u'v'E'g'p'w'f' { "R'g't'ur'g'e'v'k'g'0'D'p'p'g' "T'g'ug't'ej' .3\*5+.'438646:0f'q'k'320B46: 'k'it'423525224"
- j6\_U'j'g'k'v'j' "\' 0'U'o'c.'E'0' ( "I'q'i'c'w'g't.' "O'0' \*4237-0'D'p'p'g' "T'g'r'w'eg'o'g'p'v'0'c'v'g't'k'c'n'l'c'p'f' "V'gej'p'l's'w'g'u' "W'ug'f' "h'q'i' "C'ej'k'g'x'k'p'i' "X'g't'v'c'e'n'l'r' "C'r'x'q'q'r't' "D'p'p'g' "C'w'i'o'g'p'v'c'v'k'p'00'c'v'g't'k'c'n'l' : \*8+4; 7564; : 50f'q'k'320B5; 2'b'c: 284; 75"

# TGEQO DHP CVKQP 'QHEJ CTI G'ECTTKGTU'KP 'DWNM' J GVGTLQWPEVKQP 'UQNCT 'EGNNU'

Tqo wcrf cu'Lqpcu' gr cu<sup>3</sup>. 'Nwnu' Mwnwru<sup>3</sup>. 'I { ku'Lw-nc<sup>3</sup>. 'Mtkuklqpcu'I gpgxk kwu<sup>3</sup>'''

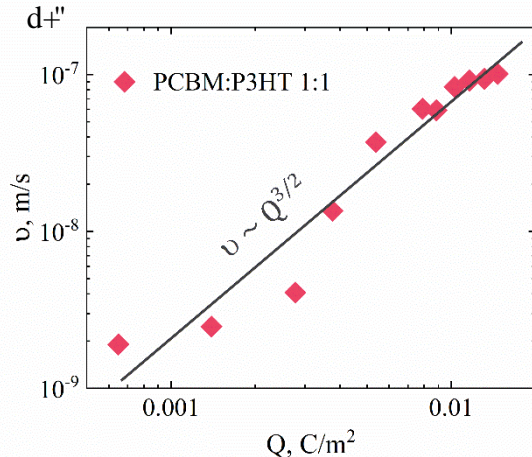
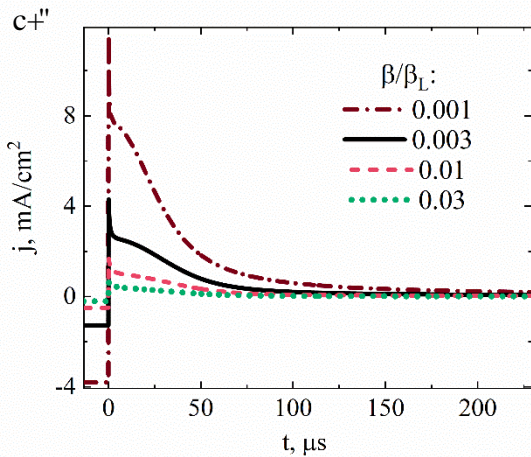
'''kpukwg'qh'Ej go lecn'Rj { uku.'Xkpkwu'Wpkxgtuk{. 'Nkj wpcle'  
tqo wcrf cu'gr cuB Hfkw0v'

Qti cple'uqnt'egmu'QUEu+j' cxg'cwtcevgf 'c'y kf g'ur tgc'f 'cwgpvkqp'lp'vj g'r cu'f gecf gu'f wg'v'q'vj gk'wpls wg'cf xcpvcu' gu' qh'riki j v'y gli j v.'hgzklkkl' { 'cpf' 'uqmwkqp r tqeguudklkkl'. 'y j lej 'gpcdr'u'ny 'equ'cpf' 'c'r qvqpcn'ht'rti' c' g'ctgc' hcdt'kcvkqp0 C' 'o clqt' 'cpf' 'wpuqrgf' 'r tqdrgo 'y kj 'qti cple' dwnm'j gvgtlwpevkqp' \*DJ L'f g'xlegu'tgo cku'vj g'qr wo k' cvkqp'qh'vj g'pgy qtni' o qtr j qmi { '0'k'f' i' gpgtcn' 'kpetgculpi 'y g'utwewt'cn'q'f' g' 'qh'vj g'DJ L'ku'f' guk'cdrg'cu'kw'lo r tqxgu'ej cti g'ecttkgt' 'o qdklkkl' 'cpf' "gz'w'cvkqp0"

Nqy 'o qdklkkl' 'qti cple' 'o cvgtkcu'gzj kdk'Ncpi g'xlp'v' r g'tgeqo dlp'cvkqp. 'dwl'p' dwnm'j gvgtlwpevkqp'u'tgf wegf 'Ncpi g'xlp' tgeqo dlp'cvkqp'ku'qdugt'xgf "j3\_ "d'gecwag'qh'vj g'p'cpqo qtr j qmi { "qh'vj g'lp'vgr gpgw'cvkpi "pgy qtni'qh'f' q'pqt' 'cpf' "ceegr vq' " o cvgtkcu'OT'gf wegf 'tgeqo dlp'cvkqp'ku'ut'qpi n' 't'gr qpukdng' "i j 'r' g'htqo c'peg'qh'uqnt'egm'ic'pf' 'ej cti g'vj cv'ecp'dg'gz'w'cevgf " Htqo 'y g'f' g'xleg' \*Hki B' \*c+0'Wuci g'q'ht' tqr g't' r' tqeguulpi 'uq'x'gpv'cpf' 'cf' f' k'k'x'gu. 'uwej 'cu'30 /f' k'q'f' k'q'q'ec'p'g' \*F IQ'+ku'c'hp'qy' p' " o g'v' qf' "v'q' h'w'v'j g't' g'pj' c'peg'f' g'xleg' g'h'k'el'g'p'e' { "j4\_0'cnj' q'w'j. 'y j g'o qu'v'r' q'r' w'ct' r' tqeguulpi "eqo dlp'cvkqp'qh'ej' r'qt'q'd'g'p' g'p'g' \*ED'+uq'x'gpv'cpf' 'F IQ'ku'hp'qy' p'v'q' t'gf' wegf' q'x'g't'cm'p'wo d'g't' q'h'q'f' g'f' g' 'ci' i' t'gi' cv'gu'lp' 'y g' 'uco' r' r'g'j5\_ 'dwl'k'pet'g'culpi 'y' l'emp'guu' qh' dwnm'j gvgtlwpevkqp' 'ecp' 'r'gef' "v'q' 'y j g' 'ej' c'pi' gu' qh' 'y j g' " o qtr j qmi { '0'Cu' uwej. " 'y j g'ug' ut'wewt'gu' 'ecp' j' cxg' f' h'k'ht'g'p'v' " o qtr j qmi k'gu. 'uq' f' h'k'ht'g'p'v'ej' cti g'ecttkgt' 'o qdklkkl'gu'cpf' 'tgeqo dlp'cvkqp' 'tcvgu'0"

Qpg'qh'vj g'o c'kp' 'o g'v'j' qf' u'w'ugf' "v'q' f' g'v'to' k'p'g' 'y j g' 'd'ko' q'rgew'ct' 'tgeqo dlp'cvkqp' 'tcvg' 'lp' 'uwej' 'o' cvgtkcu'ku'wo' g' /qh'riki j v' \*VQH+j3\_ 'v'gej' p'ls' wg. 'dwl'w'f' 'q'gu'p'q'v'cm'qy' "v'q' f' g'v'to' k'p'g' 'y j g' 'd'ko' q'rgew'ct' 'tgeqo dlp'cvkqp' 'x'ct'k'gu' 'y' kj' 'ecttkgt' 'eq'p'ep'v'cvkqp0' Vj' ku'f' t'cy' d'c'ne'ic'p' 'd'g' 't'go' q'x'g'f' 'd' { 'wulpi' 'gz'w'cvkqp' 'qh'lp'g'ev'g'f' 'ej' cti g'ecttkgt'u'd' { 'h'k'p'g'ct'n' 'k'pet'g'culpi' 'x'q'nci' g'v'gej' p'ls' wg' \*k' EGNKX'+j6.7\_ 'y j g't'g' 'y j g'v'q'cn't'g'eo' dlp'cvkqp' 'h'q'u'gu'lp' 'y j g' 'dwnm'ecp' 'd'g'f' g'v'to' k'p'g'f' 0'Vj' g'f' q'c'd'q'h'v'j' ku'f' q'tm'ly' cu'v'q' f' g'v'to' k'p'g' " d'ko' q'rgew'ct' 'tgeqo dlp'cvkqp' "f' g'p'f' g'p'e' { "q'p' dwnm'j' gvgtlwpevkqp' 'y' l'emp'guu' 'y' kj' "cpf' "y' kj' q'w'w'uq'x'gpv' 'cf' f' k'k'x'g' "F IQ' 'cpf' "v'q' " eqo r'ct'g' 'tgeqo dlp'cvkqp' "f' c'v' 'y' kj' 'y' cv'gz'w'cevgf' "Htqo' 'k'EGNKX' 'cpf' 'g'u'c'd'r'k'j' "f' g'p'f' g'p'e' { "q'p' 'ecttkgt' 'eq'p'ep'v'cvkqp0"

Wulpi' 'k'EGNKX' 'y' g'f' g'v'to' k'p'g'f' 'y' j g' 'c'v'uco' r' r'gu'r' tqeguugf' 'y' kj' "F IQ' 'uj' qy' 'ut'qpi' 'ecttkgt' 'tgeqo dlp'cvkqp' 'y' kj' 'k'pet'g'culpi' " n' { g't' 'y' l'emp'guu. 'y j k'g' 'q'o' k'w'k'pi' 'y j g' 'cf' f' k'k'x'g' 'ug'go' u'v'q' j' cxg' 'p'q' g'h'g'ev'j' y' k'g' 'x'ct' { k'pi' 'y j g' 'y' l'emp'guu'qh'vj' g' 'uco' r' r'g. "F IQ' "lp' " eqo dlp'cvkqp' 'y' kj' 'ED' 'ec'w'ug'u' 'o' qtr j qmi k'ec'n'ej' c'pi' gu' 'y' kj' 'k'pet'g'culpi' 'uco' r' r'g' 'y' l'emp'guu'0'k'v' 'y' cu'c'nu'q'f' g'v'to' k'p'g'f' 'y' cv'v' q'nt' \*5/ j' g'z' { n'j' k'qr' j' g'p'4.7/ f' k'f' n' \*R5J V+ "z' } j8.8\_ /r' j' g'p' { n'E83/ d'w' { t'le' 'c'ek' "o' g'v'j' { n'g'ug'f' \*REDO +3-3' 't'cv'q' dwnm'j' gvgtlwpevkqp' "j' cu' c'4'F' Ncpi' g'xlp' 'tgeqo dlp'cvkqp' 'o' g'ej' c'pl'uo' 'cu' dwnm'it'g'eo' dlp'cvkqp' 'tcvg' 'h'q'm'qy' u'v' ~ n<sup>2</sup> \*Hki B' \*d+0' C'f' f' k'k'q'p'c'ri' 'o' g'c'uw't'g'o' g'p'w' " f'q'p'g' 'd' { 'wo' g' /qh'riki j v' \*VQH' 'v'gej' p'ls' wg' 'uj' qy' u' 'eng'ct' 'h'k'p'm'ld'gy' g'p' 't'gf' wegf' "Ncpi' g'xlp' 'tgeqo dlp'cvkqp' 'cpf' "b' 'tgeqo dlp'cvkqp' " 'tcvgu'0"



Hki 03' \*c+ Uko w'rc'v'g'f' 'k'EGNKX' 'ew'tt'g'p'v't'c'p'uk'g'p'u'lp' 'dwnm'j' gvgtlwpevkqp' \*R5J V-REDO '3-3+'h'q'f' 'f' h'k'ht'g'p'v' tgeqo dlp'cvkqp' 'tcvgu' 'cpf' \*d+ 'dwnm'it'g'eo' dlp'cvkqp' 'tcvg' 'f' g'p'f' g'p'e' { "q'p'gz'w'cevgf' 'ej' cti g'0'''

[3] "Rkxt'k'ncu.'C'0'g'v'c'r'D'k'o' q'rgew'ct' 'tgeqo dlp'cvkqp' 'eq'g'h'k'el'g'p'v'cu'c' 'u'g'p'uk'x'g' 'g'u'k'pi' 'r' c'tco' g'v't' 'h'q'f' 'h'qy' /o' qdklkkl' 'uq'nt' /egm' 'o' cvgtkcu'0'Rj' { u'OT' g'x'0'Ngw'0; 6. \*4227-0' [4] "C'tec. 'H'0'N'q'ej. "0'0' ("N'w' i'k' 'R'0'G'p'j' c'p'el'p'i' "g'h'k'el'g'p'e' { "qh'q'ti' c'ple' dwnm'j' gvgtlwpevkqp' 'uq'nt' /egm' 'd' { "wulpi' "3.: /f' k'q'f' q'q'ec'p'g' 'cu' r' tqeguulpi' 'cf' f' k'k'x'g'0' KGG'G'LOR'j' q'q'x'q'nc'k'ei'6. '378263787' \*4236-0' [5] "I' wq. 'U'g'v'c'r'0'k'p'hw'g'p'eg' 'qh' 'uq'x'gpv' 'cpf' "uq'x'gpv' 'cf' f' k'k'x'g' 'q'p' 'y j g' 'o' qtr j qmi { "qh'RVD9' 'h'ko' u'r' tqd'g'f' 'x'ic'Z' /tc' { 'u'ec'w'g't'k'pi' 0'LOR'j' { u'0'Ej' go' OD'33: . '5666 572' \*4236-0' [6] "LO'X'c'f'li' n. 'M'0'I' g'p'g'x'k' kwu. 'I' 0'Lw-n. 'k'EGNKX' 'v'gej' p'ls' wg' 'h'q'f' 'l'p'x'g'u'ki' cvkqp' 'qh' 'ej' cti g'ecttkgt'u' 't'c'p'ur' q't'v'r' t'qr' g't'k'gu. 'Ej' go' lecn'Rj' { u'ku'69: . '348/34; " \*4238-0' [7] "I' 0'Lw-n. 'M'0'I' g'p'g'x'k' kwu. 'l'p'x'g'u'ki' cvkqp' 'qh' 'tgeqo dlp'cvkqp' 'lp' 'q'ti' c'ple' j' gvg't'q'ut'wewt'gu' 'd' { 'k'EGNKX. 'C'r' r'k'g'f' 'Rj' { u'leu'N'ew'gt'u'335. '345523' \*423: -0'

**IO RTQXKI 'F KURNCEGO GPV'GUVKO CVKQP'DI 'O GO U'  
CEEGRGTQO GVGTV'WUPI 'F GGR'S /NGCTPKPI 'CNI QTKVJ O "**

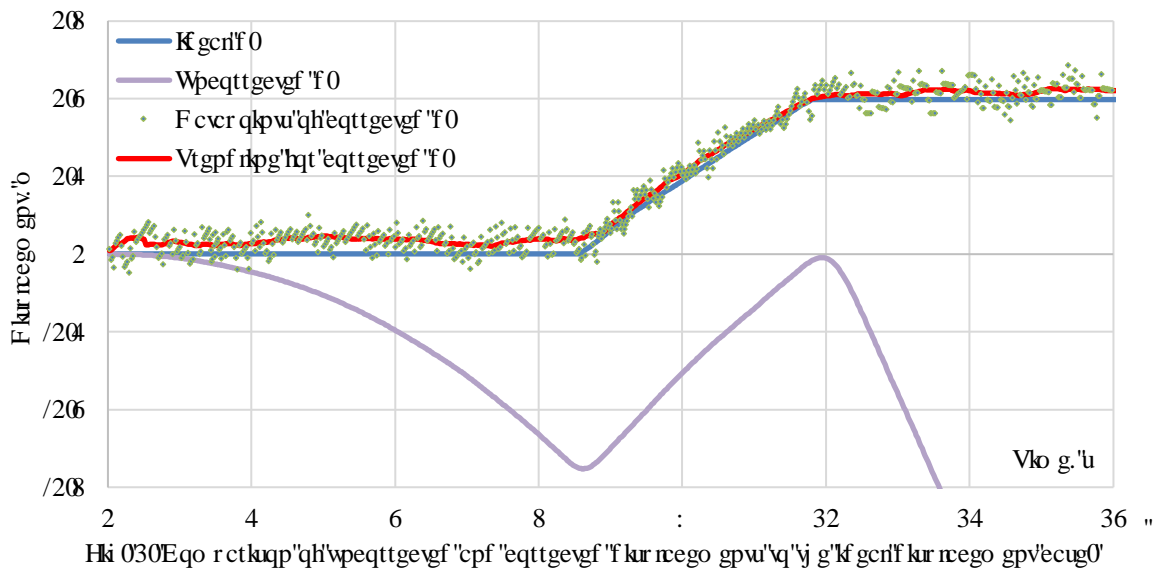
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Cpf tkw'F | gf | lenk<sup>3</sup>. 'X { cwcu'Dw kpunē<sup>3</sup>'"

<sup>3</sup>F gr ctwo gpv'qh'O gej cwtqpleu. 'Tqdqv'ku'cpf 'F ki kcn'O cpw'cewt kpi. 'Xkpkw'I gf ko kpcu'Vgej plecn'Wpkxgtuk{ "  
cri kf cu' RgtqpluB xkpkw'gej 0v'

Rtgekig" guko cvkqp" qh" o qxgo gpv' vclgevtkgu" wukpi " ej gcr "O GO U" ceegrqtgo gvtu" eqwf " j cxg" c" y kf g" tcepi g" qh" cr r rlecwvqu" uwej " cu' uko r rktg'f " kpf wutkcn' tgdqv' eqpvtqn " f tqpg' pcxki cvkqp. " gve0Ej gcr " ceegrqtgo gvtu. " j qy gxgt. " j cxg" uki plk'ecpv' gttqtu" kp" ceegrqtcvkqp" o gcuwtgo gpv' Vj gug" eqo r qwpf " vq" gztgo gn{ " ncti g" f gxlcwvqu" y j gp" ecrewv'kpi " f kur nēgo gpv' y j lej " tguwn' kp" guko cvgf " vclgevtkgu" dgeqo kpi " eqo r rēgn{ " f khtg'gpv' " Itqo " vj g" tgen' qpgu' Vtcf kskpcn' hktg'kpi " vgej pls wgu' tcepi kpi " Itqo " uko r nē" vj tguj qrf " hktg' " vq" o qtg' eqo r rēz " Mēro cp' hktg' " ecp' dg' wugf " vq" ko r tqxg' vj g" o gcuwtgo gpv' ceewtce { " y kj " xct { kpi " rēxgn' qh' uweegu' Hqt' vj ku' cr r rlecwvqu. " j qy gxgt. " vj gug' hktg' u' gkij gt' o cnē" vj g' y j qmē" u { ugo " kpu'gukxg' qt' tgs wktg' f gf lēcvgf " wv'kpi " qh' hktg' " r ctco gvtu' hqt' gcej " vclgevt { 'o gcuwtgo gpv' ecug'0

Cr r nē kpi " o cej kpg' rēctpkpi " \*O N+ cni qtkij o u' hqt' ko r tqxkpi " dqvj " ceewtce { " cpf " eqpukw'gej { " qh' vclgevtkgu' guko cvgf " dcugf " qp' ceegrqtgo gvt' f cvc' ku' c' r tqo kipi " ctgc' qh' t' guctej 0Vj gtg' cr' gcf { " ctg' uwf kgu' eqphko kpi " vj cv' dqj " NUVO / dcugf " O N' cni qtkij o " J3\_ c' pf " O N/ Mēro cp' hktg' " eqo dlp' cvkqp' " J4. " S\_ qh' hqt' ko r tqxg' f r gthqto cpeg' eqo r ctgf " vq' vcl' kskpcn' hktg' kpi " o gvj qf u'0' Vq' uwr r nēgo gpv' vj cv' t' guctej. " vj ku' y qtn' g' zr nqtgu' vj g" cr r rlecwvqu" qh' f ggr " s/ rēctpkpi " cni qtkij o " vq" ko r tqxg' f kur nēgo gpv' ceewtce { " gxcnēcvkqp' dcugf " qp' ceegrqtgo gvt' f cvc'0

Vj g' o gvj qf " kpxqrxgu' vcl' kpi " vj g' cni qtkij o " qp' kf gcn' f kur nēgo gpv' f cvc' cpf " vj g' f kur nēgo gpv' f cvc' u' ecrewv' g' f " Itqo " tcy " ceegrqtcvkqp' f cvc'0' vj g' cni qtkij o " qwr wu' eqttgevgf " f kur nēgo gpv' xcw' g' hqt' gcej " f c' vcr qkp'0' Vq' uo qvj " qw' vj g" f kur nēgo gpv' v' wtxg. " cr r tqzlo cvkpi " hktg' ku' cr r rēgf 0Qpg' qh' r tgrko kpc' { " t' guwnu' qh' vj ku' t' guctej " ku' i' kxgp' kp' \*Hk 03+ " y j lej " uj qy u' f kur nēgo gpv' v' wtxg' qh' b' qxkpi " c' O RW8272' ceegrqtgo gvt' kp' c' v' t' cki j v' hktg' c' nēpi " qp' g' cz ku' c' v' eqpucpv' x' g' rēkē { " hqt' 206' o 0' f kur nēgo



Vj gtg' ku' c' eqo r rēng' o kuo cvej " dgvy ggp' vj g' wpeqtg' evgf " f kur nēgo gpv' \* ecrewv' g' f " Itqo " tcy " ceegrqtcvkqp' f cvc- ' cpf " vj g" qp' g' v' v' y cu' r gthqto gf " kp' t' gcrkē { " kf gcn' ēcug' 0O g' cpy j kē. " vj g' f kur nēgo gpv' v' eqttgevgf " d { " c' f ggr " s/ rēctpkpi " cni qtkij o " cpf " vj gp' t' cuugf " vj tqwi j " cp' c' xgtci kpi " hktg' " vj qy p' cu' v' t' gp' f rēg' kp' Hk 03+ b' cvej gu' vj g' kf gcn' ēcug' " em' ugn' (0Vj g' c' xgtci g' f gxlcwvqu" Itqo " vj g' kf gcn' ēcug' ku' ct' qwpf " 7' . " y j kē" o czko wo " f gxlcwvqu' ku' ct' qwpf " 3: " . " y j lej " ku' c' uki plk'ecpv' ceewtce { " ko r tqxgo gpv' hqt' " uwej " v' r g" qh' ceegrqtgo gvt' 0' J qy gxgt. " y j kē" vj g' t' guwnu' ctg' r tqo kipi. " hktg' vj g' t' guctej " ku' t' g' wktg' f " vq" o cnē" vj g" vgej pls w' " cr r rēcdig' " kp' r t' cēw' g' vj g' cni qtkij o " p' g' f u' vq" dg" o cf g' " rēgu' t' g' rēkē { " qp' kf gcn' f kur nēgo gpv' f cvc. " y j kē" ku' r gthqto cpeg' hqt' b' qv' kpi " kp' eqo r rēz " vclgevtkgu' p' g' f u' vq" dg' k' p' x' guki cvgf 0'

**Cenpqy rēf i go gpv'**

Vj ku' r t' ql' evj' cu' t' gēgk' x' g' f " hwpf kpi " Itqo " vj g' Gwt' q' r gcp' " Uq' ekcn' Hwpf " \* r' t' ql' ev' P q' 2; 050NO V/M/934/44/2566- " w' pf gt " c' i' t' cp' v' ci' t' ggo gpv' y kē " vj g' t' guctej " Eqw' pēk' r' qh' Nkij w' c' p' kē " \*NO VNV-0'

[3\_ Nlo c. 'L0' Wēj k' co c. 'J 0' c' pf " Vepki wēj k' T0' 423; 0' G' pf / q' / G' pf " Nēctpkpi " Hico gy qtn' hqt' " IO W' Dcugf " 8/ F QH' Qf qo g' t' { 0' U' g' puqtu. '3; \*39+ 'r 05990'  
[4\_ " U' k' c' f' q' O' q' p' g' " Nlo c. 'L0' Wēj k' co c. 'J 0' c' pf " Vepki wēj k' T0' 423; 0' G' pf / q' / G' pf " Nēctpkpi " Hico gy qtn' hqt' " IO W' Dcugf " 8/ F QH' Qf qo g' t' { 0' U' g' puqtu. '3; \*39+ 'r 05990'  
[5\_ " W' rēj. " IO' H' c' { c. 'O' c' pf " Mko. 'F 0' 423; 0' K' r tqxkpi " Ceewtce { " qh' vj g' Mēro cp' hktg' " Cni qtkij o " kp' F { pco lē " Eq' pf k' k' q' pu' W' k' pi " CPP / Dcugf " Nēctpkpi " O' q' f' w' g' 0U { o g' t' { '33' \*3+ 'r 0 60'

**EGNK'VGEJ P IS WG'HQT'KP XGUVH CVKQP'QHRJ QVQ/I GP GT CVGF  
 EJ CTI G'ECTTKGTU'O QDKNK/ 'KP 'VJ KP'HKNO U  
 Gi kf klu'Mco ctcwun<sup>3</sup>. Tqo wcrf cu'Iqpcu" gr cu<sup>3</sup>. 'Mikuklqpcu'I gpgxk ku<sup>3</sup>**

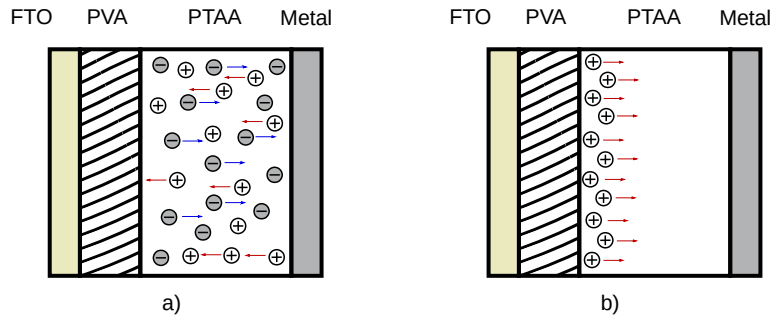
<sup>3</sup>Kpukwng'qh'Ej go kecn'Rj { ukeu. 'Hcwn' 'qh'Rj { ukeu. 'Xkpkwu'Wplxgtukf  
 gi kf klu'0mco ctcwun<sup>3</sup> B H0xw0y

Kp'pqy cf c { u. 'f wg'vq'ej gcr "u{ pyj guku'cpf "uko r ng" f gr qukkqp"vgej pls wgu"qti cple"o cvgtkcu"ctg"r tqo kukpi "ny "equv cngt pcvxgu"htq"ercuuecn'kpqti cple"o cvgtkcu'0'kp"cf f kkkqp. "qti cple"o cvgtkcu"ecp"dg" wugf "kp"vj g'r tqf wevkqp"qh'hgzkdrg f gxlegu'0'0 quv'r tqo kukpi "ctgcu'qh'cr r rdecvkqp"ctg' rki j v'go kkkpi "f kqf gu. "hgrf "ghgev'tcpukuvqtu. "f gvgevqtu'cpf "uqrc't'egmu'0' Vj g'ghhkgpe { "qt" \*cpf + "ur ggf" qh'qr gtcvkqp"qh'tcpukuvqtu. "rki j v'go kkkpi "f kqf gu. "uqrc't'egmu"qt"qyj gt"grgev'qple" f gxlegu"ku f gvto kpgf "d { "vj g'ej cti g'ecttkgtu"o qdksk { " 0

Wuwcmf "vj g'ej cti g'ecttkgt"o qdksk { " " kp"qti cple"o cvgtkcu"ku"o gcuwgf "d { "vko g/qh'rki j v' \*VQH+"vgej pls wg. cr r rdecvkqp"qh'y j lej "kp"vj kp"r { gtu"eqwrf "dg"ej cngpi kpi 0'Vj g"vko g'eqpucpv'TE"qh'vj g'u{ vgo "y kj "vj kp"r { gt "ku"uwcmf j ki j gt "vj cp"vcpuk'vko g'qh'vj g'ecttkgtu. "y j cv'eqo r rdecvgu"vj g'cpcn { uku"qh'vj g'ewtgpv'tcpukgpv'kp"vj g'ecug"qh'f kur gtukxg vcpur qt'0'CPqyj gt "r tqdngo. "qh'cr r rdecvkqp"qh"VQH"kp"vj kp"rku u. "ku"xqno g"r j qvq/i gpgtcvkqp"qh'ej cti g'ecttkgtu. "vj ku o cngu'j ctf "vq" f kukpi wkuj "vj g'uki p"qh'ej cti g'ecttkgtu

Kp'vj ku'y qtnly g'r tqr qug" c"o qf hkgf "r j qvq/EGNK'j3\_ "gzvcev'kp"qh'vj g'r j qvq/i gpgtcv'gf "ej cti g'ecttkgtu"d { "hpgctn'f kpetgculpi "xqnci g+"o gvj qf "htq" lpxgukv cvkqp"qh'vj g'ej cti g'ecttkgt"vcpur qtv'kp"vj kp"qti cple" hko u"pp" f lgrgevtle"r { gt'0"kp qtf gt "vq" f kukpi wkuj "uki p"qh'vj g'ej cti g'ecttkgtu"y g'err n'f "qh'ugv'xqnci g'dghqg'r j qvq"gzekcvkqp"o"ppg'v'f r g'qh'ecttkgtu"ctg r wuj gf "vqy ctf u"vj g"kpuwrcvqt. "cpqyj gt "v'f r g"ku"gzvcev'gf "htqo "vj g"uco r ng" \*Hki 0'3c+0'CHgt "uqo g" f gr { "vko g"y g"cr r n'f vlcpi ng" xqnci g"r wug"cpf "gzvcev'vj g'ej cti g'ecttkgtu"mcev'gf "pgct "kpuwrcvqt"kpvgthceg" \*Hki 0'3d+0'Hqt "vj g"cpn'f uku"qh gzvcev'kp"ewtgpw'cpf "guko cvkqp"qh'o qdksk { "y g'vug'uco g'cr r tqcej "cu"kp"vj g'ecug"qh'lp'gevkqp"EGNK' \*k'EGNK'-j4\_0

Vj ku"o gvj qf "cmjy u"vq" qdvc'kp"o qtg"ceewtcv'g"o qdksk { "xcm'gu"kp"xgt { "vj kp"qti cple"r { gtu. "cu"y gm'cu"vq"uwf { "c f gr gpf gpe { "qh'o qdksk { "qp"vko g. "kp"vj g'ecug"qh'f kur gtukxg"vcpur qt'0'F go qpucvkqp"qh'vj g"o qf hkgf "EGNK"vgej pls wg y cu" f qpg"y kj "vj g"r { gtu"qh"RVCC"r qn'f o gt "qp"vj g"vqr "qh"RXC"kpuwrcvqt'0'Qdvc'kpgf "tguwnu"y gt g'eqo r ctg"y kj "VQH tguwnu"kp"vj kentr { gt"qh"RVCC0



Hki 0'30'c+/"Ej cti g'ecttkgt "ugr ctcvkqp"wpf gt "cr r rkgf "xqnci g"qh'ugv. "d+/" "gzvcev'kp"qh'vj g'ej cti g'ecttkgtu"htqo kpuwrcvqt/ugo leqpf wevqt "kpvgthceg"d { "vlcpi ng'xqnci g'r wug0

j3\_ 'Lw-nc. 'I 0=P gntc-cu. 'P 0=I gpgxk ku. 'M 0=Uwej rkm' 'L 0=Mq nc. 'L 0T grzc'vkqp"qh'r j qvqzkgf "ej cti g'ecttkgt"eqpep'v'cvkqp"cpf "o qdksk { "kp" e/Ukd 0 Vj kp"Uqrik' "Hko u. '6736674. "4; 264; 5" \*4226+

j4\_ "Xcflr nc. "Lwku"="I gpgxkku. "Mikuklqpcu"="Lw-nc. 'I { vku'0'KEGNK'vgej pls wg"htq" lpxgukv cvkqp"qh'ej cti g'ecttkgtu"vcpur qtv'r tqr gt'vku. "Ej go kecn Rj { ukeu. '69: . '348/34; \*4238+

# THE INFLUENCE OF GRAPHENE SURFACE TREATMENT ON REMOTE EPITAXY OF GALLIUM NITRIDE

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Gallium nitride (GaN) is a widely used material in many optoelectronic applications due to its direct band gap, high breakdown voltage and high electron mobility. However, GaN growth on foreign substrates deteriorates its crystalline quality due to the lattice constant and thermal expansion differences. The solution to this problem would be the use of native substrates. Yet, bulk GaN substrates are relatively pricy and come in limited size. To tackle these problems, graphene interlayers could be used [1]. In the process called remote epitaxy, GaN formation is governed by its interaction with the GaN substrate through monolayer graphene. The seeding effect of the substrate enables high quality GaN growth, while weak van der Waals interaction facilitates subsequent layer release and the reuse of an expensive substrate. In addition, this growth method enables production of flexible GaN films, which can be used for novel applications. It is essential to examine interlayers quality and thickness. It was shown that graphene surface treatment has an impact on subsequent GaN formation [2].

In this work, metalorganic chemical vapour deposition (MOCVD) was used to grow GaN epilayers on the single-layer graphene covered GaN/sapphire templates (see schematics in Figure 1). Commercially available, transfer-ready monolayer graphene with PMMA support was wet-transferred to partially cover the templates prior to the MOCVD growth. The quality of graphene was evaluated by Raman shift. Particular attention to the graphene treatment temperature prior GaN deposition was given. GaN layers of different thickness were grown and investigated using XRD, AFM and PL techniques.

X-ray diffraction scan of (1 0  $\bar{1}$  0) plane GaN revealed crystalline quality improvement over the GaN template. The crystalline quality improvement is presented in the Figure 2.

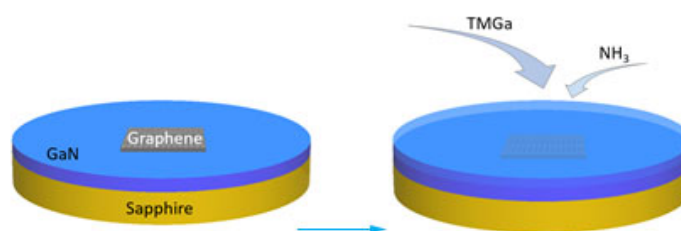


Fig. 1. Schematic representation of GaN epilayers growth process on the single-layer graphene covered GaN/sapphire template.

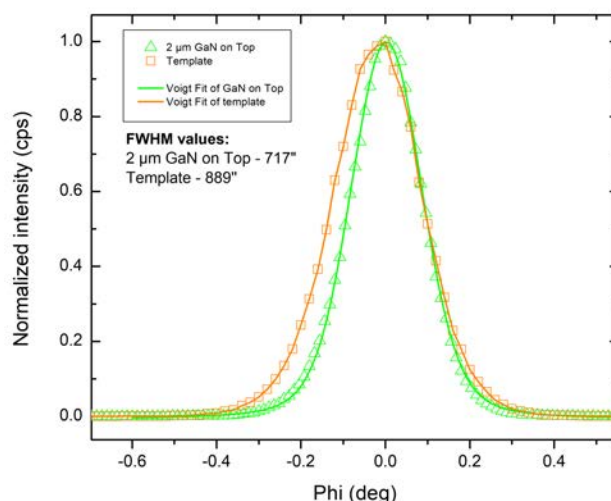


Fig. 2. XRD in-plane  $\phi$  scans of GaN template and grown GaN. FWHM of both measurements are calculated in order to evaluate crystalline quality improvement.

- [1] Kim, J., Bayram, C., Park, H., Cheng, C. W., Dimitrakopoulos, C., Ott, J. A., ... Sadana, D. K. (2014). Principle of direct van der Waals epitaxy of single-crystalline films on epitaxial graphene. *Nature Communications*, 5, 1–7. <https://doi.org/10.1038/ncomms5836>
- [2] Journot, T., Okuno, H., Mollard, N., Michon, A., Dagher, R., Gergaud, P., ... Hyot, B. (2019). Remote epitaxy using graphene enables growth of stress-free GaN. *Nanotechnology*, 30(50), 505603. <https://doi.org/10.1088/1361-6528/ab4501>

# INVESTIGATION OF THE STRUCTURE AND OPTICAL PROPERTIES OF DIAMOND LIKE CARBON THIN FILMS

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Diamond like carbon (DLC) films can have different properties depending on their atomic structure. The ratio between  $sp^2$  and  $sp^3$  bond hybridizations determines what kind of properties prevail in the film. High content of  $sp^3$  hybridization leads to properties similar to diamond, while greater amount of  $sp^2$  hybridized bonds leads to more graphitic material [1]. Atomic structure is influenced by the deposition conditions, therefore allowing to control properties of the films. This makes DLC thin films to possess great potential for applications in a variety of technological fields including wear resistance [2], medicine, optics [3] and particle accelerators [4]. An important application of DLC films in particle accelerators is related to the ability to reduce secondary electron yield. It was already shown in [4] that DLC films deposited with PECVD are characterized by secondary electron yield (SEY) coefficient of 1.5.

The objective of this research was to investigate optical properties and structure of an amorphous hydrogen-free carbon (a-C) films synthesized using different deposition methods (unbalanced magnetron sputtering (MS), high power impulse magnetron sputtering (HiPIMS) and conditions (bias voltage, deposition temperature, impulse power). Our previous research has shown that DLC films created by MS from graphite target had lower SEY coefficient in ca range of ~1-1.33 and we found direct correlation between SEY and Tauc gap and B parameter. Tauc optical band gap and B parameter of the films was determined from optical measurements (transmittance and reflectance) employing UV-VIS spectroscopy (Avantes system, 192-1100 nm, resolution – 1.4 nm). The absorption coefficient was calculated considering the thickness of the films determined with spectroscopic ellipsometer (GES5-E (Semilab)). Structure of the films was analysed with Raman scattering spectrometer inVia (Renishaw). The excitation beam from a diode laser of 532 nm wavelength was focused on the sample using a 50× objective (NA=0.75). Laser power at the sample surface was 3.5 mW.

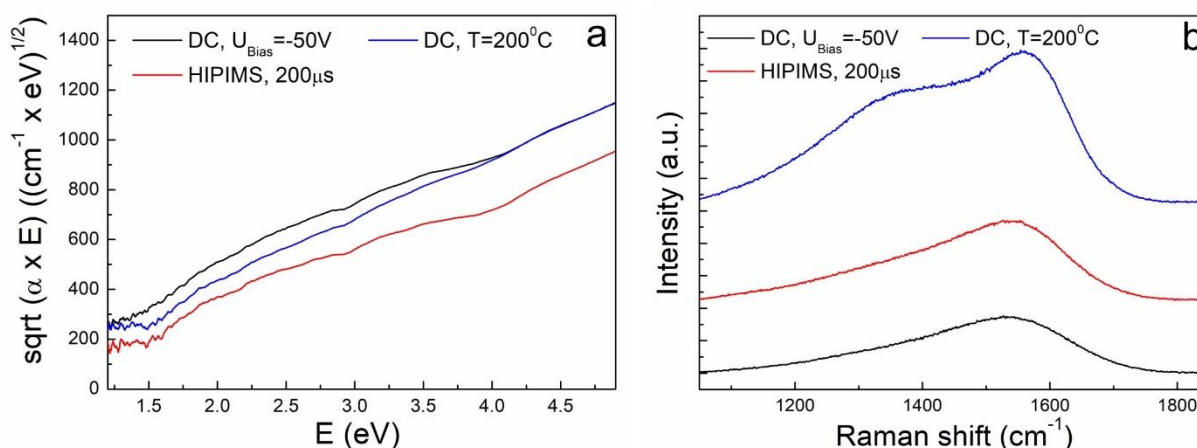


Fig. 1. (a) Tauc plots and (b) Raman scattering spectra of the films deposited employing different deposition conditions

The analysis of optical properties revealed that the optical band gap (Tauc gap determined from the graphs in Fig. 1, a) varied in a range from 0.23 eV till 1,08 eV depending on the deposition conditions. We should emphasize that the widest bandgap was determined for the films deposited using HiPIMS and its value strongly depend on the pulse duration (band gap decreases with increase of pulse duration). Analysis of Raman spectra (Fig. 1, b) revealed similar tendency for HiPIMS deposited films, where the FWHM of G peak increased indicating higher  $sp^3$  content in the film.

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**CTUGPĖ 'F GVGĖVKQP 'DĪ 'EQDCNV'I QNF 'GNĖVTQF GU''  
Ė 'CS WGQWU'O GF KC''**

Mĭkukpc'Tcf kpxk<sup>3</sup>. 'Lcf tepmē'O kĭkĭk<sup>3</sup>. 'Cĭf qpc'Dcn k pckv<sup>4</sup>. \ kc'Uwĭenĭgp<sup>4</sup>. 'Nqtgvē'  
Vco c-cwĭnēkv /Vco c-k pckv<sup>4</sup>'cpf 'Dkĭcpc''Mwĭk<sup>3</sup>"

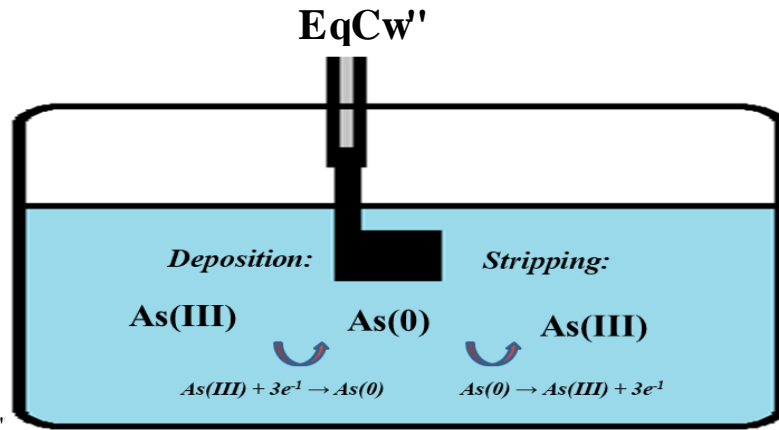
<sup>3</sup>Hcēwĭ'qh'Rj { ulecn'Ej go kut { .Wpkxgtukf 'qh'Dgri tcf g. "Uwf gpwĭk'vi "34/38."3337: "Dgri tcf g."Ugtdkē"  
<sup>4</sup>F gr ctwo gpv'qh'Ecvnē'uku. 'Egpvgt 'hqt'Rj { ulecn'Uelĭpēgu'cpf "Vgej pqmĭ { .Ucwn vĭnkq'CXg05.'NV/32479.'Xkpkwĭ."  
Nkj wcpkē"

. Lcf tepmēB ĭj Qĭ QēŪu"

F tĭkĭkĭpi "ctugple/r qmĭwgf "y cvgt"ecwugu'ugtĭkĭw"j gcnĭj "r tqdrgo u"ĭpēwĭf ĭpi "ĭtgi wĭt"j gctvdgcv"cvj gtqenĭgtuku"cpf "uĭkĭp"ecpegt"]3\_0'ctugple"ĭp"pcwĭcn'y cvgtu'wĭwcmf "gzkĭw"ĭp"ctugpkĭg"Cu\*~~KKK~~+cpf "ctugpcvĭg"Cu\*X+"cu"ĭpqi cple"ĭqto u0'K'ecp"cnĭq"gzkĭw'cu'qti cple"ĭko gĭj { rĭtukple"cpf "o qpqo gĭj { rĭtukple"cekf u0'U'km"ctugpkĭg"ku"o qtg"vqzle"vj cp"ctugpcvĭg."vj g"uco g"cu"ĭpqi cple"ctugple"dgĭpi "o qtg"vqzle"vj cp"vj g"qti cple"ctugple"ĭqto u"]4\_0'ctugple"r tĭgĭpēg"ĭp"cs wgqwu'o gf kē"ecp"dg"f gĭveĭgf "d { "ugxgtcĭf'cpcnē'vĭecn'ŵo gĭj qf u"uwej "cu"cvqo kē"cdūqtr vĭkpu"ur gēvtqēqr { .ĭpf vēvĭxgnf "eqw rĭf "r rĭuo c"ŵo"cvqo kē"go kĭkĭkĭp"ur gēvtqo gĭt { .ĭpf vēvĭxgnf "eqw rĭf "r rĭuo c"ŵo"o cuu"ur gēvtqo gĭt { .gĭe0]5\_0'Vj gug"cpēnē'uku'ctg"v{r kēcmf "mĭpi "cpf "tgs wĭt g"gzr gpukxg"gs wĭr o gpv"vj wĭ."grēvtqēj go kēcn'ŵo gĭj qf u"eqwĭf "dg"c"i qqf "tgr nēgo gpv'cu'ej gcr. "ĭcu'cpf" gcu{ "o gĭj qf u"ĭqt"ctugple"ĭf gĭveĭkĭp0"

J gtĭgp."vj tgg"ĭf kĭhgt gpv'eqdcn'ŵi qĭf "EqCw"grēvtqf gu'y gtg'r tgr ctgf "d { "grēvtqngū"ĭf gr quĭkĭq"qh'Eq"qp"Ew'wĭthcēg."ĭqmĭy gf "d { "Cw"pcpqr ctvĭergu"ĭf gr quĭkĭq"qp"vj g"r tgr ctgf "wĭthcēgu"d { "i cĭkēcple"ĭf kĭr nēgo gpv'wĭkpi "vj tgg"ĭf kĭhgt gpv'ĭf gr quĭkĭq"vko gu"\*52."82"cpf "522"u0'CW'ĭqcf ĭpi "y cu'ĭf gĭvto ĭpĭgf "d { "gpĭti { /ĭf kĭr gtukxg'Z/te { "ur gēvtqēqr { "cpcnē'uku"cpf "k'ŵy cu'ĭqwpf "vq'dg'70 . '9Ū"cpf "37Ū"Ūi "eo<sup>64</sup>"ĭqt "EqCw\*52u+ 'EqCw\*82u+cpf "EqCw\*522u+ 'tgr gēvĭxgnf "0"

P gzv."vj gug"grēvtqf gu'y gtg"vĭugf "ĭp"3"o O "P cCuQ<sub>4</sub>"ĭp"P cJ EQ<sub>5</sub>- "P c<sub>4</sub>EQ<sub>5</sub>"dĭwĭhgt"d { "cpqf kē"uĭtkr ĭpi "xqncō o gĭt { "CUX+0'ctugple"ĭf gĭvto ĭpēvĭkĭp"d { "CUX"o gĭj qf "r tqēggf u"ĭp"vĭy q"uĭgr u'y j gtg"Cu\*~~KKK~~"ku'ĭt gf vēgf "vq"Cu\*2+"cu"vj g"cf uqtdgf" ĭqto "qp"vj g"grēvtqf g'wĭthcēg"cpf "vj gp"qzĭf kē gf "vq"Cu\*~~KKK~~"ĭqto "vj cv'ĭf kĭhwgu'ĭp vĭj g"uqĭwĭkĭp."uēj go g"30"



Uēj go g"30Uēj go cvē'tgr tĭgĭpēvĭkĭp"qh'ctugple"ĭkpu'ugpĭkpi "cv'EqCw'grēvtqf gu'd { "cpqf kē"uĭtkr ĭpi "xqncō o gĭt { 0"

E { erke"xqncō o qĭ tco "EX+qh'EqCw\*52u"grēvtqf g'tgxgērgf "ku'cēvĭkĭf "ĭqt"ĭf gĭveĭkĭp"qh'Cu\*~~KKK~~"ĭp"cs wgqwu'o gf kē0'P co gnf "EqCw"i cxg"c"y gm'f gĭhĭpĭgf "r gēn'ēqtĭgur quĭkĭpĭ "vq"Cu"grēvtqzĭkēvĭkĭp0'Vj g"r gēn'ēwtgpv'f gpukf { "co qwpvĭf" vq3Ū5"o C"eo<sup>4</sup>"cv' /2Ū6"X."eqo r ctgf "vq"qpĭf { "2Ū7"o C"eo<sup>4</sup>"cv'vj g"uco g"r qvĭpēcn'ĭp"vj g"cdugpēg"qh'Cu"ĭkpu"ĭp"vj g"uqĭwĭkĭp0'Vj g"ĭpĭwĭpēg"qh'gzr gĭtko gpēcn'ēqpf kĭkĭpū"qp"ctugple"ĭf gĭveĭkĭp"y cu'vĭugf "d { "tgeqtf ĭpi "EXu"cv'ĭf kĭhgt gpv'ĭf gr quĭkĭq"r qvĭpēcn'Gr +cpf "ĭf kĭhgt gpv'ĭf gr quĭkĭq"vko g"vĭt +cpf "uĭdugs vĭpĭf "vj gug"r ctco gĭvtu'qr vko kĭgf 0"

ctugple"ĭf gĭvto ĭpēvĭkĭp"y cu'cnĭq"vĭugf "ĭp"c"tēcn'y cvgt"uco r rĭg"vj cv'y cu'ĭf kĭwĭgf "y kĭj "P cJ EQ<sub>5</sub>- "P c<sub>4</sub>EQ<sub>5</sub>"dĭwĭhgt "uco r rĭg" dĭwĭhgt "97-47"xqĭŵo "ĭcvĭq+0EqCw\*52u"grēvtqf g'ĭj qy u'c"y gm'f gĭhĭpĭgf "ctugple"qzĭkēvĭkĭp"r gēn'ĭp"vj g'tēcn'uco r rĭg0'

Y kĭj ĭp"vj ku'y qtm"EqCw\*52u"grēvtqf g."r tgr ctgf "d { uko r rĭg"cpf "ĭcu'ŵo gĭj qf "cpf "ēqpvēkĭpĭ "qpĭf "70 "Ūi "eo<sup>64</sup>"qh'CW"uj qy gf "i qqf "cēvĭkĭf "ĭqt"ctugple"ĭf gĭveĭkĭp"ĭp"cs wgqwu'o gf kē."ĭp"dĭwĭhgt"cu'y gm'cu'ĭp"c"tēcn'uco r rĭg0'Vj wĭ."vj ku'grēvtqf g"eqwĭf "dg"r qvĭpēcn'ŵo "i qqf "ugpūqt"ĭqt"ctugple"ĭf gĭveĭkĭp"ĭp"cs wgqwu'o gf kē0'

Cēnpqy rĭf i go gpv' Vj ku' tĭgĭcĭj " y cu' ĭkēpēkēm { " uwr r qtvgf " d { " vj g" O ĭpĭkĭt { " qh' Gf vēvĭkĭp." Uēĭpēg" cpf " Vgej pqmĭ kēcn'F gxgĭr o gpv'qh'vj g'Tgr wĭrē"qh'Ugtdkē"Eqpĭtēv'pwo dgt<673/25/8: 4242/36 422368-0"

[3\_ [ ( Ū 0 \ j w'RŪP ŪY ĭrĭco u."C(Ū0) gĭ cti .Gzr quwĭg'vq'ĭpqi cple'ctugple"ĭtqo "ĭkēg<C"i rĭcēn'j gcnĭj "kuuĭgA'Gpĭkĭqpo gpēcn'Rqmĭwĭkĭp"376.'38; ŵ 393"422: 40'  
[4\_ CŪI kēqo ĭpĭq."Ū0'ŪCdqĭkĭp."Ū0'ŪNē | cte."Ū0'ŪO cĭpēf tĭpĭq."Ū0'ŪO gpēcĭk'F gĭvto ĭpēvĭkĭp"qh'Cu\*~~KKK~~"d { "cpqf kē"uĭtkr ĭpi "xqncō o gĭt { "wĭkpi "c" rĭvĭcĭn' qĭf "grēvtqf g<Gzr gĭtko gpēcn'ēqpf kĭkĭpū."grēvtqf'ctēpĭgt"cpf "o qĭkĭkĭpĭ "qh'grēvtqf g'wĭthcēg."Vēncpē": 5.'364: 63657"4233-0"  
[5\_ Ū0'Ū cpi."ŵ ŪI vq."ŪP ŪNē"gv'cĭn'Ūgrēvtqēj go kēcn'f gĭvto ĭpēvĭkĭp"qh'ctugple"ĭkē"y kĭj "wĭt c/j kĭ j "cp'ĭpēvĭhgtēpēg"r gĭhĭqto cpeĭg"wĭkpi "CW'EW" dĭo gēcnē"pcpqr ctvĭergu."Ugūqū"cpf "Cēwēvĭtū."D<Ej go kēcn'453.'9269: "4238-0"



**NCUGT'CF F KWKG'O CPWHCEVWTPI 'QHET[ UVCNNKPG'5F''  
PCPQUVTWEVWTGU''**

I tgv'O gtnlpknkv<sup>3,4</sup>. 'Gf xlpku'Crngmcpf tckx kwu<sup>5</sup>. 'O cpi kf cu'O crkpcwuncu<sup>5</sup>. 'F ctkwu'I ckrxk kwu<sup>4,5</sup>.  
Uko cu''<sup>Uknk</sup> cpqxcu<sup>3,6</sup>

<sup>3</sup>Hcewn{ 'qh'Ej go kut { 'cpf 'I gquelpegu. 'Xlpxku'Wpksxtuk{. 'P cwi ctf wnt'um046. 'Xlpxku'NV/25447. 'Nkj wpcle'  
<sup>4</sup>Hgo vnc. 'Ucwn vgnkq' Cxg037. 'Xlpxku'NV/32446. 'Nkj wpcle'

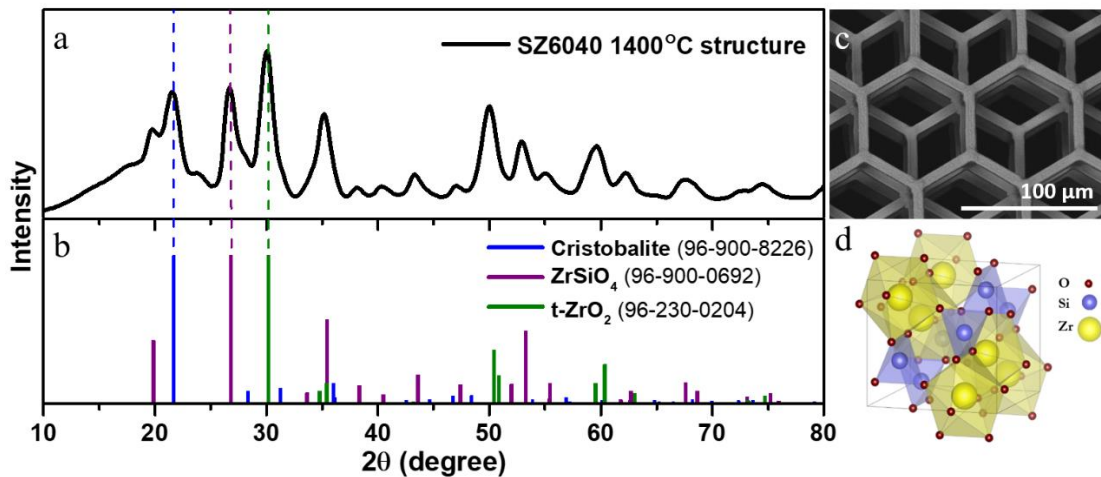
<sup>5</sup>Ncugt 'T gugctej 'Egpyt. 'Rj { uku'Hcewn{. 'Xlpxku'Wpksxtuk{. 'Ucwn vgnkq' Cxg032. 'Xlpxku'NV/32445. 'Nkj wpcle'  
<sup>6</sup>F gr ctvo gpv'qh'Ej go kecl'Gpi kpggtlpi 'cpf 'Vgej pqrni {. 'Egpyt' hqt' Rj { uku'Uelgpegu'cpf 'Vgej pqrni {. 'Ucwn vgnkq'  
Cxg05. 'Xlpxku'NV/32479. 'Nkj wpcle'

i tgvO gtnlpknkvB ej i hkwO''

Egtco leu'r r { 'cp'ko r qt wcpv'tqrg'lp'vqf c { u'uelgpeg'cpf 'lpf wnt { 'cu'k'ecp'y kj ucpf 'ko o gpug'y gto cn'o gej cplecn'  
ej go kecl'cpf' 'qvj gt' j c| ctf uOY j krg'5F'egtco le'ut wewtgu'ecp'dg'o cf g'lp'o wnkwf g'qh'y c { u'qr kecl'5F' r tlpkpi 'y kj'  
uudugs wgpv'j gcv'tgcvgf gpv'y cu'r tqxgp'v'q'dg'ppg'qh'y' g'dguv'o gvj qf u'eqo dlpki 'uko r rkek' 'qh'r j qvqkxj qi tcr j { 'y kj'  
htggf qo 'v'ej qqg'cp { 'tgs wkgf'5F' ctej kgewtgO'

kp' y ku'y qtni'y g'f kuerug'cp'cf xcepgf 'o gvj qf 'hqt' wcpuhqto kpi 'uklepp'cpf ''| kteqpkwo 'o gvcnti cple'5F'pcpq/  
ut wewtgu. 'r tgr ctgf 'xlc' uqni' gnl'cpf 'ruegt' o wnk'r j qvq' hky qi tcr j { . 'lpv'c' r wtg'lpqti cple' o cvgtkri'Uwey 'cr r tqcej 'dtlpi u'  
dtgcmj tqwi j 'hqt'gzvgo gnl' 'uo cml' hgcwtg'uk' g'ur cvclnt' guqmwkpp'w' 'v'q'82'po +'lpqti cple'5F' ut wewtgu' ]3. O'kp' qtf gt'v'  
ej ctcevtk' g'y' g' r tlpv'gf 'cpf' j' gcv'tgcvgf'5F'pcpq lo ketq' ut wewtgu'v'j g'ukpi ng/et { ucnf' khtcevkqp' vgej pls wv'y cu'wugf O'Vj g'  
r j cug' r wtk' 'qh'qdvclp'gf' ut wewtgu'ctg'wpcdng. 'tapi kpi 'htqo' 'co qtr j qwu'i r uuv'v'q' qtf gt'gf' r qn'et { ucnkpg' r j cuguO''

Y kj 'c'xctkcdng' u'p'v'j guku' r tqegf vtg'qh'y' g'lpkclnt' guku'cpf' 'c' r quv'j gcv'tgcvgf gpv'c' t'api g'qh'lpqti cple' r j cugu' hqt'v'j g'  
5F' ut wewtgu'y' gtg'cej kxgf <'co qtr j qwu'i r uuv. 'etk'v'q' dcrksg. 'v\ tQ4. 'o \ tQ4. \ tUQ6' Hki 03-40''



Hki 030% c+Z/te { 'f khtcevkqp' ZTF +'cpcl' uku'qh'y' g'U 8262' o cvgtkri'j gcv'tgcvgf 'cv3622' Å' hqt'ppg'j qwt'lp'ck'cv'cp'  
co dkgpvr' tguwtg' =d+ t'ghet' gpeg' r cwgtpu' =e+ UGO 'ko ci g'qh'U 8262' o cvgtkri'j gcv'tgcvgf 'cv3622' Å' hqt'ppg'j qwt'lp'ck'  
cv'cp'co dkgpvr' tguwtg' =f + 'r wleg' ut wewtgu'qh'y' g' \ tUQ6O'

Qxgcm' tguwml'uj qy 'o wnk'r j qvq' hky qi tcr j { 'cpf' v'j gto cni' quv' r tqegu'kpi 'cu'c' r qy gthwi'v'cpf go 'hqt'et' gcv'kpi 'wntc/  
tgu'k' dkgp'v'o wnk'wpevk' qpcr'5F' o ketq/ lpcpq/ uecrg' egtco le'et { ucnkpg' ut wewtguO'

[3] O gtnlpknkv. 'I O' Crngmcpf tckxkwu. 'GO' O crkpcwuncu. 'O O' I ckrxkkwu. 'F O' Uknk cpqxcu. 'U' Ncugt 'Cf f kxkg' Q' cpwhcewtlpi 'qh'Ukl tQ4' Wpcdng'  
Et { ucnkpg' Rj cug'5F' P cpquut wewtguO' Rgr tlpw'4242. '4242342929' f qk'32042; 66 r tgr tlpw'4242342929x340'

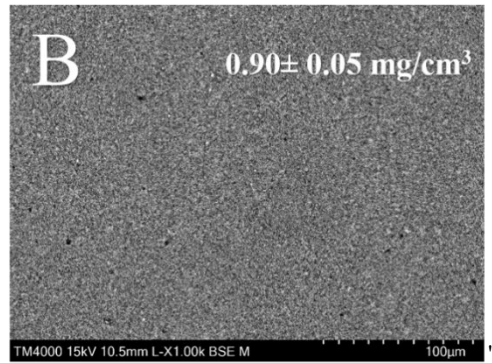
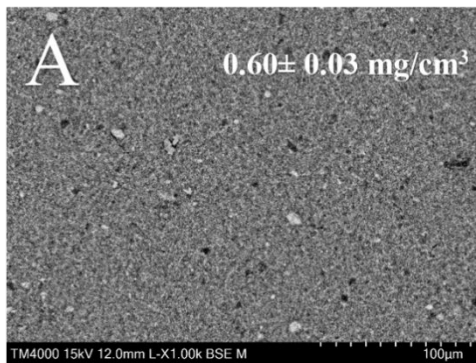
**QRVIO K CVKQP 'QH'CP QF G'RT GRCT CVKQP 'RTQE GU'HQT'CS WGQWU'  
P C/KQP 'DCVVGTKGU''**

P cf gff c "Vte-nkpc<sup>3</sup>. "Lwti ku'Rkrk cexk kwu<sup>3</sup>. "O krf c"  
Rgtwrgxk kgp<sup>3</sup>. "Lwti c" Lxqf nē | { v<sup>3</sup>. "Nkpcu'Xkn kwunū<sup>3</sup>"

<sup>3</sup>Egpgvt "hqt" Rj { ulecn'Uelkpegu'cpf "Vgej pqmī { "HVO E+. "Ucwn vgnkq'cr05. "NV/32479" Xkpkwu. "Nkj wcpk"  
pcf gl f c0tcurkpcB hwo e0n"

Kp"tgegpv" { gctu. "gpxkqpo gpvcl'eqpegtpu" j cxcg"uj khgf "y j g" uelgpkke" cwgpvkqp" vqy ctf u" y j g" f gxgrqr o gpv'qh' ppxgn' tpggy cdrng" cpf "engcp" gpgti { "uqtci g" f gxlegu0Vj g" o quv'kpxguki cvgf " cpf " f gxgrqr gf " vgej pqmī { . "nkj kwo "kqp" dcwgtkgu" \*NKDu: F gur kg'vj gk'j ki j "gpgti { "cpf" r qy gt f gpubkku. "uwhgt" hto "nkj kwo au'j ki j "equ'cpf" hremq'hp'kxkqpo gpvcl'dgpi pky0 J3\_ "Eqpugs vgpw". "uqf kwo "kqp" dcwgtkgu. "gur gekm" "y j gk'cs wqwu'xctkcvkpu. "j cxcg" go gti gf "cu'cp" er r gcrkpi "cngt'pckxg" vq" NKDu'qy kpi "v' uqf kwo au'j ki j "cdw'p'cpeg'kp'pcwtg'cpf" g'ro kpcvqp'qh'j ki j n' "vzke" cpf "hwo o cdrng'qti cple'grgevtqn' vgu0]4\_ " Cs wqwu" uqf kwo "kqp" dcwgtkgu" y kj "i qqf" ecr cexk' "cpf" e { eng'kkg" e j ctcevtkku'ctg" c" eqo d'kpcvqp'qh' r tgekgu' "ugrgevgf" grgevtqf g' eqo r quk'kqp" cpf "o qtr j qmī { . "grgevtqn' v' e j go kwt { "cpf" eqo r t' g j gpuk'g' egm' f guki p0Grgevtqf g' o qtr j qmī { "ecp" dg'vckrtgf' d' { "xct { kpi "y j g' u'j cr g' cpf "uk' g' qh' d' qy' "cevkxg" o cvgtkcn' CO + "cpf" eqpf vevkxg' cf f k' kxg' "EC" + r ct v' ergu. "y j g' d' kpf kpi " r qn' o gt' r tqr gt v' ku' cu' y gmi' cu' y j g' t' cvkq' qh' c' d' qxgo gpvkqpgf " o cvgtkcn' Uko wncpgqwan. "grgevtqf g' o qtr j qmī { " f gr gpf u' qp" y j g' r tgr ctcvkqp" r tqegu. "y j j kej "eqpxgpvkpcmf" "kpenmf gu" o k' kpi "CO. "EC. "r qn' o gt' "cpf" "uq'k'gpv" ecukpi "qh' cu' r tgr ctgf" unwtkgu" qp v' "y j g' ewtgpv' eqngvqtu" cpf "uwdugs wgv' f t { kpi 0]5\_ "F gur kg' dgkpi "i gpgtcm" "qxgtmqngf. "c" uwkcdng" o k' kpi ugs wpepg' cpf "cevkxg" o cvgtkcn' f kur gtukqp" j qo qi gpgk' { "r c" "etwekcn' tqng" kp" y j g' r tgr ctcvkqp" cpf "r tqr gt v' ku' qh' j ki j / r gthqto cpeg" grgevtqf gu0]6\_ "

Vj g' clo "qh' y ku' y qmī ku' v' kpxguki cvg' y j g' f gr gpf gpe { "qh' grgevtqf g' o qtr j qmī { "qp" o k' kpi "eqpf k' k' pu" cpf "guvcdkuj" c' t' grkcdng" unwt { "r tgr ctcvkqp" r tqegf wtg' hqt" y j g' hmwg" uwf lgu0Vj g" grgevtqf gu' y gt g' r tgr ctgf "d { "xct { kpi "y j g' f v' cvkqp" qh' o k' kpi. "dgc' f "uk' g' wugf "kp" dcm' o km' f v' kpi "y j g' f t { "r tg/ o k' kpi "qh' CO" y kj "EC" cpf "y j g' o k' kpi "qh' h' kpcn' unwt { 0' Vj g' o qtr j qmī { "qh' r tgr ctgf" grgevtqf gu' y cu' e j ctcevtk' gf "d { "Uecppkpi "Grgevtqf" O letqueqr { "UGO +0' Vj g" grgevtqej go k' cni' r tqr gt v' ku' qh' P cVki \*RQ6+5" dcugf "r tgr ctgf" grgevtqf gu' y gt g' kpxguki cvgf "d { "e j cti g' f k' e j cti g' i cixcpquv' k' e { enkpi "kp' y j g' g' grgevtqf g' dqwqo "o qwpv' h' v' uco r ng' dgcngt" egm' 0' Vj g' t' guwuu" "Hki 0'3 +k' o r n' "y j v' c' v' k' p' t' qf v' elpi "c" f t { "r tg/ o k' kpi "u' ci g' ku' j ki j n' "dgpgh' k' en' hqt" dqy' grgevtqf g' j qo qi gpgk' { . "vr" f gpuk' { "cpf" grgevtqej go k' cni' r tqr gt v' ku' 0



Hki 0'30UGO "ko ci g' qh' C + P cVki \*RQ6+5" dcugf "grgevtqf g' r tgr ctgf" d { "ukpi ng' ugr" o k' kpi =D+ P cVki \*RQ6+5" dcugf " grgevtqf g' r tgr ctgf" d { "k' p' t' qf v' elpi "f t { "CO" - "EC" r tg/ o k' kpi 0

**Cempy ngf i go gpw' "**

Vj ku' r tq' lgevj cu' t' gegkxgf "hwpf kpi "hto "y j g' Gvtqr gcp" Tgi kqpcn' F gxgrqr o gpv' Hwpf "RtqlgevP q023040/NO V/M93: /24/ 22274" wpf gt' i t' cpv' ci t' ggo gpv' y kj "y j g' Tgugctej "Eqwpeki' qh' Nkj wcpk" "NO VNV-0"

[3\_ "Y w' O 0" gv' cni' P CUIEQP / Ut wewt' gf "P cVki \*RQ6+5" hqt' "Uwvcl' pcdng' Gpgti { "Uqtci g0P cpq/ O letq' Ngwgtu' 33. '66" %423; +0  
[4\_ "Dkp. "F 0" gv' cni' Rtqi t' gu' k' C' s wqwu' Tgej cti g' cdrng' Uqf kwo / k' p' "Dewgtkgu0Cf xcpegf" Gpgti { "O cvgtkcn. ' . '392522: " %423; +0  
[5\_ "M' c { wdg' ti. "C0' cpf "I 0' G' p' / G' r' k' "Eqpxg' kpi "Cf xcpegf" "Nk' k' p' "Dewgt { "O cvgtkcn' / k' p' v' g' "Rtcevk' g' "Vj g' "K' r cev' qh' "Grgevtqf g' "Unwt { "Rtgr ctcvkqp" "Ukmi0"  
Cf xcpegf "Gpgti { "O cvgtkcn. "8. '3822877" %4238+0  
[6\_ "Nkw" 0' X0' D' wci ite. "cpf" "RROO wnj g' t' lgg. "O guquecng' gnwv' k' cvkqp' qh' y j g' l' p' h' wpepg' qh' o k' kpi "ugs wpepg' kp' grgevtqf g' r tqegu' kpi 0' N' cpi o v' k' . "52. '37324/ 35" %4236+0

# UGNGEVKXG'NCUGT 'D'O CVGT KCN'RQY F GT'O GNVKPI "

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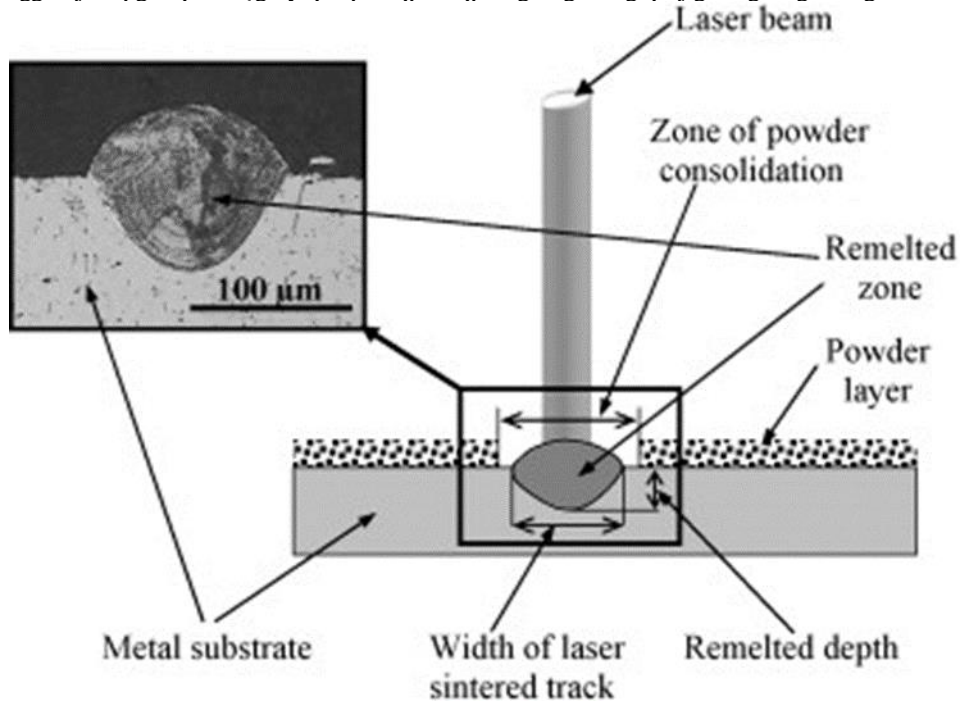
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[netqrku'UtxkpuñuB hxo eñu'](#)

Ugrgevkxg'ncugt'o gnvkpi "UNO +'vgej pqmji { "ku'cp'cf f kxg'o cpwñcewtkpi "vgej pls wg.'y j lej "cmqy u'r tqf welpi "o gvcn' r ctu'y kj 'hgy 'eqpuwo r vqp'qh'yj g'o gvcn'o cvgtkcn'Vj g'UNO "o cpwñcewtgf 'r ctu'yj cxg'i qqf 'o gej cplecn'r tqr gt vku'cpf 'ecp" dg'cr r ñgf 'kp'o cp { 'f kñgt gpv'hgrf u'uwej 'cu'o gej cplecn'gpi kpggtkpi . "cwqo qvwxg.'cgtqur ceg.'gve'Vj g'o clp'r tqr gt vku'qh'c" r ctv'o cpwñcewtgf 'd { 'UNO "vgej pqmji { 'f gr gpf "qp'yj g'cwtkdwgu'qh'c'ukpi ng'tcen'cpf "ukpi ng'rc { gt'ej ctcevgtkñku'0'K'UNO " r tqeguugu.'r qy f gt'ku'wuwcm' "hgf "d { 'rc { gtu'kp'vq'c'r rñvñqto . 'y j gtg'c'hqewugf "ncugt "dgco "j gcu'c'ur qv'qp'yj g'uwdutcvg'vq" hqto "c'o gnv'r qqn'ur qv'uqñf kñgu's wlecm' "chvgt'yj g'ncugt "dgco "o qxgu'cy c'0'

Kp'yj ku'uwf { 'ugrgevkxg'ncugt'o gnvkpi "vgej pqmji { 'y kn'dg'cr r ñgf 'y kj "f kñgt gpv'r qy f gt'o cvgtkcn'cpf "i cuugu'0C'rc { gt" qh'o cvgtkcn'r qy f gt'ku'f gr quksf "qp'c'us wctg'uj cr gf "uggn'uwdutcvg'0'Ncugt "dgco "ku'cwcej gf "vq'c'EP E"o cej kp'g'y j gtg'k" ecp"o qxg'd { 'f kñgt gpv'eqqtf kpcvgu'0'K'ku'r quukdn'vq'ug'v'f kñgt gpv'ncugt "uecpkpi "ur ggf "xcn'gu'0'Ncugt "dgco "cwce'm'yj g" uwdutcvg'kp'c'i cu'r wo r gf'ej co dgt'cpf "o gnu'c'vcen'0C'hvgt'yj g'vcen'ku'o gnv'f "y j g'tguwmu'ctg'gxcn'cvgf "d { "wukpi "UGO " cpf "qr vñcn'o letqueqr {0'

Vj g'uwf { 'tguwmu'eqpukv'qh'c'yj qtqwi j "cpcn'uku'qh'yj g'ukpi ng'ncugt'o gnv'f "r qy f gt'o cvgtkcn'r ctco gvtu'uwej "cu'ncugt" r qy gt.'uecpkpi "ur ggf . 'y j lempgu'qh'c'rc { gt.'y qtnkpi "eqpf kñkpu'vgo r gtcwgt'qh'yj g'dcug.'wugf "i cugu'0'



Hki 030Ugrgevkxg'ncugt'o gnvkpi "ukpi ng'tcen'j]3\_0'

]3\_0' cf tqkxg.'K'Uo wq'xg'0'Ugrgevkxg'ncugt'o gnvkpi "vgej pqmji { <'rto "y j'ukpi ng'ncugt'o gnv'f "vcen'wcdkñk' "vq'5F"r ctu'qh'eqo r nyz'uj cr g.'Rj { uleu' Rtqegf lc'7"4232+77367820'

**ZRU'UVWF KGU'QH'XCP CF KWO /F QRGF 'NKVJ KWO /O CPI CP GUG/DQTCVG'  
I NCUUGU'CPF 'P CP QE QO RQU'KGU'**

**Ci cvc'Ictqem<sup>3</sup>. 'Rt| go {u€y 'R00 kej cnum<sup>3</sup>. 'IcgmT {n<sup>4</sup>. 'Vqo cu| 'M0Rkgt| cm<sup>3</sup>. 'O ctgm'  
Y cukvekqpm<sup>3</sup>**

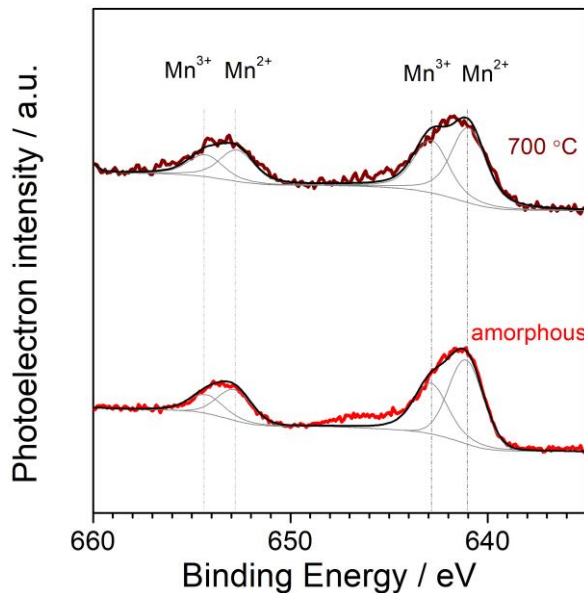
<sup>3</sup>Hcewn{ 'qh'Rj { uleu. 'Y ctucy 'Wpkxgtuk{ 'qh'Vgej pqm{ { . 'Mqu| { nqy c'97.'22/884'Y ctucy . 'Rqrpf "  
<sup>4</sup>Hcewn{ 'qh'Ej go km{ { . 'I f c um'Wpkxgtuk{ 'qh'Vgej pqm{ { . 'P ctwqy le| c'33 B4.' : 2/455' I f c um' Rqrpf "  
**ci cvc'Ictqem<sup>3</sup> qmB r y Qf v0r'**

I tqy kpi "f go cpf "qp"i qqf "s wcrk{ "uqcti g"u{ ugo u"ku"cp"gzvto go n{ "ko r qtwpv'i nqdr'eqpegtp."g0 "hqt"tgpgy cdr{  
gpgti { "uqtegu"o"uqnt"qt"y kpf "r qy gt"o"y j gp"pggf "hqt"grgvtlek{ "ku"pqv'y cv'j ki j "cpf "zegu"gpgti { "j cu"vq"dg"uqctgf O  
J gpeg"eqo gu"y j g"pggf "hqt"eqpucpv'f gxnqr o gpv'qh'pgy "uqnwkpau'0'hw'v'j gto qtg."uko krci "dw'uo cngt"u{ ugo u'ctg"cnq"c"  
etwcknr' ctv'qh'gxtg { "grgvtle"ectOC m'qh'y ku'j cu'ktghwcdrg'kphwv'peg'qp"geqni { "cpf "r qmwkq' 'gf vevkq'0"

P qy cf c{ u.'tcr kf "vej pqm{ { 'f gxnqr o gpv'lp'y j g'kgrf "qhr' qtwdrg'f gxlegu'pggf u'cf lwkpi "y qug'f gxlegu'dd'cwtg'ku'lp"  
c"y c{ "y cv'y j gk"ghlekp{ "y kn'lo r tqxg'0'Vj gtg"ku"i tqy kpi "pggf "hqt"uo cngt."rki j vt"cpf "o qtg"ghlekp'v'egm'r j qpgu"qt"  
r gtuqpcn'eqo r wgtu'cpf "y gtghqtg'cnq"ht"dcwgt'ku'gzj kdkpi "ko r tqxg'f 'r tqr gt'v'gu'0'Qpg'qh'y j g'hcvtu'y cv'j cu'uki pkl'ecpv'  
kphwv'peg"qp"egm'0'r ctco g'v'gu"ku"y j g"grgvtlecn'eqpf vevkxk{ "qh'y j gk"ecy qf g"o cvgtkcn'0'Vj gtghqtg."uelgp'v'ku"eqpf vev'  
tgugctej gu'qp"o cvgtkcn'y cv'r qv'p'v'km{ "ecp"dg"wgf "cu'ecy qf gu'cpf "ugctej "hqt"y c{ u'vq"ko r tqxg'y j gk"eqpf vevkxk'ku'0"

Cp"kpvtgukpi "o gy qf "vq"ko r tqxg'y j ku'r tqr gt'v' "ku"y gto cn'pcpqt { ucnkuc'v'kp"qh'i nuugu'f gxnqr gf "lp"Uqrf "Ucvg"  
Kqple'F kxkukq. 'Hcewn{ 'qh'Rj { uleu. 'Y ctucy 'Wpkxgtuk{ 'qh'Vgej pqm{ { O'Nkj kwo 'o cpi cpgug'dqtcvg'j cu'hqwpf 'j ki j 'kpvtgu'  
lp"pqy cf c{ u'tgugctej "qp"ecy qf g'0 cvgtkcn'ht"NK'kq'p'dcwtg'ku"o quvn{ "f wg'vq"ku'j ki j "y gq'g'v'kcn'i t'cxo g'v'ke'ecr cek{ 'qh'  
444"o Cj li "j3\_"y j lej "ku'gxp"i t'gevt'y cp'hqt'y j g'y kf gn' "uwf k'f 'r j qur j cvgu'0'J qy g'xg."qwt'tgugctej "qp"y j ku'eqo r qwpf "  
uj qy gf "y cv'h'p'cn'grgvtlecn'eqpf vevkxk{ "chgt'pcpqt { ucnkuc'v'kp"y cu'ukrip'v'uw'hlekp'v'gpqwi j 0'Dculpi "qp"y j g'uwf k'ku'j4\_"  
qp'x'cpcf kwo /f q'gf "Nk'gRQ6"eqo r qwpf "cp' "qp"eqpen'v'kq'v'j cv'gxp'uo em'bo qwp'v'qh'x'cpcf kwo "ecp'uki pkl'ecpv' "ko r tqxg"  
grgvtlecn'cpf "grgvtqej go k'cn'r tqr gt'v'gu'qh'o cvgtkcn'y g'c'wgo r v'f "vq"f q'g'chqtgo gp'v'kq'gf "Nk'O pDQ5'y kj "x'cpcf kwo 0"

I nuu{ 'Nk'O p20.47X207DQ5'y cu'uweguu'w'w' "u' p'v' g'k' gf "y kj "wg'qh'0' gn's w'gej kpi "r tqegu'0'Vj gp."y j g'uco r ngu'y gtg"  
pcpqt { ucnkugf "lp" f k'htg'gp' v'go r g'c'v'w'gu" cpf "ej ct'cevt'k' gf "j5\_0' Kp" y j ku"y qtm" o c'kpn{ "ZRU" %Z/tc{ "r j qv'g'gevt'qp"  
ur g'v't'ueqr { +uwf k'ku' "Hk' 03+"y kn'dg'r t'gug'v'f "lp"qt'f gt "vq"f go q'p'ut'cv'g'ej cpi gu'lp"O p<sup>4</sup> - IO p<sup>5</sup> - "k'p'u't'gn'v'k'g't'cv'k'q'dghqtg"  
cpf "chgt'pcpqt { ucnkuc'v'kp'0"



Hk' 030J ki j /t'guqmwkq'ZRU'ur g'v't'c' i nuu{ "uco r ng'cpf "y j g'uco r ng'et { ucnkugf "cv'922'AE'0'Hkwgf "r tqh'ku'cuet'kd'gf "vq"  
r t'gug'peg'qh'O p<sup>4</sup> - cpf "O p<sup>5</sup> - "k'p'u'ct'g'uj qy p'cu'i tg{ "h'p'gu'cd'q'x'g'y j g'd'ceni tqwpf 0"

[3\_]X0'Ngi ci pgw.'I 0Cp.'C00 qudcj .T0Rqt'v'n'C0Ng'I cn'Nc'Uemg.'C0Xgtdcgtg.'F0I w'qo ct'f.'I 0R'ht'ct'f'0'Uq'rf 'Ucv'g'Kqpleu'35: %4223+#596680  
j4\_'H0Qo gp{c.'P'0C0Ej gtpqxc.'U0W'f'gk'RQ' 0\ excrkl.'M0Y 0P co .Z'0S 0I cpi .O'0WY j k'v'pi j co .Ej go km{ "qh'O cvgtkcn'45"%4233+#6955/69620  
j5\_'C0Ictqem.'R'000 kej cnum'LOT {n'O 0Y cukvekqpm'LOGOI ct'dctel {m''V0M0Rkgt| cm'Kqpleu'423; #0j w' u-d'lf q'k'v'iti B20229h337: 3/23; /2544; /7"

# CHARACTERIZATION OF TENSILE PROPERTIES OF KNITTED UNIDIRECTIONAL THERMOPLASTIC PREPREG COMPOSITES

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Composites materials and products have got much importance from the last few decades due to their lightweight, high strength, and high modulus [1]. In this study, we investigated the mechanical properties of knitted unidirectional thermoplastic composite prepregs. Knitted prepregs were fabricated by using thermoplastic yarns (high-density polyethylene and polypropylene) and high-performance yarns (Kevlar, Basalt, and Carbon) in a double jersey inlay structure. This was a new approach to combine the reinforcing fiber with resin forming thermoplastic fiber during the knitting operation. The structures were stacked further in three stacking sequences at different angles (0/0/0/0, 0/90/0/90, 0/90/90/0), and hot compression was used to convert them into composite prepregs by melting the thermoplastic yarns. Specimen code (Inlay Yarn, Main Yarn, Plies Direction) are given as KH1 (Kevlar, HDPE, 0/0/0/0), KH2 (Kevlar, HDPE, 0/90/0/90), KH3 (Kevlar, HDPE, 0/90/90/0), KP1 (Kevlar, PP, 0/0/0/0), KP2 (Kevlar, PP, 0/90/0/90), KP3 (Kevlar, PP, 0/90/90/0), BH1 (Basalt, HDPE, 0/0/0/0), BH2 (Basalt, HDPE, 0/90/0/90), BH3 (Basalt, HDPE, 0/90/90/0), BP1 (Basalt, PP, 0/0/0/0), BP2 (Basalt, PP, 0/90/0/90), BP3 (Basalt, PP, 0/90/90/0), CH1 (Carbon, HDPE, 0/0/0/0), CH2 (Carbon, HDPE, 0/90/0/90), CH3 (Carbon, HDPE, 0/90/90/0), CP1 (Carbon, PP, 0/0/0/0), CP2 (Carbon, PP, 0/90/0/90), and CP3, (Carbon, PP, 0/90/90/0).

The tensile strength and modulus were investigated according to the standard test method of ASTM D3039. Results in Fig. 1 showed that high modulus was observed in all materials when plies were stacked in the same direction i.e. 1<sup>st</sup> direction of stacking and specimen were tested in a parallel direction to yarns. As previously reported that strength of knitted thermoplastic composites is influenced mainly by orientation and as well as breakages of reinforcing components [2]. But least modulus was observed in the same specimen when tested in cross direction as there was no breakage of reinforcement yarns [3]. Because in cross direction there was the strength of only thermoplastic material i.e. resin. But materials strength was in parallel direction and as all yarns were in that direction. From the second and third direction of stacking more strength was observed in all materials in the second direction i.e. [0/90/0/90] but the difference is not much significant. As the uniform transfer of load to resin in alternative plies second stacking sequence had higher strength than the third stacking sequence. In the third stacking sequence group of two plies are stacked which causes to concentrate force [4].

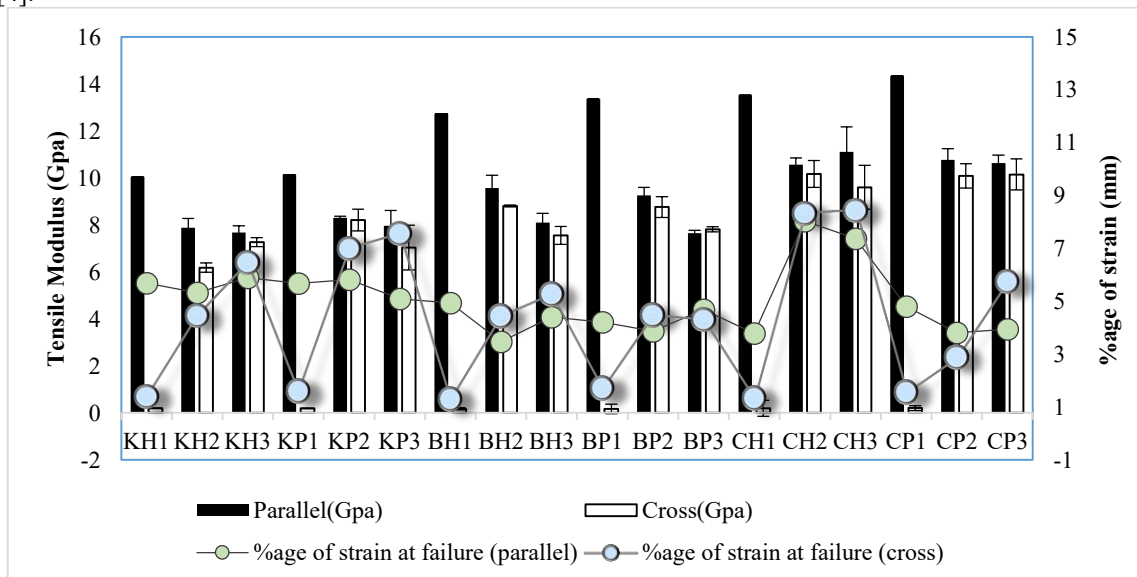


Fig. 1. Tensile modulus and percentage of strain in cross and parallel direction

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 [4] S. Van Hoa, M. Duc Hoang, and J. Simpson, Manufacturing procedure to make flat thermoplastic composite laminates by automated fibre placement and their mechanical properties, *Journal of Thermoplastic Composite Materials* **3012**, 1693-1712, (2017).

**XKUWCN'CEWV[ 'GZCO KP CVKQP 'CV'J QO G'F WTKPI 'EQXKF/3; "**  
**Mkukpg'Mcnpk/F qtqugpm<sup>3,4</sup>. 'Cki c'Uxgf g<sup>3</sup>**

<sup>3</sup>F gr ctvo gpv'qh'Qr vqo gvt { "cpf 'Xkukqp'Uekpeg. 'Wpkxgtuk' 'qh'Ncxk. 'Ncxk"  
<sup>4</sup>G{g'F kugcugu'Erhple. 'Ej kf tgp-ai'Erhplecn'Wpkxgtuk' 'J qur kcn 'Ncxk"

ntkukpgncrpkekB i o ckleqo "

"

Kp'vqcn'y g'tgegkxg'o qtg'vj cp": 2" "qh'qwt'kphqto cvkqp'cdqmw'vj g'gpv'vj tqvi j "qwt'xkukqpO'Gxcnrcv'kpi "c" r gtuqpa'u'xkuwn'cewv' 'ku'ppg'qh'vj g'o clp'erkplecn'ugr u'vq'f gvge'v'cpf "eqttgevt'ghtcevkxg'gttqtu."qt'y j gp'gxcnrcv'kpi "vj g' r tqi tguukqp'qh'xkuwn'cpqo crku'qt'r cvj qm' lkuO'Gctn'f gvge'v'kp'qh'xkukqp'r tqdngo u'cpf 'tr kf "tgcvo gpv'r tguetkdg'dgwg't tguwnuO'Tgegpv'uwf lku'lp"423; "tgr qt'v'vj cv'vj g'wug'qh'vng'o gf lekpg'htco gy qtni'kpetgcugf "vq'cee'qo o qf cvg'htq'r cvkpw' y j q' tgs wktgf "tgo qvg'g'ectg'f v'g'v'vj g'Uxgtg'"Cewg'"Tgur kcvqt { "U{pf tqo g' Eqtpccktw'4" \*EQXKF 3; +; y j lej " kphgevgf "vj g'i m'dg'lp"423; "J3\_O'K'ku'qhv'p'p'qv'r quukdng'v'g'zco lpg'r cvkpw'v'tgo qvgn' . 'uq'vng'o gf lekpg'ku'pq'u'wdukw'w'htq' hceg/vq/hceg" ur gelckuv' eqpuwncv'kpuO' Qr j vj cm qm' { " cpf " qr vqo gvt { " ctg" qpg" qh' vj g' ur gelckuv' y gm' uwk'gf " htq' vng'o gf lekpg'eqpuwncv'kpu. "cpf "cewg" r tqdngo u'lp"qr j vj cm qm' { "ctg"cp'ctgc"y j gtg'vng'o gf lekpg'ecp"eqo r ngo gpv' gzku'kpi "ur gelck'gf "ugtxlegu"]4. "5\_O'Vj gtg'ctg'ewtgpv' "o cp { "cxkrcdng'v'qnu'htq'v'kpi "xkuwn'cewv' "cv'j qo g. "qpg'qh' y j lej "ku'vj g'Hgldwti "Xkuwn'Ce'wv' ("Eqpvcu'Vguv' \*HCEV+ 'v'guv'vj g'v'guv'uj qy u'i qaf "tgrckdk' "y j gp'eqo r ctg' "v' vj g'i qf gp'w'cpf ctf 'GVF TU'ej ctv'qt'vj g'Upngnp'ej ctv']6. "7\_O'Vj g'r wtr qug'qh'v'ku'r cr gt' y cu'v'cpcn' | g'vj g'gh'gevk'gp'gu' qh' vj g' HCEV" v'gu'v'htq' v'kpi " xkuwn'cewv' "cv'j qo g'v'q'gj gt' y kj "xkukqp"ectg'ur gelckuv' O'Vj g' uwf { "kpxqk'gf " : 2" r ctvek'cpw'\*/: 8" { gctu'qf . "o gcp'ci g"4: "O'36" { gctu: "66'hgo crgu"\*77" + "cpf "58" o crgu"\*67" +O'Xkuwn'cewv' "y cu' cu'guugf "wulpi "c"ur gelck'gf "HCEV"eqo r wgt'v'guv'cv'dqj' "f'kucpeg" \*5" o "cpf "pgct" \*3" o +y kj "cpf "y kj qw'vr'v'ecni i nu'guo'P'q'cf'f'k'k'p'cn'g's'w'r o gpv'ku'tgs wktgf "y kj qw'v'c"eqo r wgt. "o qpkqt'cpf "ng{dqctf O'Vj g'eqo r wgt'gf "HCEV"v'guv' ecp'dg'ecrktcv'gf "v'q'vj g'v'k' g'cpf "tguq'w'k'p'qh'v'j g'o qpkqt'w'gf O'Dgh'q'g'vj g'xkuwn'cewv' "v'guv'wulpi "vj g'v' q'q' q'qo "xkf'gq'ecni' cr r "qt"Y j cvu'Cr r . "vj g'r ctvek'cp'vj cf "v'q'eqp'v'c'xkukqp"ur gelckuv'v'g'zr'ncp'vj g'r tqeguu'qh'v'j g'xkuwn'cewv' "v'guv'vj g' ugw'kpi u"vj g'v'guv' r ctco v'gtu'cpf "o qpkqt'vj g's wck'v' "qh'v'j g'xkuwn'cewv' "v'guv' r tqx'kf'g'p'geguuct { "cf'x'leg. "cpuy'gtu'v'q" r cvkpw'w's'v'guv'k'p'u. "tguwnu. "pgz'v'ugr uO'Vj g'tguwnu'j'cxg'uj'qy'p'vj'cv'vj'g'ur'gelck'gf "eqo r wgt'r tqi tco "HCEV"ku'c'i'q'qf "v'q'v'v'q'dg'w'ugf "cv'j qo g'v'q'ej'geni'xkuwn'cewv' "cpf "y j gv'gt'k'ku'p'qto'cn'cu'y'gm'cu'v'q'o qpkqt'xkuwn'cewv' "ko r tqx'go gpv' d { "r gthqto kpi "xctk'q'w'v' r gu'qh'xkuwn'v'j g'v'g' { "co dn'qr'lc'v'g'cvo'gpv' "o gf'lec'v'k'p'v'g'cvo'gpv' "gv'0'0'Rect'v'ek'cpw' y j q'f'kf' "pqv'r'cu'v'j g'xkukqp'v'guv'y'gtg't'gh'gt'gf "v'q'c'xkukqp"ur'gelckuv'htq'cp'cf'x'c'pegf "xkukqp"gzco'kp'cvk'p'0'K'eqpen'w'k'p. "f'v'k'pi "EQXKF/3; . 'k'y'cu'r'quukdng'v'q'ej'geni'xkuwn'cewv' "tgo qvgn' . "htqo "vj g'eqo hq'v'qh'j'qo g. "wulpi "xctk'q'w'v'q'qnu. "ur'gelck'ecni' "vj g'ur'gelck'gf "eqo r wgt'r tqi tco "HCEV'O'Vj g { "o'cng'rk'g'g'culgt'htq'v'j g'r'cvkpw'dgecwug'vj g'f'q'p'qv'j'cxg'v'q'ur'gp'f'v'ko'g' xkuk'kpi "c'xkukqp"ur'gelckuv'ej'gen'kpi "y j gv'gt'vj g'k'xkukqp'ku'p'qto'cn'v'q'vj'gt' y kj "vj g'xkukqp"ur'gelckuv'q'p'k'p'g' +. "cpf "vj g' y qtni'qh'v'j g'xkukqp"ur'gelckuv'dgecwug'k'ku'r'quukdng'v'q'o qpkqt'vj g'r'cvkpw'v'cpf'kt'vj g'tguwnu'qh'v'j g'vj g'v'g' { "o

[3\_NLOEchtg { .O'0Vc{ nqt. 'I OI qng'gv'cno'O qf gnu'qh'ectg'lp'vng'r/q'j vj cm qm' { <v'ueqr kpi 't'g'x'gy . 'L'Vng'o gf "Vng'ectg'47. '328/344"\*423; +0  
[4\_K'Vcp. 'NRO'F'qdu'p. 'UO'v'k'g'v'cno'T'gen'v'o g'vng'qr j vj cm qm' { "xgtu'w'hceg/vq/hceg'eqpuwncv'k'p'<C'v'ungo'v'k'v'g'x'gy . 'L'Vng'o gf "Vng'ectg'45\*9+ "  
84; /85: "4239+0"  
[5\_U'GO'Dctv'p'km'URO'Eqr'g'nc'p'f. "C'LO'Cleng'g'v'c'0'Qr'v'qo gvt { "h'ck'k'cv'gf'v'ng'qr j vj cm qm' { <cp'v'w'k'q'h'v'j g'htu'v' { gct "lp'Y'gu'g'p' "C'w'v'v'c'k. "Ernp'G'zr "  
Qr'v'qo "323. '922/925"\*423; +0"  
[6\_O'D'ce'j . "Vj g'Hgldwti "Xkuwn'Ce'wv' "Vguv'Xct'ck'ck'k'v' "w'pe'j'cpi'gf "d { "r'quv'q'v' "t'g'c'p'c'n'v'ku. "I'c'gh'g'v' C'tej "Ernp'G'zr "Qr'j vj cm qm'467. " ; 87; /93 "  
\*4229+0"  
[7\_L'OM'Q'm' . 'LO'OI'tc { . "C'RO'U'ck'g'v'cno'C'v'cp'f'qo'k'gf'et'quu'x'gt'uwf { "v'q'cu'gu'v'v'j g'w'cd'ck'v' "qh'v'q'p'gy "xkukqp"v'guv'lp'r'cvkpw'v'vj kj "ny' "xkukqp. "  
Qr'v'qo "X'ku'U'ek; 8\*8+ '665/674"\*423; +0"

P3-35

DID NOT PARTICIPATE

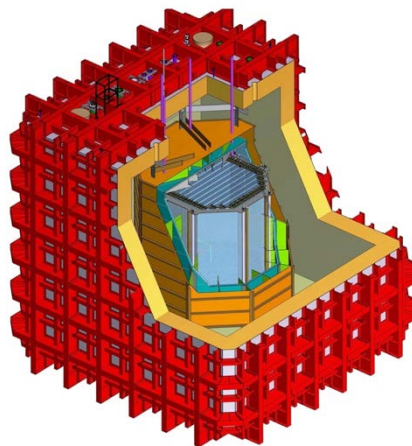
# GADOLINIUM LOADED ORGANIC DETECTOR FOR THE DARKSIDE EXPERIMENT

Cppc'O ctkpk<sup>3</sup>. 'Dkpec'Dqwkpq<sup>4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rj { uleu.'Wpkxgtuks\ 'qh'I gpqxc.'Kcn\ ""  
<sup>4</sup>P cvkqpcn'k'pukwgg'qh'P werget 'Rj { uleu.'Wpkxgtuks\ 'qh'I gpqxc.'Kcn\ ""  
cppcO ctkpkB i gOplpkv'

Vj g'F ctnLkf g't tqlgev' hqecv'f 'cv'y g'I tcp'Ucuuq'P cvkqpcn'Ncdqtcvqtkgu'/'clo u'v'f kt gev\ 'f gygev'f ctnib cwgt'r ct v'ergu." wukpi "c'hs wkf "cti qp'f gygev'f Qpg'qh'y g'ng\ 'hgcwtgu'lp'y g'F ctnLkf g/42n'gzr g'tko gpv'ku'c'pgwtqp'xgv'f gygev'f. 'wugf "vq" tglgev'y g'dceni tqw'f "uki pcni'ecwugf "d\ "pgwtqp'k'p'gtce'v'qpu'Vj g'xgv'f gygev'f y km'eqpukv'qh'c"i cf q'rk'p'kwo "n'q'cf gf" r qn\ o g'y { n'lo g'y cet { n'v'g'RO O C+'uj gm'uwttq'w'f gf "d\ 'hs wkf "cti qp'0P gwtqpu'ecr w'g'qp'y g'i cf q'rk'p'kwo "y j lej "go ku" o w'nr ng'i co o c'tc { u'y cv'k'p'gtce'v'lp'hs wkf "cti qp.'r tqf w'el'pi "uel'p'w'k'v'q'p'hi j v'0Vj ku'hi j v'ku'y gp'f gygev'f 'y kj "f gf kec'v'f" r j qv'q'ug'pu'qtu'0"

"



"

Hki 03<Vj g'F ctnLkf g/42n'let { qucv'eqpv'k'p'k'pi 'y g'xgv'f'uf'wgo 'c'pf 'y g'cti qp'VRE0'

"

K'p'y ku'eqpv'gz'v'o { 'y q'm'ku'h'qewug'f "qp'c'p'T( F'r tqlgev'v'q'o cng'c'v'p'k'q'to 'i cf q'rk'p'kwo 'qz'kf g'p'cp'q/'r ct v'erg'f kur gtuk'qp" kp'c'RO O C'o c'v'kz.'u'x'ct'v'k'pi "h'q'o "y g'hs wkf "o qp'qo gt'RO O C+'U'lp'eg'i cf q'rk'p'kwo "qz'kf g'ku'p'q'v'o kz'cd'ng'lp'RO O C.'dw'v'y g" p'cp'q'i t'cl'pu'v'gp'f "v'q'ci i t'gi c'v'g'c'p'f "v'q'f gr qu'v'f w'k'pi "y g'r qn\ o g't'k'uc'v'q'p'/"y w'u'ec'w'k'pi "k'p'j q'o q'i g'p'g'k'v'f "k'p'y g'h'k'p'c'n'r tqf w'ev' /"c"hw'p'ev'k'p'c'n'k' c'v'k'p'uw'f { "qh'y g'qz'kf g'i t'cl'pu'y kj "c"u'w'k'cd'ng'uw'h'c'v'p'v'ku't'gs w'k'gf."lp"q'tf gt"v'q"et'g'c'v'g'c"eq'c'v'k'pi "y cv' o k'p'k'o k' g'u'y g'i t'cl'pu'ew'ng't'k'uc'v'q'p'0"

"



# EGP VGT GF 'O GVCN'RQY F GT 'HNQY 'HQT 'RT GE KUKQP 'NCUGT 'O GVCN' RQY F GT 'F GRQUVKQP "

Tqo wcrf "Rgvngxk<sup>3</sup>. "Ugti glwu'Dqtqf kpcu<sup>4</sup>. 'I gptkmiO qtf cu<sup>3</sup>"

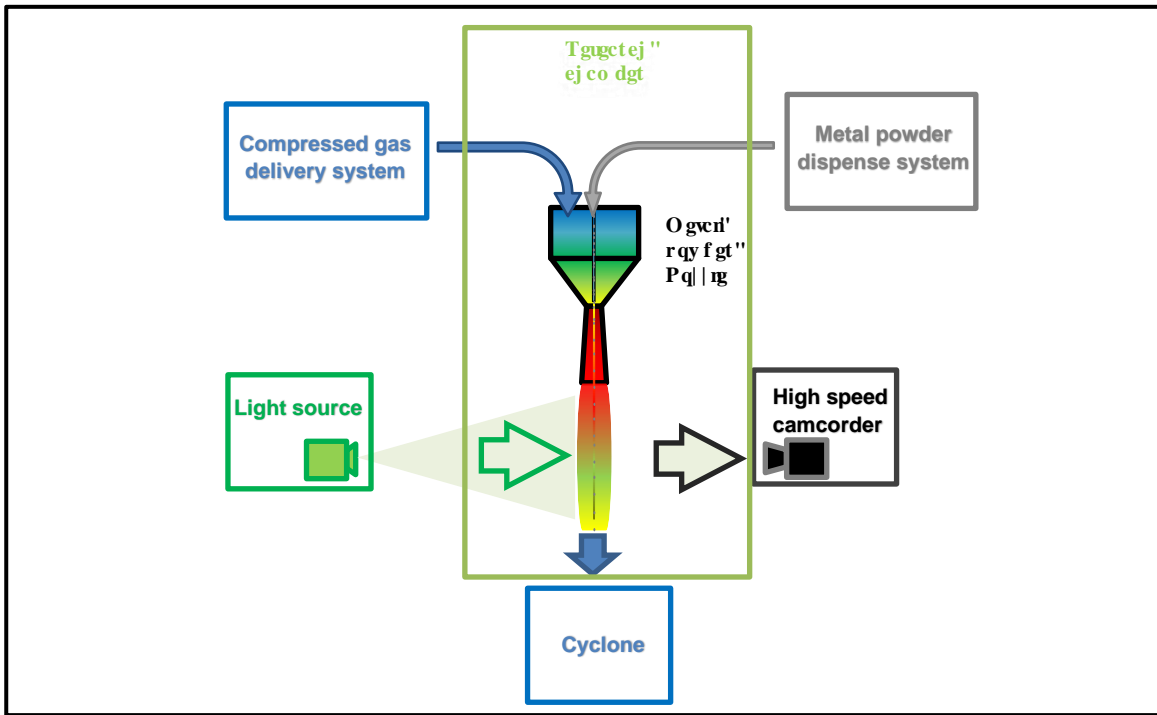
<sup>3</sup>F gr ctvo gpv'qh'Ncugt "Vgej pqmji kgu. 'Egpygt 'hqt'Rj { ulecn'Uelgpegu'cpf "Vgej pqmji { . 'Xkpkwu. 'Nkj wcpk "

<sup>4</sup>Hcewnt'qh'Ekki'Gpi kpggtkpi . 'Xkpkwu'I gf ko kpcu'Vgej pkecn'Wpkxgtukf . 'Xkpkwu. 'Nkj wcpk "  
tqo wcrf 0 gvxleB hno e0n"

Upeg<sup>3</sup>; : 2. "vj g"fgxgru opv'qh'cf f kkg"r tqf wevkqp"j cu'dgi wp'k"tgegpv" { gctu. "ugxgtr'cf f kkg"o cpwcewtkpi " vgej pqmji kgu"j cxg"dggp"fgxgru gf "dcugf "qp"vj g"etgcvkqp"qh'5f "qdlgevu" wulpi "ugs wgvkcn'rc { gtpi "r tqeguug'k" uvej " r tqeguug. "vj g"rc { gtu'hqto "c"j qo qi gpgvau'utwewtg"d { 'eqpukvgrw { 'eqcvkpi "5f "qdlgevu'y kj "r tqr gtn { "r tgr ctgf "o cvgtkcn" vj cv'ecp"uqo gvko gu'dg"o qf kkgf "f wtkpi "vj g"r tqeguug'Vj ku"etgcvgu"qr r qt wvkkgu'hqt"vj g"r tqf wevkqp"qh'pgy "wpzr nqt gf " utwewtgf "o cvgtkcn'0

Qpg'uwej "vgej pqmji { "ku'rcugt"o gvcn'f gr qukkqp"vgej pqmji { "NO F +]3\_0Vj ku'cf f kkg"o cpwcewtkpi "o gvj qf . 'y j lej " i gpgtcvgu'5F "utwewtgu'y tqwi j "vj g"kvgtcevkqp"qh'c'rcugt'dgco . '5f "qdlgevu'cpf "c"i cu'r qy f gt'utgco 0O quv'NO F "u { utgo u" wug'eqczkcn'r qy f gt'pq | rgu'vj cv'hqto "c"eqplecn'r qy f gt'hny 0Vj g'r qukkqp"qh'vj g'hqecnr'ncp'qh'uwej "c"r qy f gt'hny "ch'gew" vj g'uk'g. "gh'ekgpe { . 'cpf "tgi wrctk { "qh'vj g'ugf ko gpvr'cvj y c { u" ]4.5\_0

Vq'tgf weg"vj g"lphwpeg"qh'vj g'r qy f gt'hny "qp"vj g'r tqeguug. "c"pgy "pq | r" y cu'f gxgru gf "vq"ej cpi g"vj g"i gqo gt { " htqo "eqplecn'vq"e { rkp'f tlecn'0



Hki 03'O gcuwtgo gpv'ugwr "qh'vj g'o gvcn'r qy f gt'pq | rg'0

Kp'qtf gt "vq"eqv'qdn'vj g'r tqeguug'cpf "lpetgcug"ku'tgrkcdkks { "cpf "t'g/wug'kp'lpf wut { . 'k'ku'pgeguuct { "vq"hpqy "vj g"gzcev' ej ctcevgtkn'ku'qh'vj g'o gvcn'r qy f gt'pq | rg'0

Kp'vj ku'uwf { . 'y g'y kn'lp'xgvki cvg"vj g'hkdg't'f kntkdwkqp"qh'pq | rg'r ct'veng'u'wulpi "f khtg'gpv'i cu'r tguuwtg'xcn'ngu'0Vj g" o gcuwtgo gpv'ugwr "ku'kn'uw'cv'gf "lp'Hki 030Vj g'tguuwa'qh'vj g'gzr g'tko gpv'y kn'ldg'f vgt'o kpg'f "wulpi "c"rcu'v'x'kf gq"eco gtc. " r tguuwtg'o gcuwtgo gpwu. 'y gli j vki "o gvj qf u'vq"cpncn { g'i cu'cpf "r ct'veng'x'gv'ekf . 'r qy f gt'hny "fko vgt. "h'qecnr'ncp" r qukkqp. "cpf "f g'puk'f 0

[3]\_"Ngk"i cp. "I kccq"Ej gp. "Hicpmi'Nkq'w0" Cf f kkg"o cpwcewtkpi "qh'hwepkpcn' "i tcf gf "o gvcn' "o cvgtkcn" wulpi "rcugt"o gvcn'f gr qukkqp" "Cf f kkg" O cpwcewtkpi "53'4242-0

[4]\_" qg'Ictf qp. "Rv'klen'i wkrwo g. "Lw'kcp" Gt wgrf v. "O lej cgr'i lpf gtf cgn'I crk' "Cttqwf. "Qh'kpg"r qy f gt/i cu'pq | r" g'v'ej ctcevgtk'cvkqp" hqt "eqczkcn'rcugt" dcugf "f kt gev'f "Gp'gti { "f gr qukkqp" "Eqplecn'r qy f gt' hny 0Vj g'r qukkqp"qh'vj g'hqecnr'ncp'qh'uwej "c"r qy f gt'hny "ch'gew" vj g'uk'g. "gh'ekgpe { . 'cpf "tgi wrctk { "qh'vj g'ugf ko gpvr'cvj y c { u" ]4.5\_0

[5]\_"Uko qpg'F qpcf gmqc. "O cwtk kq"O qwcc. "C'rk'i qnj cp'F go ktc. "Detdetc"Rt'gxkcn'0"O qpl'kqt kpi "qhl'rcugt"o gvcn'f gr qukkqp"j gli j v'ld { "o gcpu'qhl'eqczkcn'rcugt" v'kpi w'rcv'qp" "Qr v'ku'cp'f "Ncugt'u'lp'Gpi kpggtkpi . "Xqno g"334. "Lepwct { "423; . "Rci gu"358/366-0

"  
"  
"

P3-38

DID NOT PARTICIPATE

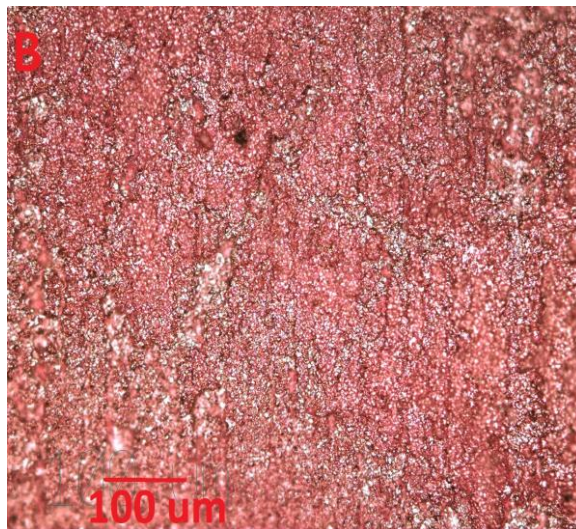
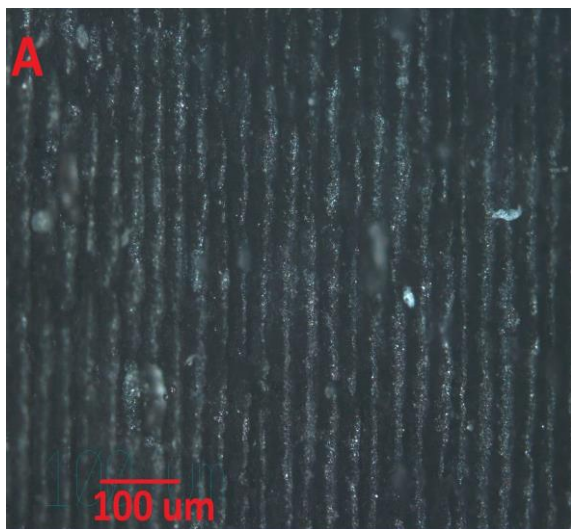


**NCUGT/CUUKUVGF 'UGNGE VK&G'HCDTKE CVKQP 'QHE QRRGT 'VTCEGUQP''**  
**RQN[ OGTUD[ 'GNGETQRNCVKPI ''**  
Xkcrkl'Hkqfqtqx<sup>3</sup>.Mctqrku'Tcxcwcu<sup>3</sup>.\ gpkwu'O qemwu<sup>4</sup>

<sup>3</sup>F gr ctvo gpv'qh'Ncugt "Vgej pqmji kgu."Egpvgt'hqt'Rj {ulecni'Uelgpegu"cpf "Vgej pqmji {."Nksj wcpkc"  
<sup>4</sup>"F gr ctvo gpv'qh'Ej go lecni'Gpi kpggtkpi "cpf "Vgej pqmji {."Egpvgt'hqt'Rj {ulecni'Uelgpegu"cpf "Vgej pqmji {."Nksj wcpkc"  
xkcrkl0hkqfqtqx8 hno e0n'

Vj g'r cr gt'tgr qt'u'c'hcekrng"cpf "ny /equv'rcugt/cuukuvf"o gjv qf "hqt'ugrgev&g'f gr qukkqp"qh'eqr r gt "vcegu"qp'r qn(o gt " uwt'cegu'Vj g'vgej plsvw'wugu"c"rcugt "hqt'ugrgev&g'r qn(o gt "uwt'cegu"o qf kilecvkqp'Vj g'grgevt'lecn'eqpf vev&v' "qh'uqo g" r qn(o gtu'eqw'f "dg'kpetgcugf "f w'v'q'rcugt 'ktcf'kcvkqp'0Mcrr vqp'RKkro "y cu'wugf "kp'qwt'g'zr g'tko gpv'Uco r rgu'y g'tg'r cwgt'pgf " wukpi "c'r lequgeqpf "rcugt "cv'3286'po "y cxgrgpi vj 0Vj g'g'zr g'tko gpw'y g'tg'r gthqto gf "wukpi "cxgtci g'r qy gtu'tcpi kpi "Itqo "6" vq": 0'Y "kp'20'Y "kpetgo gpw.'r wug'tgr g'v'kqp'tcvgu'htqo "32'v'322'nd | "cpf "c'eqpucpv'uecp'tcvq'qh'322"o o lu0Vj g'uj ggv' tgukrcpeg'y cu'o gcuw'gf "wukpi "vj g'hqwt/r tqdg"o gjv qf ."cpf "k'y cu'tgf w'gf "vq">"72"á "r gt "us wctg"chgt"rcugt "r cwgt'pki 0' Chgt'y ctf u."vj g'o qf k'k'gf "uwt'cegu'y cu'o g'v'nf gr qukk'gf "d{ "grgevtqr r'v'kpi 0"

Vj g'o clp'cf xcpvci g'qh'vj g'o gjv qf "ku'vj cv'f'k'gev'grgevtqr r'v'kpi "qp'r qn(o gtu'cmny u'xgt { "hcu'ugrgev&g'cpf "ny /equv" o g'v'nf gr qukk'qp'r tqegu'u'v'eqo r ctg'y kj "q'v'gt'f'gr qukk'qp"o gjv qf u.'h'ng'RXF "eqc'v'kpi . 'r clp'v'kpi "y kj "eqpf vev&v'kpm'gve0' Ugrgev&g'f gr qukk'qp"qh'eqr r gt "qp'r qn(o gtu'eqw'f "dg'wugf "kp'h'gz'k'ng'grgevt'q'p'le "f gx'le'gu'0'Vj ku'v'gej pqmji { "uj qy u'c'j'wi g" r q'v'p'v'cl'k'p"o cp { "h'grf u'<eqpuwo cdng'grgevt'q'p'leu.'cwqo q'v'x'g."o gf le'k'p'g'v'e0'Vj g'c'ko "qh'vj ku't'gug'cte'j "ku'v'q'h'k'p' "vj g'qr v'ko cni" rcugt "r cwgt'pki "cpf "eqr r gt "r'v'kpi "r ctco g'v'gtu'hqt'j ki j "s w'v'k'v' { . 't'gew't'gp'v'hd't'le'cv'k'qp"qh'eqr r gt "v'cegu"qp'r qn(o gt 0'



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# WIRELESS COMMUNICATION IN THE INTERNET OF THINGS

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Recently, the Internet of Things has become one of the most common trends in the development of data network transmission technologies. Modern companies such as Vodafone, Huawei, Ring and others are actively introducing the latest means of wireless communication in the Internet of Things technology. In this regard, the study of wireless communications is of interest for researchers. This is proved by the research of Yang Yu, Chen Wenzhou, Weijianhui [1; 2; 3]. The purpose of my report is to provide an overview of wireless communication types and reveal their advantages and disadvantages of each.

The Internet of Things uses both wired and wireless communications. The Wired ones are more reliable, while the wireless ones have more prospects in this area. Therefore, I paid more attention to wireless communication. There are two main types of wireless communication. Short-range wireless communications include Bluetooth Wi-Fi ZigBee and Z-Wave. Sigfox, LoRa and NB-IoT belong to the second type of long range wide area communication. Bluetooth is a large capacity communication technology. It was invented as an alternative to wired technology. Bluetooth enables data exchange over short distances among devices and personal area networks. It uses the radio waves in the ISM band from 2.4 to 2.485 GHz with a transmission rate up to 1 Mbps [1]. Bluetooth has a short transmission distance of 10 cm to 10 m, which limits its use. At the same time, there are Bluetooth devices, which have a transmission distance of up to 100 m with a high power level. Bluetooth is widely used in applications. Its usage can be found in mobile phones, headphones, home appliances and smart wearables. Low power consumption, high reliability and high speed are the advantages of Bluetooth. But it is not suitable for multi-point deployment. The next wireless technology, which is widely known in the world, is Wi-Fi. The peculiarity of Wi-Fi is that it allows electrical devices to connect to a wireless local area. It most commonly uses the 2.4 G UHF or 5G SHF ISM radio bands [1]. Wi-Fi can be either password protected or an open network. Most of the devices such as computer, mobile phone, printer and others in our house can be connected with WLAN via Wi-Fi. Wi-Fi has the highest transmission speed among short-distance technologies. It has also wide coverage. Along with this, it has also disadvantages such as low transmission security, weak stability and high energy consumption [2]. ZigBee specializes in the internet of things. It is a low-power consumption LAN protocol based on IEEE802.15.4[1]. ZigBee is widely used in the industrial area and smart homes. It is easy to use, inexpensive and possesses high reliability. For instance, ZigBee base station costs less than 200 dollars while cellular base station costs hundreds of thousands dollars to build. It also transmits data from other network nodes. ZigBee has a wide range of applications to IoT such as smart home terminals and others. Thereby, ZigBee is a low-power consumption communication technology. It has a low complexity and low speed. Transmission distances can reach hundreds of meters. But this technology in smart parking is weakened by vehicles. Z-Wave is very similar to ZigBee. The main advantages of the Z-Wave are low price, low energy consumption and high reliability. Z-Wave can be used in light control, status checking and measurements. For instance, metering, home appliance control, access control, fire detection etc. Its transmission distance is from 30m to 100m. It features a simple network structure, low power consumption and high reliability. The main disadvantage of Z-Wave is low rates and closed standards [3].

There are only three main technologies for long-range wireless communication called Low Power Wide Area. LPWA technologies include Sigfox, LoRa and NB-IoT. The main aim of Sigfox is building a private wireless IoT network, which requires a low power consumption and low costs. Sigfox can maintain stable data connection without high power consumption. It also uses ultra-narrowband technology and has transmission speed up to 100 bps [4]. The Sigfox uses license-free Sub-GHz radio waves. It works in the ISM band 868 MHz in Europe and 915 MHz in the USA. LoRa also uses Sub-GHz frequency bands in its turn to achieve a wider range by means of higher frequencies and low-power consumption. It is based on spread spectrum technology. It avoids the tradeoff between transmission range and low-power consumption and provides users with a simple system. Narrow Band IoT is built on cellular networks and uses a bandwidth of about 180 kHz. It can be deployed on GSM, UMTS and also on LTE networks. Thereby, it reduces its cost. NB-IoT technologies provide wide coverage, multiple connections, low costs, low power consumption, low speed and excellent architecture. It can be used in smart parking, remote metering, smart agriculture and more [4].

Thus, it can be concluded, that there is a large number of communication technologies. The article outlined the advantages and disadvantages of each of them. In the Internet of Things, you can combine the use of technologies, depending on what task was set.

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ecp'd'g'h'w't'yj g't'f' g'x'g'r'gf' 'hqt'yj g't'g'r'k'cd'g'cu'gu'uo g'p'v'q'h'w'ugt' g'zr gtlgpeg'hqt'yj g'yj tgg/f ko gpukpcn'xkuw'rk' c'k'q'p'u' { u'vgo u'0"

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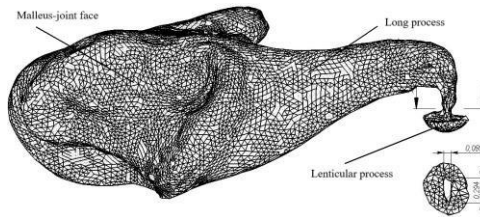
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<sup>3</sup>F gr ctwo gpv'qh'O gej cplecni'Gpi kpggtkpi 'cpf 'F guki p. 'Mcwpcu'wplxgtukf 'qh'vgej pqmji { . 'Nkj wpcle''  
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P qy cf c{ u. 'y' g' j' ki j' gt' j' wo cpau'npji gxlk' 'r' tqxkf gu'pgy 'ej cmgpi gu'j' qy 'vq' o clpvclp' j' gctkpi 'hquu. 'f' wg' vq' y' g' ci' glpi O' F gur ksg' y' cv' y' g' j' gctkpi 'hquu' o c{ 't' guwu' h' t' qo 'i' gpgvle' ecwugu. 'eqo r' r' necvclpu' cv' d' kt' y' . 'egt' vclp' l' phge' v' q' wu' f' kugcugu. 'ej' tqple'' gct' l' phge' v' q' pu. 'y' g' v' w' g' h' f' t' w' u' c' p' f' 'g' x' g' p' y' g' g' z' r' q' u' w' t' g' v' q' g' z' e' g' u' k' x' g' p' q' k' u' g' O'

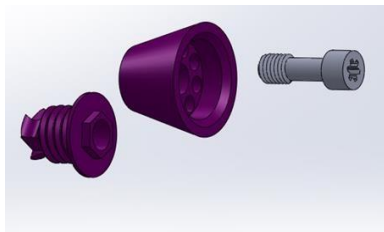
Qpg'ecwug'qh'j' gctkpi 'hquu' ku' y' g' p' p' q' p' g' / t' c' p' u' o' k' u' k' q' p' q' h' y' g' u' q' w' p' f' 'x' k' d' t' c' v' k' p' 'l' p' y' g' o' k' f' r' g' t' 'f' w' g' v' q' y' g' h' c' k' w' t' g' 'l' p' y' g' ' q' u' l' e' w' r' t' 'e' j' c' l' p' O' K' y' k' u' 'e' c' u' g' . 'c' p' ' q' u' l' e' w' r' t' r' u' w' y' 'e' c' p' ' d' g' ' f' q' p' g' . 'c' p' f' ' y' g' ' r' t' q' u' j' g' u' k' u' y' k' n' i' d' g' ' r' m' e' g' f' ' v' q' ' t' g' e' t' g' c' v' g' ' y' g' ' k' p' k' c' n' i' o' g' e' j' c' p' k' u' o' ' q' h' y' g' j' g' c' t' k' p' i' . 'd' { ' t' g' e' q' p' u' t' w' e' v' k' p' i' ' q' u' l' e' w' r' t' ' e' j' c' l' p' O' K' y' g' ' e' c' u' g' ' q' h' ' e' q' p' f' w' e' v' k' g' ' j' g' c' t' k' p' i' ' h' q' u' u' . ' y' g' ' e' q' p' x' g' p' v' k' p' c' i' l' j' g' c' t' k' p' i' ' c' k' f' ' f' q' g' u' p' q' v' y' q' t' n' i' c' p' f' ' y' g' ' w' u' c' i' g' ' q' h' j' g' c' t' k' p' i' ' c' k' f' . ' y' j' l' e' j' ' k' u' ' e' q' o' r' q' u' g' f' ' h' t' q' o' ' y' g' ' l' o' r' r' e' p' v' c' p' f' ' r' t' q' v' j' g' u' k' u' . ' d' g' e' q' o' g' u' l' p' g' x' k' c' d' r' g' O'

Eqpegtpkpi 'y' g' t' g' e' q' p' u' t' w' e' v' k' p' i' ' q' h' ' q' u' l' e' w' r' t' ' e' j' c' l' p' . ' y' g' ' u' g' r' e' v' k' p' i' ' q' h' y' g' ' v' r' g' ' q' h' r' t' q' v' j' g' u' g' u' f' g' r' g' p' f' u' ' q' p' y' g' ' e' r' k' p' l' e' c' n' i' u' k' w' c' v' k' p' ' c' p' f' ' q' h' y' g' ' c' o' q' w' p' v' q' h' f' c' o' c' i' g' O' H' q' t' ' g' z' c' o' r' i' g' . ' [ ' w' e' p' i' ' ] 3 \_ ' u' w' o' c' t' k' g' f' ' q' u' l' e' w' r' t' ' f' c' o' c' i' g' ' l' p' y' g' ' r' c' v' k' g' p' u' y' k' j' ' c' v' g' r' e' v' c' u' k' u' ' c' p' f' ' h' q' w' p' f' ' y' j' c' v' h' q' t' ' 94 ' ' q' h' ' e' c' u' g' u' ' l' p' r' q' u' g' t' k' q' t' ' t' g' t' c' e' v' k' p' i' ' r' q' e' n' g' v' ' q' p' n' i' ' l' p' e' w' u' y' c' u' g' t' q' f' g' f' O' C' u' ' k' y' c' u' h' q' w' p' f' ' l' p' ' r' t' g' x' k' q' w' t' g' u' g' c' t' e' j' ' j' 4 \_ ' s' y' q' t' n' i' p' i' ' o' . ' d' w' l' p' l' w' t' g' f' ' l' p' e' w' u' ' H' i' 03 - o' w' u' v' d' g' ' t' g' r' m' e' g' f' ' c' p' f' ' c' r' r' t' q' r' t' l' e' v' g' ' r' t' q' v' j' g' u' k' u' b' w' u' v' d' g' ' u' g' r' e' v' g' f' O' H' k' p' c' m' i' . ' h' q' t' ' y' g' ' t' g' e' q' p' u' t' w' e' v' k' p' i' ' q' h' y' g' ' q' u' l' e' w' r' t' ' e' j' c' l' p' . ' c' ' r' e' t' i' g' ' x' c' t' l' e' v' y' ' q' h' r' t' q' v' j' g' u' g' u' ' f' k' h' h' g' t' g' p' v' o' c' v' g' t' k' c' n' i' c' p' f' ' u' j' c' r' g' u' + ' j' c' x' g' ' d' g' g' p' ' r' t' q' r' q' u' g' f' O' U' q' . ' j' g' t' g' ' y' g' ' E' C' F' I' E' C' G' ' u' { ' u' g' o' u' ' c' t' g' ' c' r' r' r' k' e' g' f' ' v' q' ' f' k' h' h' g' t' g' p' v' e' v' g' ' y' g' ' d' g' i' c' x' k' q' t' ' q' h' r' t' q' v' j' g' u' k' u' . ' c' e' e' q' t' f' l' p' i' ' v' q' ' y' g' ' u' j' c' r' g' ' c' p' f' ' w' u' g' f' ' o' c' v' g' t' k' c' n' i' o'



Hki 030Vj g'uo qqvj gf 'pwo gtlecni' o qf gni'qh'j' wo cp' l'pewu'y' kj 'lplwtgf' h'pi' 'r' tqegu' j' 3 \_

Dqpg'cpej qtgf 'j' gctkpi 'ckf u' \*DCJ C+ctg' uwti lecn' i' lo r' r' e' p' v' g' f' d' { 'f' t' k' n' i' p' i' ' c' ' u' r' g' e' l' c' n' i' h' z' c' v' k' p' i' ' j' q' r' g' ' l' p' ' u' n' y' ' u' r' g' g' f' ' l' p' ' q' t' f' g' t' ' p' q' v' v' q' ' q' x' g' t' j' g' e' v' y' g' ' d' d' q' p' g' . ' y' j' c' v' h' k' p' c' m' i' ' e' q' w' f' ' l' o' r' c' e' v' y' g' ' e' q' p' f' w' e' v' k' p' i' ' q' h' u' q' w' p' f' ' h' t' q' o' ' y' g' ' r' t' q' e' g' u' u' q' t' O' F' g' v' c' k' r' g' f' ' D' C' J' C' ' l' o' r' r' e' p' v' k' u' r' t' g' u' g' p' v' g' f' ' l' p' ' H' i' 040 ' y' j' l' e' j' ' y' c' u' o' q' f' g' n' g' f' ' v' q' ' u' w' f' { ' l' o' r' r' e' p' v' u' h' z' c' v' k' p' i' o'



Hki 040Dqpg'cpej qtgf 'j' gctkpi 'ckf <lo r' r' e' p' v'

Uqrf Y qtmu' uqhy ctg' y' cu' wugf 'hqt' y' g' e' q' p' e' g' r' v' k' p' i' ' q' h' y' g' ' p' w' o' g' t' l' e' c' n' i' 5F ' o' q' f' g' n' i' c' p' f' ' E' C' G' ' c' p' c' n' i' u' k' o'

j3\_ O' O' y' O' l' w' p' i' . ' T' g' t' c' e' v' k' p' i' ' q' h' y' g' ' r' c' t' u' ' v' g' p' u' c' ' h' p' i' / v' g' t' o' ' t' g' u' w' u' ' q' h' u' w' t' i' l' e' c' n' i' t' g' c' v' o' g' p' v' . ' E' r' k' p' O' Q' v' q' r' c' t' { ' p' i' q' r' O' C' n' i' k' e' f' ' U' e' i' 044 \* 6 - \* 545 / 548 ( B ; ; 90 ' j4\_ X' O' I' { ' r' k' g' p' g' ' g' v' c' n' i' o' E' j' c' t' c' e' v' g' t' k' c' v' k' p' i' ' q' h' y' g' ' e' j' c' p' l' e' c' n' i' g' j' c' x' k' q' w' t' ' q' h' j' g' c' m' j' { ' c' p' f' ' l' p' l' w' t' g' f' ' j' w' o' c' p' ' l' p' e' w' u' i' { ' g' k' i' g' p' h' t' g' s' w' p' e' { ' g' x' c' m' c' v' k' p' i' . ' R' t' q' e' g' g' f' l' p' i' u' q' h' y' g' ' k' p' u' k' w' k' p' i' ' q' h' o' g' e' j' c' p' l' e' c' n' i' G' p' i' k' p' g' g' t' u' . ' R' c' t' v' j' ' < L' q' w' t' p' c' n' i' q' h' G' p' i' k' p' g' g' t' k' p' i' ' l' p' ' O' g' f' l' e' k' p' g' . ' 456 \* 5 + ' 4876494042420'

ECTDC\ QNG/DCUGF 'O QP QNC[ GTU'HQT'RGTQXUMK/G'UQNCT'E GNNU'

Ckf c'F t g x k m e w u n c k v <sup>3</sup>. 'Co t c p 'C n / C u j q w k <sup>4</sup>. 'U g x g 'C n d t g e j <sup>4</sup>. 'X { v w c u 'I g c w k r <sup>3</sup>. 'C t k q o " O c i q o g f q x <sup>3</sup>

<sup>3</sup>F g r c t w o g p v 'q h 'Q t i c p l e 'E j g o k u t { . 'M c w p c u 'W p k x g t u k v { 'q h 'V g e j p q n q i { . 'N k j w c p l e "

<sup>4</sup>[ q w p i " k p x g u k i c v q t 'I t q w 'R g t q x u n k g 'V c p f g o 'U q r t 'E g m u 'J g m j q n / \ g p v t w o 'D g t r k p . '346 : ; 'D g t r k p . 'I g t o c p { " c k f c f t g x k m e w u n c k g B m w o f w "

R g t q x u n k g 'u q r t 'e g m u 'R U E u + 'j c x g 't g c e j g f " c " o c l q t " l p v g t g u v 'q x g t " v j g " r c u w 'f g e c f g . " f w g " v q " v j g k t " t c r k f n { " i t a y k p i " g h h e l g p e { 'O R U E 'k u 'c 'v { r g 'q h 'u q r t 'e g m u . 'd c u g f " q p 'c p " q t i c p l e / k p q t i c p l e 'h i j v c d u q t d k p i " o c v g t k n 'e c n g f " r g t q x u n k g 'O R U E " e c p 'd g 'w u g f " c u " c 'u l p i n g / l w p e v k p 'u q r t 'e g m 'q t 'k p 'c p f g o . " k p " c " e q o d l p e v k p " y k j " e q o o g t e k n 'v e j p q n q i k g u " g f i 'O U k l e a p . " E K U + 'O k p 'v j g 'r w e g t 'e c u g . " r g t q x u n k g 'e a p x g t v u " j k i j g t " g p g t i { " r j q v q u 'h t q o " x k u d r g " h i j v 'c p f " w n t c x k i r g v 't g i k a p u . " o g c p l p i " v j g f " e c p " o c n g " j k i j g t " g h h e l g p e { " v c p f g o " y k j " n q y g t " g p g t i { " r j q v q p 'c d u q t d g t " o c v g t k n 'u q r t 'e g m u }

Y j k r g 'h i j v c d u q t d k p i " o c v g t k n 'k u 'w u w c m { 't g i c t f g f " c u 'v j g 'o q u v 'k o r q t v c p v 'e q o r q p g p v 'q h 'v j g 'u q r t 'e g m 'v j g t g 'c t g 'c n u q " q v j g t " r c { g t u . " v j c v 'c t g 'k o r q t v c p v 'v q 'g p u w t g 'v j g 'j k i j g u v 'g h h e l g p e { 'O V j g 'r g t q x u n k g " o c v g t k n 'k u 'w u w c m { " u c p f y l e j g f " d g y g g p " v y q 'u q / e c m g f " t c p u r q t v 'r c { g t u " g r g e v t q p / t c p u r q t v k p i " r c { g t " c p f " j q n g / v c p u r q t v k p i " r c { g t + . " v j c v 'c t g 'g p u w t k p i " j k i j " u g r g e v k k v " h q t " v j g 't g u r g e v k x g 'e c t t l g t u 'O C h g t " v j g 'c d u q t r v k p i . " v j g 'j q n g / g r g e v t q p " r c k 'k u 'h q t o g f " c p f " v j g 'p g i c v k x g n { " e j c t i g f " g r g e v t q p " c p f " r q u k x g n { " e j c t i g f " j q n g " c t g " o q x l p i " k p " q r r q u k e " f k t g e v k p u " v j t q w i j " t c p u r q t v k p i " r c { g t u 'O Q p g 'q h 'v j g 'o g p v k p p g f " r c { g t u . " v j g " j q n g / u g r g e v k x g . " k u 'q h g p " f g u e t k d g f " c u 'v j g 'y g c n g u v 'h k p m 'q h 'v j g 'u q r t 'e g m u } ] 3 \_

V j g t g 'c t g 'u g x g t c n r 'c t c o g v g t u . " v j c v 'c t g 'q h 'v j g 'j k i j g u v 'k o r q t v c p e g " h q t " v j g 'j q n g / v c p u r q t v k p i " o c v g t k n 'j V O + 'O Q p g 'q h 'v j g o " k u 'v j g 'c d k k v { " q h 'v j g 'J V O " v q 'r c u u 'r t i t g 'c o q w p u 'q h 'e c t t l g t u 'y j k r g 'o c l p v c k p i " j k i j " u g r g e v k k v { 'O k p 't c f k k q p c n l J V O u . " u w e j " c u " U r k t q / Q O g V C F . " v j k u " k u " w u w c m { " c e j l g x g f " d { " v j g " w u g " q h " q z k f c v k x g " f q r c p u 'O J q y g x g t . " k 'k u " n g c f k p i " v q " v j g " f g e t g c u g f " q x g t c m l u c d k k v { " q h 'v j g " u q r t " e g m u . " v j g t g h q t g " k 'k u " k o r q t v c p v " v q " u g c t e j " h q t " c n g t p e v k x g " o c v g t k n " c p f k t " v e j p q n q i k g u }

T g e g p v k { . " u g r h / c u g o d n g f " o q p q r c { g t u " y g t g " w u g f " c u " j q n g / v c p u r q t v k p i " f q r c p v 'h t g g " o c v g t k n " k p " R U E u ' ] 4 \_ " V j g " o q p q r c { g t u " u q r k g " v j g " f q r k p i / t g r v g f " k u u g u . " y j l e j " c t g " n g c f k p i " v q " u c d k k v { " r t q d n g o u 'O q t g q x g t . " v j g { " j c x g " u o g " c f f k k q p c n l c f x c p v c i g u . " u w e j " c u " u l o r r i e k v { " q h 'v j g " r c { g t " h q t o c v k p p " r t q e g u u . " c p f " v j g " j k i j " h r g z k d k k v { " v q " e j c p i g " r c { g t " r t q r g t v k u " d { " e j c p i k p i " o q r g e w g " u t w e w t g 'O Y j k r g 't c f k k q p c n l J V O " r c { g t u 'c t g " h q t o g f " d { " u r k p / e q c v k p i . " u g r h / c u g o d n g f " o q r g e w g u 'e c p " h q t o " r c { g t u 'd { " u l o r r i e k p f " u e c r d i r g " f k r k p i " o g y q f 'O H w v j g t o q t g . " k h 'v j g 'r g t q x u n k g 'u q r t 'e g m u 'k u 'h q t o g f " c u " c " c p f g o " q p " v q r " q h 'u k l e a p " u q r t 'e g m u . " v j g 'u g r h / c u g o d n g f " o q r g e w g u 'e c p " g c u k n { " e t g c v g " c " r c { g t " q p " c " t q w i j " u k l e a p " u w t h c e g . " c u 'y g m 'c u 'r t q x k f g 'o k p l o c n r c t c u k k e 'c d u q t r v k p i . " d g e c w u g 'q h 'v j g 'u o c m l v k e m p g u }



H i 030 V j g 'i g p g t c n l u t w e w t g 'q h 'v j g 'e c t d c l q n g / d c u g f 'r j q u r j q p l e " c e k f u ' p R C E | " \* p ? 4 . ' 5 . ' 6 . ' 7 . ' 8 - 0 "

C u " c " r c t v " q h " v j g " u t w e w t g / r t q r g t v k u " t g r v k p u j k r " k p x g u k i c v k p p . " c " u g t k g u " q h " p g y " e c t d c l q n g " f g t k c v k x g u " y g t g " u { p v j g u k f g 'O k p " d t l g h " k p " v j g " h k u v 'u c i g " ; J / e c t d c l q n g " y c u " c m l r e v g f " y k j " f k d t q o q c m e p g u 'O C h g t y c t f . " v j g " l p v g t o g f k c v g " e q o r q w p f u " y g t g " t c p u h q t o g f " k p v q " r j q u r j q p l e " c e k f " g v j { n ' g u g t u . " d { " v j g " w u g " q h 'v j g " v t k v j { n ' r j q u r j k g 'O k p " v j g " h k p c n l u g r . " g u g t u " y g t g " e r g c x g f " y k j " d t q o q v t k o g v j { n i k r p g " c p f " o g y c p q n " v q " i k x g " v j g " h k p c n l e q o r q w p f u " p R C E | 'O V j g " u t w e w t g u " q h " u { p v j g u k f g f " o c v g t k n " y g t g " e a p h k t o g f " d { " 3 " J " c p f " 135 E " P O T " u r g e t q u e q r { 'O V q " f g v g t o k p g " g r g e v t k e c n l r t q r g t v k u . " o c v g t k n " y g t g " v g u g f " k p " r j q v x q n c k e " f g x l e g u 'O R t g r i k o k p c t { " t g u w u " q h 'v j g " o g e u w t g o g p u " j c x g " u j q y p " v j c v 'v j g " r q y g t " e a p x g t u k p " x c n g " f g e t g c u g u " y k j " k p e t g c u l p i " c n r j c v k e " e j c k p " n g p i v j 'O H w v j g t " k p x g u k i c v k p u " y k m ' d g " r g t h q t o g f . " h q t " o q t g " f g c k k g f " e j c t c e v g t k c v k p o }

[3\_C0M0Lgpc.C0M0m0m0tpk.V00 k4 cucne.J crkf g'Rgtqxunkg'Rj qvqxqncleu'Dcem t0qwpf.Ucwu.cpf'Hwwtg'Rtqur geu0Ej go lecnTgxlgy u.'CEU'33; \*7+ 525865325\*423; #j w u d l f q l q t i B20243 keu0j go t g x o d2275: " [4\_C0Cn Cuj qwk"C0'O ci qo gf qx."O O T q E."gv'cn0'E q p h t o c n l 'o q p q r c { g t " e a p v c e u " y k j " n q u u r g u " l p v g t h c e g u " h q t " r g t q x u n k g " u l p i n g " l w p e v k p " c p f " o q p q r k j l e " c p f g o " u q r t 'e g m u 'O p g t i { " ( " G p x t q p o g p v c n U e l e p e g . '34\*33+ '55786558; 0\*423; #j w u d l f q l q t i B2025; l e : g e 2448: h "



**IP XGUVH CVKQP 'QHEJ TQO KWO 'VJ IP 'HKNO UHQ T'QRVKE CN''  
CRRNE CVKQP U'**

Me| lo kgtcuDentwacku<sup>3</sup>. 'Cpcc'U{ vej nqxc<sup>4</sup>. 'Tgo ki kluw'Lw-m pcu<sup>3</sup>. 'Xkcklc'Leuwckkcp<sup>3</sup>. "  
Tlo cpvcu'Uko pk-nku<sup>3</sup>. 'Xkmqtcu'Xck knewunau. 'Crgzcpf t'Dgrunmf vgx<sup>3</sup>"

<sup>3</sup>Egpgt 'hqt'Rj {ulecn'Uelgpegu'cpf 'Vgej pqrj {.'Ucxcpqtk 'cxg0453.'Xkpkwa'24522.'Nkj wpcle"

<sup>4</sup>Qr vlecn'Eqcwpi u'I tqwr.'GP GC.'Xlc'Cpi wknctgug'523.'Tqo c'22282.'Kcn "

Eqtgur qpf cpeg<Me| lo kgtcuDentwackuB hwo e0w.'Crgzcpf t'Dgrunmf vgx B hwo e0w'

"

Wntcy kp'o gvcn'ctg'qh'c'j ki j 'kpvgt guv'f wg'v'j gk 'wpls wg'r tqr gt vgu0F wg'v'q'uo cm'vj lenpguu'qh'pcpgo gvtg'uecrg'vj g{ " uo { 'ugo k'vcpur ctgpv'kp'c'y kf g'y cxgrpi vj 'tapi g0'Vj g{ 'ctg'wugf "kp'o cp { 'hgrf . "hqt 'gzco r rg. "qr vgrgevtqpleu. "qr vleu. " gpi kpggtkpi . 'grgevtqpleu. 'f geqtcvkw'cpf 'r'ruo qple0Ej tqo kwo "Et+o gvcn'vj kp'hko u'ctg'vwtcevxg'f wg'v'q'j gk 'o gej cplecn" grgevtlecn'cpf 'qr vlecn' tqr gt vgu0Et'hko u'l'rc { 'cp'guugpvkcn'tqrg'kp'o cp { 'cr r nckvkw'pu'cpf 'ecp'dg'wugf 'cu'f geqtcvkg'r'rcwpi . " vcpur ctgpv'grgevtqf g. "ur cegt'rc { gt. "cf j gukxg'rc { gt. "hki j v'cdudtdkpi "rc { gt. "qr vlecn'dgco "ur rkwtu. "ur v'kcn'rk j v'o qf wrcvqt" cpf "wpcdrg'hkgt0"

Kp'qwt'tugcte j . 'y g'j cxg'o cf g'c'f gvckrgf "uwf { 'qh'Et'wntcy kp'hko u0'hko u'y kj "xctkqwu'vj lenpguu'y gt g'f gr qukxg'f " wukpi "o ci pgtqp'ur wwtkpi 0'Vj g'hko u'y gt g'kpxguki cvgf "d { "xctkqwu"vej pls wgu'kp'qtf gt "v'q'i gv'dgwt "wvf gturcpf kpi "qh' qdugt xgf 'f gr gpf gpeku0C'hko 'vj lenpguu'y cu'xctkqf 'htqo "ugxgtcn'pcpgo gvtu'v'q'ugxgtcn'vpu'qh'pcpgo gtu0Uwej 'eqc'v'pi u. " hqt 'gzco r rg. "o ki j v'dg'wugf 'kp'qr vgrgevtqpleu'cpf 'r'ruo qpleu0"

K'y cu'gxcn'cvgf "vj cv'hko u'j cxg'qpn' "ej tqo kwo "ewdke'r j cug0'Vj g'grgo gpcn'eqo r qukxq'pcn { uku'eqphko gf "vj g' r wtkv' 'qh'vj g'hko u0"

Uj ggv'tgukw'peg'uki p'k'lecpv' { 'f getgcugf "y kj "vj g'hko "vj lenpguu'kpetgcugf "htqo "5"po "\*3222 lus + "v'q"34"po "\*77"

lus + "chgt y ctf . "y kj "hwt vj gt "vj lenpguu'kpetgcug'wv "v'q"79po "uj ggv'tgukw'peg'f getgcugf "v'q"3; " lus 0'Vj gug'xcn'w'ctg" eqo r ctcdrg'y kj "vj g'KVQ'xcn'w'0"

"Qr vlecn'eqpu'cpw'qh'wntcy kp'Et'hko u'y gt g'gxcn'cvgf "htqo "gnkr uqo gvt { "ctg'cpf "eqo r ctgf "y kj "ur gevqr j qvqo le" o gcuw'go gpw0'Vj gug'eqpu'cpw'o ki j v'dg'wugf "hqt'hwt vj gt "o qf gkpi "qh'o wnkrc { gt'eqc'v'pi u0"

Vj ku'r tqlg'vj cu'tgeg'xgf 'hwf kpi 'htqo "Gwtqr gcp'Uqekri'hwf "r tqlg'evP q'2; 00/NO V/M/934/3; / 2425+'w'pf gt 'i tcpv' ci tgggo gp'v'y kj "vj g'Tgugcte j 'Eqwpeki'qh'Nkj wpcle "NO VNV+0"

"

# CARRIER TRANSPORT PROCESSES IN MIXED CATION LEAD HALIDE PEROVSKITE MATERIALS

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Hybrid organic–inorganic perovskites are very promising materials for various optoelectronic applications since during one decade solar cells, LEDs, lasers [1], transistors [2] and photodetectors [3] were created using these compounds. Perovskites have many desirable properties such as solution processibility at low temperatures, high carrier mobility and a tunable bandgap. The energy bandgap tunability can be achieved by mixing cations or exchanging anions and it allows us to manufacture perovskites with different emission and absorption wavelengths which is very useful while finetuning designs of LEDs or tandem solar cells. Therefore, mixed cation perovskites require further research to determine optimal composition with the best optoelectronic parameters.

The main goal of this work was to study perovskite samples  $\text{FA}_x\text{MA}_y\text{Cs}_{(1-x-y)}\text{PbHA}_3$  (FA – phenylammonium, MA – methylammonium, HA – halide ions) of different chemical composition where ratio of cations was gradually changed. Carrier dynamics was investigated using light-induced transient grating (LITG) technique. From these measurements important photoelectric parameters such as diffusion coefficient and recombination lifetime were obtained.

Pulsed laser irradiation at 351 nm wavelength was used to excite the samples. Spatially modulated excitation caused the creation of transient grating. This grating decayed with time due to diffusion and recombination processes and it was monitored by the probe beam of 1053 nm which was delayed by an optical delay line. Photoelectric properties were investigated within the wide range of excess carrier density by employing an optical attenuator to control the excitation energy fluence. Diffraction efficiency ( $\eta$ ) decays, measured at different grating periods  $\Lambda$ , allowed us to extract carrier lifetime ( $\tau_R$ ) and diffusion coefficient ( $D$ ).

Carrier lifetime dependence on the excess carrier density in  $\text{MA}_x\text{Cs}_{(1-x)}\text{PbBr}_3$  samples can be seen in fig. 1 (a).  $\tau_R$  decreases with growing excess carrier density ( $\Delta N_{av}$ ) due to Auger recombination. Furthermore, increasing part of cesium in compound decreases carrier lifetime which can be explained by poorer crystal ideality and decreasing symmetry.

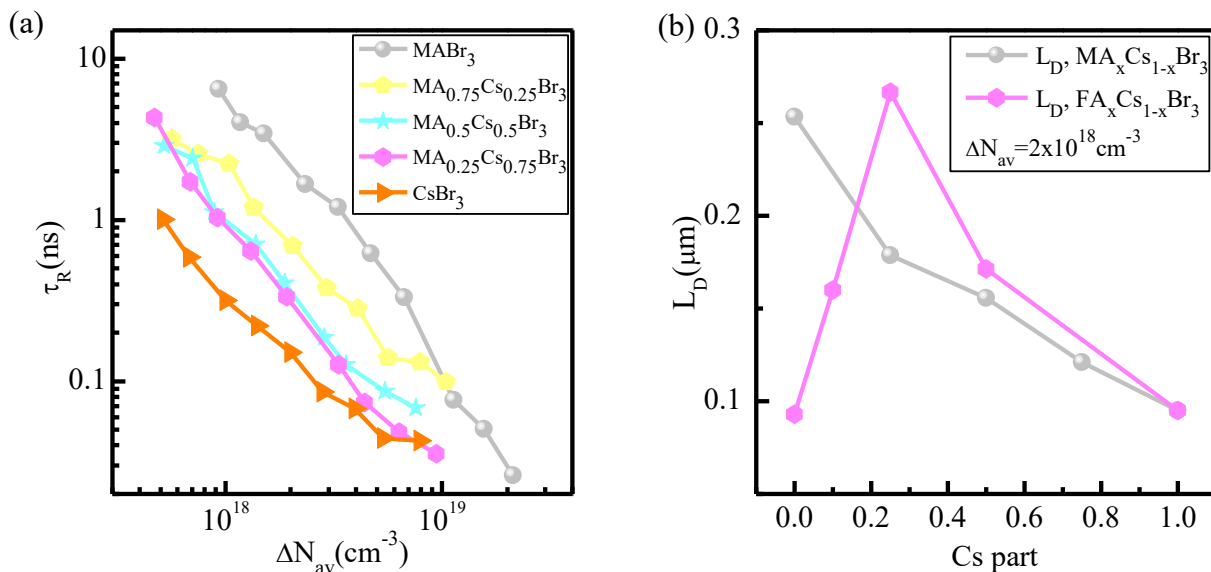


Fig. 1. (a) Carrier lifetime dependence on the excess carrier density  $\Delta N_{av}$  in  $\text{MA}_x\text{Cs}_{(1-x)}\text{PbBr}_3$  samples, (b) diffusion length dependence on the Cs part in perovskite compounds.

In fig. 1 (b) diffusion length dependence on Cs part in the compound is shown. It is evident that diffusion length decreases with more Cs and is attributed to decreasing crystal ideality. However diffusion length varies in the interval of  $0,1 \div 0,3 \mu\text{m}$  which is comparable to thickness of the layers. This fact allows us to conclude that such perovskites are suitable for optoelectronic applications where charge carriers have to diffuse from the active layer.

This research was funded by the European Social Fund (Project No. 09.3.3-LMT-K-712-22-0217).

[1] J.R. Harwell *et al.*, Green Perovskite Distributed Feedback Laser. Scientific Reports 7, 11727 (2017)

[2] T. Matsushima *et al.*, N-Channel Field-effect Transistors with an Organic-Inorganic Layered Perovskite Semiconductor. Appl. Phys. Lett. 109, 253301 (2016).

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# THIN PEROVSKITE La:BaSnO<sub>3</sub> FILMS - TOWARDS NOVEL OPTOELECTRONIC MATERIALS

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Wide bandgap semiconductor La-doped BaSnO<sub>3</sub> (LBSO) has attracted increasing attention due to its outstanding electron mobility reaching 320 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> at room temperature [1]. Many researchers have developed LBSO epitaxial films. However, the obtainable carrier mobility is much lower in thin films compared to single crystals. Worse electrical performance has been attributed to the formation of the structural defects and nonstoichiometry. Thin film electrical properties (mainly carrier mobility) were demonstrated to depend on film morphology, structure and lattice mismatch between the substrate and the film. The composition-dependent properties to-date are not fully investigated. Therefore, in this work thin La-doped BaSnO<sub>3</sub> films were deposited using pulsed injection metal organic chemical vapor deposition (PI-MOCVD) method on different substrates using different stoichiometric ratios of Sn/Ba. This method allowed easy compositional control of thin films and to investigate composition-dependent thin LBSO film properties.

Thin films were characterized using investigated using X-ray diffraction, X-ray photoelectron spectroscopy and scanning electron microscopy. La-doped film carrier mobility and carrier concentration were determined using Hall measurements. Surface morphology, microstructure and electrical properties of LBSO films were highly dependent on the selected substrate and film composition. Here we report thin film electron mobility, surface morphology and elemental core-shell electron spectroscopy dependence on thin film nonstoichiometry and successful optimization of the deposition process to achieve highly desirable electrical and structural properties.

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[1] William Shepherd et al., Accurate control of stoichiometry and doping in barium stannate perovskite oxide nanoparticles, *Chemical Communications* **55** (79) 11880-11883, (2019).

P3-48

DID NOT PARTICIPATE

P3-49

DID NOT PARTICIPATE

# FLUCTUATION CONDUCTIVITY IN YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> SINGLE CRYSTALS UNDER ELECTRON IRRADIATION

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The phenomenon of superconductivity in high-temperature superconductors (HTSC's or cuprates) can be understood by studying HTSC's properties in the normal state, which are well known to be very peculiar. The most intriguing property is a pseudogap (PG) observed mostly in oxygen deficient cuprates below any representative temperature  $T^* \gg T_c$  [1]. At present, it is believed that the proper understanding of PG physics has to offer the possibility to decipher the basic pairing mechanism in the HTSC's which still remains uncertain.

The effect of 2.5 MeV electron irradiation on the temperature dependences of the resistivity  $\rho(T)$  of an optimally doped YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> single crystal has been studied. Here we show that with an increase in dose  $\phi$ , the value of  $\rho(300K)$  increases linearly, while  $T_c$  decreases linearly. The value of  $\rho(100K)$  increases nonlinearly, demonstrating a feature for  $\phi = 4.3 \cdot 10^{18} \text{ e/cm}^2$ , which is also observed on the number of other dose dependent parameters. Regardless of the irradiation dose, in the temperature range from  $T_c$  up to  $T_{01}$ , the excess conductivity  $\sigma'(T)$  obeys the classical fluctuation theories of Aslamazov - Larkin (3D-AL) and Maki-Thompson (2D-MT), demonstrating 3D-2D crossover with increasing temperature. The crossover temperature  $T_0$  makes it possible to determine the coherence length along the  $c$ -axis,  $\xi_c(0)$ , which increases by  $\sim 2.6$  times under irradiation. Furthermore, the range of superconducting fluctuations above  $T_c$  also noticeably increases. At  $\phi = 0$ , a "classical" pseudogap dependence  $\Delta^*(T)$  is observed with a maximum at  $T_{\text{pair}} \sim 120 \text{ K}$  and a clear minimum at  $T = T_{01}$  [2]. It was determined for the first time that at  $\phi = 4.3 \cdot 10^{18} \text{ e/cm}^2$  the shape of  $\Delta^*(T)$  changes strongly and becomes the same as in optimally doped YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> single crystals with defects, which is accompanied by a sharp decrease in  $T_{\text{pair}}$  and the pseudogap opening temperature  $T^*$ , while at  $T_c(\phi)$  there are no singularities. With an increase in the irradiation dose up to  $\phi = 8.8 \cdot 10^{18} \text{ e/cm}^2$ , the shape of  $\Delta^*(T)$  is restored and becomes the same as in well-structured YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> films. Moreover, in this case,  $T_{\text{pair}}$  and  $T^*$  increase noticeably.

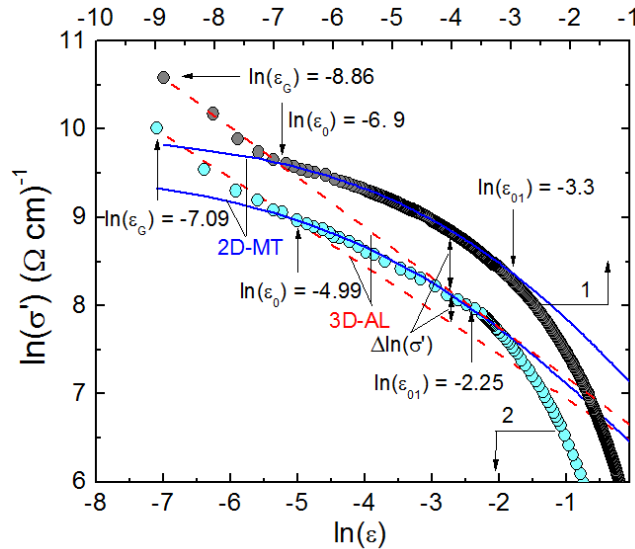


Fig. 1. Dependences of  $\ln \sigma'$  on  $\ln \epsilon$  of the YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6.94</sub> single crystal at  $\phi = 0$  (curve 1) and  $\phi = 8.8 \times 10^{18} \text{ e/cm}^2$  (curve 2) in comparison with fluctuation theories: 3D-AL (red dashed lines) and 2D-MT (solid blue curves).  $\ln(\epsilon_G)$  determines the Ginzburg temperature  $T_G$ ,  $\ln(\epsilon_0)$  determines the crossover temperature  $T_0$ , and  $\ln(\epsilon_{01})$  determines  $T_{01}$ , which limits the region of the SC fluctuations from above. The X-axis scales have been shifted for readability.

[1] A. L. Solovjov, V. M. Dmitriev, Low Temp. Phys. 35, 169 (2009).

[2] A. L. Solovjov, et al. Scientific Reports 9, 9274 (2019).

**'HCDT KE CVKQP 'QHE QO RQUKVG'J GNO GV'WUKP I 'DCP CPC'HKDTGTCPF ''  
HN[ 'CUJ ''**

Ucpguj 'O {uqtg'Ucvj {ctcl}^3.Xggtctci j cxcpg' Tlcici qr cncp^4.'J ctuj c'F {cpguj ^5. ''

<sup>3</sup>F gr ctvo gpv'qh'Grgctlecl'cpf 'Grgctqpleu'Gpi kpggtkpi .. 'Mcwpcu'Wpkxgtukf 'qh'Vgej pqrqi { . 'Nkj cwplc''

<sup>4,5</sup>F gr ctvo gpv'qh'O gej cplecl'Gpi kpggtkpi 'cpf 'F guki p. 'Mcwpcu'Wpkxgtukf 'qh'Vgej pqrqi { . 'Nkj cwplc''

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J5\_U'x'k'ct {pc. "K'O'D'w'g'p'q. "J O (O cgxc. "G'O'V'k'p'q. "L'O"SEj ctce'v'k'k' cvkqp"qh'pcwctn'hkdtg'tgkphqtegf"eqo r quks"u'y kj "cf x'c'pegf "w'v'k'cu'p'le"v'gej pls wgu.S' W'v'k'cu'p'le'v'U' o r quks"o \*KWU+ '4236'KGG'k'v'gt'p'v'k'p'cn'x'q'f'p'q0'r r 0864: .3653. '5/8'U'gr v'042360'

# DESCRIBING THE WOBBLING MOTION IN $^{163}\text{Lu}$ THROUGH A SEMI-CLASSICAL APPROACH

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Triaxial nuclei behave uniquely due to their anisotropy in both the mass and charge distributions. One clear fingerprint of nuclear triaxiality - Wobbling Motion - is the phenomenon in which the total angular momentum of the nucleus precesses and wobbles around its rotational axis, resulting in a rich rotational spectrum with a phononic character and thus making the final nuclear motion behave similarly to a harmonic oscillator. A lot of effort was made for developing theoretical models that describe wobbling motion in both even-even and even-odd nuclei. Considered the best wobbler to date,  $^{163}\text{Lu}$  has four triaxial strongly deformed bands up to high spins which are established as having a wobbling nature. A successful description of the excitation energies for all four bands using a semi-classical approach is made within the current formalism. Indeed, by starting from a quantal Hamiltonian specific to the Particle-Rotor-Model, a Time-Dependent Variational Principle is applied to obtain a set of classical equations of motion. Analysis of the nuclear motion in this isotope is also made with the use of a classical energy function which is studied in terms of its stability region. As such, conditions when nuclear wobbling motion is stable/unstable arise. Interpretation of obtained results helps to establish certain features of the current work.



# RENORMALIZING THE NEUTRINO MIXING MATRIX IN THE GRIMUS-NEUFELD MODEL

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The Grimus-Neufeld model [1] is an extension of the Standard Model (SM) of particle physics providing a mechanism of neutrino mass generation. The addition of neutrino masses to the SM also introduces mixing between neutrinos and there is a corresponding mixing matrix, known as the Pontecorvo–Maki–Nakagawa–Sakata (PMNS) matrix [2, 3]. This matrix has to be measured, however, to connect theory and experiment, it is needed to take care of ultraviolet (UV) divergences arising already in 1-loop calculations. With the procedure of renormalization it is possible to absorb all the UV divergences by adding counterterms to the Lagrangian of the theory. The PMNS matrix is no exception and one has to define a corresponding counterterm to ensure the finiteness of physical quantities. However, there is freedom in choosing a renormalization scheme and a few options are already available in literature [4, 5, 6]. One of the available schemes is gauge dependent, a feature one usually tries to avoid, while the other is slightly unconventional.

In this work we define a new scheme of fermion mixing renormalization and as an example we use the Grimus-Neufeld model. The new renormalization scheme provides explicitly gauge independent counterterms for the mixing matrix while mostly keeping in tact the usual definitions of renormalization constants. We have already checked some properties of the new scheme by explicit calculation in the Grimus-Neufeld model, but there still are outstanding tasks, for example, checking whether all of the UV divergences are correctly subtracted in the  $WV$ -vertex.

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# HEAVY GAUGE BOSON $W'$ SEARCH IN MUON CHANNEL USING MADMINER PACKAGE

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As the field of elementary particle physics is evolving, it is becoming complicated to perform analyses with usual methods due to increasing amounts of data and rising complexity of interesting processes, thus there is the need of other analysis techniques, such as machine learning. Due to the Neural Networks' ability to recognize relationships in vast amounts of data they can be used in various analyses which contain difficult data structures. MadMiner [1] is a new tool which provides machine learning techniques to efficiently approximate arbitrary ratios of likelihood functions. MadMiner streamlines the steps involved in elementary physics data analysis. It also provides interfaces to MadGraph5\_aMC [2] for the generation of events, to Pythia8 [3] for parton showering and to Delphes3 [4] for the detector simulation, therefore the tool is able to support any physics process and model.

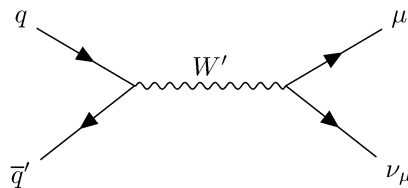


Fig. 1.  $W' \rightarrow \mu + \nu_\mu$  channel Feynman diagram

In this work we investigate the parameter space by searching for the mass of the heavy gauge boson  $W'$  [5], which is predicted in various extensions of the Standard Model (SM), including the Sequential Standard Model (SSM) [6] which we use in our work. The search is performed in the muon channel (Fig. 1) using MadMiner. To achieve that, we train neural network models on the generated data at Leading Order (LO) and use them to estimate the likelihood ratio. The ratio of Likelihood functions, in our case the ratio of SSM to the SM, is used to determine the likeliness of one model over the other. Using generated test signals we evaluate the accuracy of the pre-trained Neural Network models' ability to maximize the likelihood.

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# ANALYSIS OF Z BOSON DECAY TO NEUTRINOS USING LHC

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Current detectors used in particle accelerators are not able to detect neutrinos. Due to this, studying processes with neutrinos in high energy physics experiments is not as trivial as processes with detectable objects. A deeper understanding of neutrino processes is necessary for pushing the limits of the Standard Model of particle physics. The aim of this research is to evaluate the decay of the Z boson, one of the weak-interaction mediating particles, to neutrinos.

To get the events with Z boson decay to neutrinos, the process  $pp \rightarrow \ell\bar{\ell}\nu\bar{\nu}$  is generated with MG5\_aMC@NLO (MadGraph) [1] event generator to simulate proton–proton collisions in a collider. The process is dominated by lowest order diagrams. Of these, one is the signal process, out of five major backgrounds the two are mostly negligible (cross sections are tiny). Using the event information provided by the event generator, it is possible to split the events into signal and background. The use of physically observable quantities (like invariant mass,  $p_T$ , etc.) is necessary for analysis of real processes seen in nature. For unaltered data, the signal cannot be isolated, due to the background processes being more frequent. Cuts on the data are made around Z boson mass to help isolate the signal. Fully isolating the signal from background processes both from reducible and irreducible backgrounds is the ultimate aim of this research.

This research is one of the few attempts to directly study neutrino processes in collider-based experiments. Findings gathered from this or similar experiments can lead to a validation of the Standard Model in the lepton sector, possibly opening a door for Beyond the Standard Model physics.

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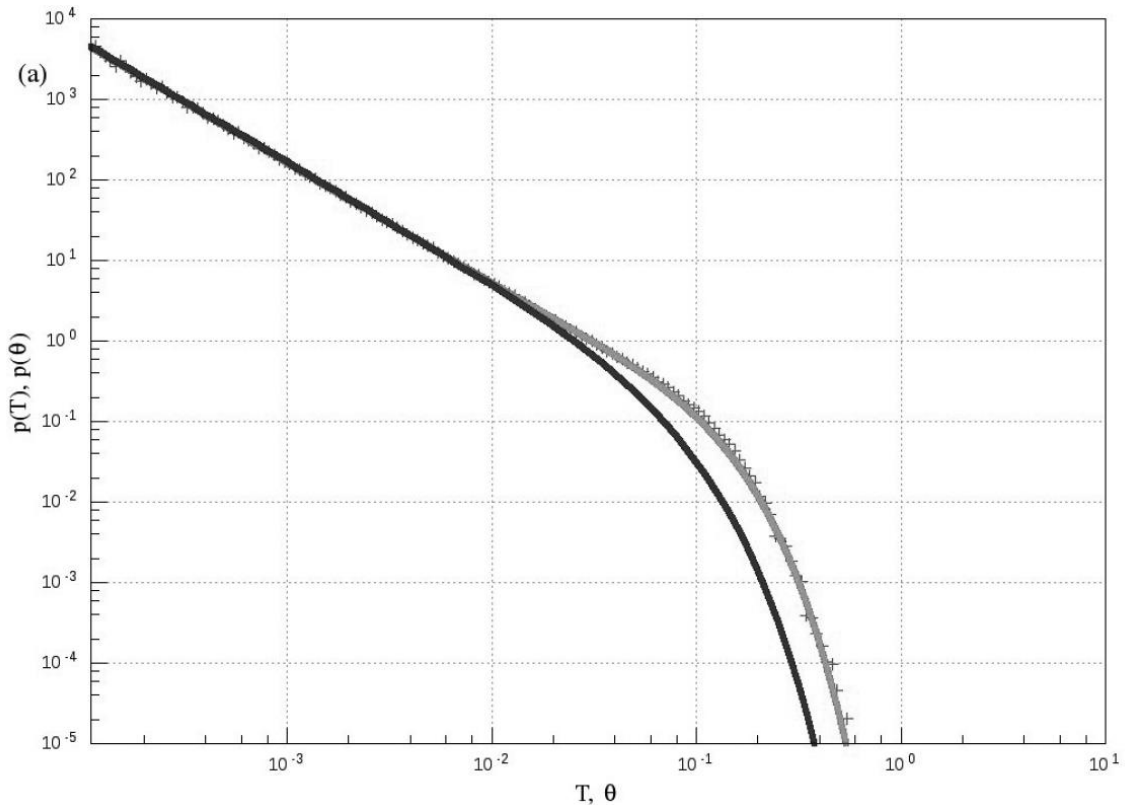
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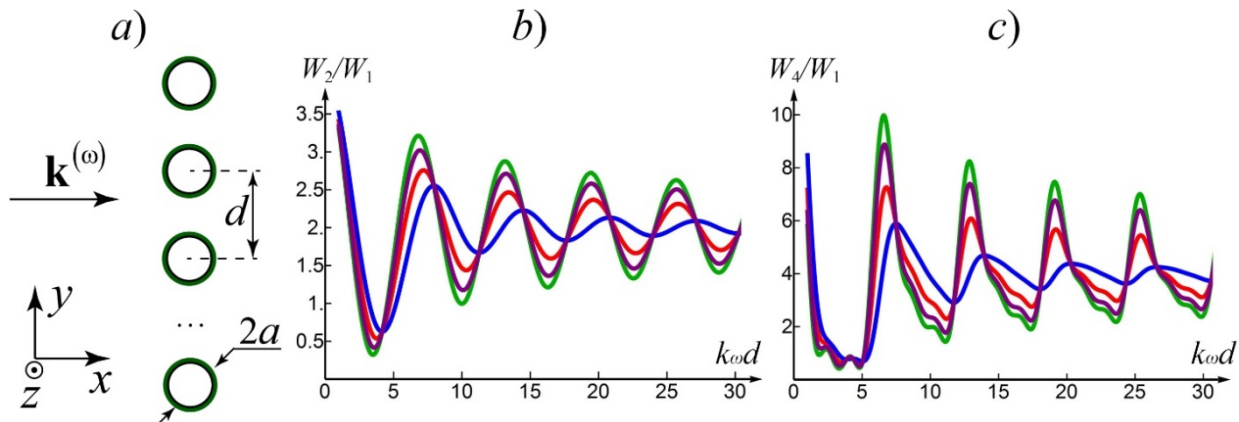
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$${}_{lm}^{(4)} = {}_3^{(4)} P_k P_l P_m + {}_4^{(4)} P_k \delta_{lm} + {}_5^{(4)} (P_l \delta_{km} + P_m \delta_{kl}) + {}_6^{(4)} P_o (P_n \epsilon_{klo} + P_l \epsilon_{kno}). \quad k, l, m = z, \{, /, \dots \quad *3+$$

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# NONLINEAR RESPONSE THEORY IN ULTRA-THIN ELECTRON LAYERS

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Perturbational response theory is one of the most successfully used tools in physics, its linear version being the standard procedure to fruitfully treat complex systems. Ongoing advances in laser power combined with increasing accuracy in material design drive the need to go beyond linearity. Here we present a general formalism for the arbitrary order response functions of any observable in Fermi systems and derive a closed form for the non-interacting case. As novel technological devices for radio- and electrical signals operating outside the linear regime, e.g. as detectors, mixers, or multipliers for terahertz waves, are often based on very thin nano-structures. The two dimensional uniform electron gas (2Deg) was chosen to test our theory. We verify our expressions by confirming the results reported by Lee [1] for the quadratic order Lindhard function and newly derive the cubic density response, which can be cast into a notably lucid form.

Interactions are then accounted for using the random phase approximation (RPA). This self-consistent mean field approach is quite accurate in experimentally studied 2Degs [2]. We extend the linear RPA up to third order in the perturbation aiming at an analysis of the collective modes, the sheet plasmons. In the harmonic co-linear case we further accomplished to extend the relations of Mikhailov [3] to hold for more general input signals. Compared to the linear case, a much richer particle-hole excitation spectrum gives rise to stronger Landau damping, significantly reducing the live-time of the collective modes, manifest in the electron-energy-loss-scattering function and in good agreement with the experiment of Nagao et. al [4].

So far, the spin degree of freedom was not treated explicitly. Work to investigate partially polarized systems [5] is in progress, aiming at a better understanding of the polarized electron sheets applicable in spintronics.

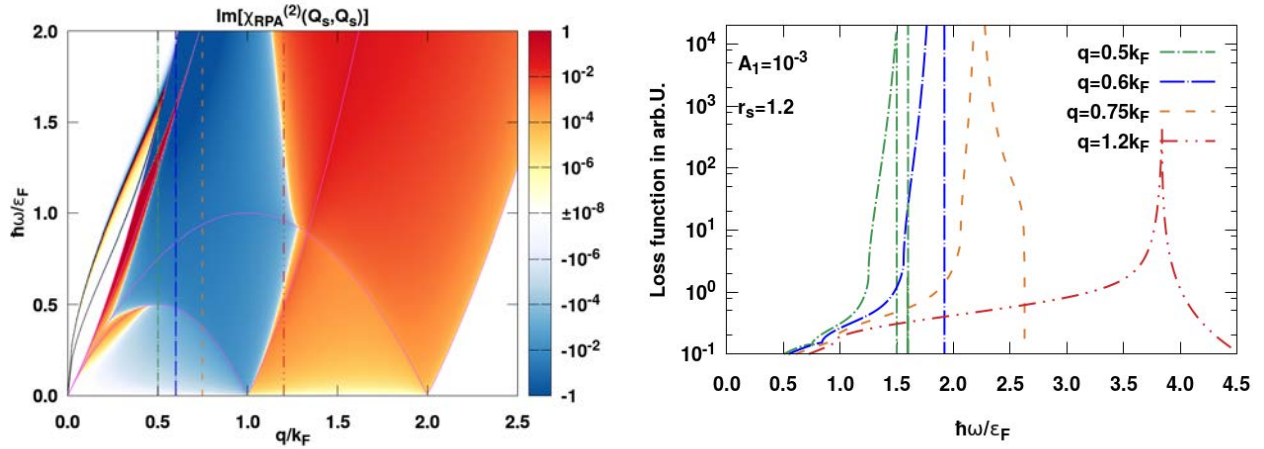


Fig. 1. **(left)**: 2<sup>nd</sup> order interacting response function  $\chi_{\text{RPA}}^{(2)}$  for a harmonic perturbation. In comparison to the first order, the second order shows two distinct and overlapping particle-hole bands (PHB), bounded with solid magenta lines. The two appearing collective modes are undamped in a wide region of wave-vectors  $q$  and enters the PHB at approx.  $0.6$  and  $0.7k_{\text{F}}$ , respectively. Additional four specific cuts at  $q_{\text{s}}/k_{\text{F}} \in \{0.5, 0.6, 0.75, 1.2\}$  are marked. **(right)**: The electron–energy–loss function within quadratic response theory for the marked wavelengths  $q$  with Wigner-Seitz radius  $r_{\text{s}} = 1.2$  and input field strength  $A_1$ . The weight and energy of the mode depends significant on  $q$ . After entering the PHB, the collective mode becomes damped quite rapidly. ( $k_{\text{F}}$ ,  $\varepsilon_{\text{F}}$  denote the Fermi wave-vector and energy, respectively)

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# \ 'DQUQP 'F GEC[ 'ENCUIKHE CVIQP 'WUKPI 'CTVHKE KCN'KP VGNNE GPEG' Y KWJ 'NJ E''

F qo kp { neu'Qtmxcu.'Cwtgrkluw'Tlprngxk kwu"

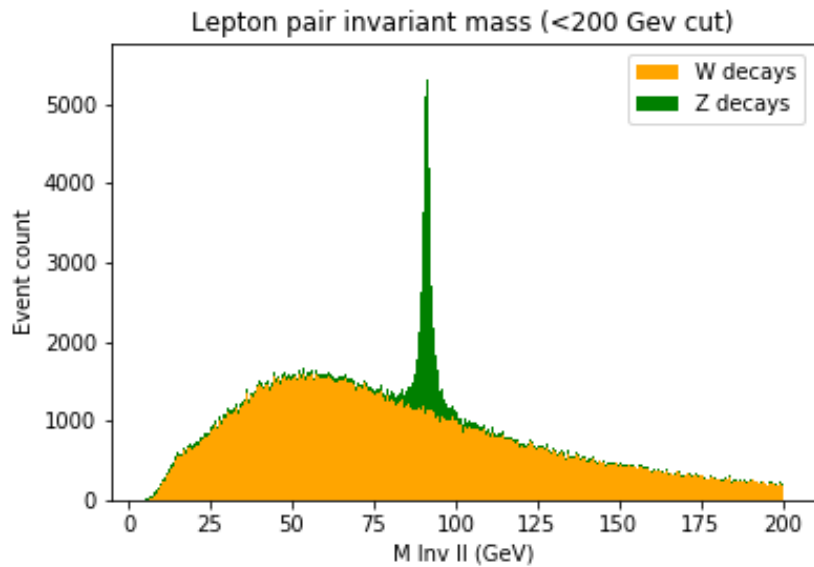
Hcewnf {qh'Rj { uleu.'Xkpkwu'Wpkxgtukf.'Xkpkwu.'Nkij wcpk'  
f qo kp { neu'QtmxcuB Hhrrwf OxwW'

Kp'r ctveng'r j { uleu.'gxp'y kj 'o cuukxg'co qwpv'qhf'c'v'eqmgevgf 'd{ 'y g'ewtgvf'v'gvevqtu.'uqo g'r ctvengu'ctg'gnwukgOUwej " ctg'pgwtkpqu0P gwtkpqu.'y j krg'eqo o qp.'qpnf 'eqwr ng'y gcmf { 'v'cmhnpqy p'o cvgt0Vj ku'o gcpu'y cv'kpvgtcevkqpu'ctg'xgt { 'tctg.' gxp'lp'y j g'r t guppeg'qhf'gpug'f'gvevqtu0"

C'y c{ 'v'qmqm'ht'y go . 'y kj qw'c'f'kt gev'f'gvevqkq.'ku'y tqwi j " o qo gpwo "dcmpeg0Kp" c'dgco "cm'r ctvengu'ctg'tqwi j n' i qkpi 'cmppi 'y j'g'dgco "czku.'y kj "xgt { 'hkwg'kh'cp{ "v'cpuxgtug'o qo gpwo 0Vj ku'o gcpu'y cv'y j g'hwm'v'cpuxgtug'o qo gpwo "qh'c" eqmkukq'ku' gtq0Kf'y ku'ku'p'q'v'y g'ecug.'y g'g'ctg'o ku'kpi 'r ctvengu'lp'y g'f'gvevqt0Vj gug'eqwr'f'hngrf' "dg'pgwtkpqu0"

Vj ku'y qtm'pcn{ | gu\ 'dquqp'f'gec { u'kp'q'c'r'ctk'qh'pgwtkpqu" % @xx+0Ukpeg'y g'g'ku'p'q'r w'g\ 'dquqp'uwteq.'y j'g'dli i guv' o cej kpg'g'xgt'dwku'y g'NJ E "Ncti g'J cf tqp'Eqmkf'gt+.'ugt'xgu'cu'y j'g'dguv'cm'r vtr qug'uwteq0NJ E'r tqxkf'gu'r tqvqu'cv'kpkcni' ucvg0Y j krg'r r "/ @xx"ku" c'r quukdr" c'p'f "c"xgt { "hkngrf "r tqeuguu."k'ku'f'khkeww'v" f'gvev0Y j gp' 'y j'g'qweqo g'ku'eqo r ngv' " w'p'f'gvevcdng"j qy "ecp" { qw'dg'uwg'y j'g'r tqeuguu'gxp'j cr r g'p'g'f'0Vj g'tg'gtg.'uqo g'f'gvevcdng'r ctvengu'ctg'pggf'gf'lp'y j'g'hkpcni' ucvg0Ngr vqpu'ctg'engcp'c'p'f "gcukf'f'gvevcdng'f'gvevqt'qdl'geu'y cv'ecp'uko r rkhf' 'y j'g'pgwtkpq'j w'p'0Hqt'y cv'v'gcuqp.'y j'g'lpk'cni' ucvg'eq'w'ck'kpi "c'r'ctk'qh'e'j'cti gf' 'hgr vqpu'lp'cf'f'k'kq'v'p'gwtkpqu'ku'ej qugp 'kq0'y j'g'r tqeuguu'r "/ @mxx0"

P'qy 'y j'g'r tqdrgo "eqo gu'lp'f'k'kpi w'kuj kpi 'y j'g' "dquqp'f'gec { u'ltqo 'y j'g'tguv'q'v'y j'g'r tqeuguu'y kj 'y j'g'uco g'lpk'cni'c'p'f' h'kpcni'ucvgu0Vj ku'ku'cej k'g'xg'f' 'y j'g'tqwi j 'y j'g'wug'qh'ct'v'k'cni'lp'v'g'ni' g'peg0Vq'dg'ur gekh'e'c'p'g'w'cni'p'gy qtm'ldug'f'em'ukh'gt0Vj ku' em'ukh'gt'y cu'eq'p'ut'w'ev'f' w'kpi "V'g'pu'qt'H'qy "j3\_c'p'f' "M'gt'cu"j4\_0Dw'c'p'w'p'v'ck'p'g'f'p'g'w'cni'p'gy qtm'ku'w'ug'uu0Vq'cr r n'f'k'v'q'c'p'f' "t'g'cni'f'c'v'k'p'g'g'f'u'v'q'dg'v'ck'p'g'f' h'k'v'0V'ck'p'kpi "f'c'v'ku'i'g'p'g'c'v'g'f' w'kpi "c'ulo w'v'k'q'p'u'q'h'y'ctg.'lp'r'ct'v'ew'rt."O'c'f'i'ter'j' "j5\_0"C" i'q'q'f' 'ec'p'f'k'c'v'g'r' tqeuguu'y kj "mxx'h'kpcni'ucvgu'ku'r'r "/ @ \ "/ @mxx.'j'g't'g'y'g'ec'p'v'cng'cf'x'c'p'v'c'g'q'h'y'g'lp'x'c't'k'c'p'v'o'cu'q'h'y'g'hr'v'q'p' r'c'k'u'y'cv'v'j'q'w'f' "dg'ct'q'w'p'f' 'y j'g' "dquqp'o'cuu.'cu'ku'ugg'p'lp'H'ki'0'3'0'Q'j'gt'r' tqeuguu'y kj "mxx'h'kpcni'ucvgu+'k'p'ew'f'g'Y'dquqp'u' c'p'f' 'y j'g'kt'uw'dugs'w'p'v'f'gec { u.'y j'ej' "ct'g'ct'q'w'p'f' "32'k'o'gu'o'qt'g'h'kngrf'.'dw'v'y'g'eng'ct'r'g'cni'ugg'p'lp'H'ki'0'3'cm'qy'u'u'v'q'ew'v'y'g'f'c'v' "lp'uw'ej'c'y'c'f' 'y j'g'cv'v'y'g'g'xp'v'eq'w'p'u'ctg'xgt { 'ulo'k'rc'0C'em'ukh'gt'ec'p'v'y'gp'dg'v'ck'p'g'f'v'q'hw'v'y'gt'f'k'et'k'o'k'p'c'v'g'v'y'g'w'p'f'g't'f'k'p'i' r' tqeuguu0"



Hki w'g'3'Ngr vq'p'r'c't'lp'x'c't'k'c'p'v'o'cu'f'k'ut'k'dw'k'q'p'ht' "mxx'g'x'gp'u'

j3\_0'ct'p'C'dcf'k'c'p'f' 'q'y'gtu0V'g'pu'qt'H'qy '<Ncti'g'uec'n'o'cej'k'p'g'ng'c't'p'kpi' 'qp'j'g'v'g't'q'i'g'p'g'q'w'u'f'ung'o'u'42370U'q'h'y'ct'g'c'x'k'c'dng'r'ht'qo' 'v'g'pu'qt'H'qy'Q'ti'0Ej'qmg'v' H0'( 'q'y'gtu0\*4237-0)

j4\_'Ej'qmg'v'H0'( 'q'y'gtu0\*4237+0M'gt'cu0'j'vr'u'<h'ng't'cu0'q'0'

j5\_'l0C'ny'cni'g'v'c'n'S'Vj'g'c'w'q'o'c'v'g'f' 'eqo'r'w'v'k'q'p'q'h'v'g'g'ng'x'gr'ic'p'f' 'p'g'z'v'q'ng'c'f'k'p'i' 'q't'f'g't'f'k'ht'g'p'v'k'c'f'et'qu'u'uge'v'k'q'p'u'c'p'f' 'y j'g'k't'o'c'v'ej'k'p'i' 'q'r'ct'v'q'p'v'j'qy'gt' "ulo'w'v'k'q'p'u's.'ct'Z'kx-362702523"lj'g'r/r'j'\_'

**EQO RCTKUQP 'QHP GWTQP 'HNWZ 'KP 'GWF GO Q'F KXGT VQT''  
 RNCUO C/HCEKPI 'EQO RQP GP VU'WUKPI 'Y ENN'CPF 'J ERD'DTGGF KPI ''  
 DNCPMGV'O QF GNU'**

Uko qpc'Dt gkf qmckg<sup>3</sup>. 'I gf ko kpcu'Ucpcmwpcu<sup>3</sup>."

<sup>3</sup>Ncdqtcvqt { 'qh'P wergct 'Kpuvcwvqp'Uchgv\ . 'Nkj wcpkcp'Gpgti { "Kpukwg. 'Nkj wcpk"  
uko qpc.dt gkf qmckgB rgl0v'

"

Vj g'r tko ct { "r wtr qug'qh'vj g'r rnoo c/hceki "eqo r qpgpv'RHE+'ku'r qy gt "gzj cwuv'cpf "tgo qxcn'qh'ko r wtk\ "r ct veng'0'  
 Vj g'r rnoo c/hceki "eqo r qpgpv'eqpukuv'qh'vj tgg'rc {gtu'cpf "c'uw r qtv'3\_0'Vj g'htuv'cpf "vj kf "rc {gtu'ctg'o cf g'qh'wpi uvgr"  
 cmq {0'Vj g'ugeqpf "rc {gt'ku'c"o kz wtg"qh'Vwpi uvgr. "EwEt\ t. "y cvgt. "cpf "c'uw r qtv'ku'o cf g"qh'Gwtqht"cmq {0'Vj ku'r cr gt "  
 eqpukf gtu'vy q'f khtgtpv'dtggf gt "dncpngv'o qf gnu'qh'F GO Q"tgcvtq<'Y cvgt/Eqqrgf "Nkj kwo "Ngcf "\*Y ENN+'cpf "J grkwo "  
 Eqqrgf "Rgddrg"Dgf "\*"J ERD+'cpf "vj g'uco g"ur gekkfg "F GO Q"pgwtqp"uqwtg0'Gxgp"vj qwi j "dqj "o qf gnu'j cxg'vj g'uco g"  
 f kxgtvt'eqphki wcvkqp. "vj g'pgwtqp'hwz'ku'urki j v\ "f khtgtpv0"

O EP R8'eqf g'j4\_'cpf 'Lqkv'Gxcncvfg 'Hkukqp'cpf 'Hwukqp'\*LGHH'50+'j5\_'pvergct'f cvc'rkdtct { 'y gtg'wugf 'hqt'pgwtqp"  
 hwz'ecrewrcvqpu00 EP R8'ku'y kf gn\ 'tgeqi pk gf 'cpf 'wugf 'hqt'hwukqp'pgwtqpkc'cr r rkecvkqpu0P gwtqpu'ctg'f kxkf gf 'kpv'92; "  
 gpgti { "i tqwr u'htqo "32/'gX'vq'3222'O gX0'

Vj g'ucvkwkccn'gittq'qh'O qpvg'Ectm'ecrewrcvq'p'tguwuv'hqt'f kxgtvt'RHE"egm'y cu'rguu'vj cp'32' "y kj "32: "r ct veng"  
 j kvqtkgu0K'gpgti { 'tgi kqp'htqo "2088", 32/'6'gX'wr "vq'707", 32/'6'gX'cpf "kp'5069'O gX'wr "vq'3708'O gX'J ERD'j cu'30'vko gu"  
 o qtg'pgwtqp'vj cp'Y ENNOY j kg'kp'tgi kqp'707", "32/'6'gX'/"5069'O gX'uj qy gf "o qtg'pgwtqpu'kp'gpgti { "i tqwr u'd { 'hcevt'  
 30'qp'cxgtci g0J qy gxgt. 'kp'tgo cklpi "i tqwr u'vj gtg'y gtg'pq'pgwtqpu'kf gpvkkfg 0'

"

"

[3\_'UOP qeg'gvr0'P wergct'cpcn\ ugu'ht'vj g'f guki p'qh'vj g'WGT/rkg' rnoo c'hceki "eqo r qpgpv'xgtvccn'vti gw'qh'vj g'F GO Q'f kxgtvt. 'Hwukqp'Gpi kpgtkpi "

cpf 'F guki p. "Xqmw g'377. "4242. "j4\_'O 0'0'0' tggp. "J ki j "Ghkegpe/ 'Ukqep'Uqrc' 'Egm'\*/Vtcpu0'Vgej 0'Rvdreccvqpu. "Uy kv gtr:pf. "3; : 9+"

j4\_'E00Y gtpgt'gkf kqt+. "SO EP R'Wigtu'O cpwci/ "Eqf g'Xgtukqp'80'S. "NC/ WI/39/4; ; : 3'4239+"

j5\_'QGEF 'P wergct 'Gpgti { "Ci gpe\ . 'LGHH/50'Gxcncvfg 'F cvc'Nkdtct { "4236-0'j wr <ly y y Qgef /pgcQtI lf dhqto ulf cvc lxc lxcvcr gullghn54]"

"



**TGI KQP CN'QXGT GUVKO CVKQP 'QHUWO O GT 'VGO RGT CVWT GU'F WG'VQ''**  
**TGI KQP CN'ENKO CVG'O QF GNU'F GHKE KPE KGU'K'P 'URCKP''**

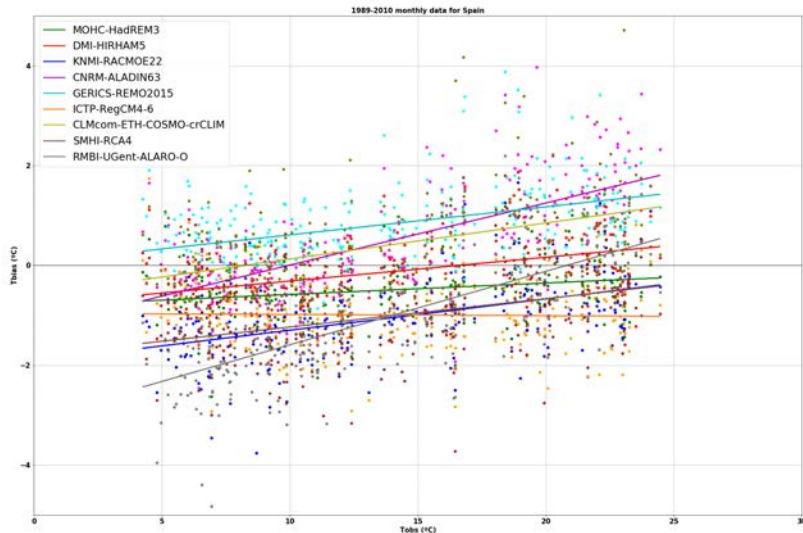
Iqu<sup>2</sup> 'Ectru'Nq| cpq'I cte'c<sup>3</sup>

<sup>3</sup>F gr ctwo gpv'qh'Rj { uleu'qh'Keg. 'Erko cvg'cpf 'Cct yj =P lgn'Dqj t 'Kpukwag. 'Wpkxgtuk{ 'qh'Eqr gpj ci gp. 'F gpo ctnl  
*npX.33: B cmo plQm(f n)*

Vj g'Kdgtkcp'Rgpkpawr'j cu'dggp'gzzr gtlgpeki 'pgy 'vgo r gtcwtg'tgeqtf u'lp'vj g'rcuv'hgy 'f gecf gu'o cni'pi 'uqo g'r ctwu'qh'  
 y ku'tgi kqp'rguu'cpf 'rguu'j cdkcdng. 'gur gekm{ 'f wtkpi 'uwo o gt0Vq'uko wrcv'rtugpv'f c{ 'erko cvg'eqpf kskpu'ceewtcvgn{ 'cpf'  
 vq'f gvgto kpg'dgvg'g'vko cvgu'qh'gz vgo g'vgo r gtcwtgu'qxgt 'vj g'uwj y guvgt'p'rtv'qh'Gwtqr g. 'j ki j /tguqmwkqp'tgi kqpcn'  
 erko cvg'o qf gnu' \*TEO u+j' cxg'dggp'cr r rkgf 0J qy gxgt. 'k'ku'wmpqy p'vq'y j kej 'f gi tgg'ucvq/gh'vj g/ctv'TEO u'o c{ 'vgpf 'vq'  
 qxgtguko cvg' tgi kqpcn' co r rkkhcvkqp'qh' i mdcn' y cto kpi. ' gur gekm{ 'f wtkpi 'vj g' y cto guv' o qpj u' 'Ej tkvngpugp' gv' cnd'  
 422: j3 =Dqdgti 'cpf 'Ej tkvngpugp. '4234j4 \_0"

Uwf kgu'j cxg'tgxgcrf 'vj cv'TEO u'j cxg'u{ ugo cve'vgo r gtcwtg'f gr gpf gpeg'qh'dlcugu'kpetgculpi 'y kj 'vgo r gtcwtg'0'  
 Vj g' y cto gt 'vj g' o qpj 'ku. 'vj g' utqpi gt 'vj g' vgp gpe{ 'ku'0Vj g' r tqlgev'clo u'vq' cpcn' ug' r qv'v'kcn' pqp/ucv'kqpc{ 'dkcugu'  
 dgvy ggp'erko cvg'uko wrcv'kpu' \*GWTQ/EQTF GZ' r tqlgev'cpf 'qdugtxcv'kpcn'f cvcugu'qxgt 'vj g'Kdgtkcp'Rgpkpawr' \*j gttgtc'  
 gv' cnd' 4237j5 \_0Uvej 'cp' cpcn'uku'j cu'pqv'dggp'f qpg'y kj 'vj g'ewtgpv'j ki j /tguqmwkqp'TEO u'qt' tgn' kpi 'qp' c'j ki j /  
 tguqmwkqp'qdugtxcv'kpcn'f cvcugu'dgh'gtg'0'K' cf f kkkp. 'vj g' cpcn'uku' y kni'dg'gz vgp'gf 'vq'cnu' cf f tguu' o qpj n' 'o gcpu'qh'  
 f ckn{ 'o czko wo 'cpf' o kpo wo 'vgo r gtcwtgu. 'y j kej 'j cu'pqv'dggp'cf f tguugf 'dgh'gtg'0'C' dlcu'eqttgev'kqp' o gv' qf 'eqwf' dg'  
 y gp'dg' r tqr qugf 'vq' o gpf 'uqo g'qh'vj g' o qf gnf gh'k'k'p'k'g'u'0'

**Model temperature biases (mean temperature)**



Hki 0300 qf gr'vgo r gtcwtg'dlcugu'eqxgtkpi 'vj g'r gtlkf '3; ; /42320TEO u'ltqo 'GWTQ/EQTF GZ' r tqlgev'cpf "  
 qdugtxcv'kpcn'i tkf f gf 'f cvcugu'ltqo 'EUKO"

j3\_'Ej tkvngpugp. 'L0J 0'Dqdgti 'H'Ej tkvngpugp. 'Q(D0( 'Nwecu/Rlej gt. 'R0'422: 0'Qp'vj g'pggf 'hqt'dlcu'eqttgev'kqp'qh'tgi kqpcn'erko cvg'ej cpi g'r tqlgev'kpu'  
 qh'vgo r gtcwtg'cpf 'r tgekr kcvkqp0"

j4\_'Dqdgti. 'H'Ej tkvngpugp. 'L0 0'42340Qxgtguko cvkqp'qh'O gf ksgttcpgep'uwo o gt 'vgo r gtcwtg'r tqlgev'kpu'f wg'vq' o qf gnf gh'k'k'p'k'g'u'0'

j5\_'J gttgtc. 'U0'Hgt'p' pf gl. 'L0'cpf 'I wkr ttgl. 'L0'O 0'42370'Wf f cvg'qh'vj g'Ur clp24'i tkf f gf 'qdugtxcv'kpcn'f cvcugu'hqt'GWTQ/EQTF GZ' gxcnvcv'kqp-<  
 cuugukpi 'vj g'gh'gev'qh'vj g'lpv'gtr qrcv'kqp' o gv' qf qm'j 0'

# STUDY OF ELECTRICAL CHARACTERISTICS OF SiGe AND CdZnTe MATERIALS APPLICABLE TO RADIATION DETECTION

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SiGe material based devices are capable to operate in the radiation harsh environment and it had been demonstrated that SiGe alloys are prospective for fabrication of  $\gamma$ -ray detectors [1]. Cadmium zinc telluride (CZT) is a promising material for the room-temperature X- and  $\gamma$ -ray detectors due to high average atomic number providing high stopping power as well as rather large band-gap which determines large resistivity, small leakage-current, and good energy resolution [2]. Generation of the undesirable point defects is inevitable during crystal growth and operation of detector in radiation harsh environment. The dopants, native impurities and radiation induced defects usually act either as recombination, trapping or carrier emission centres and contribute to the decrease of charge collection efficiency by reducing carrier lifetime. The role of point defects is also important in charge compensation processes. Therefore, the analysis of defects is important in prediction of the optical and electrical characteristics of the SiGe and CZT materials. In this work, study of pristine, 5.5 MeV electron and 1.6 MeV proton irradiated  $\text{Si}_{1-x}\text{Ge}_x$  structures, containing 1% and 5% of Ge, and two sets of CZT samples, exhibiting good and unacceptable performance of radiation detection, have been performed by combining techniques of the microwave probed photoconductivity (MW-PC) and pulsed barrier evaluation by linearly increasing voltage (BELIV).

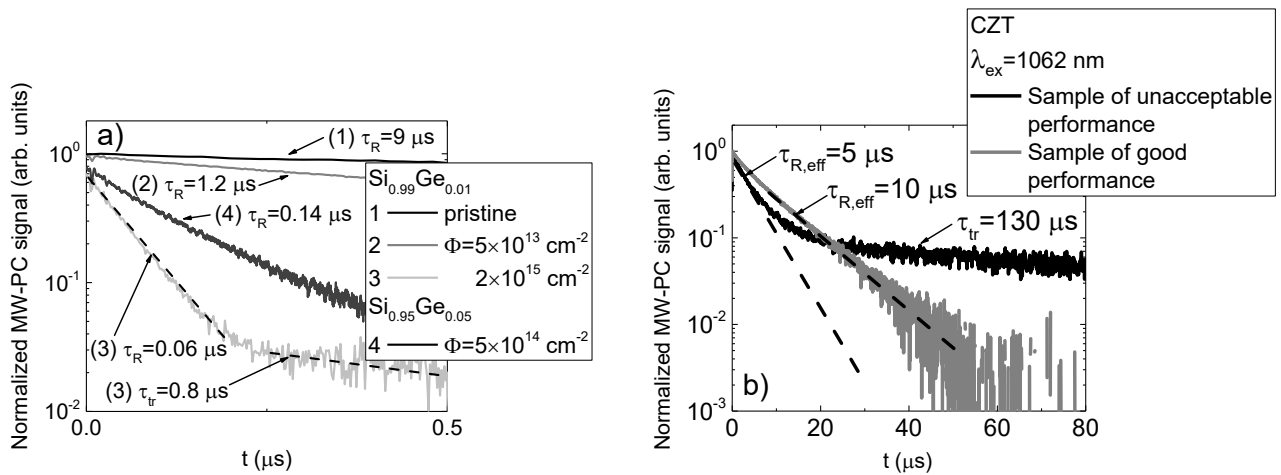


Fig. 1. The MW-PC transients normalized to a peak of the MW-PC response using bulk excitation (1062 nm wavelength) by 400 ps laser pulses: **a)** transients recorded on  $\text{Si}_{1-x}\text{Ge}_x$  diodes irradiated with different fluences of 5.5 MeV electrons; **b)** transients recorded on CZT samples, exhibiting unacceptable and good performance of radiation detection.

It has been revealed that in SiGe material both carrier recombination and trapping lifetimes decrease near-reciprocally (Fig. 1a) relative to the density of radiation defects acting as carrier capture and thermal emission centres, with predominance of point radiation defects. It has been hypothesized that the single-type deep centres are involved in both carrier photo-generation and thermal emission processes. Activity of point defects can be modified by anneal procedures, and sensor functionality can be recovered (at least, partially).

The main difference between the examined CZT diodes appeared through carrier trapping effect, observable only for diodes exhibiting unacceptable performance of radiation detection (Fig. 1b). The rather long instantaneous trapping lifetime of  $\tau_{tr} = 130 \mu\text{s}$  showed the trapping coefficient to be of the order  $K_{tr} = 27$ . The concentration of trapping centres has been estimated to be  $> 3 \times 10^{14} \text{ cm}^{-3}$  for the shallowest thermal emission centres. These trapping centre concentrations exceed dopant density by several orders of magnitude. The trapping centres in CZT material might be associated with  $\text{Te}_{\text{Cd}}$  as well as  $\text{V}_{\text{Cd}}^{0/-}$  point defects and Te inclusions.

[1] I. Yonenaga, *Si<sub>x</sub>-Ge<sub>1-x</sub> bulk crystals* (Reference Module in Materials Science and Materials Engineering, Netherlands, 2016).

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# EJ CNEQI GP KF G/RGT QXUMK/GU'HQT'O WNVLWP EVKQP 'UQNCT'E GNN' CRRNKE CVKQP "

Tqneu'Mqpf tqcu<sup>3</sup>. 'Ct pcu'Mtqmwu<sup>3</sup>. 'Ucwku'Vwo pcu<sup>3</sup>. Dtqpkurxku'Egej cxleku<sup>3</sup>. 'O cctlc' I tqudgti <sup>4</sup>. 'O ctk/Mcwm/Mwuknf. 'Zcqhgpi 'Nk<sup>4</sup>"

<sup>3</sup>Egpgt'ht'Rj { ulecn'Uekpegu'cpf "Vgej pqrni { . 'Ucxcpqtk 'Cxg0453. 'Xlpxku.'24522.'Nksj wcpkc "

<sup>4</sup>F gr ctvo gpv'qh'O cvgtkcn'cpf "Gpxktqpo gpcn'Vgej pqrni { . 'Vcnkpp'Wpksxtuks'qh'Vgej pqrni { . 'Gj kclcv'vgg'7.'3; 2: 8' Vcnkpp.'Guqpkc "

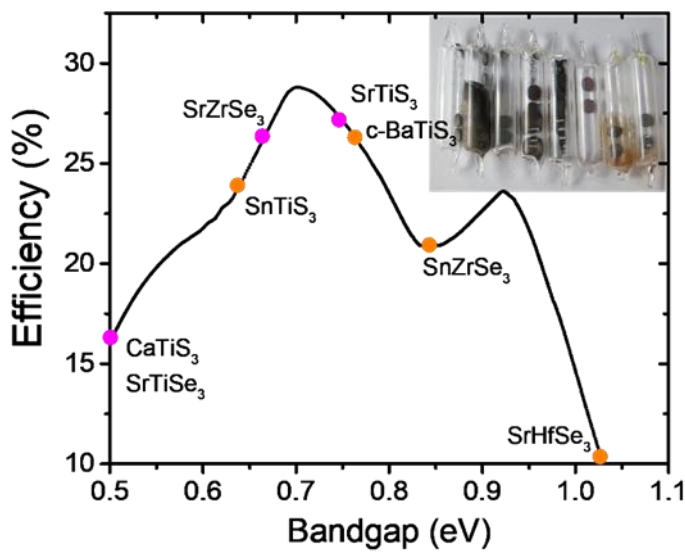
tqneuMqpf tqcuB hvo eht"

"

Qp'yj gqg'vlecn'hxgn'o wnk'wpevkp'uqnt'egmu'j cxg'c'r qv'pvcn'v'cej kxg'qxgt'82' 'r qy gt'eqpxgtukqp'ghlelgepe{0Kp' r tceveg. 'f gxleg'y kj '69' "ghlelgepe{ 'j cu'dggp'hdtkcvgf 'dcugf'qp'KXX'o cvgtkcn'cpf 'hxg/lwpevkp'utwewtg0J qy gxgt." gzv'tgo gn' 'j ki j "equv'qh'uwej "o wnk'wpevkp'f gxlegu'kpj kdk'yj gk'y kf g/ur tgc'f'cr r r'ecvkp0Kp'yj g'tgegpv' { gctu'f'wg'v'q'yj g' wpr tgegf gpv'f'gxgnr o gpv'qh'r gtqxunkg'vgej pqrni { . 'y q/lwpevkp'uqnt'egmu'eqo r tkupi 'r gtqxunkg'cpf 'y gm'gucdrkj gf " UK'j cu'f go qputcvgf 'xgt { 'r tqo kulpi 'tguwmu'tgej kpi '4; ' 'kp'4242'J3\_.'cpf 'qr gp'kpi 'y j'vgej pqrni kcn'r cvj 'ht'wntc/j ki j " cpf 'ny /equv'uqnt'egmu'Vq'ko r tqxg'uwej 'v'cpf go 'f gxleg'ht'yj gt. 'cf f kpi 'cf f kkp'cn'l'wpevkp'y kj "cduqtr vkp'gf i g'cv'20" gX'ecp'r qv'pvcn' 'cf f'7' "qh'cduqtr'ghlelgepe{0".....

Kp'yj ku'y qtm'y g'uwf { "wpf gtg'zr nrtgf "encu'qh'o cvgtkcn'ht' r qv'pvcn'cr r r'ecvkp'kp'o wnk'wpevkp'f gxlegu'cu' dqwqo "uwd/egm'Hi wtg'3+0Vj g'ugr'evgf "eqo r qwpf u'ctg'htqo 'y j'g'ej creqi gpkf g/r gtqxunkg'o cvgtkcn'i tqw. "eqp'v'k'kpi " gct'v' /cdwpf cp'v'ej go kcn'nggo gpv'cpf "eqo r cvdr'v' kj 'ny /equv'u{pvj guku'o gvj qf u'ctg'r tgf kxgf 'v'j cxg'ny 'dcpf 'i cr " \*>"20"GX+'J4\_0Ej creqi gpkf g/r gtqxunkg'u'j cxg'c'i gpgt'cn'eqo r qwpf 'htqo w'CDZ\_s.'y j gtg'kp'qw'uwf { 'C?Ec.'U.'Up=D?Vk" t."Up=Z?U.Ug'0'Uco r ngu'y gtg'u'pvj guk'gf 'xlc'ukf'ucv'g'tgcevkp'Hi wtg'3"kpugv'cpf 'ej ctcevgtk'gf 'd { "z/tc { " f kht'cevkp'o gvj qf 'v'uwf { 'ej creqi gpkf g/r gtqxunkg'yj gto qf { pco le'ucdr'k'v' 'cpf 'et { ucn'ut wewtg'0".....

Y g'hw'p'f 'y cv'o cp { 'ej creqi gpkf g/r gtqxunkg'u'ctg'pqv'ucdr'g'cpf 'f q'pqv'htqo 'wpf gt'pqto cn'y kj qw'v'cpur qv'ci gpv' qt'ecv'cn'uku'eqpf kkp'u0Kp'eqp'v'cu'v'q'j cni gp'cpf 'qz'kf g'r gtqxunkg'u.'y j'g'ut wewtg'qh'ej creqi gpkf g/r gtqxunkg'u'ecpp'v' dg'r tgf kxgf "ceeqt'f kpi "v'j g'v'q'rt'cpeg'hc'evqt'v'v'."K0'y j gp'ku'equg'v'w'p'k'v'.'cf qr v'g'ut wewtg'ku'pqv'ewd'le'0Vj ku'uj qy u' yj cv'cv'qo le'dqpf kpi "kp'ej creqi gpkf g/r gtqxunkg'u'ku'o qtg'eqxc'ng'v'v' cp'k'p'le'kp'pcwt'g'cpf 'y j'gt gh'q'g'v'uw'cm' { 'cf qr v'q'p'g' qh'yj g'ht'ny kpi 'ny gt'u' { o o g'v' { "et { ucn'ut wewtg'g'p'gg'f'ng'rk'ng'v'v' r tqv'v' r g'P J o'Ef'En\_+'j g'zci q'pcn'r tqv'v' r g'DcP kQ\_5+'qt' f ku'qt'v'g'f' r gtqxunkg'v'v' r tqv'v' r g'I f HgQ\_5+0' "



Hi 030Rqy gt'eqpxgtukqp'ghlelgepe{ 'xgtu'w'v'j g'dcpf 'i cr 'y kj kp'Uj qemg{ 6S wkuugt'yj ggt { 'wpf gt'30'CO 0Uqnt' tcf k'v'kp'y kj 'ewq'hh'cv'3322'po 0Rq'v'pvcn'ghlelgepe{ 'qh'ej creqi gpkf g/r gtqxunkg'uqnt'egmu'dcugf'qp'yj gk'dcpf 'i cr 0'

Co qpi 'uwf lgf "eqo r qwpf u.'y g'hw'p'f 'y cv'U'VKU\_5'ku'ucdr'g'wpf gt'co dl'gpv'eqpf kkp'u.'et { ucn'ku'gu'kp'v'j g'zci q'pcn' r tqv'v' r g'DcP kQ\_5+'cpf "pq'p'v'q'lej kqo g'v'le'v'U\_30'V\_50\_5+'ut wewtg'cpf 'y kj 'c'dcpi 'i cr 'cv'ct'q'wpf '2087'GX0Qp'yj g'q'v'j gt' j cpf. 'y j'gt g'cnu'q'v'j gt'r qv'pvcn'ej creqi gpkf g/r gtqxunkg'u'y j'gt g'ej go kcn'eqo r qu'kk'p'ecp'dg'ht'p'g'w'p'gf 'd { 'ec'v'k'p'le'qt' c'p'k'p'le'uw'duk'w'k'p'v'q'cej kxg'qr v'ko cn'20'GX'dcpf 'i cr 0".....

J3\_ "COCn'Cu'j q'w'k'GOM'4 pgp. 'DONK'gv'cn'0 q'p'rk'y le'r gtqxunkg'uk'le'q'v'p' go "uqnt'egm'y kj "@; ' "ghlelgepe{ 'd { 'gpj c'p'eg'f'j q'ng'z'v'ce'vkp.'Uek'peg' 592.'8744'4242+0' J4\_1 Q'U'wp.'O'ONOCi k'q'ti q'w'ku.'R0' j cpi 'gv'cn'0'ej creqi gpkf g'R'gtqxunkg'u'ht'Rj q'v'x'q'nc'leu.'P'cp'q'ig'v'gtu.'37'3+.'7: 3/7: 7' "

# KXGUVH CVKQP 'QH'VY Q'NWO KPGUEGPEG'DCPF U'K'P'P QP RQNCT'' KPI cP II cP'O WNVKRG'S WCP VWO 'Y GNNU'URGE VT C''

Grgpc'Xcmk pckv . 'L tcu'O lengxk kw''

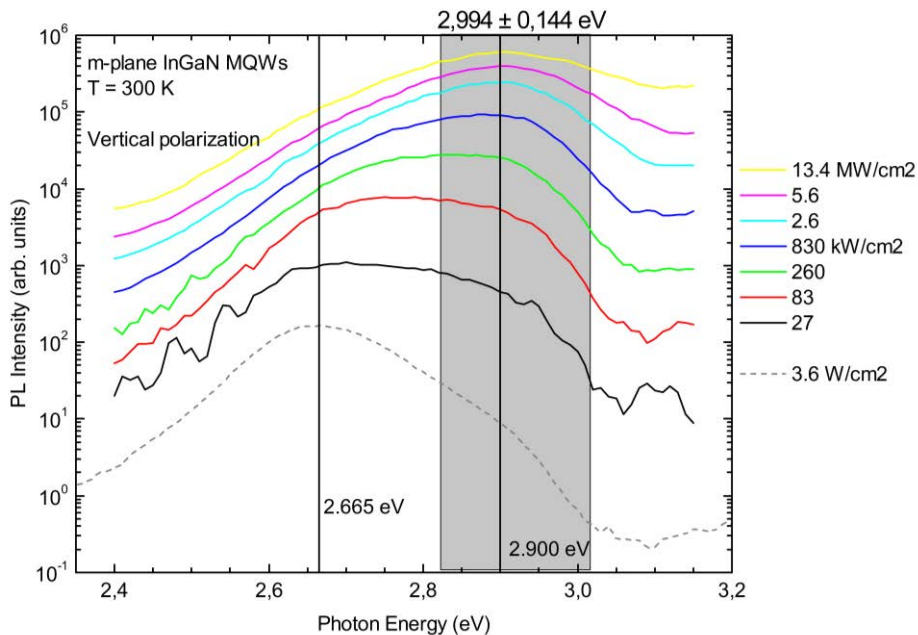
<sup>3</sup>Kpukwag'qh'Rj qvqpleu'cpf 'P cpqvej pqmji { . 'Hcwm' 'qh'Rj { uleu.'Xkpkwu'Wpkxgtukv' . 'Nkij wcpk' "[grgpc'xcmk'pckv' B H'kw'w'w'f' Q''](#) }

P qy cf c { u.'KPI cP "rki j v'go kwkpi "f kqf gu"\*NGF u+"ctg'y kf gn' "wugf "hqt"cr r dcvkqp"kp"uqrf/ucvg"rki j v'kpi "cpf"rcti g" ctgc"t kur r: { u0Vj g'eqo o gteknf gxlegu'ctg'o quw' "i tqy p"qp'r qm't'e/r n'p'g'uwdutcvgu."j qy gxgt."y g'qr v'ecnr' tqr gt'v'gu'qh' KPI cP "s wcpwo "y gmi"\*S Y u+"lp"uwej "f gxlegu'ctg'utqpi n' "ch'g'ev'g' d { "y' g'lp'v'gt'pcn'grg'v'le" h'grf "c'm'pi "y' g'r qm't' "i tqy y' " f kt'g'v'kqp" ]3\_0'P qpr qm't' "c/"qt"o /r n'p'g+' KPI cP II cP "o wnr' rg" s wcpwo "y gmi"\*O S Y u+"cwt'cev'cw'gp'v'kqp" f w'g' "v'g' "y' g' cdugpeg"qh'r qm't'k' v'kqp/t'gr'v'g' "gr'g'v'le" h'grf . "y j lej "uj qwf "ko r tqxg"y' g'qr v'ecnr' gth'qto c'peg. "cpf" "ecr cdk'k'v' "v'g' go k'v' j ki j n' "r qm't'k'ugf "h'ki j v' ]4\_0'

Kp'y' ku'y' qtm'y' g'r' t'g'ug'p'v'y' g'r' j qv'q'no k'p'g'ue'g'p'eg' "uwf' { "qh'p'qpr qm't' KPI cP II cP "O S Y u'y' k'ij "y' g'o c'k'p' h'q'ewu'q'p' "y' g' f { p'co' leu' "qh' "f q'w'd'g' /d'c'p'f "ut'w'ew't'g'0' Y' g' "j c'x'g' "uwf' k'g'f "u'g'x'g'p' "o /r n'p'g+' KPI cP II cP "uco' r' n'gu' "y' k'ij "f h'g'g'p'v' k'p'f' k'wo " e'q'p'v'p'v' q't' "S Y "y' k'f' y' 0'U'co' r' n'gu' "y' g't'g' "i tqy p"qp" u'c'r' r' j k'g' "u'w'd'ut'c'v'g'u' w'ul'p'i "o g'v'c'm't'i c'p'le" e'j go l'ec'n' x'c'r' q't' "f g'r' q'u'k'v'k'q'p' " \*O Q'EXF +0'0' g'c'u'w't'g'o g'p'u'y' g't'g'r' g't'h'q't'o g'f "w'p'f' g't' "y' g'z'ek'c'v'k'q'p' "r' q'y' g't' "f' g'p'u'k'v' "x'c't'k'g'f' "h'q'o "5'0' "Y' l'eo "4" "v'q' "35'0' "O Y' l'eo "4" " k'p' "y' k'f' g'v'g'o r g't'c'w't'g' "t'c'p'i g' "q'h' " : "522' "M'0'

Vj g' v'f' r' l'ec'n' f' q'w'd'g' /d'c'p'f "RN" ur g'ew't'wo "qh' "y' g' "p'q'p'r' qm't' KPI cP II cP "uco' r' n'gu' "e'c'p' "d'g' "e'ng'c't'n'f' "q'd'ug't'x'g'f' "c'v' "n'y' " g'z'ek'c'v'k'q'p' "5'0' "Y' l'eo "4" "y' j' g'p' "y' g' "n'y' g't' /g'p'g't'i { "d'c'p'f' "f' q'o k'p'c'v'g'u' "u'g'g' "H'i 03+0'Cu' "y' g'z'ek'c'v'k'q'p' "r' q'y' g't' "f' g'p'u'k'v' "k'u' "k'p'et' g'c'ug'f' . " y' g' "j' k'ij g't' /g'p'g't'i { "d'c'p'f' "i tqy u' "h'c'w'g't' . "c'p'f' "y' g' "e'ng'c't' "u'g'r' c't'c'v'k'q'p' "d'g'y' g'g'p' "y' g' "y' q' "r' g'c'm'i' "f' k'uc'r' r' g'c't'u'0' "O g'c'p'y' j' k'g' . "c'v' "y' g' " j' k'ij g'u'v' "g'z'ek'c'v'k'q'p' . "y' g' "j' k'ij g't' /g'p'g't'i { "d'c'p'f' 2" "f' q'o k'p'c'v'g'u'0' "U'lo k'rc't' "d'g'j' c'x'k'q'w't' "qh' "y' g' "y' q' "d'c'p'f' u' "k'u' "c'u'q' "q'd'ug't'x'g'f' "c'v' "n'y' g't' "y' g'o r g't'c'w't'g'u' "q'h' " : "M' "c'p'f' "372' "M'0' "O wnr' rg" r' g'c'm'i' "y' g't'g' "c'u'q' "q'd'ug't'x'g'f' "k'p' "y' g' "RN" ur g'ew't'c' "qh' "r' t'g'x'k'q'w'w'f' "uwf' k'g'f' "r' qm't' " KPI cP II cP "uco' r' n'gu'0'

Vj g' p'c'w't'g' "qh' "y' g' "y' q' "RN' d'c'p'f' u' "k'u' "p'q'v' { g'v' "y' g'm'i' w'p'f' g't'u'q'q'f' "c'p'f' "u'g'x'g't'c'n' "k'p'v'g'r' t'g'v'k'q'p'u' "c't'g' "w'p'f' g't' "e'q'p'u'k'f' g't'c'v'k'q'p' "y' g' go k'u'k'q'p' "h'q'o "p'c't't'q'y' "u'k'f' g'y' c'm' "O S Y u' "k'u' "X/r' k'u' " ]5\_ " q't' "d' { "y' g' "u'ny' n'f' "f' g'ec' { k'p'i "v'c'k'i' "q'h' "y' g' "f' g'p'u'k'v' "q'h' "u'c'v'g'u' "f' w'g' "v'g' " r' q'v'g'p'v'c'n' "h'w'ew'v'k'q'p'u' ]6\_0'Vj g' "q'd'ug't'x'g'f' "d'n'w'g' "u'j' k'm' "q'h' "y' g' "r' g'c'm'i' "k'u' "c'w't'k'd'w'g'f' "v'q' "y' g' "s' w'c'p'w'o "U'c't'n'g'h'g'ev' "c'p'f' "y' g' "h'k'k'p'i "q'h' "y' g' "h'q'ec'n'k' g'f' "u'c'v'g'u' ]7\_0'Vj g' "u'ko' r' n'g' "g'u'v'ko' c'v'k'q'p' "q'h' "s' w'c'p'v'k' g'f' "g'p'g't'i { "r'g'x'g'm'i' "k'p' "y' g' "KPI cP "S Y u' "k'p'f' k'ec'v'g'f' "d' { "y' g' "u'j' c'f' g'f' " t'g'i' k'q'p' "k'p' "H'i 0'3+ "c'm'q'y' g'f' "w'u' "v'q' "c'w't'k'd'w'g' "y' g' "j' k'ij g't' /g'p'g't'i { "RN' d'c'p'f' "v'q' "y' g' "t'c'p'u'k'v'k'q'p'u' "d'g'y' g'g'p' "y' g' "n'y' g'u'v' "r'g'x'g'm'0'Vj g' "n'y' g't' /g'p'g't'i { "d'c'p'f' "k'u' "y' g'p' "c'u'k'i' p'g'f' "v'q' "y' g' "t'g'eq'o d'k'p'c'v'k'q'p' "q'h' "h'q'ec'n'k' g'f' "e'c't't'k'g't'u'0'



H'i 030'Nwo k'p'g'ue'g'p'eg' "d'c'p'f' u' "q'h' "y' g' "uco' r' n'g' "x'g't' v'ec'n'r' qm't'k' v'k'q'p' +f' g'r' g'p'f' g'p'eg' "q'p' "y' g' "g'z'ek'c'v'k'q'p' "r' q'y' g't' "f' g'p'u'k'v' "c'v' 522' "M' "v'g'o r g't'c'w't'g'0'

- [3\_ "M'g'm't' . "U'0'g'v'c'n'0' "T'g'eg'p'r' t'q'i' t'g'u' "k'p' "o' g'v'c'n'q't'i' c'p'le" e'j go l'ec'n' x'c'r' q't' "f' g'r' q'u'k'v'k'q'p' "q'h' "2223\_ " +P/r' qm't' "i tqw' /k'k'p'k't'k'f' g'u'0' "U'go' l'eq'p'f' w'ev'q't' "U'ek'p'eg' "c'p'f' " V'g'ej' p'q'm'j' { "4: "335223" "4236+ "
- [4\_ "V'c'p'i . "H'0'g'v'c'n'0' "l'et'q'u't' w'ew't'c'n'f' g'r' g'p'f' g'p'e' { "q'h' "q'r' v'ec'n'r' t'q'r' g't'v'g'u' "q'h' "o' "r' n'p'g' "KPI cP "o' wnr' rg" s' w'c'p'w'o "y' g'm'i' "i tqy p"qp" "4' "A' "k'u'q't'k'ep'v'g'f' "d'w'm'i' c'p' " u'w'd'ut'c'v'g'u'0' "C'r'r' r'0'Rj { u'0'Ng'w'0329. "2: 4326" "4237+0'
- [5\_ "E'j' c'p'i . "E'0' [ 0' "Nk' "J' 0' "U'j' k'j . " [ 0'V'0' ( "Nw" "V'0'E'0' "O' c'p'k' w'v'k'q'p' "q'h' "p'c'p'q'ue'c'g' "X/r' k'u' "q'r' v'lo' k'g' "k'p'v'g't'p'c'n' s' w'c'p'w'o "g'h'g'h'k'p'e' { "q'h' "KPI cP "o' wnr' rg" s' w'c'p'w'o "y' g'm'i' "C'r'r' r'0'Rj { u'0'Ng'w'0328. "2: 3326" "4237+0'
- [6\_ "U'c'ne'k' "U'0' [ c'o' c'i' w'ej' k' "C'0'C'0' "M'w'k'j' c't'c' . "M'0' ( "P' c'i' c'q' . "U'0'R'q'u'k'v'k'q'p' "q't'k'i' k'p' "q'h' "f' q'w'd'g'r' /r' g'c'm'i'g'o' k'u'k'q'p' "k'p' "KPI cP "s' w'c'p'w'o "y' g'm'i' "q'p' "o' /r' n'p'g' "h'g'g' /u'c'p'f' "k'p'i " I c'p' "u'w'd'ut'c'v'g'u'0' "k'p' "l'ec'r' c'p'g'g' "l'q'w't'p'c'n'q'h' "C'r'r' r'g'f' "Rj { u'leu' "77. "27H'i 2: "4238+0'
- [7\_ "Nk' "L'0' "Nk' "U'0' ( "M'ep'i . "I'0'S' w'ep'k'f' g'f' "r'g'x'g'n' "t'c'p'u'k'q'p'u' "c'p'f' "o' q'f' "h'k'ec'v'k'q'p' "k'p' "KPI cP II cP "o' wnr' rg" s' w'c'p'w'o "y' g'm'i' "C'r'r' r'0'Rj { u'0'Ng'w'0; 4: "323; 4; "422: +0'

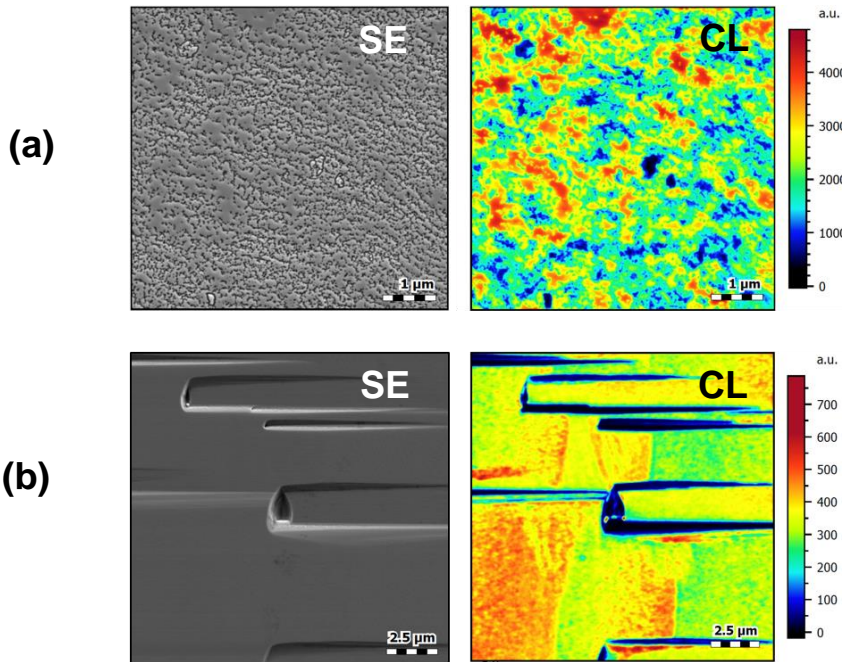
# O KETQUEQRKE 'NWO KP GUE GPE G'RT QRGTVKGU'QH'XCTKQWU' RQNCTKV[ 'KPI cP 'S WCP VVO 'UVTWEVWTGU''

O ctkco klc'P knklpc'

"Kpukwng'qh"Rj qvqpleu'cpf "P cpqvej pqmji { "Xkpkwu'Wpkxgtukf. "Nkj wcpk"  
o ctkco klc'P knklpc' B hfwf'xv'w"

P qp/r qrt'cpf "ugo k/r qrt"l tqwr /KKpktkf gu'ctg'qh'i tgcv'lpvgt gu'f wg"vq"vj gk'r qvqpleu' { "j ki j "s wcpwo "ghh'ekgpe {0' Rj qvqple" f gxlegu' dcugf "qp" ptktkf g" s wcpwo "y gmu" \*S Y u" y kj " tgf wegf "qt" gxgp" grko lpcv'gf "lpvgtpci' grgevle" h'grf u" f go qpwtcv'g' dgwgt "s wcrk'f. "ur gek'hecm' "dgwgt" tcf k'v'qp" gh'ekgpe { "ej cti g" v'cpur qtv" qr v'ecni' i c'p' j qy gxgt. "ur c'v'cni' xctk'v'qpu'qh' rki j v'go kuukqp" ukni'uki p'k'hecpv'f "ch'ge'v'j g" r' gthqto c'peg'qh' uvej "f gxlegu" ]3\_0'Vj g'g'htg. "vj g'g" ku'c' p'ggf "vq" k'pxguki cv'g'lp" o q'g' f g'v'cni' v'j g" o letqueqr k'e/uecng'qr v'ecni' r' q'g'v'gu qh'p'qp/r qrt' s wcpwo "ut wewtgu" cpf "vj gk' t'gr'v'qpu" y kj "ut wewt'cni' s wcrk'f "cpf "i tqy vj "eqpf k'v'qpu"0"

Vj ku'y q'ni'ku'f gf k'ecv'gf "vq" k'pxguki v'v'qp'qh' v'j g'ur c'v'cni' w'p'k'qto kv'f "qh' h'wo k'p'guegpe'g'qh' KPI cP "o w'kr ng' s wcpwo "y gmu" i tqy p' qp' f k'htg'gp'v'et { u'cm'qi t'cr j le" r' r'p'gu' d' { "O g'v'cni' Q'ti c'ple" E'j go k'ecni' X'cr q'w' "F gr qu'k'v'qp" \*O QEXF + "v'gej pqmji {0' K'p' q'f' g' t' v'q' f g'v'gto k'p'g' KPI cP "n'wo k'p'guegpe'g' r' t'qr g'v'gu' cpf "vj gk' "eqtt'gr'v'qpu" y kj "ut wewt'cni' f gh'geu. "U'ecpp'k'pi "G'gev'q'p' O letqueqr { " \*UGO + "cu" y g'mi' cu" dq'v'j "ur c'v'cni' "cpf "v'wo g' " t'gu'q'ng'f "ecv'j q'f q'no k'p'guegpe'g' \*EN+ "ej c't'ce'v'g't'k' v'v'qp" y g'g' go r' m'j { gf 0'UGO "c'm'q' y u'v'q' g'x'c'nc'v'g' f gh'geu' f' g'p'uk'f "cv'f k'htg'gp'v' u'co r' ng' c't'g'cu. "y j k'p' EN' c'p'cni' u'ku' ku' e'q'p'x'g'p'k'p'v' k'p' q'f' g' t' v'q' i g'v'c'p' k'p'uki j v'k'p'v'q' o cv'g't'k'ni' r' t'qr g'v'gu' cu' d'c'p'f i cr "cpf "e'c't'k'g't' f { p'co k'eu'y kj "j ki j "ur c'v'cni' c'p'f "v'go r' q't'c'ni' t'g'u'q'v'k'p'u"0"



Hki 030UG'ko ci g'cpf "vj g'EN'k'p'v'p'uk'f "f k'ut'k'd'w'k'p' "cv'v'j g' u'co g'ctgc'lp' e/r r'p'g' KPI cP 'O S Y u" \*c= "u'co g'ctgc'UG'ko ci g' c'p'f "vj g'EN'k'p'v'p'uk'f "f k'ut'k'd'w'k'p' "k'p' o / r' r'p'g' KPI cP 'O S Y u" \*d-0'

Vj g"o g'cu'w'go g'p'u' t'g'x'g'c'rf "vj cv'v'j g"ur c'v'cni' f k'ut'k'd'w'k'p' qh'EN'k'p'v'p'uk'f "ku' k'p'j qo qi g'p'g'q'w'u' cpf "eqtt'gr'v'gu" y kj " u'w'h'c'eg'v'qr qi t'cr j { "k'p' dq'v'j "r qrt' c'p'f "p'qp/r qrt' ut wewt'gu" \*h'ki 0-0' K'p' e/r r'p'g' KPI cP "s wcpwo "y gmu" v'j g' n'wo k'p'guegpe'g' r' t'qr g'v'gu' ctg' ut'q'pi n'f "ch'ge'v'gf "d' { "j ki j "f g'p'uk'f "qh' x/r ku' " \*c 32<sup>32</sup> "eo /4+ "c'p'f "t'g'p'ej "f gh'geu' 0'0 q't'g'x'g't. "vj g'EN' f g'ec { "v'wo g' u'j qy u" r qu'k'x'g' eqtt'gr'v'qpu" y kj " v'j g' go kuukqp" k'p'v'p'uk'f 0' K'p' ecug' qh' o / r' r'p'g' u'co r' ng. "vj g' eqo r c't'k'v'qp' qh' U'ge'q'p'f c't { " G'gev'q'p' \*UG+ "ko ci g' c'p'f "EN'k'p'v'p'uk'f "f k'ut'k'd'w'k'p' "k'p' f'ec'v'gu' v'j cv'uec'v'g't'gf "u'v'gr "d'w'p'ej gu' y g'g' h'qto gf. "r qu'k'd'ni' f w'g'v'q' u'w'd'ut'cv'g' ko r g'h'ge'v'q'pu' 0' K'p' uvej "f gh'geu. "s wcpwo "ut wewt'gu" qh' q'v'j g't' v'j c'p' o / r' r'p'g' r' q'rt'k'v'f "q'ee'w't. "y j k'ej "ng'c'f u" v'q' k'p'j qo qi g'p'g'q'w'u' k'p'f k'wo "f k'ut'k'd'w'k'p' "c'p'f "ur c'v'cni' x'c't'k'v'qpu' "k'p' v'j g' r'ki j v'go kuukqp' 0' h'w' v'j g'to q'g' v'j g'EN' f g'ec { "v'wo g'k'p' o / r' r'p'g' ut wewt'g' f' k'f "p'q'v'j qy "u'vej "c" r' t'q'p'q'w'p'eg'f "eqtt'gr'v'qpu" y kj "vj g' go kuukqp" k'p'v'p'uk'f "cu' k'p' r' q'rt' KPI cP 0'

[3\_0'00 qp x tk p." 0T' vj k'k" pf "F 0' H'g'g' gm"o "F ge f'g' qh'P q'p' q'n t" pf "U'go k'q'nt t'KK'p'k'k'f gu'z' "T'g'x'k'ey "qh'U'we'g'u'gu" pf "E'j ng'pi gu'ö" Rj /u'0' u'w' u'q'v'k'f k'x'q'f 0438. p'q'03. F ge 0423: 0'

**VGO RGT CVWT G/F GRGP F GP V'RJ QVQNW O K GUEGPE G"**  
**QHTQEMUCNV\ p<sub>3/2</sub>O i z Q-GRKNC[ GTU'**

O qpknc'Lqmwdcwunc<sup>3</sup>. 'Gxgrkpc'F wf wkgp<sup>3</sup>. 'Tco pcu'P gf | kpunc<sup>3</sup>. 'Nkwy gp'Ej cpi<sup>4</sup>. "  
 O ke j 'Ej qw<sup>5</sup>"

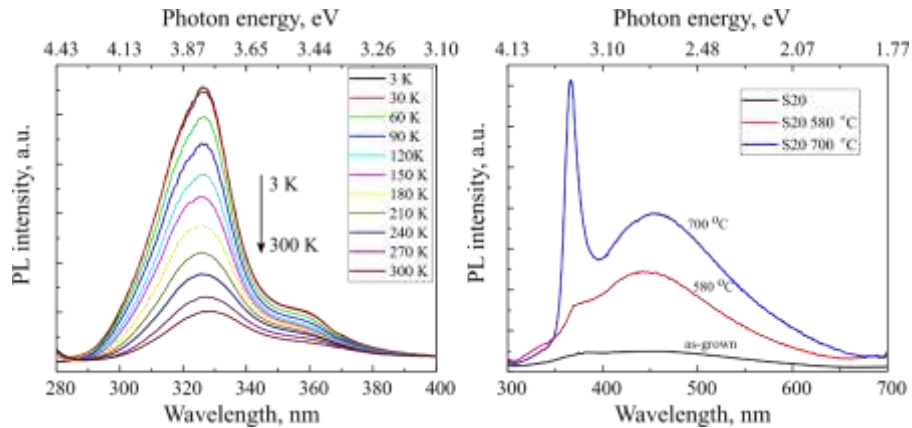
<sup>3</sup>Egpgvt'ht'Rj { ukeci'Uelgpegu'cpf "Vgej pqrqi { . 'Xkpkwu.'Nksj wcpk "

<sup>4</sup>F gr ctwo gpv'qh'O cvgtkcu'cpf 'Qr vqrgextqple'Uelgpeg. 'P cvkqpcn'Uwp' | gv'Ugp'Wpkxgtukf. 'Mcqj ukxpi . 'Vcky cp. 'TQE "

<sup>5</sup>Egpgvt'qh'Et { ucn'Tgugtej . 'P cvkqpcn'Uwp' | cv'ugp'Wpkxgtukf . 'Mcqj ukxpi . 'Vcky cp "  
o qpknc'Lqmwdcwunc<sup>3</sup>kgB hwo eht'

Kp'y gto qf { pco le'gs wrktdtkwo . 'y g'et { ucn'utwewtgu'qh' | kpe'qzlf g'pQ+'cpf "o ci pgukwo "qzlf g'pO i Q+'ctg"j gzci ppcn' y wv'kg'ky | '+'cpf "ewdle'tqemucn'utw: 'tgr gev'xgn' O'k'c'vgt'pct { 'eqo r qwpf "qh' pO i Q'dqy '\ p'cpf "O i "ecp'dg'uwdukwgwf "d { " gcej "qy gt'wr "q'z62" 'y kj qw'iqupi "utwewtci'ucdtkk' { 'J3\_0\ pO i Q'urkf "cmj { 'y kj "c'j ki n' /wpcdrg'dcpi cr "htqo "56'gX" vq'90 "gX+'vj wu'j cu'c"i tgev'r qv'p'cln'ht' cr r'ncv'qpu'qh'qr vqrgextqple'kp'y g'f ggr /wntcxkqrgv'ur gev'cni'tgi kq'p'J4\_0J qy g'xgt. " \*f w'v'q'tu/y | 'r j cug'v'c'p'uhqto cvkqp+'k'ku'f k'k'hw'v'q' i tqy 'r w'gr' { "gkj gt' y wv'kg'qt'tqemucn' \ p<sub>3/2</sub>O i z Q'gr krc { gtu'gzj kdkkpi " y j g'dcpi cr "gp'gti lgu'lp'y g'tgi kq'p'dgw ggp'65676'gX'J5\_0P g'xgt y g'rguu. 'k'y cu't'ge'p'v'q' 'tgr qt'v'f 'y cv'j g'wug'qh'O i Q'\*322+' uwduvcy' r tqxkf gu' pQ'urk'v'k'k' { "w'v'q": '7' "uw'v'k'p'k'pi "ulpi r'g'r j cug'tqemucn'et { ucn'utwewtgu'0Cm'j. 'O i Q'\*322+'uwduvcy' cmj u'ht'c'uki p'k'k'ecp'v'q' "uo cngt "r'w'le'g'o kuo cvej . 'gpj c'p'ego gpv'qh'utw'f'c'g' "tqwi j p'guu'cpf "y j g'tgh'gt'j ki j g't'qr v'ecni's w'v'k'k' { . " eqo r c'tgf "q'eq'p'x'g'p'v'k'p'cm' { "wug'f "ucr r j k'g'qt'Uk'uwduvcy'u'J6\_0'

Vj ku'y qtnir' t'gug'p'u'f g'v'k'rg'f "vgo r g'c'w'g' /'cpf "g'z'ek'v'k'p' /'f gr g'p'f gpv'r j q'v'q'w'o k'p'g'ue'g'p'eg'RN+'l'p'x'g'v'ki cvkqp'qh'tu' \ pO i Q' gr krc { gtu'f tqy p'qp'\*322+'O i Q'uwduvcy'd { 'r'cuo c/cu'k'ng'f "o q'rg'ew'ct'd'g'co "gr kcz { 'J7\_0C'ug'v'q'h'ico r'ngu'k'p'x'g'v'ki cv'gf 'eq'v'c'k'p' ukz'tu' \ p<sub>3/2</sub>O i z Q'utwewtgu'y kj 'f'k'ht'g'p'v'O i Q'eq'v'p'v'q'h'z' "208' "uco r'ng'U44+'204' \*U3: +204; \*U42+'2074' \*U38+'2088' \*U8+' c'p'f "208' \*U36+'0'RN' v'ej p'k' w'g'y cu'wug'f "v'q' g'z'r n'q't'g'p'v'g't'dc'p'f "g'z'ek'v'k'p' c'p'f "f'g'he'v't'g'v'f "qr v'ecni'v'c'p'v'k'p'p'k'p'5/522'M' vgo r g'c'w'g'g't'c'p'i g' "ugg'Hi 03. 'c'+0O q't'g'x'g't. 'c'v'k'v'k'p'p'g'p'ti lgu'f g'k'x'g'f "ht'qo 'RN' b' g'cu'w't'g'o g'p'u't' tqxkf g'f 'lp'uki j v'k'p'v'j g'to cni' s'w'p'ej k'p'i "qh'w'o k'p'g'ue'g'p'eg' r' t'q'eg'uu'g'0' C'f'f' k'k'q'p'cm' . "y j g'to cni'c'p'p'g'c'k'p'i "g'h'g'v'q'p'w'o k'p'g'ue'g'p'v'r' t'qr g't'v'g'u'qh' \ p<sub>203</sub>O i 204; Q' utwewtgu' \*U42+'y g't'g'k'p'x'g'v'ki cv'gf 0'k'ecp'dg'q'dug't'x'g'f "ht'v'j g'U42'utwewtgu' \*ugg'Hi 03. 'd+'y cv'j g'to cni'c'p'p'g'c'k'p'i "r' g't'ht'qo g'f "cv' 7: 2' "E' c'p'f "922' "E' "vgo r g'c'w'g'g'f'c'x'q'tu'lp' d'g'v'g't'qr v'ecni' { l'gn'f . 'qy k'p'i "v'j g't'g'f w'eg'f "f'g'p'uk'f "qh'v'j t'g'c'f k'p'i "f'k'ur'q'ec'v'k'p'p'k'p'v'j g'ug' j ki j n' /ut'c'k'p'g'f "tu' \ pO i Q'v'j k'p'k'ro u'J7\_0'



Hi 030'c+'Vgo r g'c'w'g'f gr g'p'f gpv'RN'ur gev'c'qh'tu' \ p<sub>204</sub>O i 208Q' "uco r'ng'U36+'r'c { g't='d+'T'q'qo "vgo r g'c'w'g'g'RN'ur gev'c' qh'cu'i tqy p'cpf "c'p'p'g'c'ng'f \ p<sub>203</sub>O i 204; Q' \*U42+'utwewtgu'

**Cenp'q' ng'f i o g'p'u'**

Vj ku'y qtnir' t'w'p'f'g'f "d { "Vcky cp/N'w'k'c/N'k'j w'c'p'k'c'Eq'qr g't'c'v'k'p'p' r' t'q'l'g'ev'P'q'0'U'0'G'1'C'0'P'G'V'3; /5'0\ pO i Q' b' cvgtkcu'y kj "w'p'cdrg'dcpi 'i cr "ht'v'q'rc't'd'k'p'f " WX'v'g'p'q'ut'0"

J3\_ "K'V'eng'w'ej k'g'v'c'ri'0' o'p'q'k'j le' b' w'v'k'ej c'p'p'g'ri'w'nt'cx'k'q'rg'v'f'g'v'g'v'q't'c'ttc' { u'c'p'f "eq'v'k'p'w'v'u'r' j c'ug'g'x'q'w'v'k'p'p'k'p' "O i z\ p<sub>3</sub> z'Q'eqo r'q'v'k'k'p'ur' t'g'c'f u'0' l'q'w'p'c'ri'qh' C'r'r'ng'f "Rj { u'k'eu'; \*6\*33+'9558/9562'\*4225-0'  
 J4\_ "I' t'w'd'g't. "Vj . "g'v'c'ri'0' \ pO i Q'gr krc { gtu'cpf " \ pQ'0\ pO i Q' s'w'c'p'w'o "y g'm'u'ht'qr v'q'rg'ext'q'p'le'c'r'r'nc'v'k'p'u'lp'k'y g'd'w'ng'c'p'f "WX'ur' gev'c'ni't'gi k'q'p'0' C'r'r'ng'f " r'j { u'k'eu'hw'g'v'tu'; \*6\*48+'757; /7583'\*4226-0'  
 J5\_ "J' 0'V'c'p'c'ri'g'v'c'ri'0' "H'ed't'k'ec'v'k'p'p'q'h'y' k'f'g'dc'p'f i cr "O i z\ p<sub>3</sub> z'Q' s'w'c'k'v'g't'p'c't' { "cmj { u'd' { "o q'rg'ew'ct'd'g'co "gr kcz { . "C'r'r'ng'f "Rj { u'k'eu'Ng'w'g'tu.": \*8\*3; +; \*3; 4; 33" \*4227-0'  
 J6\_ "N'OM'Y' c'p'i "g'v'c'ri'0'Gr kcz'k'eri'f' tqy v'j "q'h'j ki j 's'w'v'k'f' 'ewdle' 'O i \ pQ'k'ro u'q'p' 'O i Q'uwduvcy. 'l'q'w'p'c'ri'qh'et { u'c'ni'f' tqy v'j "534\*9+; 97; : 99'\*4232-0'  
 J7\_ "O'0'E'0'Y' g'p'g'v'c'ri'0'Gr kcz'k'eri'f' tqy v'j "q'h't'q'emucn' \ p<sub>3</sub> z'O i z'Q'p' 'O i Q'\*322+'uwduvcy'd { "o q'rg'ew'ct'd'g'co "gr kcz { . 'l'q'w'p'c'ri'qh'Et { u'c'ni'f' tqy v'j "699'. '38; /395" \*4239-0'

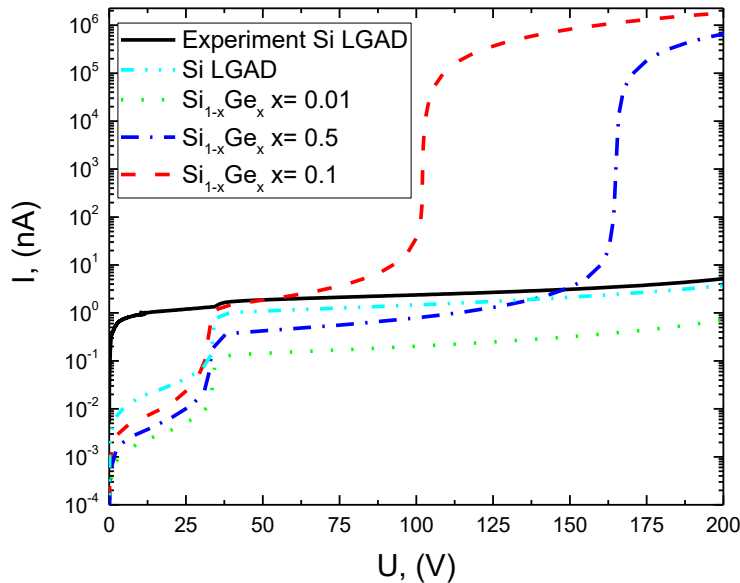
**VECF 'UKO WNCVKQP U'QHR/VJ RG'UKCPF 'U<sub>s</sub> zI g'NQY 'I CFP "**  
**CXCNCPEJ G'F GVGGEVQT 'EJ CTCEVGTKVKEU'**

Mqtprklu'R neu. "Vqo cu" gr qpk. "Gwi gplwu'I cwdu"

Xkpkwu'Wpkxgtukf. "Hewmf 'qh'Rj { uku. "Kpukwmg'qh'Rj qvpleu'cpf 'P cpqvej pqm { "  
mqtprklu'w wruB vo kxw0y"

Ukrepói gto cpkw "U<sub>s</sub> zI g'z+'dcugf 'f gxlegu'ctg'r tqo kulpi 'o cvgtknu'hqt 'qr gtcvki 'kp'j ctuj 'tcf kvkqp'gpxkqpo gpw0' Gpj cpegf 'tcf kvkqp'vqngtcepeg'ukrepói gto cpkw /dcugf 'r kzgrif gvgevtu'ctg'ecr cdng'qh'qr gtcvki 'hqt'cr r rdecvqpu'kp'hwwt'g' Ncti g'J cf tqp'Eqmkf gt' "NJ E+' ]3\_0P gxgtvj gguu. "k'ku'f khhwam'vq'i tqy "dwm'Uk' g'ulpi ng/et { ucn'y kj "kpvtg gf kv'g' I g' eqpvv'f wg'vq'f khgt'ppegu'kp'vj g'r j { ukecnr' tqr gt'vku'qh'ukrep'cpf 'i gto cpkw OK'j cu'dggp'f gvto kpgf 'vj cvU<sub>s</sub> zI g'z'ulpi ng/ et { ucn'ecp'qpn' 'dg'qdvkpgf 'hqt'eqv'ckpki 'gk'j gt'2'>'z'>'20'7'>'z'>'3'qh'I g'y j gp'wulpi 'vj g'E' qej tcnmk'vej pls wg0' Hqt'vj g'q'vj gt'z' t'cpi g'qh'I g'eqpvv'vj ku'cmq { "wucmf "dgeo gu'c'r qn'et { ucn'kpg'o cvgtknu'Vj g'tcf kvkqp'kpf wegf "f ggr " ectt'kt'v'cr u'f gvto kpg'vj g'ej cpi gu'qh'ugo keppf weqt' r ct'verg'f gvgevt'ej ctcevgtknu'0'Kó r wtkku. "uwej "cu'ectdqp"qt" qz { i gp. "ctg'cmq"ko r qt'vcp'lp' hqt' kvkqp'qh' tcf kvkqp/kpf wegf "f ggr "v'cr u'0'K' y cu' t'g'xgcngf "vj cv'vj g'ectdqp'qz { i gp" o gv'ucdng'eqo r ng'z'gu' "E<sub>k</sub>Q<sub>k</sub> +y gt'g't'cpuhqto gf 'kp'v'vj g'ucdng'ucv'g'eqo r ng'z'gu' "E<sub>k</sub>Q<sub>k</sub> +wpf gt'347•E'cppgcrkpi 'hqt'37'0' kp" qh'vj g'kt'cf kv'gf "U<sub>s</sub> zI g'z'f gvgevtu' ]4\_0'

Kp'j ku'y qtm'uko wrcvqpu'qh'gr'evt'ecn'ej ctcevgtknu'qh'vj g'Nqy 'I cfp' Cxcncpej g'F kqf gu' "NI CF +'o cf g'qh'dqj " r-v' r g'ukrep'cpf'ukrep/i gto cpkw "U<sub>s</sub> zI g'z'y kj "f khgt'gpv'I g'eqpvv'v'o cvgtknu'y gtg'r gthqto gf "d { "Vvej pqm { "qh' Eqo r wgt/Ck'gf "F guki p' "VECF +' o gcpu0' Vj g' h'wpev'qpcrk' { "qh'vj g'NI CF "f gxlegu" j cu' dggp' xcrkf cvg' "d { "f ki kcn' g'zr'g'tko gpw'r' gthqto gf "wulpi "VECF 'cni qt'kj o u'cpf 'vj g'F t'k'v'f khhwukp "F +'cr r tqcej 0'Uko wrcvqpu'j cxg'dggp'ectt'k'gf " qw'go r m { kpi 'c'Ugpcwt'w'F gxleg'v'q'hw' ctg'r' r'v'q'to 0'Eqpxgp'v'qpcnr' /v' r g'NI CF 'eqpuku'qh'P' RR'R' 'rc' { gtu'y kj 'r/y gni' hqt' gf "d { "f ggr "f khhwukp'qh'dqt'qp "D+'f v'kpi "hqt' kvkqp'qh'vj g'r /rc' { gt'0'Vj g'r' ctco gv'tu'qh'v'cr u'lp'ukrep'cpf "ukrep/ i gto cpkw "y gt'g'dqt'qy gf "h'qo "k'xgt'cwt'g'f cv'0'Vj g'v'w'w'w'g'qh'dqj "o cvgtknu'f kqf gu'y gt'g'f guki pgf "wulpi "vj g'kf gp'v'ecni' f lo gp'k'qpu. "vj g'uco g'eqpeg'v'cv'k'qpu'qh'f'qr cpw'cpf "vj g'uco g'qt'ki kp'qh'v'cr u'lp'q'tf gt'v'q'eqo r ctg'vj g'ej ctcevgtknu'qh'UK' cpf "UK' g'NI CF u0I g'eqpvv'vj cu'dggp'xct'k'gf "kp'vj g't'cpi g'h'qo "3' "v'q'32' 0"



Hi 030Eqo r ct'kuqp'qh'vj g'uko wrcv'f "KX"ej ctcevgtknu'qh'UK'cpf 'f khgt'gpv'z' 'U<sub>s</sub> zI g'z' /v' r g'NI CF u0'

Vj g'uko wrcvqpu'tgxgcngf "vj g'ny gt' "xcn'gu'qh'f'ctn'ewtt'gpv'lp'U<sub>s</sub> zI g'z'NI CF "v'w'w'w'g'eqv'ckpki "3' "I g'eqpvv'v' eqo r ctg'f "y kj "r w'g'UK'NI CF "v'w'w'w'g'0'J qy gxgt. "vj g'j ki j gt'eqpeg'v'cv'k'qpu'qh'I g'kp'vj g'UK' g'NI CF "v'w'w'w'g'ecw'gf " vj g'j ki j gt'f'ctn'ewtt'gpv'xcn'gu'eqo r ctg'f "y kj "vj g'r w'g'ukrep'NI CF 0NI CF "v'w'w'w'g'eqv'ckpki "v'cr u'g'z'j k'k'v'vj g'j ki j gt' f'ctn'ewtt'gpv'xcn'gu'lp'KX'ej ctcevgtknu'hqt'dqj "UK'cpf "UK' g'v'cr /ngu'v'w'w'w'g'u'0'Vj g'ew'tt'gpv'v'w'gu'lp'UK'NI CF 't'gur'qpug' v'cp'ulg'p'v'uj qy gf "vj g'g'rupi cv'k'qp'qh'vj g'ectt'kt'gz'v'cv'k'qp'f v'cv'k'qpu'y kj "gpj cpego gpv'qh'vj g'v'cr "eqpeg'v'cv'k'qp'0'Vj ku' eqw'f "dg'ecw'gf "d { "ectt'kt'v'cr r kpi "gh'gev'f wg'v'q'f ggr "go ku'k'qp'egp'v'tu'0'

[3\_ ] ki j "Nwo lp'qul'f "NJ E'Rtql'ge'0'CX'c'k'ndng'v'p'p'g'z'j v'r u'lj k'wo kj e0y gd@gt'p'ej I' "ceegungf "lp33" P q'xgo dgt'4242-0' ]4\_ "V0' gr qpk. "U'N'cu'x'uni'k' "GOI cwdu'g'v'cni'U'w'f { "qh'I'c'f'kv'qp'k'p'f wegf "F gh'ew'lp'r /V { r g'U<sub>s</sub> zI g'z'F kqf gu'dgh'q'g'cpf 'ch'gt' "C'ppgcrkpi . "O cvgtknu' 35.'78: 6"4242-0'

# PHOTOLUMINESCENCE STUDIES OF GaN EPITAXIAL LAYERS

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GaN and related alloys are materials widely used for applications in optical and electronic devices, such as light-emitting diodes (LEDs), laser diodes (LDs), and high-electron mobility transistors (HEMTs). GaN has been the most intensively studied in III-nitride materials due to relatively simpler growth technology, while the recombination processes are not obscured by the carrier localization. However, there are still challenges in understanding and modelling the radiative and nonradiative mechanisms, which play a key role in emission efficiency, efficiency droop in GaN-based LEDs [1] and threshold current of LDs. In this study, the recombination dynamics in GaN films were analysed by using excitation-dependent photoluminescence (PL) measurements.

The GaN epitaxial layers under study were grown on sapphire substrate by metalorganic chemical vapor deposition (MOCVD). Samples exhibiting different background carrier concentrations and carrier lifetimes were studied. The 4th harmonic (266 nm) of a nanosecond YAG:Nd laser radiation was used to excite the samples in a wide range of excitation power densities from 100 W/cm<sup>2</sup> up to 10 MW/cm<sup>2</sup>. Luminescence signal was registered by ICCD camera. All measurements were performed at room temperature.

The typical behavior of GaN PL spectra at different excitation power densities is presented in Fig. 1(a) for one sample. Similar spectra families were obtained for all samples under study. The integrated PL intensity dependence on excitation power density is shown as dots in Fig. 1(b) and reveals rapid PL intensity increase at low excitations, and saturation of PL intensity at the highest excitation power densities. To analyze the recombination processes in GaN in more detail, numerical modeling of the excitation-dependent PL intensity was carried out using the model described by Brandt et al. [2] and performed by using Python 3.8 programming language. Modeling results were compared to the experimentally obtained results. Good fit was obtained in high excitation region. The disagreement at low excitations indicates either the inadequate choice of parameters or the importance of ignored recombination mechanisms, and requires further analysis.

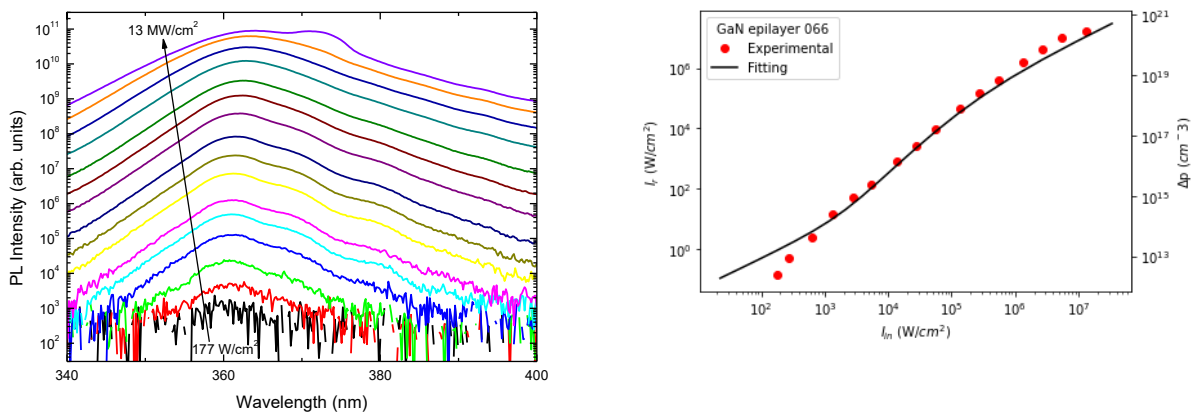


Fig. 1. (a) PL spectra of GaN sample 066 at different excitation power densities (177 W/cm<sup>2</sup> – 13 MW/cm<sup>2</sup>). (b) Excitation dependence of integrated PL intensity (dots) and modeling results (line) of GaN sample 066.

[1] Piprek, J. Efficiency models for GaN-based light-emitting diodes: Status and challenges. *Materials* **13**, 1–18 (2020).

[2] Brandt, O., Yang, H. & Ploog, K. H. Impact of recombination centers on the spontaneous emission of semiconductors under steady-state and transient conditions. *Phys. Rev. B - Condens. Matter Mater. Phys.* **54**, R5215–R5218 (1996).



# MODELING OF P-N JUNCTION OF III GROUP NITRIDE BY FINITE DIFFERENCE METHOD

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This work aims at detailed examination and modeling of p-n junction of III group nitrides.

We analyzed experimental IV curves of planar structure prepared by metal original chemical vapor deposition (MOCVD) equipment. The equivalent scheme consisting of a diode, and two resistances connected in parallel and series way was applied to fit the IV curves.

It was assumed the current in p-n junction diode is due to two components: space-charge region (scr) recombination/generation and quasi-neutral region (qnr) recombination/generation.

The modeling of p-n junction was performed by finite difference method. The equations of Poisson's, current-density, continuity including equations describing radiative and nonradiative recombination of charge carriers were applied in the model. The band diagram, carrier density and IV curve was extracted from model.

We compared the theoretical IV curve to the experimental one. The received data will be useful for the further optimization of device structure.

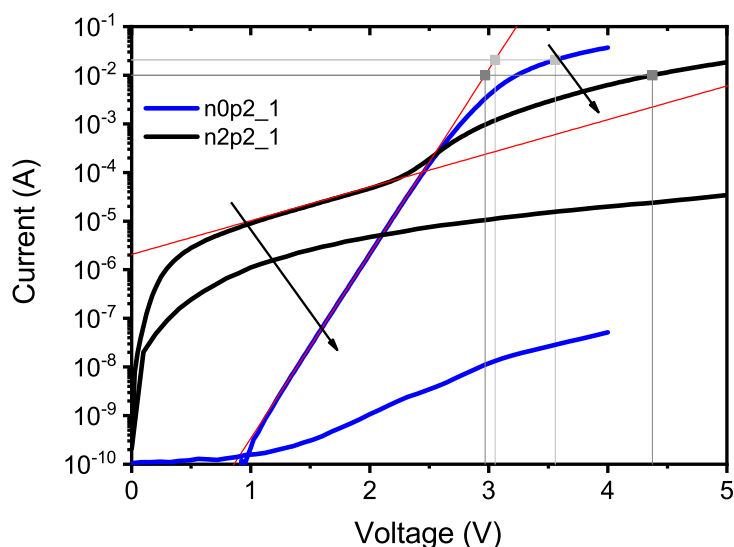


Fig. 1. Experimental IV curves. Arrows show the direction of increase resistance in low current and high current range respectively.

# HOT CARRIER EVIDENCE IN A SOLAR CELL

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The Shockley-Queisser theory puts limits on conversion efficiency of a single-junction solar cell [1]. It assumes that only photons having energy close to a semiconductor forbidden energy gap are used effectively in the formation of an electrical output signal. Lower energy photons are not absorbed at all, while the residual extra energy of the higher energy photons is reckoned in only through the process of carrier thermalization.

Our investigation is initiated by our confidence that photons having energy larger than the band gap as well as photons having energy smaller than the forbidden energy gap need to be accounted through the hot carrier phenomena participating in the photoresponse formation before the lattice heating.

GaAs p-n-junction was illuminated with 25 ns-long laser pulses of 1.06  $\mu\text{m}$  wavelength. Short enough pulse and the wavelength opened a way to reveal that the induced photoresponse consists of three components. The first one,  $U_G$ , is an electron-hole pair generation caused component resulting from the multiphoton absorption [2]. The second one,  $U_{HC}$ , follows the laser pulse shape and has opposite polarity, it is caused by the heating of free carriers. The third one,  $U_T$ , has the same polarity as  $U_{HC}$  but is much slower and is caused by the heating of a p-n junction.

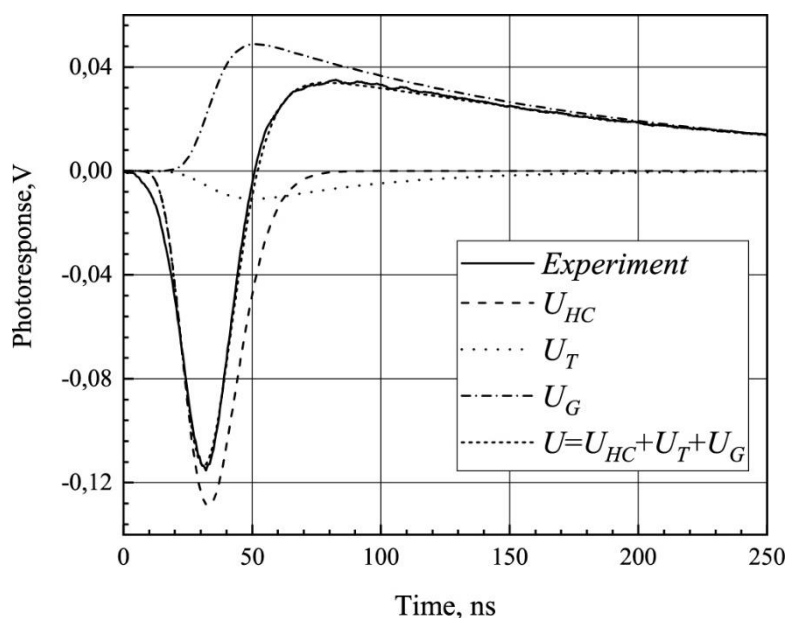


Fig. 1. Experimental photoresponse across GaAs p-n junction and modelled its components.

In addition to the experimental evidence of the hot carrier photoresponse, we propose a theoretical model of separation of the photoresponse components which gives good agreement with the experimental [3]. The model enables to reveal contribution of each component to the net magnitude of the photoresponse and opens the possibility to find the way of reducing the negative impact of hot carrier phenomena to the conversion efficiency of a solar cell.

[1] W. Shockley and H. J. Queisser, Detailed balance limit of efficiency of p-n junction solar cells, J. Appl. Phys. **32**, 510-519 (1961).

[2] W. C. Hurlbut, Y.-S. Lee, K. L. Vodopyanov et al., Multiphoton absorption and nonlinear refraction of GaAs in the mid-infrared, Opt. Lett. **32**, 668-670 (2007).

[3] J. Gradauskas, S. Ašmontas, A. Sužiedėlis et al., Unfolding hot carrier impact in photovoltage across a p-n junction, Appl. Sci. **10**, 1-8 (2020).

# VT KRNGV'GZEKVQP 'F KHHWUKQP 'R' RJ QVQP 'WREQP XGT VPI "

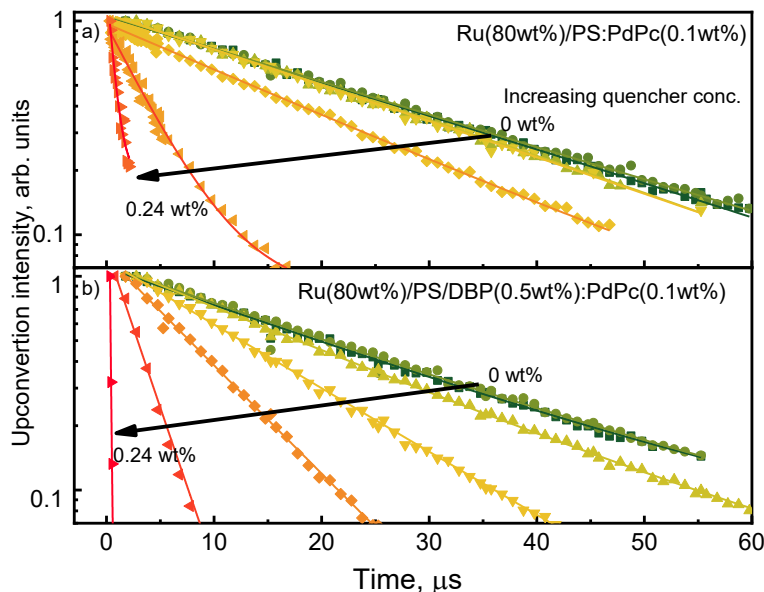
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O cpx { f cu'F cr ngxk kwu<sup>3</sup>. 'Gf xkpcu'T cf kwpcu<sup>3</sup>. 'Ucwkwu' Lwt- pcu<sup>3</sup>. 'Ugr qpccu'T ck- { u<sup>3</sup>. 'Mct qru'  
Mc| r'wuncu<sup>3</sup>"

<sup>3</sup>Kpukwng'qh'Rj qvqpleu'cpf "P cpqvej pqm { . 'Xkpkwu'Wpkxgtuk{ . 'Nkj wpcle'  
o cpx { f cuff cr ngxlekwuB hfkw0v'

Rj qvqp'wr eqpxgtukqp \*WE+vj tqwi j 'tkr ngv'vtr ngv'cplj krcvqp'ku'c't j gpqo gpqp'vj cv'kpf u'o cp { 'r quikdrng'er r rievkqpu' gfi 0'vq'kpetgcug'luqmt'egm'ghlekgpe { .j3\_'vq'cevkwcvgr' tqvqku'kpu'k'g'qti cple'kkuwng.j4\_'vq'gpj cpeg'dkq/ko ci kpi 'ecr cdkkx' j5\_' cpx { o cp { 'qvj gtu'j6\_0'T wdtggp'ku'cp'gzegm'epv'ej qleg'hq't'pgct'kph'ctgf 'vq'xkukdrng'ri j v'WE. 'ukpeg'k/hgcwv'gu'my 'vtr ngv' gpqti { 'cpf'ghlekgpv'r j qvqno kpguegpeg\*'RN+.'y j lej 'cmqy u'tgcej kpi 'WE's wcpwo { kgrf '\*WES [ +w'vq'708' 'kp'vq'wv'gp' uq'wv'qp'j7\_0J qy gxgt. 'uqrf/ucv'g'WE't wdtggp'u'vgo u'uj qy 'f tuculecm' 't'gf wegf 'WES [ 'ghlekgpe { j8\_0C'nj qwi j 'cm'v'j g' hcvqtu'ho kapi 'WES [ 'ctg'v'k'v'p'ergct. 'vj g'ci i tgi cvkqp'kpf wegf 'RN's wpej kpi 'cpf'kpg'ghlekgpv'vtr ngv'gzekqp'f khhwukqp'ctg' vj g'o quv'ikng' 'qpgu'0T gf wegf 'eqpegp'cvkqp'qh'v'j g'cplj krcvqt' o c { 'r t'g'x'gpv's wpej kpi . 'j qy gxgt. 'k'y qwf 'cnuq't'g'v'k'v' g'z'ek'qp'f khhwukqp'cpf 'j g'peg'ny g' 'vj g'r' t'q'cd'k'k'x' 'h'q't'v'k'ng'v'gzekqp'u'v'g'p'eq'w'v'g'0'Vj g't'gh'q't'g'. 'vj g'f'g'v'to k'p'cv'k'p' qh' f khhwukqp'ngpi vj '\*N'v'+'q'v'k'v'k'ng'v'gzekqp'cpf 'g'x'c'w'v'k'p'q'h'k'u'k'p'h'w'p'eg'q'p'WE'r'g'h'q't'o c'peg'ku'q'h'et'w'k'c'ri'ko r'q't'w'p'eg'0'

Kp'vj ku'y qtm'vtr ngv'gzekqp'f khhwukqp'kp'r' qn' u'v' t'g'p'g' \*RU+'h'ko u'eq'p'cv'k'p'i 't'w'd't'g'p'g'cu'cp'cplj krcvqt. 'r' cmf kwo " r j vj cmj { cpl'p'g' \*Rf Re+' cu' c' vtr ngv'gzekqp' ugpuk'k' g' t' cpx { 'v'g't'c'r j gp { r'f'k'd'g'p' q'r'g't'k'p'v'j g'p'g' \*F DR+' cu' go kwg' y cu' k'p'x'g'v'k'i cv'f'0'Vj g'h'ko u'y g't'g'r' t'g'r'ct'g'f' d { 'u'r'k'p'eq'cv'k'p'i 'w'p'f'g't'P4'g'p'x'k'q'p'o g'p'v'c'p'f'g'p'ec'r'w'v'v'g'f'v'q'r' t'q'v'g'v'h'ko u'h'q'o " co d'k'g'p'v'ck'f'w'k'p'i 'r j q'v'q'r j { u'ec'v'ej ct'ce'v'g't'k' cvkqp'0'v'k'r ngv'gzekqp'f khhwukqp'y cu'f'g'v'to k'p'g'f' h'q'o " vj g'RN's wpej kpi " ghlekgpe { 'kp'v'j g't'w'd't'g'p'g'IRUIRf Re'cpf 't'w'd't'g'p'g'IRUIRf Re IF DR'h'ko u'y k'j 't'c'p'f'q'o n'f' k'v'k'w'g'f' s'w'p'ej g't'u'0'U'g't'p'X'q'm g't' c'p'c'n' { u'k'y g't'g'c'r' r'k'g'f'v'q'c'p'c'n' { g'z'ek'g'f' 'u'c'v'g't'g'r'z'cv'k'p'f' { p'c'o' l'eu' \*H'i w'g'3+'q'h'WE'h'ko u'y k'j 'k'p'et'g'c'ul'p'i " s'w'p'ej g't' eq'p'eg'p't'cv'k'p' \*20'6'20'5'y v' +h'q't'v'j g'g'x'c'w'v'k'p'q'h'N'v'0'



H'i 030WE' h'k'p'g'v'k'u'q'h'v'j g'c+'T w'IRUIRf Re'cpf 'd+'T w'IRUIRf Re IF DR'w'co r'ng'u'y k'j 'f'k'h'g't'g'p'v'ej n'q't'c'p'k'v's w'p'ej g't' eq'p'eg'p't'cv'k'p'0'

Vj g' qd'v'k'p'g'f' t'g'u'w'u' t'g'x'g'c'ng'f' vj cv' vtr ngv'gzekqp' f khhwukqp' ngpi vj " kp' d'q'v' t'w'd't'g'p'g'IRUIRf Re' cpf' t'w'd't'g'p'g'IRUIRf Re IF DR'h'ko u'ku'c'44'p'o 0'K'y cu'h'q'w'p'f' vj cv'g'v'k'o cv'f'N'v'ku'v'q'v'g'v'g'c'x'g't'c'i g'f'k'v'c'p'eg'd'g'y g'p'ug'p'uk'k' g't' o q'rg'ew'g'u'w'i i g'v'k'p'i 'vj cv'WE'r'g'h'q't'o c'peg'kp't'w'd't'g'p'g'WE'h'ko u.'vq'u'q'o g'z'v'g'p.'ku'v'k'r ngv'gzekqp'f khhwukqp'iko k'g'f' r' t'q'eg'u'0'

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[5]\_H0N'k'w'v'0j' c'p'i . 'Y 0H'g'p'i . 'g'v'c'f'0'D'w'g'go k'u'k'x'g'w'r eq'p'x'g't'uk'q'p'p'c'p'q'r'ct'v'g'u'q'v'q'ny /r'q'y g't'g'z'ek'g'f' d'k'q'o ci k'p'i 'k'p'x'k'x'. '10Co 0Ej go 0U'q'e0356. '75; 2/75; 9' \*4234-0'  
[6]\_10\ j q'w' 'S 0N'k'w'Y 0H'g'p'i . 'g'v'c'f'0'W'r eq'p'x'g't'uk'q'p'w'o k'p'g'ue'g'p'v'o cv'g't'c'k'c'f' x'c'p'eg'u'c'p'f' 'c'r' r'iev'k'q'p'u. 'Ej go 0T'g'x'0337. '5; 7/687' \*4236-0'  
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[8]\_G0T'c'f'k'w'p'c'u. 'O 0F'c'r'ng'x'k'kwu. 'U0T'c'k- { u. 'g'v'c'f'0'K'o r'cev'q'h'v'd'w'v' n'w'd'w'k'w'k'p'k'p'c'v'w'd't'g'p'g'go kw'g't' h'q't' u'q'rf' 'u'c'v'g'P'K'/v'q/x'k'uk'd'r'g' j q'v'q'w'r eq'p'x'g't'uk'q'p'." Rj { u'0Ej go 0Ej go 0Rj { u'044. '95; 4/9625' \*4242-0'

**J [ RGTURGEVTCN'KO CI KPI 'VGEJ PQNQI [ 'Y KVI 'C'UO CTVRI QPG' CPF 'O WNVKEQNQWT'HNCUJ "**

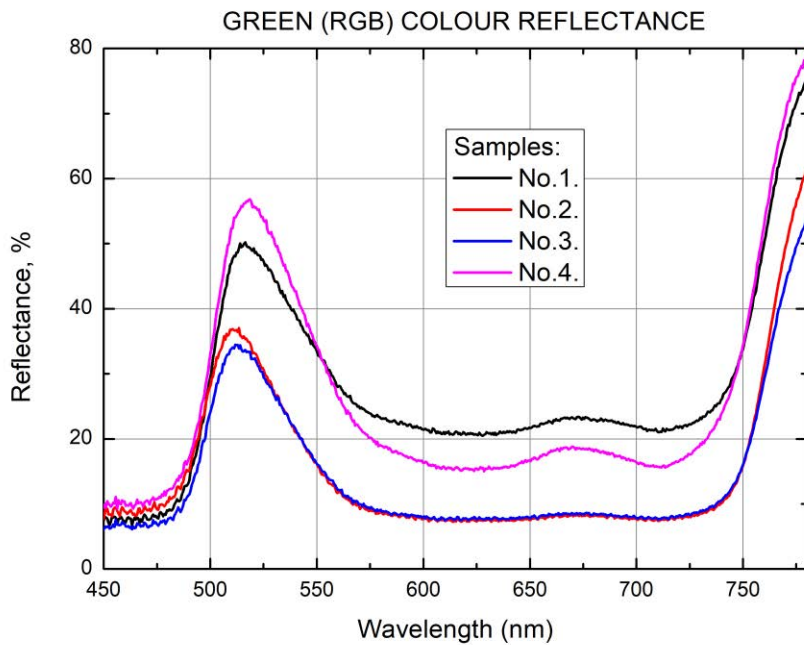
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 Ucwv vgnk'cx05. 'Xkpkwu. 'Nkj wcpk'  
nwncu'O cwrkuB hfnwf'kwfn'

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H'q't "v'j g' g'z'r g'tlo g'p'v'c'n't'k'c'u. "c'uo ctv'j qpg' "Uco u'w'p'i "I c'm'z { "P q'v'g' "32" N'kg. "ec'r c'dng' "v'q' v'c'ng' r j q'v'qu'lp' "TCY "h'q'to c'v' \*0FPI +. "y cu'w'ug'f 0'k'o ci g' "L'H'k'k' u'q'hw' ctg' y cu'w'ug'f "v'q' r g't'q'to "ur gev'tc'it' ko ci g' "c'p'c'nf u'ku. "ec'r k'd'c'v'k'p' "cpf "k'p'k'c'n' c'p'c'nf u'ku'0 Uco r ng' "eq'w'w' "r t'k'p'u' r t'k'p'v'g'f "d { "f' k'ht'gp'v' eqo o g't'ec'n' r t'k'p'v'g'u' y g't'g' "c'p'c'nf u'g'f "d { "t'g'e'q't'f k'p'i "f' k'hw'ug' t'g'h'g'ev'c'p'eg'0 Uco r ng' t'g'h'g'ev'c'p'eg' "ur gev'tc' ct'g' r t'g'ug'v'g'f "lp' H'k'i 030' "cpf "q'p'g' e'c'p' "u'g'g' v'j cv'v'j g' f' k'ht'gp'v' t'k'p'v'g'u. "r g't'q'to k'p'i "o'v'j g' u'co g'o' eq'w'w' t'g'u'w'w' k'p' f' k'ht'gp'v' t'g'h'g'ev'c'p'eg' "ur gev'tc' y j k'ej "ku'c'm' q'u'v'lp'f k'v'k'p'i v'k'uj c'dng' "d { "v'j g' p'c'ng'f "g' { g' dw' e'c'p' dg' f' g'v'g'v'g'f "d { "j { r g'tur gev'tc'it' ko ci k'p'i "f' g'x'leg'0"

Y g' eq'p'ew'f g'v'j cv'c'm' qu'v'c'p'f "eq'puwo gt/i t'c'f g'eco g'tc' e'c'p' dg' v'c'p'uh'q'to gf "k'p'v'j v'j g'j { r g'tur gev'tc'it' ko ci k'p'i "f' g'x'leg' "d { " c'f f' k'p'i "uo ctv'o w'nv'ek'q'w'w' "h'ncuj 0U'we'j "c' u' { u'go "eq'w'f "j cxg'c' "xcu'v'c'r r n'ec'd'k'k'v' { "cpf "c'p'v'ek'q'w'v'gt'g'k'klpi "ku'lw'w' q'p'g' "qh'v'j g' c'r r n'ec'v'kp' "c't'g'cu'0"



H'k'i 030Vj g't'g'h'g'ev'c'p'eg' "qh'öRwt'g'I t'gg'p'o'eq'w'w' "uco r ng'u'r t'k'p'v'g'f "d { "f' k'ht'gp'v' t'k'p'v'g'u' "q'p' f' k'ht'gp'v' c'r g't'0"

P4-23

DID NOT PARTICIPATE

# OPTOELECTRONIC PROPERTIES OF GERMANIUM-TIN LAYER

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Silicon has been dominating the market of electronic and photonic devices for several decades [1]. However, mid-IR photodetectors and lasers have been recently gaining more attention due to their applicability in military, medicine and night vision and those devices require Si emission to be shifted to mid-IR. Germanium-tin (GeSn) alloy is a highly promising material for such purposes since it is compatible with silicon technology, direct energy bandgap can be achieved in this material when Sn content reaches 6-8% and GeSn absorption and emission can be shifted to mid-IR by increasing Sn content in the alloy [2]. Because of these desirable properties GeSn photodetectors, LEDs, lasers and various transistors such as MOSFETs and TFETs were created [3]. However, not all GeSn properties are well known and understood and therefore they require further research.

In this work carrier lifetime, diffusion coefficient and diffusion length in Ge<sub>0.95</sub>Sn<sub>0.05</sub> epilayer grown on Si substrate were studied. These important optoelectronic parameters were determined using light induced transient grating technique. The sample was excited by pulsed laser irradiation at 527 nm wavelength which created transient grating in the layer. It caused the probe beam (1053 nm) to diffract and by using an optical delay line diffraction efficiency ( $\eta$ ) decays were obtained. They were measured at three different grating periods  $\Lambda$  (Fig. 1 (a)). This allowed us to determine carrier lifetime ( $\tau_R$ ) and diffusion coefficient (D) using Eq. (1), while diffusion length was later calculated from these parameters. Nitrogen cryostat was used to obtain temperature dependence.

$$\frac{1}{\tau} = \frac{1}{\tau_R} + \frac{1}{\tau_D} = \frac{1}{\tau_R} + \frac{4\pi^2 D}{\Lambda^2} \quad (1)$$

In Fig. 1 (b) it can be seen that diffusion coefficient decreases with temperature. It is attributed to increased phonon and defect scattering. Weak excitation dependences of the parameters are related to saturated trap regime. Also, the value of diffusion coefficient is lower than that of pure germanium  $D_a = 68 \frac{\text{cm}^2}{\text{s}}$  which indicates that incorporating Sn causes worse material quality.

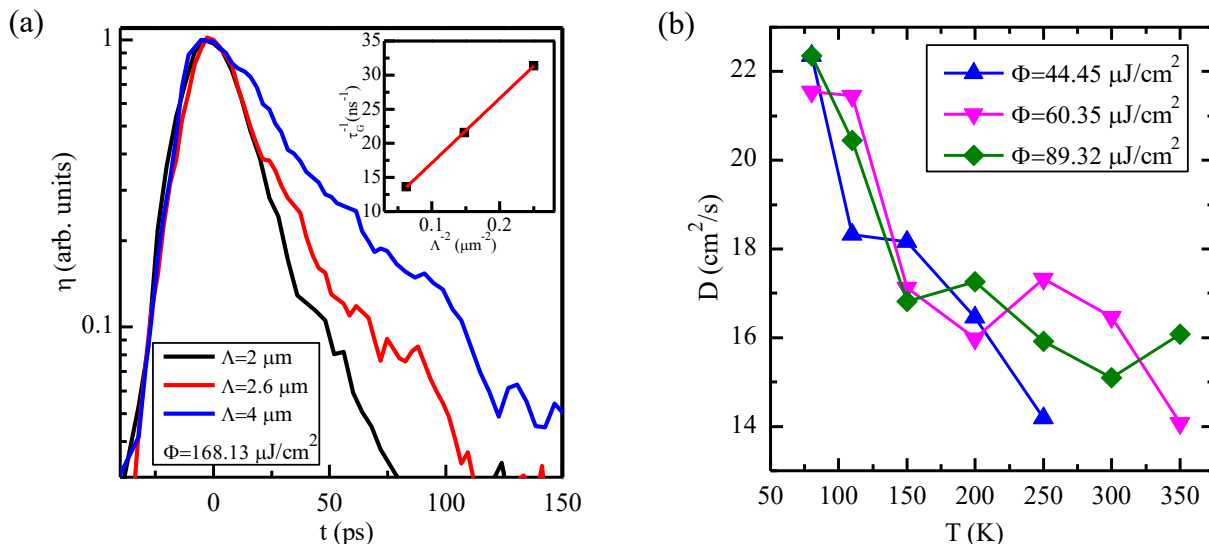


Fig. 1. (a) LITG transients measured at three different grating periods  $\Lambda$ , inset shows angular plot  $1/\tau \sim 1/\Lambda^2$ . (b) Diffusion coefficient D temperature dependence [4].

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**QRVÆCN'HT'GS WGPE[ 'EQPXGTUKQP'VQ'XKUKDNG'CPF'PGCT/KT''**  
**TCPI GU'WUKPI 'RJ QVQPÆ'ET[ UVCN'HHDGTU''**  
I wæcu'Nkwi o kpcu<sup>3</sup>. 'Lwrlkpcu'fi gmf gxk kwu<sup>3</sup>. 'M uwwku'T gi gnuku<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'Ncugt 'Vgej pqm { . 'Egpyt'ht' Rj { uecni'Uekpegu'cpf 'Vgej pqm { . 'Nkj wpc'k''  
i wæcu'Nkwi o kpcuB ho e'hw'

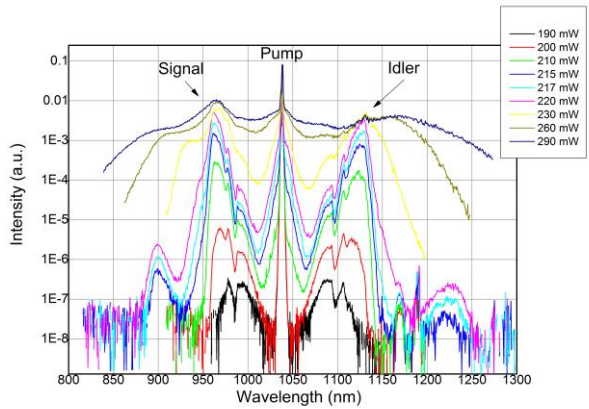
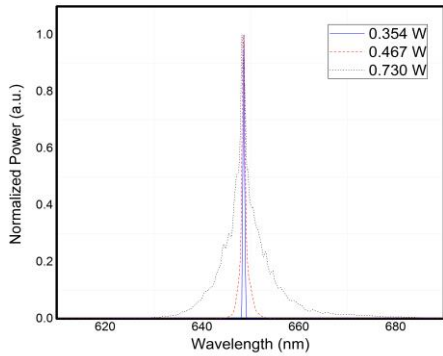
"

P gct/KT''cpf 'xkukdng'tcpi g'hkdt'æugt'u'kpf "o cp{ "cr r ñecvæpu'k'p'dkqo gf kelpg'cpf "cvo qur j gtg'o qpkaqt'kpi "]3."4\_0' J qy gxgt."y cxgrpi vj u'y cv'ecp'dg'i gpgtcvf 'htqo "vj gug'æugt'uqwtægu'ctg'qhæp'iko kwf 'd{ "co r rkh{kpi "o gf kwo "y j lej "ku" ej qugp0F gi gpgtcvf'hw/y cxg"o kzkpi "cmjy u'v'æpaxgtv'qr vëcni'htgs wgepe { "qh'vy q'r wo r "r j qvæpu'kpv"vy q"r j qvæpu'qh' f khtgtpv'y cxgrpi vj "k'c"vj kf /qtg'gt'pqp/ikpçct'k' "o gf kwo 0Hqt"vj ku'v'j' er r gp'gpçti { "æpugtxcvæp'cpf "r j cug/o cvej kpi " æpf kkp'u" uj qwf " dg" uc'v'k'kf " ]5\_0' Rj cug/o cvej kpi " æpf kkp'u" ecp" dg" o gv' y j k'g" qr gtcvæpi " pgct" | gtq/f kur gtukap" y cxgrpi vj "dw'ecp'dg"j çtf n' "uc'v'k'kf "k'p'qt'k'pçt { "hwugf "uk'æc"hdgtu'0'k'p'r j qvæp'le"et { uvcni'hdgtu'"\*REH: "qp"vj g"qv'j gt" j çpf. "f kur gtukap"æwtæg'ecp'dg'v'k'kf'gt' "d{ "f guki kpi "ur gek'le"j qrg'ut wewtg'ctqwpf "vj g'hkdt'æugt'vj wu'cmjy kpi "f khtgtpv' r j cug/o cvej kpi "ægpçt'k'p'ht'f khtgtpv'r wo r "y cxgrpi vj u'çpf "gz'wpf kpi "cxckædng'y cxgrpi vj "tcpi g0"

K'p"vj ku'y qtnly g'wugf "c"r wugf "hdgt'æugt'cu'qwt"r wo r "uqwtæg'v"r tqf wæg"422"r u'f wæcvæp. "325: "po "y cxgrpi vj " r wngu'cv'322"nj | "tgr gwæp'cv'g'0Rwngu'htqo "vj g'hkdt'æugt'ctg'vj gp"co r rkh{k'p"vy q'hdgt'co r rkh{k'p'uci gu'çpf "c'k'pçni" [ d/f qr gf "çti g/o qf g/ctgç'r qçt'k' cvæp/o çpvc'k'kpi "hdgt'co r rkh{k'p'uci g'v'çej k'æxg'uw'k'æp'v'r gçni'r qy gt'ht'htgs wgepe { " æpaxgtukap0Co r rkh{k'p'r wngu'y gtg'æqwr gf "v'q'REH'wpf gt'v'gu'wukpi "uc'p'çtf "çur j gtle'rgpu'g0"

K'p"vj ku'g'zr g'klo gpv'y g'wugf "vy q" f khtgtpv'æqo o gte'kçm{ "cxckædng'r j qvæp'le"et { uvcni'hdgtu'"\*UE/70/3262"çpf "NO C" : + "dqj"j çxkpi "f khtgtpv'f kur gtukap"æwtægu."vj g'çhtq. "f khtgtpv'r j cug/o cvej gf "y cxgrpi vj u'ht"vj g'uc'o g"r wo r 0Hqt'UE/ 70/3262"hdgt. "vy q"y cxgu'y gtg'qduçtxgf <uki pçni'cv'; ; 5"po "y kj "o çzko wo "cxçtçi g"r qy gt'qh"3.488"o Y "çpf "38.76" " æpaxgtukap" ghkæpçe { +çpf "k'f rçt"cv'32: 9"po "y kj "o çzko wo "cxçtçi g"r qy gt'qh"2.: 88"o Y "çpf "37.96" " æpaxgtukap" ghkæpçe { +0' Hqt "NO C": "hdgt." uki pçni' y cxg' cv' 86: "po "o çzko wo "cxçtçi g"r qy gt'482"o Y." çpf "53" " æpaxgtukap" ghkæpçe { +y cu'qduçtxgf "dw'k'f rçt."g'zr gævgf "cv'497; "po . "æqwr "pqv'dg" f gævgf "f wæ"v'k'ko kcvæp'qh'ur gçst wo "çpçni | gt0' Cni'qh'vj g"i gpgtcvf "y cxgrpi vj u'ht"dqj "REH"æe'wçvçni" "o cvej "vj g"y cxgrpi vj u'æc'æwçvgf "htqo "r j cug"o cvej kpi " tgrævæpu'wukpi "ur gek'k'gf "f kur gtukap"ej çtçevçt'k'æu'qh'vj g'hdgtu'0'

"T guw'u'htqo "vj ku'g'zr g'klo gpv'vj qy "r qvæp'çni'ht' r j qvæp'le"et { uvcni'hdgtu'v'q'dg'wugf "ht"qr vëcni'htgs wgepe { "æpaxgtukap" k'p'cr r ñecvæpu'y j gtg'pq'æugt"o gf kwo "ku'cxckædng'dw'c"ur gek'le"y cxgrpi vj "ku'tgs w'k'gf 0'Vj gug't guw'u'y kn'dg'wugf "k'p" hwt j gt'f gxgrçr o gpv'qh'cm'hdgt'w'wçuj çt'v'r wug'æugt'u{ u'ngo "qr gtcvæpi "k'p'c'dtqçf "y cxgrpi vj "tcpi g0"



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Hki 030Ur gçst wo u'qh'hw/y cxg"o kzkpi "r tqf wæu'ht'f khtgtpv'r j qvæp'le"et { uvcni'hdgtu'uki pçni'y cxg'k'p'NO C": "rghw:"  
 uki pçni'r wo r "çpf "k'f rçt"y cxgu'k'p'UE/70/3262"ki j v'w'"

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[3\_ "V0I qwæj cm"V0O g{ çt. "O 0'Uej o kw"l0'Rqr r. "l0'Nko r gtv."çpf "C0'Væpçtço çpp. "Hwt/y cxg/o kzkpi /dçugf "qr vëcni'r çtço g'w'k'æu'k'çvçt'f g'kççt'kpi " gpçti g'æ. "wpcdng"ej k'f gf "lgo vqæçpçf "r wngu'ht'pqp/ikpçct'dkqo gf lçcni'cr r ñecvæpu."Qr v0Gzr tgu'45"3: +; 45; 8: 645; 99"4237+4\_ "C0'Hkçf ." Vwpcdng'k'p'çtçf "æugt'k'p'wçwo gpv'ht'çkçdçtçp'çvo çur j gtle'uwf kçu."Crr r0Rj { u0D. "xqf0; 4. 'pq05. '62; 6639"422: +"  
 ]5\_1 0R0C' çy çn "P q'k'pççt' "Hkçt' Qr'wçu"æe'çf go kç. "4223+ "

P4-26

DID NOT PARTICIPATE



# HIGH REPETITION RATE LASER-INDUCED PERIODIC STRUCTURES IN TRANSPARENT DIELECTRIC MATERIALS

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Irradiation of transparent materials with femtosecond laser pulses at high repetition rate induces so called self-organized quasiperiodic nanostructures at its surface [1]. In addition, this type of material modification depends on the exposure time or a number of accumulated laser pulses. Low exposure time produces quasiperiodic structures, the so-called nano-ripples. By further increasing the exposure time, the formation of microgrooves can be observed. In this case, the nanostructures reminds the cornflake-like structures with quasiperiodic ordering. In the sequel, the higher exposure time is responsible for the formation of another type modification – laser induced periodic annular surface structures (LIPASS), containing the damage crater in the center and superimposed periodic rings around [2]. Note that such transition is universal, observed in many dielectric bulk materials and can be applied in a broad range of applications including plasmonics, photonics and microfluidics [3].

In this work we investigate the laser-induced periodic nanostructures at high repetition rate of femtosecond laser pulses in sapphire, YAG, MgF<sub>2</sub> and fused silica. The experiments were performed using Yb:KGW laser (Pharos, Light Conversion), with 180 fs FWHM pulse duration, operating at 1035 nm central wavelength and repetition rate of 200 kHz. To investigate laser induced structural changes we used PrismaSEM scanning electron microscope (SEM). Fig. 1 (a) shows SEM image of LIPASS on sapphire surface irradiated by 10<sup>4</sup> consecutive pulses and Fig. 1 (b) represents its frequency spectrum retrieved by 2D Fourier transform. The experimental results revealed that the formation of nanostructures in bulk materials is a universal process producing exposure time dependent periods of the structures as presented in Fig. 1 (c). By using the low number of pulses, high spatial frequencies are dominant, while the low spatial frequencies are obtained by irradiating with high number of pulses. In addition, such a behaviour can be observed in many other materials such as alkali metal-fluorides and fused silica. Furthermore, femtosecond laser pulses produces very similar structures in materials volume [4]. Such a phenomenon is accompanied by the appearance of the conical third harmonic (TH) indicating the multipulse optical damage [5]. Note that TH generation can be understood in the frame of four-wave mixing process, requiring to fulfill the transverse phase matching (PM) condition. Also, we show that such condition can be satisfied via reciprocal lattice vector involving the nanograting period. Indeed, the two-dimensional Fourier transform of the SEM image yields a broad distribution of nanograting periods, including the required period to satisfy the transverse the PM condition.

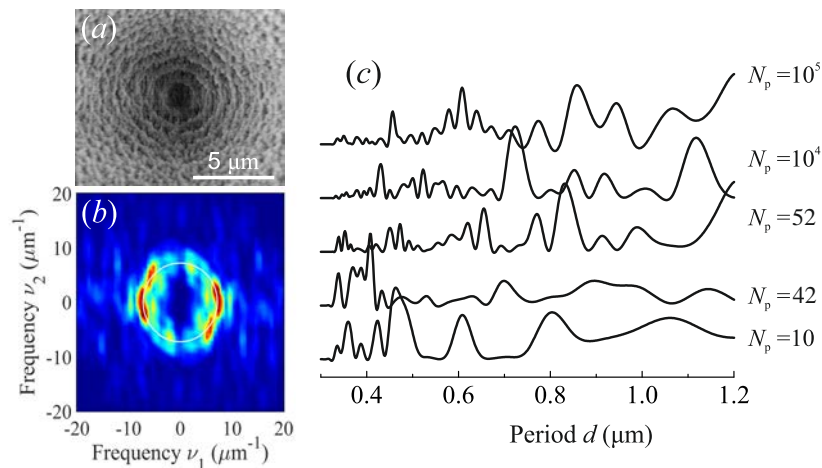


Fig. 1. (a) SEM image of LIPASS in sapphire, produced with 10<sup>4</sup> pulses at 200 kHz repetition rate, (b) Fourier transform of the SEM image and (c) period spectra of produced nanostructures with different number of pulses. The white circle in (b) marks the spatial frequencies required to fulfill the transverse phase matching condition for TH generation. Here  $d = 2\pi/\nu_s$ , where  $\nu_s$  is a spatial frequency.

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# LASER MICRO-MACHINING OF TRANSPARENT MATERIAL WITH BESSEL BEAMS GENERATED BY SPATIALLY DISPLACED AXICONS

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Bessel-Gauss beams have attracted much attention in laser micro-fabrication of transparent materials due to elongated focal zone and that is very attractive in various laser micro-machining applications where high width/depth ratio is needed. Compared to the Gaussian beam, the Bessel-Gauss beam is much more efficient in single shot micro-channel fabrication [1] or in cutting of various glasses up to a few millimeters thick [2]. Most commonly adapted Bessel-Gauss shaping element in lab is an axicon - a conical lens with sharp tip at the center. Despite the straightforwardness of axicon applicability, the element must have close to perfect shape quality, because any irregularities of its surface and especially a rounded tip greatly reduces the quality of the generated beam by inducing unwanted axial intensity modulations along the focal zone [3]. Some alternative beam shaping methods have emerged to substitute refractive axicons to increase the overall quality of the beam or create more complex patterns - from diffractive optical elements (DOEs), spatial light modulators to complex sub-wavelength metasurfaces [4, 5]. Freedom of choosing Bessel-Gauss beam generation method allows to fit in various specific beam shaping applications, thus the only limiting factors of element price or optical damage thresholds remain. Another type beam shaping element can be created by implementing birefringent nanogratings inscribed in bulk of fused silica [6]. Direct laser written nanogratings can have controllable retardance and orientation (fast axis) enabling to manufacture custom flat optical elements, usually named after geometric phase optical elements (GPOEs).

In this work we use geometric phase optical elements to create custom displaced phase axicons that form modified Bessel-Gauss beams (manufactured by Workshop of Photonics). With numerical simulation and experimental work, we present practical applications of the generated beams in transparent material laser micro-fabrication. Physical phase displacement allows to create new and fanciful patterns of Bessel-Gauss beams, varying from single elongated peak to multi-peaked intensity patterns. Taking advantage of high optical damage threshold of geometric phase optical elements, we demonstrate thin glass processing with high-peak power ultra-short pulse laser.

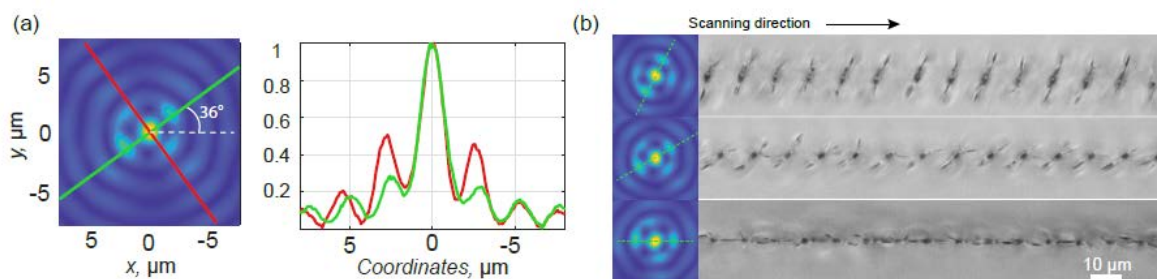


Fig. 1. (a) Intensity distribution of modified Bessel-Gauss beam, produced by geometric phase optical element. Red and green lines represent intensity profiles. (b) Images by optical microscope of dependence of volume micro-crack orientation on rotation of the intensity profile of the beam, pulses with energy of 240  $\mu$ J and 4 ps duration were used.

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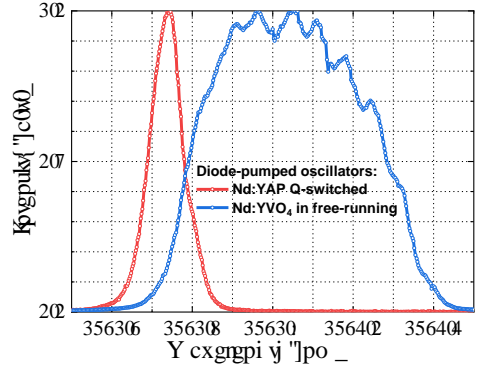
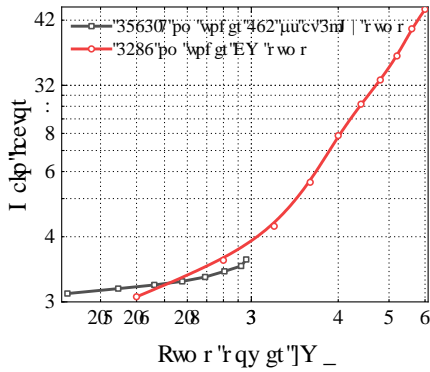
**P f 4 XQ6'CO RNHKG T UUGGF GF 'Y KVJ 'P f 4 CR'CPF 'P f 4 XQ6'NCUGT''  
 RWNUGU'CV'3056'Uo 'HQT'P QP/KP XCUKXG'DNQQF 'F KCI P QUVKEU''**

**T { ectf 'Ndgdf 'cpf 'Crgmgl'O 0Tqf kp''**

Uqrf 'Ucv'Ncugtu'Ncdqtcvt { . 'F gr ctvo gpv'qh'Ncugt 'Vgej pqm i lgu. 'Egpgvt 'hqt 'Rj { ulecn'Uekpegu'cpf 'Vgej pqm i { .  
 Ucxcpqt kw'453. 'NV/24522'Xkpkwu. 'Nkj wcpk''  
 t { ectf 'Ndgdf B hfwf 'Ovfw''

Hcuw'ceewtcv'cpf 'lpgzr gpukxg'o gf lecnf kci pqvku'ku'etk'lecn'vq'tgcv'cpf 'gtcf lecv'o cmtk'0Vj g'pqp/kpxcukxg.'j ki j /  
 ur ggf . 'cpf 'hgrf /f gr m { c dng' r j qvqceqwuke'o gvj qf 'j cu'f go apu'cv'f i tgc'v' qv'p'v'cn'lp'f g'v'g'v'p' i 'v'j ku'f cpi g'q'w'f kugcug'0  
 kp'v'j g'dm'qf . 'r cvj qi pu'f ki gu'v' go qi m'q'lp'v'q'ht'o 'pcpqr ct'v'ngu'q'h'j go q' q'lp'j3\_0J ki j 'qr v'ecn'cduqtr v'kp'q'h'j go q' q'lp'  
 o cf g'k'v' qu'k'dng'v'q'f g'v'g'v'p'f 'f g'ut'q' { 'o cmtk' r cvj qi pu'w'k'p' i 'ru'gt' t'cf k'v'kp'0'kp' t'gur qpug'v'q'c'ru'gt' r'v'ng' . 'v'j 'xcr qt'  
 pcpqd'w'ddng'u'ctg'ht'o gf 'ct'q'w'p'f 'v'j g'j go q' q'lp'lp'k'p'h'g'v'g'f 'gt { v'j t'q' { v'gu'0Vj g'ceq'w'uke'uki p'cm'q'h'v'j g'pcp'q'd'w'ddng'u'ecp'dg'  
 f g'v'g'v'g'f 'd { 'cp'w'nt'cu'q'p'le'ug'pu'q't'v'q'f kci p'q'ug'o cmtk'0Vj g'er'g'ct'gu'v'ceq'w'uke't'gur qpug'y cu'cej k'x'g'f 'cv'r'ug't'y c'x'g'r'p'i v'j 'q'h'  
 894'po " f w'g'v'q'v'j g' m'y gt "cdu'qtr v'kp'q'h'v'j g'r ki o gp'v'o g'rp'lp'p' cpf " j go qi m'q'lp' "eqo r ct'gf "v'q'j go q' q'lp' "j4\_0C'v' v'j ku'  
 y c'x'g'r'p'i v'j . "d'cm'i tq'w'p'f "p'q'ug' cpf " un'kp' v'q'p'g' f gr g'p'f g'p'eg' ct'g' u'ki p'h'k'ec'p'v'nf " t'gf w'eg'f 0' Vj g' m'y gu'v' v'j t'g'uj q'f "hqt" v'j g'  
 i g'p'g't'c'v'k'p'q'h'p'c'p'q'd'w'ddng'u'y cu'cej k'x'g'f 'cv'c'r'v'ng'y k'f v'j 'q'h'92'r'u'j5\_ "y j lej "ku'6'v'ko gu'm'y gt'eqo r ct'gf "v'q'36'pu'y k'j " f co ci g'q'h'q'p'nf ">"4' "q'h'w'p'k'p'h'g'v'g'f "gt { v'j t'q' { v'gu'eqo r ct'gf "v'q'47' "hqt'm'p'i gt'r w'ngu'f w'g'v'q'f g'p'q'ect'k' gf "r j q'v'v'j g'to c'f'  
 j g'cv'k'p'i 0Vj w'u'w'd/pu'ru'gt' r'v'ng'u'cv'c'2089'Uo 'eqo d'lp'g'v'j g'd'gu'v'ceq'w'uke't'gur qpug'y k'j "j ki j 'uch'v'0'

Vq'f cv'g' v'j g'q'p'nf 'x'k'c'dng'v'q'w'k'p'v'j cv'uko w'nc'p'g'q'w'nf "o g'g'u'v'j g't'g's'w'k'go g'p'u'ht'c'2089' o "ru'gt'y c'x'g'r'p'i v'j . 'u'w'd/pu'  
 r'v'ng'y k'f v'j 'cpf 'q'w'r w'p'g'p'ti { 'ku'uge'q'p'f 'j c'to q'p'le'i g'p'g't'c'v'k'p'ht'q'o 'P f /f q'r g'f 'ru'gt't'cf k'v'kp'cv'3056'Uo 0C't'g'eq'tf 'q'w'r w'  
 q'h'c'207'o L'c'20'pu'cv'322'J | 'y cu't'g'eg'p'v'nf 'c'ej k'x'g'f 'j6'ht'q'o 'P f 4 CR'o l'et'q'ej k'r 'q'ue'k'm'v'q't'go k'v'k'p'i 'cv'3563'po . 'u'w'k'p'q'v'  
 u'c'v'k'p'f k'p'i 'lp'v'g'to u'q'h'g'p'g'ti { 'cpf 't'gr g'v'k'k'p'v'c'v'0C'm'j q'w'i v'j "v'j g't'g'i g'p'g't'c'v'k'g'P f 4 XQ6'co r r'k'h'g't'ec'p'g'h'g'v'k'x'g'nf 'u'ec'ng'w'r "  
 r u'r w'ngu'cv'3564'po 'y c'x'g'r'p'i v'j 'ht'q'o 'v'j g'k'p'k'c'k'c'p'v'nf 'g'p'g'ti { 'h'g'x'g'nf'c'p'f 'c'v'c't'gr g'v'k'k'p'v'c'v'q'h'522'nf | 'j7\_ 'v'j g'v'k'g' 't'g'nc'd'k'k'v'f . "  
 cpf 'eq'u'v'q'h'w'ej 'ru'gt'u'f u'ng'o u'c't'g'p'q'v'w'k'c'dng'0Vj g't'g'ht'g' . 'y g'c't'g'lp'x'g'v'k'i c'v'k'p'i 'v'j g'h'c'v'k'k'k'v'f 'q'h'k'p'z'r g'p'uk'x'g'cpf 't'g'nc'd'ng'  
 v'y q' /cpf 'h'q'w'r cu'P f 4 XQ6'co r r'k'h'g't'u'w'k'p'i 'j ki j /d't'k'i j v'p'gu'u'r w'o r k'p'i 'ru'gt'f'k'q'f g'u'cv' : 2: 'po 'y c'x'g'r'p'i v'j 0'kp'c'v'y q'r cu'i'  
 P f 4 XQ6'co r r'k'h'g't'c'v'eq'p'k'p'w'q'w'u'y c'x'g'r' w'o r 'r'q'y g't'q'h'6'Y . 'c'c'45/h'q'f 'co r r'k'h'c'v'k'p'q'h'r' l'eq'uge'q'p'f 'u'gg'f 'r'w'ngu'ht'q'o "c"  
 r cu'k'x'g'nf "o q'f g'm'p'eng'f "h'k'g't' ru'gt'cv'c'y c'x'g'r'p'i v'j 'q'h'3286'po 'y k'j 'cp'lp'r w'r'q'y g't'q'h'30'o Y 'cpf "c't'gr g'v'k'k'p'v'c'v'q'h'  
 4; '0J | 'y cu'cej k'x'g'f "Hki 03'6'h'g'w'0'



Hki 030I c'k'p'cv'3286'po 'cpf 'c'35630'po 'y c'x'g'r'p'i v'j 'x'g't'u'w'r w'o r 'r'q'y g't'lp'c'f'q'w'dng'r' cu'P f 4 XQ6'co r r'k'h'g't'o'  
 r'g'h'0Go ku'k'p'ur g'ev'c'q'h'S /uy k'ej g'f 'P f 4 CR'ru'gt'cpf 'P f 4 XQ6'que'k'm'v'q't'lp'ht'g'f/t'w'p'p'k'i "o q'f g'o't'k'i j w'

K'ku'np'q'y p'v'j cv'P f 4 XQ6'et { u'cn'j cu'c'4'6'5'v'ko gu'uo c'ng't' u'ko w'v'g'f "go ku'k'p'et'qu'i'uge'v'k'p'cpf "c'4'v'ko gu'o q't'g'  
 s w'cp'w'o 'f g'h'ev'cv'3564'po 'y c'x'g'r'p'i v'j 'eqo r ct'gf 'v'q'v'j g'eqo r g'v'k'p'i 't'c'p'uk'k'p'cv'3286'po 0C'ee'q'tf k'p'i n'f . 'w'p'f g't'eq'p'f k'k'p'u'  
 q'h'r'w'ng'f 'r'w'o r k'p'i 'y k'j "c'f'w'w' "e' { er'g'q'h'46' . 'v'j g'i c'k'p'v'c'v'q't'q'h'30'pu'r'w'ngu'q'h'P f 4 CR'que'k'm'v'q't'cv'c'y c'x'g'r'p'i v'j 'q'h'  
 c'35630'po "Hki 03'6'h'g'w'y k'j "cp'c'x'g't'ci g'r'q'y g't'q'h'c'322'o Y 'cv'c't'gr g'v'k'k'p'v'c'v'q'h'3'nf | 'f q'g'up'v'g'ce'j 'g'x'g'p'w'r 'v'q'40'  
 J q'y g'x'g't' . 'u'w'ej "c'v'ko k'g'f "i c'k'p'ku'c'm'q'g'z'r' m'k'p'g'f "d { "v'j g'w'p'uc'v'k'v'c'v'q't' { "q'x'g't'r'r' "q'h'v'j g'go ku'k'p'ur g'ev'c'ht'q'o "S /uy k'ej g'f "  
 P f 4 CR'que'k'm'v'q't' "Hki 03'6'h'g'w' "i c'k'p'v'c'v'q't' "v'j g' "i c'k'p'd'c'p'f v'k'f v'j "q'h'P f 4 XQ6'co r r'k'h'g't'0Vj g't'g'ht'g' . 'h'w'v'j g't'g'u'w'w'u' q'h'v'j g'  
 k'p'x'g'v'k'i c'v'k'p'q'h'o w'nk'r' cu'P f 4 XQ6'co r r'k'h'g't' . 'u'gg'f g'f 'y k'j 'c'v'j q't'v'ec'x'k'v'f 'r' cu'k'x'g'nf 'S /uy k'ej g'f 'P f 4 XQ6'que'k'm'v'q't' . 'c't'g'  
 f k'ue'w'ug'f 0'

**C'ep'q'y r'g'f i go gp'v'v'j ku't'g'ug'tej 'y cu'r'ct'v'k'm'f 'h'w'p'f g'f 'd { 'v'j g'G'w't'q'r g'cp'U'q'ek'ri'H'w'p'f 'w'p'f g't'v'j g'P'q'2; 050NO V/M  
 934/44/2327'F g'x'g'r'p'o g'p'v'q'h'Eqo r g'v'g'p'eg'u'q'h'U'w'f g'p'u'v'j t'q'w'i j "R'ce'v'le'cn'T'g'ug'tej "C'ev'k'x'k'g'u'o g'cu'w't'g'0'**

13\_ GQ 0Nw'k'p'q'x'c/J r'gd.'MO 0Eco r d'g'm' RGOEq'p'uc'p'k'p'q'w.'J go q' q'lp'i g'p'g't'c'v'g'f "xcr qt" pcp'q'd'w'ddng'u' hqt' v'c'p'uf g'to c'nf' t'g'ci g'p'v'c'p'f "p'g'g'f ng'ht'gg'  
 f g'v'g'v'k'p'q'h'o c'nt'k' . 'R'q'eg'g'f k'p'i u'q'h'v'j g'P'c'v'k'p'c'nf'Ce'f go { 'q'h'U'ek'p'eg'u' . '333'5+; 226; 27'4236-0'  
 14\_ E0Eck 'MIC0Ect'g'f . 'F (COP g'f q'ug'np' . [ C0O g'p' { c'g'x' . 'k'p'x'k'q'f'j q'v'q'ce'q'w'uke'ht'q'y 'e' i'q'o g'v' { 'hqt'g'ct'nf 'o c'nt'k'f'k'ci p'q'ku' . 'E'f'q'o g'v'f { 'R'ct'v' . " ; \*8+ "  
 7536764. \*4238-0'  
 15\_ GQ 0Nw'k'p'q'x'c/J r'gd'k'f'Q0Ncr'q'v'nf . 'O c'nt'k'f'g'v'c'p'q'v'ku'w'k'p'i 'j go q' q'lp'i g'p'g't'c'v'g'f "xcr qt" pcp'q'd'w'ddng'u' . 'Vj g't'c'p'q'v'ku' . '6'9+; 983698; \*4236-0'  
 16\_ MOI g'q'ti k'x'g'f . 'F (P 0I g'q'ti k'x'g'c' . 'C0V't'h'q'p'q'x' . 'cpf 'k'0D'w'ej x'ct'q'x' . 'U'w'd/pu' . 'j ki j "g'p'g'ti { . 'r' cu'k'x'g'nf 'S /uy k'ej g'f 'ru'gt'cv'3056'Uo . 'CUUN'Ncugt'Eq'p'i t'g'au' . "  
 r'cr'g't'LVj 4C0B4 \*4242-0'  
 17\_ C00Tq'f'lp' . 'O 0I t'k'j k'p' . 'C00 k'ej c'k'x'c'u' . 'R'le'q'uge'q'p'f "ru'gt'y k'j "33'Y "q'w'r w'r'q'y g't'cv'3564'po "dc'ug'f "q'p'eqo r q'uk'g'o w'nk'r'ng'f q'r'k'p'i "r'g'x'g'nf'  
 P f 4 XQ6'et { u'cn'Or'k'v'c'p'f'Ncugt'Vgej pqm i { . '98. '68674'4238-0'

**WX/XKUNNG'NK J V'I GP GTCVKQP 'KP 'RJ QVQP KE'ET[ UVCN'HKDGTT'  
RWO RGF 'D[ 'KT'332'HU'RWO R'RWNUGU''**

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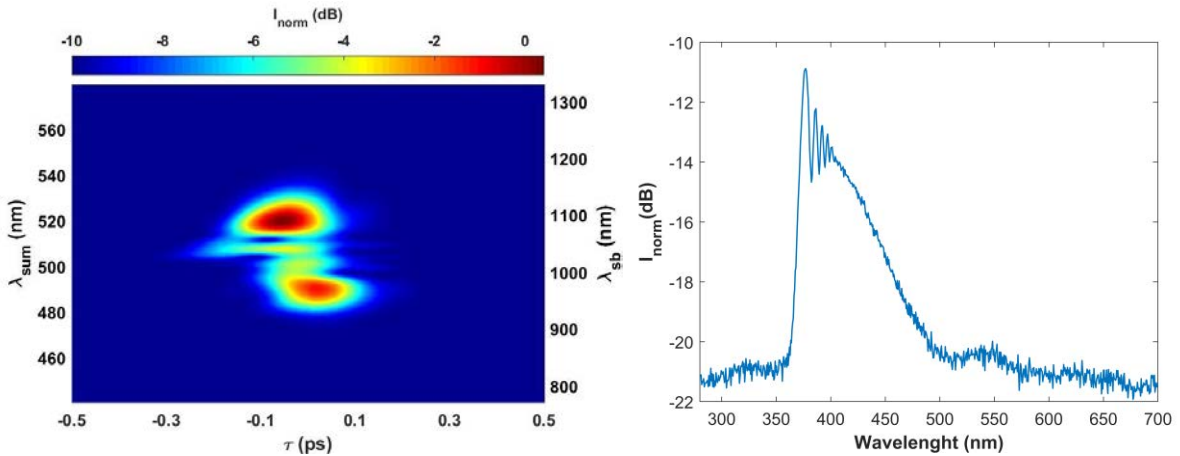
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"

Rj qvqple"et { uvcn'hkdgttu" \*REHu" ctg" f khtgtpv'ltqo " eqpxgpvkpnci'qr vlecn' hkdgtu." dgecwug" REHu" j cxg" c" r gtlqf le" o letqutwewtg'tgi kqp'lpukf g'yj go 'y j gtg'hi j v'ku'r tqr ci cvkpi "J3\_0Uqkf 'eqtg'REHu'ctg'r gthgevpqprkpgct'o gf kc."kp'y j lej " k'ku'r quikdng'ht'pqrkpgct'r tqeguugu'vq'qeeuw'f wg'vq'yj kf "qtf gt'pqrkpgctk' "J4\_0Vj kf "qtf gt'uwuegr vdkkxv' " \*5-"ku'tgrvqf " vq'qr vlecn'Mgtt" ghgeev."y j lej "rgcf u'vq"ugxgtcn'pqrkpgct'r tqeguugu'uwej "cu"r wug"ughr'r j cug"o qf wrcvkqp."etquu'r j cug" o qf wrcvkqp."hqwt/y cxg'o kz kpi "qt"gxgp'uko wrcvqf 'Tco cp'uecwgtpki . 'y j lej 'tguwuu'kp'r wug'ur gevtdtqcf gpkpi "J5\_0"

Kp'yj ku'uwf { 'y g'r tguqpv'gzr gtlco gpvcn'tguwuu'qh'qwt'lpkxguki cvkqp'qh'"WX"o'XKU'hi j v'i gpgtcvkqp'kp'r j qvqple'et { uvcn' hkdgt'r wo r gf "d{ 'KT'332'hu'r wo r 'r wngu0"Vj g' wo r 'uqwtg'ht'WX"o'XKU'hi j v'i gpgtcvkqp'y cu' d-MI Y "ncugt"o'Hkpw" quekncvt'i gpgtcvkpi "324: 'po 'y cxgrpi vj 'y kj 'tgr gvkq'p'cvq'qh'970'0 J | 'cpf "332'hu'f wrcvkqp'r wngu0C'dgco 'ur rkwgt." y j lej 'tcpuo ku'57' 'qh'gpgti { 'cpf 'tghgevu'87' 'qh'gpgti { . 'y cu'wugf 'vq'f kxf g'yj g'tcf kcvkqp'kp'vq'y q'dgco u0Vj g'dgco " y kj "o qtg"gpgti { "y cu'wugf "cu" c'tghgtgpeg"r wug'ht'etquu'eqttgrvq'p'htgs wqpe{/tguqkxg' "qr vlecn'i cvkpi " \*ZHTQI + " o gcuwtgo gpv'cpf "y j g'qj gt'dgco u'y kj 'nguu'gpgti { "y cu'wugf 'ht'yj g'i gpgtcvkqp'WX"o'XKU'hi j v'lp'REH'Rqmtk' cvkqp" o clpvkplpi "uqkf 'eqtg'REH'y kj "j ki j 'pqrkpgct'eqg'ht'k'p'v'cpf " | g'q'f kur gtukqp'y cxgrpi vj 'qh'3262'po 'y cu'wugf O'REH' rpi vj "y cu'408'eo "cpf "eqt'f kco gvt'/"60'Uo O'ZHTQI "o gcuwtgo gpv'y g'g'r gthqto gf "d{ 'pqp/eqnrkpgctn' "h'qewukpi " tghgtgpeg'tcf kcvkqp'cpf 'hi j v'ltqo "REH'kp'v'522"Uo 'y k'p'nguu'DDQ'et { uvcn'y j lej 'y cu'ew'cv' ?2A'cpf " ?52A'ht'v' r g'KK r j cug"o cvej kpi O'D{ 'ej cpi kpi 'f grc{ 'qh'tghgtgpeg"r wug'uwo "htgs wqpe{/tcf kcvkqp"ur gevto 'y cu'o gcuwtgf "cpf "c"lqkv' tgr tguqpv'cvkqp'qh'f grc{ 'wko g'cpf 'ur gevto 'y cu'qdvkqpf 'ZHTQI 'ur gevqi tco u0

Kp'yj ku'tgr qv'v'ku'uj qy p. 'y cv'y j gp'KT' r wo r 'r wug'qh'332'hu'f wrcvkqp'cpf 'egpvcn'y cxgrpi vj 'qh'324: 'po 'ku'uggf gf " kp'v'REH"r wug'ur gevto "dtqcf g'pu'htqo " ; 22"vq'3422'po . 'y j lej 'ecp'dg'uggp'htqo "t'gt'k'x'g'f "ZHTQI "v'cege'\*Hi 03+0C" uo cmr wug'dtqcf g'pki 'ku'ecwugf 'f w'v'q'uj qv'REH'rpi vj "408'eo +cpf 'uwej 'ur gevto "dtqcf g'pki 'ecp'dg'gzr r'k'p'gf "dcugf " qp"pqrkpgct'r tqegu'uwej "cu'ughr'o'r j cug"o qf wrcvkqp'0'ht'v'j gto qtg."ur gevto "o gcuwtgf "cv'REH'qwr w'uj qy gf "y cv' cm'pi uk'f g'qh'r wug'ur gevto "dtqcf g'pki 'kp'KT'tcpi g. 'c'i gpgtcvkqp'qh'y gcm'WX/XKU'y cxgrpi vj 't'cpi g'y cu'cuq'q'dugtxg'0' Vj g'dcpf y kf vj "qh'uwej 'ur gevtdt'cpi g'y cu'htqo "572"vq'722'po "cpf "ugxgtcn'quekncv'k'p'u'y g'g'q'dugtxg'f " \*Hi 03+ 'y j lej " o ki j v'dg'gzr r'k'p'gf "d{ 'lpv'ht'g'peg'qh'WX/XKU'hi j v'i gpgtcvqf 'cv'f khtgtpv'REH'ugi o gpv'0"



Hki 030Ngn'6'o gcuwtgf "ZHTQI "v'cege'qh'tcf kcvkqp'htqo "REHDTki j v'o'o gcuwtgf 'ur gevto 'qh'WX/XKU'hi j v'cv'REH' qwr w0'

"

J3\_ T0Dwe{ punk'Rj qvqple'Et { uvcn'hkdgttu.'Cevc'Rj { u0Rqr0C0328\*4+;3636389\*4226-0'  
J4\_'R0U0L0T wuugn'Rj qvqple/et { uvcn'hkdgttu.'L0Nki j y cxg'v'gej pqr046\*34+;694; 6696; \*4228-0'  
J5\_'T0Y 0Dq{f. 'P qprkpgct'Qr vleu'Vj kf 'Gf k'k'p' \*Cecf go le'Rtguu.'P gy 'l q'mi422: +0'

P4-31

DID NOT PARTICIPATE

**CVQO KE 'NC[ GT'F GRQUKVKQP 'QH'UKQ4'WUKPI 'QZ[ I GP 'RNCUO C''  
CPF'Q\ QPG''**

O cpvcu'F tc| f { u<sup>3</sup>. 'F ctklc' Cwte wunf v<sup>3</sup>. 'Xkcrklc' Lcuwrckkqp<sup>4</sup>. 'Tco wku'F tc| f { u<sup>3</sup>

<sup>3</sup>O letqqr vlecn'eqo r qpgpw'rdqtcvqt { 'Egpygt'hqt'Rj { ulecn'Uelgpegu'cpf 'Vgej pqmji { 'Nkij wcpkc'  
<sup>4</sup>F gr ctvo gpv'qh'Ej ctcevgtkucvqp'qh'O cvgtkcn'Utwewtg. 'Egpygt'hqt'Rj { ulecn'Uelgpegu'cpf 'Vgej pqmji { 'Nkij wcpkc'  
o cpvcu'f tc| f { uB ho eOn'

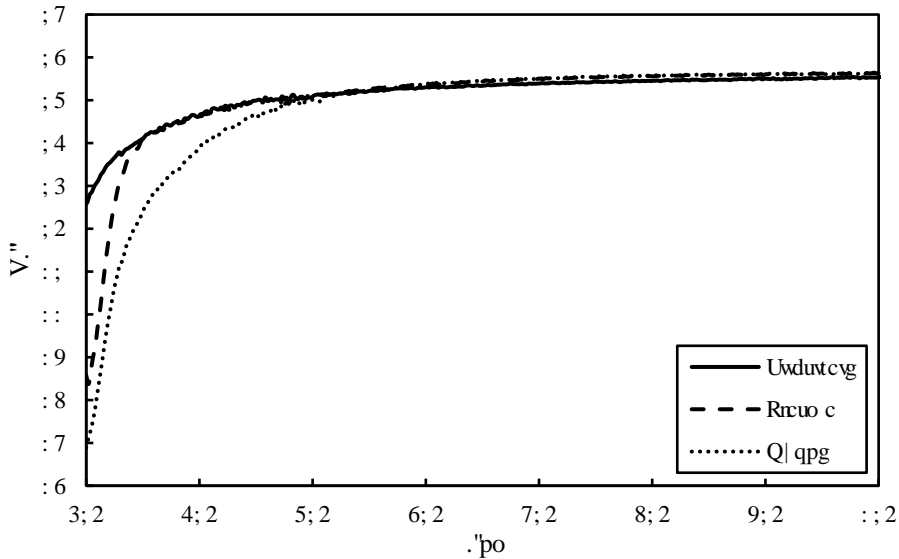
"

Vj g'o clp'tgs wktgo gpw'hqt'qr vlecn'eqcvpi u'ctg'my 'uecwtgkpi 'nqugu'cpf 'ny 'cdutqr vkp0' Cf f kkpccm { . 'Hko u'o wu' dg'f gr qukskf 'y kj "r tgekug'vj kempgu'eqpvtqri'cu'y gni'cu'vj kempgu'wplhqtto k{ 0' Vj gtg'ctg'y gni'npqy p'r j { ulecn'xcr qwt' f gr qukskqp '\*RXF + 'veej pls wgu'wugf "lp'o cpwcewtkpi "qr vlecn'eqcvpi u'0' J qy gxgt. "f wg'vq'f gxgnr o gpv'qh'rcugt "lpf wwt { . " qr vlecn'eqo r qpgpw'ctg' dgeqo kpi "kpetgculpi n' "eqo r rnz'0' Gzco r rgu'qh'eqo r rnz' "qr vleu'ctg'r j qvple" et { wcnu. "ngpugu." o letqqr vleu'ge0'Vtcf kkpccm RXF 'veej pls wgu'ctg'pqv'cdng'vq'cej kxg'j k j /r gthqt o cpeg'qr vlecn'eqcvpi u'qp'vj gug'eqo r rnz' uwdutcvgu0'

Cvqo le'nc { gt'f gr qukskqp '\*CNF + 'ku'c' dtcpej "qh'ej go lecn'xcr qwt' f gr qukskqp '\*EXF + 'veej pls wgu'cpf 'ku'c' r tqo kulpi " ej go lecn'eqcvpi "veej pqmji { 0' k'p'CNF . "y j gp'f gr qukskpi "f lgrgevt'le' hko u. "uwdutcvgu'ctg'e { erkecm' "gzt qugf "vq' i cugqwu' r tgewtuqtu'y j lej 'tgcevkp'c' ugrh'ko kulpi "o cpgt0'Vj ku'e { erke' r tgegu' r tggp'w' r tgewtuqtu'htqo 'tgcevkpi 'kp' i cu' r j cug. 'vj wu' y j g' tgevkp'ku' hko kxg' 'vq' y j g' uwt'ceg'0'Vj g' uwt'ceg' eqpvtqmgf 'CNF' tgevkp'cu'ny 'vq' eqpvtqri' hko "vj kempgu'y kj lp'c' uwd/ pcpqo gvt' t'cpi g' ]3\_0

Qr vlecn'eqcvpi 'f guki p'ku'c' ugs wpeg'qh'rc { gtu'y kj "j k j 'cpf 'ny 'tghtcevkxg'lpf legu0'Vq' o cpwcewtg'uko r rnz'eqcvpi u' wukpi 'CNF . 'CnQ5' eqw'f 'dg'wugf 'cu'c'ny 'tghtcevkxg'lpf gz' o cvgtkcn'dgecwug'vj gto cn'f gr qukskqp'qh' CnQ5' ku'y gni'npqy p' cpf "f qgu'pqv'tgs wktg'c' eqo r rnz' tgecvqt' f guki p' ]4\_0' J qy gxgt. "c' o qtg' r tgekug'cpf "eqo r rnz'qr vlecn'eqcvpi "f guki p' o c { " tgs wktg'c' j ki j gt' tghtcevkxg'lpf gz' eqpvtcu' dgy ggp' y j g' y q'rc { gtu0'Ukrleqp' f kqz'kf g' \*UkQ4' + 'ku' qpg'qh'vj g' o quv'y kf gn' "wugf " o cvgtkcn'lp' o cpwcewtkpi "qh'qr vlecn'eqcvpi u'qy kpi "vq'ku'ny 'tghtcevkxg'lpf gz'cpf 'rci' g' d'c'p' i cr 0'Wphqt wpcvgn' . 'k'j cu' dggp'lj qy p' yj cv'vj g' f gr qukskqp'UkQ4' wukpi "vj gto cn' tgeguu. 'y j gtg'qz'kf cpv'ku'y cvgt. 'ku'pqv'uw' h'ekl'gpv' ]5\_0'Vj g' g' h'gtg. 'q' qpg' cpf "qz { i gp' r ncuo c' y gtg' uct'v'g'f "vq' dg' wugf 'cu'qz'kf cpw' ]6\_0'

Kp'vj ku'y qtnly g'uwf l'gf 'UkQ4' yj lp' hko u' f gr qukskf 'd { 'CNF' wukpi 'v'ku'f ko g'j { nco k'p'q'uk'rcpg'cpf 'Q5' 'qt'qz { i gp' r ncuo c' cu'qz'kf cpv'0'Y g' c'p'cn' ugf 't'cpuo kulqp'ur gev'tc'lp' yj g'ur gev'tc'nc'p' g'qh'3; 2'6' ; : 2'po 'qh'vj lp' hko u' f gr qukskf 'wukpi 'f k'htg'gpv' CNF' r tgeguu'veej pqmji kecn' r tco g'vgtu' \*Hki 03+0'



Hki 030'Vt'cpuo kulqp'ur gev'tc'qh'UkQ4'0'

Y g'qdugt'xgf 'f k'htg'gpv'v'xgn'qr vlecn'qugu'lp' 'WX' t'cpi g'y j lej 'y gtg'j k j gt'eqo r ctg'f "vq' d'ctg'hwugf 'uk'lec' uwdutcvg'0' Vq' h'kp' "q'w' r quakdng'ecwugu'qh'cdutqr vkp' yj g' l'pxg'vki cvkqp'qh'ej go lecn'eqo r qukskqp'cpf "cr r tqr t'k'v'g' u'q'lej k'p'o g't { 'qh'vj lp' hko u'wukpi 'Z/ t'c { 'r j qv'grgevt'qp'ur gev't'queqr { '\*ZRU'+y cu' o cf g'0'

[3\_ "UO 0I g'qti g. 'Cvqo le'nc { gt'f gr qukskqp'<C'p'Qxgt'xkgy . 'Ej go 0Tgx0332. '333/353' \*4232-0'  
[4\_ 'F 0T' h'j gn'@v'c'ri0' k'p'v'qf v'ek'p'cvqo le'nc { gt'gr kscz { 'hqt' yj g'f gr qukskqp'qh'qr vlecn'vj lp' hko u. 'Vj lp'Uq'kf 'Hko u'4; ; . '472/477' \*3; ; 8+0'  
[5\_ 'D0D0Dw'v'q'p'gv'c'ri0'UkQ4' Cvqo le'nc { gt'f gr qukskqp'Wukpi 'v'ku'f ko g'j { nco k'p'q'uk'rcpg'cpf 'J { f tqi gp' Rgt'qz'kf g'Uw'f l'gf 'd { 'lp'Ukw'Vt'cpuo kulqp'HVKT' 'Ur gev't'queqr { . 'LDRj { u0Ej go 0335. ': 46; /: 479' \*422; +0'  
[6\_ 'MDR' h'htg'gv'c'ri0' Ego r t'cevkxg'uw'f { 'qh'CNF' UkQ4' yj lp' hko u' hqt'qr vlecn' r r'nc'v'k'p'u. 'Qr v'0O cvgt0'Gzr t'guu'8. '882/892' \*4238-0'

**E Q O R C T K U Q P ' Q H H K T U V / Q T F G T ' U G N G E V K X G ' F K H H T C E V K Q P ' ' G H H K E K G P E K G U ' Q H ' X Q N W O G ' D T C I I ' I T C V R P I U ' K P ' V J T G G ' F K H H G T G P V ' ' V I R G U ' Q H I N C U U ' '**

Lwxcu'Mwf knc<sup>3</sup>. 'Gto kpcu'Mqj mpxunk<sup>3</sup>. 'Cpvcpcu'Wtdcu<sup>3,4</sup>

<sup>3</sup>Egpygt'qh'Rj { ulecn'Uelgpegu'cpf "Vgej pqmji { . 'Kf wutkcn'Ncdqtcvt { 'hqt 'Rj qvqple "Vgej pqmji lgu. 'Nkj wcpk "

<sup>4</sup>Y qtmuj qr "qh'Rj qvqpleu. "O qmukpkmw'w0'8C. "Xkpkwu. 'Nkj wcpk. "2: 634 "

lwxcu'mwf kncB i o ckrqo "

"

Vtcur ctgpn' f lgrgevtle " o cvgtkcn' o qf kklecvqp " y kj " wntchuv' rucgt " r wngu " j cu' ugpp " gpqto qwu' kvgtgub' cpf " ko r ngo gpvcvqp " kp' dqj " uelgpvkle " cpf " lpf wutkcn' eqo o wplkgu' Hqto cvkqp " qh' y gm'f ghkpgf " j qo qi gpqwu " tgi kqpu " qh' o qf kkegf " tgh'cevkg " kpf gz " ku' r quukdng " d { " ngr lpi " y g " kvgpuk { " qh' hgo vqgeqpf " rucgt " r wngu " urki j wq " cdqvg " y g " i kxgp " o cvgtkcn' f co ci g " y j tguj qrf " j3\_0'Vj ku' o gyj qf " cmjy u' wu' vq " hcdtkecvg " o cp { " ut wewtgu " kp " c " pwo dgt " qh' y kf g " dcpf / i cr " vcpur ctgpn' o cvgtkcn. " y j lej " gzt cpf gf " y j " ej qleg " qh' i ruugu' uwkcdng " hqt " xqno g " Dtc i " i tcvpi " \*XDI + " hcdtkecvqp " ukpeg " r j qvqgpukxg " o cvgtkcn' ctg' pq' mpi gt " tgs wkt gf 0XDI u' ctg' r j cug " i tcvpi u' y j cv'gzj kdk' qwucpf kpi " cpi ng' cpf " y cxg rpi y j " ugrgevkxk " j4\_0 "

Vj g' f khtcevkqp' ghkekgpe { " qh' XDI u' cv' Dtc i " eqpf kxqp " ku' f gvto kpgf " d { " y j g' r tgf wev' qh' tgh'cevkg " kpf gz " o qf wrcvqp " \*TKO + " cpf " i tcvpi " y j lenpguu' 00 qtgqvg. " y j g' xcnwg " qh' TKO " ku' f gvto kpgf " d { " y j g' ut wewt g' qh' y j g' lpxguk i cvgf " o cvgtkcn' cpf " rucgt " r ctco gygtu " j5\_0' kq " qtf gt " vq " qdvclp " y j g' o quv' equv' gh' gevkg " XDI . " y j g' hcdtkecvg " XDI u' y j g' uco g' y j lenpguu' dw' f khtgtpv' TKO . " y j lej " ku' cej kxgf " d { " xct { kpi " y j g' rucgt " hnwpeg 0' kq " y j ku' y qtm " y g " eqo r ctgf " y j g' hktuv' qtf gt " ugrgevkxg " f khtcevkqp " ghkekgpe { " qh' xqno g " Dtc i " i tcvpi u' qdvclp " d { " f kge v' rucgt " y tkkpi " \*FNY + " wukpi " I cwuu' Dguugn' dgco " kp " y j tgg' f khtgtpv' r gu' qh' i ruu' ukkec. " dqtqukrecv. " cpf " i qtkm' i ruu' 0 "

Kp " y j ku' y qtm " y g " hktuv' y j gqtgvkecm { " ecwewv " y j g " o czko wo " f khtcevkqp " ghkekgpe { " hqt " gcej " v' r g' qh' i ruu' wukpi " Mqi gpknu' eqw rnf " y cxg " y j gqt { " j6\_0' Vj gp " y g " wugf " FNY " vq " hcdtkecvg " o wnr ng " XDI u' y j g' khtgtpv' rucgt " hnwpeg " kp " cm' i kxgp " uco r ngu' 0' Hkpcmf . " y j g " eqo r ctgf " hktuv' qtf gt " ugrgevkxg " f khtcevkqp " ghkekgpeku' qh' XDI u' kp " f khtgtpv' i ruugu' wukpi " c " EEF " eco gtc. " y j lej " cmjy gf " wu' vq " ecr wtg " y j g' kvgpuk { " r tqhkg " qh' y j g' f khtcevgf " dgco 0 "

"

j3\_ " HJJ g. " J 0' Uxp " gv' crf " Tcr kf " hcdtkecvqp " qh' qv' uecn' xqno g " i tcvpi ukp " Hqwtcp " i ruu' d { " hgo vqgeqpf " rucgt " o letqo cej kipi . " Cr r rkgf " Rj { uleu' C; 906. " : 756: 79 \*422; + "

j4\_ " O 0' O knwku. " V0' Mwf tkwu' gv' crf " J ki j " ; 2' " ghkekgpe { " Dtc i " i tcvpi u' hqto gf " kp " hwgf " ukkec " d { " hgo vqgeqpf " I cwuu' Dguugn' rucgt " dgco u. " Qr uecn' O cvgtkcn' Gzr tguu' 503. " 3: 84/3: 93 \*4235+ "

j5\_ " F 0' Rclr wru. " O 0' O knwku' gv' crf " Xqno gvtle " o qf kklecvqp " kp " hwgf " ukkec " wukpi " I cwuulcp' cpf " Dguugn' hgo vqgeqpf " rucgt " dgco u. " Rtqe " URKG: 9: 8 " \*4235+ "

j6\_ " J " Mqi gpknu' Eqw rnf " Y cxg " Vj gqt { " hqt " Vj leni' J qmji tco " I tcvpi u. " Dgn' U' ugo " Vgej plecn' Lqwtpcn' 6: 0 . " 4: 2; 64; 69 \*3; 8; + "

"

# SUPERCONTINUUM GENERATION IN $\text{CaF}_2$ CRYSTAL PUMPED BY HIGH REPETITION RATE GREEN FEMTOSECOND LASER PULSES

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Supercontinuum (SC) generation is an effect produced by filamentation of ultrashort laser pulses in transparent dielectric media and resulting in broad spectra with high spatial and temporal coherence [1]. SC generation in the ultraviolet (UV) spectral range is highly demanded in ultrafast time-resolved spectroscopy. However, UV SC generation is still a complicated task due to the scarcity of suitable nonlinear materials. Spectral broadening in alkali metal fluorides ( $\text{BaF}_2$ ,  $\text{CaF}_2$ ,  $\text{MgF}_2$ ,  $\text{LiF}$ ,  $\text{LiSAF}$ ) produces spectra with the largest blue shifts. As a rule,  $\text{CaF}_2$  crystal is widely considered to be the preferred material for UV SC generation due to its properties: large bandgap of 10 eV, wide transparency in the UV (short-wavelength absorption edge at 120 nm) and low chromatic dispersion [2]. However, under standard (tight focusing, thin crystal) experimental conditions for SC generation  $\text{CaF}_2$  (and other fluorides) undergoes rapid color center formation as well as heat accumulation even at relatively low (1 kHz) pulse repetition rate. This eventually leads to optical damage and results in SC spectrum narrowing within seconds. To produce stable SC generation for longer periods of time,  $\text{CaF}_2$  crystal has to be continuously translated or rotated with respect to the pump beam [3]. This complicates experimental setup and calls for optimisation of experimental settings for SC generation in the UV by proper choice of pump wavelength and focusing geometry.

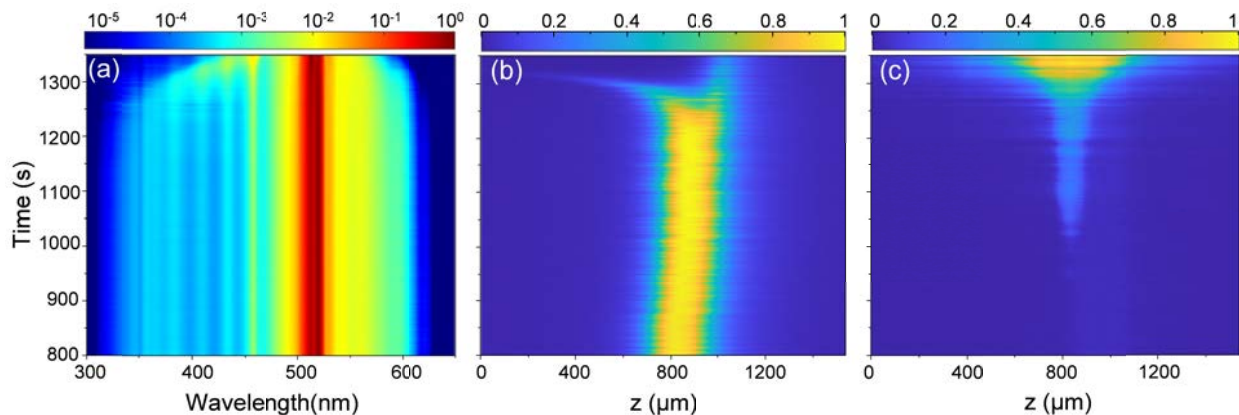


Fig. 1 The time evolutions of (a) supercontinuum spectrum, (b) filament-induced luminescence trace and (c) intensity of scattered light in a thick (25 mm)  $\text{CaF}_2$  slab measured with loosely focused ( $\text{NA} = 0.0044$ ) 180 fs, 515 nm pulses at 10 kHz repetition rate.

In this study, we investigate SC generation in an untranslated thick (25 mm)  $\text{CaF}_2$  crystal using loosely ( $\text{NA} = 0.0044$ ) focused 515 nm pulses provided by the second harmonic of Yb:KGW laser having a pulse duration of 180 fs and a central wavelength of 1035 nm at a repetition rate of 10 kHz. SC generation in thin (5 mm)  $\text{CaF}_2$  crystal in tight ( $\text{NA} = 0.0117$ ) focusing conditions was measured for a comparison.

We demonstrate that the blue-shifts (at  $\sim 300$  nm) of SC spectra do not depend on focusing condition. However, almost no red-shifted spectral broadening was observed using tight focusing conditions, while symmetric spectral broadening (up to 635 nm) was observed with loosely focused pump beam. This observation is explained by enhanced self-steepening of the leading pulse front [4]. Experiments show that SC spectrum shrinks rapidly (in a few seconds) under tight focusing conditions in a thin  $\text{CaF}_2$  sample, whereas damage-free SC generation for 20 min was observed in an untranslated thick crystal using loose focusing conditions (Fig. 1 (a)). We also recorded the dynamics of the filament-induced luminescence trace and light scattering (Figs. 1(b) and 1(c)), which demonstrate a correlation between shrinking of SC spectrum, filament break up and occurrence of strong scattering due to evolving optical damage. The longevity of SC spectrum is explained as a result of dynamic balance between the rate of color centers formation and decay.

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# O WNVKRNVCVGEQP VWP WWO 'I GP GTCVQTUHQ T'HGY 'E[ ENG'RWNUG" HQTO CVKQP "

Tco pcu'Nqi o kpcu<sup>3</sup>. 'Ct pcu'Xctcpcxk kwu<sup>3</sup>"

<sup>3</sup>Ncugt'Tgugctej 'Egpgvt.'Xlpxkw'Wpkxgtukf. 'Nkij wcpkc"  
tco wpcu'Nqi o kpcuB i o cktfeko "

C'utckij v'y c{ 'kpq'f' gpgtcvki 'wmtc/uj qt'v'qr v'ecnr' wngu'o'ku'c'ur' gteqpv'pww'o 'i' gpgtcvqp'hqmy gf 'd{ 'dtqcf /dcpf gf " r wng'go r qtcn'eqo r tguakp0Vj gtg'ctg'xctkqv{ 'qh'y c{ u'ht' r' wng'ur' gev'two 'dtqcf gplpi 'v'gej pks wgu.'j' qy gxgt. 't'gegpw{ 'c'hu'v' qh'cvp'v'p'v'p'q' y' cu'f' gf' k'ecv'gf' 'v'q.'u'q'ecn'gf. 'o' wnk'r' r'v'g'eqpv'pww'o 'i' gpgtcvqt'ugwr 0Vj g'kf'gc'd'g'j' k'f' 'k'k'k'g'c'd'wmi' o' gf' kwo 'kpq'v'j' k'p'p'gt' 't'c'v'k'p'u'q'f' g'q'f' g'q'h'r' c't'u'v'q'h'o' k'k'o' g'v'g't'+c'p'f' 'r' r'v'g'v'j' go 'c'v'eg't'v'k'p'f' k'uc'p'egu'c'm'p'i' 'v'j' g' h'q'ew'gf' 'r' wng' r' t'q'r' c'i' c'v'k'p'f' k'g'v'k'p'j'3\_0K'c'm'y' u'v'q' i' g'v'k'i' p'h'k'ec'p'w'f' 'j' k'j' g't' r' wng'u'g'p'g't'i' k'g'u'c'v'j' g'eqpv'pww'o 'i' gpgtcvqt'q'w'r' w'eqo' r' c't'g'f' 'v'q'v'c'f' k'k'p'c'n'o' g'v'j' q'f' u'g'x'p'v'o' q't'g'v'j' c'p'c'v'j' q'w'c'p'f' 'v'o' g'u'00' q't'g'q'x'g't. 'v'j' g'ur' gteqpv'pww'o 'r' wng'u'ht'q'o' 'o' wnk'r' r'v'g'ug'w'r' u' e'c'p'd'g'eqo' r' t'g'u'g'f' 'v'q'x'k'w'c'm'f' 't'c'p'u'h'q't'o' c'v'k'p'f'k'o' k'g'f' 'r' wng'j'4\_0'

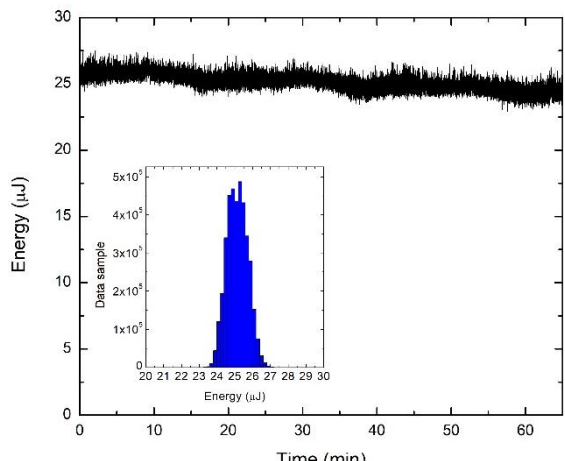
F'k'k'f' k'p'i' 'd'w'm'i'o' g'f' kwo 'kpq'v'j' k'p'p'gt' r' r'v'g'u'c'm'y' u'v'q' d'f' r' c'u'w'p'y' c'p'v'g'f' 'p'q'p'r'k'p'g'c't' 'q'r' v'ec'n'r'g'h'g'ev'u'v'j' c'v'f' k'v'q't'u'r' wng' ur' c'v'k'q'v'g'o' r' q't'c'n'r' t'q'r' g't'v'g'u'v'q' "h'q't" 'g'z'c'o' r' r'g'. 'o' wnk'r' r'v'g' 'h'k'c'o' g'p'v'c'v'k'p'+0'V'j' k'u'k'u'c'x'q'k'f' g'f' 'd'g'ec'w'ug' 't'g's' w'k'g'f' 'k'p'v'g'p'u'k'f' "h'q't" 'u'w'ej' " g'h'g'ev'u'k'p'u'k'f' g'c'd'w'm'i'o' g'f' kwo 'k'u't'g'c'ej' g'f' 'q'w'u'k'f' g'r' r'v'g'u'. 'y' j' g't'g' 'k'p'v'g'p'u'k'f' 't'g's' w'k'g'o' g'p'u'h'q't' 'u'c'o' g'r' j' g'p'q'o' g'p'c't'g'y' c'f' 'j' k'j' g't'0'

U'g'x'g't'c'n'p'q'p'r'k'p'g'c't' 'q'r' v'ec'n'r'g'h'g'ev'u'eq'p'v'k'd'w'g'v'q' r' wng' 'd't'q'c'f' g'p'l'p'i' 0J' q'y' g'x'g't. 'q'p'n'f' 'y' q' "q't" 'o' c'f' 'd'g' 'g'x'p'v'q'p'p'g'. 'f' g'r' g'p'f' u' q'p' "i' g'p'g't'c'v'q't' 'u'g'w'r' +j' c'u'eq'p'u'k'f' g't'c'n'f' 'r'c't'i' g't' 'e'q'p'v'k'd'w'k'p'u'c'v'g'h'r' j' c'ug'o' q'f' w'c'v'k'p'c'p'f' 'r' wng'ur' r'k'v'k'p'i' 0Y' j' k'g' 'u'g'h'r' j' c'ug' o' q'f' w'c'v'k'p'ur'q'y' n'f' 'd'w'eq'p'u'k'v'g'p'v'f' 'd't'q'c'f' g'p'u'r' wng'ur' g'ev'two. 'r' wng'ur' r'k'v'k'p'i' 'f' q'g'u'k'v'k'p'v'c'p'g'q'w'u'f' 'c'p'f' 'k'p'f' k'ec'v'g'u'k'ug'f'h' y' k'j' 'c'u'f' o' o' g'v'k'ec'n'd't'q'c'f' g'p'l'p'i' 'q'h'v'j' g'ur' g'ev't'c'p'f' 'r' g'f' g'u'c'n'k'p' 'u'j' q't'v't' 'y' c'x'g'g'p'i' v'j' 't'g'i' k'p'0'

C'u'o' g'p'v'k'p'p'g'f'. 'd'g'h'q't'g' 'k'v'f' g'r' g'p'f' u'q'p' 'o' wnk'r' r'v'g' "i' g'p'g't'c'v'q't' 'u'g'w'r' 'y' j' g'p'g'x'g't' 'r' wng'ur' r'k'v'k'p'i' 'y' k'n'f'q'ee'w't' 'q't' 'p'q'v'0'k'i'c'm'i' d't'q'c'f' g'p'l'p'i' 'k'u'f' q'p'g'c'v'q'p'eg' 'o' r' wng'ur' r'k'v'k'p'i' 'y' k'n'f'q'ee'w't'0J' q'y' g'x'g't. 'k'h'k'k'u'v'f' 'r' wng'ur' c'u'g'f' 'p'w'o' d'g't' 'q'h'r' r'v'g'u' 'd'g'h'q't'g' 'k'v'ur' r'k'u' c'p'f' 'v'j' g'p' 'k'v'f' g'u'v'eqo' r' t'g'u'g'f' 'k'v'ec'p' 'd'g'v'f' 'v'k'f' g'f' 'v'j' t'q'w'i' j' 'v'j' g't'g'u'v'q'h'v'j' g'r' r'v'g'u'. 'c'p'f' 'r' wng'ur' r'k'v'k'p'i' "c'p'f' 'r' g'f' g'u'c'n'k'p' 'ur' g'ev't'c'+ 'y' k'n'p'q'v'q'ee'w't'0V'j' k'u'v'g'c'f' u'v'q' 'g'x'p'v'g'w'g't' 'r' wng'eqo' r' t'g'u'k'p' 'k'p' 'v'o' g'0'V'q' 'i' g'v'c'f' g'v'c'k'g'f' 'k'p'h'q't'o' c'v'k'p' 'c'd'q'w'r' wng'ej' k'r' 'c'h'g't' 'k'v'y' c'u'd't'q'c'f' g'p'g'f' 'k'u'eq'p'x'g'p'k'p'v'q' 'w'ug' 'h't'g's' w'p'e'f' 't'g'u'q'k'g'f' 'q'r' v'ec'n'i' c'v'k'p'i' "H'Q'I' +o' g'v'j' q'f' 00' q't'g'q'x'g't. 'c'v'v'j' g'v'c'o' g'v'o' g'y' g' " y' k'n'f'c'u'q' 'i' g'v'r' wng' 'r'g'p'i' v'j' 0'

K'p' "q'w't" 'g'z'r' g't'k'o' g'p'v' 'o' wnk'r' r'v'g' "u'g'w'r' " y' c'u' r' w'o' r' g'f' " y' k'j' "V'k'ac'r' r' j' k'g' "r'c'ug't" " y' k'j' "c" 'e'g'p't'c'n' y' c'x'g'g'p'i' v'j' "d'g'l'p'i' " c'r' r' t'q'z'k'o' c'v'g'n'f' " 22'p'o' 0'N'c'ug't' 'r' wng'ur' c'u'k'p'x'g'u'k'i' c'v'g'f' 'y' k'j' "H'Q'I' "c'p'f' 'k'v'y' c'u'k'i' w'g'f' 'q'w'v'j' c'v'r' wng'ur'g'p'i' v'j' "k'u'c'72' 'h'0'Y' g' " w'ug'f' 'r' wng'ur'g'p'g't'i' { "c'u'j' k'j' "c'u'207" 'o' 10'R'v'g'u'j' c'f' "f' k'h'g't'g'p'v'j' k'emp'g'u'c'k'x'g'o'208" 'o' o' "c'p'f' "y' q' "o'208" 'o' o' 0'V'j' g'd't'q'c'f' g'p'g'f' " ur' g'ev'two "y' c'u'c'r' r' t'q'z'k'o' c'v'g'n'f' "h'q'o' "722" 'q' "3222" 'p'o' 0'V'j' g't'g'u'w'n'c'h'g't' 'c'm'i'r' r'v'g'u' 'y' c'u'v'j' g'v'c'o' g' "y' j' g'p'g'x'g't' 'h'k'u'v'r' r'v'g'u' 'y' g't'g' " v'j' k'p'p'gt' 'q't' 'v'j' l'eng't'. 'j' q'y' g'x'g't. 'ur' g'ev't'c'h'g't' 'u'c'o' g'p'w'o' d'g't' 'q'h'r' r'v'g'u' "3.4. 'i' "g'v'e'0' 'y' g't'g'ur'k'i' j' w'f' "f' k'h'g't'g'p'0'

H'q't' 'c'p'f' { "n'k'p'f' "q'h' 'c'r' r' r'k'ec'v'k'p'." 'v'j' g' "u'c'd'k'k'v'f' "q'h' 'q'w'r' w' "r' wng'ur' 'e'j' c't'c'ev'g't'k'u'k'eu' 'k'u' 'q'h' 'j' k'j' " "k'o' r' q't'v'c'p'eg'0' V'j' g' "g'p'g't'i' { " o' g'c'u'w't'g'o' g'p'u'f' v'f'w'k'p'i' "q'p'g'j' q'w't' 'q'h' 'e'q'p'v'p'w'q'w'u' 'q'r' g't'c'v'k'p' "j' c'u' 'u'j' q'y' p' "j' k'j' " "u'c'd'k'k'v'f' "q'h' 'q'w'r' w' 't'c'f' k'v'k'p' "y' k'j' "u'c'p'f' c't'f' " f' g'x'k'v'k'p' 'q'h'2040V'j' g't'g'u'w'u'c't'g'r' t'g'ug'p'v'g'f' 'k'p' 'H'k'i' 080'



H'k'i' 030Q'p'g'j' q'w't' 'u'c'd'k'k'v'f' "q'h' 'u'w'r' gteqpv'pww'o 'y' j' k'ej' 'y' c'u'f' g'p'g't'c'v'g'f' "k'p' 'o' wnk'r' r'v'g' 'u'f' 'u'g'o' 0'

C'h'g't' 'o' g'c'u'w't'k'p'i' 'v'j' g' 'k'p'r' w'g'p'g't'i' { "c'p'f' 'q'w'r' w'g'p'g't'i' { "y' g'f' 'q'v'v'j' c'v'q'w't' 'w'ug'f' 'u'g'w'r' 't'c'p'u'o' k'w'c'p'eg' 'k'u'c'5' '0'V'j' g'g'p'g't'i' { " k'p'v'j' g' 'e'g'p't'c'n'f' c't'v'q'h' 'u'w'r' gteqpv'pww'o 't'c'f' k'v'k'p' 'k'u'c'72' 'q'h' 'c'p' 'k'p'r' w'g'p'g't'i' { 0'

R't'g'ug'p'v'k'p' 'y' k'n'k'p'c'n'f' g'o' q't'g'f' c'v'c'q'p'g'p'g't'i' { "ur' g'ev't'c'n'f'c'p'f' 'v'g'o' r' q't'c'n'f' c't'c'ev'g't'k'u'k'eu'."c'p'f' 'r' t'q'ur' g'ev'u'ht'q' 'eqo' r' t'g'u'k'p' " q'h'r' wng'u'ht'q'o' 'o' wnk'r' r'v'g'ug'w'r' 0'

[3\_] 0E0Ej g'p'i' .E0J 0Nw'f' 0[ 0Nk'p.'c'p'f' 'C0J 0Mv'p'i' .U'w'r' gteqpv'pww'o 'i' g'p'g't'c'v'k'p' 'k'p'c' 'o' wnk'r' r'v'g' 'o' g'f' kwo . 'Q'r' v'0'G'z'r' t'g'u'46.'9446/9453\*4238+0'  
[4\_] 0 0U'g'q' .M'0V'g'p'f' u'w'g'p' .U'00' k'c'c' .0 0M'k'p'i' .c'p'f' 'F' 0M'k'o' .J' k'j' /e'q'p't'c'u'v' 'k'p'v'g'p'u'g' 'k'p'i' r'g'e'f' (e'ng' 'r' wng'u'ht'q'o' 'c'p'c'm'v'j' k'p'v'k'f' /r' r'v'g' 'u'g'w'r' . 'Q'r' v'0'N'g'w'067.'  
589/592\*4242+0'

# INVESTIGATION OF IMPURITIES IN LASER MEDIA: CATHODOLUMINESCENCE AND FILAMENT INDUCED LUMINESCENCE COMPARISON

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Luminescence is the light emitting process when an electron jumps from excited to a ground state. In undoped laser host material luminescence could be generated in various ways: using optical filaments, photons of light (photoluminescence), accelerated electrons (cathodoluminescence), X-ray beam (X-ray luminescence), etc.

In this work we are using filaments of light in order to induce luminescence and observe the resulting spectrum. This method is more convenient compared to cathodoluminescence or X-ray luminescence because the specimen is excited by laser beam. In this way, we have a system which is easily adjustable, requires no complex optical elements and no vacuum chamber is needed. Besides, it allows to study decay of excited states which is not possible during other experiments. Use of filaments in luminescence spectroscopy could be nondestructive way to examine transparent solid material in order to determine its quality.

Luminescence was generated by using filaments of light. Its formation is dynamic process which is caused by non-linear matter-light interaction such as self-focusing, self-phase modulation, non-linear absorption, free-electron plasma, etc. In order to observe these processes high intensities are needed. In this experiment these intensities are reached by focusing femtosecond laser pulses into the specimen. The peak intensity of the filament is sufficient to excite impurities and charge carriers in the material. The filament induced luminescence is observed and registered from the side of the filament.

The main purpose of this work is to compare two different methods: filament induced luminescence and cathodoluminescence. Therefore, spectra were registered in different popular laser media such as *YAG*,  $Al_2O_3$  and *KGW*. Specimens were provided by different manufacturers.

Overall, it was shown that characterizing lines of impurities and defects are repeated in both experiments for all specimens (*YAG*,  $Al_2O_3$  and *KGW*) provided by different manufacturers. For instance, figure 1 a) shows emission spectra of *YAG* specimens excited by filament, figure 1 b) shows spectra of samples which were excited by accelerated electrons. The characteristic peaks differ in intensity, depending on the type of the excitation. Moreover, luminescence decay of these specimens were measured.

Thus, generation of optical filament is suitable way to investigate luminescence in laser host media. On the other hand, luminescence generated by filaments is more suitable method in samples which have intense luminescence. When intensity is low it is better to use cathodoluminescence experiment because light is collected from larger area of the sample's surface.

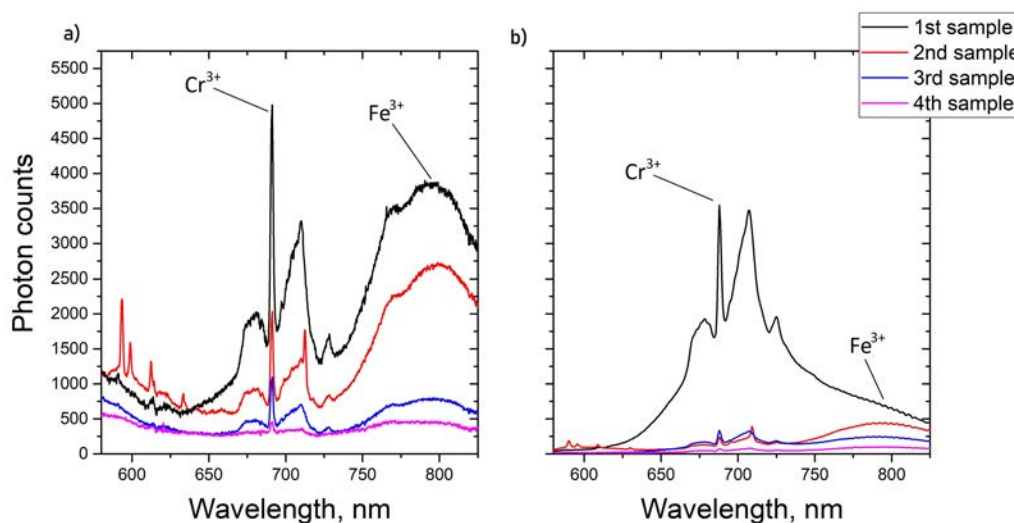


Fig. 1. Filament induced luminescence (a) and cathodoluminescence (b) spectra in *YAG* samples.

**EQP UVT WE VKQP 'CPF 'KP XGUVK CVKQP 'QHT QF /V[ RG'HKDG T''**  
**CO RNKHKGT'U UVGO 'HQT'HGO VQUGE QP F [ D-MI Y 'QUEKNNCVQT''**

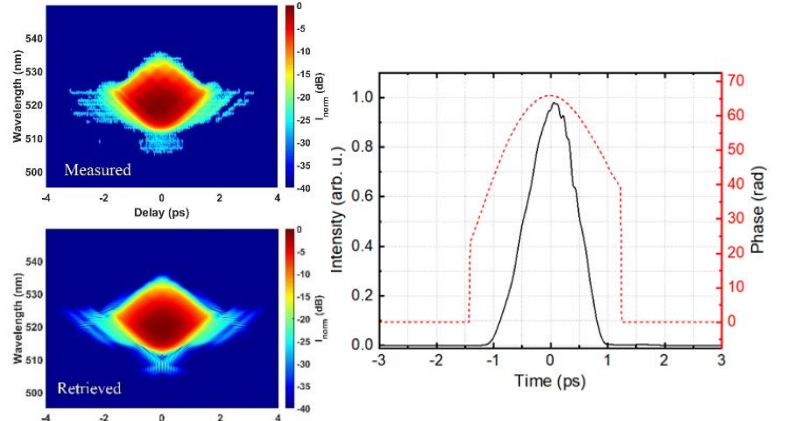
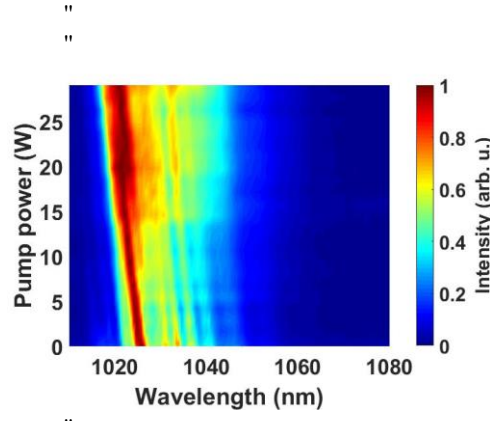
Lqpcu'Dcp{u<sup>3</sup>. 'Lwkw'Xgpi grk<sup>3</sup>"

<sup>3</sup>Ncugt "Tgugctej 'Egpygt. 'Hcewn{ 'qh'Rj { uleu. 'Xlwpkw'Wpkxgtuk{. 'Nkj wcpk"  
lqpcu'Qcp{uB Hfkwv}

Hkpf kpi "pgy "o gy qf u"vq"qdvclp"j ki j gt "cxgtci g"r qy gtu"cpf "uj qtvtg"r wng"fwcvkqpu"ku"cp"ko r qt wcpv"vqr le"qh"rcugt" r j { uleu'tgugctej "J3\_0Qpg'qh'v'j g'y c{u'vq"cej kxg'uwej "r ctco gvgtu'qh'hki j v'ku'co r rkhlecwqp'qh'wntcuj qtvr wnguy kj "hkdgt" co r rkhgtu'0'k'v'g'p'k'x'g'w'w'f'k'g'u'c'p'f "ko r tqxgo gpw'qp"l d/f q'g'f "hkdgtu"j cu'rgf "v'j g'f go qpuwcvkqp'qh'o cp{ "cf xcpwi gqwu" r tq'gt'vku"kh'eqo r ctgf "vq"eqpxgpkpcn'dwm'uqk'f'ucv'g'u{u'ngo u'0'F w'g"v'j g'k"i ggo gt ("cpf "f guki p."l d/f q'g'f "hkdgt" co r rkhgtu"hgcvw'g"q'w'w'c'p'f kpi "v'j gto q/q'v'c'n'r tq'gt'vku."rc'ti g"i c'k'p"dc'p'f y k'v'j "cpf "j ki j "qr v'c'n'r w' r kpi "ghh'ek'g'p'e{0' J qy gxgt."v'j g'f tcy d'c'c'n'q'h'co r rkhlecwqp'qh'wntcuj qtvr wnguy'lp'hkdgtu'ku'v'j g'w'p'i "eqp'k'p'g'f "r tq'ci cvkqp'w'p'i v'j "v'j cv'ko ku" dq'v'j "v'j g'r qy gt"cpf "v'j g'g'p'g'ti {"uec'n'p'i "f w'g"v'q"p'p'k'p'g'c't'r wng"fwcvkqpu"l4\_0'k'p'hkdgt"ej ktr g'f "r wng"co r rkhlecwqp"HERC+" u{u'ngo "r wnguy"ctg"vgo r q'c'm'f {"ut'g'v'j g'f "d'g'ht'g"co r rkhlecwqp."v"t'g'f w'g"p'p'k'p'g'c't"gh'g'ew"lp"v'j g"co r rkhgt."cpf "v'j g'p" eqo r t'g'u'g'f "vq">422"hu"]5\_0'Q'p"v'j g"q'v'j g'j cpf."p'p'k'p'g'c't"co r rkhlecwqp"o gy qf u"/"r ctcd'q'k'e"r wng"co r rkhlecwqp."r t'g"o" ej ktr "o c'p'ci g'f "REOC+" cpf "i c'k'p"o c'p'ci g'f "co r rkhlecwqp" \*I OC+" er'g'c't'n' "f g'p'q'v'j j qy "hkdgt" p'p'k'p'g'c't'k'f "ecp" dg" j c't'p'g'u'g'f. "t'c'v'j g't'v'j cp'd'g'k'p'i "c'k'o k'k'p'i "h'c'v'q't'co r rkh'g'f "r wnguy" c'x'g'd't'q'c'f g'p'g'f "ur g'ev'w'o."g'z'j k'k'k'p'g'c't"ej ktr "cpf"ecp"dg" gh'g'ev'k'g'n' "eqo r t'g'u'g'f "vq">72"hu"]5\_6\_0'V'j g'g'co r rkhlecwqp"v'g'ej p'k's w'g'u'p'q'y c'f c{u'c't'g'ht'g's w'g'p'v'w' "t'g'c'k'f g'f "d'f "w'k'p'i "rc'ti g" o q'f g't'c'g'e"NO C+f q'w'd'g'erc'f f kpi "r j q'v'p'k'e"et {u'c'n't'q'f /v' r g'hkdgt"co r rkhgtu'lp'y j k'ej "p'p'k'p'g'c't"gh'g'ew'ct'g'uki p'k'h'c'p'v'w' " t'g'f w'g'f "cpf"u'k'p'i g'co q'f g't'g'i ko g'eq'w'rg'f "y k'j "j ki j "qr v'c'n'gh'h'ek'g'p'e {"g'p'c'd'g'u'co r rkhlecwqp'qh'wntcuj qtvr wnguy'w'v'q"32" /"322"Y "qh'cxgtci g'r qy gt"J7\_0'

Gzcev'f "v'j ku"v' r g'qh'hkdgt"co r rkhgt"ku" w'ug'f "k'p"v'j ku"y q'tn'0'U'k'p'i g'r cu"l'hkdgt"co r rkhgt"u{u'ngo "y cu" f guki p'g'f "cpf" w'k'k'f g'f "h'q't"co r rkhlecwqp"qh' h'go v'q'uge'q'p'f "r wnguy"ht'q'o [{"d-MI Y "quek'nc'v'q't" o'H'k'p'o" \*o'N'k'i j v' E'q'p'x'g't'k'p'o-0' U'r c'v'k'n" v'go r q't'c'n' cpf "g'p'g'ti {"ej ct'c'v'g't'k'v'k'eu" q'h' co r rkh'g'f "r ki j v' y cu"o g'c'u'w'g'f 0' [{"d/f q'g'f "NO C" f q'w'd'g'erc'f "r q'r'c't'k' cvkqp" o c'k'p'c'k'p'k'i "r j q'v'p'k'e"et {u'c'n't'q'f /v' r g'hkdgt"o'P'M'V'R'j q'v'p'k'leu+y cu" w'ug'f "h'q't"v'j g'co r rkhlecwqp'0'

K'y cu" f g'v'g'to k'p'g'f "v'j cv'o czko wo "cxgtci g"q'w'r w'r qy gt "ht'q'o "v'j g"co r rkhgt"u{u'ngo "y cu"3; .7"Y "y j g'p"v'j g'r w' r " r qy gt"y cu"4; "Y "y k'j "v'j g'ug'g'f "r qy gt"qh'6"Y 0'J ki j g'u'v'eq't'g'erc'f "r qy gt"t'c'v'k'p' \*EET+qh'2; .57" \*33.8'f D+y cu"t'g'c'ej g'f "cv" o czko wo "q'w'r w'r qy gt."y j k'g"r q'r'c't'k' cvkqp"eq'p't'c'u'v' t'c'v'k'p' \*RGT+" q'h'v'j g"co r rkhgt"y cu"3; .6" f D'0'F w'g"v'q" u'g'h'r j c'ug" o q'f w'v'k'p'gh'g'ev"o q'f g'u'v'ur g'ev'c'n'd't'q'c'f g'p'k'p'i "qh'v'j g"co r rkh'g'f "r wnguy" cu"q'd'ug't'x'g'f "H'k'i 0'3-<t'q'q'v'o g'c'p'us w'c't'g'ur g'ev'c'n' y k'v'j "k'p'et'g'c'ug'f "d'f "5"o"6"po "eqo r ctgf "vq"l'p'r w'w'ug'g'f "ur g'ev'w'o 0'U'g'eq'p'f "j c'to p'k'e"HT'Q'I "o g'c'u'w'go g'p'u'uj qy g'f "v'j cv" co r rkh'g'f "r wnguy"dt'q'c'f g'p'g'f "k'p"v'ko g'ht'q'o "5"hu"ht'q'o "v'j g'quek'nc'v'q't"v'q": 86"hu"o"3.29"r u'c'v'v'j g'hkdgt"q'w'r w' \*H'k'i 0'4-0'C'nu'q." ur g'ev'c'n'cpf "vgo r q't'c'n' dt'q'c'f g'p'k'p'i "qh'r wnguy" f g'g'p'f g'f "q'p"ug'g'f "r q'r'c't'k' cvkqp'0' k'p' c'm'ec'ug'u"co r rkh'g'f "r wnguy" g'z'j k'k'k'g'f " s'w'f t'c'v'k'e"v'j g'p' q't'c'n'r j c'ug"v'j g't'g'ht'g'v'j g'r wng'ej ktr "y cu"l'p'k'c'p'f "ecp"dg'gh'g'ev'k'g'n' "eqo r g'p'uc'v'g'f "f qy p'v'q" f w'c'v'k'p'v'j cv' k'u" u'j qt'vtg"v'j cp" quek'nc'v'q't" r wng"fwcvkqp'0' T'g's w'k'g'f "i tq'w'r "f g'rc {"f k'ur g't'uk'p' "h'q't" f k'ur g't'uk'p' "eqo r g'p'uc'v'k'p' "y cu" c'nu'q" e'c'r'w'v'g'f 0'H'k'p'c'm'f. "k'y cu" g'x'c'w'c'v'g'f "v'j cv"lp"v'j ku"ec'ug."ej ktr g'f {"f k'ur g't'uk'p' "o k't'q'tu"ct'g"o q'u'v'w'k'c'd'g' "h'q't"qr v'ko c'n'eqo r t'g'u'k'p' "qh" co r rkh'g'f "r wnguy"0'H'k'p'c'n'co r rkhgt"u{u'ngo "y ku"dg' w'ug'f "cu"c"j ki j "r qy gt"cpf "j ki j "r wng" s'w'erk'f "rc'ug't"u{u'ngo "h'q't"ht'v'j g't" p'p'k'p'g'c't"qr v'k'eu"z'z'r g't'ko g'p'u'0'



H'k'i 0'30'U'r g'ev'c'n'g'x'q'w'k'p'qh'co r rkh'g'f " r wnguy" j g'p"co r rkh'g'f "v'q"3; .7"Y "q'w'r w'r r qy gt"0'

H'k'i 0'40'U' I "HT'Q'I "o g'c'u'w'g'f "cpf"t'g'v'k'g'x'g'f "t'c'eg'u'q'h" co r rkh'g'f "r wnguy"cpf "vgo r q't'c'n'k'p'g'p'k'f "r t'q'k'g'c'v' o czko wo "q'w'r w'r qy gt"0'

[3\_ E0U'c't'c'g'p'q. 'g'v'c'n'0'V't'g'p'f u'lp"j ki j /r qy gt'w'nt'c'hu'v'rc'ug'tu. 'f'p'v'g't'p'c'v'k'p'c'n'U'q'k'g'v'f "h'q't"Q'r v'k'eu"cpf "R'j q'v'p'k'leu. 'X'q'p'0; : 57.'r 0; : 572Z" \*4238-0' [4\_] [ 0\ c'q'w'g't. 'g'v'c'n'0'U't'g'v'j g't/h'g'g'j ki j "g'p'g'ti {"p'p'k'p'g'c't"co r rkhlecwqp'qh'h'go v'q'uge'q'p'f "r wnguy"lp"t'q'f /v' r g'hkdgtu. 'Q'r v'0'N'g'w'0'55\*4+ /329632; \*422: -0' [5\_] 'R'0'U'k' q't'g'p'na. 'Y 0'H'v' 'H'Y k'g. 'P'p'k'p'g'c't'w'nt'c'hu'v'hd'g't'co r rkhgtu'd'g'f q'p'f "v'j g'f i c'k'p'p'c't't'q'y k'p'i "h'o k'v'Q'r v'c'c. '8\*32+.'354; /3555" \*423; -0' [6\_] [ 0\ j c'p'i. "g'v'c'n'0'J ki j /r qy gt"r't'g'ej ktr "o c'p'ci g'f "co r rkhlecwqp'qh'ek'w'c'n'f "r q'r'c't'k' g'f "r wnguy" w'k'p'i "j ki j /f k'ur g't'uk'p' "ej ktr g'f "o k't'q'tu"cu"c" " eqo r t'g'u'q't. 'Q'U'C'Eq'v'p'w'w'o. '5\*9+.'3; : /3; : : \*4242-0' [7\_] [ 0\ j c'q. 'D'0'0'F w'j co "cpf" 'H'Y 0'Y k'g. 'I' g'p'g't'c'v'k'p'qh'372"Y "cxgtci g"cpf "3"O Y "r g'c'n'r qy gt"r'k'eq'uge'q'p'f "r wnguy"ht'q'o "c"t'q'f /v' r g'hkdgt"o c'ug't" quek'nc'v'q't"r qy gt"co r rkhgt. 'L'Q'U'C'D. '53\*3+.'55/59" \*4236-0'

# KXGUVK CVKQP'QH'VJ G'F[ P CO KĒUQH'QRVĒCN'F CO CI G'WUKPI " RWO R/RTQDG'URGE VTQUE QR[ "

Ckxctcu'Rg kwku.'O knēu'Xgpi tku"

Ncugt'Tgugctej 'Egpgt.'Xkpkwu'Wpkxgtuk\.'Nksj wcpk< "  
 c k x c t c u f g e k w k u B H f w f a w h "

"

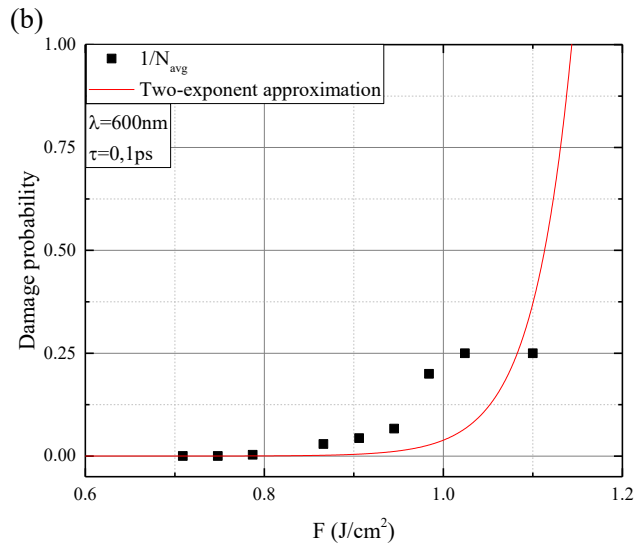
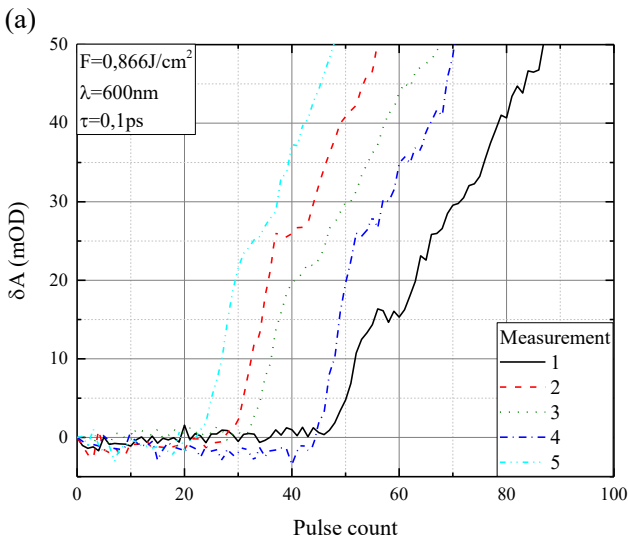
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Ej cpi g'qh'f khtgtpv'cnduqtr v'kp"ur gevte'qh'cp"grgo gpv'chgt"gzekcvkp"y kj "hgo vqugeqpf "r wugu'y cu'ej qugp"cu' lpf lecvkp"qh'ktgxgtukdrg" "f co ci g'0Hqt'ij cv'c"v'f r leci'r wo r /rtqdg"ur gevteqer { "o gcuwgo gpv'y cu'o qf khtg "v'gti kugt" ur gevte'chgt "gcej "gzekcvkp"r wug'cpf "ij gp'ecreawg"ij g'f khtg ppeg"htqo "ij g'htuv'r wug'v'ij k'ij g'uco r rg<

$$\delta A(\lambda, N) = \Delta A_0 - \Delta A_N, \tag{1}$$

y j gtg"l'ku'y cxgrgpi ij . "N'o'pwo dgt'qh'r wugu'cpf "ΔA"o'f khtgtpv'cnduqtr v'kp0Ugs wgpv'cni'r wug'v'c'ku'qh'r tgekugf "100" r wugu'r gt "gcej "y qwf "tgcej "ij g'o cvgtkci'cpf "ij gp'y g'uko r n' "ecreawg"ij qy "o cp{ "r wugu'y gtg'pggf gf "v'lpf weg"qr vceci' f co ci g'0'

O gcuwgo gpv'y gtg'r gthqto gf "y kj "0,2mm"ij kengpu'hwgf "uktec"eqxgtkpi "i rcu0'k' "Hki 0'3" \*c+"c" v'f r leci'ugv'qh' tguwuu'ku'ij qy p0'Vj g'o qo gpv'qh'f co ci g."y j gp"ΔA"dgeqo gu'i tgcvt "ij gp"0'cpf "i tqy u'hw'ij gt "uq"y g'f qp0'eqphwug'k' y kj "pqkugu+ku'ergctn' "f kxkpev'xg'htqo "ij g'i tcr j 0'Dgecwug"ij tguj qrf "f gr gpf gpe{ "qp"r wug'eqwv'ku'tcvj gt "uecvgtgf ."y g' ecp'eqpenf g'ij cv'qr vceci'f co ci g'ku'c'r tqdcdk'k' r tqegu0'



Hki 030F khtg ppeg'qh'f khtgtpv'cnduqtr v'kp"ur gevte'cv'λ = 600nm" f gr gpf gpeg"qp"r wug'eqwv'c="cp'lp'xgtug"qh' cxgtci g'eqwv'qh'r wugu'f gr gpf gpeg"qp"ukpi rg'r wug'hwgpeg"cpf "cr r tqzko cvkp"0'

Cp"lp'xgtug"qh'cxgtci g'eqwv'qh'r wugu'N<sub>avg</sub> "tgs wktgf "v'lpf weg"qr vceci'f co ci g'ecp"dg'eqpukf gtgf "cu'c'r tqdcdk'k' "v'f co ci g'ij g'uco r rg"y kj "ij g'xgt{ "htuv'r wug'0'k' "Hki 0'3" \*d+"v' cv'r tqdcdk'k' "u'f gr gpf gpeg"qp"hwgpeg"ku'r r'wgf "cpf" tguwuu'ctg"cr r tqzko cvgf "y kj "y q/gZR qpgpv'hwpev'kp0'Vj ku'ko r n'gu'ij cv'ij gtg'ctg"y q'uei gu'qh'f co ci g'r tqdcdk'k' "cpf" cv'ij ki j gt "hwgpegu'k'ku'o qtg'f gr gpf gpv'qp" f g'puk\ "qh'uwtcegu'f ghgeu." y cv'ecp'cev'cu'f co ci g'r tgeuwuqtu."tc'ij gt "ij cp" r tqr gt'v'gu'qh'o cvgtkci'kugf0'Vj g'cr r tqzko cvkp"cuq"cmqy u'v'g'x'c'w'v'cv'y j cv'o k'plo c'ni'hwgpeg"c'egt'v'kp'uco r rg'y qwf" f ghkpgk' "dg'f co ci gf "r tqdcdk'k' "ku'gs wcn'v'q"1+0'lp'qwt'ecug'k'y cu'F<sub>min</sub> = 1,143J/cm<sup>2</sup>0

# PWO GTĒ CNNĻ 'RTQE GUUGF 'ĶP VGTHGT QO GVTĒ 'PQP NĶP GCT' TGHF CE VKXG'ĶP F GZ'O GCUWT GO GP VU'CV'5462po'''

I cwf gpkulcpuqpcu<sup>3</sup>.Tlo cpvcu'Dwf tk pcu<sup>3,4</sup>. 'Ct pcu'Xctcpcxk kw<sup>3</sup>'''

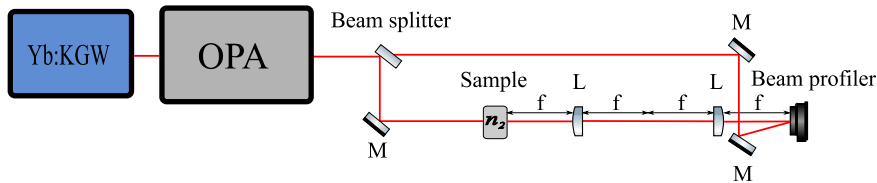
<sup>3</sup>Ncuġt'Tgugctej 'Egpvġt.'Xlġpkwu'Wpġxġtukv\.'Nġj wcpġc''

<sup>4</sup>Nġi j v'Eqpġxġtukp.'Xlġpkwu.'Nġj wcpġc''

i cwf gpkulcpuqpcuB {cj qqĒqo''

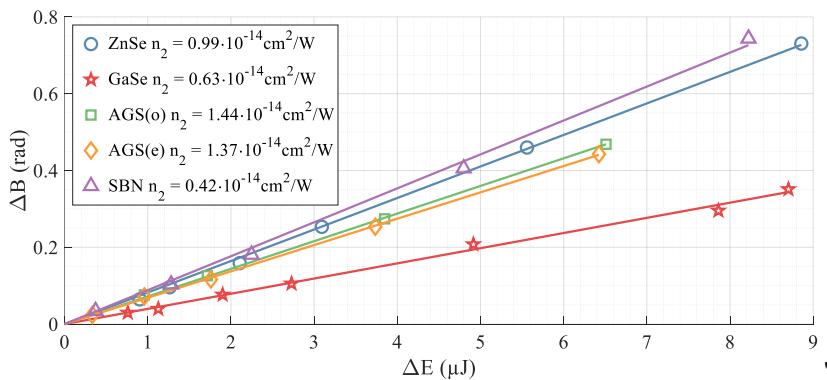
P qpġpġct'tġhtcevxġg'ġpf gZ''p<sub>4</sub>+f' guetġdġu' j qy 'y j g'tġhtcevxġg'ġpf gZ'qhi'c'o g'f kwo 'f gr ġp'f u'qp'y j g'ġp'vġpukv\ 'qhi'ġki j v'0 Vj ku'r ctco ġvġt'ku't ġur qpukġrġt' o cp { 'r j ġp'qo ġp'c'qhi'p'qġpġpġct'qr vġeu'cp'f'ġp' o q'f ġġġpi 'uweġ' 'r j ġp'qo ġp'c'k'ku'ko r q'vcp'v' vq'ġp'qy 'y j g'o qu'v' r tġeġuġ'xcnġg'qhi'p<sub>4</sub>0Rqr wrt' o ġy q'f u'ġt' o ġcuwtġpi 'p<sub>4</sub>. ġġġg' \ /uecp'ġ3\_ 'ct'g'dcug'f' q'p'y j g'cuuwo r vġp'p'y c'v' rġuġt'dġco 'cp'f' r wuġ'r tġġġu'ct'g'I c'wukcp'0ġ' r tceveġ'y ku'ku'uqo ġvko ġu'f'ġġġe'w'v'q'ġw'ġġm' ġur ġeġcm' 'ġp'y j g'o ġf /ġp'ġt'ct'g'f' " \*O KĲ+y c'xġġġpi y j 't'cpi g'dġvy ġġp'4 o "cp'f' "42 o . 'y j g'ġt'g' y j g'ġt'g'ku'c' u'j q't w'c' i g'qhi'ġp'ġt' o c'vġp' 'cdq'w' p<sub>4</sub>0' Vj g'ġġt'g' "p<sub>4</sub>" o ġcuwt'go ġp'w' y ġj 'ġp'ġmf' g'f' t'ġcġġr c'vġcġ'cp'f' v'go r q'tcġġ'ġp'vġp'ukv\ 'f' ġu'ġġd'w'ġp'p'u' 'ct'g'qhi' t'ġc'v'ko r q't'v'p'eg'0'

Y j g'o ġcuwt'g'f' "p<sub>4</sub>" d { 'w'ukpi 'cp'ġp'vġt'ġt'qo ġvġt' v'q'f' ġv'ġc'v'c' 'v'c'v'ġ'q'p' /czku'p'qġpġpġct' 'r j cug' u'j ġġ'v'D' 'ces vġt'g'f' 'ġp'c' 'u'co r ġġ' " cp'f' "ġp'ġmf' ġpi " o ġcuwt'g'f' "ur c'vġcġ' cp'f' " v'go r q'tcġġ' ġp'vġp'ukv\ 'f' ġu'ġġd'w'ġp'p'u' d { "p'wo ġġe'cm' " u'ko w'v'v'ġpi " y j g' "ġzr' ġt'ko ġp'0' C" u'ko r ġġġġf' 'qr vġcġġ'ġej go g'qhi'y j g'o ġcuwt'go ġp'v'ku'ġy q'p'ġp'ġġi 030Hq't'5462po 'ġki j v'ġ' ġp'ġt'c'v'ġp' y j g'w'ug'f' 'c'ġ'ġd'ġm'ġt'g'g'qr vġcġġ' r ctco ġt'le'co r ġġġġt' "QRc+' r wo r g'f' d { 'c'ġ'ġo v'q'ġe'q'p'f' [ d-MI Y 'ġuġt' '0Rj ct'qu'0H'qo 'y j g'ġp'vġt'ġt'g'p'eg' r c'wġt'p' y j g'q'd'v'ġp' c'w'ġt'ġe'g'qhi'ur c'vġcġ'ġ j cug'f' ġġġt'g'p'eg' d'ġvy ġġp'v' y q'ġp'vġt'ġt'ġpi 'y c'x'ġu'd { 'w'ukpi 'ġġw'ġt' v'c'p'u'ġt' o ġy q'f' "ġ4\_0Vq'c'x'q'ġf' 'y j g' ġġġe'w'qhi'ġp'ġct' y c'x'ġt'q'p'v'f' ġu'q't'v'ġp'p'u' y j g'q'd'v'ġp' c'ġ'ej c'pi g'qhi'D' \*ΔB+ġt'qo 'c'ġ'ej c'pi g'qhi'y q'r j cug'w'ġt'ġe'g'w'c'v'f' ġġġt'g'p'v'r w'uġ' " ġp'ġt' ġu'0J ġt'g'ΔB' y c'u'ġ'w'p'f' d { 'ġw'ġpi 'ur c'vġcġ'ġp'vġp'ukv\ 'f' ġu'ġġd'w'ġp'p'u' qhi'c' d'ġco 'c'v'y j g' 'u'co r ġġ'v'q'c' r j cug'f' ġġġt'g'p'eg'w'ġt'ġe'g'0'



Hġi 030Ulo r ġġġġf' 'qr vġcġġ'ġej go g'qhi'y j g'o ġcuwt'go ġp'0J ġt'g'N'0' 'eqp'xġt' ġpi 'ġġp'u' ġi'0' ġġe'cġġ'ġpi y j 'qhi'c' ġġp'u' 'O' /' o ġt'q't'0'

Hġt'uv'y j g' uweeġuġw'ġm' [ġ5\_ o ġcuwt'g'f' "p<sub>4</sub>" qhi' ġw'ug'f' "u'ġġe'c' " \*2.74 · 10<sup>-16</sup> cm<sup>2</sup>/W+ c'v' 3252po 0' Vj ġp' y j g' r t'ġe'ġġf' g'f' "v'q" o ġcuwt'g' p'Uġ. 'I c'Uġ. 'CI U'w'ukpi 'q't'f' ġp'ct' { '\*q'+cp'f' 'ġz'v'c'q't'f' ġp'ct' { '\*ġ'+r q'ġt'ġ' g'f' 'ġki j v'+cp'f' 'UDP' 'u'co r ġġu'c'v'5462po 0' Vj g' t'ġu'w'ġu'ct'g' u'j q'p'ġp'ġġi 040' Vj g'xcnġg'qhi'ΔB' y ġt'g'q'd'v'ġp'g'f' 'c'v'f' ġġġt'g'p'v'r w'uġ' ġp'ġt' i { 'ġ'ej c'pi ġu'ΔE'0' Qd'v'ġp'g'f' ΔB' xc'w'ġu' " y ġt'g'eq't'ġe'ġf' 'c'ee'q't'f' ġpi 'v'q' y j g'o ġcuwt'g'f' 'r w'uġ' u'j c'r g'cp'f' 'y j g'p<sub>4</sub> y c'u'ġ'w'p'f' 'ġt'qo 'ġġp'ġct'ġ' ġġw'ġf' 'ġzr' ġt'ko ġp'v'c'ġ'f' c'v' y ġj 'c' " ġz'ġf' 'ġp'v'ġt'eg' r v'xcnġg'qhi' ġt'q'0'Uqo g'qhi'q'w' t'ġu'w'ġu' y j g'ġ'ko ġr'ct' v'q' y j g'q'p'ġu'ġ' k'xġp'ġ' y j g'ġe'ġp'v'ġġe' ġġw'ġf' c'w'ġt'g' [6\_ġ7\_0'



Hġi 040Qd'v'ġp'g'f' ΔB' qhi'f' ġġġt'g'p'v'o c'vġt'ġcġ'ġ'cp'f' 'y j ġt' p<sub>4</sub>0F' qu'0' 'ġzr' ġt'ko ġp'v'cġġ'f' q'p'w' 'ġġp'g'0' ġġp'ġct' ġġk'0'

ġp' "eq'p'ġw'uk'p'p' y j g' r t'ġr' ct'g'f' "c" o ġy q'f' "v'q" ġp'ġmf' g' t'ġcġġ' v'go r q'tcġġ' cp'f' "ur c'vġcġ' ġp'vġp'ukv\ 'f' ġu'ġġd'w'ġp'p'u' qhi'ġki j v'ġp' p<sub>4</sub>" o ġcuwt'go ġp'w'cp'f' "uweeġuġw'ġm' [ o ġcuwt'g'f' "uqo g'r'qr wrt' "KĲ" o c'vġt'ġcġ'ġ'c'v'5462po 0' Vj ku' o ġy q'f' "eq'w'f' "d'g'w'ug'f' "v'q'ġw'ġt' v'ġ' ġt' " o ġcuwt'g'p<sub>4</sub>ġp' y j g'O KĲ. 'y j g'ġt'g' uweġ' o ġcuwt'go ġp'w'ct'g'p'ġġf' g'f' 0'

[3\_0'0Uj ġġm'dc'j c'g.'C'0C'0'U'c'k'f.'cp'f' 'G'0'Y'0'X'c'p'U't' { ġp'f' .J ġi j /uġp'uk'x'k'x\.'ġ'k'pi ġġ/d'ġco 'p<sub>4</sub>'o ġcuwt'go ġp'w' 'Qr' v'0'N'ġw'036.'; 77; 79\*3; ; : 40'  
 [4\_0'0'V'c'ġ'g'f' c.'J'0'ġ'p'c'cp'f' 'U'0'ġ'q'dc' {c'uj k'ġ'w'ġt'ġt'v'c'p'u'ġt' o ġy q'f' qhi'ġt'ġpi g'r'c'wġt'p'c'p'cġ' u'ku'ġt' 'eqo r wġt' /dc'ug'f' 'qr q'ġ' t'c'j { 'cp'f' 'ġp'vġt'ġt'qo ġt' { . 'ġ0'  
 Qr' v'0'U'q'e'0'c' o 094.'378/382\*3; ; : 44'  
 [5\_0'F'0'0'k'c'o . 'T'ġx'ġy 'cp'f' 'c'u'ġu'wo ġp'v'qhi' o ġcuwt'g'f' 'xcnġg'qhi'y j g'p'q'p'ġp'ġct' t'ġhtcevxġg'ġpf gZ' 'eq'ġġġe'ġp'v'qhi'w'ug'f' 'u'ġġe'c' . 'C'r r'0'Qr' 059.'768/772\*3; ; : 40'  
 [6\_0'V'0'T'0'G'p'ur'g' { 'cp'f' 'M'0'D'0'P' ġcġ' 'W'ġt'c'ġ'w'p'q'p'ġp'ġct' t'ġhtcevxġg' o ġcuwt'go ġp'w'qhi'ġp'ġt'ct'g'f' 'v'c'p'w' v'ġ'k'pi " o c'vġt'ġcġ'ġ'ġp' y j g'o ġf' /y c'x'ġ'ġp'ġt'ct'g'f' 0'Qr' v'ġeu'  
 ġzr't'ġu'ġ'49.'59; 62/59; 73\*423; 40'  
 [7\_0'Y'0'N'ġ'g'v'c'ġ'0' o ġcuwt'go ġp'w'qhi'p'q'p'ġp'ġct' t'ġhtcevxġg'ġp' y j g'o ġf' /ġp'ġt'ct'g'f' o c'vġt'ġcġ'ġ' pġi g'R'4'cp'f' 'C'i I c'U4.'C'r r'ġġf' 'Rj { u'ku'D'345.'; 4\*4239'0'

# LABEL-FREE IMAGING OF BIOLOGICAL TISSUE USING WIDEFIELD SECOND-HARMONIC GENERATION MICROSCOPY

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Second-harmonic generation (SHG) microscopy is a nonlinear imaging technique based on the frequency-doubling of photons interacting with non-centrosymmetric structures. It enables label-free *in vivo* and *in situ* visualization of non-centrosymmetric biopolymers such as collagen in most structural tissues and myosin filaments in the sarcomeres of striated muscles. Structural label-free nonlinear imaging emerges as a successful tool for faster biomedical diagnostics, while quantitative polarimetric imaging opens up new ways for more detailed tissue characterization.

The SHG process requires high intensity coherent light. For this reason, imaging is commonly performed by raster-scanning a tightly focused femtosecond oscillator beam and acquiring the image pixel-by-pixel using a single-element photodetector. The frame rate is thus limited by the laser scanning speed. Increasing availability of robust, affordable, high-power, femtosecond lasers operating at MHz rates has stimulated the advancement of widefield SHG microscopy. Widefield microscopy does not require scanning and therefore enables real-time imaging of large samples [1]. A high frame rate is achievable because a large imaging area is exposed to short high intensity laser pulses and the image is obtained as a single frame using a camera. It should be noted that laser parameters need to be carefully optimised because high intensity laser radiation eventually damages the sample. The signal level can also be increased by using a higher repetition rate, leading to higher average power, which eventually causes photobleaching [2].

The purpose of this work was to develop a widefield microscope and to demonstrate its performance by imaging label-free biological samples. A *PHAROS* high-repetition-rate amplified laser system was used for evaluation of the developed widefield microscope by imaging label-free rat skeletal muscle tissue (Biomax RAT901a). The laser parameters at the sample were: 1 W average power, 100 kHz repetition rate, 680  $\mu\text{m}$  beam diameter ( $1/e^2$ ), energy density of 5.5  $\mu\text{J}/\text{cm}^2$  and a peak intensity of 19  $\text{GW}/\text{cm}^2$  using 290 fs pulses. We were able to produce 410  $\mu\text{m} \times 485 \mu\text{m}$  images with sub-micron resolution and with no observable damage to the sample. The image in figure 1(a,b) exhibits a periodic structure of the sarcomere anisotropic A-bands, which are clearly distinguishable from the dark isotropic I-bands due to SHG signal from myosin nanomotors. Figure 1(c) shows the SHG intensity profile of 20 sarcomeres along a myofibril, with the average sarcomere length of approximately 1  $\mu\text{m}$ .

The work shows that widefield SHG microscopy provides sub-micron resolution over a large imaging area. The setup will be used to optimize novel high-repetition-rate amplified laser sources for nonlinear microscopy.

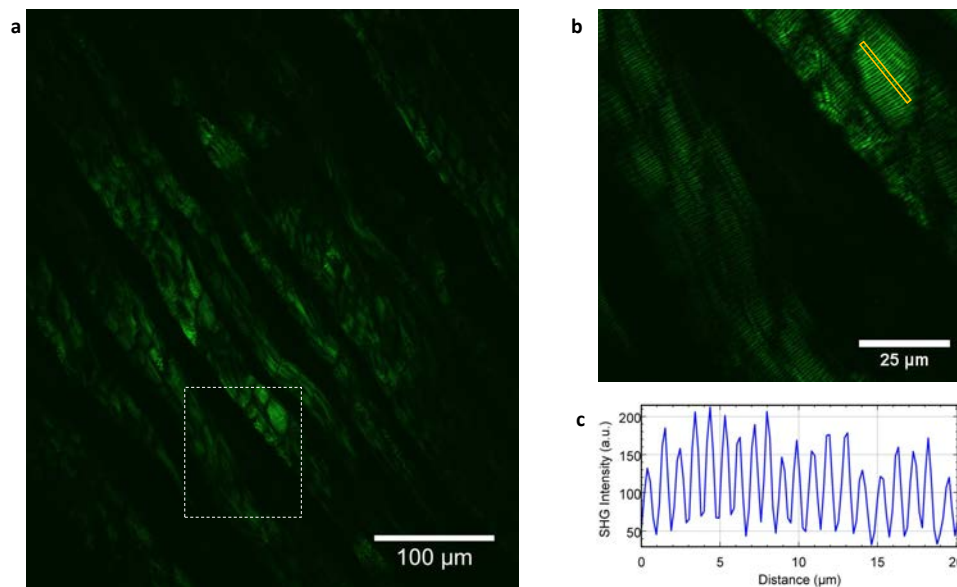


Fig. 1. Widefield SHG image of a fixed label-free rat skeletal muscle. (a) The entire 410  $\mu\text{m} \times 485 \mu\text{m}$  image area. (b) 100  $\mu\text{m} \times 100 \mu\text{m}$  cropped image area, indicated in (a) by the dashed line. (c) SHG intensity profile along the myofibrilis in the yellow rectangle.

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# INVESTIGATION OF OPTIMIZATION AND MANUFACTURE POTENTIAL FOR SCULPTURED THIN FILM BASED ACHROMATIC WAVEPLATES

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Sculptured thin film technology allows to produce nanostructured coatings featuring various properties, like certain porosity and anisotropy [1]. By optimizing these and other parameters, one can obtain coatings with different optical characteristics, which can be adapted for optical element realization. Furthermore, these coatings possess excellent resistivity to laser irradiation when silica material is used and can be deposited directly onto microlaser system components [2]. Therefore, this technology is a potential research area for microlaser component manufacture.

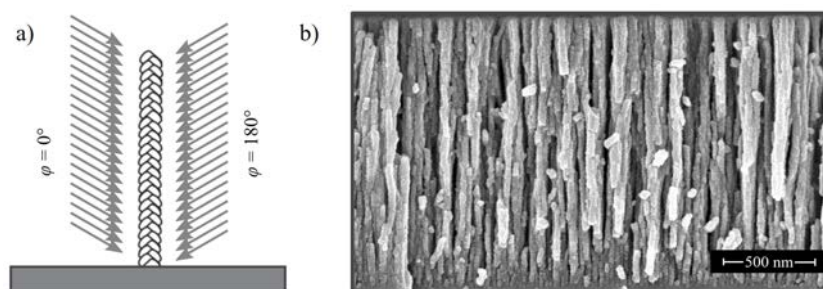


Fig. 1. (a) Illustration of serial bideposition technique involving rapid 180° substrate turns. (b) Cross-sectional SEM image of SiO<sub>2</sub> sculptured thin film.

In this work, however, the scope of investigation was limited to achromatic waveplates. Thus, the main objective was to examine the optimization and manufacture potential for sculptured thin film based achromatic waveplates. The problem was approached by utilizing anisotropic properties of serially bideposited (see Fig. 1) orthogonally birefringent SiO<sub>2</sub> multilayer structures (see Fig. 2). Due to the existence of unique Kramers-Kronig relations for transmission amplitude coefficient  $\tau$  [3], different transmittance  $T$  band-gaps for S and P polarised radiation result in corresponding phase shift differences, which allow to compensate for natural dispersion (see Fig. 2). Taking full advantage of this mechanism, achromatic waveplate designs were optimized employing Dlib global optimization C++ library routines [4].

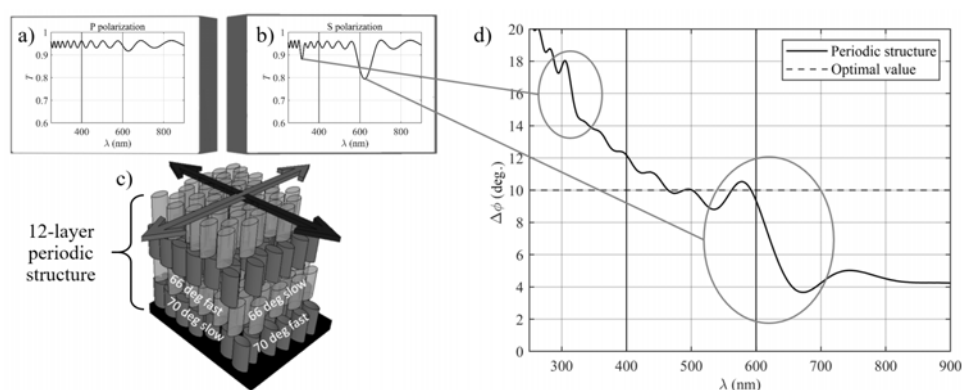


Fig. 2. Differential phase compensation mechanism. (a) and (b) Transmittance spectra for P and S polarised radiation. (c) Example of orthogonally birefringent periodic structure. (d) Phase difference spectrum.

The main source of error in manufactured waveplate optical and phase characteristics was determined to be caused by inaccurately chosen birefringence values and deposited layer thickness errors, which reached 7,5%. Nevertheless, the examination of a more robustly designed waveplate allows to conclude that with accurately chosen birefringence values a functioning achromatic waveplate can be successfully manufactured.

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**IPXGUVK CVKQP'QH'TGNCVKQP'DGVY GGP'QRVKECN'TGUKUVKXK[ ''  
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 EQCVKPI U'**

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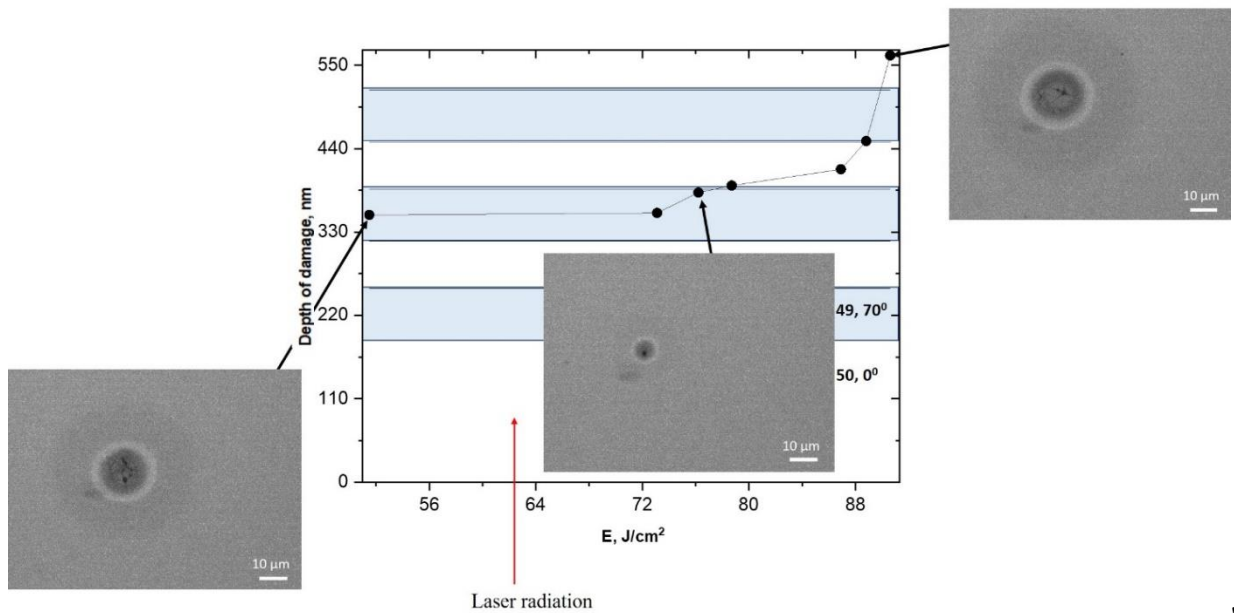
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 , wi pg(pqtmw)B hno e0w'

''

Qr vlecn'eqcvkpi u'ctg'wugf 'vq'f kt gev' cpf 'eqpvtqn'rcugt/i gpgtcvgt 'tcf kcvkqp'0Cv'r tguv'p'v'j g'g'ctg'kpetgculpi 'f go cpf u' qp'j ki j 'r gthqto cpeg'eqcvkpi u' hgcwtkpi 'uvcldkxk' 'qh'v'j g'kt'qr vlecn'r c'tco gvtu' c'pf 'v'j g'j ki j guv'r quukdr'g' t'gukucpeg'v'q'rcugt' tcf kcvkqp'0Uewr wugf 'v'j kp'hko u'o c' { 'dg'wugf 'v'q' hqto 'eqcvkpi u'y kj 'c'j ki j 'rcugt' / kpf wugf 'f co ci g'v'j tguj qrf 'NKF V+0Uvej ' eqcvkpi u'j cxg'c' r qtqwu' pcpqutwewt'g' c'pf 'ctg' hqto gf 'd' { 'tqcvkpi 'v'j g' uwdutcv'g' c'v'cp' qdrks w'g' cpi ng' kp'v'gto u' qh'xcr qt 'hwz'0' J qy gxgt. 'r qtqkxk' 'ecwugu'v'j g'eqcvkpi 'v'q' cduqtd' y cvgt' c'pf 'v'j g'j cto hwn'r ct'v'eng'u' hqto 'v'j g' g'pxk'k'qpo g'p'v'v'j wu'kp'uc'v'k'q'p' qh'v'j g'eqcvkpi 'qt' cml'grgo g'p'v'o wu'v'dg'ko r rgo g'p'v'gf 'j3\_0'

Vj g'clo 'qh'v'j ku'uwf { 'y cu'v'q' l'pxguk' cv'g'v'j g'f gr g'p'f g'peg'qh'v'j g'qr vlecn't'gukucpeg'qh'p'cpqutwewt'gf 'uk'k'eq'p' qz'k'f'g' dcugf 'D'ci i 'o k'tqtu'qp' uco r ng' u'qt'ci g'eqpf k'k'qpu'0V'j g'utwewt'gu'qh'v'j g'o w'k'k' { g't'eqcvkpi '\*72' r { g'tu' y g'tg' hqto gf ' wulpi 'gr'ev't'p' dgco 'g'xcr q'c'v'k'q'p' v'gej pqmji { 'c'v' | g'tq'f'gi tgg' c'pi ng' \*f' g'pug. 'j ki j 't'g'ht'ce'v'x'g' k'p'f'gz' r { g't+' c'pf 'u'g'x'g'p'v' / f'gi tgg' c'pi ng' \*r' q'v'w. 'r'qy 't'g'ht'ce'v'x'g' k'p'f'gz' r { g't+'0'V'q' f'g'v'to k'p'g'v'j g' g'p'x'k'k'q'p'o g'p'v'c'n'ko r c'ev' q'h'r q'tq'wu'eqcvkpi u. 'v'j tgg' uco r ng'u' y g'tg' r r'w'egf 'k'p' c'p' qz' { i g'p' g'p'x'k'k'q'p'o g'p'v' \*d' { 'k'p'g'ev'k'pi 'Q4' i cu' k'p'v'q' c' r r'c'u'k'e' d'ci +' q'v'j g'tu' v'j tgg' k'p' c' f' t { 'c'k' g'p'x'k'k'q'p'o g'p'v' k'p' c' i r'u'u' f'g'uk'ec'v'k' k'p' y j k'ej 'v'j g'eqcvkpi u' y g'tg' j g'f 'y kj 'uk'k'ec' i g'n'v'q' o c'k'p'v'k'p' o q'k'uw't'g' cu' r'qy 'cu' r quukdr'0' Uwdugs w'g'p'v'f. 'p'q'g' eqcvkpi 'y cu' t'go q'x'g'f 'h'qto 'v'j g' k'p'k'k'c'n' g'p'x'k'k'q'p'o g'p'v' g'cej 'y g'gn' c'pf 'ur' g'ev't' c'pf 'rcugt' t'gukucpeg' o g'cu'w't'go g'p'v'v'j g'tg' r g'th'qto gf 0'

NKF V'v'gu'v'3/q'p'3' o g'cu'w't'go g'p'v'v'j g'tg' b' c'f' g'w'uk'pi 'P'F <1' C'I 'rcugt' r w'ug'u' y kj 'r c'tco g'v'tu' <' ?' '577' p'o .'' '' '5' p'u. 'ur' q'v' f'k'co g'v't' '' '92' U'o 0'V'j g'q'd'v'c'k'p'f' t'g'u'w'u'uj q'y 'v'j c'v'v'j g'NKF V'q'h'v'j g'ue'w'r w't'c'n'le'q'c'v'k'pi u'ngr' v'k'p'f't' { 'c'k' h'q't'v'j t'g'g' y g'g'm'u'k'u' r'ti g't' c'pf 't'g'cej' g'u'730' 'L'eo 4' \*'u'g'g' 'H'k' 03' +y j k'g'c' 'eqcvkpi 'u'v'q't'g'f' k'p'v'j g'qz' { i g'p' g'p'x'k'k'q'p'o g'p'v' h'q't'v'j g' u'co g'r' g't'k'q'f' 'q'h'v'ko g' /'330' 'L'eo 4'0''



Hk' 030'V'j g'f'gr g'p'f'g'peg'qh'v'j g'f'co ci g'et'cv'gt'f'gr'v'j 'k'p'v'j g'ue'w'r w't'c'n'le'q'c'v'k'pi 0U'co r ng'ngr' v'k'p'f't' { 'c'k' h'q't'v'j t'g'g' y g'g'm'u'0'

Vj wu. 'c'ue'w'r w't'c'n'le'q'c'v'k'pi 'u'v'q't'g'f' k'p'c'f't' { 'c'k' g'p'x'k'k'q'p'o g'p'v'ku' o q't'g' t'gukuc'p'v'v'q'rcugt' t'cf' k'cv'k'q'p' c'pf' t'gukuc'peg' t'go c'k'p'u' eq'p'uc'p'v. 'd'g'ec'w'ug'v'j g'eqcvkpi u'v'q't'g'f' k'p'c'p'q'p'n' q'z' { i g'p' g'p'x'k'k'q'p'o g'p'v'v'j cxg'v'j g'qz' { i g'p' x'c'ec'p'e' { a. 'y j k'ej 'ec'w'ug'f' f'co ci g' d' { 'p'c'p'q'ue'q'p'f' r' w'ug'u'j4\_0'V'j ku't'g'ug'c't'ej' 'u'j q'y g'f' 'v'j c'v'c'f't' { 'c'k' g'p'x'k'k'q'p'o g'p'v'ku'd'g'w'gt' r' r'c'eg'v'q' u'v'q't'g'f' r' q't'q'wu'uk'k'ec' d'c'ug'f' '' o w'k'k'c' { g't'eqcvkpi u'v'j c'p'c'p'q'p'n' q'z' { i g'p' g'p'x'k'k'q'p'o g'p'v'o

[3] FOP i w'g'p. 'H'go v'q'ue'q'p'f' r' w'ug'f'co ci g'v'j t'g'uj q'rf' u'q'h'f' k'g'g'ev'k'e'eqcvkpi u'k'p'x'c'ew'wo 0Qr 0Gzr t'gu'u'3; .78; 2/78; 9\*4233+0''  
 [4] 'U'OR'c' g't'p'q'x'0'g'v'c'n' Q'r vlecn'r q'r g't'v'gu'q'h'v'j qz' { i g'p' x'c'ec'p'el'gu'k'p'J' h'Q4'v'j k'p'hko u'uwf' k'g'f' d' { 'c'du'q't' v'k'p' c'pf' h'wo k'p'g'ue'g'peg' r' g'ev't'q'ue'q'r' { . 'Q'r 0Gzr t'gu'u' 48.'3982: /39845\*423: +0'



**ET[ UVCNNK CVKQP 'DGJ CXKQT 'QH'VK/CP KWO 'QZKF G'VJ K'P 'HKNO U'  
 F GRQUK/GF 'D[ 'RNCUO C'GP J CPEGF 'CPF 'Q\ QP G/DCUGF 'CVQO K'  
 NC[ GT 'F GRQUK/QP "**

F ctklc'Cutcwumf v<sup>3</sup>. "O cpvcu'F tc| f {u<sup>3</sup>. "Tco wku'F tc| f {u<sup>3</sup>

<sup>3</sup>O letqqr vceci'eqo r qppgw'rdqtcvqt { . 'Egpygt'ht'Rj { uleci'Uelgpegu'cpf 'Vgej pqmji { . 'Ucxcpqtk 'cx0453.'Xkpkwu'NV/  
 24522. Nkj wcpkc "

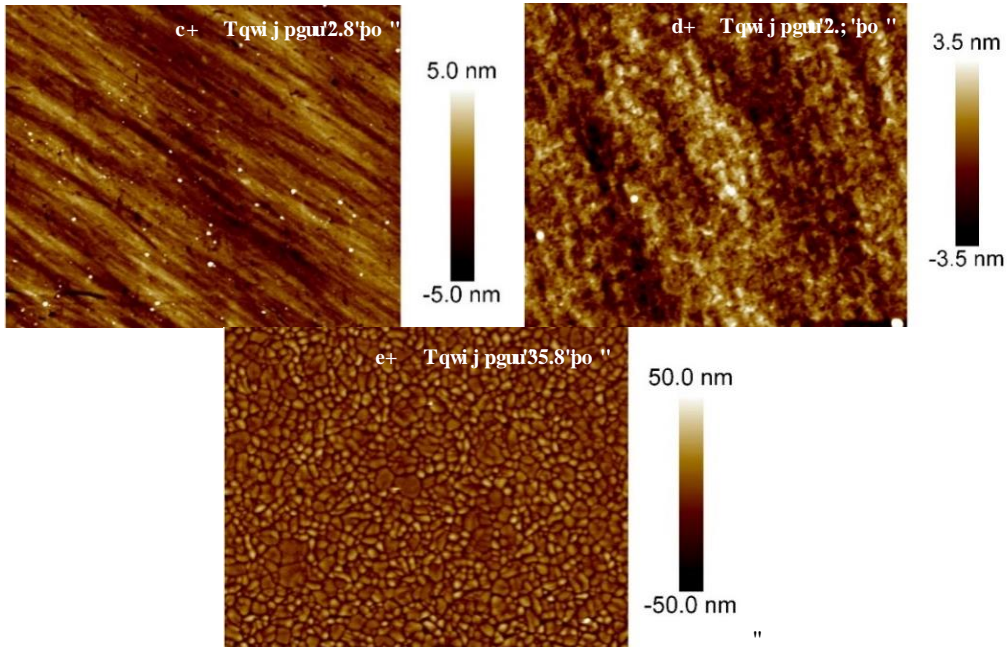
f ctklc'Cutcwumf v<sub>B</sub> hvo e0w'

"

Qr vceci'eqcvkpi u'ctg'c"o wnkrc { gt 'f lgrgextle" j ki j "cpf "mcy "tghtcevkxg" kpf gz "o cvgtkcn" y kp "hko "utvewtgu'0Vj g { "ctg" y kf gn { "wugf "hqt" f lgrgextle" o ktqtu. "cpvktghgexkxg" eqcvkpi u. "r qmctk gt u. "hkgtu" gve0" y cv'ctg" pgeguact { "eqo r qppgw'lp'rcugt" u { vgo 0'Vj g "rcugt" kpf wegf "f co ci g" y tguj qnf "qh" cp" qr vceci'eqcvkpi "f gr gpf u'qp" y g' s wcrkx { "qh" y g' y kp "hko 0'Guugp'vkn" ej ctcevgtk'vku" qh" o cvgtkcn" lpxqrxg" uwhceg" cpf " qr vceci' s wcrkx { 0'Kp" qtf gt "vq" tgcej " j ki j "qr vceci' s wcrkx { . " y g' "mjuugu" qh" cduqtr vqp" cpf "uecvgtkpi "uj qwrf "dg" uo cmi'cu'r quikdrj]3\_0Vq'cej lxxg" j ki j 's wcrkx { 'r ctco gvgtu'qh'y g' co qtr j qwu'y kp "hko u" qr vko k cvkqp'qh'eqcvkpi 'r tqegu' r ctco gvgtu'uj qwrf "dg" gucdkuj gf 0'Qpg'qh'y g' y kf gn { "wugf " j ki j 'tghtcevkxg" kpf gz "o cvgtkcn" hqt' y g' r tqf vevkqp'qh'qr vceci'eqcvkpi u'ku'vkcplwo "qz kf g" VkiQ4" qt 'ku' uwdqz kf gu' VkiQ7" cpf " VkiQ9'0'

Vj g" tgugetej " y cu" o cf g" qp" vkcplwo " qz kf g" y kp " hko u" i tqy p" d { " cvqo le" rc { gt " f gr qukkqp" \*CNF + " vgej pls vgo' Vgvtcnk' f ko gvj { rco lpa+vkcplwo " y cu'wugf " cu' r tgeuwqt" cpf " qj qpg'qt" qz { i gp" r rco c' y gt g' wugf " cu' tgevcvpu'0Vj g" y kp " hko u" eqcvkpi " r tqeguugu" y gt g" ecttkgf " qw' cv' y q" f khtgtpv' vgo r gtcwtgu' / " 87" AE" cpf " 372" AE'0'Vj g" tghtcevkxg" kpf lgu. " tqwi j pguu' cpf " i tqy yj " tcvgu' qh' o cpvhwewtgf " vkcplwo " qz kf g" o qpqr { gtu' y gt g' f vgtgo kpgf 0'0 qtr j qmji { . " hko " y kempguu" cpf " qr vceci' r tqf vku'ej cpi gu' chgt " cppgcrkpi " cv' 472" AE. " 722" AE" cpf " 972" AE" y gt g' lpxgunki cvgf 0'Vj g' uwhceg' r tqf gt vku' qh' yj g' uco r ngu' y gt g' ej ctcevgtk gf " wukpi " cvqo le" hqteg" o letqueqr { \*CHO +0I tqy yj " r gt " e { erg" cpf " hko " y kempguu" y gt g' ecvewt' vgf " hqo " t'cpuo kvcepg' ur gev' c' cpf " s wctv' " et { ucn' o letqdcrcpeg" o gcuwtgo gpv'0'Qr vceci' r tqf gt vku' y gt g' gxcn' cvgf " hqo " yj g' t'cpuo kvcepg' cpf " tghgexvcepg' ur gev' c'0'

Vkcplwo "qz kf g" o qpqr { gtu' b qtr j qmji { " cpf " qr vceci' r tqf gt vku' f gr gpf " qp" yj g" r tqegu' vgej pqmji leci' r ctco gvgtu' cpf " cppgcrkpi " vgo r gtcwtg'0'K' y cu' hqwpf " yj cv' yj gto cni' cppgcrkpi " cv' vgo r gtcwtg' u' kp" yj g' t'cpi g' qh' 722/972" AE" gpj cpeg" yj g' hqto cvkqp' qh' et { ucn' i tclpu' cpf " et { ucn' kgu' f g' puku' f " f gr gpf u' qp" yj g' cppgcrkpi " vgo r gtcwtg'0'Vj g' hko " tqwi j pguu' k' petgcugu" vq" o qtg' yj cp " 32" po " qpn' " chgt " cppgcrkpi " cv' 972" AE" vgo r gtcwtg' " Hki 0'3+0'Dghqt g" yj g' cppgcrkpi " cmi' uco r ngu' uwhceg' y cu" uo qqy j " kp' cmi' f gr qukkqp" eqpf k' k' pu'0' C" vgpf gpe { " vq" t' lueg' qh' vkcplwo " qz kf g" yj kp " hko u' tghtcevkxg" kpf gz " cv' j ki j gt " f gr qukkqp" vgo r gtcwtg' u' qd' vclp' gf " kp" yj ku' uwwf { " ku' uko k' rct " vq" r t' g' x' kwun' { " t' gr qt vgf " lpxgunki cvkpu" ]4. " 5\_0'



Hki 0'30'VkiQ4" o qpqr { gtu' CHO " uecpqi tco u' c+ " 6" 472" AE. " d+ " 6" 722" AE. " e+ " 6" 972" AE " \*Rlewtg' ulk' g' 32" " 32" o +0'

[3\_ Z0Dk' J 0C0Nqr gl . 'R0P ctculo j c. "gv' cr0' J ki j ' tcv' f' gr qukkqp' hqt' yj g' hqto cvkqp' qh' j ki j ' s wcrkx { 'qr vceci'eqcvkpi u. "WU' t' cvgpv" \*4236-0'  
 [4\_ U0Tcv' uej . 'G0D0Mng { . 'C0V' Appgto cpp. 'C0U gi j cm k' l' p' h' v' p' e' g' h' yj g' qz { i gp' r rco c' r ctco gvgtu' qp' yj g' cvqo le' r { gt " f gr qukkqp' qh' vkcplwo " f' k' z' kf g. " P cpq' vgej pqmji { " 48. " 46225" \*4236-0'  
 [5\_ C0U gi j cm k' O'0J gni gtv. 'T0D' v' p' p' gt. 'H0J g { tqy . 'W0I 3'4grg. 'O'0M' p' gl . 'C' vqo le' r { gt " f gr qukkqp' qh' CnQ5' cpf " VkiQ4" o wnkrc { gtu' hqt' " cr r r' d' e' cvkpu' cu" d' c' p' f' r' cu' h' k' gtu' u' c' p' f' cpvktghgexkxg" eqcvkpi u. " Cr r r' d' e' f' " Qr vceci' r . " 3949" \*422; +0'

# PASSIVATION OF FA<sub>0.95</sub>CS<sub>0.05</sub>PbI<sub>3</sub> PEROVSKITE WITH (PHENYLENE)DI(ETHYLAMMONIUM) ORTO-, META-, PARA- CATIONS IMPROVES CHARGE CARRIER EXTRACTION

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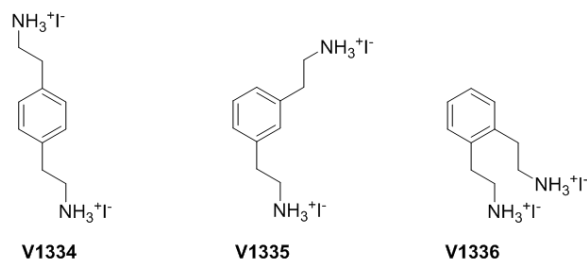
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<sup>2</sup> Department of Organic Chemistry, Kaunas University of Technology, Radvilėnų pl. 19, LT-50254 Kaunas, Lithuania  
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During the last decade, the development of perovskite solar cells has flourished, as efficiencies as high as 25% were reached [1]. This indicates a potential and cheaper substitute for conventional silicon-based solar cells. However, one of the main problems preventing wide perovskite usage is their instability in ambient atmospheric conditions.

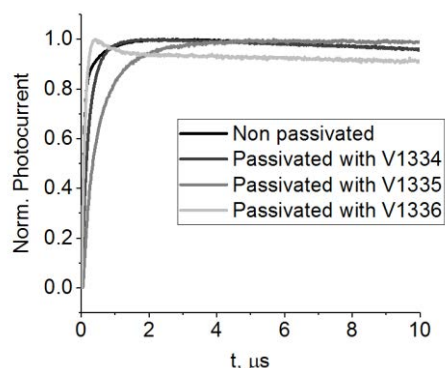
Recently a way of passivating the perovskite surface with thin layers of more stable two-dimensional perovskite was suggested. This increases the stability of the active perovskite layer and passivates surface defects but may compromise charge carrier extraction [2]. In this study, we studied the relationship between the structure of two-dimensional perovskite organic cation and charge carrier extraction through the passivating layer.

The conventional lead halide perovskite used in best performing solar cells crystallizes in cubic APbX<sub>3</sub> structure, where A is an organic cation and X the halogen atom. While this cubic perovskite structure exhibits superior optoelectronic properties compared to two-dimensional ones, the high concentration of surface defects due to organic cation and halogen vacancies and the solubility of the organic cation in water, hinder the perovskite solar cell performance and stability. By exposing the surface of three-dimensional perovskite to certain hydrophobic organic cations thin layers of two-dimensional perovskite are formed which can both reduce the density of vacancies and increase the water-resistance of the active perovskite layer [2].



**Figure 1.** Chemical formula of organic cations used for perovskite passivation.

Here we present application of three isomers of a newly synthesized (phenylene)di(ethylammonium) cation (fig. 1) towards the passivation of FA<sub>0.95</sub>CS<sub>0.05</sub>PbI<sub>3</sub> perovskite solar cells. After measuring the efficiencies of these devices, we found different values for each isomer. The cell which was passivated with V1335 performed significantly worse than non-passivated or passivated with V1336 which increased the efficiency. To further explore the causes of these differences we performed transient photocurrent and voltage dependent PL decay kinetic measurements. We observed that better-performing devices have faster photocurrent response and PL decay kinetics with applied external voltage than lower efficiency cells. We attribute this difference to a barrier that forms between the perovskite and hole transport layers which increases after passivation with V1335 and decreases with V1336. This suggest that perovskite passivation with o-(phenylene)diethylammonium cation allows improving hole extraction from perovskite to hole transporting material.



**Figure 2.** Transient photocurrent of FA<sub>0.95</sub>CS<sub>0.05</sub>PbI<sub>3</sub> perovskite solar cells.

[1] <https://www.nrel.gov/pv/cell-efficiency.html>

[2] *J. Mater. Chem. A*, 2018,6, 2122-2128

**EQUVTWEVKQP'CPF'KPXGUVK CVKQP'QHUMDP CPQUGEQPF'QRI IQRC''''**

I cdtkgn "Ucplkqpf v. "Lwrku"Xgpi grku"

Ncugt "Tgugctej "Egpygt. "Hcwmf "qhRj { uleu. "Xkpkwu" Wplkgtukf . "Nksj wcpk" "i cdtkgn "Ucplkqpf v. B H0mf 0v0v"

"

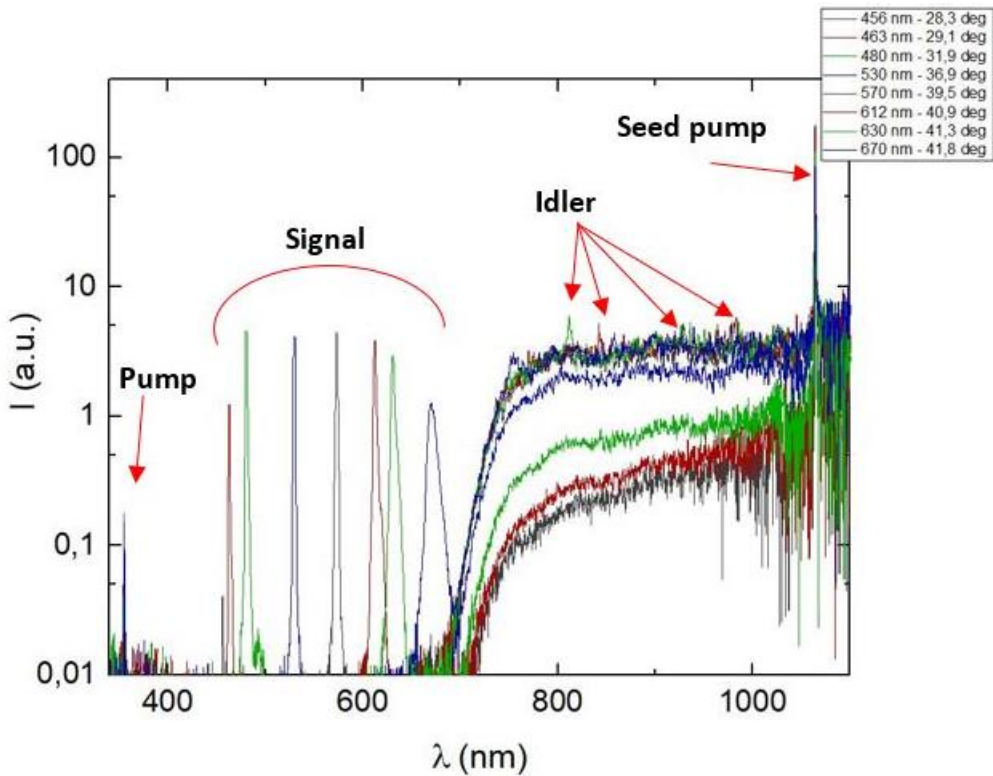
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Vj g'i qcn'qh'vj ku'tgugctej "y cu'vq"eqpuwcpv'cpf "kpxgukv cvg"cp"qr vcln'r ctco gvtle"i gpgtcvqt lco r r hgt "QRI IQRC" u{vgo. "y j lej "wugu"37"o o "NDQ"et { ucn'cu'c'pqrpkpct"o gf kwo "cpf "P f - CI "O QRC"rcugt "cu'c'uggf 0J gtg. "5tf "j cto pple" qh'rcugt "577"po +y cu'wugf "cu't wo r "tcf kcvkqp. "cpf "hwpf co gpv'nj cto pple "3286"po +o "cu't wo r "uqwtg' hqt'uggf "tcf kcvkqp 0' QRI IQRC"uggf "y cu'wv gteqpvkpwwo "i gpgtcvqpf "kp'c'r j qvqple"et { ucn' hgt "REH0"

Vj g'wv gteqpvkpwwo "tcf kcvkqp" wugf "cu'QRI IQRC"uggf "gzvqpf gf "htqo "872"po "vq"3822"po "ev'o czko wo "r wo r "r wug" gpgti { 0Vj g'b czko cnluggf "gpgti { "y cu'b gcuwgf "vq'dg'7"o Y "qxtg'vj g'g'v'k'ur gevto 0Y g'cej kxgf "uki pcnly cxg'i gpgtcvqpf "xlc"qr vcln'r ctco gvtle"co r r hgt "kcvkqp"qh'kf rgt"y cxg'0' Hwtvj gt"qp. "y g"o gcuwgf "ur gevtn'cpi "gpgti { "ej ctcevgtk'ku"qh" QRI IQRC"Uki pcnly cxg'wvplkpi "tapi g'y cu'htqo "678"po "vq"892"po "cpf "y cu'iko kxgf "d { "kf rgt"y cxg'wvplkpi "tapi g'y j lej " f gr gpf u"qp"uggf "tcf kcvkqp"ur gevto "gzvqpvkpwwo"Uki pcnly cxg' "r qy gt"y cu'qh'vj g'qtf gt"qh'o ketqy cwu'qxgt"vj g'y j qrg" y cxgrpi vj "wvplkpi "tapi g'f wq'vq"vj g"hev'vj cv'f wtkpi "vj ku'y qtm"y g" wugf "c"ukpi r g'rcu' "QRI IQRC"eqvhi wcvkqpf 0' Vj g" o gcuwgf "i gpgtcvqpf "y tguj qif "y cu'iko kct' hqt"o qv'qh'vj g'QRI IQRC" wvplkpi "tapi g'0"

Vj g'tguwv'qh'vj ku'y qtnly knldg'wugf "hqt' hwtvj gt" f g'xgru r gpv'qh'o qtg'gh'v'k'g' uwdpcpqugeqpf "QRI IQRC"u{vgo u0'

Vj ku'tgugctej "ku'hqwpf gf "d { "vj g'Gwqr gcp "Tgi kpcnF g'xgru r gpv'hw'p' "ceeqtf kpi "vq"vj g'wv r qtvgf "cev'k'v' "Tgugctej " Rtqlgeu"K0 r ngo gpygf "d { "Y qtrf /eruu" Tgugctej gt "I tqwr u'wpf gt "O gcuwgf "P q0'23040/NO V/M/93: 0I tcvp'P q0'23040/NO V/M/93: /25/22260"



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**Hki 030Ur gevte'qh'uki pcnly cxg. "r wo r "cpf "uggf "tcf kcvkqp"cv'f hgtgpv'NDQ"et { ucn'iqcvkqpf "cpi rgu0"**

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j3\_"O 0J 0F wpp"cpf "O 0Gdtej ko | cf gj. "Rctco gvtle"i gpgtcvqpf "qh'v'v'p'cdng'Nki j v'htqo "Eqpvkpwqwu/Y cxg"vq" Hgo vqugeqpf "Rwugu. "Ulepep"4: 8."37356 373: "3; ; ; 40'

j4\_"COF wdlg'vku "Pg'v'k'p' "qr'v'wv. "Rvdrkuj gt "Xkpkwu" Wplkgtukf . "Xkpkwu"4233-0"

j5\_"TOY 0Dq { f. "Pqrpkpct "Qr'v'ku'gf 05 "Cecf go ke'r' tguu. "P gy "I qtni"422: 40'

# ĦENWUKQP 'QH'UEWNRVWTGF 'VQR'NC[ GT 'Ħ' EJ KTRGF 'O KTTQT'' F GUK P 'HQT 'TGF WEGF 'I TQWR'F GNC[ 'F KURGTUKQP 'QUEKNVCVKQP U'

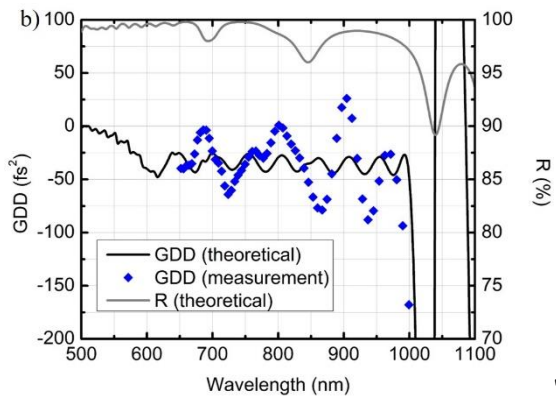
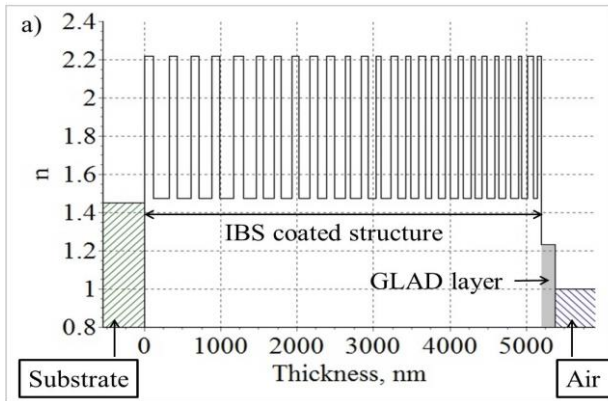
Uko cu'O gpkncu."Nwnu'Tco crku."Uko qpcu'Mk cu."Vqo cu'Vqrgpku."

Qr vkeciEaqvki u'Ncdqtcvqt { .Egpgt 'hqt 'Rj { ukeci'Uekppegu'cpf "Vgej pqmji { .Nksj wpcik"  
uko cu0 gpkncuB ho e0u"

Ej ktr gf "o ktqtu"EO u+"ctg"ur gekn'v' r g'qh'f lgrgetle "o wnkrc { gt "eqcvki u'lpvgpf gf "hqt 'ut gvej lpi "qt'eqo r tguulpi "qh' wntc/uj qtv"ngo vqugeqpf +r'ucgt 'r wngu0Xctkqwu'v' r gu'qh'EO u'y gtg'r tqr qugf "lp'vj g'r cuv'zf qwdrg'EO u"FE O u:"dcen'ukf g' eqcvgf 'EO u"DCUE+."eqo r ngo gpvt { 'EO 'r cku.'cpf "qy gt"j3\_0Uwej "ghqt'vcmy gf "q'eqo r tguu'qr vkeci' r wngu'dgmy "4'hu' wulpi "eqo r ngo gpvt { 'EO 'r ckt'cr r tqcej "j3\_0Cn'qh'v' g'o gpvqpgf 'EO 'eqph' wcvkqpu'y g'g'ko r ngo gpvgf "q'tgf weg'ur gevci' quekrcvqpu'qh'i tqwr "f grc { "f kur gtukqp" \*I FF + "o" y g' "o ckp" r cteo gvgf "qh'EO O'Ncti g"co r rkswf g" I FF "quekrcvqpu"o c { " kpetgcug'r wng'f wcvkqp. "lpf weg'cf f kkpccn'ucvnrks' r wngu'qt "f kvqt'v'qr vkeci' r wng'uj cr g'

O quv't gegpv'r r tqcej "hqt 'tgf wcvkqp'qh'I FF "quekrcvqpu'lp'EO u'ku'd { "lpenw' lpi "c' r qtqwu'uewr wtgf "rc { gt "RUN+"cu" c"vqr "rc { gt "qh'EO "utwewtg"j4.5\_0T ghtcevxg"lpf gz "qh'RUN"o c { "dg'my gt "vj cp"t ghtcevxg"lpf gz "qh'f gpug"o cvgtkcn'cpf " y gtghqtg "dgwgt"qr vkeci' r gf cpeg"o vej lpi "dgvy ggp"EO "utwewtg"cpf "co dlgpv'o gf kwo " \*Q0'ckt+"o c { "dg'cej lqxfg'0' J qy gxgt."qr vkeci' r cteo gvgtu'qh'uwej "o ktqtu"o c { "dg"o qtg'ugpukxg"q'v'j g'j" wo kf k' "lp'vj g'ct'f w'v'q'y cvgt'cf uqtr vqpu" y kj lp'vj g'r qtqwu'rc { gt0'hw'v' gto qtg. "vj g'ceewtce { "qh'r qtqwu'rc { gt "f gr qukqpu"o c { "dg'lpw'htl'ekpvhqt'EO "cr r rkecvkqpu'Uq" hct. "q'vj g'dgu'qh'qwt"npqy rgi g. "vj g'EO "y kj "RUN"y kj "y kf gt'dcpf y kf vj "vj cp"j ch'cp"qr vkeci'qevcxg"o'cp'cr r tqzko cvg' dcpf y kf vj "hko k'cej lqxcdrg'd { "ucpf ctf "o cvgtkcn"j3\_0'y cu'pgxgt'gzr g'ko gpvcml "f go qpwtcvgf "dghqtg'0'lp'vj ku'y qtn'ly g' f guki pfg "cpf" f gr qukxg' "c"ej ktr gf "o ktqt"y kj "qxgt"622"po " \*2089"qevcxg+"ur gevci' dcpf y kf vj 0'Chgt" f gr qukqpu"y g' lpxguk' cvgf "vj g'ugpukxk' "qh'ur gevci' r cteo gvgtu'v' f gr qukqpu"gttqtu'cpf "j" wo kf k' "ej cpi gu'0'

Kqp" dgco " ur wwtlpi " \*IDU+" vej pqmji { " cpf " i rpeklpi " cpi rg" f gr qukqpu" \*I NCF + " ugwr " y kj lp' "grgvtqpu" dgco " gxcr qtcvki'eqcvki "r rcp'v'y gtg'wugf "q'f gr quk'ej ktr gf "o ktqt'eqcvki " \*Hi 03+073"rc { gtu'qh'P d4Q7IUQ4"o cvgtkcn'y gtg' f gr qukxg' "wulpi "IDU"vej pqmji { 0'Vj g'rcu' \*74P' +rc { gt "qh'v' g'eqcvki "y cu'f gr qukxg' "y kj "I NCF "o gj qf "rc { gt "eqpukvki " qh'xgt'vkeci'eqnw pu'y cu'hqto gf + "j6\_0'Chgt" f gr qukqpu."ur gevci' r cteo gvgtu' \*tcpuo kvcepg"eqgh'ekp'cpf "I FF +y' gtg' o gcuwtgf "cv'pqto cneqpf k'kqpu" \*Hi 03d+'cpf "lp'tgf weg' "j" wo kf k' "gp'xkqpo gpv'0'



Hi 030T ghtcevxg'lpf gz 'r tqh'g'qh'EO "o wnkrc { gt "utwewtg'rcu'rc { gt "pé3045+y cu'f gr qukxg' "wulpi "I NCF "o gj qf "c=" ur gevci' r cteo gvgtu'qh'EO <tgh'g'vcepg" \*T +cpf "I FF "d'0'

Ceeqtf lpi "q'vj g'o gcuwtgo gpvu. I FF "quekrcvqpu'f q'bpv'gzeggf" 57092'hu'4'ho ku'lp'y cxrgppi vj "t'cpi g" ?872/3222" po 0'CF f k'kqpcn'cpcn' uku'uj qy gf "vj cv'vj ku'co r rkswf g'ku'cr r tqzko cvgn' "4/5"ko gu'uo cmgt"vj cp"vj gqg'vkeci' rko k'hqt'uco g' dcpf y kf vj "EO "y kj qw'RUNOF gr qukqpu"gttqt'cpcn' uku'lpf lecvgf "vj cv'vj g'co r rkswf g'qh'I FF "quekrcvqpu"o ki j vj cxg'dggp" tgf weg' "cv'rgcu'd { "j ch'kh'IDU" f gr qukqpu"gttqtu"j cf "dggp"cxqkf gf 0'J qy gxgt. "xctk'vqpu'qh'RUN"t ghtcevxg'lpf gz "f w'v'q" j wo kf k' "ej cpi gu'd { "cr r tqzko cvgn' "0207" "y cu'f gvgto lpgf 0'K'o c { "rgcf "q'kpetgcug'qh'I FF "quekrcvqpu'd { "0'52'hu'4'hqt" vj gqg'vkeci' f guki p0'Vj gtghqtg. "vj g'I FF "quekrcvqpu'qh'cv'rgcu'0'52'hu'4'ctg'gzr gevgf "gxgp"lp'y gr'qr vko k' gf "cpf "f gr qukxg' EO "y kj "RUN0'

[3\_ X0Rgtxcm'Q0Tc] unel qxune { c. 'gv'c'nd'F kur gtukxg"o ktqt'vej pqmji { "hqt'wnt'chcu'rcugtu'lp'vj g'c'cpi g'44266722"po. "Cf x0Qr v0'Vgej pqm0'5'3+ '77/84" \*4236+0

[4\_ L0Nkw'j 0Y cpi. 'gv'c'nd'F guki p.'hct'lecvkqp'cpf "cr r rkecvkqp'qh'f kur gtukxg"o ktqtu'y kj "c'UkQ4'uewr wtgf "rc { gt. "Qr v0'0'cvgt0'Gzr tguu.": \*6+.: 58/: 65" \*423: +0

[5\_ R0O c."C0U gi j cm k'gv'c'nd'F guki p'cpf "hct'lecvkqp'qh'Ukpi rg."Uo qqj "cpf "Dtqcf dcpf "Ej ktr gf "O ktqtu'y kj "c'Vqr "P cpq/Rqtqwu'Nc { gt. "Qr vkeci' k'p'v'ht'gpeg'Eqcvki u'Eqp'ht'gpeg" \*QE+423; . "Ucpc'c'p'c'rwgdm. "P gy "O gzleq. "Vj D05. " \*423; +0

[6\_ N0I t'lp'gk k v. "O0'CPf twrgxk ksu "gv'c'nd'J ki j n' "T'gukncpv\ g'q/Qf gt "y cxrg'rc'v'gu'Deugf "qp'c'm'Uk'leci'O wnkrc { gt "Eqcvki u. "Rj { u0'Uc'wu'Uq'rf'KC. " 436\*34+ "3992397" \*4239+0

**NUUCLQWU'HKI WTGU'CU'F CVC'RTQEGUUKPI 'O GVI QF 'HQT'  
QRVKECN'Y CXGNGPI VJ 'UJ KHV'DCUGF 'UGPUQTU'**

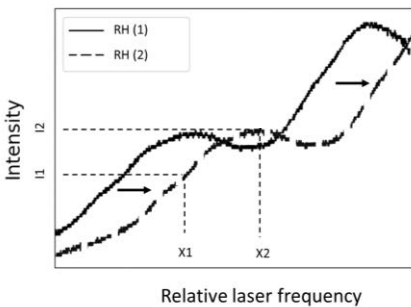
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'Cki ctu'Cwctu<sup>3</sup>"

<sup>3</sup>S wcpwo 'Qr vku'rdqtcvt { . 'Kpukwng'qh'Cvqo le'Rj { uku'cpf 'Ur gevteqer { . 'Wpkgtukf 'qh'Ncxk " "  
r cwnantkucr u0gpkub n0k "

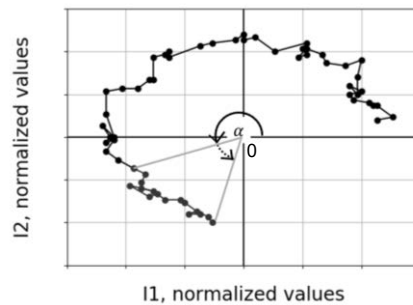
" Kp "y j g"mw'f gecf g"uelgpkwle "hgrf "tgugctej kpi "o letqueqr le "qr vkeci'ugpuqtu" j cu"tr kf n "go gti gf O'Qr vkeci'ugpuqtu" qhgt "j ki j "ugpukxkx' cu'y gm'cu'pqp/lpxcukx'ugpukpi "o gy qf u0Vj gtg'ctg'o cp { 'r quukdr'ugpukpi "o gej cpluo u'dw'y qug" dcugf "qp"o qpkqt kpi "y cxgrppi vj "uj khv'ctg'qpg'qh'y g'o quveqo o qp0'Kp'v'j ku'r cr gt'y g'uj qy "j qy "Nkuclqwu'HKI wtgu'ecp"dg" wugf "cu'f c'v'r tqeguukpi "o gy qf "cpf "f go qputcvg'y ku'o gy qf "kp'cevqpp'cu'c'r ctv'qh'paxgr'qr vkeci'qr wo kf kx' "ugpuqt0"

Y g"wugf "wcpur ctg'p'v'o letqur j gtg'tguqpcvqtu'y j lej "f w'v'q'v'q'cn'lpvgt'pcn'tgh'gevqpp'ecp"v'cr "rki j v'lpukf g'y go . "y wu' eqputwexg"lpvgt'ht'gpeg"ecp"qeev0' Vj ku'r tqeguuk'ku'c'nuq"mpqy p"cu'y j kur gt kpi "i cmgt { "o qf gu"\*Y I O +0'Qwt"qr vkeci' tgrcvkxg"j wo kf kx' "TJ +ugpuqt"o c'p'n' "eqpukwng'qh'ks w'f "i n'egtq'no letqf tqr ngv'cevki "cu'o letqur j gtg'tguqpcvqt. "982"po " wpcdr'XEUGN'rcugt. "f g'gevt'cpf "quekmueqr g0Czr g'lo gpv'y kj "i n'egtq'no letqf tqr ngv'uj qy gf "y v'v'erct'hw'p'co gpv'cn' o qf gu'ecp"dg"gzekgf "H03c+'cpf "i n'egtq'nd' "ku'pcwtg'ku'i tgc'v'o cvgt'kcn'htq"j wo kf kx' "ugpukpi "cu'k'ku"j { i tqeqr le." pqp/vzle. "pqp/ktkcvkpi . "ucdr'g. "xkueqg0Hqt'gxgt { "TJ "ngx'no letqf tqr ngv' cu'i qv'gz'cev'f lco gvg't'cpf "t'gh'cev'kxg'lpf g'z0'ki TJ "ej cpi gu'lp"y j g'uwtt'qwpf kpi "gpx'k'qpo gpv' "tguqpcpeg"eqpf k'k'pu'htq"y j g'o letqf tqr ngv'ej cpi gu'cpf "qpg'ecp"qdugt'xg" tcr kf "y cxgrppi vj "uj khv'lp'y j g'wcpuo kuuk'p'ur gevwo O'Kp'h'ev'ugpukxkx' "qh'y j g'o n'egtq'no letqf tqr ngv'ugpuqt'ku'uj"j ki j . " y cv'wr "v'q"47"tguqpcp'v'r g'cm'et'quugf "y j g'quekmueqr g'uet'ggp'htq"ej cpi g'qh'3" "TJ O'Vq"o cmg'wug'qh'uwej "r tqr gt'vku" Nkuclqwu'HKI wtgu'y gtg'lpv'qf w'egf "lpv'f'c'v'r tqeguukpi "cni q'k'j o O'Kp'v'puk' "cv'r q'p'w'K3\*Z3+"cpf "K4\*Z4+"H03c+'ht'qo " wcpuo kuuk'p'ur gevwo "y cu'eq'v'p'w'q'w' "tgeqt'f gf "cpf "Nkuclqwu'HKI wtg'eq'w'f "dg'et'g'cv'gf "kp"t'gcn'w'o g'"H03d+0'Y j gp" TJ "eqpf k'k'pu"ej cpi gf . "tguqpcp'v'o qf gu'y gtg'uj k'k'pi "v'q"m'pi gt"y cxgrppi vj u'k'i TJ "k'p'et'g'cv'gf "cpf "x'leg"xt'g'uc'0'D { " mpqy kpi "y j gy gt "y j g'y cxgrppi vj "qh't'guqpcp'v'o qf gu'k'p'et'g'cv'gf "qt"f get'g'cv'gf "cpf "htq"j qy "o wej . "r t'g'ekug" TJ "ej cpi g" eqw'f "dg'f g'v'g'to k'p'gf 0

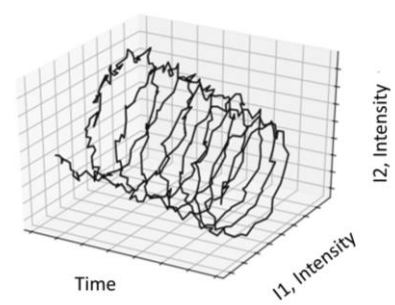
\*c+"



\*d+"



\*e+"



" Hki 0300 k'p'uvgr u'qh'y cxgrppi vj "uj khv'f g'v'g'to k'p'cv'q'p0\*c+'Ur gevwo "ht'qo "o letqur j gtg'ugpuqt0'HKI wtg'uj qy u'j qy " tguqpcp'v'o qf gu'ctg'uj k'k'pi "cpf "r q'p'w'Z3"cpf "Z4"ht'qo "y j lej "k'p'v'puk' "y cu't'geqt'f gf 0\*d+4F "Nkuclqwu'HKI wtg0'K3"cpf "K4" xcnw'u'y gtg'p'qto c'rk' gf "u'q"y v'v'ki wtg'ku't'q'cv'kpi "ct'q'w'f "y j g'q'ki k'p'r q'p'v\*2.2+0\*e+"Nkuclqwu'HKI wtg'lp'w'o g'f qo k'p'0

Gcej "r q'p'v'uj qy p"lp" H03d"j cu'f'k'ge'v' "o g'cu'w'g'f "eq'q'f'k'p'cv'u" \*p'qto c'rk' gf "K3"cpf "K4" xcnw'u'0'Wukpi "uko r ng" v'ki q'p'qo g'v' { "qpg'ecp"f g'v'g'to k'p'g'y j cv'cpi ng" "t'cf k'w'u'x'ge'v'q't'y q'w'f "j cxg'cu'uj qy p"lp" H03d0C"uj khv'qh'582'Å"ku'gs w'cn'v'q" y cxgrppi vj "uj khv'qh'ht'gg'ur gev'c'nt'cpi g0Vj ku'cm'qy u'wu'v'q"o g'cu'w'g'y cxgrppi vj "uj khv'lp't'gcn'w'o g'f gur k'g'w'p'q'f k'p'ct { "o qf g" uj khv'y j gtg'wr "v'q"522"o qf gu'ecp'et'qu'v'y j g'quekmueqr g'uet'ggp'y kj k'p'c'p'j q'w'0"

Vj g'f'c'v'r tqeguukpi "o gy qf "r t'gug'p'v'gf "lp"v'j ku'r cr gt'ecp"dg" w'gh'w'htq"qr vkeci'ugpuqtu"y j gtg'qpg"j cu'v'q"f g'cn'y kj " j ki j "ugpukxkx' "cpf "wug'qh'wpcdr'rcugt'v'j ku'o gy qf q'ni { "ku'c'nuq'r t'qo k'k'pi "htq"o letq'g'p'cv'q't'ugpuqtu"y kj "m'y gt"S / h'ev'qtu"S / h'ev'qt'qh'y j g'tguqpcv'q't'wugf "lp"v'j ku'y q'tn'y cu'32^6+0'Eq'p'ut'w'v'kpi "Nkuclqwu'HKI wtgu'cu'uj qy p"lp" H03"t'gs w'k'g" o k'p'k' c'ri'ecr'cek' "v'q'r tqegu'f'c'v'cu'q'pn' "4"f'c'v'r q'p'w'ct'g'p'gg'f gf "htq" g'cej "o g'cu'w'g'o gp'v'y j lej "i t'g'ev' "uko r r'k'ku'v'j g" r tqegu'qh'no g'cu'w'k'pi "y cxgrppi vj "uj khv'v'j ku'uw'f { "f'k'ew'u'gu'v'j g'hw'm'r tqegu'qh'Nkuclqwu'HKI wtgu'dcugf "f'c'v'r tqeguukpi " cpf "d'g'p'gh'ku'qh'k'0

Vj ku't'gug'ctej "y cu'hw'p'f gf "d { "N\ R'r t'q'lg'ev'P t0'q' r /423: B/2732"0'Qr vkeci'y j kur gt kpi "i cmgt { "o qf g"o letq'g'p'cv'q't' ugpuqtu'0'cpf "GTF Hr' t'q'lg'ev'P q(80807 B; IC 12250

[3\_1 k'qi k'p'c'0'c'x'lp'q. "U'0'0 c'ntc. "R'0'F g'P c'v'ng. "R'0'F ci n'ct'f'k'1 O'hw'p'f co gp'v'c'nt'ho ku'lp'j ki j /S "f' t'q'rg'v'o letq'g'p'cv'q'tu. "U'k'p'w'k'le "T'gr'q'v'it"4239+0' j4\_ "D'tcej o c'pp. "L'0'U'0'M'p'f'gt. "V'0'F l'g'eno c'pp. "M'0'E'c'k'ic'v'kpi "cp'lp'v'gt'ht'qo g'v'le "m'ug't'ht'g'w'g'p'e { "uc'd'k'k' c'v'k'p'v'q"o gi ej gt v' "r t'g'ek'p'0'Cr'rk'gf "Q'r'v'ku' \*4234+0'

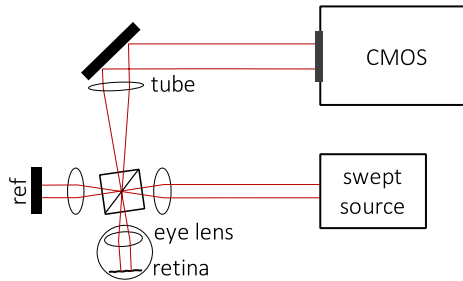
**WVVTCHCUV'XQNWO GVTRE '5F +J WO CP 'TGVKPC'KO CI KPI 'Y KVJ "**  
**HQWT KGT/F QO CKP 'HWNN/HKGNF 'QRVKE CN'E QJ GTGPEG"**  
**VQO QI TCRJ [ "**

<sup>3</sup>Mctqrku' Cf qo c xk kwu. <sup>16</sup>Kxc' fik nkgp . <sup>18,4</sup>Gi kf klwu' C wmuqt kwu. "  
<sup>4</sup>F cy kf 'Dqt {enk "Urcy qo k Vqo e| gy unk "O celgl" Y qlvnyy unk'

<sup>3</sup>Egpvt 'hqt' Rj {ulecni' Uelgpegu' cpf "Vgej pqmji { . 'F gr ctvo gpv'qh' Qr vqrgextqpleu. "Xkpkwu"  
<sup>4</sup>kpvkwwg'qh' Rj {ulecni' Ej go kwu { . 'Rqrkuj 'Cecf go { 'qh' Uelgpegu. "Y ctucy . 'Rqr cpf "  
[nctqrku' Cf qo cxlekuB hvo e0v'](#)

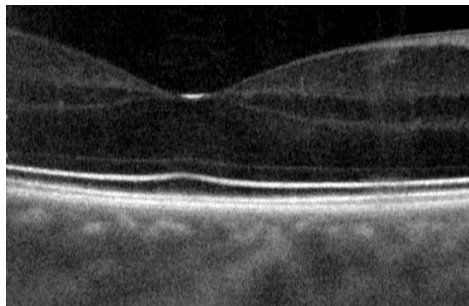
Qr vlecn'eqj gtgpeg' vqo qi tcrj { "QE V+ "ku' cp' l'pvgt hgtqo gtle' ko ci kpi "o gvj qf "o' y kf gn' "wugf "hqt' tgvkpcn' ko ci kpi "o' y cv'ecp' ko ci g' f ggr "kp' vkuvg' 0' E qo r ctgf "v' emu' ulecn' QE V' u{ ugo u' y j gtg' c' ukpi ng' r qkp' v' f gvevqt "ku' wugf "v' tgi kvgt' "y g' uki pcn' hwn' hgrf "QE V' "HH' QE V+ u{ ugo u' wkn' g' wntchruv' E O QU' eco gtcu' 0' Vj wu. 'y g' pggf "v' uecp' uco r ng' kp' dqj 'z' c' pf' / " f k gev' kpu' ku' grko kpcv' g' d{ " qdvc' kpi cp' gpvtg' ko ci g' cv' ppeg' 0' Nqy / ur ggf "o' gej cplecn' uecp' kpi " qh' kvgt hgtqo gvt' ai' tghgt' ppeg' cto "ku' tgr' nceg' d{ "uy gr v' uqvt' eg' r' c' utg' "v' gpcdn' tgi kvgt' kpi "o' wnkur' gev' cni' kvgt hgt' ppeg' r' cvgt' pu' qh' 'y g' uco r ng' ] 3\_ 0' Hqwt' lgt' "v' cpuh' qto c' v' kq' "qh' uwej "ces vkt' gf "xqno g' c' npi "y cxgr' ppi y " { kgr' u' t' gcn' uco r ng' ut' vewt' g' 0' Vj ki' guv' d' r' k' u' j gu' r' t' k' p' e' k' r' u' q' h' H' q' w' t' l' g' t' / f' q' o' c' k' p' "H' F' +H' H' Q' E' V' 0'

Y g' j cxg' d' wkn' c' "H' F' /H' H' Q' E' V' u{ ugo . 'uj qy p' kp' "Hki 03. 'y cv' eqpuk' v' g' qh' c' "uy gr v' uqvt' eg' r' c' utg' "v' gpcdn' tgi kvgt' kpi "o' wnkur' gev' cni' kvgt hgt' ppeg' r' cvgt' pu' qh' 'y g' uco r ng' ] 3\_ 0' Hqwt' lgt' "v' cpuh' qto c' v' kq' "qh' uwej "ces vkt' gf "xqno g' c' npi "y cxgr' ppi y " { kgr' u' t' gcn' uco r ng' ut' vewt' g' 0' Vj ki' guv' d' r' k' u' j gu' r' t' k' p' e' k' r' u' q' h' H' q' w' t' l' g' t' / f' q' o' c' k' p' "H' F' +H' H' Q' E' V' 0'



**Hki 030** Vj g' r' t' l' p' e' k' r' u' q' h' H' q' w' t' l' g' t' / f' q' o' c' k' p' "H' w' n' / H' k' g' n' f' "Q' r' v' l' e' c' n' i' ' E' q' j' g' t' g' p' e' g' "V' q' o' q' i' t' c' r' j' { 'u' g' w' r' "h' q' t' "j' w' o' c' p' "g' { 'g' 'l' o' c' i' k' p' i' 0'

Hki 04' u' j' q' y' u' c' "e' t' q' u' u' / u' g' e' v' k' p' c' n' i' k' o' c' i' g' "q' h' 'y' g' j' w' o' c' p' "t' g' v' k' p' c' "c' u' 'c' e' s' v' k' t' g' f' "k' p' 'x' k' x' q' "k' p' "y' g' "o' c' e' w' r' c' t' "t' g' i' k' q' p' 0' V' j' g' y' j' q' r' g' "x' q' n' o' g' " y' c' u' 'c' e' s' v' k' t' g' f' "k' p' 'l' w' u' v' : 0' b' o' u' 0'



**Hki 040** Czkn' Z \ +l' o' c' i' g' "q' h' 'y' g' j' w' o' c' p' "t' g' v' k' p' c' "c' e' s' v' k' t' g' f' "k' p' 'x' k' x' q' 0' V' j' g' l' o' c' i' g' y' c' u' f' g' t' k' x' g' f' d{ "cxgt' ci kpi '9' etquu' uge' v' k' p' c' n' i' k' o' c' i' g' u' l' p' " y' g' "x' q' n' o' g' " y' c' v' y' c' u' 'c' e' s' v' k' t' g' f' "k' p' 'l' w' u' v' : 0' b' o' u' 0'

kp' eqpenuk' p. "H' F' /H' H' Q' E' V' r' t' q' x' k' f' g' u' "k' p' e' t' g' c' u' g' "q' h' 'c' e' s' v' k' u' k' q' p' "u' r' g' g' f' "y' c' v' u' k' i' p' k' l' e' c' p' v' n' i' "t' g' f' w' e' g' "k' o' c' i' g' "f' k' u' v' t' v' k' p' u' " k' p' f' w' e' g' f' d{ "y' g' p' c' w' t' c' n' i' g' { 'g' "o' q' x' g' o' g' p' v' ] 4\_ 0'

30G0Cwmuqt kwu. 'F 0Dqt {enk' c' pf' "O 0Y qlvnyy unk' \$E' t' q' u' u' c' m' i' t' g' g' "x' q' n' o' g' t' l' e' "k' p' 'x' k' x' q' "k' o' c' i' k' p' i' "q' h' c' j' w' o' c' p' "t' g' v' k' p' c' y' k' j' "H' q' w' t' l' g' t' / f' q' o' c' k' p' "h' w' n' / h' k' g' n' f' "q' r' v' l' e' c' n' i' e' q' j' g' t' g' p' e' g' "v' q' o' q' i' t' c' r' j' { \$. 'D' k' q' o' g' f' l' e' c' n' i' Q' r' v' l' e' u' "G' z' r' t' g' u' u' "32. '85; 2/8629' 423; #0'  
 40G0Cwmuqt kwu. 'F 0Dqt {enk' "R0' U' t' g' o' r' n' g' y' u' n' k' "M' 0' N' k' g' y' u' n' k' "U' 0' V' q' o' e' l' g' y' u' n' k' "R' 0' P' k' g' f' y' k' g' f' k' w' n' "D' 0' N' 0' U' k' n' q' t' u' n' k' "c' p' f' "O 0Y qlvnyy unk' "\$k' p' 'x' k' x' q' "k' o' c' i' k' p' i' " q' h' 'y' g' j' w' o' c' p' "e' q' t' p' g' c' "y' k' j' "j' k' i' j' / u' r' g' g' f' "c' p' f' "j' k' i' j' / t' g' u' q' n' w' k' p' "H' q' w' t' l' g' t' / f' q' o' c' k' p' "h' w' n' / h' k' g' n' f' "q' r' v' l' e' c' n' i' e' q' j' g' t' g' p' e' g' "v' q' o' q' i' t' c' r' j' { \$. 'D' k' q' o' g' f' l' e' c' n' i' Q' r' v' l' e' u' "G' z' r' t' g' u' u' "33. " 4: 6; /4: 87' 4242-40'

**\*K/P/UK/W#UVWF [ 'QH'KO O QDKNK GF 'TGEGRVQT'DKPFKI 'MKPGVKEUD[ " WUKPI 'RNCPC T'RJ QVQPK E/RNCUO QPKE 'PCPQUVTWEVWTGU'HQT" DKQUGP UKPI "**

X{xcwcuI tcf cwuncu<sup>3</sup>.Lwukpc' Cpwn{ v<sup>3</sup>. 'Gtpguc' Bužavaitė/Vertelienė<sup>3</sup>. 'Kxc' Plikusienė<sup>3,4</sup>. \ ki o cu' Balevičius<sup>3,5</sup>"

<sup>3</sup>"Ucvg' T gugctej "Kpukwag' Egpvt' hqt' Rj { ulecl' Uelgpegu' cpf "Vgej pqm { . "Ucwgvgnkq' cxg05. 'NV/32479' Xkpkwu. " Nkj wpc" "

<sup>4</sup>"Hcewn{ 'qh' Ej go knt { 'cpf' I gquelpg. "Xkpkwu' Wpkxgtuk{ . 'P cwi ctf wmq' ut046. 'NV/25447' Xkpkwu. "Nkj wpc" "

<sup>5</sup>"Hcewn{ 'qh' Ggevt qpleu. "Xkpkwu' I gf lo kpcu' Vgej plecl' Wpkxgtuk{ . 'P cwi ctf wmq' ut063. 'NV/25449' Xkpkwu. "Nkj wpc" "[x{xcwcuI tcf cwuncuB Hfwnf 0xw0y](#)"

Dkqugpuqt' d'cugf "qp' uwt' hceg" r' ncuo qp' t' guqpcpeg "URT-ct' g'y kf gr{ "wugf "kp' dkqugpuki "f wg' vq' vj' g' j' ki j' "ugpukxkx{ 'qh' vj' g' URT0J qy gxt. 'xctkqwu' r' j' qvqple/ r' ncuo qple' ut' wewt' gu' ct' g' l'pxgunki cvgf "kp' qtf' gt' vq' t' gf' weg' vj' g' j' ki j' "tquugu' l'p' vj' g' o' gvcn' vj' cv' dtqcf' gpu' vj' g' y' kf vj' "qh' r' ncuo qple' t' guqpcpeg. "cpf' "cu' c' t' guwax. "f' get' gcukpi "ugpukxkx{ "qh' vj' g' ugpugt' 0' k' qtf' gt' vq' t' gf' weg' vj' g' "mquugu' l'p' vj' g' o' gvcn' c' o' qf' k' h' gf' "r' j' qvqple/ r' ncuo qple" pcpquvt' wewt' g. "uwr' r' qt' vpi " Vco o' "r' ncuo qp/ uwt' hceg" r' ncuo qp' r' qrtkqpu "VRR/ URR-+" [3\_ o' qf' g' eqwaf' "dg" go r' m{ gf' "hqt' f' g' vevqap' qh' r' tqvkl'p' kvgt' cev' kpu' qp' uqkf' / r' k' w' k' "kvgt' hceg" ]4. "5\_0' Uvej "v' r' g' qh' r' ncuo qple" o' qf' g' eqpukuu' qh' vj' q' f' k' h' gt' gpv' r' ncuo qple' g' zek' cev' kpu' vj' g' uq' ecmgf' "Vco o' "r' ncuo qp/ r' qrtkqpu "VRR-+" cpf' "uwt' hceg" r' ncuo qp/ r' qrtkqpu "URR-0' Vj' g' URR" o' qf' g' "ku' i' gpgt' cvgf' "cv' o' gvcn' f' k' r' g' ev' t' k' "kvgt' hceg" cu' vj' g' "VRR" ku' i' gpgt' cvgf' "cv' vj' g' RE lo gvcn' d' qwpf' ct' { "l'p' vj' g' r' j' qvqple' d' cpf' "i' cr' "qh' RE0'

In this research a photonic-plasmonic nanostructure consisting of PC (TiO<sub>2</sub>/SiO<sub>2</sub>) with thin (~40 nm) Au layer was investigated. A total internal reflection ellipsometry (TIRE) method for generation of plasmonic modes were employed. A stem cell factor receptor (SCF-R) and bovine serum albumin (BSA) were used in order to investigate the sensitivity of the plasmonic modes. The kinetics interactions of immobilized SCF-R receptor on the chip surface with genetically engineered ligands was studied. The results showed a higher concentration detection limit on a TPP-SPP mode, rather than that of SPR."

[3\_ E. Bužavaitė/Vertelienė, V. Vertelis and Z. Balevičius, The experimental evidence of a strong coupling regime in the hybrid Tamm plasmon/uwt' hceg" r' ncuo qp' r' qrtkqpu' o' qf' g. "Pcpqrj' qvqpleu. "42430] [w u-1f qkQti B20737 lpcqrj /4242/2882](#)"

[4\_ "G0Dw' cxckg/ Xgt' v' k' p' g. "K0R' kmul' g' p' g. "V0' V' q' r' p' k' i' g' v' c' f' 0' J { dtkf' "Vco o' /uwt' hceg" r' ncuo qp' r' qrtkqpu' o' qf' g' hqt' j' ki j' n' "ugpukxg' f' g' vevqap' qh' r' tqvkl'p' kvgt' cev' kpu. "Or' i' 0' G' r' t' gu' 4: "4; 255/4; 265" 4242-0'

[3] Z. Balevičius, Strong coupling between Tamm and surface plasmons for advanced optical biosensing, *Eq' cv' kpi u.* "32" 34+ "33: 9" 4242-0'

P5-1

DID NOT PARTICIPATE



**VJ G'I GPQVQZKE 'KO RCE V'VQ'RGT KRJ GTCN'DNQQF 'EGNNUQHPERCA  
FLUVIATILIS'KPF WEGF 'D[ 'O WNVKRN'UVTGUUQTUWEQO GV'CUUC[ "  
CPF 'PWENGCT'CDPQTO CNKVGU'CP CN[ UKU'**

I gm kp "Xcpugxk k v<sup>3</sup> . 'O krf c'Ucpngxk k v<sup>3</sup>"

<sup>3</sup>Ncdqtcvqt { "qh'I gpqvzleqmi { . 'P cwtg'Tgugtej 'Egptg.'Nkj wcpk"  
xepi gm kpgB i o cktqo "

" Cpj tqr qi gple"r qmwkq"kp"cs wvle"u{vgo u"ku"f co ci kpi "rxkpi "qti cpluo u0'Hwvj gto qtg."cs wvle"cpko cnu"ctg"  
eqpuxcpvnl "gzz qugf "vq"pcwtcmf "qeevttkpi "r ctcukle"lphgevkpu."y j lej "o c{ "lphkpi g"j quv" \*k0'g0'hkuj +"ko o wpg"u{vgo "  
y gcngpki "ksu"tgukvcpvq"vq"xtkqwu'r qmwcpw"uwej "cu'o gvcnu0'Eapugs wgvnl ."v ku'uwf { "hgewu"qp"i gpqvzle"f co ci g"vq"  
Rgtec"mwxk vku"r gtr j gtcn'dmqf "egm"lpf wegf "d{ "pcwtcmf "qeevttkpi "utguuqtu" \*eq/lphgevkp"y kj "Vtkej qf kpc"ur 0'cpf "  
Urtqrgi plc"rctcukkec+"cpf "cpj tqr qi gplecmf "ecwugf "qpgu" \*j gcx{ "o gvcnu+0'Vj gug"utguuqtu"qeevttkpi "uko wncpgqwanf "  
ngcf "vq"vpr tgf levdng"i gpqvzle"qweqo gu"lp"cs wvle"qti cpluo u0'Wpvl'pqy ."v gtg"j cxg"dggp"pq"uwf lgu"hgewkpi "qp"  
eqo dlpkf "ghgew"qh'r ctcukle"eq/lphgevkp"cpf "o gvcn'o kzwg"gzr quwtg."qpnf "qp"i gpqvzle"ghgew"ecwugf "d{ "ukpi ng"  
utguuqt0'Vj gtghqg."lp"v ku'uwf { "v g"cpnf uku"qh'pwengct'cdpqt o cnkkgu."uwej "cu'o letqpwengwu" \*OP +."pwengct'dwf u" \*PD+ "  
dnqddg" pwengk' \*DN+" cpf " eqo gv' cuuc{ " cpcn'uku" kp" gt{ vj tqe{vgu" qh" r gtr j gtcn' dqgf " egm" y cu" r gthqto gf 0' Vj g"  
gzr gto gpcn'uwf { "y cu'f guki pgf "vq"tgetgcvg"tgcrkule"kpvtcevq"eqpf kkpqu"eqpegtkpi "o wnk ng"utguu"ghgew"vq"uj qy "  
r quukdng"i gpqvzlekvf "qweqo gu0'T guwuu"lpf lecvg"v cv'uko wncpgqwanf "eq/lphgevgf"cpf "gzr qugf "vq"r qmwcpw"hkuj "vgpf "vq"  
i gv'j ki j guv'i gpqvzle"ko r cev'eqo r ctgf "vq"y j gp"qpnf "qpg"utguuqt'ku'r tgugp0'Vj g'uwf { "cnuq'wvi i guu"v cv'utguuqtu'o c{ "  
chgew'hkuj "lp"u{pgti gve"o cpgt."utgpi vj gkpi "qpg'cpqvj gtai"i gpqvzle"ko r cev0"

Vj ku'uwf { "y cu'hwpgf "d{ "v g'Tgugtej 'Eqwpekn'qh'Nkj wcpk"vj tqwi j "v g'r tqlgev'R/O RR/43/44; 0'

**QRVKO K CVKQP 'QH'UQN/I GN'UJ P VJ GUKUR'RTQEGF WT'G'QH'VWP I UVGP "**  
**\*XK'QZKF G'E QCVKPI U'HQT'GHHK KGP V'RJ QVQGNGE VTQEJ GO KECN "**  
**RTQF WEVKQP 'QH'J [ RQEJ NQTK'G "**

Gxgrkpc'I tlpkwn<sup>3,4</sup>. Kgpce'Ucxkenc<sup>4</sup>. Ctpcu'P cwlqmkku<sup>4</sup>. Lxti c'Lxqf nē { v<sup>4</sup>. 'O kf c'Rgvt wgxk kgp<sup>4</sup> " " "

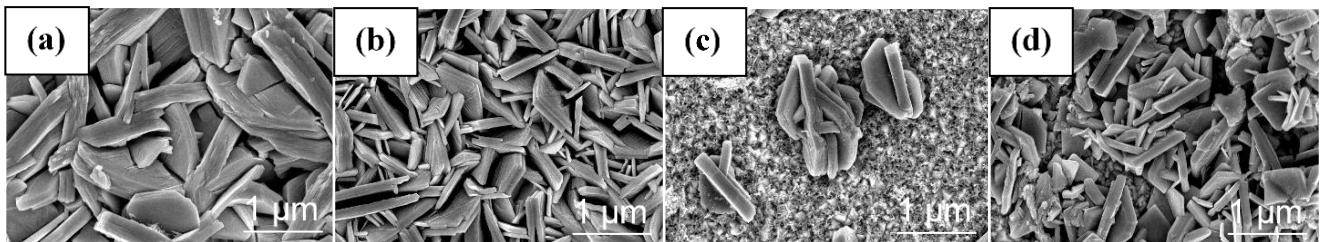
<sup>3</sup> "kpkwng'qh'Ej go kwt { .Hcewn{ "qh'Ej go kwt { "cpf 'I gquckpogu.'P cwi ctf wnt'ut046.'NV/25447'Xlpxku'Wpkxtukf. " Nkj wcpk "

<sup>4</sup> "Egpvt 'hqt'Rj { ulecn'Uelkpegu'cpf "Vgej pqrqi { .F gr ctwo gpv'qh'ej go lecn'gpi kpggtkpi "cpf "vgej pqrqi { " " Ucvn vgnk'cx05.'NV/32479'Xlpxku-"  
gxgrkpc'I tlpkwnB uwf Qej i Hxvotv

Rj qvqrgestqej go lecn' \*RGE+" vgej pls wgu" j cxg" tgegkxgf " c" m'v' qh' cwgpvkqp" dgecwug" vj g{ " r tqxkf g" kpuki j vu" kpvq" vj g" wklk' cvkqp'qh'uqnt' gpgti { "hqt'uwuclpcdnr" r tqf wevkqp'qh'j { f tqi gp'cpf "qvj gt"ej go lecn. "f gi tcf cvkqp'qh'qti cple" r qmwpv. " i gpgtcvkqp'qh'gresteksf "kp" r j qvqrgestqej. "gve0C" r kxqvc'nej cmgpi g'vq'tgerk' g'RGE" cr r nlecvkqp'kp" r tcevek g'ku'f gxmtr o gpv'qh' ghlekpv'r j qvqrgestqf g'o cvgtkcn"]3/5\_0

O cp{ "ugo leqpf wevt" o gcn'qzfk gu. "uwej "cu" VIKQ<sub>4</sub>. "Y Q<sub>5</sub>. "DkXQ<sub>6</sub>" cpf "α/Hg<sub>4</sub>Q<sub>5</sub>. "j cxg" dggp" kpvpuen' "kpxguki cvgf "cu" r j qvqrgestqf gu'f wv" vj gk" j ki j "ej go lecn'ucdkk' "kp" qzfk cvkqp" eqpf kkpku'cpf "tgcupcdn' "j ki j "lpek' gpv' rki j v/vq'ewt'gpv' eqpxgtukqp' ghlekpeku'Co qpi "vj go. "Y Q<sub>5</sub>" ku" c" r tqo kulpi "r j qvqrpqf g" o cvgtkcn' hqt'ku" o qf g'cvg' dcpf "i cr "qh'40/640" gX. " y j lej "cmqy u'cduqtdkpi "φ34" "qh'uqnt'ur gewto "y kj "c" vj g'gtgvekn'io czko wo "gpgti { "eqpxgtukqp' ghlekpe { "qh'~80" "J3\_0

Kp" vj ku" y qtm" Y Q<sub>5</sub>" vj kp" hko u'qp" eqpf wevkxg" i rui" \*HVQ+" uwduntcvg" y gtg" u{pvj guk' gf "wulpi "uqn' i gn' o gvj qf "cpf "f kr / eqcvkpi "vgej pls wv0'E qcvkpi u" y gtg" o qf hkgf "wulpi "f hhtg'gpv' co qwpv'qh' r qn' gvj { rpgg" i n' eqn' \*RGI + "lp" qtf gt "vq' gxcnvcg" vj g" kphwpep' qh' vj ku' cf f kxg" qp" r j qvqrgestqej go lecn' t'gur qpug' qh' vj g" r" c" gtu0' Vj g" u{pvj guku' y cu' ecttkgf "qw'cv": 7Å "hqt" 3: 2" o kpwgu' wulpi "f hhtg'gpv' P c<sub>4</sub> Y Q<sub>6</sub>" vj RGI "tcvku'qh" \*3-3=3-4. "3-20' =3-20-0'E qcvkpi u" y gtg" cppgcrgf "cv'622Å "hqt" 4" j "lp" ck0' Vj g" eqo r qukkqp" cpf "uwtceg" o qtr j qmji { "qh' vj g" eqcvkpi u" y gtg" kpxguki cvgf "wulpi "Z/te { "f hhtcevkqp" cpf "uecpkpi "grgestqp" o letqueqr { " \*UGO + "vgej pls wv0' Rj qvqrgestqej go lecn' t'gur qpug" y cu' kpxguki cvgf "d { "e { enle "xqnc o gvt { "kp" vj tgg" grgestqf g" egm'lp" 20' O "J<sub>4</sub> UQ<sub>6</sub>" uqnwkp' "lp" vj g' f ctn' cpf "wpf gt" hki j v'ktcf cvkqp0Ej tqpqco r gtqo gvt { "kp" vj q' grgestqf g' ugv' w' cmqpi "y kj " vktko g' tle" cpcn' uku" y gtg" wugf "vq" gxcnvcg" vj g" Hctcf cle" ghlekpe { "qh' r j qvqrgestqej go lecn' j { r qej mtkg" r tqf wevkqp" y kj " Y Q<sub>5</sub>" r j qvqrgestqf gu'lp" P cEn' uqnwkp0' " " "



Hki 0'0Vqr 'xkgy "UGO" ko ci gu'qh' Y Q<sub>5</sub> hko u'u{pvj guk' gf "y kj "f hhtg'gpv' P c<sub>4</sub> Y Q<sub>6</sub>" vj RGI "tcvku'3-20' \*c+ "3-20' \*d+. " 3-3' \*e+ "cpf "3-4' \*f +0' " " "

K' y cu' hqwpf " vj cv' f hhtg'gpv' co qwpv' qh' RGI " wugf "kp" uqn' i gn' u{pvj guku' utqpi n' "kphwpegu" o qtr j qmji { "qh' vj g" Y Q<sub>5</sub>" eqcvkpi u' "Hki 0'3-0' Cm' eqcvkpi u" y gtg" r j qvqrgestqej go lecn' "cevkg. "j gy gxt" vj g' j ki j guv' r j qvqewt'gpv' qh' 20' o C" eo /<sup>4</sup> cv"..... 30' X" \*Ci ICi En" y cu' hqwpf "hqt" vj g' eqcvkpi "u{pvj guk' gf "y kj " P c<sub>4</sub> Y Q<sub>6</sub>-RGI " o qnt' "tcvku' qh' 3-20' . "y j lej " o gcpu' vj cv' vj g' u{pvj guku' eqpf kkpku' gpugt' vj g' o qu' ghgvevkxg" i gpgtcvkqp' cpf "t'cpcu' qt' v' qh' r j qvq' gpgtcv' "ej cti g' ecttkgtu' "kp" vj g' qzfk g' r { gt0' Hctcf cle" ghlekpe { "qh' j { r qej mtkg' hqt o cvkqp' t'cpi gf "dgw ggp' 86' 6' 89' " 0' " " "

Cenpqy rgi o gpv' "

Vj ku' t'gugctej " ku' hwpf gf " d { " vj g" Gwtqr gcp" Uqekcn' Hwpf " wpf gt" vj g" P q" 2; 05/NO V/M/934/44/23: 7" 0F gxmtr o gpv' qh' Eqo r gvp'egu' qh' Uelkpvkuu. "qvj gt" T'gugctej gtu'cpf "Uwf gpv' vj tqwi j "Rtcevekn' T'gugctej "Cevkxkku' o gcuwtg0' " " "

[3\_5\_0] gpi. "l0Nk' l0Dck' Z0Nk' N0Zle. "D0' j qw' R'gr ctevkqp' qh' x'gtvekn' "crki p'gf "Y Q<sub>5</sub>" pcpqr r'v' c'tte { "hko u' d'cu'gf "qp" r g' qz' q'wpi u' v' g' t'gf wevkqp' t' g'cev'kqp' cpf "v' j gk' g' z'egm'pv' r j qvqrgestqecv' n' v' r g' h' q' to c'peg. "Cr r r'kgf "E'even' uku' D' <Gpxk' q'po gp'cn' 424. '5: : /5; 8' \*4239+ " [4\_ "M0Uc { co c. "Rtqf wevkqp' qh' j ki j / X'cnw' / Cf f gf "Ej go lecn' qp" Qz'kf g' Ugo leqpf wevt' "Rj qvqrpqf gu' w'pf gt" "X'ukdn' "Nki j v' hqt" "Uqnt' "Ej go lecn' Eqpxgtukqp' Rtqegungu. "CEU' G'p'gti { "Ngwtu' 5 \*7+ /32; 5/3323' \*423: -0' [5\_ "Y 0' [ cpi. "T0' Tco cpwko "Rtcdj cnet. "l0' Vcp. "U'F c'xk' "Vlmg { . "l0' O qpp. "U' t'cvgi l'gu' hqt" gpj cpe'kpi " vj g" r j qvqewt'gpv' r j qvq' qnci g. "cpf "ucdkk' { "qh' r j qvqrgestqf gu' hqt' r j qvqrgestqej go lecn' i cvgt' ur r'kwpi .Ej go lecn' Uqelgv' "T'gxkgy u' 6: . '6; 676739: " \*423; -0' " " "

**VTQRJ KE 'GEQNQI [ 'QH'UO CNN'O CO O CNU'K'EQO O GTEKCN'  
QTEJ CTFU'K'UK J VUHTQO 'UVCDNG'KUQVQRG'UVWF KGU'**

XkcrkwUktm<sup>3</sup>. 'Nkpcu'Dcn kcwun<sup>3</sup>. 'Ncko c'Dcn kcwun<sup>3</sup>. 'Tco kpc'Unkr kv<sup>4</sup>. 'Cpf tkwu'  
I ctdctcu<sup>4</sup>"

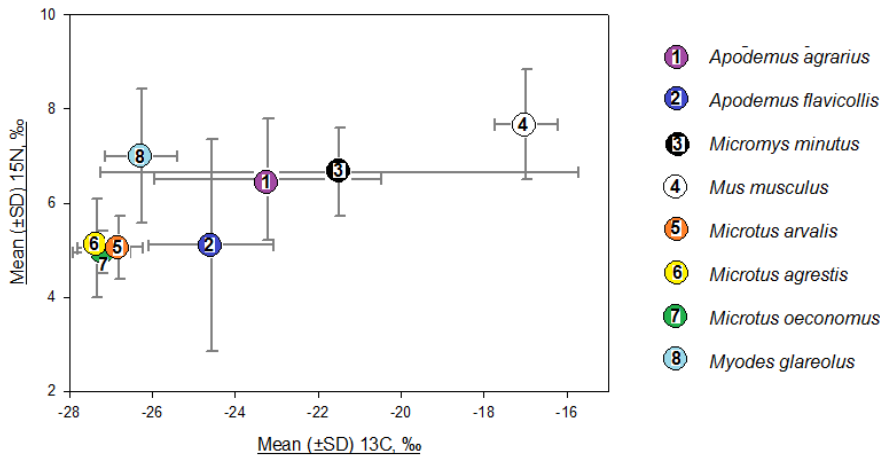
" <sup>3</sup>P cwtg'Tgugtej 'Egvtg.'Nkj wcpk"  
<sup>4</sup>Egvtg'ht'Rj { ulecn'Uekpegu'cpf 'Vgej pqrqi { . 'Nkj wcpk"  
xkcrkwUktmB i co ve0n'

" Hqtci kpi 'utcvgi kgu'lp'xctkqwu'cpko cn'ur geku'lp'tgegpv' { gctu'ctg'o cknf 'f gvgto kpgf 'd { 'yj gkt'kuqvr le'plej g'y j lej " ku' f ghpqf " d { " o gcpu'qh' ucdng' kuqvr g" cpcnf uku' Ceeqtf kpi " yj g' vqr j ke " r gewkctkkgu' uo cm' o co o cnu' qh' yj g' o kf f ng' rkwf gu'ctg'i tqwr gf "lpvq'j gtdkxqtgu." i tclpxqtgu." qo plxqtgu'cpf "lpugevaxqtgu'J gtdkxqtgu'"\*O ketqwu'ur r 0' o cknf "hgqf " qp'yj g'i tggp'r ncp'o cvgtken" i tclpxqtgu'"\*Cr qf go wu'cpf "O ketqo { u'ur r 0' qp'uggf u." htku'cpf lqt' hqqf u'qh'cpko cn'gtki kp." qo plxqtgu'"\*O { qf gu'i rwtgqmw'qp'dqvj "ryy "cpf " j ki j "gpqi g'ke'r ncp'vtguwtegu'cpf "cpko cn'hqqf . "cpf "lpugevaxqtgu'"\*Uqtgz" ur r 0' qp' hqqf u'qh'cpko cn'gtki kp0"

Kp'423: 6423; "y g'tcr r gf "uo cm'o co o cnu'lp'37"eqo o gtekn'qtej ctf u." dgt { "r ncp'vaxqpu'cpf "pgi j dqt kpi "eqvqdn' j cdkcwu." o cknf "o gcf qy u" ]3\_0'Kp "vqen"32: 9'lpf kxf wcu'"\*33"ur geku+y g'g' vqr j ke " r gewkctkkgu' uo cm' o co o cnu' qh' yj g' o kf f ng' rkwf gu'ctg'i tqwr gf "lpvq'j gtdkxqtgu." i tclpxqtgu." qo plxqtgu'cpf "lpugevaxqtgu'J gtdkxqtgu'"\*O ketqwu'ur r 0' o cknf "hgqf " qp'yj g'i tggp'r ncp'o cvgtken" i tclpxqtgu'"\*Cr qf go wu'cpf "O ketqo { u'ur r 0' qp'uggf u." htku'cpf lqt' hqqf u'qh'cpko cn'gtki kp." qo plxqtgu'"\*O { qf gu'i rwtgqmw'qp'dqvj "ryy "cpf " j ki j "gpqi g'ke'r ncp'vtguwtegu'cpf "cpko cn'hqqf . "cpf "lpugevaxqtgu'"\*Uqtgz" ur r 0' qp' hqqf u'qh'cpko cn'gtki kp0"

Mpqy kpi 'yj g'vqr j ke'geqni { "qh'yj g'ur geku'yj cv'qeew'lp'c'i kxgp'iqecvqp'ku'etwelen'ht'wpf gtuwcpf kpi "yj g' hcvqtu' yj cv'cmqy "yj g'kt'eq/gzknqpe0'Xcmgu'qh'yj g' ucdng' kuqvr gu'r tqxkf g' vqr j ke " r gewkctkkgu' uo cm' o co o cnu' qh' yj g' o kf f ng' rkwf gu'ctg'i tqwr gf "lpvq'j gtdkxqtgu." i tclpxqtgu." qo plxqtgu'cpf "lpugevaxqtgu'J gtdkxqtgu'"\*O ketqwu'ur r 0' o cknf "hgqf " qp'yj g'i tggp'r ncp'o cvgtken" i tclpxqtgu'"\*Cr qf go wu'cpf "O ketqo { u'ur r 0' qp'uggf u." htku'cpf lqt' hqqf u'qh'cpko cn'gtki kp." qo plxqtgu'"\*O { qf gu'i rwtgqmw'qp'dqvj "ryy "cpf " j ki j "gpqi g'ke'r ncp'vtguwtegu'cpf "cpko cn'hqqf . "cpf "lpugevaxqtgu'"\*Uqtgz" ur r 0' qp' hqqf u'qh'cpko cn'gtki kp0"

Ur geku' r qukkqp' ceeqtf kpi " <sup>37</sup>P " xcmgu' hqto gf " ppg" i tqwr " qh' cm' j gtdkxqtgu' ctf " yj g' { gmqy /pgemf " o qwug' \*Cr qf go wu' hcxkeqniku' " cpf " yj g'ugeqpf " qh' qo plxqtg'dcpni'xqrg' O'0' i rwtgqmw' yj kj " yj g' tgu' qh' i tclpxqtg' ur geku' <sup>37</sup>P " xcmgu'lp' Uqtgz' ur geku' gzegef " cm'o gpvqpgf " i tqwr u'465/hqf " ]4\_0'Ego r ctf " vq'pcwten' j cdkcwu'qh'yj g' hqqf g' o gcf qy u' ]4\_ " f kwtkdwkqp' qh' <sup>35</sup>E " xcmgu'lp' eqo o gtekn'qtej ctf u' y cu'xgt { " y kf g' " Hki 0'3+ " gur gekm' "lp' j ctxgu'v' o qwug' \*O ketqo { u' ur r 0' qp' hqqf u'qh'cpko cn'gtki kp0"



Hki 0'30F hhtgpegu'lp' yj g'vqr j ke'ur ceg'qh'i tclpxqtgu'\*366+.' j gtdkxqtgu'\*769+.'cpf 'qo plxqtgu'\*. +lp'eqo o gtekn'qtej ctf u0"

Eqpenw' kpi . 'y g' hqp'f 'yj cv'3+ 'uo cm'o co o cni'f kv'lp' yj g' qtej ctf u' f "pqv'f hhtg' uki pklcepvn' "htqo "yj g' uwtqwpf kpi " o gcf qy u' o' "yj ku' ko r nku' cmq" o ki tcvqp' qh' yj g' cpko cnu' dgw ggp' qtej ctf u' cfp " o gcf qy u' "4+ " ceeqtf kpi " f kwtkdwkqp' qh' <sup>37</sup>P " cpf " <sup>35</sup>E " xcmgu' " f kvct { "plej g'lp' yj g' qtej ctf u' ku' ugi tgi cvgf "dgw ggp' uo cm' o co o cnu' ur geku' cfp " i tqwr u' "5+ " ceeqtf kpi " uo cm' o co o cni' eqo o wplk' { "eqo r qukkqp' cfp " f kv' " eqo o gtekn' i ctf gnu' ctg' "lp' dgw ggp' pcwten' cfp " yj g' qj g' " ci tlewnwtcn' j cdkcwu'0'Y g' r tguwo g' r qukkdng' gh'gevu' qh' ugcup. "lpvq'p' "qh' ci tlewnwtcn' r tcevegu' cfp " etqr " v' r g' qp' yj g' " co r nkwf g' qh' yj g' vqr j ke'plej g' qh' f qo kcpv' ur geku' Rtgnko kpct { . 'yj g' lpwngpeg' qh' j cdkcwu' qp' yj g' kuqvr le' vqr j ke'plej g' ku' ur geku' f gr gpf gpv' cfp " pqv'wplk' k' tevkqpcn' yj wu' dglpi " f k' h' eww' v' q' o cmg' i gpqtcn' r tgf kv' k' qpu' qh' ur geku' t' gur qpug'0"

XU. 'ND' cfp "ND' y g' g' hqpcpegf " d { " i tcv'0 q'c' Nkj wcpk. 'P q'0 V/3: /50"

[3\_] Dcn kcwun. 'N0' Dcn kcwun. 'N0' Uktm. 'X0' O qy 'yj g' i tcv'cv' yj g' o qwug' i' r' g' t' k' f' k' x' g' t' u' k' { 'qh' uo cm' o co o cnu' lp' eqo o gtekn' h' w' h' t' o u' C' p' k' o cnu' ; \*8+ 'ct0' p' q' 0556' \*423; +0

[4\_] Dcn kcwun. 'N0' Unkr kv. 'T0' Dcn kcwun. 'N0' Uktm. 'X0' O qy 'yj g' i tcv'cv' yj g' o qwug' i' r' g' t' k' f' k' x' g' t' u' k' { 'qh' uo cm' o co o cnu' lp' eqo o gtekn' h' w' h' t' o u' C' p' k' o cnu' ; \*8+ 'ct0' p' q' 0556' \*423; +0

**ARIDIA O WCVKQPURP 'WGTG'G'NCXCI G'HNWKF 'KPFKECVGU'GCTN[ ' ' GPFQO GVTKN'CPF'QXCTKCP'ECPEGTU'**

Kxc'Xclegnwunckv<sup>3.4</sup>. 'F kpc'fikyxk<sup>3.4</sup>. 'T v' kvtrkpg<sup>3</sup>. 'Tcu'Udcnkunckv<sup>3</sup>. 'Uqpcv'  
Lcto crk<sup>3</sup>"

<sup>3</sup>P cvkpcn'Ecpegt "Kpukwv. 'Xkpkwu. 'Nkj wcpk"  
<sup>4</sup>"Kpukwv'qh'Dkqelgpegu. 'Xkpkwu'Wpkxgtukv. 'Xkpkwu. 'Nkj wcpk"  
kxc'XclegnwunckvB pxk'v"

"

**Kpvt qf wekqo** Gpf qo gvtkn'ecpegt "GE+'ku'yj g'o quv'eqo o qp" qpeqi { pgeqmi kcn'o crki pcpe { 'y qtrf y kf g. 'y j krg' qxctkcp'ecpegt "QE+'ku'yj g'f gcf rguv'o crki pcpe { [3\_0Vj g'j ki j 'lpek'f gpeg'cpf 'b qtcrk' { 'tcv'u'ctg'cvt'kdwgf 'vq'icn'q'ht'ur gekle' u{o r vqo u'qt'gh'g'v'g'uetg'p'kpi "vej plk wgu'tguw'kpi 'kp'rv'g'f'kci p'q'ku'0'QE'ku'o quv' 'f'kci p'q'ugf 'cv'uci gu'kk'kt' 'KX.'y j gp' yj g'7/ { gct'w'w'x'k'c'it'c'v'u'ctg'q'pn' '5/3; ' ' ]4\_0J qy g'xgt. 'g'x'p'y j gp'yj g'ecpegt 'ku'f'g'v'g'f'g'ctn'f. 'cu'ku'q'hw'p'y kj 'GE. 'f'kug'cug' tgevt'g'peg' 'tcv'g'ku'32/37' "cpf' 'y' g'g'ku'p'q'c'x'k'c'v'g'g' 'i' g'p'g'v'e' 'dl'q'o c'tng'tu'y kj 'c' 'r'q'v'p'k'c'v'q' 'r' t'g'f'k'v'v'j g'o quv'ci i t'g'u'k'x'g' ecugu'y kj 'c'j ki j 'tku'iq'h't'g'r'ur'g' ]5\_0Dq'v' 'GE' 'cpf' 'QE' 'ct'g'q'hw'p' 'ej' c'tce'v'g't'k' g'f' 'd' { 'i' g'p'q'o le'c'ng't'c'v'k'p'u'0'CT'K'F'3C. 'c' 'u'w'd'w'p'k'v' qh'UY KUP H'ej t'q'o cvk'p' 't'g'o q'f'g'k'p'i "eqo r'ngz. 'ku'q'hw'p' 'o' w'c'v'g'f' 'kp' 'd'q'v' 'g'p'f'q'o g'v't'k'k'u'k'u'c'u'q'ek'c'v'g'f' "QE' 'cpf' "GE'0'CT'K'F'3C' " r'c't'v'k'c'v'g'u' 'kp' 'p'v'erg'qu'o g' 't'g'r'q'uk'k'p'k'p'i. 'y' w'u' 'n'u'u' 'q'h' 'h'w'p'v'k'p' 'o' w'c'v'k'p'u' 'kp' 'y' k'u' 'w'o' q't' 'u'w'r' 't'g'u'q't' 'i' g'p'g' 'e'q'w'f' 'r'g'c'f' 'v'q' " i' m'q'd'c'ri'k'o r'c'ev'q'p' 'v'c'p'ue't'k'v'k'p' 'cpf' 'i' g'p'g' 'g'z'r' 't'g'u'k'k'p' ]6\_0C' 'n'j' q'w'i' j' 'e'w't'g'p'v' 'd'k'q'r' 'u'k'g'u' 'c't'g' 't'g'i' c't'f' g'f' 'c'u' 'y' g' 'i' q'f' 'u'c'p'f' c't'f' 'h'q't' f'k'c'i' p'q'k'u'. 'u'c'i' k'p'i "cpf' 'i' g'p'g'v'e' 'c'p'c'n'f' 'u'k'i' 'y' c'v'o' c' { 'u'w'i' i' g'u'v'c't'i' g'v'g'f' 'v't'g'ev'o' g'p'v' 'y' j' g' { 'c't'g' 'k'p'x'c'u'k'x'g' 'c'p'f' 'p'q'v' 'u'w'k'c'd'g' 'h'q't' 'n'p'i / v'g't'o' 'f' 'k'ug'c'ug' 'o' p'k'q'k't'k'p'i " ]7\_0D'q'v' 'QE' 'cpf' "GE' 'u'j' g'f' 'e'g'm' 'l'p'v'q' 'w'g't'k'p'g' 'e'c'x'k'v'f' 'y' j' k'ej' 'e'c'p' 'd'g' 'u'c'o' r' 'r'g'f' 'p'q'p' / 'k'p'x'c'u'k'x'g' 'n'f' 'd' { " w'g't'k'p'g' 'r'x'c'i' g' 'c' 'u'k'o' r' 'n'g' 'u'c'o' r' 'n'p'i " 'v'g'ej' 'p'k'w'g' 'y' c'v'ec'p' 'd'g' 'r' 'g't'h'q't'o' g'f' 'k'p' 'c' 'i' { 'p'g'eq'm'i' k'u'v'q'h'k'eg' ]8\_0U'g's' w'g'p'ek'p'i "q'h' 'w'g't'k'p'g' " r'x'c'i' g' 'h'w'k'f' 'h'q't'o' "GE' 'r' c'v'k'p'u' 'y' c'u' 'd'g'g'p' 'u'j' q'y' p' 'v'q' 'f' g'v'g'ev'o' w'c'v'k'p'u' 'kp' 'w' 'v'q' '322' " q'h'o' crki' p'c'p'ek'g'u' 'r' t'q'x'k'p'i 'y' c'v'w'g't'k'p'g' " r'x'c'i' g' 'e'q'w'f' 'd'g' 'w'g'h'w'k'f' 'i' { 'p'g'eq'm'i' k'c'n'f'ec'p'eg't' 'f'k'c'i' p'q'k'u' ]9\_0"

**Vj g'Clo** "qh'yj ku'uwf { 'y cu'v'q'wug'v'c'ti' g'v'g'f' 'ugs' w'g'p'ek'p'i "v'q'cu'gu'CT'K'F'3C' "o' w'c'v'k'p'u' 'kp' "QE' 'cpf' "GE' 'r' c'v'k'p'v'w' 'w'g't'k'p'g' " r'x'c'i' g' 'h'w'k'f' 'c'p'f' 'v'k'u'w'g' 'u'c'o' r' 'n'g'u' 'c'p'f' 'f' g'v'g't'o' k'p'g'CT'K'F'3C' "UP R'c'u'q'ek'c'v'k'p' 'y' k'j' 'e'k'p'k'c'ri' 'h'c'w'v'g'u'0'

**O g'v'j' q'f' u'56** 'w'g't'k'p'g' 'r'x'c'i' g' 'c'p'f' "43' 'v'k'u'w'g' 'u'c'o' r' 'n'g'u' 'h'q't'o' "76' 'r' c'v'k'p'w' "46' 'j' k'j' 'i' 't'c'f' g' 'u'g't'q'w'u' 'q'x'c't'k'c'p' 'e'c'p'eg't' ". 'p'q'p' / 'u'g't'q'w'u' 'q'x'c't'k'c'p' 'e'c'p'eg't' "33' 'g'p'f' q'o' g'v't'k'n' 'e'c'p'eg't' 'c'p'f' "33' 'r' c'v'k'p'w' 'y' k'j' 'd'g'p'k'i' p' 'e'q'p'f' k'k'q'p'u' 'y' g't'g' 'c'p'c'n'f' | g'f' 'd' { 'v'c't'i' g'v'g'f' 'p'g'z'v' " i' g'p'g't'c'v'k'p' 'u'g's' w'g'p'ek'p'i 'w'k'p'i 'K'p' 'C'o' r' 'n'U'g's' 'I' 'Q'p' / 'F' g'o' c'p'f' 'R'ep'g'n'v'c't'i' g'v'k'p'i "CT'K'F'3C' "o' w'c'v'k'p'u'0' 'R'c'v'j' q'i' g'p'k'ek'v' { 'q'h' 'w'p'eg't' 'c'k'p' " u'k'i' p'k'h'ec'p'eg' 'b' w'c'v'k'p'u' 'y' g't'g' 'r'g'f' 'k'ev'g'f' 'w'k'p'i' 'q'p'k'p'g' 'f' 'c'v'c'd'c'ug' 'X'c't'U'q'o' g' ]: '0' "

**T'g'u'w'u'0'36** 'CT'K'F'3C' "UP Ru' 'y' g't'g' 'f' g'v'g'ev'g'f' 'kp' '48' " "36176+' r' c'v'k'p'w'0'86' " "3; B6+' q'h' 'y' g'ug' 'y' g't'g' 'f' g'v'g't'o' k'p'g'f' 'v'q' 'd'g' " r'c'v'j' q'i' g'p'k' "c'p'f' 'y' g't'g'u'v' 'y' g't'g' 'q'h' 'w'p'eg't' 'c'k'p' 'u'k'i' p'k'h'ec'p'eg'0'CT'K'F'3C' "o' w'c'v'k'p'u' 'y' g't'g' 'r' 't'k'o' c't'k'k' 'f' g'v'g'ev'g'f' 'kp' 'g'c't'n'f' 'u'c'i' g' "r' V3. " I 3+' g'p'f' q'o' g'v't'k'k'f' "GE' 'c'p'f' "o' w'ek'p'q'w'u' 'QE. " : 1; "r'c'v'j' q'i' g'p'k' "UP Ru' 'y' g't'g' 'f' g'v'g'ev'g'f' 'kp' 'p'q'p' / 'u'g't'q'w'u' 'o' crki' p'c'p'ek'g'u'0'65' " "3; 19+' o' w'c'v'k'p'u' 'y' g't'g' 'f' g'v'g'ev'g'f' 'kp' 'd'q'v' 'v'k'u'w'g' 'c'p'f' 'w'g't'k'p'g' 'r'x'c'i' g' 'u'c'o' r' 'n'g'u'0' "

**Kp'eq'p'ew'k'p'.** 'CT'K'F'3C' "o' w'c'v'k'p'u' 'kp' 'w'g't'k'p'g' 'r'x'c'i' g' 'u'c'o' r' 'n'g'u' 'e'q'w'f' 'd'g' 'c' "w'g'h'w'k'f' 'v'q'q'n' 'v'q' 'p'q'p' / 'k'p'x'c'u'k'x'g' 'n'f' 'f' g'v'g'ev'g'c't'n'f' " u'c'i' g' 'i' { 'p'g'eq'm'i' k'c'n'f'o' crki' p'c'p'ek'g'u'0' "

"

[3\_HD]Dtc { .L0H'g't'c' { .K0U'q't'l'q'o' c'v'c't'o' 'g'v'c'ri'0'1' m'q'd'c'ri'ec'p'eg't' 'l'nc'v'k'u'c'u'423: -1 NQDQEC'P' 'g'u'k'o' c'v'g'u'q'h' 'l'pek'f' g'peg' 'c'p'f' 'b' q't'c'r'k' { 'y' q't'r'f' y' k'f' g' 'h'q't' '58' 'e'c'p'eg't'u' 'k'p'3: '7' 'e'q'w'p'v'k'g'u' 'E'c'0' 'e'c'p'eg't' 'L'0' 'e'k'p'08: '5; 6/646' "423: -0' ]4\_ 'J' 0L0'Y' j' k'y' g'm' 'L'0'Y' q't'y' k'p'i' v'p'p' "Q'0'D'n' 'v'u'u' 'g'v'c'ri'0' 'k' 'r' t'q'x'g'f' 'g'c't'n'f' 'f' g'v'g'ev'g'f' 'q'h' 'q'x'c't'k'c'p' 'e'c'p'eg't' 'w'k'p'i' 'n'p'i' k'w'f' 'l'p'c'ri'0' w'k'o' c't'ng't' 'b' q'f' g'm' 'D't'0' 'L'0' 'e'c'p'eg't' " 344. ': 69; 78' "4242-0' ]5\_ 'R'0'0' q't'leg' 'C'0'N'g'c't' { .E'0'E'g'w' 'd'g't'i' .P'0'C'd'w' 'T'w'u'w'o' .G'0'F'c't'k' 'G'p'f' q'o' g'v't'k'n' 'e'c'p'eg't' .V'j' g' 'N'c'p'eg'v'5: 9. '32; 6/332: "4238-0' ]6\_ 'V'0'V'c'ng'f' c' .M'0'D'ep'p'q' .T'0'Q'w'c'y' c' .g'v'c'ri'0' 'CT'K'F'3C' 'i' g'p'g' 'b' w'c'v'k'p' 'kp' 'q'x'c't'k'c'p' 'c'p'f' 'g'p'f' q'o' g'v't'k'n' 'e'c'p'eg't'u' \*T'g'x'k'y' + 'Q'p'eq'ri'0' 'T'g'r'057. '829/835' "4238-0' ]7\_ 'S'0'E'j' g'p' .\ '0' 'j' c'p'i' .L'0'Y' c'p'i' .L'0'J' 0'N'c'p'i' .E'k't'ew'r'v'p'i' 'e'g'm' 'h'g'g' 'F'P' 'C' 'q't' 'e'k't'ew'r'v'p'i' 'w'o' q't' 'f' 'p'c' 'l'p' 'y' g'o' c'p'c'i' g'o' g'p'v'q'h' 'q'x'c't'k'c'p' 'c'p'f' 'g'p'f' q'o' g'v't'k'n' 'e'c'p'eg't' .Q'p'eq'0'v'c't'i' g'u'0'v'j' g't'034. '33739/33752' "423; -0' ]8\_ 'L'0C'0'0' c't'v'k'i' p'g'w'k' 'F'0'R'c'p'f' { c' .P'0'P' c'i' c't'uj' g'y' 'g'v'c'ri'0' 'F' g'v'g'ev'g'f' 'q'h' 'g'p'f' q'o' g'v't'k'n' 't'g'ec'p'eg't' 'd' { 'c' 'v'c't'i' g'v'g'f' 'i' { 'p'g'eq'm'i' k'c'n'f'o' 'e'c'p'eg't' 'h'k'w'f' 'd'k'q'r' u'f' .E'q'f' 'U'f' 't'p'i' " J' c't'd'0'0' q'ri'0' 'E'c'ug' 'U'w'f'06. '3/33' "423: -0' ]9\_ 'P'0'P' c'k' .Q'0'E'c'o' c'ej' q' / 'X'c'p'g'i' c'u' .F'0'T' { 'm'p'q'x' 'g'v'c'ri'0' 'I' g'p'q'o' k'e' 'C'p'c'n'f' 'u'k'i' 'q'h' 'W'g't'k'p'g' 'N'c'x'c'i' g' 'H'w'k'f' 'f' g'v'g'ev'g'f' 'G'c't'n'f' "G'p'f' q'o' g'v't'k'n' 'e'c'p'eg't'u' 'c'p'f' 'T'g'x'g'c'n'f' 'c' " R't'g'x'c'ng'p'v'N'c'p'f' u'ec'r' g'q'h'f' 't'x'g't' 'O' w'c'v'k'p'u' 'kp' 'Y' q'o' g'p' 'y' k'j' q'w'j' 'k'u'q'r' c'v'j' q'm'i' k'e' 'G'x'k'f' g'p'g' 'q'h' 'E'c'p'eg't' <C' 'R't'q'ur' g'e'v'k'g' 'E't'q'u'u' / 'U'g'e'v'k'p'c'n'f' 'U'w'f' { .R'N'q' 'U'0' g'f'035. " 3/48' "4238-0' ]: . \_E'0'M'q'r' c'p'q'u' .X'0'V'uk'q'm'e'u' .C'0'M'q'w'k'i' 'g'v'c'ri'0' 'X'c't'U'q'o' g'c'v'j' g'j' w'o' c'p' 'i' g'p'q'o' k'e' 'x'c't'k'c'p'v'ug'c't'ej' 'g'p'i' k'p'g' .D'k'q'l'p'h'q't'o' c'v'k'u'57. '3; 9: /3; : 2' "423: -0' "

**J K J 'CHHKV[ 'DKFPI 'PJ HDKQTU'QHRTQVQ\ QCP 'RCTCUKVG'  
J UR; 2**

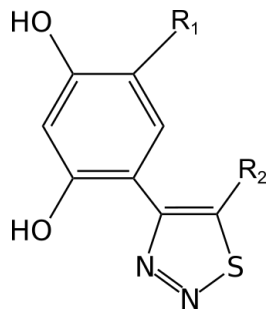
O ctkwu'I gfi cwf cu<sup>3</sup>. 'Cwt grlc'O lengxk k v<sup>3</sup>. 'Cri ktf cu'Dtwn-wu<sup>4</sup>. 'F cwo cpvcu'O cwwku<sup>3</sup>. ""  
Gi kflwu'Mc| rcwuncu<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Dkqj gto qf { pco leu'cpf 'F twi 'F guki p. 'Ipu'kwg'qh'Dkqgej pqrqi { . 'Xkpkwu'Wpksgtuks{. "Nksj wcpkc"  
<sup>4</sup>F gr ctvo gpv'qh"Qti cple'Ej go kut { . 'Hcewv'qh'Ej go kut { . 'Xkpkwu'Wpksgtuks{. "Nksj wcpkc"  
o ctkwu' gfi cwf cuB i o ekw'w"

Rctcukle'r tqvq| qcp'f kugcugu'tgo clp'c"j wi g'dwtf gp'y qtrf y kf g'chh'evkpi "o krikpu'qh'r gqr r'g0C'hgy 'pqvcdrg" f kugcugu'  
kpen'f g"o cmtkc. "ngkj o cplcuku. "vzqr r'uo quku'Vj gug'y tgg'f kugcugu'cm'pg'cee'qwpv'ht'q'xgt" c"o krikp'f gc'v'j u'g'xgt { " { gct0'  
Gxgp'y kj "ewt'gp'cf x'pegu'kp"o gf k'epg'y gug'f kugcugu'tgo clp'r tqdrgo c'le<r'ctcukgu'f g'xgmr "t'gukw'peg'ci c'kpu'ewt'gp'  
f twi u. "cxck'cdrg'y g'cr gw'ku'ecwug'ug'xgt g'ukf g'ch'geu'cpf 'hqt'uo g'qh'y g'f kugcugu'y g'g'ku'pq'v'g'w'gp'c'v'cm0'

Y g'ctg'lx'g'vki c'kpi "iki cpf u"uo cm'qti cple"o q'gew'gu. "j cv'eqwf "v'cti gv'cp"gu'gp'v'kri'rt'q'vq| qcp'r'ctcukg'r'rt'q'v'k'p"o'  
j gc'v'uj qen'r'rt'q'v'k'p"; 2"J ur; 2+0J ur; 2"ku'cp"o q'gew'wt'ej cr g'tq'p'ht'w'p'f "kp"o qu'v'gw'wt { q'v'le"egm0J g'cnj { "j wo cp"egm"  
j cxg'dggp'uj qy p'v'q'v'q'rt'cv'g'r'ct'v'kri'J ur; 2'kpj kdk'k'qp. 'y j g'tcu'r'rt'q'vq| qcp'r'ctcukgu't'gn'j g'cx'k'k'f "qp'y g'k'J ur; 2'v'q'cf cr v'v'q'  
ut'gu'hw'le'q'p'f k'k'qp'u'y j gp'k'p'h'ge'v'kpi "y g'j qu'0J ur; 2'kpj kdk'k'qp'ecp'f kut w'v'y g'r'ctcuk'g'v'rt'k'g'e' { erg'j3\_0Vj ku'o cng'u'J ur; 2'  
cp'cwt'ce'v'x'g'f twi "v'cti gv'ci c'kpu'v'y gug'f kugcugu0'

J g'tg'y g'r't'g'p'v'd'k'p'f kpi "ej ct'ce'v'g't'k'v'ku'q'h'c'ug't'ku'q'h'y k'f k'c| q'rg/dcug'f "iki cpf u"iki 03+'qh'j wo cp'cpf'r'rt'q'vq| qcp'P/  
f qo clp'J ur; 20'



Hki 030Vj kcf k| qrg/dcug'f 'kpj kdk'k'qt0'

[3\_] Depwo cvj { . "I qy tkuj cp'wt. " gv'c'f0\$J gc'v'uj qen'r'rt'q'v'k'p"; 2"hw'p'ev'k'p"ku'gu'gp'v'kri'rt'q'v'k'p" R'rt'uo q'f'kw "k'v'k'rt'wo "i tqy vj "kp"j wo cp'gt { vj tqe { v'gu'0"  
I'q'w'p'v'k'q'h'Dk'q'qi le'cn'Ej go kut { '49: 0'2'4225+0'

**RTGF KEVKQP 'QHECPEGT'EGNN'XKCDKXK[ 'CPF'E QO RTQO KUGF''**  
**O GO DTCPG'RP VGI TKV[ 'CHVGT'RWNUGF'GNGEVTKE'HKGNF''**  
**VTGCVO GPV'WUP I 'NWO RP GUEGPEG''**

Xgtqpknc'O cnf -mq<sup>3</sup>. 'Xkcrkl'P qxlentl<sup>3</sup>. 'Cwmu \ kpnxk kgp<sup>4</sup>. 'Lwtkl'P qxlentl<sup>3</sup>. 'Lwrkc'Mwrdcent<sup>5</sup>.  
P kpc'Tgo dkmqy un<sup>5</sup>. 'Kw 'I ktnpvcv<sup>4</sup>'''

<sup>3</sup>Hcewm 'qh'Grgextqpleu.'Xkpkwu'I gf lo kpcu'Vej plecn'Wpkxgtukf. 'Xkpkwu.'Nkj wcpkc''

<sup>4</sup>Ucvg'Tgugctej 'Kpukwag'Egptg'ht 'Kppqxcvkg'O gf lekp. 'F gr ctvo gpv'qh'K o vpmqi {.'Xkpkwu.'Nkj wcpkc''

<sup>5</sup>F gr ctvo gpv'qh'O qrgewrt'cpf 'Egmwrt'Dkqmi {.'Y tqerxy 'O gf lecn'Wpkxgtukf. 'Y tqerxy . 'Rqmpf''

xgtqpknc' O cnf unqB xkpkwugej 0v''

"

Grgextqr qtcvqp'r j gpqo gpc'ku'c'j ki j n[ 'ghgevxg'o gj qf 'kp'f khtgtpv'kgrf u'qh'cr r rkecvqp. 'kpenf kpi 'ecpegt'vtgcvo gpv' j3\_0Vj ku'bo gj qf 'ku'dcugf'qp'r wuuf 'grgext'le'kgrf u'RGH'cpf' r qtg'htto cvqp'kp'egm'bo go dtpcg'eqpugs wgvn[ 'ecwukpi 'yj g' kpetgcug' kp' egm' o go dtpcg' r gto gcdkkl' " j4\_0' Vj g' eqo dlpcvqp' qh' grgextqr qtcvqp' y kj " f twi u." y j lej " ku' nppq p' cu' grgextqej go qj gtr {.'ku'y g'j ki j n[ 'ghgevxg'o gj qf 'kp'ecpegt'vtgcvo gpv']5\_0Cm j qwi j "yj g'qweqo g'f gr gpf kpi "qp'r wuuf" r ctvo vgtu.'cpf' r j { ulecn'hcvtu'o c { "xct{0J gpeg' y g' qeewt gpeg' y g' r gto gcdkkl' cvqp' tcvg'kp' xktq' ku' s wkg' ht gs wgvn[ " gxcnvcgf 'wukpi 'hwqtguegpv'o ctngtu'uwej 'cu'r tqr kf kwo 'kqf kf g'RK' y j kg' y g' xkcdkkl' 'ku'ej genf 'chgt'46' j qwtu'qt' f c { u' wukpi 'o gxcdkrl'cevxk' 'vgu'qt'emppqi gple'cuuc {0'K' y ku' y qtm'cp'cnngtpcvxg' y c { 'ht' f gvgecvqp' qh' y g' grgextqr qtcvqp' ghkece { 'cpf' f tqr 'qh'egm'xkcdkkl' 'hqmqy kpi 'RGH'vtgcvo gpv'ku'r tqr qugf 0Vj ku'bo gj qf 'ku'dcugf'qp'qz kf cvqp'qh'F /mwelhtkp' uqf kwo 'ucn'wkl' gf 'q'cuuc { 'y g' nwehgtcug' i gpg'g'zr tsuakp'kp'ucdn[ 'tcpuhevgf' dlqno kpguegpv'o keg'Ur 4L' o { gmo c' egm0''

C" 265" nX. " 82" C" r wuuf " r qy gt " i gpgtcvt " \*XI VW." Nkj wcpkc+ " y cu' wuuf " kp' y j g' uwf {0' Egm' y g' g' vtgcvgf " kp' grgextqr qtcvqp'ewxgwgy kj '3'bo o 'i cr'cnwo kpo 'grgextqf gu'\*Dkqcf. 'J gtewgu.'WUC+0Rwngu'kp'y g'tcpi g'qh'3640' nX leo " 206322" u'y g'g' i gpgtcvgf 0'E gnr' gto gcdkkl' cvqp'ghkegpe { 'y cu'gxcnvcgf 'wukpi 'r tqr kf kwo 'kqf kf g'RK'Ui o c/Crf tlej + ' cpf 'hmj 'e' f qo g' {.'y j kg'xkcdkkl' y cu'gunko cvgf 'wukpi 'cmo ctDmg' 'egm'xkcdkkl' 'tgc' gpv'\*Vj gto q' Huj gt 'Uelgp'wke." WUC+'chgt'46' j 0Cngtpcvxgn. 'y g'Ur 4L' tcpuhevgf 'egm'Nwehgtcug/r eFPC5' r mwo kf. 'Cf i gpg'%6: ; 86+y g'g' vtgcvgf " d { 'RGH'cpf 'rcvt' tcpuhtgf 'kp'q' y j kg'; 8/y gnr' rvgu0Uwdugs wgvn[. 'F /Nwehgtkp' \*Rtqo gi c. 'WUC+y cu'cf f gf "q' y g' egm. 'y gp'cpcn[ | gf 'eqpegpvtcvqp' y cu'372" i bo r0U { pgti { '4' o letqr rvg'tgcf gt'cpf 'I gp7' uqhw ctg' \*DkVgm'WUC+y g'g' wuuf 'ht'UR4L' egm' nwo kpguegpeg' gxcnvcvqp0'

K'y cu'uj qy p' y j cv' y g' dlqno kpguegpeg'uki pcn' y cu'uecnkpi 'kp' c' f qug' f gr gpf gpv'bo cpgt' hqmqy kpi 'y g' uco g' vpf gpe { " cu' r gto gcdkkl' cvqp' ewxgu' qdvcpgf 'wukpi 'eqpxgpv'kpcn'vqmkwu0C' v' y g' uco g' wlo g. 'k'cnq' r tqxkf gf "c' tgc' n' wlo g' hggf dceni qp' egm' xkcdkkl' 'ulpeg' qpn[ " xkcdg' egm' nwo kpgueg0'K' y cu'cnq' u' j qy p' y j cv' y j g' g'z vgpv'qh' r gto gcdkkl' cvqp' cpf " y wu. " y j g' qz kf cvqp'qh'F /mwelhtkp' ku'p'v' y g' uco g' ht' b' letqugeqpf 'cpf' uwd/ o letqugeqpf 'r wngu. 'y j kg' dlqno kpguegpeg' ukm'ecp' dg' ko r ngo gpv'f 'cu'cp' ghgevxg'o gj qf 'ht' cpcn[ uku'qh' grgextqr qtcvqp' r j gpqo gpc' kp' xktq0'

Vj ku' y qtnly cu' uwr r qtvgf "d { 'i tcvp' P t0U/O KR/3; /44' htqo 'Tgugctej 'Eqwpekl'qh' Nkj wcpkc0Vj g' uwf { 'y cu'cnq' r ctv[ " uwr r qtvgf "d { 'RN'P EP 'I tcv'UQP CVC' DKU'8\*4238 44 IGIP \ 7 122893= RK'LO' Mwrdcent+0'

"

j3\_ "V0Mqpkm'N0Tgo u."O 0'Vgtgm'F 0'O kmx k. "O go dtpcg'Grgextqr qtcvqp'cpf'Grgextqr gto gcdkkl' cvqp-<O gej cpkuo u'cpf "O qf gm."Cpww0Tgx0' Dkqj { u0\*423; +0'

j4\_ "F 0'O kmx k. "I 0'Ugt-c."G0'Dtgegn. "I0'I gj n" F 0'Uqf gp. "I 0'Dlcej k' R0'Twi i ktk" E0'0Tquk" N0' 0'Eco r cpc. "V0' Lcto. "Grgextqej go qj gtr {< Vgej pqm' lecn'cf xcpego gpv'ht' ghkegpv'grgextqr qtcvqp/dcugf 'vtgcvo gpv'qh'kpgvtpcn'wto qtu. 'O gf 0Dkq0Gpi 0Ego r w0\*4234+0'

j5\_ 0'Ego c| ct. "I 0'Ugtu. "Tgegpv'cf xcpegu'kp'Grgextqej go qj gtr {.'Dkqgrgextlekl' 0\*423; +0'

"

**TGRTQF WE VKG'EJ CTCE VGT KUVKE UQHETKO GCP 'VCVCT'Y QO GP''  
CEEQTFKI 'VQ'VJ GKT'UWD/GVJ PKE'I TQWRU'**

**P cverkf c'Mqj em'Nwdqx'C'vco gpvqxc''**

F gr ctvo gpv'qhi' gpgve'cpf 'e{ vqri { . 'XOP 0Mctc| kp'Mj ctnkx'P cvkqpcn'Wpkxgtukf . 'Whtclpg'  
nqj cmcverkf 5B i o ckrqo .''

Kphqto cvkqp'cdqw'i' gpgve'r tqeguugu'lp'mecnr'qr wcvkpu'r rc { u'cp''ko r qtvcv'tqng'lp''wpf gtucv'f'kpi ''o cp { ''uqelq/  
f go qi tcr j le'cpf ''o gf lecn'r tqdngo u0Uwf lgu'eqpf wevf ''lp''geqppqo lecn'f 'f gxrqr gf 'eqwv'kgu'uj qy ''y cv'cdqw'j' cih'q'h'y g'  
j wo cp'i' gpg'r qndf'agu'p'qv'tgr tqf weg'lp''y g'pgz'v'i' gpgt'cvkqp''f wg'vq''y g'f gc'v'j ''qh'go dt { qu.'u'kndk'v' u.'pgqpcv'cn'o' qtvcv'kf''  
cpf ''o' qtvcv'kf ''dghq't'g''y g'tgr tqf wev'x'g''ci g.'eg'nd'ce'f''cpf ''v'ngt'kg''o' cttkci gu''j3.'4\_0Vj g'tgr tqf wev'x'g''d'gj c'x'k'q't''q'h'y qo gp''  
o' c'k'p'n'f' gr g'p'f u'q'p''ev'w'w'c'n'v't'c'f' k'k'q'p'u'c'p'f''f' k'h'g't'u'co' q'p'i' 'tgr t'g'ug'p'v'c'x'g'u'q'h'f' k'h'g't'g'p'v'g'y ple''i' tqw u'0C'u'q'h'4235.'lp''y g''  
C'w'q'p'q'o' q'u'w'g'r'w'ri'c'q'h'Et'ko' g'e.'y g'r' t'q'r'q't'v'k'q'p'q'h'Et'ko' g'ep''V'c'v't'u'.'y j' q'u'g'ev'w'w'c'n'v't'c'f' k'k'q'p'u'.'y g't'g'd'c'ug'f''q'p''y g'O' w'ur'ko' ''  
t'g'ri' k'q'p.'k'p'et'g'c'ug'f''k'p''e'q'p'p'g'ev'k'q'p''y k'j' 't'g'r'c'v'k'v'k'q'p''j5\_0Vj g'g'y ple''i' tqw ''q'h'Et'ko' g'ep''V'c'v't'u'ku'w'd'f' k'k'f' g'f''k'p'v'q''y t'g'g'w'd/  
g'y ple''i' tqw u'k'w'q'y g't'p''e'q'c'w'c'n'v'g'r' r'g'c'p'f''o' q'w'p'v'k'p/h'q'v'j k'm'j6\_0Vj g'r' w'r' q'u'g'q'h'y k'u't'g'ug'c't'ej''ku'v'w'w'f' { ''y g't'g'r' tqf wev'x'g''  
d'gj c'x'k'q't''q'h'Et'ko' g'ep''V'c'v't'y qo gp.'e'q'p'k'f' g't'k'p'i ''y g't'g'w'd/g'y ple''f' k'k'k'q'p'0'

Vj g'f'cv'y g't'g'eqm'ge'v'f''k'p''4235''k'p''y g'y qo gp'u'ev'k'p'e'q'h'y'g'Et'ko' g'ep''T'g'r'w'ri'c'ep''k'p'v'k'w'k'q'p''\$0' g'f' lecn'E'g'p'v't''h'q't''  
U'g't'x'k'p'i''F'gr'q't'v'f''R'g'q'r'g'u'f''\$'k'o' h'g't'q'r'q'n'0C'p'q'p'f' o' q'u'w'w'x'g'f''q'h'y' qo gp''k'p''y g'r' q'u'v't'g'r' tqf wev'x'g''ci g''h'q'o''67''q''; 2''  
{ g'c't'u'y' c'u'e'c't'k'f'f''q'w'0Vj' g's' w'g'u'v'k'p'p'c'k'g'k'p'e'w'f' g'f''s' w'g'u'v'k'p'u'c'd'q'w'v'y' g'y qo cp'u'f' g'c't'q'h'i'd'k'v'j . 'j' g't'p'c'v'k'p'c'k'f' . 'e'q'p'k'f' g't'k'p'i''  
y g'w'd/g'y p'q'u'.'c'u'y' g'n'c'u'y' g'p'c'v'k'p'c'k'f'f''q'h'j' g't' c't'g'p'u'0Vj' g'p'w'o' d'g't'q'h'r' t'g'i' p'c'p'el'g'u'c'p'f''y g't'g'w'eq'o' g'u'y' g't'g'w'w'f' k'f'f''c'u''  
y g'm'z'o' g'f' lecn'c'p'f''ur' q'p'v'c'p'g'q'w'u'c'd'q't'v'k'p'u'.'g'ev'q'r' k'e'r' t'g'i' p'c'p'el'g'u'.'y g'p'w'o' d'g't'q'h'i'w'k'nd'k'v'j' u'c'p'f''r'k'x'g'd'k'v'j' u'0'

Vj g'f'k'v'k'w'k'q'p'q'h'y' g'p'w'o' d'g't'q'h'r' t'g'i' p'c'p'el'g'u'c'p'f''y g't'g'w'eq'o' g'u'k'p''y qo gp'f'w'k'p'i''y g't'g'r' tqf wev'x'g'r' g't'k'f'f''k'p'f' k'ec'v'g'u''  
u'c'v'k'w'k'c'm'f''u'k'i' p'h'k'ec'p'v'f' k'h'g't'g'p'eg'u' d'g'y g'p'p''u'w'd/g'y ple''i' tqw u'k'p''v'g't'o' u'q'h'y' g'p'w'o' d'g't'q'h'r' t'g'i' p'c'p'el'g'u'c'p'f''o' g'f' lecn'  
c'd'q't'v'k'p'u'0k'p'c'x'g't'c'i' g.'c'Et'ko' g'ep''V'c'v't'y qo cp'j' c'f''508''t'g'i' p'c'p'el'g'u'f'w'k'p'i''y g't'g'r' tqf wev'x'g'r' g't'k'f'f''60''h'q't'g'r' t'g'ug'p'v'c'x'g'u''  
q'h'y' g'w'g'r' r'g'c'p'f''u'q'w'j' g't'p''u'w'd/g'y ple''i' tqw u.''408''h'q't'g'r' t'g'ug'p'v'c'x'g'u'q'h'y' g'o' q'w'p'v'k'p/h'q'v'j' k'm.'r''>2027+0C'w'q.'p'q'g''  
Et'ko' g'ep''V'c'v't'y qo cp'q'p''c'x'g't'c'i' g'j' c'f''r'g'u'v'j' c'p''p'q'g''o' g'f' lecn'c'd'q't'v'k'p'u''\*30''k'p''y g'w'q'w'j' g't'p'c'p'f''u'v'g'r' r'g.'2087''k'p''y g''  
o' q'w'p'v'k'p/h'q'v'j' k'm.'r''>2027+205''ur' q'p'v'c'p'g'q'w'u'c'd'q't'v'k'p'u'.'2026''g'ev'q'r' k'e'r' t'g'i' p'c'p'el'g'u'.'40''d'k'v'j' u.'208''u'k'nd'k'v'j' u.'c'p'f''408''r'k'x'g''  
d'k'v'j' u'0'

Eqo r'c't'k'q'p'q'h't'g'r' tqf wev'x'g'k'p'f' k'ec'v'q't'u'k'p''Et'ko' g'ep''V'c'v't'u'c'p'f''U'rc'x'u''\*W'ht'c'k'p'c'p'c'p'f''T'w'u'k'p'+r'k'x'k'p'i''k'p''y g'g'ek'f''q'h'i''  
G'w'r'c'v'q't'k'c''C'w'q'p'q'o' q'u'w'g'r'w'ri'c'q'h'Et'ko' g'e'+j7\_'t'g'x'g'r'g'f''u'c'v'k'w'k'c'm'f''u'k'i' p'h'k'ec'p'v'f' k'h'g't'g'p'eg'u'0Vj' w'u.'y' g'i' g'p'g'r' q'q'n'q'h'y' g''  
Et'ko' g'ep''V'c'v't'y' g'y' p'q'u'ku'g'r' tqf we'g'f''o' q't'g'h'w'm'f''\*9'' +y' c'p''y' g'i' g'p'g'r' q'q'n'q'h'y' g'U'rc'x'u''\*7'' +0U'rc'x'le'y' qo gp't'g'u'q't'v'f''v'q''  
c't'v'k'k'ec'v'g't'o' k'p'c'v'k'q'p'q'h'i' t'g'i' p'c'p'el'f''c'm' q'u'v'y' k'eg'o' q't'g'q'h'g'p''\*5'' +y' c'p''V'c'v't'u''\*67'' +0G'ev'q'r' k'e'r' t'g'i' p'c'p'el'g'u'.'y g't'g'p'q'v'f''  
q'p'n'f''d'f''207'' ''q'h'V'c'v't'y qo gp.'y j' k'ej''ku'36''k'o' g'u'g'u'u'f'g'v'g'p'v'y' c'p''U'rc'x'le'y' qo gp''\*9'' +0Vj' g'r' g't'eg'p'v'c'i' g'q'h'c't'v'k'k'ec'm'f''  
k'p'v'g't'w'r' v'f''r' t'g'i' p'c'p'el'g'u'c'p'f''i' V'c'v't'u'ku'c'm' q'u'w'407''k'o' g'u'g'u'u'v'j' c'p''c'o' q'p'i' 'U'rc'x'u''\*46''c'p'f''7:' '' . 't'g'ur' g'ev'k'x'g'n'f''0C'u'c't'g'u'w'm''  
y g'f'c'v'k'q'p'q'h'k'o' r' g'o' g'p'v'f''f''i' q'v'g'u'k'p''V'c'v't'u'ku'v'y' k'eg'c'u'j' k'j' j' c'u'k'p''U'rc'x'u''\*8; '' ''c'p'f''55'' +0k'p''v'g't'o' u'q'h'y' g'p'w'o' d'g't'q'h'i''  
r' t'g'i' p'c'p'el'g'u'.'U'rc'x'u'c't'g'c'm' q'u'w'p'q'g'c'p'f''c'j' c'h'i'v'k'o' g'u'h'c't'i' g't'v'j' c'p''Et'ko' g'ep''V'c'v't'u''\*70''c'p'f''508.'t'g'ur' g'ev'k'x'g'n'f''+d'w'f' g'ur' k'g'v'j' g''  
i' t'g'ev'g't'p'w'o' d'g't'q'h'r' t'g'i' p'c'p'el'g'u'.'U'rc'x'u'i' k'x'g'd'k'v'j' v'q'h'y' g't'ej' k'f'f'g'p'p'w'o' d'g't'v'j' c'p''Et'ko' g'ep''V'c'v't'u''\*q'p'c'x'g't'c'i' g.'30''c'p'f''4.9''  
ej' k'f'f'g'p''t'g'ur' g'ev'k'x'g'n'f''+0k'p'k'p'v'g't'g'y' ple''f' k'h'g't'g'p'eg'u'k'p''y g''t'c'v'g'u'q'h'p'c'w't'c'n'k'p'et'g'c'g''r' g't'k'w'v''y' g'g'y' ple''c'p'f''e'q'p'h'g'u'k'q'p'c'n'  
eqo r'q'k'k'q'p'q'h'y' g'Et'ko' g'ep'r'qr' w'cv'k'q'p'c'p'f''ku'i' g'p'g'r' q'q'n'o' c'f''ej' c'p'i' g'0'

Vj g'w'w'f' { 'q'h'y' g't'g'r' tqf wev'x'g'd'gj c'x'k'q't''q'h'Et'ko' g'ep''V'c'v't'y qo gp'q'h'f' k'h'g't'g'p'v'w'd/g'y ple''i' tqw u't'g'x'g'r'g'f''u'c'v'k'w'k'c'm'f''  
u'k'i' p'h'k'ec'p'v'f' k'h'g't'g'p'eg'u'k'p''y' g'p'w'o' d'g't'q'h'r' t'g'i' p'c'p'el'g'u'c'p'f''o' g'f' lecn'c'd'q't'v'k'p'u'0Vj' g''Et'ko' g'ep''V'c'v't''r'qr' w'cv'k'q'p'q'h'y' g''  
C'w'q'p'q'o' q'u'w'g'r'w'ri'c'q'h'Et'ko' g'e''ku'ej' c't'ce'v'g't'k'f' g'f''d'f''g'z'r' c'p'f' g'f''t'g'r' tqf wev'k'q'p.'k'p''e'q'p'v'c'v'v'q''y' g'p'c't't'q'y' g'f''p'q'g'c'o' q'p'i' ''y' g''  
U'rc'x'le'r' c't'v'q'h'y' g'r'qr' w'cv'k'q'p'0'

*Vj g'c'w'j' q't'u'c't'g'i' t'c'v'g'h'w'v'q''NCC00' w'w'c'k'f'g'x'c''h'q't''c'u'k'w'c'p'eg'k'p''e'q'ng'ev'k'p'i''q'h'f'c'ew'c'n'o' c'v'g't'k'c'i'0'*

13\_Q0N0Mw'dc'v'x'c.'F go qi tcr j le'i' g'p'g'v'le'q'h'i'w'd'c'p'r'qr' w'cv'k'q'p''c'd'w't'c'e'v'f' k'u'0'U'e'f'00' q'u'q'y .''4236+0'  
14\_G'f'0'd'f' 'L'u'0R'0C'n'w'j' q'x.'F'p'c'o' k'eu'q'h'i'r'qr' w'cv'k'q'p'i' g'p'g'r' q'q'u'v'p'f' g't'c'p'y' t'q'r'q'i' g'p'k'e'r't'g'u'w't'g'u'0'O' q'u'q'y .''P'c'w'n'e.'4226+0'  
15\_U'c'g'U'c'v'k'w'k'c'm'f'Eqo o' k'v'g'g'q'h'W'ht'c'k'p'g'0C'm'W'ht'c'k'p'c'p'r'qr' w'cv'k'q'p''e'g'p'u'w'u'42230T'w'u'k'p'x'g't'k'p'0T'g'u'w'u'0P'c'v'k'p'c'k'f'f'c'p'f''o' q'j' g't'v'q'p'i' w'g''\*4225+''  
16\_G'ev'k'p'le'g'v'q'w'g' .''j' w'r' <142230w'nt'eg'p'u'v'f' q'x'f'c'k'w'u'k'g'u'w'u'v'0'  
16\_G'f'0'd'f' 'G'0Ej' { t'd'c'q'x'c'0G'u'c'f'u'q'p''y' g'j' k'w'q't'f' 'c'p'f' 'e'w'w't'g'q'h'i'y' g'Et'ko' g'ep''V'c'v't'u''\*U'k'o' h'g't'q'r' q'n'Et'ko' g'ev'j' r'g'f' k' .''4227+0'  
17\_NCC0C'v'co' g'p'v'q'x'c.'K'R'00' g'uj' e'j' g't' c'n'q'x'c.'Q'0K'0'H'k'r' w'q'x'c.'T'g'r' tqf wev'x'g'ej' c't'ce'v'g't'k'w'k'c'm'f'c'p'f''y' g'Et'q'y' a'l'k'p'f' g'z'k'p''f' k'h'g't'g'p'v't'qr' w'cv'k'q'p'u'q'h'G'x'r'c'v'q't'k'c.'  
I' g'p'g'v'k'e''6; '' ''34.'35; : 63628''\*4235+0'

# VJ G'GHGEV'QHP CRJ VJ [ NCEGVKE 'CEK' 'QP 'ETGGRKI 'I NQZPKC''

I cdlc'ficir { v "

X{vwcu'O ci puw'Wplxgtuk'Ci tlewmwtg'Ceef go { .Hcewm'qh'Ci tppqo { .Kpukwng'qh'Ci tlewmwtcr'icpf "Hqf "Uelpegu" Nkj wpcle"

i cdlc0 cir { vB uwf 0xf w0n''

Etggr kpi "i nqzpkc"ku'c"v'gpf gt'erko dki "r nrv'y kj "dtki j v'r kpm'hray gtu."vj cv'qtki kpcv'f "kp'O gzleq"]3\_0'Vj gug'r nrv'u' ecp'dg'r tqr ci cv'f "wukpi 'uggf u'qt'ewwki u']4\_0Etggr kpi "i nqzpkc'xct'k'v'g'u'ecp'dg'q'pn' 'r tqr ci cv'f "wukpi 'ewwki u.'q'v' gty kug" vj g' "y qwf "nug" s wcr'k'g'u' vj cv' ctg"ej ctcevgt'k'v'e" vq"ur gek'le" xct'k'v'f 0'I t'qy vj "tgi wcv'qtu"ctg"tgs w'k'f" vq"i t'qy "r nrv'u' gh'ge'v'k'gn' "wukpi "ewwki u'0C wz'k'u'ctg'o quw' "t'g'ur qpuk'd'ng'ht"r nrv'v't'q'q'v'i t'qy vj "j5\_'cpf "ch'ge'v'uj q'q'v'i t'qy vj "j6\_0Dge'cwug" qh'v'j cv'o qu'v'c'w'p'v'k'p'lp'v'j ku'z'r g't'k'o gp'v'y cu'f gf k'ec'v'f "v'j g'ug'r nrv'v'j q'to q'p'g'u."gur gek'm' "p'cr j vj { r'eg'v'le'cek' "P CC-0"

Vj g'c'k'o "qh'v'j ku'uwf { "ku'v'q" f'v'g'to k'p'g'v'j g'gh'ge'v'u'qh'f'k'ht'g'p'v'eq'p'eg'p't'c'v'k'p'u'qh'p'cr j vj { r'eg'v'le'cek' "qp'et'ggr kpi " i nqzpkc'r nrv'v't'q'q'v'cp'f "uj q'q'v'i t'qy vj 0"

S wggp'Ngw'k'c'j'cp'f "S wggp'O q't'c'v'ewwki u'y g't'g'ew'ht'qo "6/{ gct'q'rf "o q'v'j g't'r nrv'u'cp'f "y g't'g'f'k'r g'f "h'qt"4"uge'q'p'f "u' k'p'v' "h'wt" f'k'ht'g'p'v'eq'p'eg'p't'c'v'k'p'u'qh'eq'p'eg'p't'c'v'g'f "ur k'k'w'q'w'u"\*72" -"p'cr j vj { r'eg'v'le'cek' "u'q'nw'k'p'cp'f "r nrv'v'f "k'p'v' "r q'w" h'k'ng'f "y k'j "r g'c'v'o qu'0'W'g'f "ewwki u'y g't'g'7/9"eo "v'c'm'q'h'h'k'u'v' { gct'uj q'q'u'0'Vj g'o g'c'u'w't'g'o g'p'u'y g't'g'ect'k'g'f "q'w'v'y k'eg'g'x'g't { " 6'y g'gm'0"

Vj g't'g'u'w'u'ecp'dg'uggp'lp'V'cd'ng'30C'n'v'j g'ewwki u't'q'q'v'f "y j g'p'v'j g'p'cr j vj { r'eg'v'le'cek' "eq'p'eg'p't'c'v'k'p'y cu'2.6' 0D{ " k'p'et'g'c'uk'p'i "v'j g'eq'p'eg'p't'c'v'k'p'qh'p'cr j vj { r'eg'v'le'cek' "v'j g'p'w'o d'gt'q'h'p'gy n' "h'q'to g'f "t'q'q'u'c'm'q'k'p'et'g'c'ug'u."cp'f "o qu'v't'q'q'u" h'q'to g'f "ch'gt'w'uk'p'i "2.5"cp'f "2.6" "eq'p'eg'p't'c'v'k'p'qh'p'cr j vj { r'eg'v'le'cek' "u'q'nw'k'p'0'Y j k'g'v'j g'ng'p'i g'u'v't'q'q'u'h'q'to g'f "lp'v'j q'ug" ewwki u'y j k'j "y g't'g'f'k'r g'f "lp'c'2.5" "eq'p'eg'p't'c'v'k'p'qh'p'cr j vj { r'eg'v'le'cek' "u'q'nw'k'p.'d'w'ch'gt't'c'k'p'i "v'j g'eq'p'eg'p't'c'v'k'p'v'j " 2.6" "v'j g'p'gy n' "h'q'to g'f "t'q'q'u'y g't'g'uj q't'v'g't'0"

Uki p'k'he'c'p'v'f'k'ht'g'p'eg'q'h'v'j g'ng'p'i vj "qh'p'gy n' "h'q'to g'f "uj q'q'u'ecp'dg'uggp'd'g'y g'p'x'ct'k'v'g'u'0'Y j k'g'v'j g'p'gy "uj q'q'u'qh' " S wggp'Ngw'k'c'0'y g't'g'o g'c'u'w't'g'f "d'g'y g'p'p' ". : "eo "cp'f "39.9"eo .p'gy "uj q'q'u'qh' "S wggp'O q't'c'v'0't'g'c'ej g'f "v'j g'ng'p'i vj "qh'44.4"eo " v'j "68.3"eo 0E'q'o r'c't'g'f "v'j eq'p'v'q'v'k'p'i p'k'he'c'p'v'f "ng'p'i g't'uj q'q'u'qh' " S wggp'Ngw'k'c'0'y g't'g'ch'gt'w'uk'p'i "2.4" "p'cr j vj { r'eg'v'le'cek' " u'q'nw'k'p." y j k'g'v'j uki p'k'he'c'p'v'f "ng'p'i g't'uj q'q'u'qh' " S wggp'O q't'c'v'0' eq'o r'c't'g'f "v'j "eq'p'v'q'v' y g't'g' ch'gt'w'uk'p'i "2.5" " P CC" eq'p'eg'p't'c'v'k'p'0'

Vcd'ng'30'Vj g'gh'ge'v'qh'p'cr j vj { r'eg'v'le'cek' "qp't'q'q'v'cp'f "uj q'q'v'i t'qy vj "qh'et'ggr kpi "i nqzpkc"

P q0'	Vtgcvo g'p'u'	S wggp'Ngw'k'c'j'				S wggp'O q't'c'v'0'			
		T'q'q'v'f " ewwki u." ' "	P w'o d'gt' " qh't'q'q'u." r eu'0'	T'q'q'v' " ng'p'i j v." eo "	Ng'p'i j v'q'h' " p'gy " u'j q'q'u."eo "	T'q'q'v'f " ewwki u." ' "	P w'o d'gt' " qh't'q'q'u." r eu'0'	T'q'q'v' " ng'p'i j v." eo "	Ng'p'i j v'q'h' " p'gy " u'j q'q'u."eo "
30'	Eq'p'v'q'v'	: 7.4"cde"	4.9"c"	5.6"c"	: : "c"	: 3.7"c"	4.4"c"	6.4"cde"	44.4"c"
40'	2.3" "PCC"	99.: "c"	6.; "d"	5.8"cd"	36.: "cde"	99.: "c"	6.2"d"	6.2"c"	56.4"cde"
50'	2.4" "PCC"	: 3.7"c"	7.7"e"	5.; "def"	39.9"e"	; 8.5"de"	6.6"de"	6.7"cde"	55.7"cde"
60'	2.5" "PCC"	; 4.8"cde"	9.4"f"	6.5"f"	36.3"ede"	; 4.8"de"	7.4"ef g"	7.8"e"	68.3"e"
70'	2.6" "PCC"	322.2"e"	9.7"f"	6.3ef"	36.7"ede"	322.2"e"	8.3g"	6.5"cde"	5; .2"de"

P q'v'g'v'f'k'ht'g'p'v'ng'v'g't'u'uj q'y "eq'p'v'k'f g't'c'd'ng'f'k'ht'g'p'eg'u'd'g'y g'p'v't'g'c'v'o g'p'u'"R">"2.27-0"

K'p'eq'p'ew'w'k'p'y g'ecp'ugg'v'j cv'j k'j g't'eq'p'eg'p't'c'v'k'p'u"\*2.5"/2.6" -"j cf "uki p'k'he'c'p'v'f "d'k'i g't'k'o r'c'ev'q'p'v'j g't'q'q'v'k'p'i "cp'f" p'w'o d'gt'q'h't'q'q'u'qh'et'ggr kpi "i nqzpkc."j q'y g'x'g't'lp'"2.6" "p'cr j vj { r'eg'v'le'cek' "eq'p'eg'p't'c'v'k'p'p'gy n' "h'q'to g'f "t'q'q'u'y g't'g' u'j q't'v'g't'0'S wggp'Ngw'k'c'j'ewwki u'i t'gy "v'j g'ng'p'i g'u'v'uj q'q'u'ch'gt'w'uk'p'i "2.4" "p'cr j vj { r'eg'v'le'cek' "eq'p'eg'p't'c'v'k'p'u'q'nw'k'p." y j k'g'v'j g'ng'p'i g'u'v'p'gy "uj q'u'lp' "S wggp'O q't'c'v'ewwki u'i t'gy "ch'gt'w'uk'p'i "2.5" "p'cr j vj { r'eg'v'le'cek' "eq'p'eg'p't'c'v'k'p'0"

[3\_10Rcz'v'p'0Rcz'v'p'u'0' ci c'l'k'p'g'q'h'd'q'v'p'f .cp'f "t'gi k'ng't'q'h'hray g't'k'p'i "r nrv'u'x'q'v'04.'r'049"\*3: 58-0'  
 [4\_0'U'F'c'r'm'p'k'p'p' . "U'0'I "k'q'f'f'g't'u'0'U'k'w'c'w'g't'w'k " \*Ng'r'j' q'ur'g't'o'w'o "F'0'F'q'p'+o' q't'k'q'm'i'k'p'k' "f'ng'q'v'c'v'x'k'1 "u'c'x' { dk "c'r'k'd' f'lp'k'o'q'c'r't'c'-cu'0'c'n'ef'g'o'k'c.'r'0'6'/: " \*4237-0'  
 [5\_0'U'0'R'c's'w'g'=F'0'Y' g'k'd'g't'u'0'S ( C<C'w'z'k'p'<v'j'g'r' nrv'v'o' q'ng'ew'g'v'j' cv'lp'hw'g'p'eg'u'c'm' qu'v'cp'v'j' k'p'i'0'D'O'E'D'k'q'm'i' { .x'q'v'036.'89"\*4238-0'  
 [6\_0'G'0'l'c'n'g'p' . "X'0'X'g'p'u'w'p'k'p'0'c'w'i'k'o' q't'g'i'w'k'v'q't'k'c'w'i'c'n'p'k'p'n'uv'lg'0'c'n'ef'g'o'k'c.'r'0'33/42"\*422: 0'





# THE INFLUENCE OF NANOSECOND ELECTROPORATION ON THE DEVELOPMENT OF ANTIBODIES AGAINST TUMOR CELLS

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Oncological diseases are one of the most common causes of death worldwide. According to the World Health Organization, over 18 million new cases of various cancers were recorded in 2018 [1]. The limited range of solutions for fighting oncological diseases encourages searching for alternative, more effective anticancer treatment strategies. One of the novel therapeutic approaches uses electroporation (EP) in combination with chemotherapeutics, calcium ions or other drugs. Pulsed electric fields (PEF) create nanoscale aqueous membrane pores, facilitating rapid intracellular, usually impermeable drug molecule delivery [2].

In this study tumors in C57BL/6J and BALB/c mice were induced by subcutaneously injecting LLC1 and SP2/0 cells respectively. When tumors reached 100 mm<sup>3</sup>, treatment was applied as described below. For C57BL/6J carcinoma tumor ablation, bleomycin electrochemotherapy (ECT) was used with four different conditions of high-frequency nanosecond EP\*<sup>1</sup> in comparison with ESOPE\*<sup>2</sup> procedure. BALB/c mice tumors were ablated with calcium electroporation (CaEP) (4.5 kV/cm x 600ns x 500 /1 MHz) with or without dendritic cells vaccine (DCV) (Fig.1). Mice survival and development of antibodies (Ab) against tumor cells were assessed during the experiment.

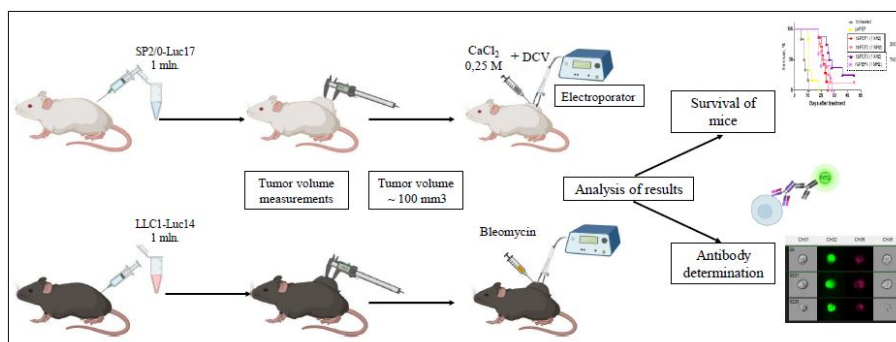


Fig. 1. Experimental scheme.

We showed that CaEP and ECT of tumors prolonged the lifespan of BALB/c and C57BL/6J mice. Tumor-bearing untreated BALB/c mice median survival was 8 days while CaEP and CaEP + DCV-treated mice median survival was 32 and 30 days, respectively. Untreated C57BL/6J tumor-bearing mice median survival was 7.5 days, whereas EP-treated mice median survival was approximately 2-3 times longer (nsPEF1 – 11 days; nsPEF2 – 22 days, nsPEF3 – 22.56 days, nsPEF4 – 27 days, and ESOPE-treated – 20 days).

Tumor-bearing untreated BALB/c mice did not develop Ab to SP2/0 tumor cells. The lifespan of untreated mice was up to 11 days. Probably, the Ab did not develop due to the rapid growth of tumors, resulting in reduced mice lifespan. Anti-Sp2/0 Ab in treated BALB/c mice were assessed at 0, 10, 20 and 30 days after the treatment. The Ab against tumor cells were detected not earlier than 20 days after the treatment. Only 30 days after treatment, CaEP + DCV-treated mice had higher level of Ab compared to only CaEP-treated mice.

We observed that tumor-bearing untreated C57BL/6J mice develop Ab against LLC1 tumor cells 10 days after development of the tumors. However, the levels of Ab in ECT-treated mice were higher. The levels of anti-LLC1 Ab have increased in nsPEF1, nsPEF2, nsPEF3 and nsPEF4-treated mice compared with the untreated and ESOPE-treated mice.

Our study has shown the EP, by itself or in combination with other drugs, to prolong the lifespan of tumor-bearing mice, resulting in increased anti-tumor Ab levels. These results suggest that anti-cancer Ab may be on the frontline in the fight against cancer. Although, further studies need to be done to confirm this hypothesis.

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\*<sup>1</sup>nsPEF1 (3.5 kV/cm x 200 ns x 200 /1 kHz); nsPEF2 (3.5 kV/cm x 200 ns x 200 /1 MHz); nsPEF3 (3.5 kV/cm x 700 ns x 200 /1 kHz); nsPEF4 (3.5 kV/cm x 700 ns x 200 /1 MHz).

\*<sup>2</sup>ESOPE - European standard operating procedures for electrochemotherapy (1.3 kV/cm x 100 μs x 8 /1 Hz).

[1] WHO. (2020). Who Report on Cancer. WHO.

[2] Chen, Y., Moser, M. A. J., Luo, Y., Zhang, W., and Zhang, B. (2019). Chemical Enhancement of Irreversible Electroporation: A Review and Future Suggestions. *Technology in Cancer Research and Treatment*, 18, 1–13. <https://doi.org/10.1177/1533033819874128>

**GUVCNDKIJ O GPV'CPF'EJ CTCEVGTK CVKQP'QHC'PGY "**  
**RCPETGCVKE'FWEVCN'CF GPQECTERQO C'EGNN'NKP'G'ECRCP/48"**

Gi n 'fien v<sup>3</sup>. 'Xgtqpkne'F gf qp{ v<sup>4</sup>. 'Dgpgf kmcu' Mwtirkmu<sup>5</sup>. 'C wf tkwu' 'kgnku<sup>5</sup>. 'Rgvgt' Uej go o gt<sup>5,6</sup>.  
 O kpf cwi cu' Xcrku<sup>3</sup>"

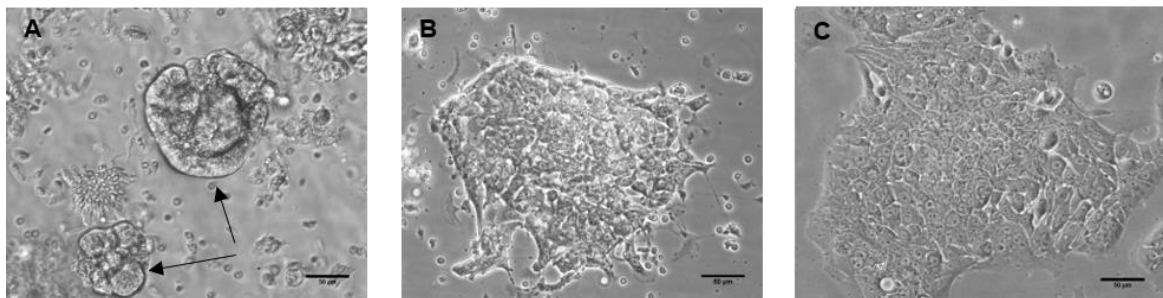
- <sup>3</sup>Rtqvgo leu'Egptg. 'kpwkwg'qh'Dkqej go kut { . 'Xkpkwu'Wpkxgtuk{ 'Nhg'Uelgpegu'Egptg. 'Xkpkwu. 'Nkj wcpk"
- <sup>4</sup>F gr ctwo gpv'qh'Dqvc{ 'cpf' 'I' gpgvku. 'kpwkwg'qh'Dkqelgpegu. 'Xkpkwu'Wpkxgtuk{ 'Nhg'Uelgpegu'Egptg. 'Xkpkwu. 'Nkj wcpk"
- <sup>5</sup>kpwkwg'qh'Erikplecn'O gf lekpg. 'Erikple'qh'I' cutqgpgvtqmi { . 'P gr j tqmi { . 'cpf' 'Uti gt { . 'Hewm{ 'qh'O gf lekpg. 'Xkpkwu' Wpkxgtuk{ . 'Xkpkwu. 'Nkj wcpk"
- <sup>6</sup>I gpgtcn'Xkuegtcn'cpf 'Vtcur rcpv'Uti gt { . 'F gr ctwo gpv'qh'Uti gt { . 'O gf lekcn'Wpkxgtuk{ 'qh'I' tc| . 'I' tc| . 'Cwutk' " gi rgo cni vqB i hkvom"

Egm'rkpgu'j cxg"dggp"wgf "kp"ecpegt"tgugctej "hqt"o cp{ "{ gctu0J qy gxgt. "cp"kf gcn'o qf gn'qh'ecpegt"o wuv'tgugo drg" r tlo ct{ "wo qt"cu'erqug"cu'r quakrg0'Guvcdrikuj gf "rkpgu'yj cv'j cxg"dggp"r cuuci gf "hqt"o rpi "ko g"cf cr v'vq"cp"ct'khekn'kp" xkt q"gp'xktqpo gpv'cpf "mqg"y'j g'kt'qt'ki'kpcn'r j gpqvf r g'f wg"vq"i gpgvke"ftkh'OCnuq. "gcej "ecpegt"r cvkpv'cpf "gcej "f kugcug"ku" f khtgtp'0'ki'y g'y cpv'vq"i clp"o"dtqcf gt "npqy rgi i g"cdqw'ecpegt"kpvtwo qtcn'j gvtqi gpgkx{ . 'y g"ctg'eqpucpvn{ 'kp'pggf "qh" pgy "ecpegt"egm'rkpgu'0'k'ku"gur gelcm{ "lo r qtvcpv'hqt"r cpetgcve"ecpegt. "y j lej "ku"qpg"qh'y'j g"o quv'ci i tguukxg"ecpegtu" npqy p'0'cnj qwi j r cpetgcve"ecpegt"ceeqwv'u'hqt"qpn{ '5' "qh'ecugu"co qpi "y j g'rcf kpi "ecpegt"v'f r gu'kp"y'j g'Wpkxgf "Ucvgu" k'r rvegu'hqwtj "ceeqtf kpi "vq"y'j g'pwo dgt"qh'f gcvj u'0'Y j gp"o gvcucvke"r cpetgcve"ecpegt"ku"f kci pqugf . "y j g'7/{ gct"r cvkpv' uwtxkcn'f getgcugu"cdqw'vq/hqf "kp"eqo r ct'kuq"vq"cp"gtcn{ "f gvevqf "f kugcug"j3\_"cpf . "wphqtwpcvgn{ . "o quv'qh'y'j g'vko g" r cpetgcve"ecpegt"ku"f kci pqugf "cv'cp"cf xcpegt"unci g'0'F khewnku"tgi ctf kpi "cp"gtcn{ "r cpetgcve"ecpegt"f gvevq"ct'kuq" htqo "i tgcv'i gpgvke"cpf "r j gpqvf r ke"fkxgtuk{ "kp"r cpetgcve"wo qtu. "y j lej "o cngu"k'f khewn"vq"f gxgnr "ugpukxg"cpf " ur gekhe"dkqo ctngtu"j4.5\_0'J gtg. "ci clp. "pgy "egm'rkpgu"y'j cv'ecp"tgr tgupv'c"xctkxv{ "qh"r cpetgcve"ecpegt"ecugu"dgeqo g" etkhecn{ "lo r qtvcpv'0"

Kp'y'ku"uwf { "y g'r tgupv'c"pqxgn'r cpetgcve"f wevni'cf gpqectekpgo c"egm'rkpg"Ecr cp/480'Vj ku'egm'rkpg'y cu'f g'kxgf " htqo "c"r tlo ct{ "wo qt"qh'c"87/{ gctu'qif "hgo cng"Nkj wcpkcp"r cvkpv'y kj "r cpetgcve"f wevni'cf gpqectekpgo c"unci g"KO'Vq" qwt"npqy rgi i g. "k'ku"y'j g'htu'r cpetgcve"ecpegt"egm'rkpg'f g'kxgf "htqo "c"Nkj wcpkcp"r cvkpv'0'Y g'ej ctcevgtk gf "y'j g'egm" hwpv'kpcmf "cpf "i gpgvkecn{ <f gvtgo kpgf "y'j g'kt"i tqy j "tcvg. "f gvevqf "g'zr tgukqp"qh"r cpetgcve"ecpegt"cpf "vgo "egm" o ctngtu"EGCECO 8. 'EC3; /; "cpf "EF 66. 'QEV6. "GD3. "tgr gev'xgn{ + "eqpkto gf "y'j cv'egm'htqo "eqm'pku'kp'uqhn'ci ct. " cpcn{ gf "net{ qv'f r g"cpf "h'wpf "o wcv'kpu'qh'ecpegt"tgrv'gf "i gpgu"MI'CU'cpf "VR750'CNuq. "y g'f kueqxtgf "y'j cv'Ecr cp/48" egm'rkpg'ku'ugpukxg"vq"i go ekcdkpg. "f twi "y'j cv'ku'y'kf gn' "wgf "hqt"r cpetgcve"ecpegt"tgcwo gp'0"

Kp'eqpenwukqp. "y g'dgrkxg"y'j cv'Ecr cp/48"egm'rkpg"tgr tgupv'c"p"gh'ev'xg"vqni'htq"r tgerkplecn'r cpetgcve"ecpegt" uwf kgu'0"

Vj ku"y qtni'y cu' hwpf gf "d" o'j gcnj { "Ci gkpi o" r tqi tco o g" qh' y'j g" Tgugctej "Eqwpeki' qh' Nkj wcpk" \*NO VNV=" ci tggp gpv'P q0U/UGP/42/380"



Hki 030Rtqegui'qh'ecpegt"egm'rkpg'gucdrkuj o gpv'0'CF c{ "2"/'f ku'qekv'gf "wo qt"ku'wg'0'cttqy u'f gr kev'eqo r ngz'gu'qh'ecpegt" egm'0'DOF c{ "4"/'r tlo ct{ "ecpegt"egm'eqm{ { 0E0F c{ "422"/'cp'gucdrkuj gf "ecpegt"egm'rkpg'0'Uecrg'dct"/'72'uo 0'

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j3\_"T0N0U'gi gn'MF 00 kngt. 'C0I'go cn'Ecpegt'ucv'ku'ku'4242. 'EC'<c'ecpegt'iqwt'pcn'htq'erikplecpu'92\*3+'%4242+'9/520' j4\_'COM'Y knigy le|. 'GC'00 eO knrp. 'W0D'cn'k'I 0'Dcgm'Y (E0N'p. 'I00'cpuqwt. 'O 00 qm'eg. 'M0W'Y ci pgt. 'R0M'qf v'w'v'0' q'r. 'O (C0'Ej qk'E'0' [ gq. 'R00'eEv. 'O (C0'Y j kg. 'G0L0M'p'w'f upg. 'Y j qrg'gzqo g'ugs wgpel'pi "qh'r cpetgcve"ecpegt"f g'kpgu'i gpgvke"fkxgtuk{ 'cpf "y'j g'ct'g'wke'cti'gu. 'P'cwt'g" eqo o wplecv'kpu'8"%4237+'89660' j5\_'U0'J'cup. 'T0'leq'd. 'W00'cpgg. 'T0'R'cn'k'C'f xcpegu'kp"r cpetgcve"ecpegt"dkqo ctngtu. 'Q'peqni { 't'g'x'ky u'35\*3+'%423; '+6320'



F GXGNQRO GP V'QH'HNWQT GUE GPE G/DCUGF 'VT CP URQUKVQP 'CUUC[ "
HQT'SACCHAROMYCES CEREVISIAE

I gtf c'Unkpf gt { v<sup>3</sup>. 'Ucwksw'Ugtxc<sup>3</sup>. 'Crgmucpf tcu'Mqppqxcrcu<sup>3</sup>"

<sup>3</sup>F gr ctwo gpv'qh'Dkqej go knt { 'cpf 'O qrgewct'Dkqrni { . 'Xkpkwa'Wpkxgtukf . 'Nkj wcpk'
i gtf c'Unkpf gt { v<sup>3</sup> i o ckrkqo "

[ gcu'Uceej ctqo { egu'egt gxlkkg'ku'qpg'qh'vj g'dgu'wpf gtuvqf "gwnct { qvle"o qf gn'qti cpluo u0'k'ku'wugf "hqt'tgugetej "
qh'xctkqwu'dkqrni kcn'r tqeguugu'rkng"i gpg'gzt rguukqp."egm'e{ eng."cpf "o gvedqrkwo ."cu'y gm'cu'hqt'xktwu'tgugetej "]3.4\_0'
UeX/NC"ku'c'f uTP C" { gcu'xktwu'dgnrpi lpi "vq"Vqkxkfcg'fco kq'0'Vj g'gz tcegmwct'r j cug'qh'vj ku'xktwu'ku'wppqy p="kp"
cf f kkkp."xktwu'f qgu'pqv'kpvtgtg'y kj "egm'i tqy vj "]5\_0' Cpqvj gt" gpf qi gpqwu"grgo gpwu'qh' { gcu'ctg"o qdkng"i gpgvle"
grgo gpwu'o'tcpur quqpu0'Uz'fco kkgu'qh'tcpur quqpu'V{3/V{7'cpf 'V{5r'dgnrpi lpi "vq"NVT/tgvtq'tcpur quqpu'ctg'hqwpf "kp"
{ gcu'v]6.7\_0'Vtcur quqpu'ecp"ko rcev'vj g'kpvgi tkf'qh'vj g"i gpqo g."cngt"vj g'gzt rguukqp"qh'cf lcegpv'i gpgu."qt'ecwug"i tqau"
ej tqo quqo cr'tgcttcepi go gpwu']8\_0'Dculpi "qp'tcpuetkr vqo le'cpf "r tqvqo le'f cvc."vj g'j { r qvj guku'y cu'tckugf "vj cv'UeX/NC"
xktwu"o c { "kphwpeg"tcur qukskqp"ghhlekpe{0'k'qtf gt"vq"cuuguv'vj g'kphwpeg'qh'UeX/NC"qp'vj g'tcpur qukskqp"tcvg."vj g'
ercuulecn'tcpur qukskqp"vuv'y cu'w'f cvgf "d { "f guli p'qh'pgy "hwqtguepeg/dcugf "tcur qukskqp"tcvg"cuuc { . "uwkcdng"htq'y krf "
v{r g" { gcu'utckpu'vq'dg'cf f tguugf 0'

kp" vj ku' uwf { . " vj g' pgy " tcur qukskqp" cuuc { " y cu' f gxgnr gf " cpf " cr r krf " r tcevecm{0' Vj g' eqpvtqni' gzt rtko gpv'
f go qpvtcvgf "vj cv'U'egt gxlkkg'egm'gzt rguulpi "I HR"ecp'dg'ugr ctcvgf "htqo "pqp/hwqtguegpv'egm0'Vj g'gzt rtko gpv'cn'
r rno kf . " eqpvcklpi " V{3' tcur quqp" ugs wpeg" cpf " hwqtguegpv' tgr qtvt " i gpg. " y cu' eqpvtwvxf " cpf " wugf " vq " vuv'
tcur qukskqp" ghhlekpe { " kp" rcdqtcvt { " { gcu' utckpu0' Hwtvj gto qtg. " uwkcdng" o gj qf " vq " hz " { gcu' egm' r tkqt " vq " hqy "
e { vqo gvt { " y cu' ugrvxf " cpf " uwkcdng'v'ko g' qh' tcur qukskqp" kpf wvqpy " y cu' f gvt o kpgf 0' Vj g' pgy " tcur qukskqp" cuuc {
dcugf "qp'hwqtguepeg'y km'dg'wugf "vq' uwf { " vj g' kpvgr r { " dgw ggp'UeX/NC' xktwu'cpf "V{3' tcur qukskqp" kp'U'egt gxlkkg'0'

- 13\_ F 0'Rgtcpqxle."M0'V{q."I P 0'Xgo wtk "L0'P kngp."Rtqr gew'qh" { gcu'u{ vgo u'dkqrni { "hqt"j wo cp"j gcnj <lpgi tcvpi "rk kf ."r tqvlp"cpf "gpqi { "
o gvedqrkwo ."HGO U[ gcu'Tgugetej 032."32686327; \*4232-0"
14\_ TQ 0' j cq."I gcu'ht'xktwu'tgugetej ."O letqd'Egn06."5336552"\*4239-0"
15\_ T0D0Y kempgt."V0Hklo wc."T0Gungdcp."Xktwgu'cpf 'r tkpu'qh'Uceej ctqo { egu'egt gxlkkg.'Cf x'Xktwu'Tgu0: 8.'3658"\*4235-0"
16\_ L0 0'Mko ."U0Xcpi wtk "L0'0Dqng."C0I cdtlgn"FH0'Xq{vcu."Vtcur qucdng'Grgo gpwu'cpf "I gpqo g'Qti cpl'cvkq-C"Eqo r tgi gpukg"Uwt xg{ "qh'
Tgvtq'tcpur quqpu'Tgxgnr' d { "vj g'Eqo r ngv'Uceej ctqo { egu'egt gxlkkg'I gpqo g'Ugs wpeg."I gpqo g'Tgu0: .686669: \*3; ; : 0"
17\_ O 0'Ectt."F 0Dgpcuq."E0 0Dgti o cp."Gxqmwqpc { "I gpqo ku'qh'Vtcur qucdng'Grgo gpwu'kp'Uceej ctqo { egu'egt gxlkkg.'RNqU'Qpg09"\*4234-0"
18\_ I 0'Dqwt vq."M0' 0'Dwtpu."O 0I gj tpi ."X0I qtdwpqxc."C0'Ugnwpcq."O 0J co o gm"O 0'K0 dgcwn\ 0'Kux" m"J N0'Nqxp."VU0'O cehctmp."F 0N0'
O ci gt."E0'Huej qvg."Vgp'vj lpi u{ qw'ij qwf "hpqy "cdqw'tcpur qucdng'grgo gpwu."I gpqo g'Dkq03; \*423: -0"
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# INVESTIGATION OF ANTICANCER DRUGS INFLUENCE ON BREAST CANCER CELL MODELS

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**Background.** The tumor consists of different malignant cells like ordinary cancer cells and cancer stem cells. It is necessary to use therapeutic agents targeting all heterogeneous tumor cells population for successful treatment. The research aimed to study the mono- and combination therapeutic effects of anticancer drugs such as methotrexate (0.1 and 1 µg/ml) and salinomycin (1-40 µM). Two anticancer drugs with different cytotoxic mechanisms were tested in 2D and 3D culture.

**Methods.** The cells MCF-7 were cultivated in standard conditions in 2D and 3D culture. MCF-7 spheroids were generated with 2% carboxymethyl cellulose on an orbital shaker (PSU-10i, Biosan, Latvia) at 80 rpm for 3–5 hours at non-adhesive conditions. Monolayer and spheroid cultures were incubated with salinomycin (1-40 µM) and methotrexate (0.1 and 1 µg/ml). MTT-test was used to detect the cytotoxicity effect of antitumor drugs. Expression markers of cancer stem cells (bmi-1, CD44, CD133) and cytokeratin (clone AE1/AE3) were performed by immunochemistry. Morphometric study on 3D culture was carried out using the AxioVision 2000 (Zeiss) program.

**Results.** The results demonstrated that the IC<sub>50</sub> for Sal was 19 µg/ml, IC<sub>50</sub> for Met 67,4 µg/ml, IC<sub>50</sub> for Sal+Met 0,1µg/ml – 42.7 µg/ml, IC<sub>50</sub> for Sal+Met1µg/ml – 34,5 µg/ml. The IC<sub>50</sub> for Sal 1-40 µM + Met 1 µg/ml had twice smaller than the IC<sub>50</sub> for Sal and Met separately. The results of immunochemistry showed that after incubation with Met 10 µg/ml expression level of cancer stem cells markers were higher 2-3 times than Sal 4 µM + Met 0,1 µg/ml. The expression of cytokeratin decreased by 25% and 0 % compared to control after combination Sal 40 µM + Met 0.1 and Sal 40 µM + Met 1 µg/ml respectively. The next stage of the work was the study of drugs in a 3D culture. The results of culturing spheroids with (Sal 40µM +Met 1µg/ml; Sal 40µM + Met 0,1 µg/ml) was decreased spheroid size by 82% and 73% in accordance. Cytotoxicity of antitumor drugs on tumor spheroids with Sal 4 µM + Met 1 µg/ml and Sal 4 µM + Met 0,1 µg/ml were reflected in decreasing spheroid volume by 40% and 36%. The decreasing of spheroids size was a dose-dependent tendency from 4µM to 40 µM of Sal.

**Conclusion.** Our result demonstrated that 2D and 3D cultures were sensitive to mono- and combination therapy. The decrease of size spheroid culture and decrease in live-cell viability after incubation with Sal 4-40 µM + Met 0,1-1 µM is a good marker for synergistic activity. The data showed that Sal + Met hasn't cytotoxic influence on the cancer stem cell population.

**KPUK J V'KP VQ'VJ G'J GVG TQI GP GKVI 'QHDTGCUV'ECPEGT''  
VJ TQW J 'PGZVI GP GTCVKQP'UGS WGPEKPI ''**

Lwukpc'I cki gxunc<sup>3,5</sup>. 'Cwuc'Uwo dt {vg/Mco kpuukg<sup>4</sup>. 'Tcuc'Ucderkcwunc<sup>3</sup>. 'Uqpcw'Leto cnc<sup>3,5</sup>"

<sup>3</sup>Ncdqtcvt { "qh'I gpgvle'F kci pqule. 'P cvkqpcn'Ecpegt'Kpuukwg. 'Xkrpkwu. 'Nkj wcpkc "

<sup>4</sup>F gr ctvo gpv'Dkqdcpm'P cvkqpcn'Ecpegt'Kpuukwg. 'Xkrpkwu. 'Nkj wcpkc "

<sup>5</sup>Kpuukwg'qh'Dkquelpegu. 'Xkrpkwu'Wpkkgtukv { 'Nkg'Uelpegu'E gpgvt. 'Xkrpkwu. 'Nkj wcpkc "

Lwukpc'I cki gxuncB pxktn'

"

Y qtrf y kf g. 'dtgcu'ecpegt' "DE+'ku'j g' o quv'eqo o qpn' f kci pquf 'v' r g'qh'ecpegt' 'kp' y qo gp' cpf 'j g' r gcf kpi 'ecwug' qh' ecpegt/ tgrv' f gcv 'j3\_0DE'ku'c'j gvtqi gpgqu'f kugcug. 'y j lej 'f kht' d'kqmi kcm' 'co qpi 'f kht' g'v' r cvkqpu' c'pf 'gxgp' y kj kp' gcej 'kp' k'k'f wcn'wo qt. 'y j g' h'q' t' c' o clqt' i qcn'qh' ko r tqxgf 'emuc' h'ecv'kp' qh' DE' u'w'v' r gu. 'ku' v' q' u' t' c' v' h' 'r' cvkqpu' r qr w'cvkqpu' Cf x'c'p'egf 'kp' o q'ngewr' t' ej ctcevg' t' k' cvkq' qh' wo qtu' p'q' v' q'pn' 'ko r tqxgf' emuc' h'ecv'kp. 'dw' c'nu' q' r' q'kp' v' f' k' g'ev' 'v' q' o q'ngewr' t' o ge'j' c'p'kuo u' v' j' cv' r' g'cf 'v' q' f' k' h' t' g' p' v' j' g' t' c' r' gw'le' t' g'ur' q'p'ug' u' ]4\_0Ck' o' qh' v' j' ku' u'w'f { 'y' cu' v' q' k' f' g' p' v' h' { 'en' p'le' q' r' cv' j' q'ni' k'ec' n' c' p' f' r' q'v' p' v' c' n' i' o' q'ngewr' t' li' g'p'g' v' e' c' n' r' t' g' f' l' e' v' q' t' u' q' h' d' t' g' c' u' v' e' c' p' e' g' t' o' "

C'v'c' n' i' q' h' 46' h' g' o' c' i' g' 'DE' f' cvkqpu' h' q' t' o' 'P' cvkqpcn' Ecpegt' Kpuukwg' y' g' t' g' l' p' e' n' f' g' f' 'kp' v' j' ku' u'w'f { 0Uk' i' g' p' g' u' <VR75. 'ECUR: . 'OVJ H. 'OFO4. 'OFO6' c' p' f' 'EET7' y' g' t' g' u' g' r' e' v' g' f' 'd' c' u' g' f' " q' p' v' j' g' k' t' o' w' c' v' k' q' p' h' t' g' s' w' p' e' { " c' p' f' " u' k' i' p' h' e' c' p' e' g' " h' q' t' " f' k' u' g' c' u' g' f' g' x' g' n' u' r' o' g' p' v' P' g' z' v' i' g' p' g' t' c' v' k' q' p' " u' g' s' w' g' p' e' k' p' i' " \*P I U' " v' e' j' p' q' n' i' { " y' c' u' ' c' r' r' i' g' f' " h' q' t' " i' g' p' q' o' k' e' " r' t' q' h' k' g' " c' p' c' n' i' u' k' i' q' h' 'DE' 0' C' n' i' k' f' g' p' v' h' g' f' " o' w' c' v' k' q' p' u' y' g' t' g' x' c' r' k' f' c' v' g' f' " d' { " t' g' x' l' e' y' k' p' i' " v' j' g' t' g' u' w' u' y' k' j' " k' p' v' i' t' c' v' x' g' I' g' p' q' o' k' e' u' X' l' e' y' g' t' " \*K X+0' C' n' i' k' f' g' p' v' h' g' f' " i' g' p' g' v' e' " e' j' c' p' i' g' u' y' g' t' g' e' m' u' c' h' g' f' " c' u' r' c' v' j' q' n' i' k' e' c' n' f' t' w' i' / t' g' u' r' q' p' u' k' x' g' . " d' g' p' k' i' p' . " c' p' f' " x' c' t' k' e' p' v' q' h' w' e' p' e' g' t' c' k' p' u' k' i' p' h' e' c' p' e' g' " \*XWU+0' V' j' q' w' i' j' . " E' n' p' X' c' t' " k' u' v' j' g' o' c' l' q' t' f' c' v' c' d' c' u' g' w' u' g' f' " k' p' e' n' p' l' e' c' n' r' t' c' e' v' e' g' . " o' w' c' v' k' q' p' u' t' c' v' g' f' " c' u' XWU' y' g' t' g' c' f' f' k' k' q' p' c' m' i' " e' j' g' e' n' g' f' " k' p' " q' j' g' t' f' c' v' c' d' c' u' g' u' o' "

352' o' w' c' v' k' q' p' u' y' g' t' g' k' f' g' p' v' h' g' f' " k' p' d' t' g' c' u' v' w' o' q' t' u' c' o' r' n' g' u' " \*46' 46' r' c' v' k' q' p' u' o' P' q' p' / r' c' v' j' q' n' i' k' e' c' n' i' e' j' c' p' i' g' u' c' e' e' q' w' p' v' g' f' " h' q' t' " 990' " q' h' c' n' i' f' g' v' e' v' g' f' " o' w' c' v' k' q' p' u' o' C' o' q' p' i' " v' j' g' o' . " d' g' p' k' i' p' " i' g' p' g' " u' g' s' w' g' e' p' e' g' " e' j' c' p' i' g' u' y' g' t' g' v' j' g' o' q' u' v' e' q' o' o' q' p' " \*8405' -0' R' c' v' j' q' n' i' k' e' c' n' i' k' n' g' n' i' " r' c' v' j' q' n' i' k' e' c' n' i' o' w' c' v' k' q' p' u' c' e' e' q' w' p' v' g' f' " h' q' t' " : 06' " q' h' c' n' i' x' c' t' k' e' p' u' f' g' v' e' v' g' f' 0' V' R' 75' j' c' f' " v' j' g' i' t' g' e' v' u' v' x' c' t' k' e' v' q' h' i' i' g' p' g' v' e' " e' j' c' p' i' g' u' 0' V' y' q' " XWU' q' h' V' R' 75' i' g' p' g' y' g' t' g' k' f' g' p' v' h' g' f' " c' u' r' k' n' g' n' i' " r' c' v' j' q' n' i' k' e' c' n' i' d' { 'EQUO' k' e' " c' p' f' " X' C' T' U' Q' O' G' f' c' v' c' d' c' u' g' u' o' ' E' C' U' R' : ' c' p' f' " O' V' j' H' T' " i' g' p' g' u' c' n' u' q' u' j' q' y' g' f' " c' j' k' i' j' " h' t' g' s' w' g' e' p' e' { " q' h' e' j' c' p' i' g' u' . " d' w' p' q' " r' c' v' j' q' n' i' k' e' c' n' i' o' w' c' v' k' q' p' u' y' g' t' g' f' g' v' e' v' g' f' 0' Y' g' f' k' f' " p' q' v' h' p' f' " c' p' { " c' u' u' q' e' k' v' k' q' p' u' d' g' y' g' g' p' " r' t' g' u' g' p' e' g' " q' h' i' r' c' v' j' q' n' i' k' e' c' n' i' e' j' c' p' i' g' u' c' p' f' " e' n' p' l' e' c' n' f' g' o' q' i' t' e' r' j' k' e' " e' j' c' t' c' e' v' g' t' k' u' k' e' u' " q' h' i' r' c' v' k' q' p' u' o' "

K'p' e' q' p' e' n' u' k' q' p' . " v' j' k' u' i' g' p' g' v' e' r' t' q' h' k' p' i' " t' g' x' g' c' r' g' f' " v' j' c' v' V' R' 75' i' g' p' g' j' c' u' v' j' g' i' t' g' e' v' u' v' x' c' t' k' e' v' q' h' i' o' w' c' v' k' q' p' u' c' p' f' " v' j' g' i' t' g' i' t' g' u' v' p' w' o' d' g' t' " q' h' i' r' c' v' j' q' n' i' k' e' c' n' i' x' c' t' k' e' p' u' k' p' " D' E' r' c' v' k' q' p' u' k' p' v' j' k' u' u' w' f' { 0J' q' y' g' x' g' t' . " o' q' t' g' t' g' u' g' c' t' e' j' " k' u' p' g' g' f' g' f' " v' q' f' g' v' t' o' k' p' g' e' q' p' p' g' e' v' k' q' p' " d' g' y' g' g' p' i' g' p' g' v' e' " e' j' c' p' i' g' u' c' p' f' " e' n' p' l' e' c' n' i' o' c' p' k' h' g' u' c' v' k' q' p' u' q' h' i' f' k' u' g' c' u' g' c' p' f' " v' q' w' u' g' v' j' g' t' g' u' w' u' k' p' " o' q' n' g' e' w' r' t' l' i' g' p' g' v' e' " e' m' u' c' h' e' c' v' k' q' p' " q' h' i' w' o' q' t' u' o' "

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[3\_ \ 00 qo gplo qxcj gf .J 0Ucngj kpk{ c.'Gr kf go kqni kecnlej ctcevgtku'ku'qh'c'p'f' tkun'f'ce'v'q' t' u' q' h' d' t' g' c' u' v' e' c' p' e' g' t' ' k' p' v' j' g' y' q' t' r' f' . ' D' t' g' c' u' v' e' c' p' e' g' t' " f' q' x' g' o' g' f' " R' t' g' u' " \*\*\*\*\*33. '373/386' \*423; +0

[4\_ 'F 0ROJ km' COJ ctr gt' gv' c' i' o' ' E' k' u' r' w' v' l' p' / t' g' u' k' u' c' p' v' t' k' r' g' p' g' i' c' v' x' g' d' t' g' c' u' v' e' c' p' e' g' t' u' w' d' v' r' g' u' z' o' w' n' k' r' g' o' g' e' j' c' p' k' u' o' u' q' h' i' t' g' u' k' u' c' p' e' g' . ' D' O' E' ' E' c' p' e' g' t' ' 3 ; . ' 325 ; " \*\*\*\*\*423; +0

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# REDOX ENZYMES INVOLVED IN *ARABIDOPSIS THALIANA* (L.) HEYNH. SEEDLING RESPONSE TO COLD PLASMA TREATMENT OF SEEDS

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Successful seed germination and seedling establishment are critical steps in agricultural production and in the maintenance of natural ecosystems. Seed treatment with cold plasma (CP), is an emerging eco-agricultural technology that has potential application for enhancement of plant growth and adaptation. In addition to sterilization effect, treatment of seeds with CP has been shown to have effect on a broad spectrum of plant development and physiological processes. Although the body of information on the biological effects of the CP is growing, the complex biological mechanisms involved in the plant response remains vague. The objective of this study was to assess role of reactive oxygen species (ROS) producing and redox balance regulating enzymes in response of the model plant *Arabidopsis thaliana* (L.) Heynh. to the seed treatment with atmospheric pressure dielectric barrier discharge plasma source. Seeds of *A. thaliana* Columbia ecotype wild-type (Col-0) and gene knockout mutant lines of ROS producing enzymes NADPH oxidase *AtRbohB* and *AtRbohF* and enzymes involved in maintenance of the cellular redox balance, *AtAPX1* and *AtCAT2*, were used in the study. Seeds were treated for 1.5 or 3.0 min at 3 mm distance from the CP source at 60-80% air humidity and stored for 7 days at 25 °C after the treatment. The significant changes in root length was observed for the 2 day old seedlings of Col-0, *AtRbohB*, *AtRbohF* and *AtCAT2* germinated from the seeds treated for 3 min. *AtRbohF* showed an enhanced (~6 % compared to control) root growth response similar to that of the wild-type genotype, meanwhile the length of roots was reduced for the *AtRbohB* and *AtCAT2* mutants (20 % and 10 %, respectively). In contrast to the effect observed for the roots, 3 min CP treatment had stimulating effect on hypocotyl development of the *AtAPX1* mutant (~7 %). Meanwhile hypocotyls of the *AtRbohF* and *AtCAT2* were shorter compared to control (9 % and 23 %, respectively). Hypocotyls of the Col-0 and *AtRbohB* mutant showed no response to CP treatment. The analysis confirmed that the redox enzymes play essential role in *A. thaliana* seedling phenotype formation in response to CP treatment and the effect could be linked to the role of ROS in seed germination and seedling organ development.



**DKQCEEWO WNCVKQP 'QHI TCRJ GP G'QZKF G'P CPQUVTWE VWTGURP "**  
**SALMO TRUTTA'CV'GCTN[ 'FGXGNQRO GP V'UVC I GU"**

Cwi wucu'O qtmx pecu<sup>3</sup>. "fiklkn 'Lwti gn p<sup>4</sup>. "Ugti gl<sup>1</sup> "Mgo kwn<sup>5</sup>. 'P klqn 'Mc| rrwunkgp<sup>4</sup>. "Xkscrklu"  
 Mctcdcpqxcu<sup>3,6</sup>"

<sup>3</sup>"Dkqo gf lecnRj { uleu'Ncdqtcvqt { . 'P cvkqpcnEcepgt 'Kpukwng. 'Dcwdrkq '5d. 'NV/2: 628. 'Xkpkwu. 'Nkj wpcle"

<sup>4</sup>"P cwtg'Tgugctej 'Egpvtg. 'Cnef go klqu'u04. 'NV/2: 634'Xkpkwu. 'Nkj wpcle"

<sup>5</sup>"UTKE gpvgt 'hqt 'Rj { ulecn'Uekppegu'cpf "Vgej pqrqi { . 'Uxcvptk 'cxg0453. 'NV/24522. 'Xkpkwu. 'Nkj wpcle"

<sup>6</sup>F gr ctwo gpv'qh'Ej go kwf { 'cpf 'Dkqgpi kpggtkpi . 'Xkpkwu'I gf lo kpcu'Vgej plecn'Wpkxgtukf { . 'Ucwrgvknq 'Cxg033. 'NV/32445"  
 Xkpkwu. 'Nkj wpcle"

c0 o qtmxgpcuB i o cltqo "

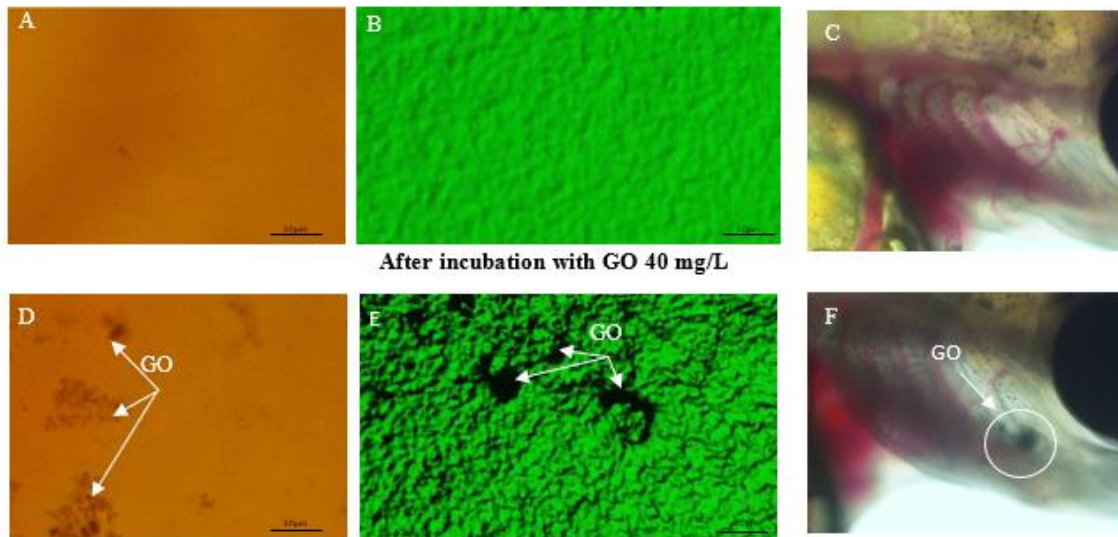
I tcrj gpg" qzkl g" \*I Q" j cu" yj g" i tgev' r qvvpkci' hqt" dkqo gf lecn' cr r rdecvkpu" cpf " gpxktqpo gpvcn' r tqvgevkp0' Vj g' kpetgcugf "wug'qh'I Q'tckugu'yj gk'tgrgcug"kpq"yj g' gpxktqpo gpv0J qy gxtg. "yj g"j gcnj "tkumu'cuqekcvf "y kj "gpxktqpo gpvcn' gzr quwtg"q" I Q'ctg'rcti gn{ "wvnpqy p0F wg"q" yj gk' "wpls wg"r j { ukqej go lecn'r tqr gtvku. "I Q'cpf "ku"eqo r qukku"eqwrf "dg" cr r rkgf "q"y cxy cvgt "tgcwo gpv'cpf "q"cf uqtr vkg'tgo gf kcvkp'qh'gpxktqpo gpvcn' qmwcpw0'

Vj g'clo 'qh'y ku'wvf { 'ku'q'gzco kpg'yj g' f kntkdwkqp'qh'I Q'62'b i IN'kp "Ucw q'itwmc" go dt { qu'cpf 'rctxcg'wukpi 'eqphqeci' hwtgugpeg'o letqueqr { 0Cpcnf uku'y cu'dcugf "qp"5F "cwqhwatgugpeg"ko ci kpi "qh'guy/qti cpkuo u" \*Hki 030D'cpf "G-0I Q" f kntkdwkqp'kp" go dt { q'ej qtkqp'cpf "gzvtpcn'dqf { "kuwgu'qh'rctxcg'y cu'gxcwcvf 0Hqt "yj g'gzr gtgo gpv' "Ucw q'itwmc" go dt { qu cv'yj g'g { gf /gi i "uci g'cpf "6"fc { "qrf "rctxcg'y g'g'qdvkpgf "Itqo "yj g"j cvej gt { "Nkj wpcle-0Uwfkgu"j cxg"dgpp"ecttkgf "qww" y kj "pqp/r tqvgevf "rhg/uci gu'ceeqtf cpeg'y kj "GWF kgevkxg"42321851GW0Vj g'rdqtcvqt { "tgcwo gpv'y cu'ecttkgf "qww'kp"cp" gpxktqpo gpvcn' ej co dgt" \*Dtqpuq" RI E/882. " \ cndqo o gn" Vj g' P gyj gtrpuf u" y kj "eqp'kpwqu" cgtcvkqp" wpf gt" ucwle" eqpf kkpau0'

Vj g'dtki j v'kgrf "ko ci g'qh'eqpvtqni'go dt { qu'uj qy "yj cv'yj g'ej qtkqp'uwthceg"ku'uo qqy "y kj "tgi wctn{ "f kntkdwgf "fctngt" ur qu" \*Hki 0'30C-0'Vj g'ug" fctngt "ur qu"ctg"ej qtkqp"r qtgu"yj cv'ctg"ko r qvcpv' hqt"qz { i gp lectdq" f kqzkl g. "pwtkcpw"cpf " gzetgkqp'r tqf wv'vcpur qtv'q'cpf "Itqo "yj g'go dt { q. 'tgr gevkgn{ 0Chtg'6'fc { u'qh'kpwedcvkqp'y kj "I Q'62'b i IN. 'kp"go dt { qu' ej qtkqp'cr r gctgf "pqp"cwqhwatgugpeg"ctgcu" \*fctm'ur quw. "y j lej "kpf kcvgf "I Q'cf j gukqp"qp"uwthceg"qh'ej qtkqp" \*Hki 030' G-0Hwt yj gto qtg. "fctm'ur quw'qh'I Q'ecp"dg'uggp" f kgevf "kp"uqo g'ctgcu'qh'go dt { qu'ej qtkqp'cpf "rctxcg'kpvtpcn'kuwgu'kp" yj g'dtki j v'kgrf "ko ci g' \*Hki 030F "cpf "H0I Q'eqwrf "enqj "yj g'ej qtkqp'r qtgu'cpf "chgevf"go dt { qple'f g'xgnr o gpv'qh'kuj "j3\_0' Vj g's wvukqp"cdqw"pqp/j qo qi gpqwu" I Q'cf j gukqp"qp"yj g'qti cpkuo "ku'wkn'qr gp. "dgecvug"yj gk' "dkqf kntkdwkqp"j cxg'pqp" dggp' hwn{ "kpxguki cvgf 0"

Vj ku'y qtnly cu'wxf gf "d { "yj g'Tgugctej 'Eqwpekn'qh'Nkj wpcle. 'Rtqlgev'P q0"U/O RR/42/440

**Control**



Hki 030Vj g'dtki j v'kgrf " \*C'cpf "F +cpf "5F "tgeqputwvukqp"ko ci gu" \*D'cpf "G+qh'Ucw q'itwmc" go dt { qu'ej qtkqp'cpf "rctxcg" \*E" cpf "H+chgt'6'fc { u'qh'kpwedcvkqp'y kj "I Q'62'b i IN0"

[3\_Ej gp" I 0'Uwp'LO'J wZ0\ j qwS 042380Ur gektle'pcpqvzlekf { 'qh'i tcrj gpg'qzkl g'f wtkpi 'j gdtckuj "go dt { qi gpguku0P cpq'vzleqni { '32\*3+ '64/740'

**I GPQ/'CPF 'E[ VQVQZKĒ 'TGURQPUGU'KP 'HNQWPF GT '\*PLATICHTHYS  
FLESUS+'HTQO 'VJ G'NKVJ WCPKCP 'E QCUVCN' QPG\*'DCNVKĒ 'UGC+'**

Tgf c'P crkxcknkp <sup>3</sup>. 'Xkti kplc 'Mcrekcp <sup>4</sup>. 'Crgmcpf tcu'T { dcnqxcu<sup>3</sup>. 'fikxkpcu'R v{u<sup>3</sup>. 'I kgt " Xk-kpungp <sup>3</sup>. 'Ncwtc'Dwtko cxx kgp <sup>3</sup>"

<sup>3</sup>P cwtg'Tgugctej 'Egvtg. 'Kpukwng'qh'Geqrni { . 'Cnef go kqu'Ut04. 'NV/2: 634'Xkpkwu. 'Nkj wcpk"

<sup>4</sup>'Xkpkwu'Wpkgtukf. 'Nhg'Uelgpegu'Egvtg. 'Kpukwng'qh'Dkuelgpegu. 'Ucwn vgnk'cx09. 'NV/32479'Xkpkwu. 'Nkj wcpk"  
tgf c'Qi rkpuncgB i co ve0M'

"  
Nkj wcpkcp"eqcucn'ctgcu'qh'j g"Denke"Ugc"ctg"wpf gt"uki pkklecpv'j tgecv'qh'eqpvo kpcvqp"htqo "y j qrg"dcukp'qh'j g"  
P go wpcu'Tkxgt. 'Mrcr f c'r qtv'0'ppg'qh'j g'rti guv'lp'j g'tgi kq. 'tguqtu'cpf "qk'vto kpcn0I gpqzle"eqpvo kpcwu'ecp"  
r qug'tkum'vq"o ctkg'qti cpluo u'cpf "gxpwmcm' "kpf weg"ej cpi gu'lp'y j qrg"gequ'vgo O'kp'ukw'r gthqto gf "gpqkqpo gpvcn"  
o qpkqt'kpi. 'y j lej 'ku'dcugf 'qp'e'q' q' g'p'v'cuuguo gpv.'r tqxf gu'f c'c'cdqww'j g'ewt'gpv'ucwu'qh'vcti gv'qti cpluo u'cpf 'ecp"  
dg'uweegu'wm' "vugf 'hqt'j g'g'xcn'v'qp'qh'ko r cew'ecwugf "d' "ceek'gpvcn'ur kmu'cpf kq't'g'rgcug'qh'j c'j ctf qwu'eqpvo kpcwu"  
kp'j g"o ctkg'gpqkqpo gpv'0P wo dgt'qh'uww'kgu'r gthqto gf "lp'ukw'kp" f' h'ht'gpv'ctgcu'qh'j g"Denke"Ugc" f go qpu'vcgu. 'y cv'  
Rrv'kej j { u'h'guu'ku'ugpukxg'cpf 'lphqto cxxg'dkqpf kecvt'qh'i gpqzle"eqpvo kpcvqp"j3. '4. '5\_0

Vj g'c'ko "qh'j ku'uwf { 'y cu'v'cuuguo'rgxgn'qh'gpqkqpo gpvcn' gpqzle"cpf "e' { vqzle"kp"RO'h'guu'cv'j tgg'uwf { "  
ukgu'qh'j g"eqcucn' ppg'qh'Nkj wcpk" \*Mrcr f c/D vpi "ctgc+'lp'wo o gt'qh'4238'cpf "lp'423; 0'Ugngv' "ucv'qpu'y g'g"  
ej ctcev'k'gf "d' { "f'ht'gpv'r qm'w'kp'0'D vpi "ucv'qpu'y cu'neq'cv'v'x'le'k'p' { "qh'j g'D vpi "qk'vto kpcn'Mrcr f c'ucv'qpu"  
o'ukw'cv'f 'i cvgu'qh'j g'Mrcr f c'r qtv'cpf "qk'vto kpcn'cpf 'Rrcpi c'ucv'qpu'o'wpf gt'j g'lp'hw'peg'qh'j g'rti g'tguqt'0

Vj g'r'tgr'ctv'q'qh'dkq'ki'lecn'o'cv'g'k'nc'p'f'g'xcn'v'q'qh'j g'i'gpq/'\*o' letq'weng'k'cpf 'pweng't'dw'f'uc'p'f' "e' { vqzle"kp" "  
\*ht'ci o'gpv'f' /cr'qr'v'le'ep'f' "dl'weng'cv'f' "egm'+'gp'f'r'q'lp'w'y g'tg'ect'k'f' "q'w'h'q'm'y kpi 'y g'g'ct'ng't'f' g'uet'k'g'f' "o' g'j'q'f' q'm'i { "j3\_0

Cuugugf 'ht'gs'w'p'el'gu'qh'i' letq'weng'k' \*O P +lp' 'h'uj' 'ht'qo 'D vpi 'cpf' 'Rrcpi c' "ceeq't'f' kpi n' { '208'Y' 'cpf' '208; Y' + 'y' g'g"  
gr'x'cv'f'. 'eqo r'ctg'v'q'j g'f'c'w'q'v'c'k'p'f' "lp'4223\*204Y' "cpf' '208Y' "t'g'ur'g'v'x'gn' + 'y' j'gp' 'uwej' 'uwf' { 'y' cu'eq'p'f' w'v'f' "hqt'j' g"  
h'ku'v' wo g'0'kp' "RO'h'guu'ur' geko' g'pu'eq'ng'v'f' "lp' "Mrcr f c'ucv'qpu'j' g'tg' "y' g'tg' "o' g'cu'w'g'f' "j' k'j' " \*70Y' + "cpf' "ucv'k'nc'm' "  
uki pkklecpv' k'p'et'g'cug' "qh'pweng't' dw'f' " \*P D+ "kp' "eqo r'ctk'up' "v'q' q'j' g't' "dq'j' "ucv'qpu'0' Uki pkklecpv' "k'p'et'g'cug' "rgx'gn' qh'  
o' letq'weng'k'pweng't' dw'f'uc'p'f' "ht'ci o'gpv'f' /cr'qr'v'le'egm' 'y' g'tg'hw'p'f' "lp' 'h'uj' 'cpf' "dl'x'c'x'gu'c'ht'g' "y' g'q'k'it'ur' k'ni'k'p' "y' g'D vpi "  
v'to kpcn'lp' "P q'x'go dgt'4223'cpf "Lcpwct { "422: "j5. "6. "7\_0'k'p'et'g'cug'f' "P D'ht'gs'w'p'el'gu'j' g'tg' "q'd'ug't'x'g'f' "lp' "RO'h'guu'ht'qo "y' g"  
I w'hi'q'h'I f'cp'unc'p'f' "Tki c'Dc' { "j4. "5\_0J k'j' "rgx'gn'qh'P D'lp'gt' { v'j' t'q'e' { v'gu'y' g'tg'hw'p'f' "lp' 'h'uj' 'ecw'j' v'cv'q'k'ic'p'f' "i' cu'r'v'w'ht'o "  
| q'p'gu. 'cn'wo k'p'wo 'uo' g'ng't' | q'p'g' "cpf' "kp' "o' w'u'gn'c'ht'g' "q'k'it'ur' k'ni'k'p' "j6. "7\_0E { vqzle"t'g'ur'q'p'ug'u'd'g'y' g'p' "uwf' { "ucv'qpu'j' g'tg' "p'q'v'  
ucv'k'nc'm' "uki pkklecpv'0

K'p'et'g'cug'f' "ht'gs'w'p'el'gu'qh'i' gpq/'cpf' "e' { vqzle"kp" "r'ctco' g'v'tu'lp' "RO'h'guu'ht'qo "k'p'x'g'uki' cv'f' "ukgu'qh'j g' "Nkj wcpkcp"  
eqcucn' p'p'gu'k'p'f' kec'v'u'j' g'r' t'g'ug'peg'q'h'r' q'm'w'k'p' "y' k'j' 'i' gpqzle"ci' g'p'v' "y' j' lej' "o' k'j' v'ht'g'f' "v'q' 'i' g'p'go g'k'p'uc'd'k'k'f' . 'h'qto c'v'k'p"  
qh'ec'p'eg't. "t'g'r'q'f' w'v'x'g'f' k'ut'f' g'tu. "cd'p'q'to' c'n'r'j { uk'q'ni' lecn't'g'ur' q'p'ug'u. "k'p'et'g'cug' "t'k'um'q'h'f' g'x'g'nr' o' gpvcn'cpf' "f' g'i' g'p'gt'c'v'x'g"  
f' k'ug'c'ug'u. "j' g'tgd' { "ch'g'ev'd'k'q'f' k'x'g't'uk'f' "j8\_0'k'p'q't'f' g't' "v'q'cej' k'x'g' "i' q'q'f' "gpqk'qpo' gpvcn'uc'wu. "eq'p'k'p'w'q'u' "k'p'x'g'uki' c'v'k'p'u'qh'j g"  
dk'q'ni' lecn'gh'g'ev'qh'gpqk'qpo' gpvcn'r' q'm'w'k'p' "lp' "o' ctkg'eqcucn'gequ' v'go u'ct'g' "gu'g'p'v'c'n'0

aa  
j3\_ "C0T { dcnqxcu. 'L0'Dct-kgp. 'Nepi "V0'Nepi. "Gp'x'k'q'po' gpvcn'i' gpqzle"cpf' "e' { vqzle"kp"j' g'q'h'uj' q't'g' "p'p'gu'qh'j' g' "Denke"cpf' "y' g'P'q't'j' "Ugcu."  
O'ctkg'G'p'x'k'q'po' gpvcn'i' T'g'ug'ctej. '8: -468/478"422; +0

j4\_ "N0'Dwtko cxx kgp. 'L0'Dct-kgp. 'L0'I' t'g'lek' p'ckv. 'O'0'U'c'p'ng'x'k' k'v. 'T'0'X'c'n'ng'p. "Gp'x'k'q'po' gpvcn'i' gpqzle"cpf' "k'um'ic'ug'uo' gp'v'lp' "y' g'I' w'hi'q'h' "Tki c"  
\*Denke"Ugc+'w'ul'p'i' 'h'uj'. 'dl'x'c'x'gu' "cpf' "et'w'nce'ge'p'u. "Gp'x'k'q'po' gpvcn'i' U'el'g'p'eg' "cpf' "R'q'm'w'k'p' "T'g'ug'ctej. "47-46: 3: 646: 4: "423: +0

j5\_ "T'0'X'c'n'ng'p. "L0'Dct-kgp. "N0'Dwtko cxx kgp. "L0'R'c'f'w'ul'g'p. "Y'0'I' t' { i' l'gn' "O'0'U'c'p'ng'x'k' k'v. "C'0'T' { dcnqxcu. "k'p'f' w'v'k'p' "qh'pweng't' "cd'p'q'to' c'k'k'gu' "lp"  
j' g't'k'p'i' \*E'nr'g'c'j' c't'g'p'i' w'ub' go d't'cu: 'h'w'p'f' g't' \*R'rv'kej' j' { u'h'guu' "cpf' "C'w'p'v'le' "eq'f' "I' c'f' w'ub' q't'j' w'e' + "eq'ng'v'f' "ht'qo "y' g'k'w'j' g't'p'f' c't'v'q'h'j' g'I' q'w'c'p'f' "  
D'cul'p' "y' g' "Denke"Ugc"423264239+. "Gp'x'k'q'po' gpvcn'i' U'el'g'p'eg' "cpf' "R'q'm'w'k'p' "T'g'ug'ctej. "48\*35+35588/355: 2"423; +0

j6\_ "L0'Dct-kgp. "N0'c'p'f' t'g'k'n' p'ckv. "I'0'I' c't'p'c'i. "C'0'T' { dcnqxcu. "I' gpqzle"cpf' "e' { vqzle"gh'g'ev'lp' "dl'x'c'x'g' "o' q'm'w'ni' "O'c'eq'o' c' "dc'n'j' k'ec' "cpf' "O' { v'w'u' "g'f' w'hi'  
ht'qo "y' g' "Denke"Ugc. "G'n'q'ni' k'c. "76-66/72"422: +0

j7\_ "L0'Dct-kgp. "C'0'T' { dcnqxcu. "I'0'I' c't'p'c'i. "N0'c'p'f' t'g'k'n' p'ckv. "Gp'x'k'q'po' gpvcn'i' gpqzle"cpf' "e' { vqzle"kp" "uw'f' l'gu'lp' "o' w'u'gn' "d'gh'q't'g' "cpf' "ch'g't' "y' g' "q'h'i'  
ur' k'ni'k'p' "o' ctkg'q'k'v'to' kpcn' "Denke"Ugc+. "Gp'x'k'q'po' gpvcn'i' O'q'p'k'q't'k'p'i' "cpf' "Cu'gu'uo' gpv' "3: 6-4289/429: "4234+0

j8\_ "C'0'I' k'p'g'd't'g'c. "O'0'M'w' o' c'p'q'x'le. "J'0'I' w'c'uej. "O'0'N'r'g' "f'g' "C'f'c. "L'E'0'N'r'g' /F' q'x'c'n' g'v'c'n'0' "Cu'gu'uo' gpv' "qh'i' o' w'nk'ej' go' lecn'r' q'm'w'k'p' "lp' "cs' w'v'le"  
gequ' v'go u'w'ul'p'i' "q'zle'w'p'ku' "E'q'o' r'q'w'p'f' "t'k'q't'k'k' c'v'k'p. "o' k'z'w'g'ej' c't'cev'k'k' c'v'k'p' "cpf' "l'g'nc'v'k'p'uj' k'r' u'y' k'j' "dk'q'ni' lecn'f' g'uet'k' v'q'tu. "U'el'g'p'eg' "qh'j' g' "V'q'c'n'  
G'p'x'k'q'po' gpv' "68: l68; -937/945"4236+0

**F GPFTK/KE 'EGNN'XCEE P G'O QF WNCVKQP 'IN VITRO'Y KJ J "**  
**EJ CTCE VGT KUGF 'GRKJ GNKN'QXCTKCP 'ECPEGT 'EGNN'NKP G"**  
**N[ UC VG"**

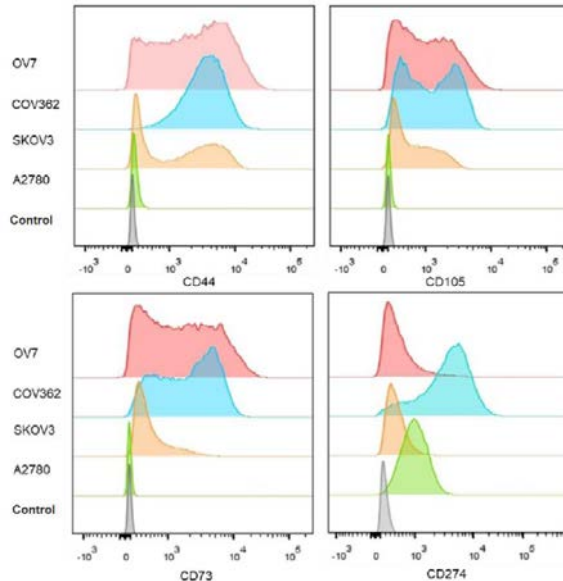
Gi n "fi {o cpvckv<sup>3</sup>. 'Lcp' Crgmcpf gt 'Mtc nq<sup>4</sup>. 'Ci cvc' O n{ pun<sup>4</sup>. 'Go krklc' Redgtcn<sup>4</sup>"

<sup>3</sup>Hcewn{ 'qh' O gf lelpog. 'Xkrpkwu' Wpkrgtulv{. 'Nkj wcpkc"

<sup>4</sup>Ko o wpqni { 'Ncdqtcvt{. 'P cvkqpcn' Ecpegt 'Kpukwv. 'Xkrpkwu. 'Nkj wcpkc"

gi n[ o cpvckv B o hnwf kvwn

Gr kj grkcn'qxctkcp'ectekpgo c" \*GQE+'ku'c" j ki j n{ "j gvgqi gpgqwa'cpf "ci i tguukxg'f kugcug'v cv'tgo ckpu'y g'o quw'rgj cni' i { pceqni qicri cki pcp{ OGQE'ku'y g'o quw'rgs wgpv'qxctkcp'wo qwt. 'f kwpki wki j gf "d{ "j ki j 'o qtcrkv{ 'kp'rcv'uci gu'y j gp" eqpxgpv'kqpcn' y gtr kgu'ctg"pq"npi gt "ghge'v'xg'Vj g"tqrq"qh' y g"ko o wpg"u'f ugo "ku'r kxqvcn' hqt "ghh'ekp'v'eqpvtqil' cpf " f gwt wv'kq'qh'ecpegt'egm'OF gpf tkle'egm' \*F Eu+'ug'xg'cu'qtej gwtcvqtu'qh'y g'e{ vq'vz'le't gur qpug'qh'y g'cf cr v'xg'cto "qh" y j g"ko o wpg'u'f ugo "cpf 'cu'wej 'ku'cp'cwtce'v'xg'v'cti gv'qt'eqo r ppgpv'qh'eww'kpi "gf i g'egm'dcugf "ko o wpqj gtr kgu'ci ckpu' ecpegt'OF E "xceekp'gu" j cxg'uj qy p"r tqo kulpi "tguw'u'lp'qxctkcp'cpf "ugxgtcn'qj y t"v'f r gu'qh'ecpegtu'wej "cu"o gncpgo c." r tqucv'g. "npi "ecpegt" ]3\_0Uqo g'qh'y g'o quw'eqo o qpn{ "wugf 'ctg' F E /dcugf "xceekp'gu'ncf gf "y kj "cmqj gpgle'ecpegt'egm' nkp'g'h' ucvg. "y j lej "o ko leu'y g'wo qwt 'r t'gugpv'lp' y g'r cvkqpcn{ ucvg'f g'xgnr gf "h'qo "f khtg'gp'v'ecpegt'egm' nkp'g'o qf gmi'qh' y j g"uco g'wo qwt "o ki j v. "j qy g'xg. "j cxg'c'f kuko krct "ghge'v'q" F E "o cwtcvkq" cpf "uwt'ceg" r tqv'kp' "g'zr t'guukp'Vj cv'ku" dgecv'wug'f khtg'gp'v'egm' nkp'gu" tgr t'gugpv'f kwp'v' xctk'pegu'qh' y j g"uco g'f kugcug' cpf. "y j g'htg. "j cxg'f khtg'gp'v' r tqv'kp' eqpukw'kqpu'0]4.5\_0K'qwt'uwf { . "y g'wpf gt vq'ni'y g'cun'qh'et'gcvkq'qh'c' F E /dcugf "xceekp'gu' y kj "f khtg'gp'v'qxctkcp'ecpegt' egm' nkp'g'h' ucvgu'cpf "y j g'ko k'wt g'v'q' h'p'f "q'w'y j g'v' gt "wps w'GQE'egm' n' ucvgu' j cxg'cp'ko r cev'q'p' f gpf tkle'egm' b' cwtcvkq'0 Y g'ej ctcevg'kugf "h'qwt'f khtg'gp'v'GQE'egm' n'kp'g'<QX9. "UMQX5. "EQX584. "C49: 2=wpf gt "ucpf ctf kugf "eww'wt'g'eqpf k'kqpu." d{ "r g'htqo kpi "h'qy "e{ v'qo g'v{ " \*HCEU+ "Hki 0'30" cpf "cpcn' ukpi "45" ko o wpg/t'grv'gf "i gpgu'g'zr t'guukp' d{ "s wcp'v'k'x'g' t'gcn' v'ko g'RET "s RET+0E { v'ni'kp'g'cttc{ "y cu'wugf "v'q'g'x'c'v'c'v'g'327" e{ v'ni'kp'gu'eqpegp'v'cvkq'kp' r tqf w'egf "ecpegt'egm' n'kp'g'h' ucvgu' r'vgt'wugf "h'q'f g'p'f tkle'egm' b' cwtcvkq'0Y g'p'q'v'gf "y j cv'y g' h'qwt'qxctkcp'ecpegt'egm' n'kp'g'u'f khtg' d'qj "kp' ugo p'guu' /t'grv'gf " EF496. "EF66. "EF327. "EF95" b' ctngt'g'zr t'guukp' \*HCEU+ "c'p'f "kp'ko o wpg/t'grv'gf "i gpg'g'zr t'guukp' \*s RET+0K'ci t'ggo g'p'v' y j g'e{ v'ni'kp'g'cttc{ "t'g'x'g'c'v'gf "y j cv'qxctkcp'ecpegt'egm' n'kp'g'h' ucvg' r tq'k'gu'ct'g' j ki j n{ "f k'x'g'ug'0"



Hki 030F khtg'gp'v'ugo p'guu' o ctngt'g'zr t'guukp'kp'6'f khtg'gp'v'qxctkcp'ecpegt'egm' n'kp'gu'0"

Chgt'ecpegt'egm' n'kp'g'ej ctcevg'kucv'kq'p. "y g'uweegul'wn{ 'r tqf w'egf "F Eu'ncf gf "y kj "f khtg'gp'v'qxctkcp'ecpegt'egm' n'kp'g' n' ucvgu'cpf "y j g'ko k'wt g'OF E "ej ctcevg'kucv'kq'p" y cu'r g'htqo gf "wulpi "HCEU." o cwtcvkq' o ctngtu'EF33e. "EF: 2. "EF: 5." O J EK'Y g'tg' "gzco k'p'gf O'Y g' utqpi n{ "d'gr'x'g' y j cv'qwt "h'p'f kpi u" y kn'rg'cf "v'q" f g'x'g'nr o g'p'v'qh' o qtg' r q'v'p'v'egm'dcugf " ko o wpqj gtr kgu' hqt' r cvkqpcn' u'w'htg'kpi "h'qo "GQE" c'p'f. "r quukdn'. "q'v' gt'wo qtu'0"

[3\_ " I ctf pgt. " Cn'ele. " c'p'f " Dtkp' T'w'htgn'0' d'f g'p'f tkle " Egm' " c'p'f " Ecpegt" Ko o wplv{0'Vt'g'p'f u" lp" ko o wpqni { "xqnl' 59.34" \*4238+< : 77/: 870 f qk3203238110x042380; 028"

[4\_ "N'r gl. "O gtegf gu'P "g'v'cn'0'R'iq'ni gf "uwt'x'c'v'qh'f g'p'f tkle'egm'x'ceekp'cv'gf "o gncpgo c'r cvkqpu'eqtt'g'v'gu' y kj "wo qt/ur g'ek'le" f g'nc'gf "v'f r g'KX" j { r g'ug'p'k'k'k'k'f "t'gur qpug'c'p'f "t'g'f w'v'kq'p'qh'wo qt"i tqy y "t'rcv'qt" d'g'v'g'zr t'guulpi "V'egm'0' L'q'w'p'c'n'qh' er'p'le'c'n'q'p'eq'ni { "q'ht'le'c'n' l'q'w'p'c'n'qh' y j g' Co g'tle'c'p' U'q'el'g'v' q'h' er'p'le'c'n' Q'p'eq'ni { "xqnl'49.8" \*422; +<: 67/740f qk3203238110x0422: 0: 029; 6"

[5\_ H'q'g'u. "K'a p" g'v'cn'0'f g'p'f tkle "Egm' N'q'cf gf "y kj "J g'cv'Uj q'em'E'q'p'f k'k'p'g'f "Q'x'c't'k'c'p' Gr kj grkcn' E'c't'el'p'q'o c" Egm' N{ ucvgu' G'rl'c'k' V' Egm' F g'p'f g'p'v' C'p'v'k'w'o qt'Ko o wpg' T'gur qpug'u' K' X'k'q'0' L'q'w'p'c'n' q'h'ko o wpqni { "t'g'ug'c't'ej "xqnl'423; "; 853737047'P q'x'0423; . "f qk32032377423; t; 853737"

# GXCNCVCQP 'QH' J 'KPNWGPEG'QP 'QPKP 'TQQV' TQY VJ 'CPF' I GPQVQZKEK [ 'KPFEGUD' 'ALLIUM CEPA' CUUC U

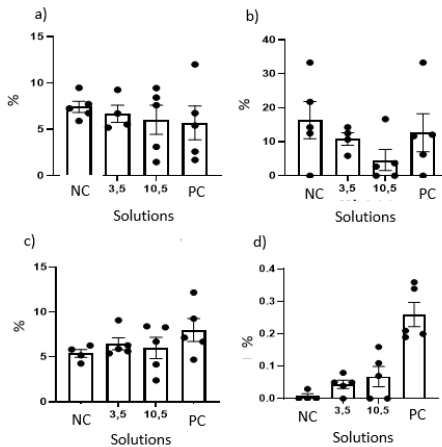
Lqgrku'Xgtf lpi cu<sup>3</sup>. 'Cuc'Ucr wkqp { v<sup>3</sup>

<sup>3</sup>Kpukwng'qh'Dlquekpegu 'Nhg'Uekpegu'Egpygt. 'Xkpkwa'Wpkxgtukf. 'Nkj wcpk' lqgrku'Xgtf lpi cuB i o eUwfw'kwfn'

Rrcpw'ctg'y gni'cf cr wgf "v" i tgy "k" c" egtvcp" tci p' g' qh' gpxkqpo gpcni' eqpf kkpqu' Qpg' qh' vj' g' o quw' ko r qtvcv' gpxkqpo gpcni' hceqv' l' hnwepkpi 'r rcpvi' tgy vj' 'ku'v' g' r' J 'qh'v' gk' i' tgy vj' 'b' g' kwo 0J3\_ F khtg'pvr' rcpv' ur' geku' c' p' f' ewnkxctu' xct' { 'd' { 'r' J 'tci p' g' vj' g' { 'ecp' i' tgy 'y' kj' qw' t' g' ut' k' v' k' p' c' p' f' e' { 'v' q' v' z' k' e' f' c' o' c' i' g' 0' Vj' k' u' t' g' u' g' c' t' e' j' "c' k' o' g' f' "v' q' f' g' v' t' o' k' p' g' " r' J 'tci p' g' "k" p' y' j' k' e' j' "e' q' o' o' q' p' q' p' k' p' u' " \*Cnkwo "egrc" "N0" "ecp" i' tgy "y' kj' qw' "g' z' r' g' t' k' e' p' e' k' p' i' "v' z' k' e' "c' p' f' i' g' p' q' v' z' k' e' "g' h' g' e' w' "c' p' f' y' j' g' y' g' t' v' g' t' g' r' q' p' u' g' q' h' f' k' h' g' t' g' p' v' r' q' p' k' p' "ewnkxctu' v' q' xct' { lpi 'r' J 'ku' u' k' o' k' c' t' 0"

r' J "v' z' k' e' k' { 'y' c' u' f' g' v' t' o' k' p' g' f' "w' u' k' p' i' "Cnkwo "egrc" t' q' q' v' i' t' q' y' vj' "k' p' j' k' d' k' k' p' "v' g' u' v' y' j' g' t' g' q' p' k' p' u' y' g' t' g' i' t' q' y' p' "k' p' c' p' "k' p' v' g' t' x' c' n' i' q' h' 4' / 34' r' J "h' q' t' ; 8' j' 0' d' C' r' g' r' j' s' "c' p' f' "o' U' w' t' q' p' s' "ewnkxctu' y' g' t' g' w' u' g' f' 0' O' g' c' p' t' q' q' v' i' g' p' i' vj' "k' p' t' q' q' v' d' w' p' f' r' g' "c' p' f' t' q' q' v' o' q' t' r' j' q' m' i' { " y' g' t' g' g' x' c' n' w' e' v' g' f' 0' J' g' t' g' c' h' g' t' . i' g' p' q' v' z' k' e' k' { 'q' h' r' J 'y' c' u' c' u' g' u' g' f' "c' p' c' n' f' | lpi "q' p' k' p' t' q' q' v' o' g' t' k' u' g' o' k' e' "e' g' m' u' y' j' k' e' j' "y' g' t' g' i' t' q' y' p' "k' p' " r' J "u' q' n' w' k' p' "v' j' c' v' k' u' g' s' w' e' n' v' q' "G' E' 72' h' q' t' d' q' v' j' "c' e' k' f' k' e' "c' p' f' d' c' u' k' e' "o' g' f' k' w' o' u' 5.7' c' p' f' "32.7. "t' g' u' r' g' e' v' x' g' n' i' 0' V' c' r' "y' c' v' g' t' "c' p' f' "32' o' i' h' i' 0' O' U' u' q' n' w' k' p' "y' g' t' g' w' u' g' f' "c' u' c' "p' g' i' c' v' k' x' g' "e' q' p' v' t' q' n' i' \*P' E+ "c' p' f' "r' q' u' k' k' x' g' "e' q' p' v' t' q' n' i' \*R' E+ . "c' e' e' q' t' f' lpi n' { 0' E' g' m' u' y' g' t' g' g' x' c' n' w' e' v' g' f' " o' k' e' t' q' u' e' r' k' e' c' n' i' "w' u' k' p' i' "c' p' c' r' j' c' u' g' / v' g' n' r' j' c' u' g' "e' j' t' q' o' q' u' o' g' "c' d' g' t' t' e' v' k' p' u' "c' u' c' { "c' h' g' t' "46' j' "g' z' r' q' u' w' t' g' "c' p' f' "o' k' e' t' q' p' w' e' r' g' k' c' u' c' { "c' h' g' t' " 46' j' "t' g' e' q' x' g' t' { 'r' g' t' k' f' "c' m' p' p' i' "y' k' j' "v' j' g' f' g' v' t' o' k' p' c' v' k' p' q' h' o' k' q' v' e' "c' p' f' "r' j' c' u' k' e' "k' p' f' k' e' g' u' 0' U' c' v' k' u' k' e' c' n' i' c' p' c' n' f' u' k' i' y' c' u' f' q' p' g' w' u' k' p' i' "y' q' / y' c' { 'C' P' Q' X' C' "h' q' m' y' lpi "V' w' n' g' { 'r' q' u' v' j' q' e' "v' g' u' 0"

T' q' q' v' i' t' q' y' vj' "y' c' u' l' p' j' k' d' k' g' f' "c' p' f' t' q' q' v' o' q' t' r' j' q' m' i' { 'e' j' c' p' i' g' f' "k' p' g' z' v' t' o' g' r' J "u' q' n' w' k' p' u' 0' N' g' p' i' vj' "q' h' t' q' q' u' y' c' u' o' k' p' v' c' l' p' g' f' " k' p' 6' / 32' r' J "k' p' v' t' x' c' n' i' e' q' o' r' c' t' g' f' "v' q' P' E" c' p' f' "k' p' 4' c' p' f' "34' r' J "u' q' n' w' k' p' t' q' q' u' y' g' t' g' w' r' "v' q' 5' / 7' "k' o' g' u' u' j' q' t' v' t' 0' V' j' t' q' w' i' j' "g' p' v' k' g' ; 8' j' " i' t' q' y' vj' "r' g' t' k' f' . "k' p' 6' / 32' t' q' q' u' i' t' g' y' "c' v' c' "u' k' o' k' r' c' t' "t' e' v' g' . "y' j' k' g' t' q' q' u' "g' z' r' q' u' g' f' "v' q' j' k' i' j' g' u' v' c' p' f' "r' q' y' g' u' v' r' J "f' k' f' "p' q' v' i' t' q' y' "c' v' c' n' i' 0' F' k' h' t' g' p' v' r' e' w' n' k' x' c' t' "t' g' u' r' q' p' u' g' "v' q' "r' J "y' c' u' v' j' g' "u' c' o' g' "k' p' g' x' g' t' { "u' q' n' w' k' p' . "g' z' e' g' r' v' "k' p' 32' r' J 0' k' p' c' i' g' p' q' v' z' k' e' k' { "c' u' c' { . "o' q' u' v' e' j' t' q' o' q' u' o' g' "c' d' g' t' t' e' v' k' p' u' y' g' t' g' h' q' w' p' f' "k' p' y' c' v' g' t' "u' c' o' r' i' g' u' " \*H' i' "3d0' d' w' o' q' u' v' o' k' e' t' q' p' w' e' r' g' k' y' g' t' g' h' q' w' p' f' "k' p' y' g' r' q' u' k' k' x' g' "e' q' p' v' t' q' n' i' \*H' i' 03f' -00' k' q' v' e' "c' e' v' k' x' k' { 'y' c' u' p' q' v' t' o' c' t' n' e' d' n' i' "k' p' e' t' g' c' u' g' f' "q' t' k' p' j' k' d' k' g' f' "k' p' f' k' h' t' g' p' v' r' J "u' q' n' w' k' p' u' c' p' f' f' k' f' "p' q' v' f' g' x' k' e' v' k' p' f' k' t' g' e' v' " g' z' r' q' u' w' t' g' "c' p' f' "c' h' g' t' c' t' g' e' q' x' g' t' { 0' \*H' i' 0' c' . "e' +R' t' q' r' j' c' u' g' y' c' u' v' j' g' b' o' q' u' v' e' d' w' p' f' c' p' v' r' j' c' u' g' k' p' o' k' q' v' e' "e' g' m' u' . "d' w' k' u' t' e' v' g' j' c' u' f' g' e' t' g' c' u' g' f' " c' h' g' t' v' j' g' t' g' e' q' x' g' t' { 'r' g' t' k' f' "y' j' g' t' g' t' g' r' v' k' x' g' r' c' t' v' q' h' e' g' m' u' k' p' q' v' j' g' t' o' k' q' v' e' "r' j' c' u' g' u' k' p' e' t' g' c' u' g' f' 0' ""



H' i' 0' 30' I' g' p' q' v' z' k' e' k' { "c' u' c' { u' t' g' u' w' m' i' c' + " o' k' q' v' e' "k' p' f' g' z' "c' h' g' t' " 46' j' " g' z' r' q' u' w' t' g' " d' + e' j' t' q' o' q' u' o' g' "c' d' g' t' t' e' v' k' p' u' "c' h' g' t' " 46' j' " g' z' r' q' u' w' t' g' " e' + " o' k' q' v' e' "k' p' f' g' z' "c' h' g' t' " 46' j' " t' g' e' q' x' g' t' { f' + " o' k' e' t' q' p' w' e' r' g' k' c' h' g' t' " 46' j' " t' g' e' q' x' g' t' { 0' D' r' e' n' i' f' q' u' t' g' r' t' g' u' g' p' v' u' k' p' i' r' g' "u' c' o' r' i' g' u' 0' ""

N' q' y' "c' p' f' " j' k' i' j' " r' J " p' g' i' c' v' k' x' g' n' i' " c' h' g' e' u' " q' p' k' p' t' q' q' v' i' t' q' y' vj' . " r' t' q' d' c' d' n' i' " d' g' e' c' w' u' g' " k' p' v' k' p' u' k' e' " r' J " t' g' i' w' r' v' k' p' u' " u' f' u' n' g' o' u' " c' t' g' " f' k' u' w' t' d' g' f' 0' J4\_ " E' q' o' r' c' t' k' u' p' " q' h' f' k' h' t' g' p' v' r' e' w' n' k' x' c' t' u' u' j' q' y' g' f' " c' m' q' u' v' u' k' o' k' r' c' t' " k' p' v' j' g' k' t' " t' g' u' r' q' p' u' g' " v' q' x' c' t' { lpi " r' J 0' E' j' t' q' o' q' u' o' g' " c' d' g' t' t' e' v' k' p' t' e' v' g' f' k' f' " p' q' v' f' g' r' g' p' f' " q' p' u' q' n' w' k' p' r' J " c' p' f' i' g' p' q' v' z' k' e' f' c' o' c' i' g' y' c' u' t' g' x' g' t' u' k' d' n' g' " d' g' e' c' w' u' g' v' j' g' t' g' y' c' u' c' m' q' u' v' p' q' h' q' t' o' c' v' k' p' " q' h' o' k' e' t' q' p' w' e' r' g' k' 0' J' k' i' j' " t' g' s' w' g' p' e' { " q' h' e' j' t' q' o' q' u' o' c' n' i' c' d' g' t' t' e' v' k' p' u' k' p' " q' p' k' p' u' i' t' q' y' p' " k' p' y' c' v' g' t' " e' c' p' " d' g' " g' z' r' k' k' p' g' f' " d' { " t' g' r' v' k' x' g' n' i' " r' q' y' " p' w' o' d' g' t' " q' h' o' k' q' v' e' " e' g' m' u' " k' p' " c' p' c' r' j' c' u' g' " / " v' g' n' r' j' c' u' g' 0' E' g' n' i' f' k' x' k' u' k' p' " c' e' v' k' x' k' { " f' k' f' " p' q' v' f' g' r' g' p' f' " q' p' u' q' n' w' k' p' " r' J 0' R' j' c' u' k' e' " k' p' f' k' e' g' u' " e' j' c' p' i' g' f' " k' p' u' k' i' p' h' h' e' c' p' w' i' " c' p' f' . " f' w' l' k' p' i' " t' g' e' q' x' g' t' { . " q' r' f' g' t' " e' g' m' u' y' c' v' y' g' t' g' k' p' r' t' q' r' j' c' u' g' " e' q' w' i' f' " r' t' q' e' g' g' f' " h' w' t' v' j' g' t' " k' p' v' j' g' t' " e' g' m' i' e' { e' r' g' 0' ""

[3\_P g' l' p' c' F' 0' v' j' g' T' q' n' g' q' h' U' k' i' r' J ' k' p' R' c' p' v' P' w' t' k' k' p' c' p' f' U' k' i' T' g' o' f' k' e' v' k' p' . " C' r' r' n' g' f' " c' p' f' " G' p' x' k' t' q' p' o' g' p' c' n' i' U' k' i' U' e' k' p' e' g' . " x' q' r' 0423 ; . 423 ; " [4\_ ] c' p' " H' " U' e' j' w' d' g' t' v' U' . " O' g' p' i' g' n' i' M' 0' G' h' g' e' v' q' h' i' N' q' y' " T' q' q' v' 0' g' f' k' w' o' " r' J " q' p' " P' g' v' R' t' q' v' p' T' g' n' c' u' g' . " T' q' q' v' T' g' u' r' k' e' v' k' p' . " c' p' f' " T' q' q' v' i' t' q' y' vj' " q' h' E' q' t' p' " g' c' o' c' { u' N' 0' " c' p' f' " D' t' q' c' f' " D' g' c' p' " X' l' e' k' " d' c' " N' 0' 0' R' c' p' v' R' j' { u' k' i' 03 ; ; 4' L' x' p' ; ; \*4+637/430' ""

**IPHNWGPEG'QH'VJ G'KUQHOTO 'R: 7'U8MB'QP 'VJ G'CEVKKV[ 'QH'  
QVJ GT'KUQHOTO U'K'EGNNU'Y K'VJ 'ETKURT/GF K'GF 'GZRTGUUKP'  
QH'U8MB0'**

O ctkc'P cwo qxc<sup>3,4</sup> . 'Nkrc'Ucxkpunc<sup>3</sup>

<sup>3</sup>Kpukwag'qh'O qrgewrt'Dkqmi { 'cpf'I gpgvku'P CU'qh'Wntckpg.'Wntckpg"

<sup>4</sup>GUE"okpukwag'qh'Dkqmi { 'cpf'O gf lekpgö'Vctcu'Uj gxej gpmq'P cvkqpcn'Wpkxgtuk' 'qh'Mi kx.'Wntckpg"

o ctkc49po B i o cktfego "

U8MB"/"nkpcug"3"qh'yj g'tkdquqo crir tqvklp"U8"hwpevku'cu'qpg'qh'yj g'ngf "eqo r qpgpw'qh'yj g'RISM'I'o VQT"U8MB"  
uki pcikpi 'r cvj 0Vj ku'uki pcikpi 'r cvj y c { 'tgi wcvgu'xctkqwu'egnwrt'r tqeguugu/'r tqvklp'u'pyj guku.'egm'i tqy yj . 'r tqvklp'vklp."  
j qo gqucuku'cpf'qyj gtuOK'j cu'cnuq'dggp'uj qy p'yj cv'f { utgi wcvkqp'qh'U8MB'ku'cu'qekcv'f'y kj 'r cvj qm'i kgu'uwej 'cu'ecpegt."  
qdguk'f.'ci kpi . 'cpf'f'kcdggu0Uq'fct.'y j g'kuqhoto u'r : 7.'r 92'cpf'r 82.'y j lej 'ctg'r tqf wv'f'wukpi 'y j g'htuv'yj tgg'v'cpcur'vklp"  
kpkcvklp'uvct u.'j cxg'dggp'f'guetkdgf . 'cu'y gmi'cu'cp'cngt'p'cvkxgn' "ur r'egf "r 53"kuqhoto . 'y j lej "ku'eqpuk'gtgf "cu'r tqvq/  
qpeqi gple0'

Gctnigt.'qp'yj g'OEH9'egm'ikpg.'wukpi 'ETKURT'IEcu; 'vej p'qmi { . "4"o qf gni'egm'ikpgu'y g'g'qdvclpgf "y kj 'f'khtg'gpv"  
g'zr tguukp'qh'yj g'uwf k'f'kuqhoto u'engpg'H5'y kj 'dmengf'g'zr tguukp'qh'yj g'r : 7'kuqhoto \*r : 7/'Tr 92'- 'Tr 82'- +cpf'engpg"  
H5'y j g'g'zr tguukp'qh'cm'kuqhoto u'y cu'dmngf \*r : 7/'Tr 92/'Tr 82/+0Vq'uwf { "y j g'eqp'v'kdwkqp'qh'yj g'r : 7'kuqhoto "v"  
uki pcikpi . 'o TP C'qh'yj g'hw'ngpi yj "U8MB"ugs wv'peg'y cu'v'cpcur'v'f'k'p'v'yj g'egm'i'qh'engpg'H5.'cpf'uwcdng'egm'ikpg'y kj "  
r : 7'qxgtg'zr tguukp'y cu'qdvclpgf \*H5 r : 7-0' "

Vq'uwf { "y j g'cevkxk'f'qh'kuqhoto u.'y j g'hw'ngpi kpi 'egm'v'g'cu'gpw'y g'g'ectk'f'q'w'46'j qwtu'qh'v'ct'x'v'klp.'46'j qwtu'qh'  
ugt'wo "v'ct'x'v'klp"- "5"j qwtu'qh't'g'v'k'w'v'klp"\*37' "HDU"cpf'46'j qwtu'qh'v'ct'x'v'klp"- "5"j qwtu'qh't'g'v'k'w'v'klp'y kj "  
tcr co { elp."cp'k'p'k'k'k'q'qh'yj g'o VQTE3'eqo r ngz0'Vj g'hw'ngpi kpi "cp'v'k'q'f'k'g'u'y g'g'w'v'f' "hqt"Y g'v'g'p'dm'v'cpcn'f'uku'<E/  
v'g'to k'pcn'r qn'empcn'c'f'k'p'k'f' "r w'k'k'f' "cp'v'k'q'f'k'g'u"J'Ucxkpunc"N."4237\_ "r Vj t5 : ; "U8MB"cp'v'k'q'f'k'g'u"\*Egmi'Uki pcikpi +."r Ugt"  
457458'U8"\*Egmi'Uki pcikpi +."d'g'v'c'v'klp"\*Uki o c+0"

Vj g' tguwuu'uj qy gf " yj cv' yj g'g' y cu'pq"uki p'k'k'c'p'v'ej cpi g'lp" yj g'H5'empg'eqo r ctgf "vq" yj g'y k'f' v'f'g'0'Chgt"  
t'g'v'k'w'v'klp."c"j ki j 'ng'x'gn'qh't'cr co { elp'ug'p'uk'k'x'g'r j qur j qt { v'klp'qh'r tqvklp"U8'ku'q'dug'x'g'f'0Cp'cpcn'f'uku'qh'yj g'cevkxk'f'  
qh'x'ct'k'q'w'kuqhoto u'uj qy gf 'y j cv'yj g'r 92'kuqhoto 'ku'o quv't'gur q'p'k'd'ng'hqt'yj g'r j qur j qt { v'klp'qh'yj g'U8'r tqvklp0"

Kp'empg'H5'Tr : 7.'lp'cf'f'k'k'q'v'c'j ki j 'ng'x'gn'qh'zr tguukp'qh'yj g'r : 7'hqto 'lp'yj g'r t'g'v'p'eg'qh'v'g'two 'lp'yj g'o gf kwo . "  
yj g'r 82'kuqhoto 'ku'cnuq'g'zr tguugf . 'y j lej 'r tqdcdn'f'w'g'u'cp'cngt'p'cvkxg.'y j k'f' "v'ct'v'qh'v'cpcur'v'klp.'y j g'g'cu'p'g'k'j g't'yj g'ng'x'gn'  
qh'r 92'g'zr tguukp'p'q't'ku'r j qur j qt { v'klp'ku'lp'et'g'c'ug'f'lp'eqo r ct'k'q'p'y kj 'empg'H50Dqj 'g'zr tguugf 'hqt' u.'r 82'cpf'r : 7."  
j cf "c"j ki j 'ng'x'gn'qh'r j qur j qt { v'klp'0'K' r q't'v'p'v'f' . 'v'ct'x'v'klp'f'k'f' "p'q'v'f' get'g'c'ug'yj g'ng'x'gn'qh'Vj t5 : ; "r j qur j qt { v'klp'qh'cm'  
U8MB'cpf'Ugt'457458'kuqhoto u'lp'U80'K'p'yj ku'y c { . "qxgtg'zr tguukp'qh'yj g'r : 7'kuqhoto "o c { "eqp'v'k'dw'g'v'egm'uw'x'k'c'n"  
y j lej "f'q'g'u'p'q'v'eqp'v'c'f'k'v'yj g'v'g'u'v'k'g't'c'w'g'f'c'v"j3\_0"

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j3\_\ j cpi 'L'I wq'L'S kp'Z.'.gv'cr0Vj g'r : 7'kuqhoto 'qh'yj g'hw'ngpi'U8MB'hwpevku'cu'c'v'g'et'g'v'f'q'p'eqr tqvklp'v'f'c'ek'k'v'g'egm'io ki t'cv'klp'cpf'wo q't'i tqy yj 0'  
Uel'peg'Uki pcikpi 0423: 'O ct=33\*745+0'

"  
"  
"  
"  
"

# EKTEWNCVPI 'O KTP CU'CU'FKI PQUVK'DKQO CTMGTUHQT' RGTKQF QP VKVU'

Dgpkc'Dwtci ckg/Ucr qpnlpgg<sup>3</sup>. 'Mikukpc'Uplr cklpgg<sup>3</sup>. 'Cf qo cu'Tqxcu<sup>4</sup>. 'T wc'O cwrngxlekkg<sup>3</sup>. 'Gi ng'Rwpegxlekpgg<sup>5</sup>. 'Kgp' Dwtlo kpgg<sup>5</sup>. 'Ckpc'Rwtkpgg<sup>3,4</sup>. 'Uqpcw' Lcto crkkg<sup>3</sup>'''

<sup>3</sup>J wo cp'I gpqo g'Tgugctej 'I tqw . 'Nhg'Uelgpegu'Egpgvt. 'Xkpkwu'Wpkxgtuks\ 'Xkpkwu.'Nkj wcpk'''

<sup>4</sup>Xkpkwu'Wpkxgtuks\ 'J qur kcn\ cni kku'Erkpe. 'Xkpkwu.'Nkj wcpk'''

<sup>5</sup>Xkpkwu'Wpkxgtuks\ 'J qur kcn'Ucpvtqu'Erkpeu. 'Xkpkwu.'Nkj wcpk'''

dgpkc@wtci ckg/ucr qpnlpggB i o ehwf kxwv

''

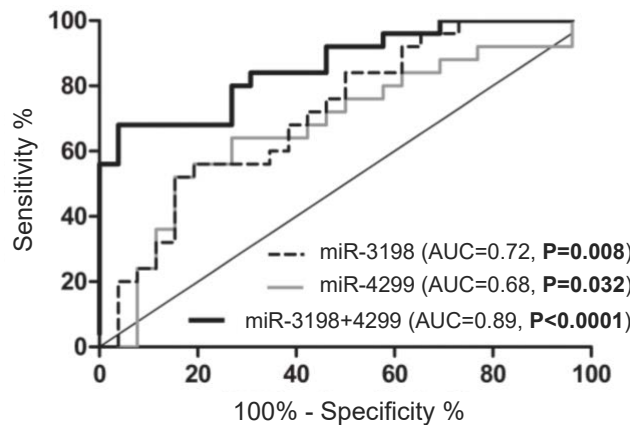
Rgtkqf qpvku''RF +'ku'j ki j n' r t g x c r p v' l p h r o o c v q t { ' q t c n f k u g c u g' c h g e v p i ' j g' u w r r q t v p i ' v k u u w g' q h' j g' v g g j ' c p f ' n g c f k p i ' v q' e q p p g e v k g' v k u u w g' c w c e j o g p v' r q u u' c p f' d q p g' t g u t r v k p o' D g u l f g u' k u' p g i c v k x g' l o r c e v' q p' s w e r k v' q h' n h g. ' R F ' k u' c n u q' u t q p i n' ' c u u q e k c v g f' y k j ' c p' k p e t g c u g f' t k u n' q h' r c t v e w r t' u' u g o k e' f k u q t f g t u. ' g f 0' t g u r k c v q t { ' c p f' e c t f k q x c u e w r t' f k u g c u g u. ' t j g w o c v q k f' c t v j t k k u. ' f k c d g v u. ' e c p e g t' g v e 0 ] 3 / 7. ' O' X c t k q w u' o g e j c p l u o u' q h' R F' r c v j q i g p g u k u' c t g' g r k i g p g v e c m' t g i w r v g f' c p f' o k e t q T P C u' \* o k T P C u' c t g' e q p u l f g t g f' c u' q p p' q h' j g' n g { ' o q f w r v q t u' j v c v' k p h w g p e g u' r g t k q f q p v c n' j q o g q u c u k u' V j k u' u w f { ' c k o g f' v q' t g x g c n' R F / c u u q e k c v g f' o k T P C u' l p' i k p i k c n' v k u u w g' c p f' d q f k n' ' h n w k' u. ' l p e n w f l p i' i k p i k c n' e t g x l e w r t' h n w k' \* H i E H: ' u c r k x c' c p f' r r u o c. ' c p f' v q' g x c n c v g' j g' w k r k v' q h' j q u g' o k T P C u' c u' o l p k o c m' / ' c p f' p q p / l p x c u k x g' f k c i p q u k e' o c t n g t u' h q t' R F 0'

O k T P C' g z r t g u k q p' y c u' r t q h g f' l p' g l i j v' i l p i k c n' v k u u w g' u c o r n g u' w u l p i' o l e t q c t t c { ' r r e v h q t o' \* j w o c p' o k T P C' O l e t q c t t c { u. : z 8 2 M' h q t o c v' 0 H q w' u k i p h l e c p v n' f l h g t g p v n' g z r t g u g f' o k T P C u' y g t g' x c r k f c v g f' l p' i l p i k c n' v k u u w g' u c o r n g u' \* P ? 8 3 + c p f' h w v j g t' c p c n' | g f' l p' d q f k n' ' h n w k' u r g e k o g p u' \* P ? 3 9 3 + d { ' o g e p u' q h' s w c p v k c v k x g' t g x g t u g' t c p u e t r v k p' R E T 0'

C' p w o d g t' q h' o k T P C u' y c u' h q w p f' v q' d g' u k i p h l e c p v n' w r t g i w r v g f' l p' l p h r o g f' i l p i k c n' v k u u w g' u' e q o r c t g f' v q' r g t k q f q p v c m' j g c n j { ' v k u u w g u' C' h g t' j q t q w i j' x c r k f c v k p. ' o k T / 3 ; ; c / 7 r. ' o k T / 6 : 5 / 7 r. ' o k T / 5 3 ; ; ' c p f' o k T / 6 4 ; ; ' y g t g' c p c n' | g f' l p' d q f k n' ' h n w k' u' V j g' n g x g n' q h' I E H' o k T / 5 3 ; ; ' y c u' u k i p h l e c p v n' j k i j g t' c o q p i u v' r c t v e k r c p w' y k j' R F' \* R ? 2 0 2 3 ; + 0' V j g' n g x g n' q h' o k T / 3 ; ; c / 7 r' y c u' l p e t g c u g f' l p' u c r k x c' u c o r n g u' h t q o' r c v k e p w' y k j' u g x g t g' R F' \* R ? 2 0 6 7 + ' c p f' f g e t g c u g f' l p' r r u o c' u c o r n g u' e q m g e v g f' h t q o' R F / c h g e v g f' r c v k e p w' \* R ? 2 0 2 2 : + ' c u' e q o r c t g f' v q' r g t k q f q p v c m' j g c n j { ' r c t v e k r c p w' \* R > 2 0 7 2 + 0' C' e q o d l p c v k p' q h' I E H' o k T / 5 3 ; ; ' c p f' o k T / 6 4 ; ; ' f g o q p u t c v g f' j k i j' f k c i p q u k e' r q v g p v c n' \* C W E ? 2 0 8. ' R > 2 0 2 2 3 + y k j' 8: ' ' u g p u k x k v' c p f' ; 8' ' u r g e k h e k v' \* H i 0 3 + 0'

V j g' t g u w u' q h' j g' e w t g p v' u w f { ' u w i i g u v' j c v' R F / u r g e k h e' l p h r o o c v q t { ' o k T P C u' l p' d q f k n' ' h n w k' u' e c p' u g t x g' c u' r q v g p v c n' d l q o c t n g t u' q h' R F' j c v' e q w f' d g' c r r d g f' h q t' o l p k o c m' / ' c p f' p q p / l p x c u k x g' f k c i p q u k e' u' q h' j g' f k u g c u g 0'

miR-3198 + miR-4299 in GCF



H i 0 3 0 T Q E' e w t x g' c p c n' u k i' q h' i l p i k c n' e t g x l e w r t' h n w k' \* H i E H: / f g t k x g f' o k T / 5 3 ; ; . ' o k T / 6 4 ; ; ' c p f' c' e q o d l p c v k p' q h' j g o 0'

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[3\_ 'Z 0 0 \ g p i. ' O' N 0' V w' F Q' O' N k v' g v' c r 0' R g t k q f q p v c n' f k u g c u g' c p f' t k u n' q h' e j' t q p l e' q d u t w e k x g' r w o q p c t { ' f k u g c u g' c' o' g v c' c p c n' u k i' q h' i' q d u g t x c v k p c n' u w f l g u. ' R N q U' Q p g' 9 \* 3 2 + ' g 6 8 7 2: ' \* 4 2 3 4 + 0'

[4\_ ' C 0' D n e k' q v' l p' O' X g t i' p g u. ' U O P' w y' y' c t g j' g v' c r 0' R g t k q f q p v c n' f k u g c u g' c p f' e c t f k q x c u e w r t' g x g p w' < o' g v c' c p c n' u k i' q h' i' q d u g t x c v k p c n' u w f l g u. ' k p v' F' g p v' L 0' 7 ; ' 3 ; 9 6 4 2 ; \* 4 2 2 ; + 0'

[5\_ ' Z 0' \ j c q. \ ' O' N k v' F 0' U j' w g v' c r 0' C u u q e k c v k p' q h' R g t k q f q p v k u' y k j' ' T j g w o c v q k f' C t v j t k k u' c p f' ' j g' C h g e v' q h' P' q p' U w t i' k e c n' R g t k q f q p v c n' V t g e v o' g p v' q p' F k u g c u g' C e v k x k v' l p' R e v k p w' y k j' ' T j g w o c v q k f' C t v j t k k u' o g f' ' U e k' O' q p k 0 4 6. ' 7: 2 4 / 7: 3 2 \* 4 2 3: + 0'

[6\_ ' O' O' J' O' R c v n' l k O' M w o' c t. ' O' ( G 0' O' q u u' F' k e d g v u' c p f' ' v q v j' ' i q u u' < C' p' c p c n' u k i' q h' i' c v' h t q o' ' j g' p' v c v k p c n' j' g c n j' c p f' p' w k k l p' g z c o' l p e v k p' u w t x g { . ' 4 2 2 5 / 4 2 2 6 0' L' C o' ' F' g p v' C u u q e 0 3 6 6. ' 6 9: 6 6: 7 \* 4 2 3 5 + 0'

[7\_ ' F' E 0' I' A x g p. ' ' O' F k f' c t. ' C' E 0' C n o' c p' g v' c r 0' G x c n c v k p' q h' e c p e g t' t k u n' l p' r c v k e p w' y k j' ' r g t k q f q p v c n' f k u g c u g u' 0' V w' n i' L' O' g f' ' U e k 0 6 ; \* 5 + : . 4 8 / : 5 3 \* 4 2 3 ; + 0'

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**EQP UVT WE VQP 'QH'UCEEJ CTQO [ EGU'EGT GXKUCG'F QNKEJ QN'  
 MRP CUG'O WCP VU'WUR'I 'ETKURT/ECU; 'U UVGO 'CPF "  
 KP XGUVH CVIQP 'QH'VJ GK'I N[ EQU NCVIQP 'RTQRGT VKGU'  
 Cpf tkwu'Dwtf wku<sup>3</sup>. 'F cpi wqn 'fikqi kcp <sup>3</sup>. 'Cm c'I gf xkrckv <sup>3</sup>"**

<sup>3</sup>F gr ctwo gpv'qh'Gwnct { qvg'I gpgvle'Gpi kpggtkpi . 'Kpukwg'qh'Dkqvej pqrqi { . 'Nhg'Uelgpegu'Egpygt. 'Xkpkwu'Wpkgtukf . " Nkj wcpk "

cpf tkwu'Dwtf wkuB i o eGwrf OxwOw"

[ gcu'Uceej ctqo { egu'egt gxkucg'ku'c'wplegmwct'gwnct { qvg'y kf gn { 'wugf 'hqt'tgeqo dlpcpv'r tqvklp'r tqf wevqp'cpf 'cu'c' o qf grlqti cpluo 'hqt'lxpxguki cvkqp'qh'xctkqu'egmwrct'r tqeguug'kperwf kpi 'r tqvklp'uggetgkqp'cpf 'i n' equ { rkvqp'kp'hy gt'cpf " j ki j gt'gwnct { qvgu'RTqvklp "i n' equ { rkvqp'ku'cp'gp } { o cvle'qrki quceej ctkf g'cwcej o gpv'q' r tqvklp'co kq' celf u'OF qrkej qn' nkpug'F M+; 'gpeqf gf 'd { 'y j g'UGE7; 'i gpg'lp'UWegt gxkucg . 'ku'guugpv'kclhqt'eqtg'ugr u'qh'r tqvklp'i n' equ { rkvqp'OF M't gukf gu' kp'yj g'o go dtcpg'qh'gpf qr ncuo le'tgvlewmo 'y j gt'g'k'r j qur j qt { rvgu'f qrkej qn'U { p'v guk gf 'f qrkej qn'r j qur j cvg'ku'yj gp'wugf " cu'c'ecttktg'qp'y j lej 'y j'eqt'g'qrki quceej ctkf g'ku'cuugo drgf 'cpf 't'cpuhgtt'g'qp'r tqvklp'kp'yj g'r tqeguug'qh'ku'i n' equ { rkvqp'OF Uwej 'i n' eqr tqvklp'u'ctg'yj gp'hwtyj gt'o qf hkgf 'lp'yj g'I qni k'err ctcwu'cpf 'j ki j n' 'f kxgtug'i n' eqr tqvklp'u'pggf gf 'hqt'xctkqu' egmwrct 'hwpevklpu'ctg'r tqf wegf "J3\_0"

Cnj qwi j "eqt'g'ugr u'qh'r tqvklp'i n' equ { rkvqp'kp'f hkgf gpv' { gcu'ur geku'ctg'xgt { 'uko kct. 'uqo g'uki plhkecpv'hwpevklp'cni' f hkgf gpegu'cnuq'gzku'OK'y cu'uj qy p'yj cv't'gf wegf "F M'cevkkk' 'qh'vgo r gtcwtg'ugpukxg'UWegt gxkucg'F M'o wcpv'uge7; /3" tguwuu'lp'f getgcug'f 'uggetgkqp'cpf 'i n' equ { rkvqp'qh'dqy 'lp'xgt'cug'cpf 'ectdqz { r gr wf cug'l "ERL +. 'cnegt'cvklpu'qh'egmly cni' utwewt'g'cpf 'ceewo wcvkqp'qh'j } { r qi n' equ { rkvqp' "r tqvklp'u'ku'gp'f qr ncuo le'tgvlewmo "J4. "5\_0Mw'xgtqo { egu'rcvku'F M' utwewt'g'U'cnuq'f go qputcvgf "r tqvklp'i n' equ { rkvqp'f ghelgpeku'dw'v'j ku'j cf 'hgy gt'ghgeu'qp' { gcu'vegmly cni'k'v'gi tkf " cpf 'gxgp'ko r tqxgf 'uggetgkqp'qh'uqo g'tgeqo dlpcpv'r tqvklp'u'eqo r c'tgf "q'y kf 'v' r g'egm'J6\_0"

Vj g'clo 'qh'yj ku't'gugctej 'y cu'v'lp'xguki cvg'yj g'ghgeu'qh'f hkgf gpv'F M'o wcvklpu'qp'r tqvklp'i n' equ { rkvqp'r tqeguug'lp' { gcu'UWegt gxkucg'OHqt'k'p'tqf wevqp'qh'o wcvklpu'lp'v'UGE7; 'i gpg'y g'wugf 'eqo r qpgp'u'qh'dcevgtk'cl'cf cr vlxg'ko o wplk' u'ungo 'ETKURT/Ecu; 'y j lej 'dgeco g'qpg'qh'yj g'o quv'y kf gn { 'wugf 'i gpg'o g'gf k'kpi 'v'qnu'cpf 'j cu'dggp'cr r rkgf 'v'q'o qf hkl' { gcu'v' gpg'o gu'cu'y gm'Go r m' { o gpv'qh'yj ku'u'ungo "cmqy gf 'v'gf k'v'j g'i gpg'o g'qh'UWegt gxkucg'y kj 'y j g'ghgeu'xgpguu' enqug'v'322 " "cpf 'y kj qw'v'j g'wug'qh'cp { 'ugrgevxg'o ctngt'u'J7\_0Y g'k'p'tqf wegf "o wcvklpu'gpeqf kpi "Y 554I . "I 629U" I 642F .N643U'cpf 'f qwdrg'I 629U'cpf 'N643U'hwdukwkqp'u'lp'F M'co kq' celf 'ugs wpeg. 'lp'v'UGE7; 'i gpg'qh'UWegt gxkucg' cpf 'lp'xguki cvgf 'y j g'ERL 'i n' equ { rkvqp'cdk'k' 'cu'y gm'cu'ugpukxk' 'v'wpleco { ekp'cpf 'hwqt'gug'p'v'Ecrc'qh'wqt'y j k'g'f { g' \*EHY + 'qh'cmilhxg'eqput wevgf " { gcu'v'ut'cl'pu'Q'w't'guwuu'uj qy gf 'y j cv'v'j g'f gi tgg'qh'ERL 'i n' equ { rkvqp'f ghelgpe { 'eqt'grv'gf " y kj 'ugpukxk' 'qh'eqput wevgf "o wcpw'v'w'wpleco { ekp'cpf 'vgo r gtcwt'g'cpf "y j g'ug'ej cpi gu'y gt'g'o quv'r tqp'wpegf "lp' f qwdrg'F M'o wcpv'uko kct'v'q'MO'r'evku'Y U'w' wcpv'y kj 'y j g'eqtt'gur qpf kpi "o wcvklpu'OP qpg'y g'guu.'y j g'f getgcug'lp'F M' cevkkk' 'lp'UWegt gxkucg'f qwdrg'o wcpv'u'lp'eqput'cu'v'q'MO'r'evku'o wcpv'u'j cf 'ko r cev'qp' { gcu'vegmly cni'utwewt'g.'cu'o wcpv' egm'dgeco g'ugpukxg'v'EHY OK'ku'r quukdr. 'y j cv'v'j g'f getgcug'lp'F M'cevkkk' 'lp'UWegt gxkucg'."o qt'g'ut'qpi n' 'y j cp'lp'MO'r'evku'cl'hw'v'j g'egmly cni'r tqvklp'eqo r quk'k'p'v'j tqw'j 'ej cpi gu'qh'k'f "o g'vcd'qrkuo "cpf k't'I RKi n' equ { rkvqp'OF

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J3\_CgdKO OP /n'pngf 'r tqvklp'i n' equ { rkvqp'lp'yj g'GTODkqej ko 'Dkqrj { u'Cev' "O qri'egm't'gu04235-3; 55-4652690  
 J4\_Qt'Gy unkl'O cej w'e'M'Lep'kniC. \ f gdunc'G. Rerc'o cte } { m'l OF kugev'pi 'y j'q'ng'qh'f qrkej qn'lp'egmly cni'cuugo drf 'lp'yj g' { gcu'o wcpv'u'lo r ckt'gf 'lp' gctn' 'i n' equ { rkvqp'lgce'v'kpu'U' gcu'04229-46-45; 6740"  
 J5\_Dgt'pug'lp'O . Mgr gu'H'Uej gmo cp'TO'Uge7; 'gpeqf gu'c'o go dtcpg'r tqvklp'g's wkt'gf 'hqt'eqt'g'i n' equ { rkvqp'lp'Uceej ctqo { egu'egt gxkucg'00 qri'egm' Dkqr03; ; : -33; 36; 0"  
 J6\_'fikqi kcp 'F. 'Xcr'xk k v 'O. 'P qtn'kcp 'O. 'Vko k'punc'u'C. 'I gf xkrckv 'C00 wcvklpu'qh'Mw'xgtqo { egu'rcvku'f qrkej qn'k'p'cug'gpj cpegu'uggetgkqp'qh' tgeqo dlpcpv'r tqvklp'U'GOU' gcu'T'gu0423; -3; 0"  
 J7\_'Flectn'LG. 'P qtx'kng'LG.'O crk'R. 'T'ku'Z. 'Ccej 'L'Ej wtej 'I O'OI gpg'o g'gpi kpggtkpi 'lp'Uceej ctqo { egu'egt gxkucg'w'k'pi 'ETKURT/Ecu'u'ungo u'P wengle' Celf u'T'gu04235-63-65586650"

**IP XGUVH CVKQP 'QH'CNWO IP WO 'VQZKEKV[ 'TGURQPUG'QH'PGY N[ ' ' ETGCVGF 'NKJ WCP KCP 'DCTNG[ 'EWNVXCTU'**

Xlkwu'O gpuqpcu<sup>3</sup>. 'Tcko qpf cu'<sup>1</sup>kwac<sup>3,4</sup>. 'Xkqgvc'Mrgk ckv<sup>3</sup>"

<sup>3</sup>Kpukwng'qh'Dkquelgepegu. 'Nhg'Uelgepegu'Egptg. 'Xlkwu'Wpkxgtukv{. 'Ucwn vgnku'Cxg09. 'NV/32479'Xlkwu. "'  
Nkj wpclc"

<sup>4</sup>DqwcplecnI ctf gp'qh'Xlkwu'Wpkxgtukv{. 'Mckt pck'Ut065. 'NV/3245; . 'Xlkwu. 'Nkj wpclc0'  
xlkwuB gpuqpcuB i o e0wfw0w0w"

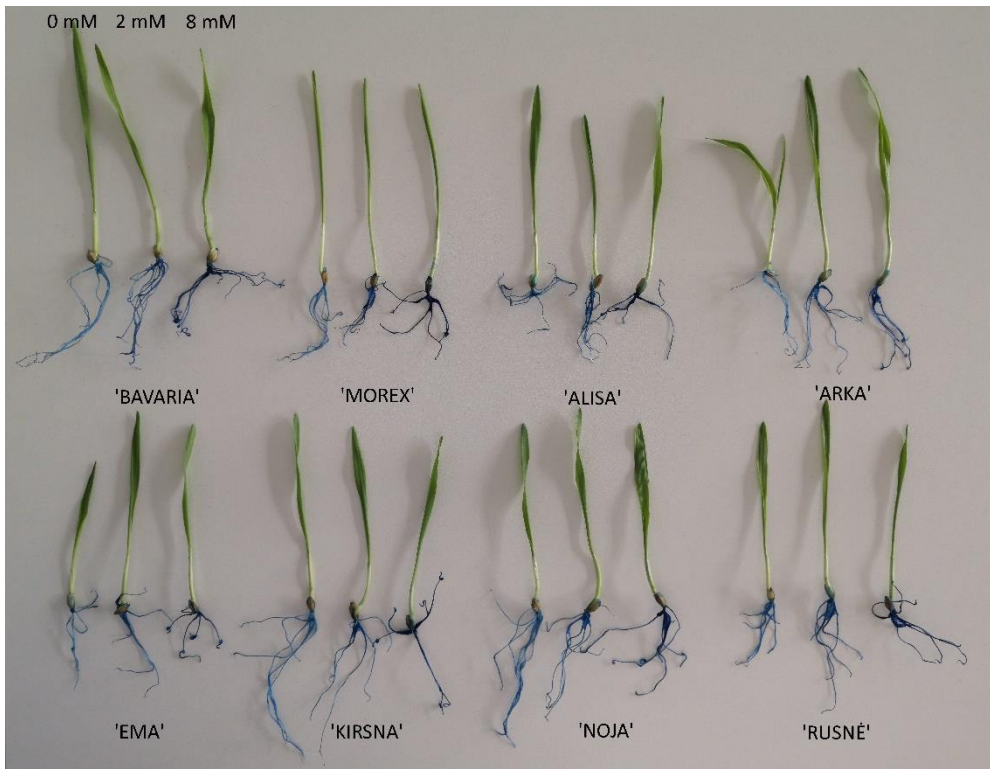
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Uqki'cekl kv{ "j cu'dggp'cpf "eqpvkpwgu"vq'dg'co qpi "vj g'dki i guv'r tqdrgo u'htq'fcto gtu'y qtrf y kf g0Y kj "cr r tqzko cvgn " ppg'vj kf "qh'uqku'lp'vj g'y qtrf "j3\_cpf "qxgt'42' "lp'Nkj wpclc'ctgcf { "dglpi "cekl kv{. cu'y gni'cu'y kj "kpetgculpi "i mdcl'wuci g" qh'pkitqi gp'htvklk gt'j4\_ "vj g'r tqdrgo "ku'g'zr gevfg "vq'dg'gxgp'ob qtg'ceegpwcvgf "lp'vj g'hwmg0Wi gp'v'iqnwkqpu'ctg'pgeguuct {." cpf "cmppi "y kj "uqki'gpi kpggtkpi "cpf "vj g'etgcvkqp'qh'tgur qpukdrg'htvklk cvkqp"u{ uvgo u." r rcpv'i gpgvle" gpi kpggtkpi "cpf " vti gvgf "ugrgevqap'cr r gct'vq'dg'r quukdrg'cpuy gtu0"

Vj g'o ckp'kuwg'ecwugf "d{ "uqki'cekl kv{. "cmppi "y kj "ko dcrpeg'lp'o letq'cpf"o cetq'grgo gpw. "ku'vj g'vzlekv{ "ecwugf "d{ " hgg'cni' "kpu0Wt qp'pvgtkpi "tqqv. "cnwo kpw "kpu'ecp'ecwug'r gto cpgpvf co ci g'vq'egmwct'hwpevqpu'cpf "lp'wtp'j co r g" vj g"i tqy vj "qh'r rcpv'tqqv. "vj w'u'ny gtlpi "ku'wtxkcdkxv{0'Qpg'qh'vj g'o quv'cnwo kpw /uwegr vldrg"o clqt'etqr "ku'dctrg{ " \*J qtf gwo 'xwri ctg'N00'k'vj ku'cpcn'uku'y g'eqo r ctg'mecni'Nkj wpclc'p'dctrg{ "ewnxctu'y kj "kpvtpcvkqpcn'wpcpf ctf u. "lp'cp" cwgo r v'vq' "hpf" "vj g'o quv'cnwo kpw /tgukrcpv'i gpqv' r gu'cpf "kf gpvkh{ "i gpgvle" cpf "o qrgewct"o gej cpluo u' dgj kpf "vj ku' tgukrcpeg0"

Vq'f vgyto kpg'dctrg{ "xctkvku'dguv'uwkxgf "vq'cekl kv{ "gpvktqpo gpw'c"j quv'qh'o qtr j qmji lecn'dkqej go lecn'cpf "i gpgvle" cpcn'ugu'y cu'go r m{ gf 0Vj tqwi j qw'vj g'gctn' "uggf r kpi "i tqy vj "r gt kqf "lp'Crilw'gu'gpvktqpo gpw'y g'qdugtxgf "vj g'ej cpi kpi " o qtr j qmji { . "vj gp. "chgt y ctf u'y g'o gcuwgf "ej go lecn'ej cpi gu'lp'xctkvku'r rcpv'kuwgu0'Hpkm{. "y g'g'zr mgtgf "vj g"i gpgvle" dcuku'ht'cnwo kpw "vzlekv{ "tgukrcpeg"qt'rceni'y g'gqhf0"

Qw'tguwuu'uj qy "cp'qdugtxcdrg"o qtr j qmji lecn'ej cpi g'lp'cnwo kpw "utguu'i tqw u0'htgo "dkqej go lecn'r gtur gevkg. " Gxcpu'dwng'cpf "J go cvqz { r kpg'wcklpi "cuuc{ u'cr r gctgf "vq'dg'vj g'o quv'kpf kec'vkg'qh'ej cpi gu'kpf wegf "d{ "Cn' "vzlekv{0' Hw'vj gt'cpcn'ugu'y knlpeqr qtcv'g'i gpgvle "hpf kpi u. "y j lej "y g'j q'g'vq'eqttgr'v'y kj "f'cvc'kqwpf "lp'rcd'g'zr g'kto gpw'cu'y gm' cu'qdvckpgf "lp'vj g' "hgrf 0'Ceetqf kpi "vq'q'w'cpcn'uku'vq'ht. "vj g'ewnxct "Go c0'cr r gctu'vq'dg'vj g'o quv'tgukrcpv0"



"

Hki 0'30'kpf kxk wcl'r rcpv'tqqv'qh'xctkvku'dctrg{ "ewnxctu'chgt'Gxcpu'Dwng'v'gu0'Vj tgg'r rcpw'lp'gej "ewnxctu" tgr tgugpvf khtg'gp'v'gxgn'qh'Crilw'gu'2'6'eqpv'qni tqw "xgtuu'4"o O "cpf ": o O "CrEh'v'g'cwo gpv'i tqw u0"

"

j3\_ "U0M0'Dgj gtc. "U0Mwo ct "gv'cn0'42370'0Ur cvkci'F kxkdwkqp'qh'Uwtrcg'Uqki'cekl kv{. "Grgv'lecn'Eqpf wevkv{. "Uqki'Qti cple"Ectdqp"Eqpv'cpf " Gzej cpi g'cdig'Rqvcuuko . "Ecekw0 'cpf 'O ci pguko "lp'Uqo g'Etqr r gf "Cek "Uqku'qh'kpf kv{Ncpf "F gi tcf cvkqp'cpf "F g'xgnr o gpv'48'3+2'9369; 0' j4\_ "U0U0M'c'mj q'cpc. "gv'cn0'423; 06'Uqki'cekl kv{. "Nko g'Cr r r'ckvq. "P ksqi gp'htvklk{. "cpf "I tggpj qwug' I cu'Go kuukpu'Qr v0 k'kpi "Vj gk' "lqkpv'Gepqo ke" O cpci go gpv'0'Ci thev'wcti'U{ uvgo u'398"

"



**KUQNCVKQP 'CPF 'EJ CTCEVGTK CVKQP "QHE'GNNWNCUG'RTQF WEKPI "**  
**O KETQQTI CPKUO UHTQO 'DKQI CUFK GUVCVG"**

Kpf t "Lwqf xkt -f v<sup>3</sup>. 'Lwukpc 'Mc| k plgp "d. 'Cwf tkwu'I gi genu<sup>5</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Dkqmi { 'X{ vewcu'O ci pwa'Wpkxgtukf. 'Nkj wpcle"

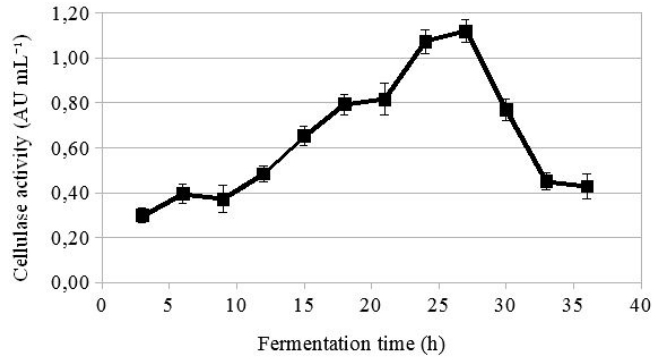
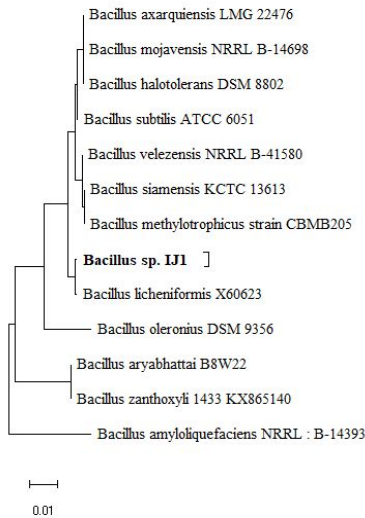
<sup>4</sup>Kpukwag'qh'Dkqmi { 'cpf 'Rrcpv'Dkqvej pqmi { 'X{ vewcu'O ci pwa'Wpkxgtukf. 'Nkj wpcle"

<sup>5</sup>F gr ctvo gpv'qh'O letqdkqmi { 'cpf 'Dkqvej pqmi { 'Xkpkwu'Wpkxgtukf. 'Nkj wpcle"

lwqf xktuf vqpf t gB i o ckrteqo "

Egmmwug" ku" c" r qn{ o gt" eqpukwpi "qh" "rkpnf "F/i nweug0' Egmmwug" f gi tcf cvkqp" ku" c" xgt { "unqy " r t qegu" ]3\_0' Egmmwug" ku" o ckn{ "f gi tcf gf "d{ "egmmwug" gp| o g' y j lej "ku" eqo o qn{ "r tqf weg" d{ "dcevtkc" cpf "hwpi k' ]4\_0' Vj gtg' ctg" y j tgg" v{ r gu" qh' egmmwug" gpf qi nwepcugu" gzqi nwepcugu" cpf " /i nweukf cugu' Vj g{ "ecp" dg" wugf " xgt { "y kf gn{. "hqt" gzco r ng< r cr gt. "vgz vkg' kpf wut lgu" cu' f gygti gpw' k' r wpf t { . 'tgpdy cdrp' gpgti { 'r tqf wekqp" ]5\_0"

Kp" y ku" t guctej " o letqati cpluo u' y gtg' ku' r vgf " hqo " dkqi cu' utcy " f ki guvcg0' Egmmwug" v{ cevkxkf " y cu' kpf kecvgf " d{ " ergt" ] qpgu' ctqwpf " y g' eqmplegu' qp' EO E' y kj " Eqpi q' tgf " ci ct' r nvgu' Ukw vggp' f k hgt gpv' o qtr j qmi { " o letqati cpluo u' y j cv' r tqf weg" egmmwug" y gtg' ku' r vgf 0' Vj g' nti guv' cevkxkf " ] qpg' r tqf weg" " o letqati cpluo " y cu' pco gf " K3" cpf " ugrgevgf " hqt" hwt y gt " kpxgukl cvkqp0' Rj { mi gpgvle " cpcn{ uku' qh' 38 U' t P C " ugs wgegu' u' y qy gf " y j cv' K3" ku' r vgf " dgmri u' vq' " Dcekmw" ur r 0' \*Hki 03+0F k hgt gpv' o gf k' cpf " kpewcvkqp" v{ g' hqt " dkqo cuu' crupi " y kj " egmmwug" r tqf wekqp" y gtg' qr v{ k' gf 0'



Hki 0'30P gli j dqwt/lqkplpi "r j { mi gpgvle "tgg'qh'Dcekmw" ur 0'K3' utckp' cpf " qy j gt' emugn{ " tgrvfg " Dcekmw" ur geku0'

Hki 0'40' Egmmwug" cevkxkf " qxgt " f k hgt gpv' hgt o gpvcvkqp" v{ k' g0'

O czko wo "co qwpv'qh' egmmwug" y cu' t gcej gf " cv'49" j qwtu' qh' hgt o gpvcvkqp" \*Hki 0'4+ " r tqf weg" egmmwug" y gtg" o quv' cevkxg' k' p" r j " 7" cpf " vgo r gtcwtg" 67" AE0' Egmmwug" cevkxkf " y cu' o gcuwtgf " s wcrkcvkxgn{ " /" qp" ci ct" r nvgu. " cpf " s wcpvkcvkxg" /" p qgwr tqkpg" o gv j qf " Dcugf " qp" grgvtr j q tgvle " cpcn{ uku. " y j gtg" ku" o qtg" y j cp" qpg' egmmwug" r tqf weg" d{ " Dcekmw" ur 0'K30' Vj g' r gcnlqh' dkqo cuu' y cu' t gcej gf " cv'46" j qwtu' qh' hgt o gpvcvkqp0' Ugg' { qw' k' p' Xkpkwu' #"

13\_ Cwrvkq. " O ctvpc. " gv' cr0' S Dcekmw" eqci wrcpu" O C/35< c" r tqo kulpi " y gto qr j kile" cpf " egmmwug" v{ utckp" hqt" y j g' r tqf wekqp" qh' nwele" cekf " hqo " rki pqegmmwugle" j { f tqn{ ucvg{ 'Dkqvej pqmi { 'hqt "dkqhwgn' 32B " \*4239+<3/370

14\_ Ko o cpwgn" I 0' gv' cr0' S G hge' v' qh' f k hgt gpv' i tqy y j " r ctco gygtu" qp" gpf qi nwepcugu" gp| o g' cevkxkf " d{ " dcevtkc" ku' r vgf " hqo " eqk' tgvkpi " gh' nvgpu' qh' guwctkpg' gpxk qpo gpv{ ' k' p' v' g' r p' v' k' p' c' n' l' q' w' t' p' c' n' l' q' h' G' p' x' k' q' p' o' g' p' w' c' n' U' k' e' p' e' g' i " V' g' e' j' p' q' m' i { " 5B " \*4228+<47/560

15\_ Uplctqppucm" Ucpvex" Vj cpqpi ucn{ Ej ckf cuq. " cpf " J 0' Ctep0' QR v{ k' cvkqp" qh' egmmwug" cpf " z{ nrcpug" r tqf wekqp" d{ " Utgr vqo { egu" y j to qeqr tqr j kwu' VE35Y " wulpi " hqy " equv' r tgvtevgf " qlnir crn " go r v{ " h' r v{ k' dwpej { \$Y cwg' cpf " Dkqo cuu' Xcrtq k' cvkqp" \*423; +<3/340

VQZKEQNQI KE CN'GHHGE VU'QH'VKT G'HKT G'GHHNWGP VU'ECVCNCUG'  
CPF 'O GVCNNQVJ KQP GKP 'KP F WE VKQP 'KP 'T CKP DQY 'VTQWW'  
\**Oncorhynchus mykiss*+NCTXCG''

Nkpc'Cpwxk k v<sup>3,4</sup>. 'I kpxt 'Ucwkw<sup>4</sup>. 'Ct{x {f cu' O ctnwem<sup>3</sup>. 'fikkn 'Lxti gn p<sup>4</sup>. 'O kf c'  
Ucpxk k v<sup>4</sup>

<sup>3</sup>Xkpkwu'Wpkxtukv'. 'Nkg'Uekpegu'Egpgt. 'Ucwn vgnk'cx09. '32445'Xkpkwu. 'Nkj wpcle''

<sup>4</sup>P cwtg'Tgugtej 'Egpgt. 'Cnef go kqu'U04. 'NV/2: 634'Xkpkwu. 'Nkj wpcle''

nkpc'pwxkxkewgB ej hhwf kxwm'

Gpxkqpo gpwn'ej go lecn'utguqtu'ecwug'qzlf cwxg'utguu'lp'cs wcle'' qti cpluo 0'Vj g''eqpugs wpegu''qh'qzlf cwxg''  
f co ci g'lpemf g'o qf kkecvkpu'qh'kr kf u'cpf 'ectdqj {f tcvu. 'rtqvgp'f gpcwvcvqp. 'FPC'cpf 'TPC'f co ci g'0'Vj g'c'ko 'qh'yj g''  
uwf {"y cu'vq'kpxgukv cvg'yj g'dkqo ctngtu'qh'qzlf cwxg'utguu'lp'yj g'rtxcg'qh'tckpdqy "tqvw'\*Qpeqtj {pej wu'o {nkau'+chgt''  
gZR quwtg'vq'vkg'htg'ghhwgpv'0'Vj g'dkqej go lecn'ucwuu'qh'cpv'qzlf cpv'f ghpegu'qh'tckpdqy "tqvw'\*Q0o {nkau'+rtxcg. 'y j lej ''  
ku'c'xcwcdrg'o qf gn'hkuj "hqt'o qpkqt'kpi "y cvgt'r qmwkq. "y gtg''uwf kgf "chgt"6'f c {u'gZR quwtg'vq'vkg'htg'ghhwgpv'0'k''  
cf f kkp.": "f c {u'tgeqxt { "gZR g'klo gpv'y cu'ectk'gf "qwo'Cu'dkqej go lecn'dkqo ctngtu'qh'qzlf cwxg'utguu''  
o gvcmyj kppgkpu''\*O V+'lpf wcvkq'cpf "ecvrcug''\*ECV+'cevkxk' "y gtg''epcn'ugf 0'O gvcmyj kppgkpu'rgxgn'y cu'o gcuwtgf "d {''  
eqmtlo g'kle'tgcevkq'wukpi "Gm cp'tgci gpv'0'Ecvcrcug'cevkxk' "y cu'cuugugf "d { "c'o qf kkgf "eqmtlo g'kle'tgcevkq'0'Rtqvgk''  
eqpvgpv'y cu'f gvgto kpgf "d { "y j g'Dtcf hqtf "o gyj qf 0'Hkuj "rtxcg'y gtg''gZR qugf "vq'vkg'htg'ghhwgpv'cv'322'' "cpf "340'' ''  
eqpegpvcv'kpu'0'Vj g'tguwuu'uj qy gf "y cv'vkg'htg'ghhwgpv'tguwugf "kp'f getgcugf "co qwpv'qh'0'V'cpf "kpetgcugf "cevkxk' "qh''  
ECV'kp''Q0o {nkau'+rtxcg'0'Vj g'f cv' "qdvckpgf "uj qy gf "y cv'chgt": "f c {u'qh'tgeqxt { "0'V'co qwpv'kpetgcugf "vq'c'eqpvtqni''  
rgxgn' Ceeqtf kpi n'." ECV' cevkxk' "tgcej gf "c" rgxgn' qh' eqpvtqni' kp' cni' tgeqxt { "i tqw u' Vj ku' uwf { "j ki j rki j w' yj g''  
geqvzleqni lecn'r qv'p'kn'qh'vkg'htg'ceekf gpv'vq'yj g'cs wcle'dkvc0'

**Cempy ngf i o gpw'**

Vj ku'uwf {"y cu'hwf gf "d {"y j g'Tgugtej 'Eqwpeki'qh'Nkj wpcle''y tqwi j 'y j g'r tqlgev'R/O KR/43/44; 0'

"

"

**KF GP VHKKE CVKQP 'QHE TKVKE CN'I GP GVKE 'GXGP V'QHE NGCT 'EGNN' TGP CN'E GNN'E CTE KP QO C'DCUGF 'QP 'RNCUO C'b TPC'NGXGNU''**

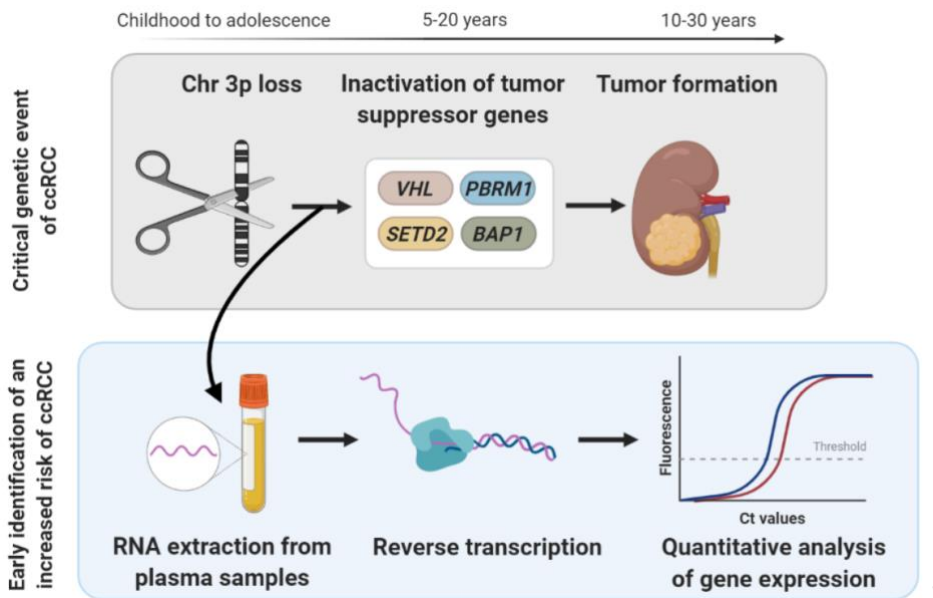
Cwi wuw "Xkr ctvckv"<sup>3</sup>. "Mikukpc"fi wne wumekv<sup>4</sup>. "Tcuc"Ucderkewumekv<sup>3,4</sup>. "Uqpcw"lcto cnekv<sup>3,4</sup>"

<sup>3</sup>"Kpukwng"qh'Dkquelgegu. "Nkg"Uelgep"egpvt. "Xkpkwa"Wpkxgtukv. "Xkpkwa. "Nkj wcpk"

<sup>4</sup>P cvkqpcn'Ecpegt "Kpukwng. "Xkpkwa. "Nkj wcpk"

cwi wuw0kr ctvckvB i o e0wfw 0x0w

Tgpcn'egm'ectekpqo c" \*TEE+"ku"vj g'o quv'eqo o qp"v r g"qh'nf pgf "ecpegt'O quv'ecugu"qh'TEE" ctg" f kueqxtgf " kpekf gpcm' c'pf "uwxkcn'ku" ki j n' "f gr gpf gpv'w qp"vj g'unci g'qh'f kugcug'cvf kci pqku. "y kj "vj g'hw/uci g'o gxcwv'f kugcug' j cxkpi "qpn' "c"34" "7/{ gct"uwxkcn'tcv"j3\_0'TEE"ku" c"j ki j n' "j gvtqi gpgqwa'f kugcug'O'Erct"egm'tgpcn'egm'ectekpqo c" \*eeTEE+"ku"vj g'o quv'eqo o qp"cpf "r ctvkwctn' "ej cngpi kpi "j kxqni le"TEE"uwdv' r g"j4\_0'K'ku'ercuulecm' "cuulekvgf "y kj "c" nquu'qh'vj g'uj qtv'cto "qh'ej tqo quqo g"5r "y j lej "ku'tgi ctf gf "cu"vj g'eqo o qp" gctrkuv'i gpgv' "gxgpv' "h'w'pf "kp"@ 2" "eeTEE" r cvkqpu'0'vj ku'i gpgv' "ej cpi g'ku'uggo kpi n' "ctkupi "kp"ej kf j qaf "qt"cf qnguepgep. "gxgp"vj qwi j "ecpegt"o c' { "pqv'dg'f kci pqugf " hqt "cpqj gt "52/72" "f gctu'0'vj g'f grvgf "tgi kqp" gpeqo r cuugu'hw' "wo qt" uwr r tguuq'f i gpgu <XJ N.'RDTO 3.'DCR3. "cpf "UGVF 4" \*Hki 03-0'Gctn' "kf gpv'k'ecv'kp"qh'vj g'f kugcug'ku"j ki j n' "ko r qt'cvp'dgecvug'k'ecp"ko r cev'ekplecn' o cpci go gp'0'E'qpu'k'gtkpi " vj g'rcen'qh'uw'k'elgpv'pqp/kpxcukxg'o c'tngtu'hw' "eeTEE" f kci pqku. "ks w'f "dkr ulgu'wvej "cu'dmqf "r ruo c'eqwf "r tqxkf g"cp" cwtcev'xg. "o loko cm' "kpxcukxg. "cpf "r tqo k'kpi "o gj qf "v'kf gpv'k' "f kci pqv'le"dkqo c'tngtu'kp"eeTEE" r cvkqpu'0"



Hki 030Uej go cve'tgr tgupv'kqp"qh'eeTEE"hwto cvkq"cpf "r qv'p'c'n'r quukdkk'v' "qh'gctn' "f kugcug' r tgf k'v'kqp'0

Vj g'clo "qh'vj ku'uwf { "y cu"v'f vgtto kpg'vj g'ej cpi gu'lp"vj g'zr tguakqp"qh'i gpgu"XJ N.'RDTO 3."UGVF 4"cpf "DCR3"kp" vj g'r ruo c'qh'r cvkqpu'y kj "eeTEE"eqo r ctgf "v"uco r ngu'hwto "r gqr ng'y kj "pqp/o c'ki pcpv'wo qtu'lp"qt'f gt"v'cf cr v'vj go " hqt "f kugcug'k'kum'cuuguo gpv'cpf "gctn' "f kci pqku'0

Kp"vj g'r tgupv'uwf { .; "r ruo c'uco r ngu'qh'eeTEE" r cvkqpu'cpf "38" r ruo c'uco r ngu'hwto "r cvkqpu'y kj "dgpki p"nkf pgf { " wo qtu'y gtg"cpn' { gf 0'Erkplecn'uco r ngu'y gtg"eqng'v'f "f w'kpi "423; /4243"cv'P cvkqpcn'Ecpegt "Kpukwng'0'Rruo c"o TPC" r'xgn'u'y gtg'gxcwv'v' "wulpi "tgxgtug"t'cpuetk'v'kqp"r qn' o gtcug'ej ckp'tgcev'kqp'0"

Vj g'tguw'u'qh'q'w'uwf { "tgxgng'f "uki p'k'ecv'f k'htg'pgegu'lp"XJ N.'UGVF 4. "cpf "DCR3"b TPC"tgxgn'u'eqo r ctkpi "r ruo c" uco r ngu'hwto "r cvkqpu'y kj "eeTEE"cpf "dgpki p"wo qtu"cm'R"> "207-01" gpg'zr tguakqp"cpn' uku't'g'x'g'ng'f "vj cv'XJ N.'UGVF 4." cpf "DCR3"r ruo c"o TPC"r'xgn'u'kp"eeTEE"uco r ngu'y gtg"uki p'k'ecv'v' "ny gt"eqo r ctgf "v"pqpecpegt'qwa'ecugu'0'Uvej " f k'htg'pgegu'lp"i gpg'zr tguakqp"o c' { "j cxg'q'ee'wt'gf "d'gh'gt'g'y "j qpug'v'qh'vj g'f kugcug'0'Gctn' "f g'vek'qp"qh'ej tqo quqo g"5r "nquu" cuulekvgf "y kj "f g'et'cugf "XJ N.'RDTO 3."UGVF 4. "cpf "DCR3"zr tguakqp'y qwf "j gn "v'kf gpv'k' "cp"ket'g'cugf "k'um'qh't'gpcn' ecpegt"cpf "v"r tqxkf g'vj g'o quv'cr r tqr tkv'g't'gevo gpv'lp" c'w'o gn' "o c'p'p'gt'0

Kp"eqpen'wuk'qp. "f g'vek'qp"qh'XJ N.'RDTO 3."UGVF 4. "cpf "DCR3"zr tguakqp"ej cpi gu'lp"r ruo c'uco r ngu'eqwf "j gn "v'kf f g'k'p'g'vj g'r qv'p'c'n'qh'q'ee'wt'kpi "f kugcug'cpf "vj w'u' w'f g'r cvkqpu' b cpci go gp'0

[3\_ Ref cr: "Uc'p' ggr "C'p'p'f "g'v'c'f'0'Gr k'f go k'q'ni { "qh'T'gpcn'Egm'ectekpqo c'0'Y q'rf "10'Q'p'eq'lx'q'0'3.5" \*4242+<9; /: 90" j4\_ "V'qo cu' gy un'k' L'gh'g'f "L'g'v'c'f'0'j gvtqi gpgk'f "cpf "t'gpcn' b cu'ld'qr u'f <c't'g'x'g'y "qh'ku't'q'ng'cpf "t'g'rc'ld'k'k'v' { 0'Ecpegt "D'k'q'0' g'f "x'q'0'33.5" \*4236+<384/" 3940

**GXCNCVKQP'QHE[ VQVQZKEK[ 'CPF'I GPQVQZKEK[ 'QH\ KPE"  
QZKF'GPCQRCTVKEGUD[ 'ALLIUM CEPA'VGUV"**

F qo kp { nc'Dt gko gn v<sup>3</sup>. 'Cuv'Ucr wtkp { v<sup>3</sup>"

<sup>3</sup>Kpukwng'qh'Dkuekpegu.'Nkg'Uekpegu'Egpgt.'Xkpkwu'Wpkxgtukf.'Nkj wpcic"  
f qo kp { nc'Dt gko gn v gB i o eUwfw & vOm"

Vj g'pcpqvej pqmji { "kpf wut { "ku"i tqy kpi "tcr kf n{." gpeqo r cuukpi "c"y kf g"tapi g"qh'kpf wutku"htqo "o gf lekpg"vq"  
gpi kpggtkpi OF wg'v'j gk'uo cmluk g."cu'y gm'cu'r j { ulecn'cpf "ej go lecn'r tqr gtvku."v'g'cr r rdecvqp'qh'pcpqr ctvlegu'ku'xgt { "  
xgtucvng'gO'p'pcpqr ctvlegu'ecp'dg'wugf 'v'ko r tqxg'v'j g'r tqr gtvku'qh'j gcv'tgukucpeg'cpf 'gucvlek { 'qh'c'i kxgp'o cvgtkro'Vj g"  
kpetgculpi "wug'qh'pcpqr ctvlegu'ecm'ht'f ggr gt'uwf lgu'qh'v'j gk'i gpqvzlek { O\ kpe"qz kf g"pQ+'pcpqr ctvlegu'"P R+'y gtg"  
ugrgev'f "ht'v'j ku'uwf { "dgecvug'v'j g { "ctg"cn'ng { "kpi tgf kgp'v'k"o cp { "r tqf wew'uwej "cu'uwpuetggpu."r clpu."cur j cn'grgevtle"  
f kqf gu'cpf "ej go lecn'ecvnc' uuo'

K'j cu'dggp"qdugtxgf "k"r tglqwu'tgugctej "v'cv\ pQ'pcpqr ctvlegu'ecp"ecwug"qz kf cvkxg'utguu'y j gp"v'j g { "gpvgt"v'j g"  
egm'O\ pQ'P Ru'ecwug'htqo cvkqp'qh'kpvgtgmnwct'tgcevkg'qz { i gp'ur gelgu'v'j cv'ctg'tgur qpukdrg'ht'ej cpi gu'k'bo kqej qpf tkcn'  
r qv'p'cn'cm'pi "y kj "uy qmgp"o kqej qpf tkc'O'qtgqxt." pQ'P R'ecp"cf j gtg"v'j"ej tqo quqo gu'kpxqkxgf "k"v'j g'pqto cni'  
r tqeguu'qh'o kquku."cpf "v'w'ecp"ecwug"cdpqto crkku'v'j cv'uvr "pqto cni'egm'f kxkukp"cpf "v'g'egm'e { eng'OHqt'v'j gug'tgcuqpu."  
k'ku'ko r qt'cv'v'q'kpf "qww'y j cv'ku'v'j g'ny gu'v'gxn'qh'eqpegpvtcvkqp"ecp"ecwug'f gvtko gpv'cn'j gcn'j "gh'gewo'

Vq'cuuguu'v'j g'r qv'p'cn'v'zlek { 'qh' kpe"qz kf g" Cnkwo 'egrc"cuuc { 'y cu'r gthqto gf O'Vj g'r tgr ctgf "qpkpu'y gtg'tcpuhgtgf "  
v'ugrgev'f "eqpegpvtcvkqp'qh'8" pQ'P R'uqnvkqp'u'xct { kpi "htqo "204"v'847"r ro O'Vj g'gh'gewkxg"eqpegpvtcvkqp"GE 72"y cu"  
f gvgto kpgf "htqo "v'j g'i tqy v'j "ewxgu'd { "r gthqto kpi "c"tqqv'k'j kdkkqp'v'gu'cpf "gxcncv'kpi "v'j g'ug'eqpegpvtcvkqp'O'Vj g"GE 72"  
y cu'qdv'k'p'gf 'cv'2Q 'r ro 'y kj 'v'j g"-'Uj cngur gctg'ewkxct.'y j lej 'kpf kec'v'v'j g'f gvtko gpv'cn'r qv'p'e { 'qh'v'j g'uwduv'peg'O'k'v'j ku"  
r ctv'qh'v'j g'g'zr gtko gpv."c'Ot gi tguukp"cp'cn' uku'y cu'r gthqto gf O'Tqqv'ngpi v'j "chgt"; 8'j qwtu'y cu't gi tguugf "qp'v'gxn'v'qh' pQ"  
eqpegpvtcvkqp'k'v'j g'uqnvkqp'O'Vj ku'f gr gpf gpeg'y cu'cuugugf "cu'uv'v'k'v'ecm { 'uki p'k'lecpv."pqv'kpi "v'j cv'r /xcnwg">"2030'

aa  
]3\_'" Cj o gf 'D.'F y kxgf kU.'Cdf kp'O\ .'gv'cn'O'kqej qpf tkcn'cpf "Ej tqo quqo cni'F co ci g'kpf wgf "d { 'Qz kf cvkxg'Ut'guu'k'p' p\*4- +k'qpu.\ pQ/Dwmi'  
cpf "\ pQ'P Ru'v'gev'f "Cnkwo "egrc"tqqw'UekTgr'04239-9-628: 70f qk32025: lut gr 628: 7"

**I GPGVÆ 'F KXGTUK[ 'CPCN[ UK'QH'HERACLEUM SOSNOWSKYI K' "**  
**XKNPKW'EKV[ 'CPF'UWTTQWF KPI U'WUKPI 'KUT'O QNGEWNCT" "**  
**O CTMGTU**

Tco kpxc'Ucwn pckv<sup>3</sup>. 'Iqrpcw'Revco u{ v<sup>3</sup>."

<sup>3</sup>Kpxkwg'qh'Dkquekpegu."Xlpxku'Wpkxgtuk{ 'Nkg'Uekpegu'Egpgt.'Nksj wpc{k"  
tco kpxc'Ucwn pckvB i o eQwaf (xwQw'

*J gt cergwo "ku' eqo o qp" kp" Pqtvj " cpf " Gcu' Gwtqr g0' Vj gtg" ctg" c" hgy " J gt cergwo " ur gelgu" uvej " cu" J gt cergwo " o cpygi c//kcpwo . "J O'urj qpf {rkwo . "J O'rgtukewo 'cpf" o quv'eqo o qp"kp"Nksj wpc{k"J gt cergwo "uqupqy unfk'Vj gug'r rcpw."cu" dgkpi "cp" kpxcukxg" ur gelgu" f co ci g" pcwtcn' gequ{ ungo . " f kur rckpi " pcwtcm{ " i tqy kpi " ur gelgu" cpf " ecwukpi " geqppo le" f co ci g'cpf " gpf cpi gtlpi " j wo cp" j gcnj O'Ugr ctcvgf " lwkeg" htgo " vj g' r rcpv'vj cv'i gw'qp" j wo cp' unkp" cpf " tgccew' y kj " uwpki j v' ecp' ecwug" unkp" dwtpu' J cl ctf qwu' r rcpv' eqo r qwpf u' ecp' ecwug" ecepgt" cpf " dk'vj " f ghgevu" kp" vj g' f gxgnr kpi " go dt { q0' Vj g" clo " qh'vj g' uwf { 'y cu' vq' gmwk' cvg' vj g' r qn{ o qtr j kuo " qh'Xlpxku'ekv{ 'uco r ngu' qh' J O'iqupqy unfk' wukpi " KUT" o ctngtu0"*

*Vj g' r rcpw' y gtg' eqmgevgf " htgo " ukz" r qr wcvkpu< Ekv{ " egpgt. " Wflw ku" Rc-kck kck" Rgtm pnkgo ku " Xgtmck" cpf " Xluqtck'kp" Xlpxku'ekv{ 'cpf " uwtqwpf kpi u'kp" 423; " o' 4242' f wtkpi " gctn{ " cwwwo p' ugcup0' F P C" y cu' gzxtcevgf " wukpi " EVCD" o gy qf O' Chgt" vj cv' KUT" o " RET" y cu' f qpg" y kj " ukz " KUT" r tko gtu" y j lej " y gtg' r tguqgevgf " hqt" J O'iqupqy unfk' RET" r tqf wew' y gtg' h'cew' qpcvgf " qp" c" 30# " ci ctqg' i gr0' Cnuq. " ucvk' ecn' f cv' " cpcn{ uku' y cu' r gthqto gf " wukpi " grgevtqr j qtguku" tguwnu' cu' c' i wkf g' vq' etgcvg' dlpct { " o cvtkz0"*

*Ukz" r qr wcvkpu' y gtg' gzo kpgf " cpf " f gvto kpgf " o gcp" qh' F P C" r qn{ o qtr j kuo " kp" vj g' r qr wcvkpu' y cu' h'qwpf " vq" dg" 78' O' Vj g' " uo cnguv' i gpgvle" f kucpeg" y cu' h'qwpf " dgw ggp" Xlpxku'ekv{ " egpgt" cpf " Wflw ku" r qr wcvkpu. " y j lej " y gtg' vj g' enqugw0' Vj g' rcti guv' i gpgvle" f kucpeg" y cu' dgw ggp" Rc-kck kck" cpf " Xluqtck' r qr wcvkpu' C" o clqt" r ctv' qh' vj g' i gpgvle" f kxgtukv{ " qh' J O'iqupqy unfk' r qr wcvkpu' y cu' y kj kp' r qr wcvkpu" \*83' -0"*

*Kp' eqpenukqp. " kp" ukz" r qr wcvkpu' qh' J gt cergwo " uqupqy unfk' " vj g' j ki j guv' r qn{ o qtr j kuo " qh' KUT" n'ek' y cu' h'qwpf " kp" vj g' Xgtmck' r qr wcvkpu" \*8; 0 3' +cpf " vj g' n' y guv' kp' vj g' Ekv{ " egpgt" r qr wcvkpu" \*6704: ' -0' J O'iqupqy unfk' r qr wcvkpu' qh' Wflw ku" Ekv{ " egpgt" cpf " Xgtmck' y gtg' i gpgvlecm{ " enqug0' Vj gk' uko krtk' v{ " y cu": 2' O' Vj g' r qr wcvkpu' qh' J O'iqupqy unfk' Rc-kck kck' cpf " Xluqtck' y gtg' vj g' o quv' i gpgvlecm{ " f h'gtgp0' Vj gk' uko krtk' v{ " y cu" 88' O' Qwt' t guwnu' kp' lecvg' f h'gtgpv' qtki kp' qh' uwf lgf " J gt cergwo " uqupqy unfk' r qr wcvkpu0"*

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**RJ QVQO GEJ CP KECN'GHHGEV'KPF WEGF 'QP 'KPF TCF GTO CN'VCVVQQ''  
RK O GP VU'Y KVJ 'RKEQUGE QPF 'P f < CI 'NCUGT''**

Lwukpcu'Dcngk-ku<sup>3</sup>. 'f t0Tqo wcrf cu'Twf {u<sup>3</sup>0'

<sup>3</sup>F gr ctvo gpv'qh'Dkqo qf gnu.'Ucv'g'Tgugctej 'Kpukw'g'Epvt'g'ht'Kppqxcv'kg'O gf kelpg.'Nksj wcpk'''

Lwukpcu0lcrngkkuB ko egpvcu0n''

C"Vcwqq'ku'c'r gto cpgpv'o ctmiqt'f guki p'o cf g'qp'vj g'dqf { 'd{ 'vj g'k'p'qt'qf vewkqp'qh'r ki o gpv'vj tqwi j 'twr wv'gu'lp'vj g'unlp'0  
Ewttgpw' 'vj g'vcwqq'u'o ctngv'ku'i tqy kpi 'cv'c'r j g'p'qo gpcn'tcv'g'0'Vj ku'j cu'rgf'lp'i tqy vj 'qh'vcwqq'tgo qxcn'r tqegf wtg'cu'y g'nt'  
O g'v' qf u'qh'vcwqq'tgo qxcn'lpenmf g'f gto cdtcukqp.'unlp'i tchm'qt'r r'u'w'le'uw'it g't {.'cpf'ncugt'uw'it g't {0'Vj g'o quv'cr r g'c'k'pi 'h'qto "  
ku'vj g'S /uy ke'j gf 'p'cp'q'ugeqpf 'f qo clp'ncugt'u.'vj cv'wr 'wp'v'it'gegpv' 'y g't'g'vj g'i q'f 'u'c'p'f'ctf'lp'vj g'h'g'f'0'E'qo r r'g'z'c'p'f'o w'nc'eq'm't "  
r ki o gpv'lp'f'wegf 'vcwqq'u'ct'g'c'ej cm'p'pi g'v'q't'go q'x'g'c'p'f'r t'qo k'ul'pi 't'g'u'w'u'ct'g'ug'p'lp'vj g'r v'd'rk'uj gf 'f'c'v't'g'i'ctf'k'pi 'vj g'w'ug'q'h'  
uj q't'v't'o'r'le'q'ugeqpf 'f qo clp'ncugt'u'j3\_0'Vj g't'g'cu'q'p'd'g'j k'p'f'vj cv'd'g'k'pi 'vj cv'h'q't'r'le'q'ugeqpf 'f qo clp'r w'ng'u'c'm'q'y g't 'h'w'g'p'eg'ku'  
p'g'g'f'gf'f'w'k'pi 'vj g't'g'c'v'o gpv'ug'u'k'p'u'f'w'g'v'q'v'j g'j k'j j g't'r'g'c'n'r'q'y g't'c'p'f'i' t'g'c'v'g't'r'j q'v'q'c'eq'w'w'le'g'h'g'ev.'y j k'ej 'e'c'p'q'h'g't'g'u'u'k'f'g/  
g'h'g'ev'c'p'f'c'd'g'w'g't'r'ki o gpv'eng'ct'c'p'eg'j4\_0''

Y j gp'uw'v'k'pi 'vj g'v'g'to 'd'vc'w'q'g't'go q'x'c'r'o'k'v'k'u'p'ge'g'u'uct { 'v'q'g'z'r'k'p'.'vj cv'vj g'ot'g'o q'x'c'r'o'ku'vj g'h't'c'i o gpv'v'k'p'q'h'vj g'v'c't'i g'v'g'f "  
r'ct'v'eng'lp'w'q'uo'c'ng't'ht'c'i o gpw'0'Vj g'to c'n'c'p'f'ut'g'u'u'e'q'p'h'k'p'g'f'ncugt/g'p'g'ti { 'f'g'r'q'uk'k'p'lp'vj g'v'c't'i g'v'g'f 'r'ct'v'eng'ku'p'g'g'f'gf.'v'q "  
i'g'p'g't'c'v'g'c'p'lp'v'g't'p'c'n'r'g'u'w'g't'y'c'x'g'q't'c'eq'w'w'le'y'c'x'g'0'h'c'ew'g'ec'p'q'ee'w't'y j gp'vj g'v'p'uk'g'h'q't'eg'q'h'vj g'c'eq'w'w'le'y'c'x'g'g'z'eg'g'f'u "  
vj g'eq't'g'ur'q'p'f'k'pi 'h'o'k'v'q'h'vj g'r'ct'v'eng'0'Vj cv'ec'p'd'g'c'h'g'ev'g'f'd { 'vj g'k'p'h'w'g'p'eg'q'h'vj g'w'ug'f'ncugt'r'w'ng'g'p'pi vj . 'cu'y'k'j 'uj'q't'v't "  
g'p'pi vj 'e'c'p'd'g'p'q'v'g'f'c'p'lp'et'g'c'ug'q'h'r'ct'v'eng'ht'c'ew'g'0'Vj ku't'g'r'v'k'p'uj k'r'j' cu'ku'h'o'ku'y j gp'vj g'c'eq'w'w'le'y'c'x'g'e'q'p'h'k'p'go gpv'v'o'g "  
ku'h'q'pi g't'vj'c'p'vj g'r'w'ng'g'p'pi vj 'j5\_0''

O quv'eq'o o g't'el'cm'f'c'x'c'k'c'd'ng'ncugt'u'g'z'eg'n'c'v'522/822'r u'0'k'p'q'w't'uw'f { . 'y'g'c'lo'gf'v'q'k'p'x'g'u'ki'c'v'g'vj g'h'c'ug't/v'ku'w'g'lp'v'g't'c'v'k'p'u "  
q'h'c'r'le'q'ugeqpf 'f qo clp'P'f'< CI 'ncugt.'vj cv'ec'p'i'g'p'g't'c'v'g'372'r u'r'w'ng'u'c'p'f'g'p'g'ti'k'u't'c'p'i'k'pi 'w'r'v'q'472'o L'c'p'f'342'o L'h'q't "  
3286'c'p'f'754'p'o 'y'c'x'g'r'g'p'pi vj . 't'g'ur'g'v'k'x'g'n'0'Vj w'u'r'q'x'k'f'k'pi 'k'p'uki'j'v'k'p'uj'q't'v't'r'w'ng'g'h'h'c'ee { 'c'p'f'uch'g'v'f'lp'vj g'w'ug'h'q't'vcw'q'q "  
r ki o gpv'ht'c'i o gpv'v'k'p'0'Vj g'g'h'g'ev'q'h'372'r u'w'nt'c'uj'q't'v'r'w'ng'u'y'g't'g'p'q'v'ew'tt'g'p'w'f'f'g'u'et'k'd'g'f'.'c'p'f'vj g'c't'g'c'y'cu'c'd'ug'p'v'q'h'k'p "  
x'k'q'c'p'lo'c'n'uw'f'k'u'vj cv'eq'w'f'q'h'g't'f'g'c'v'v'c'p'ur'v'k'p'c'n'x'c'w'g.'y j gp'lp'v'g't'r'g'v'k'pi 'uw'f { 't'g'u'w'u'ht'q'o'c'p'lo'c'n'v'q'j'wo'c'p'0'h'q't'vj'cv "  
t'g'cu'q'p.'vj'ku'uw'f { 'y'cu'r'g'h'q'to'gf'q'p'c'lp'x'k'q'r'q't'el'k'p'g'o'q'f'g'nt''

Cu'g'z'eg'u'k'x'g'g'p'g'ti { 'f'g'r'k'x'g't'g'f'v'q'vj g'w'r'g't'h'el'c'n'uw'k'p'ec'p'ng'c'f'v'q'd'rk'v'g't'k'pi . 'r'q'm'p'i'gf'j'g'c'k'p'i . 'u'ew'tt { k'pi'c'p'f'ej'c'p'i'g'k'p "  
r ki o gpv'v'k'p'j6\_'k'v'k'i'ko' r'q't'v'c'p'v'v'q'r'v'o'k'g'vj g'h'w'g'p'eg'q'h'vj g'ncugt'g'p'g'ti { 0'k'o'r'c'ev'q'h'f'k'h'g't'g'p'v'h'w'g'p'el'g'u'h'q't'uk'f'g'h'g'ev "  
f'g'x'g'r' o gpv'c'p'f'r'ki o gpv'ht'c'i o gpv'v'k'p'g'h'h'c'ee { 'y'g't'g'k'p'x'g'u'ki'c'v'g'f'q'p'f'k'h'g't'g'p'v'eq'm't'vcw'q'q'q'h'hp'q'y'p'r'ki o gpv'v'eq'o'r'q'uk'k'p'0 "  
Vj'ku'j'cu'd'g'g'p'ec'tt'k'g'f'q'w'd { 'ej'c'p'i'k'pi'vj'g'y'c'x'g'r'g'p'pi vj . 'ur'q'v'v'k'g'c'p'f'r'w'ng'g'p'g'ti { 'q'h'vj'g'h'c'ug't'0'Vj'g'vcw'q'q't'go'q'x'c'n'y'cu'c'p'c'n' { gf "  
w'ul'p'i'ek'p'le'c'n'o'c'et'q'ue'q'r'le'g'z'c'o'k'p'c'v'k'p'v'k'c'ue'q'r { +c'p'f'j'k'w'q'ej'go'k'm't { 0'

aa  
j3\_0'V'q't'd'gem'N'0'U'ej'k'k'p'i . 'j'0'm'j'q't'c'uc'p'k'10'f'q'x'g't'g'v'c'r'o'G'x'q'w'k'p'q'q'h'vj g'R'eq'ugeq'p'f'N'cugt'<C'T'g'x'k'g'y'q'h'N'k'g't'c'w'g'0'f'g'to'c'v'q'r'q'i'le'U'w'i'067\*4+3: 56; 6 "  
\*423; +0''

j4\_'Q'0'T'g'k'g't.'N'0'c'v'j'q'p'f'.'N'0'c'ng'to'c'p'.'C'N'g'x'k'g'v'c'r'o'R'le'q'ugeq'p'f'ncugt'u'ht'vcw'q'q't'go'q'x'c'n'c'v'u'g'ungo'c'v'e't'g'x'k'g'y'0'N'cugt'u'0'gf'U'ek'j'k'p'v'g't'p'g'v'53\*9+35; 966270 "  
C'x'c'k'c'd'ng'ht'q'o'<j'w'r'<l'f'z'f'q'k'q't'i' B208229'k'32325/238/4223/2\*4238+0

j5\_'F'0'Y'w.'O'R'0'I'q'f'c'p'.'J'0'Y'c'v'g'v'c'r'o'c'U'f'ungo'c'v'e'U'g'x'k'g'y'q'h'R'le'q'ugeq'p'f'N'cugt'lp'f'g'to'c'v'q'r'q'i { <G'x'k'f'g'p'eg'c'p'f'T'g'eq'o'g'p'f'c'v'k'p'u'0'N'cugt'u'U'w'i "  
O'gf'0#O'c't'ej'+3663\*4242+0''

j6\_'Y'0'D'0'x'o'ng't'0'N'cugt'V't'g'c'v'o'gpv'q'h'V'cw'q'q'<D'c'ule'R't'l'p'ek'r'ng'u'0'E'w't'R't'q'd'n'f'g'to'c'v'q'r'q'i { "74< 66326\*4239+0''

# ALLELOPATHIC ACTIVITY OF INVASIVE PLANT CANADIAN GOLDENROD (*SOLIDAGO CANADENSIS* L.)

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Canadian goldenrod (*Solidago canadensis* L.) is one of the most successful and widespread invasive plant species in the world. Native to North America, it was introduced to Europe as an ornamental plant and rapidly spread throughout almost all of Europe and other parts of the world including China, Japan, Taiwan as well as Australia, New Zealand [1]. As other alien plants, *S. canadensis* causes negative effects on natural ecosystems, which affect biodiversity and native species communities [2].

In 2004 *S. canadensis* among other 17 plant species was listed as invasive to Lithuania. The rapid spread of the plant is determined by several reasons. Firstly, plant has broad climatic tolerance. In addition, it is tolerant to wide range of soil fertility, texture conditions and soil pH. Other important aspect is plant lifecycle and dispersion. *S. canadensis* is a perennial rhizomatous hemicryptophyte and spreads via seeds and underground rhizomes. Plant has relatively long flowering time (from late July to mid-September and sometimes until October) and one sprout of Canadian goldenrod can mature more than 10 000 or even up to 20 000 seeds per season [3]. Seeds are essential for long-distance dispersal and the colonisation of unoccupied sites. However, for the expansion of established populations rhizomatous growth is substantial. Individual clones are long lived (can reach an age of 100 years) and spreads fast with each year.

On the other hand, invasion success of Canadian goldenrod may be determined by its allelopathic compounds. It is known, that allelochemicals can be obtained from varied parts of the plant (leaves, stems, flowers, buds, fruits and roots) and can affect seed germination and root formation, as well as the growth of the whole plant: membrane conductivity, chlorophyll production, photosynthetic activity, etc. The allelopathic effect of the *S. canadensis* on other plants has not been studied very widely. Thus, it is important to identify allelopathic compounds and its role in the spread of invasive species.

The aim of the present study was to determine the activity of leaf/stem extracts of the Canadian goldenrod to seed germination and seedling growth. Under laboratory conditions allelopathic properties of acidic, neutral and alkaline fractions were tested on Lettuce (*Lactuca sativa* L.) and Garden pepper cress (*Lepidium sativum* L.) seeds. Inhibitory allelopathic effect was established. The effect of leaf/stem exudates were the most active at neutral fraction and at tested concentration inhibited lettuce seed germination up to 100 %. Neutral fraction in all relative concentrations (1.0; 0.1; 0.01) has shown highest inhibitory effect. It suppressed growth of *L. sativa* (from 0 to 2.3 mm in comparison to 22.7 mm in control) and *L. sativum* (from 0.5 to 16.8 mm in comparison to 35.3 mm in control) (Fig. 1). Seven potentially allelopathically active compounds have been identified.

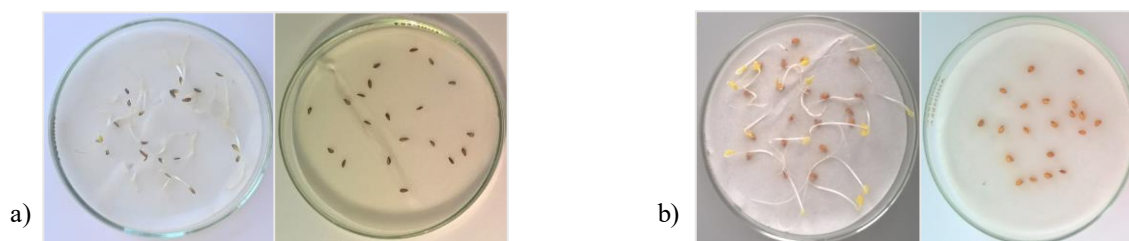


Fig.1. Growth of model objects a) *Lactuca sativa* and b) *Lepidium sativum* in control solution and in neutral leaf/stem extract of Canadian goldenrod

[1] Wang C., Xiao H., Zhao L., Liu J., Wang L., Zhang F., Shi Y., Du D. 2016. The allelopathic effects of invasive plant *Solidago canadensis* on seed germination and growth of *Lactuca sativa* enhanced by different types of acid deposition. *Ecotoxicology*, 25: 555–562.

[2] Gudžinskas Z., Kazlauskas M., Pilate D., Balalaikins M., Pilats M., Šaulys A., Šaulienė I., Šukienė L. 2014. Lietuvos ir Latvijos pasienio regiono invaziniai organizmai. Vilnius, BMK leidykla. p. 8–16; 52–53.

[3] [http://www.am.lt/V1/article.php3?article\\_id=17545](http://www.am.lt/V1/article.php3?article_id=17545)

**CPCNI UKU'QHEKTEWNCVPI 'O KTPC'NGXGNU'K'DNQGF'QHY QO GP'  
F KCI PQUGF 'Y KJ 'I GUVCVKQPCN'F KCDGVGU'**

I cdtlgn 'F | ko ktexk k v<sup>3</sup>. 'Mtkwpc'F cpk pckv<sup>3</sup>

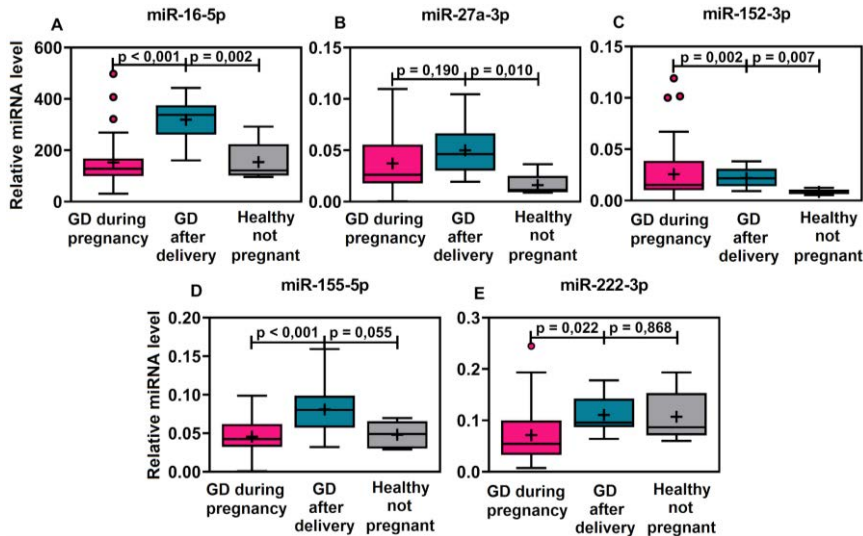
<sup>3</sup>Kpukwq'qh'Dkuekgpegu. Nkkg'Uekgpegu'Egpygt. 'Xkpkwu'Wpkxgtukf. 'Xkpkwu. Nkij wcpk'  
i cdtlgn'f | ko ktexkewgB i o eXw0n'

" I guvcvkpcn'f kcdgvu'o grkwa<sup>3</sup> F +ku'c'ej tqple'j { rgti n'ego k'f kci pqugf 'f wtkpi 'y g'4pf 'vko gwgt'qh'r tgi pcpv' } J3\_0' F gur kg'ij g'v'gpf gpe{ "vq'f kucr r gct'chgt'f grkxgt { "y g'r t'gxcnpeg'qh'ij ku'f kugcug'ku'eqpucpvn' 'i tqy kpi "kp'Nkij wcpk'cpf" y qtrf y kf g'cpf 'eqttgrcvu'y kj 'ij g'v'r g'4'f kcdgvu'o grkwa<sup>3</sup>V4F +cu'I F 'ecwugul'j ki j gt'tkum'qh'V4F 'hqt'ij g'o qy gt'cpf 'j gt' ej kf "J4. '5\_0'Vj gt'ghqtg. 'k'ku'ko r q'wcpv'v'q'gwelk'cvg'o qrgewrt'dkqo ctngtu'hqt'ij g'tkum'gxcnvcvkp'qh'dqy 'I F 'cpf "V4F" f g'xgnr o gp'0

" Cu'gr ki gpgwke'cngtcvkpu'uj qy "i t'gcv'r g'ur ge'v'x'gu'cu'ns w'f /dkru { "dkqo ctngtu' } J6. "ij g'c'ko "qh'ij ku'uwf { "y cu'vq" cpcn' | g'8'ugrgev'f "o letq'TP Cu'6'o kT/38/7r. "o kT/49c/5r. "o kT/374/5r. "o kT/377/7r. "o kT/444/5r. "cpf "o kT/73: f/7r "6' kp'y j qn' /dqf' uco r rgu'qh'y qo gp'f kci pqugf 'y kj "I F 'cpf "v'cuuqekcv'ij go 'y kj "en'p'le'cn'I F 'kpf lecvqtu'0"

" Kp'v'q'cn'78'y qo gp'\*6; "f kci pqugf 'y kj "I F 'cpf "9'j genj { "r tgi pcpv'y qo gp'+y gtg'k'p'nm'f g'f "kp'ij g'uwf { "cpf "32: " uco r rgu'y gtg'v'g'w'f 0'Dm'q'f "uco r rgu'y gtg'v'c'ngp'cv'4664: "y ggmu'qh'i guvcvkp'ij "p"? "5; +. 'cv'8634'y ggmu'chgt'f grkxgt { "p"? " 34+. 'cpf "cuq'ht'qo "ij g'wo dk'le'cn'ct'v'gt { "p"? "48+'cpf "x'g'k'p'ij "48+0'Vj g'ugrgev'f "o kTP Cu'y gtg's wcp'v'k'g'f "d { "o g'cpu'qh' s wcp'v'k'v'x'g'RET'wulpi "Vcs O cp/dcug'f "cuuc { u'chgt'f'x'g'tug'v'c'puet'k'v'k'p'ij TV+qh'cm'io kTP Cu'0

" J ki j gt'co qwpv'qh'o kT/38/7r. "o kT/374/5r. "o kT/377/7r 'cpf "o kT/444/5r 'y gtg'f g'v'g'ev'f "kp'ij g'dm'q'f "qh'I F 'y qo gp' chgt'f grkxgt { "eqo r c'tgf "v'q'ij g'i guvcvkpcn'f g'k'q'f "cm'r ">"2027+0C'nuq. "j ki j gt'rg'x'gn'qh'o kT/38/7r. "o kT/49c/5r 'cpf "o kT/ 374/5r 'y gtg'f g'v'g'ev'f "kp'ij g'dm'q'f "qh'I F 'y qo gp'chgt'f grkxgt { "cu'eqo r c'tgf "v'q'ij genj { "pqv'r tgi pcpv'y qo gp'cm'r ">"2027± Hki 03+0'Vj g'o kTP C'rg'x'gn'f k'f "pqv'f k'ht'g' d'gy ggp'ij g'I F 'cpf "p'q'p/I F 'y qo gp'kp'dm'q'f "f wtkpi 'i guvcvkpcn'f g'k'q'f "cm'r "@ 2027+00 kT/73: f/7r 'y cu'f g'v'g'ev'f "q'pn' "kp'dm'q'f "ht'qo "ij g'wo dk'le'cn'ct'v'gt { 0'Vj g'co qwpv'qh'o kT/38/7r 'kp'I F 'y qo gp'f wtkpi " i guvcvkpcn'f g'k'q'f "y cu'cuuqekcv'f 'y kj "dq'f { "o cu'k'p'f g'z' d'gh'q't'g'r tgi pcpv' { "y j kg'o kT/49c/5r 'cpf "o kT/377/7r "eqttgrcv'f " y kj "r'ncuo c'i n'equg'rg'x'gn'cm'r "@2027+0H'w'ij g'to q'tg. "ij g'dm'q'f "rg'x'gn'qh'o kT/377/7r 'chgt'f grkxgt { "y cu'cuuqekcv'f 'y kj " y qo gp'au'ci g'r " "20239+'cpf "ko k'rt'v'g'p'f g'p'el'gu'y gtg'q'dug'x'g'f "tgi c'tf kpi "o kT/38/7r 'cpf "o kT/444/5r 'kp'dm'q'f "ht'qo "ij g' w'o dk'le'cn'x'g'k'p'0



**Hki 030E**qo r c'tk'up'qh'o kTP C'dm'q'f "rg'x'gn'c'o qpi 'I F 'y qo gp'f wtkpi 'i guvcvkpcn'f g'k'q'f. 'I F 'y qo gp'chgt'f grkxgt { " cpf 'j genj { "pqv'r tgi pcpv'y qo gp'0C'6'o kT/38/7r. 'D'6'o kT/49c/5r. 'E'6'o kT/374/5r. 'F'6'o kT/377/7r. 'G'6'o kT/444/ 5r 0'Vj g'o k'f f'ng'rk'p'g'kp'ij g'dqz'6'o g'f k'cp. " - "6'o g'cp. "v'q'r "cpf "dqwqo "rk'p'gu'qh'ij g'dqz'6'o'97" " cpf "47" " s w'ct'v'kgu" \*t'gur ge'v'x'gn' +. "y j kum'gu'6'o czko wo "cpf "o k'plo wo "x'c'w'gu. "f'q'u'/"q'w'k'g'tu'0"

" Vj ku'uwf { "uj qy g'f "x'ct'k'w'cuuqekcvkpu'dgy ggp'ij g'rg'x'gn'qh'cpcn' | g'f "o kTP Cu'kp'ij g'dm'q'f "qh'I F 'y qo gp'cpf" ij g'k' "en'p'le'cn' k'p' lecvqtu. " k'p' lecv'k'pi "ij g'k' "r q'v'p'k'cn' hqt" I F " cpf " V4F " f kci pqug'f "cpf " I " qt" r tqi p'q'ku'0' J qy g'x'gt. " eqo r t'gi g'p'uk'g'uwf k'gu'k'p'rti gt'eqj q'tu'c'tg'p'gg'f g'f "v'q'x'c'k'f'cv'g'ij g'ug'o kTP Cu'cu'r q'v'p'k'cn'I F "dkqo ctngtu'0"

J3\_ T0F kpi "gv'cn'0'k'v'gi t'cv'f "v'c'puet'k'v'qo g'ugs w'p'elpi "cpcn'uku't'g'x'gn'c'u'q'ng'qh'o kT/35: /7r I'VDN3Z "kp'r r'ceg'p'v'ht'qo "i guvcvkpcn'f kcdgvu'o grkwa'0 Egnwrt'Rj { uk'q'ni { "cpf "D'k'q'ej go k'ut { 0423: -73%+8520'  
J4\_ LOT r -ckv "gv'cn'0'E'q'p'p'g'v'k'p'qh'i guvcvkpcn'f kcdgvu'cpf "o g'v'cd'q'le'uf'p'f tqo g'co qpi "y qo gp'f kci pqug'f 'y kj "ij guvcvkpcn'f kcdgvu'o q'tg'ij cp'37'f g'ctu' ci q'0M'v'p'cu'Nkij wcpk'p'Wpkxgtukf'qh'ij genj "u'ek'g'p'eu'042390'  
J5\_ U0F ku'gv'cn'0' q'rgewrt'Dkqo ctngtu'ht'I guvcvkpcn'f kcdgvu'0 grkwa'0'k'p'gt'p'c'v'k'p'cn'I'q'w'p'cn'qh'0' q'rgewrt'U'ek'g'p'eu'0423: -3; \*32+4; 480'  
J6\_ E0X0'E'q'q'ct'g'u'gv'cn'0'k'p'v'k'k'p' "eqo o q'p'cpf "ur g'ek'le'o letq'TP Cu'g'z'r t'g'w'g'f "kp'r g'k'r j g't'cn'dm'q'f "o q'p'p'w'g'c't'eg'm'q'ih'v'r g'3. "v'r g'4. "cpf "i guvcvkpcn'f kcdgvu'o grkwa'r'v'k'p'p'u'0'DO E'T'g'ug'c'ej "P'q'v'u'04235-8-6; 30"



**GXCNWCVP I 'QH'VY Q'GNKUC'CUUC[ U'RP 'MJ CTMKX'QDNCUV''**

Uxgvpc'Qj kqpm<sup>3,4</sup>. 'Tqo cp'Vtqmj {o ej wni<sup>3</sup>. [ wkk 'kej gpm<sup>4</sup>. 'P cf kk \ qmvtqxc<sup>4</sup>"

<sup>3</sup>Tugctej 'kpwkwg'qh'Dkqmj { . 'XOP 0Mctc| kp'Mj ctnkx'P cvkpcn'Wpkxgtukv\ . 'Wntckpg"

<sup>4</sup>Nko kgf 'Ncdkxv' 'Eqo rcp { 'ëO GF [ EJ P [ KVUGP VT \ F QTQXKì . 'Wntckpg"

qj kqpm(UxgvpcB i o ckrqo "

Kp'vj g'o qf gtp'r cpf go le'ukwcvkp. 'vj g'o clp'qdlgevkg'ku'uy kh'cpf 'eqttgevf kci pquku'qh'UCTU/EqX/40Vj ku'ku'guugpvcn' kuuwg. 'gur gekm' 'hqt'gr kf go kqmj lecn'ukwcvkpu'kp'dki 'ekkgu'y j gtg'xk wu'ektewrcvgu'kp'j wi g'f gpukv' 'qhr' gqr rg'0K'uj qwr' 'dg' pqvgf. 'vj cv'cpvi gple'vguu'qh'xktcn'r tqvqpu'ctg'ej gcr gt'cpf 'hcvgt' 'vj cp'o qrgewrt'f kci pquku'Wntckpg'cu'c'f gxgnr kpi " eqwvt { "j cu'ugxgtcn'vuv'u{ ugo u. 'y j lej 'y gtg'ugr ctvvgf "kpvq'r quv'Uqxlgv. 'cpf "GW'vcf g'eqwvtkgu'ppgu'0Vj g'cko "qh'vj ku' kpxguki cvkqp" ku" vq" eqo rctg" cp" kp/j qwug" u{ ugo " \*GNKUC" Xktqvgu" UCTU/EqX/4+ " cpf "GNKUC'nk'P qxcNkuc'Ì "UCTU/EqX/40'kpxguki cvkqp'y gtg'ecttkgf "qvw'qp'vj g'r cvkcpu'qh'Mj ctnkx'qdruv'0"

Dmqf 'uco r ngu'r qukkxg' hqt 'EQXKf /3; 'y gtg'eqmgevfg 'htqo 'u{ o r vqo cve'r cvkcpu'y j q'eco g'v'vj g'go gti gpe { 'tqo " qh'O gf lecn'egpvt 'ëO GF [ EJ P [ KVUGP VT \ F QTQXKì 0Rcvkcpu'y gtg'eqpukf gtgf 'r qukkxg'ceeqt' kpi 'vq'vj g't guwmu'qh' vj g's wcpvkvkxg' t gxtug' 't cpuetr vqp/r qn{ o gtcug'ej clp' t gcvkqp " \*T V/s RET -0' Dmqf "uco r ngu'y gtg'eqmgevfg 'lp' ugt wo " eqmgevqp'wdgu' \*DF 'Xcewclpgt' UUV'Kcf xcpvg. 'DF. 'Rn{ o qwj . 'WM-0Y g'gxcnvcvgf 'y q'eqo o gtelecn'GNKUC' hku'GNKUC' Xktqvgu'UCTU/EqX/4" \*KI . "KO + \*M{ kx. 'Wntckpg. 'j gtg'chgt'ecmgf "öXktqvguö-" cpf "P qxcNkuc'Ì "UCTU/EqX/4" \*KI . " KO + \*P qxcVgeÌ . "F lgv' gpdcej . "I gto cp { . "j gtg'chgt'ecmgf "öP qxcNkuc'0' Hqt " gcej "GNKUC" nkx. "pgi cvkxg" cpf "r qukkxg" eqpvtqm'y gtg'cuugugf "cpf "uweguuhwm' "r cuugf 0'kqepennukxg'GNKUC' t guwmu'y gtg'eqpukf gtgf 'cu'pgi cvkxg' hqt "ucvkvlecn' cpcn'uku'0Uki pkk'ecpv'cuuqekv'kpu'dgy ggp'xctkdr'u'y gtg'ugctej gf 'wukpi 'ej k/us wctg'v'guv' \*qt' Hkij gt'au'gz'cev'v'guv'v'q' r t gxp'v' qxgtguko cvkqp'qh'ucvkvlecn'uki pkk'ecpeg' hqt "uo cni'f cv'ugvu+ "cpf "f gvgto kpcv'kqp'qh'ci t ggo gpv'tcvg'cpf "Eqj gp'au' Mcr r c0' Vj g'uki pkk'ecpeg'vj tguj qn' 'y cu'ugv'cv'r < '2070'

Eqpvtqm'uwdlgevu'v'guv'f "pgi cvkxg' hqt "UCTU/EqX/4" cpv'kdf lgu'y kj "cni'v' q' u{ ugo u'0'Gu'ko cvgf "ugpukxk'kku'xctk'gf " htqo "94.7"vq"; 30' "hqt" KI "f gvev'kqp'cpf "htqo "82.8"vq": 40' "hqt" KO "f gvev'kqp'0' Hqt" KI . "Xktqvgu'cpf "P qxcNkuc' f kur r { gf "846920' "ci t ggo gpv'y kj "qvj gt' u{ ugo u'0'k'v'gto gvj qf "ci t ggo gpv' hqt "KO "f gvgto kpcv'kqp' y cu'dgy ggp "52" cpf " 940' 0' Eqo r ctluqp' qh' vy q' u{ ugo u' hqt " UCTU/EqX/4" KI " cpf " KO " cpv'kdf lgu' uj qy gf " ugpu'kxk'v' " cpf " qxgtcni' eqpvt'f cpeg'0"

Vj g'qdcv'kpgf 't guwmu'cmqy "wukpi "kp/j qwug' u{ ugo "vq'f gvev'kqp'qh'eqt'qpcxk' wugu' lph'ge'v'kqp' UCTU/EqX/4' eqtt'ge'v'f 0"

Vj g'cwj qt u'ctg'i tcvghw'v'q' cni'r gt'uppu'y j q'eqpvt'kdwg' hqt "eqmgevpi "o cvgt'kci'0"

**PCVWTCN'TGRGNNGPVUHQT'O GCNY QTO '\*TENEBRIO MOLITOR'NO'  
NCTXCG''**

I cdtkgn 'Dwo dwnf v<sup>3,4</sup>. 'Xkpecu'D f c<sup>3</sup>

<sup>3</sup>Vj g'P cwtg'Tgugctej 'Egptg.'Nedqtcvqt { 'qh'Ej go kecn'cpf 'Dgi cxkqwtcn'Geqrqi { . 'Xkpkwu'

<sup>4</sup>Xkpkwu'Wpkxgtuks' 'Nkg'Uekgpegu'Egptg.'Xkpkwu'

i cdtkgn'Qdwo dwnf vGB i o ckrteqo . "

"

"

Vj g'wug'qh'kpugeu'hqt'hqf 'j cu'cwtcevgf 'kpetgculpi 'kpxtgu'kp'tgegpv' { gctuo'kpugeu'cu'o gcnv qto u'\*Vgpgdtkq'o qrkqz'NO'  
o c { 'tgr tgu'p'v'cp'cngt'p'v'k'g'lwte'g'qh'f' t'v'g'k'p'u'c'p'f 'b letq'p'w't'k'p'u'e'q'o r ctgf 'q'eq'p'x'g'p'v'k'p'c'ri'b gcv'lwte'g'u'0'k'k'u'x'g't { 'ko r q't'v'p'v'  
v'q'k'p'et'g'c'ug'v'j g'g'h'g'e'v'k'g'p'g'u'q'h'v'j g'eq'm'g'e'v'k'p'q'h'k'p'uge'v'rt'x'c'g'd'k'q'o cu'k'p'q't'v'j g'k'p'uge'v'd't'g'g'f'g't'u'0'Q'p'g'q'h'v'j g'r qu'k'd'k'k'k'g'u'eq'w'f "  
dg"v'j g'o c'p'k'w'v'k'p'q'h'k'p'uge'v'rt'x'c'g'd'g'j cxkq't'w'k'p'i 'p'c'w't'c'n't'g'r g'ng'p'w'0'k'p'r t'g'x'k'q'u'u'w'w'f'g'u'y g'h'q'w'p'f'v'j cv'o gcnv qto "rt'x'c'g'  
j cxg'v'j g'w't'q'p'i gu'v't'g'r g'ng'p'v'g'h'g'e'v'q'p'"O'g'p'v'j c'ur'k'ec'w'"NO'c'p'f' "Vj { o w'u'x'w'i c't'k'i'NO'g'u'g'p'v'k'c'n'q'k'u'0'V'j w'u.'v'j g'q'd'l'g'e'v'k'g'q'h'v'j k'u'  
y q't'n'y cu'q'f'g'v't'o k'p'g'v'j g'g'h'g'e'v'q'h'g'u'g'p'v'k'c'n'q'k'u'"\*O'0'w'k'ec'w'"c'p'f' "V0'x'w'i c't'k'i"e'q'o r q'w'p'f' u'h'q't' b' gcnv qto u'0'V'j g'd'g'j cxkq'w't'c'n'  
g'z'r g't'k'o g'p'v'y cu'f'g't'q't'o g'f' 'k'p'c'R'g'v'k'f'k'j 'w'k'p'i 'd'g'j cxkq'w't'c'n'c'u'c { 0'N'c't'x'c'd'g'j cxkq'w't'y cu't'g'e'q't'f'g'f' 'c'p'f' b' q'p'k'q't'g'f' 'd' { 'c'eq'o r w'g't'  
r t'q'i t'c'o "o" G'v'j q'X'k'k'p' "Z V"34" \*P' q'f' w'u.'v'j g'P' g'v'j g't'c'p'f' u'0'D'g'j cxkq't'y cu't'g'e'q't'f'g'f' "h'q't"7"o k'p'w'g'u'c'p'f' "32"t'g'r n'k'c'v'k'p'u'y g't'g'  
r g't'h'q't'o g'f' 'y k'j "g'c'ej 'v'j g'b qu'v'c'd'w'p'f' c'p'v'g'u'g'p'v'k'c'n'q'k'u'le'q'o r q'w'p'f' 0'H'k'g'ur' q'u'q'p'c'R'g'v'k'f'k'j 'u'k'f'g'y g't'g'c'r r n'g'f' 'y k'j 'v'j g'g'u'g'p'v'k'c'n'  
q'k'u'le'j go kecn'le'q'o r q'w'p'f' "4 n'g'c'ej .32 n'v'q'c'n'0'V'j g't'g'u'w'u'v'j q'y g'f' 'v'j cv'v'j g'b qu'v't'g'r g'ng'p'v'c'e'v'k'g'le'q'o r q'w'p'f' 'h'q't'v'j g'o gcnv qto "  
rt'x'c'g'y cu'ect'x'q'p'g.'c'e'v'k'g'c'v'eq'p'eg'p't'c'v'k'p'u'q'h'32'c'p'f' "322"b' O'0"

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# I GP G'GZRTGUUKQP'CP CN[ UKU'QHJ KUVQP G'O GVJ [ NCVKQP" CUUQEKVGF 'I GP GU'K'RTQUVCVG'VWO QTU"

I tgv'O gkf w<sup>3</sup>.T v'O cngenkv<sup>3</sup>.Mkukpc'F cpk pckv<sup>3</sup>0

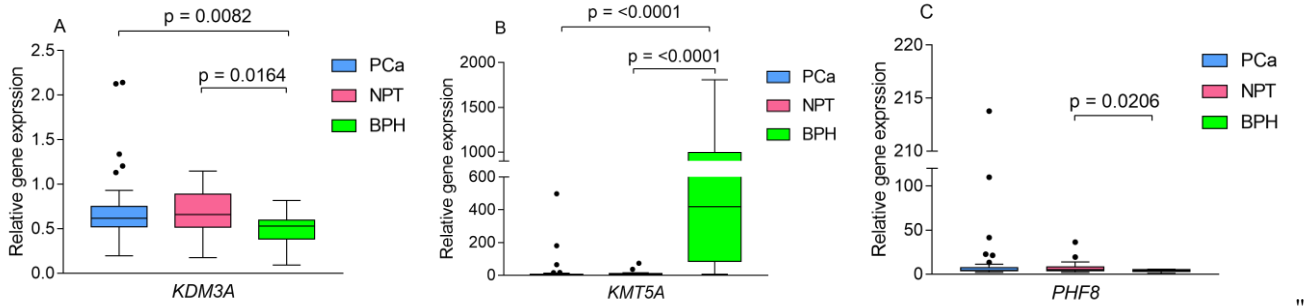
<sup>3</sup>J wo cp'I gpqo g'Tgugctej 'I tqwr. 'Kpukwag'qh'Dkquekpegu. 'Nkq'Uelkpegu'Egpgvt. 'Xkpkwu'Wpkxgtukf. 'Xkpkwu.'Nkj wcpk'  
i tgv(O gkf wgb i o eDwaf OXwO)

Rtquvcg'ecpegt\*'REc+'ku'y'g'o quv'r tgcxcpv'v'f'g'qh'o crg'ecpegt'cpf 'y'g'7vj 'rgcf kpi 'ecwug'qh'f'g'cv' 'kp'o' crgu'y'kj 'ecpegt' y' qtrf y' kf g'lp'4242'J3\_0C'rci'g'r' tqr'qt'v'kp'qh'REc'ku'rcv'p'v'cpf 'f'g'u'pq'v'v'g'p'f'v'q'r' tqi' tguu. 'y' j'gt'g'u'q'y' gtu'ct'g'ci' i' tguukx'g'cpf 'uki' p'k'le'cp'v'f' 'ch'ge'v' 'y' g' r'k'g'w' 's' wkv'f' O'Vj' g't'g'ht'g'. 'k' 'ku' 'qh' 'j' 'k' 'j' 'ko' r'qt'v'p'eg'v'q' 'kf' g'p'v'k'f' 'y' 'j' 'k' 'j' 'REc' 'ecugu' p'gg'f' 'ko' o' g'f' k'v'g' v'g'c'v'o' g'p'v' 'y' 'j' 'k' 'g' 'q' 'y' gtu'eq'w'f' 'w'p'f' g'ti' q' 'c'v'k'x'g' 'u'w'x'g'm'p'eg'0'Rtquvcg'ur' g'ek'h'k' 'c'p'v'k' g'p' \*RUC+'u'et'g'p'k'p'i' 't'g'o' c'k'p'u'cu'c' 'r' t'k'o' c't' { 'o' g'v' q'f' 'h'q' 'REc' 'f' k'ci' p'qu'k'u' = 'j' q'y' g'x'g't. 'k' 'r'c'emi' 'ur' g'ek'h'k'f' 'h'q' 't' 'q'y' g't' r' t'quvcg' 'f' k'ug'c'ug'u. 'u'w'ej' 'cu' 'd'g'p'k'i' p' 'r' t'quvcg' 'j' { 'r' g't'r' r'u'k'e' \*DRJ '+' 'c'p'f' 'ec'p' 'q'h'g'p' 'r'g'c'f' 'v'q' 'h'c'ng' 'r' q'u'k'x'g' 't'g'u'w'u' 'c'p'f'. 'kp' 'w't'p'. 'w'p'p'g'g'g'u'c't' { 'v'g'c'v'o' g'p'v' O' q't' g'q'x'g't. 'k' 'r'c'emi' 'r' t'qi' p'qu'k'e' 'x'c'w'g' J4\_0' C'd'p'q't'o' c'h' 'e'j' c'p'i' g'u' 'lp' 'i' g'p'g' 'z'r' t'g'u'k'q'p' 'c'p'f' 'g'r' k'i' g'p'g'v'k'e' 't'g'i' w'v'k'q'p' 'c't'g' 'h'w'p'f' c'o' g'p'v'c'i' 'lp' 'c'p'f' { 'w'o' q't' 'v'f' r' g' 'c'p'f' 'r'g'c'f' 'v'q' 'y' g' 'f' g'x'g'r' o' g'p'v' 'c'p'f' 'h'w'v'j' g't' r' t'qi' t'g'u'k'q'p' 'q'h' 'REc' 'cu' 'y' g'm'f' J5\_0' C'ng't'g'f' 'j' k'v'q'p'g' 'o' g'v'j' { 'r'v'k'q'p' 'ku' 'q'p'g' 'q'h' 'y' g' 'e'j' c't'c'v'g't'k'u'k'e' 'h'g'c'w'g'u' 'f' w't'k'p'i' 'e'c't'el'p'q'i' g'p'g'u'k'u. 'y' 'j' 'k' 'j' 'o' c' { 'd'g' 'f' w'g' 'v'q' 'c'ng't'g'f' 'z'r' t'g'u'k'q'p' 'q'h' 't'g'i' w'v'v'q't' { 'i' g'p'g'u. 'r'k'ng' 'j' k'v'q'p'g' 'n' 'u'k'p'g' 'o' g'v'j' { 'n't' c'p'u'h't'g'c'ug'u' \*MO' V'u'+'c'p'f' 'f' g'o' g'v'j' { 'r'c'ug'u' \*MF' O' u'+'O'Vj' g't'g'ht'g'. 'j' k'v'q'p'g' 'o' g'v'j' { 'r'v'k'q'p' 't'g'i' w'v'v'q't'u' 'o' k' 'j' 'v' 'd'g' 'w'k'k'f' g'f' 'cu' 'g'h'g'v'k'x'g' 'd'k'q'o' c't'ng't'u' 'h'q't' 'o' q't'g' 'c'ee'w't'c'v'g' 'f' k'ci' p'qu'k'u' 'c'p'f' 'e'j' c't'c'v'g't'k' 'c'v'k'q'p' 'q'h' 'REc' O'

Vj'g'c'k'o' 'q'h' 'y' 'k'u' 'u'w'f' { 'y' 'cu' 'v'q' 'c'p'c'n' | 'g' 'y' 'g' 'z'r' t'g'u'k'q'p' 'q'h' 'MF' O' 5C. 'MF' O' 7F. 'MO' V7C' 'c'p'f' 'RJ' H: '\*c'0'0'0' MF' O' 9D+' 'i' g'p'g'u' c'u'q'ek'v'g'f' 'y' 'k'j' 'j' k'v'q'p'g' 'o' g'v'j' { 'r'v'k'q'p' 'lp' 'r' t'quvcg' 'w'o' q't'u' 'c'p'f' 'e'q'p'w'q'n' 'u'c'o' r' n'g'u' 'c'u' 'r' q'v'g'p'v'c'i' 'd'k'q'o' c't'ng't'u' O'

Kp' 'y' g' 'r' t'g'ug'p'v' 'u'w'f' { '.86' 'REc'. '47' 'p'q'p'ec'p'eg't'q'w'u' r' t'quvcg' 'v'k'u'w'g'u' \*P' RV+' 'c'p'f' '38' 'DRJ' 'u'c'o' r' n'g'u' 'y' g't'g' 'c'p'c'n' | 'g'f' 'h'q't' 'i' g'p'g' 'z'r' t'g'u'k'q'p' O'Vj' g' 'v'k'u'w'g' 'u'c'o' r' n'g'u' 'y' g't'g' 'e'q'ng'e'v'g'f' 'lp' '422: /4236' 'f' w't'k'p'i' 'y' g' 'r' t'g'x'k'w'u' 'r' t'q'l'g'ew' O' H'k'u'v' 'v'q'v'c'i' 'g'z't'c'v'g'f' 'TP' C' 'y' 'cu' 'w'ug'f' 'h'q't' 'y' g' 'u'f' 'p'v'j' g'u'k'u' 'q'h' 'e'q'o' r' n'g'o' g'p'v'c't' { 'F' P' C' O'Vj' g' 'r'w'g't' 'y' 'cu' 'w'ug'f' 'h'q't' 's' w'c'p'v'k'v'k'x'g' 'i' g'p'g' 'z'r' t'g'u'k'q'p' 'c'p'c'n' | 'u'k'u' 'd' { 'o' g'c'p'u' 'q'h' 't'g'c'n' 'v'k'o' g' 'RET' \*s' RET+' O'

Vj'g' 't'g'u'w'u' 'q'h' 'q'w' 'u'w'f' { 't'g'x'g'c'g'f' 'f' k'h'g't'g'p'eg'u' 'lp' 'y' g' 'z'r' t'g'u'k'q'p' 'q'h' 'u'g'g'v'g'f' 'i' g'p'g'u' c'u'q'ek'v'g'f' 'y' 'k'j' 'j' k'v'q'p'g' 'o' g'v'j' { 'r'v'k'q'p' 'lp' 'REc' 'cu' 'e'q'o' r' c't'g'f' 'v'q' 'P' RV+' 'c'p'f' 'DRJ' O'Vj' g' 'z'r' t'g'u'k'q'p' 'q'h' 'MF' O' 5C' 'lp' 'w'o' q't'u' 'c'p'f' 'P' RV' 'y' 'cu' 'j' 'k' 'j' g't' 'y' 'c'p' 'y' 'c'v' 'lp' 'DRJ' \*r' '?' '202: 4' 'c'p'f' 'r' '?' '202386. 't'g'u'r' g'v'k'x'g' 'n' '+' 'd'w' 'k' 'f' 'k' 'f' 'p'q'v'f' k'h'g't' 'd'g'y' g'p'g' 'REc' 'c'p'f' 'P' RV' \*r' '@202722=H'i' 0'3C+' O' 'MO' V7C' 'y' 'cu' 'j' 'k' 'j' n' 'z'r' t'g'u'g'f' 'lp' 'DRJ' 'cu' 'e'q'o' r' c't'g'f' 'v'q' 'd'q'j' 'REc' 'c'p'f' 'P' RV' \*d'q'j' 'r' '>' '20223=H'i' 0'3D+' 'y' 'j' g't'g'c'u' 'RJ' H: 'j' 'c'f' 'i' g'p'g't'c'm'f' 'n'q'y' 'z'r' t'g'u'k'q'p' 'lp' 'c'm' 'u'c'o' r' n'g'u. 'p'g'x'g't' 'y' g'g'u'u. 'k' 'y' 'cu' 'u'k'i' p'k'le'c'p'v'f' 'f' k'h'g't'g'p'v' 'd'g'y' g'p'g' 'P' RV' 'c'p'f' 'DRJ' \*r' '?' '202428=H'i' 0'3E+' O' 'P' q' 'c'u'q'ek'v'k'p'u' 'y' g't'g' 'h'q'w'f' 'd'g'y' g'p'g' 'MF' O' 5C. 'MF' O' 7F. 'MO' V7C' 'c'p'f' 'RJ' H: 'z'r' t'g'u'k'q'p' 'c'p'f' 'r' 'c'v'k'p'v'w' 'c'i' g. 'r' t'quvcg' 'o' c'u' 'u'g't'w'o' 'RUC' 'r'g'x'g'u. 'w'o' q't' 'u'c'i' g' 'q't' 'd'k'q'ej' g'o' k'ec'n'f' k'ug'c'g' 't'g'ew't'g'p'eg' \*c'm'r' '@202722. 'p'q'v'uj' q'y' p+' O'



H'i' 03' T'g'r'v'k'x'g' 'z'r' t'g'u'k'q'p' 'r'g'x'g'u' 'q'h' 'i' g'p'g'u' 'MF' O' 5C+' \*C+' 'MO' V7C' \*D+' 'c'p'f' 'RJ' H: '\*E+' 'lp' 'r' t'quvcg' 'w'o' q't'u' \*REc+' 'p'q'p'ec'p'eg't'q'w'u' r' t'quvcg' 'v'k'u'w'g'u' \*P' RV+' 'c'p'f' 'd'g'p'k'i' p' 'r' t'quvcg' 'e'j' { 'r' g't'r' r'u'k'e' \*DRJ '+' 'u'c'o' r' n'g'u'

Kp' 'e'q'p'ew'k'q'p. 'q'w't' 'c'p'c'n'f' 'u'k'u' 't'g'x'g'c'g'f' 'f' 'u'k'i' p'k'le'c'p'v'f' k'h'g't'g'p'eg'u' 'lp' 'y' g' 'z'r' t'g'u'k'q'p' 'q'h' 'MO' V7C. 'MF' O' 5C' 'c'p'f' 'RJ' H: 'i' g'p'g'u' 'lp' 'r' t'quvcg' 'v'k'u'w'g'u. 'y' 'j' 'k' 'j' 'u'w'i' 'i' g'u'v' 'y' g'k' 'r' q'v'g'p'v'c'i' 'w'k'k'f' 'h'q't' 'k'o' r' t'q'x'g'f' 'REc' 'f' k'ci' p'qu'k'u' O'J' q'y' g'x'g't. 'y' g'k' 'r' t'qi' p'qu'k'e' 'x'c'w'g' 'y' 'cu' 'p'q'v'f' g'v'g't'o' k'p'g'f' O' C' f' k'k'q'p'c'n' l'p'x'g'u'k'i' c'v'k'q'p' 'lp' 'r'c't'i' g't' 'l'p'f' g'r' g'p'f' g'p'v'eq' q't'w' 'u'k'u' 'p'g'g'f' g'f' 'h'q't' 'h'w'v'j' g't' 'g'w'v'k'f' c'v'k'q'p' 'q'h' 'y' g' 't'q'g' 'q'h' 'j' k'v'q'p'g' 'o' g'v'j' { 'r'v'k'q'p' 't'g'i' w'v'v'q't' { 'i' g'p'g'u' 'lp' 'REc' O'

J3\_ 'I' n'q'd'e'n' 'Ec'p'eg't' 'Q'd'ug't'x'c'v'q't' { = } w'r' u'd'li' e'q'0'c't'e'0'r' \*Y' q't'r'f' 'J' g'c'n'j' 'Q't'i' c'p'k'v'k'q'p. 'H'ic'p'eg' '4243+' O'  
J4\_ 'Z' O' H'k'ng'm'. 'G' O' H'g't'p' 'p'f' g'l' /I' c'n'p'. 'T' O' H'g't'p' 'p'f' g'l' 'D'q'p'l'k'c'el'q'. 'N' O' H'q'l' O' G'o' g't'i' k'p'i' 'd'k'q'o' c't'ng't'u' 'lp' 'y' g' 'f' k'ci' p'qu'k'u' 'q'h' 'r' t'quvcg' 'ec'p'eg't' O' R'j' c't'o' c'e'q'i' g'p'q'o' k'u' 'c'p'f' "R'g't' u'q'p'c'i'k'f' 'O' g'f' k'ek'p'g'. '33. ': 56; 6' \*423: 40'  
J5\_ 'U'U'W'Y' k'm'c'f'. 'U'W'q'q'ej' g'n'r' q'w't' O' T' g'i' w'v'v'q't'u' 'q'h' 'i' g'p'g' 'z'r' t'g'u'k'q'p' 'cu' 'd'k'q'o' c't'ng't'u' 'h'q't' 'r' t'quvcg' 'ec'p'eg't' O' C'o' g't'k'ec'p' 'L'q'w't' p'c'n' 'q'h' 'Ec'p'eg't' 'T'g'ug'c't'ej'. '4' \*8+' '8426879' \*4234+' O'

**GXCNCVKQP'QH'CPVRECP EGT'CEVKKV[ 'QH'MKP CUG'KP J KDKVQTU'KP''  
O F C/O D/453'DTGCUV'ECPEGT'EGNN'NKP G''**

Rcwlpk' "Mo cky<sup>3</sup>. 'Gricu' O ceekpk<sup>4</sup>. 'Xkm c' Rgvtknek<sup>3</sup>. "

<sup>3</sup>Ncdqtcvqt { 'qh'F twi 'Veti gu'J kuxr cvj qmri { . 'Kpukwng'qh'Ectf kqri { . 'Nkj wcpkcp'Wpkxgtuk{ 'qh'J gcni 'Uelgpegu.'  
Nkj wcpkcp''

<sup>4</sup>F gr ctvo gpv'qh'Nhg'cpf 'Gpxkqpo gpvni'Uelgpegu.'Wpkxgtuk{ 'qh'Eci rctk'Kcn{ "  
xkm cr gvtknkkgB i o cktfgo

"

Dtgcuv'ecpegt'ku'vj g'o quv'eqo o qp'v'r g'qh'f kci pqugf 'o crki pcpelgu'cpf 'vj g'ugeqpf 'rgcf kpi 'ecwug'qh'ecpegt'f gcvj 'kp' y qo gp'ctqwpf 'vj g'y qtrf 'J6\_0Vtkr rg/pgi c'v'xg'dtgcuv'ecpegt''VP DE+'ku'ej ctcevgtk gf 'd { 'vj g'ci i tguukg'pcwt g'cpf 'rcen'qh' vti gvgf 'vj g'tcr lgu.'y j lej 'tguwnu'lp'xgt { "rko ksf "v gcvo gpv'qr v'kpu"]7\_0'Rtqvgk'npkug'ctg't gur qpukrg'hqt "tgi wcvkpi " f khtg'gpv'egm'wct'hwpev'kpu.'uwej 'cu'r tqktg'cvkqp.'egmle { erg.'cr qr v'quku.'o qv'kks{ . 'f khtg'gpv'k'v'kpu'00 cp { 'u'w'f lgu'j c'xg'uj qy p' " c'ecwucn'tqng'qh'r tqvgk'npkug'f { ut gi wcv'kpu'qt'o wcv'kpu'lp'f khtg'gpv'j wo cp'f kugcugu.'kpen'f kpi 'ecpegt']3\_0'Qxgt'47" npkug'kpj kdkqtu'ctg'cr r tqxgf 'cu'cpv'ecpegt'f twi u']4\_0'Qpg'qh'vj go 'ku'wv'kpkpd.'y j lej 'ku'wv'g' 'v'g'v'nc'v'nk'pg { 'ecpegt'cpf " i c'ut'q'k'p'v'g'uk'p'ri'ut'qo c'ri'wo qtu']5\_0'

Vj g'clo 'qh'q'w'uwf { 'y cu'v'g'xcn'w'v'vj g'cpv'ecpegt'ce'v'kks{ 'qh'p'gy 'u'wv'kpkpd'cpcni wgu'qp'VP DE'egm'npk'g'O F C/O D/4530''

O cvgt'kcn'cpf 'o gvj qf u'0Gzr g'tko gpw'y gtg'r gthqto gf 'qp'j wo cp'egm'npk'g'O F C/O D/453039'npkug'kpj kdkqtu.'y j lej " ctg'wv'kpkpd'cpcni wgu.'j c'xg'dggp'v'gungf 0Vj gug'cpcni wgu'y gtg'u'p'vj guk'gf 'cv'vj g'Wpkxgtuk{ 'qh'Eci rctk'Kcn{ . 'cpf 'vj gk' u'p'vj guk'cpf 'ej ctcevgtk'cvkqp'y cu'r wdrkuj gf 'J8\_0Vj g'gh'ge'v'qh'npkug'kpj kdkqtu'qp'egm'x'kcd'kks{ 'y cu'g'xcn'w'v'g'f 'd { 'O VV' cuuc { 'chgt'94'j qwtu'qh'k'pew'cv'kqp'0H'ut'v'y g'ug'rg'ev'f 'vj g'o quv'ce'v'xg'npkug'kpj kdkqtu'vj cv'tgf wegf 'egm'x'kcd'kks{ 'w' 'v'q'7' " qt'rgu'0Vj gp'vj g'GE72'xcn'w'v'qh'vj g'o quv'ce'v'xg'eqo r qwpf u'y gtg'g'v'cd'kuj gf 'cpf 'eqo r ctgf 'v'q'vj g'wv'kpkpd'ce'v'kks{ 0' Eqo r qwpf 'ce'v'kks{ 'qp'dtgcuv'ecpegt'egm'cd'kks{ 'v'q'v' ki tcw'y cu'g'zco k'p'gf 'wukpi 'ukpi ng'egm'v'ceni'kpi 'cuuc { 0Vj ku'g'zr g'tko gpv' y cu'r gthqto gf 'qp'c'ur gekri'ko ci kpi 'f'kuj 'y kj 'c'i tkf 0Egmu'y gtg'uggf gf 'cv'c'ny 'eqpegp'v'cv'kqp'lp'vj g'f'kuj . 'v'q'i gv'72/92" egm'lp'v'q'ri'qp'c'i tkf 'ctgc0Egmi'y gtg'cm'y gf 'v'q'c'w'cej 'q'xgt'p'ki j v'cpf 'vj gp'vj g'v'q'w'v'k'p'u'y kj 'v'gungf 'eqo r qwpf u'lp'c'it'g'uj " o gf kwo 'y gtg'cf'f'gf 0K'ci gu'qh'vj g'o ki tcv'kpi 'egm'y gtg'v'cngp'cv'q'p'g'j qw'k'p'v'g'x'cm'hqt'": 'j qwtu'd { 'wukpi 'cp'k'p'xgt'v'g'f " o let'que'qr g'0Ukpi ng'egm'y gtg'v'cengf 'cpf 'vj g'egm'o ki tcv'kqp'f'k'nc'peg'y cu'o gcuw'gf 0Vj gp'vj g'c'xgt'ci g'egm'o ki tcv'kqp' xng'ekv' { 'y cu'ec'w'v'v'g'f 0'

Tguwnu'0M'npkug'kpj kdkqtu'3.'8.'9.'. 'cpf '39'y gtg'vj g'o quv'ce'v'xg'q'p'gu'0Co qpi 'v'gungf 'eqo r qwpf u.'y j g'eqo r qwpf '3" r qu'gungf 'vj g'i tgc'v'g'v'gh'ge'v'qp'egm'x'kcd'kks{ '\*GE72'xcn'w'v'chgt'94'j "qp'O F C/O D/453'y cu'95083'0'709" O +0O quv'qh' vj g'q'vj gt'eqo r qwpf u'tgf wegf 'ecpegt'egm'x'kcd'kks{ 'cv'vj g'eqpegp'v'cv'kqp'u'tcpi kpi 'ht'qo '392'v'q'822'p'0'0Cm'v'gungf 'wv'kpkpd' cpcni wgu'y gtg'o qtg'ce'v'xg'vj cp'wv'kpkpd'0Cnuq.'v'gungf 'eqo r qwpf u'tgf wegf "vj g'O F C/O D/453'egm'o ki tcv'kqp'0'Vj g' eqo r qwpf '8.'q'p'g'qh'vj g'o quv'ce'v'xg'q'p'gu.'kpj kdkgf 'dtgcuv'ecpegt'egm'o ki tcv'kqp'd { 'cd'q'w'4: ' 'eqo r ctgf 'v'q'vj g'eq'p'v'q'ri'0'

Eqpen'w'k'p'u'0'V'gungf "npkug'kpj kdkqtu'r qu'gung'cpv'ecpegt'ce'v'kks{ "qp'v'kr ng/pgi c'v'xg'dtgcuv'ecpegt'egm'npk'g'0'Vj g' { 'tgf wegf 'vj g'x'kcd'kks{ 'cpf 'kpj kdk'o ki tcv'kqp'qh'egm.'cpf 'o c { 'dg'y qt'vj { 'hqt'hw'vj gt'uwf lgu'0'

"

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[3\_10'Elegpcu.'G0' cni'v'g.'C0Dektqej 'gv'c'ri'0'M'npkug'cpf 'Ecpegt.'Ecpegtu.'32\*5+'85'\*423: +0'  
[4\_00I tqau.'T0T'ej cn'P'0U'ct'p'ni' { 'gv'c'ri'0'V'cti gv'kpi 'ecpegt'y kj 'npkug'kpj kdkqtu.'L'E'np'k'p'x'g'u'0'347\*7+39: 26; '\*4237+0'  
[5\_] 0J cq.'k'0U'ef gm'U'wv'kpkpd'v'j g'cp'v'kpi kpi g'p'le'gh'ge'w'cpf 'dg'q'p'f.'Q'p'eq'v'cti gu'v'j gt0: <76; 76727'\*4238+0'  
[6\_]C'10T'gf ki . 'U'00 eC'nk'ugt.'Dtgcuv'ecpegt'cu'c'uf'ungo le'f'kugcug'<'x'kgy 'qh'o g'v'c'v'c'ku'0L'k'p'v'g't'p'0'gf . '496\*4+335648'\*4235+0'  
[7\_]M'0C { u'q'ic.'C'0F'g'uck'E'0Y'g'raj 'gv'c'ri'0'V'k'r ng'P'gi c'v'xg'Dtgcuv'Ecpegt'o'c'p'Q'xgt'x'kgy . 'J' gt'gf kct { 'I' g'p'g'0'4235\*U'w'r n'4+<223'\*4235+0'  
[8\_]T'0O'g'ng'f'w.'X'0'R'g't'k'nek'g.'U'0F'k'p'v'q'gv'c'ri'0'k'p'x'g'ni'k'v'kpi 'vj g'C'p'v'ecpegt'Ce'v'kks{ 'qh'k'c'v'p'IF'k'j { 'f'q'r { 'tc'q'ng'J' { 'dt'k'f' u.'CE'U'0'gf'k'ep'ci'E'j'go'k'ut' { " Ngw'gtu.'32.'6.'7936798'\*423; +0'

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**IO RCE V'QH'Y CVGT'VT CP URQT V'QP'Y CVGT'EQWTUGU'Y K'J "**  
**RANUNCULION'XGI GVCVKQP '6'J CDK'CV'VJ RG'5482'QH'GWTQRGCP "**  
**IO RQTVCEP'EG"**

Nkvelc'Mco ckl v /Dwngnunkp <sup>3</sup>. 'Lwti kc'Dwmxklp <sup>4,5</sup>. 'F qpcvu'P cwi flgo { u<sup>6</sup>"

<sup>3</sup>"Ncdqtcvqt { "qh'Hrqt"cpf "I gqdqcp { .P cwtg'Tgugctej 'Egptg.'Nkj wcpk"  
<sup>4</sup>"K'vukwq'qh'Dkuelgpegu.'Nkg'Uelgpegu'Egptg.'Xkpkwu'Wpkgtukf . 'Nkj wcpk"  
<sup>5</sup>"Dqvcplecni' ctf gp.'Xkpkwu'Wpkgtukf . 'Nkj wcpk"  
rkvelc@dwngnunkp@B i co ve@v"

F wtkpi 'y g'r gtlqf 'qh'uwo o gt'tkgtu'ctg'lpvgpukxgn' 'wugf 'hqt'rgkwtg'cevxklgu'wej 'cu'nc { cnkpi 0Vj g'o quv'pq'legcdrg"  
ko r cev'qh'wej "y cvgt'vcpur qtv'ku'c"o gej cplecni'f kuwtdcpeg'qh'cs wvke'r rcpvu'\*ew'qhi'y g'hny gtu'cpf "Hvku'+cpf "y gk"  
j cdkcu' \*ecwukpi "y g"gtqulqp"qh' tkxgdgf " cpf " ceewo wvklp"qh' ugf ko gpvu'lp" tkxgt" qpuj qtg-0 Y cvgt" eqwtugu" y kj "  
Tcwpewkqp'hwkcpki'cpf "Ecnktkej q/Dcvcejkqp"xgi gcvkqp'6'j cdkcv'v' r g\*J V+qh'Gwtqr gcp'ko r qtvcepeg'5482'ku'qpg'qh'  
y g'j cdkcv'v' r gu'y cv'ku'ugpukxg'v'nc { cnkpi "ecwugf "f kuwtdcpegu'0K'tgs vktgu'ur gekni'c'wvklp."dgecwug'ku'uawckpcdkk'  
tgrv'gf "pqv' qpn' " y kj " uwr r qtv' qh' v' r lecn' gpv'kqpo gpv'ni' eqpf kklpu" \*fcu' eqwtug. "ny " vgo r gtcwv'gu. " eqctug" dqwqo "  
ugf ko gpvu'+dw'cnq'y kj "y g'lp'hwepg'qh'cpvj tqr qi gple"cevxklgu'0Vj g'Tcwpewmu'ugev'0Dcvcejkwo "cu'c'ng { "xgi gcvkqp"  
eqo r qpgp'qh'y gug'j cdkcu'ctg'cv'tkunid { 'tgcup'qh'lpetgculpi 'j wo cp'cevxklgu."gpv'kqpo gpv'ni' qmwkqp."cpf 'tgetgcvkqp'  
Vj g'uwwf { "lpxguk' cvgf "y g"ko r cev'qh'f kuwtdcpeg'f v'g"v'nc { cnkpi "lp'7" Nkj wcpkcp'tkxgtu'qh'37"gzr gtko gpv'ni'hwg' u'  
cpf "7"eqp'v'q'hwg' u'0K'gcej 'hwg'. 'y g'ur gelgu'eqo r quksqp'qh'y g'r rcpvu'cpf "y gk'eqxgt"\*ceeqtf kpi "v'y g'Dtcwp/Drcps wgv'  
uecrg'+cpf "y g'v'q'v'eqxgt'qh'cnlr rcpvu'\* +y g'g'cuugugf 0'

Vj g'uwwf { "uj qy gf "y cv'nc { cnkpi "ku'o quv'lp'vgpug"lp'y g'o qpvj u'qh'Lw' "cpf "Cwi wv'y j gp" Tcwpewmu"ur gelgu'ctg"  
hny gtlpi "qt'r tqf wtkpi "y g'cej gpgu'0Y g'eqwf "cnq'hw' "c'pgi cvkxg"eqtgrvklp"dgw ggp'y g'pwo dgt'qh'nc { cmi'cpf "y g"  
cdw'pf cpeg'qh'Tcwpewmu'r rcpvu'lp'qwt'gzr gtko gpv'ni' rqu'0K'cf f kklp.'nc { cnkpi "o qxgu'ugf ko gpvu'y cv'ceewo wv'v'cnqpi "  
y g'tkxgt'u'dcpmu.'hceklcvkpi 'y g'gucdrkuj o gpv'qh'uj cf g/v'rgt'cpv'r rcpvu.'hng'lp'xcukxg'Graf gc'ecpcf gpuk'0'  
Vj ku'tgugctej 'ku'hw'pf gf "d { 'i tcpv'pq'0U/UK/42/3'htqo "y g'Tgugctej 'Eqwpeki'qh'Nkj wcpk'0'

**F G V G T O K P C V K Q P ' Q H D K Q N Q I K E C N N [ ' C E V K X G ' E Q O R Q W P F U C P F ' K U ' T C F K E C N ' U E C X G P I K P I ' C E V K X K V [ ' K P ' C A N N A B I S S A T I V A ' N O ' O Q T R J Q N Q I K E C N ' R C T V U ' K x c " c m e k v <sup>3.5</sup> . ' C n i k o c p v ' M w p f t q v c k v <sup>4.5</sup> . ' M e t q r k p e ' D e t c w u n e k v <sup>5</sup> "**

"  
<sup>1</sup> M w p c u ' W p k x g t u k v { ' q h ' V g e j p q r n i { . ' H e w m { ' q h ' E j g o l e c n ' V g e j p q r n i { . ' F g r c t w o g p v ' q h ' R q n { o g t ' E j g o k u t { ' c p f ' V g e j p q r n i { . ' M w p c u ' N k j w c p k ' "   
<sup>4</sup> X { w w c u ' O c i p w u ' W p k x g t u k v { . ' H e w m { ' q h ' P c w t c n ' U e l g p e g u ' F g r c t w o g p v ' q h ' D k q n i { . ' M w p c u ' N k j w c p k ' "   
<sup>5</sup> N k j w c p k c p ' T g u g c t e j ' E g p v t g ' h q t ' C i t l e w m w t g ' c p f ' H q t g u t { . ' K p u k w w g ' q h ' C i t l e w m w t g . ' N k j w c p k ' "   
K x c ( E c m e k g B m o o e O n )"

"  
 H d t g ' j g o r " \* E c p p e d k u ' u c v k x c ' N O ' k u ' y j g ' p q p / V J E / r t q f w e l p i ' u r g e k u ' q p g ' q h ' y j g ' q n f g u v e t q r u ' e w n k x c v g f ' c n i q x g t ' y j g ' y q t r f "   
 v q ' r t q f w e g ' h d t g . ' h q q f ' r t q f w e w ' c p f ' d k q o c u u ' y j l e j ' k u ' l e j ' k p ' d k q n i l e c m { ' c e v k x g ' e q o r q w p f u ' j 3 \_ O V j g t g ' c t g ' o c p { ' u q w e g u ' c d q w '   
 j g o r u g g f ' e q o r q u k k q p ' c p f ' p w t k k q w u p g u u ' k p ' x c t k q w u ' f c v d c u g u . ' d w ' q y j g t ' r c t w ' q h ' y j k u ' r n p v ' u g o . ' h g c x g u ' c p f ' k p h n t g u e p e g u ' "   
 y g t g ' p q v l p x g u k i c v g f ' c u ' b w e j O U c o r n g ' h u v ' c p f ' x g i g v c k q p ' u n c i g l p x g u k i c v g f ' k p ' y j k u ' u w f { ' r t g u g p v g f ' k p ' c d n g ' 3 0 R t g x k q w u ' u w f k g u '   
 f k f ' p q v ' g z r n q t g ' f h h g t g p e g u ' k p ' c m l r c t w ' q h ' y j g ' r n p v ' c p f ' j q y ' y j g ' s w c p v k { ' q h ' r q n { r j g p q n e ' e q o r q w p f u ' c p f ' h x x q p q k f u ' e j c p i g '   
 k p ' x c t k q w u ' x g i g v c k q p ' u n c i g u ' V j g t g h q t g . ' g z r g t k o g p w u ' y j l e j ' e c p ' j g r ' v q ' h p f ' q w w ' j q y ' f h h g t g p v f g p u k { ' q h ' r n p w \* 3 7 ' r n p w u ' r g t '   
 u s w e t g ' o g v g t ' c p f ' : 2 ' r n p w u ' r g t ' u s w e t g ' o g v g t + l p h n g p e g u ' d k q n i l e c m { ' c e v k x g ' e q o r q w p f u ' c e e w o w e v k q p ' k p ' x c t k q w u ' r c t w ' q h ' y j g '   
 r n p v . ' y g t g ' r g t h q t o g f O ' k p f w u t k e n ' j g o r u ' h t q o " u r c t u g " c t g c " c e e w o w e v g f " u n k i j w { " j k i j g t " c o q w p v ' q h ' d k q n i l e c m { ' c e v k x g '   
 e q o r q w p f u ' y j c p ' y j g ' q p g ' y j l e j ' i t g y ' w r ' w p f g t ' f g p u g t ' e q p f k k q p u O "

V e d r g ' 3 0 U c o r n g u ' c p f ' k p f w u t k e n ' j g o r ' x g i g v c k q p ' r j c u g u ' c v ' j c t x g u k p i ' k o g ' j 4 \_ "

"	3u'j' ctxguv'	4pf'j' ctxguv'	5tf'j' ctxguv'	6vj'j' ctxguv'	7vj'j' ctxguv'	8vj'j' ctxguv'
6y' hqch'r' ckl'"	I X'r' qkpv."	Hgo cng'hny gt"	Dgi kppkpi 'qh'	Ngch'	Ugo "	
Ej cpi g'qh'	hqt o c'kq p' "	uggf 'o cwt k'v' .	f guleec'kq p' "	f guleec'kq p' "		
r j { nqczk'k'q p"	" "	" "	" "	" "	" "	" "
y j g' o c'k p' u g o "	" "	" "	" "	" "	" "	" "
h t q o ' q r r q u k g "	" "	" "	" "	" "	" "	" "
v q ' c n g t p c v g " "	" "	" "	" "	" "	" "	" "
Ugo "	- "	- "	- "	- "	- "	- "
Ngcxgu"	- "	- "	- "	- "	- "	- "
Kphntguepegu"	/"	/"	/"	- "	- "	- "

H t q o ' r t g x k q w u ' u w f k g u ' k ' y c u ' n p q y p ' y c v t c f l e c n ' u e c x g p i k p i ' c e v k x k v { ' f k g e w l ' e q t t g r v g u ' y k j ' p w o d g t ' q h ' j { f t q z { n i t q w u '   
 j 5 \_ ' E a p u g s w g p w { . ' k ' e c p ' d g ' c u u w o g f ' y j c v ' y j g ' o q t g ' r j g p q n e ' e q o r q w p f u ' c t g ' h q w p f ' k p ' g z v c e v ' y j g ' j k i j g t ' t c f l e c n ' u e c x g p i k p i '   
 c e v k x k v { ' u j q w f ' d g O k p ' y k u ' t g u g c t e j . ' y j k u ' u c v g o g p v ' j c u ' d g g p ' r t q x g p ' d { ' w u k p i ' u n k i j w { ' o q f h k g f ' D t c p f / Y k r k c o u . ' E w x g r k g t ' c p f ' "   
 D g t u g y b g y j q f " \* 3 ; ; 7 + 0 V j g ' g z v c e v ' e c r c d k k v { ' v q ' d n g e j ' F R R J ' h t g g ' t c f l e c n i t q n w k q p ' y c u ' g u k o c v g f ' w u k p i ' y j g ' h q n y k p i ' h q t o w e <   
 k p j k k k k p " \* + ? " \* C D / C G + C D + " " 3 2 2 "   
 y j g t g ' C D ' o ' c d u q t r v k p ' q h ' d r e p n i u c o r n g . ' v ? ' 2 o k p . ' C G ' o ' c d u q t r v k p ' q h ' v g u g f ' g z v c e v ' v ? ' 5 2 o k p O '   
 C m ' o g c u w t g o g p w u ' y g t g ' e c t t k g f ' q w w u k p i ' u r g e v t q r j q v q o g w k e ' c p c n { u k u O '   
 "

j 3 \_ F O h h q t k p k ' C O O q n g . ' O O P c d k u k ' I O U c p v k p ' I O D g p n k ' c p f ' H O O c i i k ' X c n q t k k p i ' k p f w u t k e n ' j g o r " \* E c p p e d k u ' u c v k x c ' N O ' d { / r t q f w e w < E c p p e d k k q n i '   
 g p t l e j o g p v k p ' y j g ' l p h n t g u e p e g u ' g u g p v k r i q k i q r v o k k p i ' u c o r n g ' r t g / t g e v o g p v r t q t ' v q ' f k n k n e v k p . ' k p f O E t q r u ' R t q f O ' x q r 0 3 4 : . ' p q O Q e v d g t ' 4 2 3 : . ' r r O '   
 7 : 3 6 7 : ; . ' 4 2 3 : O '   
 j 4 \_ X O O g f k c x k n e . ' O O l q p s w g t e . ' K U e j o k f / U g o d t q w e m ' c p f ' C O U q r f c k ' F g e l o c n e q f g ' h q t ' i t q y y ' u c i g u ' q h ' j g o r . " I q w t p e r i q h ' y j g ' k p g t p e v k p e n j g o r "   
 C u u e k v k p . ' 3 ; ; : O '   
 j 5 \_ Q O R O U j c t o c ' c p f ' ' V O M O D j c v ' F R R J ' c p v k z k f c p v ' c u u c { ' t g x k u k g f . ' H q q f ' E j g o O ' x q r 0 3 3 5 . ' p q 0 6 . ' r r 0 3 4 2 4 6 3 4 2 7 . ' 4 2 2 : O ' "

**RQUV/GZVTCEVKQP 'UKVG'Y QWPF 'J GCNPI 'WUPI 'RNCVGNV/TKEJ /  
HKTQ'K'FQI U'**

**Kpftg\ cnkpgg<sup>3</sup>. 'I kvctg\ kmckkg<sup>4</sup>. 'Lwq| cu' tki cu<sup>3</sup>. 'Ctpqrf cu' Rcwkgpkwu<sup>3</sup>. 'Lwf kc\ { o cpvkpgg<sup>3</sup>'**

<sup>3</sup>F gr ctvo gpv'qh' Cpcvqo { 'cpf 'Rj { ukqni { . 'Nkj wcpkcp 'Wpkxgtuk\ 'qh'J gcmj 'Uelgpegu. 'Nkj wcpkcp "

<sup>4</sup>Uo cmicplo cn'ekple. 'Nf 'XgvRgv'NV. 'Nkj wcpkcp "

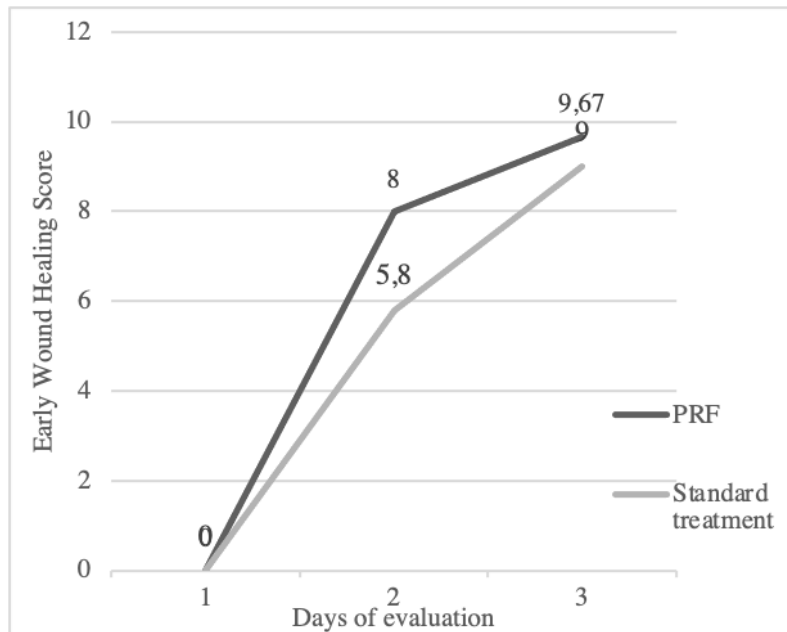
**kpf tg0 cnkpggB no v0v'**

**Kpvt qf wevkqp0** Rgtkqf qpvcn'f kugcug'ku'qpg'qh'yj g'o quveqo o qp"eqpf kkkp'lp'f qi u'cpf 'f gpvcn'gzvcevkqp'ku'wuwcmf " tgs wktgf "j3\_0'Rrcvgrv'tlej "hdtkp" \*RTH'o go dtepgu'ctg'y kf gn' 'cpf "uweeguuhwm' "wugf "kp'yj g'qtcn'uwti gt {"qh'j wo cpu0 Rrcvgrv'tlej /hdtkp"o go dtepg'eqpvckpu" c "hdtkp" o cvtk'y kj "rgwnqe { vgu. 'gt { yj tqe { vgu. 'r rcvgrvu. 'D'cpf "V'n { o rj qe { vgu. " o qpqe { vgu. 'ungo "egm'cpf 'i tqy yj 'rcvqtu'y j lej 'r tqxkf gu'dgwtg'cpf 'rcvgt'kuuug'tgi ppgtcvki "j4\_0'Hcuvgt'y qwpf 'j gcrkpi " j gr u'vq'tgf weg'yj g'co qwpv'qh'pqpugtqkf cn'cpv'kph'co o cvqt { 'f twi u'cpf 'o cngu'i ppgtcn'eqo hqt'vht' yj g'f qi 0"

**O gvj qf u0** Enpkrcn'eqpf kkkp'cpf 'r gtrkqf qpvcn'f kugcug'uci g'y g'g'xgcncv'gf "kp'yj g'i tqwr "qh'33'f qi u'yj cvj cf "pq'cp { " qvj gt "ej tqple'f kugcug'0'Vj g'f qi u'yj g'g'ur nk'lp'y q' i tqwr u'p3? 8=p4? 7+<'yj g'r tqegf wtg'qh'vqqy "gzvcevkqp"cpf "wug'qh' r rcvgrv'tlej "hdtkp"p3? 8=p4? 7+<'yj g'r tqegf wtg'qh'vqqy "gzvcevkqp"p4? 7+0"

Rtqegf wtg' qh' enqugf " f gpvcn' g'z'vcevkqp" y cu' o cf g' wpf gt" i ppgtcn' cpcguj gukc'0' Qtcn' ecxk\ " y cu' ergcpgf " y kj " ej nqtj gzkf kpg"204' " uqnvkqp'0'Y j qrg' dnuqf "uco r ng" \*7' o n' y cu' eqmgev'gf "htqo " ucr j gpqwa' xgk'lp'vq' yj g'vgtkrg' wdg" y kj qw'cpv'eqci wrcp'0'Y D'uco r ng' y cu' egpvtkwi gf "qp"4622"tr o . "34"o kp0"722"i 0'Chgt'ugr ctcv'kqp'cpf "eqo r tguukp. " RTH'o go dtepg'y cu'r w'cpf "hkcvgf "kp'yj g'c'rkqgrt'y qwpf "qh'yj g'htuv'i tqwr "f qi u'p3-0'0 wequcn'hr' y cu'etgev'gf "cpf " uwwtgf "vq'enqug'yj g'y qwpf 0'Chgt'yj g'r tqegf wtg'yj g'tguwn'qh'Gctn' 'Y qwpf "J gcrkpi "Ueqtg" \*GY J U+"j5\_ 'cpf "Rckp'Ueqtg" j6\_ y g'g'xgcncv'gf "qp'yj g'htuv'yj ktf 'cpf 'ugxgp'yj 'f c { 'chgt'yj g'r tqegf wtg'0"

**T guwnu0Vj** g'cxgtci g'qh'GY J U'chgt'5'f c { u'y cu'uki pkkcpcv'nf "dki i gt'kp'yj g'i tqwr "p3?: . 'r >2027'y j g'g'r rcvgrv'tlej " hdtkp" y cu' wugf. "eqo r ctkpi "vq'yj g'i tqwr "p4? 70. 'r >2027' \*Hki 0'3+0'Vj g'uco g'tguwn' dw'y kj "c'rguu'eqpv'cu' dgy ggp" i tqwr u. 'y cu' hqwpf "chgt'9'f c { u'p3? ; 089. 'p4? ; . 'r >2027+0'Vj g'cxgtci g'qh'Rckp'Ueqtg'kp'yj g'htuv'i tqwr "y kj "r rcvgrv'tlej " hdtkp" y cu'uo cngt'eqo r ctkpi "vq'yj g'ugeqpf "i tqwr "kp'yj g'3uv' \*p3? 20 5. 'p4? 306. 'r >2027+' cpf "5tf "p3? 2089. 'p4? 208. 'r >2027+' f c { u'qh'g'xgcncv'kqp'0'Q'p'yj g'9'yj 'f c { 'y g'tguwn' y cu'pqp/uki pkkcpcv'nf "dqj 'i tqwr u0"



**Hki 030E**qo r ctkuqp'qh'U'c'p'f ctf "Vtgcwo gpv'cpf "RTH'v'g'cwo gpv'qh'yj g'c'rkqgrt'y qwpf. 'Gctn' 'Y qwpf "J gcrkpi "Ueqtg" y g'g'eqw'p'v'gf 0"

**E qpenukqp0** RTH'o c { "dg" c' wughwn'vqni'lp' r quv'gz'vcevkqp" c'rkqgrt'y qwpf "v'g'cwo gpv'dw" yj g'g'ku' c' pggf "qh'o qtg" tgugctej "cdqwk'ku'eqpegr v'lp'f qi u0"

j3\_ 'E'GOJ c'x'g { 0'Rgtkqf qpvcn'f kugcug'lp'f qi u0G'k'q'v'j qi gpguku' r'g'x'c'ng'peg. 'cpf 'uki pkkcpcv'nf 0'X'g'v'Er'lp'P' q't'y 'Co 'Uo cmic'plo 'Rtce'0\*3; ; : + 4: \*7+3333/4: 0'  
j4\_ 'U0I j c'p'c'ck 'R0D'q'qo u. 'C0Q'tny un: 'gv'cn'0'c'f x'c'p'eg'f 'r rcvgrv'tlej "hdtkp"<c'p'gy "eqpegr v'ht' 'egm'd'cu'gf 'kuuug'g'pi kpggt'kpi 'd { 'o g'p'u'qh' kph'co o cvqt { 'egm'0'L'Q'tcn'k' r rcvgrv'0\*4236+62\*8+89; /; : 0'  
j5\_ 'N0O c't'k'p'0' (C'0'T'q'lcu. 'R0U'c'j o epp. 'T0C'i j c'f c'c. 'C0R'k'm'p'k'0'G'ctn' 'Y qwpf "J gcrkpi "Ueqtg"<c'lu' ungo 'vq'g'x'c'nc'v'g'yj g'g'ctn' 'j gcrkpi "qh'r g'k'q'f qpvcn' u'q'h'kuuug'y qwpf u0'L'Rgtkqf qpvcn'k' r rcv'v'U'el'0\*423: +6: \*7+496/4: 50"  
j6\_ 'R0Y 0J gn'f. 'U0'0'W'k'j . 'P'0I 0'T'q'd'k'p'p'0'E'c'p'k'g' 'C'ew'g' 'R'c'p' 'U'c'ng'0'X'g'g't'k'p'c't { 'O' g'f k'c'n' 'E'g'p'v'gt'0'E'c'p'k'g' 'C'ew'g' 'R'c'p' 'U'c'ng'0"

# RHNWGP EG'QH'CP VKO KETQDKCN'RJ QVQRP CE VKC'VKQP 'QP' O QP QE WNVWT CN'DCE VGT KCN'DKQHKNO U'

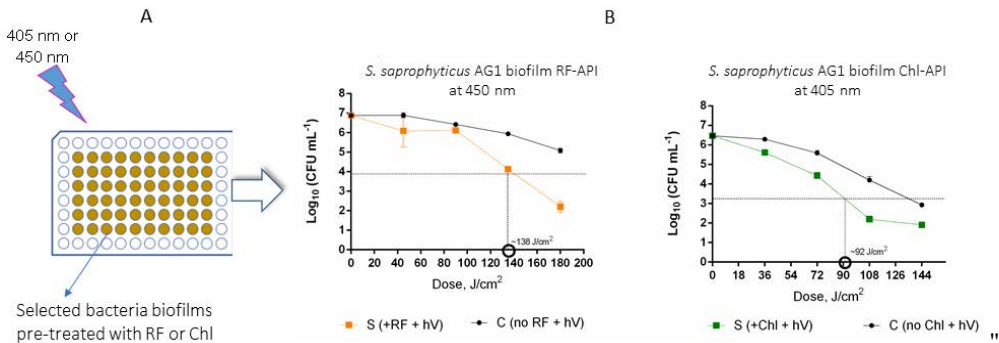
Ncwtc'lxtnckv v. 'kxc'F wo -{ v. 'Cruk'I tleclgxc. 'Nwnu'Ucukwkqplu. 'Nkrkc'Mcn f kgp "

F gr ctwo gpv'qh'O letqdkmqi { 'cpf 'Dkqvej pqmqi { . 'Nhg'Uelgpegu'Egpgvt. 'kpuwkg'qh'Dkquekpegu. 'Xkpkwu'Wpkxgtukv{ .  
Xkpkwu. 'Nkj wcpk"  
nwtc'lxtnckv vB i o e'lwaf'lxv'w'

O quv'qh'yj g'dcevtkc"ctg"pcwtcm{ "hqwpf" rlxkpi "kp"ugukng"eqqtf kpcvfg "hwpevkqpcn'eqo o wpkkgu"ecmgf "dkqhko uO  
O letqdkn'dkqhko u'ctg'y kf gur tgcf "kp"yj g'gpv'cpf "hqt"o "qp"dkqve"cpf "cdkqve"uwxhcegu"kh'eqpucpv'o qluwtg"ku"  
rtgugp'0' Cf j gukap" qh' dkqhko u' vq" f khtgtpv' uwxhcegu" ku" r tqo qvgf "d{ "yj g' g'z'wcegmwrt"o cvtkz" yj cv' dcevtkc"ctg" ugrh/  
go dfg f gf "kp"j3\_0'Ego r ctgf "vq" hqcvkpi "qt" r rcpmqple'egmu. "qpg'qh'yj g'dgpg'ghku"qh' rlxkpi "kp"dkqhko u'ku'yj g' uwduxpvcnm{ "  
j ki j gt' t'gukvcpvg'vq'cf xgtug'gzvgtpcn'r j { ulecn'cpf 'ej go lecn'ko r cev'j4\_0"

Dkqhko u' r r{ "cp"ko r qvcpv' t'qrg"kp" j wo cp" kphgevkqpu" cpf "ecp" r qug" c" r qvcpvcn' yj t'gecv' vq" o cvgtkn' k'p'v'gi t'kv{ "kp"  
eqp'hp'gf "hcekn'kgu" uwej "cu" j qur kcn. "hqqf. "cpf "q'v' gt" k'p' wutken'ugv'kpi u'0'v'j wu. "pqy cf c{ u. "hcekn' "yj g'gpqto qwun{ "hcu"  
f g'xgnr o gpv'qh' dcevtkn' t'gukvcpvg'vq' f khtgtpv' eqpxgpvkqpcn' cpvko letqdkn' ci gpv' yj gtg' ku" c" pggf "kp" c" f k'ueq'xg { "cpf "  
cpn{ uku'qh'p'gy . "pcwtcn'dcevtkn' eqp'v'q'no gy qf u'yj cv'y qwf "dg'uchg"cpf "ghhgevkxg"vq'wug. "gur gekm{ "ci ckpuv'tgecnek'cpv"  
dcevtkn'dkqhko u'j5\_0"

Vj gtghqg. "yj ku" uwf { " clo gf" vq" kpxguki cvg" c" r j qvqgpusk'k' cvkp/dcugf" o gy qf" npqy p" cu" cpvko letqdkn'  
r j qvq'p'cevk'cvkp" \*CRK" j6\_ "ci ckpuv' o qpqeww'cn' dkqhko u. "cu" y gm'cu" r rcpmqple'egmu" \*vq" kpxguki cvg" r t'g'xgp'v'kp" qh'  
dkqhko "hqt"o cvkp+" qh' Rugv' qo qpcu' cgtwi k'p'quc" cvee" 49: 75. "Ucr j {mqeewu'ucrtqr j {vewu' CI 3" cpf "Ucr j {mqeewu'  
gr kf gt o kf kl' cvee" 3444: " \*qp' n' r rcpmqple'egmu' gxc'nc'v'gf +0'Hqt "yj g'CRK" pcwtcn' r j qvqgpusk'k' gt u" \*RU+ uwej "cu" t'kdq'hc'x'k'p"  
\*TH" cpf "ej m'qr j { m'k'p" \*Ej n" k'p" eqo d'k'p'cv'kp" y kj "cr r t'qr t'k'v'g" r j qvqgpusk'k' kpi "x'k'kd'g' r'ki j v'ktcf k'cv'kp" y gtg' wugf '0'K'  
y cu' h'q'wpf "yj cv'TH" cpf "Ej n' dcug'CRK" cp' j cxg' dcevtk'q'ek' f' ghhgev' ci ckpuv' dkqhko u' qh' yj g' ugrgevgf "dcevtkc" 0' J qy g'xgt. "  
eqp'k'f' g'kpi "cewcn' cr r r'ecv'kp" qh' yj g' v'ej pqmqi { . "eqpegp'cv'kp" qh' ugrgevgf "pcwtcn' RUu. "ktcf k'cv'kp" f' q'ugu" cpf "q'v' gt"  
qr vko k' cv'kp" uwf k'gu' yj qwf "dg' h'w' yj gt' r g' h'qto gf 0"



Hki 030Uko r r'k'k'gf "uej go g'qh'yj g'CRK"o gy qf "wugf" k'p' yj ku'y qtni \*C =t guwmu'qh'TH" cpf "Ej n' dcugf "CRK"gz go r r'k'k'gf "  
d{ "U'ucrtqr j {vewu' CI 3" \*D+0C" j qtk' qpvcn'f cuj gf "h'p'g' k'p' yj g' i tcr j uf gpq'gu' o k'p'ko cn'5' h'q' i "tgf w'ek'p"  
\*k'p'f k'cv'kpi dcevtk'ek'f cn'ghhgev'0"

[3]\_O'Dgtncpi c. "T01 wgtt'gtq. "Nlxkpi "vq' yj gt' "kp"dkqhko u'<yj g' o letqdkn'egm' h'cevt { "cpf "ku'dkq'vej pqmqi lecn'ko r r'ecv'kpu. "O letqdkn' Egm' h'cevt'k'gu"  
37. "387" \*4238-0'  
[4]\_J '0'E0' Hgo o kpi . "L0'Y kpi gp'f'gt. "W0'U gy | { n'g'v'cn'0' "Dkqhko u'<cp" go gti gpv' hqt"o "qh' dcevtkn' r'k'k'g. "P cwtg" T'gx'ky u' O letqdkmqi { "36. "7856797"  
\*4238-0'  
[5]\_J '0' M'q. "T0' P'0' C'ncp. "T0' R0' J qy r'k'p" gv' cn'0' Vcti g'k'pi "o letqdkn' dkqhko u'< ewt'g'p'v' cpf " r t'qr g'ev'k'g" yj g'tcr g'w'k'e" ut'cv'gi k'gu. "P cwtg" T'gx'ky u'  
O letqdkmqi { "37. "9626977" \*4239-0'  
[6]\_R0' D'we'j q'x'g. "C0' I tleclgxc. "N0' M'cn f k'gp . "R0' X'k'w. "Cp'vko letqdkn' r j qvq'p'cevk'cvkp" cr r t'q'cej "dcugf" "qp" pcwtcn' ci gpv' h'q' t' eqp'v'q'ni' qh' dcevtkc"  
dkqhko u' k'p' ur cegetch' "k'p'gt'p'cv'kpcn' L'q'w'p'cn' qh' O q'ngewr' t' Uelgpegu' 43: 8; 54" \*4242-0'



**CPVKECPEGT'CEVXKX[ 'QH'UWP KVP KØ'CP CNQI WGU'KP 'DT CKP "**  
**ECPEGT'O QF GNU"**

I ktuvcw 'F cdngxk k v<sup>3</sup>. Gricu'O ceekqpk<sup>4</sup>. 'Xkno c'Rgvtknckv<sup>3</sup>, "

<sup>3</sup>F gr ctvo gpv'qh'Ftwi "Vcti gw'J kvqr cvj qm { . 'kpuwkwg'qh'Ectf kqm { . 'Nkj wcpkcp'Wpkxgtukv' 'qh'J gcnj "Uekpegu."  
Nkj wcpkcp"

<sup>4</sup>F gr ctvo gpv'qh'Nkg'cpf "Gpxkqpo gpvcn'Uekpegu.'Eci nctk'Wpkxgtukv' . 'Kcn' "  
xkno ct gvtknckvB mo wpln'

I rkdrcuqo c'¶I DO +'ku'y g'o qu'ci i tguukxg'v' r g'qh'dtckp'ecpegt00 gf kcp'uwtxkcn'vko g'hqt'I DO 'r cvkpwu'ku'cdqww"  
3408"vq"368"o qpj "J3\_."cpf "v'j g'g'ctg'uvkn'gzvgo gn' rko kgf "qr r qt wpkkgu'qh'eqp'gpv'kpcn'v'j gtr { '0'V' tqukpg'nkpcug"  
k'j kdkqtu'ewtgpw' 'ctg'eqpuk' g'g'f 'cu'c'r' g'ur gev'xg'v'cti g'v'g'f 'v'j gtr { 'hqt'I DO 0Vj g'g'ctg'pwo g'qwu'uwf lgu'kpn'kpi 'ej cpi gu'  
k'p'nkpcug'cev'xk'v' "v'q'ectekqi g'puku'cpf "wo qt 'r' tqi tguukp0V' tqukpg'nkpcug'k'j kdkqtu'i g'p'g'ctm' "v'cti g'v'v'j g'cev'xg'v'k'g'q'h'  
v'j g'nkpcug'cpf "v'j g'gd { 'r' t'gxgp'v'j g'r' j qur j qt { r'v'v'k'p' t'guw'kpi 'k'p'k'j kdkk'p'q'h'o ki t'v'v'k'p' 'cpf' "cr qr v'uku'qh'ecpegt'egm'j4\_0'  
Qpg'qh'y go 'ku'w'p'k'p'k'd.'c'o w'nk'v'cti g'v'g'f 'ci g'p'v'c'r' t'qx'g'f 'hqt'v'j g'v'g'c'v' go gpv'qh'nk'f pg'f "ecpegt' 'cpf' "i' c'ut'q'k'p'v'g'u'k'p'c'ri'uw'qo' c'ri'  
wo qwtu'j5\_00 q'g'x'g'x'g'g'f "v'j g'p'gy 'ej go k'c'ri'eqo r' q'w'p'f' u'ct'g'uw' i' g'v'g'f 'cu' b' qt'g'g'v'g'v'x'g'v'w'p'k'p'k'd'c'p'c'ri' wgu'j6\_0Vj g'c'ko 'q'h'  
q'w'uwf { 'y' cu'v'q'g'x'c'nc'v'g'v'j g'g'v'g'ev'q'h'p'gy 'w'p'k'p'k'd'c'p'c'ri' wgu'q'p'j' wo cp'dtckp'ecpegt'egm'x'k'c'd'k'k'v' 'cpf' "o ki t'v'v'k'p'0'

Vj g'y q'j' wo cp'I DO 'egm'k'p'gu.'W: 9/O I "cpf 'C394.'cpf "p'q'p/o c'ri' p'cp'v'j' wo cp'h'k't'q'd'rc'uw'v' g'g'v'g'f 'v'q'k'p'x'g'u'k'v'g'v'  
cp'v'ecpegt'cev'xk'v' "qh'39'w'p'k'p'k'd'c'p'c'ri' wgu'k'p'x'k't'q'0Vj g'g'v'g'ev'q'h'nkpcug'k'j kdkqtu'q'p'egm'x'k'c'd'k'k'v' "y' cu'g'x'c'nc'v'g'f "d { "  
O VV'cuuc { 'chgt'94'j' qwtu'qh'k'p'ew'c'v'q'p'0Vj gp'v'j g'o qu'cev'xg'v'nkpcug'k'j kdkqtu'v'j cv't'g'f we'g'v'g'ev'x'k'c'd'k'k'v' "w'v'q'7' "qt'v'g'u"  
j'cx'g'd'ggp'v'g'v'g'f 'hqt'v'w'v'j g't'uw'f lgu'0Vj g'GE<sub>72</sub>'x'c'n'gu'q'h'y g'o qu'cev'xg'v'eqo r' q'w'p'f' u'y g'g'v'g'v'g'v'c'ri'k'j g'f "cpf' "eqo r' ct'g'f 'v'q'  
v'j g'w'p'k'p'k'd'e { 'v'q'z'k'ek'v'0'U'k'p' r'egm'lo ki t'v'v'k'p'cuuc { 'y' cu'r' g'v'g'v'g'v'g'f "v'q'g'z'c'ko k'p'g'v'j g'g'v'g'ev'q'h'v'g'v'g'f "eqo r' q'w'p'f' u'q'p'  
W: 9/O I "egm'lo ki t'v'v'k'p'0'Egm'y g'g'v'g'v'g'f g'f "k'p'v'j g'f'k'j g'u'y' k'j "p'wo d'g'g'f "i' t'k'f' u'k'p'uw'ej "y' c { 'v'j' cv'cd'q'w'72/92'egm'y' q'w'f "  
dg'q'p'v'j g'i' t'k'f' g'f "ct'g'c'0'k' ci' gu'q'h'egm'y g'g'v'c'ng'p'g'x'g'f { 'j' q'w'v'g'f "v'j' q'w'v'g'f "o k'et'q'ue'q' g'0'E'q'q'f' k'p'c'v'g'u'q'h'y' g'egm'  
y' g'g'v'g'v'c'ri'k'j g'f "cpf' "v'j g'v'c'x'g'ng'f "f'k'v'c'p'eg'j' cu'd'ggp'v'g'v'g'f'0Vj g'v'g'v'g'f' r'egm'f'k'v'c'p'eg'v'c'x'g'ng'f "r' g'f' q'w'v'g'f' cu'f' g'h'k'p'g'f' cu'  
v'j g'egm'x'g'v'g'v'g'f'0Vj g'f' c'v'v'j g'g'v'g'v'g'f' "cu'c'x'g'v'c' g'egm'x'g'v'g'v'g'f' "0'uw'c'p'f' c't'f' "f' g'x'k'v'k'p'0'

Vj g't'guw'u'q'h'O VV'cuuc { 'g'z'r' g't'ko' gp'v'j' c'x'g'v'j' q'y' p'v'j' cv'eqo r' q'w'p'f' u'3."8'cpf' "9'y' g't'g'v'j' g'o qu'cev'xg'v'q'p'g'u'0C'm'v'j' t'gg'  
v'g'v'g'f' "eqo r' q'w'p'f' u'j' c'f' "o' q't'g'r' q'v'p'v'g'f' w'k'p'i "g'v'g'ev'q'p'v'j' g'dtckp'ecpegt'egm'x'k'c'd'k'k'v' "qh'394'egm'k'p'g'eqo r' ct'g'f' "v'q'W: 9/  
O I "egm'k'p'g'cpf' "p'q'p/o c'ri' p'cp'v'egm'0'k'v'j' q'w'f' "dg'p'q'v'g'f' "v'j' cv'eqo r' q'w'p'f' "8'y' cu'v'j' g'g'v'g'v'g'f' "q'p'v'j' cv'v'j' q'y' g'f' "c'uw'q'p'i' g't'  
e { 'v'q'z'k'ek'v'g'v'g'f' "ecpegt'egm'k'p'g'u'k'p'eqo r' ct'k'p'v'j' k'j' "p'q'p/o c'ri' p'cp'v'egm'0'j' q'y' g'x'g'f' "f'c'v'c'p'c'ri' u'k'u'g'x'g'c'g'f' "v'j' cv'  
eqo r' q'w'p'f' "3'j' c'f' "v'j' g'i' t'g'c'v'g'u'g'v'g'v'g'f'v'g'f' w'k'p'i "egm'x'k'c'd'k'k'v' "GE<sub>72</sub>'x'c'n'gu'chgt'94'j' q'p'W: 9/O I . 'C394'cpf' "J' H'y' g't'g'f' "4'  
0'8'p'0 . '94'0'8'p'0 'cpf' "4'0'8'p'0 . 't'g'ur' g'ev'x'g'v'g'f' "0C'm'v'g'v'g'f' "w'p'k'p'k'd'c'p'c'ri' wgu'y' g'g'v'g'v'g'f' "o' q't'g'v'g'f' "v'j' cp'w'p'k'p'k'd'0'k'p'  
o ki t'v'v'k'p'cuuc { 'eqo r' q'w'p'f' "8'v'g'f' we'g'f' "W: 9/O I "egm'lo ki t'v'v'k'p'd { '35' "o' q't'g'g'v'g'v'g'f' "v'j' cp'w'p'k'p'k'd'c'p'f' "f' g'et'g'c'v'g'f' "v'j' g'  
c'x'g'v'c'ri' g'egm'x'g'v'g'v'g'f' "d { "4'v'ko' gu'eqo r' ct'g'f' "v'q'v'j' g'eq'p'v'g'v'g'f'v'g'f' r' "eqo r' q'w'p'f' u'3'cpf' "9'v'j' q'y' g'f' "cp'qr' r' q'u'k'g'g'v'g'v'g'f'  
q'p'egm'lo ki t'v'v'k'p'cu'egm'x'g'v'g'v'g'f' "y' cu'k'p'et'g'c'v'g'f' "d { "55' "cpf' "95' . 't'g'ur' g'ev'x'g'v'g'f' "eqo r' ct'g'f' "v'q'v'j' g'eq'p'v'g'v'g'f'

Vq'eq'p'c'v'g' "eqo r' q'w'p'f' "8'o c'f' "d'g'y' q't'v'j' { "qh'v'w'v'j' g't'uw'f' lgu'cu'k'v'j' c'f' W: 9/O I "cpf' "C394'ecpegt'egm'ur' g'ek'k'le"  
e { 'v'q'z'k'ek'v' "cu'y' g'm'c'u'y' cu'v'j' g'o qu'g'v'g'v'g'v'g'f'k'p'k'j' kdkqt'k'p'W: 9/O I "egm'k'p'g'0'

[3\_ 'Dej cf w'U' 'Uc'j' w'CM' 'Dei j' gn'R' 'Uc'j' e'U'OE'wt'gp'v'v'g'v'g'f' t'q'o k'p'i "v'g'c'v'o' gp'v'v'g'v'g'f' { 'hqt'v' r'kd'rc'uw'qo c'o w'nk'v'g'v'g'f' "C'v'g'x'g'v'g'f' 0Q'p'eq'n'g'x'v'j' k'v'g'v'g'f' 0423; 'Lw'i'  
47'v'j'ek'g'f' "4242'Q'ev'33\_35\*4-0C'x'c'k'v'd'ng'v'g'f' t'q'o <'j' w'r' u'ly' y' y' p'ed'k'p'm' p'k'j' 0' q'x'k' o' e'k't'v'k'v'g'u'l'RO E888374: 1"  
[4\_ 'V' { 't'q'u'k'p'g' 'M'p'c'ug' 'k'j' kdkqtu'k'p' "Ecpegt-<'D't'g'cm'j' t'q'w'j' "cpf' "E'j' c'ng'p'i' gu'q'h' 'V'cti' g'v'g'f' "V'j' g't'c'r' { " 'J'k'v'g'v'g'f'0'v'j'ek'g'f' "4242" Q'ev'33\_0' C'x'c'k'v'd'ng'v'g'f' t'q'o <'j' w'r' u'ly' y' y' p'ed'k'p'm' p'k'j' 0' q'x'k' o' e'k't'v'k'v'g'u'l'RO E93622; 5"  
[5\_ 'Ng'v'q'w'p'g'c'w'E' . 'T'c' { 'o' q'p'f' "G' "H'ek'v'g'v'g'f' "U'U'w'p'k'p'k'd'c'v'g'v'g'f' "t'q'u'k'p'g'v'g'f' "k'p'j' kdkqt'0'c' "d't'g'h'v'g'x'g'v'g'f' "q'h'k'u'v'j' g't'c'r' g'w'k'v'c'ri' "v'j' g'v'g'c'v'o' gp'v'q'h'  
t'g'p'c'ri'c't'ek'p'q'o c'cpf' "i' c'ut'q'k'p'v'g'u'k'p'c'ri'uw'qo' c'ri'w'o' q'tu'¶I KUV'0Vj g't' 'E'k'p' "T'k'ni'0' c'p'c'i' 04229'U'v'p-5\*4+5636: 0'  
[6\_ 'O' g'ng'f' f' w'T' . 'R'g'v't'k'v'g'v'g'f' "X' "F'k'v'k'p'v'q'U' "C't'k'f' w'C' "C'p'i' k'v'u'v'g' . 'U'g't'w'k'v'N' . 'g'v'c'ri'0'k'p'x'g'v'g'f' c'v'k'p'i' "v'j' g'c'p'v'ecpegt'cev'xk'v' "qh'K'c'v'k'p' I'f' k'j' { 'f' t'q'r' { 't'c'j' q'ng'J' { 'd't'k'f' u'0'  
CEUO g'f' 'E'j' go 'Ngw'0423; 'C'rt'33-32\*6+793680

P5-43

DID NOT PARTICIPATE

P5-44

DID NOT PARTICIPATE

# APPLICATION OF A MULTIFUNCTIONAL LASER DIAGNOSTIC COMPLEX "LAKK-M" IN DENTISTRY

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Investigation of microcirculation in the periodontium can be beneficially conducted with certain devices like a multifunctional laser diagnostic complex "LAKK-M" and simultaneously using a number of non-invasive diagnostic methods. The study evaluates the following characteristics:

1) Microhemodynamics (laser Doppler fluometry – LDF method)

The essence of this method is that a low-intensity monochromatic light beam emitted by a laser diode embedded in a Doppler laser flowmeter passes through a flexible light guide and through the tip of the sensor illuminates the tissue under study. In the fabric, the light is scattered by reflecting particles. Part of the light is reflected back and passes through the receiving light guide to the internal photodetector of the device. In accordance with the Doppler effect, only moving particles (mainly red blood cells) lead to a frequency shift. The spectrum of the received signal is processed in the device in accordance with the algorithm obtained by Bonner for this type of reflection, and the flow volume (ml/min/100 g of tissue) is calculated. Thus, the LDF method is based on the measurement of the Doppler component in the spectrum of the reflected laser signal scattered on the shaped blood elements moving in the microvessels.

2) Delivery and consumption of oxygen in the microcirculatory bed (optical tissue oximetry – GRT method)

The method of optical tissue oximetry (GR) estimated delivery and consumption of oxygen in the microvasculature; and the relative volume fraction of erythrocytes (Vr) in the study of  $\approx 4-5$  mm<sup>3</sup> and saturation mixed-blood (that is, arteriole and venules)

3) Saturation of arterial blood with oxygen (pulse oximetry method)

4) Content of oxidative metabolism enzymes (laser fluorescent diagnostics (LPD) method))

The spectrum of reflected radiation of the tissue is recorded when a laser beam probes it with a wavelength corresponding to the wavelength of the maximum absorption of the beam by a certain enzyme, sources with three wavelengths are used to excite the fluorescence of enzymes (nicotinamides, flavins, lipofuscin, porphyrin, etc.): 365 nm, 532 nm and 630 nm. Diagnosis of the main functions of the microcirculatory bed in the form of their comprehensive assessment (LDF + OTO + LPD) is more informative compared to the individual methods mentioned above, since microcirculation is variable and adapts to the specific physiological needs of the tissue. An integrated approach to the study of tissue in vivo allows obtaining complementary data on microdynamics, oxygen consumption and the state of metabolic processes for their analysis and decision-making in dental diagnostics.

# PHYSICS IN MEDICINE: DISORDERS OF MICROCIRCULATORY PROCESSES IN THE MUSCLE AND THEIR DIAGNOSIS IN DISEASES OF THE NERVOUS SYSTEM

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Currently, there is a problem of cerebral palsy; it is one of the most urgent problems in Pediatric Orthopedics and Neuropathology. In the social context, the problem is significance as well [1]. Due to the combination of underdevelopment and pathology of motor development, disorders of the regulation of muscle tone - such as spasticity, rigidity, dystonia, and hypotension-are particularly significant and complicated [2]. The aim of the treatment of cerebral palsy children with is a possible more complete adaptation, the degree of which largely depends on mental and motor functions, speech development, and intelligence. Adaptation is associated with the choice of an individual rehabilitation scheme for each patient.

In children, motor disorders are primarily determined by a pronounced increase in muscle tone (spasticity) in combination with muscle weakness (paretic). This leads to difficulty or impossibility of voluntary movements. Prolonged muscle spasm in cerebral palsy affects the capillaries and leads to a violation of microcirculation in the muscle.

As a non-medicinal means of restoring normal peripheral blood circulation, we consider effects aimed at relaxing the muscle-tours – massage. Differentiated technique of segmental reflex massage with physical therapy developed by us reduces muscle tone and most intensively contributes to an increase in peripheral blood circulation, the external manifestation of which is arterial hyperemia. Determining the degree of severity of muscle spasticity, we can talk about the qualitative (indirect) state of peripheral blood circulation. Identification the level of muscle tone and correction the strength and duration of massage effects are key elements in management of cerebral palsy patients.

In our study to assess and monitor the functional state of the muscles, we used such device as myotonometer, which is an analog of the myotonometer system of Dr. Sirmai (Hungary). We examined 14 children under the age of 3 years with cerebral palsy (spastic form).

Methods of measurement: 1. Checking the calibration of the device. Firstly, we put the myotonometer with its base on the glass and count the reading of the device on the scale. This reading should be equal to 250 myotons (1 myoton is equal to the deviation of the arrow of the device by 1 division). If the reading of the device is different from 250, then we move the stop flange to get this reading. 2. Place the device with its base on the measured muscle group. With a light force, press the device against the measured area of the body and touch the flange-limiter of this area. 3. Make a reading on the myotonometer scale.

Muscle tone was determined in the center of the abdomen of individual muscles. The rod of the myotonometer was installed strictly perpendicular to the examined muscle. All measurements were performed in the initial lying position (before the massage, after the massage). Experimental data were obtained (significance level  $\alpha = 0,05$ ):

Points for measuring muscle tone	Before the massage (readings in myotonic)		After the massage (readings in myotonic)	
	Experiment roup	Control group	Experiment group	Control group
Mid-biceps	86,77±1,26	83,07±1,42	64,85±1,01	73,14±1,42
Mid-calf muscle	91,23±1,44	94,14±1,69	73,64±1,29	86,14±0,74
Middle of the adductor muscle of the thigh	82,50±1,75	79,21±0,46	66,64±1,10	72,07±0,77

The level of muscle tone is significantly reduced in the experimental group, where an individual massage technique is used with the inclusion of elements of physical therapy. We use a modern method of prevention and treatment – massage, providing the correct, differentiated in time and strength massage effect. Taking into account the severity of cerebral palsy and using a myotonometer, we create a more effective therapeutic result in the conditions of the procedure, by increasing the work on the muscle group that is more prone to spastic reactions. This technique is being implemented in the practice of a massage therapist.

The activities can significantly facilitate the efforts of experts in various fields (doctors, remedial gymnastics trainers, speech therapists, speech pathologists, educators of special institutions, as well as parents) in order to ensure maximal social adaptation of patients and their proper inclusion into the society.

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[2] E.V. Semenova, E.V. Klochkova. Rehabilitation of children with cerebral palsy: a review of modern approaches to help rehabilitation centers-Moscow: Lepta Kniga, 2018. - 584 p.

P5-47

DID NOT PARTICIPATE

VJ G'TQNG'QH'NCRCCTQUEQRĪ 'Ĳ'VJ G'O CPCI GO GPV'QH'  
CDF QO Ĳ CN'VT CWO C''

Wi pg'Ĳ dtcuckg<sup>3</sup>. 'Dtqpkw'Dwemwu<sup>4</sup>"

<sup>3</sup>HcewnĲ 'qh'O gf lekpg. 'XĲpkwu'WpĲxgtukĲ. 'NĲj wcpĲc'

<sup>4</sup>ErĲpĲc'qh'I cwtqgpvtqmi { .P gr j tq/Wtqmi { 'cpf'Uwti gt { 'HcewnĲ'qh'O gf lekpg. 'XĲpkwu'WpĲxgtukĲ. 'NĲj wcpĲc'  
wi pg'Ĳo dtcuckgB o Ĳnwf'ĲwĲh'

Cdf qo Ĳcni'vteco c'ō'qpg'qh'j g'o clqt'ecwugu'qh'o qtdĲf Ĳ' 'cpf' o qt wĲkĲf 'y qtrf y Ĳf g'Ĳ'Ĳ'ceeqwpu'Ĳqt'; 6360' 'qh'cni' vteco c'ecugu']3\_'cpf' 'Ĳ'xgt { 'eqo o qp'Ĳ'j g'ecug'qh' { qwp' 'r gr r' w'p'f gt'j g'ci g'qh'62' { gctu']4\_'Ncr ctqvo { 'j cu' vcf ĲĲpĲc' " dggp' 'j g' ucpf'ctf' " qh' ectg' Ĳqt' " gxcnĲwĲp' " cpf' " vgcvo gpv' qh' r cĲgpw' y Ĳj " cdf qo Ĳcni' vteco c' ]4.5\_0' Ncr ctqueqr le'wti gt { 'j cu' i tgcwĲf "lo r tqxgf "wti Ĳcni'qweqo g'Ĳ' o cp { 'ctgcu'qh'cdf qo Ĳcni'wti gt {0J' qy gxgt. 'j g'ctg' " o cp { 'eqp'vtxgtukĲ'qr ĲĲp'p'cdq'w'ku'uchgvĲ' 'Ĳ'cdf qo Ĳcni'vteco c'wti gt {0C'eeqt'f Ĳi 'v'Ĳ'g'xgt'cni'w'f'Ĳ'gu. 'r'ctqueqr { 'j cu' c'j Ĳ j 't'v'g'qh'o Ĳugf 'Ĳ'p'w'Ĳ'gu' \*w' "v'q'62' +]668\_ "c' r gteĲxgf 'Ĳ'c'Ĳ'Ĳ'Ĳ'Ĳ' "v'q'x'Ĳ'w'Ĳ'Ĳ' g'cni'ctgcu'qh'j g'cdf qo gp' ]8\_'cpf' "Ĳ' tgs wĲ'gu'wti g'p'p' y Ĳj 'cf'gs wcv'g'zr g'Ĳ'p'eg'cpf' 'r'qr g't'gs wĲ' o gpw']6.9\_0'

Vj g'cĲo "qh'qwt'uwf { 'y cu'v'q'g'w'Ĳo c'v'g'j g'w'ug'qh' r'ctqueqr { "Ĳ'j g'gxcnĲwĲp' " cpf' " vgcvo gpv' qh' r cĲgpw' y Ĳj " cdf qo Ĳcni'vteco c'0'Vj Ĳ' y cu'c't'g'v'q'ur g'v'x'g'66' { gct' \*4237/423: +uwf { "ectĲ'Ĳ'f' q'w'Ĳ'j g'T'gr w'Ĳ'Ĳ'c'p' "XĲpkwu'WpĲxgtukĲ' " j qur Ĳcni'0'c'ni'cdf qo Ĳcni'vteco c' r cĲgpw' o cpci gf "d { "qr g'v'x'g'Ĳ'v'g'x'g'p'v'Ĳ'p' y g'g'Ĳ'p'w'f' gf 0'R'c'v'g'p'w' y g'g'f' Ĳ'Ĳ'f' gf "Ĳ'v'q' y q' i tqw u' r'ctqvo { "cpf' "r'ctqueqr { "cpf' "y g'g'eqo r ctg' "y Ĳj "g'c'j' "q'v' g'0'C' "v'q'w'ni'qh'422' vteco c' r cĲgpw' y g'g' gxcnĲwĲf' "Ĳ' "cdf qo Ĳcni'p'w'Ĳ' {0'Q'w'qh'j g'ug. '337' \*79072' +w'p'f' g' y gpv'w'w' i' Ĳcni'Ĳ'v'g'x'g'p'v'Ĳ'p' "Ĳ' "cdf qo Ĳcni'vteco c'cpf' " y g'g'j' v'w'Ĳ'p'w'f' gf "Ĳ'j g'uwf { <46' \*420 9' +r cĲgpw'Ĳ' r'ctqueqr { "i tqw "cpf"; 3' \*9; 05' +; "r'ctqvo {0'Vj g'g' y cu' p'q' "u'c'w'Ĳ'Ĳ'c'ni' "u'Ĳ' p'Ĳ'Ĳ'c'p'v'f'Ĳ'Ĳ'g'p'eg' "Ĳ' "f' go q' i t'c'j' le' "e'Ĳ'g'Ĳ'c' "d'g'y g'g'p' "j g' i tqw u' \*r @027+0'Vj g'g' o g'c'p' "ci g' "qh' r cĲgpw' " y cu'64667' { gct'cpf' "j g' o clqt'Ĳ'f' "qh'j g' o "y g'g' o c'g'u' \*9; 08' +0'D'w'p'v'vteco c' y cu' u'w'w'Ĳ'p'g'f' "d { "5; " \*550 3' +r cĲgpw' " cpf' "98' \*880; +r cĲgpw' u'w'w'Ĳ'p'g'f' "r g'p'g'v'c'p' i "Ĳ'w'Ĳ' { "r @027+0'R'g'q' r g'v'x'g' "Ĳo c' i Ĳi "y cu' r g'Ĳ'Ĳ' o gf "v'q' c'ni' r cĲgpw' " Ĳ'q' o "r'ctqueqr { "i tqw "cpf"; 9' " / "r'ctqvo { "i tqw " \*@2' "g'zr g'Ĳ'p'eg'f' "v'q' "Ĳo c' i Ĳi "o g'j' q'f' u'0'H'c'w'g'p'g' i c'v'x'g' t'g'u'w'w' " qh'j g' "Ĳo c' i Ĳi "g'ej' p'Ĳ' w'g'u'ceeqw'p'v'f' "Ĳ' "42/52' "qh'c'ni'j g' t'g'u'w'w'0'H'c'w'g' r'q'Ĳ'x'g' t'g'u'w'w' y g'g' "6' "Ĳ' r'ctqueqr { "i tqw " cpf' "8' "r'ctqvo {0'0' w'Ĳ' r'g'p'g'cpf' "p'q'Ĳ'p'w'Ĳ'gu' y g'g' r' t'g'p'v'g'f' "Ĳ' "6' \*38089' + "38' \*88088' +cpf' "6' \*38089' +r cĲgpw'qh' r'ctqueqr { "i tqw "t'g'ur g'v'x'g'ni' 0'P'Ĳ'g' \*59072' +r cĲgpw' t'g'w'Ĳ'gf' "eq'p'x'g'Ĳ'p'v'q' "r'ctqvo { <4' r cĲgpw' \*44044' +c'Ĳ'g' t' d'w'p'v'vteco c'cpf' "9' "r' g'p'g'v'c'p' i "Ĳ'w'Ĳ' { " \*990: +f' w'g' "v'q' q'ni' y "x'Ĳ'w'w'Ĳ'p'w'Ĳ'gu. "Ĳ'v'g'p'Ĳ'x'g' d'g'g'f' Ĳi "cpf' "o w'Ĳ' r'g'Ĳ'p'w'Ĳ'gu'0' Ncr ctqvo { "y cu'j' g'c'v' g'w'Ĳ' "Ĳ' "2' r cĲgpw' \* 90 3' +Ĳ'p'w'f' Ĳi "3; " \*4507' +r cĲgpw' y Ĳj "o w'Ĳ' r'g'Ĳ'p'w'Ĳ'gu'cpf' "83" \*98047' +ō'Ĳ'p' i'g' "cpf' "y cu'f' Ĳ'c' i p'q'w'Ĳ' "Ĳ' "33' \*340; +r cĲgpw'0'0' w'Ĳ' r'g'Ĳ'p'w'Ĳ'gu'ceeqw'p'v'f' "Ĳ' "42' "qh'c'ni'j g'ecugu'cpf' " j g' o q'w'v'eqo o qp'Ĳ'w'Ĳ' { "y cu'j' g'Ĳ'p'w'Ĳ' { "qh'Ĳ'v'g'Ĳ'p'g'gu'0'Vj g'g' y cu'p'q' "u'c'w'Ĳ'Ĳ'c'ni' "u'Ĳ' p'Ĳ'Ĳ'c'p'v'f'Ĳ'Ĳ'g'p'eg' "Ĳ' "j g' o g'c'p' " q' r g'v'c'p' i "w'Ĳo g'cpf' "r' q'w'v'g' g'v'x'g'eqo r r'Ĳ'c'v'q'p' "t'c'v'g'u' d'g'y g'g'p' "j g' i tqw u' \*r @027+0'D'w'v'j g'g' o g'c'p' "r'g'p' i'j' q' "qh'j' qur Ĳcni'w'c' { " y cu'Ĳ'j' q'v'p' "r'ctqueqr { "i tqw " \*r >027+0'P' q' o Ĳugf' "Ĳ'p'w'Ĳ'gu' y g'g'c'ni'q' "t'g' q'v'g'f' "Ĳ'j' g' r'ctqueqr { "i tqw 0' "

Ceeqt'f' Ĳi "v'q'j' Ĳ' t'g'v'q'ur g'v'x'g'uwf { .y g'eq'p'w'f' g'j' c'v' r'ctqueqr { "eq'w'f' "d'geqo g'c' "uch'g'cpf' "g'Ĳ'g'v'x'g' o g'j' q'f' "qh' v'g'v'p' i " r cĲgpw' y Ĳj " cdf qo Ĳcni' vteco c'0' Vj Ĳ' o g'j' q'f' " o Ĳi j' v' t'g'f' w'g' "j g' "Ĳ' g'g'v'p' e { " qh' "w'p'p'eg'g'u'c' t { " r'ctqvo Ĳ'gu. " Ĳ'p'w'f' Ĳi "r'ctqvo { /t'g'v'g'f' "eqo r r'Ĳ'c'v'q'p'cpf' "r'g'p' i'j' "qh'j' qur Ĳcni'w'c' {0'Y' g'c'ni'q' r' t'g'g'p'v'c' r' q'Ĳ'Ĳ'g' "c'ni' q'Ĳ'Ĳ' o "Ĳ' "j' g'v'g' " qh' r'ctqueqr { "Ĳ' "j g' o cpci go gpv' qh' cdf qo Ĳcni' vteco c' r cĲgpw' d'cug'f' "q'p' q'w' "r'Ĳo Ĳ'g'f' "uwf { "cpf' "c' "t'g'x'Ĳ'g' "qh'j' g' " r'Ĳ'g'c'w'w'g'0' "

[3\_ "Q0'X0'Q] n'p. "X0'Ĳ'w'Ĳ'p. "C0'H'Ĳi g'j' w' "cpf' "U'W'c'p'w'g'u. "ō'Ncr ctqueqr { "Ĳ' "Cdf qo Ĳcni'vteco c.ō' "E'w'w'0'vteco c' "T'g' r'q'w' "x'q'04. "p'q'06. "r' r'045: 6468." \*4238-0'  
[4\_ "R0M'Uj cto c. "I 0I w'c. "ō'Vj g't'q'g'qh' r'ctqueqr { "Ĳ' "cdf qo Ĳcni'vteco c.ō' "Ĳ'p'v'Ĳ' "T'g'u'0'gf' "Ĳ' "Ĳ' "p'q'07. "r' r'03: 7563: 83. \*423: +0'  
[5\_ "O 0'Ĳ'p'g. "ō'Vj g'T'q'g'qh'Ncr ctqueqr { "Ĳ' "Cdf qo Ĳcni'vteco c' <C'32/ [ gct' "T'g'x'Ĳ'g' .ō' "x'q'0336. "p'q'05. "r' r'057: 658: . \*423: +0'  
[6\_ "M'J' 0'N'Ĳo. "D'0'U'Ĳ'j w'p' i. "Ĳ'0' [ 0'M'Ĳo. "cpf' "U'0'U'0'M'Ĳo. "ō'Ncr ctqueqr le'wti gt { "Ĳ' "cdf qo Ĳcni'vteco c' <C' "Ĳ'p' i'g' "eg'p'v'f' "t'g'x'Ĳ'g' "qh'c'9' / { gct' "g'zr g'Ĳ'p'eg. "ō' " Y q'v'f' "Ĳ'0'g' g'ti 0'U'w' i'0'x'q'032. "p'q'03. "r' r'0369. \*4237-0'  
[7\_ "O 0' \ 0'M'q'v. "Q'0' [ 0'O c'w'g'x' {ej. "cpf' "U'0'T'0'O q'v'w'c'm' "ō'Vj g'T'q'g'qh'Ncr ctqueqr { "Ĳ' "R'g'p'g'v'c'p' i "Cdf qo Ĳcni'vteco c' <Q'w' "Ĳ'Ĳ'c'Ĳ'ni' "G'zr g'Ĳ'p'eg. "ō'Ĳ'0' Ncr ctq'p'p' que0'c'f' x'0'U'w' i'0'V'g'ej' 0'x'q'047. "p'q'0; "r' r'09526958. \*4237-0'  
[8\_ "R'0'Ĳ'0'Ĳ'j g'u'x'Ĳ'j. "V'0'F'0'D't'q' y' g'f. "U'0'N'0'O q'v'w'c'm' { "F'0'T'0'H'c'w'g'f. "P'0'M'0'Ĳ'p' i'c'ni. "cpf' "Ĳ'0'Ĳ'0'H'f' "gu. "ō'0' Ĳ'p'Ĳo c'ni' "Ĳ'p'x'c'Ĳ'g' "Ĳ' "o c'z'Ĳo c'ni' "g'Ĳ'g'v'x'g' < F'Ĳ'c' i'p'q'w'Ĳ'c'p'f' "j' g'c'v' g'w'Ĳ' "r'ctqueqr { "Ĳ' "r' g'p'g'v'c'p' i "cdf qo Ĳcni'p'w'Ĳ'gu. "ō'Ĳ'0'vteco c' "C'ew'g' "E'c't'g' "U'w' i'0'x'q'09: . "p'q'08. "r' r'03298632: 7. \*4237-0'  
[9\_ "N'0'J' 0'H'0' "E'0' [ 0'F'0'cpf' "E'0'U'0'E'0' "ō'X'c'w'g' "qh'f' Ĳ'c' i p'q'w'Ĳ'c'p'f' "j' g'c'v' g'w'Ĳ' "r'ctqueqr { "Ĳ' "r' cĲgpw' y Ĳj "d'w'p'v'cdf qo Ĳcni'vteco c' <C'32/ { gct' "o' gf' Ĳcni' "eg'p'v'f' "g'zr g'Ĳ'p'eg. "ō' "R'N'Ĳ'U'Q'p'g. "x'q'035. "p'q'04. "r' r'03636. \*423: +0'

P5-49

DID NOT PARTICIPATE



# EQO RCTVO GP V/URGEHKE 'RTQVGQO G'EQPUVTCRPVUF TKKG EJ CPI GU'R' [ GCUV'O GVCNQNUO

RtepcuI tki cku<sup>3</sup>. 'Kltcj ko 'Gn/Ugo o cp<sup>4,9</sup>. 'Cpi grlec'Tqf tki wgu'Rtcf q<sup>3,5</sup>. 'O cpwgnI ctekc'Crdqtpqj<sup>6</sup>.  
Xlevqtkc'J cto cp<sup>7</sup>. 'Uvgr j gp'J qm cp<sup>7</sup>. 'Lqj cp'xcp'J ggtf gp<sup>3</sup>. 'Uko qp'J wddctf<sup>6</sup>. 'Tqd'Dg{ppp<sup>7</sup>. 'HcpmlI0  
Dtwi i go cp<sup>3</sup>. 'Rcuercg'F ctcP/Ncr wlcg<sup>5</sup>. 'P knjrcwu'Uqppgpuej gk<sup>4</sup>. 'Lgpu'P kgnug<sup>4,8</sup>. 'cpf 'Dcu'Vgwukpm<sup>3</sup>

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'G tki ckuB xwQj'

O gvcdqruo "ku'cv'yj g"eqtg"qh'egmwrct "hmpexkpu"cu'kv'r tqxkf gu"gpgti { "cpf "dwkrf lpi "dmjemu"tgs vktgf "hqt "egmwrct o clpvpcpeg"cpf "i tqy yj ="yj gtg"ku"yj gthgtg"o wej "kpvgtguv'lp"yj g"ftlxkpi "hqtegu"yj cv'uj cr g"o gvcdqruo"cf cr wkvkpu0'kP dcevgtkc. "eqputckpu"qp"egmwrct "tguqwtegu"gzr nklp"cmqecvkkp"qh'r tqvgkpu"vq"ft hgtgpv"egmwrct "r tqeguugu0'kP"gwnt { qvgu. j qy gxgt. "o gvcdqruo "ku'f kwtldwgf "kpvq"ugxgtcn'f khtgpv"eqo r ctvo gpw0'Vj wu"kv'ku"vpergct "y j lej "eqputckpu"uj cr g egmwrct"o gvcdqruo 0'J gtg"y g"kpvgi tcvgf "o gvcdqruo"hwzgu"cpf "r tqvgqo leu"fcv"y kj "c"i gpqo g/uecrg"o qf gn"qh'dwf f lpi { gcuv"Ueej ctqo {egu"egt gxkukc.g."gpj cpegf "y kj "f gvckrgf. "i tqy yj "tcvg/fr gpv"fguetkr vkkp"qh'r tqvgkpu"wtppxgt"cpf cuuqekvqf. "eqo r ctvo gpvur gekhle. "r tqvgqo g"eqputckpu0'Y g"lkip "yj cv'yj g"Etcdvgg"ghgev. "kQ0'yj g"qpugv"qh"creqj qre hgtto gpvkkp"\*cpcrqi quu"vq"yj g"Y ctdwti "ghgev"lp"ecpegt+"ku"i qxgtpgf "d { "o kqej qpf tlcn"qt "e { vquqre "eqputckpu. f gr gpv lpi "qp"pwtkpv'cxckrdkikv"cpf 's wcrkv(0Vj gug"ghgevu"ctg't ghgevgf "lp"r tgf kvkpu"qh'eqpf kkkp/"cpf "eqo r ctvo gpv ur gekhle"r tqvgqo g"eqo r qukkp. "y j lej "ctg"lp"ci tgggo gpv'y kj "s wcpvkcvxg"r tqvgqo leu"o gcuwtgo gpw0'Qwt "o qf grkpi cr r tqcej "r tqxkf gu"c"r qy gthwn"r rlvhcto "vq"uwf { "o wnkrg"uegpctkqu"qh"eqo r ctvo gpvur gekhle" { gcuv"o gvcdqruo "cv i gpqo g/uecrg'lp"c"lkip/i tclpgf "o cpgt0

# MODELING OF CONCENTRATION QUENCHING IN TWO-DIMENSIONAL SYSTEMS

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The phenomenon of concentration quenching has been investigated throughout the last century, however, its origin is not fully understood to this day. An example of such occurrence has been observed in chlorophyll solutions: at higher concentrations the relative fluorescence intensity becomes dependent on the concentration and starts decreasing [1]. It is important to note that in artificial systems the fluorescence is usually significantly quenched at fluorophore concentrations typical to that of unquenched *in vivo* photosynthetic systems.

In this work, concentration quenching in a two-dimensional system was simulated using approach similar to Ref. [2]. The two-dimensional model was chosen for simplicity, however, its real life equivalent could be an especially thin film or membrane. Molecules, each 1 nm in diameter, were scattered in a 10000 nm<sup>2</sup> area using a uniform distribution. Different concentrations were obtained by changing the number of molecules from 100 to 1000. Randomly chosen molecules acted as traps; excitation, after reaching such molecule, could not escape. The amount of traps used were 1%; 2%; 5%; 10%; 20% of the total number of molecules. At the initial time moment, excitation was distributed equally among all non-trap molecules. Time dependence of the total excitation probability was calculated by solving the system of kinetic equations with energy transfer rates between the molecules being proportional to the inverse sixth power of the distance between the molecules, following the Forster level of description. Obtained results were averaged over different molecule distributions and are shown in Fig. 1.

As expected, we can observe that in larger concentrations quenching is more rapid. A comparison between this model and a dynamic quenching model (where traps are formed when two or more molecules are closer to each other than a certain distance) will be presented.

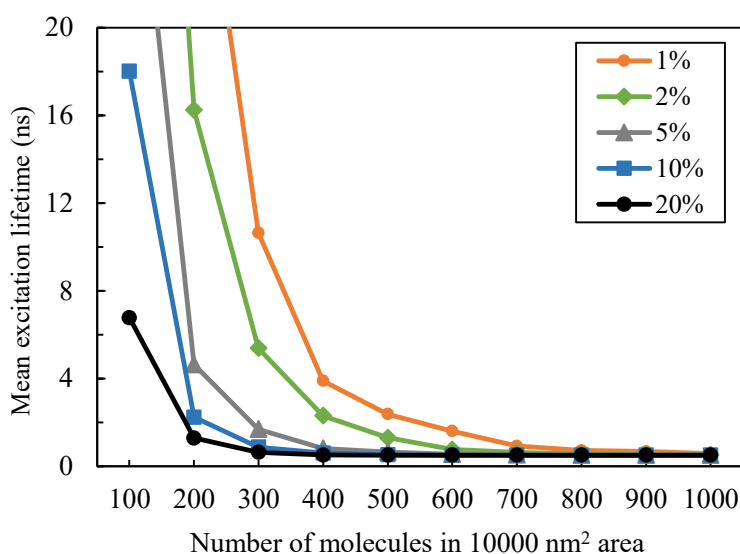


Fig. 1. Dependence of mean excitation lifetime on different molecular concentrations and relative amount of traps.

[1] G. Beddard, G. Porter, Concentration quenching in chlorophyll, *Nature* **260**, 366–367 (1976).

[2] W.-J. Shi, J. Barber, Y. Zhao, Role of Formation of Statistical Aggregates in Chlorophyll Fluorescence Concentration Quenching, *The Journal of Physical Chemistry B* **2013** 117 (15), 3976-3982

**U P VJ GUK'CPF 'KXGUVH CVKQP'QHPGY 'QTI CPHE''**  
**UGO KEQPF WEVQTU'Y KVJ 'CO KEG'CPF 'TGCEVKXG'HWP EVKQP CN''**  
**I TQWRU'**

Grfidkxc'Rq qdw.'Vcf cu'O crkpcwuru''

"Hewm{'qh'Ej go lecn'Vej pqrri {.'M:wpou'Wpksgtuks{'qhl'Vej pqrri {.'Nkj wcpk''"  
gn dkgc0 qeqdwB mw0kf w''"

P qy cf c{u'hqukrlhwgn'tgo clp'vj g'o quv'eqo o qp'uqwteg'qhl'gpsti {0Nko kgf 'tgugtXgu.'cf xgtug'ghgev'qp'j' wo cp'j' genj ''  
 cpf 'vj g'gpXtkqpo gpv'ctg'f go cpf lpi 'o qtg'kpvgpug'tgugcte'j 'qp'uwuclpcdrng'cpf 'tgpgy cdng'cnngtpcvkXgu0'Uqrnt'gpsti {'j' cu'  
 vj g'icri guv'r qvgv'lc'nco qpi 'cmt'gpgy cdng'gpsti {'uqwtegu'cpf 'k'ecp'dg'tcpulqto gf 'lpvq'uwdng'gngv'lekv' 'd{'r'j' qvqXncle''  
 eqpxgtukqp'lp'uqrnt'egmu']3\_0'

Ukdeqp'uqrnt'egmu'j' cXg'dggp'vj g'f go kpcpv'f tkXlpi 'hqt'eg'lp'r'j' qvqXncle'vej pqrri {'hqt'vj g'r' cuv'ugXgtcnf'gecf'gu'f'wg''  
 vq'vj gk'y gmn'pqy p'o ge'j' cpluo 'qhl'cev'qp.'vj g'rupi gXkv'{'cpf 't'grk'dkXk'{'f' w' lpi 'vj g'qr' g'c'vkqp'0'k'p'cf'f' kXkp.'ukdeqp'ku'vj g''  
 cdwpf'cpv'gng' gpv'lp'gctv'j' d'etwuv'cpf 'ku'pcwtg'ku'gpXtkqpo gpcvm'{'t'kgpf' n' 0'Vj g'gh'lekepe{'qhl'ewt'g'p'v'j' k'p/hkro'' ukdeqp''  
 uqrnt'egmu'ku'cdqkw'48'. 'dww'j' ku't'gs wkt'gu'vj' g'Xgt {'r' w't g'ukdeqp'cpf' eqo r r'gz'vej pqrri lecn'r' t'qeguugu']4\_0Hqt'vj g'ug't'gcuqpu''  
 vj g'ukdeqp'/dcugf' uqrnt'egmu'r' t'qf' wev'qp'ku'wkn'g'zr' g'pukXg0''

RgtqXunXg'uqrnt'egmu'RUEu+ecp'dg'qpg'qhl'vj g'cnngt'pcvkXgu'vq'ukdeqp'uqrnt'egmu'0REUu'j' cXg't'gegpw'{'c'w't'cev'g'f'c' h'v'q'h'  
 cwgp'vkp'f'wg'v'q'j' gk'j' ki j' r'qy'gt'eqpxgtukqp'gh'lekepe{'\*REG-.'k'p'g'zr' g'pukXg'w'c't'v'k'p' 'o' cvgt'kcu.'cpf' 'gcug'qhl'r' t'qf' wev'qp'0'k'p''  
 r'guu'vj' cp'c'f'gecf'g.'vj' g'ug'r'j' qvqXncleu'j' cXg'o' cf'g't'go' g'p'f' qwu'r' t'qi' t'guu'lp'gh'g'ev'Xg'p'guu.'k'ulpi' 'REG't'qo' '50' ' 'vq'4707'' ''  
 ]5\_0RgtqXunXgu'r' quuguu'lpv'lpule'r' t'qr' g't'v'gu'kn'g'y' k'f' g'c'duq'r' v'kp'ur' ge'v'wo'. 'h'cu'v'ej' c'ti' g'ug'r' c'tev'k'p.'rupi' 't'c'pur' q't'v'f' k'uc'peg''  
 qh'g'ngv't'qpu'cpf' 'j' q'rgu.'rupi' 'ect't'g't'ug'r' c't'ev'k'p'ri'g'v'o' g'0'Vj g'RUE'eqpuku'u'q'h'c'p'cev'Xg'r' g't'q'XunXg'n'{'gt' 'ng'ev'g'f' d'gw' g'gp''  
 vj' g' g'ngv't'q'p' v't'c'pur' q't'v'k'p' 'n'{'gt' '\*GVN+' cpf' 'vj' g'j' qng' v't'c'pur' q't'v'k'p' 'n'{'gt' '\*J VN+0' Vj' g'J VN' r'n'{'u' 'cp' 'ko' r' q't'v'p'v' 't'qng' 'k'p''  
 v't'c'pur' q't'v'k'p' 'j' q'rgu.'d'm'en'k'p'i' 'g'ngv't'q'p'u'cpf' 'r' t'q'v'ev'k'p'i' vj' g'r' g't'q'XunXg't'qo' 'gzv'g't'p'c'n'i'h'ev'qt'u.'k'p'ev'k'p'i' 'o' q'k'u'w't'g'j' g'cv' 'cpf''  
 qz {i' gp']6\_0'Vj g'o' clp'f' kuc'f' x'c'p'v'c'i' g'q'h'J' VN'ku'ku'eqpf' wev'Xk'v'{'.'y' j' lej' 'ecp'dg' 'l'p'et'g'cugf' 'd{' 'vj' g'cf'f' kXkp'qh'f' q'r' cpw'0'Vj' g''  
 w'ug'qhl'f' q'r' cpw.'j' qy' g'Xgt. 'ko' r' c'tu'v'j' g'u'c'd'k'k'v' {'q'h'v'j' g'r' g't'q'XunXg'u'qrnt'egmu.'uq' 'k'p'v'g'pukXg't'gugcte'j' 'ku'eqpf' wev'g'f' vq'c'd'c'p'f' q'p''  
 vj' go' 0'

Qpg'y' c {'vq'cXqk'f' 'vj' g'wug'qhl'f' q'r' cpw'lp'J' VN'ku'vq'wug'ugr'h'cuugo' d'rkpi '\*UCO+'r' q'ukXg'ej' c'ti' g'ectt'{'lpi' 'eqo' r' q'wp'f' u'0'  
 Vt'kt'{'nco' l'p'g/v'r' g'o' q'ng'ew'gu'c't'g'eqpuk'f' g't'g'f' 'cu'xgt' {'gh'lekepe'v'hw'ev'k'p'c'n'i'w'p'ku'v'j' c'v'ct'g'y' k'f' gn' {'wug'f' 'cu'r'j' q'v'eq'p'f' wev'qt'u''  
 cpf' 'ej' c'ti' g'ectt'g't'u']7\_0E'qo' d'l'p'k'pi' ''v't'r'j' g'p'{'nco' l'p'g'y' k'j' 'co' k'f' g'o' q'l'g'v'gu'ec'p'c'm'ny' 'o' q'ng'ew'gu'vq'ugr'h'cuugo' d'ng'k'p'v'j' g'ri'c'n'i'  
 c'i' i' t'g'i' c'v'g'u'y' j' g'p' 'z'r' q'ug'f' ''vq'Xk'ud'ng''n'i' j' v'0'O' g'c'p'y' j' k'g.'r' t'g'ug'peg'q'h'v'j' g'f' k'ev'v'{'ng'p'g'hw'ev'k'p'c'n'i' t'q'w' u' c'm'ny' u' 'h'q'to' g'f''  
 ut'w'ew't'g'v'q'd'g' 'k'z'c'v'g'f' 'y' k'j' 'eq'Xc'g'p'v'd'q'p'f' u'lp'v'q' 'u'c'd'ng' 'c'i' i' t'g'i' c'v'g'f' w't'k'p'i' 'vj' g'r'j' q'v'r' q'n' o' g't'k' c'v'k'p' 'l'p'f' we'g'f' 'd' {'w'nt'c'Xk'ng'v''  
 n'i' j' v'0'

k'p'vj' ku'y' q't'm'ug'Xgt'c'n'v't'r'j' g'p'{'nco' l'p'g'dcugf' 'q'ti' c'p'le' 'ugo' leq'p'f' wev'qt'u'y' k'j' 'co' k'f' g'cpf' 'tgce'v'Xg'hw'ev'k'p'c'n'i' t'q'w' u'y' g't'g''  
 u'{'p'v'j' g'uk'f' g'f' 'cu'f' q'r' cpv'h'g'g'UCO' 'J' VO' u'0'Vj' gk't' 'q'r' v'ec'n'r'j' q'v'r' j' {'u'le'c'n'c'p'f' 'vj' g'to' c'n'r' t'q'r' g't'v'g'u'y' g't'g' 'l'p'X'g'v'k'i' c'v'g'f' 0''''  
 ''''''''Vj' k'u't'gugcte'j' 'y' cu'hw'p'f' g'f' 'd' {'vj' g'G'w't'q'r' g'ep' 'U'q'el'c'n'i'hw'p'f' 'w'p'f' g't' 'vj' g'P' q'2; 06/NO' V/M'934/44/2248'of' g'Xg'r' o' g'p'v'q'h'  
 E'qo' r' g'v'p'eg'u'q'h'U'el'g'p'v'kuu.'q'v'j' g't'g'ugcte'j' g't'u'c'p'f' 'U'w'f' g'p'u'v'j' t'q'w' i' j' 'R't'cev'ec'n't'gugcte'j' 'C'ev'Xk'k'g'u'o' 'o' g'cu'w't'g'0'  
 ''

[3\_'C'0Dq] | q'r.'R0M'y' c're| g'y' un'k'O' 0'N'k'e'k'f' l'p'k'N0T' g'f' q't'le'k'0'Uk'leqp'Uqrnt'E'g'mu'<V'qy' c'tf' u'v'j' g'G'h'lekepe{' 'N'o' k'u'0'f'x'c'p'eg'u'lp'R'j' {'u'k'u'<Z0423; .6.'3.''  
 376: 5270'  
 [4\_'Dj' c'w'ce'j' c't'c.'U'D'lj' p.'U'D'g'{'q'p'f' '52' 'E'q'p'x'g't'uk'q'p'G'h'lekepe{' 'l'p'U'k'leqp'Uqrnt'E'g'mu'<C'P' w'o' g't'le'c'n'f' g'o' q'p'u't'c'v'k'p'0'U'k'k'T'g'r'; .346: 4'423; +0'  
 [5\_'Nk'\ 0'F' q'p'i' .l0'N'k'w' 'E'0'g'v'c'n'U'w'h'c'eg'r' c'u'k'X'c'v'k'p'q'h'R'g't'q'X'unX'g'Uqrnt'E'g'mu'V'qy' c'tf' 'k' r' t'q'X'g'f' 'G'h'lekepe{' 'c'p'f' 'U'c'd'k'k'v'{'0'P'c'p'q'/'O'k'et'q'N'g'w'033.'72''  
 \*423; +0'  
 [6\_'T'0'Y' c'p'i' .O' 0'0' w'c'j' k'f. 'l' 0'F' w'c'p. '\ 0'M'0'Y' c'p'i' .l0'Z' w'g. 'l' 0'f' c'p'i' 0'C' 'T'g'x'g'y' 'q'h'R'g't'q'X'unX'g'u'Uqrnt'E'g'mu'u'c'd'k'k'v'{'0'f'x'0'H'w'p'e'i'0'O' c'v'g't'0423; .4; .69.''  
 3: 2: : 650'  
 [7\_'O' q'w'k'p'G'P' k'g'u'u'H'O' c'c'n'q'w' 'O'. 'D'w'j' n'g'r' 'G'P' {'t'n'q'X'c'K'I' k'w'g'r' r' q'p'g'P' 0'Vj' g'j' k'g't'c't'ej' k'ec'n'ug'r'h'cuugo' d'nf' 'q'h'ej' c'ti' g'p'c'p'q'ec'tt'g't'u'c'c'j' k'i' j' n' {'e'q'q'r' g't'c'v'X'g''  
 r' t'q'eg'u'u'r' t'q'o' q'v'g'f' 'd' {'X'k'ud'ng'h'i' j' v'0'C'p'i' g'y' 'E'j' g'o' 'k'p'v'G'f' 'G'p'i' n'04232'U'g'r' '39-6; \*5; +8; 96/: 0'  
 ''  
 ''  
 ''

# U P V J G U K ' C P F ' R P X G U V K C V K Q P ' Q H ' N / V [ R G ' Q T I C P K E "

## U G O K E Q P F W E V Q T U E Q P V C K P K P I ' C P E J Q T K P I ' I T Q W R U "

Ncw { pc'O qpkne'Uxktuncky . 'Vcf cu'O crkpcwunau"

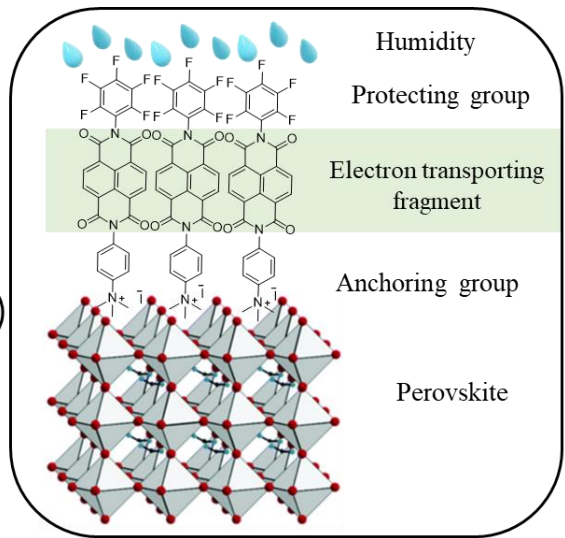
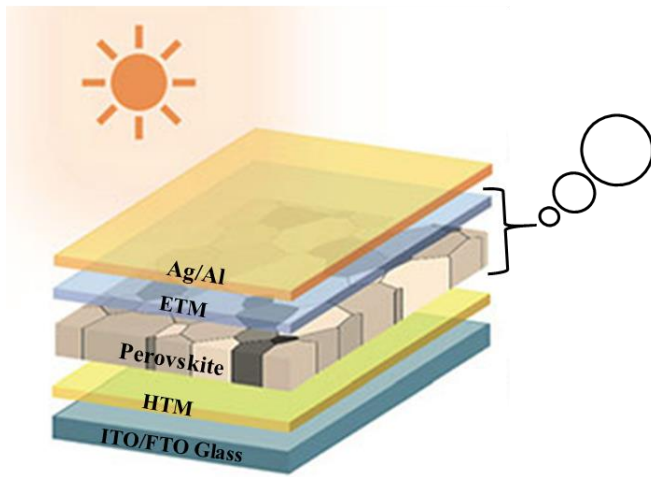
F gr ctvo gpv'qh'Qti cple'Ej go kwt { . 'Mcwpcu'Wpklxtukv' "qh'Vgej pqmji { . 'Tcf xkn p ' r f03; . 'Nksj wpcle" rcwt { pc'0xktunckyB mw0y"

"

Ego rctgf "y kj " vcf kkkpcn' hqto u' qh' grgevtlekv' " r tqf wevkp. " r j qvqxqncle " vgej pqmji { " qh'gtu' wu' y j g' r quukdkkv' " vq " r tqf weg' i tggp' cpf " uwuclpcdng' gpgti { " cpf ' tgf wekpi " go kulkqp' qh' i tggpj qwug' i cuugu' cpf " qvj gt " vqzle' qt " j cto hwi' r ct vlergu' 0 " C " i tgevf gcn' qh' gh' hqt' v' j cu' dggp' o cf g' f wtkpi " y j g' r cuv' hgy " { gctv' vq' ko r tqxg' y j g' r gthqto cpeg' qh' r gtqxunkg' uqrc' t' egm' " \*RUE- d' { " qr vko k kpi " y j g' f gxleg' utwewtg. " eqo r quukqp' cpf " o qtr j qmji { " qh' y j g' r gtqxunkg' r' { gt. " cu' y gni' cu' u' { pj guk kpi " cpf " cr r n' kpi " o qtg' gh' hkegpv' grgevtqp " \*GVO - d' cpf " j qng' v' t' cpur qt vki " o cvgtkcu' j3\_0Cu' c' t' guw. " RUE' eqpxgtukp' gh' hkegpe { " \*REG+ t' gcej gf " 470' " " j4\_ ' y j lej " o cngu' RUE' s' wkg' r' tqo kuki " r j qvqxqncle " vgej pqmji { 0J qy gxtg. " ucdkkrk' " kuuwu' t' go clp " cu' c' o clp' qduccng. " j kpf gt kpi " eqo o gteckrk' cvkqp' qh' RUE u' 0

Hqt' kpxgtvgf " RUE u. " hwngt gpgu' cpf " y j g' k' o qf kkgf " f g' k' xcvkxgu' ctg' y k' gni' " wugf " cu' GVO u. " co qpi " y j lej " REDO " ku' y j g' " o quv' r t' g' x' r' p' v' q' p' p' q' p' 0' W' p' h' t' w' p' c' v' g' n' . " nko kkgf " uqndkkrk' { " qh' " p' q' p' / o qf kkgf " hwngt gpgu' k' p' " qti cple " uqngp' w' j k' p' f' g' t' u' y j g' k' t' cr r n' ecdkkrk' { " k' p' " RUE u. " y j k' g' " o qf kkgf " q' p' g' u' ctg' t' v' j g' t' " g' z' r' g' p' u' k' x' g' j5\_0' GH' hkegpv' o g' v' j qf " vq' ko r tqxg' y j g' r gthqto cpeg' cpf " ucdkkrk' { " qh' RUE " ku' vq' eqcv' r' gtqxunkg' y kj " f' g' k' xcvkxgu. " cdng' vq' hqto " ugrh' cuugo drgf " o q' p' q' r' { gtu' \*UCO + . " g' f' 0' GVO " UCO 0' Vj g' k' p' k' e' p' c' w' t' g' qh' y j g' r' gtqxunkg' r' { gt " ecr' cdng' qh' k' p' v' t' c' v' k' p' y kj " f' h' h' t' g' p' v' c' p' e' j' q' t' k' p' i " i' t' q' w' u. " d' { " h' q' t' o' k' p' i " e' q' q' t' f' k' p' c' v' k' p' " q' t' " k' p' k' e' " d' q' p' f' u' 0' Vj g' t' g' h' q' t' g. " UCO u' ecp' hqto " q' t' f' g' t' g' f' " q' p' g' / c' v' q' o " y j k' e' n' i' r' { g' t' y j k' j " y g' m' f' g' h' k' p' g' f' " q' t' k' p' v' c' v' k' p' " q' p' y j g' r' gtqxunkg' " u' t' h' c' e' g' 0' Vj g' r' { q' w' qh' f' k' t' g' e' v' g' f' " GVO u' o' q' r' g' e' w' u' o' c' l' p' v' c' k' p' " e' q' p' u' c' p' v' f' k' r' q' n' g' o' q' o' g' p' v. " y j lej " k' p' h' w' g' p' e' g' u' e' j' c' t' i' g' v' t' c' p' u' r' q' t' v' k' i " g' h' h' e' k' g' p' e { " c' p' f' " y j g' r' c' r' k' i' p' o' g' p' v' qh' g' p' g' t' i { " r' g' x' g' n' i' c' v' y j g' r' { g' t' u' " k' p' v' t' h' c' e' g' 0' k' p' e' q' t' r' q' t' c' v' k' i " r' c' t' v' e' w' r' t' " h' w' p' e' v' k' p' c' n' i' t' q' w' u. " y j lej " r' t' q' x' k' f' g' j " { f' t' q' r' j' q' d' l' e' k' v' . " k' p' v' q' " UCO " o' q' r' g' e' w' r' t' " u' t' w' e' w' t' g. " g' f' 0' h' w' a' t' k' p' g' c' v' q' o' u' " e' c' p' " c' n' u' q' " k' o' r' t' q' x' g' r' g' t' q' x' u' n' k' g' t' g' u' k' u' c' p' e' g' v' q' " o' q' k' u' w' t' g' j6\_0

Kp' y j k' u' y q' t' n' i' p' g' y " p' / v' r' g' " u' g' o' k' e' q' p' f' w' e' v' q' t' u' " e' q' p' v' c' k' p' i " 3.6.7. : / p' c' r' j' w' r' p' p' g' v' t' c' e' c' t' d' q' z { r' e' " f' k' o' k' f' g' " \*P F K' i' " e' g' p' v' c' n' i' h' t' c' i' o' g' p' v' c' u' p' i " y j k' j " x' c' t' k' w' a' c' p' e' j' q' t' k' p' i " c' p' f' " r' t' q' v' e' w' x' g' i' t' q' w' u' y j g' t' g' u' f' p' j' g' u' k' f' g' 0



Hki 030' Rgtqxunkg' u' t' h' c' e' g' o' qf k' h' e' c' v' k' p' d' { " P F K U C O " }

Rj qvqgrgevtlecn' qr v' e' c' n' y j g' t' o' c' n' i' r' t' q' r' g' t' v' k' u' " qh' " y j g' " u' { p' j' g' u' k' f' g' " eqo r qwpf u' y g' t' g' " k' p' x' g' u' k' i' c' v' g' f' " c' p' f' " f' h' h' t' g' p' v' " o' q' p' q' r' { g' t' " h' q' t' o' k' p' i " r' t' q' e' g' f' v' g' u' y j g' t' g' " v' g' u' g' f' 0' UCO u' y j k' j " r' g' p' c' h' w' i' r' j' g' p' { n' i' h' t' c' i' o' g' p' w' i' h' q' t' o' g' f' " y j g' o' q' u' v' j " { f' t' q' r' j' q' d' l' e' " r' { g' t' " q' p' " y j g' u' t' h' c' e' g' " qh' r' g' t' q' x' u' n' k' g' . " y j lej " j' c' u' " l' o' r' t' q' x' g' f' " o' q' k' u' w' t' g' t' g' u' k' u' c' p' e' g' " qh' y j g' r' g' t' q' x' u' n' k' g' 0' C' f' f' k' k' q' p' c' m' { . " w' u' k' p' i " u' { p' j' g' u' k' f' g' " GVO u' r' g' t' q' x' u' n' k' g' u' q' r' c' t' " e' g' m' u' y j g' t' g' " e' q' p' u' t' w' e' v' g' f' " c' p' f' " r' j' q' v' q' x' q' n' c' l' e' " e' j' c' t' c' e' v' g' t' k' u' k' e' u' " qh' y j g' u' g' f' g' x' l' e' g' u' y j g' t' g' o' g' c' u' w' t' g' f' 0

"

[3]\_Dckw'Nk " gv' c' n' i' C' p' e' j' q' t' k' p' i " Hwngt gpg' q' p' v' q' Rgtqxunkg' Hko " x' c' " I' t' e' h' k' p' i " R { t' k' k' p' g' v' q' y' c' t' f' " G' p' j' c' p' e' g' f' " G' r' e' v' t' q' p' " V' t' c' p' u' r' q' t' v' k' p' " J' k' i' j' / G' H' h' e' k' g' p' e { " U' q' r' c' t' " E' g' m' u' . " C' E' U' C' r' r' i' f' 0' c' v' g' t' 0' k' p' v' t' h' c' e' g' u' 423; . " 32. " 54693 546: 40" [4]\_Dguv' T' u' g' u' c' t' e' j' / E' g' m' i' G' H' h' e' k' g' p' e { " E' j' c' t' 0' j' w' r' u' l' i' y' y' (p' t' g' r' i' q' x' l' r' x' l' e' g' m' g' h' h' e' k' g' p' e { " j' v' o' n' i' " [5]\_E' j' c' q' j' w' c' " E' w' k' " g' v' 0' c' n' i' Hwngt gpg' f' g' t' k' x' c' v' k' x' g' u' h' q' t' " y j g' r' r' n' e' c' v' k' p' u' " c' u' " C' e' e' g' r' v' t' " c' p' f' " E' c' v' j' q' f' g' " D' w' i' h' t' " N' c' { g' t' " O' c' v' g' t' k' e' n' i' h' q' t' " Q' t' i' c' p' l' e' " c' p' f' " R' g' t' q' x' u' n' k' g' " U' q' r' c' t' " E' g' m' u' . " C' f' x' 0' G' p' g' t' i { " O' c' v' g' t' 04239. " 9. " 38234730" [6]\_T' w' S' l' e' q' " c' p' f' " N' i' d' k' p' " v' q' . " U' g' r' h' c' u' g' o' d' n' i' " o' q' p' q' r' { g' t' u' " d' q' u' k' p' i " q' t' i' c' p' l' e' / k' p' q' t' i' c' p' l' e' " j' c' r' k' f' g' r' g' t' q' x' u' n' k' g' " u' q' r' c' t' " e' g' m' i' r' g' t' h' q' t' o' c' p' e' g' . " I' q' w' t' p' c' n' i' qh' " O' c' v' g' t' k' e' n' i' " T' g' u' g' e' j' " x' q' n' w' o' g. " 423; . " 55. " 5: 966220

# DEEP EUTECTIC SOLVENTS FOR HEADSPACE GAS CHROMATOGRAPHIC DETERMINATION OF HEXANAL

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During storage and when subjected to heat, unsaturated fatty acids of edible oils undergo oxidation forming hydroperoxides and secondary volatile oxidation products [1]. Oxidation has a great impact on the quality of food products because of off-flavours, of a decrease in the nutritional properties and especially because of the formation of toxic compounds and can increase propensities to various cardiovascular and metabolic diseases [2]. Thus there is a great interest on fast and simple detection of lipid oxidation. The evaluation of the oxidation level can be based on the quantity of hexanal as it is the main secondary oxidation product of linoleic acid which is one of the principle fatty acids of many edible oils [3].

The most complicated step of the determination of volatile compounds in complex matrices is the separation of analytes from the matrix. Traditional analyte separation methods (liquid extraction, Soxhlet extraction) require a lot of time and labour, moreover, there is a risk to lose the volatile analytes. In recent years, headspace gas chromatography has been used to determine the volatile compounds. To date, traditional extraction solvents have been used in headspace gas chromatography. As a rule, such solvents are rather volatile; therefore, a large amount of solvent vapour enters into the headspace together with the analyte. Because of that the determination sensitivity of the analyte is reduced, a huge solvent peak in the chromatogram can overlap with the peaks of the analytes. The sensitivity is also limited by the fact that the sample can't be heated at a higher temperature than the solvent boiling point.

Hexanal in fat-rich food can be determined by static headspace gas chromatography (SHS-GC). It includes a partial transfer of the volatile compounds into the gaseous phase and subsequently to GC system, meanwhile high molecular weight non-volatile molecules remain in the sample. For SHS extraction a solvent should be used to disperse the matrix and to prepare calibration solutions of hexanal. To promote the transfer of the volatile analyte into the headspace, the sample should be heated. Heating temperature should not reach the boiling point of the solvent, otherwise the vapour pressure becomes too great and leakages can occur or the vial could even burst. In order to increase heating temperature and to drive the equilibrium in favour of the gas phase, nonvolatile solvent should be advantageous.

In this work we suggest to replace traditional headspace gas chromatographic solvents by non-volatile, eco-friendly, biodegradable, inexpensive, easy to prepare deep eutectic solvents (DESS).

Eight hydrophilic and hydrophobic DESS have been synthesized and the influence of the temperature on their headspace gas chromatographic behaviour has been investigated. All the DESS studied were resistant to heating at 80 °C temperature. Among the solvents studied, DES composed of choline chloride, glucose and water showed the highest hexanal extraction efficiency. Using this solvent, headspace gas chromatographic conditions have been optimized for the determination of hexanal in potato chips. Under optimized conditions quality parameters of the prepared technique have been determined. The suggested technique was applied for the determination of hexanal in fat-rich food.

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**CU O O GVTKE 'Hlkgf gn/Etchvucnm] ncvkqp 'qh'p f qngu'  
 ECVCN[ \ GF 'D[ 'EJ KTCN'C\ KfKf KpG/RJ QURJ KpGU'  
 Crgmcpf tc'Dwejele.'Cpcc\ cy ku c.'Ucplu'ey 'Ng plcm'O lej c'Etcej y cnuK'**

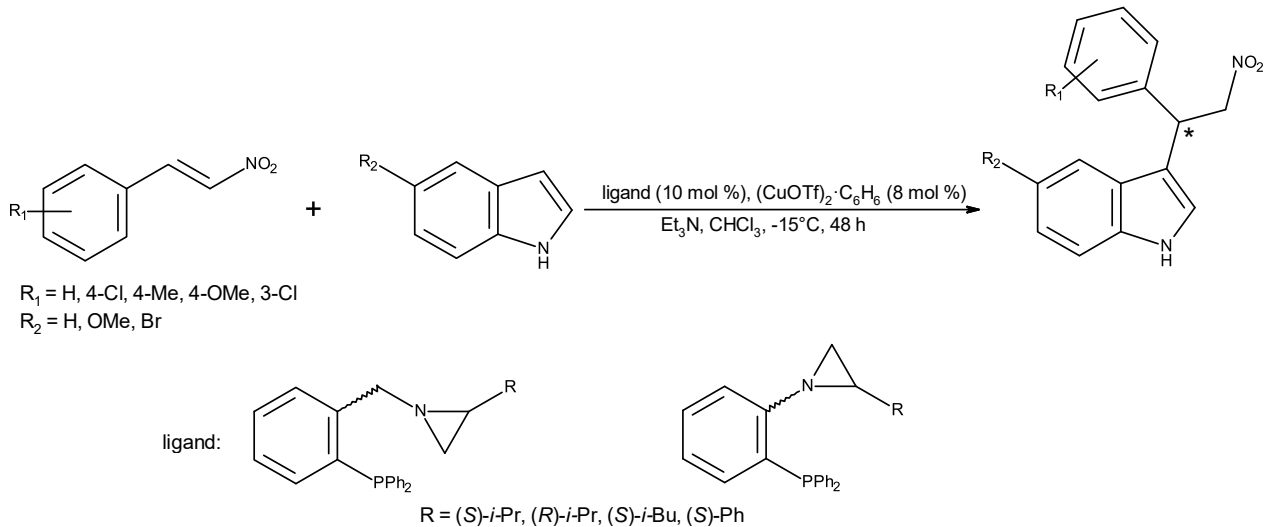
" F gr ctwo gpv'qh'Qti cple'cpf 'Crr rkgf 'Ej go kut { . 'Hcewm' {qh'Ej go kut { . 'Wpkxgtuk' {qh'Nqf | . 'Rqrcpf "  
 crgmcpf tc'DwejeleB gf w0pK0qf | 0 n'

Vj g' pgeguuk' { "vq" f gxgrq "pgy " o gy qf u" qh' r tqf wevkqp" qh' dkgm] kecm' { "cevkg" eqo r qwpf u" o cngu' cu{ o o gvtke" u{ pyj guku'cp' kpvgtgukpi 'cpf 'uwni'gzr nqt]pi 'hgrf' qh'qti cple'ej go kut {0Vj g'o clqtK' {qh'ur geku'cr r rkgf 'kp' r j cto ce' { 'eqwf " dg" qdvc]pgf "wkk] kpi "vj ku'o gy qf 0Cu{ o o gvtke" u{ pyj guku' j cxg'c" m'v'qh'cf xcpvc] gu. "g0 0vj g' r tgupeg' qh'd' { r tqf wevu'cpf " wpy cpvg' { gpcpvkqo gt' ku'xgt { "uo cm' uq'vj g' rquu' qh' uwdustcvgu' ku'urki j v'cpf "vj g' r tqf wevu'gzj kdk'j ki j "qr v'ecnr' wtk' {0"

Kpf qrg' f g' kxcvkgu' ctg' ng' { "ur geku'kp" j wo cp' d'qf { < "vj ku' ungrvqp" ku' r tguvp'kp" v' { r q' r j cp. "y j lej "ku'vj g' uwdustcvg" kp" o grvq]p'cpf "ugtq]vq]p' u{ pyj guku' 0Dqj "qh' o gv]pgf "eqo r qwpf u' ctg' t'gur qpukdg' hqt "xctkqwu' hwevkpu'kp" qti cpluo . "uwej " cu" ekecf kcp" tj { yj o . "uo qqj " o waerg" etco r u. "dqf { "vgo r gtcwtg. "ge0' Vj g' f twi u' cevki "wr qp" 7/j { f tqz { v' { r wco kpg" tgegr vqtu' ctg' dcugf "qp" kpf qrg' ungrvqp 0Vj g' eqo o qpn' wugf "o gf lekpgu' ctg' qpf cugvqp. "uwo cvtk vcp. "kpf qo gy cekp" qt" cm]ugtqp 0Co qpi "vj g' xctkqwu' kpf qrg' r quugukpi "f twi u' wuwm' { dgkpi "7/J V" cpvc] qpkuu' cpf "ci qpkuu. "cp' v'ecp'egt" ci gpwu' eqwf "dg' hqwpf . "g0 0xkpeco kpg' qt' xkpetkvpkpg 0]3 \_"

""Cu{ o o gvtke" Hlkgf gn/Etchu' cm' { r'v'qp" eqpukwgu' qpg" qh' yj g' o quw' ko r q'v'p'v' o gy qf u" qh' gpcpvkqugr'evkg" hqt o cvkq' qh' ectdq' / ectdq' / d'qpf 0Vj ku' t'gecvkq' ku' wkk] gf 'p'q'v'p'p' "kp" xctkqwu' v'q'v'cu' u{ pyj guku' qh' p'cw'c' h' eqo r qwpf u' "g0 0' chrvqz]p' D4 ]4 \_ " \*0' / dtcukis wkpqpg' D' ]5 \_ " dw'cnuq' kp' 4 / " qt' 5 / uwdustcvgu' kpf qrgu. "kpf qs wkpq]kpgu' cpf "ur kqtqqz]p' qrgu' ]6\_ 0' Hlkgf gn/Etchu' cm' { r'v'qp" eqwf "dg' g' h'gevkgn' { ecvcn' | gf "d' { "ej l'p'ej qpc" cm' r'kf u. "vj kqwtgc" f g' kxcvkgu' qt' "xctkqwu' eqr r gt' \*Kk' eqo r r'gz gu' ]7\_ " dw'vj gt' g' ku' r'eni' qh' l'phqto cvkq' cdq'w'cr r n' l'pi "r j qur j kpgu' cu' ej k'c'n' h' i' cpf u' kp' yj ku' t'gecvkq' 0'

Dcugf "qp" ej k'c'n' r j qur j kpg' { n' c' | k'k' k'p'g' ungrvqp" ]8\_ " c' ugt' k'gu' qh' ej k'c'n' r j qur j kpg' / c' | k'k' k'p'gu' y cu' u' pyj guk' gf "y kj " tgc]vq]p' c' d' { k'gr f u' 0Vj g' u' eqo r qwpf u' y gt' g' v'ugf "kp" cu{ o o gvtke" Hlkgf gn/Etchu' cm' { r'v'qp" qh' k'p'f qrg' d' { " / p'k'q'v' t' g' p'g' kp' yj g' r t'gupeg' qh' eqr r gt' \*Kk' u' h' w'q'q' o gy cp'gu' w' h' p'c'v'g' d' g' p'g' eqo r r'gz " \*Hk' 0'3-0'Vj g' r tqf wevu' y gt' g' qdvc]pgf "y kj " i' q'q' f " ej go k'c'n' { k'gr f u' cpf "gpcpvkqugr'evkgu' \* : 2 / ; 4 " " -0'Vj g' l'phw'p'eg' qh' r'ki cpf "ut wewt' g' cpf " ct { n' uwdustcvgu' kp' uwdustcvgu' y k'nd' g' f k'uewugf 'kp' r quvg' r t'gupeg' cvkq' 0'



" Hk' 0'30Cu{ o o gvtke" Hlkgf gn/Etchu' cm' { r'v'qp" ecvcn' | gf "d' { "ej k'c'n' r j qur j kpg' / c' | k'k' k'p'gu' 0'

- [3\_ "P 0M0M'cwuj km" P 0M0M'cwuj km" R0C'wtk" P 0M0w' ct. "E0J 0M0o . "C0M0'X'gto c. "G0J 0Ej qk" D'kqo gf k'c'n' ko r q'v'p'eg' qh' k'p'f qrgu' 0' qrgewru' 3: "8842/8884" \*4235-0'
- [4\_ " 0Y cpi . "N0" w' "Qti cpqecv'c' v' "gpcpvkqugr'evkg" f k'ge'v'cm' { r'v'qp" qh' r j nqtq] n'w'ep'q'nt'f g' kxcvkgu' < "cu{ o o gvtke" v'q'v'cu' u{ pyj guku' qh' " \* - / chrvqz]p' D4\_ 0' Ej go 0Eqo o wp'07393/7396" \*423; +0'
- [5\_ "O 0N0R'cvk' J 0D0D'q'c'v'g. "F 0G0R'q'p'f g. "X0J 0F guj r cpf g. "V'q'v'cu' u{ pyj guku' qh' \*0' / dtcukis wkpqpg' D. "V'g'v'c] gf tq'p' 7: "8837/8842" \*4224-0'
- [6\_ "G0U'epul'p'p'g'c. "G0H0 ct'v'p'g' . "C0Q'v'k' . "Qti cpqecv'c' v' "u{ pyj guku' qh' ej k'c'n' r k'qz]p' qrgu' y kj "s w'c'v'p'c' t' { "ugt'g'q] g'p'le' eg'p'v'g' u. "Gw'0L0Qti 0Ej go 0' 54. "7323/733: " \*4242-0"
- [7\_ "R0M0U'p] j . "C0D'k'ck' "X0M0U'p] j . "Gpcpvkqugr'evkg" Hlkgf gn/Etchu' cm' { r'v'qp" qh' k'p'f qrgu' y kj "p'k'q'c' m' p'g' u' ecvcn' | gf "d' { "c' d'ku' t'qz] c' | q'k'p'g' - / Ew' \*Kk' " eqo r r'gz 0'V'g'v'c] gf tq'p' Ngv'06: "3349/334: " \*4229-0'
- [8\_ "C0'Dwejele. "C0\ cy ku c. "U'Ng plcm' L0' Cf co el { m' C0'O 0' R'g'el qpne. "O 0T'cej y cnuK' "Gpcpvkqugr'evkg" O c'p'p'lej "t'g'cev'kq'p" r tqo qv'g' d' { "ej k'c'n' r j qur j kpg' { n' c' | k'k' k'p'gu' Ecvcn' u' u' ; . : 59 / : 6: " \*423; +0'
- [9\_ ""C0'Dwejele. "C0\ cy ku c. "U'Ng plcm' O 0T'cej y cnuK' Cu{ o o gvtke" Hlkgf gn/Etchu' cm' { r'v'qp" qh' k'p'f qrgu' ecvcn' | gf "d' { "ej k'c'n' c' | k'k' k'p'g' / r j qur j kpgu' " Ecvcn' u' u' 32. ; 93 / ; : 3 " \*4242-0"

VJ G'VJ GTO CN'F GEQO RQUK/QP'QHI TCRJ GP'G'QZK'G'K'P'VJ G'  
RTGUGPE'G'QHECTDQP'UWDQZK'G'

T wC'wma-cmql{v<sup>3</sup>.'Lwukpc'I ckl wngxk<sup>3</sup>.'Lxti ku'Dctnewuneu<sup>3</sup>'

<sup>3</sup>Kpukswg"qh'Ej go knt { .Hcewm'qh'Ej go knt { "cpf'I gquelpegu."Xkpkwu'Wpkxgtukv{ ."  
"P cwi ctf wng"46.'NV/25447'Xkpkwu.'Nkj wcpkc"

tweC'wma-cmql{vB'ej i l0x0n'

"

I tcr j gpg'ku'cp'cmq'qr g'qh'ectdqp'vj cv'r quuguu'wps wg'vj gto cn'ej go lecn'grgestlecn'qr wecn'r j { ulecn'cpf''  
o gej cplecn'r tqr g'wgu'K'j cu'dtqcf'cr r nckvqp'r tqr gew'kp'j ki j /Itgs wpe { "grgestqpleu."y cvgt'r wkleckvqp'u{ungo u."  
ugo leqpf wexq"o cvgtkcu."f twi "ecttkgtu."hgzkdng" gpgti { "uqtci g."cpf" dkugpukpi "f gxlegu" j3\_0'P qy cf c{u."vj gto cni'  
tgf wvqpp'qh'i tcr j gpg'qz'kf g'Q+'ku'qpg'qh'vj g'r qvgnvkn'u{pvj guku'o gvj qf u'vq'qdvclp'i tcr j gpg'kp"c'uko r rg."ny /equw"  
j ki j "{kgrf."cpf"sko g'ucxkpi "y c{0'J qy gxgt."I Q'ku'cwtldwgf "vq"c'encu'qh'gpgti gvke'o cvgtkcu'f wv'vq'ku'j ki j "gpvj cr { "  
ej cpi g'qh'vj gto cni'f geqo r qukqpp"\* J +0'Vj wu.'k'eqwf "f geqo r qug'xkqrgpvw' "k'pqv'r tqr gtn' "uqtqf"cpf" j cpf rgrf ."cpf"  
ecwug'ktgxgtukdng'f co ci g"j4\_0'Hwt'vj gto qtg."vj g'o gej cpluo "qh'vj gto cni'tgf wvqpp'qh'I Q'ku'eqo r ngz'cpf"pqv' { gv'hwnt"  
wvf gtuqqf "dgecwug'qh'vj g'eqpugewvkg'uci gu'qh'y cvgt'gxcr qtcvqpp."qz { i gp'eqpvcvklpi "hwpevqpcni' tqr u'tgo qxcn'cpf"  
dcucnr'wpg'ectdqp'f geqo r qukqpp'qeewt'kpi "f wtkpi "vj g'vj gto cni'gz'hz'kvqpp"j5\_0'Vj g'ghqg."k'ku'pgeguu' { "v'hwewu'qp'vj g"  
nkp'vle'cpcn'uku'qh'I Q'vj gto cni'f geqo r qukqpp'ht" c'f ggr g'wvf gtuwcp'kpi "qh'vj g'dg'cxkqwt'qh'vj g'gz'qj gto le'tgf wvqpp"  
tgcewqpp'cpf'gpuwt'kpi "uchg'o c'wv'cew'kpi "qh'i tcr j gpg'0"

Kp'vj ku'uwf { .y g'r tguv'vj g'ko r cev'qh'ectdqp'uwqz'kf g'E5Q4+qp'vj g'nkp'vleu'qh'I Q'vj gto cni'f geqo r qukqpp'0I Q'  
y cu'r tgr ctgf "Itqo 'pcw'cni' tcr j kg'd { 'vj g'u{pvj guku'r tqveqnt'gr qv'gf "d { 'I cp'gv'cni'0'6\_0'K'c'v'r lecn'gzr g'ko gp'v' tcr j kg"  
r qy f g'ty cu'tgcwgf "y kj "eqpep'vcwgf "J 4UQ6.'M4U4Q. "cpf "R4Q7\_0'Vj g'qdvclp'gf "r tg/qz'kf k'gf "i tcr j kg'y cu'uwld'gevgf "vq"  
qz'kf v'qpp'd { "J wo o gtu'o gvj qf "j7\_0'Ceeqtf kpi "vq'vj g'rkv'c'wv'g."E5Q4+eqwf "dg'u{pvj guk'gf "d { "j gcvkpi "vj g'o kzw'g'qh'  
o cmple'cek'cpf "r j qur j qtwu'r gpv'qz'kf g"j8\_0'Vq'gxcn'cv'vj g'gh'ge'v'qh'E5Q4+qp'vj g'nkp'vleu'qh'I Q'vj gto cni'tgf wvqpp."vj g"  
j qo qi gp'v'w'o kzw'g'qh'I Q."o cmple'cek'cpf "r j qur j qtwu'r gpv'qz'kf g'y cu'r tgr ctgf 0'K'y cu'pco gf "I QaO CaR'Vj g'  
r tgr ctgf "uco r ngu'y g'g'cpcn'ugf "d { 'wukpi "vj gto qi t'cxko gv { "VI +cpf "f k'ht'g'p'v'kn'uec'p'kpi "eqm'tko gv { "F UE+o gvj qf u'  
cv'vj tgg'f k'ht'g'p'vj gcvkpi "t'cv'gu<407'AE"o k'p<sup>63</sup>."7'AE"o k'p<sup>63</sup>."cpf "32'AE"o k'p<sup>63</sup>0'Vj g'nkp'vle'cpf "vj gto qf { pco le'r c'tco gv'gtu"  
qh'vj g'vj gto cni'f geqo r qukqpp'tgcewqpp'qh'I Q'cpf "I QaO CaR'y g'tg'f gv'to k'p'gf "d { "wukpi "Dqtej ctf v'F cpl'gn."Mku'kpi gt."  
cpf "Q' cy c'o qf gm'j9\_0'

FUE'tguwu'tgxg'grf "vj cv'vj g'tgf wvqpp'vgo r g'cwt'g'qh'I Q'ku'tgf wv'g' "w'v'vq'347'C+d { "wukpi "E5Q4'0'0'qtg'q'xg."k'  
y cu'qdu'g'xg' "vj cv'E5Q4'ny gtu'vj g'gp'vj cr { " J "cpf "cew'x'cv'qpp'gpgti { "Gc'dw'f'qgu'pqv'k'p'hw'p'eg'vj g'tgcewqpp'qtf gt "p'qh'  
I Q'vj gto cni'f geqo r qukqpp'0'Vj g'xcn'w'gu'qh'Gc'ht'vj g'vj gto cni'f gr qukqpp'qh'I Q'cpf "I QaO CaR'y g'tg'qdvclp'gf "uko k'rt" d { "  
wukpi "cni'vj tgg'o gvj qf u' "Mku'kpi gt."Q' cy c' "cpf "Dqtej ctf v'F cpl'gn+0' T'guwu' qdvclp'gf "d { "Dqtej ctf v'F cpl'gn"o gvj qf "  
uj qy gf "vj cv'vj g'xcn'w'gu'qh'Gc'k'p'et'g'cug'y kj "k'p'et'g'cukpi "vj g'j gcvkpi "t'cv'g'ht'dqj "uwf k'gf "uco r ngu'0'Vj g'cr r ct'gpv'tgcewqpp"  
qtf gt "p'ht"dqj "I Q'cpf "I QaO CaR'gs wcn'290'K' "h'ce'v'vj g'o gej cpluo "qh'vj ku'r t'qegu'ep'de"o qf g'ngf "k'p'w'f'kpi "  
uko w'nc'p'g'w'u' | g'tq/qtf gt" cpf "ht'uv'qtf gt" uci gu'0'Vj g' | g'tq/qtf gt" r t'qegu' "o c { "qtki k'p'cv'g'kp"vj g'ecug'y j gp'vj g'gpgti { "  
equ'wo gf "kp'vj g'vj gto cni'f geqo r qukqpp'tgcewqpp'eqo gu'vj tqw'j "vj g'ducn'i' tcr j gpg'r'w'p'g'v'j gp'vj g'tgcewqpp't'cv'g'uj q'w'f "  
pqv'f gr g'p' "qp'vj g'tgci gp'v'eqpep'vcwqpp' "K'g'0'vj g'eqpep'vcwqpp'qh'hw'p'v'qpcni' tqr u'0'Vj g'ht'uv'qtf gt" r t'qegu' "o c { "qeew"  
kp'vj g'ecug'y j gp'vj g'gpgti { "ku'cdu'qtd'gf "f k'g'w'f "d { "c'hw'p'v'qpcni' tqr u'v'j ku'v'o g'vj g'tgcewqpp't'cv'g'f gr g'p'f u'q'p'nf "qp'vj g"  
eqpep'vcwqpp'qh'vj g'tgci gp'0'Vj g'uco g'tgcewqpp'qtf gt "ht" I Q'cpf "I QaO CaR'tgf wvqpp'tgx'g'cni'vj g'uco g'o gej cpluo "ht"  
dqj "r t'qegu'gu'0'

"

j3\_ "UOT'gp.'ROT'qpi ."S 0[ w'Rtgr c'tcv'k'p'u.'r tqr g'wgu'cpf'cr r nckvqpp'qh'i tcr j gpg'kp'hw'p'v'qpcni'f gx'legu'c' "eqpelug'tgx'g'y ."Eg'tco 0'K'p'0'66."33; 626  
33; 77"423; -0'

j4\_ [ OS kw.'H0I wq.'T0J wv.'IOM'Arc'qu.'Gzr'w'k'x'g'vj gto cni'tgf wvqpp'qh'i tcr j gpg'qz'kf g'dcug'f "o cvgtkcu'0' gej cpluo "cpf "uch'g'v' "lo r nckv'k'p'u.'Ectdqp."  
94."4376445"4236-0'

j5\_ [ O'W'0'Ng.'L0O cp { co ."R0'Qr cr t'neuk' "P 0'Ej c'p'ngm' "P 0I k'f'cpw'cm' "R0'U'g'g'et'w'p'q'v' ck' "F k'x'gti gp'v'o gej cpluo u'ht'vj gto cni'tgf wvqpp'qh'i tcr j gpg'  
qz'kf g'cpf "vj g'k'j ki j n' "f k'ht'g'p'v'k'p'c'ht'p'k'g'u.'F l'co 0T'gr'v'0O cvgt0; ; "4686478"423; -0'

j6\_ Z0' [ cp." I0' Ej gp." I0' [ cpi." S 0' Zw'g." R0' O k'ng. Hed't'le'ck'v'p' qh' H'gg/U'c'p'f'kpi ." Gr'gest'q'ej go lecn' "Cev'x'g." cpf " Dk'q'eqo r cv'k'ng" I tcr j gpg'  
Qz'kf g' R'q'nf'c'p'k'p'g'cpf "I tcr j gpg' R'q'nf'c'p'k'p'g'J { dt'k' "R'cr'gtu.'C'r'r 0O cvgt0; "4743-474; "4232-0'

j7\_ Y 0U'W wo o gtu.'T0G0'Q'ht'go cp.'Rtgr c'tcv'k'p'qh'i tcr j k'le'Qz'kf g.'L0Co 0Ej go 0U'q'0; 2.'355; "3; 7; -0'

j8\_ "Q0'D'q't'v'q'p'k' "N0'R'c'p'f'q'rt'q."E0'V'q'o c'ug'nk' "R0'V'c'f'k' "k'p' /o q'rg'ew'g'ej go knt { "qh'ectdqp'uwqz'kf g'kp'cp' "k'p' /stcr "o cu'ur' g'ew'qo g'gt."K'p'0'L0'0' cu'ur'  
U'g'et'qo 03; 263; 3.'393639; "3; ; -0'

j9\_ "O 0X0'C'm'p'uq.'O 0'Q'ng'v.'L0 0R'2'g'l.'H0T'q'f'f' w'l.'L0G'ej g'x'gt'f'f.'F g'v'to k'p'v'qpp'qh'ew't'kpi "nkp'v'le' r c'tco gv'gtu'qh'i'ki p'p' /r j gp'q'n'ht'o c'f' g'j { f g't'gu'q'nf'  
t'g'k'p'u'd { 'u'g'x'g'c'ni'f { pco le'f k'ht'g'p'v'kn'uec'p'kpi "eqm'tko gv { "o gvj qf u' "Vj gto q'ej ko 0'C'ev'063; "3836389"4226-0'

"

# O QF GNP I 'QH'UPI NGV6UKPI NGV'CPP KI KNCVKQP 'R' "

## QP G/F KO GP UKQP CN'O QNGE VNCT'NCVVKEG' "

I cdt kgn "Tcprngl v<sup>3</sup>. 'Lgxi gpl' 'Ej o grkqx<sup>3,4</sup>"

<sup>3</sup>kpukwng'qh'Ej go kcrn'Rj { uleu. "Hcewn' 'qh'Rj { uleu. "Xkpkwu'Wpkxgtul'f. "Xkpkwu. "Nkj wcpk"

<sup>4</sup>F gr ctvo gpv'qh'O qrgewrt 'Ego r qwpf 'Rj { uleu. "Egvt g' hqt 'Rj { uleu. "Uekppegu'cpf "Vgej pqmji { . "Xkpkwu. "Nkj wcpk"

[i cdt kgn t cprngl v g B H f u w f k v o n](#)

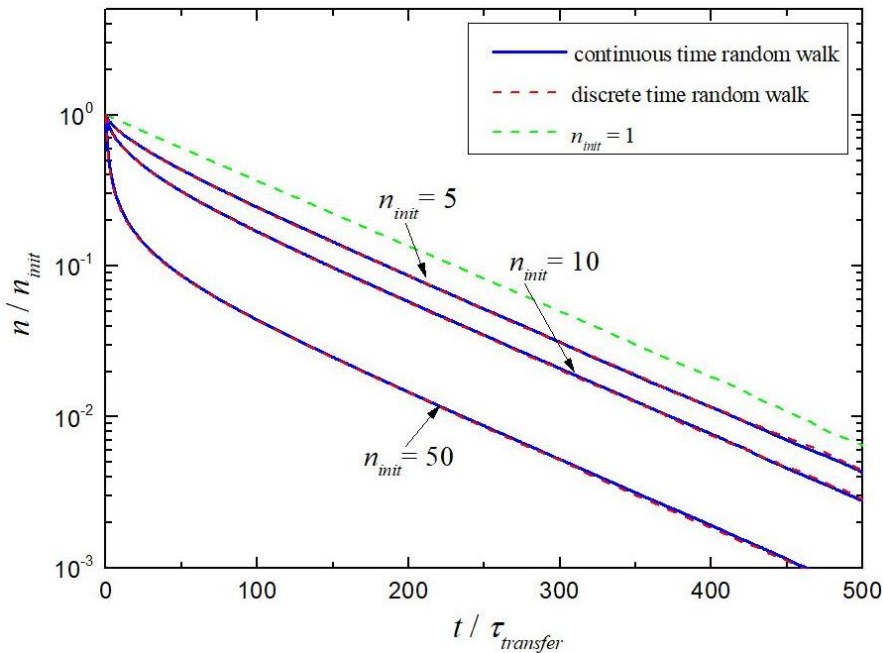
Ukpi ngv6ulpi ngv'cpplj krcvkqp"ku" c" eqo o qp" r j gpqo gpqp"kp" o qrgewrt "ut wewt gu'0'K' ku" qhngp" f h h e w n" vq" r t q x k f g" g z r g t k o g p v n l e q p f k k q p u' v j c v e q w r f' r t g x g p v' c p p l j k r c v k q p' o' v j g' g z e k c v k q p' t c f k c v k q p' q h' h q y' l p v g p u k f' b' w u v' d g' w u g f. "uq' v j c v' c v" o q u v' p q g' r k i j v' r j q v q p' r g t' g z e k c v k q p' r w u g' k u' c d u q t d g f' r g t' o q r g e w r t' c i i t g i c v g. "i g p g t c v k p i' l w u v' c" u k p i r g' g r g e v t q p l e" g z e k c v k q p' 0' E q p u g s w g p v n l. "vq" l p e t c g u g' u k i p c n' v q' p q k u g' t c v k. "v j g' b' g c u w t g o g p v' k o g' o w u v' d g' g z v g p f g f 0' V j g u g' g z r g t k o g p v n l' e q p f k k q p u' b' c { "p q v' d g' u w k c d n g' h q t' u q o g' u c o r r g u v' v j g t g h q t g. "k' b' o k i j v' q h n g p' d g' p g e g u c t { "vq" c e e q w p v' h q t' c p p l j k r c v k q p' y j k g" c p c n l' k p i' f' c v o' "

Uk r ng'cpplj krcvkqp"o qf gr'ecp"dg'f guetldgf "d { 't'cvg"gs wcvkqp"Gs 03<

"  $\frac{dn}{dt} = -\gamma n^2.$  \*34"

j g t g' n(t) "k u' v j g' o g c p' p w o d g t' q h' t g o c l p k p i' " g z e k c v k q p u' k p' v j g' u' u g o' c v' k o g' v' c p f' y' k u' v j g' t c v g' e q u x c p v' h q t' c p p l j k r c v k q p' 0' k p' v j k u' o q f g n' v j g' u' k' g' q h' o q r g e w r t' c i i t g i c v g. " g z e k c v k q p' t c p u h g t' t c v g' c e t q u u' v j g' c i i t g i c v g. " c p f' " l p k k c n' r' q r w c v k q p' q h' g z e k c v k q p u' c t g' e q p u k f' g t g f' " x g t { " r c t i g 0' k p' q t f g t' v q' l p e n f' g' h k p k g' t c p u h g t' t c v g. " y' o w u v' d g' e q p u k f' g t g f' " c u' c' h w p e v k q p' q h' v k o' g' y j l e j' c v' n p i g t' v k o g u' e c p' d g' c r r t q z k o c v g f' d { " c' r' q y g t' r e y' " j 3\_0' O q t g' r t g e k u g' o q f g n k p i' y q w f' c n u q' l p e n f' g' f' k u e t g v g' p w o d g t' q h' g z e k c v k q p u' t g u w n k p i' l p' v j g' u' u g o' q h' R c w k' O c u v g t' g s w c v k q p u' j 4\_0' "

Vq' c e e q w p v' h q t' d q v j' h k p k g' t c p u h g t' t c v g' c p f' f' k u e t g v g' p w o d g t' q h' g z e k c v k q p u' k p' c p p l j k r c v k q p' o q f g n' y' g' j' c x g' e j' q u g p' v q' w u g' O q p v g' E c t n q' o g y q f 0' F w t k p i' v j g' o q f g n k p i' r t q e g u u' p q g' f k o g p u k p c n' o q r g e w r t' r w l e g' k u' h q t o g f' c p f' g z e k c v k q p u' c t g' t c p f' q o n l' f' k u t k d w g f' l p' v j g' r w l e g' 0' C' v' g c e j' v k o g' u n g r. " v j g' g z e k g f' u c v g' j' c u' v j t g g' h c v g u' < k' e c p' u w c { " l p' v j g' u c o g' r' q u k k q p. " t g r z' v q' v j g' i' t q w p f' u w c v g. " q t' o q x g' v q' c p q v j g t' r' q u k k q p' y k j' r' t q d c d k l w f' " v q' c p p l j k r c v g' k h' v j c v' u k g' k u' c r t g c f' { " q e e w l g f' 0' V j g' h c v g' k u' f' g e k f' g f' d { " i g p g t c v k p i' t c p f' q o' p w o d g t u' 0' G x g p w e m f. " p w o d g t' q h' g z e k c v k q p u' k p' v j g' r w l e g' d g e q o g u' l' g t q. " c p f' v j g p' v j g' u c o g' t' t q e g u u' k u' t r g c v g f' d { " i g p g t c v k p i' p g y' l p k k c n l' k u t k d w k q p' 0' C' h g t' 32' 222' r w l e g u j' c x g' d g g p' i' g p g t c v g f. " v j g' c x g t c i g' n p g v l e u' k u' e c r e w c v g f' \* H i 03-0' V j g' h k u v' o q f g r i y' c u' d c u g f' q p' f' k u e t g v g' v k o g' t c p f' q o' y' c m 0' V j g' u c o g' o q f g r i k u' p q y' o q f h h e f' c p f' d c u g f' q p' e q p v p w q u' v k o g' t c p f' q o' y' c m 0' V j k u' o q f h h e c v k q p' t g f' w e g u' v j g' e q o r w k p i' v k o g' c r r t q z k o c v g n l' v g p' v k o g u' 0' "



Hki 030'Gzekcvkqp"r qr wcvkqp"mpgvleu"p<sub>plv</sub>"ku"v j g' l p k k c n' r' q r w c v k q p' u k' g. " o q r g e w r t' r w l e g' u k' g' k u' P' ? " 322' p q f g u' 0' Y j g p' q p g' g z e k c v k q p' k u' h g h' l p' v j g' r w l e g. " s w g p e j l p i' d g e q o g u' g z r q p g p v c n l' f' w g' v q' h k p g c t' t g r z c v k q p' t' g r z c v k q p' t c v g' k u' m g i t' ? " 32' 4' m c p u h g t' 0' "

[3\_] J 0xcp'Co gtqpi gp. 'NO'Xcmwpcu. 'T0xcp'I tqpf gng. 'Rj qvqul'py gve'Gzekvpu'\*Y qtf 'Uekp'wke. 'Ukpi cr qtg. '4222-0'  
 [4\_] X0Dct| f c. 'X0I wul'pau. 'T0M'epcpx'leku. 'X0E'gt'xpun'cu. 'J 0xcp'Co gtqpi gp. 'T0xcp'I tqpf gng. 'N'Xcmwpcu. 'Ukpi ngv'Ukpi ngv'Cpplj krcvkqp' Mlpvleu' l p' C i i t g i c v g u' c p f' v k o g t u' q h' N J E K' D k q j { u 0' L O: 2. '462; 64643' \*4223-0'



# TOTAL INTERNAL REFLECTION ELLIPSOMETRY FOR THE INVESTIGATION OF SARS-CoV-2 NUCLEOCAPSID PROTEIN AND SPECIFIC ANTIBODY BINDING KINETICS

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a virus that causes COVID-19 disease. This illness started global pandemic in late 2019 which is still going. It is extremely important to investigate SARS-CoV-2 proteins structure and their binding mechanisms because this knowledge could help scientists to develop new virus detection and monitoring methods. SARS-CoV-2 virus contains 4 structural proteins: nucleocapsid (N), spike (S), envelope (E) and membrane (M) [1]. N-protein enters host's cell and releases RNA which starts its replication and virus spreads to other cells [2]. Nucleocapsid protein is highly immunogenic and causes strong immune response. Thus, we chose to study N-protein in this investigation.

Various methods can be applied to study kinetics of antigen and specific antibodies binding. In this case, optical methods get special attention. Many of them are nondestructive and label-free which are huge advantages when investigating protein-protein interactions. One of such methods is total internal reflection ellipsometry (TIRE). The real time measurements can be performed and information about protein binding mechanisms can be obtained using TIRE [3].

In this study TIRE was applied for the investigation of SARS-CoV-2 N-protein and polyclonal antibodies against this protein interaction kinetics. The obtained results showed that the two steps binding kinetic model is suitable to describe the immune complex formation. Association and dissociation rate constants, affinity and dissociation constants were evaluated from two-steps binding kinetic model. Calculated thermodynamic properties of such immune complex showed that it has very strict steric requirements. Estimated Gibbs free energy ( $\Delta G_{\text{Form}}$ ) was  $-34$  kJ/mol. These findings could be useful for the design of new analytical systems for the determination of specific antibodies formed in the organism after infection, for the development of new SARS-CoV-2 detection methods, and for production of medications that are blocking viral SARS-CoV-2 proteins.

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This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-19-0106) under grant agreement with the Research Council of Lithuania (LMTLT).

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**F'GXGNQRO GP V'QHCF F/QP'RTQVQV[ RG'HQT'I E'QXGP'EQQNKI "**  
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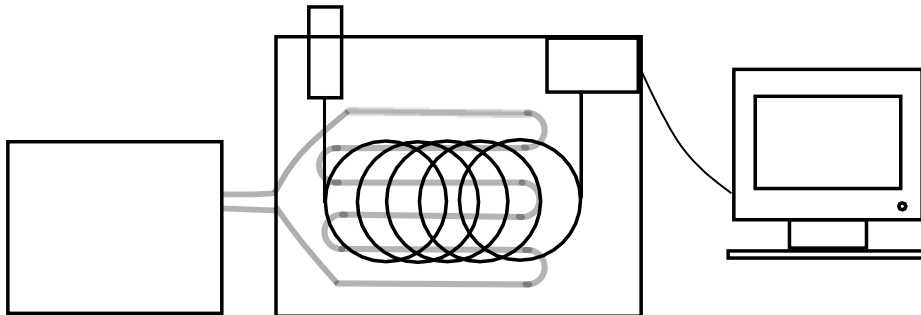
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 Nwnk-nk 'um0'; .NV/2332: 'Xkpkwu.'Nkj wpcle"  
cwf tkwu'Ucf cwp{neuB hno e0v"

"

Qpg'qh'vj g'o quv'r qr wnt'cpcn' vlecn'o gy qf 'wugf' ctqwpf 'vj g'y qtnf 'ku'i cu'ej tqo cvqi ter j { "¶1 E+.'y j lej 'ku'cr r nkgf "  
 hqt'xctkqwu'xqrc'vkg"eqo r qwpf u'cpcn' uku'0'rtkpek r g'qh'i cu'ej tqo cvqi ter j { 'ku'ugr'ctc'v'kp.'r'gthqto gf "qp'ej tqo cvqi ter j le"  
 eqmno p'0I E'eqmno p'ku'wuwcm' 'c'vj kp'uklec'ecr kmrt { 'r'ncrgf 'kp'cp'qxgp'y kj "r'tgekug'vgo r gtcwgt'eqpvt'q'0'cpcn' vgu'ctg"  
 dgkpi "tgv'k'pgf' d { "ucv'k'pct { 'r'j cug'lp' 'vj g'eqmno p'cpf' r'qr gmgf' hqty'ctf' d { "i cu' hqy "cpf' vgo r gtcwgt' k'petgcug"}3\_0'  
 Tco r lpi "vgo r gtcwgt' l'tqo "62/82" ðE"vq" gxgp"422/522" ðE "ku'eqo o qp'lp" I E"cr r nlec'v'kpu'0'Vj ku'y c { "tgugctej'gtu'ecp"  
 eqpvt'q'cpcn' v'ugr'ctc'v'kp'cpf' o'cng'cpcn' uku'o qtg'gh'kekpg'0'Vj g'r'qdrgo 'y kj 'ucpf'ctf' I E'qxgp'ku'vj cv'vj g { 'f'kf'pqv'  
 gxq'k'g'uki'pk'hecpv' { 'ulpeg'vj g { 'y'gtg'ucv'v'g'vq'wug'lp'3; 92u'0'K'vcngu'c'np' 'v'ko g'v'eqqn'f'qy p'ch'gt'gcej 't'wp'cpf' 'vj g { "  
 eqo o qpn' 'ecppq'v'dg'eqqng' 'dgm'y "co d'kpv'v'go r gtcwgt'y j cv'ku'c'o' wv'ht'uo' g'o qtg'xqrc'v'k'eqo r qwpf 'cpcn' uku'4\_0'  
 Y'g'c'ko "vq'uq'k'g'vj ku'r'qdrgo 'y kj 'lp'/j'qvw'f'guki'p'g'f'cpf' 'd'w'k'v'eqq'kpi' 'c'f'f'/qp' r' tqv'v' r' g'ht' I E'qxgp'0'

Vj ku'r' tqv'v' r' g'uej go g'uj qy gf "lp'Hki' wtg'3"ku'dcugf "qp'g'xcr' qtc'v'kpi' "eqq'kpi' "r' tkpek'rgu"}5\_0'Wpk'q'wukf' g'y'g' I E'  
 j'q'wugu'eqo r' tgu'qt. "eqpf'gpu't'cpf' "vj' gto' cni'g'zr'cpuk'p'x'cxg'0'E'qo r' tgu'gf' "t'g'ht'ki' g'tc'p'v'ku'eqqng' "f'qy'p'lp'eqpf'gpu't'cpf' "  
 v'cx'gn'u'k'puk'f' g'y'g' I E' 'vj' tqw'i' j' ku'r'v'g'f' "t'c'p'uh't' k'p'g'y' j' g'g'k'v'z'r'cpf' u'k'puk'f' g'y'g'g'x'cr' q'tc'v'k' p'f' "eqq'n'f'qy' p'vj'g' I E'qxgp'0'  
 Vj'gp' t'g'ht'ki' g'tc'p'v'ku'v'c'p'ur'q't'v'g'f' d'c'em'v'q'eqo r' tgu'qt. 'y'j' g'g'k'v' r' g'ht'qto' u'v'j' g'e { 'eng'ci' c'k'p'0'D { 'wuk'pi' 'vj' ku'r' tqv'v' r' g' 'y' g'j' cxg'  
 cej' k'g'x'g'f' "h'c'v'gt' "eqq'kpi' "qh' 'vj' g' I E'qxgp'0'Vgo r' g'c'w'gt' "lp' 'vj' g'qxgp' f' getgcug'f' l'tqo "422" ðE "vq" 62" ðE "lp' c'd'q'w'w' 3.7" o' k'p'0'  
 k'p'ug'c'f' "q'h'c't'q'w'p'f' : "o' lp'p'q'to' c'm { '0'Vj' cv'ku'c'p'ko r' t'q'x'g'o' g'p'v'q'h'c'm' quv' : 2" 0'Vj' ku'h'k'p'f' "q'h'k'petgcug'y' q'w'f' 'ur' g'g'f' 'w'r' t'q'w'k'p'g"  
 cpcn' uku'lp' 'vj' g' h'rd'q't'cv'qt { 'uki' pk'hecpv' { 'd' { 't'g'f' w'ep'i' I E' 'u'f'ug'o' "gs'w'k'd't'c'v'k'p'v'ko' g'd'g'y' g'g'p'lp'l'g'v'k'p'u'0'

Ugeqpf' n'f' .y' g'v'g'ug'f' 'vj' g'u'f'ug'o' 'd' { "o' g'cu'w'k'p'i' "r'ki' j' v'g't' i' cu'o' k'z'w't'g'y' j' k'ej' "o' qu'v' { 'eqp'v'k'p'u'k'q'd'w'c'p'g'cpf' "ku'ku'o' g'tu'0'  
 P'q'to' c'm { 'y' g'eq'w'f' "q'p'n'f' "uc't'v'vj' g'c'p'n'f' uku'c'v'57" ðE "lp' 'vj' g' I E'qxgp'0'U'c't'v'k'p'i' "cv'vj' ku'v'go r' g'c'w'gt'g'y' g'eq'w'f' p'p' 'ugg'cp { "  
 ugr'ctc'v'k'p' "d'w'v' y' kj "cr' r' nlec'v'k'p' "q'h'q'w' "eqq'kpi' "c'f'f'/qp. "vj' g'c'p'n'f' uku'eq'w'f' "d'g'uc't'v'g'f' "cv'/32" ðE "cpf' "y' g' t'gi' k'v'gt'g'f' "vj' t'gg'  
 ugr'ctc'v'g' r' g'cm'0' Vj' ku' d't'q'c'f' g'p'u' e'c'r' c'd'k'k'k'g'u' "q'h' I E" c'p'n'f' uku' c'p'f' "k' / ku' x'g't { "d'g'p'g'h'ek'n' h'qt' "j' k'j' n'f' "x'q'rc'v'k'g'eqo r' q'w'p'f' u'  
 uet'g'p'k'pi' 0'



Hki' 030I' cu'ej tqo cvqi ter j { 'u'f'ug'o' u'y' k'j' "qxgp'eqq'kpi' "c'f'f'/qp"

Vj'gug' t'gu'w'u'ctg' l'w'u'vj' g' d'gi' k'p'l'k'p'i' "q'h'q'w't' y' q't'n'q'p' 'vj' ku'v'q'r' le" c'p'f' "y' g'y' k'n'eq'p'v'k'p'w'g' y' k'j' "ko r' t'q'x'g'o' g'p'v'q'h' 'vj' g'  
 r' tqv'v' r' g'0'

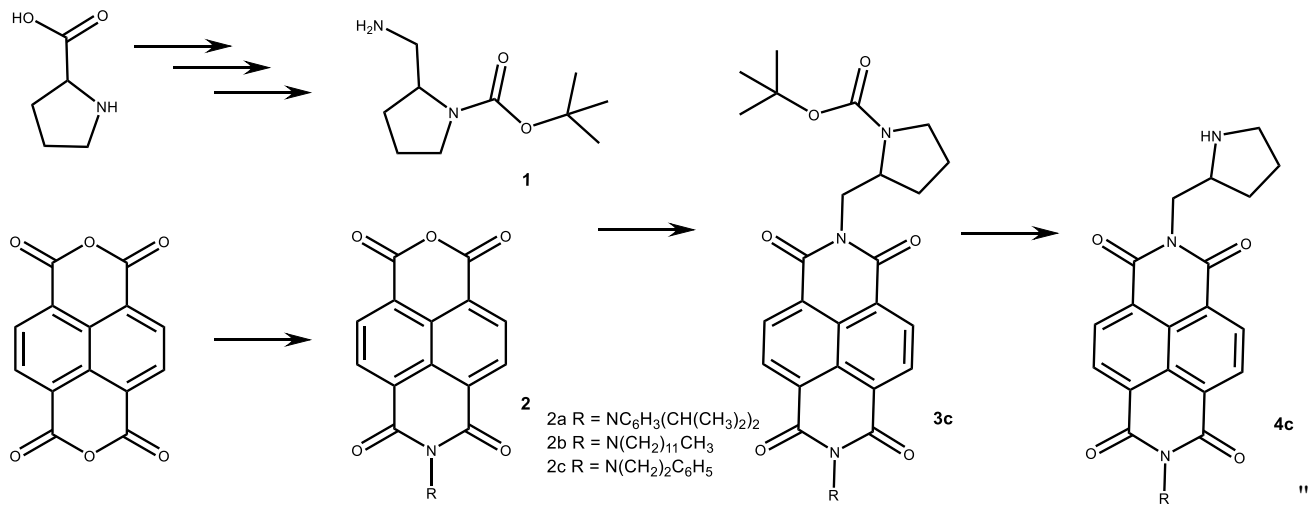
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 \*4235-#UDP /35-; 9: /26; 777: 4: 8"  
 [4]\_U'ej' q'o' d'w'i' I' 0' R't'c'e'v'c'n' N'ko' k'c'v'k'p'u'q'h' E'c'r' k'm'r't' { "I' cu'ej' tqo' cvqi' ter' j' { . "L'q'w't'p'c'n' l'q'h'J' k'i' j' "T'g'u'q'n'w'k'q'p' E'j' tqo' cvqi' ter' j' { . "4\*9+ '683/696. \*3; 9; - 0'  
 [5]\_O' e'F'qy' c'm' T'0'H'w'p'f' c'o' g'p'v'c'u'q'h'J' X'c'e' "U'f'ug'o' u' "G'ng'x'k'g't. "U'c'p'F'k'g'i' q. "r'ci' g'38. \*4228+ "

**U P V J G U K U Q H C U O O G V T K E P C R J V J C N G P G F K O K F G C U C "**  
**O Q F G N R J Q V Q E C V C N U V H Q T O W N V K E Q O R Q P G P V R J Q V Q T G F Q Z "**  
**T G C E V K Q P U "**

Wi p "Tko mckv."Kxc"Mcrr cxk kcp ."Gf xkpcu"Qtgpcu"

Xkpkwu"Wpkxgtuks".Hcewn{"qh'Ej go knt {"cpf "I gquckpegu."P cwi ctf wnt"46."NV/25447."Xkpkwu."Nkj wpcle"  
[wi pgtko mckgB i o cktqo](#)""

Vj g'ko r q t v p e g q h r j q v e j g o k u t { " j c u i t q y p u k i p h e c p v { " k p t g e g p v f g e c f g u c m p i " y k j " y g t g x k c n q h l p v g t g u v l p " t c f l e c n r t q e g u g u Q p g q h y j g o q u v g u g p v k n h g r f " q h r j q v e j g o k u t { " k p q t i c p l e u { p v j g u k u f g x g n r o g p v c p f " c r r n e c v k p " q h r j q v t g f z " e c v n u u 0 V j g u g e q o r q w p f u c t g r t q o k u p i " b c v g t k n i l p l p p q x c k x g u { p v j g u k u f w g v q y g k c d k r k v " v q i g p g t c v g " w p k s w g t g c e v k x g t c f l e c n r g e l g u v j c v t g f f k h l e w n q t " u q o g v k o g u g x g p " k o r q u u k d r g v q q d v c l p d { " c p q v j g t e j g o l e c n o g v j q f u 0 H w t v j g t o q t g . c e v k x c k p q h t g c e v k p u . y j l e j " c t g e c v n { | g f " d { " q t i c p l e r j q v t g f q z " e c v n u u . k u d c u g f " q p r k i j v o " q p g q h y j g " e j g c r g u v g p g t i { " u q w t e g " o " c d u q t r v k p 0 V j k u k u e q p u k f g t c d r g u w r g t k t k v { " k p e q o r c t g y k j " t g c e v k p u v j c v t g e c v n { | g f " d { " p q y c f c { u y k f g n { " w u g f " g z r g p u k x g c p f " q h g p g p x k t q p o g p v c m { " f o c i l p i " t c p u k k p b o g v n e c v n { u v } 3 / 4 0 k p q w t t g u g t e j . " y g " u g g m i v q " u { p v j g u k g " c u { o o g v k e " p c r j v j c r g p g " f k o k f g " \* P F K c p f " g z r m t g " k u r q u u k d r g " c r r n e c v k p " h q t " c " r j q v " k p f w e g f " k p t c o q i g e w r t " g p c o l p g c e v k x c k p t g c e v k p u w p f g t " o k f " e q p f k k q p u 0 "



Uej go g'30U{p v j g u k u q h c u { o o g t k e P F K

Vj g'u{p v j g u k u q h f g u k g f " P F K e c v n { u v y c u u c t v g f " t q o " o q f k h e c v k p q h e q o o g t e k m { " c x k c k d r g N / r t q i k p g l p " q t f g t " v q d v c l p e j k c n 4 / o g v j { n k t q i k l p g f g t k x c v k x g 3 y k j " r t q v g e g f " c o l p g i t q w r " \* U e j g o g ' 3 - 0 H w t v j g t . p c r j v j c r g p g l p v t o g f k e v g " 4 y c u u { p v j g u k g f " c p f " h e y " f k h g t g p v o g v j q f u y g t g w u g f " q p r w r q u g v q l p e t g c u g { k e r f " q h y k u u v g r 0 E q p f g p u c v k p t g c e v k p " q h e q o r q w p f u 3 c p f " 4 r g f " v q y j g h q t o c v k p q h P F K f g t k x c v k x g 5 0 H p c m { . " c o l p g f g r t q v g e v k p t g c e v k p y c u l p k k e v g f " c p f " o q f g r i e c v n { u v 6 y c u q d v c l p g f 0 "

Cenp q y r g f i o g p v " V j k u t g u g t e j " k u l w p f g f " d { " y j g " G w t r g c p " U e k e n i H w p f " w p f g t " y j g P q " 2 ; 0 5 / N O V / M 9 3 4 / 4 4 / 2 3 : 3 " o F g x g n r o g p v q h " E q o r g v g e p e g u q h " U e l g p v k u u . " q v j g t " T g u g t e j g t u c p f " U w f g p u v j t q w i j " R t c e v k e n i T g u g t e j " C e v k k k g u o " o g c u w t g "



[3\_0 0 M 0 D q i f q u . G 0 R p c t f . L 0 C 0 0 w t r j { . " C r r n e c v k p u q h i q t i c p q e c v n { | g f " x l u k d r g / n i j v r j q v t g f q z " t g c e v k p u h q t " o g f l e c n r e j g o k u t { . " D g k u n g l p " I q w t p e n i q h Q t i c p l e E j g o k u t { " 3 6 . 4 2 5 7 6 4 2 8 6 " \* 4 2 3 : 4 0 " ] 4 \_ P 0 C 0 T q o g t q . F 0 C 0 P l e g y k e j . " Q t i c p l e R j q v t g f q z " E c v n { u k u . E j g o l e c n T g x l e y u " 3 3 8 . 3 2 2 9 7 3 2 3 8 8 " \* 4 2 3 8 4 0 "

# IN-SITU'UJ RGTUCPCN[ UKUQHKO K C\ QNG'TRPI 'VGTO R CVGF'' O QPQNC[ GT'CV'GNGEVTQEJ GO KECN'R VGTHCEG''

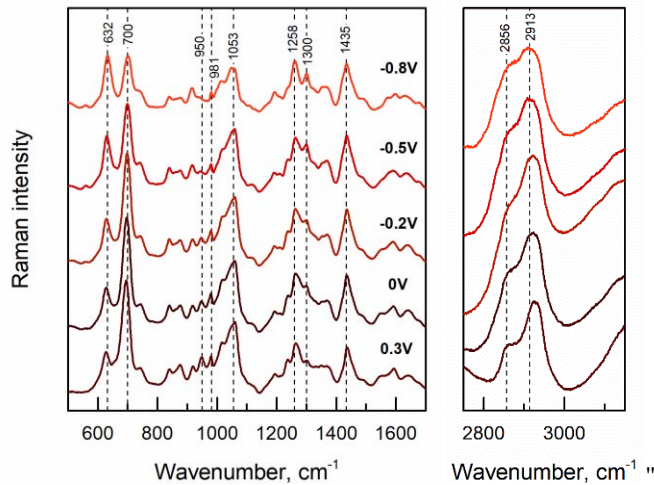
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'F gr ctvo gpv'qh'Qti cple'Ej go kwt { . 'Egpvgt'ht'Rj { ulecn'Uelkpegu'cpf "Vgej pqm { . 'Nkj wpcle'''  
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Uwthceg/gpj cpegf "Tco cp'ur gev'queqr { "UGTU+ku'c"r qy gthw'ur gev'queqr ke'v'gej pls w'v'q'uwf { "o qngewrt'uwewt'g'cpf " kpwgtcevkp"o gej cpluo u' dgy ggp" c" v'go kpcn'hwpevkpcn'i tqwr "qh'c"o qpqr { gt" cpf "uqnwkp"ur gekgu'cv'o gvcn'g'ev'qni' v'g" kpwgtcegu'P qp'ij g'guu. "UGTU'ku'ko k'gf "d { "UGTU'cevkxg"uwdu'cv'gu"o quw' "Ci . "Cw"cpf "Ew: "cpf "ij g'tgs w'k'go gpv'v'q'uwg" tqwi j g'p'gf "qt'p'cp'qu'uwewt'gf "uwthcegu't'g'v'k'ij g'c'r r n'ecdk'ij "qh'ij ku'c'p'cn'uku'ij g'ij qf 0Vj g't'g'ht'g. "Vkp'g'v'c'ri'uw'ij i guw'f "c'p'q'x'gn' UGTU'v'gej pls w'p'co gf "u'ij gm'ku'q'v'gf "p'cp'qr ct'v'ng'gpj cpegf "Tco cp'ur gev'queqr { "U RGTU+0Vj g'o g'ij qf "ku'dcu'gf "qp" ij g'gpj cpego gpv'qh'Tco cp'uki p'cn'd { "uw'q'pi "g'ng'ev'qo ci pg'v'le'k'gf "r tqxf gf "d { "p'dng'o gvcn'eqt'g'p'cp'qr ct'v'ng'u'uw'v'q'w'p'gf "d { " c'hy "p'cp'qo g'v'g'ij k'ni'k'p'gt'v'uk'ec'ij gm'j6\_0'

Kp'ij ku'y qtm'U RGTU'y cu'cr r n'gf "v'f v'g'v'go k'p'ij g'r qv'p'kcn'lp'f w'v'gf "ej cpi gu'lp'ij g'o qngewrt'uwewt'g'qh'P /%4/\*3J / ko kf c| qn'6/ { n'ij { n'8/o g'ecr v'ij g'z'c'p'co kf g"K O J C +cv'c"uo q'q'ij "Cw'g'ng'ev'qf g'0U RGTU'o g'ij qf "go r n'ij { kpi "u'p'ij gu'k'gf " ur j g't'k'ni'uw'k'gt'p'cp'qr ct'v'ng'u'y kj " : 7'0'7"po "eqt'g'uk'g'cpf "UQ4'ij gm'q'h'5"po "ij k'eng'uu'0'



Hki 030U RGTU'ur gev'c'qh'K O J C "cf uqtd'gf "qp'c'uo q'q'ij "Cw'g'ng'ev'qf g'cv'k'p'f k'ev'gf "r qv'p'kcn'lp'208'O "P c4UQ6"uqnwkp" eq'v'k'p'ki "203'O "r j qur j cv'g'dw'ht' "r J "9+0Vj g'gz'ek'v'q'p'y cx'g'g'pi ij "ku'9: 7"po 0

Ur gev'queqr ke'gxk'g'peg'ht' "r qv'p'kcn'f tkxgp"eq'p'ht'o cv'k'p'cn'ij cpi gu'lp'ij g'uwewt'g'qh'K O J C "o qpqr { gt"y cu't'gx'g'c'ng'f 0' k'p'uw'g'ng'ev'q'ej go k'cni'U RGTU't'gu'nu'ij qy "ij cv'ij g'k'p'v'p'k'ij "qh' "E/U+v"o qf g"8; 9"eo /3"cv'20"X+qh'v'c'pu'eq'p'ht'o gt "ku" j ki j "cv'r qukkxg"ng'ev'q'f g'r qv'p'kcn'x'cn'ng'cpf "p'q'v'k'ec'dni' "f get'c'g'cu'cu'ng'ev'q'f g'r qv'p'kcn'ij k'nu'v'q' /20 "X0Vj g"kw'ij t'cv'f " k'p'v'p'k'ij "qh'ij g" "E/U+v'd'c'p'f "f get'c'g'cu'd { "c'hw'ev'q'qh'4050Vj g'qr r qukk'qh'v'g'p'f g'pe { "ij kj "eq'tt'gur q'p'f kpi "i c'we'j g'd'c'p'f " "E/U+ " \*852"eo /3"cv'20"X+ "ij g'k'p'v'p'k'ij "qh'ij ku' o qf g'k'p'et'c'g'cu'd { "c'hw'ev'q'qh'30680Vj g'ug'ur gev'queqr ke'f cv'k'p'f k'ev'gf "j f tqectdqp" ej clp'eq'p'ht'o cv'k'p'cn'ij cpi gu'ht'qo "r t'gf qo k'p'cv'v'c'pu'v'q'ij c'we'j g'cu'ng'ev'q'f g'r qv'p'kcn'ij k'nu'v'q'ij g'o q't'g'p'gi cv'k'x'c'cn'ng'0"

[3] "I0E0Nq'g'v'c'ri'Ugrh'cuugo drgf "o qpqr { gtu'qh'ij k'rc'v'gu'ap"o gvcn'cu'c'htqto "qh'p'cp'q'v'ge'pqm { . 'Ej go 0Tgx0327."3325/8; "4227-0"  
[4] "0Mv'q'f ku'g'v'c'ri'0Tgh'ev'k'p'c'du'qr v'k'p'k'p'ht'ct'gf "ur gev'queqr { "ej ct'ce'v'g'k'cv'k'p'qh'UCO "htqto cv'k'p'ht'qo " : /o g'ecr v'q'p' /r j g'p'ij { n'q'ev'c'p'co kf g'ij k'ni'y kj " Rj g'k'pi "cpf "co kf g'ij tqwr u' "O qngewgu'47."7855"4242+0  
[5] "Xgt'k'ev' "E" g'v'c'ri'0Ugrh'cuugo drgf "o qpqr { gtu'qh'ij k'rc'v'gu'ap"o gvcn'c' "t'g'x'g'y "ct'v'ng'ap"uw'ht'o o gvcn'ij go kwt { "cpf "uwthceg"uwewt'gu. "TUE"cf x06." 49952649976"4236+0  
[6] "I0H0Nk'g'v'c'ri'0Uj gm'ku'q'v'gf "p'cp'qr ct'v'ng'gpj cpegf "Tco cp'ur gev'queqr { 0P c'w'g'686."5; 4 5; 7"4232-0"



# J [ FTQVJ GTO CN'U P VJ GUKU'QH\ KPE'Y J KNQEMKVG'

Ci pg'Mk crkkg.'Crgmgl\ ctnqx"

Kpukwg'qh'Ej go knt { .Xkpkwu'Wpkxtukv\ .Nkj wcpk "  
ci pg'Ok crkkgB ej i hkw0w"

"

O ci pgukwo "y j knqemkg"\*Ec3: O i 4J 4\*RQ6+36+"ku"j g'ugeqpf "o qu'cdwvf cpv'o kpgtcr'lp"j wo cp'dqf {"cpf "qpg"qh'y j g" o clp"eqo r qpgpw'qh'y j g"j wo cp"j ctf "kuuwg."eqpukwkpi "v"cr r tqzko cvgn "42657"y v "j3\_0Vj ku'eqo r qwpf "ku'npqy p'ht" ku'gzegmpv'dkqeqo r cvdkkx\ "cpf "quvgi gple'ecr cdkkx\ "y j kej "o cngv'y ku'o cvgtkcr'c'r tqo kuki "ecpf kf cvg'ht"cr r rdecvkp" kp" dqpg" tgi gpgtckqp" j4\_0'J qy gxgt. "u{pvj guku'qh' r wtg" r j cug" y j knqemkg" tgo clpu" c" ej cngpi g" f wg" vq" r qqt" y j gto cil' ucdkx\." j ki j "ugpukxkx\ "v"u{pvj guku'eqpf kkpup'cpf "rcti g'co qwpv'qh'r quukdrg'kpvto gf kvg'r j cugu0"

Kpeqtr qtcvkp" qh' dkrqi lecn\ "cevkg" kpu" kvq" y j g" utwewt" qh' y j g" o cvgtkcr' ecp" tguwn' kp" uw' g'ktq" dkrqi lecn' r gthqto cpeg"qh'ecrekwo "r j qur j cvg"dcugf "o cvgtkcr'lp"cf f kkp"v" q" g'zr cpf gf "ekplecn'cr r rdecvkpu'qh'y j g" o cvgtkcr' Vq" hwtj gt "lo r tqxg'dkrqi lecn'r tqr gt vgu'qh'y j knqemkg."cu'y gm'cu'f guki p'pgy "r tqr gt vgu'ht"ur gekhe "o gf lecn'hgrf u"qvj gt" kpu'kpvugf "qh'O i "eqwf "dg"vugf "ht"u{pvj guku'qh'y j g'eqo r qwpf 0\ p'uwdvkwgwf "ecrekwo "r j qur j cvg'ctg'ej ctcvgtk' gf "d" gpj cpegf "tcvg"qh'o gvcdqke" r treguugu'cpf "cpvdcvgtkcr' tqr gt vgu'y j kej "o cngv'y gug"o cvgtkcr'xgt {"cwtcevkg'ht" wuci" g" kp" o gf kelpg"j5\_0"

Vj g'o clp"i qcn'qh'y j g'r tguvp'y qtn'y cu'v" f gxgnr "c"j { f tqv j gto cnu{pvj guku"o gy qf "v"qdckp"r wtg'r j cug"cpf "ny" et { ucnkpk\ "y j knqemkg"r qy f gtu"eqpvckkpi "\ p"kpup'0'ht" y ku'r wtr qug"u{pvj guku'eqpf kkpup'uwej "cu'vgo r gtcwtg."vko g." r J ."eqpegptcvkqp"cpf "Ec\ p"o qmt "cvkq"lp"y j g'kpkcr'luqnwkp"y gtg'ectghwm\ "uwf kfg"cpf "qr vko k' gf 0'Ecrekwo "j { f tqi gp" r j qur j cvg" f kj { f tcvg"cpf" | kpe"cegvv" f kj { f tcvg"y gtg"vugf "cu'uctvki" o cvgtkcr'0U{pvj guk' gf "eqo r qwpf u'y gtg'cpcn\ | gf" d {"Z/tc {"f khtcevkkp" \*ZTF + "Hqwtkt/ tcpuhtqto "kplctgf" ur gvtqueqr {"\*HVKT + "uecpkpi "grgvtq" o ketqueqr {"\*UGO + " kpf vevkgn\ "eqw rgt" r nuco c"qr vcecr'go kuukp"ur gvtqueqr {"\*ER/QGU+cpf "Tco cp"ur gvtqueqr {0"

### Cenpqy rgi i go gpvu'

Vj ku'r tqlgev"j cu't gegkxgf "hwpf kpi "htqo "Gwtqr gcp"Uqekcn'Hwpf "r tqlgev" P q0'2; 05/NO V/M/934/3; /228; +"wvf gt" i tcv'ci tgggo gpv'y kj "y j g" Tgugctej "Eqwpek'qh'Nkj wcpk" \*NO VNV-0"

j3\_ J 0'Ej gpi. "T0'Ej cdqm'gv'cnu'U{pgti kule"lvgr n{"dgw ggp" y j g"y q" o clqt "dqpg" o kpgtcr'j { f tqz { cr cvkg"cpf "y j knqemkg"pcpqr ctvengu."ht" quvgi gple'f higtgpvcvkp'qh'o gupvej {o cnu'go 'egmu.'Cev'Dlqo cvgtkcr'8; .564/573"423: -0'  
j4\_ J 0NO'cpi. 'I 0Dkp\ j gpi "gv'cnu'."Kp"Xkxq"cpf "Kp"Xkxq"Gxcnvcvkp'qh'Y j knqemkg"Dlqeqo r cvdkkx\ <Eqo r ctcvkg"Uwf { "y kj "J { f tqz { cr cvkg"cpf" /Vtecrekwo "Rj qur j cvg."Cf xcpgef "J gcnj ectg'O cvgtkcr'7."34: 6358"4237-0'  
j5\_ KX0H:f ggxc."O 0T0I chwqx'gv'cnu'Vtecrekwo "Rj qur j cvg'Egtco leu'F qr gf "y kj "Ukrxgt."Eqr r gt." | kpe."cpf "Kqp" \*Kk" kpu"lp"Eqpegptcvkpu'qh' Ngum'v'j cp'20'y v0 "ht"Dqpg'Vkuuwg" Tgi gpgtckqp. DkqP cpqUekpeg'9."656665: "4239-0'

U P V J G U K ' C P F ' P X G U V K C V K Q P ' Q H ' N W C I < R t . D ' E Q C V K P I U ' Q P " S W C T V \ ' U W D U V T C V G ' Q D V C K P G F ' D [ ' U Q N / I G N ' U R K P ' E Q C V K P I " V G E J P I S W G " " I t g v c ' K p m t c v k y <sup>3</sup> . ' T c o p c u ' U n e w f f l k w u <sup>3</sup> " "

I t g v c ' K p m t c v k y <sup>3</sup> . ' T c o p c u ' U n e w f f l k w u <sup>3</sup> "

<sup>3</sup> K p u k w w g ' q h ' E j g o k u t { . H e w n n { ' q h ' E j g o k u t { ' c p f ' I g q u e k p e g u . X k p k w u ' W p k x g t u k { . X k p k w u . " N k j w e p l e " i t g v c ' K p m t c v k y B e j i f l k w u "

K p ' t g e g p v ' { g t u ' o c v g t k e n u ' y k j " n w o k p g u e g p v ' r t q r g t v g u ' j c x g " d e q o g " x g t { " r q r w r t O ' K p ' c f f k l k p . " v j g u g " o c v g t k e n u ' c t g " x g t { " r q r w r t " h q t " w u c i g " l p " n o r u ' c p f " q v j g t " r i j v ' g o k v k p i " f g x l e g u . " d w w p q y c f c { u ' u e k p v k n e v q t u " c p f " v j g k t " t g u g c t e j " k u " d g e q o k p i " c " x g t { " l p v g t g u k p i " u w d l g e v " h q t " u e l g p v k n e v q t u " U e l p v k n e v q t u " c t g " v j g " d c u k u " h q t " f g x l e g u . " v j c v ' c t g " w u g f " h q t " t c f k q c e v k x g " e q p v c o k p c v k p " f g v g e v k p " c p f " o g c u w t g o g p v " p w e r g c t " o c v g t k e n o p k p q t k p i . " c n u q " v j g { " c t g " k p e n w f g f " l p " v j g " e q o r w g t " f g v g e v t " e q o r q u k k q p " q h ' v j g " v q o q i t e r j { " f g x l e g u ' V j g t g " c t g " x c t k q u " e q o r q w p f u ' v j c v ' e c p " d g " w u g f " c u " u e k p v k n e v q t u . " d w w ' q p g " q h ' v j g " o q u v r q r w r t " c t g " v j g u g " y j l e j " j c x g " c " i c t p g v ' u t w e w t g " j 3 \_ O C o q p i u v " q v j g t u . " v j g u g " e c p " d g " { w t k w o " q t " n w g v k w o " c n w o k p w o " i c t p g v " f q r g f " y k j " f k h g t g p v ' n p v j c p k f g u " f C I < N p = N w C I < N p - O ' V j g u g " k p q t i c p l e u " e q o r q w p f u ' j c x g " v j g " t g s w k t g f " q r v l e c n " r t q r g t v g u " c p f " t c f k c v k p " t g u k u c p e g " j 4 \_ O ' V j g f " g x g n r o g p v ' q h ' p g y " u e k p v k n e v q t u " k u " k o r q t w e p o J J q y g x g t . " p q ' v j g " o c v g t k e n u " y j l e j " c t g " w u g f " c t g " k o r q t w e p v d w ' c n u q " v j g k t " h q t o O V j g r ' t g r c t c v k p " q h ' r q y f g t " k u " v j g " u k o r n g u w " d w v j g l " c t g " p q v ' u w k c d n g " h q t " v j g " e q p u t w e v k p " q h ' u e k p v k n e v q t " f g v g e v t u O D g u v u w k g f " c p f " w u g f " h q t " v j g " o c p w h e w t g " q h ' x c t k q u " f g x l e g u " c t g " u k p i n g ' e t { u c n u O ' K p " c f f k l k p " v j " u k p i n g ' e t { u c n u . " e q c v k p i u " q p " x c t k q u " r c n g u " q t " o k e t q h k d g t u " e c p " d g " w u g f " j 5 \_ O F w g " v j g " r q u i k l k k v { " q h ' w u k p i " f k h g t g p v ' u w d u t c v g u . " f k h g t g p v ' o g v j q f u " q h ' e q c v k p i . " o c v g t k e n u ' y k j " f k h g t g p v ' r t q r g t v g u " e c p " d g " r t g r c t g f . " y j l e j " o c n g u " v j k u " o g v j q f " " y k f g n " " w u g f O ' W u k p i " v j g " u q n ' i g n ' o g v j q f " y g " e c p " q d v e k p " j q o q i g p g q w u " o w n k e q o r q p g p v ' e q c v k p i u " c v ' n y " v g o r g t c w t g . " i g c x l p i " v j g r ' q u i k l k k v { " q h ' u { p v j g u k k p i " e q o r q w p f u ' y k j " g o k u k q p " k p v g p u k v { " j 6 \_ O "

K o r t q x g o g p v ' q h ' n w o k p g u e g p e g " k u " g u g p v k n e v q t u " i g w k p i " v j g " h u v g u v " u e k p v k n e v q t u " r t q r g t v g u O Q p g " y c { " v q " f q " v j k u " k u " v q " c f f k l k p c m f " f q r g " e q o r q w p f u ' y k j " q v j g t " g n g o g p u O ' T g r n e k p i " q p g " g n g o g p v " y k j " c p q v j g t " l p " v j g " e t { u c n i " n e w k e g " e c p " k p h w g p e g " v j g r t q r g t v g u " q h ' v j g " o c v g t k e n u O ' V j g " o q u v e q o o q p " i q c n i " k u " v q " k o r t q x g " n g { " r c t c o g v g t u " e q o r q w p f " g o k u k q p " k p v g p u k v . " s w e p w o " g h i k l e g p e { " c p f " f g e c { " k o g u O Q p g " q h ' v j g " i t g c v g u v " u e k p v k n e v q t u " f t c y d c e n u " v j c v " k u " d g l p i " c f f t g u g f " k u " v j c v " f g e c { " k o g u " k u " v q q " n p i O ' Y j g p " k v " k u " g z v t g o g n { " n p i . " v j g p " v j g u g " u g e q p f " u k i p e r n e c r w t g f " d { " v j g " o c v g t k e n u " q x g t e r u e u y k j " v j g " h k u . " o c n k p i " v j g t g u w u " w p t g r k e d n g " c p f " r t q x k f g u " n g u u " f c v " v j c p " k v " e q w f O ' U e k p v k n e v q t u " u e j " c u " c p f " N w C I < R t " f q r g f " y k j " d q t q p " e c p " u q n g " v j k u " r t q d r g o O ' K l ' c " s w e n i " s w g e j " q h ' f g e c { " k o g y c u " q d v e k p g f " i k x g p " t g u w n " y q w f " d g " o q t g " c e e w t c v g . " c p f " v j k u " o g v j q f " q h ' u { p v j g u k k p i " u e k p v k n e v q t u " e q w f " d g " r t c e v k e c m { " c r r n e c d n g " j 7 . ' 8 \_ O "

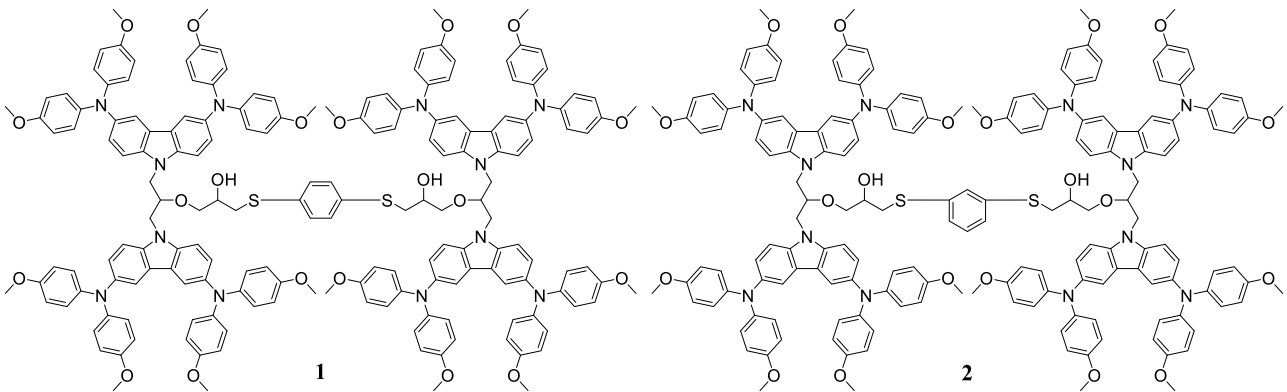
K p ' v j k u ' y q t n i r t e u q g f { o k w o " c p f " d q t q p " f q r g f " N w C I " c t g " u { p v j g u k k f g f " q p " s w e t v " u w d u t c v g u " u k p i " u q n ' i g n ' u r k p " e q c v k p i " o g v j q f O ' D q t q p " k " g z r g e v g f " v q " k o r t q x g " t g s w k t g f " n w o k p g u e g p v ' r t q r g t v g u . " c p f " y k j " v j g " u q n ' i g n ' o g v j q f . " j q o q i g p g q w u " e q o r q w p f u ' y k n i d g " u { p v j g u k k f g f " c v ' n y " v g o r g t c w t g u O ' R j q u r j q t " e q c v k p i u ' y g t g " c p c n { | g f " d { " z / t c { " f k h i t c e v k p " % Z T F + " c p f " u e c p p k p i " g r e v t q p " o k e t q u e q r { " % U G O + O Q h ' e q w t u g . " g o k u k q p . " g z e k e v k p " u r g e v t " c p f " f g e c { " k o g u " j c x g " d g g p " k p x g u k i c v g f " c u " y g n o " " " " "

[3]\_F 0 U O e I t g i q t . ' O c v g t k e n u ' h q t ' I c o o c / T c { ' U r g e v t q o g v g t u " k p q t i c p l e " U e k p v k n e v q t u . " C p p w e n " T g x l g y " q h ' O c v g t k e n u " T g u g c t e j . ' 6 : ' 4 7 6 / 4 9 9 " % 4 2 3 : - 0 '  
[4]\_C F O ' U q p v c n m g . " L O ' W g f c . " L O ' Z w " g v o c i o " C " E q o r c t k u a p " q p " E g 5 - " N w o k p g u e g p e g " k p " D q t c v g " I n e u " c p f " I C I " E g t c o l e " W p f g t u c p f k p i " v j g " T q r g " q h ' J q u w i ' E j c t c e v g t k u e u . " v j g L q w t p e n i q h ' R j { u l e c n E j g o k u t { ' E . ' 3 4 2 . ' 5 3 . ' 3 9 8 . ' 5 ' 6 ' 3 9 8 ; ' 3 " % 4 2 3 8 - 0 '  
[5]\_L O ' T c y c v " O O ' V { c i k " R O ' M o P g t e n e p k " g v o c i o " R w n g " u j c r g " f k u e t k o k p c v k p " r t q r g t v g u " q h ' I f 5 1 c 5 C n # Q 3 4 - E g . D " u k p i n g ' e t { u c n i " k p " e q o r c t k u a p " y k j " E u k V n " P w e n g t " K p u t w o g p u u " c p f " O g v j q f u " l p " R j { u k e u " T g u g c t e j " U e v k p " C " C e e g r t c v q t u . " U r g e v t q o g v g t u " F g v g e v t u " c p f " C u u q e k v g f " G s w k r o g p v " : 6 2 . ' 3 : 8 ' 6 ' 3 ; ' 3 " % 4 2 3 8 - 0 '  
[6]\_C O R q v g x l p . " I O E j c f g { t q p . " F O D q { g t . " g v o c i o " U q n i g n i d c u g f " I C I < V d 5 - " q t " G w 5 - " r j q u r j q t u " h q t " c r r n e c v k p " k p " h i j v k p i " u q w t e g u . " L q w t p e n i q h ' R j { u k e u " F < C r r n i g f " R j { u k e u . " 5 4 7 3 ' 6 ' 5 4 8 2 " % 4 2 2 7 - 0 '  
[7]\_E O ' H q u v g t . " I O ' Y w " O O ' M q u e j c p . " g v o c i o " D q t q p " E q q r k p i " q h ' E j q e j t e n n k ' I t a y p " N w g v k w o " C n w o k p w o " I c t p g v " c p f " v j g " G t h g e v " q p " U e k p v k n e v k p " R t q r g t v g u . " L q w t p e n i q h ' E t { u c n i " T a y y . ' 6 : 8 . ' 3 4 8 ' 6 ' 3 4 ; ' % 4 2 3 : - 0 '  
[8]\_J O ' U W [ q q . " Y O ' D O ' K . " L O ' J O ' M e p i . " F O ' I O ' L g q p . " R t g r c t c v k p " c p f " r j q v q n w o k p g u e g p e g " r t q r g t v g u " q h ' [ C n # D Q 5 + 6 - V d 5 - . " D k 5 - " r j q u r j q t " w p f g t " X W X I W X " g z e k e v k p " Q r v e c n i O c v g t k e n u . " 5 3 . ' 4 . ' 3 5 3 ' 6 ' 3 5 7 " % 4 2 2 : - 0 '

**U P VJ GUK'CPF 'EJ CTCE VGT KUVÆU QH'QTI CPÆ"**  
**UGO KQPFW VQTU'Y KVJ 'N/ECTDC\ QN\ N/DCUGF 'EJ TQO QRJ QTGU"**  
Rqxkru'Nwk {u<sup>3</sup>. 'O ct {v'F cunxkxkpgg<sup>3</sup>. 'Mcur ctcu' Tcmv{u<sup>3</sup>. 'X {i kpvu' Lcpnæwunæ<sup>4</sup>. 'Gi kf kluw  
Mco ctcwunæ<sup>4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Qti cplæ'Ej go kvt { . 'Mæwpcu'Wpkkgtukv{ 'qh'Vgej pqrqi { . 'Nkj wcpkæ"  
<sup>4</sup>kpvkwwg'qh'Ej go lecn'Rj { ukeu. 'Xkpkwu'Wpkkgtukv{ . 'Nkj wcpkæ"  
r qxkru'Nwk {uB mw0v"

Y kj 'c'i tqy kpi 'y qtrf 'eqo o wpkv{ u'eqpegt'qh'gpxktqpo gpvcnr' qmwkqp'vj gtg'ctg'kpet gcugf 'kpvgt guv'j qy 'vj ku'ecp'dg" cf f tguugf 0'Qpg'qh'vj g'o ckp'ecwugu'qh'gpxktqpo gpvcnr' tqdrgo u'ku'vj g'gpgti { 'r tqf wevkqp. 'y j lej 'ku'pqv'gcu{ 'vq'uqrxg'f wæ" vq'vj g'i tqy kpi 'i mqdcilf go cpf 'qh'gpgti { 'J3\_0Vj gtghqtg. 'k'ku'pqv'uwtr tlukpi 'vj cv'c'i tgcv'f gcn'qh'cwgpvkqp'ku'dgkpi 'r ckl'vq" tpggy cdrg"gpgti { "uqwtægu."i kxgp"vj gkt"gpvktqpo gpvcnr'htkpf rkpguu'cpf "r qvqpvkcn'htq" wug'0'Qpg'qh'vj g'o quv'r tqo kulpi " tpggy cdrg"gpgti { "uqwtægu'ku'uqrcr"gpgti { . 'y j lej 'vj gqrgvæcm{ "eqwv'ucvkuh{ 'vj g'gpgti { "pggf u'qh'o cpmkpf 0'Ukæqp'uqrcr" egmu'ctg'ewttgpv{ 'vj g'o quv'y kf gn{ "wugf "qp'vj g'o ctngv."dw'f wæ"vj g'kt"j ki j 'r tqf wevkqp"equu."ugctej "qh'cngt'pvcxkgu'ku" wpf gty c{0'Qpg'qh'r qukdrng"cngt'pvcxkg'ku'r gtqxunkg'uqrcr"egmu."y j lej "lwv'kp"c"rcuv'f gecf g'j cxg"dgeqo g'c"uwldgev'qh" i tgcv'kpvgt guv'kp"vj g'f gxnqr o gpv'qh'pgzv'i gpgt'vqpp'uqrcr"egmu'vj cv'j cxg'ctgcf { "gzeeggf gf "4707" "r qy gt"eqpxgtukqp" ghækæpæ{ "J4\_0'Rgtqxunkg'uqrcr"egmu"j qrf "r tqo kug'ht"lpgzr gpukxg'tey "o cvgtkcn'cpf "ny "f gxleg'r tqf wevkqp"equu."dw" r gtqxunkg'uqrcr"egmu'eqo o gteclik'cvkqp"ku"j kpf gtgf "d{ "f tcy dcemu"y j lej "pggf "vq"dg"tguqrxg'0'Qpg'qh'vj go "ku'vj cv" r gtqxunkg'ku'ugpvkxg'vq"o qkuwtg."y j lej "tgf wæ"v'f gxleg'ucdtkk{0'K'ku'r tqr qugf "vq'uqrxg'vj ku'r tqdrgo "d{ "eqxgtkpi "vj g" r gtqxunkg"rc{gt"y kj "o qkuwtg"ko r gto gcdrg"grævtp"cpf "j qrg"æcpur qt'vpi "rc{gtu'0'Hwt'j gto qtg."qhægp"cf f kxkgu'ctg" pggf gf "vq" kpet gcug'vj g'eqpf wevxxk{ "qh"j qrg"æcpur qt'vpi "o cvgtkcn"y j lej "o c{ "ecwæ"vj g'f gxleg" f gi tcf cvkqp"J5\_0' Vj gtghqtg."vj g'ugctej 'htq'pgy 'uwæcdrg'qti cplæ'ugo leqpf wevqtu'tgo cku'j ki j n{ 'tgræxcp'0' k'vj ku'y qtm'pgy "j qrg"æcpur qt'vpi "qti cplæ'ugo leqpf wevqtu'y kj "hwt" P/ectdc| qn' n'ej tqo qr j qtgu"\*Hi B-"y gtg" u{pvj guk' gf "htq"vj g'wæ"kp'r gtqxunkg'uqrcr"egmu'0'



Hi 0'30Utwæwtgu'qh'u{pvj guk' gf "qti cplæ'ugo leqpf wevqtu'y kj "hwt" P/ectdc| qn' n'ej tqo qr j qtgu'

P gy 'j qrg"æcpur qt'vpi "qti cplæ'ugo leqpf wevqtu'y gtg'qdvcxkpf 'xlc'ugr /d{/ugr 'u{pvj guku'00 qrgæwrc'æwtæwtg'qh'vj g" pgy n{ 'u{pvj guk' gf "qti cplæ'eqo r qwpf u'y gtg'eqpht o gf "d{<sup>16</sup>J "P O T. <sup>165</sup>E'P O T'cpf "K"ur gevæqæqr {0'Vj gto qi tæxko gætkæ" cpcn{uku' uj qy u'vj cv' u{pvj guk' gf "o qrgæwru" ctg"vj gto cm{ "ucdrg" cv'j ki j "vgo r gtcwægu'0' Vj gto cni' f geqo r qukkqp" qh' eqo r qwpf "3"uætw'cv'596"Æ"cpf "cv'59; "Æ"htq"eqo r qwpf "4."t'gur gevæxgn{0'F khtg'gpvcnr'uec'p'kpi "ecm'tko gæ{ "cpcn{uku'qh" vti g'v'eqo r qwpf u'r tqxgf "vj cv'vj g{ "ctg"o qrgæwrc"i rcuugu'cpf "f go qputcvg"ucdrg"co qtr j qwu'ucvæ'0'I rcuu'æcpukæqp" vgo r gtcwæg'qh'eqo r qwpf "3"ku"338"Æ"cpf "333"Æ"htq"eqo r qwpf "4."t'gur gevæxgn{0'Rj qvqrgævtp"ur gevæqæqr { "kp"ck" o gy qf "y cu'wægf "vq"o gcuwtg'kpkæ'cvkqp'r qvqpvkcn'qh'qti cplæ'ugo leqpf wevqtu'3"cpf "40'Qdvcxkpf "K"xcnæ"qh'o qrgæwrc"3" ku"7048"æX."y j kæ"4"j cu'urki j w{ "ny gt"xcnæ"qh'708"æX0'K"o gcuwtgo gpv'lpf kecvg'vj cv'vj g"J QO Q"gpgti { "ngxgn'qh'vj g" u{pvj guk' gf "r tqf wev'ku'eqo r cvkdrng"y kj "vj g'xcrgpeg'dcpf "qh'vj g'r j qvqævæxg'r gtqxunkg"rc{gt'0'Vj gtghqtg."pgy "qti cplæ" ugo leqpf wevqtu'eqwv' r qvqpvkcn{ 'dg'wægf 'kp'æqpæv wevkqp'qh'r gtqxunkg'uqrcr"egmu'0'

[3]\_I mqdcilf tlo ct{ "gpgti { "equuwo r vkp'd{ "uqwtægu."j wru'1qwy qtrf kpf cvc'qti li tcr j gt li mqdcn'gpgti { /uwdukwkqp'Awko g? gctriku'0'rc'vuv'"æceguugf "4242/ 24/244'  
 [4]\_Dguv'Tugætej /Egn'Ghækæpæ{ 'Ej ctv. Rj qvqvxncle'Tugætej . P TGN. '42430'  
 [5]\_Z0\ j cq'cpf 'O OY cpi . 'Qti cplæ'j qrg'æcpur qt'vpi "o cvgtkcn'htq"ghækæpæ'r gtqxunkg'uqrcr"egmu.'O cvgt'0'Vqf c{ "Gpgti { '9. '42. /442"æ423: -0'



# STRUCTURAL AND MAGNETIC STUDY OF YFeO<sub>3</sub>-GdFeO<sub>3</sub> SOLID SOLUTIONS

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Multiferroicity, where two or more kinds of ferroicities coexist in the same phase, have attracted a lot of attention in materials science and condensed matter physics in recent years [1]. This type of compounds can be applied in magnetic field sensing, data recording, as field probes etc. Different material classes, like borates (GdFe<sub>3</sub>(BO<sub>3</sub>)<sub>4</sub>) [2], boracites (Ni<sub>3</sub>B<sub>7</sub>O<sub>13</sub>I) [3] and most notably perovskites are known for possible concurrence of both magnetic and ferroelectric orders. Orthoferrites RFeO<sub>3</sub> (where R=rare earth element) are perovskite-type materials with multiferroic properties.

YFeO<sub>3</sub> orthoferrite has demonstrated ferroelectric and weak ferromagnetic characteristics at room temperature in bulk and thin film forms [4, 5]. Equivalently, GdFeO<sub>3</sub> has showed improper ferroelectric ordering, antiferromagnetism and weak magnetoelectric coupling [6]. It was displayed that different Y<sub>1-x</sub>Gd<sub>x</sub>FeO<sub>3</sub> solid solutions compositions can lead to peculiar magnetic properties, with higher Y<sup>3+</sup> concentration leading to enhanced magnetization values [7].

In this study, YFeO<sub>3</sub>-GdFeO<sub>3</sub> solid solutions were prepared for the first time by sol-gel synthesis. Thermogravimetric analysis was performed in order to determine possible calcination temperature and investigate thermal degradation of different composition precursor gels. X-ray diffraction, Mössbauer and Raman measurements were carried out to assess structural changes. Morphology of prepared samples was investigated with scanning electron microscopy (SEM). Lastly, magnetization studies were employed for all solid solutions.

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**O QF GNNPI 'DKPCT[ 'U UVGO U''**  
**QH'CEGVK'CEK'CPF'FKO GVI [ N'UWNHQZK'G<'**  
**UVTWEVWTCN'PCPN[ UK'CPF 'J 'POT'URGEVTC**  
fi {i kpc'Gkqt {v<sup>3</sup>. 'I tgc'O clcwunkv<sup>3</sup>. 'M uwwk'Clk cu<sup>3</sup>

<sup>3</sup>Kpukwng'qh'Ej go lecn'Rj {uleu.'Hcewn{ 'qh'Rj {uleu.'Xkpkwu'Wpkxgtuk{ . 'Nkj wcpk'  
{i kpc'Gkqt {vgB H'Uw'U'U'U'

"

Vj g'dcuku'ht 'y ku'uwf { 'eqo gu'htqo 'y g<sup>3</sup>J 'POT'ur gev'c'lp'dkpt { 'u{ ugo u'qh'cegve'cekf "CC+cpf 'f ko gy { n'uwhtqz'kf g" \*FO UQ+0'Ceetf lpi "v" g'zr g'ko gpv'n'uwf lgu'j3\_ 'y g'eqt'g'v'k'p'p'dgy ggp'POT'ej go lecn'uj k'v'qh'y'g'cekf le'r tqv'p'lp' cegve'cekf 'cpf 'y' g'o q'rt' r'ctv'qh'cekf 'lp'c'CC IF O UQ'dkpt { 'u{ ugo 'ku'p'p'p/o' p'p'v'p'p'le'0Y j gp 'y' g'o q'rg'ht'cekv'p'qh'cegve' cef' 'lp'c'dkpt { 'u{ ugo 'l'p'et'g'c'ug'u'htqo '2'v'q'20. 'y' g'ej go lecn'uj k'v'qh'y' { f tqi gp 'f' t'q' u'ct'q'w'p'f'20'rro "htqo '330'rro 'v'q' 330'rro + 'y' gp't'k'gu. 't'gej lpi 'ct'q'w'p'f'330'rro 'lp'r'w'g'cegve'cekf'0Vj ku'r'j gp'qo gp'p'ku'ec'w'ug'f' d { 'y' g'uj k'v'p'i 'gs'w'k'd't'k'w'o " dgy ggp'xct'k'w'u'o q'rgew'rt' \*j { f tqi gp'd'q'p'f'+'ci i t'gi cv'g'u'htqo gf 'dgy ggp'cegve'cekf "o q'rgew'rt' y' go u'g'x'g'u'cu' y' g'm'cu' dgy ggp'cegve'cekf 'cpf 'FO UQ'y' j gp'y' g'o q'rt' l'p'c'v'k'p'p'qh'y' g'dkpt { 'o k'z'w'g'ku'ej c'p'i l'p'i 0'k'ku'p'g'c't'n' { 'o r'q'k'k'd'g'v'q' h'k'p'f' q'w'y' g'p'c'w'g'q'h'y' g'ug'o q'rgew'rt'ci i t'gi cv'g'u'lp'r'ct'v'w'rt'y' g't' r'q'r'w'v'k'p'p'z'r'g't'ko gp'v'm' { . 'j' q'y' g'x'g't. 'y' g'ug'r' t'q'd'g'o u'ec'p' dg'x'g't { 'g'h'g'v'k'x'g'n' 'f' g'c'n'y' k'j "d { "w'k'p'i "c'f'x'c'p'eg'f" o q'rgew'rt' "o q'f' g'k'p'i "v'g'ej p'k'w'g'u'w'ej "cu' o q'rgew'rt' f { p'c'o l'eu' "OF + u'ko w'v'k'p'p'u'c'p'f' "eqo d'k'p'f' 's' w'c'p'w'o "o g'ej c'p'le'u'o q'rgew'rt' "o g'ej c'p'le'u' "S O IO " + 'c'r' r' t'q'c'ej g'u'0Vj g'ug'v'g'ej p'k'w'g'u'j' c'x'g'c'm'q' d'g'g'p'x'g't { 't'g'ep'w'f' "c'r' r'k'g'f' "v'uwf' { "o q'rgew'rt'ci i t'gi cv'k'p'lp'i' m'ek'c'i'cegve'cekf "j4\_0"

Vj g't'g'c't'g'y' q'o c'lp' "q'd'l'g'v'k'x'g'u'qh'y' ku'uwf { <'ectt { lpi "q'w'c's'w'k'v'k'x'g' "c'p'f' "s'w'c'p'v'k'v'k'x'g' "c'p'c'n' { uku' q'h' o q'rgew'rt' "ci i t'gi cv'g'u'c'p'f' "ec'w'v'w'k'p'i "y' g'ej go lecn'uj k'v'qh'y' g'cekf le'r tqv'p'lp'CC IF O UQ"u{ ugo u'qh'f'k'ht'g'p'v'eqo r'q'k'k'p'0' Eqo r'ct'k'p'p'dgy ggp'eqo r'w'v'k'p'p'c'n'c'p'f' "z'r'g't'ko gp'v'n't'g'u'w'm'c'm'y' u'ht'c'f' g'v'k'g'f' "w'p'f'g't'w'c'p'f' l'p'i "q'h'y' g't'g'c'q'p'u'q'h'ew't'k'w'u' eq'p'eg'p'v'c'k'p'p'f' g'r'g'p'f'g'p'eg'q'h'y' g'ej go lecn'uj k'v'qh'y' g'cekf le'r tqv'p'0C'f'k'ht'g'p'v'dkpt { 'u{ ugo "qh'cegve'cekf 'cpf 'c'p'q'p/ r'q'rt' "u'q'k'g'p'v'0' "e { emj g'z'c'p'g. "c'm'q'f' k'ur'w' { u'c'p'q'p/o' p'p'v'p'p'le' "h'uj' k'p' "j3\_ "d'w'k'ku'ec'w'ug'f' "q'p'k' "d { "k'p'v'g'c'v'k'p'p'u'dgy ggp' cegve'cekf "o q'rgew'rt' y' go u'g'x'g'u'0J q'y' g'x'g't. "y' j gp'c'p'c'n' { u'k'p'i "CC IF O UQ"u{ ugo u'k'ku'ko r'q't'v'p'v'q' "c'm'q' "c'ee'q'w'p'v'ht' "k'p'v'g'c'v'k'p'p'u'dgy ggp'cegve'cekf 'cpf 'FO UQ'd'g'ec'w'ug'q'h'r' q'rt'k'v' { 'q'h'y' g'u'q'k'g'p'0"

"Vj g'c'p'c'n' { uku'q'h' o q'rgew'rt'ci i t'gi cv'g'u'lp'c'dkpt { 'u{ ugo 'y' cu'ectt'k'g'f' "q'w'ht' "y' t'g'g'f'k'ht'g'p'v'CC-FO UQ"o k'z'w'g'u'< 3-5. '3-3'c'p'f' '5-3' "o q'rt' 't'c'k'q'u'0O F "u'ko w'v'k'p'p'u'y' g't'g'g'z'g'ew'g'f' "w'k'p'i "c'p'c'm'c'v'qo "QRNU'ht'g'eg'h'k'g'f' "c'p'f' "u'c'p'f'c't'f' "Eq'w'q'o d' "r'w'u'34/8' "v'f' r'g'N'g'p'p'c't'f' /L'q'p'g'u'r' q'v'g'v'k'r'0U { ugo a'u'g's'w'k'd't'k'w'o "y' cu'c'ej' k'g'x'g'f' d { 'c'm'y' l'p'i "u{ ugo a'u'f'g'p'k'v' { "v'q' "eq'p'x'g'ti' g'lp' "P'RV"u'ko w'v'k'p'p'u' "y' gp'uy' k'ej' l'p'i "v'q' "P'XV"gp'ugo d'g' "t'w'p'p'k'i "c'p'q'y' g't'g's'w'k'd't'c'k'p'p' "t'w'p'c'p'f' "eqo r'g'v'k'p'i "y' k'j "4'p'u' "m'p'i " r'q'f'w'v'k'p'p' "t'w'p'0C'v'q'o l'e'r' q'k'p'v'ej' c'ti' g'u'y' g't'g'ec'w'v'w'g'f' "ht' "r'w'g' "CC"c'p'f' "FO UQ. "c'ee'q'f' l'p'i "v'q' "y' g'EJ' g'r'I "uej' go g' "c'p'f' "y' gp'c'x'g't'c'i' g'f' "eq'p'k'f' g't'k'p'i "o q'rg'ht'cekv'p'p'qh'eqo r'q'p'g'p'w'lp'g'cej' "u{ ugo 0POT'uj' k'g'f' l'p'i "eq'p'w'c'p'w'y' g't'g'ec'w'v'w'g'f' "ht' "c'm' "y' t'g'g' "CC IF O UQ"u{ ugo u'w'k'p'i "S O IO "ec'w'v'w'k'p'p'u' "Vj g'ug' "ec'w'v'w'k'p'p'u' "y' g't'g' "r'g'ht'q'o g'f' "ht' "c' "u'g'v' q'h' o q'rgew'rt' " eq'p'h'i' w'v'k'p'p'u'ec'r'w'g'f' "f'w'k'p'i "OF "u'ko w'v'k'p'p'u'q'h'c'i' k'x'g'p' "u{ ugo 0Vj g'c'p'c'n' { uku'q'h'y' { f tqi gp'd'q'p'f' u'lp'f'k'ht'g'p'v'CC IF O UQ" u{ ugo u'y' cu'd'c'ug'f' "q'p'i' g'q'o g't'k'e' "f'g'h'p'k'k'p'q'h'c'j' { f tqi gp'd'q'p'f' "y' j' k'ej' "c'm'y' g'f' "v'q' "k'f' g'p'v'k'h' { "f'k'ht'g'p'v'v'f' r'g'u'q'h' o q'rgew'rt' "ci i t'gi cv'g'u'ht'q'o l'p'i "lp'y' g'ug' "u{ ugo u'0"

Vj g'r' t'g'ug'p'v'k'p'p'y' k'm'k'p'ew'f' g'c' "eqo r'ct'k'p'p'dgy ggp'z'r'g't'ko gp'v'n'c'p'f' "eqo r'w'g'f' "J 'POT'ur gev'c'qh'cekf le'r tqv'p'lp' qh'cegve'cekf 'cpf' "t'g'u'w'u'q'h'y' g'c'p'c'n' { uku'q'h' o q'rgew'rt'ci i t'gi cv'g'u'lp'CC IF O UQ"dkpt { 'u{ ugo u'0"

"

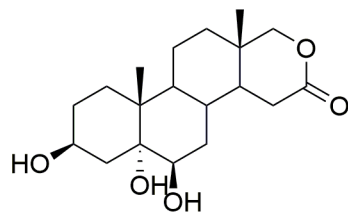
[3\_ J 0Hmly etc. 'Uw'f' l'gu'q'h'y' { f tqi gp'd'q'p'f' l'p'i "l'p'ect'd'q'z' { r'ie'cekf' /f ko gy { n'uwhtqz'kf g'u{ ugo u'd { 'p'w'g'c't' "o ci p'g'v'e' "t'g'u'p'c'p'eg'f' k'w'k'p'p'uj' k'w'u. 'L'0' Rj { u'0Ej go 09: \*3; 96+3884638880j w'u-1f' q'l'q'ht'i B20243 I32282; c2350'  
 [4\_ F 0N'g'p'i x'lp'ck'g. 'MOC'k'cu. 'NOM'ko v'f' u' "O q'rgew'rt'ci i t'gi cv'k'p'lp' "i's'w'k'f' "cegve'cekf <'k'p'uki' j'v'ht'q'o "o q'rgew'rt' f { p'c'o l'eu's'w'c'p'w'o "o g'ej c'p'le'u' "o q'f' g'k'p'i "q'h'ut'w'ew'c'n'c'p'f' "POT'ur' t'q'r'g't'k'g'u' "Rj { u'0Ej go 0Ej go 0Rj { u'043\*423; +36: 33636: 420j w'u-1f' q'l'q'ht'i B2025; k'er 23: ; 4c0'

**E Q O R C T C V K G ' U V W F [ ' Q H ' i n s i l i c o ' V Q Q N U ' V Q ' R T G F K E V ' V J G ' C F O G ' ' R T Q H K N P I ' H Q T ' U G N G E V G F ' 7.8 / Q Z [ I G P C V G F ' F / J Q O Q ' U V G T Q K F U ' ' O k r e c ' K k <sup>3</sup> . ' K c p c ' M w j o k p c e <sup>3</sup> . ' O c t k l c ' U c m e <sup>3</sup> "**

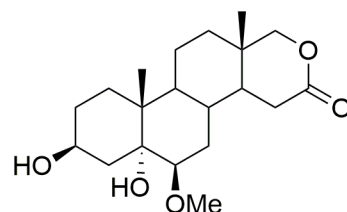
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C F O G " \* c d u q t r v k p p . " f k w t k d w k q p . " o g v c d q r k u o . " c p f " g z e t g v k p p + " r t q r g t v g u " c h g e v " r j c t o c e q n i k e c n i c e v k x k v { " q h ' f t w i " e c p f k f c v g O ' V j g u g " e c p " d g " f g v g t o k p g f " h t q o " r j { u l e q e j g o k e c n i r t q r g t v g u " y j c v ' e c p " d g " r t g f k e v g f " h t q o " y j g " u t w e w t g " q h ' y j g " f t w i " e c p f k f c v g O ' F g v g t o k p k p i " k p ' u k r e q " C F O G ' e j c t c e v g t k u k e u " q h ' p g y n i " u { p v j g u k g f " e q o r q w p f u ' e c p " d g " e t w e k r i k p " y j g " f t w i " f k e a x g t { " r t q e g u u O w n k r n g " y g d " u g t x g t u " c p f " u q h y c t g " y g t g " f g x g n q r g f " h q t " y j k u ' r w r q u g O " "

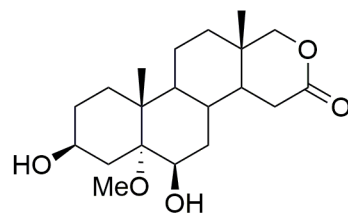
Kp " q w t " r t g x k q w u " y q t m " y g " j c x g " u { p v j g u k g f " c " u g t k g " q h " 7.8 / q z { i g p c v g f " u v g t q k f c n i F / j q o q " r e v q p g u " c p f " v g u v g f " y j g k t " c p v k e c p e g t " r t q r g t v g u " ] 3 \_ O J g t g k p . " y g j " c x g ' u g r e g e v g f " h q w t " q h ' y j g u g " e q o r q w p f u ' y k j " y j g j " k i j g u v e { v q v z k e k v { " H k i O 3 + " c p f " k p " u k r e q " v g u v g f " y j g k t " C F O G ' r t q r g t v g u O ' K p " q t f g t " v q " f g v g t o k p g " q r v o c n i k p " u k r e q " v q n i h q t " C F O G ' r t q r g t v g u " e c r e w r v k p p . " y g j c x g " e q o r c t g f " t g u w u " q d v c k p g f " h t q o " h k x g " v q n i " E j g o F t c y . " O q r k p u r k e v k p p " ] 4 \_ " U y k u C F O G " ] 5 \_ " c f o g U C T " ] 6 \_ " c p f " r n E U O " ] 7 \_ O D g u k f g u " y j g " p w o d g t " q h ' e c r e w r v g f " r c t c o g v g t u . " y g j c x g " c n u q " v e n g p " k p v q " c e e q w p v j g " g r i r u g f " v o g " c p f " p w o d g t " q h ' u t w e w t g u " y j c v ' e c p " d g " u w d o k w g f " u k o w n c p g q w u n { O " "



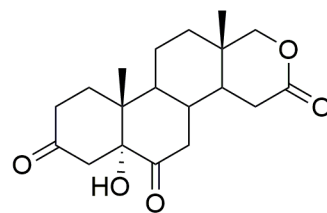
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MDA-MB-231 3.38



MDA-MB-231 4.40



MDA-MB-231 4.81

H k i O 3 O u t w e w t g u " c p f " o q u v ' u k i p h k e c p v e { v q v z k e k v { " K E 7 2 " x c n w g u " \* o q n i N + " q h ' u g r e g e v g f " u v g t q k f c n i e q o r q w p f u " ] 3 \_ O " "

[3\_ " K O ' O M w j o k p c e . " F O U L c m i o q x " g v ' c r i O " U { p v j g u k u " c p f " c p v k e c p e g t " r q w p v c n i " q h ' p q x g n 7.8 / q z { i g p c v g f " c p f k t " j c n i j g p c v g f " u v g t q k f c n i F / j q o q " r e v q p g u . " D k q t i O O g f O E j g o O 5 2 . " 3 3 7 ; 5 7 " \* 4 2 4 3 + 0  
 [4\_ " y y y O q r k p u r k e v k p p e q o " \* c e e g u n g f " 2 : ( 2 4 0 4 2 4 3 + 0  
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 [7\_ " F O G O X O ' R k t g u . " V O N O ' D n w p g m " F O ' D O ' C u e j g t . " r n E U O < r t g f k e v k p i " u o c m i o q n g e w g " r j c t o c e q n i p g v e u " c p f " v z k e k v { " r t q r g t v g u " w u l p i " i t e r j / d c u g f " u k i p e w t g u . " L O O g f O E j g o O 7 : . " 6 2 8 8 6 6 2 9 4 " \* 4 2 3 7 + 0  
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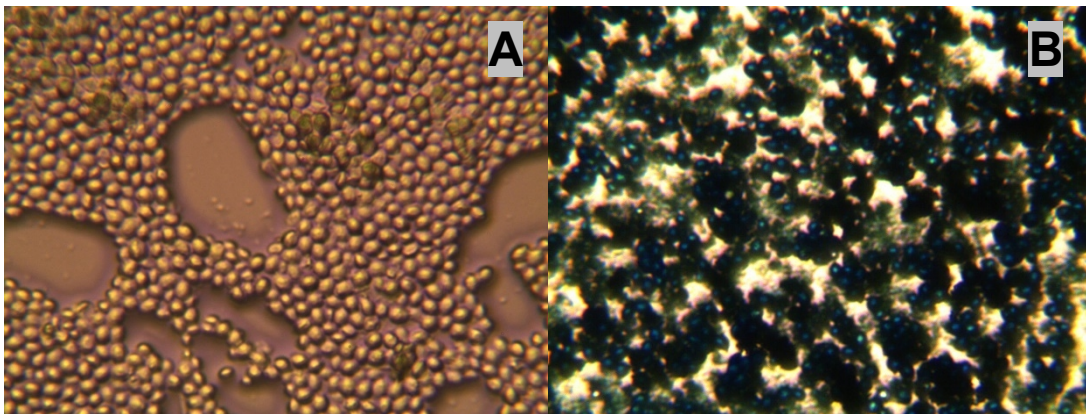
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<sup>3</sup>F gr ctwo gpvqhRj {ulecnEj go knt{. Hcwm{ qhEj go knt{ cpf I gquckpegu. Xkpkwu Wpkxgtuk{. Nksj wcpk  
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Hi 030[ gcuvegm r j qvi tcr j gf y kj qr lecn ketqueqr g | qgo gf kp 62 wo gu<C+dghqtg o qf kkecvkqp y kj kqp  
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\*423; +

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hco k{ qh hcxqr tqv{kp qzlf qtgf wevcugu Ej go EcEj go . xqr04. kuwrg : \*4232+

# SYNTHESIS OF BILE ACID PRECURSOR FOR NEW GLUCOCORTICOID DERIVATIVES

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[ljubicabrenjo@gmail.com](mailto:ljubicabrenjo@gmail.com)

Inflammation is part of the non-specific immune response that occurs in reaction to harmful stimuli [1], which is recognized by the cardinal signs of heat, redness, swelling, pain and loss of function [2]. Whereas inflammation is beneficial and protective response, excessive or persistent inflammation incites tissue destruction and disease. Anti-inflammatory drugs decrease or neutralize the level of pro-inflammatory mediators and/or inhibit the recruitment and activation of leukocytes [2]. Glucocorticoids (GC) are class of steroid hormones that regulate several immunological functions and are among the most commonly prescribed drugs used for the treatment of inflammatory and immune disorders [3], however their therapeutic use is limited by severe side effects, and there is a need for GC with enhanced therapeutic activities and fewer or less severe side effects. GC mediate their physiological effect through number of mechanisms where the most important are transrepression (TR) and transactivation (TA) [4].

Our goal is the synthesis of a series of compounds that will manifest a different ratio of TR and TA activity and will lead to potential drug candidate. Starting from the deoxycholic acid we have developed a method for synthesis of precursor **1** (Fig. 1), that could be easily functionalized at the position C3 and C11, positions which are crucial for interaction with glucocorticoid receptors. Synthesis of this compound will be presented in detail.

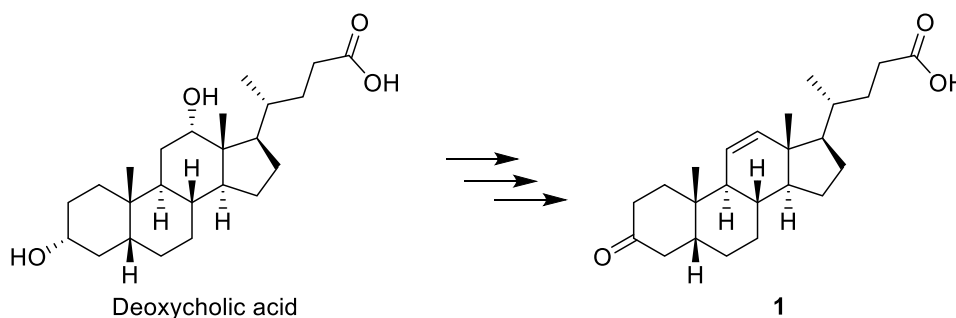


Fig. 1. Multistep synthesis of precursor **1** from deoxycholic acid.

- [1] L. Ferrero-Miliani, O. H. Nielsen, P. S. Andersen, S. E. Girardin, Chronic inflammation: importance of NOD2 and NALP3 in interleukin-1 $\beta$  generation, *Clin Exp Immunol.* **147**, 227-235 (2007).
- [2] A. L. Alessandri, L. P. Sousa, C. D. Lucas, A. G. Rossi, V. Pinho, M. M. Teixeira, Resolution of inflammation: Mechanisms and opportunity for drug development, *Pharmacology and Therapeutics* **139**, 189-212 (2013).
- [3] A. Shimba and K. Ikuta, Control of immunity by glucocorticoids in health and disease, *Seminars in Immunopathology* **42**, 669-680 (2020).
- [4] B. M. Vayssière, S. Dupont, A. Choquart, F. Petit, T. Garcia, C. Marchandeu, H. Gronemeyer, M. Resche-Rigon, Synthetic glucocorticoids that dissociate transactivation and AP-1 transrepression exhibit antiinflammatory activity in vivo, *Mol Endocrinol.* **11**, 1245-1255 (1997).

# O KETQY CXG/CUUKUVGF 'U P VJ GUK'QH'UKNXGT'PCPQRCTVÆNGU' Y K V J 'RQN[ QNU'

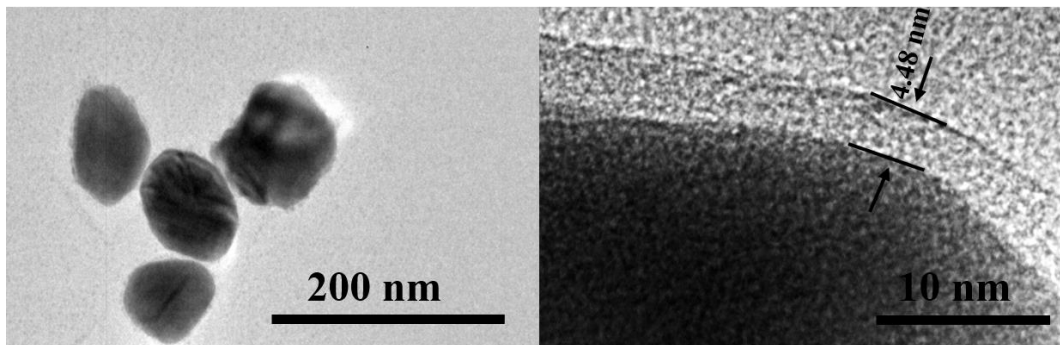
Gf kc'F cwdn[ v<sup>3</sup>. 'Ci p \ f c p k w u n k p<sup>4</sup>. 'Vc d c p c' E j c t n q x c<sup>4</sup>''

<sup>3</sup>Nh'g'Uelgpegu'Egpgt. 'Xkpkwu'Wpks gtukf. 'Nkj wcpk'

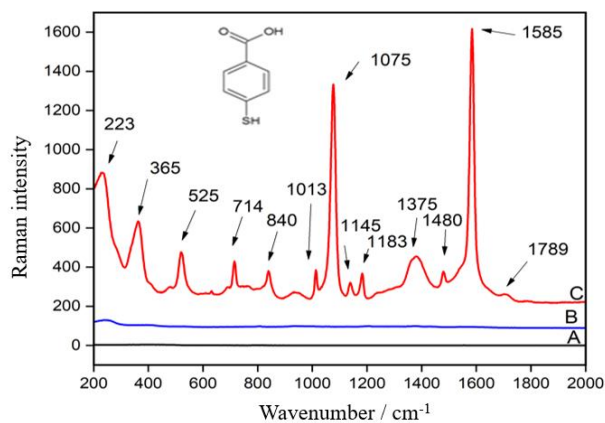
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gf kcf cwdn[ v g B i o c h r e q o . "

Kp'tgegpv' { gctu. 'ukxgt' pcpqr ctvængu'j cxg'dggp'kpvpugn' 'uwf kgf' hqt'vj gk' wpls wg'qr væcn'grævtæcn'ecvncf væ. 'vj gto cn' cpf "qyj gt' tgrævgf' r tqr gt vgu'0' Rtgekqwu' o gvcn' pcpqr ctvængu' qh'c' egt vcp' uk' g. 'uj cr g. 'cpf' eqcvkpi u'co r rkh' { "Tco cp' uki pcni' htqo " f khgtgpv' cpcn' væcni' vcti gvu' Vj ku' r tqo kuki " o gj qf " ku' ecngf " uj gm'kuqrævgf " pcpqr ctvæng/gpj cpegf " Tco cp' ur gev t q e q r { " \* U J R P G T U + " ] 3 0 " "

Xctkqwu'tgf velpi "cpf' ucdkkt kpi 'ci gpwu'ctg' wugf 'vq'qr vko k g'vj g' r tqr gt vgu'qh'u' p v j g u k' g f ' p c p q r c t v æ n g u ' ] 4 0 ' R q n' q m ' ctg'y kf gn' wugf 'dgecvug'vj g' { 'j gr 'vq' o c p v c p' j' k i j ' v g o r g c w t g u ' c p f ' h g g r ' w p k h q t o ' j' g c v k p i 0 0 l e t q y c x g / c u u k u n g f ' u' p v j g u k u ' q h' p c p q u t w e w t g u ' j' c u' u g x g t e n' c f' x c p v c i g u' q x g t' q y j g t' o' g j q f u' t u j q t v g t' t g c v k p' v k o g u. 'n y g t' g p g t i { " e q u w o r v k p. " j' k i j g t' r t q f w e v' { k g n' u' y k j " p e t t q y g t' u k' g' f' k u t k d w k p u " ] 5 0 ' E q p u g s w g p v n' . " y g' e q o d k p g f " o l e t q y c x g' u' p v j g u k u' c p f ' e j g o l e c n' t g f w e v k p' v q' u' p v j g u k' g' u k x g t' p c p q r c t v æ n g u' w u l p i " r q r w æ t' r q n' q n u' < g y j { r e p p' i n' e q n' \* G I + " v g t c g y { r e p p' i n' e q n' \* V G I + " r g p v g y j { r e p p' i n' e q n' \* R G I + " r q n' g y j { r e p p' i n' e q n' 4 2 2 \* R G I / 4 2 2 + 0 Y g' c l o " v q' e q o r c t g' y j l e j ' c i g p w u' c t g' o' q u v' u w k c d r g' h q t' q d v c l p k i " u c d r g. " o q p q f k u r g t u g' u k x g t' p c p q r c t v æ n g u' V j g' p c p q r c t v æ n g u' o g g v k p i " q w t' e t k g t k e' y g t g' e q c v g f' y k j " c' u k i e c " \* U Q 4 + " u j g n' v q' c x q k f' f k t g e v' e j g o l e c n' c p f " g r æ v t l e c n' e q p v e v' q h' v j g' p c p q r c t v æ n g u' y k j " c' i q i f' u w d u t c v g. " c p c n' v g. " c p f " g p x k t q p o g p v' k p' v j k u' y c { . " u k x g t' e q t g' u k i e c' u j g n' C i B U Q 4 + " p c p q r j g t g u' y k j " c' u k' g' q h' 9 2 0 7 ' p o ' y g t g' u' p v j g u k' g f' \* H i 0 3 0 J T / V G O " u g h' c u u g o d r g f " o q p q r c { g t' q h' 6 / o g t e c r v d g p' q l e' c e k f " \* O D C + " y c u' h q t o g f " q p v q' c' i q i f' r r æ v g' c p f " C i B U Q 4 " p c p q r c t v æ n g u' y g t g' u r t g c f' q p' k v' q' c o r r k h' { ' v j g' T c o c p' u k i p c n' i C' e n g t' g p j c p e g f ' U J R P G T U' u r g e v t w o ' q h' O D C' q p' c' u o q q y j " i q i f' r r æ v g' y c u' q d v c l p g f' \* H i 0 4 0 " "



Hli 030J T/VGO 'lo ci gu'qh'9207'po 'Ci B UQ4'pcpqr j gt gu'y kj '60207'po 'qh'uktec'uj gm'u' p v j g u k' g f' y k j 'RGI /4220'



Hli 040Tco cp'ur gev t w o ' q h' O D C' c f u q t d g f ' q p' c' u o q q y j ' C w' u w t h e g e y' k j q w' p c p q r c t v æ n g u' \* C' o' d r e m e: " T c o c p' u r g e v t w o " q h' C i B U Q 4' p c p q r c t v æ n g u' u' p v j g u k' g f' y k j ' R G I / 4 2 2 \* D' o' d m æ g' c p f ' U J R P G T U' u r g e v t w o ' q h' O D C' y k j ' C i B U Q 4' p c p q r c t v æ n g u' "

[3\_ 'LOHONk' [ OLO\ j cpi. 'UO\ OF kpi. 'TORepppgtugkco. '\ OS OVkp. 'Eqtg/uj gn' pcpqr ctvæng/gpj cpegf "Tco cp'ur gev t q e q r { . 'LOEj go OT gx0339. '7224/728; \*4239-0"  
[4\_ 'UO wnj gtlk'UODj ctv'k' O Uj wmc. 'UO wnj gtlk'U' p v j g u k' c p f ' e j c t c e v g k' c v k p' q h' u k' g' c p f' u j c r g' e q p t q m g f' u k x g t' p c p q r c t v æ n g u. 'Rj { u O U e k O T g x 0 6 . " 423922: 4\*423; -0"  
[5\_ [ OLO\ j w: 'HDEj gp. 'O letqy cxg/cuukngf' r tgr ctvæng' qh'kpqi cple' pcpqrctvængu' k' p' t s w k' ' r j c u g. 'LOEj go OT gx0336. '8684/8777\*4236-0"

**U P VJ GUKU'EJ CTCEVGTĶ CVĶQP 'CPF 'CRRNĶ CVĶQP 'QH'EJ ĶVQUCP /  
ENCĶ /DCUGF 'P CP QE QO RQUĶGU'HQT 'UQTRVĶQP 'QH'  
O GVCNUIT CF ĶQP WENĶ GU'**

Mctqkpc'Mctcpxk k v<sup>3,4</sup>. 'I crikpc'"Nwlcplcp<sup>4</sup>. "Tco cp'P qxkncw<sup>4</sup>. 'Xlf cu'Rcm-cu<sup>5</sup>. 'Cwf tkwu'  
F tcdexk kw<sup>5</sup>. 'Ctpcu'P cwlqnckku<sup>5</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Cpcn{ vccn'cpf 'Gpxktqpo gpvniEj go knt { 'Hewm{ 'qh'Ej go knt { 'cpf 'I gquelpegu. 'Xkplku'Wpkkgtukv{. "  
Nkj wcpk"

<sup>4</sup>F gr ctvo gpv'qh'Gpxktqpo gpvniTgugctej . 'Egpgvt 'hqt' Rj { ulecn'Uelgpegu'cpf 'Vgej pqm{ { . 'Nkj wcpk"

<sup>5</sup>F gr ctvo gpv'qh'Ej ctcevgtkucvqp'qh'O cvgtkcn'Utwewtg. 'Egpgvt 'hqt' Rj { ulecn'Uelgpegu'cpf 'Vgej pqm{ { . 'Nkj wcpk"  
mctqkpc'htctcpxkewgB ej i htwf kvw"

"  
Wpks wg"r tqr gtvku'qh'ej kvqcp"uwej "cu'dkqeqo r cvdkk{. "dkqf gi tcf cdkk{. "cpko letqdkn'cevkk{ "cpf "pqp/vzkek{ "  
j cxg'tgumngf 'lp'cp'kpetgculpi 'kpvgtuv'qh'ku'kpxguki cvkqp'cpf 'y kf gur tgc{ 'cr r rccvkvq'j3\_0Ej kvqcp'dkqr qn{ o gt'ku'wugf 'lp'  
xctkqwu'kgrf u'zo gf lekpg. 'r j cto ce{. 'ci tlewmwtg. 'hqqf 'r cenai kpi "cpf 'equo gve'kpf wut { 'cu'y gni'cu'hqt'tgo qxcni'qh'j gcx{ "  
o gvcni'htqo 'y cvgy cvgt'j4\_0J qy gxtg. 'ej kvqcp'j cu'hqy 'y cvgt'tgukcpeg. 'r qqt'bo gej cplecn'cpf 'y gto cni' tqr gtvku'ho kkp{ "  
ku'wuci g0

C"eqo o qpn{ "wugf "y c{ "hqt"ko r tqxkpi "y j g"o gej cplecn'cpf "dcttltg" r tqr gtvku'qh'ej kvqcp"ku'vq'cf f "pcpquk{ gf "  
tghphtekpi "grgo gpw'lvq'ej kvqcp'ej ckpu'j5\_0Vj g'wug'qh'erc{ 'cu'cp'cf uqtdgpv'ku'f wg'vq'y j g'r gewlctkku'qh'ku'utwewtg. 'cu'  
y gni'cu'ku'geqpqo le'cxkncdkk{ 'cpf 'vdkvks{0Vj g'vtpgf 'vqy ctf u'y j g'wug'qh'erc{ 'j cu'wvf gti qpg'ugxgtcni'ej cpi gu. 'htqo 'ku'  
wug'lp'ku'f wtg'htqo 'vq'bo qf kkecvkvpu'cpf 'eqo dlpvcvq'y kj 'vqy gt'cf uqtdgpw0Ej kvqcp/erc{ 'pcpqqeo r qukvgu'j cxg'cwtcevgf "  
eqpukf gtdcng'kpvgtuv'dgecwug'j g{ 'eqo dlpv'j g'utwewtg. 'r j { ulecn'cpf "ej go kcn'r tqr gtvku'qh'kpvqti cple"cpf "qti cple"  
o cvgtkcn'j6\_0

Vj g'cdo 'qh'y ku'wuf { 'y cu'vq'r tgr ctg'ej kvqcp'o'erc{ 'pcpqqeo r qukvgu'y kj 'xctkqwu'erc{ 'eqpegpvcvkvpu. 'lp'qtf gt'vq'  
kf gpvkh{ "cpf "ej ctcevgtk{ g" y j g' utwewtg" qh' pcpqqeo r qukvgu' wulpi "Z/tc{ " f khtcevkvq" \*ZTF+." vcpuo kuukqp" grgestqp"  
o letqueqr g"\*VGO +cpf "uecpkpi "grgestqp"o letqueqr { "\*UGO +cu'y gni'cu'vq'cr r n{ "y j u{pvj guk{ gf "pcpqqeo r qukvgu'htq"  
uqtr kvq'qh'bo gvcni'cpf "tcf kqpwerkf gu0

Kp'y ku'tgugctej . 'ej kvqcp'r qy f gt'y cu'f kuukngf 'lp'322"o ni'qh'cp'cs wgvwu'uqmwkvq'qh'cegve'celk "3' . 'x lx+ 'wulpi "c"  
o ci pgve'ukttkpi 'r mvg'cv'; 2'AE'cpf "372"tr o "hqt"3"j qwtu'cpf "y j gp'eqqkpi "y j g'uqmwkvq"vq'tqqo "vgo r gtcwvgt0Ej kvqcp/  
erc{ "pcpqqeo r qukvgu'y gtg'qdvckpgf "d{ "o kzkpi "y j g'ej kvqcp"y kj "f khtgtgpv'co qwpvu'qh'erc{ "2."7."32."37"y v" +0Vj g"  
utwewtg" o qtrj qm{ { " cpf " eqo r qukvq" qh' pcpqqeo r qukvgu" y gtg" ej ctcevgtk{ gf " wulpi " Z/tc{ " f khtcevkvq" \*ZTF+."  
vcpuo kuukqp'grgestqp'bo letqueqr g"\*VGO +cpf "uecpkpi "grgestqp"bo letqueqr { "\*UGO +0Vj ku'kpxguki cvkqp'gv'wul'kf gpvkh{ 'y j cv'  
uj cr gu'cpf "uk{ g'qh'r ctvkvgu'y gtg'u{pvj guk{ gf 0Vj g'qdvckpgf 'pcpqqeo r qukvgu'y gtg'cr r rkgf "hqt"y j g'uqtr kvq'qh'bo gvcni'cpf "  
tcf kqpwerkf gu0

]3\_Dkuy cu'U0'Tcu j k' V0W0'F gdpvj 'V0'J cs wg'R042420C'r rccvkvq'qh'Ej kvqcp/erc{ 'Dkqeqo r qukv'gdcf u'htq'Tgo qxcni'qh'j gcx{ 'O gvcni'cpf 'F { g'htqo "  
kpf wutkni'Ghmvgpv.<36360'F QK'3205; 2 lleu62322380  
]4\_ " Mxuo pqp. " Cdf wttej lo " K' 423; 0' Y cvgt" uqtr kvq. " cpko letqdkn' cevkk{. " cpf " y j gto cni' cpf " o gej cplecn' r tqr gtvku' qh' ej kvqcp knc{ li n'egtqf "  
pcpqqeo r qukv'kko u.'J gkq'pp'7\*: +<g245640'F QK'320238 llq grkq'pp023; <g245640  
]5\_ "P giKCD0'Li k'KO 0'nej cqw'J 0'P cut'KO 0'F j qwd'Ucj pqwp'T042420R'gr ctcevgtk cvkqp."o gej cplecn'cpf "dcttltg" r tqr gtvku'kpxguki cvkqp "  
qh'ej kvqcp/mctqkpc'pcpqqeo r qukv. Rqn{ o gt'Vgukpi ": 6\*Qevdgt'423; +3285: 20'F QK'320238 llq qn{ o gt'vukpi 04240285: 20  
]6\_ "C'P gxgu'O 042380F gxgnr o gpv'cpf 'Ej ctcevgtk cvkqp'qh'Ej kvqcp/P cpqnc{ 'Eqo r qukv'kko u'htq'Gpj cpegf 'I cu'Dcttltg'cpf 'O gej cplecn'Rtqr gtvku' "  
Hqqf 'Uelgpeg'(' P wtkkqp'4\*3+<3690'F QK'32046; 88 lhp/3298B222290  
"  
"

**RPVGTCEVQP'QHEQRRGT\*KK'Y K/J 'CEK'HKGF'UQF KWO''  
 QTVQVWPI UVCVG'CS WGQWU'UQNWWKQP U'**

F wxcpqxc'Gmc<sup>3</sup>. 'Tcf kq'Ugtj k<sup>4</sup>. 'Tqj cpwugx'I gqti k<sup>3</sup>

<sup>3</sup>Hcewm'qhi'Ej go knt { 'Dkqni { 'cpf 'Dkqvej pqrni lgu=Xcu{n}Uwu'F qpgvniP cvkqpcn'Wpkxgtukf. 'Wntclpg'  
<sup>4</sup>F gr ctvo gpv'htq'Tgugctej. 'Tgugctej 'Ncdqtevt { 'δEj go knt { 'qh'Rqn'qzqo gvcrygu'cpf 'Eqo r rgz'Qz'kf'U{ ugo uδ'Xcu{n}  
 Uwu'F qpgvniP cvkqpcn'Wpkxgtukf. 'Wntclpg'  
gOxcpruqxcB fppwOgf wOxc

Eqr r gt\*KK'kuqr qn'wpi ucvgu'EwRVC+'j cxg'c'xctkqv'qhi'r gtur gevkg'r tqr gt'vku'yj cv'cmqy u'v'wug'yj go 'cu'cpv'k'cni'  
 cpf " cpv'kwo qt" o gf lekpgu' Eqpukf g'kpi " vj ku." vj g" ugctej " qh" pgy " u{pvj guku' tqwgu." vj g" utwewt'g" cpf " r tqr gt'vku'  
 ej ctcevtgk'cvkq'qhi'yj ku'eqo r qwpf u'ctg'cewcn'tgugctej 'vcumu'

Vj g'o quv'uwf'kgf "co qpi 'EwRVC'ctg'r ctcwpi ucvgu'yj lej 'eqpv'clp'yj g'Y<sub>34Q62</sub>\*QJ<sub>±4</sub><sup>326</sup>cpkqp0'Vj gug'eqo r qwpf u'  
 ctg'wuwcm' "u{pvj guk'gf 'd{ 'cp'gzej cpi g'tgcev'kp'itqo 'f kuq'k'gf 'kp'y cvgt 'cmek'o gcn'r ctcwpi ucvg. 'qt'itqo 'cekf'HKGF'vq'  
 vj g'pggf gf 'cekf k' " " 'E\*J - +TE\*Y Q<sub>6</sub><sup>46</sup>+ 'cs wgwu' uq'nw'kpu'qhi'qt'v qwpi ucvg'cpkq'f w'kpi 'ugr'cu'go d'ni'0'Vj g'ugeqpf "  
 u{pvj guku'tqwg'ku'uko r rgt'cpf 'h'cugt. 'd'gecvug'k'f qgu'p'qv'tgs w'k'g'yj g'u{pvj guku'qhi'cmek'o gcn'r ctcwpi ucvg'D0'

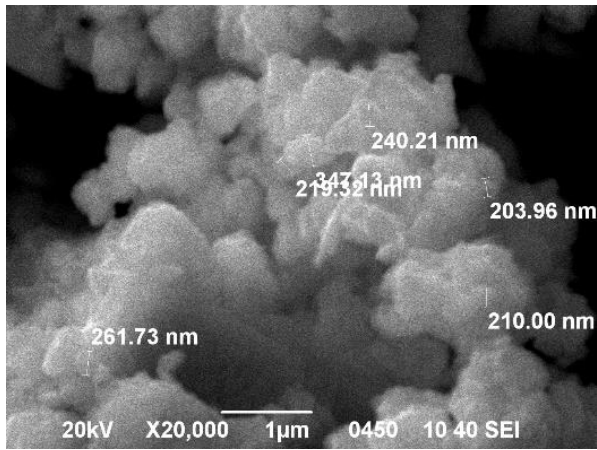
Cv'yj g'uco g'v'o g'yj g'cekf k'f 't'cpi g'yj g'gt'g'f'gh'pk'g'kuqr qn' 'cpk'p'u'f'qo k'p'cv'g'ct'g'cv'j g't'y k'f g'0'cp'f 'v'j g'u{pvj guku'ecp'd'g'  
 f'q'p'g'k'p'c'y k'f g'r J 't'cpi g'qhi' uq'nw'k'p'0'Vj wu' 'cp'cs wgwu' uq'nw'k'p'qhi'Ew<sup>4</sup> 'δ'Y Q<sub>6</sub><sup>46</sup>\* " ? '3089+δ'J - IQJ<sup>6</sup>'δ'J<sub>4</sub>Q'y cu'uwf' lgu'  
 d{ 'b' g'y qf u'qhi' b' cvj go cv'ec'n'b' qf g'r'kpi. 'y j lej 'b' cf g'k'r' qu'k'd'ng'v'q'f' g'v'g'to k'p'g'yj g'o quv'cew'cv'g'Eqr r gt\*KK'r ctcwpi ucvgu'D'  
 u{pvj guku'eqpf k'k'p'u'0'

Kp'v'j ku'tgi ctf "c"r J /r qv'g'p'k'qo g'tle'v'k'c'v'k'p'qhi'yj g'Ew<sup>4</sup> "δ"Y Q<sub>6</sub><sup>46</sup>\* " ? "3089+δ"J<sub>4</sub>Q'u{ ugo 'd{ 'cekf'qt'cmek'k'p'  
 \ " ? "3089δ3089'cpf "\ " ? "3089δ3027'cekf k'f 't'cpi gu' t'g'ur gev'k'g'ni' "y k'j "v'j g" " ? "2027=2022=2027=2042=2047" \*o qmδ<sup>63</sup>+'k'p'le'  
 ut'g'pi vj g'u'y cu'ectt'k'f "q'w'0'Vj g'v'k'c'v'k'p' 't'g'u'w'u'y g't'g'w'ug'f "h'q't'o qf g'r'kpi 'k'p'ENK'R'408'r tqi t'co 'y j lej 'uj'qy gf "v'j cv'yj g'  
 g'zr g'ev'g'f "C'p'f'g'tu'q'p" j g'v'g't'q'r qn' 'cp'k'p'u'y g't'g'p'q'v' h'q'to gf "cv'yj ku'cekf k'f 't'cpi g'0'C" o qf g'r'y k'j "JEw<sup>4</sup>. "Y<sub>34Q62</sub>\*QJ<sub>±4</sub><sup>9</sup>.  
 JEw<sup>4</sup>. "J Y<sub>34Q62</sub>\*QJ<sub>±4</sub><sup>96</sup>. "JEw<sup>4</sup>. "J<sub>4</sub>Y<sub>34Q62</sub>\*QJ<sub>±4</sub><sup>86</sup>. "JEw<sup>4</sup>. "J<sub>5</sub>Y<sub>34Q62</sub>\*QJ<sub>±4</sub><sup>76</sup> k'p'r cktu'cpf "EH'7208; \*<sup>4</sup> g'zr0" ? "4: 02"<<"  
<sup>4</sup>h" ?2027" ? "76079+y cu'ej qu'g'p'v'q'f' g'uet'k'd'g'yj g'k'p' 'u'c'v'g'k'p'yj g'u{ ugo 0'Vj cv'g'zr' r'k'p'u'yj g'r' t'g'ug't'x'cv'k'p'qhi'yj g'j qo q'j g'p'g'k'f 'qhi'  
 vj g'u{ ugo 'cv'c'uw'f'k'el'g'p'v'f' j k'j j 'eq'v'g'p'v'qhi'it'gg'Ew<sup>4</sup> 'cpf "Y Q<sub>6</sub><sup>46</sup> k'p'u'0'

Kp'v'g't'ce'v'k'p'u'lp'yj g'u{ ugo 'y g't'g'k'p'x'g'uk'i cv'g'f 'd{ 'eq'p'f'w'v'k'k'f' 'b' g'cu'w't'go g'p'v'y j lej 'ecp'r' t'q'x'g'yj g'r' t'g'ug'peg'qhi'k'p'r' cktu'  
 dg'y g'p'p'Eqr r gt\*KK'ec'v'k'p'u'cpf 'kuqr qn' 'wpi ucvgu'cp'k'p'u'qhi'yj g'34'yj 't'q'y 0'

Vj g'ec'w'v'c'v'g'f "x'c'w'g'u'qhi'yj g'ni' c't'k'j o u'qhi'eq'peg'p'v'c'v'k'p'eq'p'uc'p'w'u'qhi'yj g'cp'k'p'u'h'q'to cv'k'p'cv'yj g'eq'tt'g'ur q'p'f'k'pi "  
 x'c'w'g'u'qhi'k'p'le'ut'g'pi vj 'y g't'g'w'ug'f 'v'q'ec'w'v'c'v'g'yj g'ni' c't'k'j o u'qhi'yj g'to qf { p'co k'e'eq'p'uc'p'w'u'ni M'f'd{ 'v'j g'R'k'g't'o g'yj qf 'd{ "  
 g'z'v't'c'r q'r'v'k'pi 'v'j g'f'g'r g'p'f'g'p'eg'ni M<sub>E</sub>' ? 'h' \* + 'v'q' " ? "2" \*o qmδ<sup>63</sup>+'0'

C" pgy " u{pvj guku' r t'q'eg'f'w'g' " y cu' f'g'x'g'q'r'g'f " cpf " c" pgy " uq'f'k'wo /eq'r r gt\*KK' r ctcwpi ucvgu'D"  
 P<sub>c4Ew5</sub>\*EwQJ<sub>±4</sub>Y<sub>34Q62</sub>\*QJ<sub>±4</sub>-54J<sub>4</sub>Q'k'p'cekf'HKGF'vq'\ " ? "3089" cs wgwu' uq'nw'k'p'u' y k'j " \*P<sub>c4Y</sub>Q<sub>6</sub>+ " ? " \*J P Q<sub>5</sub>+ " ? "  
 2027" \*o qmδ<sup>63</sup>+'cpf "E\*Ew\*P Q<sub>5</sub>+ " ? " .5555 32<sup>65</sup> \*o qmδ<sup>63</sup>+'y cu' u{pvj guk'gf 0'Vj g'q'd'v'c'k'p'g'f "ucn'y cu'uwf'kgf "d{ "ej go k'ec'n'  
 g'rg'o g'p'v'c'n'c'p'c'n'f' uku' 'u'ec'p'p'k'pi 'g'rg'ev't'q'p'o k'et'q'ue'q'r { "UGO + 'c'p'f 'HV/KI' 'r' g'ev't'q'ue'q'r { 0'Vj g'uw'f { 'qhi'uw'f'c'eg'o k'et'q'o q't'r j q'm'i { "  
 u'j'qy gf "v'j cv'ucn'g'z'k'w'u'k'p'yj g'h'q'to 'qhi'r'v'g'u'y k'j "462/562'po "i t'cl'p'uk' gu'\*H'k'i 03-0'Vj g'r' t'q'r'q'ug'f 'u{pvj guku'r' t'q'eg'f'w'g'ec'p'  
 dg'w'ug'f 'v'q'q'd'v'c'k'p' 'u'k'o k'c't' 'u'c'm'a'y k'j 'ec'v'k'p'u'qhi'yj g't'f' /o g'c'u'0'



H'k'i 030UGO 'lo ci g'qhi'P<sub>c4Ew5</sub>\*EwQJ<sub>±4</sub>Y<sub>34Q62</sub>\*QJ<sub>±4</sub>-54J<sub>4</sub>Q'k'p'UGK'g'ev't'q'p'o qf g' \* "42.222+ "

Vj g'uw'f { 'y cu'ectt'k'f "q'w'y k'j k'p'yj g'H'w'p'f'c'o g'p'v'c'n'T'gugctej 'R't'q'i t'co o g'H'w'p'f'g'f 'd{ 'v'j g'O'k'p'k'w' { 'qhi'G'f'w'ec'v'k'p'cpf "  
 U'ek'p'eg'qhi'Wntclpg' \*i t'c'p'v'K'F'233; W322247+0'





**U P V J G U K U' Q H D G P \ K O K F C \ Q N G' F G T K C V K G U' C U R Q V G P V K C N' K P J K D K V Q T U H Q T' J U R; 2''**

Nwncu'P gxgtf cwuncu.'Rcwkp'c'Mc| kmnp{ v .'Cni kf cu'Dtwn-wu'

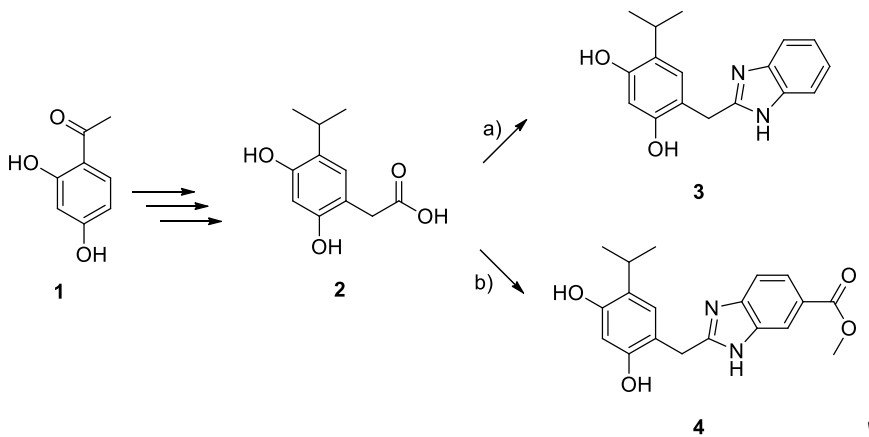
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"

J gcv'uj qen'r tqv'kpu"\*J URu+"ctg"tgr qpukdng"htq"vj g'ucdkkucv'kqp"qh'r tqv'kpu"lp"vj g'egm'j3\_0'Uki plkecpv'o go dgt"qh' J URu"ku"J UR; 2.'y j lej "ku'tgur qpukdng"htq"3/4' "qh'vqcn'egmwt'r tqv'kpu"y j gp"vj g'egm'ku"gzr qugf "vq'ut'guuhwi'eqpf k'kqpu" uwej "cu"j gcv.'eqrf.'WX'iki j v.'gve0]4\_0'Ku'hwpev'kqp" f gr gpf u'qp"ku'cdk'k'v' "vq'dkpf "cpf"j { f tqn'ug'CVR'tguwn'kpi "lp"ej cpi gf " eqo r ngz"cpf "h'qf gf "eikgp'r tqv'kpu'0'J qy gxgt."J UR; 2'"kp"wo qwt"egm"ku"qxgtgzr tguugf "cpf"o c { "ecwug"wp'eqp'v'qngf " tgr tqf w'v'kqp"qh'o wcv'gf "egm'0'Vj ku'o gcpu"vj cv'k'p'j kdk'k'qp"qh'vj ku"J UR'ecp'ngcf "vq'gh'ge'v'k'g'ut'cv'gi { "lp"ecpegt"vj gtrc { "j3\_0' R'q'v'p'k'cn'ut'wewt'gu"qh'lp'j kdk'k'qtu"qh'vj g"J UR; 2'"ctg"r tgf levgf "wulpi "o qrgewr't'f'qen'kpi "cpf."ceeqtf kpi "vq"vj g"423; "uwwf {." 3: "J UR; 2'"lp'j kdk'k'qtu'ctg"wpf gti qkpi "en'ple'cn'v'k'cn'."cv'ng'cu'v'c"vj kf "qh'vj go "y kj "tgu'q'le'k'p'q'ni' q'k'g'v'f"j5\_0'Vj g'tgh'q'g."y g'c'ko " vq'u { pvj g'ukug'u'qo g'dgp| ko kf c| qrg'f'g't'k'c'v'k'g'u'eq'p'v'k'p'k'pi "t'gu'q'le'k'p'q'ni' q'k'g'v'f"cu'r q'v'p'v'k'cn'lp'j kdk'k'qtu'htq"J UR; 20"

Vj g"u { pvj g'uku"y cu"uctv'gf "htqo "eqo o gte'k'cm { "cx'k'c'k'dng"3/\*4.6/f kj { f tqz { r j gp { ngvj gp'qpg"3+"\*Hki 0'300'32/uvgr " u { pvj g'uku'r cvj y c { ."k'p'en'f'k'pi "r tq'v'g'ev'k'qp"qh'j { f tqz { n'i tq'w' u'd { "dgp| { n'v'k'qp"cpf "t'g'c'ev'k'q'pu"uwej "cu"Y k'wi "t'g'c'ev'k'qp"cpf " X'k'no g'lg't/J c'cen't'g'c'ev'k'qp."ngf "vq"u'we'g'gu'uh'wi'htqo c'v'k'qp"qh'4/\*4.6/f kj { f tqz { /7/kuqr tqr { r j gp { n'ee'g'v'k'c'ek'f"4+0'U { pvj g'uku" qh'v'cti g'v'dgp| ko kf c| qrg'u"5"cpf "6+"y cu"ectt'k'gf "q'w'd { "j g'cv'k'pi "q/r j gp { ng'p'g'f'k'c'o k'p'g" f'g't'k'c'v'k'g'u"y kj "eqo r q'w'p'f"4"lp" Y q'q'f'u'o g'cn'd'cvj "y kj "p'q"u'q'k'p'v'o

"



"

**Hki 030U** { pvj g'uku'r cvj y c { "qh'dgp| ko kf c| qrg'f'g't'k'c'v'k'g'u'htqo "3/\*4.6/f kj { f tqz { r j gp { ngvj gp'qpg'0'T'gci gp'u'cpf " eqpf k'k'q'pu'c'+d'g'p| gp'g/3.4/f k'co k'p'g."5"j "cv'367"AE=d+'b' g'v { n'5.6/f k'co k'p'q'd'g'p| q'cv'g."5"j "cv'367"AE'0

"

H'p'cn'r tqf w'eu'5'c'p'f "6'c't'g" { g'v'v'q'd'g'c'p'cn' { u'gf "qh'lp'j kdk'k'qp"r tq'v'g'v'k'u'htq"J UR; 20'

[3\_0'0'Cddcuk"J 0'U'ef gi j k'Cr'k'c'f'k"0'0'Co ep'rq'w'0'Rt'gf'le'v'k'p'p'q'h'p'gy "J ur; 2'"lp'j kdk'k'qtu'd'cu'gf "qp"5.6/kuqzcl q'ng'f'k'co k'f'g"ue'ch'q'rf "wulpi "S UCT"u'w'f {." o qrgewr't'f'qen'kpi "cpf"o qrgewr't'f { p'co le'ulo w'v'k'qp'0'F'CT'W.'LOR'j'cto 0'U'ek'0'4239."47"\*3+."36380  
 [4\_0'MDU'k'g'tc.'GOR'c'v'c'x'q'w'f'0'J UR; 2'"lp'j kdk'k'qtu'2'E'w't'g'p'v'F'g'x'g'nr'o gp'v'c'p'f'R'q'v'p'v'k'cn'lp"E'ce'p'eg't"Vj gtrc { 0'T'g'eg'p'v'R'c'v'0'C'p'v'k'c'p'eg't'0'F't'wi "F'l'ue'q'x'0'4235."; " 3+."36420  
 [5\_0' N'kw"Z'0' N'kw" N'0' N'k" T'0' F'c'k" O'0' Uj k" J 0' Z'v'g." [ 0' N'kw" J 0' Y' c'pi 0' K'g'p'v'k'c'ev'k'qp" c'p'f" U't'w'ew't'g'/'C'ev'k'k'v'f" U'w'f'lg'u" q'h" 3.5/F'k'd'g'p| { n'4/ct { n' ko kf c| q'rf'k'p'gu'cu'P'q'x'g'rl'J ur; 2'"lp'j kdk'k'qtu'0'0' q'rg'ew'ng'u'423; ."46"\*33+."36330

**C\ KKF KP/4/[ N'O GVI CPQNU' CUEJ K'CN'UQNXCVRPI 'CI GPVU'''  
HQT'ECTDQZ[ NKE'CEK'U'''**

**O ctv\pc'O crkqy unc.'Cpcc\ cy ku| c.'Ucprk'ey 'Ng plcm'**

F gr ctvo gpv'qh'Qti cple'cpf 'Cr r nlgf 'Ej go kut {.'Wpkxgtuk\ 'qh'Nqf | . 'Rqrpf "  
o ctv\pc'O crkqy unc' B ej go k'0xpl'0qf | 0 n'

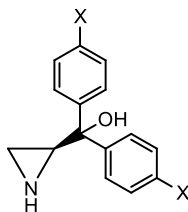
"

Ej kcrk\ 'r n\ {u'c'uki p'k'ecpv'tqrg"kp"ej go kut {.'dkmqi { "cpf"r j cto ce{0Hqt'vj ku'tgcuq. "vj g'f gxgr o gpv'qh'lcu'cpf" gcu\ 'o gjv qf u'vq'f gvgto kpg'vj g'cduqnwg'eap'hi v'c'v'kp'qh'eqo r qwpf u'cu'y gni'cu'vj gk'gpcpv'kqo gtle'r v'k'v\ 'ku'qh'k'p'vgt'g'u'v'q" o cp\ 't'gugtej 'i tqw u'0Cnj qwi j 'o cp\ 'o gjv qf u'q'hi'c'pcn\| kpi "ej k'cn'eqo r qwpf u'ct'g'ewt'g'p'v\ 'hpqy p. 'uwej 'cu'I E'c'pcn\ uku" J RNE. "h'w'qt'g'ue'g'peg"ur gev't'queqr {.'o cuu"ur gev't'queqr {.'ekt'ewr't'f lej tqkuo . "gr'gev't'qr j qt'guku'qt" P O T "ur gev't'queqr {.'pgy " o gjv qf u'ct'g'v'k'ni'd'g'k'pi "u'q'wi j v'vj cv'cmqy "t'cr k'f "c'pcn\ uku"y kj qw'vj g'pggf "v'q" f g'k'c'v'k' v'k'q'p'vj g'c'pcn\ v'g"]3\_0Co qpi "vj g'ug" o gjv qf u. "P O T"ur gev't'queqr { "qeew k'gu" c"ur gek'ni'r m'eg. "d'ge'cw'g" w'uk'pi "q'p'ni" "3" o i "qh'vj g'cr r tq' r t'k'v'g't'g'ci gpv'k'p"rgu'u'vj cp"" 3"o n'q'hf g'w'gt'cv'g'f "u'q'x'gp'v'y g'i c'k'p"cp" gcu\ { 'cpf "gp'x'k'q'po gp'v'cm\ "h'k'p'f n\ "c'pcn\ v'k'ec'n'v'q'q'ni"

Vj ku'v'gej p'ks v'g"t'gs v'k'gu" h'p'f k'pi "cp" g'h'g'ev'x'g"u'q/ecm'gf "ej go k'ec'n'uj k'm't'g'ci gpv'vj cv'k'p"eqo d'k'p'v'k'q'p"y kj "vj g'v'g'v'g'f" uco r rg. "i k'x'gu" f k'cu'v'g't'g'q'kuo g'tle" h'q'to u'vj cv'uj qy "f k'h'g't'g'p'eg'u'k'p"vj g'ej go k'ec'n'uj k'm'u'q'h'u'q'o g'uki p'cu" ]4\_0Vj g't'g'q't'g. "vj g' f'g'uki p'c'p'f 'u\ {p'vj g'uki'q'h'p'gy 'o q'rg'ew'gu'vj cv'cev'cu'ej go k'ec'n'uj k'm't'g'ci gpv'ku'c'p'k'o r qt'v'p'v'c'p'f 'u'k'ni't'g'x'c'p'v'k'uu'g'k'p"o qf g't'p" q'ti c'p'le"u\ {p'vj g'uki'0"

O { " r'q'v'g't" y k'ni' r' t'g'ug'p'v' vj g' c'd'k'k'v\ " v'q" ej k'c'n' t'ge'q'i p'k'k'q'p" /u'w'd'uk'w'w'g'f " ectd'qz {r'le" c'ek'f' u' w'uk'pi " u\ {p'vj g'uk' g'f" c\ k'k'f' k'p\ r'ec't'd'k'p'q'ni'd\ { 'o g'cu'v't'k'pi "vj g'p'q'p/g's v'k'x'c'rg'p'eg'q'h'ej go k'ec'n'uj k'm'u"\* +vj g'g'p'c'p'v'k'q'o g'tu'q'h'v'j g'c'pcn\ | g'f 'ectd'qz {r'le" c'ek'f' u'0"

"



X = H, CH<sub>3</sub>, OCH<sub>3</sub>, F, CF<sub>3</sub>, H

"

**H'ki 030U'eqr g'q'h'c\ k'k'f' k'p\ {r'ec't'd'k'p'q'ni'w'w'g'f "cu'ej k'c'n'ej go k'ec'n'uj k'm't'g'ci gpv'0'**

"

[3\_0'O'O' crkqy unc'gv'c'ni'Qr v'k'ec'n\ "R'w'g'c\ | k'k'f' k'p/4/ {n'O' g'v' c'p'q'ni'cu" T'g'c'f' k'q\ "C'x'c'k'c'rd'g'"<sup>3</sup>J "P O T"U'g'p'q'tu' h'q't'G'p'c'p'v'k'f' k'uet'lo l'p'c'v'k'q'p"q'h' /T'cego k'e" """"E'c't'd'qz {r'le' C'ek'f' u'E'q'p'v'k'p'k'pi "V'g't'v'k't { "q't'S w'c'v'g't'p'c't { "U'g't'g'q'i g'p'le'E'g'p'v'g'tu. *L'0Q't'i 0'E'j go 0: 7. 339; 6 33: 23*<sup>3</sup>4242-0'

[4\_0'O'0'T'ed'c'p."M'O' k'ur'y. " Vj g'f g'v'g'to l'p'c'v'k'q'p" q'h' q'r v'k'ec'n' r'v'k'v\ d\ { "p'v'ew'g't" o c'i p'g'v'k'v' t'g'u'p'c'p'eg"ur gev't'queqr {0' K'0' E'q'o r q'wp'f' u'y j lej "qy g'v'j g'k'" """"f'kuu\ o o g't\ { "q'f' g'w'g't'k'wo "u'w'd'uk'w'k'q'p."V'g't'c'j g'f t'q'p'N'g'w'g'tu 55.5; 83/5; 88<sup>3</sup>; 88-0'

**UVTWEVWTG'QRVKO K̄ CVIQP 'CPF 'VCF H'RTQRGT VKGUQH'P QXGN''  
CETK̄K̄P G/R| TKO K̄K̄P G'F GTK̄K̄CVK̄GU''**

**K̄kpc' H̄kqf q̄tqxc**<sup>3</sup>. "Vqo cu'Ugtgxx k̄w<sup>4</sup>. "Tqncu'Unckui k̄k<sup>4</sup>. "I gf ko k̄pcu'Mi gk̄ c<sup>4</sup>. "F qx { f cu'Dcpgxx k̄w<sup>4</sup>. "Mctqrku'Mc| rcwncu<sup>4</sup>. "Ucwksw'Uxt – pcu<sup>4</sup>. "Uki kcu'Vwo ngxk k̄w<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Qti cple'Ej go k̄rt { . 'Hcewn' 'qh'Ej go k̄rt { 'cpf 'I gquekpegu. "Xkpkwu'Wp̄k̄gtuk{ . "P cwi ctf w̄nq'46. 'NV/25447'Xkpkwu. 'Nkj wcpk"

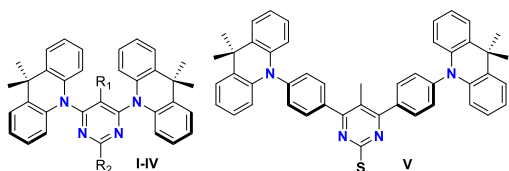
<sup>4</sup>K̄p̄unkw̄g'qh'Rj qv̄pleu'cpf 'P cpq̄vej p̄qr̄i { . 'Hcewn' 'qh'Rj { ukeu. "Xkpkwu'Wp̄k̄gtuk{ . "Uc̄w̄rḡn̄k'5. 'NV/32479'Xkpkwu. 'Nkj wcpk"

· **k̄kpc' H̄kqf q̄tqxc B ej i h̄kw̄n̄v**

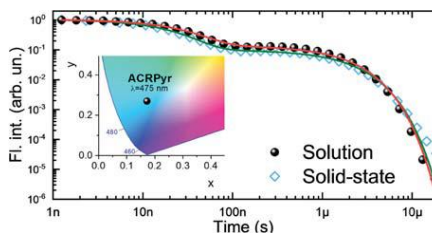
Qti cple'iki j v go k̄w̄kpi 'f k̄qf gu'\*QNGF u+'ctg'qpg'qh'yj g'o quv'r tqo kulpi 'i tggp'v̄ej p̄qr̄i k̄gu'ht'f̄k̄r̄ cu' 'u'cpf 'iki j v̄kpi "tguq̄w̄tegu'qy k̄pi "v̄q' 'y gk' 'ny "r qy gt' 'eqpuwo r v̄k̄p' 'cpf 'y gk' 'dgkpi "w̄ntc/ 'y k̄p. "iki j y gk̄ j v̄. 'cpf "h̄rz̄k̄d̄g' J3\_0'Vj gto c̄m̄f "cevk̄xcv̄f "f gr { gf "h̄w̄qt̄guegp̄v' \*VCF H+ go k̄v̄gtu'eqpuk̄k̄pi "qh' r wtg' qti cple" o cv̄t̄k̄cn̄" j cxg' d̄ggp' f gxgn̄r gf "cu'c' pgy "i gpḡt̄cv̄k̄p'qh' go k̄v̄gtu'v̄q' j ct̄x̄gu'v̄cn̄' yj g'o q̄rgew̄rt "gzek̄q̄pu'0'Vj g'o c̄k̄p' t̄gs w̄k̄t go gpv'ht' ḡh̄k̄k̄ep̄v' VCF H'ku' y q̄w̄i j v̄'q' dg'c" p̄gi r̄i k̄d̄g' ḡp̄gti { 'f h̄h̄t̄ḡp̄eg' d̄gvy ḡp̄' yj g'ny ḡu'v̄k̄pi r̄v' c̄p̄f 'v̄k̄ r̄v' u'c̄v̄gu' \*ε G<sub>UV+</sub> "y j k̄j "q̄h̄ḡp' ku' q̄d̄v̄k̄p̄gf "k̄p' yj g' p̄q̄p/ h̄rc'v' \*j ḡv̄t̄q̄-ct̄qo c̄v̄k̄e' u' qūgūk̄pi 'f q̄p̄q̄t \*F + c̄p̄f 'ceegr v̄q̄t \*C+ h̄t̄ci o gp̄v' J4\_0J qy ḡx̄gt. 'c' b' q̄rgew̄rt 'ut̄w̄ew̄t' g. 'y j ḡt̄g' yj g' F' 'c̄p̄f " C' w̄p̄ku' ctg' t̄q̄v̄k̄p̄cm̄ 'h̄rz̄k̄d̄g. 'uko w̄nc̄p̄ḡq̄w̄n̄' "dt̄k̄pi u' v̄py c̄p̄v̄g' "eqp̄ugs w̄p̄eḡu. "ūej "cu' f k̄v̄k̄p̄ev' go k̄ūk̄p' r' t̄qr ḡt̄v̄k̄u' k̄p' "uq̄n̄w̄k̄p' c̄p̄f "y j "uq̄r̄k' 'u'c̄v̄g' J5\_0' k̄p' uq̄r̄k' "j qūu. "y j g' t̄k̄i k̄f "uwt̄q̄w̄p̄f k̄pi u' r̄t̄ḡx̄gp̄v' ut̄w̄ew̄t' c̄n̄t' ḡr̄zc̄v̄k̄p' 'v̄qy c̄t̄f u' yj g' r' q̄v̄p̄k̄cn̄' o k̄p̄o w̄o. "h̄q̄to k̄pi 'c' h̄v̄q̄h̄b' q̄rgew̄rt 'i ḡqo ḡt̄v̄k̄u' y k̄j 'f h̄h̄t̄ḡp̄v̄k̄pi r̄v̄v̄t̄k̄ r̄v' ḡp̄gti k̄gu. "uq' 'ēc̄m̄g' 'eq̄p̄h̄q̄to c̄v̄k̄p̄c̄n̄f k̄uq̄t̄f ḡt' Eqp̄ugs w̄p̄v̄n̄f. "y j g' f̄k̄r ḡt̄uq̄p' q̄h' ΔG<sub>UV</sub> 'i cr u' f k̄w̄t̄du' yj g' u'k̄pi r̄g' z̄r q̄p̄ḡv̄k̄cn̄ VCF H' f ḡec { 'r t̄q̄h̄k̄g. "v̄r k̄c̄n̄h̄q̄t' yj g' u'q̄n̄w̄k̄p' "u'c̄v̄g. 'c̄p̄f 'h̄ḡc̄f u' v̄q' yj g' go ḡti ḡp̄eg' q̄h' b' w̄n̄k̄z̄r q̄p̄ḡv̄k̄cn̄ VCF H' f ḡec { 'y k̄j 'r t̄q̄m̄pi gf 'h̄h̄k̄v̄k̄o g. 'h̄ḡc̄f k̄pi 'v̄q' c' f̄ ḡet̄ḡc̄ūg' 'cx̄ḡt̄ci g' " t̄k̄E' t̄c̄v̄g' 0'Vj g' ut̄w̄ew̄t' c̄n̄k̄p̄j qo q̄i ḡp̄ḡk̄v̄' q̄h' VCF H' eqo r q̄w̄p̄f u' l̄p' uq̄r̄k' h̄k̄ro u' b' c' { 'dg' h̄y ḡt̄gf 'd' { 'y j g' 'ect̄gh̄w̄i' ḡp̄j c̄p̄eḡo gp̄v' q̄h' yj g' ut̄w̄ew̄t' c̄n̄k̄i k̄f k̄v̄' q̄h' yj g' b' q̄rgew̄rt 'eq̄t̄g' 0' k̄p' yj k̄u' eq̄p̄p̄ḡv̄k̄p̄. "q̄p' yj g' b̄z̄c̄o r r̄g' q̄h̄c̄et̄k̄f k̄p̄g' r { t̄k̄o k̄f k̄p̄g' d̄c̄ūg' 'eq̄o r q̄w̄p̄f u' y g' r̄ ḡt̄h̄q̄to gf 'c̄p' q̄r v̄k̄o k̄ c̄v̄k̄p' q̄h' yj g' b' q̄rgew̄rt 'ut̄w̄ew̄t' g' h̄ḡc̄f k̄pi 'v̄q' yj g' b' k̄p̄o k̄ c̄v̄k̄p' q̄h' eq̄p̄h̄q̄to c̄v̄k̄p̄c̄n̄f k̄uq̄t̄f ḡt' 'c̄p̄f 'y w̄u. " gp̄w̄t̄k̄pi 'y j g' u'k̄pi r̄g' z̄r q̄p̄ḡv̄k̄cn̄ VCF H' f ḡec { 'r t̄q̄h̄k̄g' k̄p' yj g' uq̄r̄k' 'u'c̄v̄g. "y j k̄g' uo c̄n̄' u'k̄pi r̄v̄v̄t̄k̄ r̄v' i cr u' y ḡt̄g' u' yj qy p' v̄q' " r tqo q̄v̄g' t̄cr k̄f "t̄k̄E' 0"

U| p̄v̄j ḡuku' q̄h' yj g' v̄cti ḡv̄eqo r q̄w̄p̄f u' **KX** \*H̄i 0'3- "c̄p̄f "uqo g' k̄p̄v̄t̄o gf k̄c̄v̄gu' y cu' c̄eeq̄o r r̄k̄j gf "ut̄v̄k̄pi "h̄t̄qo "ḡc̄uk̄f " c̄eeḡūk̄d̄g' j c̄n̄r { t̄k̄o k̄f k̄p̄g' f̄t̄k̄x̄c̄v̄k̄gu' d' { "c" eqo d̄l̄p̄c̄v̄k̄p' q̄h' Dwey j c̄f /J c̄t̄y k̄i. "Uw' w̄n̄k̄ O k̄ c̄w̄t' r c̄n̄f k̄w̄o /c̄v̄cn̄ | gf " et̄quu/eqw' r̄k̄pi "c̄p̄f 'T̄c̄p̄g' 'P̄k̄t̄g' f̄v̄k̄p' t̄ḡc̄v̄k̄q̄pu' 0"

Vj g' p̄q̄p̄eḡp̄v̄k̄p̄w̄n̄' eq̄p̄l̄w̄i c̄v̄g' 'cet̄k̄f k̄p̄g' v̄ḡp̄f u' v̄q' h̄q̄to "y q' f̄ k̄v̄k̄p̄ev' eq̄p̄h̄q̄to ḡtu. 'p̄co ḡn̄' 's w̄c̄k̄/ c̄z̄k̄cn̄' s c- 'c̄p̄f 's w̄c̄k̄/ ḡs w̄c̄v̄t̄k̄cn̄' s g+ J6\_0T ḡcm̄. "eqo r q̄w̄p̄f u' **KHX** y g' h̄q̄w̄p̄f "v̄q' u' j qy "c' ut̄q̄pi "go k̄ūk̄p' q̄h' s' c' eq̄p̄h̄q̄to ḡtu' 0'Vj q̄x̄ḡteqo g' yj k̄u' r t̄q̄d̄rgo. "c' 7/ o ḡy | n̄i t̄q̄w' 'y cu' k̄p̄t̄q̄f w̄eḡf 'k̄p̄v̄q' yj g' r { t̄k̄o k̄f k̄p̄g' o q̄k̄v̄' 'v̄q' ḡp̄r̄cti g' yj g' u'v̄t̄k̄e' j k̄p̄f t̄c̄p̄eg' d̄gvy ḡp̄' yj g' F' 'c̄p̄f " C' w̄p̄ku' c̄p̄f 'r t̄ḡx̄gp̄v̄j g' h̄q̄to c̄v̄k̄p' q̄h' s' c' eq̄p̄h̄q̄to ḡtu' 0'F HV' uko w̄v̄k̄p̄u' y ḡt̄g' go r m̄q' { gf "v̄q' cūguu' yj g' i t̄q̄w̄p̄f 'u'c̄v̄g' i ḡqo ḡt' { " c̄p̄f 'y j g' eq̄t̄t̄ḡur q̄p̄f k̄pi "t̄c̄p̄uk̄k̄p' ḡp̄gti k̄gu' q̄h' eqo r q̄w̄p̄f **KX** 0'Uk̄pi r̄g' et' u'c̄n̄ Z TF "c̄p̄c̄n̄ u'k̄u' eq̄p̄h̄k̄to gf "y j g' F HV/ r t̄ḡf k̄ev̄g' " f k̄w̄q̄t̄v̄g' 0' q̄rgew̄rt 'i ḡqo ḡt' { 0"



I: R<sub>1</sub> = R<sub>2</sub> = H; II: R<sub>1</sub> = Me, R<sub>2</sub> = H;  
III: R<sub>1</sub> = H, R<sub>2</sub> = SMe; IV: R<sub>1</sub> = Me, R<sub>2</sub> = SMe



**H̄i 030** Ut̄w̄ew̄t' gu' q̄h' cet̄k̄f k̄p̄g' r { t̄k̄o k̄f k̄p̄g' d̄c̄ūg' f̄ h̄w̄qt̄qr j q̄t̄gu' **KX**

**H̄i 040** H̄w̄qt̄guep̄eg' f̄ ḡec { 't̄c̄p̄uk̄k̄p' q̄h' \*\*\*\*\* eqo r q̄w̄p̄f **KX** \*CETR { t+ l̄p' v̄q̄w̄p̄g' c̄p̄f " 5' y v̄ "VURQ3' h̄k̄ro 0'

Vj g' ḡp̄r̄cti gf "ut̄w̄ew̄t' c̄n̄t̄k̄i k̄f k̄v̄' q̄h' q̄r v̄k̄o k̄ gf "ut̄w̄ew̄t' g' **KX** \*CETR { t+ o k̄p̄o k̄ gf "y j g' ΔG<sub>UV</sub> 'f k̄ur ḡt̄uq̄p. "h̄ḡc̄f k̄pi "v̄q' c" t̄cr k̄f " o q̄p̄q' z̄r q̄p̄ḡv̄k̄cn̄ VCF H' f ḡec { 'k̄p' yj g' uq̄r̄k' "j quv' y k̄j "c' h̄h̄k̄v̄k̄o g' q̄h' 308 μm \*H̄i 04-00 q̄t̄ḡx̄ḡt. "c' j k̄j "h̄w̄qt̄guep̄eg' " s w̄cp̄w̄o " { k̄gr̄f 'q̄h' c̄d̄q̄w' 2089' c̄p̄f 'c̄p' ḡz̄egr v̄k̄p̄c̄n̄t̄ k̄E' t̄c̄v̄g' q̄h' 70' z' 32<sup>8</sup> u<sup>3</sup> y ḡt̄g' q̄d̄ūḡt̄x̄ḡf 'h̄q̄t' yj g' q̄r v̄k̄o k̄ gf 'eqo r q̄w̄p̄f **KX** 0' Vj g' r' t̄q̄p̄q̄w̄eḡf 'VCF H' c̄v̄k̄k̄v̄' q̄h' eqo r q̄w̄p̄f **KX** c̄m̄y gf "w̄u' v̄q' c̄v̄k̄p' ḡh̄k̄k̄ep̄v̄u' n̄f / d̄w̄g' ḡr̄ḡev̄t̄q̄n̄w̄o k̄p̄guep̄eg' 0'Vj g' QNGF " f ḡx̄k̄eg' u' j qy gf "u' n̄f / d̄w̄g' ḡr̄ḡev̄t̄q̄n̄w̄o k̄p̄guep̄eg' \*λ<sup>o</sup> " 697' po -y k̄j "c' w̄t̄p/ q̄p' x̄q̄n̄ci g' q̄h' c̄d̄q̄w' 50' X. "eq̄t̄t̄ḡur q̄p̄f k̄pi "v̄q' EKG' 3; 57' eq̄m̄q̄t' eq̄q̄t̄f k̄p̄c̄v̄gu' q̄h' \*2089. "2049+ \*H̄i 0'4+0'Vj g' QNGF "f ḡx̄k̄eg' { k̄gr̄f gf "c' 3605' "GS G' y k̄j "o k̄p̄q̄t' t̄q̄m' q̄h' c̄v̄n̄cti g' n̄w̄o k̄p̄c̄p̄eg' 0"

Qw' h̄k̄p' k̄pi u. 'y j' q̄r g. 'y k̄n̄h̄q̄w̄ḡt' h̄w̄t̄y j g' t̄c'f x̄c̄p̄eg' k̄p' yj g' f̄ ḡx̄gn̄r o gpv'qh' VCF H' eqo r q̄w̄p̄f u' 0"

J3\_Qj 'E0J 0'Uj k̄p' J 0L0'P co 'Y 0L0'Cj p'D0E0'Ej c'U0| 0'J ḡq' U0F 0'UF 'k̄p̄oU' o r OF k̄i 0Vgej 0Rcr 0'4235. '66. '45; 64640  
J4\_Wq{ co c' J 0'J q̄w̄j k̄M0'Uj k̄ w̄M0'P qo w̄c' J 0' C' f̄c̄ej k̄E0'P c̄w̄t' g. '4234. '6; 4. '456645: 0'  
J5\_Ugt̄ḡx̄k̄ k̄u' V0' U'nc̄k̄i k̄k̄i' T0'F qf q̄p̄q̄xc' L0' M'c| r̄w̄nc̄u' M' L'w̄t̄ḡp̄cu' U0' V'wo n̄ḡx̄k̄e'w̄u' U0' Rj { u0Ej go 0Ej go 0Rj { u0'4242. '44. '48764940  
J6\_Y cpi 'M' \ j ḡpi 'E0L0' Nk̄w' Y 0' Nk̄c̄pi 'M' Uj k̄l' 0\ 0' V̄c̄q' U0N0' Ngg' E0U0' Q'w' Z00' 0\ j c̄pi 'Z0J 0' C' f̄x̄00' c̄v̄ḡt' 0'4239. '4; . '39236980

VJ G'RR[ 'NC[ GT'VJ KEMP GU'E QP VT QN'HQT'VJ G'F GXGNQRO GP V'QH'  
VJ G'UGP UQT'''

Tclo qpf c'Dqi wfckv<sup>3</sup>. 'Xkro c'Tcvcwckv<sup>3</sup>. 'Gt'pguvu'Dtc| {u<sup>4</sup>. 'Ct pcu'Tco cpeck kw<sup>3,4</sup>"

<sup>3</sup>Egpgvt'hqt'Rj {ukecni'Uekpegu'cpf'Vegej pqrni {.'F gr ctvo gpv'qh'Hwpevkqpcni'O cvgtkcm'cpf'Grgextqpleu.'Ncdqtcvqt { 'qh' P cpqvegej pqrni {.'Ucwgvgmk'cx'05.'Xkpkwu'NV/32479.'Nkj wcpk'

<sup>4</sup>'Xkpkwu'Wpkxgtukv{.'Hcwmw'qh'Ej go kut { 'cpf' 'I gquckpegu.'Kpukwag'qh'Ej go kut {.'P cwi ctf wmq'ut'046.'NV/25447' Xkpkwu'

tclo qpf c'Qlqi w' ckgB i o ckrqgo.

O qrgewrctn' "ko r tlpvgf" r qn' o gtu' \*O RRu+ ctg' gpeqwtci kpi "o cvgtkcm" y' cv' ecp" dg" wugf "kp" y' g' tgeqi pklqpp' r tqeguu' ]3.4\_0' Vj g' vgej plsvw' qh' o qrgewrct' ko r tlpvki "gpdcrgu" y' g' eqputwvqpp' qh' ugrgevkxg' o qrgewrct' tgeqi pklqpp' ukgu' kp' r qn' o gtle' o cvtlegu' y' cv' qr gtcvg' qp' y' g' r tlpkr' qh' c' m'eni' c'pf' ng' { 'o gej cpkuo ]5\_0' Vj g' hwpevkqpcni' o qpqo gtu' l'pklcm' hqto "c' eqo r rgez' y' kj' y' g' ko r tlpv' o qrgewrgu. "cpf' hqmqy kpi' r qn' o gtl' cvkqp. "y' gk' hwpevkqpcni' tqrw' u' ctg' j' grf' l'p' r' qukqpp' d' { 'y' g' j' ki j' n' 'etquw' r' p'ngf' r' qn' o gtle' utwewtg' ]6\_0' O RRu' g' zj' kdku' g' zegr' vkqpcni' y' gto' cni' c'pf' 'ej go k'ecni' u' c' d'krk' { ' ]7\_0' K' y' g' f' g' x' g' r' o' gpv' qh' O RRu' r' { ttqrg' ku' p'pg' qh' y' g' o' quv' wugf' r' qn' o' gtu' O' K' ku' r' r' r' k' g' f' d' g' ecwag' qh' y' g' u' ko' r' r' e' k' k' { ' c' d' k' r' k' { ' v' q' h' q' t' o' y' k' p' e' q' c' v' k' p' i' u' . ' u' c' d' k' r' k' { ' . ' c' p' f' ' c' d' k' r' k' { ' v' q' g' r' g' e' v' t' q' r' q' n' o' g' t' k' ]8\_0'

Hw' y' gto' qtg. "wuwcm' l' k' ku' p' g' e' g' u' c' t' { ' v' q' e' q' p' t' q' n' y' g' y' k' e' m' p' g' u' u' q' h' y' g' O' R' R' r' c' { ' g' t' k' p' q' t' f' g' t' v' q' q' r' w' o' k' g' y' g' u' g' p' u' k' k' v' } " ]7\_0' Vj g' y' k' e' m' p' g' u' u' e' c' p' d' g' r' c' t' v' k' m' { ' e' q' p' t' q' n' g' f' d' { ' e' j' c' p' i' k' p' i' y' g' e' q' e' p' e' g' p' t' c' v' k' p' q' h' y' g' o' q' p' q' o' g' t' . ' y' g' p' w' o' d' g' t' q' h' r' q' v' p' k' e' n' i' r' w' u' g' u' o' f' w' t' k' p' i' y' g' f' g' x' g' r' o' g' p' v' q' h' w' t' e' c' e' k' f' / o' r' t' l' p' v' g' f' r' q' n' o' { ' t' t' q' r' g' / d' c' u' g' f' ' u' g' p' u' q' t' . ' O' R' R' r' t' g' r' c' t' c' v' k' p' y' c' u' d' c' u' g' f' ' q' p' c' u' l' k' p' i' r' g' r' q' v' p' k' e' n' i' r' w' u' g' q' h' '3' X' x' u' C' i' C' i' E' n' i' r' u' k' p' i' h' q' t' '32' u' 0' Vj g' r' q' n' o' g' t' k' c' v' k' p' o' k' z' w' t' g' e' q' p' u' k' v' g' f' q' h' '7' o' O' w' t' e' c' e' k' f' c' p' f' '72' o' O' r' { ' t' t' q' r' g' u' q' n' w' k' p' k' p' R' D' U' ]5\_0' Q' p' y' g' q' y' g' t' j' c' p' f' . ' v' q' f' g' x' g' r' r' c' r' { ' t' t' q' r' g' / d' c' u' g' f' ' E' Q' 4' u' g' p' u' q' t' . ' r' { ' t' t' q' r' g' y' c' u' r' q' n' o' g' t' k' g' f' g' r' g' e' v' t' q' e' j' g' o' k' e' c' m' { ' q' p' i' r' u' u' i' l' K' V' Q' t' i' r' u' u' i' l' K' V' Q' v' g' o' u' r' g' r' e' v' t' q' f' g' u' w' t' h' e' g' f' t' q' o' c' u' q' n' w' k' p' e' q' p' v' k' p' k' p' i' '32' o' O' q' h' r' { ' t' t' q' r' g' c' p' f' ' 2' 0' ' O' q' h' N' k' E' r' Q' 6' c' u' c' p' g' r' g' e' v' t' q' n' g' o' R' q' n' o' g' t' k' c' v' k' p' y' c' u' r' g' t' h' q' t' o' g' f' l' p' t' q' q' o' v' g' o' r' g' t' c' w' t' g' d' { ' '32' r' q' v' p' k' e' n' i' e' e' r' g' u' k' p' y' g' t' c' p' i' g' h' t' q' o' " 2' 0' X' v' q' - 3' 0' X' x' u' C' i' C' i' E' n' s' o' ' M' E' n' c' v' y' g' u' y' g' r' t' c' v' g' q' h' '72' o' X' l' u' c' p' f' u' v' g' r' r' q' v' p' k' e' n' i' q' h' '4' 0' 6' 6' o' X' ]9\_0' D' { ' e' j' q' q' u' k' p' i' c' j' k' j' g' t' r' q' n' o' g' t' e' q' e' p' e' g' p' t' c' v' k' p' c' p' f' c' i' n' y' g' t' p' w' o' d' g' t' q' h' r' q' v' p' k' e' n' i' r' w' u' g' u' . ' q' t' c' i' n' y' g' t' e' q' e' p' e' g' p' t' c' v' k' p' d' w' i' c' j' k' j' g' t' p' w' o' d' g' t' q' h' r' q' v' p' k' e' n' i' r' w' u' g' u' . ' d' q' y' j' o' g' y' q' f' u' r' g' e' c' f' v' q' y' g' h' q' t' o' c' v' k' p' q' h' c' u' w' h' l' e' k' e' p' w' i' v' y' k' p' i' r' c' { ' g' t' y' c' v' e' c' p' d' g' c' f' c' r' v' g' f' v' q' y' g' f' g' u' k' i' p' q' h' y' g' u' g' p' u' q' t' o' "

**T g' h' t' g' p' e' g' u' "**

- 13\_ "Q'00C' o' c' f' . ' V' u' u' D' g' f' y' g' m' ' E' 0' G' u' p' . ' C' 0' I' c' t' e' k' / e' t' w' . ' C' 0' R' k' g' u' m' i' . ' N' 0' N' g' . ' O' q' r' g' e' w' r' c' t' n' ' K' o' r' t' l' p' v' g' f' ' R' q' n' o' g' t' u' k' p' ' G' r' g' e' v' t' q' e' j' g' o' k' e' c' n' i' c' p' f' ' Q' r' w' e' c' n' i' U' g' p' u' q' t' u' . ' V' t' g' p' f' u' D' i' k' v' e' j' p' q' n' 059' \*423; +4; 6652; 0j' w' r' u' d' l' f' q' l' q' t' i' B20238 l' l' 0' k' d' v' e' j' 0423; 0: 02; 0'
- 14\_ "X' 0' T' c' v' c' w' e' c' k' v' . ' O' 0' P' g' u' r' c' f' g' m' ' C' 0' T' c' o' c' p' e' x' l' e' k' p' p' . ' K' 0' D' e' r' g' x' l' e' k' w' g' . ' C' 0' T' c' o' c' p' e' x' l' e' k' u' . ' G' x' c' m' e' v' k' p' q' h' ' J' k' u' c' o' k' p' g' ' K' o' r' t' l' p' v' g' f' ' R' q' n' o' { ' t' t' q' r' g' ' F' g' r' q' u' k' g' f' " q' p' " D' q' t' q' p' ' F' q' r' g' f' ' P' c' p' q' e' t' { ' u' c' n' i' p' g' ' F' l' e' o' q' p' f' . ' G' r' g' e' v' t' q' c' p' e' n' i' u' k' 048' \*4236+467; 646860j' w' r' u' d' l' f' q' l' q' t' i' l' j' w' r' u' d' l' f' q' l' q' t' i' B20224 l' g' r' e' p' 04236224; 60'
- 15\_ "F' 0' R' r' e' w' u' l' p' c' k' k' u' . ' N' 0' U' p' n' g' x' l' e' k' u' . ' W' 0' U' c' o' w' n' e' k' g' / d' w' d' p' l' e' p' g' . ' X' 0' T' c' v' c' w' e' c' k' v' . ' G' x' c' m' e' v' k' p' q' h' ' g' r' g' e' v' t' q' e' j' g' o' k' e' c' n' i' s' w' e' t' v' { ' e' t' { ' u' c' n' i' o' l' e' t' q' d' e' c' r' e' p' e' g' d' c' u' g' f' " u' g' p' u' q' t' " o' q' f' h' i' g' f' d' { ' w' t' e' c' e' k' f' / o' r' t' l' p' v' g' f' r' q' n' o' { ' t' t' q' r' g' . ' V' e' r' e' p' v' c' 0442' \*4242+3436360j' w' r' u' d' l' f' q' l' q' t' i' B20238 l' l' 0' c' r' e' p' v' c' 042420436360'
- 16\_ "M' J' 0' D' k' p' ' E' j' g' p' c' . ' E' j' w' e' p' l' w' p' ' N' k' w' d' . ' N' k' p' i' r' w' I' g' c' . ' N' q' e' c' i' k' g' f' " u' w' t' h' e' g' f' r' u' o' q' p' " t' g' u' a' p' e' p' e' g' i' c' u' u' g' p' u' q' t' q' h' ' C' w' p' c' p' q' / k' u' r' p' f' u' e' q' c' v' g' f' y' k' j' o' q' r' g' e' w' r' c' t' n' " k' o' r' t' l' p' v' g' f' r' q' n' o' g' t' a' ' K' o' h' n' g' p' e' g' q' h' r' q' n' o' g' t' y' k' e' m' p' g' u' u' q' p' u' g' p' u' k' k' v' { ' c' p' f' u' g' r' e' v' k' x' g' a' " G' p' j' c' e' p' e' g' f' T' g' e' f' g' t' f' h' ' U' g' p' u' q' t' u' C' e' w' e' v' t' u' D' E' j' g' o' 0' \*4238+0' j' w' r' u' d' l' f' q' l' q' t' i' l' j' w' r' u' d' l' f' z' f' q' l' q' t' i' B20238 l' l' 0' p' d' 04238050390'
- 17\_ "T' 0' 0' U' e' j' o' k' f' v' . ' M' 0' 0' q' u' d' e' j' . ' M' 0' J' c' w' r' v' . ' C' ' U' o' r' r' g' e' O' g' y' q' f' h' q' t' ' U' r' k' p' / E' q' c' v' k' p' i' " O' q' r' g' e' w' r' c' t' n' ' K' o' r' t' l' p' v' g' f' ' R' q' n' o' g' t' ' H' k' o' u' q' h' ' E' a' p' t' q' n' g' f' " V' j' k' e' m' p' g' u' u' c' p' f' " R' q' t' q' u' k' s' { . ' C' f' x' 0' 0' c' v' e' t' 038' \*4226+93; 69440j' w' r' u' d' l' f' q' l' q' t' i' l' j' w' r' u' d' l' f' q' l' q' t' i' B20224 k' f' o' c' 04225285960'
- 18\_ "C' 0' T' c' o' c' p' e' x' l' e' k' u' . ' [ ' 0' Q' ] v' g' n' p' . " C' 0' T' c' o' c' p' e' x' l' e' k' p' p' . " G' r' g' e' v' t' q' e' j' g' o' k' e' c' n' i' h' q' t' o' c' v' k' p' q' h' r' q' n' o' { ' t' t' q' r' g' / d' c' u' g' f' " r' c' { ' g' t' h' q' t' " k' o' o' w' p' q' u' g' p' u' q' t' f' g' u' k' i' p' . " U' g' p' u' q' t' u' C' e' w' e' v' t' u' D' 0' E' j' g' o' 03; 9' \*4236+45964650j' w' r' u' d' l' f' q' l' q' t' i' B20238 l' l' 0' p' d' 04236040940'
- 19\_ "X' 0' T' c' v' c' w' e' c' k' v' . ' I' 0' D' e' i' f' l' k' w' p' c' u' . " C' 0' T' c' o' c' p' e' x' l' e' k' u' . " C' 0' T' c' o' c' p' e' x' l' e' k' p' p' . " " C' p' " C' r' r' n' e' c' v' k' p' q' h' ' E' q' p' f' w' e' v' k' p' i' " R' q' n' o' g' t' " R' q' n' o' { ' t' t' q' r' g' h' q' t' y' g' f' g' u' k' i' p' q' h' ' G' r' g' e' v' t' q' e' j' t' q' o' l' e' r' J' ' c' p' f' ' E' Q' '4' U' g' p' u' q' t' u' . ' I' 0' G' r' g' e' v' t' q' e' j' g' o' 0' U' q' e' 0388' \*423; +D4; 96D5250j' w' r' u' d' l' f' q' l' q' t' i' B2036; 408443; 261g' u' o' "

**RJ QVQRJ [ UĖCN'UVWF [ 'QH'VKĲCRC\ CO ĲG'DCUGF 'EQO RQWPFU''**

Mco kn "Vwckv" <sup>3</sup>. "Lwukpc" Lqxck-ckv <sup>3</sup>. "Lgrpc" Vco wkgp <sup>4</sup>. "Lqpcu" <sup>5</sup> "ĖtrcwunĖ" <sup>5</sup>. "P ctko cpvcu" pcu<sup>5</sup> cpf " Ucwkwu" Lwt – pcu<sup>3</sup>"

<sup>3</sup>Ĳukwkg"qh'Rj qvqpleu"cpf "P cpqvej pqmji { . "Ĥeewm" "qh'Rj { ukeu. "XĲpkwu" Wpkxgtukv { . "Nkj wcpkc"   
 <sup>4</sup>Ĳukwkg"qh'Vj gqtgvlecn'Rj { ukeu"cpf "C'utqpqo { . "XĲpkwu" Wpkxgtukv { . "Nkj wcpkc"   
 <sup>5</sup>Ĳukwkg"qh'Dkqej go kwt { . "NĲg" Uelgpegu" E gpvt. "XĲpkwu" Wpkxgtukv { . "Nkj wcpkc"   
 [neo kg0wckkgB H0wfw 0kw0n'](#)

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j3\_0 0l0F ppg"cpf "l00 0Dtqy p. "Vwo qt/ur gelĲe." Uej gf wrg/f gr gpf gpv'Ĳv'gt'ce'v'qp'dgw ggp"vkr c| co lpg"\*UT"6455+cpf "Ekr v'v'p. "Epegt" Tgu'75." 685566858\*3; ; 5-0'   
 j4\_0 0D0T gf f { "cpf "U0M0Y knco uq. "vkr c| co lpg"<C" p'q'xgn'ci gpv'v'ci v'kpi "j { r qzle"wo qt"egmu. "Gzr gtv'Qr Ĳk'qp"qp"Ĳv'guki cv'q'p'ci F twi u."3: .996 : 9\*422; +0'   
 j5\_1 0F 0Lqpu"cpf "0 0Y gl'p'grf . "F wcn'v'v'p'qh'vkr c| co lpg"lp"vj g"lp'v'v'q'p'qh'F P C"utcpf "dtgcm0" Epegt" Tgu'78."37: 66; 2\*3; ; 8-0'

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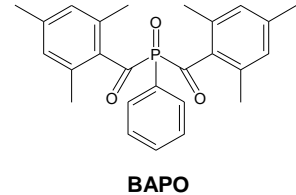
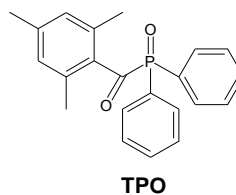
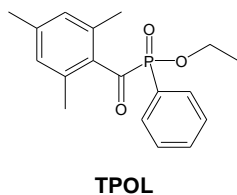
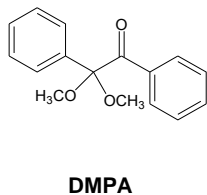
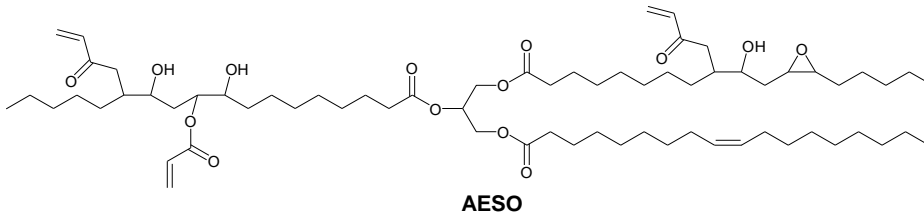
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Mwpcu."Nkj wpcle""

o ki rNgdof gxckgB mwth'

Vj g"WX/ewtki "qh'rj qvqr qn(o gtlk cdng"u{vgo u"eqpvclopi "o qpqo gt larki qo gt."rj qvqpkckvqt"cpf "cf f kxku."j cu" hqwpf "cp" kpf wutken' cr r rdecvqp" o clpn{ "kp" eqcvpi u."xctpkj gu."cf j gukxu."cpf "o letqgngvtpkleu" ]3\_0' Vj gug"u{vgo u" wpf gti q'r tqo r v'eqpxgtukp"htqo "rks wkf "o qpqo gt larki qo gt "kpq"uqkf "r qn(o gt "gcukl "d{ "gzw quwtg"vq"WX"ktcf kcvqp"kp" vj g" r tgupeg" qh' rj qvqpkckvqtu" ]4\_0' Cu" vj g" rj qvqetquu/rpnkpi "tgcevkp" ku" c" tcr kf " r tgeguu. "kpxguki cvkqp" qh' vj g" rj qvqetkpi "nkpgleu" qh' \*o gj +cet { rvgu" f vgtto kpkpi " vj gk" tgcevkp" r tqr ci cvkqp" cpf " vgtto kpcvqp" o gej cpluo u" qt" wpf gtuwcpf kpi "vj g" kphwpeg"qh'xctkqwu'r tgeguu'r tceco vgtu" kq0'ri j v'kpvguks. "eqpegpvcvqp"cpf "v{ r g"qh'rj qvqpkckvqt." qt"vgo r gtcwgt+ku'etwken"]5\_

Cet { rvgf gr qzfk k gf "uq { dgcp"qkn"CGUQ+"ku" c"dkq/dcugf "o cvgtken"gcukl "etquu/rpnngf "xlc"WX/kpf wegf "htgg"tcf kcnl' r qn(o gtlk cvkqp."tguwtkpi "kpq" c" j ki j n' "f gpug"r qn(o gt0'Kj" cu'dtqwi j v'c"qv'qh'tgugctej gt ar'cwgpvqp"cu"t'gr rvego gpv'ht" u{pvj gvle" \*o gj +cet { rvgu"kp"WX/ewtcdng"eqcvpi u."xctpkj gu."cpf "gxgp"kp"qr vkenl'5F "r tkpvkpi " ]6\_0'Gxgp"vj qwi j "k"j cu" c" y kf g'ur gevwo "qh'cr r rdecvqp."vj g" kpxguki cvkqp"qh'CGUQ"WX/ewtki "nkpgleu"ku'vknro cpf cvqt { 0



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# EXAMINATION OF NEW SPIROHYDANTOINS AND THEIR MOLECULAR DESCRIPTORS RELATED TO THEIR BIOACTIVITY AND TOXICITY

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Hydantoin derivatives are a well-known class of antiepileptic drugs used in the treatment of epilepsy for decades. Besides anticonvulsive hydantoins shows and other types of activities, such as antiarrhythmic, antimicrobial agents, and skeletal muscle relaxants [1]. Similarly, spirohydantoins represent a pharmacologically activities important class of compounds with a wide range of activities [2].

One of the most important properties closely related to the biological activity is lipophilicity. Lipophilicity refers to the tendency of a compound to partition between a lipophilic organic phase and a polar aqueous phase. In drug development lipophilicity of a compound is represented either as partition coefficient,  $\log P$ , or distribution coefficient,  $\log D$ . Lipophilicity is responsible for pharmacokinetics, and hence important for further development of potentially active compounds [3]. In addition to lipophilicity, adequate bioavailability is one of the crucial properties of drug candidates. Recognition of potentially biologically active compounds can be supported by the use of very simple rules, such as the Lipinski Rule of five [4]. The rule describes molecular properties important for a drug's pharmacokinetics and includes absorption, distribution, metabolism, excretion, and toxicity (ADMET).

The goal of this study was to determine chromatographic lipophilicity parameters of cycloalkylspiro-5-hidantoins using different mobile phase and to find the correlation between retention,  $\log P$  as well as in silico ADMET descriptors of the investigated spirohydantoins. Lipinski rule of five is carrying out to verify if investigated spirohydantoins exhibit good (theoretical) oral bioavailability. To estimate the potential acute toxicity of the investigate spirohydantoin derivatives, their effective concentrations,  $EC_{50}$ , on the selected test organisms have been calculated.

The lipophilicity of 21 new spirohydantoin derivatives was determined using reversed-phase thin-layer chromatography on C-18 modified silica gel and a two-component aqueous mobile phase. As a modifier of the mobile phase were used different organic solvents (ethanol, *n*-propanol, *i*-propanol, or *t*-butanol). Also, lipophilicity was calculated by using the relevant software packages. The calculated partition coefficient,  $\log P$ , as a standard measure of lipophilicity are compared with experimentally determined lipophilicity.

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# INDUCTION OF VISCOSITY INCREASE DURING POLYGLYCOL ADDITION TO ISOCYANATES

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Two-component polyurethane adhesives often require accurate viscosity control for curing. When mixing the components, polyols engage into addition reaction with isocyanates, which increases mol. wt. resulting in higher viscosity and solidification. Multifunctional additives can be employed to assure cross-linking. However, viscosity does not necessarily increase in parallel with polymerization and such discrepancy cannot be easily explained. In this study, an oligomeric ether-ester macro diol (EEMD of 2700 g/mol) was used as a polyol, diluting it with polyethylene glycols (PEG of 200 g/mol or 400 g/mol) for viscosity control. The polyols were mixed with a trifunctional adduct of hexamethylene diisocyanate (HDI3) to initiate the addition reaction and viscosity was monitored, similarly to the previous report [1].

A rotary viscometer Lamy CP-2000 Plus was used with a 1° cone spindle RM100. Beforehand, EEMD was premixed with PEG and heated separately at 50°C for 15 minutes, as was HDI3. The polyol was mixed with HDI3 at 1+1.4 mol ratio. Within 1 min a 1 mL sample was placed onto a bottom plate of the viscometer, which was preheated to 50°C. The upper spindle was lowered and viscosity was periodically recorded at 100 s<sup>-1</sup> shear rate. The full rotational (not oscillatory) trajectory was used and the spindle was not removed from the plate until the end of the polymerization test. Three blends were tested: w/o PEG (EEMD at 83.25%+ HDI3 at 16.75% wt/wt), with PEG 200 (at 12.1%+ EEMD at 48.5% + HDI3 at 39.4%) and with PEG 400 (at 22.3% + EEMD at 41.4% + HDI3 at 36.3%). Two runs were performed for each blend, see average values in Fig. 1.

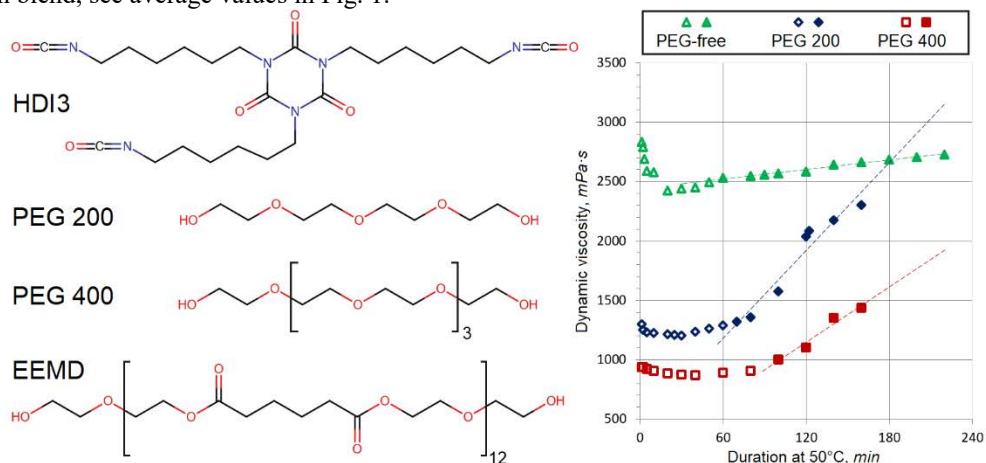


Fig. 1. Left: structures of employed compounds for addition reaction. Right: viscosity change during the reaction between HDI3 and EEMD (with or without PEG); filled symbols denote viscosities, higher than the early values.

Counter-intuitively, all the blends showed some thinning initially. The drop in viscosity was the most evident in the PEG-free blend. On the other hand, this blend was more viscous than the other two. Nevertheless, its polymerization proceeded slower as a result of lower HDI3 concentration and during the later stages viscosity of PEG 200 blend became more similar. The initial viscosity drop was also evident in the blends with PEG. After the drop, viscosity stagnated or was slowly recovering for quite some time. Only well after 1 hr of polymerization viscosities finally exceeded the initial values, which were measured in the beginning of the test. Further viscosity increase approximately followed linear kinetics, with trendline correlations of the average values better than  $R^2 = 0.938$ .

This suggests that some induction period is present before viscosity begins increasing despite ongoing polymerization. It remains unclear, which factors might cause such induction effect. Inclusion of PEG seems to enhance the effect, because the PEG-free blend simply thinned down initially and began thickening quite soon. Bubble formation or compositional non-homogeneities in the blend are not likely to have a strong effect, since the blends were agitated quite vigorously between the cone and plate of the viscometer when measuring each point.

It might be possible that supramolecular arrangements could yield the observed induction of viscosity increase. However, more diverse formulations, extensive testing and additional analytical techniques might be needed to further elaborate on this hypothesis.

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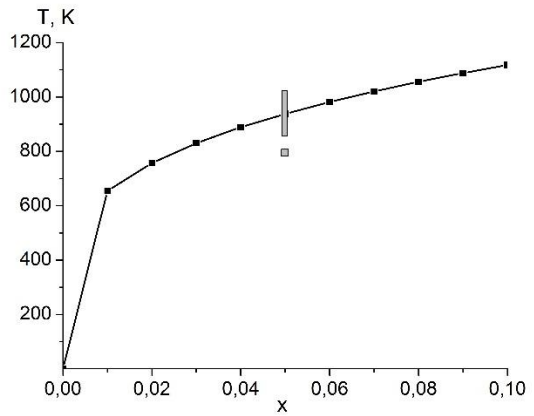
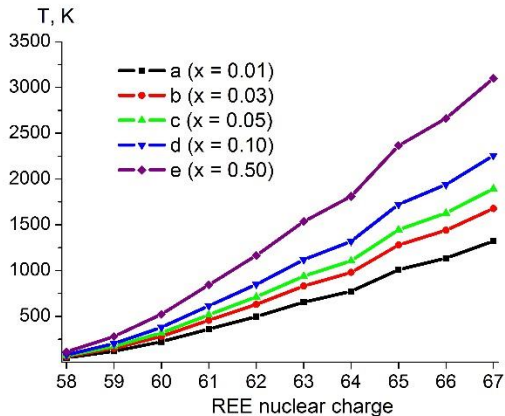
[1] S. Mačiulytė, P. Nemaniūtė, D. Bražinskienė et al., Influence of ester diluents and chain extension on polyurethane viscosities. Proc. of 22nd Conf. Advanced Materials and Technologies, ISSN 1822-7759, pg 128, Palanga, DOI: 10.5281/zenodo.4064006 (2020).

**KUQO QTRJ QWU'UWUWKV'WQKP 'CPF 'UVCDKVK[ 'QH'UQNK' "**  
**UQNWKQP'U'K' 'VJ G'Nc<sub>30z</sub>Np<sub>z</sub>H<sub>5</sub>. 'Np'? 'Eg'δ'J q'U' UVGO U'**  
 [ wkkc'Qrgmkk<sup>3</sup>. "Ugtj k'Tcf kq<sup>4</sup>. "Gwi gpk'I gyò cp<sup>4</sup>"

<sup>3</sup>Hcewn{ "qh'Ej go knt { "Dkqni { "cpf "Dkqvej pqrni lgu="Xcu{ n}Uwu'F qpgvniP cvkqpcn'Wpkxgtuk{. "Wntckpg"  
<sup>4</sup>F gr ctvo gpv'htq' Tgugctej . Tgugctej "Ncdqtevt { "òEj go knt { "qh'Rqn{ qzqo gcvrvgu'cpf "Eqo r rnz "Qz kf g'U{ ugo uò. "Xcu{ n}  
 Uwu'F qpgvniP cvkqpcn'Wpkxgtuk{. "Wntckpg"  
qrgmkkQB f qppwQf vòw"

Uqrf "uqmwkqpu"qh'v'khwqtkf gu"tctg/gctvj "grgo gpw" \*TGGu+"lp"vj g"htqo "qh'r qy f gtu."egtco leu."ukpi ng"et { uvcni"cpf "pcpqo cvgtkcu"ctg'evttgpw{ "dglpi "kpvpuksn{ "uwwf kcf "ukpeg"vj g{ "qhwgp"uwtr cuu'vj g'eqtgur qpf kpi "ej nqtkf gu"cpf "dtqo kf gu"lp"o cp { "r tqr gtvku0Vj g{ "ecp"dg"wgf "cu"o cvgtkcu"htq'rcugtu."uekp'wrcvqtu."r j qur j qtu."f kur rc { u."rki j v'uwtegu."ecvnc{ usu."kqple"eqpf wvqtu."hdtg/qr vè"co r rkhgtu."cu"y gni'cu"dkqni kecn'rdgnu."f twi "f grkxgt { "ci gpw'0'K'ku"cnq"mpqy p"vq"wg"v'khwqtkf gu"htq"o letqgrcvqpleu."cpnc{ v'ecn'ej go knt { "vj g"vej pqrni { "qh"ugr ctcvkqp"qh'grgo gpw."tgi gpgtcvkqp"cpf "r v'khwqtkf"qh'pwenct"hwgr0"

Wukpi "vj g"et { uvcn'ej go kecn'cr r tqcej "kp"vj g"cr r tqzko cvkqp"qh'tgi wrc"uqmwkqpu."vj g"o kzkpi "gpgti lgu" \*kpvgtcvkqp" r ctco cvgtu"cpf "f geqo r qukskqp"vgo r gtcwtgu"qh'Nc<sub>30z</sub>Np<sub>z</sub>H<sub>5</sub>"uqrf "uqmwkqpu"y j g'g"Np"? "EgòJ q."ctg"ecrewrvgf 0Y kj "cp" kpetgcug"lp"vj g" \*TGG"pwenct"ej cti g."vj g"ecrewrvgf "o kzkpi "gpgti lgu"cpf "etk'kecn'f geqo r qukskqp"vgo r gtcwtgu"qh'uqrf "uqmwkqpu"tgi wrcn{ "kpetgcug"htqo "30 5"vq'730 4"nLlo qn'c'p'htqo "332"vq'5322"M"tgr gevkxgn{. "y j lej "ku"v'wg"vq"v'f getgcug"lp"vj g" \*kqple"tcf k'qh'TGGu"lp"vj g"ugtkgu"htqo "Eg"vq"J q0K'ku"vj qy p"vj cv'vj g"v'cn'x'cnw'g"qh'vj g"o kzkpi "gpgti { "ku"v'vgto kpgf "o ckn{ "d { "vj g"eqo r qpgpv'ecwugf "d { "vj g"v'khwqtkf"lp"vj g"uk' gu"qh'vj g"u'wdukwvgf "ut wewtcn'w'pku0Vj g'r t'gugpv'f "f kci tco " \*Hki 03+"htq"vj g"Nc<sub>30z</sub>Np<sub>z</sub>H<sub>5</sub>"u{ ugo u."y j g'g"Np"? "EgòJ q."o cngu'k'v'qukskqp"vq" guko cvg"pqv'qpn{ "vj g"vj gto qf { pco le" u'cdk'k'v'f. "kpu'cdk'k'v'f"cpf "o g'v'cdk'k'v'f"qh'uqrf "uqmwkqpu"lp"v'f k'g"t'cpi g"qh'eqo r qukskqp"cpf "vgo r gtcwtgu."dw"cnq"vq" r t'gf lev"vj g"rko ku"qh'u'wdukwkqpu"htq"rko k'g'f "ugtkgu"qh'uqrf "uqmwkqpu"d { "c"i kxgp"v'f gec { "vgo r gtcwtg."qt"vj g'k'f gec { "vgo r gtcwtg"cv'c"i kxgp"u'wdukwkqpu"rko k'f0"



Hki 030F gr gpf gpegu"qh'vj g'ecrewrvgf "f geqo r qukskqp" vgo r gtcwtgu"qh'Nc<sub>30z</sub>Np<sub>z</sub>H<sub>5</sub>"uqrf "uqmwkqpu"htq"z"? "203" \*c="z"? "205" \*d="z"? "207" \*e="z"? "202" \*f "+"cpf "z"? "202" \*g+"qp"vj g" \*TGG"pwenct"ej cti g" \*f kci tco "qh'vj g" vj gto qf { pco le"u'cdk'k'v'f"qh'uqrf "uqmwkqpu"0"

Hki 040F gr gpf gpeg"qh'vj g'vgo r gtcwtgu" \*M+"qh'vj g" f geqo r qukskqp"qh'uqrf "uqmwkqpu"qh'vj g"Nc<sub>30z</sub>Gw<sub>5</sub>H<sub>5</sub>"u{ ugo " qp"vj g'eqo r qukskqp" \* "+"cpf "vj g'u{ p'vj g'ku"vgo r gtcwtg"qh' vj g'uqrf "uqmwkqpu" \*995M+"qh'vj g'eqo r qukskqp" Nc<sub>20</sub>7Gw<sub>207</sub>H<sub>5</sub>"ceeqt'f kpi "vq"vj g'f cv'qh'j3\_0"us wctg+0' Xgtv'kecn't'gevcpi ng"ò'ecrewrvgf"gttqt0"

Vj g"ecrewrvgf"t'guwru"htq" Nc<sub>30z</sub>E<sub>g</sub>H<sub>5</sub>. "Nc<sub>30z</sub>Rt<sub>z</sub>H<sub>5</sub>. "Nc<sub>30z</sub>P f<sub>z</sub>H<sub>5</sub>"u{ ugo u" f q"pqv'eqpvtcf lev"vj g" g'zr g'klo gpvni'f cv" qdvc'k'g'f "gct'k'g'f "d { "kpu'w' g'v'cn't'gugctej "o gv' qf u"lp"vj g'ugpug"vj cv'eqpv'k'w'q'w'u'ugtkgu"qh'uqrf "uqmwkqpu"lp"vj g'ug'u{ ugo u" ctg"lp"vj g"r t'gf lev'f "t'gi kqp"qh'vj gto qf { pco le"u'cdk'k'v'f 0Vj g"ecrewrvgf "f geqo r qukskqp"vgo r gtcwtg"qh'vj g"Nc<sub>20</sub>7Gw<sub>207</sub>H<sub>5</sub>" uqrf "uqmwkqpu" \*Hki 04+"ku"lp"uc'v'k'w'c'v'q'f { "ci t'ggo gpv'vj kj "vj g" g'zr g'klo gpvni'f "h'q'w'p'f "q'p'g"j3\_0Vj g"t'guwru"qh'ecrewrvgf"uqmwkqpu"qh' vj g"o kzkpi "gpgti lgu"qh'vj g'u{ ugo u"wpf gt"eqpuk'f gtcvkqp"ecp"dg"wgf "vq"u'w' r ngo gpv'vj g'k'f "r j cu'g" f kci tco u"lp"vj g"r qy / vgo r gtcwtg"t'gi kqp"v'q'eqpvt'w'v'c" f qo g"qh'uqrf "uqmwkqpu" f geqo r qukskqp+0"

Vj g'awf / "y cu'ectt'k'g'f "q'w'v' kj kp"vj g" \*Hwpf co gpvni' Tgugctej "Rtqi tco o g'hw'p'f g'f "d { "vj g"O'k'p'k'nt { "qh'G'f w'ec'v'k'p'cpf" Uek'p'eg"qh'Wm'ck'p'g" \*i t'cpw'k'f "233; W322247. '2342W32427; -0"

j3\_V01 t { d. UONu0Rj qv'vno l'p'ge'gpv't'qr g'v'ku'qh'Nc<sub>5</sub>Gw<sub>5</sub>" cpf "I f<sub>5</sub>Gw<sub>5</sub>" p'cpqr c't'v'ku'g'u't'gr ct'g'f "d { "eq/r t'g'ek'k'v'k'p'b gv' qf . Lq'w'p'c'q'q'ht'ct'g'ct'vj u" 49.7: : 67; 4" \*422; -0"

**CRRNKE CVKQP 'QHUVCTEJ 'CEGVCVG'HQT'TGO QXCN'QH'  
CNM N'RCTCDGPUHTQO 'CS WGQWU'O GF KWO "**

**Mctqrkpc@rmpckg. "Ncwtc'Rgekwn{vg. 'F glo cpvg'Tqurkwn'Tco wpg'Twnckg"**

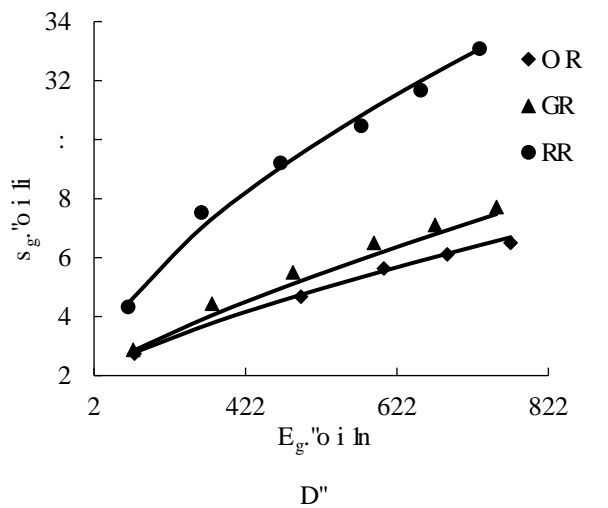
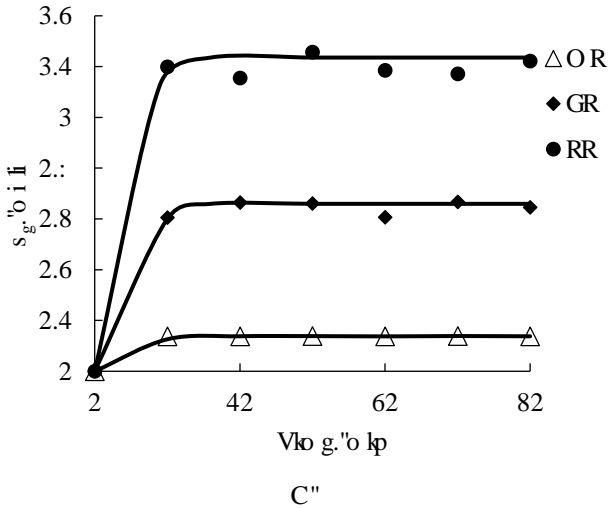
F gr ctwo gpv'qh'Rqn{o gt'Ej go knt { 'cpf 'Vgej pqmji { . 'Mwpcu'Wpkxgtukv{ 'qh'Vgej pqmji { . 'Mwpcu. 'Nkj wcpk "

[mctqrkpc@rmpckgB\\_mwqf\\_w](mailto:mctqrkpc@rmpckgB_mwqf_w)

Qxgt 'vj g'r cuv'ugxgtcnf gecf gu. 'cf xcpogo gpv'kp'uqelgvnlo qf gtpk' cvkqp'j cu'rgf 'vq'grgxcvgf 'hxxkpi 'ucpf ctf u'hqt'j wo cp' dgkpi u'cpf 'i tqy kpi 'ugrh'eqpuekqwapguu'kp'r gtuqpcrlectg'cpf 'j { i kpgg0Vj gug'uqelcr'gxqmwkqpu'cnuq't guwv'kp'j g'gzvpuks'g' wug'qh'equo gke'cpf 'r gtuqpcrlectg'r tqf wvu'ERE Ru+0Vj g'qeewtgpeg'qh'ERER't gukf wgu'kp'f qo guke'ugy ci g. 'o wplek'cni' y cuv'g'ycvt'cpf 'y cuv'g'ycvt'vtgcvo gpv'u{ uvgu u'ku'lp'gkxkcdng0Vj g'o qpkqtkpi 't guwv'u'uj qy gf 'vj gk' 'co dkgpv'ceewo wrcv'kqp' g'zj kdkkpi 'cp'kpetgculpi 't gpf 'f wtkpi 'vj g'r cuv'hy 'j' gctu'j3\_0Co qpi 'vj g'q'dugt xgf 'eqpukwgpw'qh'ERER't gukf wcu. 't ctcdgpu' ctg'c'i tqw'qh'eqo r qwpf u'qh'eqpegt'p'dgecvw'g'qh'vj gk'r qr wrc'k'v'cu'cf f kx'gu'OF vg'v'q'vj gk' 'r qv'p'v'cr'v'q'z'k'k'v' { 'cpf 'g'ut'qi' gp/ o ko lenkpi 'r tqr gt'v'. 'vj g'r t'gugpeg'qh'r ctcdgpu'cnuq'r qugu'c'r qv'p'v'cr'v'j t'gcv'v'q'vj g'uc'd'k'k'v' 'qh'o ketq'd'k'r'eqo o w'p'k'g'u'kp'c' " d'k'q'ni' k'c'n'v'g'c'vo gpv'u{ uvgu 'cu'y g'm'cu'kp' 'vj g'ge'q'ni' k'c'n'g'p'x'k'q'po gpv'j4\_0J g'peg. 'vj g't'g'ku'c'p'ggf 'hqt'ugctej 'hqt'p'gy 'y c{ u' v'q'cf f k'k'p'c'm' 'g'ro k'p'ev'g'v'j q'ug'eq'p'v'co k'p'c'p'u'0

Kp'vj ku'uwf { 'vj g'lu'p'vj guk' gf 'o letqi t'cpw'ct' 'u'ctej 'cegvc'v'j' c'x'g'd'ggp'v'g'ugf 'cu'c'r q'v'p'v'cr'v'ut'd'g'p'v'ht' 't'go q'x'c'n'q'h'c'm'f n' r ctcdgpu'ht'qo 'cs w'g'q'u'o' g'f k'wo 0'U'ctej 'cegvc'v'j'UC'+o letqi t'cpw'gu'y' k'j 'vj g'f'g'i' t'gg'q'h'uw'd'v'k'w'k'p' 'qh'ceg'v'f' n'i' tqw' u'qh' 2063'y cu'q'd'v'k'p'g'f' d' { 't'g'ev'k'pi 'r q'v'c'v' 'u'ctej 'i' t'cpw'gu'y' k'j 'ceg'v'k'ep'j { f' t'k'f' g'w'k'p'i 'cs w'g'q'u'P' c'Q'J 'u'q'w'k'p'cu'c'ec'v'c'n' u'0

Vj g'cf uqtr v'k'p' 'qh'c'm'f n'r ctcdgpu. 'p'co g'n' 'o g'v' { r' ctcdg'p' "OR+" g'v' { r' ctcdg'p' "GR+" c'p'f 'r' t'qr { r' ctcdg'p' "RR+" 'q'p'UC' " o letqi t'cpw'gu'kp'y' cv'g'j' cu'd'ggp' 'k'p'x'g'w'k'i' cv'g'f' d' { 'g'o r' m'j' k'p'i 'vj g'g'v'k'k'v'k'w'o 'cf uqtr v'k'p' "o g'v' q'f 0'V'j g'cf uqtr v'k'p' n'k'p'g'v'eu' u'w'f' k'g'u'uj' q'y' g'f 'vj' cv' 'vj' g'cf uqtr v'k'p' "g'v'k'k'v'k'w'o 'j' cu'd'ggp' "t'g'ce'j' g'f 'y' k'j' k'p'9" o k'p' "H'k'i 0'3C+0'V'j g'q'd'v'k'p'g'f "ku'q'v'j' g'to u'qh' " o g'v' { n' "g'v' { n' "c'p'f 'r' t'qr { r' ctcdg'p' "q'p'UC' "cv'42"AE' "ct'g'r' t'gug'p'v'g'f' k'p' "H'k'i 03D0



H'k'i 030Cf uqtr v'k'p' n'k'p'g'v'eu' "C'+c'p'f 'ku'q'v'j' g'to u' "D'+q'h'c'm'f n'r ctcdgpu'q'p'UC' "cv'42"AE' "

Vcdrg'30Cf uqtr v'k'p' "o q'f g'n'r' c'teo g'v'g'tu' h'qt' 'cf uqtr v'k'p' "qh'c'm'f n'r ctcdgpu'q'p'UC' "cv'42"AE' "

Cm'f n' r'ctcdg'p' "	N'c'p'i o w'k' 'b' q'f g'n'f' "		H't'g'w'p'f' n'ej 'b' q'f g'n'f' "		F'w'd'k'p'p'/T'c'f w'uj n'g'x'lej ' " o q'f g'n'f' "	
	Q <sub>L</sub> (mg/g)	R <sup>2</sup>	n <sub>F</sub>	R <sup>2</sup>	E <sub>DR</sub> (kJ/mol)	R <sup>2</sup>
OR' "	3208; "	20 87; "	3052; "	20; 6; "	904; "	20; 9; "
GR' "	35086; "	20; 4; "	3047; "	20; 6; "	908; "	20; ; ; "
RR' "	38072; "	20 8; ; "	3083; "	2.; ; 2; "	: 0; "	20; 7; "

Vj g'N'c'p'i o w'k' "H't'g'w'p'f' n'ej "c'p'f "F'w'd'k'p'p'0T'c'f w'uj n'g'x'lej " 'cf uqtr v'k'p' "o q'f g'n'f' y' g't'g'w'ug'f "v'q'f' g'uet'k'd'g'v'j' g'cf uqtr v'k'p' " ku'q'v'j' g'to u' "ugg' "Vcdrg' "3+0'V'j g'cf uqtr v'k'p' "o q'f g'n'r' c'teo g'v'g'tu' f'c'v' "t'g'x'g'c'rg'f " 'vj' cv'cf uqtr v'k'p' "y' cu' 'o c'k'p'n' { 'f' w'g'v'q' "r' j' { u'k'ec'f' k'p'v'g't'c'v'k'p'p'u'0'V'j g'x'c'n'g'u'q'h'N'c'p'i o w'k' "uqtr v'k'p' "ec'r' c'ek'f' "S'N' "k'p'et'g'c'ug'f' d' { "k'p'et'g'c'ul'p'i " 'vj' g'n'g'p'i' v'j' "qh'c'm'f' n'ej' c'k'p' "k'p' "r' ctcdg'p' " o q'rg'ew'g' "k'p' "v'j' g'h'q'm'y' k'p'i "q't'f' g't' "t'qr { r' ctcdg'p' " @g'v'j' { r' ctcdg'p' " @b' g'v'j' { r' ctcdg'p' 0V'j g'q'd'v'k'p'g'f 't'gu'w'v' "eq'p'ht'k'o' g'f' "vj' cv'UC' " i' t'cp'w'gu' "ec'p' "d'g' "r' t'q'o' k'k'p'i' "cf uqtr d'g'p'v'ht' "vj' g't'g'o' q'x'c'n'q'h'r' ctcdg'p'u'ht'qo' "cs w'g'q'u'g'p'x'k'q'po' g'p'u'0

[3\_] 0'f' "q' r' n'k'p'u' N'0D'nc'p'g' { . 'C'p' "c'i' i' t'g'i' cv'g' "ep'c'n'f' u'k'v'q'h'r' g'tu'q'pc'r'lect'g'f' r' tq'f' w'v'u'k'p' "v'j' g'g'p'x'k'q'po' g'p'v'k'f' g'p'w'h'k'p'i' "v'j' g'f' k'w'k'v'k'w'k'p' "qh'g'p'x'k'q'po' g'p'v'c'm'f' /t'g'g'x'c'p'v' "eq'p'eg'p'v'c'v'k'p'p'u' "G'p'x'k'q'po' g'p'v'f'p'g't'p'c'v'k'p'c'ni' /4/; 5. "523/538" "4238+ "

[4\_] E'0J' "co' g'p'v'c'n'0' "Q'ee'w't'g'peg' "h'v'g' "c'p'f' "d'g'j' c'x'k'q't' "q'h'r' ctcdg'p'u'kp' "cs w'c'v'e' "g'p'x'k'q'po' g'p'w' "C' "t'g'x'k'g'y' <Y' cv'g't' "T'g'ug'ctej' "8: "3/33" "4237+ "

# MEASUREMENT OF STORAGE MODULUS IN UNCURED ELASTOMERS USING PLATE-PLATE AND MOVING DIE TECHNIQUES

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Development of new elastomers and their recycling technology is often focused on rheological properties, dynamic moduli in particular [1]. A number of methods can be used for their measurement, primarily highlighting the dependence of storage modulus  $G'$  on strain, temperature and other factors. Plate-plate and moving die techniques are often employed. Despite different sample sizes and topography, the techniques exert similar stress onto the elastomer and record the same factors as feedback. This study attempts to compare  $G'$ , recorded by both techniques on same elastomers. Non-vulcanized Isoprene Rubber (IR) was used to simulate the elastomer with or without squalane (SQ) at 13% wt. as a plasticizer.

Storage modulus  $G'$  was measured using the two techniques tuned to operate under similar thermal and mechanical regimes. Plate-plate technique employed a MCR 302 rheometer with  $\varnothing$  8 mm spindle PP08 (Anton Paar). Temperature sweep was carried out under 0.5% strain at 1 Hz with 5 min preheating for each temperature. Frequency sweeps were taken progressively at 25°C, 100°C and 120°C with 5 min preheating under 0.5% strain, total duration of ~2 h. Load was constant at 1 N. The elastomer samples were pre-cut into  $\varnothing$  8.5 ± 0.5 mm discs 0.5 ± 0.1 mm thick. Moving die technique employed D-MDR 3000 rheometer (Montech, Germany) with biconical dies per ASTM D6204, guarded by disposable polymer sheets. Strain sweep (0.02 – 90% range, 3 cycles for each angle under 1 Hz) and frequency sweep (0.01 – 50 Hz range, 3 cycles for each frequency under 0.5% strain) were carried concurrently on the same specimen at 25°C, 100°C and 120°C with 5 min preheating and total duration of 2 h per sample. Temperature sweep (25 – 120°C with 5°C step every 1.4 min under 1 Hz and 0.5% strain) was performed on different specimens. In both techniques the attempts were made to avoid bubbles, wrinkles or other imperfections, however perfect adherence to plate surface could not be assured. Built-in software calculated  $G'$  whose values were processed from multiple runs using Origin software to derive error bars. The most representative curves are shown in Fig. 1.

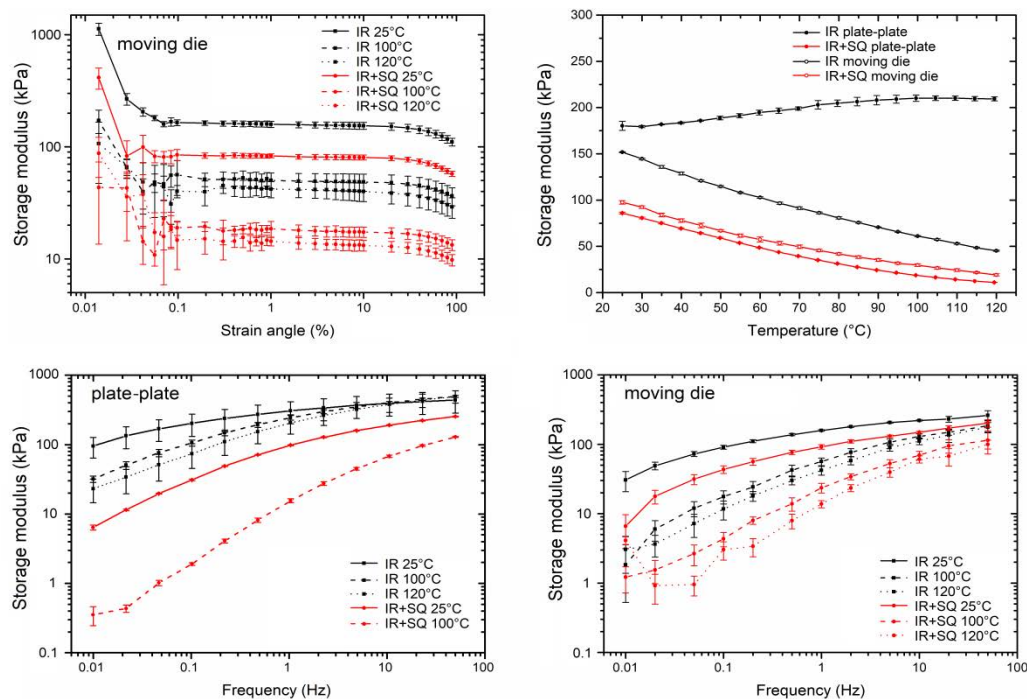


Fig. 1. Variation of storage modulus  $G'$  due to increasing strain or temperature (top) or frequency (bottom). Plate-plate (MCR) or moving die (MDR) rheometers were used.

Temperature effects on non-plastified IR appear inexplicably opposite. Despite these and other differences in recorded values, tendencies of  $G'$  dependence on frequency and plastification appear similar and match expectations. It can be noted that frequency sweep at 120°C by the plate-plate technique matches results from other researchers quite well [1]. Therefore, both techniques can be instrumental in evaluation of rheological properties of elastomers and composites.

[1] X. Sun, A.I. Isayev, Ultrasound devulcanization: comparison of synthetic isoprene and natural rubbers, *J. Materials Sci.* **42** (17), 7520-7529 (2007).

**U PVJ GUKU'EJ CTCEVGTK CVKQP.'CPF'KPXGUVH CVKQP'QH'  
PK/TQI GP/FQRGF'ECTDQP'UWRRQTVGF'O CPI CP GUG/EQDCNV''  
PCPQRCTVÆNGU'**

Nqtgvc'Vco c-cwunckv /Vco c-k pckv .Glxkn 'Dwf t { v . 'Crf qpc'Den k pckv . 'L tev 'Xck k pkgp . 'Gwi gpklwu'  
P qtmwu'

F gr ctvo gpv'qh'Ecvn{uku 'Egpgvt'hqt'Rj {ukeci'Uelgpegu'cpf 'Vgej pqrqi { . 'Ucwn vgnkq'Cxg05.'NV/32479.'Xkpkwu 'Nkj wcpk''  
mtgvc0co cucwunckgB hxo e0m'

Vj g'f gxnqr o gpv'cpf 'kpxguki cvkqp'qh'xctkqwu'o cvgtknu'wugf "lp'hwgn'egmu."cu'c'tgpgy cdng'gpgti { "uqwtg."ku'c'o clqt"  
ej cmgpi g'co qpi "yj g'uelgpkhke"eqo o wpxk{0'k'j ku'uwwf { . "pkxqi gp/f qr gf "ectdqp"\*P/f qr gf "E+."y j lej "j cu'c"i tcr j gpg/rkng"  
utwewtg."j cu'dggp'ej qugp'cu'c'uw r qtv'hqt"yj g'f gr qukkqp"qh'O p/Eq'pcpqr ctvængu"\*O p/EqP Ru+"wukpi "o letqy cxg"j gcvkpi "  
o gyj qf "vq" wug" yj go "cu'cpqf g"o cvgtkci' hqt" f kt gev' j { f tc| kpg" hwgn' egmu" \*FJ HEu+." rkngy kug." kf gpvkh{ "ku" hgcwtgu" cu' c"  
uw gtecr cekqt0'Hqt" eqo r ctluqp."r wtg"EqP RuLP /f qr gf "E" cpf "O pP RuLP /f qr gf "E"ecvnc'usu"j cxg'dggp"u{pvj guk gf "wpgt"  
kf gpvkeci'eqpf kkkpu0"

Vj g'utwewtg."o qtr j qnqi { . "cpf "eqo r qukkqp"qh'pcpqqeo r qukgu"j cxg'dggp'ej ctcevgtk gf "wukpi "Vtcpuo kuukqp'Grgvtp"  
O letqueqr { \*VGO +.'Tco cp'Ur gevqueqr { . 'Z/tc{ 'Rj qvqrgvtp'Ur gevqueqr { \*ZRU+.'cpf 'kpf wexkgn{ 'Eqwr ngf 'Rrcuo c'Qr vkeci'  
Go kuukqp'Ur gevqueqr { \*KER/QU+0'O qtgqxtg."grgevteqj go keci'r gthto cpeg"j cu'dggp'kpxguki cvgf "d{ "e{erke"xqnc o gt { "  
\*EX+lp'c'3'O 'P c4UQ6'uqnwkp'cv'yj g'uecp'tcvgu'qh'3.'7.'32.'42.'322.'cpf '372'o X'u<sup>3</sup>0E {erke"xqnc o qi tco u'qp'yj g'r tgr ctgf "  
ecvnc'uv'j cxg'dggp'cnuq'tgeqtf gf 'lp'c'207'O 'P 4J 6- '3'O 'P cQJ 'uqnwkp'cv'c'r qvqvkci'uecp'tcvg'qh'32'o X'u<sup>3</sup>0'

K'j cu'dggp" f gyto kpgf "yj cv'O p/EqP RuLP /f qr gf "E."EqP RuLP /f qr gf "E." cpf "O pP RuLP /f qr gf "E"ecvnc'usu"uj qy "cp"  
gpj cpegf "grgevteqecvnc'vle"cevkkv{ "vqy ctf u'yj g'qz kf cvkqp"qh'j { f tc| kpg"lp'cp'cmvckpg"o gf kwo "cpf "k'ku'eqpvtqngf "d{ "yj g"  
f khwukqp"r tqeguugu0'Y j cv'ku"o qtg."k'y cu'hqwpf "yj cv'yj g"ur gekhke"ecr cekcpeg"\*E+."xcnwg" hqt "yj g"O p/EqP RuLP /f qr gf "E"  
pcpqqeo r qukg'lp'c'3'O 'P c4UQ6'uqnwkp"y cu'gs wcn'vq"6; 90/Hi<sup>3</sup>cv'c'uecp'tcvg'qh'3'o X'u<sup>3</sup>cpf "f getgcugf "vq"47606"Hi<sup>3</sup>cv'c"  
uecp'tcvg'qh'372"o X'u<sup>3</sup>0'Vj g"O p/EqP RuLP /f qr gf "E"ecvnc'uv'r tguqtxgu"7308" "qh'ku'ur gekhke"ecr cekcpeg"cu'yj g'uecp'tcvg"  
kpetgcugu'itqo "3"o X'u<sup>3</sup>vq"372"o X'u<sup>3</sup>0'Vj g'qdvckpgf "tguwmu'eqphkto gf "yj g'i qqf "r gthto cpeg'qh'yj g'r tgr ctgf "O p/EqP RuLP /  
f qr gf "E"pcpqqeo r qukg'cu'yj g'grgevteqf g'bo cvgtkci'hqt'uw gtecr cekqtu'cr r rkecvkqp0'

**KPXGUVK CVKQP'QHJ [ FTQI GP'RGTOZKF'G'TGF WEVKQP'QP'EQRRT/ P KEMGN'HQCO U'**

Crf qpc'Den k pckv . "VkcUcpgxk kuu. "Nqtgvc"Vco c-cwumekv /Vco c-k pckv . "Gwi gplwu'P qtmwu"

F gr ctvo gpv'qh'Ecvn(uku. 'Egpgvt'ht'Rj { ulecn'Uelgpegu'cpf "Vgej pqmji { . "Ucwn vgnk"cxg05. "NV/32479. "Xkpkwu. "Nkj wcpk""  
crf qpc@lcrekwpckvgB ho e0w"

Kp"vj ku'uwf { . "vj g"eqr r gt/plengn"EwP k'hqco u'j cxg"dggp"kpXgUVK cvgf "cu"cecvn(uv'ht"vj g'tgf wevkqp"qh'j { f tqi gp" r gtqzkf g"\*J 4Q4+0Vj g"EwP k'hqco u'j cxg"dggp"r tgr ctgf "wukpi "vj g"nqy /eqw'grgevtqej go lecn'o gvcn'f gr qukkqp"o gvj qf 0' Ej go lecn'dcvj u'eqpckpvgf "c"eqpucpv'eqpepvtcvkqp"qh'Ew+ "kpu"2027'O +cpf "f khtgtpv'eqpepvtcvkqp"qh'P k+ "kpu'lp"vj g" tpci g'htqo "2027"vq"207"O "j cxg"dggp"wugf "ht"vj g"grgevtqf gr qukkqp"qh'vj g'EwP k'hqco u'qp"vj g'kxcpkwo "Vk+uwthceg0Vj g" uwthceg"o qtr j qmji { . "utwewtg. "cpf"eqo r qukkqp"qh'vj g"r tgr ctgf "ecvnc(uv'j cxg"dggp"gzco kpgf "wukpi "Uecpplpi "Grgevtqp" O letqueqr { "UGO + "Z/Tc { "F khtcevkqp"ZTF +. "cpf "kpf wekxgnf "Eqw rnf "Rruo c"Qr vlcen'Go kuukqp"Ur gevtqueqr { "KER/ QGU+0Vj g'grgevtqevkxk\ 'qh'vj g'r tgr ctgf "ecvnc(uv'j cu'dggp"gxcnwcvgf "ht"vj g'tgf wevkqp'tgcevkqp"qh'J 4Q4'go r nq { kpi "kpgct" uy ggr "xqnc o gvt { "lp"208"MQJ "grgevtqnf vg'cv'c"r qvgnvknuecp'tcvg'qh'72'o X'u'30"

K'y cu'hwppf "vj cv'vj g'dgu'grgevtqevkxk\ "ht"vj g'J 4Q4'tgf wevkqp'tgcevkqp'uj qy u'vj g'EwP k'hqco u'f gr qukkqp "wukpi "c" ej go lecn'dcvj "eqpckpvgf "2027"O "Ew+ "kpu"cpf "204"O "P k+ "kpu'0'O qt gqxt. "J 4Q4'tgf wevkqp"ewtgpv'f gpukv\ 'tgeqtf gf "qp" vj g'EwP k'hqco u'lp"vj g'Q4/ucwtcvgf "208"O "MQJ "uqnwkp"eqpckpplpi "7"o O "J 4Q4"ku'ec030'wlo gu'j ki j gt"vj cp"vj cv'lp"vj g' Q4/ucwtcvgf "208"O "MQJ "uqnwkp"y kj qw'J 4Q40"

Cempqy rnf i o gpv'

Vj ku'tgugctej 'ku'hwppf gf 'd { 'vj g'Gwtqr gcp'UleknHwppf "wppf gt'O gcuwtg'P q02; 00/NO V/M/934/3; /235: "F gxnqr o gpv' qh'Ego r gvpegu'qh'Uelgp'kuu. "qvj gt'Tgugctej gtu. 'cpf "Uwf gpw'vj tqwi j "Rtcevcen'Tgugctej "Cevkxkku0"

**P KVTQI GP/FQRGF 'ECTDQP 'UWRRQTVGF 'Y KVJ 'I QNF''  
P CPQRCTVKENGU'CU'CP 'GHHKEKGP V'E CVCN[ UV'HQT'I NWEQUG''  
GNGETQ/QZKF CVIKP''**

F ckc'W' unxkcp <sup>3</sup>. 'L' tev 'Xck k pkep <sup>3</sup>. 'Kct' 'M' wuqpdgti <sup>4</sup>. 'Mcvkp' 'Mctg' <sup>4</sup>. 'Crgmcpf tu' 'Xqir gt wu' <sup>5</sup>.  
I crikp' 'F qdgn' <sup>5</sup>. 'Ckxctu' \ wtkp' <sup>5</sup>. 'Nqtgvc' 'Vco c-ewumkv / Vco c-k pckv' <sup>3</sup>. 'Gwi gplwu' 'P qtmw' <sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Ecvn[ uku. 'Egpyt' 'hqt' 'Rj { ulecn'Uelgpegu'cpf 'Vgej pqmji { . 'Ucwgvgnkq' 'C'xg05. 'NV/32479. 'Xlcpku. "  
Nkj wcpk"

<sup>4</sup>P cvkqpcn' 'kpukwg' 'qh' 'Ej go lecn' 'Rj { uleu' 'cpf' 'Dkqr j { uleu. 'C'ncf ggo lc' 'Vgg' 45. '3483: . 'Vcnkpp. 'Guvpkc"

<sup>5</sup>Ncvkcp' 'Ucvg' 'kpukwg' 'qh' 'Y qqf' 'Ej go knt { . 'F | gtdgpgu' 'U' tggv' 49. 'Tki c' 'NX/3228. 'Ncvk' "

Ucwn vnkq' 'C'xg05. 'NV/32479. 'Xlcpku. 'Nkj wcpk' ""

g/o cln' f ckc'w' unxkcpB hno e0v'

Vj ku'uwf { "ku' hqewugf "qp' 'y g' r tgr ctvqpp" 'qh' i qf "pcpqr ctvngu" \*CwP Ru' uwr r qtvgf "ectdqp" \*E+ 'cpf "pktqi gp/f qr gf" 'cevkxcvgf "ectdqp" \*P / f qr gf "E+ 'pcpqqeo r qukgu' 'cpf 'y gk' 'cr r necvkp' 'hqt' 'y g' grgvtq/qz kf cvkqp' 'qh' i nwequg' 0' Vj g' 'CwP Ru' lP / f qr gf "E' 'pcpqqeo r qukg' j' cu' dggp' r tgr ctgf 'd { 'c' 'y q/ ugr' 'r tqegu' 0' C' v' h' u' 'cevkxcvgf 'y qqf / dcugf 'ectdqp' j' cu' dggp' r tgr ctgf 'htqo' 'crf gt' 'ej cteqcn' 'cpf' 'f qr gf' 'y kj' 'pktqi gp' 'd { 'r { tqn { | kpi' 'uco r ngu' 'cv' 'c' 'vgo r gtcwtg' 'qh' : 22' 'AE' 'kp' 'y g' r tggpeg' 'qh' f le { cpf kco kf g' \*F EF C+ 0' H' w' y gt. 'y g' 'CwP Ru' j' cxg' dggp' f gr qukgf "qp' 'y g' qdvclop' 'P / f qr gf' 'cevkxcvgf' 'ectdqp' 'o' cvgtkn' 'qt' 'ectdqp' 'wulpi' 'i' nwequg' 'cpf' 'cueqtdle' 'cekf' 'cu' 'tgf' 'welpi' 'ci' 'gpv' 0' Vj g' r tgr ctgf "pcpqqeo r qukgu' j' cxg' dggp' 'ej' 'ctcevtk' gf' 'd { " ucpplpi' "grgvtqpp' 'o' ketqueqr { \*UGO +. 'gpgti { / f kur gtukxg' 'ur' 'gevtqueqr { \*GF U+. 'Z/ tc { 'r' 'qy' 'f' 'gt' 'f' 'k' 'h' 'cevkcp' \*ZTF +. 'Tco' 'cp' 'cpf' 'Z/ tc { 'r' j' qvgrgvtqpp' 'ur' 'gevtqueqr { \*ZRU+ 0' Vj g' grgvtqecvnc' 'vle' 'cevkxkv' 'qh' 'y g' 'pcpqqeo r qukgu' 'hqt' 'i' nwequg' 'grgvtq/ qz kf cvkqp' j' cu' dggp' 'kpxguk' 'cvgf' 'kp' 'cmekp' 'o' 'gf' 'lc' 'wulpi' 'e { erke' 'xqnc' 'o' 'gt' { 0

Kj' cu' dggp' f gvgto kpgf 'y' cv' y g' 'CwP Ru' lP / f qr gf "E" 'cpf' 'CwP Ru' lE' 'pcpqqeo r qukgu' j' cf' 'c' j' gt' 'ecvnc' 'vle' 'cevkxkv' 'hqt' 'y g' 'grgvtq/ qz kf cvkqp' 'qh' i nwequg' 'y' cp' 'y g' r wtg' 'Cw' 'qt' 'ectdqp' 'cpf' 'P / f qr gf' 'ectdqp' 'cnppg' . 'kpf' 'lecvpi' 'y g' u' { pgti' 'kule' 'gh' 'gev' 'qh' 'CwP Ru' 'cpf' 'P / f qr gf' 'ectdqp' 'qt' 'ectdqp' 0' 0' qtqxtg. 'y g' j' ki j' guv' 'cevkxkv' 'uj' 'qy' 'u' 'y g' 'CwP Ru' 'uwr r qtvgf' 'P / f qr gf' 'ectdqp' 'cu' 'eqo r ctgf' 'y' 'kj' 'y' 'cv' 'qh' 'CwP Ru' 'uwr r qtvgf' 'ectdqp' 0

**CUUGUO GPV'QH'VJ G'K P CNKPC'P WENGCT'RQY GT'RNCPV'  
 KPHNWGPE G'QP 'T CF KQE CTDQP 'EQPE GP VT CVKQP 'K' 'NCMG'  
 F T WMUKK'**

Nwt {pcu'Dwmw<sup>3</sup>. 'T vc'Dctlugxk k v<sup>3</sup>. 'Lwukpc'<sup>T</sup>er qrcv<sup>3</sup>. 'fi kxkpcu'Gfletkpunk<sup>3</sup>. 'Gxcif cu'  
 O cegknc<sup>3</sup>. 'Cri ktf cu'Redgd kpunu<sup>3</sup>. 'Cpf tkwu'I etdctcu<sup>3</sup>. 'Xkf o cpwu'Tgo gkku<sup>3</sup>"

<sup>3</sup>Ucvg'Tgugctej 'Kpukswg'Egpvgt'hqt'Rj {ulecni'Uelgpegu'cpf 'Vgej pqm {'. 'Xkpkwu'Nkj wcpke"  
 nwt {pcu'QlwmwB hwo e0n"

"

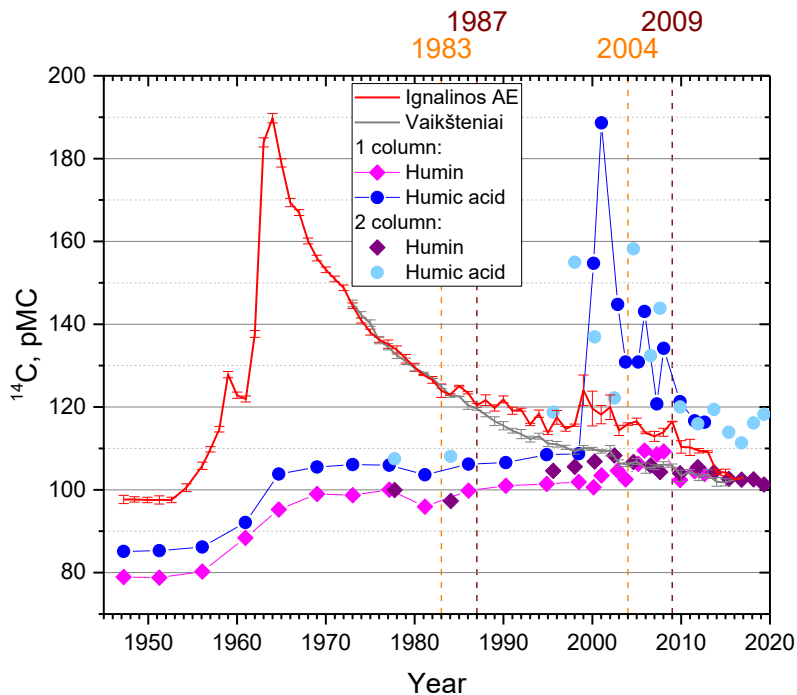
Tcf kqectdqp<sup>36</sup>E+'ku'c'mpi /rxgf 'ectdqp'kuqqr g'vj cv'j cu'c'j crh'rhg'qh'7952'0'62' { gctu'OP verget 'r qy gt'r rcpw'ctg'  
 qpg'qh'vj g'o clp'r tqf wgtu'qh'cpj tqr qi gple'tcf kqectdqp'OCpy tqr qi gple'tcf kqectdqp'ecp'dg'tgrgcugf 'kpq'vj g'gp'xkqpo gpv'  
 kp'i cugqu'htqto u'y kj 'hs wkf 'tgrgcugu'qt'y kj 'ur gpv'pverget 'hwgr'OF gur kg'vj ku'r qmwkqp'ku'pqv'uki pkkcepv'kp'vj g'ugpug'qh'  
 r qr wcvkqp'g'zr quwtg'f qugu.'dw'k'ku'c'uki pkkcepv'<sup>36</sup>E' lpetgcug'cdqxg' dcmi tqwpf "gh'gev'vj cv'cmjy u'y g'wug'k'cu'cp"  
 cp'vj tqr qi gple'eqpwo kpcvqp'tcegt'v'uwf { 'vj g'f kuugo kpcvqp.'ceewo wcvkqp.'cpf 'f { pco leu'tgf kntkdwkqp'r tqeguugu'qh'  
 vj g'r qmwcpv'kp'gequ { ugo 'j3\_0

Vj g'ncng'ugf ko gpv'cpf 'huj 'uecrg'uco r rgu'y gtg'eqmgevgf 'htqo 'vj g'F twmukk'ncng'0'Vj g'ncng'y cvgt'y cu'wugf "v'eqqn'  
 vj g'tgcev'q'qh'vj g'K pckpc'pverget 'r qy gt'r rcpv'<sup>36</sup>RR-0CDC\*'cekf /dcug/cekf +ej go lecnr' tgv'g'cvo gpvr' tqegf w'g'y cu'wugf "  
 v'gz'v'cev'j wo kp'\*J O '+cpf 'j wo le'cekf '\*J C +'htcevkqp'htqo 'vj g'ugf ko gpw'htqo 'vy q'f khtg'gpv'ncng'ugf ko gpv'eqnwo pu'0'  
 Tcf kqectdqp'o gcuwtgo gpw'kp'vj gug'uco r rgu'y gtg'r gthqto gf 'wukpi 'vj g'ceegrg'cvqt'o cu'ur gev'tgo gvt'<sup>36</sup>CO U'0'

<sup>36</sup>E'o gcuwtgo gpw'kp'j wo kp'cpf 'j wo le'cekf 'htcevkqp'j cxg'uj qy p'vj cv'vo qur j gtg'ncng'E'Q<sub>4</sub>'gzej cpi g'cee'w'p'vgf 'htq'  
 cdqw'44' 'ectdqp'kp'dqwgo 'ugf ko gpw'OF v'kpi 'vj g'3; : 5/3; ; : 'r g'k'qf. "<sup>36</sup>E/gptlej gf 'f kuukrgf 'kp'qti cple'ectdqp'F K E +  
 y cu'eqp'v'p'w'w'w' 'tgrgcugf 'kp'v'Ncng'F twmukk'OF v'kpi 'vj cv'ko g.'cp'cxg'tci g'qh'cdqw'2046'I Ds 'qh'tcf kqectdqp'y cu'tgrgcugf "  
 r gt' { gct'0' O gcuwtgo gpw' qh' tcf kqectdqp' eqep'v'cv'k'p'v'kp' 'huj " \*dq'vj " dgp'vj le" cpf " r g'v'ci le+' eqp'ht'o " vj cv' vj g' "<sup>36</sup>E"  
 eqp'v'cv'k'p'v'cu'kp'f kuukrgf 'kp'qti cple'htqo '0'

Ctqwpf "4222. "<sup>36</sup>E/gptlej gf 'F K E " \*405'I Ds 'tcf kqectdqp+'y cu'tgrgcugf "kp'v'Ncng'F twmukk'htqo 'K pckpc'P RR'  
 Hwt'vj gto qtg.'qti cple'eqo r qwpf u'y gtg'cf f k'k'p'cm' { 'tgrgcugf 'kp'vj g'uco g' { gct'0'Vj gug'eqo r qwpf u'y gtg'p'q'v'<sup>36</sup>E/gptlej gf "  
 dw'ch'gevgf "vj g'kp'v'g'cv'k'p'v'dgy ggp'j wo le'cpf 'j wo le'cekf u'0'Chgt'33' { gctu'chgt'vj g'g'pf 'qh'vj g'K RR'qr g'cv'k'p'v'vj g'  
 eqep'v'cv'k'p'v'qh'tcf kqectdqp'kp'vj g'dqwgo 'ugf ko gpw'ku'j ki j gt'vj cp'kp'vj g'c'vo qur j gtg'0'

"



Hi 030Vgo r qtcni<sup>36</sup>E'xctk'v'k'p'v'Ncng'F twmukk'

"

[j3\_ 'T0'Dctlugxk k v 'gv'c'0'V'c'el'pi 'Ectdqp'Kq'q'g'Xctk'v'k'p'v'Ncng'Ugf ko gpw'E'c'w'g'f 'd { 'G'p'x'k'q'p'o gpv'ri'He'v'q'tu'F w'k'p'i 'vj g'R'cu'v'E'g'p'w' { '<C'E'cu'g'  
 Uwf { 'q'hi'Ncng'V'cr g'rick'Nkj wcpke.'Tcf kqectdqp'83\*6+.' : 76; 25\*423; +0

"



**ƆP HN WGP E G'QH RGC V'GZ VT CE V'QP 'VJ G'RT QRGT VKGU'QH NIS WK' "**  
**HGT VKNK GTU'**

I qf c'I wf kpuņckv . 'F cpi wqn 'Lenko cxx k v . 'T cuc' "T kpm kgp "

Hcewn' qh'Ej go lecn'Vgej pqrni { . 'Mwpcu'Wpkxgtukv' qh'Vgej pqrni { . 'Nkj wepkc' "  
[i qf c'I wf kpuņckv7B i o cktęqo "](#)

F qmgo kg'ku'c'ectdqpcv/i tcf g'o kpgtcr'ij cv'eqpvc'kpu'ecreko "cpf" o ci pguiko 0'Vj g'eqm' qh'ij ku'o kpgtcr'ecp'xct { " htqo "y j kg'vq'dtqy p'f gr gpf kpi "qp'ij g'pwo dgt'qh'ko r wtklgu0Rqy f g'g'f 'f qmgo kg'ku'g'cukn' 'f geqo r qugf 'd { 'o kpgtcr'cefk u' y j krg'ectdq'f'kz'kf g'ku'tgrgcugf 0Cn'j qwi j 'f qmgo kg/dgctkpi 'tqemu'ctg'hqwpf 'cm'q'xgt'ij g'y qtrf . 'ij g'o qu'w'co qwu's wctt'kgu' ctg'lp" ij g'O kf y guwtp" Wpk'kf "Ucvgu" Ecp'cf c. "Uy k'j gtr'p'f . "Ur'clp. "cpf" "O g'z'leq" ]3\_0'Ncti g'f qmgo kg's wctt'kgu'ctg'cnuq" g'zr'rk'kgf 'lp'pqt'ij g'tp'Nkj wepkc'0F qmgo kg'ku'wugf 'cu'c'ij g'to c'nlpuw'v'kqp' o cvgt'kcn'cnuq'lp'ci t'kew'wtg'cu'c'iko kpi 'o cvgt'kcn' gr'g'v'k'ecr'gpi kpggt'kpi . 'egtco leu. 'r'clp'v'f' r'cuu'cpf 'd'w'kf kpi 'o cvgt'kcn'lp'f wut { 0'Vj ku'b' kpgtcr'ecp'cnuq'dg'wugf 'cu'c'iq'w'v'g'q' h' ecreko "o ci pguiko 'lp'ij g'r' t'qf we'k'qp'qh'ht'v'k'k' gtu'd' { 'f geqo r qukpi 'k'v'ij k'j 'xct'k'wu'e'q'p'eg'p't'c'v'k'p'u'q'h'p'k't'le'cefk'0

Dcugf "qp" r' t'g'x'k'wu't'g'ug'ctej "lp'q'w" f'gr'ct'vo g'p'v'f' k'ht'g'p'v'e'q'p'eg'p't'c'v'k'p'u'\*57."62."67" " +qh'p'k't'le'cefk' "y g't'g'wugf 'lp" ij ku'y q't'm'ht'ij g'f'geqo r qu'k'k'p'q'h'f' qmgo kg'0F geqo r qu'k'k'p'y cu'r' g't'ht'qo g'f'cv't'q'qo 'vgo r g't'c'w't'g'cv'42'647'āE0'G'z'eg'u'q'h' 42" "cpf"62" "p'k't'le'cefk' "y cu'e'q'o r'ct'g'f'v'q'ij g'u'q'le'j k'q'o g'v'k'le'co q'w'p'v'c'p'f'wugf'0'K'y cu'h'q'w'p'f'ij cv'ij g't'g'c'v'k'p'ku'hc'ug't' cpf' "f'geqo r qu'k'k'p'v'c'ng'u'72"o k'p'w'gu. "y j g'p'362" "cefk'ku'wugf'0F w'k'pi "ij g'f'geqo r qu'k'k'p. "ij g'vgo r g't'c'w't'g'k'p'et'g'cugf'v'q' "62'672'āE"cpf'p'q'v'q'p'n' 'E'Q'4' cu'd'w'c'nuq'dt'q'y p'P'Q'4' cu'y cu't'g'g'cugf'v'q'0'K'ij ku'y c { . 'lp'ij g'r' t'qf we'k'qp'q'h'ht'k'k' w'k' h'g't'v'k'k' gtu. " k'ku'p'g'eg'ug'ct { "v'q'r' t'q'x'k'f'g'ht'ij g'r' w'k'ht'ec'v'k'p'q'h'ij g'f'k'ht'g'p'v'ij c'ug'u'lp'ij g'v'g'ej p'qrni lecn'ht'p'g'0F w'k'pi "ij g'f'geqo r qu'k'k'p'ht'ij 72"o k'p'w'gu. "ij g'j k'ij g'u'v'e'q'p'eg'p't'c'v'k'p'q'h'E'c'Q'cpf" "O i Q'y cu'q'd'v'c'p'g'f" y j g'p'67" "p'k't'le'cefk' "y cu'wugf'lp"ij g'f'q'q'o kg' f'geqo r qu'k'k'p'r' t'q'eg'u'0

U'q'w'k'p'u'c'ht'g'ij g'f'geqo r qu'k'k'p'ct'g'x'g't { "cefk'le. "u'q'p'g'w't'c'ri'k' c'v'k'p'p'g'g'f' u'v'q'd'g'r' g't'ht'qo g'f'0'47" "co o q'p'k'c'y cv'gt' y cu'ej qu'p'ht'ij ku'r' t'q'eg'u'0N'k' w'k' p'k't'q'i g'p'ecreko "o ci pguiko 'ht'v'k'k' g't' u'q'w'k'p'u'q'h'f' k'ht'g'p'v'ij J 'x'c'w'g'u'y g't'g'r' t'g'r'ct'g'f' h'q't'p'g'w't'c'ri'k' c'v'k'p'w'k'p'i 'f'k'ht'g'p'v'co q'w'p'u'q'h'co o q'p'k'c'y cv'gt'0'Vj g'r' t'q'f we'g'f' h'g't'v'k'k' gtu'e'q'p'v'c'p'g'f'č'32" 'P. 'č'8" 'E'c'Q'cpf" č'6" "O i Q'0'Vj g'r'j { u'lecn'r' t'q'r' g't'v'g'u'q'h'ij g'r' t'g'r'ct'g'f' h'g't'v'k'k' g't' u'q'w'k'p'u'ij j' k'ej 'ct'g'ko r q't'c'p'v'ht'ij g'f'g'x'g'p'r' o g'p'v'q'h'ij g' r'k' w'k' h'g't'v'k'k' g't'r' t'q'f we'k'qp'v'g'ej p'qrni { . 'ct'g'f' k'x'g'p'lp'ij g'v'c'd'g'0

V'c'd'g'0'Rj { u'leq'ej go lecn'r' t'q'r' g't'v'g'u'q'h'c's w'g'q'u' u'q'w'k'p'u'q'h'ecreko "o ci pguiko "cpf"co o q'p'k'w'o "p'k't'c'v'g'u"

U'co r'ng'P'q'0'	Co o q'p'k'c' y cv'gt' s'w'c'p'v'k'f'." "	Et { u'cn'k' c'v'k'p' v'go r g't'c'w't'g'." āE"	r J "	F'g'p'uk'f'." i'le'o 5"	X'k'ue'q'uk'f'." o'le'o l'4	G'rg'v't'lecn' eq'p'f' v'v'k'k'f'." o'U'le'o 5"
3"	3308"	/52"	6087"	30886"	405; 7"	35; 06"
4"	330 "	/54"	6072"	30886"	405; 2"	3590 "
5"	340 "	/52"	7082"	30882"	404; 4"	3570 "

K'p' q't'f'g't'v'q' k'p'et'g'c'ug'ij g'p'k't'q'i g'p' e'q'p'eg'p't'c'v'k'p'lp"ij g'ht'v'k'k' gtu. "cpf" c'ht'g' g'x'c'w'c'v'k'p'i "ij g' u'q'w'k'k'k'f' "f'c'v' q'h' o w'k'le'q'o r q'p'g'p'v'u'f' u'v'go u'c'x'c'k'c'd'g'lp"ij g'v'k'g't'c'w't'g'."cf'f'k'k'q'p'c'n'p'k't'q'i g'p'k'p'et'g'c'ul'p'i "u'w'w'c'p'eg'u' u'w'ej "cu'w't'g'c'y cu'cf'f'g'f'0' Vj g'ug' "u'w'w'c'p'eg'u' k'p'et'g'c'ug'f'ij g'p'k't'q'i g'p' e'q'p'eg'p't'c'v'k'p'lp" r'k' w'k' "ht'v'k'k' gtu. "d'w'f'q'p'q'v' k'p'et'g'c'ug'ij g'g'k'et { u'cn'k' c'v'k'p' v'go r g't'c'w't'g'."y j' k'ej "ku'q'p'g'q'h'ij g'o qu'v'ko r q't'c'p'v'r' qu'k'k'x'g'r' t'q'r' g't'v'g'u'q'h'ht'k'k' w'k' h'g't'v'k'k' gtu'0C'ht'g'f'geqo r qu'k'k'p'q'h'f' q'q'o kg' y k'ij "p'k't'le'cefk' . 'p'g'w't'c'ri'k' c'v'k'p'q'h' u'q'w'k'p'u'c'p'f'cf'f'k'k'q'p'q'h'w't'g'c'."ij g'p'k't'q'i g'p' e'q'p'eg'p't'c'v'k'p'lp'et'g'c'ug'f'v'q'44" 0

V'q'r' t'q'f we'g'ij g'o qu'v'g'h'ht'k'k'p'v'ht'k' w'k' h'g't'v'k'k' gtu. "c'r' g'c'v'z't'c'v'c'f'f'k'k'x'g'y cu'cf'f'g'f'v'q'ij g' u'q'w'k'p'u. "y j' k'ej "c'eu'cu'c'c' d'k'q'c'v'k'g' u'w'w'c'p'eg'."c'v'k'c'v'g'u'ij g'r' t'q'eg'u'g'u'c'v'n'k'p'i "r'c'eg'lp"ij g'u'q'k'c'p'f' "ko r t'q'x'g'u'ij g'w'r' c'v'ng'q'h'p'w't'k'p'w'lp'r' r'c'p'w'u"]4\_0' WCD'ōM'rc'uo c'p'p'f'g'k'o c'p'p'ō" "k'w'w" r'g'c'v'c'p'f' r'q'c'w'k'uo "j { f'q'z'k'f'g'y g't'g'w'ug'f'v'q'q'd'v'c'p'ij g'z't'c'v'c'v'w'r'v'q'42" "q'h'ij g' q'd'v'c'p'g'f' g'z't'c'v'c'v' cu'cf'f'g'f'v'q'ij g'ht'k'k' w'k' h'g't'v'k'k' gtu'0'K'ij g'r'c'd'q't'c'v'q't { "v'g'u'k'v'y cu'ht'q'w'p'f'ij cv'ij g'c'f'f'k'k'q'p'q'h'r' g'c'v'z't'c'v'c'v' r'k' w'k' "p'k't'q'i g'p'ecreko "o ci pguiko 'ht'v'k'k' gtu't'g'f' we'g'f'ij g'p'k't'q'i g'p' e'q'p'eg'p't'c'v'k'p'lp'ht'q'o "č'44" "v'q'č'38" . "cpf"ij g'c'f'f'k'k'q'p' q'h'ij g'z't'c'v'c'v'f'k'p'q'v'c'h'g'ev'ij g'ecreko "cpf" o ci pguiko "e'q'p'eg'p't'c'v'k'p'0'Vj g'r'J "x'c'w'g'q'h'ht'k'k' w'k' h'g't'v'k'k' gtu'y k'ij "r' g'c'v'z't'c'v'c'v' k'p'et'g'c'ug'u'c'p'f' "x'c't'k'g'u'd'g'y g'g'p'707"cpf'90. "ij g'f'g'p'uk'f' "k'p'et'g'c'ug'u'ht'q'o "30487630492"i'le'o 5"v'q'30554630557"i'le'o 5"cpf"ij g' x'k'ue'q'uk'f' "k'p'et'g'c'ug'u'ht'q'o "207762097"o'le'o l'4"v'q'20876206"o'le'o l'4'0'Vj g'et { u'cn'k' c'v'k'p'v'go r g't'c'w't'g'q'h'ht'k'k' w'k' "p'k't'q'i g'p'ecreko " o ci pguiko 'ht'v'k'k' gtu'y k'ij "r' g'c'v'z't'c'v'c'v'x'c't'k'g'u'lp'ij g't'c'p'i g'q'h' /3407'ō'37'āE0'c'm'ij g'ur' g'k'ht'g'f' r'j { u'lecn'r' t'q'r' g't'v'g'u'eq'o r n'ij y k'ij "ij g't'g's'v'k't'go g'p'u'ht'ij h'k' w'k' h'g't'v'k'k' gtu'0

K'p' e'q'p'en'w'k'p'."c' u'q'w'k'p'q'h'ij g'f'geqo r qu'k'k'p'q'h'f' q'q'o kg'y k'ij "67" "p'k't'le'cefk' . 'p'g'w't'c'ri'k' g'f'ij k'ij "47" "co o q'p'k'c'y cv'gt'cpf"ij k'ij "ij g'c'f'f'k'k'q'p'q'h'5: " "w'g'c'ecp'r' t'q'f we'g'f'ht'k'k' w'k' "p'k't'q'i g'p'ecreko "o ci pguiko 'ht'v'k'k' gtu'e'q'p'v'c'p'k'p'i "4307" " P. "50" "M'q. "508" "E'c'Q'cpf"407" "O i Q'y k'ij "c'et { u'cn'k' c'v'k'p'v'go r g't'c'w't'g'q'h'5'āE0'c'f'f'k'k'q'p'q'h'42" "r' g'c'v'z't'c'v'c'v'c'p' dg'w'ug'f'v'q'r' t'q'f we'g'd'k'q'c'v'k'g'ht'k'k' w'k' "p'k't'q'i g'p'ecreko "o ci pguiko 'ht'v'k'k' gtu'e'q'p'v'c'p'k'p'i "3708" "P. "50" "M'q. "508" "E'c'Q' cpf"407" "O i Q'y k'ij "c'et { u'cn'k' c'v'k'p'v'go r g't'c'w't'g'q'h' /37'āE0'

[3\_Y c't'p'g't. 'I'qj p'0'F q'q'o kg'q'c'ew't'g'p'eg'g'x'q'w'k'p'."cpf' "g'eq'p'q'o lecn'r' "ko r q't'c'p'v'c'w'q'k'c'v'k'p'u'0'G'ct'ij /U'el'g'p'eg' T'x'k'g'y u'4222-0'  
 [4\_F] k'c'f'g'm' MOD'c'ule'ej go lecn'eq'o r qu'k'k'p'c'p'f' d'k'q'c'v'k'g'eq'o r q'w'p'f' u'eq'p'v'p'lp' h'g'g'ev'g'f' "w'k'w'c't'u'q'h'd'w'eny j' g'c'v'ij j' q'g' "h'g'g'f' u'f' g'ij w'ng'f' "h'g'g'f' u'c'p'f' j' w'w'0'  
 I0'E'g't'c'n'U'el'08; .3/: 'r'0\*4238-0'

# OPTICAL AND REDOX PROPERTIES OF POLYMETHINE DYES

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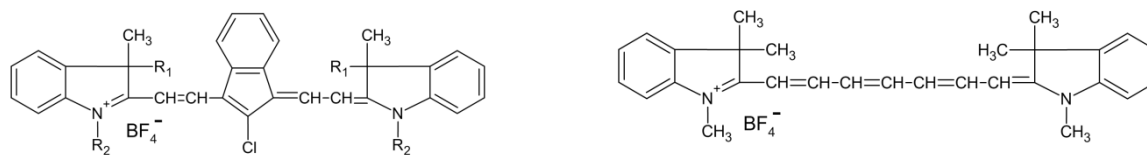
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Polymethine dyes (PD) have become important for many biomedical applications, including photodynamic therapy of cancer [1]. Among a great number of polymethine dyes, indotricarbocyanine dyes attract special interest due to long-wavelength absorption possessing a high penetration depth into the majority of biological tissues. To increase the water solubility and specificity of accumulation in tumor, indotricarbocyanine dyes can be modified with biocompatible compounds, such as polyethylene glycols [1]. Some features of the photochemical transformations of indotricarbocyanine dyes can be investigated using the combination of cyclic voltammetry and optical spectroscopy to reveal the parameters for optimal performance of dyes in model and physiological media. Herein, we studied the optical and redox properties of different indotricarbocyanine dyes by optical spectroscopy and cyclic voltammetry.

Symmetric cationic indotricarbocyanine dyes (PD1–4) were synthesized and purified as previously described [2]. The concentration of dyes in acetonitrile solutions was 0.14 mM (PD1), 0.25 mM (PD2, PD3) and 0.2 mM (PD4). The redox activity of the indotricarbocyanine dyes was examined by cyclic voltammetry (CV) using an Autolab PGSTAT 302N potentiostat in a standard three-electrode cell. Pt disc electrode (diameter - 0.4 mm) and Pt wire were used as the working and the counter electrodes, respectively. An Ag/Ag<sup>+</sup> (0.01 M AgBF<sub>4</sub>) electrode (+0.32 V relative to the SCE) served as the reference electrode. UV-vis spectra were acquired on a SOLAR PV 1251 spectrophotometer.



**PD1** (R<sub>1</sub>=CH<sub>3</sub>, R<sub>2</sub>=C<sub>3</sub>H<sub>6</sub>COOH);

**PD2** (R<sub>1</sub>=CH<sub>3</sub>, R<sub>2</sub>=C<sub>3</sub>H<sub>6</sub>COOPEG<sub>300</sub>); **PD3** (R<sub>1</sub>=C<sub>2</sub>H<sub>5</sub>, R<sub>2</sub>=CH<sub>3</sub>)

**PD4**

Fig.1. Structural formulas of the studied indotricarbocyanine dyes.

Figure 2a demonstrates the absorption spectra of indotricarbocyanine dyes in acetonitrile containing a supporting electrolyte (0.1 M tetrabutylammonium tetrafluoroborate (TBABF<sub>4</sub>)). The absorption maxima of the long-wavelength band of dyes are at 713 (PD1 and PD2), 705 (PD3), and 739 nm (PD4). Figure 2b shows typical CV curves recorded for the dyes in the range from -0.5 to 1.1 V (sweep rate - 0.2 V/s). The pronounced wave is observed at anodic polarization. Moreover, maximum of this wave (E<sub>ox</sub>) as well as reversibility of the electrooxidation depend significantly on the structure of the dye. The dyes PD1–3, characterized by the same structure of the polymethine chain, but different groups bound to nitrogen atoms of heterocycle, have similar E<sub>ox</sub> values ranging from 0.88 to 0.91 V. Moreover, the dyes PD2 and PD3 demonstrate a relatively high reversibility of the oxidation process. The electrooxidation of the PD1 is only partially reversible: the reduction wave on the reverse scan is much smaller in magnitude than the oxidation wave. At the same time, the PD4 exhibits completely irreversible oxidation process with E<sub>ox</sub> = 0.55 V.



Fig. 2. Absorption spectra (a) and CV curves (b) of indotricarbocyanine dyes in acetonitrile containing 0.1 M TBABF<sub>4</sub>. The curve number corresponds to the dye number in Fig.1.

Based on the literature data [2], it can be assumed that the electrooxidation of cyanine dyes PD1–4 in the potential range of 0.4 – 1.1 V is associated with the formation of radical dication. The stability of radical dications, as measured by their anodic CV response, is markedly dependent on the structure of the dye. The radical dications of PD4, which has no substituents in the polymethine chain, undergo rapid dimerization through the even carbon atoms of the polymethine chain, which explains the irreversibility of the oxidation reaction of this dye. The appearance of a substituent (aromatic ring) in the polymethine chain in the case of PD1–3 dyes creates steric hindrance for the dimerization reaction of the resulting radical dications, which significantly increases their lifetime and, accordingly, the reversibility of the electrooxidation process.

[1] A. A. Lugovski, M. P. Samtsov, K. N. Kaplevsky et al., Novel indotricarbocyanine dyes covalently bonded to polyethylene glycol for theranostics, *J. Photochem. Photobiol. A: Chem.* **316**, 31-36 (2016).

[2] R. L. Parton, J. R. Lenhard, Dimerization reaction of cyanine radical dications, *J. Org. Chem.* **55**, 49-57 (1990).

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DID NOT PARTICIPATE

**HCDTKE CVKQP 'QHRJ QURJ QT'KPI NCUU'O CVTKZ'O CVGTKCNU'  
 WKNK KPI 'PQXGN'NQY 'O GNVKPI 'VGO RGTCVWTG'RJ QURJ CVG'  
 I NCUUGU'**

O cpvcu'P qtmw<sup>3</sup>. 'I gf ko kpcu'P kwte<sup>4,5</sup>. 'Tco pcu'Uhwf flkw<sup>3</sup>. "

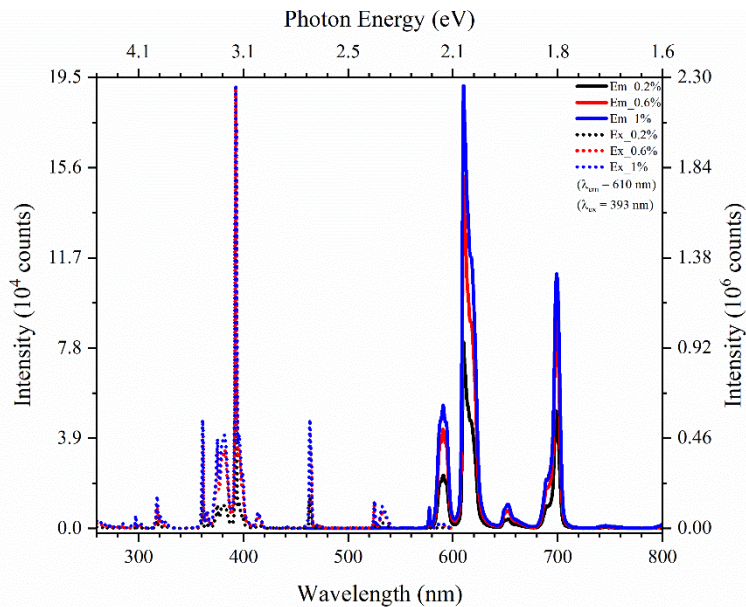
<sup>3</sup>Hcwm{ "qh'Ej go kwt { "cpf 'I gqukgpegu'kpukwg'qh'Ej go kwt { . 'Xkpkwu'Wpkgtuk{ . 'P cwi ctf wmq'w046. 'NV/25447'  
 Xkpkwu. 'Nkj wcpk"

<sup>4</sup>Fgr ctwo gpv'qh'Qti cple'Ej go kwt { . 'Egpyt'ht' Rj { ulecn'Uekpegu'cpf 'Vgej pqmji { "HVO E+. 'Ucwn vgnkq' Cxg05. 'NV/  
 32479. 'Xkpkwu. 'Nkj wcpk"

<sup>5</sup>kpukwg'qh'Ej go lecn'Rj { uleu. 'Hcwm{ "qh'Rj { uleu. 'Xkpkwu'Wpkgtuk{ . 'Ucwn vgnkq' Cxg05. 'NV/32479. 'Xkpkwu. 'Nkj wcpk"  
o cpvcu'pqtmwB ej i hkwth'

Kpecpf guegpv'iki j v'uwtegu'j cxg'o quw{ "dggp"uj khgf "qw'qh'yj gk"cr r rdecvqp"ctgcu'y kj "vj g'eqo o gteknk cvkqp"qh" NGF'iki j vpi 'uqmwkpu. 'gur gekm{ 'y kj "vj g'tkug'qh'y j kg'NGF u'j3\_0Qpg'qh'yj g'o quv'eqo o qp'y c{ 'u'qh'g'cuk{ 'tgerkupi 'uwej " c'f gxleg'ku'v'eqo dkgp{ "gmuy 'rj qur j qt' "CI <Eg<sup>5</sup> +f kur gtugf "kp'ukleqpg'qt'qvj gt'qti cple'tgukp'cpf 'dnwg'go kwkpi 'kpi cP" ej k'u0Vj ku'hwf "qh'vgej pqmji { "j cu'ku'iko kcvkpu'kp'cr r rdecvqp"ctgcu'y j g'g'j ki j "dtki j vpgu'qh'NGF u'ctg'tgs wkt gf "ctkugu" c'p'ggf "v'wug'j ki j 'ewtgpv'f g'pukgu'y j lej 'kp'wtp'o cng'u'y g'lwpevqp'dgy ggp'dnwg'NGF'cpf { "gmuy 'rj qur j qt'f tco v'ecm{ " kpetgucg'kp'vgo r gtcwtg. "y j lej "j cu'cp"ko r cev'qp"vj g'mpi g'xk{ "qh'yj g'rj qur j qt'eqo r qukg0C'v'j ki j "vgo r gtcwtg'u'yj g' vj gto cni'ci kpi "qh'yj g'ukleqpg'tgukp'ku'ur gf "w. "y j lej "rgcf u'v'q'no kpwu'ghlekpe{ "f gi tcf cvkqp'cpf "eqpu'cpv'eqm{ "uj kh" vj wu'rgcf kpi "v'q'tgf vevkqp'kp'mpi /vgo "tgrkdtk{ "j4.5\_0'k'qt'gf "v'ko r tqxg"vj gto cni'ej ctcevt k'ku'cpf "gzv'p'f "NGF u' qr gtcvpi "vgo r gtcwtg'tcpi g'ugxg'cn' uqmwkpu"j cxg'dggp'r tqr qugf "kp'tgegpv'rkgtcwtg. "uwej "cu. "vj g'waci g'qh'xctk'wu' k'qti cple"i nuugu'dqv "cu'o cv'legu'cpf "cu'eqo r qukg'o cvgtkcu'ht'rj qur j qtu. "et{ ucnk' kpi "rj qur j qtu'f k'gevn{ "kp'o qnwp" i nuu'r'tgewtu'qt'u{pvj guk' kpi "t'cpur ctgpv'egtco le'rj qur j qt' r'v'gu'j6\_0'

Kp'y ku'y qtmr'j qur j cvg'i nuugu'y kj "f'khgtgpv'eqo r qukwkpu'y g'g'u{pvj guk' gf "cpf "gucdrkij gf "cu'j quw'o cvgtkcu'ht" Gw<sup>5</sup> "kpu0Vj g'i nuu'r'tgewtu'qt'u'cpf "no k'puegpv'o cvgtkcu'y g'g'i tqwpf "cpf"o kzgf "v'q' g'v'gt. "o gngf "k'c"o whng'hwtpceg0' Vj g'o qnwp'o k'wtg'y cu'r'qwtg' "kp'v'r'tgo cf g'dtcu'v' qnf u'cpf "j gev'f "ci c'k'p'cv'hw'gt'vgo r gtcwtg'u'v'q'tgrk'x'g'kp'v'p'ncil'wt'gu' "pco gf"o gm's wpej kpi "v'gej p'ks w'g'0'Vj g'q'v'cl'p'gf "uco r ng'u'y g'tg'r qn'k'j gf "cpf"ej ctcevt k'gf "d{ "z/tc{ "f'k'ht'cevgo g't{. " uecp'kpi "gr'gevt'qp"o let'queqr { . 'Tco cp'ur gev'queqr { . 'rj qv'q'no k'puegpep'o gcuwtgo gpw'cpf "k'p'v'ev'k'gn{ "eqw'rgf "r'nuo c" qr v'ecni'go ku'kqp'ur gev'to g't{0'



Hki wtg'30Go ku'kqp'cpf "gzekcvkqp'ur gev'tc'qh'r'j qur j cvg'i nuugu'y kj "f'khgtgpv'o qrl "qh'Gw<sup>5</sup>"

[3]\_UOP cmo wtc. "O 0Ugpqj . 'U'K'P ci c'j co c'gv'cn0'k'p' cP/Deugf "O wnk'S wcpwo /Y gm'Ut weww'g'Neugt'F kqf gu. 'Lcr cpgug'Lqwt'pni'qh'Cr r r'ngf "Rj { uleu." 57. 'N96/N98. "3; ; 8+0'  
 [4]\_L0L0Y l'gt'gt. 'L0L' 0'Vu'q. 'F 0'U'U'k' qx. 'E'qo r c'tk'qp'dgy ggp'dnwg'rcu'gtu'cpf "r'ki j v'go kwkpi "f'k'f'gu'ht'hw'wtg'u'rkf/ucv'v'ki j v'pi . 'Neugt'(" 'Rj qv'q'pleu" T'gx'ly u. '9. ; 85/ ; 5. "4235+0'  
 [5]\_O 0 0Ej cpi . 'F 0F cu. 'R0X0'Xctf g. 'O 0R'gej v'N'ki j v'go kwkpi "f'k'f'gu't'gr'kdtk{ 't'gx'ly . 'O let'q'gr'gevt'p'leu'T'gr'kdtk{ . '74. '984/9: 4. "4234+0'  
 [6]\_J 0N'p. 'V0J w'l' 0Ej gpi 'g'v'cn0' nuu'E'gtco le'Rj qur j qtu-<V'qy ctf u'N'qpi /N'k'hw'o g'J ki j /R'qy g't'Y j kg'N'ki j v'Go kwkpi /F'k'f'g'Cr r r'ecv'k'pu/C' T'gx'ly . " Neugt'(" 'Rj qv'q'pleu" T'gx'ly u. '34. '3922566"423: +0'

# C'O KETQY CXG/HCEKWK/CVGF 'U P VJ GUKU'QH'O CI PGVKE 'Hg<sub>5</sub>Q<sub>6</sub>' P CPQRCTVÆNGU'

I { vwg'Ukti gf ckg<sup>3</sup>. 'Nkpc 'O knrkwpckg<sup>3</sup>.<sup>4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rj { ulecn'Ej go knt { . 'Kpukwag'qh'Ej go knt { . 'Hewm { 'qh'Ej go knt { 'cpf 'I gquelpegu. 'Xkpkwu'Wpkxgtuk { . " Nkj wcpk "

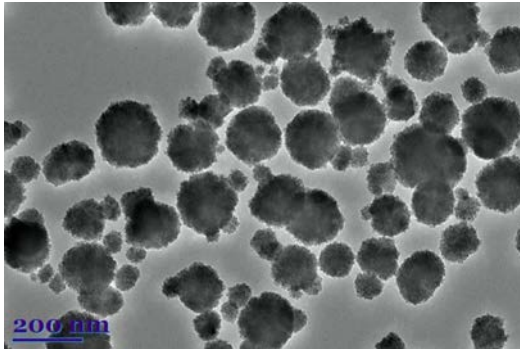
<sup>4</sup>F gr ctvo gpv'qh'Qti cple'Ej go knt { . 'Egpygt'ht'Rj { ulecn'Uelgpegu'cpf 'Vgej pqmji { . 'Nkj wcpk "  
i { vwg'Ukti gf ckgB ej i hmwf'kw0m "

Qxgt'vj g'mu'wy q'f gecf gu.'o ci pgve'pcpqr ctvængu'j cxg'i clpgf 'r qr wrtkv' f'wg'v'j gk'vj gto qrj { ulecn'r tqr gtvægu." y j lej "ecp"dg"cr r rkgf "kp"xctkqwu'f luekr rkgu'/'dlqmj { . "o gf lekpg. 'ej go knt { . "rj { uleu'Vj gte'ctg"o cp { "cr r rkecvæpu'qh' pcpqr ctvængu'cpf "vj g' 'ctg"o cnpk "r tqi tguu'kp"o cp { "hkrf u'qh'uelgpeg<'f twi "f grkxgt { . "vj gter gwle"ci gpu'ht "ecpegt" vtgcvo gpv.'o ci pgve'tguqpcpeg'ko ci kpi . 'dlqmj lecn'ugpuqtu.'ecvcl'uu.'o ci pgve'tgeqtf kpi 'o gf k'j3\_0"

O ci pgve'pcpqr ctvængu'ctg'qdvclpgf "Itqo "qzfk gu'qh'ktqp."eqdcn'qt'plengn'y j lej "j cxg'ur gekn'r tqr gtvægu."uwej "cu' uwtæceg'cpf 'xqmw g'tcvægu.'cpf "j ki j 'o ci pgve'vo go gpv'OKap'qzfk g'pcpqr ctvængu'ctg'ugrægef 'ht'bo ci pgve'uwf lgu'f'wg'v'j vj gk'gcu { "cxkckdkk { 'cpf "uwr gtr ctco ci pgve'r tqr gtvægu"14\_ "j5\_0Vj g'uk' g'qh'v'j g'pcpqr ctvængu'ctg'gu'htqo "32"po "vq"322" po 0Vj g'uj cr g'cpf "uk' g'qh'pcpqr ctvængu'ctg'ko r qtcv'v' ctco gvgtu'ht'u { pvj guku'cpf "cr r rkecvæpu'dgecvægu"ci "rti g'uwæceg" ctgc "kpetgcugu'tgcevkxk { . "kq'v'ctpuhtg. "qt"eqpvcv'0Dguk' gu.'rj { ulecn'r tqr gtvægu'uwej "cu'uj cr g."eqo r qukkqp."ej cti g."cpf " uqmwdkk { "ecp"wp'rgf lcvcln { "ej cpi g"pcpqr ctvængu'dg'cxkqwt'K'ku'v'j g'ghgtg"ko r qtcv'v'v'f lueqxtg"o gvj qf u'v'q"qdvclp" f gultgf "uk' g.'uj cr g."cpf "r tqr gtvægu'qh'bo ci pgve'pcpqr ctvængu'j3\_0'

O ci pgve'pcpqr ctvængu'ctg'u { pvj guk' gf "wukpi "vj tgg'f khtgtpv'r tgr ctvæqp'tqwg'u'c+'dlqmj lecn'o gvj qf u."d+r'j { ulecn' o gvj qf u."cpf 'e+'ej go lecn'o gvj qf u'ORj { ulecn'o gvj qf u'ctg'gcu { "v'g' gthqto . 'j' qy gxtg. 'eqpvtqnh'v'j g'r ctvæng'uk' g'ku'f khtewn'0 Dkqmj lecn'o gvj qf u'cuuwtkpi "hty "equv."j ki j " { kgrf . "tgr tqf wekdkk { . "dw'v'ko g/equwo kpi 0Ej go lecn'u { pvj guku'bo gvj qf u'ctg" o clpn { "wug' f'wg'v'hty 'r tqf wekqp'equ'v'cpf "j ki j 'r tqf wekxk { 0Ej go lecn'u { pvj guku'tqwg'kpxqrgu'grægtqej go lecn'o gvj qf . " uqni'gr' o gvj qf . "j { f tqv' gto cil' o gvj qf . " ej go lecn'eq'r tgekr kcvæqp. "o letqgo wukqp. "uqrxqy gto cil' o gvj qf . "o letqy cxg" o gvj qf 0Eqo r ctkpi "vj gug'v'gej plx wgu."gcej "qh'v'j go "j cu'cf xcpvc' gu'cpf "f kucf xcpvc' gu."f gr gpf kpi "qp'uk' g.'utwewt g.'v'ko g." { kgrf . "tgr tqf wekdkk { 0'k'cni'v'j gug'v'gej plx wgu."cs wgwu' o gf kwo "ku'v'j g' o qu'v'ghlekp'v'r cvj y c { "v'q"qdvclp"ktqp"o ci pgve" pcpqr ctvængu'OK'j cu'dggp'f go qpuv'cv'g'f "vj cv'v'j g'r ctvæng'uk' g."cu'y gml'cu'v'j g'r qn'f kur gtuk { "qh'v'j g'pcpqr ctvængu."eqw'f "dg" vclq'gt'f "d { 'ej cpi kpi 'hcvæqtu'uwej "cu'Hg<sup>4</sup> IHg<sup>5</sup> 'tcvæ. 'dcug'P cQJ . 'co o qpkwo "j { f tqz'k'g+'cpf 'kqple'utgpi vj 0Qv'j gt' hcvæqtu" cu'bo kzkpi 'tcvæ. 'vgo r gtcvæw'g.'ci kcvæqp.'rj . 'cpf 'tgcvcv'p'u'cvæq'kphwæpeg'pcpqr ctvængu'uk' g'cu'y gml'j6\_0"

Kp'v'j ku'y qtm'y g'r tgu'gpv'c'eqo r ctvæqp'qh'ktqp'qzfk g'pcpqr ctvængu'u { pvj guk' gf "d { "o letqy cxg'v'gej plx wgo'F khtgtpv' u { pvj guku'v'ko g.'vgo r gtcvæw'g'y cu'kpxguki cv'g'f "cu'y gml'cu'v'g'f wekqp'ci gpv'0Qdvclpgf "pcpqr ctvængu'y gte'g'kpxguki cv'g'f "wukpi " Z/Tc { "Ur gestqueqr { . 'Vtcpuo kulkqp'Ggestqp'O letqueqr { 'cpf "Tco cp'Ur gestqueqr { 0



Hk' 030VGO 'lo ci g'qh'bo ci pgve'ktqp'qzfk g'pcpqr ctvængu'u { pvj guk' gf "wukpi "o letqy cxg'u { pvj guku'tgcevt'0

## Cenpqy ngf i go gpv'

Vj ku' tgu'gctej "ku' hwpf gf" d { "vj g' Gwtqr gcp" Uqelcn' Hwpf "wpf gt" vj g' P q" 2; 05/NO V/M/934" 0F gxgnr' o gpv' qh' Eqo r gvgpegu'qh'Uelgpkwu."qjy gt'Tgugctej gtu'cpf "Uwv'gpw'v'j tqwi j 'Rtcevecn'Tgugctej "Cevækkku'bo gcuwt'g'0

13\_ 'C'0UUVgcl.'RQ' 0Mqj . 'U { pvj guku.'r tqr gtvægu.'cpf "cr r rkecvæpu'qh'bo ci pgve'ktqp'qzfk g'pcpqr ctvængu'0Rtqi tguu'lp'Et { ucn'I tqy vj "cpf 'Ej ctcevgtk' cvæqp' qh'0 cvgtkcn.'77\*3/4+'44/67'\*422; +0"

14\_ 'X'0'Ej cvf'j ct { . "T'0'Ej cvf'j ct { . "O ci pgve" 'Pcpqr ctvængu'<'U { pvj guku' 'Hwpvæq'pck'cvæqp. "cpf " 'Crr rkecvæpu'0'Gpe { enyr'gf'k' " qh' 'Pcpquækgpeg' "cpf " Pcpq'gej pqmji / . \*Xcngpek<'Co gtlecp'Uelg'v'hle'Rvdrkij'gtu.'423; +0

15\_ 'F'0Z'kq. "gv'cn'0'Rtgr ctvæqp'cpf "j ki j v'g'f "cr r rkecvæpu'qh'bo ci pgve"o letqy ctvængu'cpf "pcpqr ctvængu'c'tgxly 'qp'tegpev'v'f xcpv'00 letqej ko lec" Cev. '3: 5\*32+'487764897'\*4238+0

16\_ 'C'0C'rk'gv'cn'0'U { pvj guku.'ej ctcevgtk' cvæqp.'cr r rkecvæpu.'cpf "ej cngpi gu'qh'ktqp'qzfk g'pcpqr ctvængu'0P cpq'gej pqmji { . 'Uelgpeg'cpf "C' r rkecvæpu; . " 6; 089\*4238+0

P6-45

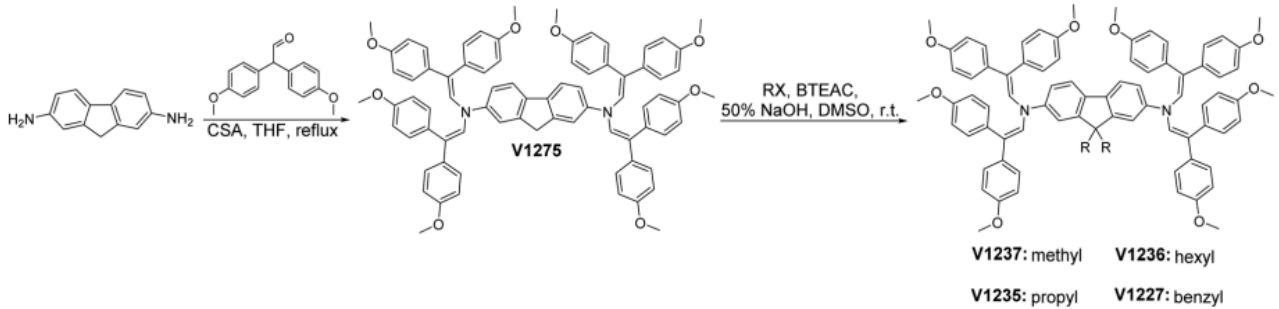
DID NOT PARTICIPATE

**HNWQTGP G/DCUGF 'GPCO KPGUCUNQY /EQUV'CPF 'FQRCPV/HTGG'  
J QNG'VTCPURQTVKPI 'O CVGTKCNU'HQT'J K J 'RGTHQTO CPEG'CPF "  
UVCDNG'RGTXUMKVG'UQNCT'EGNNU'**

Uctwpg'F cunxlekwg<sup>3</sup>. 'Et kxkpc' O qo dmpc<sup>4</sup>. 'Mcur ctu' Tcmv{ u<sup>3</sup>. 'Crdgt wu' Cftkcp' Uwcpvq<sup>4</sup>.  
O ct { v'g' F cunxlekwg<sup>3</sup>. 'X { i kpcu' Lcpnawm<sup>5</sup>. 'Cn { ku' I twqf k<sup>5</sup>. 'I kgt g' Dwdpkpg<sup>3</sup>. 'X { cwcu'  
I gxcw<sup>3</sup>. 'O qj co o cf' 'Mj clc' P c| ggtwf f k<sup>4</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Qti cple' Ej go kvt { . 'Mwpcu' Wpkxgtuk{ 'qh' Vgej pqm { . 'Nkj wcpk' "  
<sup>4</sup>I tqw' 'hqt' O qngewct' Gpi kpggtkpi 'qh' Hwpevkpcn' O cvgtkcn' Kpukwv' qh' Ej go lecn' Uekpegu' cpf 'Gpi kpggtkpi . ' eqng'  
Rqn' vgej pls w'g' Hf<sup>2</sup> teng' f' g' Ncwcpvg. 'Uy kj gtrpf "  
<sup>5</sup>Kpukwv' qh' Ej go lecn' Rj { uku. 'Xkpkw' Wpkxgtuk{ . 'Nkj wcpk' "  
uctwpg' F cunxlekwg B mw<sup>3</sup>"

Vj g' r qy gt' eqpxgtukp' ghlekpe { "qh' r gtqxunkg' uqnt' egmu' ku' cr r tqcej kpi " vj g' Uj qemg { 6S wkuugt' rko kv' cpf "  
vj g' ghqtg' vj ku' vgej pqm { " ku' pgz' v' q' vj g' eqo o gtekrk' c' vkp' u' ci g' ]3\_0' kpgzr' gpukxg' cpf " ucdng' j' qng' t' c' pur' qt' v' kpi " o cvgtkcn'  
ctg' j' ki j' n' " f' gukt' cdng' " hqt' " vj g' uweeguuhwi' uecng' w' r' O' O' quv' j' ki j' " r' gthqto kpi " f' gxlegu' i' gpgtcm { " go r' m { " g' zr' gpukxg' j' qng'  
eqpf' wev' tu' vj' cv' ctg' u' { vj' guk' gf' " xlc' " etquu' eqw' r' kpi " t' gcevkpu' y' j' kej' " t' gs' wktg' " g' zr' gpukxg' " ecv' cn' u' u' . " kpgt' v' t' gcevkp' " eqpf' k' k' pu'  
cpf' " ko' g' eqpuwo kpi " uqr' j' k' u' ecv' gf' " r' tqf' we' r' w' k' h' ecv' k' p' ]4\_0' k' c' s' wgu' v' q' go r' m { " eqv' gh' g' ev' xg' " ej' go kvt { " v' q' eqo' d' k' pg' vj' g'  
dwkf' kpi " d' m' emu' . " y' g' " g' zr' m' t' g' " g' pco' k' pg' / dcugf' " uo' cni' o' qngewgu' vj' cv' ecp' " dg' u' { vj' guk' gf' " k' p' c' " uko' r' ng' " eqpf' gpuc' vkp' " t' gcevkp'  
htqo' " eqo o gtekrk' " c' x' c' k' cdng' o' cvgtkcn' " r' g' cf' kpi " v' q' " cp' " guko' cv' gf' " o' cvgtkcn' " eqv' qh' c' " h' gy' " g' w' tu' r' t' g' i' t' co' 0' "



Hki 030Utkci j' vhty ctf' t' gcevkp' uej go g' qh' hnwqtgpg' g' pco' kpg' J VO u' c' pf' vj' gk' o' qngewct' ut' wewt' gu0'

Vj g' u' { vj' guk' gf' " hnwqtgpg' / dcugf' " g' pco' kpgu' " g' z' j' k' k' v' c' " xgt' { " j' ki j' " j' qng' o' qd' k' k' v' " w' " v' q' " 50 " " 32 / 6 " eo " 4 " X<sup>3</sup> " u<sup>3</sup> " c' pf' " g' p' cdng' "  
vj' g' h' d' t' k' ecv' k' p' " qh' r' g' t' q' x' u' n' k' g' " u' q' n' t' " e' g' m' u' " y' k' j' " c' o' c' z' k' o' w' o' " r' q' y' g' t' " e' q' p' x' g' t' u' k' p' " g' h' l' e' k' p' e' { " qh' 3; 0 " " k' p' c' " f' q' r' g' f' " e' q' p' h' i' w' t' c' v' k' p' "  
c' pf' " 390 " " y' k' j' q' w' f' q' r' k' pi' 0' k' p' " c' f' k' k' p' . " d' q' j' " RUE " u' { v' g' o' u' f' go' q' p' u' t' c' v' g' " u' w' r' g' t' k' q' t' " m' p' i' / v' g' t' o' " u' c' d' k' k' v' { " e' q' o' r' c' t' g' f' " v' q' " u' r' k' t' q' /  
QO g' VCF 0' "

	HTM	V <sub>oc</sub> (mV)	J <sub>sc</sub> (mA cm <sup>-2</sup> )	FF	PCE (%)	R <sub>s</sub> (Ω)	HTM thickness (nm)
Doped-HTM	V1275	1077	23.24 (23.11)	0.77	19.3	5.9	~150
	V1237	1090	22.97 (22.74)	0.76	19.2	6.2	~150
	V1235	1089	22.86 (22.85)	0.77	19.2	5.1	~150
	V1236	1094	22.95 (22.94)	0.76	19.1	5.2	~150
	V1227	1024	22.32 (21.82)	0.55	12.6	26.0	~120
	Spiro-OMeTAD	1115	22.97 (21.86)	0.77	19.7	5.7	~260
Dopant-free HTM	V1275	1033	22.95 (22.81)	0.72	17.1	22.2	~70
	V1237	1038	22.98 (22.93)	0.71	16.9	22.9	~70
	V1235	1029	23.09 (22.81)	0.70	16.6	24.5	~70
	V1236	1022	23.02 (22.88)	0.69	16.2	25.2	~70
	Spiro-OMeTAD <sup>58</sup>	972	22.83	0.47	10.4		

Vcdng' 30Rj' qvqxncle' r' ctco' gvgtu' " ugt' lgu' t' guku' c' peg' . " c' pf' " vj' kempuu' qh' vj' g' hnwqtgpg' / dcugf' " g' pco' kpg' J VO u' g' z' v' t' c' ev' gf' "  
htqo' " vj' g' d' gu' r' g' thqto kpi " f' gxlegu0' "

Vj ku' y' qtn' luj' qy u' vj' cv' j' qng' t' c' pur' qt' v' kpi " o' cvgtkcn' r' t' gr' ctg' f' " xlc' c' " uko' r' ng' " eqpf' gpuc' vkp' r' tqv' eqn' j' c' xg' vj' g' r' qv' gp' v' k' n' v' q' "  
eqo' r' g' v' g' " k' p' " v' g' t' o' u' qh' r' g' thqto' c' peg' y' k' j' " o' cvgtkcn' " q' d' v' c' k' p' g' f' " xlc' " g' zr' gpukxg' " etquu' eqw' r' kpi " o' g' y' q' f' u' " cv' c' " h' t' c' ev' k' p' " qh' vj' gk' "  
eqv' c' pf' " f' g' r' k' x' g' t' " g' z' e' g' r' v' k' p' c' n' i' u' c' d' k' k' v' { " qh' vj' g' h' k' p' c' n' f' g' x' l' e' g' 0' "

[3] P.TGN. 'Rj' qvqxncle' T' g' u' g' c' t' e' j' < D' g' u' w' T' g' u' g' c' t' e' j' ' E' g' m' i' G' h' l' e' k' p' e' / ' E' j' c' t' v' : ' j' w' r' u' d' l' y' y' ( p' t' g' r' i' q' x' l' r' x' l' e' g' m' i' G' h' l' e' k' p' e' { ' j' vo n' c' e' e' g' u' g' f' 4: ' C' r' t' k' i' 42420  
[4] VOROKUtkci k' VOU' g' t' . ' COU' k' d' g' t' v' VO' H' vj' to' c' pp' / N' l' e' n' g' t' " c' pf' " LO' U' c' r' d' g' e' m' " E' j' go' OT' g' r' 0' 4229. ' 329. ' 3233632870

P6-47

DID NOT PARTICIPATE



# MODELING OF ELECTROCHEMICAL-BASED IMMUNOSENSORS FOR THE DETECTION OF SPECIFIC ANTIBODIES

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For the purpose to handle the ongoing pandemic of the coronavirus disease 2019 (COVID-19) rapid, specific, sensitive, and simple diagnosis methods are required. The causative agent of the COVID-19 is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), whose RNA, structural proteins, or antibodies against it can act as target biomolecules for the detection of infection in a patient sample. Biosensors are widely used for the identifications of informational biomolecules, namely, nucleic acids [1] and proteins. The latter type includes immunosensors, which work principal is the detection of antigen-antibody coupling [2]. One of the most common types of immunosensors are based on electrochemistry, because of their affordability and simplicity without loss in accuracy and sensitivity.

Our study aimed to investigate the possibility to develop a novel method for viral disease diagnosis employing a common electrochemical technique. In our work, we used electrochemical impedance spectroscopy (EIS) as a powerful tool for observing the interaction between an immobilized virus antigen and antiviral antibodies at the modified working electrode surface. Immobilization of the antigen and formation of the antigen-antibody complex affected ion diffusion and electrical capacitance, thus influencing on electrochemical impedance of electrodes [3]. To immobilize the virus antigen on the working surface a self-assembled monolayer (SAM) was used, as an effective reusable tool for stable covalent binding of biomolecules to the different solid surfaces [4]. SAM modification was applied to the working gold electrode being part of an electrochemical cell that also included the platinum counter electrode and the reference [Ag/AgCl/KCl<sub>sat</sub>] electrode.

Our experiments showed correspondences between impedimetric signals and stepwise modifications of electrode surface. We achieved a reproducible trend of significant increasing electrical impedance, i.e. electron-transfer resistance, on the key stage of antibody coupling. That fact indicates an increase in the layer thickness on the working surface and thereby testifies to the registered interaction. Hence, our outcome gives us the reason to suggest EIS-based immunosensor as an effective, rapid, easy to use, and to interpret detection tool. It is also worth noting that our experiment will serve as the basis for our further research in the field of electrochemical biosensors for the diagnosis of viral diseases in particular COVID-19.

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**'VJ G'GHHGEV'QH'UVCDKX KPI 'CI GPVUR'UQNI GN'U PVJ GUK'QH'  
DIXQ<sub>6</sub>'EQCVKI U''**

F qpcvu'Rng-nf u<sup>3</sup>. 'Kgpcc'Ucxlemc<sup>4</sup>. 'Xkf cu'Rcm-æu<sup>4</sup>. 'Ctpcu'P cwlqmækk<sup>4</sup>. 'Lwti c'Lxqf mæ| { v<sup>4</sup>. "  
O kf c'Rgvtwrgxk lgp<sup>4</sup>"

<sup>3</sup>"Kpukwng'qh'Ej go knt { . 'Hæwn{ "qh'Ej go knt { "cpf "I gquelpegu "P cwi ctf wnt "ut046. "NV/25447"Xkpkwu'Wpksgtukv{ . "  
Nkj wpcle"

<sup>4</sup>"Egpgt'ht'Rj { ulecn'Uekpogu'cpf "Vgej pqrni { . 'F gr ctwo gpv'qh'ej go lecn'gpi kpggtkpi "cpf "vej pqrni { ""  
Ucwn vntk "cx05. "NV/32479"Xkpkwu-"  
g/o ckt'f qpcvu'f rgnuf uB ej i hnwf 0xv0y"

"

Tgegpw{ . 'r j qvqrgestqej go lecn'RGE+"ugpukpi "vgej pls wgu"j cxg"cwtevgf "uuducpvcn'tgugctej "kpvgtgu""lp"vj g"ctgc" qh'f gvevqpp"qh'dlqo qrgewgu0Ego r ctgf "vq"eqpxgpvqpcn'grgestqej go lecn'o gvj qf u. "vj g"RGE"ugpuqt"j cu"j ki j "ugpukxkxk" cpf "c" nqy "dcemi tqwpf" uki pcn" y j lej "ecp" dg" cuetldgf "vq" ku" ugr ctcvg" gzekcvkqp" uqvtg" cpf " f gvevqpp" uki pcn" ]3\_0' Ghhekepe{ "qh'RGE"u{ ugo u'utqpi n{ "f gr gpf u"qp"r j qvqcpqf gu. "y j lej "eqpxgtv'vj g"gpgti { "qh'xkukdrg'riki j v'kpvq"ej go lecn' gpgti { 0'Co qpi "vj g"xctkquw"r j qvqrgestqf gu"uwf lgf "ht"RGE"cr r necvkpu. "o qpqerple"dkwo wj "xpcpf cvg"\*DkXQ<sub>6</sub>+"ku" eqpukf gtf "vq"dg"cr t qo kulpi "o cvgtkcn'qy kpi "vq"ku"o qf gtcvg"dcpf"i cr "406"GX+"cpf "cr r tqr tlevg"dcpf /gf i g"r qukxkpu. " y j lej "cmqy "kv"vq"cdudtd"cu'o vej "cu"33" "qh'vj g"uqrc't'ur gextwo 0P gxgtvj grguu. "vj g"r j qvqecvni'æ'cevkxkxk"qh'dctg"DkXQ<sub>6</sub>" ku'ukn'pv'kf gcn'ht"r tcevecn'cr r necvkpu'dgecvug'qh'ku"gzeguukxg"ej cti g'tgeqo dlvkqp. "r qqt'ej cti g'tcpur qtv. "cpf "uqy " qz kf cvkqp"nkpgeu"j4\_0'

Kp"qw"y qtm'ektle"cek. "wtgc"cpf "r qn'gvj { rpgg"i n'eqn'"RGI "+"y gte"wgf" cu"ucdckk kpi "ci gpw"ht"htgo cvkqp"qh' DkXQ<sub>6</sub>"vj kp"hkro u"lp"uqn'i gn'cr r tqcej 0'Qti cple"cf f kxku"ugtxg"cu"eqo r rgzkpi "ci gpw"qh'DkXQ<sub>6</sub>"kqp. "vj gthgt" f khtgpv" o qtr j qm{ "cpf "r j qvqrgestqej go lecn'r tqr gvku"qh'DkXQ<sub>6</sub>"eqcvkpi u"ctg"qdvkpgf 0'Tcvkq"qh'ektle"cek"cpf "RGI "vq" DkXQ<sub>6</sub>"y cu'ej qugp"vq"dg"4-3. "j qy gxgt"tcvkq"qh'wtgc"vq"DkXQ<sub>6</sub>"y cu'20'3. "dgecvug"cv'j ki j gt"co qwpw"qh'wtgc"htgo cvkqp"qh' r tgekr kcvu"qeevttgf 0'Chgt" f kr /eqcvkpi "qh'DkXQ<sub>6</sub>"qp"eqpf vevkpi "i ruu" \*HVQ+"uudutcvg"cm'uco r rgu"y gte"cppgcrf"cv' 672Å"ht"4j 0'Et { ucn'pks{ "cpf "o qtr j qm{ "qh'eqcvkpi u"y gte"gxncvvgf"vukpi "Z/tc{ "f khtcvkqp"\*ZTF "+"cpf "æcpkpi " grgestq"o letqueqr { "\*UGO "+"cpcn'uku'Rj qvqrgestqej go lecn'tgur qpug"qh'qdvkpgf "eqcvkpi u"y gte"cpncf | gf "vukpi "e{ erke" xqnc o gvt { "kp" y tgg" grgestqf g" egm' kp" 20'0 " P c4UQ<sub>6</sub>" uqnvkqp" kp" vj g" f ctn' cpf " wpf gt" kmo kpcvqp" \*Hi 0' 3-0' Rj qvqrgestqej go lecn'qz kf cvkqp"qh'i næqug"y cu'uwf lgf "kp"vj tgg"grgestqf g'egm'kp"uqf kwo "dqtcvg"dwhtg" \*r J ?; "+y kj "7/ 57o O "qh'i næqug0"

"

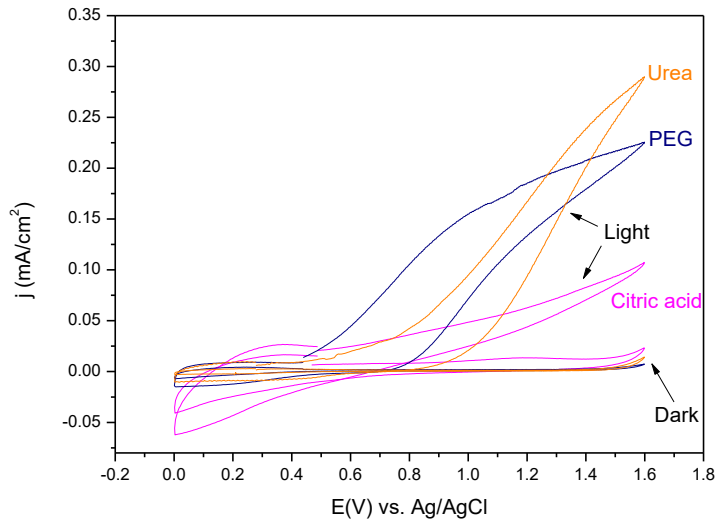


Fig. 1. Cyclic voltammograms of BiVO<sub>4</sub> electrodes in 0.5 M Na<sub>2</sub>SO<sub>4</sub> solution; potential scan rate 50 mV/s, intensity of illumination ~ 100 mW cm<sup>-2</sup>

Qdvkpgf "tguwu'tgxgrgf . "vj cv'f khtgpv'ucdckk kpi "ci gpw"utqpi n{ "kpvwpgpeg"o qtr j qm{ { "cpf "RGE"cevkxkxk"qh'vj g" eqcvkpi u0'Vj g"j ki j guv"r j qvqewtgpv"y cu"qdvkpgf "ht"eqcvkpi "u{ pvj guk'gf "y kj "wtgc" \*Hi 0' 3-0' Rj qvqrgestqej go lecn' qz kf cvkqp"qh'i næqug"uj qy gf "vj g"nkpget"gpj cpego gpv'qh'r j qvqewtgpv"y kj "kpetgcugf"eqpegpvcvqpp"qh'i næqug"kp"vj g" tcpi g'qh'7'æ'57'o O 0'Qdvkpgf "ugpukxkxkxk"qh'DkXQ<sub>6</sub>"ht"i næqug"i gvevqpp"y kn'dg'gxncvvgf "cpf "r tguvpgf 0'

[3\_]UUY cpi . "UONk"Y 0Y cpi "gv'cn'0C"pqp/gpl { o cve'r j qvqrgestqej go lecn'i næqug"ugpuqt"dcugf "qp"DkXQ<sub>6</sub>"grgestqf g'wpgf gt'xkukdrg'riki j v. "Ugpuqtu"cpf " Cewevqtu'D-Ej go lecn'4; 3. '56/63"423; -0'

[4\_]NOZlc. "LONk"LODck'gv'cn'DkXQ<sub>6</sub>"Rj qvqcpqf g'y kj "Gzr qugf "262+Hægu'ht"Gpj cpegf "Rj qvqrgestqej go lecn'Rgthgo cpeg. "P cpq/o letq'Ngvgtu"33. " 3/32"423; -0'

**O QF KHKE CVKQP 'QH'DKXQ<sub>6</sub>' CPF 'FP XGUVK CVKQP 'QH'  
RJ QVQNGE VTQEJ GO KECN'CE VKXK[ "**

Nwte' O lej ckrxc<sup>3,4</sup>. "Kgp' Uexlemc<sup>4</sup>. "I kvet "Rig mekv<sup>4</sup>. "Ctpcu' P cwlqmeku<sup>4</sup>. "Xkf cu' Rcm-cu<sup>4</sup>.  
O kf c' Rgt wgxk kgp<sup>4</sup>. "Lwti c' Lxqf ne | v<sup>4</sup>. "Tko cpvcu' Tco cpcwne<sup>4</sup>"

<sup>3</sup>"Kpukwg' qh'Ej go knt { "Hewm' "qh'Ej go knt { "cpf "I gquekpegu' P cwi ctf wna' ut046. "NV/25447" Xkpkwu' Wpkxgtukv { " Nkj wcpk"

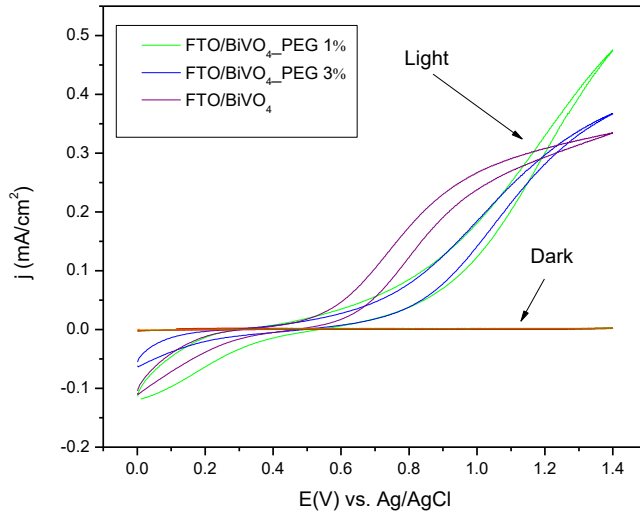
<sup>4</sup>"Egvg' hqt' Rj { uecni' Uekpegu' cpf "Vgej pqrni { "F gr cto gpv' qh'ej go kecn' gpi kpggtkpi 'cpf 'vgej pqrni { "" Ucvn vgnk' cx05. "NV/32479" Xkpkwu"  
g/o ckn' rwtc' lej ckrxcB ej i hmwf' kvom'

"

Qxgt wug' qh' hquki' hmg'j cu' tguwng' "kp' ugtk' wu' gpxk' qpo gpvcn' r tqdrgo u' "cpf "i nqden' gpgti { "uj qtvc' gu' j' cxg' dgego g" cp' "kpetgculpi n' "vti gpv' kuwng' O'Equgs wgpv' . "ergcp' cpf "tggpy cdrg' gpgti { "uqtvegu' uvej "cu' uqnt' gpgti { "j' cxg' dgego g" cp' cwtcevk' g' y' c { "q' cf f tgu' v' j' ku' gpgti { "etkuku' RJ qvqng' v' t' q' go kecn' "RGE + y' cvgt' ur' nk' w' pi' "cpf "qti' cple' r' qmwcpv' f' gi' tcf' cvk' p' f' tk' xp' "d { "xkuk' d' r' i' j' v' j' cxg' cwtcevg' "y' qtr' y' kf' g' cwgp' vk' qp' cu' r' tqo' kulpi "cr' r' nek' vk' pu' qh' uqnt' gpgti { "OJ' qy' gxgt. "c' ng' { "vgej' plecn' r' tqdrgo "tcegf' "kp' RGE" cr' r' nek' vk' pu' ku' v' j' g' f' gxgnr' o' gpv' qh' u' w' k' cdrg' r' j' qvqng' v' t' q' gu' y' j' lej' r' ne' { "cp' ko' r' qt' v' p' v' t' q' mg' kp' v' j' g' RGE" eqpxgtuk' qp' qh' uqnt' gpgti { "v' q' ej' go kecn' gpgti { "j3\_0"

Qxgt' v' j' g' ru' v' y' q' f' gecf' gu' "dkuo' wj' "xcpcf' cvg' "DkXQ<sub>6</sub>" j' cu' cwtcevg' "o' wej' "cwgp' vk' qp' cu' q' pg' qh' v' j' g' "o' qu' v' gh' h' k' gpv' " tqd' wu' v' cp' f' "k' p' g' z' r' gpuk' g' "o' g' c' n' q' z' k' f' g' r' j' qvq' cp' q' f' gu' O' Rj' qvq' ce' vk' g' e' / DkXQ<sub>6</sub> v' j' ky' "406" g' X' d' cp' f' "i' cr' "gpgti { "ecp' cduqtd' WX' cp' f' " xkuk' d' r' i' j' v' w' "v' q' "742" po' "j4\_0Rct' v' k' e' ng' uk' g' . "t' q' t' q' u' k' v' { "cpf "o' qtr' j' q' r' ni' { "qh' d' ku' wj' "xcpcf' cvg' "ecp' d' g' eq' p' v' t' q' ng' f' "y' k' j' "v' j' g' j' gr' " qh' u' t' w' e' w' t' g' f' k' t' g' e' v' k' i' "ci' gp' w' u' w' g' f' "kp' v' j' g' u' { "pvj' g' u' k' u' 0"

K' v' j' ku' y' q' t' n' l' u' q' n' i' g' n' c' r' r' t' q' c' e' j' "cpf "f' k' r' / e' q' c' v' k' i' "v' e' j' p' l' s' w' g' y' cu' r' r' n' g' f' "v' q' u' { "pvj' g' u' k' g' d' ku' wj' "xcpcf' cvg' "e' q' c' v' k' i' u' w' u' l' k' i' " f' k' h' g' t' g' p' v' co' q' w' p' u' qh' r' q' n' { "g' y' { "rgpg' "i' n' e' q' n' "RGI + \*3" "cpf "5" + "cu' c' u' t' w' e' w' t' g' f' k' t' g' e' v' k' i' "ci' gp' v' O' K' y' cu' k' p' x' g' u' k' i' cvg' f' "j' q' y' " f' k' h' g' t' g' p' v' DkXQ<sub>6</sub> - RGI "t' e' v' k' u' l' p' h' m' g' p' e' g' v' j' g' o' qtr' j' q' r' ni' { "cpf "r' j' qvq' ng' v' t' q' e' j' go kecn' r' gur' q' p' u' g' qh' v' j' g' v' j' kp' h' k' r' u' O' E' q' o' r' q' u' k' k' q' p' " cpf "o' qtr' j' q' r' ni' { "qh' v' j' g' e' q' c' v' k' i' u' y' g' t' g' "c' p' c' n' | g' f' "d { "o' g' c' p' u' qh' Z' T' F "cpf "U' G' O' "v' e' j' p' l' s' w' g' u' O' V' I' / F' U' E' "c' p' c' n' u' k' u' y' cu' w' u' g' f' "v' q' " c' p' c' n' u' g' v' j' g' v' j' g' t' o' c' n' f' g' e' q' o' r' q' u' k' k' q' p' qh' v' j' g' r' t' g' e' w' t' u' q' t' u' q' n' w' k' q' p' o' k' z' w' t' g' O' Rj' qvq' ng' v' t' q' e' j' go kecn' c' e' v' k' k' v' { "qh' DkXQ<sub>6</sub> h' k' r' u' u' y' cu' " k' p' x' g' u' k' i' cvg' f' "w' u' l' k' i' "e' { "e' r' k' e' "x' q' n' c' o' o' g' t' { "kp' v' j' t' g' g' "g' r' e' v' t' q' f' g' e' g' m' l' p' "20" O' P' c' E' n' l' u' q' n' w' k' q' p' kp' v' j' g' f' c' t' n' i' c' p' f' "w' p' f' g' t' k' m' w' k' p' c' v' k' q' p' 0"



**Hk 030E** { erke' xqnc' o' q' i' t' c' o' u' qh' w' p' o' q' f' k' h' g' f' "c' p' f' "RGI / o' q' f' k' h' g' f' "DkXQ<sub>6</sub> g' r' e' v' t' q' f' g' u' k' p' "20" O' P' c' E' n' l' u' q' n' w' k' q' p' - r' q' v' g' v' k' n' i' u' e' c' p' t' e' w' g' "72" o' X' l' u' . "k' p' v' g' p' u' k' v' { "qh' k' m' w' o' k' p' c' v' k' q' p' "e' "322" o' Y' "e' o' "4"

K' y' cu' h' q' w' p' f' "v' j' c' v' o' qtr' j' q' r' ni' { "qh' e' q' c' v' k' i' u' u' t' q' p' i' n' { "f' g' r' g' p' f' u' q' p' co' q' w' p' v' qh' RGI "w' u' g' f' "kp' v' j' g' u' { "pvj' g' u' k' u' 0" T' g' u' w' n' u' qh' e' { "e' r' k' e' "x' q' n' c' o' o' g' t' { "Hk 03" + t' g' x' g' c' r' g' f' "f' k' h' g' t' g' p' e' g' u' k' p' r' j' qvq' ng' v' t' q' e' j' go kecn' r' g' h' q' t' o' c' p' e' g' qh' v' j' g' u' c' o' r' r' i' g' u' 0"

Cempqy r' g' f' i' o' g' p' v' "

Vj' ku' t' g' u' g' c' t' e' j' "ku' h' w' p' f' g' f' "d { "v' j' g' "G' w' t' q' r' g' c' p' "U' q' e' k' n' i' H' w' p' f' "w' p' f' g' t' v' j' g' "P' q' "2; 05/NO V/M/934/44/24: 8" d' f' g' x' g' n' r' o' g' p' v' qh' E' q' o' r' g' v' g' e' g' u' qh' U' e' l' g' p' v' k' u' . "q' v' g' t' "T' g' u' g' c' t' e' j' g' t' u' c' p' f' "U' w' f' g' p' u' v' j' t' q' w' i' j' "R' t' c' e' v' e' c' n' i' T' g' u' g' c' t' e' j' "C' e' v' k' k' l' g' u' o' b' o' c' u' w' t' g' 0"

[3] "O' H' e' n' j' t' w' n' T' O' U' c' o' u' w' f' l' p' c' . "T' O' D' c' u' j' k' l' d' . "V' c' k' i' t' k' i' "v' j' g' o' qtr' j' q' r' ni' kecn' u' t' w' e' w' t' g' qh' DkXQ<sub>6</sub> r' j' qvq' ce' v' k' n' u' w' h' q' t' "g' p' j' c' p' e' g' f' "r' j' qvq' ng' v' t' q' e' j' go kecn' u' q' n' t' " j' { "f' t' q' i' g' p' r' t' q' f' w' e' l' q' p' h' t' q' o' "p' e' w' t' o' n' i' c' n' g' y' c' v' g' t' . "I' q' w' t' p' e' n' i' qh' v' j' g' v' c' l' y' c' p' "k' p' u' k' w' g' qh' E' j' go kecn' G' p' i' k' p' g' g' t' u' ; 5"7: 467 ; ; "423: +"

[4] "N' O' I' w' q' . "L' O' N' k' "P' O' N' g' k' "S' O' U' q' p' "g' v' c' r' o' "O' qtr' j' q' r' ni' kecn' g' x' q' n' w' k' q' p' "c' p' f' "g' p' j' c' p' e' g' f' "r' j' qvq' ng' v' t' q' e' j' go kecn' r' g' h' q' t' o' c' p' e' g' qh' X' 6- "u' g' r' i' f' q' r' g' f' . "j232\_ q' t' l' g' p' v' g' f' " DkXQ<sub>6</sub> h' q' t' y' c' v' g' t' ur' nk' w' p' i' . "I' q' w' t' p' e' n' i' qh' E' q' n' i' k' "c' p' f' "k' p' v' g' t' h' e' g' U' e' l' g' p' e' g' 756. "59668" "423; +"

**PGY 'DIRQNCT'J QUVU'HQT'J K J 'GHHKGP E[ 'QNGFU'**

Uko cu'O cekqpk<sup>3</sup>. 'F crkwu'I wf gknc<sup>3</sup>. 'F o { vq'Xqn{pkwm<sup>3</sup>. 'Qrgmcpf t'Dg| xknupp{k<sup>3</sup>. 'Lkwp'J cy 'Ngg<sup>4</sup>."  
Rgk/J uk'Ngg<sup>4</sup>. 'Ej kc/J uwp'Ej gp<sup>4</sup>. 'Vkgp/Nwpi 'Ej kw<sup>7</sup>. 'Lxq| cu'XOI tc| wgxkoku<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'Rqn{o gt'Ej go kwt { 'cpf 'Vgej pqm| { . 'Mcwpcu'Wpkxgtuk{ 'qh'Vgej pqm| { . 'Tcf xkkgpw'r r03; . 'NV/72476." Mcwpcu.'Nkj wcpk. "<sup>4</sup>I tcf wcvg'kpukswg'qh'Rj qvqpleu'cpf 'Qr vgrgevtqpleu.'P cvkqpcn'Vcky cp'Wpkxgtuk{ . '3.'Ugevkqp'6." Tqqugxgn'Tqcf. 'Vckr gk'32839. 'Vcky cp. "<sup>6</sup>F gr ctvo gpv'qh'Grgvtlecti'Gpi kpggtkpi . 'I wcp\ g'Wpkxgtuk{ . '357'I wcp/Vwpi " Tqcf. 'Vcq{ wcp'54225. 'Vcky cp"  
uko cuO cekqpkB nwQf w'

"

Qti cple'ri j vgo kwkpi 'f kqf gu'\*QNGF u+'pqy cf c{ u'tgr tguqpv'qpg'qh'yj g'o quv'r tqo kukpi "cpf 'f qo kpcpv'gej pqm| { "kp" vj g'o ctngv'qh'f kur r{ u'cpf "kno kpcvkp"gs wkr o gpv'O'QNGF u'ctg'uw'gtkqt"vq"eqo r gvkskg"vgej pqm| kgu"y kj "tgr gev'qh' o gej cplecti'hrzkdtkk{ . "ny " tgr qpug"vko g." swckk{ "qh" ko ci g." vcpur ctgpe{ . "ny " o cuu" cpf " y kf g" tci g" qh" y qtnkpi " vgo r gtcwtgu"j3.4\_0'k'v'j ku'y qtn'dnwg'r j qur j qtguegpv'qti cple'ri j vgo kwkpi 'f kqf gu'\*Rj QNGF u+'y kj "o czko wo "gz vgtpci' s wcpwo "ghkkgpe{ "Itqo "440"vq"520" y gtg'hdtkecv'f wukpi 'pgy "dkr qrt'f gtlxckxgu'qh'dgpl ko kf c| qng'rkpngf "vj tqwi j " r j gp{ n'ur cegt" y kj " vj g'f kktgpv' pwo dgt" qh' vgrv/dw{ n' uwdukwgf "ectdc| qng." cu'j quw'O'Cr r rkecdtkk{ "qh' vj g' pgy n' " u{pvj gulk gf "eqo r qwpf u'cu'j quw'ht" dnwg'Rj QNGF u'y cu'lwukhgf "d{ "vj gk" j k j "vkr ngv'ngxgn" \*40 6/40 : "gX+"dkr qrt" vcpur qtvkpi " r tqr gtvku" y kj "ej cti g" o qdkkkgu" w "vq" 406 32/5" eo 4 IX u'cv'grgevtle" hkrf " qh' 40 327" Xleo . "cpf " j k j " kqpk cvkqp'r qvqpkcu" \*7085/70 3" gX+0'

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[3\_ 'P 0Uxcic g. 'Vqo qttqy au'lpf wutlgu'htqo 'QNGF u'v'q'pccpgo cvgtkcu.'P cwtg'798. \*99: 8+U42/U44. \*423; -0'  
[4\_ 'MDNgq. 'Ghkegpv'cpf 'hrzkdrg' uqnwkp. 'P cv0Rj qvq. '7. '938 \*4233-0'



**EJ NQTQRJ [ NN'è'KO O QDKNK CVMQP 'KP VQ'VGVJ GTGF 'DKNC[ GT''  
NKRK' O GO DTCPG''**

Xlmqtklc'Nkwutqxcxg<sup>3</sup>. 'Cwutc'Xcrkwpkpg<sup>3</sup>. 'I kpvtcu'Xcrkpekwa<sup>4</sup>. 'Ctwpcu'Tco cpcxleku<sup>3,5</sup>

<sup>3</sup>Fgr ctwo gpv'qh'Rj {ulecn'Ej go kut { 'Hcewn' { 'qh'Ej go kut { 'cpf' 'I gquekpegu. 'Xkpkwu'Wpkxgtuk' { 'Xkpkwu. 'Nkj wcpk' <sup>4</sup>Egpgt'g'ht'P cwtcn'Uekpegu. 'Xkpkwu'Wpkxgtuk' { 'Xkpkwu. 'Nkj wcpk'

<sup>5</sup>Ncdqtcvqt { 'qh'P cpqvej pqmji { . 'Ucv'g' Tgugctej { 'Kpukw'g' Egpgt'ht' Rj {ulecn'Uekpegu'cpf' 'Vvej pqmji { . 'Xkpkwu. 'Nkj wcpk'

xlmqtklc'NkwutqxcxgB ej i hnwf'kwth'

"

Ej nqtqr j { m' \*Ej n'c+ku'c'ur gekn' / / eqplwi cvgf "utwewt'g'ukwcv'g'ctqwpf'ku'o cetqe { erke'ungrgv'p. 'cpf' 'y' g'xctk'g'v' qh'uk'g'i tqw u'ctqwpf'k'cmny u'cmr'j qvqu { pvj g'v'ur geku'v'q'ugt'x'g'cu'c'o clqt' r'j qvqcev'x'g'cpf' 'utwewt'cn'r'ctv' ]3\_0'Ej n'c' j cu'dggp'etgcv'g' d { 'gxqmw'k'p'v'q'k'p'gt'cev'y' kj 'rki' j v'cpf' 'ku't'gur'qpuk'ng'ht' 'cduqtdkpi' 'y' g'w'p'r'j qvqu'cpf' 'eqpxgt'v'pi' 'y' g'k' gpgti { 'kp'v'ej go lecn'dqpf' 'gpgti' { 'kp'c'uj cr'g'v'y' cv'ku'qr'gp'v'q'p'gctn' { 'cmr'k'g'ht'o u' ]4\_0'ku'd'g'ng'x'g' 'y' cv'ej nqtqr j { m'ku'kp' 'y' g'egm'r'nuo c'o go dtcpg. 'y' j lej 'o gcpu'v'y' cv'y' g'ctgc'dgw'ggp' 'y' g'egm'q'w'gt' 'cpf' 'k'p'p'g't'o g'f'kwo 'ku'f'k'k'f'g'f. 'cpf' 'ku'p'c'w'g' 'cpf' 'ctt'cpi go gpv'ctg'r' t'q'x'k'f'k'pi' 'c'uj cr'g'v'q' 'y' g'egm' ]5\_0'Vj g'v'y' g'g'f' 'dkc' { gt' 'r'k'f' 'o go dtcpg' \*DNO +ku'c'eqo r'ngz' u' u'go' 'y' cv'ecp'dg'w'ug'f' 'cu'cp'g'z'r'g't'lo g'p'v'cn'r' r'v'ht'o 'ht' 'h'w'p'f'co g'p'v'cn'u'w'f'k'g'u'q'h'y' g'ut'wewt'g' 'cpf' 'h'w'p'v'k'p' 'qh'y' g'dk' 'o go dtcpg' 'k'p' 'y' ku'y' qtm' 'q'p'g' 'qh' 'u'w'ej' 'o q'f'g'u. 'DNO' 'q'p' 'y' g' 'i' q'f' 'u'w'ht'c'eg' 'ct'g' 'ht'o g'f' 'd' { 'w'uk'pi' 'y' g' 'h'w'uk'p' 'qh' 'x'g'ul'eng'u' ]6\_0'Vj ku' lo o qd'k'k'f'g'f' 'o go dtcpg' 'c'ng't'c'v'k'p' 'g'p'c'd'ng'u'f' 'k'k'ht'g'p'v' 'dk'ug'p'u'q'tu'v'q' 'd'g' 'r' t'q'f' w'eg'f' 'd' { 'c'f'f'k'pi' 'r'k'f' 'eqo r'q'p'g'p'w' 'u'w'ej' 'cu' F QRE \*3.4/f'k'q'ng'q' { n'up/i n'eg't'q/5/r'j qur'j cv'k'f' { n'ej' q'k'p'g'+ 'cpf' 'ej' q'ng'w'g't'q'n' ]7\_ 'j' c'x'k'pi' 'u'w'c'd'k'k'f' 'y' j lej 'ecp'dg' 'o q'f' k'k'g'f' 'd' { 'c'f'f'k'pi' 'o q'ng'ew'g'u' 'u'w'ej' 'cu' 'ej' nqtqr j { m'c' \*Ej n'c+0'

Vj g'c'ko "qh'v'y'ku'uw'f' { 'ku'v'q' 'etg'c'v'g' 'r'j qur'j q'r'k'f' "dkc' { gt' "o q'f'g'n'y' kj "lo o qd'k'k'f'g'f' "Ej n'c'0'Vj g' 'k'p'x'g'u'ki' cv'k'p' "ku' r'g't'ht'o g'f' 'y' kj "g'ng'ev't'q'ej go lecn'lo r'g'f' c'p'eg'ur' g'ev't'que'qr { \*GKU+ 'v'q' 'o g'cu'w'g'f' 'k'g'ng'ev't'k' 'ecr' c'ek'v' { 'cpf' 'eq'p'f' w'ev'x'k'v' { 'ej' c'pi' g'u'0' H'w'q't'g'ue'g'p'eg' 'o let'que'qr { \*HO +ku'w'ug'f' 'v'q' 'g'u'k'o cv'g' 'y' g' 'o q't'r'j q'm'ji { "qh'v'y' g' 'o go dtcpg'u'0'Vj g' 'i' q'cn'q'h'v'y' ku't'g'ug'ct'ej' 'ku'v'q' "g'z'r' n'qt'g' 'y' g' 'g'h'g'ev'x'g'p'g'u' 'qh' 'l'p'eq't'r' q't'c'v'k'pi' 'y' g' 'r'j qvqcev'x'g' 'eqo r'q'w'p'f' 'Ej n'c' 'kp'v' 'y' g' 'v'g'y' g'g'f' 'dkc' { gt' 'r'k'f' 'o go dtcpg' 'k'p' q't'f'g't' 'v' 'd'w'k'f' 'c' 'r' r'v'ht'o 'y' cv'eq'w'f' 'd'g'w'ug'f' 'k'p' 'y' g' 'h'w'w't'g' 'ht' 'y' g'f' g'x'g'ng'r' 'o g'p'v'q'h'r'j qvq'ug'p'uk'x'g' 'u'w'ht'c'eg' 'ut'wewt'g'u' 'dc'ug'f' "qp' 'DNO' 'y' cv'eq'w'f' 'y' g'q't'g'v'k'c'm' 'd'g'w'ug'f' 'ht' 'y' g'f' g'x'g'ng'r' 'o g'p'v'q'h'p'gy' 'dk'q'o lo g'v'k' 'c't'v'k'k'le'cn'r'g'c'x'g'u' 'cpf' 'dk'ug'p'u'q'tu'0'

"

[3\_ "I'0'0'0' C'p'f' g'tu'p'f. "C'0'0' g'ru. "N'q'ec'ik' cv'k'p' 'qh'f' 'k'ht'g'p'v' 'r'j qvqu { u'go u' 'k'p' 'u'g'r' c't'c'v'g' 't'g'i' k'p'u' 'qh' 'ej' nqtqr' n'w' 'o go dtcpgu' \*r'j qvqu { pvj g'uk'ej' nqtqr' n'w' 'ut'wewt'g' 'ej' nqtqr' n'w' 'h'w'p'v'k'p' 'l'g'cev'k'p' 'eg'p'v't' lo go dtcpg' 'f' 'k'ht'g'p'v'k'v'k'p' + "R't'q'eg'g'f' k'pi' u' 'qh' 'y' g' 'P' cv'k'p'c'n' 'C'ec'f' go { "qh' 'U'ek'p'eg'u. " : 2 \*S+ "967/96; " \*3; : 5-0'

[4\_ "D'0'M' @w'ng't. "U'0'J '3/4'g'p'v'g'k'p'g't. "Ej nqtqr j { m' 'ec'v'c'd'q'k'g'u' 'cpf' 'y' g' 'd'k'ej' go kut { "qh' 'ej' nqtqr j { m' 'd't'g'c'n'f' q'y' p. "Ej nqtqr j { m' 'c'p'f' "D'cev't'k'q'ej' nqtqr j { m' " 459/482" \*4229+0'

[5\_ "O'0'G'0'G'r' M'j' q'w'f. "G'0'G'r' O' q'j' u'p'cy { . "U'0'H'w'w' wo k' "U'q'r't' "gp'gti { "eq'p'x'g't'uk'p' -H'k'q' 'p'c'w't'c'n'v'q' 'c't'v'k'k'le'cn'r'j qvqu { pvj g'uk' "L'q'w'p'c'n'q'h' 'R'j qvq'ej go kut { " 'cpf' 'R'j qvq'd'k'q'm'ji { 'E' -R'j qvq'ej go kut { 'T'g'x'k'g'y' u' '53. '58/ : 5" \*4239+0'

[6\_ "C'0'X'c'k' p'k'p' . "K'0'I' c'd't'k'p'c'k'g' . "O'0'R'q'f' g't' { v'g. "C'0'T'co c'p'c'x'le'k'w' . "G'ng'ev't'q'r' q't'c'v'k'p' "qh' 'c' "j { d't'k' "dkc' { gt' "o go dtcpg' "d' { "ue'c'p'k'pi' "g'ng'ev't'q'ej go lecn' 'o let'que'qr' g' 'D'k'g'ng'ev't'q'ej go kut { . '358. '329839" \*4242-0'

[7\_ "I'0'X'c'k'p'ek'w' . "O'0'0' l'eng'x'le'k'w' . "V'g'y' g'g'f' 'r'j qur'j q'r'k'f' "dkc' { gt' "o go dtcpg' <C'p' 'k'p'v't'r'g'c'v'k'p' 'qh' 'y' g' 'g'ng'ev't'q'ej go lecn'lo r'g'f' c'p'eg' 't'g'ur' q'p'ug. "C'f'x'c'p'eg'u' 'k'p' 'R'v'c'p't' 'N'r'k'f' 'D'k'c' { g't'u' 'c'p'f' 'N'r'k'f' q'ug'o gu. "43. '49/83" \*4237-0'

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**UVWF [ 'QH'HQTO CVKQP 'QH'VKP 'UWNHFK G'  
'NC[ GTU'QP 'RQN[ CO KF G'UJ GGV'''**

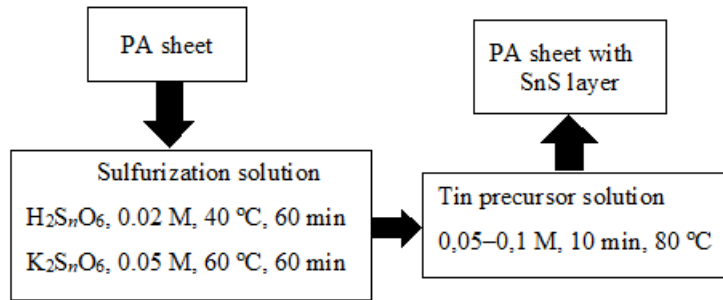
Lqpc"Ukpngxk k v<sup>3</sup>. 'T go ki klu'k'cpcwuncu. 'kpi tkf c'c'pewkqp . 'C'ri ko cpvcu'k'cpcwuncu'

<sup>3</sup>F gr ctwo gpv'qh'Rj { ulecn'cpf "k'p'qti cple'Ej go kut { . 'Mcwpcu'Wpkxgtuk\ "qh'Vgej pqrqi { . 'Nkj wcpk. "  
lqpc"Ukpngxk k wgb mwqf w'

k'p'qti cpleoqti cple'eqo r quksu'ctg'c's wlem\ 'f gxgrqr kpi 'i tqwr 'qh'b cvgtknu'y kj 'c'tgo gpf qwu'tcpi g'qh'j ki j n\ 'wpcdrq' utwewtcn"r j { ulecn'cpf "ej go lecn'r tqr gt'vku'J ki j "eqo r quksu'q'c'ctg'c'g' "qh'v'gug'o cvgtknu'cmjy u' l'p'eqtr qtcv'kpi " xctk'v\ "qh' k'p'qti cple" eqo r qwpf u' Qh' r ct'vewrt" k'p'vgt'guv' ctg" eqo r quksu' o cvgtknu' y kj "i tqwr " KXOXK i tqwr " d'p'ct { " ej creqi gpk'gu. "y j lej "r quuguu'wps wg'r j { ulecn'r tqr gt'vku'qh'v'tgo gpf qwu'ko r qt'v'peg'v'q'o qf gtp'uek'p'eg'cpf "v'gej pqrqi { O' Co qpi " v'j go . "v'p" uwr j kf g" \*UpU" j cu' cwt'cev'g' " v'j g" cwgp'v'k'p' qh' o cp { " t'gug'ctej gtu' d'gecv'w'g' qh' ku' j ki j gt " cduqtr v'k'p' " eqg'h'lek'p'w" \*@26" eo 63" cpf " v'j g" gp'gti { "i cr "qh' ~36" gX" ]3\_0'k'ku' o cf g'v'j g' eqo r quksu' y kj "rc { gt "qh' UpU" r q'v'p'v'k'c'nd' cr r d'ec'd'k'v' { "k'p'v'j g'h'g'f "qh'uq'rt" gp'gti { "eq'p'x'g't'uk'q'p' ut'c'v'g'i k'g'u' ]4\_0'k'cf f k'k'p' . "UpU" j cu' i t'g'c'v'r q'v'p'v'k'c'nd' h'q't "wug'k'p' o go qt { " uy kej kpi " f gx'k'eg'u. " j q'rti t'cr j le "t'ge'q't'f k'p'i "u' u'go u' c'p'f "cu' c'p' "cp'q'f g" o cvgtk'c'nd' h'q't "rkj kw " d'c'w'g't'k'g'u' ]5\_0'k'v'j ku' y q't'nd' h'q't " h'q'to c'v'k'p' qh'v'p' uwr j kf g'rc { gt "q'p' r q'nd' co kf g'RC"8" u'j g'g'u' u'q't'r v'k'p' l'f k'h'w'k'q'p' o g'v'j q'f "k'p'v'j q' u'v'ci gu' y cu'w'ug'f 0"

Rq'nd' co kf g'uj g'g'u' c'w't'k'd'w'g'f "v'j g'v'g'o k'j { f t'q'r j k'le "r q'nd' o g't'0'v'j g't'g'q't'g. "v'j g't'g'ku' e'c'r c'd'rg "v'j c'd'u'q't'd' k'q'p'u' qh' x'c't'k'q'w'u' g'g'e'v'q'nd' q'u' h'q'to "cs w'g'q'w'u' u'q'nd'w'k'q'p'u' 0'v'j ku' h'c'v'c'm'jy u' u'w'h't' c'p'k'q'p'u' y kj "c" n'jy "q'z'k'f c'v'k'p' u'v'c'v'g'v'q' d'g' l'p'v'q'f w'eg'f "k'p'v'j RC" u'j g'g'u' 0' h'w'v'j g't' v't'g'ev'o gp'v'q'h' u'w'h't'k' g'f "RC" u'j g'g'u' y kj "o g'v'c'n' u'c'm'u' y cv'g't' u'q'nd'w'k'q'p' r'g'c'f u'v'j g'v'j g' h'q'to c'v'k'p' qh' o g'v'c'n' u'w'h't'k' g' r'c { g't'u' q'p' v'j g' u'w'h't'c'g' c'p'f "o c'v't'k'z' q'h'v'j g'r q'nd' o g't' u'j g'g'u' 0'

V'j g'c'lo "qh'v'j ku' u'w'f { "y cu'v'q' u'g'r'g'ev'v'j g' o q'u' u'w'k'c'd'rg "eqo r q'w'p'f u' h'q't "r q'nd' o g't' u'j g'g'v' u'c'w't'c'v'k'p' y kj "c'p'k'q'p'u' qh' n'jy " q'z'k'f c'v'k'p' u'v'c'v'g' u'w'h't' "cu' y g'nd' cu' h'q'to g'f "v'p' u'w'h't'k' g' r'c { g't'u' q'p' r' q'nd' o g't' 0' h'k' u'w'f . "v'j g'r k'g'eg'u' qh' d'q'k'g'f "r q'nd' co kf g'uj g'g'u' \*V'geco k'f "8.722" u'o "v'j l'emp'g'u' . I g'to c'p { +37x82" o "k'p' u'k' g'v'j g't'g'v't'g'c'v'g'f "k'p' c'v'j g'to q'u'c'v'k'x'g'u'g'nd' h'q't "q'p'g'j q'w'u' k'p' u'q'nd'w'k'q'p' qh' u'w'h't'k' c'v'k'p' "ci g'p'v'0'c'u' u'w'h't'k' c'v'k'p' "ci g'p'v' u' y g'w'ug'f "v'j g' u'q'nd'w'k'q'p'u' qh' j ki j g't' r' q'nd' v'j k'p'le "c'ek'f u' . J 4U'Q8" \*p' ? "7÷55" +c'p'f " v'j g't' r' q'v'c'u'k'w'o "u'c'm'u' \*M4U'Q8+0'k'p' "v'j g' u'g'ep'q'f "u'c'i g'v'j g'r k'g'eg'u' qh' u'w'h't'k' g'f "RC" u'j g'g'u' y g't'g'v't'g'c'v'g'f "y kj "c" u'q'nd'w'k'q'p' qh' f k'x'c'rg'p'v'k'p' r' t'g'ew't' u'q't' u'q'nd'w'k'q'p' 0'



Hki 030Uej go c'v'ku' qh'v'p' u'w'h't'k' g'rc { g't' h'q'to c'v'k'p' r' t'q'eg'f w'g'0'

U'w'ew'w't'c'n' c'p'f "g'rg'o g'p'v'c'nd' eqo r quksu' qh'v'j g'q'd'v'c'k'p'g'f "rc { g't'u' y g't'g' l'p'x'g'u'k'v' cv'g'f "d' { "c'v'q'o l'e" c'd'u'q't'r v'k'p' "ur g'ev't'q'ue'q'r { "CCU" c'p'f "Z/tc { 'f k'h't'c'v'k'p' \*ZTF +c'p'c'nd' u'ku'0'

**Cenpq' r'g'f i go g'p'v'0'**

V'j ku' t'gug'ctej "ku' h'w'p'f g'f "d' { "v'j g' g'w't'q'r g'c'p' "U'q'ek'c'nd' H'w'p'f "w'p'f g't'v'j g' P q" 2; 66/NO V/M/934/44/2474" o'f g'x'g'r'q'r o g'p'v' qh' Eqo r g'v'g'p'eg'u' qh' U'ek'p'v'ku'u. "q'v'j g't' T'gug'ctej g't'u' c'p'f "U'w'f g'p'v'v'j t'q'w'i j "R't'c'v'ek'c'nd' T'gug'ctej "C'ev'k'x'k'g'u'o" g'c'u'w't'g'0'

<sup>3</sup>J3\_0'0' 0'U'q'w'c. 'C'0'f'c' E'w'p'j c. 'R'0'0' h'et'c'p'c'p'f g'u. 'C'p'p'g'c'k'p'i "qh'T'H'o ci g'v't'q'p'ur w'w'g't'g'f "UpU" r' t'g'ew't' u'c'u'c'p'gy 't'q'w'g' h'q't' u'k'p'i n'g'r'j c'ug' "UpU" v'j k'p' h'k'nd' u" l'q'w't'p'c'nd' q'h' c'm'jy { u'c'p'f "Eqo r q'w'p'f u' 7; 4. " 2/: 7" \*4236-0'

J4\_ "X(GOI q'p' " n'g'l' /H'q't'g'u. T'0'P g'g'p'f q'q't' g'v'0'c'nd' v'j k'p' h'k'nd' "u'q'nd'c'nd' g'm'u' q'h' e'j go l'ec'm' { 'f g'r quks'g'f "UpU" q'h' e'w'd'le' c'p'f "q't'v'j q't'j q'o d'le' u'w'ew'w't'g'u. "v'j k'p' u'q'nd'k'f "h'k'nd' u' 894.84/87" \*423; -0'

J5\_ "D'0'R'w'w'q'w'c'o "T'g'f'f { c. '0'0' E'j c'p'f t'c' U'g'n'j c't'c' g'v'0'c'nd' u'q'nd'w'k'q'p' /d'c'ug'f "ur k'p' /e'q'c'v'g'f "v'p' u'w'h't'k' g'v'j k'p' h'k'nd' u' h'q't' r'j q'v'q'x'q'nd'c'le' c'p'f "u'w' g't'ec'r c'ek'sq't' c'r r d'ec'v'k'p'u. " O'cv'g't'k'c'nd' T'gug'ctej "D'w'ng'v'k'p' 325.3563: " \*423; -0'

**XCTKVKQP UQH TCTG'GCTVJ 'GNGO GP VU'K' 'VJ G'DQVVQO 'CPF 'HN[ " Y QQF'CUJ**

O gi klc'P glo cpg<sup>3</sup>. 'Xkv rkl'u'Nc| ctgpm<sup>3</sup>. 'O tku'D tk -<sup>3</sup>. 'Ctwtu'X mpc<sup>3</sup>. 'F ci plc'Nc| f k c<sup>4</sup>. " Mtkwcr u'O cnqxunk<sup>4</sup>. 'Kl g'M tmk c<sup>4</sup>. 'Cpf ku'Nc| f k -<sup>4</sup>"

<sup>3</sup>Wplxgtukf "qh'Ncxlc. 'Hcewmf "qh'Ej go knt { . 'Lgni cxc'wtggv<sup>3</sup>. 'Tki c. 'Ncxlc" <sup>4</sup>Ncxkcp'Ucvg'Hqtguv'Tgugctej "Kpukwng'oUkxcö. 'Tki c'wtggv<sup>3</sup>33. 'Ucrur ku. 'Ncxlc" o gi klcp glo cpggB i o chlqeo "

Y qaf "cuj 'ku'dlko cuu'qdvclpgf "d{ 'y g'eqo dwukqp'qh'y qaf 'r tqf weu'y qaf 'ej lr u. 'hqi u. 'gve00Dwtlpi 'y qaf 'r tqf weu" r tqf wegu'cdqw'8/32' "cuj 'Htqo "y g'vqcn'y gli j v'qh'y qaf 0'Y qaf "cuj "eqpvckpu" c" j ki j "co qwpv'qh'o cetq/"cpf "o letq/" grgo gpw0J qy gxgt. 'ugxgtcn'uwf lgu'uj qy "y cv'y qaf "cuj "cnuq'eqpvckpu'tctg'gctv'j "grgo gpw0Y qaf "cuj 'ku'r tqf wegf 'lp'rti g" s wcpvklgu'y tqwi j "y g'eqo dwukqp'qh'y qaf 'hqt'gppti { 'cpf 'j gcv'r tqf wekqp0Hqt'gzco r ng. 'hcevtlgu" hqt'gppti { 'r tqf wekqp+" cpf "dqkgt'j qwugu" hqt'j gcv'r tqf wekqp+'wug'y qaf 'r tqf weu'cu'hwgr0'

P qy cf c{ u. 'ugxgtcn'cr r necvklpu"j cxg"dggp"hwgf "hqt'y g'wug'qh'y qaf "cuj 0'Kp'ugxgtcn'Gwtqr gcp" Wplkqp"eqwptlgu." y qaf "cuj 'ku'wugf 'lp'tqcf "eqpvtwekqp"cpf "cur j cnkpi 'y qtm0J qy gxgt. 'y g'o quv'eqo o qp'cr r necvklpu'qh'y qaf "cuj 'ku'cu'c" hgtvkl gt' hqt'ci tlewmtcn'cpf "hqtguv'uqlk0Vj g'j ki j "eqpvcpv'qh'o cetq/"cpf "o letq/"grgo gpw'lp'y g'y qaf "cuj "gpwmtgu'r rcpw" y kj "y g'pgeguuct { 'pwtlgpw'cpf "tgf wegu'uqlki'celf k{ 0'Vj g'wug'qh'y qaf "cuj "ecp'etgcvg"dlqe{ eng. "kpetgcug'y g"co qwpv'qh' tpggy cdrq'gppti { . 'tgf weg'y g'pwo dgt'qh'r'cpf hmiukgu'cpf "EQ4" go kuukpu0'

Y qaf "cuj 'f kxgf 'lpv'y q'o clp'v' r gu'o'dqvwqo "cuj "cpf 'h{ "cuj 0Dqvwqo "cuj 'ku'c'eqctuguv'cpf 'i tcpwv'vf "cuj 'Htcevkqp" y kj "r ctv'eng'uk' g"206/60" o o "y cv'eqpvckpu"lo r wtklgu"\*uqpgu. "ucpf u. "gve0"cpf "o quv'qh'y g'y qaf "cuj "o cuu'eqpukwu'qh' ukleqp"\*c79" +cpf "ecrekwo \*c3; " -0Hh{ "cuj 'ku'y g'hkpguvtcevkqp'y kj 'r ctv'eng'uk' g"34/472" o "y j lej 'eqpvckpu'kqti cplc" eqo r qwpf u'cpf "c'uo cm'co qwpv'qh'wpdwtpgf "ectdqp0'

Vj g'clo "qh'y ku'tgugctej 'y cu'v'gxcnvcg'tctg'gctv'j "grgo gpv'eqpvcpv'lp'y g'dqvwqo "cpf 'h{ 'y qaf "cuj 0Dqvy 'v' r gu'qh' y qaf "cuj "uco r ngu'y gtg'eqmgev'f "Htqo "dqkgt'j qwugu'htqo "f khtgtpv'r ctv'qh'Ncxlc"lp"42360'Y qaf "cuj "uco r ngu'y gtg' gztcevgf "lp"7"o N'qh'eqpegpvcvgf "J P Q5'd{ "vulpi 'c'uj cngt"\*7"j qwtu."3; 2'tr o -0Vj g'tguwtkpi "uqmwkqp'y cu'f kwwgf "y kj " f glkpk gf "y cvgt"cpf "hngtgf"\*Y j cw cp"763+'v"i gv'tk"qh'wvf kuukrgf "r ctv'eng0'Vj g'tctg'gctv'j "grgo gpv'eqpvcpv'y cu' f gvto kpgf "d{ "KER'/"O U"\*Ci krgpv' : ; 22"KER/SS S +cpcn{uku"o gv'qf 0'Vj g'r J "cpf "grgevtlecn'eqpf wevklk{ "y gtg'cnuq" f gvto kpgf "lp'y g'gzv'cevl'lp'y g'y cvgt0'

Qdvclpgf "tguwmu'uj qy "y cv'y qaf "cuj 'ku'c'j ki j n{ "dcule'o cvgtkcr"r J "@34-0Vj g'grgevtlecn'eqpf wevklk{ "qh'dqvwqo "cuj " ku'j ki j gt'v' cp'h{ "cuj 0Vj g'eqpvcpv'qh'tctg'gctv'j "grgo gpw'uj qy u'y g'f kxgtukf "qh'y g'eqpvcpw'dgy ggp'y g'dqvwqo "cpf 'h{ " y qaf "cuj 0"



**CD'P KWQ'ECNE WNCVKQP U'QHP c<sub>3-4z</sub>O p<sub>z</sub>Vk<sub>4/z</sub>\*RQ<sub>6-5</sub>\*z'? '202=302+'  
TCO CP 'URGEVTC''**

P qlwu'T cf | gxk kw<sup>3</sup>. 'Nkpcu'Xkn kwumcu<sup>3,4</sup>

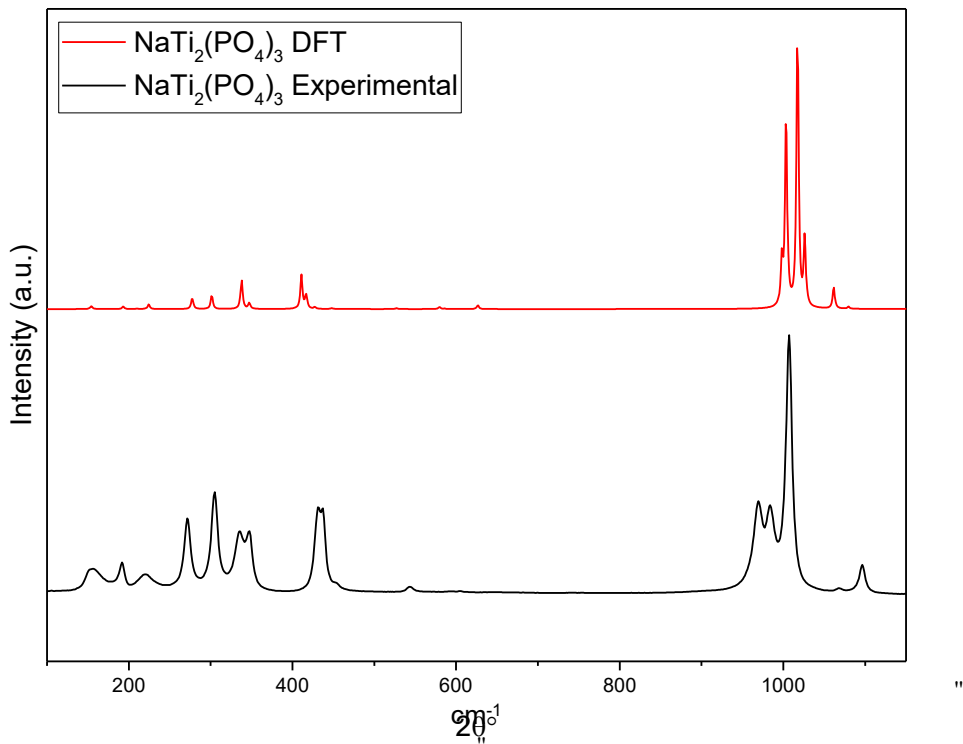
<sup>3</sup>ƒpukwng'qh'Ej go kmt { 'Hewn' 'qh'Ej go kmt { 'cpf 'I gquelpegu. 'Xkpkwu'Wpkxgtuky'. 'Nkj wcpk "

<sup>4</sup>Egpvt 'hqt 'Rj { ulecn'Uelqpegu'cpf "Vgej pqni { "HVO E+" 'Ucwn vgnk' cni05. 'NV/32479. 'Nkj wcpk "  
P qlwu'T cf | gxlekuB ej i hnwf kvwn"

Vj g'ugctej 'hqt'pgy "dcwgt { "grgetqf g"o cvgtkni"ku'dgeqo kpi "qpg'qh'vj g"o quv'cevkg'ctgcu'qh'tgugctej "kp"o qf gtp" ej go kmt { "cpf" o cvgtkni' uelqpegu' P CUKEQP /utwewtgf " r j qur j cvg" lto gy qtn' eqo r qwpf u" y kj " i gpgtcni hqto wnc" P c<sub>z</sub>O g<sub>4</sub>\*RQ<sub>6+5</sub>. 'y j gt g'O g'ku'wuwcm' c'vcpuklqp'o gcn'uctvgf "vq"go gti g'cu'ugo g'qh'vj g'o quv' qvqpv'uqkf "grgetqf' vg'cpf " grgetqf g" o cvgtkni' hqt" vj g" w eqo kpi " i gpgtcvkqp" qh" P c/kqp" dcwgtkgu' j3\_ " Vj g { " uj qy " uwr gkqt " vj gto cni' cpf " grgetqej go lecn'ucdkks'. "ny /equ'cpf "gpukqpo gpcn'uwucpkcdks'0'J qy gxgt. "vj g"eqo r rvg" wpf gtwcpf kpi "qh'hcevtu" i qxgtkpi "vj gk' r tqr gtvku'cpf "rko kcvkpu'ku'vkn'rcenkpi 0'

F gpuk' 'Hwpevkpcn'Vj gqt { "F HV+"ecrewv'kpu'j cvg'dgeqo g'c'ucpf ctf "vqni'hqt'ecrewv'kpi "vj g'grgetqple'utwewt g" cpf "o qrgewt' r tqr gtvku'qh'kp' r tkpek rg. "cp { "ej go lecn' u'ungo 0'Vj g { "pqv'qpn' j gr "vq'qdvk' r j { ulecn'r cto gytu'dw' cnuq' r tqxgf "vq'dg'gzvgo gn' j gr hwi'kp'gnwk'cvkpi "ej go lecn'r tqr gtvku. "cpcn' | kpi "ur gev'queqr ke'f cv. "i wkf kpi "o cvgtkni" u { p'j guku'gve'0' Tco cp'ur gev'queqr { "ku" c' xgtucvkg' vqni'vq'pqv'qpn' "kpxguki cvg'vj g' xkdtcvkpcn' r tqr gtvku'dw' cnuq' tgrcvg' vj go "vq'qy g' b' cvgtkni' r tqr gtvku. 'kf gpv'k' r j cugu'cpf "vj gk' hqto cvkqp'uki pcwtgu'0'4\_ "

ƒp' vj ku' uwf { "y g' r gthqto " j { dtkf " F HV" ecrewv'kpu. "eqo r wng" vj gk' Tco cp' ur gev'c' cpf "eqo r ctg' tguwmu" vq" g'zr g' tko g'p'v'qh' P c<sub>3-4z</sub>O p<sub>z</sub>Vk<sub>4/z</sub>\*RQ<sub>6+5</sub>\*z'? '202=302+' eqo r qwpf u'0'Vj g' ecrewv'kpu' tguwmu'uj qy "i qqf "ci t'ggo gpv'y kj "vj g" cxc'kdng' g'zr g' tko g'p'v'f cv' "ugg' Hki 03+' cpf "kpf kecv'vj cv' Tco cp' ur gev'queqr { "ku" c' ec' c' dng' v'gej pks w' hqt "kpxguki cvkpi " r j cug' hqto cvkqp' kp' vj ku' cpf "uko kct' u'ungo u'cpf "vj cv' F HV" ecrewv'kpu' ctg' kpf kur gpucdng' hqt "j gr kpi "vq' kvqtr tgv' vj g' ur gev'queqr ke'f cv'0' "



Hki 030Eqo r ctkuq'qh'F HV"ecrewv'gf 'cpf "g'zr g' tko g'p'v' Tco cp' ur gev'c' hqt "P c<sub>3-4z</sub>O p<sub>z</sub>Vk<sub>4/z</sub>\*RQ<sub>6+5</sub>\*z'? '202+0

j3\_ J 0I cq. 'L0D0I qqf gpqvi j . 'Cpi gy 0Ej go 0'ƒv'0'Gf 077. '3498: /34994\*4238-0'

j4\_ F 0I t { c } ppx. 'U0M0Ucwhtg. 'G0C0Mqvo kp. 'N0Xkn kwumcu. 'Rj { u0Ej go 0Ej go 0Rj { u044. '33: 83/33: 92\*4242-0'

**U PVJ GUK'CPF'EJ CTCEVGTK CVKQP'QH'FIDGP\ QVJ KQRJ GPG'  
FGTKCVKXGUCU'VJ GTO CNN[ 'CEVXCVGF'FGNC[ GF"  
HNWQTGUEGPEG'GO KVVGTU'**

Vqo cu'Lcpgrkpcu<sup>3</sup>. 'O crgn'O cj o qwf k<sup>3</sup>. 'O grkne'I j cugo k<sup>3</sup>. 'F crkwi'I wf gkne<sup>3</sup>. 'F o { tq'Xqn[ pkwn<sup>3</sup>. "  
Lxq| cu'Xkf cu'I tc| wrgxlekwi"

<sup>3</sup>F gr ctvo gpv'qh'Rqn(o gt'Ej go kwt { "cpf "Vgej pqm{ { ."Mwpcu'Wpkxgtuk{ 'qh'Vgej pqm{ { ."Nkj wpcle"  
vqo cu'LcpgrkpcuB mwqf w'

Vj gto cm{ " cevxcvgf " fgr{gf " hnwqtguepeg" o cvgtkcn" j cxg" go gti gf " cu" vj g" o quv" r tqo kulpi " ecpf kf cvgu" hqt"  
eqputwvki "j ki j /r gthqto cpeg"qti cple"ri j vgo kwki /f kf gu"<sup>3</sup>QNGF u+f wg"vq"vj gk "ghlelcpv"j ctvgu'qh'dqv "ukpi rgv'cpf "  
vkr rgv'gzeksqpu"vj tqwi j "vj g'tgxgtug'lpvtu{vgo "etqukpi "TKUE+r tqeguu"3.4.0'k'vj ku'y qtmqti cple"vgo leqpf wvqtu'y kj "  
f khtgtpv{ "uwdukwgf "f ppqt/ceegr vt"o qrgewrt"utvewt g"y gtg"u{pvj guk gf "cpf "kpxguki cvgf "d{ "f khtgtpv'gzzr gto gpvcn"  
o gvj qf u'Vj g"o qrgewrt"utvewt gu"y gtg"egt vkgf "vj tqwi j "<sup>3</sup>J "cpf "<sup>35</sup>E"PO T"ur gevqueqr kgu."o cuu"ur gevqo gt { 0'Vj g"  
hqny ki "ej ctcevtk cvkpu'qh'pgy "eqo r qwpf u'y gtg'o clpn{ "r gthqto gf "3+r j qvr j { ulecn'o gcwtgo gpv."4+"gxcnvcvqp"qh"  
vj gto cn'r tqr gvku."5+"gppti { "rgxgn'o gcwtgo gpv."6+"ej cti g"vcpur qt v'ej ctcevtk cvkpu'Wf qp"uwej "gzco kpcvku'k'y cu"  
eqpenf gf "vj cv"vj gk "pgcvhko u'go k'e{ cp li tggp'hnwqtguepeg"y kj "RNS [ "qh'90" "kp"vj g'dgu'ecug0Vj gk'7' "y gi j v'qau"  
vgo r gtcwtg"gzegf gf "qh'522"qE0'kpk cvkpu'r qvkvkn'qh'vj g'uwf kfg "eqo r qwpf u'y gtg'kp"vj g'tcpi g"qh'70/7084"GX0Vj g"  
uwf kfg "eqo r qwpf u'y gtg'ej ctcevtk gf "d{ "j qrg/vcpur qt vpi "r tqr gvku'tgcej kpi "32/5"eo <sup>4</sup>Xu'cvj ki j "grgevt k'hkrf u'kp"vj g"  
dgu'ecug0'Ceetf kpi "r tqxkf gf "ej ctcevtk cvkpu."ugrgevgf "eqo r qwpf u"o c{ "dg"vugf "cu"j qrg/vcpur qt vpi "o cvgtkcn"kp"  
QNGF u'

"  
]3\_"J 0Wq{ co c.'MDI qvuj k'MDUj k w'gv'cn'J ki j n' "ghlelcpv"qti cple"ri j vgo kwki "f kf gu"tqo "f gr{gf "hnwqtguepeg."P cwtg."6; 4."456645: "4234-"  
]4\_"MDI qvuj k'MD[ quj kf c.'MDE'OCfej k'gv'cn'Qti cple"ri j vgo kwki "f kf gu"go r m{ kpi "ghlelcpv'tgxgtug'lpvtu{vgo "etqukpi "hqt"vkr rgv'vq/ukpi rgv'  
ucvg'eqpxgtukp."P cv'Rj qvqpleu'8."475647: "4234-"

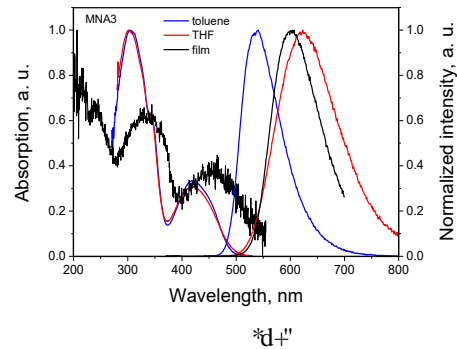
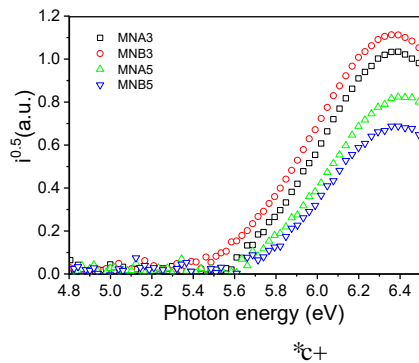
### 3.: /PCRJ VJ CNKO KFG'FGTKXCVKXGUGZJ KDKVPI 'VJ GTO CNN[ ' ' CEVXCVGF 'F GNC[ GF 'HNWQTGUEGPEG'

Pcxggp'O cuko wmw<sup>3</sup>. 'F crkwu'I wf gknc<sup>3</sup>. 'Qrgmcpf t 'Dgl xknppp{k<sup>3</sup>. 'F o { tq'Xqn{ pkm<sup>3</sup>. "'  
Lxq| cu'Xkf cu'I tcl wgxkxkw<sup>3</sup>"

"  
"Mwpcu'Wpkxgtuk{ 'qh'Vej pqm{ . 'F gr ctwo gpv'qh'Rqn{ o gt'Ej go kwt { 'cpf 'vej pqm{ " }  
Tcf xkrgpw'r ngpcu'3; . 'NV/72476. 'Mwpcu. 'Nkj wcpk"  
pcxggpO cuko wmwB mwQf w"

Qti cple'b cvgtkcu'gzj kdkkpi 'vj gto cmf 'cevkxcvfg' f grc{ gf 'hnwqtguegpeg'\*VCF H+'j cxg'cwtcevgf 'o wej 'cwgpvkqp'f wg'vq' vj gk'gpj cpegf 'ghhlekpe{ 'lp'qti cple'ri j v'go kwlpi 'f kqf gu'\*QNGF u+'y j lej 'ku'r quukdng'f wg'vq'j ctg'xg'vki "vtr ngv'gzekqpu" ]3\_0Tgf 'go kwlpi 'o cvgtkcu'ctg'cny c{ u'v'j g'uj qt'v'urd'co qpi 'vj g'o cvgtkcu'gzj kdkkpi "go kuukqp'qh'v'j tgg'r tko ct{ 'eqmwtu" f wg'vq'v'j g'cpcdcvle'lpvgtpcn'eqpxgtukqp'\*E+'eqghhlekpv'o cpci gf 'd{ 'vj g'gpgti { 'i cr 'rey ]4\_0Tgf 'r j qur j qt'o cvgtkcu'ctg' y kf gn{ "wugf 'lp'v'j g'lpf wut { 'cv'r t'gugpv'qy kpi "vq'v'j g'322" "gzekqap'wkrk'cvkqp'ghhlekpe{ '\*GWG+0'Vj g'"lpvqf vevkqp'qh' r tgekqwu'b gvcu. 'uwej 'cu'K. 'Rv. 'gve0'lpetgcug'v'j g'equu'cpf 'r j qur j qt'guegpv'go kvgtu'ctg'pqv'geq/h'kpf n{ ]5\_0QNGF u'dcugf' qp'b gvcn'htgg'VCF H'b cvgtkcu'ecp'cuq'cej kxg'322" 'lpvgtpcn's wcpwo "ghhlekpe{ 'd{ 't'g'gtug'lpvgtu{ ugo 'etqukpi '\*TKUE+' r tqeguu'qh'v'v'j g'gzekqpu'0'J ki j "r j q'v'wo kpguegpeg'\*RN+'s wcpwo " { kgrf '\*RNS [ +'cpf "uo cmf'gpgti { "ur rkwkpi "\* Gvt+' dgw ggp'v'j g'htuv'gzekgf 'ukpi ngv'ucv'g'\*U<sub>3</sub>+'cpf 'gzekgf 'v'v'ng'ucv'g'\*V<sub>3</sub>+'ctg'etwecn'hevcvtu'ht'j ki j /r gthqto cpeg'VCF H' o cvgtkcu']5\_0P gy 'ghhlekpv'qtcpj g/tgf 'VCF H'go kvgtu'ctg'j ki j n{ 'f go cpf gf 'vq'hnk'lp'v'j g'i cr 0Vj g'urqy 'f g'xgru' o gpv'qh' ghhlekpv'qtcpj g/q/tgf "VCF H'go kvgtu'ku'cuqekcvf' y kj "v'j g' pwo gtqwu'utlev' o qrgewrt' f guki p' eqpukf gtcv'kqp' cpf " eqttgur qpf kpi 'f h'lewnku'0P cr j v'j crko kf g'ceegr vt/f qpqt' b qrgewrt' f guki p'ku'lwkcdr'ht'v'j g'f'g'xgru' o gpv'qh'qtcpj g/tgf " VCF H'go kvgtu'

Kp'v'j ku'y qtnly g'u{pvj guk'gf 'htwt'go kvgtu.'y j lej 'y g'tg'q'd'cvk'p'gf 'd{ 'v'j g'tcevk'qpu'qh'f'kr j gp{ rco kpg'r j gp{ n'dqt'qple'cekf " cpf 'xlp{ n'r j gp{ n'f'kr j gp{ rco kpg'y kj "8.9/f kdtqo q/4/\*4.8/f ko gy { r j gp{ n/3J /dgp| q|f g'kuqs wkpqkpg/3.5\*4J -f kqpg'cpf " 7.: /f kdtqo q/4/\*4.8/f ko gy { r j gp{ n/3J /dgp| q|f g'kuqs wkpqkpg/3.5\*4J -f kqpg'0'Vj g" { kgrf u' qh' v'j g" eqo r qwpf u' t'cpi gf " htqo "74"v'q'92" 0I r'uu'v'c'puk'k'p'v'go r g'tc'w't'gu'qh'v'j g'u{pvj guk'gf 'i r'uu'htqto kpi "eqo r qwpf u'y g'tg'q'dug'x'gf 'lp'v'j g'tcpi g' qh'354/378"AE0K'p'k'cvkqp'r'q'v'p'v'c'n'x'c'w'gu'qh'v'j g'eqo r qwpf u't'cpi gf "htqo "705: "v'q'708; "gX"\*Hki 03c+'Vj g'RN'ur g'v'c'qh' VJ H'uu'w'k'p'p'cpf 'h'ko u'uj qy gf 'ukpi ng'r' g'nu'ht'ecv'gf 'cv'y'cxg'g'pi v'j u'x'ct { kpi 'htqo "822"v'q'872'po "Hki 03d+0Vj g'r'quk'x'g' u'q'nc'v'q'ej tqo kuo 'lpf'lec'v'u'v'j g'lpv'w'co qrgewrt'ej cti g't'c'p'uh't'ej c't'ce'v't'qh'v'j g'go kuukqp'0Vj g'RN'f'gec{ 'ew'x'gu'uj qy gf 'v'j g' r t'gug'peg'qh'c' r'p'p' /r'x'gf "go kuukqp'eqo r q'p'p'w'v'j j lej 'y g'tg'c'm' qu'p'q'v'lp'hw'g'peg'f 'd{ 'v'j g'lpv'gt'cevk'p'v'j kj "qz { i gp'0'Vj g' go kuukqp'qh'v'j g'eqo r qwpf u'wpf gty gpv'ci i t'gi cvkqp'ecwugf 's w'p'ej kpi ORNS [ 'x'c'w'gu'qh'v'j gk'f'k'w'g'v'c'w'k'p'p'v'c'pi gf 'htqo " 65"v'q'97" 'y j k'g'v'j q'ug'qh'v'j g'u'q'rk'f 'h'ko u't'cpi gf 'htqo "3"v'q'47" 0



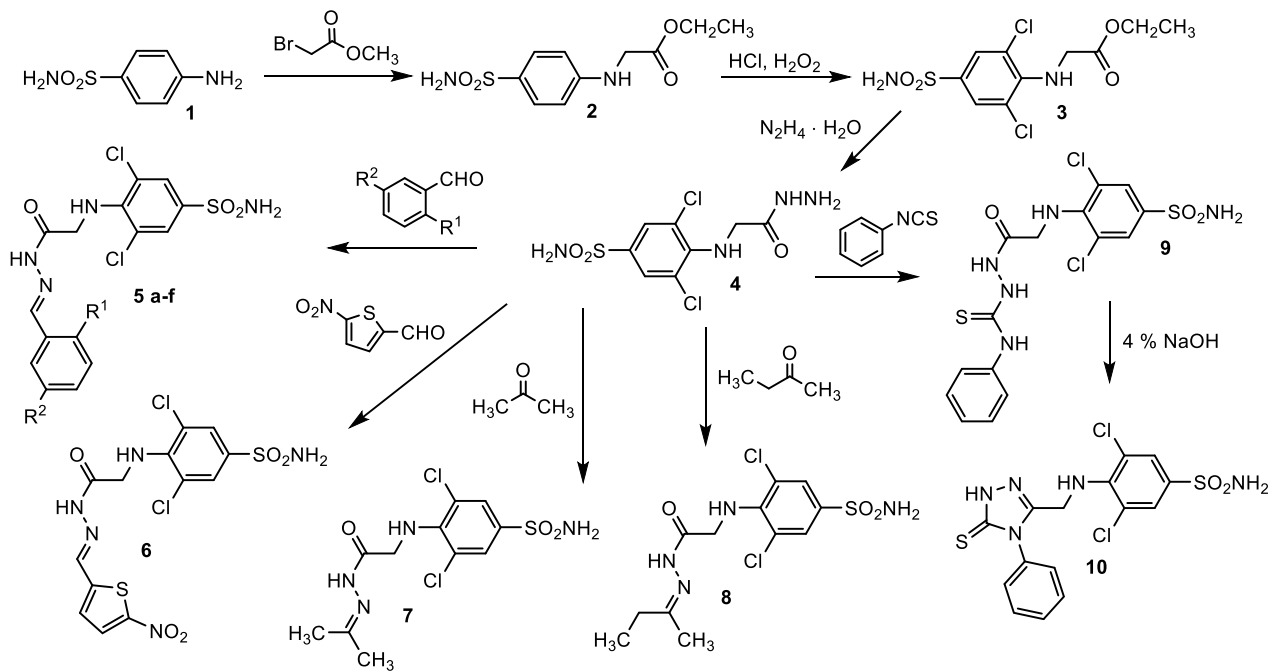
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.....  
[3\_ "V0L0R'p'ht'f. 'H0D0F'kcu. 'C0D0O' q'p'no cp. "Vj g'v'j g'gt { 'qh'v'j gto cmf 'cevkxcvfg' f grc{ gf 'hnwqtguegpeg'ht'qti cple'go kwlpi 'f kqf gu.'Ej go 0Ego o wp'7: ." 5; 47\*423: -0'  
[4\_ "V0O'ky c. "U0M'wdq. 'M0U'j k'w'g'v'c'f'0'D'w'g'qti cple'ri j v'go kwlpi 'f kqf gu't'g'c'rk' kpi "gz'v'gt'pcn's wcpwo "ghhlekpe{ 'q'x'gt'47" "wulpi 'vj gto cmf 'cevkxcvfg' " f grc{ gf 'hnwqtguegpeg'go kvgtu.'P'c'w'g'9.'3/4\*4239-0'  
[5\_ "J 0Nk'V0[ cpi. 'L0Y'cpi 'g'v'c'f'0'J ki j n{ "GHhlekpv'Qtcpj g/Tgf "Vj gto cmf 'cevkxcvfg' f grc{ gf 'hnwqtguegpeg'Eqo r qwpf u'Eqo r tkupi 'f w'c'n'f'k'c{ cpq/ U'w'w'k'w'g'f 'R{tcl' k'p'g'IS' w'p'q'z'c'rk'p'g'Ceegr'v'qtu.'Ej go R'w'u'Ej go ": 8.; 76324\*4243-0'

**U P V J G U K U' Q H P Q X G N' 4 / ] \* 4.8 / F K E J N Q T Q / 6 /**  
**U W N H C O Q [ N R J G P [ N + C O K P Q \_ C E G V K E ' C E K F ' F G T K C V K G U " "**  
Nkwekc'Wtdgn[ v . "Dkt wv "I t { dckv . "X { cwcu' O kengxk kwu" "

"F gr ctwo gpv'qh'Qti cple'Ej go kwt { . "Mcvpcu'Wpkxgtukv' qh'Vgej pqrni { . "Mcvpcu'Nkaj wcpk" "  
dkwgd t { dckvB mwQf w" "

Vcti gygf "vj gtrc { "ku'ewttgpvn{ "c"xgt { "ko r qtvcpv'tgc"qh'cpwkepegt"ej go qvj gtrc { "cpf "ku'dgeqo kpi "qpg'qh'vj g"o ckp" y c { "kp"vj g"hi j v'ci cklpuv"qpeqi gpguku'Dgp| gpguwhtqpcu kf gu'dcuqf "eqo r qwpf u"ctg"gh'gevkxg"kp"kpj kdkkpi "wo qt"egm" i tqy vj "kp'xlktq"cpf "kp'xlxq'0Vj g'cpkwo qt'cevkkv' qh'vj gug'kpj kdkkqtu'g'zr rclpu'kpj kdkkqp'qh'ectdqple"cpj { f t cugu'Z "cpf" ectdqple"cpj { f t cugu'Z KOF gtxcwxgu'qh'dgp| gpguwhtqpcu kf gu'wtqpi n{ "kpj kdkk'vj g'htqto cvkqp'qh'o gvcucugu'd { "vj g'j k j n{ " ci i tguukxg" 6V3" o co o ct { " wo qt" egm" cpf " j wo cp" dtgcu' ectekpco " ] 3\_0' J wo cp" ectdqple" cpj { f t cugu' \*EC-" ctg" o gvcuqg| { o gu'vj cv'ecvnl { g'vj g"j { f tcvkqp'qh'ectdqple" f kqz kf g"kpq' dlectdqpcv'0'Vj g'ctg"vy g'xg"ecvnl' v'ecm{ "cevkkxg" j wo cp"EC"kuqhtqto u'lxpxq'kf "kp"o cp { "etweknl'r j { ukqmj kecn'r tqeguugu'0' Cmi'dgp| gpguwhtqpcu kf gu'dcuqf "kpj kdkkqtu'ctg" ej ctcevgtk gf "d { "c"uwhtqpcu kf g"j gcf "i tqw . "cdng"vq"dkpf "vj g" \ p<sup>4</sup> "kp"kp" c" r qengv'qh'vj g"EC"cevkkxg"ukxg" ] 4\_0' Cnuq" dgp| gpguwhtqpcu kf gu'y kj "ctqo cvk'qt"j gvtq { erke"o qlgyv' "kp"vj g'kt'uxvwewt"uj qy "r tqo kuki "kpj kdkkqp'cevkkxv{ "ci cklpuv" vj g'ur'gelgu'Uej kuruqo c"o cpukpk'ku'gpf go ke'kp'Ch'lec . "y j g'g'k'ecwugu'k'p'gukp'cluej kuruqo kuku" ] 5\_0'



a-f: a R<sup>1</sup>, R<sup>2</sup>=H; b R<sup>1</sup>=Cl, R<sup>2</sup>=H; c R<sup>1</sup>=OH, R<sup>2</sup>=H; d R<sup>1</sup>=OCH<sub>3</sub>, R<sup>2</sup>=H; e R<sup>1</sup>=NO<sub>2</sub>, R<sup>2</sup>=H; f R<sup>1</sup>=Cl, R<sup>2</sup>=NO<sub>2</sub>

**Hki 030U{pvj guku'qh'uwdukwvgf "dgp| gpguwhtqpcu kf gu'4/32"**

Vj g'clo "qh'vj ku'y qtm'y cu'vq"u{pvj guk' g'pgy "dgp| gpguwhtqpcu kf gu'vj cv'ep"j cxg'dkqmj kecn'cevkkv{ 0\*"Hki 0'3-0'Hqt" vj ku'r vtr'qug . "eqo r qwpf "3" hku' y cu'cm{ r'v'f "y kj "o gvj { n' dtqo qcegv'v" "kp" gvj cpqn' vq" i kxg' g'vgt "40' Gvj { n' 4 / ] \* 4.8 / f lej m'qtq / 6 / uwhtco q { n j gp { neo k'p'q \_ cegv'v " \* 5 + " y cu' u { pvj guk' gf " d { " v'g'v'k'p' " 4 " y kj " J En' k'p' vj g' r t'gugpeg" qh' j { f t q' i gp" r g'qz'kf g'0'Vj gp' vj g' q'd'v'k'p'gf " g'vgt " 5 " y cu' eqpxgt'v'gf " vq' vj g' j { f t c' l' f g' 60J { f t c' l' p'p'g' 7c'oh' 8 " y g'g' r' t'g' r' ct'gf " d { " vj g' t'g'cevkqp" qh' eqtt'gur p'qf k'p' i j { f t c' l' f g' 6 " cpf " j g'vgt'q { erke " qt " ctqo cvk' c'f g' j { f g' u' k'p' 4 / r t'q' r' cp'q'0'Vj g' t'g'cevkqp" y kj " cegv'v'q' t' g'v' j { n' o gvj { n' n'g'v'p'p' " kp" vj g' r t'gugpeg" qh' c" ecvnl' v'k' co qwpv' qh' cegv'k' c'ek' r t'q'x'k'f' g' j { f t c' l' p'p'g' 9 . : 0' P / r j gp { n j { f t c' l' k'p'g'ectdqv' k'qco k'f' g' ; " y cu' u { pvj guk' gf " d { " vj g' k'p'v'g' t'cev'k'p' qh' vj g' j { f t c' l' f g' 6 " y kj " r j gp { r'ku'v'j k'q'ek'p'c'v'v " kp" o gvj cp'q'0'Vj ku'eqo r qwpf " y cu' v'ugf " h'q' vj g' u { pvj guku' qh' 3.4.6 / v'k'c' l' q'rg " 320 "

Cm' qh' vj g' u { pvj guk' gf " eqo r qwpf u" y g'g' ej ctcevgtk gf " d { " <sup>3</sup>J " cpf " <sup>35</sup>E " P O T . " g'rgo g'p'v'cl' c'p'cn' uku' cpf " uqo g" t'g' r t'gug'p'c'v'k'xg' eqo r qwpf u' y g'g' ej ctcevgtk gf " d { " o cu' u' r' g'ew'qo g'v { " c'p'cn' uku' "

[3]\_R0'C"E'q'it'p'cu . "P q'x'g'ni'uwhtqpcu kf g'eqo r qwpf u" h'q' t' kpj kdkkqp" qh' o gvcucvle" wo qt" i tqy vj . "G'zr g'v' Qr' k'p'k'p' " q" Vj g'tr' gw'le" R'c'v'p'w' 45 . "9836985" \*4235-0'  
 [4]\_R'X'c'-m'x'k' k'p' . "X'0'R'engw't { v . "C'0' w'd't'k'p' " cv'gr'0'P / U'w'htco q { n j gp { n' cpf " P / U'w'htco q { n j gp { n' P / vj k'c' l' q' n' d' / c'p'k'p'gu' cpf " vj g'k' f' g' t'k'c'v'k'g' u' cu' k'p' j kdkkqtu' qh' j wo cp' ectdqple" cpj { f t cugu' . "D'k'q'q' t' c'p'le 'Ej go kwt { " 97 . "3864 ; \*4239-0'  
 [5]\_C'0' C'p' i g'rk' O'0'R'p'v'g'c' . "U'U'0'0' c'k'g' cv'gr'0' U'w'htqpcu kf g' k'p' j kdkkqp" U'w'f' l'gu' qh' cp' " / E'ctdqple" C'p' j { f t cugu' h'q' to "U'ej kuruqo c' b' cpukpk' c' R'v'v' j g'ro k'p' vj " R'c't'c'uk'g' T'g'ur' q'p'uk'd'g' h'q' t' U'ej kuruqo k'uku . "k'p'v'g' t'p'c'v'k'p'c'p'cl' i'q'w'p'c'l' qh' 0' g'ew'w'c' t' U'ek'p'eg' u' 43 . '3 : 64 \*4242-0'

# ƁURGE VIKP 'QH VJ G' O QTRJ QVTQRK' RJ CUG' DQWT CP F[ 'Ɓ'

## UCO CT ƁWO 'UWDUV ƁWGF 'DƁQ5'

Cpf tkwu' Rcnepk-nku<sup>3</sup>. 'Tco pcu' Unerf flku<sup>3</sup>. 'Vqo cu' O wtewmu<sup>3</sup>. 'Uctj gk' ƁNcwuj nē<sup>4</sup>. 'F gpku' Crknk<sup>5</sup>.  
Cni kf cu' Ugnuku<sup>6</sup>. 'F o kt { 'Mctr kpun<sup>4</sup>. 'Ckxctcu' Mct gkxc<sup>3</sup>

- <sup>3</sup>Ɓunkwg'qh'Ej go kut { . 'Xkpkwu' Wpkxgtuk { . 'P cwi ctf wng<sup>46</sup>. 'NV/25447' Xkpkwu. 'Nkj wcpk'
  - <sup>4</sup>Uelgpwke/ Rtevecln' O cvgtkcn' T gugctej 'Egpvt g'qh' P CU'qh' Dgrctwu. '442294' O kpum' Dgrctwu
  - <sup>5</sup>Uej qqr'qh' P cwtcn' Uelgpegu' c'p'f 'O cvj go cweu. 'Wcn' Hgf g'cn' Wpkxgtuk { . 'T wuik'
  - <sup>6</sup>Egpvt 'hqt' 'Rj { uelcn' Uelgpegu' c'p'f 'Vgej pqrqi { . 'NV/24522' Xkpkwu. 'Nkj wcpk'
- c'p'f tkwu' t cnepkuknB ej i hkwō''''

Vj g'vgo 'o qtr j qvtqr le' r j cug' dqwpf ct { '\*O RD+ wuwcn' 'tghgtu' vq' c' eqpegv' v'kqp' tgi kqp' y j g' g' f hgtg' p'v' et { ucni' utwewt' gu' y kj 'c' hty' 'gpgti { 'dctkt'g' 'ecp' 'eqgz' ku' ]3\_0Vj g' b' quv' eqo o qp' c'p'f 'y gni' w'p'f g' tu' w'p'f 'O RD' g' z' ku' w' d' g' y g' g' p' v' j g' r' q' r' t' j' q' o' d' a' j' g' f' t' c' n' ' \*T5o + 'c'p'f 'v'g' t' c' i' q' p' c' n' 'R6o o + 'u' t' w' e' w' t' g' u' ' k' p' ' r' g' c' f' ' ' l' e' q' p' c' v' g' ' w' k' c' p' e' v' g' ' ]4\_0Y j' k' r' g' ' u' e' j' ' ' v' t' c' p' u' k' k' q' p' u' c' t' g' ' p' q' v' c' m' y' g' f' ' d' { 'u' { o o g' t' { ' t' w' g' u' . ' t' g' e' g' p' v' n' ' ' k' j' ' c' u' ' d' g' g' p' ' g' z' r' n' e' l' p' g' f' ' y' c' v' j' g' { 'c' t' g' o' g' f' k' e' v' g' f' ' d' { 'c' ' h' q' t' o' c' v' k' q' p' ' d' { 'v' t' c' p' u' k' k' q' p' c' t' { 'o' q' p' q' e' n' l' e' ' r' j' c' u' g' ' 0' V' j' k' u' ' r' j' c' u' g' ' e' q' g' z' k' u' g' p' e' g' ' t' g' i' k' q' p' ' j' c' u' ' c' w' t' c' e' v' g' f' ' c' ' i' p' v' q' h' ' c' v' g' p' v' k' q' p' ' h' t' q' o' ' u' e' l' g' p' w' u' c' u' ' k' j' ' c' u' ' d' g' g' p' ' f' k' u' e' x' g' t' g' f' ' y' c' v' u' e' j' ' e' q' o' r' q' w' p' f' u' i' j' q' y' ' r' e' t' i' g' ' u' g' p' u' k' k' v' ' v' q' ' g' z' v' t' p' c' n' ' u' l' o' w' r' 0' ' J' q' y' g' x' g' t' . ' y' j' k' r' g' ' e' w' t' g' p' v' n' ' ' f' o' k' p' c' p' v' r' k' e' l' g' q' g' e' v' t' e' ' o' c' v' g' t' c' n' ' y' k' j' ' O' R' D' ' \*R\ ' V. ' R' O' P' / D' V' + ' c' t' g' ' g' z' v' t' g' o' g' n' { ' g' h' h' e' l' g' p' v' ' j' g' { ' e' q' p' v' c' l' p' ' r' g' c' f' ' y' j' k' e' j' ' ' k' u' ' j' ' k' i' j' n' ' ' v' z' k' e' O' F' w' g' ' v' q' ' j' k' u' ' f' t' c' y' d' c' e' m' ' c' p' f' ' q' x' g' t' c' n' ' u' j' k' u' ' v' a' y' c' t' f' u' i' t' g' g' p' ' c' p' f' ' u' u' w' x' l' p' c' d' i' g' ' e' j' g' o' k' u' t' { . ' y' j' k' e' j' ' y' c' u' ' r' c' t' v' n' ' ' l' p' f' w' e' g' f' ' d' { 'c' p' v' k' R' d' ' r' g' i' k' u' r' w' k' q' p' u' . ' c' ' u' g' t' e' j' ' ' h' q' t' ' c' ' i' t' e' g' g' e' t' ' c' n' g' t' p' c' v' k' x' g' ' k' u' ' q' p' i' q' k' p' i' 0'

Qxgt 'vj g' r' cu' v' eqw' r' g' h' f' g' e' c' f' g' u' ' o' c' p' { 'f' hgtg' p' v' eqo r qwpf u' y g' g' c' p' c' n' | g' f' ' k' p' u' g' t' e' j' ' q' h' ' c' ' r' q' u' i' k' d' i' g' ' c' n' g' t' p' c' v' k' x' g' ' 0' D' ƁQ5 . ' c' ' r' g' c' f' ' h' t' g' g' ' o' w' n' k' h' g' t' q' l' e' ' e' q' o' r' q' w' p' f' ' y' k' j' ' r' g' t' x' u' n' k' s' g' ' v' f' r' g' ' u' t' w' e' w' t' g' . ' y' c' u' ' h' q' w' p' f' ' v' q' ' j' c' x' g' ' c' ' r' q' r' c' t' ' v' q' p' q' p' / r' q' r' c' t' ' o' q' r' j' q' v' q' r' l' e' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { ' w' r' q' p' ' f' r' k' p' i' ' y' k' j' ' T' G' ' k' a' p' u' ' \*Nc' ' o' ' N' w' i' ' ]5\_0Vj' g' ' w' p' f' q' r' g' f' ' e' q' o' r' q' w' p' f' ' k' u' ' e' j' c' t' c' e' v' g' t' k' g' f' ' d' { ' r' q' r' c' t' ' c' e' v' k' x' g' ' t' j' q' o' d' a' j' g' f' t' c' n' ' u' t' w' e' w' t' g' ' f' u' e' t' k' d' g' f' ' d' { ' T5e' u' r' c' e' g' ' i' t' q' w' r' ' c' u' ' y' g' n' i' ' c' u' ' o' c' i' p' g' l' e' c' n' ' ' c' e' v' k' x' g' ' u' d' n' e' w' l' e' g' ' h' t' o' g' f' ' d' { ' k' t' q' p' ' k' a' p' u' ' y' j' k' e' j' ' o' c' n' g' u' ' k' v' q' ' d' g' ' t' q' q' o' ' v' g' o' r' g' t' c' w' t' g' ' o' w' n' k' h' g' t' t' q' l' e' ' y' k' j' ' E' w' t' l' g' ' v' g' o' r' g' t' c' w' t' g' ' q' h' ' i' Ɓ322' M' c' p' f' ' P' g' g' n' ' v' g' o' r' g' t' c' w' t' g' ' q' h' ' 865' M' ]3\_0' V' j' g' t' g' ' c' t' g' ' u' q' o' g' ' f' t' c' y' d' c' e' m' ' u' r' g' e' k' l' e' ' h' q' t' ' v' j' g' ' k' p' k' c' n' ' e' q' o' r' q' w' p' f' . ' x' k' 0' d' k' u' o' w' j' ' ' h' g' t' k' l' g' ' k' u' ' e' j' c' t' c' e' v' g' t' k' g' f' ' d' { ' c' ' r' e' t' i' g' ' r' g' c' e' i' g' ' e' w' t' g' p' v' c' u' ' y' g' n' i' ' c' u' ' f' h' h' e' w' m' g' u' ' l' p' ' r' t' g' r' c' t' e' v' k' q' p' ' q' h' ' l' u' p' i' r' g' ' r' j' c' u' g' ' o' c' v' g' t' c' n' ' 0' F' q' r' k' p' i' ' q' h' ' v' j' g' ' l' p' k' k' c' n' ' e' q' o' r' q' w' p' f' ' y' k' j' ' t' e' t' g' ' g' c' t' v' j' ' k' a' p' u' ' j' c' u' i' j' q' y' p' v' q' ' c' v' h' g' c' u' ' r' c' t' v' n' ' u' i' r' g' u' ' v' j' g' u' g' ' r' t' q' d' i' g' o' u' c' u' ' y' g' n' i' ' c' e' w' u' g' u' ' c' ' r' q' r' c' t' ' \*T5e+ ' v' q' p' q' p' / r' q' r' c' t' ' \*R' p' o' c' + ' u' t' w' e' w' t' c' n' ' v' t' c' p' u' k' k' q' p' . ' y' k' j' ' c' p' ' k' p' v' t' o' g' f' k' e' v' g' ' R' d\ t' Q5/ n' k' g' ' c' p' k' r' q' r' c' t' ' \*R' d' c' o' + ' r' j' c' u' g' ' ]3\_0Y j' k' r' g' ' v' j' g' ' e' q' e' p' e' g' p' v' e' c' v' k' p' ' t' c' p' i' g' ' q' h' ' O' R' D' ' x' c' t' k' u' f' g' r' g' p' f' k' p' i' ' q' p' ' v' j' g' v' r' g' ' q' h' ' T' G' ' k' a' p' u' . ' v' j' g' ' u' c' d' k' k' c' v' k' q' p' ' q' h' ' v' j' g' ' c' p' w' k' r' q' r' c' t' ' r' j' c' u' g' ' j' c' u' ' q' n' ' l' ' d' g' g' p' ' r' q' u' i' k' d' i' g' ' y' k' j' ' T' G' ' k' a' p' u' ' w' r' ' v' q' ' U' o' ' y' k' j' k' p' ' v' j' g' ' O' R' D' ' y' j' k' e' j' ' k' u' ' x' g' t' { ' p' c' t' t' q' y' ' c' o' q' p' i' ' u' l' o' k' r' e' t' ' q' z' k' g' ' u' f' v' g' o' u' Ɓ' 3' ' ' ]6\_0' O' q' t' g' q' x' g' t' . ' e' q' t' t' g' e' v' f' v' g' y' t' o' k' p' c' v' k' q' p' ' q' h' ' o' q' t' r' j' q' v' t' q' r' l' e' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { ' k' u' ' s' v' k' s' g' ' f' h' h' e' w' n' ' d' g' e' c' w' u' g' ' k' v' k' u' ' u' t' q' p' i' n' ' f' r' g' g' p' f' g' p' v' q' p' ' r' t' g' r' c' t' e' v' k' q' p' ' v' g' e' j' p' l' s' w' g' ' c' p' f' ' r' q' u' v' u' { p' v' j' g' u' k' u' ' t' g' c' w' o' g' p' v' ]5\_0' K' u' j' q' w' f' ' d' g' p' a' q' e' f' . ' v' j' c' v' u' t' w' e' w' t' c' n' ' e' j' c' t' c' e' v' g' t' k' c' v' k' q' p' ' q' h' ' O' R' D' ' t' g' i' k' a' p' ' r' g' h' t' h' o' g' f' ' d' c' u' g' f' ' q' p' ' Z' / T' c' { ' f' h' h' e' c' e' v' k' q' p' ' c' p' c' n' l' u' k' i' c' p' f' ' o' l' e' t' q' u' e' q' r' l' e' ' b' g' c' u' w' t' g' o' g' p' w' u' u' e' j' ' c' u' ' T' c' o' c' p' ' q' t' ' K' ' u' r' g' e' w' q' e' q' r' { ' e' c' p' ' i' k' x' g' ' f' h' h' e' g' p' v' i' g' u' w' n' u' ' c' u' ' e' q' o' r' c' t' g' f' ' v' q' ' i' q' e' c' n' i' o' g' c' u' w' t' g' o' g' p' w' u' u' e' j' ' c' u' ' V' G' O' ' q' t' ' R' H' O' . ' y' j' k' e' j' ' r' q' u' g' u' ' c' i' t' g' c' v' ' r' t' q' d' i' g' o' ' h' q' t' ' h' w' t' v' j' g' ' u' e' l' g' p' v' k' i' e' t' u' g' u' c' t' e' j' ' ]7\_0'

J gpeg 'vj g' o c' l' p' ' c' l' o' ' q' h' ' v' j' k' u' ' y' q' n' i' ' y' c' u' ' v' q' ' l' p' x' g' u' k' i' c' v' g' ' j' g' o' q' t' r' j' q' v' t' q' r' l' e' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { ' t' g' i' k' a' p' ' k' p' ' U' o' / f' q' r' g' f' ' D' ƁQ5 ' ' e' q' o' r' q' w' p' f' u' r' t' g' r' c' t' g' f' ' d' { ' g' y' j' { r' p' g' ' i' n' e' q' n' i' c' u' u' k' u' g' f' ' u' u' r' i' g' n' ' v' g' e' j' p' l' s' w' g' . ' x' k' 0' v' q' ' k' s' g' o' k' g' ' y' j' g' ' u' t' w' e' w' t' c' n' ' r' j' c' u' g' ' v' t' c' p' u' k' k' q' p' ' h' t' q' o' ' v' j' g' ' r' q' r' c' t' ' t' j' q' o' d' a' j' g' f' t' c' n' l' v' j' g' ' c' p' w' k' r' q' r' c' t' ' q' t' v' j' q' t' j' q' o' d' l' e' ' h' q' n' i' y' g' f' ' d' { ' v' j' g' ' p' q' p' / r' q' r' c' t' ' q' t' v' j' q' t' j' q' o' d' l' e' ' r' j' c' u' g' ' f' t' k' x' g' p' ' d' { ' v' j' g' ' r' q' r' c' p' v' l' e' q' p' v' g' p' v' w' u' l' p' i' ' d' a' j' j' ' i' q' e' c' n' i' u' e' c' r' g' ' c' p' f' ' o' l' e' t' q' u' e' q' r' l' e' ' o' g' c' u' w' t' g' o' g' p' v' v' g' e' j' p' l' s' w' g' u' 0' V' j' g' ' q' d' v' c' l' p' g' f' ' t' g' u' w' n' u' ' j' k' i' j' r' k' i' j' v' v' j' g' ' f' h' h' e' g' p' e' g' u' ' u' r' g' e' k' l' e' ' h' q' t' ' v' j' g' ' O' R' D' ' c' u' u' o' k' p' i' ' v' j' g' ' f' c' v' ' q' d' v' c' l' p' g' f' ' d' { ' o' l' e' t' q' u' e' q' r' l' e' ' o' g' c' u' w' t' g' o' g' p' w' u' u' e' q' o' r' c' t' g' f' ' v' q' ' i' q' e' c' n' i' u' e' c' r' g' ' u' t' w' e' w' t' c' n' i' g' u' w' n' u' 0'

**Cempqy ngf i go gpwu** Vj ku' y qtni' y cu' uwr r qtvf ' d { ' v' j' g' ' G' w' t' q' r' g' c' p' ' W' p' k' a' p' u' ' J' q' t' k' q' p' ' 4242' ' t' u' g' u' c' t' e' j' ' c' p' f' ' k' p' p' x' c' v' k' q' p' ' r' t' q' i' t' c' o' o' g' ' w' p' f' g' t' ' v' j' g' ' O' c' t' k' e' ' U' n' e' f' q' y' u' n' e' / E' w' t' k' e' i' t' c' p' v' c' i' t' e' g' g' o' g' p' v' P' q' 099: 2920'

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[3\_10Y cmtg. 'J 0Ulo qpu' F QOCrknk. 'g'v' n' o' F v' c' n' i' u' t' c' l' p' ' o' g' e' j' c' p' l' u' o' u' l' p' ' c' ' r' g' c' f' / h' t' g' g' o' q' t' r' j' q' v' t' q' r' l' e' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { ' h' g' t' g' r' g' e' v' t' e' . ' U' e' l' g' p' v' k' i' e' ' T' g' r' q' t' u' 8. ' 36: ' \*4238-0'

[4\_ 'H0' j' g' p' i' . ' 10Ej' g' p' . ' Z' 0Nk' ' O' 0Uj' g' p' . ' O' q' t' r' j' q' v' t' q' r' l' e' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { '\*O RD+ ' g' h' t' g' e' v' l' p' ' R' d' ' \* t' . V' k' e' Q' 5' ' t' j' q' o' d' a' j' g' f' t' c' n' l' g' t' c' i' q' p' e' r' i' o' w' n' k' e' { g' t' g' f' ' i' k' u' o' u' ' O' c' v' g' t' c' n' i' ' N' g' v' g' t' u' . ' O' c' v' g' t' 0N' g' w' 082. ' 495564959' \*4228-0'

[5\_ 'V0T q' l' c' e' . ' C' O' D' g' p' e' c' p' . ' D' 0' O' c' r' l' e' . ' g' v' n' o' ' D' ƁQ5 . ' E' g' t' c' o' l' e' u' < R' t' e' q' e' g' u' l' p' i' . ' G' r' e' g' e' l' e' c' n' ' c' p' f' ' G' r' e' g' e' q' o' g' e' j' c' p' l' e' c' n' ' R' t' q' r' g' t' v' e' u' ' L' a' w' t' p' c' n' ' q' h' ' v' j' g' ' C' o' g' t' l' e' c' p' ' E' g' t' c' o' l' e' ' U' q' e' l' g' v' ' ; ' 9' 3 ; ; 564233' \*4236-0'

[6\_ 'F 0X0M' t' r' k' p' u' n' f' . ' C' O' R' c' n' e' p' k' - n' k' u' . ' I' 0P l' e' w' c' . ' g' v' n' o' ' G' x' q' n' w' k' q' p' ' q' h' v' j' g' ' l' e' t' { u' c' n' i' u' t' w' e' w' t' g' ' c' p' f' ' o' c' i' p' g' l' e' ' r' t' q' r' g' t' v' e' u' ' q' h' ' U' o' / f' q' r' g' f' ' D' ƁQ5 . ' e' g' t' c' o' l' e' u' ' c' e' t' q' u' i' v' j' g' ' r' j' c' u' g' ' d' q' w' p' f' c' t' { ' t' g' i' k' a' p' . ' E' g' t' c' o' l' e' u' ' k' p' v' t' p' e' v' k' p' c' n' i' 69. ' 75 ; ; / 7628. ' \*4243-0'

[7\_ 'U0Dj' c' w' e' j' c' t' { { . ' L' 0' T' 0' l' l' p' u' e' j' g' m' ' J' 0' E' c' e' . ' g' v' n' o' ' F' k' e' v' j' k' i' j' / t' g' u' q' n' w' k' q' p' ' v' t' c' p' u' k' k' q' p' ' g' r' e' v' t' q' p' ' o' l' e' t' q' u' e' q' r' { ' q' d' u' g' t' x' e' v' k' p' ' q' h' ' v' g' t' c' i' q' p' e' r' i' o' p' q' y' l' p' u' y' k' j' k' p' ' v' j' g' ' o' q' p' q' e' n' l' e' ' O' E' ' r' j' c' u' g' ' q' h' ' R' d' ' \*O' i' 35P d' 45+Q5/2 057Rd' V' k' Q5' e' t' { u' c' n' i' . ' C' r' r' i' g' f' ' R' j' { u' k' e' u' ' N' g' w' t' u' ; ' 4' \*422: -0'

# NGGEVTQEJ GO KECNN[ 'CEVKG'UWTHCEG'CTGC'O GCUWTGO GPV'QH' J QPG[ EQO D/NKMG'EQRRT'HQCO 'NGGEVTQF G'

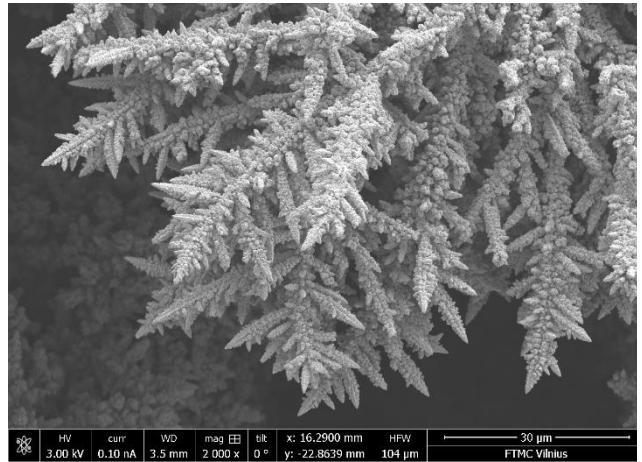
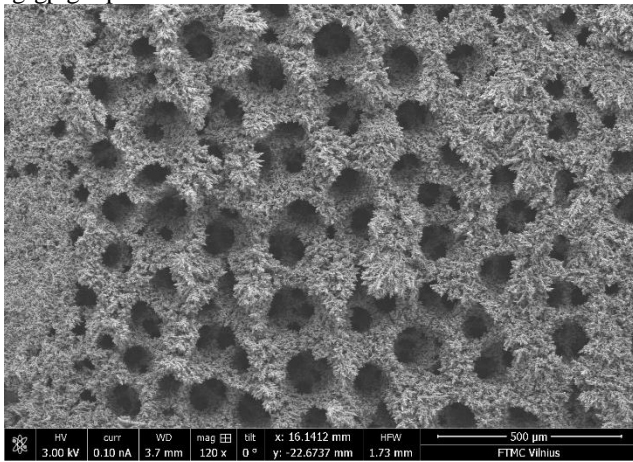
Dktw 'Ugter kpgp . 'Lwti c'Lwqf mē { v . 'Ncko c'I wf cxx k v . 'Cni kf cu'Ugnnku. ""  
Tlo cpvcu'Tco cpwunū"

" Egpvt 'hqt'Rj { ulecl'Uekppegu'cpf "Vgej pqrqi { . 'Ucwn vgnkq'crl05. 'NV/32479'Xkpkwu. 'Nky wpcle"  
dktw'ugter kpgpB ho ehw"

Vj g'o clp'i qcn'qh'Rctku'Ci tgggo gpv'ku'v'q'tgf weg'y qtrf y kf g'vgo r gtcwtg'd { 'tgf wekpi 'i tggpj qwug'i cu'go kuukpu']3\_0' EQ4'grgevtqej go lecn'tgf wekqp'ku'qpg'qh'r quukdrng'uqmwkpu'qh'y ku'r tqdrngo 0Kp'cf f kkkp. 'y ku'tgcewkp'ku'qh'o clqt 'kpgvtgux' f wg'v'q'j g'r quukdrng' { 'qh'u' pyj guk lpi 'wughw'r tqf weu'hqt' 'y g'ej go lecn'kpf wut { 'Itqo 'c' r tcewecm' 'kpgzj cwukdrng'ectdqp' uqwtg0Vj gtg'j cxg'dggp' o cp { 'cwgo r u'v'q'f gxnqr 'uwxcdng'ecvcl' uwoCo qpi 'y go 'o gvcnle' Ew'j cu'dggp'f go qpwtcvf 'v' dg'r tqo kulpi 'hqt'ugrgevxg'EQ4'tgf wekqp'v'J EQQJ . 'EQ'qt. 'o qtg'ko r qtvcprn' . 'v'EJ 6. 'E4J 6'cpf 'E4J 8'y kj 'tgrvxxgn' " j ki j 'ghhkegpe { 'J4\_0J qy gxt. 'y g'uo qqj 'r qn'et { ucn'kpg'cpf 'lupi ng'et { ucn'Ew'grgevtqf g'uwthceg'j cu'hqy 'ecvcl' v'le'cevxk' { 0' K'ku'zr gwgf 'y cv'y g'grgevtqecvcl' v'le'cevxk' { 'cpf 'y g'ugrgevxk' { 'qh'Ew'grgevtqf gu'ecp'dg'ko r tqxgf 'd' { 'o qf kh' lpi 'y g' uwthceg0Vj g'pcpquw wwtlpi 'ecp'r tqxkf g'f khtg'gpv'uwthceg'o qtr: j qrqi kgu'y kj 'o qtg'cevxk' 'ukgu'hqt' 'EQ4'grgevtqf g' wekqp' cpf 'j gr 'eqpvtqnp' 'y g'r tqf we'ugrgevxk' { 0"

Vj tggf lo gpukpcn'5F +r qtqwu'o gcn'hqco 'j cu'c'y kf g'ur tgc'f 'kpgvtgux'cu'ku'qr gp'r qtqwu'ut wewt g'ku'xgt { 'uwxcdng' hqt'grgevtqf g' y j lej 'tgs wkt gu'c'rti g'ur gekle'uwthceg'ctgc'hqt'grgevtqej go lecn'tgcewkp0Vj g'r tqf wekqp'o gjv qf 'qh'o gcn' hqco u'kpxqng'ub' b' gcn'grgevtqf gr quukdrng' r tqeguu'y j lej 'ku'ceeqo r cplgf 'd' { 'j { f tqi gp'gxqmwkqp0Eqr r gt'hqco u'y kj 'j ki j n' " qr gp'r qtqwu'y cmi'j cxg'dggp' uweegulhnm' 'uewr wtf 'wukpi 'y g'i cu'gxqmwkpi 'kp'cp'grgevtqej go lecn'f gr quukdrng' r tqeguu'lp' c'f kwwgf 'cek' le'uw'r j cvg'uqmwkqp0Vj g'r qtg'uk' gu'cpf 'y cmi'ut wewt gu'qh'y g'hqco u'ctg'wpcdrng'd { 'cf lwwkpi 'y g'f gr quukdrng' eqpf kkkpu']5\_0"

Ghhkegpe { 'qh'y g'ecvcl' u'w'cpf 'tgf wekqp'r tqf we'ugrgevxk' { 'f gr gp'f u'qp'grgevtqej go lecn'f 'cevxk'uwthceg'ctgc'qh'y g' grgevtqf g0Vj g'cko 'qh'y ku'tgugctej 'y cu'v'q'hpf 'gcu' { 'hcu'cpf 'tgrkcdng'o gjv qf 'hqt'v'j g'o gcuwtgo gpv'qh'tgcn'grgevtqej go lecn'f 'cevxk' uwthceg' ctgc' qh' Ew' j qpg { eqo d/rkng' ut wewt g' grgevtqf gu' Ew' 5F " r qtqwu' o gcn' hqco " y cu' r tqf weg' " d' " grgevtqf gr quukdrng'qp' Ew'grgevtqf g'lp'c'207'O 'EwUQ6'- '407'O 'J 4UQ6'grgevtqf v'g'cv'5'C leo 4'ewtgp'v'f gpuk' { 'hqt'42'u0Vj g' uwthceg'o qtr: j qrqi { 'qh'y g'qdcwlp'gf 'ut wewt gu'y cu'gxncwv'gf 'Itqo 'UGO 'cpcn' uku0Uqo g'qh'y g'Ew'hqco 'UGO 'ko ci gu'ctg' r tggp'v'gf 'lp'Hki 030'



Hki 030UGO 'ko ci gu'qh'Ew'j qpg { eqo d/rkng' ut wewt g'grgevtqf gr quukdrng' 'lp'207'O 'EwUQ6. '407'O 'J 4UQ6'grgevtqf v'g'0"

Uxgtcni'grgevtqej go lecn'o gjv qf u'ctg'cxkcdng'hqt'cevxk'uwthceg'ctgc'f gvgto kpcv'kp. 'y j lej 'ctg'dcugf "qp' y g' o gcuwtgo gpv'qh'ej cti g'cuuqekv'gf 'y kj 'y g'f gr quukdrng'qt'tgo qxcn'qh'ej go kuqtdgf "o qpqr: { gt'qh'ur geku0Vj g'ghq'g. 'y g' tgcni'grgevtqej go lecn'f 'cevxk'uwthceg'ctgc'qh'Ew'j qpg { eqo d/rkng'grgevtqf gu'y cu'cuugugf "d' { 'y g'Ew'qz'kf cvkqp'tgf wekqp' o gjv qf " \*Ew'Q" o qpqr: { gt' "hqt' c'v'kp+." wpf gtr qv'p'v'cl' f gr quukdrng' \*WRF + "qh'Rd" o qpqr: { gt' o gjv qf " cpf " f qwdng' n' { gt' ecr ceksp'eg'o gjv qf 0Cf xcpvci gu'cpf 'f kuf xcpvci gu'qh'y g'o gp'v'kpgf "o gjv qf u'ctg'f kuewugf 0"

[3\_] w u'kwp'heef'pvr tqeguu'cpf/o ggv'pi ulj g'r ctku/ci tgggo gpv'ij g'r ctku/ci tgggo gpv'  
[4\_]'Z'kg. 'J 0'Y cpi. 'VO'Nkpi. 'LO'Nk'S 0'X' 'Uwp. 'UDEw'dcugf 'pcp'qecvcl' u'w'hqt'grgevtqej go lecn'tgf wekqp'qh'EQ40P cpq'Vqf c { . '43. '636760\*423: -'  
[5\_]'Uj kp. 'J 0E0'X' 'Nkw'0'E0Eqr r gt'hqco 'ut wewt gu'y kj 'j ki j n' r qtqwu'pcpquw wewt'gf 'y cmi'0Ej go kut { 'qh'O cvgt'kcu. '38\*47+ '7682676860\*4226-0'

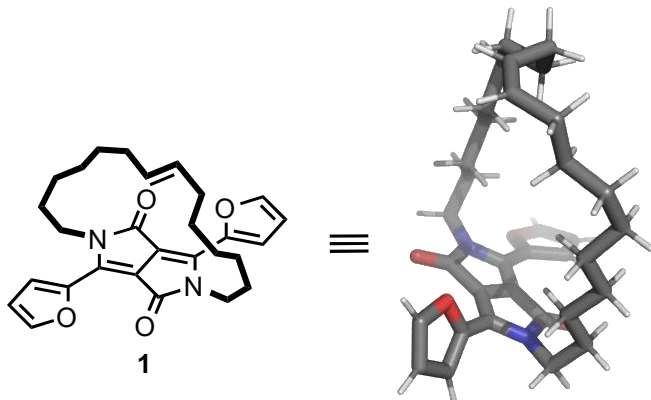
**O CETQO QNGEWNCT'F KMGVQR| TTQNQR| TTQNG'CUVJ G'  
CPPKI KNCVQT'KP'WREQPXGTVP|I 'QTI CPKE'HKNO U'**

**Dctdctc'Ej cvkpxum<sup>3</sup>. 'Cvi wvkc' lq| grk pckv<sup>3</sup>. 'Gf xkpcu' Tcf kvpcu<sup>4</sup>. 'Nwncu' P cko qxk kwu<sup>4</sup>.  
Mctqrku' Mc| nwwncu<sup>4</sup>. 'Gf xkpcu' Qtgpvcu<sup>3</sup>**

<sup>3</sup>F gr ctwo gpv'qh'Qti cple'Ej go kw { . 'Hcwm' 'qh'Ej go kw { 'cpf' 'I gqukgpegu. 'Xkpkwu' Wpkxgtukv { . 'Nkj wpcle' "  
<sup>4</sup>'kpukwg'qh'Rj qvpleu'cpf' P cpqvej pqrqj { . 'Hcwm' 'qh'Rj { uku. 'Xkpkwu' Wpkxgtukv { . 'Nkj wpcle' "  
dctdctc'ej cvkpxumcB ej i lhwf 0x0w"

Vtkr rnv'hwkqp '\*VH+' wr eqpxgtukqp 'ku'c' r tgegu'cmjy kpi 'vj g'eqpxgtukqp'qh'vy q'qt'o qtg'mjy 'o'gpgti { 'rj qvpu'vq'qpg' j ki j "o'gpgti { "rj qvpu'Nki j v'wr eqpxgtukqp "u' ugo u" j cxg" i tgecv'ko r rtec'vqpu"kp" o cp { "hgrf u." uwej "cu" r j qvqncleu." r j qvqecv'uku' qt" dlqko ci kpi O'F gur kg" c" rcti g" f go cpf. "vj g" ej qleg" qh' gh'ekp'v' qti cple" o cvgtkcu' ku' tcvj gt" rko kkpj. " gur gekm' "hqt" 'vj g' o quv' r tce'v'ecm' "tgrxcpv' P KI" vq' xkukdrg" wr eqpxgtukqp" j3/4\_0'VH' wr eqpxgtukqp" tgs wktgu'vy q'v' r gu'qh' o qrgewgu. "c" ugpuk'k' gt" cpf "cp" cplj kcvqt. "vj g" r wgt' qh'gp" dglpi "vj g" rko kkpj "eqo r qppg'v' Vq" gz vgf "vj g" eqmge'v'kp' qh' r quukdrg" go kwgtu'cpf "vq" i clp' hwpf co gpvcn' kpu'ki j w'kp'v' wr eqpxgtukqp" r tgegu' kugrh' qvt" vgo "uqwi j v'vq" f g'xg'qr "pgy" f g'kxc'v'x'gu'qh'f kngvr { ttqr { ttqr '\*F RR+' c' eqo o qpn' "wugf" f { g'kp' qti cple' qr vqrg'v'qpleu"o

FRR" j cu' dggp' y kf g'zr' r' tgf' "kp" vj g' hgrf' qh' qti cple' r j qvqncleu' dgecv'w'g' qh' ku' g'z' egm'gp' v'qr v'ecn' r' tqr g'v'ku. "uwej" cu' utqpi 'cdu'qr v'kp' kp' vj g' xkukdrg' t'cpi g' cpf' j ki j 'hw'qt' g'ue'p'eg' s' wcpwo " { kgrf " j5\_0'f' q' t'f' g' v'q' cr r' n' 'F RRu' kp' wr eqpxgtukqp" f g'x'legu. "vj g' k' j ki j "ci i tgi cvkqp" r' tqr gpuk' f. 'F g'v'ko gpvcn' v'q' hw'qt' g'ue'p'eg' j cu' v'q' dg' cvgp' w'cv'gf' d { 'ut' wewt' c' r' f' guki p'0' Vq' vj ku' gp'f' y g' j' cxg' f' guki pgf. 'u' p'v' guk' gf' cpf' g'x'c'w'v'gf' 'pgy' c'm' n' e'j' clp' ut' cr r' gf' 'u' g' t' k' c' m' j' kp' f' g' t' f' 'F RR' f' g' t' k' c' v' x' g' "3" \*Hki 03-0' Vj g' uwe'gu' h'w' b' qf w'v'v'kp' qh' 'ci i tgi cvkqp' r' tgegu' ku' g'z' r' g'ev'g' v'q' r' t'q'x'k' f' g' c' y' q' t' n' k' p' i' o' cvgt' k' c' n' p' q' v' q' p' n' f' 'hqt' u' q' n' w' k' p' d' w' c' n' u' q' " hqt' o' q' t' g' f' k' h' l' e' w' n' v' q' c' e' j' k' g' x' g' w' r' e' q' p' x' g' t' u' k' q' p' k' p' h' k' r' o' u' o' "



**Hki 030Ej go k'c' n' u' t' wewt' g' qh' b' cetq' e' r' k' e' 'F RR' f' g' t' k' c' v' x' g' o'**

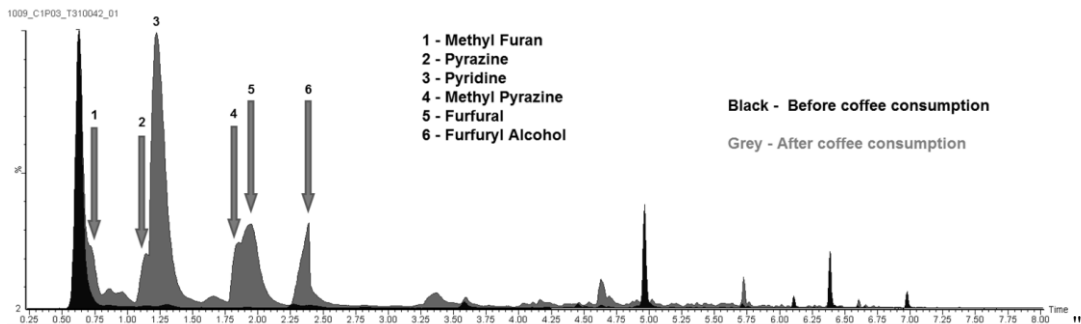
[3\_10] j qw' S ONkw' Y O' H' e' p' i' "g' v' c' r' o' W' f' e' q' p' x' g' t' u' k' q' p' h' w' o' k' p' g' u' e' p' v' o' c' v' g' t' k' c' n' c' f' x' c' p' e' g' u' c' p' f' 'c' r' r' t' e' c' v' q' p' u' 'E' j' g' o' k' e' c' n' T' g' x' l' g' y' u' 337. 'S; 7/687' \*4237-0'  
[4\_UOY gp. 10] j qw' 10U' e' j' w' e' n' l' v' c' r' o' H' w' w' t' g' c' p' f' 'e' j' c' m' g' p' i' g' u' h' t' j' { d' t' k' 'w' r' e' q' p' x' g' t' u' k' q' p' 'p' e' p' q' u' u' g' o' u' 'P' c' w' t' g' R' j' q' v' p' l' e' u' 35. '4; /: 5: \*423; +0'  
[5\_CODO' Rwp. 'NOO' O' Eco' r' q' u' 'F' O' P' O' E' q' p' i' t' g' x' g' o' 'V' w' p' c' d' n' g' 'G' o' k' u' k' q' p' 'I' t' q' o' 'V' t' k' r' n' v' 'H' w' k' q' p' 'W' f' e' q' p' x' g' t' u' k' q' p' k' p' 'F' k' n' g' v' r' { t' t' q' n' r' { t' t' q' n' u' 'L' O' C' o' O' E' j' g' o' O' U' q' e' 0363. " ; . 'S999/59: 3' \*423; +0'  
**C' e' m' p' q' y' r' g' f' i' g' o' g' p' v' u' k' 'V' j' k' u' r' t' q' l' g' e' v' j' c' u' t' g' e' g' k' g' f' "h' w' p' f' k' p' i' "I' t' q' o' "v' j' g' 'G' w' t' q' r' g' c' p' T' g' i' k' a' p' c' n' f' F' g' x' g' n' r' o' g' p' v' H' w' p' f' "R' t' q' l' g' e' v' P' q' 0' 2; 0' 0' 6' /' N' O' V' /' M' 9' 3' 4' /' 4' 4' /' 2' 3; 3-4' w' p' f' g' t' i' t' e' p' v' c' i' t' g' g' o' g' p' v' y' k' j' "v' j' g' T' g' u' e' t' e' j' 'E' q' w' e' k' i' q' h' N' k' j' w' e' p' l' c' "N' O' V' N' V' +'**

**EQT TGNCVKQP 'DGVY GGP 'R[ T K F P G 'C P F 'H W T H W T [ N 'C N E Q J Q N''**  
**K P I G U V K Q P 'C P F 'V J G K T 'R T G U G P E G 'K P 'D T G C V J "**

**Cf tk<sup>a</sup> p "Xlegpv Emtco wpy "Gxcrf cu'P cwlcru"**

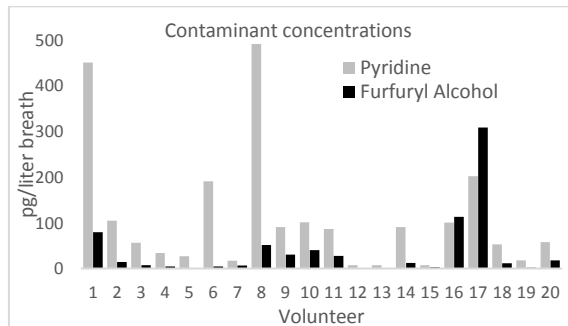
O g t q m i { 'F g r c t v o g p v 'U c v g 'T g u g c t e j 'I p u k w w g 'E g p v g t 'h q t 'R j { u l e c n 'U e l g p e g u 'c p f 'V g e j p q m i { ' N w n k - n k 'u t 0 ; . 'N V / 2 3 3 2 : 'X k p k w u . 'N k j w e p k 0 ' c f t k c p 0 k l e g p v B h o e 0 h "

H w t h w t { n 'c r e a j q n i 'H H C ' + c p f 'R { t k l p g ' \* R { + c t g . 'c o q p i ' o c p { ' q j g t ' e q o r q w p f u . ' h q q f ' e q p v c o k p c p w ' r t q f w e g f ' o c k p n f " k p ' y g t o c m l ' r t q e g u n g f ' h q q f ' u w e j ' c u ' e q l h g g . ' l w l e g u . ' c r e a j q n i e ' d g x g t c i g u ' q t ' d c n g f ' h q q f ' ] 3 . 4 \_ 0 V j q u g ' e q o r q w p f u . ' y j l e j ' c t g " e q p u k f g t g f ' v q z l e ' c p f ' r q w p v c r i e c t e k p q i g p l e ' ] 5 \_ ' c t g ' p q v ' r t g u g p v l p ' j g c n j { ' j w o c p u ' d w ' e c p ' d g ' h q w p f ' k p ' j k i j ' e q p e g p v c v k p p " k p ' d t g c v j ' c h g t ' e q l h g g ' e q p u w o r v k p p 0 ' E q l h g g ' k u ' a p g ' q h ' y j g ' o q u v ' r q r w r t ' f t k p m u ' c p f ' y k f g n l ' e q p u w o g f ' c m i c t q w p f ' y j g ' y q t r f 0 ' k p ' 4 2 3 ; 1 4 2 4 2 . ' c t q w p f ' 3 2 ' o k n k q p ' v p u ' q h ' e q l h g g ' y g t g ' e q p u w o g f ' y q t r f y k f g ' ] 6 \_ 0 V j g ' c l o ' q h ' y j k u ' y q t m i k u ' v q ' k f g p v k h { ' c p f " s w e p v k h { ' R { ' c p f ' H H C ' c h g t ' k p i g u v k p p ' d { ' w u k p i ' d t g c v j ' c p c n l u k 0 C p f ' e q o r c t g ' k v y k j ' y j g ' c e w e n i c o q w p v k p i g u n g f ' d { ' c p c n l u k p i " y j g ' d t g y g f ' e q l h g g ' u c o r r g u 0 "



*Hki 0 < E j t q o c v i t c o ' h t q o ' d t g c v j ' u c o r r g . ' d g l q t g ' c p f ' c h g t ' e q l h g g ' e q p u w o r v k p p 0 "*  
*E q m o p ' F D / 7 0 U \* 5 2 z 2 0 7 z 2 0 7 - 0 0 c i p g v ' U e c p ' 7 2 / 4 2 2 o l / 0 V g o r 0 t c p i g < 6 2 ' v q ' 4 : 2 ' a E "*

D t g y g f ' e q l h g g ' u c o r r g u ' y g t g ' r t g r c t g f ' w u k p i ' E c h g T q o c v e c ' \* P k x q p c - e q l h g g ' o c e j k p g 0 C ' 3 2 ' o n i c r k s w q v ' q h ' y j g ' d t g y g f " y c u ' e q m g e v g f ' v q ' d g ' c p c n l u g f ' d { ' J R N E ' v q ' u e d r k u j ' y j g ' s w e p v k h { ' q h ' R { ' c p f ' H H C ' r t g u g p v l p ' y j g ' u c o r r g u 0 ' k p ' q t f g t ' v q ' s w e p v k h { ' y j g ' c p c n l v g u . ' u e c p f c t f ' c f f k k q p ' o g v j q f ' y c u ' g o r r m q { g f 0 ' D t g c v j ' u c o r r g u ' h t q o ' x q m p v g t u ' y g t g ' e q m g e v g f ' d g h t g ' c p f ' c h g t " y j g ' e q p u w o r v k p p ' q h ' y j g ' d t g y g f ' e q l h g g ' k p ' q t f g t ' v q ' f g v g t o k p g ' y j g ' e q p e g p v c v k p p ' f g v g e v g f ' k p ' k 0 U c o r r g u ' y j g t g ' e q m g e v g f ' w u k p i " u g n l / f g u k i p g f ' N F R G ' r m u k e u ' d c i u ' h q t ' u c o r r n p i 0 E c r i d t e v k p p ' q h ' r { t k l p g ' c p f ' h w t h w t { n ' c r e a j q n i y c u ' c n u q ' d v c k p g f ' h k n p i ' y j g " d c i u ' y k j " ' y j g ' u e c p f c t f " u q n w k p u 0 ' C m ' y j g " u c o r r g u ' y g t g " c p c n l u g f " w u k p i " V j g t o c n l ' F g u q t r v k p p " e q w r g f " v q " I c u " E j t q o c v i t c r j { ' 0 c u u ' U r g e v t q o g y g t ' \* V F I I E / O U 0 "



*Hki 0 < E q p e g p v t c v k p p u ' q h ' R { ' c p f ' H H C ' h q w p f ' k p ' d t g c v j ' c h g t ' e q l h g g ' e q p u w o r v k p p 0 "*

F k h g t g p v ' r x g n u ' q h ' e q p v c o k p c p w ' y g t g ' s w e p v k h f ' h t q o ' x q m p v g t u ' u c o r r g u ' \* H i 0 - 0 ' V j g t g ' u g g o u ' v q ' d g ' p q v ' e r g c t " t g r v k p p ' d g y g g p ' y j g ' s w e p v k h { ' q h ' d q j ' e q o r q w p f u ' l p i g u n g f ' c p f ' y j g k ' r t g u g p e g ' k p ' d t g c v j 0 0 c p { ' h c e v t u . ' i k n g ' w o g ' v q ' f t k p n i ' y j g ' e q l h g g . ' w o g ' c h g t ' e q m g e v k p p ' q h ' y j g ' u c o r r g u . ' g c v k p i ' q t ' f t k p n i k p i ' u q o g v j k p i ' g n u g ' y j k p g ' e q p u w o k p i ' y j g ' e q l h g g . ' k h ' y j g ' e q l h g g " k u ' f k n w g f " c h g t y c t f u ' q t ' e q p u w o g f ' y k j " o k m " q t ' g x g p ' y j g ' d q f { " c u u l o k r v k p p ' e q w r ' k p h n w g p e g ' y j g ' e q t t g r v k p p 0 J q y g x g t . " d t g c v j " X Q E u ' e q m g e v k p p " e c p ' d g ' w u g f " h q t " y j g ' f g v g e v k p p ' q h ' h q q f " e q p v c o k p c p w ' c h g t " e q p u w o r v k p p ' g x g p ' c v ' x g t { " n y " e q p e g p v c v k p p u 0 "

[3]\_COP 01 r g u u . ' E 0 l g t g v l k p . ' T O M p q e j g p o w u u . ' O 0 l t q g u n i ' I p g t p e v k p c n l q w t p e n i q h ' O c u u ' U r g e v t q o g t { ' X q m o g ' 6 4 6 . ' l e p w e t { ' 4 2 3 : . ' R c i ' 6 ; / 7 9 0  
 [4]\_HDE l p e q w c ' g v c r 0 T N Y V ' ' ' H q q f ' U e l g p e g ' c p f ' V g e j p q m i { ' 3 3 : ' \* 4 2 4 2 + 3 2 : 9 3 : 0  
 [5]\_C00Q0 m e t w ' c p f ' F 0 Y 0 N c e j g p o g k e t ' T V q z k e u ' 4 2 3 9 . ' 7 . ; 0  
 [6]\_I p g t p e v k p c n l E q l h g g ' Q t i c p k c v k p ' y y 0 e q 0 t i 4 0 "



**C'TTF G'UVWF [ 'QH'O P/DCUGF 'ECVJ QF G'O CVGT KCN'FGI TCF CVKQP "**  
**IP 'CS WGQWUP C/KQP 'DCVVGTKGU'**

F c x k / V g f k u j x k r k <sup>3,4</sup> N k p c u ' X k n k e w u n e u <sup>4</sup>

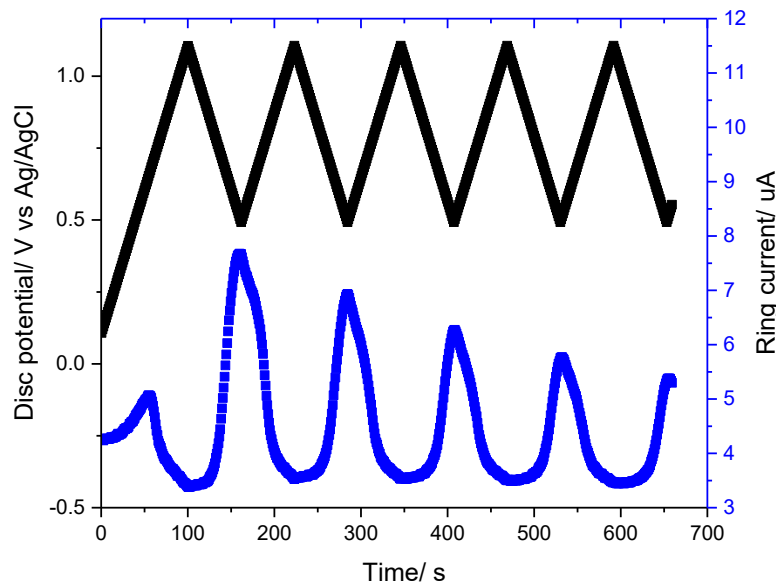
<sup>3</sup> K p u k w w g ' q h ' E j g o k u t { . H e w n { ' q h ' E j g o k u t { ' c p f ' I g q u e l g p e g u . ' X k p k w u ' W p k x g t u k y { . ' N k j w c p k e "   
<sup>4</sup> E g p v g t ' h q t ' R j { u l e c n ' U e l g p e g u ' c p f ' V g e j p q r n i { . ' U c w r g v n k y ' c i 0 5 . ' N V / 3 2 4 7 9 ' X k p k w u . ' N k j w c p k e "

F c x k / V g f k u j x k r k B h o e 0 u "

Tgej cti gcdrg' rksj kwo /kqp' dcwgtkgu' y kj " qti cple" grgevtqn' vgu' ctg' y kf gn' " wugf " cu' eqo o gtekn' gpgti { " uqtci g' f gxlegu' Vj g { " j cxg' o cp { " cwtcevkxg' r tqr gt vku . " uwej " cu' j ki j " ghlekgpe { . " gpgti { " f gpuk { " c p f " u c d k r k y { 0 J q y g x g t . " cu' y j g' gpgti { " uqtci g' f go c p f ' l p e t g c u g u . ' i t q y k p i ' r t l e g u ' q p ' u e c t e g ' r k s j k w o ' t g u q w t e g u ' c n u q ' l p e t g c u g . ' o c n k p i ' r k s j k w o / k q p ' d c w g t k g u ' r g u u ' c w t c e v k x g ' Q p ' v j g ' q y g t ' j c p f . " u q f k w o " k u ' y j g " u l z v j " o q u v ' c d w p f c p v ' g r g o g p v ' k p ' g c t v j ' a i ' e t w u 0 ' C p q v j g t ' d k i " k u w g " q h ' eqo o gtekn' dcwgtkgu' tgo ckpu' y j g' wuci g' qh' qti cple " uqrxgpwu' y j lej " lpetgcug' r tqf wevkqp' equv' c p f " t c k u g ' u c h e v y ' e q p e g t p u 0 ' V j k u ' r t q d r g o " k u ' u q r x g f " d { " t g r m e k p i " q t i c p l e " u q r x g p w u ' y k j " c s w g q w u " g r g e v t q n { v g u 0 ' V t c f k k p c m { . " y j g " w u g " q h ' c s w g q w u " g r g e v t q n { v g u " l p " d c w g t k g u " y c u ' r k o k g f " d { " p c t t q y " r q v g p v k n ' y l p f q y " q h ' q r g t e v k p . " d g { q p f " y j l e j " y c v g t " f g e q o r q u g u 0 ' J q y g x g t . " t g e g p v n { " f g x g r n r g f " y c v g t / k p / u c n " g r g e v t q n { v g u " e c p " g z r c p f " y j k u ' r q v g p v k n ' y l p f q y " j 3 . " o c n k p i " c s w g q w u " g r g e v t q n { v g u " c " x l e d r g " c n g t p c v k x g 0 J q y g x g t . " y j g ' r t q d r g o " q h ' g r g e v t q f g " o c v g t k n ' u c d k r k y { " f w t k p i " q r g t e v k p p g g f u " v q " d g " u q r x g f " v q ' h w n { " w k r k g ' y j k u ' v e j p q r n i { 0 "

Y kj " i gpgtcn' hqto wr' qh' P c s O 4 \* R Q 6 + 5 . " P C U K E Q P / u t w e w t g f " o c v g t k n i ' c t g ' g z e g r v k p c n i ' f w g ' v q ' y j g k t " w p l s w g " h t c o g y q t n i u t w e w t g ' r t q x l f k p i ' h c u v ' P c / k q p ' t c p u r q t v 0 ' V j g { " e c p " q h h g t " j k i j " y j g q t g v e c n ' e c r c e k y { " c p f " q r g t e v k p i " x q n c i g . " j q y g x g t . " o k i j v u w h g t ' h t q o ' r q q t ' e { e r k p i ' r g t h q t o c p e g ' g u r g e k c m { ' l p ' c s w g q w u ' g r g e v t q n { v g u ' j 4 . 0 "

J gtg. " y g ' r t g u g p v ' c " t q v c v k p i " t k p i / f k u e " g r g e v t q f g " \* T T F G + u w f { " q h ' y j g " P c s O p V k \* R Q 6 + 5 . f g i t c f c v k p p " k p " c s w g q w u " g r g e v t q n { v g O ' C " u l o k r c t " u w f { " y c u ' e c t t k g f " q w w ' q p " N i O p 4 Q 6 . " c p f " u j q y g f " y j c v ' o c v g t k n i ' f g i t c f c v k p p " v e n g u ' r m e g " l p " h w n { " e j c t i g f " q t " h w n { " f k u e j c t i g f " u c v g " j 5 . 0 ' k p " y j g " e c u g " q h ' P c s O p V k \* R Q 6 + 5 . " y j g ' t g u w u u ' u j q y " y j c v ' f g i t c f c v k p p " q e e w u ' q p n { " f w t k p i " y j g ' f k u e j c t i g " r j c u g " \* 2 0 " X " x u 0 ' C i ' C i E n " q t " t g f w e v k p " q h ' O p 6 . " u w i i g u k p i " y j c v ' k ' k u ' f t k x g p " d { " e j g o l e c n i ' f k u u n w k p " q h ' O p 4 " h q t o g f " l p " c s w g q w u " o g f k e 0 ' V j g ' f g i t c f c v k p p " q h ' P c s X 4 \* R Q 6 + 5 H 5 " \* P X R H " y c u ' c n u q " u w f k g f " y k j " y j g " u c o g " v e j p l s w g 0 ' Q x g t c m " y j g " w p f g t u c p f k p i " q h ' f g i t c f c v k p p " o g e j c p k u u " q h ' g r g e v t q f g " o c v g t k n i " k u ' e t w e k n i ' h q t " y j g k t " o k k i c v k p ' c p f " T T F G ' k u ' u l o r n g ' c p f " w u g h w i ' v q r i h q t " y j k u ' c u n 0 "



H k i w t g ' 3 0 C r r n g f ' r q v g p v k n i q p ' c ' f k u e " d i e m " c p f " e w t t g p v t g u r q p u g " q p ' R v t k p i " d n w g + f w t k p i " T T F G " g z r g t k o g p v q p " P O V R 0 "

**Cempqy rgi go gpwuk'**

Vj ku' r tqlgev' j cu' tgeglxgf " hwpf kpi " hqto " y j g " Gwtqr gcp " T gi kqpcn' F gxgrnr o gpv' hwpf " \* Rtqlgev' P q 0 ' 23 0 0 1 / N O V / M 93 : / 2 4 / 2 2 2 7 + w p f g t ' i t c p v ' c i t g g o g p v y k j " y j g " T g u g t e j " E q w p e k i ' q h ' N k j w c p k e " \* N O V N V + "

[3\_ N O U w q ' g v ' e r f ' 0 Y c v g t / k p / u c n 0 ' g r g e v t q n { v g ' g p c d r g u ' j k i j / x q n c i g ' c s w g q w u ' h k j k w o / k q p ' e j g o k u t l g u . ' U e l g p e g ' 5 7 2 . ' ; 5 : / ; 6 5 \* 4 2 3 7 + "   
 [4\_ F 0 D l p ' g v ' e r f ' R t q i t g u u ' k p ' C s w g q w u ' T g e j c t i g c d r g ' U q f k w o / k p ' D c v g t k g u . ' C f x e p e g f ' G p g t i { ' O c v g t k n i ' ; \* 3 9 + ' 3 / 5 3 \* 4 2 3 : + "   
 [5\_ " N " Y c p i " g v ' e r f " U w f { " q h ' O p " F k u u n w k p " h t q o " N i O p 4 Q 6 " U r l p g n ' G r g e v t q f g u ' W u l p i " T q v c v k p i " T k p i / F k n i ' E q n g e v k p p " G z r g t k o g p u . " l q w t p c n i ' q h ' G r g e v t q e j g o l e c n i ' U e l g v y . ' 3 7 2 \* 9 + ; ' 2 7 ; ' 3 3 \* 4 2 2 5 + "

**U P V J G U K U Q H E W E Q P V C R P I ' E C N E K W O ' R J Q U R J C V G ' Y K V J "**  
**Y J K V N Q E M K V G ' U T W E V W T G ' V J T Q W J ' V J G ' N Q Y / V G O R G T C V W T G "**  
**F K U Q N W W I Q P / R T G E K R I V C V I Q P ' R T Q E G U U "**  
**F k p c p " I t k g u k w g . " C i p g " M k c r k v g . " J c p p c " M k r c p . " C r g m i g l \ " c t n q x "**

"kpukwg"qh'Ej go kut { . 'Xkpkwu'Wpkxgtukv { . 'P cwi ctf wmq' i 046. 'NV/25447. 'Xkpkwu. 'Nkxj wcpk'"  
f k p c p f t k g u k w g B e j i h k v o h "

Ecrekwo "r j qur j cvgu" \*EcRu"ctg" y j g" o clp "kpqti cple" eqpuwkwgpw" qh'j wo cp" j ctf "vkuwgu" Vj gtg" ctg" c" rjv" qh' EcR' r j cugu" y j lej " j cxg" f k h g t g p v" r j { ulecn' r tqr gt vku" cpf " cr r n e c v k p p' J wo cp" j ctf " vkuwgu" o quwv " eqpukv" qh' ecrekwo " j { f t q z { c r c v k g " \* J Cr + y j lej " ku' y g' o quv' ucdng" EcR' r j cug" ctqwpf " p g w t c n r' J " J 3\_0 V j g' u g e q p f " o q u v' c d w p f c p v' EcR' r j cug" ku' y j k r j e n k g' O' O' c i p g u k w o " y j k r j e n k g' k u' c' o g o d g t' q h' EcR u' h c o k f . " y j g t g' u o g' e c r e k w o " k p u' c t g' u w d u k w w g f " d { " u o c n g t " o c i p g u k w o " k p u' O' E j g o k e c n' h q t o w a c " q h' o c i p g u k w o " y j k r j e n k g' k u' Ec3. O i 4 \* J R Q 6 + 4 \* R Q 6 + 3 4 " J 4\_0' W p h q t w p c v g n . " y j g' r t g r c t c v k p p' q h' r j c u g / r w t g' y j k r j e n k g' t g o c l p u' x g t { " e j c n g p i k p i " c p f " y j g' q d v c l p g f " u { p v j g u k u' r t q f w e w u' q h n g p' e q p v c l p k' k o r w k l g u O' P g x g t y g r g u u . " y j k u' o c v g t k e n' k u' c' r t q o k u k p i " e c p f k f c v g " k p' q t v j q r g f k e " u w t i g t { " d g e c w u g' k' k u' d l q e q o r c v k d n g' c p f " r q u u g u g u' g z e g m p v' q u v g q i g p l e " r t q r g t v k u O' Y j k r j e n k g' r j c u g' k u' o q t g' u c d n g' y j c p' J Cr " k p' c e k f k e " u q r n w k p p' u q' k' k u' d g p g h e k e n' k p' d a p g' o k p g t e r k c v k p p' J 3\_0'

F q r k p i " q h' EcR u' y k j " q v j g t' k p u' o c { " t g u w n' k p' y j g' c r r g e t c p e g' q h' p g y " r j { u l e c n' c p f " d k q m i k e c n' r t q r g t v k u . " y j l e j " e c p " d g' w u g f " k p' y k f g t' c r r n e c v k p p' c t g c O' E q r r g t' k u' c p' g u u g p v k e n' t c e g' g r g o g p v' p g e g u a c t { " h q t' o c o o c r k e p' r i k g' c p f " k' r n e { u' c' " e t w e k n' t q r g' k p' y j g' e t q u u' r k p n k p i " q h' e q n c i g p' c p f " d a p g' g r c u v k p' J 5\_0' k' k u' k o r q t v c p v' h q t' o g x c d q r k u o " r t q e g u u g u' d g e c w u g' k' c e w u' r n g' e q h' c e w t' h q t' o c p { " g p l { o g u' J 6\_0' E q r r g t' " g z j k d k u' c p v k d c e v g t k e n' r t q r g t v k u' c p f " r k o k g f " e { v q v z l e k v { . " f w g' v q' y j g u g' t g c u q p u' k' k u' c' r t q o k u k p i " e c p f k f c v g' h q t' f q r k p i " k p v q' EcR u' o c v t l e g u O' E w u w d u k w w g f " EcR u' c t g' y g n i' n p q y p' h q t' y j g k' " c p v k d c e v g t k e n' c p i k q i g p l e " c p f " q u v g q i g p l e " r t q r g t v k u' J 7\_0'

V j g' o c l p' i q e n' q h' y k u' y q t n i y c u' v q' u f p v j g u k' g' u k p i n g' r j c u g' y j k r j e n k g' r q y f g t u O' E q r r g t' y j k r j e n k g' r q y f g t u' y g t g' u { p v j g u k' g f " d { " f k u u q n w k p p' r t g e k r c v k p p' o g y q f " w p f g t' j { f t q v j g t o c n' e q p f k k p p u' w u k p i " e c r e k w o " j { f t q i g p' r j q u r j c v g' f l j { f t e v g' \* E c J R Q 6\_4 J\_4 Q + c p f " e q r r g t' p k t c v g' v k j { f t e v g' \* E w \* P Q 5 + 4 J\_4 Q + c u' u v c t v k p i " o c v g t k e n' O' V j g' e t { u c n i k p k v { . " e t { u c n i' u t w e w t g' c p f " u t w e w t e n' l e j c p i g u' y g t g' g x c n e v g f " d { " r q y f g t' Z / t c { " f k h t c v k p p' \* Z T F + . " H q w l g t / s t e p u h q t o " l p h t c t g f " \* H V K T + " c p f " T c o c p' u r g e t q u e q r k g u O' U e c p p k p i " g r e v t q p' o l e t q u e q r { " \* U G O + y c u' w u g f " h q t' y j g' e j c t c e v g t k c v k p p' q h' o q t r j q m i k e c n' h g c w t g u' q h' r t q f w e w u O' E j g o k e c n' l e q o r q u k k p p' q h' u { p v j g u k' g f " r q y f g t u' y c u' c p c n' | g f " d { " k p f w e k x g n' " e q w r n g f " r n u o c' q r v l e c n' g o k u k p p' u r g e t q o g t { " \* K E R / Q G U O'

V j g' t g u w n u' q h' Z T F . " H V K T " c p f " T c o c p' u r g e t q u e q r k g u' e q p h t o g f " y j c v u { p v j g u k' g f " EcR' j' c u' y j k r j e n k g' u t w e w t g O' K' y c u' f g o q p u t e v g f " y j c v' q r v k o c n' t g c e v k p p' v o r g t c w t g' k u' 4 2 2 E . " c v' y j k u' v o r g t c w t g' y c u' u f p v j g u k' g f " u k p i n g' r j c u g' y j k r j e n k g' r q y f g t u O' Q r v k o c n' r' J " t c p i g' y c u' f g v g t o k p g f " v q' d g' h t q o " 8 0 6 " v q' 8 0 8 0 P g l i j d a t k p i " e t { u c n i' r j c u g u' y g t g' q d v c l p g f " c v' n i y g t' v o r g t c w t g u' c p f " j k i j g t h q y g t' r J " q h' y j g' t g c e v k p p' o g f k w o O' C n u q . " k' y c u' h q w p f . " y j c v q r v k o c n' t g c e v k p p' v k o g' k u' c d q w' 5 " j q w t u O' V j g t o c n' u c d k h k v { " u w f k g u' t g x g c n g f " y j c v' e q r r g t / e q p v c l p k p i " y j k r j e n k g' k u' y j g t o c n' " w p u c d n g' c p f " f g e q o r q u g u' c h g t' c' j g c v' t g c v o g p v O'

**C e n p q y n g f i g o g p w "**

V j k u' t g u g t e j " y c u' h w p f g f " d { " y j g' G w t q r g c p' U q e k e n' H w p f " w p f g t' y j g' P q O' 2; 0 6 / N O V / M / 9 3 4 " o F g x g r r o g p v' q h' E q o r g y p e g u' q h' U e k p p k u u . " q v j g t' T g u g t e j g t u' c p f " U w f g p w " y j t q w i j " R t c e v k e c n' T g u g t e j " C e v k x k g u o " o g c u w t g' \* i t c p v' P q O 2; 0 6 0 N O V / M / 9 3 4 / 4 4 / 2 2 7 5 + 0'

[3\_] J 0' N O L c p i . " J 0' M O' N g g . " M O' L p . " J 0' l' O' C j p . " J 0' G O' N g g . " ( " M O' V O' P c o . " R j c u g' u t c p u h q t o c v k p p' h t q o " j { f t q z { c r c v k g' v q' y j g' u g e q p f c t { " d a p g' o k p g t e n' " y j k r j e n k g' O' L q w p e n' q h' O' c v g t k e n' E j g o k u t { " D . " 5 " \* 4 2 3 7 + 3 5 6 4 6 3 5 6 ; 0 j w r u 4 l f q k Q t i B 2 0 2 5 ; k 6 v d 2 3 9 ; 5 g 0'

[4\_] J 0' E j g p i . " T O E j c d q m' Z O I w e p . " C O E j c y n . " I 0' N k' C O M j c f g o j q u e g l p k' ( " J 0' N O L c p i . " U { p g t i k u l e' k p v g r n e { " d g w g p p' y j g' y q' o c l q t' d a p g' o k p g t e n' " j { f t q z { c r c v k g' c p f " y j k r j e n k g' p e p q r c t v e r g u . " h q t' q u v g q i g p l e " f k h g t g p v c v k p p' q h' o g u g e j { o c n' u g o " e g m i O' C e v' D k q o c v g t k e r k . " 8 ; " \* 4 2 3 : + 3 5 6 4 6 3 7 3 0' j w r u 4 l f q k Q t i B 2 0 2 3 8 I I @ e v d l q 0 4 2 3 : 0 3 0 2 3 8 0 J 3 . " J 0' N O L c p i . " J 0' M O' N g g . " M O' L p . " J 0' l' O' C j p . " J 0' G O' N g g . " ( " M O' V O' P c o . " R j c u g' u t c p u h q t o c v k p p' h t q o " j { f t q z { c r c v k g' " v q' y j g' u g e q p f c t { " d a p g' o k p g t e n' " y j k r j e n k g' O' L q w p e n' q h' O' c v g t k e n' E j g o k u t { " D . " 5 " \* 4 2 3 7 + 3 5 6 4 6 3 5 6 ; 0' j w r u 4 l f q k Q t i B 2 0 2 5 ; k 6 v d 2 3 9 ; 5 g 0'

[5\_] U O I q o g u . " E O' X l e j g t { . " U F g u e c o r u . " J 0' O' c t v k p l . " C O' M c w . " C O' l c e q d u . " I O' O' P g f g r e . " ( " I 0' T g p c w f k p . " E w f q r k p i " q h' e c r e k w o " r j q u r j c v g' d l q e g t c o l e u . " H i q o " o g e j e p l u o " v q' y j g' e q p v t q n' q h' e { v q v z l e k v { O' C e v " D k q o c v g t k e r k . " 8 7 " \* 4 2 3 : + 6 8 4 6 6 9 6 0' j w r u 4 l f q k Q t i B 2 0 2 3 8 I I @ e v d l q 0 4 2 3 9 0 2 0 4 : 0'

[6\_] O 0' D q u w " U O j q w f c t v O' O' Q d g t r i k " G O' M c n p l k' I O' H O j w p g c w " ( " K O' c t i c t k k u . " F l e v t { " e q r r g t' c p f " j w o c p' j g e n j < E w t g p v' g x l f g p e g' c p f " w p t g u n g f " k u w g u O' L q w p e n' q h' V t e g' G r g o g p w' l p' O g f k e l p g' c p f " D k q m i { . " 5 7 " \* 4 2 3 8 + 3 2 9 6 3 3 7 0 j w r u 4 l f q k Q t i B 2 0 2 3 8 I I @ e v d l q 0 4 2 3 8 0 2 0 4 2 8 0'

[7\_] C O' l c e q d u . " I 0' T g p c w f k p . " E O' H q t u n k t . " I O' O' P g f g r e . " ( " U O F g u e c o r u . " D k q m i k e c n' r t q r g t v k u' q h' e q r r g t / f q r g f " d l q o c v g t k e n' h q t' q t v j q r g f k e " c r r n e c v k p p' C " t e x l g y " q h' c p v k d c e v g t k e n' c p i k q i g p l e " c p f " q u v g q i g p l e " c u r g e w u O' C e v " D k q o c v g t k e r k . " 3 3 9 " \* 4 2 4 2 + 4 3 6 5 ; 0' j w r u 4 l f q k Q t i B 2 0 2 3 8 I I @ e v d l q 0 4 2 4 2 0 : 0 6 6 0'

**U P V J G U K U C P F ' E T [ U V C N ' U V T W E V W T G U Q H U C O C T K W O \* K K K 6**  
**E Q P V C K P K P I ' J G V G T Q R Q N [ ' U C N V U ' Y K V J ' R G C E Q E M 6 Y G C M N G [ ' V [ R G "**  
**C P K Q P ' P c ; 6 z J z ] U 6 \* Y 7 Q 3 : t 4 \_ n J 4 Q "**  
Q r g m c p f t c ' O c t k e j c m <sup>3,4</sup> . ' I g q t i k k T q l c p v u g x <sup>3</sup> . ' U g t j k k T c f k q <sup>4</sup> "

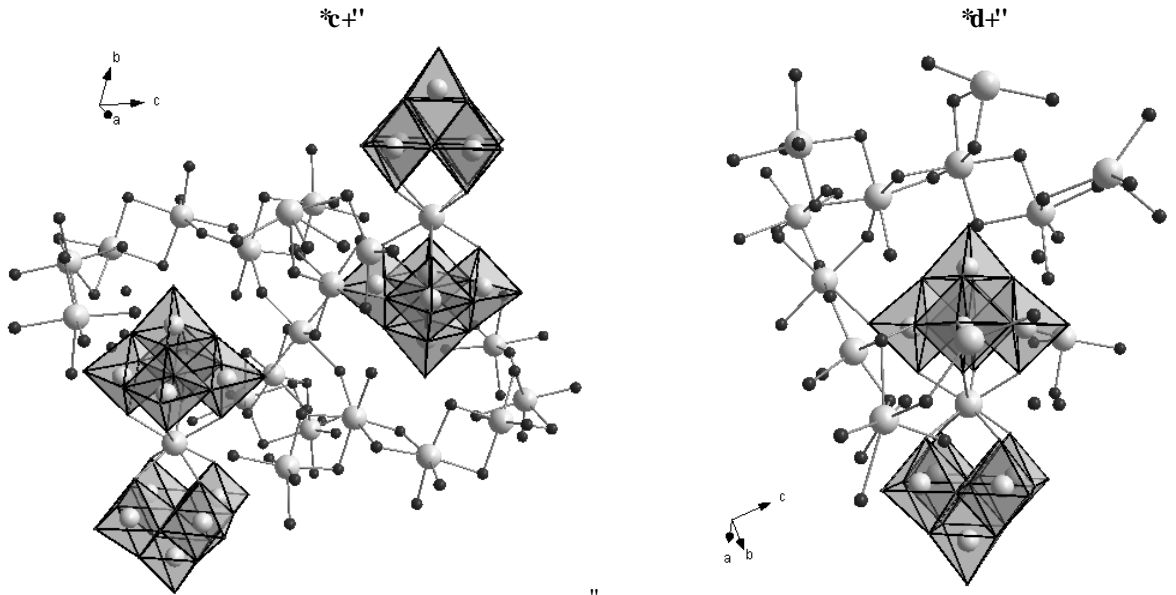
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<sup>4</sup>F gr ctvo gpv'htq' Tgugctej . 'Tgugctej "Ncdqtcvt { "6Ej go knt { "qh'Rqn{ qzqo gncv'gu'cpf "Eqo r rnz'Qz'kf g'U{ ungo u6 . "Xcu{n}"  
 Uwu'F qpgvni'P cvkqpcn'Wpkxgt ukv{ . 'Wntclpg"  
 tcf kqB f qppw'gf w6c"

Vq'f gvgto lpg'yj g'etk'lecn'icekf kv' hqt' qdvc'k'p'ki "qh'nc'p'j cpl'f g' \* K K K / e q p v c k p l p i ' j g v g t q r q n { ' u c n u ' y k j ' R g c e q e m 6 Y g c m n g { " v { r g " c p k q p " ] N p \* Y 7 Q 3 : t 4 \_ 6 " \* N p " ? ' n p j c p k f g + " c " p g y " r t q e g f w t g " h q t " y j g " u { p v j g u k u " q h " u q f k w o " j g v g t q r q n { " f g e c w p i u q u c o c t c v g \* K K K ' h t q o ' U 6 \* P Q 5 + 6 ' P c 4 Y Q 6 ' 6 ' J P Q 5 ' 6 ' J 4 Q ' u q n w k q p u ' y k j ' y j g ' t c v k q " \* U 6 + < " \* Y + ? ' 3 < 3 2 . ' y j k e j " c e k f k h g f ' w r ' v q " ? " \* J P Q 5 + 1 ' P c 4 Y Q 6 + ? " 2 Q 2 6 3 0 4 2 \* O c t k e j c m i Q Q w 0 " g v ' c i O R c v g p v q h ' W n t c l p g P q 0 3 4 3 5 4 4 . ' 4 2 3 9 + ' y c u " w u f 0 V j g ' h t o c v k q p ' q h ' j g v g t q r q n { ' c p k q p u ' d { ' u g n i c u g o d n { ' r t q e g u ' e q t t g u r q p f u ' v q ' y j g ' g s w c v k q p < "

U 6 - " 3 2 " Y Q 6 <sup>46</sup> - \* \* - + J - " ? " ] U 6 \* Y 7 Q 3 : t 4 \_ 6 " 6 ' J 4 Q 0 "

Vj g' u { p v j g u k u g f ' e t { u c n l p g ' u c n u ' q h ' P c . J ] U 6 \* Y 7 Q 3 : t 4 \_ 5 : 0 4 7 J 4 Q " \* " ? " 2 Q 2 + c p f " P c 9 J 4 ] U 6 \* Y 7 Q 3 : t 4 \_ 4 6 0 7 J 4 Q " \* " ? " 3 0 2 + y g t g e j c t c e v g t k f g f ' d { " U p i n g ' E t { u c n i Z / t c { " c p c n { u k u " \* H i 0 3 + : ' H V / K I " u r g e v t q u e q r { " c p f ' g r g o g p v c i ' c p c n { u k u }

Vj g' o c l p " e t { u c n i t r j k e " f c v " h q t " P c . J ] U 6 \* Y 7 Q 3 : t 4 \_ 5 : 0 4 7 J 4 Q " c t g < " v l e n p l e . " R 6 3 . " c " ? " 3 4 0 ; 6 \* 6 + x . " d " ? " 3 5 0 3 4 \* 6 + x . " e " ? " 4 2 0 ; 7 \* 8 + x . " ? " 9 8 0 ; \* 5 + A " ? " : 6 0 7 \* 5 + A " ? " 9 9 0 6 4 \* 5 + A " X " ? " 5 5 7 4 0 \* 3 : + x 5 . " \ " ? " 4 = " c p f " h q t " P c 9 J 4 ] U 6 \* Y 7 Q 3 : t 4 \_ 4 6 0 7 J 4 Q " c t g < " v l e n p l e . " R 6 3 . " c " ? " 3 4 0 7 2 8 \* 6 + x . " d " ? " 3 4 0 8 7 8 \* 4 + x . " e " ? " 3 : Q 9 6 6 \* : + x . " ? " ; 8 0 6 8 3 \* 4 + A " ? " 3 2 2 0 6 ; \* 5 + A " ? " 3 2 4 0 6 9 4 \* 4 + A " X " ? " 4 : 4 : 0 4 5 \* 3 9 + x 5 . \ " ? " 4 0 "



Hi 030Et {ucn'utwewt'gu'qh'P c: J ] U 6 \* Y 7 Q 3 : t 4 \_ 5 : 0 4 7 J 4 Q " \* c + : " c p f " P c 9 J 4 ] U 6 \* Y 7 Q 3 : t 4 \_ 4 6 0 7 J 4 Q " \* d + 0 "

Co qtrj qwu' r t g e k r k e v g u ' y j k e j " k u r e v g f " h t q o " u q n w k q p u ' y k j " \ " ? " 3 0 2 " c p f " 3 0 4 2 . " y g t g " l p x g u k i c v g f " d { " H V / K I " u r g e v t q u e q r { 0 ' V j g ' t g u v n u ' q h ' v j g ' u w f { " u j q y g f " y j g ' r t g u g p e g " q h ' R g c e q e m 6 Y g c m n g { " v { r g " c p k q p " l p " y j g ' u c n ' q d v c k p g f " c v \ " ? " 3 0 2 . " c p f " j g r v e w p i u c v g ' c p k q p " ] Y 9 Q 4 6 - 8 6 ' 6 ' c v \ " ? " 3 0 4 2 0 V j w u . \ " ? " 3 0 2 " k u ' v j g ' e t k k e c n i c e k f k v . " y j k e j " c m n y u ' v q ' q d v c k p " u c n u ' y k j ' j g v g t q r q n { " f g e c w p i u q u c o c t c v g \* K K K ' c p k q p 0 "

Vj g' q d v c k p g f " Z / t c { " f k h t c e v k q p " f c v " u w r r i g o g p v ' y j g ' t g u v n u ' q h ' u t w e w t c n i ' u w f k g u ' q h ' v y q " U 6 \* K K K / e q p v c k p l p i " r q n { q z q w p i u c v g u ' y k j ' R g c e q e m 6 Y g c m n g { " v { r g " c p k q p " f g u e t k d g f " l p " y j g ' r k g t c w t g < " P c 8 J 5 ] U 6 \* Y 7 Q 3 : t 4 \_ 0 4 : J 4 Q " ] 3 \_ " c p f " M 6 P c 6 J 4 ] U 6 \* Y 7 Q 3 : t 4 \_ 0 4 4 J 4 Q " ] 4 \_ 0 H q o " y j g ' c p c n { u k u ' q h ' v j g ' e q o r c t k u q p ' q h ' u t w e w t c n i ' r c t c o g v g t u ' q h ' e q o r q w p f u ' k v ' e c p ' d g " e q p e n f g f " y j c v e j c p i g u ' l p ' y j g ' e q o r q u k k q p ' q h ' v j g ' e c v k p l e ' u w d r c w e g ' c p f " y j g ' r t g u g p e g " q h ' f k h g t g p v p w o d g t u ' q h ' e q q t f l p c v g f " c p f " w p e q q t f l p c v g f " y c v g " o q r g e w r g u ' j c x g ' c m q u v ' p q ' g h g e v ' q p " y j g ' x c n w g u ' q h ' d q p f " r e p i v j u ' c p f " x c r p e g " c p i r g u ' l p " y j g ' j g v g t q r q n { " c p k q p 0 "

Vj g' u w f { " y c u ' e c t t k f " q w ' y k j k p ' y j g ' H w p f c o g p v c n i T g u g t e j " R t q i t c o o g ' h w p f g f " d { " y j g ' O k p k m t { " q h ' G f w e c v k q p " c p f " U e k p e g " q h ' W n t c l p g " \* i t c p u ' K F " 2 3 3 ; W 3 2 2 2 4 7 . ' 2 3 4 2 W 3 2 4 2 7 ; 4 0 "

[3\_V0Q] gnk^V0[ co cug.'J gzcuf'kwo "Vtkj {ftqi gp'F gecwpi uquco ctcvg'Qevceqzj {ftcvg.'Cev'Et {u0E72.'5496552^\*3; ; 6-0  
 [4\_V0Q] gnk^V0[ co cug.'Ghgev'q'hr'p'j cpl'f g'eq'p't'cev'k'p'q'p'yj g'ut'wewt'gu'qh'yj g'f gecwpi uqr'p'j cp'c'v'g'c'p'k'q'u'k'p'M6P c6J 4]NpY 32Q58\_cpJ 4Q^\*Np^? 'Rt.'  
 P f . ' U 6 . ' I f . ' V d . ' F { + e t { u c n u . " C e v ' E t { u 0 D 7 2 . ' 3 4 : 6 3 5 6 ^ \* 3 ; ; 6 - 0 "

# DETERMINATION OF COMPOUNDS STRUCTURES FORMED DURING ELECTROPHILIC CYCLIZATION REACTIONS OF BENZIMIDAZOL-2-YL ALKYNES USING NMR

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Identification of compounds in proteomics [1], metabolomics [2] and scientific laboratories is very important in organic chemistry. There are many analytical techniques that allow such studies to be performed, for example, chromatography, mass spectroscopy or quantification of the absorption of radiation [3]. However, these methods do not allow the structure of compounds to be determined. Nuclear magnetic resonance (NMR) spectroscopy and X-ray crystallography can solve this problem. Crystallography, however, has a number of limitations. The most significant is the need of single crystals. Therefore, NMR spectroscopy is used more widely. This method is nondestructive, easily quantifiable and very informative. One-dimensional (1-D) spectra (e.g.  $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{15}\text{N}$ ,  $^{31}\text{P}$ ) provide information about the presence of different atoms in a molecule, while two-dimensional (2-D) spectra help to determine how they are connected. The major 2-D NMR experiments can be divided in two categories: homonuclear and heteronuclear [4]. The homonuclear 2-D NMR experiments are the correlation spectroscopy (COSY) and the total correlation spectroscopy (TOCSY). In the heteronuclear experiment category, there are the heteronuclear single quantum correlation experiment (HSQC) and heteronuclear multiple bond correlation (HMBC). By combining these methods, the structure of the compound can be easily determined. Keeping this in mind we determined the structures by 2-D NMR spectroscopy of the formed compounds in the electrophilic cyclization reactions of benzimidazol-2-yl alkynes.

The electrophile induced alkynes cyclization reactions can proceed through *endo-dig* or *exo-dig* cyclization modes, depending on the chain length, the substitution pattern on the chain, and the electrophile employed. In our research we have several groups of starting materials (**Fig. 1**). After NMR spectra analysis, it was found that in reactions with iodine 2-((3-aryl prop-2-yn-1-yl)thio)-1*H*-benzo[d]imidazoles **1a-d** formed 6-*endo-dig* **2a-d** and 2-((2-prop-2-yn-1-yl)thio)-1*H*-benzo[d]imidazoles **1e** formed 5-*exo-dig* cyclization products **3e** respectively. Hence, after 2-D NMR analysis of the cyclization reactions of both starting materials **4** and **5** spectra data showed that only seven-membered heterocyclic frameworks were formed *via* a 7-*endo-dig* ring-closing pathway. The main proof of formed products was obtained using HMBC spectra. For example, the HMBC spectrum of compound **7a** showed only the interaction of the  $-\text{CH}_2$  group (3H) with the carbon to which the electrophile was attached (10C). Because HMBC spectra show  $^1\text{H}$ - $^{13}\text{C}$  interaction through 2-3 bonds R-group hydrogen (8H) did not show interaction with the carbon 10C. If this interaction was visible, it would mean that hydrogens 8H are distant through 3 bonds from 10C and the 6-*exo-dig* cyclization product was formed. More details about 2-D NMR analysis and spectra will be discussed in presentation.

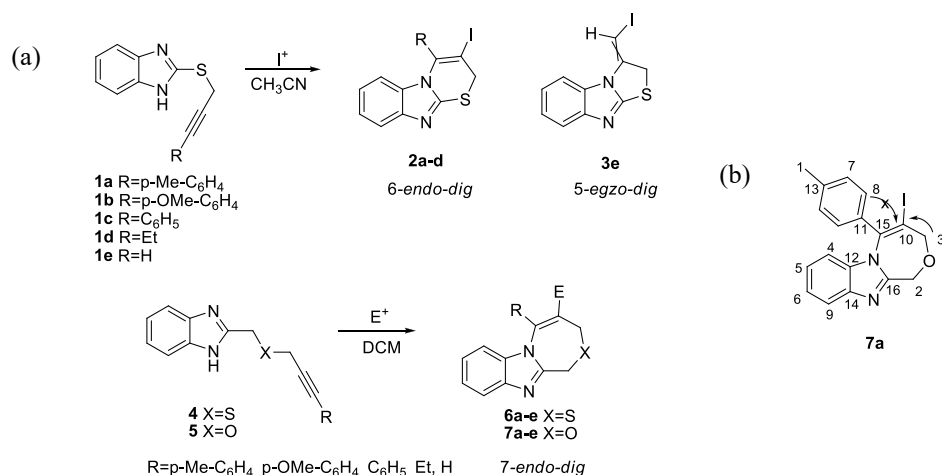


Fig.1. (a) General scheme of reactions, (b) 4-iodo-5-(p-tolyl)-1*H*,3*H*-benz[4,5]imidazo[2,1-c][1,4]oksazepine **7a**

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# INVESTIGATION OF ELECTROPORATION EFFECTS BY MEDIATED AMPEROMETRY AT YEAST MODIFIED ELECTRODES

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Budding yeast (*Saccharomyces cerevisiae*) is one of the most well-studied and understood eukaryotic organisms. Yeast cells could be used for whole-cell bioprocesses such as biocatalysis and recombinant protein fermentation, but natural barrier functions of the cell wall and cell membrane often retards entry of substrates and release of products [1]. One of the possible techniques which could be used to improve permeability for target molecules is pulsed electric field (PEF), yet there is still a lack of sufficient data related to the effects of PEF on yeast cells especially in combination with whole-cell bioprocesses.

In this study we modified electrodes with whole yeast cells to detect electroporation effects. For the analysis, PEF-treated cells were immobilized on carbon paste electrodes which were then immersed into solution with potassium ferricyanide or menadione acting as mediators and producing measurable currents through oxidizing at electrode surface. Menadione-mediated amperometry was used for measurement of redox activity inside the yeast cells [2], while ferricyanide currents from amperometric sensor for lactic acid reflected membrane permeability (Fig 1.) [3]. Viability of cells was evaluated by counting colony-forming units. Leakage of intracellular compounds was evaluated by measuring fluorescence of supernatant or staining it with Ellman's reagent. Cells were exposed to single square shaped electric field pulses with pulse duration  $\tau = 300 \mu\text{s}$  and electric field strengths (E) up to 16 kV/cm.

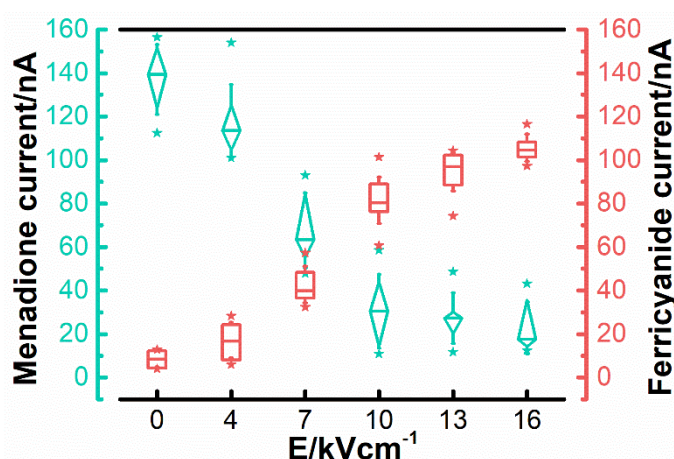


Fig. 1. Effect of electric field strength on current responses of yeast-modified electrode. Teal diamonds: 67  $\mu\text{M}$  menadione at an operating potential 0.3 V in phosphate buffer at pH 6.5. Pink squares: 0.2 mM lactic acid at yeast-modified electrodes at an operating potential 0.3 V in phosphate buffer at pH 7.3 containing 0.5 mM mediator  $\text{K}_3[\text{Fe}(\text{CN})_6]$ .

We showed that after exposure to PEF, permeability of cell membrane/wall increased while viability decreased. Yeast-modified electrode responses to lactic acid and menadione were dependent on PEF exposure. Currents obtained from amperometric biosensor with treated cells increased from  $9 \pm 4 \text{ nA}$  ( $E = 0 \text{ kV/cm}$ ) up to  $103 \pm 10 \text{ nA}$  ( $E = 16 \text{ kV/cm}$ ). PEF treated yeast cells also showed lower redox activity which decreased (from  $138 \pm 15 \text{ nA}$  to  $23 \pm 12 \text{ nA}$ ) with raise in electric field strength ( $0 \text{ kV/cm}$  up to  $16 \text{ kV/cm}$ ). Decrease of menadione-mediated current showed similar pattern with viability. Viability of yeast cells decreased (from 100 % up to  $\sim 2\%$ ) with raise in electric field strength ( $E = 10 \text{ kV/cm}$ ). We conclude that amperometric measurements can be effectively used for investigation of various cellular responses after PEF treatment.

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**J RNE'O GVJ QF 'F GXGNQRO GP V'CPF 'XCNEF CVKQP 'HQT'O CKP''  
 ECPPCDKPKQF U'F GVGTO KP CVKQP 'KP'J GO R'DKQO CUU'CPF 'QKN''**

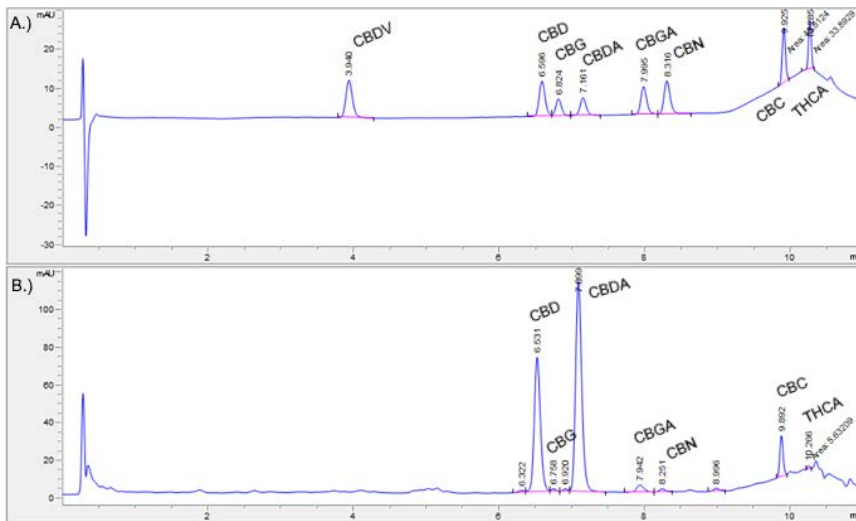
**O ki n 'Dctmw<sup>3</sup>. 'Cwf tkwu'Ucf cwp { nru<sup>4</sup>. 'Gxcrf cu'P cwlcru<sup>4</sup>. "**

<sup>3</sup>F gr ctvo gpv'qh'cpcn'f v'ecn'cpf 'Gpxktpo gpvcn'Ej go knt { . 'Hewm' {qh'Ej go knt { 'cpf 'I gquekpegu. 'Xkpkwu'Wpkxgtuk'f .  
 Nkj wpc'k "

<sup>4</sup>O gvtqmi { 'F gr ctvo gpv.'Ucvg'Tgugcte'j 'Kpukw'g'Egpgt' 'hqt' 'Rj { ulecn'Uelkpegu'cpf 'Vgej pqmi { . 'Nkj wpc'k "  
o ki n'g'dctmw'g' B ej i h'w'f' 0'x'w'f' "

Vj g' o clp' r wtr qug' qh' v' j' ku' y qtni' y cu' v' q' f g'xgnr' " cpf' " xcrkf' cvg' " c' o gvj qf' " hqt' " f gvge'v'k'p' " cpf' " s wcp'v'k'ec'v'k'p' " qh' ecppcdk'p'k'f' u' k'p' " f k'ht'g'p'v'j' go r' u'co r' r'gu'0'P' qy' cf' c' { u'c' " i'q'v'q'h'c'w'g'p'v'k'p' " j' cu' d'ggp' r' c'k' " v'q' " v'j' g' r' r'p'v'ec'ng'f' " Ecppcdk'u'ic'v'k'c' " cpf' " v'j' g' o clp' " t'g'cu'p' " hqt' " v'j' ku' k'p'v'g'g'v'k'p' " u'v'j' g' t'c'g'w'k' " g'ht'g'v'0'Ec'p'p'c'd'k'u'ic'v'k'c' " j' cu' o' q't'g'v'j' cp' " 722' " eqo r' q'w'p'f' u' " h'q'o " y' j' k'ej' " v'j' g' o' cl'q't' " t'q'g' " q'h'c'v'k'k'v'f' " r' g'ht'q'to' u' " eqo r' q'w'p'f' u' " n'p'q'y' p' " cu' " ecppcdk'p'k'f' u' " j'3\_0'Rj' { v'ecppcdk'p'k'f' u' r' qu'g'u'c' " i'q'v'q'h'f' k'ht'g'p'v' c'v'k'k'k'g'u' " u'w'ej' " cu' " c'p'c'n' i' g'ule. " c'p'w'k'p'h'c'o' o' c'v'q't' { . " c'p'v'k'o' k'o' g'w'k' " c'p'f' " c'p'v'k'ec'p'eg't' " g'ht'g'v'u' " c'p'f' " v'j' c'v'k'u' " y' j' { " v'j' g'ug' " eqo r' q'w'p'f' u' " j' cu' " u'w'ej' " c' " d'ki' " k'p'v'g'g'v'k'p' " j'4\_0' "

Vj g' h'c'v'v'j' c'v'v'j' g' ecppcdk' u' r' r'p'v'j' cu' c' " i'q'v'q'h'f' k'ht'g'p'v' " eqo r' q'w'p'f' u' " o' c'ng'u' " k' " c' " eqo r' r'g'z' " o' c'v'k'z' " c'p'f' " k' " t'g's' w'k'g'u' " c'p' " c'ee'w't'c'v'g' " c'p'f' " t'g'k'c'd'g' " o' g'v'j' qf' " hqt' " f' g'v'g'to' k'p'c'v'k'p' " qh' " ecppcdk'p'k'f' u' " 0'Q'p'g' " qh' " v'j' g' o' clp' " o' g'v'j' qf' u' " y' j' k'ej' " j' " c'x'g' " d'ggp' " o' c'k'p'n'f' " w'ug'f' " k'p' " v'j' g' o' q'u'v' " qh' " t'g'ug'cte'j' " y' q't'm'u' " f' g'c'r'k'p'i' " y' k'j' " v'j' g' " c'p'c'n'f' " u'k'u' " qh' " ecppcdk'p'k'f' u' " k'u' " c' " j' k' i' j' " r' g'ht'q'to' c'p'eg' " i'k's' w'k'f' " e'j' t'q'o' c'v'q'i' t'c'r'j' { " \*J RNE+ " j'5\_0'Vj' ku' " o' g'v'j' qf' " u'w'i' i' g'u'v' " h'c'u'v' " c'p'f' " t'g'k'c'd'g' " f' g'v'g'to' k'p'c'v'k'p' " c'p'f' " s wcp'v'k'ec'v'k'p' " qh' " v'j' g' o' clp' " ecppcdk'p'k'f' u' " k'p' " f' k'ht'g'p'v' " ecppcdk' u' " o' c'v'k'leg'u' " E'q'p'ug's' w'g'p'v' " q'w't' " o' c'k'p' " h'q'ew'u' " y' cu' " q'p' " v'j' g' " f' g'x'g'n'r' o' g'p'v' " c'p'f' " x'c'r'k'f' " c'v'k'p' " qh' " g'ht'g'p'v' " c'p'f' " c'ee'w't'c'v'g' " J RNE " o' g'v'j' qf' " 0'Y' g' " f' g'x'g'n'r' g'f' " v'j' g' " c'p'c'n'f' " v'ec'n' " o' g'v'j' qf' . " y' j' k'ej' " k'p' " 33' " o' k'p'w'g'u' " c'm'y' u' " v'q' " f' g'v'g'to' k'p'g' " c' " d't'q'c'f' " u'r' g'ew'to' " qh' " ecppcdk'p'k'f' u' " k'p' " f' k'ht'g'p'v'j' go r' " u'co r' r'gu' " H'k'i' 0'3-0'Vj' g' o' g'v'j' qf' " y' cu' " x'c'r'k'f' " c'v'g'f' " hqt' " v'j' g' " j' go r' " d'k'q'o' c'u' " c'p'f' " j' go r' " q'k'i' " u'j' q'y' k'p'i' " i' q'q'f' " u'g'p'k'k'k'v'f' " 0' " N'Q'F' " hqt' " j' go r' " d'k'q'o' c'u' " 2.227' " " / " 2.23: " " . " hqt' " q'k'i' " 2.223' " " / " 2.258' " " . " N'Q'S' " hqt' " j' go r' " d'k'q'o' c'u' " 2.224' " " / " 2.277' " " c'p'f' " hqt' " j' go r' " q'k'i' " 2.225' " " / " 2.332' " 0' " "



Hki 030Ej t'q'o' c'v'q'i' t'c'o' u'q'h'i: " ecppcdk'p'k'f' u' c'p'c'n'f' v'g'u' " \*C+32' " r'ro' " i'w'c'p'f' c't'f' " i'q'w'k'p' " k'p' " o' g'v'j' c'p'q'n'f' c'p'f' " \*D+ " i'c'o' r' r'g' " q'h' " f't'k'g'f' " j' go r' " d'k'q'o' c'u' " 0'J RNE " o' g'v'j' qf' " r'c't'c'o' g'v'g'tu' " <eq'rw'o' p' " C'i' k'g'p'v' " R'q't'q'uj' g'm'i'G'E/E3: . " 5.2' " z' " 82' " o' " . " 4.9' " o' " = " o' " q'd'k'g' " r'j' c'ug' <y' " c'v'g't' " c'p'f' " o' g'v'j' c'p'q'n'y' k'j' " 2.3' " " hqt' " o' k'e' " c'ek'f' " = " h'q'y' " 3' " o' " N'l'o' " k'p' " = " f' " g'v'g'v'k'p' " c'v'44: " 'p'o' 0' "

Vj ku' o' g'v'j' qf' " y' cu' " u'w'ee'g'u' " l'w'm' " c'r' r' r'g'f' " hqt' " v'j' g' " f' g'v'g'v'k'p' " c'p'f' " s wcp'v'k'ec'v'k'p' " qh' " : " ecppcdk'p'k'f' u' " c'p'c'n'f' " v'g'u' " k'p' " f' k'ht'g'p'v' " t'g'c'n' " u'co r' r'gu' " c'x'k'c'd'g' " k'p' " c' " h'q'ec'n' " o' c't'ng'v'0'Vj' g' " e'q'p'eg'p't'c'v'k'p'u' " y' g'g' " eqo r' c't'g'f' " v'q' " v'j' g' " u'r' g'ek'k'g'f' " d' { " v'j' g' " o' c'p'w'k'c'w't'g't'u' " "

[3]\_Q(C'k' r' w'w'c' / Q'ic'k' q'r'c' . " L'Q'o' c't' . " R'P' c'x'c't't'q' " g'v'c'r'0' " k'g'p'v'k'ec'v'k'p' " c'p'f' " s wcp'v'k'ec'v'k'p' " qh' " ecppcdk'p'k'f' u' " k'p' " Ecppcdk'u'ic'v'k'c' " N'0' " r'p'u'd' { " j' k' i' j' " r' g'ht'q'to' c'p'eg' " i'k's' w'k'f' " e'j' t'q'o' c'v'q'i' t'c'r'j' { / o' c'u' " u'r' g'ew'to' g'v't' { . " C'p'c'n'f' " D'k'q'c'p'c'n' " E'j' go " 628. '976; / 9782 " \*4236-0' "

[4]\_H'i' t'q'v'p'j' g'to' g'p' . " M'0' w'ng't' / X'c'j' n' " V'j' g'v'j' g' t'c'g'w'k' " r' q'v'p'k'c'n'q'h' " ecppcdk'u' " c'p'f' " ecppcdk'p'k'f' u' " F' u'ej' " C't' / d'v'g'n'i' " k'p'32; \*4; / 52+; \*6; 7/723 " \*4234-0' "

[5]\_ " U' " k'x'q'l'p'q'x'k' . " T'0' C'f' g't' . " O' 0'F' 0' C'ng'p'ur' c'ej' " g'v'c'r'0' " F' g'v'g'to' k'p'c'v'k'p' " qh' " ecppcdk'p'k'f' u' " k'p' " Ecppcdk'u'ic'v'k'c' " N'0' " u'co r' r'gu' " hqt' " t'g'et'g'v'k'p'c'n' " o' g'f' " l'ec'n' " c'p'f' " hqt'g'p'ule' " r' w't'r' q'ug'u'd' { " t'g'x't'g'uf' / r'j' c'ug' " i'k's' w'k'f' " e'j' t'q'o' c'v'q'i' t'c'r'j' { / w'nt'c'x'l'q'ng'v'f' " g'v'g'v'k'p' . " L' " C'p'c'n'f' " U'k'V'ge'j' " p'q'm'i' ; . " 49 " \*423: " -0' " "

# NEW FLUORENE CLASS SEMICONDUCTORS AS HOLE TRANSPORTING MATERIALS FOR PEROVSKITE SOLAR CELLS

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Nowadays, people cannot imagine their life without everyday appliances. Most of these devices require electricity to operate. One of the most popular ways to extract energy is from non-renewable energy sources. Scientists have been looking for alternative ways to generate energy from renewable sources, such as wind energy, geothermal energy, solar energy, hydropower etc. The Sun is known to be the most powerful source of energy. Solar cells are devices that convert absorbed light into electricity and silicon solar cells are currently the most commonly used technology to do that. However, it has its own drawbacks and other high efficiency solar cell technologies have been developed. The efficiency of perovskite solar cells has increased significantly over the last decade [1]. In addition, their production requires cheap raw materials. Perovskite Solar cells are among the most efficient third-generation cells however, there are several obstacles that need to be addressed in order for it to see a widespread use. One of them is that Perovskite layer is unstable. And the other problem is the use of expensive charge-transporting semiconductors such as Spiro-OMeTAD or fullerene derivatives to obtain efficient devices [2]. Therefore, there is a vigorous search for cheaper and simpler methods for the synthesis of organic semiconductors. Fluorene class derivatives are known to be promising as positive charge carriers [3]. Carbazole class compounds have also attracted the attention of scientist due to their plain synthesis and simple purification methods [4].

The aim of this project is to synthesize inexpensive materials, containing carbazolyl- and fluorenyl-chromophores, that would be obtained by a simple synthetic methods and would be suitable as hole-transporting semiconductors for perovskite solar cells.

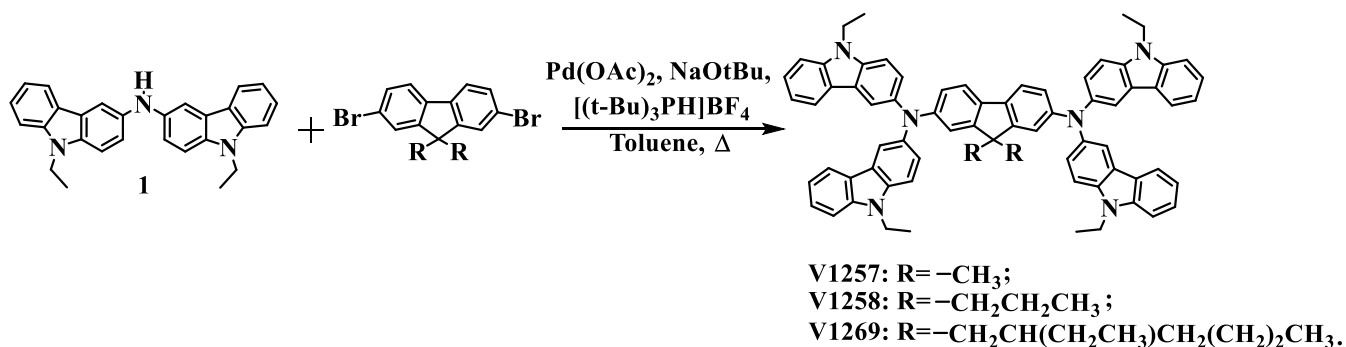


Fig. 1. Synthesis of new fluorene derivatives.

All target compounds are amorphous and has thermal stability greater than 400 °C. The length of alkyl chain affects thermal stability and glass transition temperatures. T<sub>d</sub> decreases when there are longer alkyl chains in fluorene „central“ fragment except with ethylhexyl substitutes. The obtained data shows that jonization potential increases with the lenght of alkylchain and it is near up to 5 eV. The charge carrier mobility is in range of 1.8 · 10<sup>-4</sup> – 7.8 · 10<sup>-4</sup> cm<sup>2</sup>/V·s in strong fields.

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# DATE SEED: A GREAT SOURCE OF BIOACTIVE COMPOUNDS WITH ANTIOXIDANT POTENTIAL

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The date palm (*Phoenix dactylifera* L.) is a popular fruit among Middle Eastern countries. Indeed, it is a staple food for millions of people in these countries. Besides, Date palm plays an important economic, social and ecological role for people living in arid and semi-arid areas. Date seeds, also known as pits or seeds, are waste products from date processing and packaging plants. Therefore, seeds contain many precious substances such as carbohydrates, vegetable oil, dietary fiber, bioactive polyphenols, and natural antioxidants. The latter can be used in many applications such as the formulation of food supplements, cosmetics, or alternative medicine[1]. In south Moroccan folklore, date seeds are frequently used for making non-caffeinated coffee or for making eyeliner kohl and hair coloring by ladies. They can also be used as an alternate feed ingredient for cattle to increase their weight[2]. Phytochemical profiling indicates the presence of some important compounds such as polyphenols, flavonoids, tannins, carotenoids, saponins, terpenes, anthocyanins, and leucoanthocyanins with a lack of tannins gallic and cardiac glycosides[3]. Likewise, date seed oil contains 38.71-50.08% of saturated fatty acid and 48.89-60.77% of unsaturated fatty acid with lauric and oleic as the main ones, respectively. The quantitative analysis of date seed extract showed a high amount of phenolics, flavonoids, and tannins content. It also contains an important amount of alkaloids and saponins. The inhibitory activity by DPPH, ABTS, and FRAP of date seed extract shows that Moroccan date palm seeds have a high antioxidant potential. It can be considered as a great source of natural antioxidants and bioactive compounds having a decent biological process, therapeutic, medicinal, and purposeful values.

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# EVALUATION OF THE POLYMER FILMS DEGRADATION IN VITRO

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The environmental situation in the world is one of the most important problems of our time. Huge mountains of unutilized plastic continue to pollute the atmosphere of our planet, its water and soil. In this regard, the creation of biodegradable materials is very relevant. Biodegradable polymers are designed to degrade upon disposal by the action of living organisms. They can be used in various fields: heavy and light industry, food industry, as well as medicine. The field of using depends on different properties that polymer material have. For instance, biodegradable material for medical use must possess a number of specific properties: do not cause a local inflammatory reaction, do not have a toxic and allergic effect on the body, do not have a carcinogenic effect, do not provoke the development of infection and maintain functional properties during the intended service life.

The time period during which the material decomposes under the influence of various factors directly depends on the composition of the polymer. The aim of our study was to correlate the data on the degradation time of composite polymer films with its composition.

In this work, different kinds of polymer films based on the natural polysaccharides blends were prepared for studying their degradation. Carboxymethyl cellulose (CMC) possess outstanding characteristics, including good biocompatibility, high thermal stability, and good affinity with body tissue, for which reason CMC-based material can be widely used [1]. Polyvinyl alcohol (PVA) is biocompatible, nontoxic, and relatively inert in body fluids. Such favourable properties have gained wide interest in its use for biomedical applications such as contact lenses, linings in artificial heart, and polymeric scaffolds for tissue engineering [2]. Sodium alginate (SA) can improve the residency stability of hydrophilic polymers in the body because of the embedding of hydrophilic polymers in the alginate network structure [3]. Alginate dressings in the dry form absorb wound fluid to re-gel, and the films then can supply water to a dry wound, maintaining a physiologically moist microenvironment and minimizing bacterial infection at the wound site during surgical operations. Alginate can be selectively ionically cross-linked with calcium ions to maximize its performance as a film. In addition, we used glycerol in different concentrations as the plasticizing agent in all samples.

To study the degradation process we choose medium of the PBS (phosphate buffered saline, pH = 7,4). It is a balanced salt solution used for a variety of cell culture applications, such as washing cells before dissociation, transporting cells or tissue, diluting cells for counting, and preparing reagents. It was prepared according to the method described in the source [3].

Prepared membranes were cut into 20×20 mm pieces, then placed in a test tube containing 30 ml of pH 7.4 phosphate-buffered saline for the study of degradation in vitro. The tubes were immersed in a 37 °C and observed for 16 weeks. At predetermined time intervals, the PBS was collected and replaced with a fresh one. The assessment was carried out according to the following marks: the beginning of destruction, complete decomposition of the film into pieces, complete dissolving.

During the experiment, the following results were obtained: the optimal concentration of the calcium chloride solution for crosslinking the alginate was selected in order to obtain a film with a established dissolution time. For comparison, when the film is cross-linked with a 2% solution of calcium chloride, the destruction of the film begins on the second day, while without it, the film completely dissolves in 15 minutes. However, due to the interaction of phosphate anions and calcium cations, turbidity is formed due to the appearance of insoluble calcium phosphates and calcium hydrophosphates. An increase in the alginate content also extends the degradation time of the film compared to a single-component composition. The film with a mass content of 50% alginate disintegrated into segments in 3 days, while the 30% alginate film began to degrade on 2 days. The addition of PVA extends the degradation time, but all samples didn't dissolve during the all time of experiment. An important factor is the content of glycerol in the film sample: excess or lack of it negatively affects the process of degradation. For comparison, after treating the film with a 5% glycerol solution for 15, 30, and 90 seconds, destruction began on the 2<sup>nd</sup>, 7<sup>th</sup>, and 2<sup>nd</sup> day, respectively.

During the experiment, it can be concluded that the best compositions based on CMC and alginate completely dissolve within 3 weeks, therefore, they can be used for effective prevention of peritoneal adhesions. PVA-based films have shown themselves to be quite resistant to the external environment. They can be offered for use as the same packaging materials for products for which a long shelf life is important.

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# DEVELOPMENT OF A VOLTAMMETRIC METHOD FOR THE DETERMINATION OF CU (II) IONS IN AQUEOUS SAMPLES USING NOVEL AZO-AZOMETHINE COMPOUNDS AS COMPLEXING AGENTS

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The compounds and their derivatives containing the azo component N = N are increasingly used in various fields of life and practice. They are used as indicators, dyes, optical sensors and recording devices in holographic environments, in photodynamic therapy, in molecular motors and in other photonic devices, and some of their metal complexes as drugs. Unfortunately, the literature has no enough information for azo-azomethine derivatives application for the determination of metal ions in samples with different matrix compositions. The mention above gives us the reason for developing a sensitive and selective method for the determination of heavy metals in aqueous samples. Therefore, the present abstract describes the development of a voltammetric method for the determination of Cu (II) ions in surface water samples using novel N-phthalimide azo-azomethine compounds as ligands. The assays were performed in a three-electrode cell with a voltammeter (Metrohm 797 VA, with 797 VA stand) on a HMDE-working electrode against Ag / AgCl, KCl (3.00 mol l<sup>-1</sup>) as a reference electrode. The results showed that the proposed method allows selective determination of Cu (II) with detection limits: 0.230 ng ml<sup>-1</sup> and determination: 0.423 ng ml<sup>-1</sup>. The method is sensitive with a coefficient of analytical function: 5x10<sup>6</sup> μA.ml mol<sup>-1</sup>. The precision of the determinations estimated by the relative standard deviation is Sr = 0.8%.

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**5F 'O GVCNNÆ 'EQRRGT/P ÆMGN'HQCO U'CU'ECVCN[ UVU'HQT'VJ G'  
GNGETQOZKF CVKQP 'QHUQF KWO 'DQTQJ [ FTKF G'**

ficpc" kp kgp ."Crf qpc"Dcn k pckv ."Nqtgvc"Vco c-cwunckv /Vco c-k pckv ."Gwi gplkwu'P qtmwu"

"

F gr ctvo gpv'qh'Ecvn[uku.'Egpgvt'hqt'Rj {ulecn'Uelgpegu'cpf "Vgej pqmji {."Ucwn vgnkq'cxg05.'NV/32479.'Xkpkwu.'Nkj wcpk"  
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Vj g"ugctej "hqt"pqxgn'ghhlekpv"ecvn[usu" hqt"hwgn'egmu"ku" kpf wutkcm[ "xkcn0' Vj ku"y qtni'clo u"vq" hqto "ghhlekpv"  
pcpquwewtgf "ecvn[usu"d{ "grgetqr rckpi "5F"o gvcnle"eqrr gt/plengn"EwP k'hqco u'y kj "vj g'hwvj gt" f geqtcvkqp"qh'vj go "  
y kj "i qrf "pcpqr ctvengn"\*CwP Ru+"hqt"vj g"grgetqqz kf cvkqp" hqt"uqf kwo "dqtqj { f tkf g"\*P cDJ 6+0'EwP k'hqco u"j cxg"dggp"  
grgetqr rckvf "qp'vj g'vscpkwo "vka'uwthceg"grgetqn[ vgu'eqpckpgf "207'O 'P k+ 'kpu'cpf 'Ew+ 'kpu'eqpegpvcvkpu'kp'vj g'tcpi g"  
hqo "2023"vq"2024'O 0CwP Ru"j cxg"dggp" f gr qukvgf "qp'vj g'EwP k'V'k'grgetqf gu'd{ "vj gkt"ko o gtukqp"kpvc"3"o O "J CwEn"  
uqnvkqp"cv'47"æE" hqt"3"o kp'Vj g"o qtr j qmji { "cpf "eqo r qukvgf"qh'u{pvj guk[ gf "ecvn[usu'y gtg"gzco kpgf "wukpi "Uecppkpi "  
Grgetqr'O letqueqr { "UGO +."Z/Tc{ 'F khtcevkqp"\*ZTF +."cpf "kpf wexkgn[ 'Eqw rnf "Rruo c'Qr vlcniGo kuukqp'Ur getqueqr { "  
\*ÆR/QGU+0"

K'y cu'hqwpf "vj cv'vj g't tgr ctgf '5F' o gvcnle'EwP k'hqco u'cpf "vj qug'f geqtcvgf 'y kj "CwP Ru'uj qy 'i qqf 'grgetqej go kcn'  
uadkiv[ "kp'cp"cmcnkpg" P cDJ 6"uqnvkqp" hqt" c"mipi "vko g'kp" c'r qvpgvkn'tcpi g" hqo "/304"vq"208"X"cv'cp"grgetqf g'r qvpgvkn'  
uecp"tcvg"qh'32"o X"u'3'0'O qtgqxt. "f geqtcvkqp"qh'EwP k'hqco u'y kj "CwP Ru'tguwmu"kp"gpj cpego gpv'qh'grgetqecvkn[ vke"  
cevkxkv[ "hqt"vj g"grgetqqz kf cvkqp"qh'P cDJ 6"cu'eqo r ctgf "y kj "vj cv'cv'r wtg'EwP k'hqco u0"

"

Cenpqy rnf i o gpwu"

Vj ku'tgugctej 'ku'hwf gf 'd{ 'vj g'Gwtqr gcp'Uqelcn'hwf 'wfp gt'O gcuwtg'P q02; 05/NO V/M934/3; /235: "F gxnqr o gpv"  
qh'Eqo r gvpegu'qh'Uelgpvkuu."qj gt'Tgugctej gtu'cpf "Uwf gpw'vj tqwi j "RtcevkcnTg/ugctej "Cevxkkgu0'

"

# O GVJ QF UHQ T'VJ G'F GVGTO K'P CVKQP 'QHE QXCNGP V'DQP F U'K' "

## UO CNN'O QNGE WNG'ET[ UVCNU

Gi n "T'F r wunckv<sup>3</sup>. 'Cpf tkwu'O gtm u<sup>4</sup>

<sup>3</sup>F gr ctwo gpv'qh'O cyj go cveclnEqo r wgt "Uelgpeg. 'Xkpkwu'Wpkxgtukv{. 'Nkj wcpk

<sup>4</sup>F gr ctwo gpv'qh'RtqykpóF P C "K'pvtcevkqp. 'K'pukwng'qh'Dkqvej pqrqi { . 'Xkpkwu'Wpkxgtukv{. 'Nkj wcpk  
gi r g'ukf r wunckvB o k'hwf k'v'w

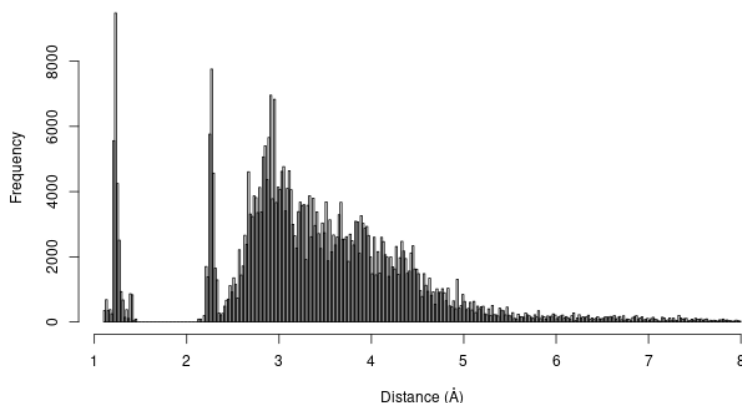
"

Et { uvcnqi tcr j { "cmny u'v'q'f gvgto k'p'g'g'zcev'r qukskqp"qh'j'g'c'v'q' u'v'j'cv'eqpukwng'et { uvcn'ut wewt gu"}3\_0'Et { uvcn' ut wewt g'f gvgto k'p'cvkqp'o g'j'q'f' u'j' qy g'x'g't'c't'g'w'p'c'd'ng'v'q'ecr w't'g'ej go k'ec'n'd'q'p'f' k'p'i'0'k'p'r't'c'v'e'g'. 'y' q'c'v'q' u'c't'g'eqpukf' g't'g'f' "v'q'd'g'eqppgevg'f'd' { "c'ej go k'ec'n'd'q'p'f'k'h'ec'r'w'v'g'f'f'k'uc'p'eg'd'g'y'g'g'p'v'j' go "k'u'uo'c'm'g't'q't'g's'w'n'v'q'v'j'g'u'wo' "q'h'j'g'k't'eqxcngp'v' t'c'f'k'0'V'j'k'u'f'k'uc'p'eg'k'u'ec'm'g'f'eqxcngp'v'd'q'p'f' 'rg'p'i'v'j'0

"Eqxcngp'v't'c'f'k'k'v'd'ng'u'v'j'c'v'c't'g'q'h'ng'p'w'ug'f' "v'q'f' g'v'g't'o' k'p'g'ej go k'ec'n'd'q'p'f' u'd'g'y'g'g'p'v'c'v'q' u'c't'g'et'g'c'v'g'f' "d' { "u'v'c'k'u'k'ec'm'f' "c'p'c'n'f' u'k'p'i' "rg'p'i'v'j' u'q'h'q'd'ug't'x'g'f' "ej go k'ec'n'd'q'p'f' u'0'V'j' g'o' q'u'v'r' q'r' w'c't' "eqxcngp'v't'c'f'k'k'v'd'ng'u'v'j'4\_0'c't'g'f'g't'k'x'g'f' "t'q'o' "f'c'v'c' "t'q'o' "E'c'o' d't'k'f' i' g' "U'v'w'w'c'n'f'F'c'v'd'c'ug' "j'5\_0'y'j' l'ej' "k'u'p'q'v'c'p'q'r'g'p'c'e'g'u'f'c'v'd'c'ug'. 'y'j'g't'g'h'q't'g't'g'u't'k'w'w'c'i' g'c'p'f' "u'r' t'g'c'f' "q'h'k'u'f'c'v'c' "c'p'f' "f'g't'k'x'g'f' "t'g'u'w'u'0'V'j'k'u'k'u'w'g'o' q'v'k'c'v'g'u't'g'ug'c't'ej' "h'q't'c' "u'w'k'c'd'ng' "o' g'j' q'f' "h'q't'f' g'v'g't'o' k'p'c'v'k'q'p'q'h'f'eqxcngp'v'd'q'p'f' u'y'j' l'ej' "y' q'w'f' "c'm'ny' "eqxcngp'v't'c'f'k'k'v'd'ng'u'v'q' "d'g' "e'c'r'w'v'g'f' "d'c'ug'f' "q'p' "f'c'v'c' "t'q'o' "c'p' "q'r'g'p'c'e'g'u'f'c'v'd'c'ug'. "g'f'0'Et { uvcnqi tcr j { "Q'r'g'p' "F'c'v'd'c'ug' "j'6\_0

Xcp'f'g't'Y'ccn'i'cr' "k'u'c'p'k'p'v'g't'x'c'n'f'y'j' l'ej' "u'g'r'c't'c'v'g'u'eqxcngp'v'd'q'p'f' 'rg'p'i'v'j' u' "t'q'o' "f'k'uc'p'eg'u'd'g'y'g'g'p'v'c'v'q' u'c'h'g'v'g'f' "d' { "Xcp'f'g't'Y'ccn'i' "h'q't'eg'u'0'k'p'v'j'k'u'k'p'v'g't'x'c'n'f'k'uc'p'eg'u'd'g'y'g'g'p'v'c'v'q' u'c't'g'p'q'v'q'd'ug't'x'g'f'0'V'j'w'u' "Xcp'f'g't'Y'ccn'i'cr' "e'q't't'g'ur'q'p'f' u' "v'q'v'j'g'h'ny'g'u'v'f'g'p'u'k'v' { "t'g'i'k'q'p'k'p'v'j'g'f'c'v'c'ug'v'j'7\_0'k'p'q't'f'g't' "v'q'k'f'g'p'v'k'h' { "v'j'g'h'ny'g'u'v'f'g'p'u'k'v' { "t'g'i'k'q'p'. 'I'c'w'u'k'c'p'f'k'u't'k'd'w'k'q'p'o'k'z'w't'g' "o'q'f'g'r'ie'c'p'd'g'c'r'r' "r'ng'f' "v'q'v'j'g'f'k'u't'k'd'w'k'q'p'q'h'f'k'uc'p'eg'u'd'g'y'g'g'p'v'c'v'q' u' "H'k'i'03+0

N-O atom distance class



H'k'i'0'30'Xcp'f'g't'Y'ccn'i'cr' "30'64" +q'd'ug't'x'g'f'k'p'j'k'u'q'i't'c'o' "q'h'f'k'uc'p'eg'u'd'g'y'g'g'p'v'k't'q'i'g'p'c'p'f'q'z' { i'g'p'c'v'q' u'0

"

F'k'u't'k'd'w'k'q'p'q'h'f'k'uc'p'eg'u'd'g'y'g'g'p'v'c'v'q' u' "e'c'p'd'g'c'r'r' "t'q'z'k'o'c'v'g'f' "d' { "c' "y'q' "e'q'o' r'q'p'g'p'v'I'c'w'u'k'c'p' "o'k'z'w't'g' "o'q'f'g'n' "y'k'j' "h'k'u'v' "e'q'o' r'q'p'g'p'v't'g'r't'g'ug'p'v'k'p'i' "eqxcngp'v'd'q'p'f' u'r'g'c'n'f'c'p'f' "u'g'eq'p'f' "e'q'o' r'q'p'g'p'v't'g'r't'g'ug'p'v'k'p'i' "Xcp'f'g't'Y'ccn'i'r'g'c'n'0'N'q'y'g'u'v'f'g'p'u'k'v' { "t'g'i'k'q'p'q'h'v'j'g'o'q'f'g'r'k'u'f'g'v'g't'o'k'p'g'f' "w'ul'p'i' "u'k'o' r'ng'z' "o'g'j'q'f'0'V'j'k'u'r't'q'eg'u' "k'u' "e'q'o' r' "h'ec'v'g'f' "d' { "t'c'p'f'q'o' "f'k'u't'k'd'w'k'q'p' "q'd'ug't'x'g'f' "q'p'v'j'g't'k'i'j'v' "u'k'f'g' " \*@05" +q'h' "H'k'i'03+0'k'p'q't'f'g't' "v'q' "t'g'f'w'eg'v'j'g' "k'o' r'c'ev'q'h't'c'p'f'q'o' "f'k'u't'k'd'w'k'q'p'v'j' "t'g'g'o' "g'j'q'f' u'y'g't'g' "c'p'c'n'f' "u'g'f' <t'g'r' "m'ego'g'p'v'q'h'v'j'g' "k'p'k'c'r'k'c'v'k'q'p' "x'g'ev'q't'. "t'g'o'q'x'c'n'q'h' "u'o'c'm'r' "t'q'r'q't'v'k'q'p'g'f' "o'q'f'g'i' "e'q'o' r'q'p'g'p'v' "c'p'f' "t'g'o'q'x'c'n'q'h' "q'd'ug't'x'c'v'k'q'p'u'g'z'eg'g'f'k'p'i' "Xcp'f'g't'Y'ccn'i'k'p'v'g't'c'v'k'q'p' "rg'p'i'v'j'0

F'w't'k'p'i' "v'j'g't'g'ug'c't'ej' "o'g'j'q'f'q'r'q'i' { "h'q't'c'w'q'o'c'v'g'f' "f'g'v'g't'o'k'p'c'v'k'q'p'q'h' "h'ny'g'u'v'f'g'p'u'k'v' { "t'g'i'k'q'p'u'y'c'u'f'g'x'g'n'r'g'f'0'V'j'g'o'q'u'v' "g'h'g'v'k'x'g' "o'g'j'q'f' "y'c'u'f'g'v'g't'o'k'p'g'f' "v'q' "d'g'v'j'g't'g'o'q'x'c'n'q'h' "u'o'c'm'r' "t'q'r'q't'v'k'q'p'g'f' "o'q'f'g'r' "e'q'o' r'q'p'g'p'v' "t'g'u'w'k'p'i' "k'p' "o'q'f'g'r' "y'k'j' " "y'q' "e'q'o' r'q'p'g'p'v' "u'ng'ev'g'f' "c'u' "d'g'u'v' "k'p' "c'm'q'u'v' "72' " "q'h'v'j'g' "e'c'ug'u'0' "T'g'o'q'x'c'n'q'h' "q'd'ug't'x'c'v'k'q'p'u'g'z'eg'g'f'k'p'i' "Xcp'f'g't'Y'ccn'i'k'p'v'g't'c'v'k'q'p' "rg'p'i'v'j' "j'c'u' "c'n'q'f' "g'o'q'p'u't'c'v'g'f' "r'q'u'k'x'g'f' "t'g'u'w'w'u'y'j' l'ej' "k'p'ek'g'u' "h'w'v'j'g't' "c'p'c'n'f' "u'k'u'q'p' "o'g'j'q'f' u'v'q' "t'g'f'w'eg'v'j'g' "k'o' r'c'ev'q'h't'c'p'f'q'o' "f'k'u't'k'd'w'k'q'p' "q'p' "r'c't'c'o'g'v'g't'u'q'h' "o'k'z'w't'g' "o'q'f'g'r' "e'q'o' r'q'p'g'p'v'0

- [1]\_I' t'c'f'w'k'u' "U'O'g't'm'f' "C'0'X'c'k'm'w'u' "C'0' ("Q'm'w'k' /M'c'j' c't'l'p'c'u' "O'0'E'q'o' r'w'k'p'i' "i'w'q'ej'k'q'o'g'v'k'e' "o'q'rg'ew'c't' "e'q'o' r'q'u'k'k'q'p' "t'q'o' "e't' { u'v'c'n'l'at'w'ew't'g'u'0'l'q'w't'p'c'n' "q'h'c'r'r' "r'ng'f' "E't' { uvcnqi tcr j { . '6: \*3+ : 7/; 30\*4237+ 'f'q'k'320329'u3822798936247; 26
- [2]\_E'q'f'g't'q' "D'O'I' »o'g'l' "X'0' "R'ev'g't'q' /R'ec'u' "C'0'G'0' "T'g'x'2' "u' "O'0' "G'ej'g'x'g't'f' "l'0' "E't'g'o'c'f'g'u' "G'0' "D'c't'c'i' "p' "H'0' ("C'r'k'c't'g'l' "U'0'E'q'x'c'ng'p'v't'c'f'k'k't'g'x'k'x'g'f'0'F'c'n'q'p' "V't'c'p'u'0'43+74: 5464: 5: 0\*422: +f'q'k'320825; l'd: 233371
- [3]\_I' "t'q'q'o' "E'0'T'0' "D't'w'p'q' "K'0'L'0' "N'i'j' "h'q'v' "O'0'R'0' ("Y'c't'f' "U'0'E'0'V'j'g' "E'c'o' "d'k'f'g' "i'g' "U't'w'ew't'c'n'f'F'c'v'd'c'ug'0'C'ev'c' "E't' { u'0\* 'D'94+ : '393/39; 0\*4238+ 'f'q'k' 320329'u4274742838225; 76
- [4]\_I' t'c'f'w'k'u' "U'0'F'c'-ng'x'k' "C'0' "O'g't'm'f' "u' "C'0' "E'j'c'v'g'k'i'p'g't' "F'0' "N'w'w'g't'q'w'k' "N'0' "S'w'k' »u' "O'0' "U'g't'g'd't' { c'p'c' { c' "P'0'T'0' "O'q'g'em' "R'0' "F'q'y'p'u' "T'0'V'0' ("N'g'D'c'l'n' "C'0' "E't' { uvcnqi tcr j { "Q'r'g'p'F'c'v'd'c'ug' "E'Q'F' +<v'p'q'r'g'p'c'e'g'u'f'eq'ng'ev'k'q'p' "q'h'l'et' { u'v'c'n'l'at'w'ew't'g'u'c'p'f' "r'c'v'v'q't'o' "h'q't' "y'q't'f' /y'k'f'g' "e'q'm'c'q't'c'v'k'q'p'0'P'w'eng'k' "C'ek'f' "u' "T'g'ug'c't'ej' " \*62+ : F'642/F'6490\*4234+ 'f'q'k'32082; 5'p'c't' "i' "n't; 22
- [5]\_C'r'k'c't'g'l' "U'0'C'ec't'q'i' tcr j { "q'h'j'g'x'c'p'f'g't'Y'ccn'i'v'g't'k'q't'k'q'u'0'F'c'n'q'p' "V't'c'p'u'0' \*64+ : 839/ : 8580\*4235+ 'f'q'k'320825; IE5F'V727; : G

# CHARACTERISATION OF LOW MOLECULAR WEIGHT BIOMARKERS OF INFLAMMATION AND CANCER

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Increased amino acid catabolism is essential for tumor growth and immune regulation in cancer. This is especially true for the kynurenine metabolites of tryptophan, which exert diverse biological effects and have been investigated as markers of tumor progression and therapeutic effect. The kynurenine pathway has been associated mostly with immune tolerance and tumor escape [1]. Approximately 95% of the free L-Trp in the body is metabolised down the Kyn pathway, generating several biologically active metabolites, including kynurenine (Kyn), kynurenic acid, 3-hydroxykynurenine (3-HK), 3-hydroxyanthranilic acid (3-HAA) [2].

In this research the main tasks were to review low molecular weight (LMW) biomarkers of inflammation and cancer, which are derivatives of amino acids, e.g., derivatives of histidine, tryptophan, arginine, etc; to evaluate methods enabling transdermal detection of amino-acid derived LMW biomarkers of inflammation and cancer; to experimentally assess the relevance of some of these methods for detection of skin inflammation and cancer, e.g., skin penetration assays and cell culture methods.

Our results showed that the 3-HKYN and 3-HAA are relatively stable in the pH range 5.5-7.4. If we are going to make extraction of these compounds from skin at basic solutions we might need to study stability at pH 10 and higher. It is possible to measure penetration of these compounds through skin after lipid extraction from skin using electrochemical methods. Detection limits by electrochemistry are 1  $\mu$ M or higher.

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[1] Clara R. O., Assmann N., Moreno A. C. R., Coimbra J. B. 2015. Melanocytes are more responsive to IFN- $\gamma$  and produce higher amounts of kynurenine than melanoma cells. *Biol. Chem.* Vol. 397. No. 1. P. 85–90.

[2] Yeung A. W.S., Terentis A. C., King N. J.C., Thomas S. R. 2015. Role of indoleamine 2,3-dioxygenase in health and disease. *Clinical Science.* Vol. 129. No. 7. P. 601–672.

VJ G'GHHGEV'QHUVQTCI G'VKO G'QP'VJ G'NQCF KP I 'GHHKEKGP E[ ' ' QHP KUP/NQCF GF 'WNXCP'RCTVKENGU  
Gf kc'Mqf {vg<sup>3</sup>. 'Twc'I twunkpg<sup>3</sup>. 'Lqmpvc'Ugtgknckg<sup>3</sup>

<sup>3</sup>F gr ctwo gpv'qh'Ej go knt { 'cpf 'Dlqgpi lpggtkpi . 'Xkpkwu'I gf ko lpcu'Vgej plecn'Wpkxgtukv{ . 'Nkj wcpk' "gf kc0mqf {B i o chkeqo "

P kulp."y j lej "ku'r tqf wegf "d{ "vj g'rveke'cekf "dcevgtkc."Nceveqeewu'rceku'uwdur Orveku."ku'c'uo cmi'5732'F c'ecvkaple" r gr vkf g'eqo r qugf "qh'56'co kpq'cekf "tgukf wgu'OK'ku'c"dtqcf /ur gevto "cpko letqdkn'ci gpv'ci ckwu'I tco /r qukskg'dcevgtkc' P kulp"ku'y kf gn{ "wugf "lp"vj g"lqqf "ugevqt "hqt"ko r tqxkpi "lqqf "uchgv{ . "hqt"gzco r rg."f ckt { "cpf "ecppgf "hqqf "r tqf wewu"}3\_0' J qy gxgt. 'pkulp'cpko letqdkn'ghhece { 'ku'lp'hwgpegf "d{ "o cp { 'hcevtu. 'Kq0kpvtcevkpu'y kj "hqqf "eqo r qpgpw'qt 'eqpf kkkpu" wugf "hqt 'hqqf "r tqf wevkp'0'Vq'gpwt g'pkulp'ucdkkv{ . 'pkulp'ku'eqcvkpi 'y kj "vj g'y cmi'o cvgtkcu."g0 Or tqvkvu.'r qn{uceej ctkf gu." qt "rkr kf u" ]4\_0' Kp' vj ku'y qtm" hqt" r ctvkgu" r tgr ctvkvq" wxcp" y cu" wugf 0' Wxcp" ku' c" y cvgt/uqndrg" cplkple" uwr j cvgf " r qn{uceej ctkf g." y j lej "ku' f gtxgf " Itqo " i tggp" cni cg. "Wxcrgu'0' Wxcp" r qn{uceej ctkf g" ku' kpgzr gpukxg." dlqeqo r cvkdrg." dlqf gi tcf cdrg." cpf " pqpqvzle" ]5\_0' F vg" vq" pwo gtqwu' cf xcpvci gu. "wxcp" ecp" dg" wugf "cu" c" eqcvkpi "o cvgtkcn' vj cv' hqt o " u" eqo r rgzgu'y kj "cp'qr r qukvgn{ 'ej cti gf "o qngewg'0'

Vj g'clo "qh'vj ku'y qtm'y cu'vq" r tgr ctg'pkulp/mqcf gf "wxcp" r ctvkgu'wulpi "vj g'eqo r rgzcvkvq" o gvj qf "cpf "qdugt'xg" vj g" ghge'v'qh'uvqci g'vko g"qp" vj g"mqf kpi "ghhekgpe {0' P kulp/mqcf gf "wxcp" r ctvkgu'cv'c" f khhgt gpv' r J "tapi g'qh'60/90" y gtg" r tgr ctgf "cpf "uvqtf' cv'6" AE0Vj g' hpcn'eqpegpvtcvkvq' qh'wxcp' y cu'206' o i lo N. "cpf "vj g'pkulp'eqpegpvtcvkvq' y cu'lp' vj g'tapi g" qh'208/3" o i lo NO' Vj g' mqf kpi "ghhekgpe { " y cu' f gvto kpgf "d{ "vj g" ecr kmt { " | ppg" grgevtqr j qtguku" o gvj qf "wulpi "9322" Ecr kmt { "Grgevtqr j qtguku'wplv' \*Ci kpgv'Vgej pqrqi lgu+0"

Vj g'hqcf kpi "ghhekgpe { " y cu' gxcn'cvgf "chgt" vj q'cpf "hqw" y gmu'cpf "y cu'eqo r ctgf "y kj "vj g'lpkcn'mqf kpi "ghhekgpe {0' K'f kf p'v'ej pi g'cv'cml' J "xcn'gu" y kj "pkulp'eqpegpvtcvkvq" w" vq" 206' o i lo NO' Vj g' mqf kpi "ghhekgpe { " j cu' f getgcugf "xgt { " urki j v{ "qxtg" vko g'y j gp'pkulp'eqpegpvtcvkvq' y cu'lp' vj g'tapi g' Itqo "206' vq" 3' o i lo NO"

**Cempqy rgi go gpv'k'**

Y g'vj cpni'Rtqhguaqt "Xcuukrku" Tqwuuku' Itqo "vj g'P cvkqpcn'cpf "Mcr qf kmtkcp" Wpkxgtukv{ "qh'C vj g'pu' hqt "vj g" i km'qh' vj g" wxcp' uco r rg' wugf "lp" vj ku' uwf {0'

Vj ku" tgugctej " y cu" hwpf gf " d{ " vj g" Gwtqr gcp" Uqekcn' Hwpf" wpf gt" vj g" P q" 2; 05/NO V/M'934" 0F gxgnr o gpv'qh'Eqo r gygpegu'qh' Uekgpvkuu. "Qvj gt" Tgugctej gtu'cpf "Uwf gpw" vj tqwi j "Rtcevekn' Tgugctej "Cevkxkkuo" o gcuw'g0I tcvp' P q' 2; 050 NO V/M'934/44/22620

[3\_ NO'0f g'Ctewj . 'C0HDLq| cnc. 'R0I 00 c| | qrc. "VOE0X0Rppc0P kulp' dlq'vgej pqrqi lecnr tqf wevkp'cpf "cr r rkecvkp'c' t'xkgy 0'Vtgp' u'lp' Hqqf "Uekpeg" ( 'Vgej pqrqi { . '42\*5/6+ :368/376\*422; -0'  
[4\_ '0Mj cp. 'F 0J 0Qj 0K'v'gi tcvkvq' qh'pkulp'lpvq'pcpqr ctvkgu' hqt "cr r rkecvkp'lp' hqqf u'0K'ppqcxv'xg' Hqqf "Uekpeg" ( 'Go gti kpi "Vgej pqrqi lgu. '56. '598/" 5: 6\*4238-0'  
[5\_ 'NOC0V' kxgrnec. 'G0K'c'ppqvw' X0Tqwuuku' Wxcp. 'c' dlq'cevkxg' o ct'kg' uwr j cvgf "r qn{ucej ctkf g'cu'c'ng{ 'eqpukwgpv'qh'j { dtkf "dlqo cvgtkcn' C' t'xkgy . " Ectdqj { f tcvg' Rqn{ o gtu'43: . '577/592\*423; -0"

**KFGPVKH KPI 'KPUWNK' HDTKN'E QPHQTO CVKQP CN'F KHGTGPE GUD[ ''**  
**VJ KQHNCXK/V'DKPF KPI 'EJ CTCE VGT KUVKE U'**  
O cpvcu\ kwp{u<sup>3</sup>. 'Cpf tkwu'Ucnrcwunru<sup>3</sup>. 'X{ vewcu'Uo ktpqxcu<sup>3</sup>

<sup>3</sup>Kpukswg"qh'Dkqvej pqrni { . 'Nkg'Uekpegu'Egpgt. 'Xkpkwu'Wpkxgtuk{ . 'Nksj wpcik'  
o cpvcu0 kwp{uB i o cktqgo "

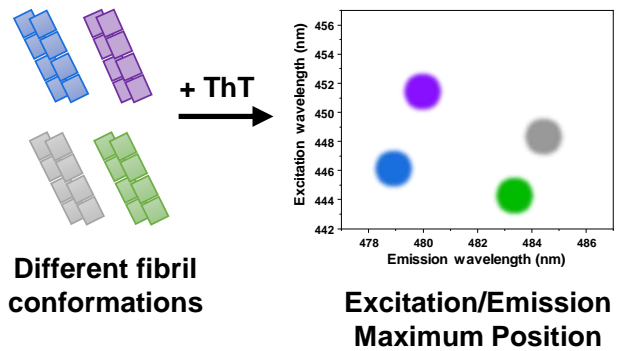
"

Co { nkl qi gple'r tqvlp"ci i tgi cvkqp"lpvq"lpuqndrg"hdtkmct"ci i tgi cvgu"ku'rkpngf "vq"ugxgtcn'co { nkl qugu."kpenwf kpi " pgwtqf gi gpgtcvkg"CN j glo gt)u"cpf "Rctnkpuqpai'f kugcugu"]3\_0F gur kg'o cp{ "{ gctu"cpf "eqwprguu"uwf lgu."vj gtg"ctg"uwni' xgt{ "hgy "ghgcvkg"cpvk/co { nkl "f twi u'cxckndrg"cpf"o quvr qvppvkn'eqo r qwpf u'hckl'vq"r cuu'cm'erikplecn'v'kcn0Qpg'qh'vj g" o clp'tgcuqpu'hqt"vj gug'hckm'gu'ku'vj g'eqo r rgz'pcwtg'qhi'co { nkl "ci i tgi cvgu'K'ku'npqy p"vj cv'vj g'uco g'r tqvlp"o qrgewg" o c{ "hqt0 "hdtku'y kj "f kpkpev'eqphqto cvkqpcn'cpf"o qtr j qmji kccn'ej ctcevgtku0Gcej "qh'vj gug'hdtkl'v' r gu'cnuq"r quugu" ur gekkle"ugrh'tgr rccvqpp"vqpf gpekgu"cpf"o c{ "tgr qpf "f khgtgpv"vq"r qvppvkn'cpvk/co { nkl "eqo r qwpf u0'K'o cp{ "ecugu." hdtkl'kf gpv'kccvqpp"ku" f qpg"d{ "go r m{ kpi "cvqo le" hqteg"o letqueqr {."y j gtg"tgwuu"ctg"j ki j n{ "f gr gpf gpv'qp"uco r rg" f gr qukkqp"vej pls wgu."cu'y gm'cu"lphctgf "ur gev'queqr {."y j lej "tgs vkt gu'tgrcvkgn{ "j ki j "eqpegpvcvqpu'qh'vj g"r tqvlp" uco r ng0'K"tgegpv" { gctu"kv" cu'dggp"qdugtxgf "vj cv'f kpkpev'r tqvlp"hdtku'j cxg"ur gekkle"co { nkl qv' r kke" f { g"dkpf kpi "j4\_ ej ctcevgtku0"chhkv{ . 'hwtgugpeg'kpvqpvk{ + "y j lej "eqwrf" r qvppvkn{ "dg" wugf "vq" k'f gpv'k{ "wpls wgo" { nkl "ci i tgi cvgu'0

Kp"qtf gt"vq"gzco kpg"y j gvj gt"cp"co { nkl /ur gekkle" f { g"o"vj khrxlp/V"]5\_ eqwrf "dg" wugf "vq" f khgtgpvcvq"dgw ggp" eqphqto cvkqpcn{/f khgtgpv'hdtku." lpuwkp"y cu"ci i tgi cvgf "lpvq" hqt" f kpkpev'hdtkl' v' r gu" wpf gt" hqt" gpv'kqpo gpv'ni' eqpf kkpau0J wo cp'tgeqo dkpcpv'kpuwkp'r qy f gt'y cu'f kuqrxgf "kp" hqt"v' r gu'qh'uqnvkqpu"3042" cegvke'cekf ."eqpvckkpi " 322"o O "P cEn#40322"o O "uqf kwo "r j qur j cvg'dwhtg"r J "40#="50322"o O "uqf kwo "r j qur j cvg'dwhtg"r J "40#="eqpvckkpi " 322"o O "P cEn#60RDU"r J "906#+ "cpf "lpewcvgf "cv'82AE0'Chgt"hdtku'y gtg" hqt0 gf."vj g{ "y gtg"kpkkcm{ "gzco kpgf"d{ " cvqo le" hqteg" o letqueqr { "cpf" Hqwtkgt/vtcpuqto " lphctgf" ur gev'queqr {." vq" xgtkh{ " o qtr j qmji kccn' cpf" utwewtci' f khgtgpegu0'Chgt y ctf u."vj g'uco r ngu'y gtg"o kzgf"y kj "c'tcpi g"qh'vj khrxlp/V"eqpegpvcvqpu"cpf "vj gk"cdtuqdcpeg."cu' y gm'cu'gzekcvkq/go kuukqp"o cvtlegu'y gtg'uecppgf 0

Vj g'tguwuu'uj qy "vj cv'gcej "v' r g"qh'ci i tgi cvg"j cu" wpls wgdqwpf /f { g" hwtgugpeg"r tqr gvku."uwej "cu"o czko wo " gzekcvkq" cpf "go kuukqp"y cxgrgpi vj u."cu"y gm'cu" hwtgugpeg" s wcpwo " { kgrf 0'Eqpvk'gtkpi "vj cv'uwej "c" f { g/dcugf" gzco kpcvqpp"tgs vkt gu'o lpo cni'co qwpw"qh'hdtku"cpf "ku'tgrcvkgn{ "s wlen'vq"r gthqto ."k'o c{ "dg" wugf "cu"cp"cngtpcvkg" o gvj qf "vq" k'f gpv'k{ "co { nkl "hdtkl'eqphqto cvkqp" f khgtgpegu'0

**Conformation-specific**



Hki 030F khgtgpv'kpuwkp'hdtkl'eqphqto cvkqpu'j cxg'ur gekkle"Vj V'dkpf kpi "cpf "hwtgugpeg"ej ctcevgtku0'

"

[3\_ "Mpqy ngu."Vvqo cu'R0'L0" gv'ci0'ovj g"Co { nkl "Ucvg"cpf "Ku"Cuqekcvkq"y kj "Rtqvglp"O kuhqf kpi "F kugcugu0" P cwtg" Tgxky u"O qrgewtct"Egni' Dkqmi { ."xqr037."pq08."42360"

[4\_ "Mfgdu."O 0T0J 0"gv'ci0'ovj g"Dkpf kpi "qh'Vj khrxlp/V"vq"Co { nkl "Hdtku'Nqecrkvq"cpf "K' r rccvqpu0' lqwtpcn'qh'Ut wewtci'Dkqmi { ."xqr036; ." pq03."42270"

[5\_ "Zwg."Ej tkvpg."gv'ci0'ovj khrxlp/V"cu"cp"Co { nkl "F { g'hdtkl'S wcpv'kccvqpp."Qr vko cni'Eqpegpvcvqpp"cpf "Ghgev'qp"Ci i tgi cvkqp0'Tq{ cni'Uqekv' Qr gp "Uekpeg."xqr06."pq03."42390"

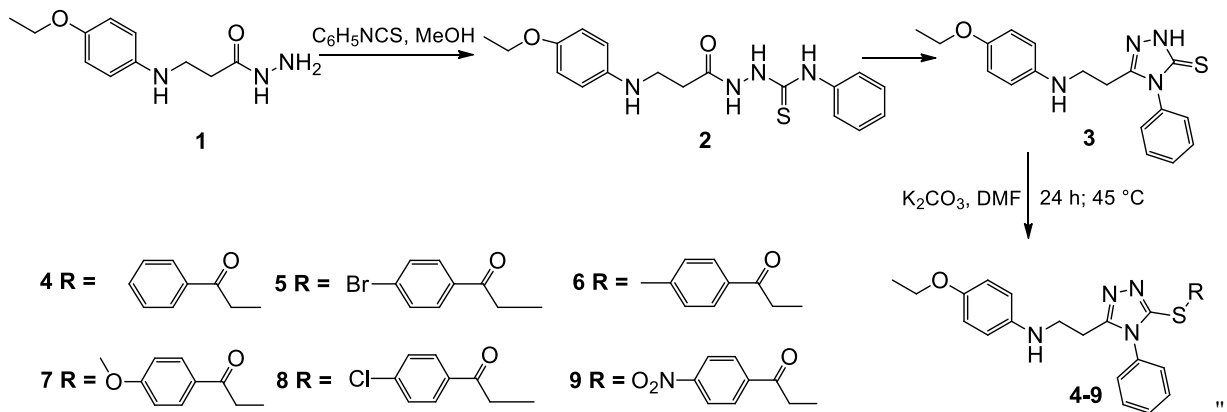
**S/UWUVK/VWGF '7/\*4/\*6/GVJ QZ[ RJ GP[ N+CO P Q+GVJ [ N+6/RJ GP[ N/  
4.6/FK [ FTQ/5H/3.4.6/VTK\ QNG/5/VJ KQP G'F GTKCVKXGU'CU'  
RQVGP VKN'CP VKQZKF CP V'CI GP VU'**

**Ck c'Uto wmp{ v<sup>3</sup>. 'Ipi tkf c'Vwo qukgp<sup>3</sup>. 'Mtknkpc' Mcpvo kpkp<sup>4</sup>**

<sup>3</sup>F gr ctvo gpv'qh'Qti cple'Ej go knt { . 'Mwpcu'Wpkxgtukf 'qh'Vgej pqrni { . 'Tcf xkn p ' r r03; . 'NV/72476' Mwpcu. 'Nkj wpcle'  
<sup>4</sup>F gr ctvo gpv'qh'Rj { ukecn'cpf 'Iqti cple'Ej go knt { . 'Mwpcu'Wpkxgtukf 'qh'Vgej pqrni { . 'Tcf xkn p ' r r03; . 'NV/72476'  
Mwpcu. 'Nkj wpcle'  
ckf cUto wmp{ vGB mwQf w'

3.4.6/Vtkl qng'f gtxcvkxgu'ctg'r tqo kulpi "ej go lecn'uechqrf u'lp"o gf lekpcn'ej go knt { "f wg'vq'v'j gk"xcuv'dlqmi lecn'  
cevkxk' "cpf "gz vpkxg'ut wewtcno qf khec'vq'ecr cdkkx' 03.4.6/Vtkl qng'o qlkv' "j cu'dggp' lpeqtr qtcvqf 'lpv'c'ut wewt'g'qh'  
o cp { "f twi u." kpmf lpi " y g" qpgu" y kj " cpvkxk'cni \*tkdcxk'k+ " cpvko ki tclpg" \*tk ctkr vcp+" cpf " cpvkxpi cni \*hneqpc' qng'  
ktceqpc' qng.'cpf "xqtkeqpc' qng'+cevkxk'gu'Y gm'npqy p'f twi u.'tkl' qro . 'crr tc' qro . 'guc' qro . 'eqvckp'v'j g'3.4.6/vtkl qng'  
e{ eng'cu'y gni' ]3\_03.4.6/Vtkl qng/5/v' kppg'f gtxcvkxgu'r quugu'c'dtqcf 'ur gevwo "qh'r qv'p'v'cni'dlqmi lecn'cevkxk' 'kpmf lpi "  
cpvko letqdkcn'cpvkz'kf cpv'cpv'kepegt. "cpv'wdgtewrct. "cpv'eqpxwucpv'hwpi kelf cn'cpv'kr kgr vte. "cpf "cpv'k'p'hrco o cvqt { "  
qpgu' ]4\_0"

C'ugt'gu'qh'p'q'x'gn'U'wdukw'wgf '6/rj gp{n/4.6/f kj { ftq/5J /3.4.6/vtkl qng/5/v' kppg'f gtxcvkxgu'y g'g'u' { p'j g'uk' gf "Itqo "  
5/]\*/6/g'y qz { rj gp{ neo kq\_r tqr cpqj { ftc' k'g' \*Uej go g' 3+0' Hktuv." r tqr cpqj { ftc' k'g' " 3" y cu' v'ge'v'f " y kj " rj gp{n'  
ku'j kq' { cpv'g'lp'o g'y cpq'v'q'i kxg'b'eqttgur qpf lpi 'y' k'ugo lectdc' k'g'4. 'y' j' lej 'u'w'dugs w'g'p'v'f 'wpf g'ty g'p'v'e' { erk' cv'k'p'wp' g't'  
cm'ek'p'g'eqpf k'k'p'u'v'q'r tqx'k'f g'7/\*4/\*6/g'y qz { rj gp{ neo kq+g'y { n/6/rj gp{n/4.6/f kj { ftq/5J /3.4.6/vtkl qng/5/v' kppg' "5+  
 ]5\_ ]6\_0' T'g'cev'k'p'u'qh'v'j g'rcw'gt' y kj "c'ugt'gu'qh'ceg'v'q'r j' g'p'p'g'f g'tk'cv'k'x'gu'c'ht'q'f' g'f "y'j g'v'cti g'v'eqo r qwpf u'6/; " ]7\_0'  
U'w'w'w'gu'qh'v'j g'u' { p'j g'uk' gf "eqo r qwpf u'y' g't'g'eq'p'k'to g'f "d' { 'K'. 'J . '65' E' P' O' T'ur gev'queqr { "cpf "o cu'ur gev'tqo g't { "f'cv'0'  
"



**Uej go g'30U{ p'j g'uk'qh'eqo r qwpf u'46; 0'**

Cpv'kz'kf cpv'cevkxk' "qh'v'j g'u' { p'j g'uk' gf "eqo r qwpf u'5/; "y cu'uetggp'gf "d' { "FRRJ " \*4.4/f krj gp{ n/3/r let { nj { ftc' { n'  
tcf lecn'uecxgpi lpi "cuuc { "cpf "HICR" \*hgttle' t'gf welpi "cpv'kz'kf cpv'r qy g't+cuuc { 04/\*7/\*4/\*6/G'y qz { rj gp{ n'co kq+g'y { n/  
6/rj gp{ n/6J /3.4.6/vtkl qn/5/ { n'v' kq+3/\*6/plk'qrj gp{ n'g'y cp/3/qpg' \*; +j cu'dggp' k'f g'p'v'k'g'f "cu'c'r tqo kulpi "cpv'kz'kf cpv'  
ci g'p'v'r quugu'kpi "cpv'kz'kf cpv'cevkxk' { "30'ko gu'j ki j' g't'v'j cp'v'j cv'qh'c'y gm'npqy p'cpv'kz'kf cpv'cueqtdle'cek' cu'f g'v'to k'p'gf "  
d' { "FRRJ " tcf lecn'uecxgpi lpi "cuuc { "cpf "30'ko gu'j ki j' g't'cee'q'f lpi "v'q' "HICR" cuuc { 0'Eqo r qwpf " : "dgct'kpi "En'uwdukw'wgp'  
lp'ku'o qngew'g' cu'uj qy p'j ki j' g't'cpv'kz'kf cpv'cevkxk' { "v'j cp'v'j cv'qh'xkco k'p' "E'cu'f g'v'ge'v'f "d' { "dq'v' "o g'y qf u'cu'y g'ni'  
"

- [3\_ O' M' A' A' ni A' gn' R' O' Y' , m' / U' A' i A' p' . 'T'ge'gp'v'cf x'c'p'egu' d' l'q'c'ev'k'x'g' 3.4.6/vtkl qng/5/v' kppgu. 'G'w'q'r g'cp' "l'q'w'p'c'ni'qh' "O' g'f lekpcn'ej go knt { " ; 9. " : 52/ : 92" \*4237+0
- [4\_ C' C' O' C' n' f . ' C' C' O' J' cu'cp . ' O' O' O' O' c'ni' n'q'w' "g'v'c'ri'0' E'j go knt { "cpf "D'k'q'ni' lecn'cevkxk'k'gu'qh'3.4.6/vtkl qng'y kppgu/ C'p'v'k'k'c'ni'c'p'f "C'p'v'k'p'g'v'k'x'g'f' twi u' " O' qngew'gu'47. '5258" \*4242+0
- [5\_ V'wo qu'k'ep . "M' O' M' p'vo k'p'k'p . "C' O' R' c'x'k'p'k'u' "g'v'c'ri'0' U' { p'j g'uk'qh'c' qng'f g'tk'cv'k'x'gu' "Itqo "5/rj gp{ neo kq\_r tqr cpqj { ftc' k'g'cpf "g'x'c'v'k'p'qh'v'j g'k' " cpvko letqdkcn'gh'hece { . 'J' g'v't'q'c' { eng'9 : . '7 ; /92" \*422 ; +0
- [6\_ V'wo qu'k'ep . "K' O' l'p'w'ni'k'p . "M' O' M' p'vo k'p'k'p . "g'v'c'ri'0' V'j g'u' { p'j g'uk'qh'c' qng'f g'tk'cv'k'x'gu' "Itqo "5/]\*/6/g'y { n'j gp{ neo kq\_r tqr cpqj { ftc' k'g'cpf "ku' " P' /rj gp{ n'ctdco q' { n'f g'tk'cv'k'x'gu' "cpf "v'j g'k' "cpv'k'c'v'g't'c'ri'cevkxk'k' . "O' q'p'c'v'j g'h'g' h' A' "E'j go k'g' l'ej go lecn' O' p'v'j n' "365. '3663/3672" \*4234+0
- [7\_ K' O' V'wo qu'k'ep . "K' O' l'p'w'ni'k'p . "M' O' M' p'vo k'p'k'p . "g'v'c'ri'0' V'j g'u' { p'j g'uk'qh' "U'wdukw'wgf "f g'tk'cv'k'x'gu'qh'5/ ]4/]\*/6/g'y { n'j gp{ neo kq\_g'y { n/6/rj gp{ n' 6.7/f kj { ftq/3J /3.4.6/vtkl qng/7/v' kppgu'cpf "v'j g'k' "cpv'kz'kf cv'k'g'cevkxk'k' . "O' q'p'c'v'j g'h'g' h' A' "E'j go k'g' l'ej go lecn' O' p'v'j n' "367. '53 ; /549" \*4236+0



**KUQNCVQQP 'QHRJ QURJ CVG'UQNWDKKN KPI 'O KETQQTI CP KUO 'CPF''**  
**KPF WUVTKCN'HGTO GP VCVQQP 'RT QEGUUQRVKO K C VQQP''**

Tclo qpf c'O cfl{ n{ v<sup>3</sup>. 'Lwukpc'Mc| k plgp<sup>4</sup>. 'Gi n 'Ncuvwunqgp<sup>3</sup>. 'Cwf tkwu'I gi genæu<sup>3</sup>

<sup>3</sup>F gr ctvo gpv'qh'O letqdkmqi { 'cpf 'Dkqvej pqmqi { . 'Xlpxku'Wpkxgtuk{ . 'Nkj wcpk'  
<sup>4</sup>Kpukwag'qh'Dkqmqi { 'cpf 'Rrppv'Dkqvej pqmqi { . 'X{ wwu'O ci pwa'Wpkxgtuk{ . 'Nkj wcpk'  
tclo qpf cO c| n{ v{B i o ckrteqo "

"

Rj qur j qt wu'ku'qpg'qh'vj g'o quv'pgeguuct { "o cetqpwtkgpw'vj cv'tg'kpf kur gpucdrng'hqt'r rcpv'f gxgnr o gpv'cpf "i tqy vj O' K'p'r rcpv'egmu.'r j qur j qt wu'r m{ u'cp'lo r qtvcpv'tqng'kp'vj g'gpgti { "cpf 'pwtkpv'o gvcdrkuo . 'kp'vj g'hkuqpp'cpf 'tgr tqf wv'kqp" uci gu'qh'egmu.'r tqo qv'gu'xkcrk{ "cpf "tgukv'peg'vq'f kugcug"}3\_0'Rj qur j cvg' uqndkkrk kpi "dcevgtk"\*RUD+'j cu'cdkkrk{ "vq" eqpxgtv'kpuqndng'vq'kkr'j qur j cvg'hqto u'kp'v'c'dkqxcckdrng'hqto "vj tqwi j "uqndkkrk cvkqp'cpf "o kpgtcrk cvkqp'r tqeguugu'cpf " o cnkpi "k'cxckdrng'vq'r rcpw'cu'dkqhg'v'kkr'gtuO'K'p'vj ku'uwf { "c'r j qur j cvg' uqndkkrk kpi "o letqqt i cpkuo "y cu'kuqrv'f "Itqo " vj g' uqkr' uco r ng' qh' Nkj wcpk" ci tlewnwtcn' hkrf " wukpi " Rknuxunc{ cæu' \*RXM+ " ci ct" cpf " P cvkqpcn' Dqvcplecn' Tgugctej " Kpukwag'u'r j qur j cvg' i tqy vj "o gf kwo "y kj " dtqo qj { o qn'dwng " \*P DT RR/DO D+ " eqpv'clpki " Ec<sub>5</sub>\*RQ<sub>6</sub>+ " cu'vj g' kpuqndng' v'lecrekwo 'r j qur j cvg' \*VER+ " 4\_0 "

Dcugf " qp" 38Uu' tTP C " i gpg' ugs wpeg' cpcn' uku' cpf " r j gpv'f r le" cpf " o qrgewrt " ej ctcevgtkwku " vj g' utckp " y cu' kf gpv'kkr'f " cu' Dcekmul' ur O' O X [ /2260' Vj g' ewnw'g' pwtkpv'o gf kwo " cpf " hqto gpv'kqp " r tqegu " i tqy vj " eqpf kkr'puy g'g' qv' k' gf < o qm'uguy' cu' wugf " cu' c' ectdqp " uqwtg = { gcu'gz'tcevr' qy f g' y cu' wugf " cu' c' qti cple " uqwtg = P J 6 J 4RQ<sub>6</sub> " y cu' wugf " cu' c' pkr'q' gp " uqwtg = vj g' ewnw'g' vgo r gtcwtg " y cu' 52020' " AE = vj g' kpkcn' xcnw' qh' r J " y cu' 90207 = vj g' r ctv'cn' r tguuw'g' qh' qz { i gp " \*r Q<sub>4</sub> + " y cu' 82040 = vj g' o kztg " t'gxqndkqpu' r gt " o kpwg " \*TRO + " y cu' 47 / : 72 = cpf " vj g' kpev'cvkqp " cpf " hqto gpv'kqp " v'lo g' y cu' 6 : / 72 " j qwtu' Dcevgtkcn' uwar gpukpu' cpcn' uku' wukpi " Nks w'f " Ej tqo cvqi tcr j { " Vko g' qh' Hki j v' O cuu' Ur gev'qo g' t { " \*NU' VQHIO U " + " vj qy gf " vj cv' Dcekmul' ur O' O X [ /226 " y cu' r tqf vegf " qti cple " celf u' cu' z' ekte. " uweekple. " 4 / ngv'qi nweekple. " i nweekple. " o crke. " hve. " qzcrke " celf u' "

Uco rng"	Eqpegp'tcvkqp. 'U lo N' *cxgt ci g'lt qo 't' l' r' necv'g' OUF +'						
P q0'	Ekste' celf .."	Uweekple' celf .."	4/ngv'qi nweekple' celf .."	I nweekple' celf .."	O crke' celf .."	Neeve' celf .."	Qzcrke' celf .."
30'	350'0208"	479'0208"	8: 0204"	4: 902085"	454'0208"	63: 0208"	56'0204"

.. eqpegp'tcvkqp'ecrewe'v'f "wukpi "ekste' celf "ecr'dt'cvkqp'ew'xg"  
 .. eqpegp'tcvkqp'ecrewe'v'f "wukpi "uweekple' celf "ecr'dt'cvkqp'ew'xg"  
 .. eqpegp'tcvkqp'ecrewe'v'f "wukpi "qzcrke' celf "ecr'dt'cvkqp'ew'xg"

"

**Hki 030Qti cple' celf u'f gvev'kqp' wukpi 'NE/VQHIO U'**

Hwt'v gto qtg. "vj g'zr g'kto gpv'uj qy gf "vj cv' Dcekmul' ur O' O X [ /226 " ecp' r tqf vegf "r j { vj qto qpgu' cu' kpf qng/5/cevgk " \*KC+ " lcuo qple " \*LC+ " cpf " i kddgt'gmle " \*I C<sub>5</sub>+ " celf u' Rj qur j cvg' uqndkkrk kpi " dcevgtk " \*RUD+ " Dcekmul' ur O' O X [ /226 " u{ vj gu'k' gu'cpf "gzr qt wu' r j { vj qto qpgu' y lej "ctg' ecngf " r rcpv' i tqy vj " tgi wv'qtu " \*RI Tu+ORI Tu' ctg' qti cple " uwdv'pegu " vj cv' kphw'peg' r j { ulqmqi kecn' r tqeguug' qh' r rcpw' cv'gz'tgo gn' " hqy " eqpegp'tcvkqp " 5\_0 "

Uco rng"	Eqpegp'tcvkqp. 'U lo N' *cxgt ci g'lt qo 't' l' r' necv'g' OUF +'		
P q0'	Kpf qng/5/cevgk' celf .."	Lcuo qple' celf .."	I kddgt'gmle' celf .."
30'	369202042"	208950202; "	20 2202082"

.. eqpegp'tcvkqp'ecrewe'v'f "wukpi "kpf qng/5/cevgk' celf "ecr'dt'cvkqp'ew'xg"  
 .. eqpegp'tcvkqp'ecrewe'v'f "wukpi "lcuo qple' celf "ecr'dt'cvkqp'ew'xg"  
 .. eqpegp'tcvkqp'ecrewe'v'f "wukpi "i kddgt'gmle' celf "ecr'dt'cvkqp'ew'xg"

**Hki 040Rj { vj qto qpgu'f gvev'kqp' wukpi 'NE/VQHIO U'**

Vj g' wug' qh' RUD " kp " ci tlewnwtg " ku " i clpki " lo r qtv'peg " cpf " ku " dgeqo kpi " c " r gto cpgpv' r ctv' qh' etqr r kpi " u{ ugo u' vj tqwi j qw' vj g' y qtrf O' K' ku' pqv' qpn' " gp'x'k'qpo gpv' h' k' p' f " dw' cnq " equv' g' h' g' v' k' x' g. " t' g' r' k' d' r' g. " cpf " f w' t' c' d' r' g' O' G' h' k' e' k' p' v' r j qur j cvg' uqndkkrk cvkqp " d { " Dcekmul' ur O' O X [ /226 " f go qpu' t' cv' g' f " vj g' u' t' q' p' i " cr' r' necv'kqp " r' qv'g' v' k' n' c' p' f " j' c' x' g' r' t' q' d' c' d' r' g' w' u' g' h' q' t' h' w' w' t' g' c' i' t' l' e' w' n' w' t' c' n' c' p' f " d' k' q' v' e' j' p' q' m' q' i' k' e' c' n' r' r' n' e' c' v' k' p' o "

"

[3]\_H0Y cpi . 'O 0F gpi . 'I0Z w'g'v'cn'0' qrgewrt " o gej cpluo u' qh' r j qur j cvg' t' c' p' u' r' t' v' c' p' f " u' k' i' p' c' n' k' i' " k' p' j' k' i' g' t' r' r' e' p' u' . ' U' g' o' k' p' c' t' u' k' p' ' E' g' m' i' c' p' f " F' g' x' g' n' r' o' g' p' v' c' n' Dkqmqi { '96. '336/344' \*4239+0  
 [4]\_O 0T0' Uctknj cpk " D0Mj qij tw' cpf " T0I t' g' k' p' g' t. " K' q' n' v' k' p' " c' p' f " k' g' p' v' h' e' c' v' k' p' " q' h' v' g' o' r' g' t' c' w' t' g' v' q' n' g' t' c' p' v' r' j' qur j cvg' uqndkkrk kpi " dcevgtk " cu' c' r' q' v' g' v' k' n' c' i' o' letqdkn' h' g' t' v' k' k' g' t. " Y' q' t' r' f " I' q' w' p' c' n' q' h' O' letqdkmqi { " cpf " Dkqvej pqmqi { '57. '348' \*423; +0  
 [5]\_F 0Gi co dgtf k' g' x' c. " U0L0Y k' v' j. " C0C0Cn' s' c' t' c' y' K' g' v' c' n' 0' Rj { vj qto qpgu' cpf " Dgp' g' h' e' k' c' r' O' letqdg' u' c' G' u' g' p' v' k' c' r' i' E' q' o' r' q' p' g' w' i' h' q' t' R' r' e' p' v' v' q' D' c' n' r' e' p' e' g' U' t' g' u' i' c' p' f " H' k' p' g' u' . " H' q' v' g' t' u' k' p' O' letqdkmqi { . : ' 4326' \*4239+0

**CP VKQZKF CP V'CEVKKV[ 'R' TRIFOLIUM PRATENSE'N0DNQUUQO U'  
WUKPI 'F KHGTGP V'GZVTCEVKQP 'O GVI QF U'**

Lxti c' Cpf t lc' Me| rwumekv<sup>3,4</sup>. Lxti c' Dgtpcvplkgp<sup>3,4</sup>"

<sup>3</sup>F gr ctwo gpv'qh'F twi "Vgej pqmji { "cpf "Uqelcn'Rj cto ce{ . "Nkj wcpkcp "Wpkxgtuk{ "qh'J gcnj "Uelgpegu. "Nkj wcpkcp"  
"kpwkwg'qh'Rj cto cegwlecn'Vgej pqmji lgu. 'O gf lecn'Ceef go { . "Nkj wcpkcp "Wpkxgtuk{ "qh'J gcnj "Uelgpegu. "Nkj wcpkcp"  
[lxti c' Cpf t lc' Me| rwumekv](#)<sup>3,4</sup> [lxti c' Dgtpcvplkgp](#)<sup>3,4</sup>"

"

Tgf "emqxtg" \**Vtkhkw* "rtcvpug" NO'ku'c'r gtgppkcn'rgi wo g'ku'c'tlej "uqwtg"qh'kuqhxqpgu. 'y j lej "ctg'tgr qtvgf "vq"j cxg"  
dpgphlecn'j gcnj "ghgew"j3\_0'O qtgqxtg. "k'eqpvc'ku'uki p'k'ecp'co qwpw'qh'r j gpqite"eqo r qwpf u'y j lej "ctg"npqy p'ht"  
yj g't r qv'p'cn'dkq/cev'k'g'cp'v'k'z'k'f'cp'v'r' tqr'gt'v'ku'cpf' t'cf'lecn'uecxgpi kpi "ecr'cekf"j4\_0"

Vj g'c'ko "qh'y'j ku'uwf { "y cu'v'q'k'p'x'g'uki' cv'g'j g'cp'v'k'z'k'f'cp'v'cev'k'k'v' "qh'Vtkhkw"rtcvpug"NO'drnuquo u'gzvtcevgf "wukpi"  
f'k'htg'gp'v'gzvtcevkqp"o' g'j qf u'0

Wntcuqwpf "cuukngf"gzvtcevkqp"y cu'r gthqto gf "wukpi"3"0'2023"i "qh'f'tkgf"cpf"o' kngf"hty'gt"j gcf u'cpf"52"o' N'qh'  
72" "g'j cpqn'Vgo r gtcwtg'f wtkpi "gzvtcevkqp"o'62"cpf"82"AE'0'Wntcuqwpf "r qy gt"472"Y "cpf"gzvtcevkqp"ko g'32"cpf"52"  
o'lp"j5\_0'Vj gto cn'rtqegulpi "y cu"r gthqto gf "chgt"uqplecvkqp"r'ceki "gzvtcev"lp"o'j g'cv'kpi "o'cpwg"wpf'gt"o' tghwz"  
eqpf'gpugt"ht"qpg'j qwt0"J gcv'tghwz"gzvtcevkqp"y cu'f'qpg"wukpi"3"0'2023"i "qh'f'tkgf"cpf"o' kngf"hty'gt"j cv'y cu'0'kz'gf"  
y'kj"52"o' N'qh'72" "g'j cpqn'lp"o'472"o' N'tqwpf"dqwqo "h'cun'cpf"t'ghwz'gf"lp"j'g'uepf"dcy"cv'322"AE"ht"3"j qwt0'  
O'cegtcvkqp"j6\_tgumw'y cu'wugf"cu'eqpvtqn'Vj g'cp'v'k'z'k'f'cp'v'cev'k'k'v' "qh'gzvtcew'j cu'dggp'gxcn'w'v'g'wukpi"4.4/f'kr'j gp{ n'3/  
r'let{ n'j { f'tc { n' \*F R R J + } j7\_ "cpf"4.4 /c| k'p'q/dku\*5/g'j { n'dgp| v'j k'c| q'k'p'g/8/uw'ht'p'le"cekf + \*CDVU+ } j8\_ "t'cf'lecn'uecxgpi kpi"  
o'g'j qf u'0Cm'gzr'g'tko g'p'u'y g't'g'r'g'th'qto gf "lp't'k' r'ec'v'g'0

Ur g'w'qr'j q'qo g'v'k'le"cpn'uku"uj qy gf "v'j cv' v'j g' cp'v'k'z'k'f'cp'v'cev'k'k'v' f'k'htg'gf"uki p'k'ecp'v' "dgy'ggp" f'k'htg'gp'v'  
r'tgr'ctgf"gzvtcew'0'J k'j g'v't'cf'lecn'uecxgpi kpi "ecr'cekf"lp'dqy"cp'v'k'z'k'f'cp'v'cev'k'k'v' "o'g'j qf u'y g't'g'f'g'v'to'k'p'gf"lp'uco' r'rg"  
WV6"\*: :045" "cpf"6204; "CDVU"cpf"FRRJ "tgumw'u't'g'ur'ge'v'k'ng' + "v'j cv'y cu'r'g't'g'ctgf" wukpi "wntcuqwpf"52"o'lp=82"AE-0'  
Wukpi "wntcuqwpf. "y'g'lp'et'g'cug'lp'cp'v'k'z'k'f'cp'v'cev'k'k'v' "y cu'q'dugt'x'gf" d { "gz'v'p'f'kpi "y'g'f'w'v'k'v'p'qh'y'g'wntcuqple't'g'cvo'gp'  
ht'qo "32"v'q"52"o' k'p'w'gu'0'Vj g'ht'y'gu'v'cp'v'k'z'k'f'cp'v'cev'k'k'v' "y cu'ht'q'wpf"lp"O'uco' r'rg. "y'cv'y cu'r'g't'g'ctgf" wukpi "o'cegtcvkqp"cpf"  
wugf"cu'eqpvtqn"790'4" "cpf"3507; "CDVU"cpf"FRRJ "tgumw'u't'g'ur'ge'v'k'ng' +0'E'qo r'ctkpi "CDVU"cpf"FRRJ "o'g'j qf u"  
FRRJ "uj qy gf"cm'qu'4/5"ko gu'ht'y'gt"cp'v'k'z'k'f'cp'v'cev'k'k'v' "lp"gzvtcew. "dw'FRRJ "ku'c"o' q't'g'uc'd'ng't'cf'lecn'cpf"y'g't'g'umw"  
qh'y'g'gzvtcew'ctg"o' q't'g'r'g'v'k'k'g'0

**Cenpqy igf i go g'p'w"**

Vj g'cwj qtu'y qwf "rkng"v'j cpn'Qr'gp"Ceegu'E'g'p't'g'ht"v'j g'C'f'xc'pegf"Rj cto cegwlecn'cpf"J gcnj "Vgej pqmji lgu"  
\*Nkj wcpkcp" wpkxgtuk{ "qh'J gcnj "Uelgpegu" cpf "ht" v'j g'qr'rt'w'p'k'f' "v'q" wug"o' qf g'tp"l'p'ht'c'w'w'w'g'cpf"r'g'th'qto "v'j ku"  
t'g'ug'tej'0'Vj g'cwj qtu'f'g'ern't'g'p'q'eq'p'h'le'w'qh'lp'v'gt'g'u'0

Vj ku'y qtnly cu'uw' r'qt'v'g'f' d { "v'j g'T'g'ug'tej "eq'w'pek'iq'h'Nkj wcpkcp"i' t'cp'v'p'q'02; 0505/GUHC/X/933/23/2223+0

[3\_ "V0'Ucdw'f'cni'cpf" "P'0'1' w'ngt." *o'Vtkhkw* "N0'/" "C" t'g'x'ley "qp"ku"r'j { q'ej go lecn'cpf"r'j cto ceqm'lecn'r'q'ht'g.0' Rj { v'j g't'0'T'gu'0" 65; 6668." 422; "  
f'qk'320224' r'v'0492; 0'  
[4\_ "C'0'V'c'x'c'." 0'R'g'ek'q. "T'0'N'q'U'ec'n'q. "C'0'U'q'ej o'cn'cpf" "N'0'R'g'ew'k'0'R'j'gp'q'ite"Eq'v'g'p'v'cpf" "C'p'v'k'z'k'f'cp'v'cev'k'k'v' "lp"Vtkhkw" "I'g'to' r'nc'uo' "ht'qo' "F'k'htg'gp'v"  
G'p'x'ht'q'p'o' g'p'u.0' "O'q'g'ew'gu."4; : .423; .f'qk'32055; 2'lo' q'g'ew'gu'462424; : 0'  
[5\_ "I' 0'U'wp." 0'N'kw"cpf" "L'0'Y'cpi. "o'Wntcuqwpf/cuukngf"gzvtcevkqp"qh'ht'x'g"kuqhxqpgu"ht'qo "Kku'v'g'ev'two "O'czko .0' "Ugr'0'R'w'ht'0'V'gej'p'q'0"6; 676."4233."  
f'qk'320238' l'0'gr' r'w'04233030390'  
[6\_ "C'0'M'0' g't. "I' 0'1' w'f'k' "P'0'Y' g'j'g't. "O'0'1' k'g't'w. "Y' 0'U'ej' A'j'g. "c'p'f' "J' 0'U'ej' w'j. "o'E'j' c't'ce'v't'k'k'v'k'p'c'p'f' "s'w'p'v'k'ec'v'k'p'qh'uge'q'p'f'c't' { "o'g'v'c'd'q'it'g'r' t'q'ht'g'u'lp"  
ng'c'x'gu'qh'ht'gf"cpf"y'j'k'g'em'q'x'g't'ur'ge'ku'd { "P'K' "c'p'f' "C'V'T' /K' "ur'ge'v't'ue'q'r { .0' "X'k'd'0'U' r'ge'v't'q'ue'0"4235. "f'qk'320238' l'0'k'd'ur'ge'042350702340'  
[7\_ "C'0'Y' q'lf { 0' "L'0'Q' u'lc' unk'c'p'f' "T'0'E' go' g't { u. "o'C'p'v'k'z'k'f'cp'v'cev'k'k'v' "c'p'f' "r'j'gp'q'ite"eqo r'qwpf u'lp"54"ug'ge'v'g'f'j'g't'g'u.0' "H'q'f' "E'j' go' 0"; 626; 6; .4229."  
f'qk'320238' l'0'q'q'f'ej' go' 04229026025: 0'  
[8\_ "C'0'R'0'V'k'x'g't'q'p. "R'0'U'0' g'ng. "M'0'D'0' D'g'ti'co' cue'j'k' "V'0'O' 0'H'0'U'X'k'g'c. "O'0'C'0'D'0'T'g'i'k'c'p'f'f' o'c'teg. "c'p'f' "U'0'O' 0'C'ng'p'ect. "o'C'p'v'k'z'k'f'cp'v'cev'k'k'v' "qh"  
D'tc| k'ic'p'X'g'i'g'v'c'd'rg'u'c'p'f' "ku'T'g'w'v'k'p' y'k'j' "R'j'gp'q'ite"Eqo r'q'uk'k'p.0' "p'0'L'0'O' q'0'U'k'0"; : 656; : 79."4234. "f'qk'32055; 2' l'ko' u'3529; : 650

**CP VKQZKF CP V'CE VKK[V 'QHP WWO GI 'GUUGP VKCN'QKN'RWTG.'Y KVJ ''  
O CI PGUKWO 'CNWO KPQO GVCUKNE CVG'CU'GZEKRKGP V'CPF 'VJ GKT''  
O KZVWTG'R' C'TCVIQ'QH3-3+'**

**Kpi c'O cwnf v<sup>3,4</sup>. 'Cmxln 'O cvctckv<sup>5</sup>. 'Lxti c'Dgtpcvqpkp<sup>3,4</sup>**

<sup>3</sup>F gr ctwo gpv'qh'F twi "Vgej pqmji { 'cpf "Uqelcn'Rj cto ce. "Nkij wcpkcp" Wpkxgtuks' "qh'J gcnj "Uelgpegu."Nkij wcpkcp"

<sup>4</sup>"Kpukwag'qh'Rj cto cegwlecn'Vgej pqmji kgu."Nkij wcpkcp" Wpkxgtuks' "qh'J gcnj "Uelgpegu."Nkij wcpkcp"

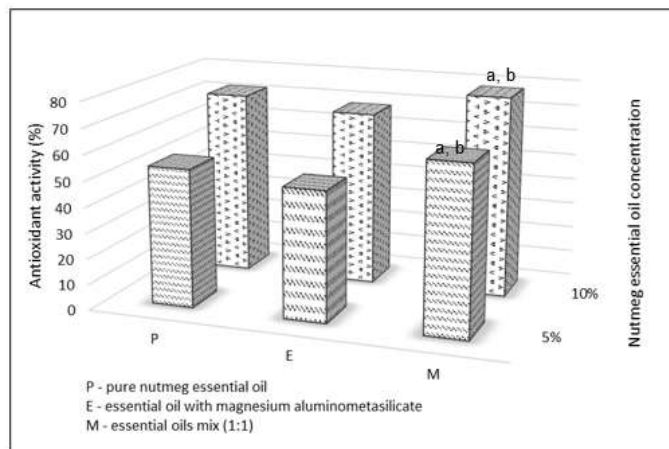
<sup>5</sup>Hcewmf "qh'O gf lekpg."Nkij wcpkcp" Wpkxgtuks' "qh'J gcnj "Uelgpegu."Nkij wcpkcp"

kpi c(b cwnf vB mo vOn'

P wo gi "guugpvkn'qkn'leqnt'nguu'vq'r'crg/ { gmqy 'y kj 'c'ur gekkle"qf qt "J3\_0KJ' cu'cpvo letqdken'cpvkgr vte.'cpvk'ctcukle." cpvk'kphco o cvqt {."cpf'cpvkz'kf cpv'ghgeu"J4.5\_0Ej go lecnleqo r qwpf u."gzukpi 'kp'guugpvkn'qkn'ecp'dlkpf'htgg'tcf lecn'cpf" r tqgev'v'g'rkxg'qti cpkwo "htqo 'pgi cvkxg'kphwvgeg"J6\_0Vj g'clo "qh'y ku'uwf { 'y cu'vq'eqo r ctg'v'g'cpvkz'kf cpv'cevkxk' "qh" pwo gi "guugpvkn'qkn'r tgr ctgf 'kp'f kHgtgp'v'eqpf kkkpuO'

Vj g'f'klgf 'uggf u'qh'pwo gi "O {tknec'htci tcpu+y' g'g'htqo 'I tgp'cf c0J { f tqf kknk'v'kq'p'rcu'v'f'6'j qwu'cpf 'y cu'ect'klgf" qw'd { "wulpi "Engxgpi gt'v'f'g'c'rr'ctewu."pwo gi "cpf'f'kknk'g'f' y cvgt'v'cvk'y cu'3-42"kp'c'tqwpf "dqvqo "hrcun'O ci pgukwo " cnwo kpqo gvcuk'ecv'g'3" "qh'y cvgt'co qwpv'y cu'wugf'cu'gzek kgp'p'o qf kHgf'j { f tqf kknk'v'kq'p'0C'pvkz'kf cpv'cevkxk' 'y cu' gxcn'cv'gf "d { "wulpi "4.4/f'kr j gp {n'3/r let {ij { f tc { n'F RRR ."Uki o c'c'f' tlej ."WUC+0C"v'v'cn'qh'3"o N'qh'g'v' cpqkte'F RRR " uqnv'kq'p'2B'o O +y cu' r'ceg'f'kp'c'ur'gew'qr j qvqo v'g't'ew'gw'g'cpf'322UN'qh'g'v' cpqkte'guugpvkn'qkn'uqnv'kq'p'u'7' "cpf'32" +y g'g'cf'f'gf'0C'm'uco r ngu'v'rtg'guugpvkn'qkn'guugpvkn'qkn'y kj "gzek kgp'v'r tgr ctgf "d { j { f tqf kknk'v'kq'p'cpf'c'o k'z'qh'y'gug" uqnv'kq'p'u'kp'c'tcvk'qh'3-3+y g'g'f'p'ew'd'cv'gf "kp'y'g'f'ctn'l'ht'52"o kp'wgu'cpf'cduq't'd'c'peg'y cu'o gcuw'gf'cv'737"po "WX" Ur'gew'qr j qvqo v'g't'WX/3: 22"Uj ko cf | w.'M'f'q'v'g'."Lcr cp+0Vj g't'guw'u'ct'g'r't'guugpv'gf'cu'o gcp'OU'F O'

Cpvkz'kf cpv'cevkxk' "qh'r'v'g'pwo gi "guugpvkn'qkn'y cu'750 7O2B2" 'cpf'94B6O2B5' 0Guugpvkn'qkn'y kj "gzek kgp'v' cpvkz'kf cpv'cevkxk' "y cu'8065" "cpf'7075" "ny gt'v'j cp'r'v'g'guugpvkn'qkn'y'7" "cpf'32" "guugpvkn'qkn'eqpeg'p'v'cvk'p." tgr'gew'gn'f'0C'pvkz'kf cpv'cevkxk' "qh'7" "eqpeg'p'v'cvk'p'qh'y'g'guugpvkn'qkn'o k'z'y cu'3043'cpf'304; "ko gu'j ki j gt'v'j cp'v'j cv' qh'r'v'g'guugpvkn'qkn'cpf' "guugpvkn'qkn'y kj "gzek kgp'v' tgr'gew'gn'f'0'Guugpvkn'qkn'o k'z'32" +j cf "cp'cr'rtqzko cvgn' " 33079O5B9" "j ki j gt'cevkxk' "v'j cp'v'j g'kp'k'k'f'v'cn'pwo gi "guugpvkn'qkn'uqnv'kq'p'u'v'j g'wugf' "o k'z'qh'pwo gi "guugpvkn'qkn' uqnv'kq'p'u'j cf 'c'uki pkk'ec'v'v'j ki j gt'cpvkz'kf cpv'cevkxk' "v'j cp'v'j g'v'gr'ctcv'g'guugpvkn'qkn'o'



Hki 030P wo gi "guugpvkn'qkn'cpvkz'kf cpv'cevkxk' {0c'/"r>2O27'xgtuwu'r v'g'guugpvkn'qkn'd'/"r>2O27'xgtuwu'guugpvkn'qkn'y kj "gzek kgp'v'0, C'm'uco r ngu'v'uc'p'f'ctf'f'g'x'k'v'k'p'qh'cpvkz'kf cpv'cevkxk' "ku'ngu'u'v'j cp'2O: ' "cpf' "y cu'p'q'v'o ctngf'kp'y'g'hki v'g'O'

Vj g'gzek kgp'v'f'get'g'cu'gf'v'j g'cpvkz'kf cpv'cevkxk' "qh'pwo gi "guugpvkn'qkn'd'w'v'j g'o k'z'qh'r'v'g'guugpvkn'qkn'cpf' "guugpvkn' qkn'y kj "o ci pgukwo "cnwo kpqo gvcuk'ecv'g'j cf "c'j ki j gt'cpvkz'kf cpv'cevkxk' "v'j cp'v'j g'v'gr'ctcv'g'guugpvkn'qkn'o'v'y q'guugpvkn' qkn'uqnv'kq'p'u'y qtni'uf'pgti kkn'ecm'f' "cpf' "v'j g'o k'z'wt'g'u'cpvkz'kf cpv'cevkxk' "ku'j ki j gt'O'

[3]\_F lkrpk'c'0'f'lenq.'C'0'v'j g'v'j g'c'r'gw'le'Depghku'qh'Guugpvkn'Qkn'0P'wt'0Y'gn'Dgkpi'J'gcn'04234.'P'q'0'Hg'd'tw'ct' { '42340j'vr'u'klf'qk'q'ti' B207994'475660' J4\_'D'cug't.'M'0J'0'D'w'p'ej'd'ew'gt.'I'0J'c'p'f'd'q'q'n'l'q'h'Guugpvkn'Qkn-'U'el'g'p'eg.'V'g'ej'p'q'q'i'f'.'c'p'f' 'C'r'r'k'ec'v'k'p'u'='E'f'f'g' 'R't'g'u'p'Y'.'42320' J5\_'O'w'ej'v'ct'f'k'c'U'w'd'c't'p'c'u.'C'0'c'r't'k'f'c'p'v'q'p'q.'C'0'0'w'w'c't'le'j'k'g.'T'0'k'g'p'v'k'k'ec'v'k'p'qh'E'q'o r'q'w'p'f'u'kp'y'g'Guugpvkn'Qkn'qh'P'w'o gi 'U'gg'f'u'0' {tknec'htci tcpu' J'q'w'0'v'j'c'v'k'j'k'k'l'N'q'eq'o'q'v't' 'C'ev'k'x'k'f' 'kp'o'le'g'0'f'p'o'LO'0'q'r'0'U'k'0'4232.'33'\*33+:'6993069: 30j'vr'u'klf'qk'q'ti' B2055; 2'k'o' u333369930' J6\_'C'o'q't'ek'T'0'X'c'ri'k'o'k'i'ik'N'0'o'g'v'j'q'f'u'v'q'O'g'cu'w'g'v'j'g'c'p'vkz'kf'cpv'cevkxk'f' "qh'Rj' {v'q'ej'go'le'cn'cpf' "R'r'p'v'G'z't'c'ev'u'LO'Ci't'k'e'0'H'q'q'f' 'E'j'go'0423:.'88" \*35+:'55466554; 0j'vr'u'klf'qk'q'ti' B208243'keu'0'c'he'0'd'2329; 0'



**J GVG TQNQI QWU'GZRTGUKQP 'QHP QXGN'DCE VGT KQE K'HI'QO "**  
**VJ GTO QRJ KNE 'DCE VGT K'"**

Cmkn "Xkr k-cwunckv<sup>3</sup>. "Ucwn "Wkpcwunckv<sup>3</sup>. "Cni kf cu"Mcw kpk<sup>4</sup>. "O kpf cwi cu"Xcrku<sup>4</sup>. "Ctpqf cu" Mcwplkv<sup>3</sup>"

<sup>3</sup>F gr ctvo gpv'qh'O letqdkrqi { "cpf "Dkqvej pqrqi { . "Kpukwv'qh'Dkqvepgeu. "Nkg'Uelpegu'Ecpvgt. "Xkrkku'Wpkxgtukf. " Ucwn vgnk'cxg<sup>0</sup>. "Xkrkku. "Nkj wpc" "

<sup>4</sup>Rtqvgqo leu'Egvtg. "Kpukwv'qh'Dkqej go knt { . "Nkg'Uelpegu'Ecpvgt. "Xkrkku'Wpkxgtukf. "Ucwn vgnk'cxg<sup>0</sup>. "Xkrkku. " Nkj wpc" "cmknkpkkr kucwunckvB i o eQrwf Qwfn"

Dcevtkqekpu'ctg"j gvgtqi gpgqwu'i tqwr "qh'tkduqo cmf "u{ py gukgf "cpko letqdkr'r gr vkf gu'y kj "y g"cdkksf "v"nkni' emqunf "tgrvxf "pcttqy "ur gevto +:qt"cfkxgtug'tcpi g'qh'\*/dtqcf "ur gevto +:o letqati cpkuo u']3\_0Vj g{ "ctg'ercuukhgf "kpv" y tgg"o clqt "ercuug'dcugf "qp"vj gk "urtwewtcr'cpf "r j { uleqej go kcrn'r tqr g'vku'ercu'Kdcevtkqekpu. "ercu'Kdcevtkqekpu. " cpf "ercu'Kdcevtkqekpu0Vj gug'cpvkcevtkcn'kpv kds'vj g'i tqy y "qh'vcti gv'qti cpkuo u'd{ "hwpevkpki "r tko ctkf "qp"vj g'egm' gpxgnr g"cpf "d{ "chgevkpi "i gpg"gzr tguakp"cpf "r tqvlp"r tqf vevkp"y kj kp"egm0Vj gug'o qngewgu"j cxg"cpko letqdkr' cevkkf "ci ckpu"r cvj qi gpk"cpf "f gvgtkqcvpi "dcevtk. "y j lej "lwukhgu"vj gk "dkqvej pqrqi kcrn'r qvgpvcn0Vj g" wug"qh' dcevtkqekpu"j cu"dgpp"tgr qtvgf "hqt"vj g'hmqy kpi <"hqf"r tguvxcvqp. "f kxgtug"vj gtr gwle"r wtr qugu'wej "cu"tgevo gpv'qh' r gr v'e wregt. "ur gto kcf cr'ci gpv'cpf "y qo cp'ectg. "cp'ecpegtqwu'ci gpv'xgvgtkpct { "wug. "unpctg. "cpf "qtr'ectg. "cpf "cuq'hqt" r mpv'i tqy y "r tqo qvqp"kp"ci tlewwtg"co qpi "qvj gtu"j4\_0"

Vj g'i gpwu'I ggdcekmul'eqo r tkgu'dcevtk'vj cv'ctg'I tco /r qukxg. "vj gto qr j kke"ur qtg/hqto gtu. "y j lej "ctg'hqwpf "kp" c'xctkvf "qh'gpxkqpo gpw'ltqo "j qv'ur tkpi u. "eqnrluknu. "v'hqf"b cpwcewtkpi "r mpvu. "kpenf kpi "f ckt { "b cpwcewtkpi "r mpvu" j5\_0I ggdcekmul'j cu'j kuqtkcmf "dgpp"cuqekcvf "y kj "ur qkrci g'qh'ecppgf "hqf 0J qy gxtg. "kp'tgegpv' { gctu'k'j cu'dgeqo g" y j g'uwldgevh'o wej "cvwvqp"i v'g'ku'dkqvej pqrqi kcrn'r qvgpvcn0Qpg'cur gev'qh'vj ku'i gpwu'vj cv'j cu'pqv'dgpp'hwf "gzr nqtgf " qt"tgcik gf "ku"ku" wug"cu" c"uqwtg"qh'pqxgn'hqto u'qh' y j g"tkduqo cmf "u{ py guk gf "cpko letqdkr'r gr vkf gu"mpqy p"cu' dcevtkqekpu"j6\_0Dcevtkqekpu'ltqo "vj gto qr j kke"dcevtk'j cxg'vj g'r qvgpvcn'v'dg'wugf "kp"xctkpw'kpf wukgu'vj cv'o ckpckp" j ki j gt"vgo r gtcwtgu. "ukpeg"vj gto qr j kke"dcevtk'r tqvkvpu'ctg'wuwcmf "vj gto quvcdrg0"

I ggdcekmul'wgctqvj gto qr j kmu"37. "kuqrvf "ltqo "qkrlgf "nqecvf "kp" Nkj wpc. "r tqf wegu" y q" dcevtkqekpu" i ggdcekmp"48"\*/ gq48+"cpf "i ggdcekmp"3; "\*/ gq3; +0Ukpeg'I gq48"j cxg'ctgcf { "dgpp"r wkhgf. "j gvgtqrqi qwu"gzr tguugf " kp"Guej g'k'ej k'v'q'k'cpf "ej ctcevtk gf. "y j g'clo "qh'qwt'uwf { "ku'v'empg. "r gthqto "j gvgtqrqi qwu"gzr tguakp"qh'tgeqo dkpcpv' pqxgn'I gq3; "dcevtkqekp"kp"GQqk'cpf "v'ej ctcevtk gf "k0Vj ku'dcevtkqekp"ecp"dg'cuuki pgf "v'ercu'Kk'k'j cu'uko kctk'v' "v" c'tgcf { "ej ctcevtk gf "dcevtkqekp"UF R0P cvkxg'I gq3; "ku'cevkg"ci ckpu'vj gto qr j kke"dcevtk. "y j lej "qhwg"uwtxkg"j ki j " vgo r gtcwtgu"i wtkpi "j gev'tgevo gpv'qh'hqf "cpf "eqwf "vj g'ghqg'dg"y kf gm' "cr r rkgf "kp"vj g'hqf "kpf wut { 0"

j3\_ "Rcw"O "QeAppqt. "Vc"u"O "Mpk'quj k'Tlectf q"RU'Qrkxgk. "Eqrk"J km"tg'pqr u'Rcwit'quu. "Rcwit"Eqvgt. "Cpko letqdkr'ht'hqf "cpf "hggf =c" dcevtkqekp'r gtur gevkg. "Ewtgpp'Qr kpkp"kp'Dkqvej pqrqi { . "382/389"\*/4242+0"

j4\_ "Cdgdg"Y qtmw'P gi cuj. "Dgtj cpw'CPF wrgo "Vugj ck"Ewtgpp'Cr r r'ecvkvpu'qh'Dcevtkqekp. " Tgxky "Ct'veng"\*/4242+0"

j5\_ "Dwti guu. "UCO"Hi'pv. "UJ 0"Nkpf uc. { "F 0'gv'cr'0'kuki j u'kpv"vj g'I ggdcekmul'wgctqvj gto qr j kmu"ur geku'dcugf "qp"r j { nqi gpqo k'r tkpek rgu'0DO E" O letqdkr'39. "362"\*/4239+0"

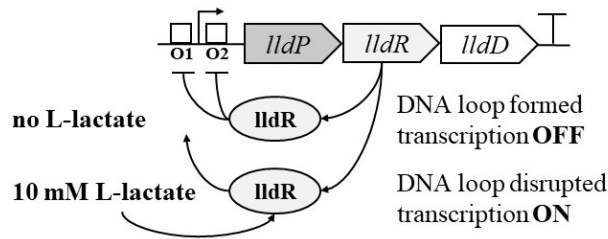
j6\_ "Mxlp"Gi cp. "F gu'Hkrf. "T0Rcwit'quu. "Rcwit'0Eqvgt. "Eqrk"J km'k'ukleq "Rt'gf k'vqp"cpf "Gzr nqt'vqp"qh'Rqvgpvcn'Dcevtkqekp'I gpg'Enwvgtu"Y kj kp" y j g'Dcevtkcn'I gpwu'I ggdcekmul'0H'q'v'gtu'kp'O letqdkrqi { ; "\*/423: +0"

**HF GP VHKC CVKQP 'CPF 'EJ CTCE VGTK CVKQP 'QHN/ 'CPF 'F/ NCE VKE "**  
**CEKF/ KPF WEKNG'U UVGO UHQ T'VT CP UET KRVKQP 'HCE VQT/ DCUGF "**  
**DKUGP UQT 'F GXGNQRO GP V"**  
Gtpguc 'Cwi wukpqp<sup>3</sup>. "P ci rku' O cni<sup>3</sup>"

<sup>3</sup>Dqr tqegu' Tgugtej 'Egvtg. 'Heww{ 'qh' Ej go lecn' Vgej pqmji { . 'Mwpcu' Wpkxgtuk{ 'qh' Vgej pqmji { . 'Tcf xkn p 'r r03; . "  
Mwpcu. 'Nkj wpcle"  
gtpguc' Cwi wukpqpB mw0n'

Nceve' cefk 'ku' cp' ko r qt cpv' r n' vqto "ej go lecn' wugf "lp' hqf. "ci tlewwt g. "equo gve. "r j cto cegwlecn' cpf "ej go lecn' kpf wutku' O' Kp' cf f kkkp. "qr vlecni' "r wtg' hqto u' qh' y' ku' cefk "N/ "cpf "F/ "u' ugtg' lkuo gtu' ctg' guugp' kcn' hqt' y' g' r' tqf wevkqp' qh' r qn' rvele' cefk. "c' d' kqf gi tcf cdrg' r qn' o gt' y' cv' j' cu' r qv' p' kcn' v' q' tgr n' eeg' t' cf kkkp' cn' r' g' v' q' r' g' w' o / dcugf "r n' eueu' cpf "tg' weg' gp' x' k' q' p' o' g' p' v' n' r' q' m' w' k' q' p' O' P' c' v' w' t' c' m' f. "n' e' v' e' l' e' c' e' f' k. "cu' c' r' t' k' o' c' t' { "h' g' t' o' g' p' v' e' k' p' r' t' q' f' w' e' v' "ku' r' t' q' f' w' e' g' "d' { "c' "p' w' o' d' g' t' "q' h' o' l' e' t' q' q' t' i' c' p' k' u' o' "l' p' e' n' f' l' p' i' "n' e' v' e' l' e' c' e' f' k' "d' c' e' v' g' t' k' "N' O' n' e' v' e' l' e' "N' O' r' t' c' e' c' u' g' k' "G' O' j' k' c' g' +. "D' c' e' k' n' u' "u' r' g' e' l' g' u' "D' O' e' q' c' i' w' r' p' u' "D' O' i' m' d' v' k' k' u' +. "c' p' f' "h' k' r' o' g' p' v' w' u' h' w' p' i' k' \*T' O' l' q' t' / / c' g' + O' j' q' y' g' x' g' t' . "l' p' 'q' t' f' g' t' 'v' q' 'c' e' j' k' x' g' 'v' e' j' p' q' m' j' i' k' e' c' m' f' 'c' p' f' 'g' e' a' p' p' o' l' e' c' m' f' 'u' w' u' c' k' p' c' d' r' g' "r' t' q' f' w' e' v' k' p' . "v' j' g' e' q' o' r' n' g' z' "u' g' r' e' v' k' p' "h' q' t' "d' g' u' v' r' t' q' f' w' e' l' p' i' "d' c' e' v' g' t' k' e' n' i' r' t' q' e' g' u' u' q' r' w' o' k' k' v' k' p' c' t' g' "q' h' w' g' p' "t' g' s' w' k' g' f' O' H' q' t' w' p' c' v' g' n' f' . "j' k' i' j' / v' j' t' q' w' i' j' r' w' w' e' j' e' j' p' q' m' j' i' k' e' u' d' c' u' g' f' "q' p' "y' j' q' r' e' / e' g' m' i' g' p' g' v' e' c' m' f' "g' p' e' q' f' g' f' "d' k' u' g' p' u' q' t' u' u' j' q' y' "i' t' g' c' v' r' q' v' p' k' c' i' n' i' v' h' e' k' k' e' v' g' 'c' p' f' "f' t' k' x' g' 'v' j' g' o' w' n' k' r' e' g' v' g' f' "u' e' t' g' g' p' k' i' "r' t' q' e' g' u' o' "

Tgegpv' uwf' l' g' u' j' c' x' g' 'u' j' q' y' p' v' j' c' v' t' c' p' u' e' t' k' v' k' p' "h' e' v' q' t' "VH/ dcugf "dkugpuqtu' ecp' dg' wugf "hqt' t' gcn' v' k' o' g' o' q' p' k' q' t' k' p' i' "q' h' g' z' v' t' c' e' g' n' w' c' t' "c' p' f' "l' p' v' t' c' e' g' n' w' c' t' "o' g' v' c' d' q' r' k' g' "e' q' p' e' g' p' t' c' v' k' p' u' . "j' k' i' j' / v' j' t' q' w' i' j' r' w' w' e' j' e' j' p' q' m' j' i' k' e' u' d' c' u' g' f' "q' h' x' c' u' v' o' w' c' p' v' i' k' d' t' c' t' k' e' u' . "f' { p' c' o' l' e' "r' c' v' j' y' c' { "e' q' p' w' q' n' "c' p' f' "c' f' c' r' v' k' g' "r' e' d' q' t' c' v' q' t' { "g' x' q' i' w' k' p' p' " j' 3. "4\_0' Vj' g' f' g' u' k' i' p' "q' h' v' j' g' "d' k' u' g' p' u' q' t' "k' u' d' c' u' g' f' "q' p' "y' q' "g' u' a' p' v' k' c' i' n' i' e' q' o' r' q' p' g' p' v' u' g' p' u' k' i' "c' p' f' "t' g' r' q' t' v' k' p' i' "w' p' k' u' O' Vj' g' u' g' p' u' q' t' { "o' q' f' w' e' g' "e' a' p' p' u' k' u' "q' h' "VH/ r' t' q' o' q' v' g' t' "r' c' k' t' "v' j' c' v' k' u' "l' p' "c' p' "l' p' f' w' e' l' d' r' g' "i' g' p' g' "g' z' r' t' g' u' k' q' p' "u' { u' v' g' o' "c' p' f' "t' g' u' r' q' p' f' u' v' q' "v' j' g' e' q' t' t' g' u' r' q' p' f' l' p' i' "h' i' c' p' f' "o' q' r' e' g' w' e' g' O' T' g' r' q' t' v' k' p' i' "w' p' k' v' { r' l' e' c' m' f' "e' q' p' u' k' u' "q' h' v' j' g' "h' w' a' t' g' u' e' g' p' v' r' t' q' v' k' p' "c' p' f' "k' u' e' q' w' r' e' g' f' "v' q' "v' j' g' u' g' p' u' k' i' "w' p' k' v' "u' q' "v' j' c' v' e' j' c' p' i' g' u' l' p' "v' j' g' u' g' p' u' q' t' { "d' r' i' e' n' l' e' j' c' p' i' g' v' j' g' "q' w' r' w' " j' 5\_0' "



Hki 030I gpg' emwgtu' l' p' Guej gtkej k' e' q' r' k' O I 3877' g' p' e' q' f' l' p' i' "v' j' g' g' p' l' { o' g' u' t' g' s' w' k' g' f' "h' q' t' "N' o' r' e' v' e' l' e' c' e' f' k' "e' c' v' c' d' q' r' k' u' o' " j' 6\_0' "

C" h' y' "n' e' v' e' l' e' c' e' f' k' / l' p' f' w' e' l' d' r' g' "i' g' p' g' "g' z' r' t' g' u' k' q' p' "u' { u' v' g' o' u' j' "c' x' g' "d' g' g' p' "t' g' r' q' t' v' g' f' "r' t' g' x' l' q' w' u' n' { "l' p' "x' c' t' k' q' w' u' o' l' e' t' q' q' t' i' c' p' k' u' o' u' . "l' p' e' n' f' l' p' i' "G' e' N' i' f' T' I' R' n' f' R' " \*G' O' e' q' r' k' " O I 3877+ " j' 6\_ " E' i' N' i' f' T' I' R' n' f' R' " \*E' q' t' / p' g' d' c' e' v' g' t' k' w' o' " i' n' w' o' k' e' w' o' " C' V' E' E' " 35254+ " j' 7\_ " R' e' N' i' f' T' I' R' n' f' R' " \*R' u' g' v' f' q' o' q' p' c' u' c' g' t' w' i' l' p' q' u' e' " Z' O' I' + " j' 8\_ " D' e' N' w' T' I' R' n' m' c' " \*D' c' e' k' n' u' i' w' a' d' v' k' u' " 38: + " j' 9\_ " F' x' N' w' T' I' R' r' q' t' " \*F' g' u' w' h' t' x' k' d' t' k' q' " x' w' i' c' t' k' u' j' k' f' g' p' d' q' t' q' w' i' j' + " j' : \_ " c' p' f' "C' y' N' e' v' C' I' R' w' e' d' " \*C' e' g' v' d' c' e' v' g' t' k' w' o' " y' q' q' f' k' k' F' U' O' " 3252+ " j' ; \_ 0' Vj' g' d' c' u' e' t' g' i' w' e' v' k' p' o' g' e' j' c' p' k' u' o' " q' h' N' n' e' v' e' l' e' c' e' f' k' / l' p' f' w' e' l' d' r' g' "i' g' p' g' "g' z' r' t' g' u' k' q' p' "u' { u' v' g' o' "h' t' q' o' "G' O' e' q' r' k' k' u' r' t' g' u' g' p' v' g' f' "l' p' "H' k' i' w' t' g' "30' Vj' k' u' u' { u' v' g' o' "e' q' p' t' q' m' . "c' p' n' f' R' T' F' " q' r' g' t' q' p' . "t' g' u' r' q' p' u' k' d' r' g' "h' q' t' "c' g' t' q' d' l' e' "N' n' e' v' e' l' e' c' e' f' k' o' g' v' c' d' q' r' k' u' o' O' Y' g' k' f' g' p' v' k' h' { "c' p' f' "e' j' c' t' c' e' v' g' t' k' g' N' "c' p' f' "F' / n' e' v' e' l' e' c' e' f' k' / l' p' f' w' e' l' d' r' g' "u' { u' v' g' o' u' " v' j' c' v' e' c' p' "r' q' v' p' v' k' c' m' f' "d' g' "w' u' g' f' "h' q' t' "f' g' x' g' n' r' l' p' i' "v' t' c' p' u' e' t' k' v' k' p' "h' e' v' q' t' / d' c' u' g' f' "d' k' u' g' p' u' q' t' u' O' Q' w' "f' c' v' e' "u' j' q' y' "v' j' c' v' v' j' g' "G' e' N' i' f' T' I' R' n' f' R' " l' p' f' w' e' l' d' r' g' "u' { u' v' g' o' "k' u' "u' r' g' e' k' h' e' "v' q' "v' j' g' N' n' e' v' e' l' e' c' e' f' k' "c' p' f' "e' c' p' "d' g' "w' u' g' f' "v' q' "c' e' j' k' x' g' "w' "v' q' "47/ h' q' r' f' "l' p' f' w' e' l' d' r' g' "q' h' i' g' p' g' "g' z' r' t' g' u' k' q' p' " w' u' k' p' i' "o' l' e' t' q' o' q' r' t' "l' p' f' w' e' g' t' "e' q' p' e' g' p' t' c' v' k' p' u' O' "

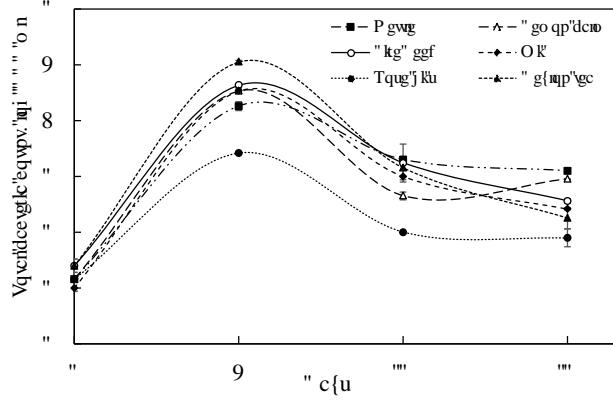
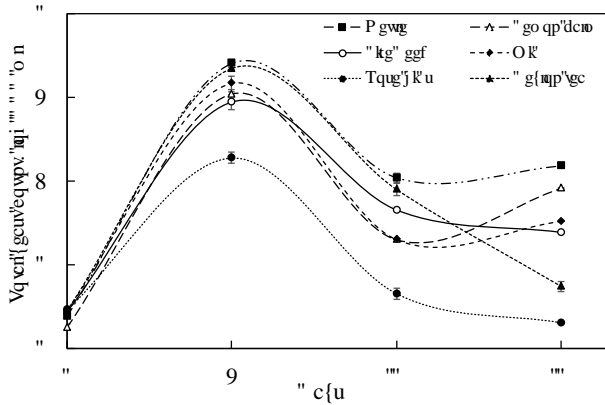
[3]\_J quucp. I O0Ug'v'c' r' O' I' g' p' g' v' e' l' e' c' e' f' k' / l' p' f' w' e' l' d' r' g' "u' { u' v' g' o' u' j' "c' x' g' "d' g' g' p' "t' g' r' q' t' v' g' f' "r' t' g' x' l' q' w' u' n' { "l' p' "x' c' t' k' q' w' u' o' l' e' t' q' q' t' i' c' p' k' u' o' u' . "v' t' g' p' f' u' l' p' "D' k' v' g' e' j' p' q' m' j' i' { ' 5: \*9+; 9; 32\*4242+0  
j4\_ "O' k' e' j' n' g' t' . "O' O' O' 0' I' c' t' e' k' . "I' O' O' 0' O' q' p' v' g' t' q' . "P' O' G' O' ( "Y' k' n' i' c' o' u' . "I' O' I' O' "v' t' c' p' u' e' t' k' v' k' p' "h' e' v' q' t' / d' c' u' g' f' "d' k' u' g' p' u' q' t' u' c' o' "o' q' r' e' g' w' e' t' / i' w' k' f' g' "c' r' r' t' q' e' j' "h' q' t' "p' c' w' t' c' i' n' i' r' t' q' f' w' e' v' g' p' i' l' p' g' g' t' k' p' i' . "E' w' t' g' p' v' O' r' k' p' l' q' p' "l' p' "D' k' v' g' e' j' p' q' m' j' i' { ' 8; . '394/3; 3\*4243+0  
j5\_ "J' c' p' n' i' . "G' O' O' k' p' v' q' p' . "P' O' ( "O' c' n' u' . "P' O' F' g' u' k' i' p' . "e' n' i' p' l' p' i' "c' p' f' "e' j' c' t' c' e' v' g' t' k' c' v' k' p' "q' h' i' v' t' c' p' u' e' t' k' v' k' p' "h' e' v' q' t' / d' c' u' g' f' "l' p' f' w' e' l' d' r' g' "i' g' p' g' "g' z' r' t' g' u' k' q' p' "u' { u' v' g' o' u' . "O' g' v' j' q' f' u' "l' p' "G' p' l' { o' q' m' j' i' { ' 843; '375/38; \*423; +0  
j6\_ "C' i' w' k' g' t' c' . "N' O' g' v' c' i' n' i' "F' w' c' i' t' q' n' g' "q' h' i' N' i' f' T' "l' p' "t' g' i' w' e' v' k' p' "q' h' i' v' j' g' "n' f' R' T' F' "q' r' g' t' q' p' . "l' p' x' q' r' x' g' f' "l' p' "N' n' e' v' e' l' e' c' e' f' k' o' g' v' c' d' q' r' k' u' o' "l' p' "G' u' e' j' g' t' k' e' j' k' e' "e' q' r' k' "l' a' w' t' p' e' n' i' q' h' i' D' c' e' v' g' t' k' q' m' j' i' { ' 3; 2\*+; 4; ; 965227\*422; +0  
j7\_ "I' c' q' . "I' O' I' ( g' v' c' i' n' i' "U' t' w' e' w' t' c' i' n' i' c' p' f' "h' m' p' e' v' k' p' c' i' n' i' e' j' c' t' c' e' v' g' t' k' c' v' k' p' "q' h' i' v' j' g' "N' i' f' T' "h' t' q' o' "E' q' t' / p' g' d' c' e' v' g' t' k' w' o' " i' n' w' o' k' e' w' o' c' o' "v' t' c' p' u' e' t' k' v' k' p' c' i' n' i' r' t' g' u' a' t' "l' p' x' q' r' x' g' f' "l' p' "N' n' e' v' e' l' e' c' e' f' k' / l' p' f' w' e' l' d' r' g' "u' { u' v' g' o' "l' u' i' c' t' "w' k' k' c' v' k' p' . "P' w' e' n' g' l' e' C' e' l' f' u' T' g' u' g' t' e' j' "58\*44+; '933269345\*422; +0  
j8\_ "I' c' q' . "E' O' g' v' c' i' n' i' "N' e' e' v' g' w' k' k' c' v' k' p' "k' u' i' g' i' w' e' v' g' f' "d' { "v' j' g' "H' e' f' T' / v' r' g' t' g' i' w' e' v' q' "N' i' f' T' "l' p' "R' u' g' v' f' q' o' q' p' c' u' c' g' t' w' i' l' p' q' u' e' . "l' a' w' t' p' e' n' i' q' h' i' D' c' e' v' g' t' k' q' m' j' i' { ' 3; 6\*32+; 48; 9/48; 4\*4234+0  
j9\_ "E' j' k' w' "M' E' O' "N' p' . "E' O' I' O' ( "U' j' c' y' . "I' O' E' O' "v' t' c' p' u' e' t' k' v' k' p' c' i' n' i' g' w' e' v' k' p' "q' h' i' v' j' g' "N' n' e' v' e' l' e' c' e' f' k' o' g' v' c' d' q' r' k' u' o' "l' p' "G' u' e' j' g' t' k' e' j' k' e' "e' q' r' k' "l' a' w' t' p' e' n' i' q' h' i' D' c' e' k' n' u' i' w' a' d' v' k' u' " T' Q' / P' P' / 3. "O' l' e' t' q' d' k' q' m' j' i' { ' 382; '439; 643; ; \*4236+0  
j10\_ "I' c' l' g' g' x' . "N' O' g' v' c' i' n' i' "N' w' T' "k' u' e' l' g' i' w' e' v' q' t' "q' h' i' v' j' g' "e' g' p' v' t' c' i' n' i' e' v' e' c' v' g' "q' z' k' c' v' k' p' "r' c' v' j' y' c' { "l' p' "u' w' i' t' c' v' g' t' g' f' w' e' l' p' i' "F' g' u' w' h' t' x' k' d' t' k' q' "u' r' g' e' l' g' u' . "R' N' q' U' Q' P' G' "36\*6+; "g' 2436; 82" \*423; +0  
j11\_ "U' e' j' q' a' g' n' o' g' t' e' j' . "O' O' E' O' g' v' c' i' n' i' "T' g' i' w' e' v' k' p' "q' h' i' v' e' v' g' o' g' v' c' d' q' r' k' u' o' "l' p' "v' j' g' "c' e' g' e' q' i' g' p' l' e' "d' c' e' v' g' t' k' w' o' "C' e' g' v' d' c' e' v' g' t' k' w' o' "y' q' q' f' k' k' "G' p' x' k' q' p' o' g' p' v' e' n' i' O' l' e' t' q' d' k' q' m' j' i' { " 42\*34+; '67; 9667; 7\*423; +0

# EJ CPI GUR 'VJ G'VQVCN'O KET QDKCN'E QWP V'CPF 'CP VEDCE VGT KCN' CEVKKV 'QHMQO DWEJ C'RTGRCTGF 'Y KJ 'J GTDCN'VVCU'

O krf c'Dwmyckv . 'Xkn c'Mc-nuplpgp . 'T w'O lenkpgp . 'Cwf tkwu'O ctw-ne'

Kpntwo gpvniCpni uku'Qr gp 'Ceegui'Egptg . 'Hewm' 'qh'P cwctri'Uelgpegu 'X{ vcwcu'O ci puw'Wpkxgtuks' 'Xkgnkuu' : . ' NV/66626'Mcvpcu . 'Nkj wcpkc' o krf cdwmyckvgoB i o ckrfego "

Mqo dwej c'ku'c'htgo gpvgt 'Eco gnik 'tkp gpuku'NO'drcem'vc'f' tlpni kj 'c'uy ggv'cpf 'uqwt'vcug0'Vj ku'htgo gpvgt 'f' tlpni cu' tgegpw' 'cwtcevg' 'y' g'cwepw'q'p'q'ht'gugctej' gu'f' w'q'ku'xctkcdrg'cpf 'wps w'eqo r qukkqp0Mqo dwej c'ku'q'wps w'g'dgecwug' qh'v' g'u' o dkwle'ewmw'g'q'hdcevgtk'cpf '{ gcu'UEQD[ '+y j lej 'chgew'v' g'r'qr'gt'v'gu'q'v'g'f' tlpni0Ceeqtf' kpi 'v' t'gugctej' . ' nqo dwej c'ewmw'g'cdqwp' u' l'p'cegk' cefk '\*Cegvdccevg'ceg'g+' r'evk' cefk 'dcevgtk' . 'cpf 'quo q'j' kke' '{ gcu' ]3.4\_0'Vj g' o letqdkm' keni' t'q'k'q'q'h'c' h'qo dwej c'ewmw'g'o c' { 'f' gr'gp'f' q'p'v' g'tcy 'o' v'gt'k'ni'w'ug'f' 'cpf 'v'j' g'htgo gpw'v'q'p'eq'pf' k'k'p'u' ]4.5\_0' Vj g'c'k'o 'qh'v' ku'u'w'f' { 'y' cu'v'g'x'cn'w'v'g'v'j' e'j' cpi gu'q'h'v'cn'eq'wp'v'q'h'o' ketq'q'ti' cpkuo u'cpf 'cp'w'dcevgtk'ni'ce'v'k'k'v' 'qh'htw' f' k'ht'gp'v'o' g'f' k'ep'cn'i' r'p'u'c'p'f' 'v'j' g't' o' k'z'gu'y' cvgt' 'l'p'h'w'uk'p'u'c'ht'g' '9' . '36' 'cpf' '43' 'f' c' { 'u'q'h'htgo gpw'v'q'p'v'j' k'j' 'nqo dwej c'ewmw'g'o' K'p'v'j' ku'ht'gugctej' 'htgo gpw'v'q'p'v'j' cu'r' g'ht'qto' g'f' 'w'uk'p'i' 'v'j' g'ht'c'ni'w'ug' dwej c'ewmw'g'r' w'ej' cu'g'f' 'cv'ht'c'ni'w'ug' g'to' ctng'0Cni' g'zr' g'tko' g'p'u'y' g't'g'f' p'q'g'v' k'j' 'u'w'i' ct'g'f' 'f' t'lp'ni'ht'qo' 'p'g'w'g' '\*W'v'k'ec' 'f' 'k'k'ec' 'NO' . 't'go' q'p' 'd'c'm'o' '\*O' g'ri'k'uc' 'q'ht'k'p'c'ri' 'NO' . 'ht'g'y' g'g'f' '\*Ej' c'o' c'g'p'g't'k'p' 'c'p'i' w'ak'q'ik'w'o' 'NO' . 't'q'ug'j' k'r' u' '\*T'q'uc' 'ec'p'k'c' 'NO' 'c'p'f' 'v'j' g't' o' k'z'gu'0Mqo dwej c'rt'g'r' ct'g'f' 'ht'qo' 'E'g' 'r'p' 'v'g'c' 'ht'qo' ' U'k'N'c'p'ni' y' cu'w'ug'f' 'h'q' 'eqo' r' c't'k'q'p'0Mqo dwej c'y' cu'r' t'g'r' ct'g'f' 'p'v'j' g'uc'o' g'e'q'p'f' k'k'p'u'c'p'f' 'htgo gpw'v'q'p'v'j' cu'r' g'ht'qto' g'f' 'h'q' ' 43' 'f' c' { 'u'lp'c'f' c't'ni't'q'q'o' 'cv'42'0' 'A'0'E'q'o' r' c'ev'F' t' { 'v'g'u'r' r'ev'u'y' g't'g'w'ug'f' 'h'q' 'v'c'ni'd'cevgtk' 'c'p'f' '{ 'g'cu'eq'wp'v'o' C'p'v'o' let'q'd'k'c'ni' ce'v'k'k'v' 'y' cu'f' g'v't'o' k'p'g'f' 'c'i' c'k'p'u'v' t'c'o' / r' q'uk'x'g' 'D'c'ek'm'u'o' q'lc'x'g'p'uk'i' 'c'p'f' 'D'c'ek'm'u'o' g'i' c'v'g't'k'w'o' . 'i' t'c'o' / p'g'i' c'v'k'x'g' / C' / q'v'q'd'c'ev'g't' ' x'k'p'g'r' p'f' k'w'uk'p'i' 'c'i' c't' y' g'm'f' k'ht'w'uk'p'o' g'v'j' q'f' ]6\_0'



Hki 030'Vq'v'ni'eq'wp'v'q'h' { gcu'v'eq'w'v'c'p'f' 'dcevgtk' \*ki j v' \*UP P 08089' . 'p? :5-0'

Vj g'j' ki j guv'eq'wp'v'q'h' { gcu'v'c'p'f' 'dcevgtk' y' g't'g' 'h'q'w'p'f' 'p'v'j' g'p'g'w'g'v'g'c' nqo dwej c'c'p'f' 'E'g' { n'p'v'g'c' nqo dwej c' . 'c'ht'g' '9' f' c' { 'u'q'h'htgo gpw'v'q'p' . '9'63'0'2'0'3' 'h'i' 'E'HW'lo' n'c'p'f' '9'0'7'0'2'0'4' 'h'i' 'E'HW'lo' n't'g'ur' g'ev'k'g'n' { '\*H'k'i' '0'3'-0'V'j' g' 'h'q' guv'v'q'v'ni'eq'wp'v'q'h' { gcu'v'c'p'f' 'dcevgtk' y' g't'g' 'h'q'w'p'f' 'p'v'j' t'q'ug'j' k'r' u' nqo dwej c' . 'c'ht'g' '43' 'f' c' { 'u'q'h'htgo gpw'v'q'p' . '6'0'5'2'0'2'0'3' 'h'i' 'E'HW'lo' n'c'p'f' '5'0' ; '0'2'0'8' 'n'q' 'E'HW'lo' n't'g'ur' g'ev'k'g'n' { '\*H'k'i' '0'3'-0'V'j' g'r' t'g'r' ct'g'f' 'f' t'lp'ni' 'f' k'f' 'p'q'v'ij' q'y' 'c'p' { 'c'p'w'd'c'ev'g't'k'ni'ce'v'k'k'v' 'c'i' c'k'p'u'v'g'u'g'f' 'dcevgtk' 'd'g'h'q't'g' 'c'p'f' 'c'ht'g' '9' 'f' c' { 'u'q'h'htgo dwej c'htgo gpw'v'q'p' . 'y' j' k'g' 'c'ht'g' '36' 'f' c' { 'u' . 'o' l'p'lo' c'ni'c'p'w'd'c'ev'g't'k'ni'ce'v'k'k'v' 'y' cu'p'q'v'g'f' 'c'i' c'k'p'u'v' C' / q'v'q'd'c'ev'g't' 'x'k'p'g'r' p'f' k'w'o' V'j' g' 'l'p'j' k'k'k'p'v' | 'q'p'g' 't'c'f' k'u' 'l'p'et'g'c'ug'f' 'w'r' 'v'q' '2'0'0' / '4'0' 'o' o' 'l'p' 'c'ni'htgo gpw'v'g'f' 'f' t'lp'ni' 'c'ht'g' '43' 'f' c' { 'u'q'h' h'g'to' gpw'v'q'p'0' V'j' g' y' k'f' g'u'v' | 'q'p'g' 'q'h' 'l'p'j' k'k'k'p'v' | 'c'i' c'k'p'u'v' 'D'c'ek'm'u' 'o' q'lc'x'g'p'uk'i' 'c'p'f' 'C' / q'v'q'd'c'ev'g't' 'x'k'p'g'r' p'f' k'w'o' y' cu' 'l'p' 'O' g'ri'k'uc' 'q'ht'k'p'c'ri' 'NO' nqo dwej c'c'p'f' 'c'i' c'k'p'u'v' 'D'c'ek'm'u' 'o' g'i' c'v'g't'k'w'o' 'y' cu' 'l'p'j' g't'd'c'ni' 'o' k'z' 'nqo dwej c'0'V'j' ku' u'w'f' { 'uj' q'y' g'f' 'v'j' c'v'j' g't'd'c'ni' v'g'cu' 'c't'g' 'c' 'u'v'k'c'd'g' 'o' g'f' k'w'o' 'h'q't' 'v'j' g' 'i' t'q'y' 'v'j' 'q'h'c' 'nqo dwej c'ewmw'g' 'c'p'f' 'v'j' g'f' w'c'v'q'p' 'q'h'htgo gpw'v'q'p' 'j' cu' 'c'p' 'g'h'g'ev' 'q'p' 'c'p'w'd'c'ev'g't'k'ni'ce'v'k'k'v' { 0' "

Cempqy ngf i go gpwv' Hkpcpeln' uwr r qt'v'htqo 'T'gugctej' 'Eqwpek'ni'q'h'Nkj wcpkc' r tq'lg'v'P q02; 05/NO V/M/934/44/ 2326'ku'cempqy ngf i gf 0'

[3]\_0'0'E'q'v'q'p' . 'C'0'R'ey' q'y' un'k' 'D'0'V'co' k'p'c'w'g'v'c'ri'0' 'W'p't'x'g'k'p'i' 'o' let'q'd'k'c'ni'g'e'q'm'i' { 'q'h'k'p'f' w'ut'k'ni'uc'ng' 'M'q'o dwej c'htgo gpw'v'q'p'u'd' { 'o' g'cd'c'te'q'f' k'p'i' 'c'p'f' 'ewmw'g' / d'c'ug'f' 'o' g'y' q'f' u' . 'H'G'O' U'O' let'q'd'k'q'ni' { 'G'eq'm'i' { . '4239' . 'X'q'ri'0' ; 5 . 'K'u'07'0' }  
 [4]\_ 'H'0'f' g' 'H'k'k' r' k'u' 'C'0'F'0'V't'q'k'g' . 'R'0'X'k'ni' k'q'p'g'v'c'ri'0' 'F'ht'g't'g'p'v'o' r' g't'c'w'g'u' 'u'g'g'ev'f' k'ul'p'ev'k'g' 'c'eg'v'k'c' 'c'efk' 'd'cevgtk' 'ur' g'el'gu' 'c'p'f' 'r' t'q'o' q'v'g'u'q't'i' c'p'k'c' 'c'efk' u' r' t'q'f' v'ev'q'p' 'f' w'k'p'i' 'M'q'o dwej c'v'g'c' 'htgo gpw'v'q'p' . 'H'q'q'f' 'O' let'q'd'k'q'ni' { . '423 ; . 'X'q'ri'0'95 . 'r'0336380'  
 [5]\_ 'Q'0'P'0'T'g'x'c' . 'R'0'G'0' / c'g'u' . 'N'0'R'0'Q'x'ej' c't'g'p'ni' 'g'v'c'ri'0' 'O' g'cd'c'te'q'f' k'p'i' 'q'h'v'j' g' 'M'q'o dwej c'0' let'q'd'k'c'ni'eq'o' o' w'p'k' { 'i' t'q'y' p' 'l'p' 'f' k'ht'g'p'v'o' let'q'g'p'x't'q'p'o' g'p'u'0' 'C'0' 'D' 'G'z'r' t'g'u' . '4237' . 'X'q'ri'07' . 'K'u'0570'  
 [6]\_ 'E'0'X'c'ni' cu' 'U'0'0'F' g' 'U'q'w'c' . 'G'H'0'0'U'0' -p'k'c' 'g'v'c'ri'0' 'U'et'g'g'p'k'p'i' 'o' g'y' q'f' u' 'q'f' g'v'g'to' k'p'g' 'c'p'w'd'c'ev'g't'k'ni'ce'v'k'k'v' { 'q'h'p'ew'c'ni'r' t'q'f' w'ev'u' . 'D't'c' k'k'p' 'l'q'w'p'c'ni'q'h' 'O' let'q'd'k'q'ni' { . '4229' . 'K'u'05' . 'r'058 ; 5 : 20'

# SCREENING OF PURIFICATION METHODS FOR ANTIMICROBIAL PEPTIDE FROM *PEDIOCOCCUS ACIDILACTICI* JEM-1

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Nowadays, a healthy lifestyle is rapidly gaining popularity around the world. People promote not only an active leisure, sports, but also tend to pay more attention to a healthy nutrition. Customers want to consume food without chemical preservatives. Lactic acid bacteria which secrete bacteriocins are extensively studied since bacteriocins such as pediocins could replace chemical preservatives. Bacteriocins as bioconservants could be used to prolong the shelf life of foods and prevent the growth of microorganisms. Moreover, bacteriocins could be also an appealing alternative to antibiotics [1]. The use of those antimicrobial peptides is still limited due to the challenging procedures of purification and low yields [2].

Previously, we purified pediocin from *Pediococcus acidilactici* JEM-1 based on the adsorption method of pediocin on the cells and the following desorption. The yield of purification was low. About 1.6 µg of partially purified pediocin was obtained from 250 mL of *Pediococcus acidilactici* JEM-1 cultivation medium. The molecular mass of peptide was about 4.4 kDa as judged by Tricine-SDS polyacrylamide gel-electrophoresis. The chosen purification step is not effective and does not meet the expectations. To obtain higher yield of pediocin, the experiments are continued for choosing one-step purification method using ion-exchange chromatography.

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[1] M. Papagianni, S. Anastasiadou, Pediocins: The bacteriocins of *Pediococci*. Sources, production, properties and application, *Microbial Cell Factories*, **8** (3), 1-16 (2009).

[2] J. M. Rodríguez, M. I. Martínez, J. Kok, Pediocin PA-1, a wide-spectrum bacteriocin from lactic acid bacteria, *Critical Reviews in Food Science and Nutrition*, **42** (2), 91-121 (2002).



# KUQNCVQP 'CPF 'UETGGPKPI 'QHFK\ QVTQRJ KE'O KETQQTI CPKUO U' Y J KEJ 'CTG'UK PKHECPV'HQT'UWUVCKP CDNG'CI TREWNVWTG''

Lwukpc'Mc| k plgp <sup>13</sup>. Tcko qpf c'O cfl{ n| v <sup>14</sup>. 'Cwf tkw'I gi genou<sup>15</sup>"

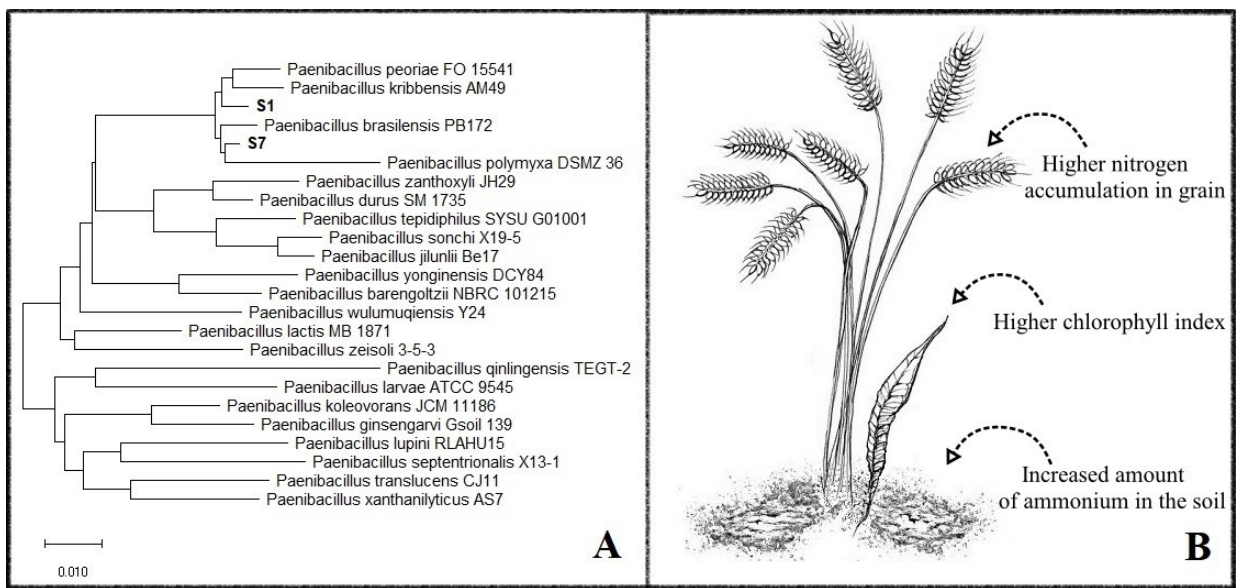
<sup>3</sup>"Kpukwng'qh'Dkqrqi { 'cpf 'Rrppv'Dkqvej pqrqi { .X{ wewu'O ci pwa'Wpksgtuks{ .Nkj wcpkc"

<sup>4</sup>"F gr ctvo gpv'qh'O letqdkqrqi { 'cpf 'Dkqvej pqrqi { .Xkpkwu'Wpksgtuks{ .Nkj wcpkc"

Lwukpc(ho grB i o ckrfgo "

O letqdkr'dkquwo wrpw'eqpvcplpi 'pktqi gp'hzkpi 'o letqtti cpkuo u'ctg'r gtur gevxg'r tqf wew'y j lej 'j gr u'v'q'tgf weg" co qwpw'qh'o kpgtcn'pktqi gp'htvkk' gt'qp'ci tlewnwt'g'cpf 'y' g'pgi cwxg'ko r cev'qp'y' g'gpxkqpo gpv'cp'j' wo cp'ecwugf 'd{ 'y' g' o kwug'qh'ej go kecn'htvkk' gtu"j3\_j4\_0'k'ku'j' w' g'ko r qt'wpeg'vq"ugrgev'tki j v'o letqtti cpkuo u'ht'q'o letqdkr'dkquwo wrpw' r tqf wevkpp.'o letqtti cpkuo u'p'ggf 'vq'j' cxg'r quksxg'ghgev'qp'r' rpw'cpf 'uj' qwf' gcu{ 'dg'cr r n' kpi 'qp'cp'kp' wutken'uecrg'j5\_0'

Cmi'y' k'wggp"kuqrcv'u'y' g'g' uetggpgf "d{ "wukpi "f' hhtgpv'pktqi gp'ht'gg"o gf'kc'0'Rj { nqi gpgvle"cpn'uku'qh'38"tTPC" ugs wpegu'uj' qy' gf' 'y' cv'kuqrcv'u'dgrpi 'hqt' h'x'g'f' hhtgpv'i gpwu'Deckmu'ur r 0'Rc'gpkd'eckmu'ur r 0'Gpukgt'ur r 0'Tj'k'qdkwo" ur r 0'cpf "Ngntkwk'ur r 0'Vj' g'o quv'kp'wpxg'i' tqy' y' 'qp'pktqi gp'ht'gg"o gf'kc'y' g'g'uj' qy' gf' 'y' q'kuqrcv'u'U3"cpf "U9"y' j' lej" dqyj' 'ctg'o go dgtu'qh'Rc'gpkd'eckmu'ur r 0'Hk' 03C-0'



Hk' 03C'kuqrcv'u'r' j { nqi gpgvle'tgg'cpf 'y' g'kt'ghgev'qp'ur' tkpi 'y' j' gc'vf' g'xgnr' o' gp'0C'0'Vj' g'r' j { nqi gpgvle'tgr'vk'p'uj' k' u' qh'Rc'gpkd'eckmu'ur' U3"cpf "Rc'gpkd'eckmu'ur' U9"y' kj' kp' 'y' g'i' gpwu'qh'Rc'gpkd'eckmu'ur' r 0'k'px'guxi' cvgf' "wukpi "38UtTPC"

i' gpg'ugs' wpeg'cpn'uku'0D0'ur' tkpi 'y' j' gc'vf' g'xgnr' o' gp'v'chgt' 'Rc'gpkd'eckmu'ur' U9"cr' r' r'ec'v'k'p'0'

Vj' g'ko' r' cev'qh'Rc'gpkd'eckmu'ur' U3"cpf "Rc'gpkd'eckmu'ur' U9"kuqrcv'u'qp' 'y' g'f' g'xgnr' o' gpv'cpf' "i' tqy' y' 'qh'ur' tkpi" 'y' j' gc'v' y' cu'cpn' | gf' O'kuqrcv' "Rc'gpkd'eckmu'ur' U9"y' cu' h'qwpf' 'vq'uki' p'k'hec'p'v' "k'pet'gcug' 'y' g'co' qwpv'qh'co' o' q'pkwo' "kp' 'y' g'u'q'n' h'wt'j' gto' q'tg' .r' quksxg'ghgev'qp'ej' n'qt'qr' j { ml'kf' g'z'cpf' 'pktqi' gp'ceewo' wr'v'k'p'kp' i' t'cl'p'y' g'tg'f' g'v'to' k'pgf' "Hk' 03D-0' Vj' g'o' quv'uv'k'cd'rg'pktqi' gp'cpf' 'ect'd'qp' u'q'w'tegu'y' g'tg' h'qwpf' gf' h'qt' d'k'qo' cuu'r' tqf' wevk'qp'qh'Rc'gpkd'eckmu'ur' U9'0'

Ugg' { qw'lp' 'Xk'p'kwu' #"

[3]\_ C0Dgpgf' w' k'C0C' o' dt'qu'pk' 'cpf' 'N0O' 0'R0'R'cu'ci' r'ic' .0'R'p'v'1' tqy' vj' /r' tqo' q'v'pi' 'tj' k' q'd'cev'tlc' "RI' RT' <'Vj' g'kt' r' q'v'p'v'c'i'cu'c'p'v'ci' q'p'ku'v'cpf' " d'k'q'ep'v'q'n'ci' gp'w'0' 'I' g'p'g'v'eu'c'p'f' 'O' q'g'ew'v' 'D'k'q'r'i' { 0'4234 . 'Y' q'k'c'32087 ; 2' I'U'3'637 / 697942342228222420'

[4]\_ \ 0'C0'U'f' f' l's' w'k' 0'R' RT' <'R't'qr' g'ev'xg' d'k'q'ep'v'q'n'ci' gp'w'qh'r' r'cp'v'r' c'v' q'i' gp'u'0' 'k'p' "RI' RT' <'D'k'q'ep'v'q'n'ci' 'D'k'q'ht'v'k'k' c'v'k'p' . "42280'

[5]\_ U0'U'cx'ek' 0'h'p'x'g'uxi' c'v'k'p'qh'G'hh'gev'qh'E'j' go' k'ecn'ht'v'k'k' gtu'0'p'p'k'x'q'po' gp'v'0' 'C'RE'D'G'G' 'R't' q'ef' k' . "4234 . 'Y' q'k'c'3208238' I' l'0' r' ed'gg'0'23402502690'

# RTQF WEVKQP 'QHTGE QO DHP CPV'O QWUG'ECTDQP KE 'CPJ [ F T CUG'ZKX'' RTQVGP''

Vcwx { f cu' Mq lku. 'C wt grlc' O lengxk k v . 'Nkpc' Dctcpcwunkgp 0

F gr ctvo gpv'qh'Dkqj gto qf { pco leu'cpf 'F twi 'F guki p. 'kpukwg'qh'Dkqvej pqmji { . 'Nhg' Uelgpegu' Egpvt. 'Xkpkwu' Wpkxgtukv' .  
Xkpkwu. 'Nksj wpcle"

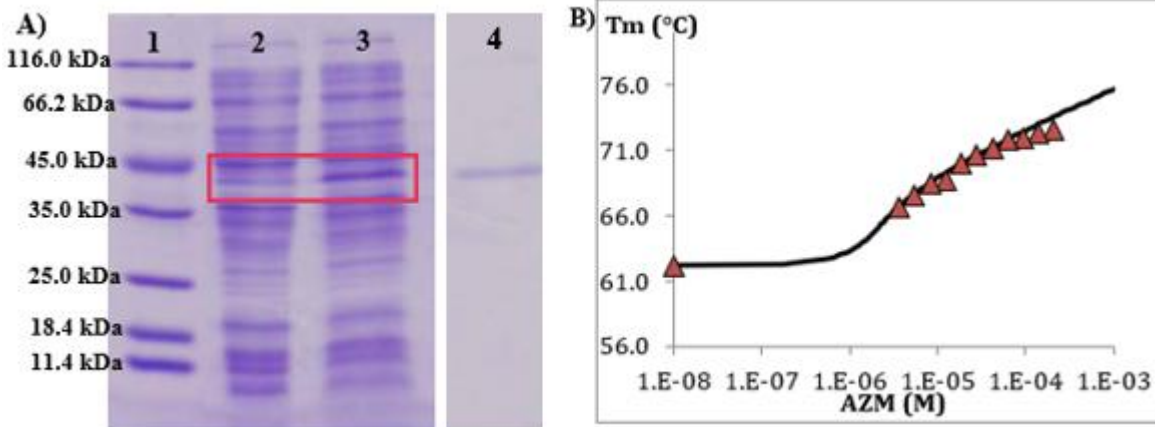
vcwx { f cu' Mq lku B ej i hnwf 0 w0w'

Ectdqpke'cpj { ftcugu' \*EC+'ctg'gp| { o gu' yj cv'ecvni' ug'tgxgtukdng'j { ftcvqp'qh'ectdqp'f kqz kf g' \*EQ4- " J 4Q" = "J EQ5"- " J +0'ECu'ctg"o gvcnr' tqvklpu"o"o quv'qh' yj go "eqpckp" | lpe"lp" yj gk'cevkg'egpvtg'O wnk' ng"EC"kuqgp| { o gu'ctg'y kf gn' " gzt'guugf "lp" f'khtgtpv'o co o crikp'vkuwgu. "cu' yj g { "r ctvkr cvg'lp"r J "tgi wvklp. 'EQ4+cpf "J EQ5"/wcpur qtv. "i mepqgqi gpguku" rkr qi gpguku. "cpf" qy' gtr' tqeguugu' ]3\_0' F khtgtpv' EC"kuq| { o gu'ctg' tgeqi pk' gf "cu' ftwi "vcti gw' hqt" o cpci go gpv'qh' hmkf" ugetgkqp"cpf "r J "ej cpi g' rpnf' f' kugcugu'O qwug'ectdqpke'cpj { ftcug'ZKX' \*Ect'ZKX+'ku'qt yj qmji qwu'vq' j wo cp'EC'ZKX' r tqvklp. "cpf" ku'o quw' "gzt'guugf "lp" dtclp. "j gctv. "cpf" nk' pg { "vkuwgu" ]4\_0"

Vj g'clo "qh' yj ku'uwf { "ku'vq" r tqf weg' hwpvklp'cm' "cevkg" tgego dlpcpv' Ect'ZKX' r tqvklp' Y g' eqpvt wegf "tgego dlpcpv' r ruo kf "wukpi "xgevq" r GV/37d' Vj ku' xgevq" lptqf wegu' P /vgo lpcn' J ku' vci "vq" vcti gv' r tqvklp' vq" o cng' r wtkhlevklp' qh' yj g' r tqvklp' o qtg' ghgevg" d { "wukpi "ko o qdkk' gf "o gvcn' chhpkv' "ej tqo cvqi tcr j { 0' Vq' eqphko " yj g' F P C" ugs wgep' qh' lpuvtv" r ruo kf "y cu' ugs wgep' 0"

Chgt'ectghw'ugrevklp' qh' r tqvklp' gzt'guukqp' eqpf kkp'pu. "y g' qdvcpgf "qr vko cni' gzt'guukqp' qh' Ect'ZKX' lp' Guej g' tkej ke 'eqrk' Qtki co k'D' \*F G5+'utclp' ewnwgf "lp' ND" o gf kwo "cv'59' AE" wvkl' QF 822? 2.7/2.8" cpf "yj gp' lpf wegf "y kj "2.7" o O "KRVI" cpf "2.7" o O " \ pEncpf lpewdcvgf " cv' 38' AE" qxgtpl' j 0' Y g' wugf " y q/uvr " chhpkv' " ej tqo cvqi tcr j { " hqt" Ect'ZKX' r wtkhlevklp' < ko o qdkk' gf "o gvcn' chhpkv' " ej tqo cvqi tcr j { " hqmjy gf " d { " r wtkhlevklp' wukpi " r/co lqqo gj { rdgp| gpguw' hqpc' ko kf g' ci ctqug' 0' Gzt'guukqp' cpf "r wtkv' "qh' Ect'ZKX' r tqvklp' j cu' dggp' eqphko gf "wukpi "UF U/RCI G' hki 03' C+0"

Rtqvklp' hwpvklp' cni' cevkg' "y cu' eqphko gf "ceeqf lpi "vq' ku' dlpf lpi "vq' EC/ur gekhe" uo cni' o qrgewg' eqo r qwpf u. "dgctkpi " wpuwdukw' wgf "uw' hqpc' ko kf g' i tqw. "wukpi "hwqt' guegpv' yj gto cni' j kv' cuuc { \*HVUC+0' Wphqf lpi "qh' tgego dlpcpv' Ect'ZKX' r tqvklp' gzt' kdkgf "ulpi ng' wcpukqp' ewt' xgu. "v' r kecn' hqt" ulpi ng' f' qo clp' i rdwrt' r tqvklp' u' Dlpf lpi "qh' uo cni' o qrgewg' rki cpf u' y cu' eqphko gf " d { " lpetgcugf "o gmkpi "vgo r gtcwtg' qh' r tqvklp' rki cpf "eqo r rnz" lp' c" eqpegv' tcvklp' /f gr gpf gpv' o cpgp' \*hki 0' 3D+0"



**Hki wt g'30 Ect'ZKX' gzt'guukqp. 'r wt kv' . 'cpf 'hwpvklp' cni' cevkg' 0'C+UF U/RCI G' qh' Ect'ZKX' r tqvklp' gzt'guukqp' cpf 'r wtkv' < rpg' 3" o" O Y " o ctngtu. "4" o" dcevgtlen' n' ucvg' dghqtg' lpf wevklp. "5" o" dcevgtlen' n' ucvg' chgt' lpf wevklp=6" o" r wtkhgf "Ect'ZKX' \*D+HVUC" tguwru' qh' Ect'ZKX' dlpf lpi "vq' cegcv' qm' ko kf g' o" u { o dqn' eqttgur qpf "vq' gzt' gto gpcn' f' cv. "cpf "hpg' r' tguwru' hwpvklp' wukpi M' r' gto lpcvklp' o qf gr ]5\_0"**

[3\_ "Y j kwpki vqu. 'F 0C0' g' lcn' Gzt'guukqp. "Cuuc { . "cpf "Utwewt' qh' yj g' Gz' tcegmwrt' F qo clp' qh' O wtkp' Ectdqpke' Cpj { ftcug' ZKX' < ko r rlevklp' u' hqt' ugrgevg' kpi kdkkqp' qh' o go dtepg' cuuqelcvgf "kuq| { o gu' 04225. 'I0Dkq0Ej go 0'49; \* : 40  
[4\_ 'P EDK' gpe' f' cvdcug' o' Ugetej 'tguwru' w' u' l' y y (pedk' p' m' p' k' 0 qx' i' gpg' 45: 53"  
[5\_ 'Elo o r gto cp. "R0" g' lcn' "C" S wpcvkg' O qf gr ]qh' Vj gto cni' Ucdk' k' v' klp' cpf "F gucdk' k' v' klp' qh' Rtqvklp' u' d { "Nki cpf u' 0422: . "Dlqr j { ulecn' lqwt' pcn"; 7\*9+ " 544465453"

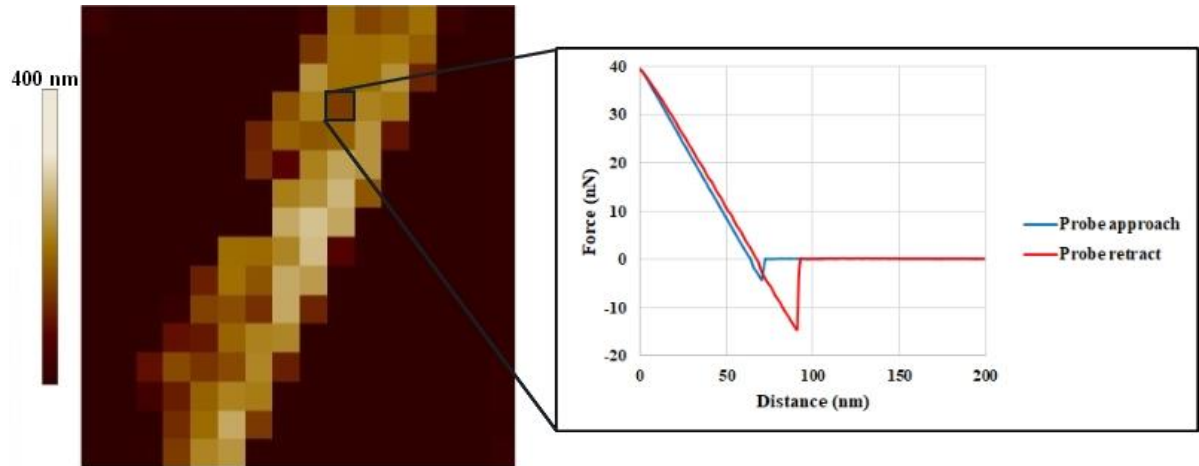
# CP VKO KETQDKCN'GHHGE V'QHI GQDCEKNNK'48'DI 'CVQO KE'HQTEG' O KETQUEQR "

O cpv 'Tcncwunckv<sup>3,4</sup>. 'Ctpqrf cu'Mcwpkgyku<sup>3</sup>. 'O ctkc'Lcpmwpge<sup>4</sup>

<sup>3</sup>Kpukwag'qh'Dkquekgpegu.'Nkg'Uelgpegu'Egpgvt.'Xkpkwu'Wpkxgtukv{.'Xkpkwu.'Nkj wcpkc"  
<sup>4</sup>Kpukwag'qh'Dkqej go kut{.'Nkg'Uelgpegu'Egpgvt.'Xkpkwu'Wpkxgtukv{.'Xkpkwu.'Nkj wcpkc"  
.o.cpv@tncwunckvB i o e@wfkw@h'

Kp' yj g' y qtrf y kf g' hki j v' ci ckpuv' dcevgtkn' tgukucpeg. " yj gtg' ku' c" pggf " hqt' c" pqxgn' hco kn' " qh' cpvko letqdkn' f twi u0' Cpvko letqdkn'r gr vkf gu" \*CO Ru+ctg'r tqo kulpi "ecpf kf cvgu'v' tgr mæg"cpvdkqveu'Ukm" yj g' o clqtkv' qh' yj go " j cxg'cp" wpergt" o gej cpluo " qh'cevqpp'CVqo le" hqteg" o letqueqr { " \*CHO + " ku' c" uwt hæg/ugpukxg" vgej plx wg" cpf " cko u'vq" uwf { " yj g' r j { ulecn' r tqr gt vku'qh' hxlpi " dlqmi lecn' egm' wpf gt' r j { ukqmi lecn' tgrxcpv' eqpf klqpu' y kj qw' yj g' f gult wvqpp' qh' yj g' uco r r g0J qy gxgt. " yj g' uwf lgu' kpxqkxpi " rkg' dcevgtk' rko ku' yj g' pgeguks' vq' cwcej " c' ur geko gp' vq' yj g' uwdut cvg' 0Vj gtghqtg. " yj g' gzkuvpi " r tqvqen' pggf u'vq' dg' cf cr vgf 0J gtg' y g' r tguv' c' r tqvqen' v' ko o qdkk' g' I tco / r quksxg' dcevgtkn' egm' o go dtcpgu0

Vj ku' uwf { ' hewegu' qp' yj g' cpvko letqdkn' g' hge' v' qh' j gcv' r dkg' I gqdcenkp' 48' r gr vkf g' ci ckpuv' I tco / r quksxg' dcevgtk' 0Vj g' dcevgtk' ctg' cwcej gf " vq' yj g' uwdut cvg' xlc' etquurkpnki " y kj " i nwctrf gj { f g' 0Vko g' tguqmgf " CHO " ko ci gu' t g' xg' cngf " pq' ej cpi gu' kp' yj g' vq' qi tcr j { " qh' yj g' chgevgf " egm' y cni' 0Vj ku' t guw' ku' kp' rkpj' y kj " tgegp' uwf lgu. " I gqdcenkp' 48' y cu' pco gf " cu' pqv' c' egm' y cni' f gi tcf lpi " gp' { o g' } 3\_0J qy gxgt. " yj g' f k' hgt gpegu' kp' egm' xqno g' qh' chgevgf " dcevgtk' h' tqo " c' eqptqn' i tqwr " uj qy gf " yj g' r genci g' qh' kpkf g' h' wkf u' 0Vj cv' kpf kecvgu' yj g' nqu' qh' o go dtcpg' kp' i tki' 0Dw' yj g' o qf g' qh' cevqpp' qh' I gqdcenkp' 48' tgo ckp' u' wpergt 0Hqt' yj ku' r wtr qug. " dg' hqt g' cpf " chgt' yj g' ko r cevq' h' I gqdcenkp' 48. " dcevgtk' yj g' g' x' cncv' gf " d { " hqteg' ur gev' queqr { " Hki 0-0 Vj g' vgej plx wg' y j gt g' uwdv' g' ej cpi gu' kp' egm' y cni' gruv' ekv' { ctg' f g' vgevgf 0



**Hi 03.** 'Hqteg' ur gev' queqr { 'cpnc' uku' qh' dcevgtk' " eqptqn' i tqwr 0

"j3\_ Xck knwunckv " 0 0' I gt " 0 0' Xerkwu' 0 0' O cpvknku' C 0' Ncucwunckp " G0' Men f lgp " N0' Mcwpkgyku' C 0' I gqdcenkp' 48' 6' j i j " o qrgewrt' y gli j v' dcevgtk' qekp' hqo " c' yj gto qr j klc' dcevgtkwo 0' k' vgt' pcv' qpcn' Lqwt' pcn' qh' Dkqmi lecn' O cetqo qrgewru' 423; \*363+<555/5660

**IN SILICO'CPCNĲ UKU'QHEWKP CUG'HT'QO 'STREPTOMYCES SCABIEI'  
: 9044''**

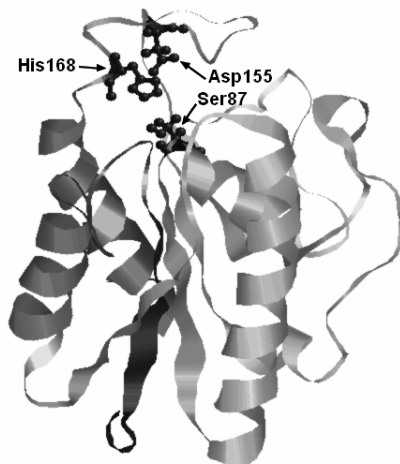
**Ci p "Ucxlenckv"<sup>3</sup>. "Tgpcv" I wf kwnckv<sup>3</sup>"**

<sup>3</sup>"Kpukwng'qh'Dkquelgegu. "Nktg'Uelgegu'Egpgvt. "Xlpxku'Wpksxtukf. "Ucwn vgnku'cxg09. 'NV/32479'Xlpxku. 'Nkj wpcpk"  
ci pgUcxlenckvB i o eUwfwUvUw"

Ewłpcugu'ctg'j { f tqn' vĕ'gp| { o gu'vj cv'ecvnl| g'j } { f tqn' uku' u{ p'j guku. "qt' t'cpugvgt'khecvkpp' t'gcevqpu'qh'gugt' d'qpf u" y j lej "o cngu"vj go "cvtcevkxg"vq"vj g"lpf wutkcn'ugevqt"}3\_0'Qpg'qh'vj g"o quv'r tqo kulpi "cr r rkecvkppu'qh'uwej "gp| { o gu'ku" f gi tcf cvkpp'qh'r qn' o gtu' \*r' rnkueu+. "uwej "cu"REN" \*r qn' ecr tqncevqpgu" cpf "RGV" \*r qn' g'j { rpgg' vgt gr j vj cncv:0' Vj gug' r qn' o gtu'ctg'y kf gnl "wugf 'lp'xctkqwu'lpf wutkcn'ugevqtu" \*r j cto cegwkecu. "hqqf "lpf wut { . "ci tlewnwtg+"4\_0'Vj wu. "tge { enki " cpf. "o quv'ko r qt vcpvnl. "vj g'tgwug'qh'r rnkue'y cuv'g'ku'c'ugtkqwu'i rjdcnr' tqdrgo 0P gxgt'vj g'g'uu. "vj g'co qwpv'qh't'gugctej "t'grcvf" vq"vj g"cpcl'uku'qh'vj g"ut wewt g/hwpevkpp"t'grcvkppuj kr "qh'o' letqdken'ewłpcugu'cpf "vj g'r' g'ur gevkxu'qh'vj g'kt' r rkecvkpp"ku" rko ksf 0'Vj gtg'ctg'qpn' "c'hgy "r wdrkecvkppu'cdqww'vj g'kuqrvkpp. "r wtkhecvkpp"cpf "ej ctcevgtk' cvkpp'qh'vj gug'gp| { o gu'j5\_0'k'p' npqy p'i g'pgo gu. "qr gp/tgcf lpi "t'co gu'vj cv'gpeqf g'ewłpcugu'ctg'f k'hevw'vq'kf gpvkh{. "y j lej "o cngu"vj g'cpcl'uku'qh'vj gug' gp| { o gu'gxgp"o qtg'eqo r rkecvf 0'O qtgqxtg. "ewłpcugu"vj go ugr'ku'ctg'qh'g'p'ercu'k'k'g'f "cu"r'rcu'gu. "gugtcugu. "qt"qj gt" j { f tqn' vĕ'gp| { o gu'0'Vj wu. "vj gtg'ku'c'rcem'qh'hwf co gpvcn'hpqy rgi g'cdqww'vj gug'dcevgtkcn'gp| { o gu'0"

F wtkpi "gctnkt"uwf lgu. "c"u{ p'j g'vĕ "Ut gr vqo { egu'uecdkgl": 9044"ewłpcug'y cu'etgcvf 0'Uqo g'cwj qtu'f guetkdg"vj ku" gp| { o g'cu'uwtdgt'kpcug'j6\_ "qj gtu'o"cu'ewłpcug'j7\_ "y j gtgcu'lp'Wp'kRtqv'f cvcdug'k'ku'ecmgf "ugetgvf "gugtcug0'Ukpeg'vj g" r tko ct { "gp| { o g'w'pf gt'vj g'uwf { "y cu'c'ewłpcug'y kj "cp'P /vto kpcn'uki pcn'ugs wpeg. "k'ku'ko r qt vcpv'vq'gxcnvcv'ku'gh'gev' qp"gp| { o g' { k'gn' "cpf "cevkxk'0'k'p'vj g'ecug'qh'nr qn' vĕ'gp| { o gu'vj g'P /vto kpcn'uki pcn'ugs wpeg'j cu'dggp'uj qy p'p'qv'qpn' " vq'rgcf "vq'f k'ht'g'p'eg'p'k'p'r tqv'k'p' { k'grf "dw'cnuq'lp'r tqv'k'p'j8\_0'k'p'vj ku'uwf { . "k'p'uk'k'eq"cpcl'uku'qh'Uuecdkgl": 9044"ewłpcug' y cu'r gthqto gf 0'Hktu'v'qh'cm" P /vto kpcn'uki pcn'ugs wpeg'y cu'r tgf k'evf "wulpi "Uki pcn'R/70'Ugtxgt0'Vj gp"vj g'ut wewt g'qh' ewłpcug'y kj qw'uki pcn'ugs wpeg" \*Hki 03+"cpf "hki cpf "dkpf lpi "ukgu'y gtg'r tgf k'evf "y kj "KVC UUGT 0'Dcugf "qp"KVC UUGT" cpcl'uku't'guw'uw'cpf "qj gt'uwf lgu'j7\_ "ecvnl vĕ'co k'p'q'cekf u'y gtg'cnuq'kf gpvkh'g'f 0O qtgqxtg. "Uuecdkgl": 9044"ewłpcug'i g'p'g" y cu'crki p'gf "wulpi "P wengq'kf g'Drcuv'ugs wpegu'y kj "vj g'b quv'ko k'ctk'v' y gtg'ej qugp'cpf 'eqpugt'xgf 'tgi k'p'u'y gtg'cpcl' | gf 0'

Vj g't'guw'uw'q'd'v'k'p'gf "f wtkpi "vj ku'uwf { "y q'w'f "w'pf q'w'v'g'f n' "eqp'v'k'w'g'v'q' h'k'k'p'i "vj g'rcem'qh'hwf co gpvcn'k'p'ht'o cvkpp" cdqww'dcevgtkcn'ewłpcugu'0'Vj gtg'htg. "lp'vj g'hw'wt g'k'y q'w'f "dg'w'gh'w'v'q' 'cr r n' "o wci g'p'g'uku'ut'cvgi k'gu'ht' 'eqpugt'xgf 'ewłpcug' tgi k'p'u'cpf "vj ku'y c { "r tqxk'f g'o qtg'k'puki j v'q'vj g'ut wewt g/hwpevkpp' t'grcvkppuj kr 0'



**Hki 030'Ut wewt g'qh'Uuecdkgl": 9044"ewłpcug'y kj qw'P /vto kpcn'uki pcn'ugs wpeg0'Ecvnl vĕ'co k'p'q'cekf u'ctg'o' ctngf " lp'd'ren0'**

**Cempqy r'gf i o gpv'0' Vj ku' t'gugctej " y cu' hw'pf gf " d { " vj g' Gwtqr gcp" Uqeken' Hw'pf " w'pf gt" vj g' P q" 2; 05/NO V/M'934" 0'F gxgnr o gpv'qh'E'qo r g'v'pegu'qh'Uelgp'v'kuu. "qj gt" T'gugctej gtu'cpf "Uw'f gp'u'vj tqwi j "Rtcev'ecn'T'gugctej "Cev'k'k'gu'0" o gcuw'g. "I t'cpv'P q02; 05/NO V/M'934/44/22960"**

[3\_ "MDCn'Vco o ct. "Q0'Qo ct. "C0'0'0'cd'f w'f'0' w'cf "g'v'cn'0'Gzr t'gu'k'p'cpf "ej ctcevgtk' cvkpp'qh'c'ewłpcug" \*CpE'WV4+'t'qo "Cur'gti k'mu'p'ki gt. "Qr gp'Nktg' Uelgegu'33.4; /5: \*4238+  
[4\_ "C0'Depgt'lgg. "MDEj cvgt'lgg. "I 0'0'cf t'cu'Gp| { o cvĕ'f gi tcf cvkpp'qh'r qn' o gtu'c' "d'ht'g'x'k'g'y. "O cvgt'kcu'Uelgpeg'cpf "Vgej p'qmi { "52.7896795" \*4236+  
[5\_ "U0'Ej gp. "Z'0'Vqpi. "T'0'Y 0'Y q'q'f c'tf "g'v'cn'0'k'gp'w'kecvkpp'cpf "ej ctcevgtk' cvkpp'qh'dcevgtkcn'ewłpcug. "Vj g'Uq'w'pcn'qh'D'k'q'ni k'ecn'Ej go k'ut { "4: 5." 47: 76647: 84" \*422: +  
[6\_ "F 0'M'qo g'ka" C'0'0'U'ko cq/Dgcw'q'k't. "E'0'Dgcw'k'g'w'F g'v'cvkpp'qh'r' q'v'p'v'cn'uw'dgt'k'p'cug/ g'p'eqf lpi "i g'p'gu'lp' "Ut gr vqo { egu'uecdkgl'ut'k'p'u'cpf "qj gt" cev'k'p'q'cd'cevgtk'. "E'c'p'f k'p' "I'q'w'p'cn'qh'0' letqdk'q'ni { "7; .4; 66525" \*4235+  
[7\_ "T'0'L'cd'q'w'p'g. "O 0'M'j c'rn' "D'0'0' q'w'w'c'g'v'cn'0'Gp| { o cvĕ'f gi tcf cvkpp'qh'r' /p'k't'q'r j gp| { n'g'v'g'u'tu. "r qn' g'j { rpgg' vgt gr j vj cncv. "ewłp. "cpf "uw'dgt'k'p' d { "Uwd3. "c" uw'dgt'k'p'cug' g'p'eqf gf "d { "vj g'r' r'p'v'r' cvj qj gp' "Ut gr vqo { egu'uecdkglu. "O letqdk'g'u'cpf "G'p'k'q'p'o g'p'u'57" \*4242+  
[8\_ "T'0'I wf kwnckv. "C'0'I gi g'enuu. "F 0'M'c' r'w'w'ncu'g'v'cn'0'k'p'hw'p'eg'qh'P /'cpf k'q't' "E' /vto kpcn'it gi k'p'u'q'p'cev'k'k'f. "g'zr t'gu'k'p'. "ej ctcevgtk'ku'v'cpf "ut wewt g' qh'nr cug'ht'qo "I g'q'd'c'ek'mu'ur 0; 7. "Gz'v'to q'r j k'gu'3: . "3536367" \*4236+ "

VJ G'CPVKQZKF CPV'CEVKKV[ 'QHPKUR/NQCF GF 'RGEVVP/  
 EJ KVQQNK QUCEEJ CTKF GURCTVÆNGU"

Lqrkx'Rcej cpxc<sup>3</sup>. 'Twe'I twunkpg<sup>3</sup>. 'Cmo c'Dqemwkgpg<sup>4</sup>. 'Lqmpvc'Ugtgkmc<sup>3</sup>, ""

<sup>3</sup>F gr ctwo gpv'qh'Ej go kut { 'cpf 'Dkqgpi lpggtkpi . 'Xkpkwu'I gf ko lpcu'Vgej pkeci'Wpkxgtuks{ . 'Xkpkwu. 'Nkj wcpkc'"

<sup>4</sup>F gr ctwo gpv'qh'Rqn o gt'Ej go kut { . 'Xkpkwu'Wpkxgtuks{ . 'Xkpkwu. 'Nkj wcpkc'"

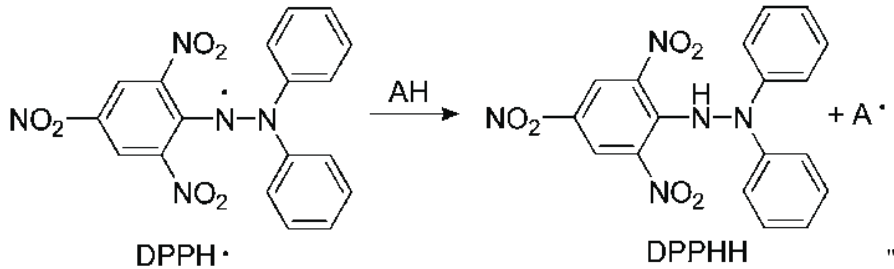
lqrkx'Rcej cpxcB uwf Oxi w0n"

Vqf c{ 'hqqf 'uwr n r{ 'cpf 'f go cpf 'ctg' i tqy lpi . 'cpf 'v' j g' r' t' g' u' g' t' x' c' v' k' p' 'v' c' n' g' u' 'c' p' 'k' o' r' q' t' v' p' v' r' r' e' g' e' l' p' 'v' j' g' 'h' q' q' f' 'k' p' f' w' u' t' { '0' U{ p' v' j' g' v' e' 'c' p' v' k' d' c' e' v' t' k' e' n' i' h' q' q' f' 'c' f' f' k' k' x' g' u' j' c' x' g' 'c' p' 'k' o' r' c' e' v' 'q' p' 'v' j' g' 's' w' e' r' k' s' { 'c' p' f' 'e' q' o' o' g' t' e' k' n' i' c' r' r' g' t' c' p' e' g' 'q' h' 'v' j' g' 'h' q' q' f' 'r' t' q' f' w' e' u' 0' O' c' p' { 'g' h' i' q' u' j' c' x' g' 'd' g' g' p' 'h' e' w' u' g' 'q' p' 'p' c' w' t' c' i' h' q' q' f' 'r' t' g' u' g' t' x' c' v' k' x' g' u' 'c' p' f' 'v' j' g' k' 'w' u' g' 'l' p' 'v' j' g' 'h' q' q' f' 'k' p' f' w' u' t' { '0' P' k' u' l' p' 'k' u' 'q' p' g' 'q' h' 'v' j' g' 'o' q' u' v' n' p' q' y' p' 'p' c' w' t' c' i' h' q' q' f' 'r' t' g' u' g' t' x' c' v' k' x' g' u' 'w' u' g' f' 'h' q' t' 'f' c' k' { 'r' t' q' f' w' e' u' . 'i' g' p' g' t' c' m' f' 't' g' e' q' i' p' k' g' f' 'c' u' 'u' c' h' e' g' 'i' T' C' U' : 'c' p' f' 'j' c' u' 'c' 'p' w' o' d' g' t' 'G' 4' 5' 6' 0' P' k' u' l' p' 'k' u' 'c' 'u' o' c' m' i' 5' 7' 3' 2' 'F' c' 'r' g' r' v' k' f' g' 'r' t' q' f' w' e' g' f' 'd' { 'N' e' w' e' q' e' e' u' w' 'r' e' v' u' } '3\_0'"

Vj g'cpvko letqdkci'cevxkx{ 'qh'dcevtkqelp"ecp" f getcgug" f wg" vq" r tqvgn{ v"e" f gi tcf cvkqp"qt" v' j' g' l' p' v' g' t' c' v' k' p' y' k' j' "h' q' q' f' " e' q' o' r' q' p' g' p' v' u' 0' P' k' u' l' p' 'c' r' r' i' e' c' v' k' p' 'h' q' t' 'h' q' q' f' 'r' t' g' u' g' t' x' c' v' k' p' 'd' g' e' q' o' g' u' 't' k' o' k' g' f' 0' P' k' u' l' p' 'g' p' e' c' r' u' w' e' v' k' p' 'l' p' v' q' 'x' c' t' k' q' u' 'd' l' q' r' q' n' f' o' g' t' u' 'e' c' p' " r' t' q' v' e' v' 'v' j' g' 'd' c' e' v' t' k' q' e' l' p' " h' t' q' o' " g' z' v' g' t' p' c' i' n' l' p' v' g' t' c' v' k' p' u' 'c' p' f' " r' t' q' x' l' f' g' " c' f' f' k' k' q' p' c' i' n' h' g' c' w' t' g' u' 0' C' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'k' u' 'c' 'x' c' n' e' c' d' r' g' " r' t' q' r' g' t' v' { 'q' h' i' h' q' q' f' 'c' f' f' k' k' x' g' u' 0' Z' k' f' c' v' k' p' 'l' p' 'h' q' q' f' u' o' q' f' h' k' g' u' r' t' q' v' g' k' p' u' . 'h' i' k' f' u' . 'c' p' f' 'e' c' t' d' q' j' { 'f' t' e' v' g' u' 0' H' i' g' g' 't' c' f' l' e' c' n' u' . 't' g' e' v' k' x' g' 'q' z' { 'i' g' p' " u' r' g' e' k' u' \*T' Q' U' + 'j' c' t' o' 'e' g' m' w' r' t' 'u' f' u' g' o' u' 'c' p' f' 'e' c' w' u' g' 'f' k' u' c' u' g' u' 0' C' p' v' k' z' k' f' c' p' u' r' t' g' x' g' p' v' k' p' i' 'c' u' v' g' 'e' j' c' p' i' g' u' 'q' h' 'h' q' q' f' 'f' w' g' 'v' q' 'q' z' k' f' c' v' k' p' . " n' g' p' i' v' j' g' p' " v' j' g' " u' j' g' r' h' i' k' h' g' " q' h' 'r' t' q' f' w' e' u' " c' p' f' " j' c' x' g' " c' " r' q' u' k' x' g' " g' h' g' e' v' " q' p' " j' w' o' c' p' " j' g' c' n' j' " j' 4\_0' D' l' q' r' q' n' f' o' g' t' u' " r' g' e' v' k' p' " c' p' f' " e' j' k' q' q' r' k' i' q' u' c' e' e' j' c' t' k' f' g' u' 'c' t' g' " e' q' o' o' q' p' n' f' " w' u' g' f' " o' c' v' g' t' k' e' n' i' h' q' t' " g' p' e' c' r' u' w' e' v' k' p' " u' f' u' g' o' u' 0' V' j' g' u' g' " u' w' d' u' c' p' e' g' u' 'c' t' g' " u' l' o' r' r' g' " k' p' " w' u' g' . " d' k' q' f' g' i' t' c' f' c' d' i' g' . 'j' c' x' g' 'j' k' i' j' 'h' q' f' l' p' i' 'e' c' r' c' e' k' s' { 'c' p' f' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'r' t' q' r' g' t' v' g' u' } '5\_16\_0'" "" ""

Vj ku'uwf { 'ku' c' k' o' g' f' 'v' q' 'g' x' c' n' e' c' v' g' 'v' j' g' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'q' h' 'p' k' u' l' p' / n' q' c' f' g' f' 'r' c' t' v' l' e' n' g' u' 0' H' q' t' 'p' k' u' l' p' / n' q' c' f' l' p' i' . 'v' j' t' g' g' 'f' k' h' g' t' g' p' v' v' f' r' g' u' 'q' h' 'c' p' k' p' l' e' 'r' g' e' v' k' p' 'd' l' q' r' q' n' f' o' g' t' . 'k' g' 0' j' k' i' j' " o' g' v' j' z' { 'r' g' e' v' k' p' " j' O' R' + 'h' q' y' " o' g' v' j' z' { 'r' g' e' v' k' p' " \*N' O' R' + 'c' p' f' 'r' g' e' v' k' e' 'c' e' k' f' " \*R' g' e' C' - " y' g' t' g' " w' u' g' f' 0' V' j' g' " e' q' o' r' n' g' z' c' v' k' p' " r' t' q' e' g' u' u' 'd' g' y' g' p' p' " p' k' u' l' p' " c' p' f' " r' g' e' v' k' p' " y' c' u' " r' g' t' h' q' t' o' g' f' " c' v' r' j' 7' 0' R' i' g' r' c' t' g' f' " e' q' o' r' n' g' z' g' u' 'y' g' t' g' " c' f' f' k' k' q' p' c' m' f' 'e' q' c' v' g' f' " w' u' k' p' i' 2' 0' 4' 7' " c' p' f' " 2' 0' 5' " o' i' l' o' n' i' q' h' e' j' k' q' q' r' k' i' q' u' c' e' e' j' c' t' k' f' g' u' 0' V' j' g' 'h' k' p' c' r' i' e' q' p' e' g' p' v' c' v' k' p' 'q' h' 'p' k' u' l' p' 'c' p' f' 'r' g' e' v' k' p' " y' c' u' " 2' 0' 5' " o' i' l' o' n' i' c' p' f' " 2' 0' 4' " o' i' l' o' n' i' t' g' u' r' g' e' v' k' x' g' n' { 0' " "

Vj g'cpvkvz kf cpv'cevxkx{ 'qh'pkulp/nqcf gf 'pcpqr ctvenguy cu'gxcnecv'g' f' d' { '4.4/fkrj gp{ n/3/r let{ nj { ftc| { n\*FRRJ +hgg" tcf lecn'o gjv qf " \*Hi 03-0' "



Hi 030'Tgcevkv'qh'FRRJ 'y kj 'cpvkz kf cpw' ]7\_ "

Vj g'tcevkv'p' y cu' r g' t' h' q' t' o' g' f' 'c' v' v' j' g' f' k' h' g' t' g' p' v' g' o' r' g' t' c' w' t' g' u' 'q' h' 4' 2' Å . 4' 7' Å . 'c' p' f' '5' 9' Å' h' q' t' 4' 6' j' q' w' u' 0' C' m' i' v' r' g' u' 'q' h' i' t' c' t' v' l' e' n' g' u' " u' j' q' y' g' f' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 0' K' y' c' u' 'h' q' w' p' f' 'v' j' c' v' v' j' g' 'v' o' r' g' t' e' w' t' g' j' c' f' 'p' q' 'u' k' i' p' k' h' e' c' p' v' g' h' g' e' v' q' p' 'v' j' g' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'q' h' 'v' j' g' " p' k' u' l' p' / n' q' c' f' g' f' 'r' c' t' v' l' e' n' g' u' 0' V' j' g' o' c' z' l' o' w' o' 'x' c' n' e' g' 'q' h' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'q' h' 'r' c' t' v' l' e' n' g' u' 'y' c' u' 't' g' e' j' g' f' " y' j' g' p' 'e' j' k' q' q' r' k' i' q' u' c' e' j' c' t' k' f' g' u' " e' q' p' e' g' p' v' c' v' k' p' 'y' c' u' 2' 0' 5' " o' i' l' o' n' i' 0' V' j' g' 'p' k' u' l' p' / n' q' c' f' g' f' 'r' c' t' v' l' e' n' g' u' 'y' k' j' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'e' q' w' f' 'd' g' 'w' u' g' f' 'h' q' t' 'v' j' g' 'r' t' g' u' g' t' x' c' v' k' p' 'c' p' f' " s' w' e' r' k' s' { 'k' o' r' t' q' x' g' o' g' p' v' 'q' h' 'h' q' q' f' 'r' t' q' f' w' e' u' 0' "

**Cempqy ngf i go gpw' Vj ku' t' g' u' g' t' e' j' " y' c' u' 'h' w' p' f' g' f' " d' { " y' j' g' " G' w' t' q' r' g' e' p' " U' e' k' e' c' i' n' ' H' w' p' f' " w' p' f' g' t' " y' j' g' " P' q' 2; 05/NO V/M/9340**  
 ðF g' x' g' n' r' o' g' p' v' 'q' h' 'E' q' o' r' g' v' g' e' p' e' g' u' 'q' h' 'U' e' l' g' p' v' k' u' u' . " Q' v' j' g' t' " T' g' u' g' t' e' j' g' t' u' 'c' p' f' " U' w' f' g' p' u' 'v' j' t' q' w' i' j' " R' t' c' v' e' c' i' n' ' T' g' u' g' t' e' j' " C' e' v' k' x' k' g' u' o' " o' g' e' u' w' t' g' 0' I' t' c' p' v' P' q' 2; 05/NO V/M/934/44/225; 0'

[3\_ "N010f g' C' t' c' w' . 'C' 0' H' 0' I' q' c' r' . 'R' 0' I' 0' 0' c' | | q' r' : 'V' 0' E' 0' X' 0' R' e' p' p' c' 0' P' k' u' l' p' / d' l' q' v' e' j' p' q' m' i' l' e' c' n' i' r' t' q' f' w' e' v' k' p' " c' p' f' " c' r' r' i' e' c' v' k' p' - c' ' t' g' e' x' g' u' 0' V' t' g' p' f' u' l' p' 'h' q' q' f' 'U' e' l' g' p' e' g' " ( 'V' g' e' j' p' a' r' t' i' { . '4' 2' \* 5' / 6 + ' 3' 6' 8' / 3' 7' 6 \* 4' 2' 2 ; + 0' )

[4\_ 'I' 0' Y' 'H' p' n' g' f' . 'C' 0' P' 0' M' q' p' i' . 'h' u' l' 0' l' p' v' g' . 'G' 0' 0' l' g' h' t' g' t' . 'N' N' l' i' 0' ( 'Z' 0' I' 'N' g' k' 'C' p' v' k' z' k' f' c' p' u' l' p' 'h' q' q' f' u' - 'U' c' v' g' 'q' h' 'v' j' g' 'U' e' l' g' p' e' g' 'k' o' r' q' t' v' e' p' v' 'v' j' g' 'h' q' q' f' 'k' p' f' w' u' t' { 0' l' q' w' t' p' e' n' i' q' h' 'C' i' t' k' e' w' w' t' c' i' e' p' f' 'h' q' q' f' 'E' j' g' o' k' u' t' { . '7 ; \* 3' 5 + : ' 8 : 5' 9' 6' 8 : 6' 8' 0 \* 4' 2' 3' 3 + "

[5\_ 'F' 0' U' w' p' . 'Z' 0' E' j' g' p' . 'E' 0' \ j' w' 'R' j' { 'u' l' e' q' e' j' g' o' l' e' c' n' i' r' t' q' r' g' t' v' g' u' 'c' p' f' 'c' p' v' k' z' k' f' c' p' v' c' e' v' x' k' x' { 'q' h' 'r' g' e' v' k' p' " h' t' q' o' " j' c' y' v' j' q' t' p' 'y' l' p' g' 'r' q' o' c' e' g' - C' " e' q' o' r' c' t' l' u' x' p' 'q' h' 'v' j' g' 'h' i' g' t' g' p' v' g' z' v' e' v' k' p' " o' g' v' j' q' u' . 'l' p' v' g' t' p' e' v' k' p' c' i' n' l' q' w' t' p' e' n' i' q' h' 'D' l' q' n' j' i' l' e' c' n' i' o' c' e' t' q' o' q' r' g' e' w' u' . 'X' q' n' w' o' g' '3' 7 : . '4' 2' 4' 2' . 'R' e' i' g' u' '3' 4' 5 ; / 3' 4' 6' 9' 0 \* 4' 2' 4' 2 + "

[6\_ 'F' 0' 0' P' i' q' 0' ( 'U' 0' M' 0' 0' C' p' v' k' z' k' f' c' p' v' c' h' g' e' u' 'q' h' 'E' j' k' l' p' . 'E' j' k' q' u' c' p' . 'c' p' f' " V' j' g' t' 'F' g' t' k' c' v' k' x' g' u' 0' C' f' x' c' p' e' g' u' l' p' 'h' q' q' f' " c' p' f' " P' w' t' k' k' p' " T' g' u' g' t' e' j' . '3' 7' 6' 5' 3' 0 \* 4' 2' 3' 6 + "

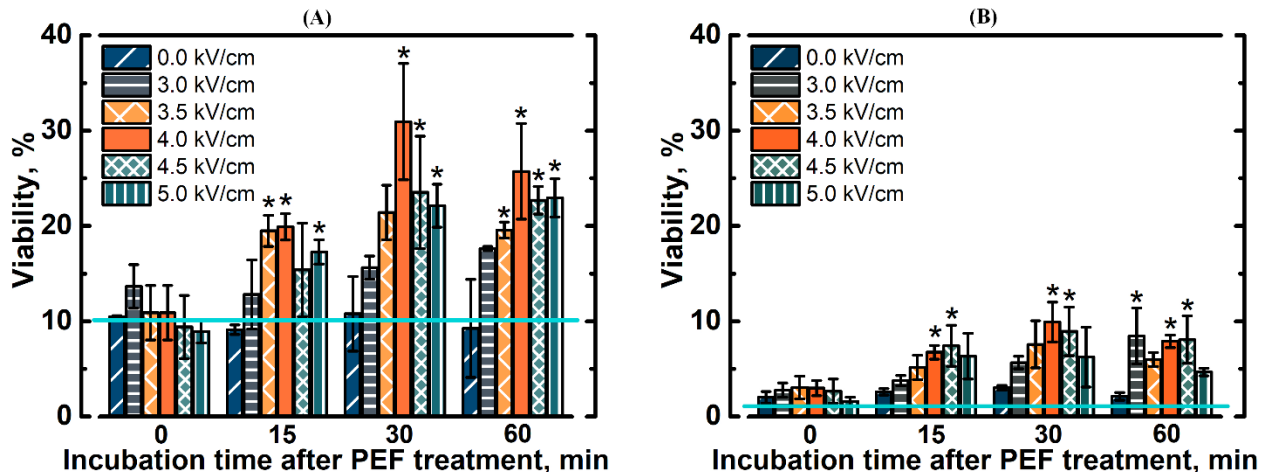
[7\_ 'O' 0' 0' c' u' a' c' t' q' . 'U' 0' l' g' r' e' . 'U' 0' l' v' g' t' p' g' n' k' 'R' 0' H' 0' R' e' t' k' i' 'I' 0' N' c' | | e' t' c' . 'C' 0' D' c' u' e' j' l' g' t' k' 'N' O' X' c' i' l' o' k' i' k' 'T' 'C' o' q' t' e' v' 0' C' 'h' i' p' g' t' i' k' e' 'p' c' p' c' p' v' k' z' k' f' c' p' v' d' c' u' g' f' 'q' p' 'e' q' x' c' n' e' p' v' f' " o' q' f' h' i' g' f' 'j' c' m' i' { 'u' l' s' g' o' t' q' n' z' 'p' e' c' p' q' w' d' g' u' 'y' k' j' 'l' p' v' c' / n' w' o' g' p' 'h' q' c' f' g' f' 's' w' g' t' e' g' l' p' 0' l' 0' 0' c' v' g' t' 0' E' j' g' o' 0' D' 0' 6' 0 \* 4' 2' 3' 8 + "

# NGGEVTQRQTCVQKP 'CUUKUVGF 'KO RTQXGO GP V'QHHTGG KPI ' ' VQNGTCPEG'K' [ GCUV'EGNNU'

Grix {tc'I wo dlpckv<sup>3</sup>. 'Rqxxku' "ko qpk<sup>3</sup>. 'Cw-tc' Nkpnxk k v<sup>4</sup>. 'Ct pcu' Uktm<sup>3</sup>"

<sup>3</sup>Ncdqtcvqt { "qh'Dkqgrgewtkeu. "<sup>4</sup>Ncdqtcvqt { "qh'O cvgtkcu'cpcn{uku. "  
Ucv'gT gugctej "kpwkwg. 'Egpyt' hqt' Rj { ukecl'Uekpegu'cpf "Vgej pqmji { . "Nkj wcpk"   
grix {tc'I wo dlpckvB i o eUwfw (kwfM'

Rt gugtxcvqp'qh' { gcu'egm'xkcdk'ku' guugpvk'lp' t'gugctej 'cpf 'y' g' hq'qf 'lpf wut { 0k' t'gugctej 'k'ku'ko r q' t'cvp'v'q' 'o' clp'v'kp' ut'clpu' r' quugulpi "wughw'v' t'cku' hqt' hpi 'r' g' t'k'q'f' u'q' h'v'ko g'00 g'c'p' y' k'g. 'k'p' 'y' g' hq'qf 'lpf wut { 'x'k'cdk'ku' 'ku' t'g' s' w'k'g'f' 'hqt' 'g' h'k'k'g'p'v' h'g'to g'p'v'clp'p' q'h' h'q'q'f' 'r' t'q'f' w'v' u' h'k'g' 'h'q'q'f' g'p' f' q'w' i' j' ]3\_0Rt gugtxcvqp'ku' q' h'g'p' 'c'ej' l'g'x'g'f' 'd' { 'h' t'g'g' l'p' i' . 'y' j' k'ej' 'e'c'p' 'e'c'w'g' 'h'q'to' c'v'k'p' " q'h' l'eg' 'e't' { 'u'c'ni' 'c'p'f' 'y' j' g' 't'g'o' q'x'c'ni' q'h' 'y' c'v'g't' 'h' t'q'o' 'y' k'j' l'p' 'y' g' 'e'g'm' ]4\_0E't { q'r' t'q'v'g'c'p'w' 'h'k'g' 'v'g'j' c'q'u'g' . 'y' j' k'ej' 'p'c'w'c'm' 'q'ee'w'tu' " k'p' { 'g'c'u' . 'c't'g' 'w'g'f' 'v'q' 'l'p'j' k'k'k' 'y' g'ug' 'h' t'g'g' l'p' i' 'l'p'w' t'k'g'u'00 w'k'r' n'g' 'u'w'f' l'g'u' 'u'j' q'y' 'y' c'v' 'v'q' r'g't'c'p'eg' 'v'q' 'h' t'g'g' l'p' i' 'k'u' 'u't' q'p' i' n' { 't'g'w'x'f' 'v'q' " 'y' j' g' 'e'q'p'eg'p't'c'v'k'p' 'q'h' 'l'p'w't'c'eg'm'w'c't' 'v'g'j' c'q'u'g' ]5/7\_0E't { q'r' t'q'v'g'c'p'w' 'j' c'x'g' 'd'g'p'g'h'k'u' 'd'q'v'j' 'g'z'v'c'eg'm'w'c't'n' { 'c'p'f' "k'p'w't'c'eg'm'w'c't'n' . " d'w' 'q'p'n' { 'h'g'y' 'e't' { q'r' t'q'v'g'c'p'w' 'e'q'w'f' 'g'p'v'g't' 'y' j' g' 'e'g'm' 'u't'c'k' i' j' v' h' t'q'o' 'y' j' g' 'o' g'f' k'c'0Q'p'g' 'q'h' 'y' j' g' 'v'g'ej' p'k' s' w'g'u' 'y' c'v' e'q'w'f' 'k'o' r' t'q'x'g' { 'g'c'u' 'e'g'm' 'r' g't'o' g'c'd'k'k'ku' 'v'q' 'e't' { q'r' t'q'v'g'c'p'w' 'd' { 'y' g'c'ng'p'k'p' i' "o' g'o' d't'c'p'g' 'd'c't'k'g't' 'k'u' 'g'z'r' q'u'w't'g' 'v'q' 'r' w'w'g'f' 'g'g'v'k'le' 'h'g'f' u' "RGH'0' " k'p' 'y' k'u' 'u'w'f' { 'y' j' g' 'l'p'x'g'k' i' c'v'g'f' "g'g'v'k'le' 'h'g'f' 'l'p'f' w'eg'f' "g'h'g'ew' 'd' { 'c'p'c'n' { l'p' i' " { 'g'c'u' 'e'g'm' 'x'k'cdk'ku' { 0'k'p' 'q't'f' g't' 'v'q' 'h'k'p'f' 'q'r' 'v'k'o' c'n' 'v'g'c'w'o' g'p'v' 'e'q'p'f' k'k'q'p'u' 'h'q't' 'y' j' g' 'l'p'w't'q'f' w'v'k'p' 'q'h' 'e't' { q'r' t'q'v'g'c'p'w' 'v' 'e'g'm' 'u'w'ur' g'p'k'q'p' 'y' c'u' 'g'z'r' q'u'g'f' 'v'q' 'r' w'w'g'u' 'y' k'j' 'f' 'k'h'g't' g'p'v' 'g'g'v'k'le' " h'g'f' 'u't'g'p' i' j' u' "G'0' : 'n'x' l'eo' +0D'g'h'q't'g' 'g'z'r' q'u'w't'g' 'v'q' 'g'g'v'k'le' 'h'g'f' u' { 'g'c'u' 'e'g'm' 'y' g't'g' 'y' c'uj' g'f' 'y' k'eg' 'y' k'j' 'g'g'v'k'le' q'r' q't'c'v'k'p' 'd'w'h'g't' " c'p'f' "t'g'u'w'ur' g'p'f' g'f' "k'p' "g'g'v'k'le' q'r' q't'c'v'k'p' "d'w'h'g't' "u'w'r' n'g'o' g'p'v'g'f' "y' k'j' "F' / \* . +V't'g'j' c'q'u'g' "f' l'j' { 'f' t'c'v'g' "t' "u'q't'd'k'q'f'0' V'j' g' " { 'g'c'u' 'e'g'm' 'u'w'ur' g'p'k'q'p' 'y' c'u' 'g'z'r' q'u'g'f' 'v'q' 'c' 'u'k'p' i' n'g' "g'g'v'k'le' 'h'g'f' "r' w'w'g' "c'p'f' 'y' j' g' 't'g'c'h'g't' 'u'q'c'ng'f' "k'p' 'y' j' g' 'v'g'j' c'q'u'g' 'u'q'w'k'q'p' 'h'q't' 'w'r' "v'q' '82' "o' k'p' " d'g'h'q't'g' 'h' t'g'g' l'p' i' 0' h'q't' 'g'x'c'w'c'v'k'p' i' 'h' t'g'g' l'p' i' "g'h'g'ew' 'q'p' " { 'g'c'u' 'e'g'm' 'y' g' 'n'g'r' 'v' 'e'g'm' 'u'w'ur' g'p'k'q'p' 'c'v' / 42' " E' 'h' t'q'o' '6' "v'q' '62' "f' c' { 'u' "H'k' i' 0' 3+0'X'k'cdk'ku' 'q'h' 'e'g'm' 'y' c'u' 'g'x'c'w'c'v'g'f' 'd' { 'e'q'w'v'k'p' i' 'e'q'q'p' { / h'q't'o' k'p' i' "w'p'k'u'0'c'u'c' "e'q'p't'q'n' "RGH' 'w'p't'g'c'v'g'f' 'u'w'ur' g'p'k'q'p' 'y' c'u' 'w'g'f' 0' k'p' "q't'f' g't' "v'q' 'x'c'k'f' c'v'g' 'y' j' g'v'j' g't' "RGH' 'v'g'c'w'o' g'p'v' 'k'o' r' t'q'x'g'f' " 'y' j' g' 'l'p'w't'q'f' w'v'k'p' 'q'h' 'v'g'j' c'q'u'g' "k'p'v'q' " { 'g'c'u' 'e'g'm' 'y' j' g' 'g'x'c'w'c'v'g'f' "k'u' " e'q'p'eg'p't'c'v'k'p' "k'p' " { 'g'c'u' 'e'g'm' "U' "q'h' 'v'g'j' c'q'u'g' l'o' i' "q'h' 'f' t' { " { 'g'c'u' 'o' c'u'w'0'G'z'v'c'ew' 'h' t'q'o' " { 'g'c'u' 'e'g'm' 'n' 'u'c'w'u' 'y' g't'g' 'c'p'c'n' { l'p' i' g'f' "x'k'c' " e'j' t'q'o' c'v'q' i' t'c'r'j' { 0



Hki 030Xkcdk'ku' 'qh' { 'g'c'u' 'e'g'm' 'c'h'g't' 'g'z'r' q'u'w't'g' 'v'q' 'u'k'p' i' n'g' "g'g'v'k'le' 'h'g'f' "r' w'w'g' "c'p'f' 'u'w'd'g's' w'p'v' 'h' t'g'g' l'p' i' 'h'q't' "C'+6' 'f' c' { 'u'q't' "D'+62' 'f' c' { 'u'c'v' 42' "E'0'V'g'c'n' 'h'k'p'g' 't'g'r' t'g'p'w' 'x'k'cdk'ku' 'q'h' { 'g'c'u' 'e'g'm' 'y' k'j' q'w' 'u'q'c'n'k'p' i' "k'p' 'v'g'j' c'q'u'g' "c'p'f' 'r' w'w'g'f' "g'g'v'k'le' 'h'g'f' "RGH' "v'g'c'w'o' g'p'v'0'c'v'g't'k'u'm' " \* . +l'p'f' l'ec'v'g' 'u'k' p'k'h'c'p'v'f' k'h'g't'g'p'eg' "r' ">207+ 'l'p' 'y' j' g' 'x'k'cdk'ku' 'y' j' g'p' 'e'q'o' r' c't'g'f' "v'q' 'RGH' 'w'p't'g'c'v'g'f' 'e'g'm' 'y' k'j' 'y' j' g' 'u'c'o' g' 'u'q'c'n'k'p' i' 'k'o' g'0'

Y' g' 'u'j' q'y' g'f' "y' c'v' 'y' j' g' "RGH' 'r' t'g't'g'c'w'o' g'p'v' 'e'q'w'f' "k'o' r' t'q'x'g' 'y' j' g' 'h' t'g'g' l'p' i' "v'q' r'g't'c'p'eg' 'q'h' { 'g'c'u' 'e'g'm' 'y' w' 't'g'u'w'k'p' i' "k'p' "j' k' i' j' g't' " x'k'cdk'ku' { 'k'h' 'w'r' 'v'q' '5' "k'o' g'u'0R't'g't'g'c'w'o' g'p'v'k'p' 'v'g'j' c'q'u'g' 'u'q'w'k'q'p' 'c'v'k'p' 't'g'u'w'g'f' 'l'p' "j' k' i' j' g't' 'e'q'p'eg'p't'c'v'k'p' 'q'h' 'l'p'w't'c'eg'm'w'c't' 'v'g'j' c'q'u'g' " \*d' { "w'r' "v'q' '82' " + 'y' j' g'p' 'e'q'o' r' c't'g'f' "v'q' 'RGH' 'w'p't'g'c'v'g'f' 'e'g'm' '0'V'j' g' 'q'r' 'v'k'o' c'n' 'g'g'v'k'le' 'h'g'f' 'u't'g'p' i' j' "k'p' 'y' j' g' 'e'c'ug' 'q'h' 'u'k'p' i' n'g' "u's' w'c't'g' " u'j' c'r' g'f' "r' w'w'g' 'y' k'j' "f' w'c'v'k'p' 'q'h' '372' "U' 'y' c'u' '6' "n'x' l'eo' 0'U'q'c'n'k'p' i' "v'k'o' g' 'j' c'f' "c'p' "g'h'g'ew' 'q'p' 'y' j' g' 'x'k'cdk'ku' { 'c'h'g't' 'y' c'y' k'p' i' "q'p'n' { "h'q't' " RGH' 'v'g'c'v'g'f' "e'g'm' '0'V'j' g' 'q'r' 'v'k'o' c'n' 'u'q'c'n'k'p' i' "v'k'o' g' "c'h'g't' "RGH' 'v'g'c'w'o' g'p'v'k'p' "v'g'j' c'q'u'g' "u'q'w'k'q'p' "y' c'u' '52' "o' k'p'0' 'k'p'x'g'k' i' c'v'k'p' 'q'h' 'l'p'w't'c'eg'm'w'c't' 'v'g'j' c'q'u'g' 'e'q'p'v'g'p'w' 'e'q'p'h't'o' g'f' "y' j' c'v'k'u' 'e'q'p'eg'p't'c'v'k'p' 'l'p'et'g'c'ug'f' "y' k'j' 't'k'g' 'l'p' 'u't'g'p' i' j' "q'h' 'y' j' g' 'g'g'v'k'le' 'h'g'f' 0' " V'j' g' 'r' t'q'ur' g'ev'q'h'q'w' 't'g'ug't'ej' 'k'u' 'v'q' 'f' g'x'g'r' 'c' 'p'g'y' 'h' t'g'g' l'p' i' "v'g'ej' p'q'm'j' { 'u'w'k'c'd'g' 'h'q't' { 'g'c'u' 'c'p'f' 'q'v'j' g't' 'e'g'm' 'd' { 'l'p'et'g'c'uk'p' i' " y' j' g't' 't'g'uk'w'c'p'eg' 'v'q' 'h' t'g'g' l'p' i' "l'p'w't'g'u' 'y' k'j' q'w' 'o' c'p'k' w'c'v'k'p' i' "y' j' g' 'p'g'v'k'le' 'd'c'c'm' t'q'w'p'f' 0' "

[3\_ "Nwq. "Y' 0'U'w'p. 'F'0'Y' 0' \ j' w' \ 0'Y' c'p' i' . 'S' 0'0'k'6' r' t'q'x'k'p' i' 'h' t'g'g' l'p' i' "v'q' r'g't'c'p'eg' 'q'h' { 'g'c'u' 'c'p'f' 'f' q'w' i' j' 'r' t'q'ur' g'v'k'u' 'h'q't' 'g'p'j' c'p'el'k'p' i' 'h'q'q' g'p'f' q'w' i' j' 's' w'v'k'w'f' { 0' 'C' 't'g'x'k'g'y' 'q'h' 'g'h'g'ew'k'g' 'o' g'y' q'f' u'0'V'g'p'f' u' 'h'q'q'f' 'U'el'0'V'g'ej' p'q'm'0423: . '94. '476550' "

[4\_ "F' c'x'k'k'k'c'p' . 'O' 0' 'l'j' c' . 'R'0'0' 'V'c'x'c'ni'k' 'l'0' 'F' c't'g'k'1' c't'o' c'n'j' c'p' { . 'C'0' 'Z'c'p'y' c'n'k' . 'G'0' 'N'g' 'D'c'k'n' 'C'0' 'T'g'x'k'g'y' "q'p' 'k'f' g'p'v'k'h'c'v'k'q'p' . 'w'p'f' g't'n' { l'p' i' "o' g'ej' c'p'l'uo' "u' "c'p'f' "g'x'c'w'c'v'k'p' 'q'h' 'h' t'g'g' l'p' i' "f' c'o' c'i' g'0' 'L'0' 'h'q'q'f' 'G'p' i' 0423: . '477. '726820' "

[5\_ "E'q'w'k'p'j' q' . 'E'0' 'D'g't'p'c't'f' g'u' . 'G'0' 'H' 'r'z' . 'F' 0' 'R'c'p'g'm' 'C'F' 0'V'g'j' c'q'u'g' "c'p'f' { q'r' t'q'v'g'c'p'w' 'h'q't' "r' t'g'g' t'c'v'k'p' 'q'h' { 'g'c'u' 'u't'c'p'u' 0' 'L'0' 'D'k'g'v'ej' p'q'm'03: . . '9. '456540' "

[6\_ "I' g'p'c'u' . 'R'0' 'H'ug'v' . 'I' 0' 'Y' 'k'ng'o' q'v' . 'E'0' 'I' 'q'w'g'v' . 'L'0' 'N'k' 'k'f' 'e'q'p'v'g'p' 'c'p'f' 'e't' { q'v'q' r'g't'c'p'eg' 'q'h' 'd'c'ng't'w'0' { 'g'c'u' 'l'p' 'h'q'q' g'p'f' q'w' i' j' u'0' 'C'r' r'0' 'G'p'x'k'k'p'0'0' k'et'q'd'k'q'f'03: . 3. " 79. '685668: 0' "

[7\_ "U'w'p. 'Z'0' \ j' c'p' i' . 'E'Q' 0' 'Y' w' 'O' Q' 0' 'H'p' . \ 0' 0' 'N'w' "U'P'0' \ j' w' 'Y' 0'0' 'Z'k'c'q' . 'F' 0' 0'0' 'C'N'84' 'q'x'g't'g'z'r' t'g'u'k'q'p' 'c'p'f' "P' V'j' 3' 'f' g'v'k'q'p' 'g'p'j' c'p'eg' 'y' j' g' 'h' t'g'g' l'p' i' "v'q' r'g't'c'p'eg' 'c'p'f' "h'g't'o' g'p'v'c'v'k'p' 'e'c'r' c'ek'k' { 'q'h' 'y' j' g' 'd'c'ng't'w'0' { 'g'c'u' 'l'p' 'h'g'c'p'f' q'w' i' j' 0'0' k'et'q'd'0' 'E'g'm' 'f' e'v'04238. '37. '36: 0' "

**UNC'5F'RTKVPKI 'CRRNĒCVKQP'HQT'HCUV'GNGEVTQEJ GO ĒECN'  
FGXĒG'RTQVQV[ RPI "**

O ctv[pcu'Tckn<sup>3.4</sup>. 'Gkx { f cu' Cpftkwnqpk<sup>3.4</sup>. 'Ct pcu'Tco cpcxk kw<sup>3.4</sup>"

<sup>3</sup>'kpukwg'qh'Ej go knt { . 'Hewm { 'qh'Ej go knt { 'cpf 'T gquelpegu. 'Xkpkw'Wpkgtuks { . 'Nkj wpcle "  
<sup>4</sup>'F gr ctvo gpv'qh'Hwpevkpcn'O cvgtkcu'cpf "Grgextqpleu. 'Ucvg'tgugctej 'kpukwg'Egpvt'hqt'Rj { ulecn'Uekpegu'cpf "  
Vgej pqmji { . 'Nkj wpcle "  
o ctv[pcu'ccknB ej hhwf'kw'hw'

Ugtgqkxj qi tcrj { "UNC +ku'c'vgej pqmji { 'eqo o qpn' 'wugf 'hqt' j ki j 'tguqnwqap'f gumqr '5F' r tlvkpi 0UNC'ku'cp'cf f kxg' o cpwcewtkpi 'r tqegu'f wtkpi 'y j lej 'vj g'o qf gnu'ctg'r tqf wegf 'd { 'kmo kpcvpi 'rc { gt'chgt'rc { gt'qh'iks wkf 'r rcwle' r tgewtuqt' y kj "wntcxkqrgv'ri j v'Vj g'ri j v'kpkcvgu'c'r qn' o gk' cvkqp'tgcevkqp'kp'vj g'r tgewtuqt. "ecwukpi 'k'vq' uqnf kh'Vj g'r qvvpkcn' hgrf 'qh'cr r nccvkpu'hqt'UNC'ku'y kf g. 'tapi kpi 'hqt' r tqvq' r kpi 'lpf wntkcn' ctw'vq'dkqgpi kpggtkpi 0'

F wtkpi "qwt'tgugctej . 'y g'wugf "UNC'5F' r tlvkpi "v'eqputwev'cp'grgextqej go lecn'hqy "egm'r tqvq' r g'Vj g'egm'y cu' qv' wo k' gf "cpf 'xgt'hkgf 'vq'dg'c'uwkcdng'f gxleg'hqt'grgextqpcn'uku'qh'ikxg'egm'uwar gpukpu0'

Vj g'eqputwevkqp'qh'vj g'grgextqej go lecn'egm'ku'cu'hqny u'v' q'o ckp' r ctw'r tqf wegf 'hqt' r rcwle'tgukp'ctg'eqppgevgf " d { 'c' uclp'rguu'vuggn'wdg. 'y j lej 'cnuq'cew'cu'cp'cvz'kkt { 'grgextqf g' "eqwvgt'grgextqf g. 'EG+kp'vj g'egm'c' r rcw'pwo 'y qtnkpi " grgextqf g'cpf "c'Ci ICi En'tghgt'gpeg'grgextqf g'ctg'kpugtvgf "kp'v'ur gekcm' f guki pgf "j qrgu'kp'qpg'qh'vj g'r rcwle' r ctw'vj g' r tlvkpi' r ctw'j cxg'j qrgu'cv'dqj "gpf u. 'y j lej "j cxg'kp'dwkm'vj tgc'f u'hqt'gcu' { 'cpf "rcu'eqppgevkqp'qh'twddgt'wdgu'cpf "ctg' wugf 'vq' uwr r n' 'vj g'cpcn' | gf 'uqnwqap'kp'v'vj g'grgextqej go lecn'egm'Vj g'hqy "qh'vj g'hwk'ku'kpkcvgf "d { 'c' r g'kucnle' r wo r " eqppgevgf 'vq'qpg'qh'vj g'wdgu0'

Qv' wo k' cvkqp'qh'vj g'r tqvq' r g' y cu' ectt'kgf "qww' d { " o gcuwtkpi " vj g' grgextle " uki pcn' cv' f khtg'gpv' hqy " ur gg'f u. " d { " f gvgto kpkpi 'vj g'qr' wo cr'eqppgevkpi 'qtf gt'qh'vj g'hqy "egm'leqo r qpgpu'cpf "d { 'hkp' kpi 'vj g'eqttgevo' gf kcvq'vq'dg'wugf "kp' vj g'egm'0'

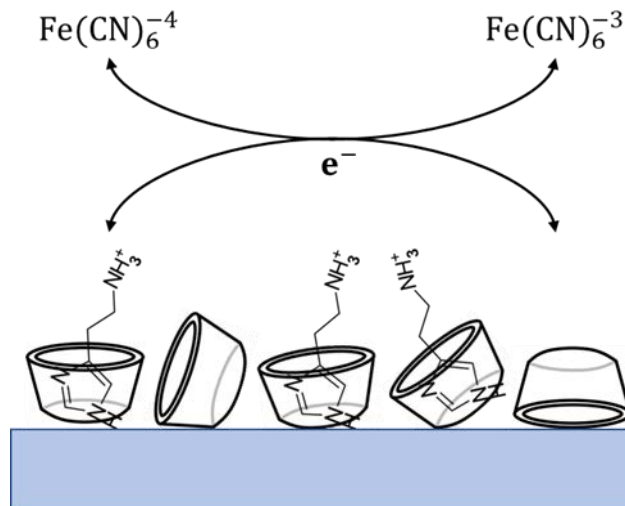
Vj g'r tqvq' r g'qh'vj g'grgextqej go lecn'egm'y cu'wugf 'vq'cpcn' | g'c' uwar gpukqp'qh'U'eej ctqo { egu'egt'gxkuk'g'egm. 'y j lej " y cu'tw'vj tqwi j "vj g'grgextqej go lecn'egm'kp'c'equgf "ekerg'cpf 'vj g'ej cpi g'qh'grgextle'ewt'gpv'kp'wo g'y cu'o gcuwtg' y kj " c' ucdng' r qvvpkcn'cr r nkgf "vq'vj g'y qtnkpi "grgextqf g'OC'hgy "uco r ngu'qh' { gcu'egm' o qf kkgf "d { "grgextlecn' "eqpf wekxg" r qn' o gt' r qn' r { ttqrg' "Rr { +kpkf g'vj gkt'y cmu'y gtg'cnuq'vugf "kp'vj ku'r tqvq' r g'Vj g'grgextqej go lecn'egm'y cu'cdng'vq" o gcuwtg'vj g'f khtg'gpv'grgextle'uki pcn' r tqf wegf 'f gr gpf kpi 'qp'vj g'eqpegpvtcvkqp'qh'vj g' { gcu'egm'cpf 'qp'vj g'eqpegpvtcvkqp' qh'Rr { 'kp'vj g'egm'y cmu'Vj g'ug'tgum'uwi i gu'vj cv'cp' ro r tqxgf 'xgtukap'qh'vj g'r tqvq' r g'o c { 'r qvvpkcn' "dg'cr r nccdng'hqt" kpf wntkcn'wugu. 'uwej 'cu' o qpkqt'kpi 'kp'dkqhwgn'egm'0'

**GNGEVTQEJ GO ĶECN'ĶP XGUVĶ CVĶQP 'QH'CF UQTDGF "**  
**E[ ENQF GZ VTĶP U'QP 'ĶVQ'GNGEVTQF G'HQT'RQVGP VĶCN'J [ UVCO ĶP G' "**  
**UGPUĶI "**

F grkpcu'Rerkpcwunū. 'I kpcwcu'Dei f flk pcu'

Ķpukwag'qh'Dkqej go kux { . 'F gr ctvo gpv'qh'Dkqpcn' uku. 'Nhg'Uelgpegu'Egptg. 'Xkpkwu'Wpkxgtuk{ . 'Ucwgvgnk'cx09. "  
 NV/32445. 'Xkpkwu.'Nkj wpcle"  
[f grkpcu'erkpcwunūB ej i hōwōh'](#)

Grgvteqej go lecn'ugpukpi "j cu'tgegkxgf"o wej "cwgpvkqp'cpf "ku"go r nq{ gf "lp"vj g'f gvevqp'qh'dkqo qrgewgu'f wg'vq'ku" ej gcr "cpf" r qtvcdrg" kpuwto gvu. "ny " equv'cpf" tcr kf "cpcn'uku. "j ki j " ugpukxkx{ "cpf" ugrgevskx{ '0' Vj g" ugrgevskx{ "cpf" f gxrgr o gpv'qh'ghge'v'o cvgtkcu'hqt"o qf kh'kpi "grgevtf gu'ctg'ng{ "hcevqtu"vq"ko r tqxg"vj g"ugpukxkx{ "cpf" ugrgevskx{ "qh' grgevteqej go lecn'ugpukpi '0' Vj gug" ghge'v'o cvgtkcu'ctg" uq/ecmgf "j quvōi wguv' uwr tco qrgewrt" tgeqi pkkqp"u{ ungo u'0' Qpg" hco k{ "qh'ecpf kf cvgu'hqt" ghge'v'o cvgtkcu'cu'c"j quv'i wguv'kpvgtcevkqp/dcuqf "uwr tco qrgewrt" tgeqi pkkqp"u{ ungo u'ctg'ecuu' qh' e{erke" qnki quceej ctkf gu. "pco gn{ "e{enqf gzt'kpu" \*EF u'0' O quv' y gm'npqy p" EF u' eqpuku' qh' 8" vq" : " lqkpgf" vqi gj gt" F/\*- #i nœqr {tcpug" uwdwku'cpf "ctg"ecmgf "α/." β/." /EF u." ceeqtf kpi n'0' Qpg"ko r qtvcpv' utwewcn' hgcwtg" qh' vj gug" eqo r qwpf u'ku'vj gkt'eqplecn'uj cr g'y kj "j {ftqrj qdle'ecxkx{ "cpf" "j {ftqrj kke'gzvgtkqt'0'F wg'vq'vj ku'utwewcn' hgcwtg. "EF u' ctg'ecr cdrg'qh'hqto kpi "j quv'i wguv'eqo r ngz'gu'd{ "vj g'o gpcu'qh'j" {ftqrj qdle'kpvgtcevkpu'0' "



**Hki 030**Uej go g'qh'ej cti g'tcphgt'htqo hq'tgf qz'r tqdg'vj tqwi j 'ugrh'cuugo drgf "o qpqr: gt'qp'ĶVQ'grgevtf g' eqpukukpi "qh'cf uqtdgf "β"/qt" /EF "o qrgewgu'cpf "vj gkt'3-3" kpcwukqp'eqo r ngz'y kj "j {uwo kpg'wvf gt'r j {ukqmi lecn'J " eqpf kkpū\*906+ "

Qp"vj g" qv gt"j cpf. "j {uwo kpg"ku"ko r qtvcpv' dkqo qrgewg" vj cv' eqpvtqn'r j {ukqmi lecn' hwpvkkp" qh' vj g"i w' cpf "ku" kpxqkxgf "lp" r tqeguug'qh' qwt' egpvtcn' pgtxqwu' u{ ungo "cu" c" pgtvqtcpuo kvgt "j6\_0'Vj gt ghqg. "vj g" cpcn' uku' qh'j" {uwo kpg"lp" dkquco r ngu' ku' qh' i tgcv' enplecn' cpf "r j cto cegwlecn' ko r qtvcpv' 0' Qpg" gzcō r ng' qh' grgevteqej go lecn' f gvgto kpcvqp' qh' j {uwo kpg" eqpegpvtcvkqp" lp" i w' kpxqkxgu' wuci g' qh' o qrgewrtn{ " ko r tkpvf" r qn{ o gtu' cu" c" uwr tco qrgewrt" ghge'v' o cvgtkcu'j7\_0'J gtg. "y g'r t gupv'kpxguki cvkqp'qh'vj g'ugrh'cuugo drgf "β"/cpf" /EF "o qpqr: {gtu'qp'ĶVQ' \*Ķf kwo "Vlp" Qz kf g+ grgevtf g" cu' r qukdrg' uwr tco qrgewrt" r rchqto "hqt" f gvgto kpcvqp' qh'j {uwo kpg" eqpegpvtcvkqp" \*Hki 0'3-0' Ķp" vj ku' y qtm" hctcf cke'grgevteqej go lecn' ko r gf cpeg'ur gevteqqr { "f gvevqp'qh'j kucō kpg'cu'cp'gpj cpegf "cpcn' vq' y cu' cr r nkgf 0' Ceeqtf kpi " vq" gs wxcrgpv'ektevks" o qf gnkpi. "vj g" o qrgewrt" tgeqi pkkqp" qh' j kucō kpg" d{ "vj g" EF u' ecxkx{ "kpetgcugu" vj g" tgukvkg" eqo r qpgpv'qh'vj g' grgevtf g' uqmwkqp' kpvgtce'g'y j kng' ecr celskxg' ghge'v' ctg' pgi nki kdrg'0' qtgqxt. "vj ku'ugpuqt' gpcdrgu'vj g' swcpv'kpcvqp'qh'j kucō kpg'lp'c' dtqcf "eqpegpvtcvkqp' tci g'htqo "32'p0 "vq'3" O 0' "

**Cempqy nfi go gpwu:** Vj ku'ōUwr tco qrgewrt' tgeqi pkkqp/dcuqf 'ugpuqtu' hqt' grgevtf gvevqp' qh' dkqo qrgewgu' r tqlgv'j cu' tgegkxgf "hwpf kpi 'htqo "vj g' Tgugctej 'Eqwpeki' qh' Nkj wpcle" \*NO VNV+ "ci tggō gpv'pq0U/O RR/42/670' "

[3\_ 'I 0'Dei f flk pcu. 'F(Rerkpcwunū. 'Rqn{ \*; J /ectdc| qng-'cu'c' "Qti cple" Ugo leqpf vevqt' hqt' Gpl { o cve" cpf "P qp/Gpl { o cve" T nœqug' Ugpūqtu' Dkqupuqtu. " 32. '326" \*4242-0' ]  
 [4\_ 'I 0'Vj kntco u'gv'cn'0' Cf xcepegu'lp' cr r nkgf "uwr tco qrgewrt" vgej pqrni kgu. 'Ej go 0'Uqe0Tgx0'32. '325; " \*4243-0' ]  
 [5\_ 'I 0' j w' [ 0' k' LĶEj gp. "Tgegpv'cf xcepegu' hqt" e{ enqf gzt'kpu/dcuqf "o cvgtkcu'lp' grgevteqej go lecn'ugpukpi. "ViCE "Vt gpf u'lp' Cpcn' vlcni' Ej go kux { .: 2. " 4546463 " \*4238-0' ]  
 [6\_ 'P kqv/ Ciro km' gv'cn'0' Vj g' J kucō kpg' J 5' Tgegr vqt <Utwewtg. 'Rj cto ceqrni { .: 'cpf' Hwpvkkp. '0' qrgewrt' Rj cto ceqrni { .: 2\*7+ '86; 0' ]  
 [7\_ "ROY ci pgt' gv'cn'0' Grgvteqej qn{ o gkt' gf "Tgegr vqt' Eqcūpi u' hqt' vj g' S wcpv'kxg' F gvevqp' qh' J kucō kpg' y kj "c' Ecv' gvg/ Dcuqf. "F kci pqule" Ugpūqt. " CEU' Ugpū0'8\*3+ :3220' "



**UVWF [ 'QH'VJ G'RP VGTCEVKQP 'QH'O KUHQNF GF 'RTQVGR U'Y K'J ' ' O GO DTCPG'O QF GN'U UVGO U'**

**Gxgrkpc'Leprnk{v<sup>3</sup> \ ki o cpwcu'Vqrgknk<sup>4</sup>. 'X {vcwcu'Uo ktpqxcu<sup>4</sup>. 'I kpwctcu'Xcrkp kwu<sup>3</sup>. '""**  
**Tlo c'Dwf x {v<sup>3</sup>**

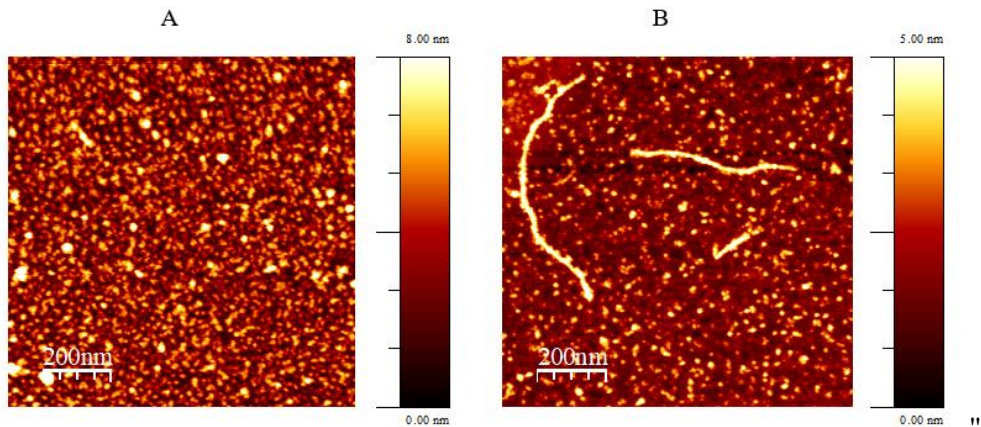
<sup>3</sup>"Kpukwag'qh'Dkqej go kurt {.'Nkg'Uelkpegu'Egpgvt.'Xkpkwu'Wpkxgtuk{.'Xkpkwu.'Nkj wcpkc""  
<sup>4</sup>"Kpukwag'qh'Dkqvej pqrqi {.'Nkg'Uelkpegu'Egpgvt.'Xkpkwu'Wpkxgtuk{.'Xkpkwu.'Nkj wcpkc".....  
**gxgrkpc'Leprnk{vgB i o e0xw0n"**

"

Rtqvglp'o kuhqf kpi 'ku'c'eqo o qp'egmwrct'gxgpv'y cv'ecp'qeewt'y tqwi j qw'y g'rhguko g'qhl'c'egm0Vj g'ceewo wrcvqp'qh' o kuhqf gf "rtqvglpu"lp"y g"dtclp"ku" c"j cmo ctm'qh'ugxgtcn'pgwtqf gi gpgtcvkg" f kugcugu'0Hqt"gzco r ng." dgvc/co {nklf "ku" cuuqekcvgf "y kj "Cn j glo gt au'f kugcug'0Kp"y g'CN j glo gt u'dtclp."cdpqt o cni'ngxgn'qh'y ku'pcwtcm' "qeewtkpi "rtqvglp"enwo r " vqi gj gt "vq" hqto " r rcs wgu" y cv' ceewo wrcvg" dgvy ggp" pgwtqpu" cpf " f kut w v' egm' hwpvkapu" ]3\_0' U322C; " r tqvglp" j cu"" co {nklf /rkngr'rtqr gt vku'cpf "ecp"dg'hqwpf "kp"gzvcegmwrct 'ugpkgr' r rcs wgu'vqi gj gt "y kj "dgvc/co {nklf 0U322C; "ku'lp'xqrgf " kp"ci i t gi cvgu'hqto cvkqp"cpf "kphco o cvqt { "rtqeguugu"cuuqekcvgf "y kj "pgwtqf gi gpgtcvqp"]4\_0'Kp"y ku'y qtn'y g'lpvgtcvkqp" qh'U322C; "cpf "dgvc/co {nklf "y kj "o go dtcpg"o qf gr'u{uvgo u'y cu'uwf kfg 0Vgy gt gf "dkr {gt "rkr kf" o go dtcpgu'kDNO + "cpf" rkr quqo gu"y gt g"wgf "cu'uko r rkhgf "o go dtcpg"o qf gr'u'hqt "y gug"uwf kgu'0Vj g'c'ko "qh'y ku'y qtn'y cu'vq" hqto "vgj gt gf " dkr {gt "rkr kf" o go dtcpgu"]5\_ "cpf "wpkco gmt "rkr quqo gu"y kj "gpecr uwrcvgf "hwtgugp"ecrvgp"cpf "wug"y go "vq"uwf { "" "" lpvgtcvkqp"y kj "o kuhqf gf "rtqvglpu"0"

Cvqo le"hteg"o letqueqr {"\*CHO + "cpf" f {pco le"rki j v'uecwtkpi {"\*F NU"o gj qf u'y gt g"wgf "hqt"ej ctcevgtkcvkqp"qh' U322C; " cpf" dgvc/co {nklf " \*Hi 0' 3+0' D{" go r nq {kpi " grgvtqej go lecn' ko r gf cpeg" ur gevqueqr {" cpf" hwtgugpeg" ur gevqueqr {" y g"lp'xguki cvg"lpvgtcvkqp"qh'r j qur j qrk kf "dkr {gt"y kj " U322C; "cpf" dgvc/co {nklf "f gr gpf kpi "qp"y gk" qri qo gt k' cvkqp'ucvg'0"

.....



""Hi 030CHO "vqr qi tcrj le'ko ci gu'qh' /co {nklf "3/64+"qri qo gtu"0C+"cpf "hktku"0D+0"

"

[3\_0' | ctq "F H "DgmweeK' C. "Dtwpf lp" R. "Qwglq "VH'Gf kqtkcn="Rtqvglp" O kuhqf kpi "cpf "Ur tgef kpi "Rcv j qnqi { "lp" P gwtqf gi gpgtcvkg" F kugcugu'0H qp'kgtu" lp" O qngewrt "P gwtquekpeg04242=34-5340'  
 [4\_0' Y cpi "E. "Mgej knqx" CI. "I j ctld {cp" CN. "Y @o n@pf gt "UMVU' Lctxg' L" \ j cq" N. "Zwggp" L' Uj cpnet "UM" Qmhuuq" C. "Dtepputqo "V. "O wI. "I teunpf" C. "O qtqj qxc/ Tqej g' NC'0Vj g' tng' qh' r tq/ kphco o cvqt { "U322C; "lp" Cn j glo gt au'f kugcug' co {nklf /pgwtqkphco o cvqt { "ecuecf g'0Cev" P gwtqr cvj qnqi lec'0' 4235=349\*6+7296440"  
 [5\_0' Dwf x {v<sup>3</sup> "T. "Xcrkp kwu' I. "P kwc' I. "Xqlekw' X. "O lengxk kwu' O. "Ej cr o cp" J. "I qj " J \ . "Uj gnj ct "R. "J gkptlej "H. "Uj gpq { "U. "Nquej g' O. "Xcpf gtcj " F I0Utwewt g'cpf "Rtqr gt vku'qh'Vgy gt gf "Dkr {gt "Nkr kf" O go dtcpgu"y kj "Wpucwtcvgf "Cpej qt" O qngewgu' Ncpi o wk04235=4; \*49+< 8676780"

**J CTPGUURPI 'VJ G'FKXGTUKV[ 'QHECU; 'QTVJ QNQi UHQTI GP QO G"  
GFVKPI "**

Vqo cu"Udcku<sup>3,5</sup>. "I kgtkw'I cukwpcu<sup>3</sup>. "Lqij we"MO[ qwpi<sup>4</sup>. "O qpkne"Leupcwumekg<sup>3</sup>. "O cpw{f c"  
I twu{vg<sup>3</sup>. "Uwuj o kj c"Rcwrc<sup>4</sup>. "Lgppkht"NOEtwew<sup>6</sup>. "O gi wo w'O cdwej k<sup>6</sup>. "T {cp"V0Hwej u<sup>6</sup>. "G{tc"  
Uej kf ntcw<sup>6</sup>. "I O'Dt gwTqdd<sup>6</sup>"cpf "Xkt i kpkwu"Ukup{u<sup>3,5</sup>"

<sup>3</sup>Ecu{ o g."Xkpkwu"NV/32479."Nkj wcpk"

<sup>4</sup>F gr ctwo gpv'qh'O qrgewrc"Gpi kpggtkpi . "Eqtvxc"Ci tkekgpegĀ "Ci tlewnwg"FKxkukq"qh'F qy F wRqpĀ . "Lqj puwq. "  
KC"72353."WUC"

<sup>5</sup>Kpukwq"qh'Dkqvej pami { ."Xkpkwu"Vpkxgtukv{ ."Xkpkwu"NV/32479."Nkj wcpk"

<sup>6</sup>P gy "Gpi rpf "Dkqrcdu."Kuy lej . "O C"23; 5: . "WUC"

vqo cuUdckuB i o eKwHv"

"

Vj g'Ecu; "rtqvkp"ltqo "ETKURT"\*Enwngt gf "Tgi wrctn{ "Kpvturceg"Rcnlptqo le"Trg gcvu+/Ecu"ETKURT"Cuuqekcvf +"  
dcevtkn'f ghpgug"u{ungo u'j cu"dgpp"cf qr vgf "cu"tqdwu"cpf"o wnkkegyvf "i gpqo g"gf kkp i "vqqr0Vj g"Ecu; "TP C"i wkf gf"  
F P C"gpf qpwegcug"ecp"dg"fk gevfg"vq"ergcxg."plenlqt"dkpf "c"ur gekke'ukg"lp'y g"ej tqo quqo cn'F P C"lwu'd{ "ej cpi kpi 'y g"  
i wkf g"TP C"ugs wpeg0'Ecu; /dcugf "vqnu"j cxg"dgpp" wugf "vq"gf k"i gpqo le"F P C."o qf wrcv"i gpg"gzr tguukq."xkucrk g"  
i gpqo le"mek'lp"egmu"cpf "f geo kpcv"pwegqvk g"dcugu'J qy gxgt. "hqt"Ecu; "vq"dkpf "c"i kxgp"vti gv"u"uj qt v'pwegqvk g"  
ugs wpeg'o qvkh"vgt o gf "RCO."ku'tgs wkt gf 0Vj ku"RCO"eqpustclp'cu'y gni'cu'lpuwHkekgp'ur gekkekv' "ctg'o clqt "qduwercu"ht"  
Ecu; "i gpqo g"gf kkp i 0Vj wu"cpn{uku'qh'pcwt cn'Ecu; "qt vj qm i u'eqwrf "qHgt"cp"ket gcugf "f kxgtukv{ "qh"RCO"ugs wpegu"cpf"  
dkqej go kecnr' tqr gt vku'y j lej "o c{ "dg"dgpgHkekn'v"i gpqo g"gf kkp i "cr r'kecvkpu0"

Ecu; "pwegcugu"ctg"cdwpcp'lp"o letqdgu0Vq"gzr mtg"y ku'rti g"vpej ctcevtk gf "f kxgtukv{ "qh'Ecu; "qt vj qm i u"y g"  
guvdrkuj gf "c"r j {m i gp{/i wkf gf "dkqkphqto cve"ugrgekq"err tqcej "cpf"fxgnr gf "dkqej go kecn'uet ggu'dcugf "qp"egm'ht gg"  
tgeqo dkpcp'rtqvkp"gzr tguukq"cpf "kpvgtqi cvkq"qh'r cuo k"rkdctkgu"eqpvcvlp i "tcpf qo k gf "RCO"ugs wpegu"ht"y g"  
tr kf "ej ctcevtk cvkq"qh'pqxgn'Ecu; "rtqvkpu"cpf "kf gpvHkecvkq"qh"RCO"tgs wkt go gpv0I wkf g"TP Cu"ht"gej "Ecu; "  
qt vj qm i "y gt g"f guki pgf "kp"ukkeq" d{ "kf gpvkh{ kpi "r wcvkxg"t cet TP C"\*tcpu/cevxcvpi "ETKURT"TP C"+eqf kpi "tgi kqpu"lp"  
t gur gevkg'pcvkg'mek0Vj g"gzco kpgf "ugv't gxgrgf "pwegcugu'y cv'gzj kdkc'y kf g'tcpi g"qh'f kpkvkvxg'V/. 'C/. 'E/"cpf "I /tlej "  
RCO"r tghgt ppegu."tcp i kpi "ltqo "y q"v"o qt g"y cp"htw'pwegqvk gu."cu'y gni'cu'i gpgtcv'uci i gt gf /gpf "dt gcm'qt"tgs wkt g"  
m i gt "ur cegt u"v"hpvkvq"tqdwu{0Qwt "t guwu"lpf kecv'j cv'y g'pcwt cn'f kxgtukv{ "qh'Ecu; "qt vj qm i u'r tqxkf gu"cu'qwt eg"qh"  
xctkqu"RCO"tgeqi pkkq"ugs wpegu"cpf "qj gt"r qvkvcm{ "f gukt cdrq"r tqr gt vku'y cv'o c{ "dg" wugf "vq"gzr cpf "y g"i gpqo g"  
gf kkp i "vqqr0qz0"

**U P VJ GUK'CPF 'K XGUVK CVKQP 'QH'QNK QO GTK GF 'CTQO CVK' "**  
**CO KPG'HQT'NCEE CUG'CE VKXK[ 'CUUC[ "**

Lwukpcu'Dcdkpcu<sup>3</sup>. 'Lgtkec'Ucdqk<sup>4</sup>. 'Kpi c'O cvkq-{v<sup>3</sup>"

<sup>3</sup>Ugevq't'qh'Cr r rkgf "Dkqecvnt'uku. 'Kpukwng'qh'Dkqvej pqrqi { . 'Nkht'Uelgpegu'E gprvt. 'Xkrpkwu'Wpkxgtukv{ . 'Nkj wcpk' "

<sup>4</sup>F gr ctvo gpv'qh'Dkqvej pqrqi { . 'Lqfgh'Ughcp'Kpukwng. 'Urxgpk' "

Lwukpcu'DcdkpcuB i o e'xv'w'

"

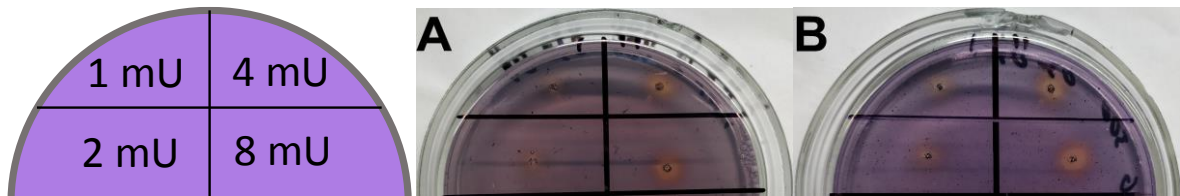
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Vj qwi j v'j g' { g'ctu'qh'k'p'x'g'uki'cvkpi "xct'k'q'w'u' "r'ee'cugu. "c' "n'v' "qh'k'p'ht'o'cvkqp"j'cu'c'it'g'cf { "d'ggp'ce'ewo'w'v'v'f' <'t'gf'qz' " r'q'v'p'v'k'ri' "gp| { o g' "u'q'w'eg'u' "t'g'q'ti'c'p'k' cvkqp"gp'gti'k'u. "ec'vnt'vle'o'gej'cpkuo . "g'v'e'0'J'qy'g'x'gt. "c'p'i'k'ng'cr' r' r'ek'cvkqp'qh' "r'ee'cugu' "ku'j'k'p'f'g'gf' "d { "v'j g' "w'p't'g'u'x'ng'f' "f' t'cy' d'c'emi' "u'w'ej' "cu' r' q'q't' "u'cd'k'k'v'f' . "eqo' o' g't'ek'ni'w'p'c'x'c'k'c'k'v'f' . "r'eni'qh'g'h'k'ek'p'v'g'z'r' t'g'u'k'q'p' " u' { u'go' u' "h'qy' "k'o' o' q'd'k'k' cvkqp" { k'rf' u' "g'v'e'0'

Qpg'qh'v'j g' "uj'qt'v'eqo'kpi' u' "h'q't' "f'k'ue'q'x'gt'k'pi' "r'ee'cugu' "y'k'j' "p'gy' "c'p'f' k'q't' "p'q'x'g'ri'g'c'w'g'u'ku'c' "r'eni'qh' "u'wdut'cvg'u'w'k'c'd'ng' "h'q't' " j'ki'j' /v'j' t'q'w'i'j' r'w'w'et'g'p'k'pi' "c'p'f' "h'w'p'ek'q'p'c'ri'c'p'c'ri' u'ku'0'E'w't'g'p'v'f' . "v'j g' "o' q'u'v'eqo' o' q'p' "eqo' r'qwp'f' u' "w'ug'f' "h'q't' "r'ee'cugu' "h'w'p'ek'q'p'c'ri' "c'p'c'ri' "uku' "ct'g' "4.4) /c| k'p'q' /d'u'k' \*5/ g'v'j { n'lg'p| q'v'j'k'c| q'ri'k'p'g' /8/ u'w'r'j' p'k'le' "c'ek'f' "v'p'f' g't' "v'j g' "v'k'k'c'ri' "p'co' g' "CDVU" c'p'f' "6/ ]4/ ] \*5.7/ f'k'o' g'v'j' qz { /6/ qz'q' { e' m'j' g'z'c' /4.7/ f'k'p' /3/ { r'k'f' g'p'g' +o' g'v'j { n'j' { f' t'c| k'p' n'0' g'v'j { r'k'f' g'p'g' /4.8/ f'k'o' g'v'j' qz { e' { m'j' g'z'c' /4.7/ f'k'p' /3/ q'p'g' "h'p'q'y' p' "cu' "u' { t'k'pi' c'ri' c| k'p'g' ]4.5\_0'U' r' g'v't'q'r'j' q'q'o' g'v'k'le' "c'ev'k'k'v'f' "cu'uc' { u' "y'k'j' "v'j' g'ug' "u'wdut'cvg'u' "i'k'g' "c'ee'g'v'c'd'ng' "t'g'u'w'u' . "d'w' "v'j' g'ug' "eqo' r'qwp'f' u' "j' c'x'g' "r' q'q't' "u'cd'k'k'v'f' . "h'qy' "r' g'ek'h'ek'v'f' "c'p'f' "c't'g' "t'c'v'j' g't' "g'z'r' g'p'uk'g'0'

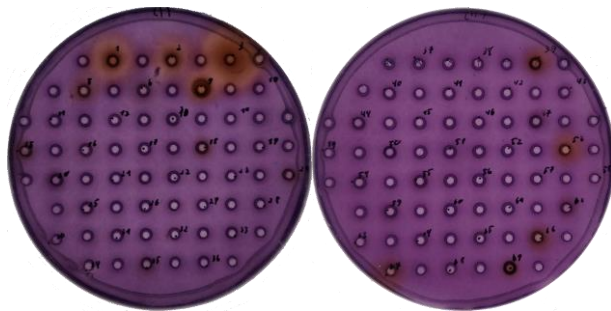
D { "q'w' "k'p'x'g'uki'cvkqp. "y' g' "r' "t'g'ug'p'v'c' "p'gy' "u'wdut'cvg' "h'q't' "r'ee'cugu' "c'ev'k'k'v'f' "u'et'g'p'k'pi' "q'p' "j'ki'j' /v'j' t'q'w'i'j' r'w'w'ci'ct' /r' "r'v'g'u'0' "Vj'ku' "eqo' r'qwp'f' "y'cu' "u' { p'v'j' g'uk'gf' "w'ukpi' "t'g'r'x'c'p'v'f' "h'qy' "r' "t'k'eg'f' "ct'qo'cvk' "f'k'o'k'p'g' "o' "P. P/ f'k'o' g'v'j' { n'r' /r'j' g'p' { n'p'g'f'k'o'k'p'g' "f'k'j' { f' t'q'ej' m'k'f' g'0'Vj' g' "r'v'w'g't' "u'wdut'cvg' "y'cu' "v'g'v'f' "q'p' "u'wdut'cvg' /ci'ct' /r' "r'v'g'u' "y'k'j' "eqo' o' g't'ek'ni' "c'x'c'k'c'd'ng' "r'ee'cugu' "P'q'x'q| { o' "73225"ht'qo' "Cur'gti'k'm'u'q't' /g'c' "H'i 03" +c'p'f' "y'k'j' "v'j' g' "eq'm'g'ev'k'q'p' "qh' "y'k'f' "h'w'p'i' k'r' t'q'v'k'p' "g'z'v'c'ew' "r' t'q'x'k'f' g'f' "d { "L'q'f'g'h' "U'gh'c'p' "K'p'uk'w'ng' "H'i 04" +0'Vj' g' "t'g'u'w'u' "k'p' "o' q't'g' "f' g'v'k'ri'y' k'ni'd'g'r' "t'g'ug'p'v'f' "f'w'k'pi' "v'j' g' "r'q'v'g't' "u'g'u'k'p'0'

"



**H'i 030** Vj g'co' q'wp'v'qh' "r'ee'cugu' "gp| { o'cvk' "c'ev'k'k'v'f' "w'p'ku'w'ug'f' "h'q't' "t'g'ev'k'q'p' "q'p' "u'wdut'cvg' /ci'ct' /r' "r'v'g'u' "y'k'j' "f'k'h'gt'g'p'v'f' "eq'p'eg'p'v'c'v'k'p'u' "qh' "v'j' g' "u'wdut'cvg' <C' "o' "6'22" O =D' "o' "6'722" O' 0'

"



**H'i 040** Vj g' "t'g'u'w'u' "qh' "u'et'g'p'k'pi' "h'q't' "r'ee'cugu' "c'ev'k'k'v'f' "y'k'j' "v'j' g' "eq'm'g'ev'k'q'p' "qh' "y'k'f' "h'w'p'i' k'r' t'q'v'k'p' "g'z'v'c'ew' "q'p' "ci'ct' /r' "r'v'g'u' "y'k'j' " : 52" O "u'wdut'cvg'0'

"

[3\_ 'L'q'p'gu' "U'0'0' "U'q'no' q'p' "G'0'U'G'g'ev't'q'p' "t'cp'uhgt' "c'p'f' "t'g'ev'k'q'p' "o' g'ej'cpkuo' "qh' "r'ee'cugu' "0'E'g'w'v'c't' "c'p'f' "O'q'rg'ew'v'c't' "N'k'g' "U'el'g'p'egu' "94. " : 8; / : : 5" \*4236-0'

[4\_ "E'c'ni' "J' 0' "R. "O' "A'ng' "K'J' k'v'q't' { . "q'x'g't'x'lg'y' "c'p'f' "c'r' r'ek'cvk'p'u' "qh' "o' g'f'k'v'g'f' "r'ki' p'q'n' "v'e' "u' { u'go' u' "g'ur' g'ek'c'ni' "r'ee'cugu' /o' g'f'k'v'q't' /u' { u'go' u' "N'k'i' p'q| { o' i' / r' t'q'eg'u' +0' "L'q'w't'p'c'ri' "qh' "D'k'q'v'ej' p'q'r'qi' { "75. "385/424" \*3; ; 9-0'

[5\_ "N'w'ecu' "O' 0' "H'0' g'v'c'ri' "U'k'o' w'v'v'k'pi' "u'wdut'cvg' "t'g'eq'i' p'k'k'q'p' "c'p'f' "q'z'k'f'cvk'q'p' "k'p' "r'ee'cugu' <'ht'qo' "f' g'uet'k'v'k'p' "v'q' "f' g'uk'i' p'0' "L'q'w't'p'c'ri' "qh' "E'j' g'o' k'ec'ni' "Vj' g'q't' { "c'p'f' "E'q'o' r'w'v'k'q'p' "35. "3684/3689" \*4239-0'

**J [ FTQI GN'DCUGF 'O KETQ'CI ICI EN'TGHGTGPEG'GNGETVF GU'  
S WEMRTQVQV[ RKPI 'QHT'GHGTGPEG'GNGETVF GU'**

Glx {f cu' Cpf tkwmpku<sup>3,4</sup>. 'O ctkwu' Dwnngxleku<sup>5</sup>

<sup>3</sup>Hcewm\ 'qh'Ej go kut { 'cpf 'I gquelpegu. 'F gr ctwo gpv'qh'Rj { ulecn'Ej go kut { . 'Xlrpkwu' Wpkxgtuk\ . 'Xlrpkwu. 'Nkj wcpkcO'  
Nkj wcpkcO'

<sup>4</sup>Ncdqtcvt { 'qh'P cpqvej pqmji { . 'Egpyt 'hqt'Rj { ulecn'Uelgpegu'cpf "Vgej pqmji { . 'Xlrpkwu. 'Nkj wcpkcO'

<sup>5</sup>Kpukwwg'qh'Dkqej go kut { . 'Nkhe'Uelgpegu'Egpyt. 'Xlrpkwu' Wpkxgtuk\ . 'Xlrpkwu. 'Nkj wcpkcO'  
glx {f cu' Cpf tkwmpkuB hno eOw'

Grgextqej go lecn'o gcuwtgo gpw'ctg'dcugf "qp'yj g'eqpvtqnlqt'qdugtxcvqp'qh'r qvqpvkn'cv'yj g'y qtnkpi "grgextqf g. 'hqt' 'yj cv' r wtr qug'cp'grgextqf g'qh'eqpucpvr' qvqpvkn'ku'pggf gf OTghgtgpeg'grgextqf g'\*TG+j cu'c'hkzgf 'r qvqpvkn'cpf 'yj ku'r qvqpvkn'f qgu' pqv'ej cpi g'cu'ewtgpv'hny u'yj tqwi j "kO'Qpg'qh'yj g'o quv'r qr wct'TG'ku'Ci ICI En'grgextqf g'OCi ICI En'TG'ku'qh'ngp'wugf 'hqt' "grgextqej go lecn' o gcuwtgo gpw' f wq" vq" uko r rlek\ . " kpgzr gpukxg" f guki p. " cpf " pqpqzle" eqo r qpgpwo' Vj gug" TG" ctg" eqo o gtekm\ " cxckrdng" kp" xctkqwu" uj cr gu. " uk\ gu. " lwpevqpu" cpf " qyj gt" r ctco gygtuO' J qy gxgt" y j gp" f gxgnr kpi " cp" grgextqej go lecn'f gxleg'r tqv\ r gu'yj gtg'ecp'tkug'pgeguuk\ 'vq'o cng'wpeqpxgpvqpcn'uj cr g'qt'uk\ g'TGO"

J gtg'y g'gizr nqtg'cr r rlecdrk\ 'qh'TG'o go dtcpg'r tgr ctvqpp'itqo 'r qn\ cet { no kf g'j { f tqi gn'F wtkpi "gizr gtko gpvki " y g'qdugt xgf "cm quv'gzegngpv'grgextqej go lecn'r gthqto cpeg'qh'okp'j qwug'o cf g'TG'eqo r ctgf 'y kj 'ugxgtr'eqo o gtekm\ " cxckrdng" qpguO' Vj g" grgextqf g" r qvqpvkn' f k'htgpeg" y cu' 62'o X" xgtuwu" yj g" ecnqo gn' grgextqf g" cpf " 9'o X" xgtuwu" yj g" eqo o gtekn'Ci ICI En'grgextqf g'O'Qp'yj g"qyj gt"j cpf "r qn\ cet { no kf g"o go dtcpgu'j cxg"r qtqwu'o letq'pccq'utwewtg"y kj " xct { kpi " r qtg'uk\ gu. " y j lej "y cu'qdugt xgf "y kj "uecpkpi "grgextqf"o letqeqr {O'Qdugt xgf "r qtqwu'utwewtg" f qgu'pqv'r gto kv' rncni g'qh'kppgt'ej ntkf g'kqpu. "cu'ej ntkf g'hwz'y cu'gxcn'v'gf ORgto gcdk\ 'vq'ej ntkf g'kqpu'f qgup'o cng'r qn\ cet { no kf g" j { f tqi gn'cp'kf gcn'o go dtcpg'kp'nqpi 'vgo "gizr gtko gpwO'Vj qwi j "cu'o go dtcpgu'ctg's wem\ 'cpf "gcuk\ 'r tgr ctgf 'kv'ku'kf gcn' ecpf kf cvg'hqt' s wem'grgextqej go lecn'u\ ugo "f guki pki "cpf "vgvki "gxgp"r quukdng"cr r rlecdrk'kp" f kur qucdng'qpg'wko g'wug" f gxleguO'

**CE VIKQP 'RQVGP VIKN'RTQRCI CVIKQP 'XGNQEKV[ ''  
 KP 'NITELLOPSIS OBTUSA''**

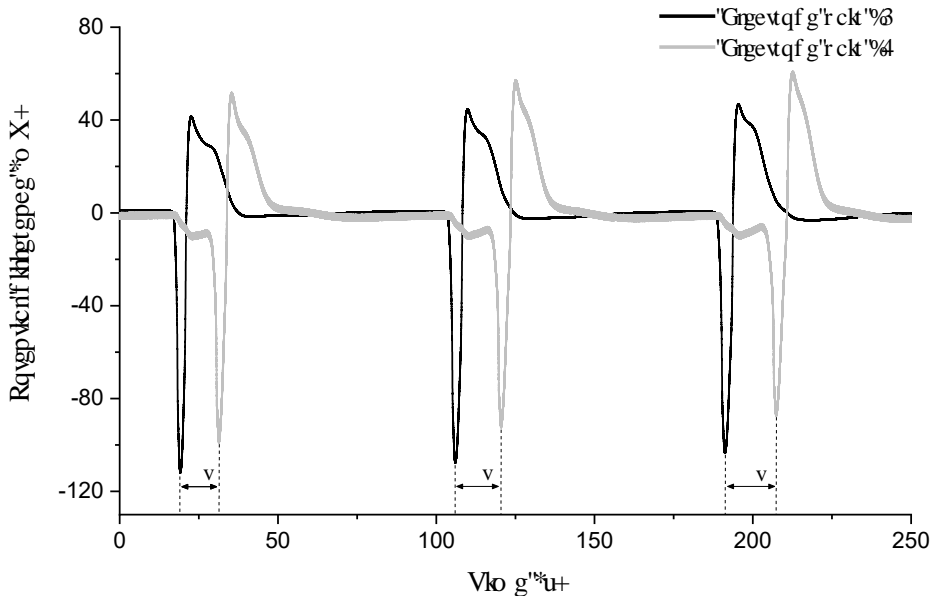
**Gi ng'Rnwckvg<sup>3</sup>. 'Xkro cpvcu'Rwr nku<sup>3</sup>. 'kpf tg'Ncr gknckvg<sup>3</sup>. 'Xkro c'Mkuplgtkpgg<sup>3</sup>. ''**

<sup>3</sup>F gr ctvo gpv'qh'P gwtqdkmqi { 'cpf 'Dkqr j { uleu. 'Xkpkwu'Wpkxgtuk{. 'Xkpkwu'Nkj wcpkc"  
gi ng'RnwckvgB i o eOmwf OvwOw"

"

Grgvteknlo r wngu'lp'r npvu'ecp'eqf g'cpf 'tcpuht'lphto cvkqp'cdqw'xctkqwu'gpxktqpo gpwne'ej cpi gu'cpf 'eqpf kskqp' cp'er r tqr tlcvg'tgur qpug'j3\_0l gpgtcvkqp'qh'vj gug'ko r wngu'lp'r npv'egm'j gcxkl' f gr gpf u'qp'vj g'r'ncuo c'b go dtcp'g'ugrgevkg' r gto gcdkkl' 'q'f'ctvewat'kpu'cpf 'vj gkt' i tcf kcpv'qp'dqv' 'ukf gu'qh'vj g'o go dtcp'g'0Wuwcm'. Ec<sup>4</sup> 'eqpegpvcv'kqp'lp'vj g'e { vquqnl' ku'ngr v'my. 'y j gtgcu'ku'kpetgcug'ecwugu'vj g'f gr qrtk'cvkqp'qh'vj g'o go dtcp'g'r qv'gpcn'cpf 'kpkckv'gu'cev'kqp'r qv'gpcn' i gpgtcvkqp'j4\_0'J qy gxgt. 'pqv'o wej 'ku'npqy p'cdqw'vj g'v'cpuo ku'kqp'ej ctcev'gt'k'leu'qh'vj gug'ko r wngu'uwej 'cu'vj gkt' r tqr ci cvkqp'xgnckvg' 'cpf'vj g'eqo r qwpf u'r qv'gpcn' 'cthgev'kpi 'vj go 0'

Y g'wugf "cp"gzv'cegmv'at'g'eqtf kpi "u{vgo "j5\_"d{ "r'nekpi "cp"qdrupi "e{r'kpf gt/uj cr gf "Pkgmqr'uku'qdwuc"i kcpv' kpvtpqf'c'egm'c'qpi "c'ej co dgt'y kj "grv'ekcm' "ku'cv'gf "eqo r ctvo gpw'cpf "kz'kpi "y q'r qv'gpcn' f kht'gpeg'teqtf kpi " grv'eqf g'r'cku'0'npqy kpi "vj g'gzcev'f'kucpeg'dgy ggp'vj gug'r'cku'cpf "o gcuwt'kpi "vj g'v'ko g'c'r qv'gpcn'v'qam'v'q'r tqr ci cvg' ht'qo "qpg'r'ck'v'q'cp'vj gt"\* v'ugg'Hi 03+'xgnckvg' 'qh'ep'cev'kqp'r qv'gpcn'r tqr ci cvkqp'ecp'dg'gxcn'cv'gf 0'Gzr g'klo gpw'y gt'g' r gth'qto gf 'wukpi 'y q'v'f' r gu'qh'v'ko w'k'lp'32'o k'p'0'k'p'v'gt'x'cnu'o'grv'ekn'ep'f'qh'c'ny 'vgo r gtcw'g'u'q'w'k'p'. 'cpf' 'y q'v'f' r gu'qh' o gf'kwo "o'ct'w'k'el'cn'r'qpf'y cvg' "CRY + "cpf "c'u'q'w'k'p'qh'Ec<sup>4</sup> 'ej c'p'p'gn'd'm'q'ngt'x'g'ter co k'i'208'o O '+o'c'eqo r qwpf 'vj cv' o ki j v'cth'gev'vj g'ko r wngu'r tqr ci cvkqp'xgnckvg'0'



**Hi 030**Rtqr ci cvkqp'qh'vj tgg'ur qpvcpgqwu'cev'kqp'r qv'gpcn't'gi k'v'gt'f'd { 'y q'grv'eqf g'r'cku'0' v'o'vj g'v'ko g'c' r qv'gpcn'v'qam'v'q'r tqr ci cvg'ht'qo 'vj g'ht'v'grv'eqf g'r'ck'v'q'vj g'ugeqpf 'qpg'0'

T'gu'w'u'uj qy gf 'vj g'f { pco leu'qh'cev'kqp'r qv'gpcn'r tqr ci cvkqp'xgnckvg' "lp'v'ko g'c'lp'eqpvt'qnl'v'q'w'k'p'. 'tgi ctf ng'u'qh' v'ko w'u'u'o qf'ckl' 'vj g'xgt { 'ht'v'v'ko w'cv'gf 'r qv'gpcn'r tqr ci cvg' 'y kj 'vj g'i tgc'v'gu'xgnckvg' 'cpf' 'y kj 'gcej 'i kxgp'v'ko w'u'u' k'f'getgcugf 'v'p'v'k'vj g'x'cn'v'g'v'gf'k'f'0208'o O 'xg'ter co k'lu'q'w'k'p'g'x'q'ng'f'c'v'gs w'gpeg'qh'ur qpvcpgqwu'r qv'gpcn'g'xgp'd'gh'q't'g' 'vj g'v'ko w'u'u'eq'w'f'd'g'r' t'q'x'k'f'gf 0C'ht'v'vj g'ur qpvcpgqwu'cev'k'v'f' 'eg'cugf. 'y g'q'd'ug't'x'gf 'vj cv'vj g'ht'v'v'ko w'cv'gf 'cev'kqp'r qv'gpcn' r tqr ci cvg' 'vj g'v'ny gu'y kj 'vj g'xgnckvg' 'v'ko k'rc'v'q'vj g'v'g'f'k'f' "qpg'lp'vj g'eqpvt'qnl'i t'q'w'0'Xg'ter co k'f'k'f' "p'q'v'cth'gev'vj g' cev'kqp'r qv'gpcn'r tqr ci cvkqp'xgnckvg'. 'd'w't'cv'j gt'r t'q'x'q'ng'f'ur qpvcpgqwu'r qv'gpcn' 'cpf' 't'g'f' 'vj g'egm'v'q'f' g'cv'j 0Vj g'o q't'v'ck'v' qh'egm'g'z'r' q'ug'f' 'v'q'208'o O 'xg'ter co k'ir' t'q'x'gf' 'v'q'd'g'q'h'c'322' 0'

J p'peg' 'vj g'cev'kqp'r qv'gpcn'lp'r npv'egm'r tqr ci cvg'ut'gi ctf ng'u'qh'vj j gv'j gt'k'v'ko w'cv'gf 'qt'ur qpvcpgqwu'0Vj g'xgnckvg' ' qh'v'ko w'cv'gf 'cev'kqp'r qv'gpcn'r tqr ci cvkqp'f' gr gpf u'qp'k'i'cpf' 'j qy "o cp { 'v'ko gu'k'j' cu'd'ggp't'g'eg'v'p' 'g'x'q'ng'f' 0'

j3\_0'lh'qo o "U'0'N'w'p'gt. "Grgv'ekn'li'p'cnu'cpf' 'vj g't' 'Rj { u'k'q'qi' k'ec'n'li'p'k'ht'ec'peg'lp' 'R'rc'p'u'0'R'rc'p'v' 'E'g'm'i' ( "G'p'x'k'q'po gpv'v'R'rc'p'v' 'E'g'm'i'G'p'x'k'q'p' "4229." O'c'tej '+'

j4\_ "X'0'M'kup'lt'k'p'g. 'k'0'N'cr g'kn'ckvg. 'X'0'R'w' nku. "Grgv'ekn'li'p'cnu'k'pi' lp' "P'kg'm'q'r'uku'q'd'w'uc' < "R'q'v'g'p'c'n'd'k'q'o c't'ng't'u'q'h'l'd'k'q'qi' k'ec'n'f' "cev'k'g'eqo r q'wp'f' u'0' H'v'p'v'q'p'c'n'R'rc'p'v'D'k'q'qi' { <HRD. '67'4+.'3546364'423: '+'

j5\_ "X'0'R'w' nku. 'T'0'D'w'k'uc. 'k'0'N'cr g'kn'ckvg. 'X'0'M'kup'lt'k'p'g. 'W'uk'pi' 'R'rc'p'v' 'E'g'm'i'q'h'l'P'kg'm'q'r'uku'q'd'w'uc' 't'q't' 'D'k'q'r'j { u'k'ec'n'G'f' w'ec'v'k'p'0Vj g'D'k'q'r'j { u'k'ek'u'4242+'

**CRRNĒ CVKQP 'QH'UE CPP Ē I 'GNGETVTEJ GO Ē CN'KO RGF CPEG"  
 O Ē TQUE QRG'HQT'Ē XGUVĒ CVKQP 'QH'GNGETVTEJ QRT CVKQP "  
 RTQEGUU"**

O cti ctke Rqf gt { vg."C wut c"Xcrkwpkgg."Ēpi c"i cdtkwpckg"

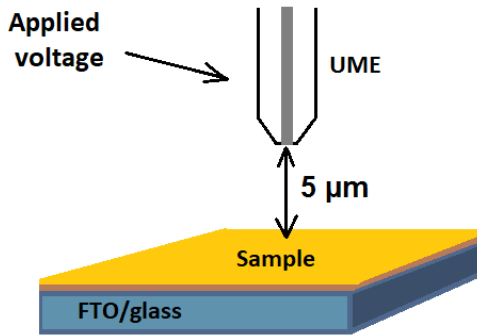
HĒewnĒ "qh'Ej go knt { "cpf "i gquekgpegu."Xkpkwu"Ŵpłxgtukf { "P cwi ctf wnt "ut046."Xkpkwu."Nkj wcpkĒ"  
o cti ctke0 qf gt { vgB ej i Ēnwf 0xw0n

Uecpłki "grĒvtqej go Ēcni'ko r gf cpeg"o letqueqr { "ku"cp"łphqto cłxg"tgugctej "o gĵ qf "ĵ cv'ecp"dg"uwgf "ĵ"uwf { "r tqeguug"ĵ cv'cmg"r mĒg"łp"r kłłpi "egm"y kj qw"fc o ci Ēpi "ĵ go 0Vĵ ku"vgu"o gĵ qf "ku"ceqo dłpcvkqp"qh"y q"ugr ctcvg" o gĵ qf u"/"uecpłki "grĒvtqej go Ēcni'ko letqueqr { "cpf "grĒvtqej go Ēcni'ko r gf cpeg"ur gevtqueqr { "Ĵ3\_0Y kj "ĵ g"j gr "qh"ce" uecpłki "grĒvtqej go Ēcni'ko letqueqr g."ko o qdktk gf "egm"ecp"dg"gzco łpgf "cv"xctkqu"j gk j w"Ētqo "ĵ gk"uwĒceg"cpf" j qtk qpcni' uecpu" ecp" dg" r gthqto gf "ĵ" f ggeve" łpf kłf wci" egm" q" "ĵ gk" j k j g" eqpegvtcvkqp" qp" ĵ g" uwĒceg" Ĵ4\_0' GrĒvtqej go Ēcni'ko r gf cpeg"ur gevtqueqr { "gs wkr o gv'cmqy u'o qpłkqłpi "qh"Ēcu'v o qłłpi "r tqeguug"łp"cp"grĒvtqej go Ēcni' u{ ugo 0Vĵ ku"eqo dłpgf "vgu"o gĵ qf "ecp"dg"cr r rĒgf "pqr"qpnĒ "ĵ"egm"dw"cmq"ĵ" dktqni Ēcni'ugpuqtu."eqttqkqp."xctkqu" uwĒcegu"cpf "ĵ gk "f ghĒew"Ĵ5\_0'

Vĵ g"r mĒo c"o go dtepg"ku"ceqo r nĒz" dktqni Ēcni' u{ ugo "tgr qpłkdnĒ" Ēqt" xkci" egm"mĒt "Ēwpevkpu"0' o go dtepgu"j cxg" ugĒvekvxg"r gto gcdktk "ĵ cv'ecp"dg"o qf kłłgf 0'Qpg"qh"ĵ g"o qf kłłcevkqp"o gĵ qf u"ku"grĒvtqr qtcvkqp"/"c"r j { uĒcni'ko gĵ qf "łp" y j Ēj "egm"ctg"gzr qugf "ĵ" c" utqpi "grĒvtĒcni' r wug"cdqw"3"mX"eo /3+."y j Ēj "tguwu"łp"ĵ g" Ēqto cvkqp"qh"vg o r qtct { "qt" r gto cpĒvr qtgu"łp"ĵ g"r j qur j qkr kf "Ē" gt"Ĵ6\_0'

Vĵ g"clo "qh"ĵ g"ug"uwf kgu"ku"ĵ" f gxnĒr "c" eqpvtqngf "o qf gn'qh"ĵ g"grĒvtqr qtcvkqp"r j gpqo gpqr"cpf"cr r nĒ "k"ĵ"ĵ g" uwf { "qh" dktqni Ēcni' u{ ugo u' włpi "ĵ g"o gĵ qf "qh" uecpłki "grĒvtqej go Ēcni'ko letqueqr { "UGEO +0' Vq"cxqkf "wpf gukt gf" f co ci g"ĵ"ĵ g" dktqni Ēcni' u{ ugo "wpf gt"uwf { "gzr gto gv'ctg"r gthqto gf "d { "ugĒvevkpi "ĵ g"qr w o cni' kncpeg"dgw ggp"ĵ g" wntco letqgrĒvtqf g"WO G"cpf "ĵ g"uwĒceg"qh"u o r nĒ"cpf" i kłłpi "c" tgrcvkgnĒ "Ēqy "r qvgpłcni"Ēqto "3"ĵ"4"X+dgy ggp"ĵ g" WO G"cpf "ĵ g" tghgtpeg"grĒvtqf g" włpi "c" ĵ tgg/grĒvtqf g" u{ ugo 0'Vĵ g"gzr gto gv'ctg"r gthqto gf "y kj "y q"Ēr gu"qh" u o r nĒu" k" r kxg" { gcu'egm"ko o qdktk gf "qp" c" Rgvtk" f kuj "cpf "k" c" r j qur j qkr kf "dkt { gt"o go dtepg" Ēqto gf "qp" c" uqkf" uwĒceg0'

Vĵ g" uĒj go g" qh" ĵ g" grĒvtqr qtcvkqp" r tqegu" ku" xkwi r kĒ gf "łp" Ēi wtg" 30' Włpi " UGEO " Ēggf dceni' o qf g." ĵ g" wntco letqgrĒvtqf g"ku" cr r tqej gf "ĵ" ĵ g" u o r nĒ0' Vĵ gp"ĵ g" grĒvtqr qtcvkqp" r tqegu" ku" dktkpi "r tqeggf gf 0' K o r gf cpeg" ur gevtqueqr { "ku" uwgf "ĵ" gxcncwv"grĒvtqej go Ēcni'ej cpi gu"qh" r kxg" { gcu'egm" dghgtg" cpf "chgt" grĒvtqr qtcvkqp0' Włpi " UGEO " uecpłki "o qf g." uwĒceg"ej cpi gu"ctg" xkwi r kĒ gf "chgt" ĵ g" grĒvtqr qtcvkqp0' k" y cu" f wgt o łpgf "ĵ cv'c" r qtg" j cu" dggp" Ēqto gf "gzcew" dgtqy "ĵ g" y qtnłpi "grĒvtqf g0'



Ēi 030Uej go g"qh"grĒvtqr qtcvkqp" r tqegu" włpi "UGEO 0'

GrĒvtqr qtcvkqp"ku"ct gcf { "dktkpi "uwgf "łp"xctkqu"Ēgrf u."uĒj "cu"o gf ĒkĒp."i gpg" gpi łpggtłpi ."qt"ĵ g"Ēqf "łpf wnt { 0' Cnĵ qwi j "ĵ g"r tqegu"ku"j k j nĒ "cr r rĒcednĒ."k"ku"u knt cpf qo "cpf "łpeqo r nĒg" eqpvtqncdnĒ"Ĵ7\_0Uq."ĵ g"i qci'qh"ĵ g"ug"uwf kgu" ku"ĵ" f gxnĒr "c" vcti gvf "grĒvtqr qtcvkqp" r tqegu"o qf gn"y kj "i qf "ghĒkĒp { "cpf "gcu" { "r gthqto cpeg0'

Vĵ ku"r tqłĒv"j cu" tgegkxgf "Ēwpf Ēpi "Ētqo "ĵ g" Gwtqr gcp" Uqekni" Ēwpf "r tqłĒv"pwo dgt"Ĵ2; 050NO V/M/934/44/2267\_ "wpf gt" c"i tcpłci tgg o gv'v kj "ĵ g" Tgugctej "Eqwpeki'qh" Nkj wcpkĒ" NO VNV-0'

Ĵ3\_ "O qtnxgpcskg"o "Xknpkepg."Ĵ0"Xcrk plĒp ."C0"RgtqłĒp."Ĵ0" Tco cpcxkku."C0J { dktk "u{ ugo "dcugf "qp"Ēcu"Ēqwtłgt "tcpułqto "grĒvtqej go Ēcni' ko r gf cpeg"ur gevtqueqr { "eqo dłpgf "y kj "uecpłki "grĒvtqej go Ēcni'ko letqueqr { "Eqo o wpevkqp": 5."3326"334."%4239-0'

Ĵ4\_ "Uvp."R0"NĒhqi g."Ĵ0Q0'O kntk."O 0X0'uecpłki "grĒvtqej go Ēcni'ko letqueqr { "łp"ĵ g"43uĒgpw { "Rj { uĒj go 0Ej go 0Rj { u0; .": 246; 45."%4229-0'

Ĵ5\_ "F cpłgn"O." "O letq/"cpf "P cpqr cvgtłpi " Włpi " Uecpłki " GrĒvtqej go Ēcni'ko letqueqr { 0'uecpłki " GrĒvtqej go Ēcni'ko letqueqr { "Ugeqf "Gf kłłp." 6: ; 6746."%4234-0'

Ĵ6\_ "T0Uco r Ēk" TgxgtukdnĒ grĒvtĒcni' dgtcmf qy p"qh"ĵ g"gzekdnĒ"o go dtepg" qhc" Tcpxłgt" p qf g0Cp0Cecf 0'Dctuk0'EłĒu052."79685"%3; 7: :0'

Ĵ7\_ "C0" "Xcrkwpkgg."Ĵ0' cdtkwpckg."O 0'Rqf gt { vg."C0'Tco cpcxkku"0' GrĒvtqr qtcvkqp"qh" c"j { dktk "dkt { gt"o go dtepg" d { "uecpłki "grĒvtqej go Ēcni' o letqueqr g0'DktqgrĒvtqej go knt { "%4242-0'

# TOWARD TO AN ENZYMATIC BIOFUEL CELL POWERED BY GLUCOSE

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To replace energy production from fossil fuel or nuclear energy, researchers have put a lot of effort into developing fuel cells (FCs) - electrochemical devices that convert chemical energy into electrical energy by oxidizing fuel at the anode and reducing oxidant at the cathode using noble metal catalysts and supplying electrical energy until sufficient fuel and oxidant are available [1]. Biological fuel cells (biofuel cells, BFCs) are devices capable of directly transform chemical energy to electrical energy via electrochemical reactions involving biochemical pathways. These devices have received considerable attention in the last few decades due to their potential use as alternative energy sources and the advantages over conventional fuel cells. BFCs use enzymes as catalysts, alone or within an organism, and tend to operate under mild conditions. Therefore, they are an attractive alternative when it is not possible to use high temperatures or where harsh reaction conditions are undesirable. Enzymatic fuel cells (EBFCs) are the sub-class of FCs relying on purified redox enzymes to achieve electrocatalytic reactions [2]. EBFCs are very attractive due to high specificity of enzymes to their respective substrate, high catalytic activity at mild conditions and variety of enzymes. Moreover, enzymes immobilized on the electrode surface allow membrane-less configuration of FCs, opening up possibility of developing miniature EBFCs [3]. Researchers have focused on development of EBFCs that could supply energy using fuel oxidation, such as blood glucose, at the anode, and reduction of O<sub>2</sub> or H<sub>2</sub>O<sub>2</sub>, which is formed during enzymatic oxidation of glucose, at the cathode [4]. Glucose and O<sub>2</sub> are an ideal source of fuel and oxidizer because they are readily available in all organic tissues and can be constantly replenished in biological fluids during metabolism, [5]. EBFCs that use enzymatic reactions on both electrodes have also been researched and published over the past decade. It is likely that in the future, miniature membrane-less EBFCs will supply energy to implantable medical devices and will also be used as self-powered biosensors, which, using an analyte as a fuel, are able to supply themselves with energy, and at the same time determine the amount of analyte [6]. However, for this EBFCs must produce enough energy and have a long lifetime. Therefore, the development of high-performance EBFC is still promising.

The aim of this work was to develop a biocathode for a glucose powered EBFC. The proposed biocathode was based on a graphite rod electrode with an electrochemically coated layer with electrocatalytic properties for H<sub>2</sub>O<sub>2</sub> reduction and a layer of a conjugated polymer with carboxyl functional groups. Carboxylic groups allowed covalent immobilization of an enzyme that catalysed the reaction between glucose and dissolved O<sub>2</sub> and produced H<sub>2</sub>O<sub>2</sub>, which was electrocatalytically reduced on the biocathode surface and caused an increase in the reduction current. The basic scheme of the biocathode and the principle of operation are shown in Fig. 1.

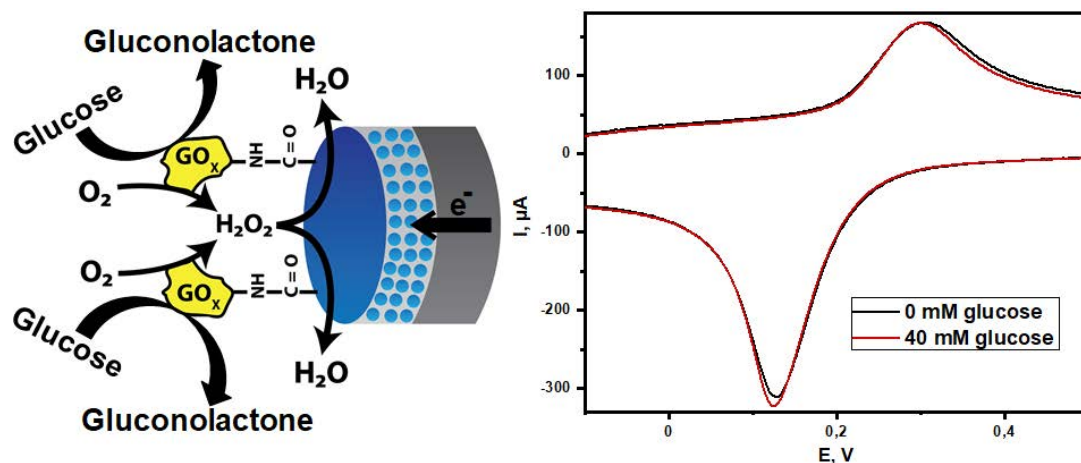


Fig. 1. The basic scheme of the biocathode and the principle of operation

## Acknowledgment

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# CEVKQP 'RQVGP VKCNU'QH'RNCP VU'GHHGE VU'QHEJ NQT'K'G' EJ CPPGNU'K'J KDKVQP''

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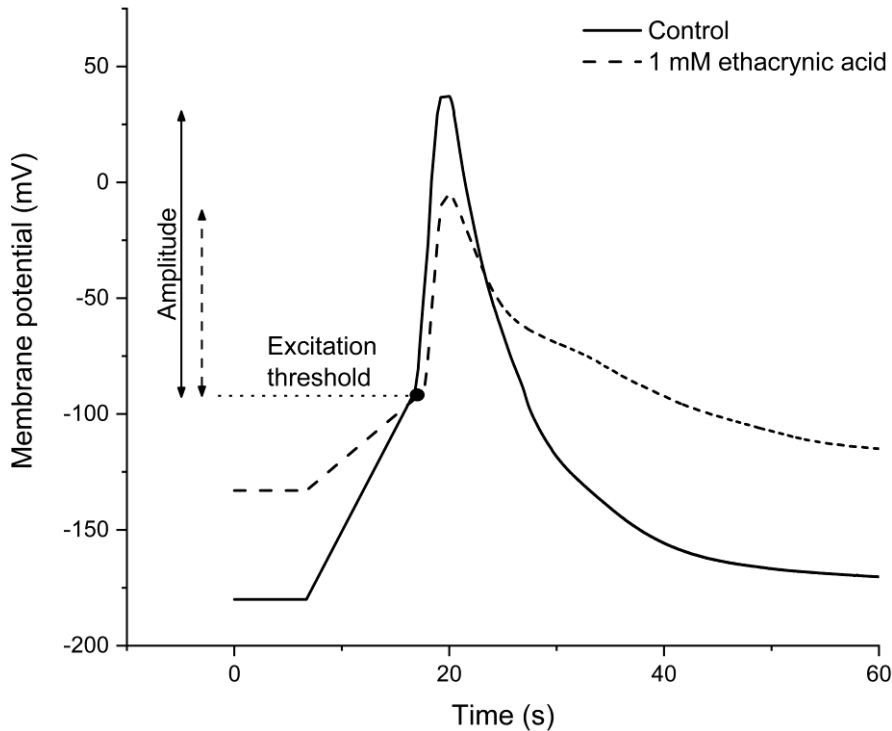
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Nkj wcpk"

dgpcu'wfo o ctunkuB i o e'wfw'kwfo'

Kp'r rcpv'egmu."cevkqp'r qvqpcnu"CR+"dgi kp'y kj "cp'lpetgcuq'qh'e{ vqr rcoo le"Ec<sup>4+</sup>"eqpegpvcvkqp."eqpugs wgpv'v{ "vj g' En"ghmwz"xlc"ur gekhe"lqp"ej cpgnu"ku"cevkxcvgf "o"vj ku"ecwugu"vj g'f gr qmktk cvkqp"qh'egm'o go dtcpg'K'ku"fkhewa"vq" f kvkpi wkuj "Ec<sup>4+</sup>"lphwz"htqo "En"ghmwz"dgecwug"vj g{ "ectt{ "wpkf k'gevkqpcr'ewttgpv'Vq"fcvg"vj g'ej ctcevtgkvku"cpf" ucpf ctf k'gf "cuuguo gpv'qhi'kphwz"qh'Ec<sup>4+</sup>"j cxg'pqv'dggp'f guetkdgf'Vj wu"y g'wugf "gvj cet { ple'cekf "GC<sup>+</sup>"vq"dnqem'En" ej cpgnu"kp"i kcpv' Ej ctcegcgp"egm'o Vj g"ghgev'qh'3"o O "GC"uqnvkqp"qp"Phgmqr uku'qdwuc"grgetqr j { ukmqi kecn' r ctco gvtu'y g'g'gugf "wukpi "lpvtcegmvct'i rcoo'letqgrgetqf g'cpf "y q'r ckt'ewttgpv'xqnci g'erco r 'o gvj qf uo'

Hqt "vj g'htuv'wo g."kp'cf f kvkqp"vq"vj g'f getgcuq'qh'En"ghmwz"ewttgpv'wr qp"gzr quwtg'vq"GC."vj g'cngtcvkqp'qh'CR" r ctco gvtu'y g'g'f guetkdgf'CR'r gcm'htqo "vj g'wucn'r qukkxg'xcwgu'y cu'tgf wegf "vq'pgi cvkxg'qpgu."vj wu'CR"co r rkwf g" y cu'cuq'f getgcuq'f d{ "52" . "y j kg"vj g'gzekcvkqp"vj tguj qif "y cu'pqv'cngt'gf "cv'cm'o'htv'j gto qtg."f gr qmktk cvkqp"qh'vj g" o go dtcpg'tgukpi "r qvqpcnu'y kj "lpetgcuq'f ur gekhe"tgukucpeg"cpf "c"uwtr tkukpi n' "gzv'p'gf "f wcvkqp"qh'tgr qmktk cvkqp" r j cug'y cu'qdugtxgf "wr qp"gzr quwtg'vq"GC"o'vj wu'ko r rlec'vpi "lpvgt'htg'peg'y kj "qvj gt'kqp'tc'p'ur qv'v'v'ugo uo'

Uwo o ctk'kpi "ewttgpv'xqnci g'erco r "tgum'u'y g'chkt'o "vj cv'kp'r rcpv'egmu'CR"co r rkwf g'ku"f gr gpf gpv'qp"En"ghmwz'o Y g'eqpenxf g'vj cv'vj g'cevkqp'r qvqpcnu'gzekcvkqp"vj tguj qif "f qgu'pqv'f gr gpf "qp'ej mtk'f g'ej cpgnu'cevkxk{o'



Hli 030C'xgtci g'cevkqp'r qvqpcnu'qh'Phgmqr uku'qdwuc"kp"ucpf ctf "eqpf kvkqp'cpf "chgt'gzr quwtg'vq"3"o O " gvj cet { ple'cekf "p?9-o'



# STUDY OF THE INTERACTION OF HSP70 WITH UNILAMELLAR VESICLES

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Cells produce a various heat shock proteins in response to stress. 70-kDa heat shock protein (Hsp70) is one of the best known heat shock proteins. Hsp70 participates in folding and assembly of newly synthesized proteins, refolding of misfolded and aggregated proteins. Hsp70 expression is increased during stress conditions, and their function is vital for the recovery of cells after the insult [1]. Hsp70 is mainly localized in subcellular compartments, for example, cytosol, endoplasmic reticulum and mitochondria. In addition, Hsp70 is detected in extracellular space where this protein appear to play a different function from their chaperone activity [2].

Extracellular Hsp70 do not contain a consensus signal for their secretion via classical ER-Golgi compartment. Therefore, they are likely export by an alternative mechanism but the exact Hsp70 translocation mechanism across the plasma membrane remain to be elucidates.

The aim of this work was to investigate Hsp70 interaction with various compositions unilamellar vesicles. In this study, Hsp70 was added to DOPC, DOPC/Chol (60:40) and DOPC/DOPE/Chol/DOPS (20:30:20:30) vesicles solutions and the change in fluorescence intensity due to calcein release from vesicles was detected. Results show that the incubation time of Hsp70 and unilamellar vesicles was 10 min. The smallest Hsp70 concentration which disturbs the integrity of membrane was 0,25 nM. Furthermore, fluorescence intensity of calcein release was about 1.5 times bigger at higher (>2nM) Hsp70 concentrations and vesicles contained negatively charged phospholipids (Fig. 1)

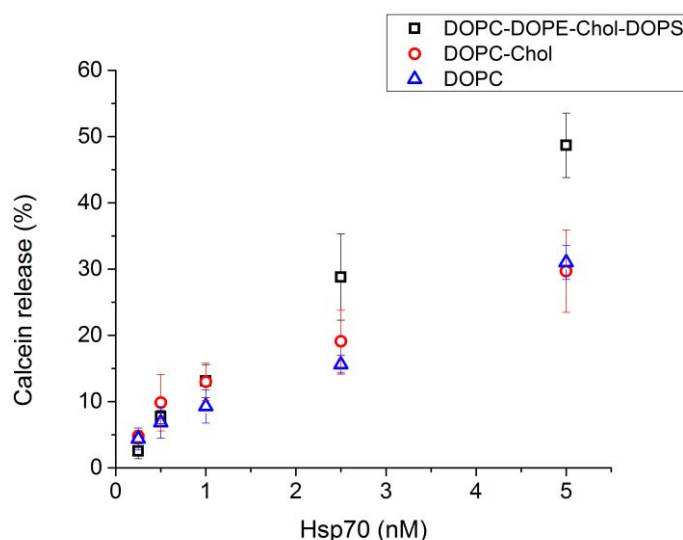


Fig. 1. Hsp70 interaction with unilamellar vesicles. Calcein release from vesicles was similar at lower Hsp70 concentrations (<1 nM). At higher (>2 nM) Hsp70 concentrations, calcein release was 1.5 times bigger in case of negatively charged vesicles. Incubation time – 10 min.

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**RPXGUVK CVKQP'QH[ GCUV'EGNN'Y CNN'DCTTKGT'HWP EVKQP U'CHVGT''  
RGH'VTGCVO GP V''**

Ct pcu'Uktm<sup>3</sup>.Telo qpf c'Egrkuk v /I gto cplgp<sup>3</sup>.Cwtgrklwu\ ko mwu<sup>4</sup>.P gtlc'fi wtcwunlgp<sup>3</sup>.Rqxkruc"  
TNo qpk<sup>3</sup>.Cnf cu'F gtxlpx<sup>3</sup>.Ct pcu'Tco cpxk kw<sup>3,5</sup>.Ucwkw'Dcrgxk kw<sup>3</sup>.Mrcwf klc'O c k v<sup>3</sup>.Lwukpc  
Mtkxckv<sup>3</sup>"

<sup>3</sup>Egpgvt'ht'Rj {ulecn'Uelgpegu'cpf "Vgej pqrqi {."F gr ctwo gpv'qh'Dkqej go kwt {"cpf "Dkqr j {uleu."Nhg'Uelgpegu'Egpgvt."  
<sup>5</sup>F gr ctwo gpv'qh'Rj {ulecn'Ej go kwt {"Hewm'qh'Ej go kwt {"cpf "I gquelgpegu."Xlpxkw'Wpkxgtuk{"  
LwukpcOmtkxckvB i o eOmf OcuOv"

*Uceej ctgo {egu'egtgxkkcg'ku'qpg'qh'vj g'o quv'cpcn'ugf "gwmet {qve"qti cpluo u'dgecwug'qh'vj gk"j ki j "r qvgrvkn'qh'wug"  
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vj ku'uwf {"vj g'cduqtr v'kp'qh'vj g'v'g'cr j gp { r j qur j qpkwo "VRR: -'kq'p'd { "vj g" { gcu'egm'y cu'uwf kq' "v'kpxgunki cvg'tgugcrlpi "  
r tqeguu'qh'vj g" { gcu'egm'f gr gpf kpi "qp"gzr gto gpv'cni'epf k'k'apu0"*

Kp'vj ku'tgugcfej "r wugf "grgevt'le'kgrif "RGH'tgi ko g'y cu'cf cr v'f "v'kpxgunki cvg'grgevt'lecn'r gto gcdkkl'cv'kp'qh'vj g" { gcu'  
egm'y kj qw'ecwukpi "cp {"f co ci g"v'vj g'egm."k'g'o quv'qh'vj g'egm'ecp"tgeqxtg'v'vj gk"pqp/r gto gcdkkl'gf "ucv'g'Vj gug"  
uwf lgu'y g'g'r gthqto gf "d {"cr r n' kpi "v'q" f k'ht'g'p'v'o gvj qf u'Q'p'g'o gvj qf "y cu'dcugf "qp"vj g"t'gugcfej "qh'vj g"VRR: "kq'p"  
cduqtr v'kp'ni'p'g'v'eu'y kj "vj g'wug'qh'r qv'p'v'qo g'v'le'kq'p'ug'v'g'v'g'grgevt'qf g."y j lej "r tqxk'f gu'f cv'cdq'w'vj g" { gcu'egm'y cni'  
r gto gcdkkl'cv'kp'Vj g'q'vj g't'o gvj qf "y cu'dcugf "qp"hw'qt'g'ue'gp'v'f { g'cu'gu'uo gp'v'vj cv'f go qp'ut'cv'g'f "vj g'r gto gcdkkl'gf "ucv'g"  
qh'vj g'egm'o go dtcpg'OT'gu'w'u'y g'g'cpcn'ugf "d {"cr r n' kpi "vj g'o cvj go cv'lecn'o qf gn'G'zr gto gp'u'j cxg'f kur r { gf "h'ko "  
eqpp'ge'v'kp'd'g'v'g'gp'vj g" { gcu'egm'r muo c"o go dtcpg'cpf "vj g'egm'y cni'tgugcrlpi "r tqeguu'ch'vgt"RGH'ko r ce'v'k'y cu'  
f g'v'gto k'p'gf "vj cv'vj g"o clp"dcttkgt'ht'vj g'w'v'cng'qh'VRR: "ku'vj g'egm'y cni'Rt'g'riko k'p'ct {"f cv'tgi ctf kpi {" gcu'egm'dcttkgt"  
hw'p'v'kp'u'k'f k'ht'g'p'v'r J "d'w'ht'g'u.'v't'g'pi vj u'qh'RGH'cpf "f v'v'v'kp'u'qh'grgevt'le'ko r wug'u'y kn'd'g'r tqxk'f gf 0'

**EJ CTCEVGTĶ CVĶQP'QH'XĶT WU/NĶMG'RCTVĶNGU'QH'  
TORULASPORADĶBRUECKII'XĶT WU'VF X/3'RTQF WEGF 'ĶP'  
SACCHAROMYCES CEREVISIAE**

Qpc'DctvĶpĶncĶ<sup>3</sup>. 'Crgmcpf tcu'Mqpxcxmxcu<sup>3</sup>. 'Lwxcu'Nc| wnc<sup>4</sup>. 'Grgpc'UgtxĶgp<sup>5</sup>. 'Ucwkcu'Ugtxc<sup>3</sup>"

<sup>3</sup>ĶpĶkwg'qh'DĶqueĶpegu 'NĶg'UeĶpegu'Egpvt. 'XĶpĶw'WpĶgtuĶf. 'NĶj wĶpĶc"  
<sup>4</sup>ĶpĶkwg'qh'DĶqveĶ pĶqĶj { 'NĶg'UeĶpegu'Egpvt. 'XĶpĶw'WpĶgtuĶf. 'NĶj wĶpĶc"  
<sup>5</sup>Ncdqtcvqt { 'qh'I gpgvĶu. 'ĶpĶkwg'qh'Dqvc { . 'P cwtg'Tgugctej 'Egpvt. 'XĶpĶw'NĶj wĶpĶc"  
qpcDctvĶpĶncĶgB i o eĶwĶf űwĶh"

" [ gcuu'ctg'y kf grĶ " wugf " o qf gn' o letqti cpluo " hqt " xĶt wu " t g u g c t e j ' O ' Ķ p " c f f k Ķ q p . " u q o g " { g c u u " q y p " f q w d r g / u t c p f g f " T P C " x Ķ t w u g u " v j c v ' c t g " e q p u k f g t g f " c u " p q p / l p h g e v Ķ q u w u l p e g " p q " p c w t c m Ķ " q e e w t Ķ p i " g z v c e g m w r t " t q w g " q h ' t c p u o k u Ķ q p " j c u " d g g p " f g y t o l p g f " j 3 \_ 0 [ g c u u ' c t g " c m q " c p " c w t c e v x g " r r e v h q t o " v q " u { p j g u Ķ g " x Ķ t w u / r Ķ n g " r c t v l e n g u " \* X N R u + " f w g " v q " p w o g t q w u " c f x c p v i g u " u w e j " c u " e c r c d Ķ k Ķ " h q t " r q u v ' t c p u r v Ķ p c n ' o q f h Ķ c e v Ķ q u . " j k i j " { k e n " q h " t g e q o d Ķ p c p v " r t q v Ķ p " c p f " u k o " r n g " e w n x c v Ķ q p " r t q e g f w g 0 V j g " o c l q t k v " q h ' x Ķ t w u / r Ķ n g " r c t v l e n g u " y g t g " d k u f p j g u Ķ g f " Ķ p " U ' e g t g x Ķ u c g " g z r t g u Ķ q p " u { u g o u " h q m y g f " d { " R 0 r c u a q t k l " c p f " J O r q f o q t r j c O Ķ " v j g " r c u v u g x g t c n { g c t u . " u k i p h Ķ c p v ' e j c p i g u " q e e w t g f " Ķ p " x Ķ t w u / r Ķ n g " r c t v l e n g u " d k u { p j g u Ķ u t c v g i l g u ' l p e n w f Ķ p i " o w n k e { g t g f " X N R u " t q f w e g f " q h ' o q t g ' y c p " q p g " v { r g " q h ' u t w e w t c n r t q v Ķ p " j 4 \_ 0 "

Ķp' r t g x Ķ q u w ' y q t m ' v j g ' f u T P C " x Ķ t w u ' V f X / 3 " q h ' v j g " R c t v Ķ k x k t f c g " x Ķ t w u ' h c o k Ķ " y c u ' k f g p v h Ķ g f " Ķ p " p q p e a p x g p v Ķ p c n i { g c u v ' V q t w u r q t c ' f g u l t w g e n k 0 " V j g " r c t v Ķ k x k t w u g u ' c t g " v { r l e c m f " k u q r v g f " h t q o " h k r o g p v q u w ' h w p i k " r t q v l q c p " c p f " r r e p v j q u u " j 5 \_ 0 " V j g " R c t v Ķ k x k t f c g " x Ķ t w u ' h q t o u " p q p / g p x g r q r g f " r c t v l e n g u " Ķ p " v j g " t c p i g " q h ' 4 7 " p o " v q " 6 5 " p o " Ķ p " f k c o g v g t 0 V j g t g h q t g . " V f X / 3 " k u " v j g " h k t u v ' x Ķ t w u " v q " d g " f k u e q x g t g f " Ķ p " p q p / h k r o g p v q u w ' h w p i k " d g r q p i Ķ p i " v q " v j g " R c t v Ķ k x k t f c g " h c o k Ķ { 0 V j k u ' u w f { " c k o g f " v q " e j c t c e v g t k g " v j g " r t q r g t v g u " q h ' v j g " e c r u k f " r t q v Ķ p " g p e q f g f " d { " V f X / 3 " x Ķ t w u 0 "

Vq' r t q f w e g " V f X / 3 " e c r u k f " r t q v Ķ p . " { g c u v " g z r t g u Ķ q p " r n u o k f u " g p e q f Ķ p i " t g e q o d Ķ p c p v " V f X / 3 " e c r u k f " r t q v Ķ p " y g t g " e q p u t w e v g f " c p f " r t q v Ķ p " d k u { p j g u Ķ u " Ķ p " U ' e g t g x Ķ u c g " j c u " d g g p " r g t h q t o g f 0 ' R t q v Ķ p " c p c n { u k u " e q p h k o g f " v j c v " V f X / 3 " t g e q o d Ķ p c p v " e c r u k f " r t q v Ķ p " d k u { p j g u Ķ u " q e e w t u " Ķ p " U ' e g t g x Ķ u c g 0 C e e q t f Ķ p i " v q " t c p u o k u Ķ q p " g r e v t q p " o l e t q u e q r { " \* V G O + " c p c n { u k u . " v j g " t g e q o d Ķ p c p v " V f X / 3 " e c r u k f " r t q v Ķ p " k u " e c r c d r g " v q " h q t o " x Ķ t w u / r Ķ n g " r c t v l e n g u " q h ' 5 2 " p o " Ķ p " f k c o g v g t 0 V q " g x c n w e v g " V f X / 3 " x Ķ t w u / r Ķ n g " r c t v l e n g u " c u u g o d n { " e c r c d Ķ k Ķ g u . " e c r u k f " r t q v Ķ p " y c u " h w u g f " y k j " v j g " h w q t g u e g p v " r t q v Ķ p " o E j g t t { " c p f " d k u { p j g u Ķ u " q h ' o q f h Ķ g f " t g e q o d Ķ p c p v " e c r u k f " r t q v Ķ p " y c u " r g t h q t o g f " Ķ p " U ' e g t g x Ķ u c g 0 ' O l e t q u e q r { " c p c n { u k u " q h " V G O " f g o q p u t c v g f " v j c v " o q f h Ķ g f " V f X / 3 " e c r u k f " r t q v Ķ p " k u " c d r g " v q " c u u g o d r g " Ķ p v q " X N R u . " v j w u " o E j g t t { " h w q t q r j q t g " f q g u " p q v " Ķ p v g t h g t g " y k j " X N R u " c u u g o d n { 0 V q " k f g p v h { " V f X / 3 " t g e q o d Ķ p c p v " e c r u k f " r t q v Ķ p " E / v g t o Ķ p w u " h e c r k Ķ c v Ķ q p " Ķ p " X N R . " k s " y c u " n c d g r g f " y k j " 8 z J k u " c h h Ķ p k v { " v i " c p f " l o o q d k Ķ g f " o g v c n { c h h Ķ p k v { " e j t q o c v q i t e r j { " r w t h Ķ c e v Ķ q p " y c u " e c t t Ķ g f " q w 0 ' R t q v Ķ p " h c e v Ķ q p " r t q h k g " c p c n { u k u " u w i i g u g f " v j c v E / v g t o Ķ p w u " q h " V f X / 3 " e c r u k f " r t q v Ķ p " k u " h e c v g f " q p " v j g " Ķ p p g t " u w t h e c g " q h " X N R 0 "

j3\_ 'T0D0Y lenpgt'gv'crl'XĶt wugu'cpf'RtĶpu'qh'Uceej ctqo {egu'egtgxĶkcg. 'Cf xcpegu'Ķp'XĶt wu'Tgugctej ': 8.'3658'4235-0'  
j4\_ 'J 0'LO'Mo' 'gv'crl' [ gcu'cu'cp'g'zr tguĶqp'u'ugo 'hqt' r tqf wĶpĶ "xĶt wu/rĶng" r ctvĶngu' y j c v' h c e v q t u ' f q ' y g ' p g g f " v q " e q p u k f g t A " N g w t u " Ķ p " C r r n g f " O l e t q d k q m j { ' 8 6 . ' 3 3 3 / 3 4 5 ' 4 2 3 8 - 0 '  
j5\_ 'G0L0XcĶpĶq'gv'crl'ĶE V X 'xĶt wu'czqppo { 'r tqhrg'<RctvĶkxkĶf cg. 'Lqwtpci'qh'I gpgtci'XĶt qm j { ' ; ; . ' 3 9 / 3 : ' 4 2 3 : - 4 0 "

**CPVQZKFCPV'CEVKKV[ 'CPF'TGUKVCEG'VQ'NQY 'RJ 'QHUVTCPU'  
DGNQPI KPI 'VQ'NCEVQDCEKNNWU'CPF'DKHFQDCEVGTKWO 'I GP'GTC''**

Iqrkc'Lci grxlekwg.'F crkc'Ek gkngpg''

F gr ctwo gpv'qh'Hqqf "Uelgpeg'cpf "Vgej pqmji {.'Mwpcu'Wpkgtukv{ 'qh'Vgej pqmji {.'Nkij weple''"  
IqrkcLci grxlekwgB mw0n'

"

Rtdkqveu"j cxg'dggp'f ghp'gf "d{ "Vj g'Hqqf "Ci tlewnwtcn'Qti cpk cvkqp'Y qtrf "J gcnj "Qti cpk cvkqp"HCQ'Y J Q+'cu" d'rxg'o ketqati cpkwo u'y j lej "y j gp'cf o l'p'vgt gf "lp"cf gs wcv'co qwpw'eqphgt"c"j gcnj "d'gpg'k'qp"y j g"j quwö"]3\_0'Rtdkqveu" dcevgtk'pqv'qpnf "j cxg'vq'dg'uchg'dw'cnq"j cxg'vq'wtxkg'lp"y j g"i cwtq'p'v'g'v'p'cn't'ce'v'eqpf k'k'q'pu'cpf "r quugu'd'gpg'h'ekcn' r tqr gt v'gu"]3\_0'Hqqf "w'r r go gpv'gf "y kj "r t'q'dk'q'v'e'u'ku't'ghgt'cdrg'hqt'eqpuwo gtu'v'j cp'w'r r go gpv'v'q'p'y kj "ecr uwgu.'v'cdrgu" cpf "q'v'j gt "f twi "h'qto u'0'Hqqf "j cu'dw'h'gt'kpi "r tqr gt v'gu'cpf "o c{ "o c'p'v'k'p"y j g'w't'x'k'c'n'q'h'r t'q'dk'q'v'e" dcevgtk'f w'kpi "r cuuci g" y j tqwi j "y j g"i w"]4\_0O qt'g'x'g't.'ut'ckpu'y kj "ut'qpi "h'w'p'v'k'p'cn'r tqr gt v'gu'lp'cn'f kpi "cp'v'k'z'k'f'cp'v'cpf "cp'v'k'o ket'q'd'k'c'n'c'v'k'x'k'v" y qwf "dg'f'g'uk'cdrg'hqt'f'g'x'g'r kpi "p'q'x'g'n'h'w'p'v'k'p'cn'r'h'q'q'f "w'r r go gpv'gf "y kj "r t'q'dk'q'v'e"o ketqati cpkwo u'0J qy g'x'g't."f'w'g'v'q" f'k'h'g't'gp'v'r t'q'dk'q'v'e" dcevgtk' "r tqr gt v'gu."q'p'g'q'h'y j g"o quv'gu'g'p'v'k'c'n'h'c'v'q'tu'c't'g'y j g'w'g'r'v'k'p'q'h'y j g"r tqr gt "e'w'w'w'g'u"]5\_0'Vj g" g'x'c'w'v'k'p'q'h'r q'v'p'v'k'c'n'r t'q'dk'q'v'e" dcevgtk'hqt'r t'q'dk'q'v'e"r tqr gt v'gu'y kj "y j g'r q'v'p'v'k'c'n'r r' n'c'c'v'k'p'hqt'h'w'p'v'k'p'cn'r tqf w'eu'cu" w'r r go gpv'ku'i tqy kpi "pqy cf c{u"]6.7\_0

Vj g'clo "qh'y ku'uwf { "y cu'v'q'g'x'c'w'v'g"r t'q'dk'q'v'e"ej ctcevgtk'v'eu"lp'x'k't'q"uwej "cu't'g'uk'v'c'p'eg"v'q"m'y "r J "cpf "d'k'g"ucnu" cpf "cp'v'k'z'k'f'cp'v'c'v'k'x'k'v"qh'eqo o g'tek'c'm'f "c'x'c'k'c'd'rg'ut'ckpu'd'g'r'q'pi kpi "v'q"N'c'v'q'd'c'c'k'm'u'cpf "D'k'h'f'q'd'c'c'v'g't'k'w'o "i g'p'g't'c'0

Vj g'lp'x'k't'q"t'g'uk'v'c'p'eg"qh"; "N'c'v'q'd'c'c'k'm'u'cpf "7"D'k'h'f'q'd'c'c'v'g't'k'w'o "ur r 0'v'q"m'y "r J "cpf "d'k'g"ucnu'y gt g'lp'x'g'v'k'i cv'g' 0' O quv'q'h'v'g'v'g'f "dcevgtk'y gt g'cd'rg'v'q'v'q'rg't'c'v'g'r J "5'hqt'6"j .y j k'g'lp'r J "4'hqt'6"j "u'w'x'k'g'f": "qh'36'ut'ckpu'0'D'k'h'f'q'd'c'c'v'g't'k'w'o " rug'v'f'q'v'p'i wo "F UO "422; ; ."D'k'h'f'q'd'c'c'v'g't'k'w'o "c'p'k'o'c'k'i" F UO "42327"uj qy g'f "t'g'uk'v'c'p'eg"v'q"r J "4'hqt'6"j 0'Vj g'cp'v'k'z'k'f'cp'v' c'v'k'x'k'v"qh'r t'q'dk'q'v'e" dcevgtk'lp'c'v'c'v'g'n'c'p'f "lp'v'c'c'g'm'w'c't'egm'ht'gg"z'v'c'c'v'y cu'f'g'v'g'to k'p'g'f "d{ "3/f'k'r j gp{n/4/r let {n} {f'c'c} {n' \*F R R J "+"cpf "4/c' l'p'q'd'k'u'\*/5/g'j {n'd'g'p' q'y k'c' l'q'k'p'g/8/u'w'h'q'p'k'e"cek'+"f'c'o o q'p'k'w'o "ucn"\*C'D'V'U+"t'c'f'k'c'n'ue'c'x'g'p'i kpi "cuuc {u'0' Vj g't'g'u'w'u'uj qy g'f "y j cv'cp'v'k'z'k'f'cp'v'c'v'k'x'k'v" "x'c't'g'f"co q'p'i "y j g'f'k'h'g't'gp'v'ut'ckp'qh'v'g'v'g'f "r t'q'dk'q'v'e'u'0'k'p'c'v'c'v'g'n'c'p'f "egm' h'g'g'z'v'c'c'v'q'h'N'0'h'g'w'g't'k'F UO "42237"cpf "N'0'r'c't'c'c'c'ug'k'u'w'dur 0'r'c't'c'c'c'ug'k'F UO "6; 27"gz'j k'k'g'f "y j g'j k'j g'v'F R R J "t'c'f'k'c'n' ue'c'x'g'p'i kpi "c'v'k'x'k'v" .y j k'g'v'j g'j k'j g'v'CD'V'U"t'c'f'k'c'n'ue'c'x'g'p'i kpi "c'v'k'x'k'v" "y cu'gz'j k'k'g'f "d{ 'lp'c'v'c'v'g'n'c'p'f "lp'v'c'c'g'm'w'c't' egm'ht'gg"z'v'c'c'v'q'h'D'0'v'p'i wo "u'w'dur 0'lp'v'p'k'i" F UO "422: : 0'J qy g'x'g't."y j g'g'ut'ckpu"y gt g'ug'p'v'k'x'g'v'q"m'y "r J 0'T'g'u'w'u' u'w'i i g'v'v'j cv'r t'q'dk'q'v'e" dcevgtk'y j lej "u'w'x'k'g'lp"m'y "r J "eq'w'f "dg'w'k'c'd'rg'ec'p'f'k'f'c'v'g'u'hqt'h'q'q'f "r tqf w'v'k'p'p."y j k'g'v'j gt "ut'ckpu'uj qwf "dg'r tq'g'v'g'f "y kj "ur g'ek'h'e"x'g'j k'eng'0"

"  
"

[3\_"Y qtrf "J gcnj "Qti cpkcvkqp"\*Y J Q+"cpf "Hqqf "cpf "Ci tlewnwtg"Qti cpk cvkqp"qh'Wpk'gf "P cvkqpu"HCQ+"Rtdkqveu"lp'Hqqf "<j gcnj "cpf "pwt'k'k'p'cn' r tqr gt v'gu'cpf "i w'f'g'p'p'u'hqt'g'x'c'w'v'k'p'0'HCQ'hqqf'cpf "pwt'k'k'p' r'cr gt."KUP "2476/6947"4228+0

[4\_"T'c'f "C'0'f' qo c{q'p'k'G'0'X'c'i j g'h'O g'j t'ed'c'p{.'D'0'c'r'k'q'q't.'N'0'X'c'i j g'h'O g'j t'ed'c'p{.'Vj g'eqo r c't'k'w'p'q'h'h'q'q'f "cpf "w'r r go gpv'cu't' t'q'dk'q'v'e" f'g'x'g't { "x'g'j k'eng'u'0' E't'k'v'g'x' "Hqqf "U'ek'P'w'w'78< ; 86; 2; "4238+0

[5\_"C'0'V'g't'r q'w.'C'0'R'c'f'c'n'k'W'0'N'c'r r c.'g'v'c'f'0' "Rtdkqveu"lp'Hqqf "u{ u'ng'o u'c'k'i p'h'k'c'p'eg'c'p'f "go g'ti kpi "u't'c'v'g'i k'g'u'q'y c't'f' u'k'o r t'q'x'g'f "x'k'c'd'k'k'v" "cpf "f'g'x'g't { " q'h'g'p'j c'p'eg'f "d'g'p'g'h'ek'c'n'x'c'w'g'0'P'w't'k'p'u'33\*9+37; 3"423; +0

[6\_"I 0O w'c'y . 'V'0'U'k'c'f "V'g'u'ng'o c.'F'0O w'g'v'c.'C'0'V'g'u'h'c'f'g.'k'p'x'k't'q'g'x'c'w'v'k'p'q'h'r t'q'dk'q'v'e"r tqr gt v'gu'q'h'c'v'e"cek'f "d'c'v'g't'k'k'u'q'v'g'f "h'q'o "u'q'o g'v'c'f'k'k'p'c'm'f " h'g'to gpv'gf "g'j k'q'r'k'p'h'q'q'f "r tqf w'eu'0'p'v'U'0' ket'q'd'k'n"423; +"

[7\_"Z'0'Y'g'k'f' 0\ j c'p'i . 'J 0\ j q'w.'H'V'k'c'p.'f' 0'P'k'0'C'p'k'o ket'q'd'k'c'n'c'v'k'x'k'v'c'p'f "lp'x'k't'q"r tqr gt v'gu'q'h'eq'f /cf cr v'g'f "N'c'v'q'd'c'c'k'm'u'ut'ckpu'k'u'q'v'g'f "h'q'o "y j g" k'p'v'g'v'k'c'n'v'c'v'q'h'eq'f "y cv'g't "h'uj g'u'q'h'j k'j "n'v'k'w'f'g'y cv'g't'c't'g'c'u'lp'Z'lp'k'c'p'i . 'E'j k'p'c'0'0' E'0' ket'q'd'k'q'n3; \*3+469\*423; +"

# DCMGT AU [ GCUV/DCUGF 'S WKP QP GU/O GF KCVGF 'O KET QDKCN'HWGN' EGNN''

Mcvc | {pc'Drc| gxle<sup>3</sup>. 'Lwug'Tq| gpg<sup>3</sup>. 'Xcmtg'I wqdc'Uvcvk<sup>3</sup>. 'kpi c'O qtnxgpckg/Xkmqpekgp<sup>3</sup>'

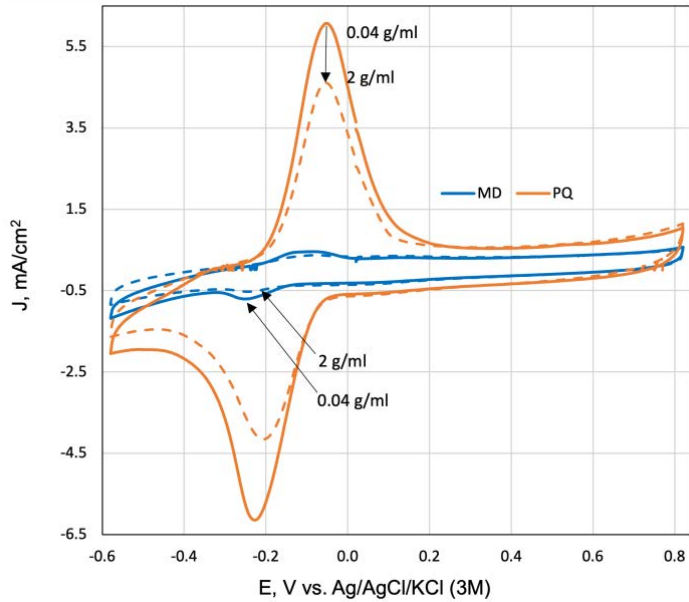
<sup>3</sup>F gr ctwo gpv'qh'O gej cwtqpleu. 'Tqdq'leu. 'cpf 'F ki kcn'O cpw'zewtkpi . 'Xkpkwu'I gf ko kpcu'Vgej pkecn'Wpkxgtuk' .  
Xkpkwu. 'Nkj wcpk'  
ncvc | {pc@lrc| gxleB xkpkwuvej 0n'

"

Tgegpw'."vq'gpuwtg'vj g'ghlekgpe { "qh'xctkqwu'cngt'pcvkxg'gpgti { "uqwtegu'vq'uvqr "vj g"i tggpj qwug'ghgevc'cpf "wkkk' g" tpggy cdrng'qti cple'o cvgtkcu. "vj g'iqewu'ku'qp'dkqhwgn'egm"}3\_0'O letqdkcn'hwgn'egm' \*O HE+'dkqgrgestqej go kecn'f gxlegu' cxckcdng'vq'f kgew' "t'cpuhqto "ej go kecn'gpgti { "vq'grgestkecn'gpgti { "xlc'c'ugt'kgu'qh'grgestqej go kecn'f gcew'kqpu'ecv'cn' | gf 'd' " o letqati cpluo u0'k' "vj g'f guki p'qhi'c' o letqdkcn'hwgn'egm' 'k'ku'guugpv'kcn'vq'ej qqug'pqv'qpn' "vj g'cpqf g. 'tgf qz' "o gf kcvqtu'dw' cnuq'vj g' "o letqati cpluo u0'Wwcm'. 'Igy "f khtg'gp' { gcu'v'utckpu'ctg'wugf "cu'dkqecv'cn' u'u'kp'O HE "y kj "qt' "y kj qw'gzv'gt'pcn' o gf kcvqtu'4\_0Qpg'qh'vj g'o quv' q' r wct'gwmt { qv'le'qti cpluo u'ku'uko r ng'cpf "gcu' "vq'ew'kxcv'g'dcngt'ai' gcu' \*U'eej ctqo {egu' egtgxkkc g-0Vj g' { "ctg'tguk'cpv'vq'gp'xkqpo gp'cn'lphw'gpegu'cpf "ecp' "o g'vcdqik' g'c'y kf g'tcpi g'qh'uwdutcv'gu'5\_0

Kp' "vj ku' "tgugctej . "y g' wugf "vj tgg' grgestqf gu' u'ungo <'s wkp'p'gu'o gf kcvgf "i tcr j kg' tqf "cu' vj g' y qtnkpi "grgestqf g. " Ci ICi EnlME n' \*50 +'cu'c'tghgt'gpeg'grgestqf g. 'cpf 'r'nc'w'pwo "cu'vj g'eqw'p'vgt'grgestqf gOE { erke'xqnc'o o gt { \*EX+'y cu'cr r rkgf " hqt'vj g'grgestqej go kecn'o gcuwtgo gpv'0Vj g'ej cpi gu'kp'ewt'gp'v'f gpuk' "ecp'dg'uggp'0

Vq' "ko r tqxg'ej cti g' "t'cpuhgt' "htqo "vj g' { gcu'egm' "vq' "vj g' grgestqf g. "y g' wugf "y q' "nr q' r j kke' "o gf kcvqtu'<'k'"; .32/ r j gpcp'tgpgs wkp'p'g' \*RS + "cpf "kk' 4/o gy { n'3.6/pcr j vj qs wkp'p'g' \*o gpcf kqpg. " O F +0' Dcngt'ai' { gcu' uq'nw'kq'p' y cu' ugs wgp'v'cm' "ej cpi gf 'd' { "cf f kpi 'k'kp' "vj g' uco g' "o gcuwtgo gpv'egm'0Vj g't'guw'w'ku'uj qy p'kp' "Hki wtg'30"



Hki 030E {erke'xqnc'o o qi tco u'y kj "RS" cpf "O F" o gf kcvqtu'cv'f hhtg'gp'v'dcngt'ai' { gcu'v'eqpegp'tcv'kq'p'0"

Vj g'ewt'gp'v'f gpuk' "f getgcugf "y j k' "k'p'et'g'cukpi "dcngt'ai' { gcu'v'q'nw'kq'p' "eqpegp'tcv'kq'p'u' y j kg'wukpi "dqj "O F" cpf "RS" o gf kcvqtu'0Y j kg' "vj g' { gcu'v'eqpegp'tcv'kq'p' y cu' "k'p'et'g'cugf "72" "ko gu. "vj g'ewt'gp'v'f gpuk' "f getgcugf "d' { "30" "o C'leo 4"y kj "ko o qd'k' gf "RS" cpf "d' { "20" "o C'leo 4"y kj "O F" "k'o g'cpu'vj cv'k'ku'w'p'p'gegu'ct { "vq'wug'c'j" ki j "eqpegp'tcv'kq'p' "qh' { gcu'v'k'p' "vj g' dkq'hwgn'egm' "vq' "i gp'gt'cv'g' "o q'tg' grgest'k'v' { 0'Vq' "ko r tqxg' "vj g' ghlekgpe { "qh' "vj g' "O HE" "kp' "vj g' "hwwtg. "y g' p'ggf "vq' "eqpuk'f gt' "o qf kh'kpi "q'j gt' "eqo r qpg'p'u0

**Cempqy ngf i go gpv'0Vj** ku'r tq'lg'evj cu't'geg'k'x'gf 'hw'p'f kpi 'htqo 'Gwt'qr gcp'U'ek'cn'hw'p' "h' tq'lg'ev'P q'2; 050'NO V/M/934/44/2547+'w'p'f gt' "i t'cpv'ci t'ggo gpv'y kj "vj g' "T'gugctej "Eqw'pek'i'qh' "Nkj wcpk' "h'NO VNV+0'

- 13\_ HOF cxku'cpf "UOROLOJ ki uqp. "0'dkq'hwgn'egm' /T'ge'gp'v'f' x'c'p'eg'u'cpf "cr r n'ecv'k'p'u'0' "Dk'q'g'p'u'0' "Dk'q'grgest'q'p'0' "42290'
- 14\_ IOT q' gpg. "KO qtnxgpckg/ Xkmqpekgp. "KOD'w' ckg. "COF | gf | kenku. 'cpf "CO' "T'co c'p'cx'leku. "0' gcu'v'dcugf "o letqdkcn'ldkq'hwgn'egm' "o gf kcvgf "d' { : .32/ r j gpcp'tgpgs wkp'p'g. "0' "Grgest'qej ko OC'ev. "r 0359; 3: "42430'
- 15\_ I 0U'k'x'g'k'c. "O 0'k'ig'i cnk' 'cpf "LOO 0'U'ej p'ggf q'th' "0C' "h'y /eqw'v' { gcu'v'dcugf "dkq'hwgn'egm' "c'p'gf w'ecv'k'p'cn'i' t'ggp' "cr r tq'cej. "0' "I t'ggp' "Ej go 0'Ngw'0' T'gx'0' "x'q'0'32. "pq'03. "r 054663. "42390'

"

**SACCHAROMYCETALES'CPF'VJ GKT'CNNKGU'KP'DKQNQI KECN'  
XGTUCVKNK/[ "**

Mikuwr cu'Rewkwu.'Crgmucpf tcu'Mqpqxcmqxcu.'Uewkwu'Ugtxc"

F gr ctvo gpv'qh'Dkqej go kwt { "cpf 'O qrgewrct'Dkqni { . 'Kpukwag'qh'Dkquekgpegu.'Nkng'Uelgpegu'Egpygt.'Xkpkwu'Wpkxgtuk{ ."  
Xkpkwu.'Nkj wcpkc"  
mtkuwr cu' cwkwb ej i hnwf kw0n"

Vj g'uj ggt'hpqy rgi g'cdqww' { gcuu'o'wplegmwrt'qti cpluo u.'vj gkt'eqpugt'xgf "dkqni { "cpf "o quv'xkcn'r tqeguugu'cmqy "  
wu"vq"j cxg"uw'hlekgpv'eqpvz wcn' hqwpf c'kqpu" hqt" dtqcf gplpi "vj g'r gtur gev'xg"kp"vj gkt" gxqnw'kqpc { "dgj cxkqt0' [ gcuu"  
cf cr w'kqp"vq'gpxk'qpo gpv'ku'f t'kxgp.'co qpi 'qyj gtu.'d { 'ur gek'le'dkqek'le.'qt'nkngt'rj gpqo gpqo'o'vj g'o c'kp'co d'k'kqp'qh'vj ku"  
tgugctej 0'Qwt"i qcn'y cu'vq"cpn { | g'vj g'r tqeguugu'f g'kxgf "htqo " { gcuu'kp"vj gkt"tgr'v'kppuj k'r "y kj "f qwdrg'w'w'cpf gf "TP C"  
\*f u'TP C+'xk'wagu0'Vj g'uelgp'v'k'le'rksgt'cwt'g"ku'o quv' { 'rko kgf "vq"vj g'h'kpf kpi u'r gek'le'cm { "kp"U'eej ctqo { egu'ugpuw'w'w'k'vq."  
cmj qwi j 'y g'f gekf gf "vq"fy gmf ggr gt'kp'vq'qyj gt" { gcuu'htqo "vj g'y kf "qtki kp"cu'y gm0'

Y g'kpxguki cvgf "4: "plej gu'qh'xct'k'qwa'hrqtc"vj tqwi j "f k'htg'gpv'i gqi tcr j le" | qp'gu'qh'Nkj wcpkc."eqpuk'kpi "qh'wpls wg"  
ht'w'k'v'gggu." qcmu." h'wpi k" cpf "hgy " qyj gt" uwt'q'w'p'f kpi u0'462" wpls wg' ut'c'k'pu' qh' { gcuu" y gtg" vj q'q'w'j n' "kp'ur gev'gf " hqt"  
o qtr j qni { . 'i tqy vj . 'cpf 'uki pu'q'hr quuguukpi 'c'xk'cn' gpqo g0Qw'q'h'c'pcn { | gf " { gcuu'w'c'k'pu. 'cdq'w'v'j kf 'r quuguugf 'f u'TP Cu."  
cpf "j c'rh'qh'vj go "f go q'p'w'c'v'gf "uqo g'w'q't'v'q'h'nkngt"ce'v'x'k'k' { . "wpeq'x'g't'gf "d { "TP C"i gn'gr'g'ext'qr j q'g'uku'cpf "ew'w'k'c'v'k'p"qp"  
ugr'gev'x'g"o gf k'c0J qy gxgt." gcej "qh'vj g'nkngt"rj gpq'v'f r g'y cu'w'pls w'g'kp"ku'o cpl'g'u'c'v'k'p"o'y g'h'q'w'p'f "uk'g'p'v' "r tqi t'gu'k'x'g."  
cpf 'y g'cn'nkngtu.'vj tgg'w'c'w'k'le'c'v'k'p'q'h'vj g'luco g'r j gpqo gpqo0Vj gug'h'k'p'f kpi u'r tq'x'k'f g'w'u'y kj 'p'gy 'r tqur gew'q'hr q'v'p'v'cn'  
tgugctej "qp'p'c'w'w'c'nr tqeguugu'q'ee'w't'k'pi 'kp'f k'htg'gpv'plej gu0'

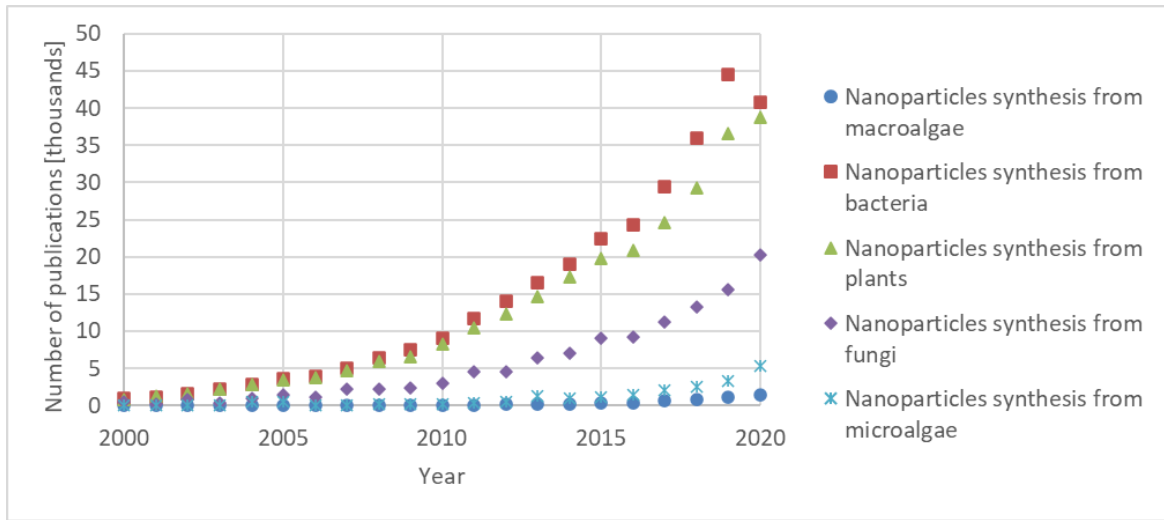
# U P V J G U K U ' Q H ' O G V C N / Q Z K F G ' P C P Q R C T V K E N G U H T Q O " O C E T Q C N I C N ' G Z V T C E V U ' "

Mxvt | { pc'F | kgti qy umc<sup>3</sup> . 'Kcdgrc 'O lej crm<sup>3</sup> "

"Y tqe-ey "Wpkxgtukv { "qh'Uekppeg"cpf "Vgej pqmji { . 'Hewm { "qh'Ej go km { . 'F gr ctvo gpv'qh' Cf xcepgf 'O cvgtkcn' Vgej pqmji lgu. '72/594'Y tqe-ey . 'Rqrpf " nxvt | { pc'F | kgti qy umcB r y t'Qf w'Q n' "

Vj g'clo "qh'y ku'r cr gt "ku'v' r t gupv'c'pqxgn'dkqmi lecn'o gj qf "qh'o gvcn/qz kf g'pcpqr ctvengu" \*P Ru+u { "pvj guku'y kj "y g" wug"qh'o cetqcn' cn'gzvcev'cpf "v"cpn { | g'r ctco gvtu. "y j lej "ecp"j cxg'cp"lphwpeg"qp"y ku'u { "pvj guku'Cu'cp"gzco r rg. " \ pQ" cpf "EwQ" P Ru" y gtg" dkqu { "pvj guku'y kj "y g" wug" qh' "gzvcev" qdvckpgf "Hqo " i tggp" o cetqcn' c" o " *Erf qj qtc* " i njo gt cv' O cetqcn' cg"ecp"dg" wugf "hqt" u { "pvj guku'qh'o cp { "f k'htgtpv'o gvcn' dcugf "pcpqr ctvengu" f w'g"v"y g' r t guppeg"qh' dkqcv'xg" eqo r qwpf u" uwaj " cu" r qn' uceej ct k' gu. " r ki o gpv. " r tqv'kpu" cpf " cpv'kz kf cpv. " y j lej " cev' cu" dkqeo r cvk'rg" tgf wexpu" ]3.6.0

P Ru'ecp"dg'u { "pvj guku' gf "lp"y tgg'y c { u'r j { ulecn'ej go lecn'cpf "dkqmi lecn'P qy cf c { u. "dkqmi lecn'o gj qf u'ctg'o qtg" cpf "o qtg"qh'wpg"gzco kpgf. "dgcwug"y g { "ctg"gp'xkqpo gpv'ht'kpf n' "cpf"ny "lp"v'z'lek'f " ]3.0' Ew' tgpv' n' . "co qpi "dkqmi lecn' o gj qf u. "xgt { "r qr w'ct "ku' dkqu { "pvj guku'y kj "y g" wug" qh' r'cpv'gzvcev" \*o qum' "o cf g" Hqo " r'g'cxgu+ " dcev'k'c. "hwi k'cpf " o letqcn' cg" ]4.0' qy g'xg. "r'v'gn' "o gj qf u' dcugf "qp" o cetqcn' cn'gzvcev'ctg'k'p'et'g'cukpi "lp"r'qr w'ct'k'f " ]5.0' Hki 03' "eqo r ctgu" y j g'pwo dgt'qh'r' w'nd'ec'v'k'pu"qp" f k'htgtpv't'gf w'ekpi "ci gpv'w'ugf "lp" P Ru' dkqu { "pvj guku'qxgt"y j g'r' cuv'42' { gct u'0



Hki 030'Rqr w'ct'k'f { "qh'f k'htgtpv't'gf w'ekpi "ci gpv'w'ugf "lp" P Ru' dkqu { "pvj guku'qxgt"y j g'r' cuv'42' { gct u' \*dcugf "qp" I qqi rg" Uej qmct. "ceeguugf "qp" 32'y' H'gdwtct { "4243+0

Kp"y j g' r t gupv'uwf { . "f k'htgtpv'dkqu { "pvj guku" o gj qf u'qh' \ pQ" cpf "EwQ" P Ru'y kj "y g" wug"qh'o cetqcn' c"gzvcev'y gtg" eqo r ctg'0" Cni cn'gzvcev'y cu' qdvckpgf "d { "w'nt'cuqwpf "cuukv'gf "gzvcev'k'p"y kj "y cvgt "qt" gj cpq'0' Vj g' u'q'k'gpv' wugf "hqt" "gzvcev'k'p"j cu'cp"lphwpeg"qp"r'v'gt "P Ru' dkqu { "pvj guku'0'k'y cu' h'qwpf "q'w'y cv'o cp { "r ctco gvtu"lphwpegf "y g" g' h'ek'gpe { " qh'pcpqr ctvengu"dkqu { "pvj guku. "co qpi "y go "y gtg' <v' r g'qh'ucn' wugf " \*k'p'qti cple "o' p'k't'cv'g' l'w'ht'v'g'qt" qti cple "o' ce'g'cv'g+ . ucnu' eqpegp'v'cv'k'p. "ucn'v'q'gzvcev't'cv'k' . "r J . "vgo r g'cwtg. "vgo g'qh'lp'ewd'cv'k'p'0

Vj g'j ki j guv' { k'gr "qh'P Ru' dkqu { "pvj guku'j cu'd'ggp' qdvckpgf "hqt" y j g' wug"qh' qti cple "ucnu. "ucn'eqpegp'v'cv'k'p"j ki j gt "y cp" 20'0 . "r J "34. "qti cple "u'q'k'gpv' \*gj cpq' n'cpf "vgo r g'cwtg"j ki j gt "y cp"t'q'qo "vgo r g'cwtg'0' H'w'j gt "lp'x'g'unk' cv'k'p"ku'p'ggf gf " v" h'k'p' "y j g'qr v'ko cn'vgo r g'cwtg. "ucn'v'q"gzvcev't'cv'k' . "vgo g'qh'lp'ewd'cv'k'p" cpf "k' h'j g' wug"qh' w'nt'cuqwpf u'qt" o letqy cxg" t'cf'k'v'k'p"ecp"ko r t'q'x'g'j g'r' t'q'eu'0

[3]\_ "N0' Rqwtmctd. " U' U'k'x'cuj " O qj i cf f'co . " l0' Rqr q'xk /F lqtf l'g'xk . " U { "pvj guku' qh' o gvcn'o gvcn' qz'k'f g' p'c'p'q'r' ctvengu" d { " i tggp" o gj qf u' cpf "y j g' k' cr r' r'ec'v'k'p'u'0' H'p'z'U'0' c { cv' l0' R'lej v'gn' O'0' H'ek' cp. "S'0' H'et'k' w'f' l'p' \*G'f' u'0' U'w'nc'p'cdng' C'i t'le'w'w'g' T'g'x'g'y u'6'30' P' cp'q'g'ej' p'q'mji { " hqt' R'rc'p'v' I' t'q'y' y' "cpf " F'g'x'g'nr' o' g'p'0' U'r' t'p'i' g't' P' c'w'g' U'y' k'j' g't'r'p'f' C'I . "6. "85/: 3' \*4242+0

[4]\_ "C'0' U'ct'x'c'p'p. "R'0' U'g'p'y' k'i' M'wo' ct. "U' M'et'k'uj' o' c. "g'v' c'f'0' C' "t'g'x'g'y "qp" dkqu { "pvj guku' qh' o gvcn' p'c'p'q'r' ctvengu" cpf "ku" gp'x'k'q'p'o' gp'v'ci' cr r' r'ec'v'k'p'u. " E'j' go' q'ur' j' g't'g'486. "34: 7: 2' \*4243+0

[5]\_ "U'0' T'q' { . "C' T'g'x'g'y <I' tggp' u' { "pvj guku' qh' p'c'p'q'r' ctvengu" H'qo "ugcy' g'g'f' u' c'p'f' "ku' u'q'o' g'c'r' r' r'ec'v'k'p'u. "C'w'w'p' l'q'w'p'c'ni'q'h' P' cp'q'o' g'f' k'el'p'g' ( " P' cp'q'g'ej' p'q'mji { " 9' \*3+ "R'U'P' "45: 3/: ; 78' \*423; +0

[6]\_ "R'0' M'j' c'p'p'c. "C'0' M'c'w'. "F'0' I' q' { cn' C'ni' cg' dcugf "o' gvcn'te" p'c'p'q'r' ctvengu' U' { "pvj guku. "ej' ct'ce'g't'k' cv'k'p" cpf "cr r' r'ec'v'k'p'u. "l'q'w'p'c'ni' q'h' "O' let'q'd'k'q'mi' lecn' O' gj' qf' u'385. "327878' \*423; +0

Cen'p'q'y' n'g'f' i' o' gpv'

Vj ku'y qtniy cu' h'k'p'egf "lp"y g' h'co gy qtni'qh'r' t'q'lg'ev'gp'v'k'g'f "o' Geq' /H'k'p'f' n' "v'gej' p'q'mji' l'gu' hqt" y j g'o' c'p'ci' go' gpv'qh' u'gcy' g'g'f' dk'q'o' cu' hqt" r' t'q'f' w'eu' w'gh'w' d' hqt' u'w'nc'p'cdng' c' i' t'le'w'w'g' c'p'f' "dk'q'ud'g'p'u' w'ugf' hqt" y j g' t'go' q'x'c'ni'q'h'j' g'c'x' { "o' gvcn' l'q'p'u' H'qo "y j g'gp'x'k'q'p'o' gp'v'o' \*P q'423; 155 IDIP \ ; 123: 66+ c'w't'k'w'g'f' d' { " Vj g' P' cv'k'p'c'ni' U'ek'p'eg' E'g'p'v' k'p' R'q'r'p'f' 0

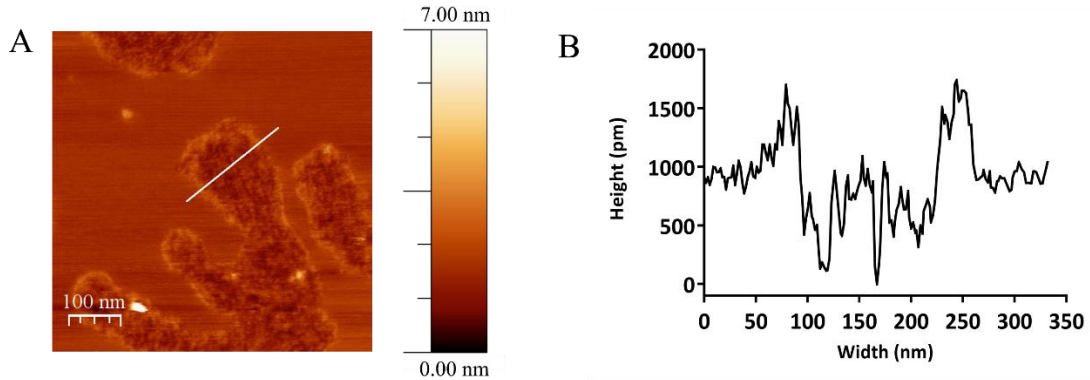
# UVWF [ 'QH'VJ G'RP VGT CE VQP 'QH'U322C; 'RTQVGR'Y K'VJ 'N'KRF' " O GO DTCP GU' "

Tlo i ckn "Vco wnf v<sup>3</sup>. 'Gxgnkpc' Lcpnckv{ v<sup>3</sup>. \ ki o cpvcu' Vqrgnkku<sup>4</sup>. 'O ctkc' Lcpmwpge<sup>3</sup>"

<sup>3</sup>Kpukwng'qh'Dkqej go kurt { . 'Nhg' Uelgpegu' Egpvgt. 'Xkpkwu' Wpkxgtukv{ . 'Xkpkwu. 'Nkj wcpkc' "  
<sup>4</sup>Kpukwng'qh'Dkqvej pqmji { . 'Nhg' Uelgpegu' Egpvgt. 'Xkpkwu' Wpkxgtukv{ . 'Xkpkwu. 'Nkj wcpkc' "  
 tlo i ckn0co wnf vgb i o eQrwf 0xw0h' "

Co { nklf " r ncs wng " hqto cvkqp " cpf " pgwtqkphro o cvqt { " r tqeguugu " ctg " yj g " o clp " hgcwtgu " qh " Cn j glo gtai " f kugcug " r cvj qmji { 0'U322C; " ku'r tq/kphro o cvqt { . " ecrekwo /dkpf kpi " r tqvklp. " dgrupi kpi " vq " yj g " U322 " hco kn { " J3\_0'U322C; " r tqvklp " r xgnm " ctg " kpetgcugf " kp " o cp { " kphro o cvqt { " f kuqtf gtu. " kperwf kpi " Cn j glo gtai " f kugcug " J4\_0' Kp " Cn j glo gtai " f kugcug. " U322C; " ugtxgu " cu " c " lvpewkqp " dgvy ggp " co { nklf " cpf " pgwtqkphro o cvqt { " ecuecf gu " J5\_0' F wng " vq " ku " co { nklf qi gplekx{ . " vqi gvj gt " y kj " /co { nklf " U322C; " hqto u'pgwtqkphro o cvqt { " r ncs wng " J5\_ " y j lej " tguwuu " kp " pgwtqkphro f gcvj " cpf " o go qt { " ko r cko gpv0'Uko krt " vq " /co { nklf . " kp " xkt q " U322C; " hqto u " e { vq vzkle " hktkmt " cpf " cppwrt " ut wewtgu " J5\_0' J qy gxgt. " yj g " gzcev'o gej cpluo " qh'vj g'kpvgtcevqp " qh'U322C; " y kj " rkr kf " o go dtcpgu " ku'ukm'wmpqy p0' "

Vj g'cld " qh'vj ku'y qtm'ku " vq " kpxguki cvg " yj g " o gej cpluo u " qh'U322C; " r tqvklp " ci i tgi cvkqp " cpf " kpvgtcevqp " y kj " rkr kf " dkr { gt0'Y g " wugf " yj g " uqrf " uwr r qtvgf " o go dtcpg " cpf " wprko gmrt " xgukergu " o qf gnu " vq " o ko le " yj g " hwpf co gpvcn'ej go kecn' cpf " r j { ulecn' r tqvgtvku " qh'c " egm' o go dtcpg0' Vq " xkwrk' g " yj g " r tqvklp / o go dtcpg " kpvgtcevqp " cpf " vq " f vgtv kpg " yj g " pcpqo gej cplecn' r tqvgtvku " qh' rkr kf " dkr { gt. " yj g " wugf " cvqo le " hqteg " o ketqueqr { " \*CHO +0'CHO " ku'pqp / f gwtvewkxg " cpf " j ki j / tguqmwkqp " ko ci kpi " vqqr0'CHO " pqv'qpn { " r tqxkf gu " kphqto cvkqp " qp " yj g " o qtr j qmji { " dw'cnuq " qp " r j { ulecn' r tqvgtvku " qh'vj g " uco r r g0' Y g " f go qpvtcvg " yj cv' r tqvklp " U322C; " kpf weg " mjecn' yj kppkpi " qh'vj g " o go dtcpg " eqo r qugf " qh' dtckp " vqvcn' rkr kf " gzvcev' \*VNG+ \*Hi 03+0' "



Hki wtg'30'CHO " qdugtcevqp " qh'U322C; " f kutw vqp " qp " uqrf " uwr r qtvgf " o go dtcpg0' \*C+ 'CHO " vqr qi tcr j { " ko ci g " uj qy kpi " yj g " mjecn' yj kppkpi " qh'c " VNG " o go dtcpg0' \*D+ 'J gki j v' r tqhkg " cmppi " yj g " rkp' g " yj g " CHO " ko ci g0' "

J3\_ 'E0Y cpi. " K0'Kuj ej kuj { p. 'L0Rcpukg'kv'cr0' U322C; /F tkxgp " Co { nklf / P gwtqkphro o cvqt { " Ecuecf g'lp " Vtco cvk " Dtckp " kplvt { " cu " c " Rt gsvtuqt " Ucvng " hqt " Cn j glo gtai " f kugcug0' UkkTgr " : . '34: 58 \*423: +0' "  
 J4\_ 'MC0'Ej cpi. " J 'L0Mko . 'I '0'Uvj 0'Vj g' tqrq' qh'U322C; " kp " yj g " r cvj qi gpguku " qh' Cn j glo gtai " f kugcug < yj g " yj g " tcr gwle " ghgewa " qh'U322C; " npqenf qy p " qt " npqenf w0'P gwtqf gi gpgtevkxg " F ku0'32. "49; " \*4234+0' "  
 J5\_ 'E0Y cpi. " Cd '0'Mgej knqx. " C0'N0' I j ctkd { cp " gv'cr0' " Vj g " tqng " qh' r tq/kphro o cvqt { " U322C; " kp " Cn j glo gtai " f kugcug " co { nklf / pgwtqkphro o cvqt { " ecuecf g0' Cev " P gwtqf cvj qn0'349. "729/440 \*4236+0' "



**'CRRNĒCVKQP'QH'GP\ [ O CVĒ'CPF'DCEVGTKCN'J [ FTQN[ UKU'HQT''  
 ĀPETGCUG'QH'VJ G'DIQNQI ĒCN'CEVĒK\ 'QH'TCY 'RNCPV''  
 O CVGTKCN''**

Cw-tpk "Xgpenckv. Xko c'Mc-nupksp .T v'O lenksp .Cwf tkwu'O ctw-ne"

Instrumental Analysis Open Access Centre, X{ wwcū'O ci puw'Wpkxtuks{ . 'Nkj wcpk"  
cwutkpg0xgpenckv vgb uwf 0xf v0w'

U{pĵ gvkē'cpvkzĳ cpw'cpf "cpvk letqdkn'ecp"ecwug"o cp{ "wpy cpvgf "ukf g'ghgeu"ĵ cv'cwtcev'ĵ g"kpvgt guv'qh'Ĥqf" r tdf wegū'cpf "eqpuwo gtu'kp'ĵ gk'ugctej "Ĥqt'Ĥpi tgf kēpv'qh'pcwtcn'qtĳi kp0Vĵ g'gxcnēcvkqp'qh'pcwtcn'r tdf weu'cu'uchg'cpf" ghgevkxg'cpvk letqdkn'ku'qpg'qh'ĵ g'uelgpv'kĤe'utcvgi kgu'vq'rguugp'ĵ g'ĵ tgcv'qh'f twi /tgukvcpv'r cvĳ gĳ pu0Ĥf'tgegpv' { gctū." ĵ g'kpvgt guv'kp'pcwtcn'r rpv'tcy "o cvgtkcn'ku'dgkpi "kpvgpukĤgf .cu'ĵ g' { "j cxg'etgcvgf "cp"ko r tguvkxg'pwo dgt'qh'o qf gtp" o gf kēlpgu' ]3\_0Dgg'r qmgp." *Ucnkē'j krcpkēc* 'N0\*ēj kē+cpf "Cpgĵ wo 'i tēxgqrgpu'N0\*f km+uggf u'o c { 'dg'co qpi 'ĵ g'r rpv'tcy " o cvgtkcn' ĵ cv'ecp" dg"ħwĵ gt" kpxgukē cvgf ." cu'ĵ gug" r rpv'r tdf weu' eqpvēkp" j kē j "rgxgnū' qh' r j gpqkē" eqo r qwpf u" cpf" Ĥxqppkfu. cu'ĵ gm'cu'ĵ cxg'uki pĤēcpv'cpvk letqdkn'cpvk'kphro o cvqt { "qt'qĵ gt'r qukēxg'ghgeu'qp'ĵ wo cp'ĵ gcnĵ 0"

Tgugctej "qp'dgg'r qmgp'kpenf gf "ĵ g'f gvgto kēcvkqp'qh'ĵ gk'f gckēgf "eqo r qukēkp. "gur gekm { 'tgi ctf kpi "dkqni kēcm { 'cevēxg'eqo r qwpf u. "uwej "cu's wtegvēp. "pctkpi gpk. "nēgo r Ĥgtqn'kuqtj co pgvēp. "cu'ĵ gm'cu'twkp'cpf "5/Q/i nēquk' gu']4\_0Ĥf' cff kēkp" vq'ĵ ku. "dgg'r qmgp" j gr u'vq' qxgteqo g" o gcvdēkē" r tqdēgo u" cpf "tgf wegu'ĵ g'cevēxkē" qh' j cto Ĥwī'dcevgtkē" ]5\_0 P xgtĵ gngū. "Ucnkē'j krcpkēc'uggf u'ecp'dg'xgt { "ko r qtēpv'ħqt' j gcnĵ "f wē'vq" eqpvēkpēpi "j kē j "r gtegpvcī g'qh'ħcw { 'cekf u." y j kēj "ctg" cniq' ūkī pĤēcpv' Ĥqt" cpvkzĳ cpv' cpf "cpvk letqdkn'cevēxkē" ]6\_0' O qtēgqxt. "Cpgĵ wo "i tēxgqrgpu" eqpvēkpū' ūkī pĤēcpv'dkēcevēxg'eqo r qwpf u'vq. "uwej "cu'r j gpqkē'cekf u'xcpkēkē. "ēclĤēle. "Ĥgtwīle" cpf "qĵ gtu' ]7\_0"

Qp'ĵ g'qĵ gt' j cpf. 'k'ku'ħpqy p'ĵ cv'ĵ gug'tcy 'r rpv'vō cvgtkcn'ctg'ūwtqwpf gf 'd { 'c'y cniĵ j kēj 'o c { 'r tēxgpv'ĵ g'ĵ wo cp" dqf { "Ĥtqo 'cduqtĳkpi 'ĵ g'dkqni kēcm { 'xcnēdēg'ūwdūcpegu0Vĵ gĤĤtēg. 'k'ku'xgt { "ko r qtēpv'vq' r gĤĤtē "ūwf kgu'qh'gz vteu" vtecvf " cpf " pqp/vtecvf " y kēj " gp { o cvē" cpf " dcevgtkcn' j { f tqn { ūkū' Uwej " ūwf kgu" y km' j gr " vq" tēxgcn' y j gĵ gt " ĵ g" dkēcxkēdkēkē' qh'r tdf weu'ecp'dg'kpetgcuĳ 0Vĵ g'cēko 'qh'ĵ ku'ĵ qtnīku'vq'ūwf { 'ĵ g'r rpv'r tdf weu'qh'kpvgt guv'vq'ħkpf 'qww'ĵ g" eqo r qukēkp' cpf " r tqr gtvēgu' qh'ĵ gk' eqo r qwpf u'0Cnq. "vq'eqo r ctg" ĵ g'ghgeu' qh'gp { o cvē" cpf " dcevgtkcn' j { f tqn { ūkū' vtecvō gpw'qp'kpetgcuĳi "ĵ g'dkēcxkēdkēkē' qh'dgg'r qmgp. "f km'uggf u." cpf "ēj kē"uggf u'vq'ĵ g'ĵ wo cp" f kē gūvkxg" u { vgo 0' Cēēqt f kpi 'vq'qwt' f cv. 'ĵ g'eqo dkēgf 'gp { o cvē" cpf " dcevgtkcn' j { f tqn { ūkū' cu'p'q'v'dggp' cr r nēgf "vq'cp { 'r tdf wev0"

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[3\_ "Vcdctv'Ĥ0'Ĥcpem"V0'Mgxgtu. 'E0'Rlpego ckn'Ĥ0'Ugtv { p. 'F0'F Ĥtēkē pg. 'Ĥ0'Q0' ( 'F qo o gu'Ĥ0' Cpvkzĳ cpv'cpf "cpvk'kphro o cvqt { 'cevēxkēgu'qh'Ĥkēgu' pĤi t wō "gz vtecu0Ĥqf 'Ej go km { '353.'333863344' %4234-0'  
 [4\_ \ j cpi. \ 0' cpi. 'Ĥ0'Ĥco cĳk'0'0' ( 'Rēpi. \ 0' Cpvkzĳ cpv'Gp { o g'cevēxkēgu'cpf 'Nkē'k'Qzĳ cvēkp'kp'Tcr g' %Dēcnēkē'ēco r gūnt'ħ'N0'Dgg'Rqmgp'Cff gf " vq'Ĥcēo kē wēkpi 'Rtēgeuĳi 00 qēgēvrgū'43.'3635' %4238-0'  
 [5\_ \ wncē c F qo 'pī vēj. 'E0'Ĥcūntq 0 gtecf q. 'N0' ( 'Egēkē' S wēcē' p. 'O 0' Ghgeu'qh'gp { o cvē' { f tqn { ūkū'qp'ūwēwtcn'ēj ctevgtkēu'cpf "dkēcevēxg' eqo r qukēkp'qh'dgg'r qmgp0Ĥqwtēcn'qh'Ĥqf 'Rtēgeuĳi "cpf 'Rtēgūtcvēkp'65.'5633' %423; -0'  
 [6\_ "O qj f "Cik" P0' [ gcr. "Ĥ0'M0" J q. "Y 0' [ 0' Dēj. "D0'M0" Vcp. "Ĥ0'Y 0' ( "Vcp. "Ĥ0'1 0' Vĵ g'Rtēo kēkpi "Ĥwwtg'qh'Ej kē. "Ucnkē'j krcpkēc" N0'Ĥqwtēcn'qh' Dkēo gf kēlpg'cpf 'Dkēgēj pēqni { '3.'36; %4234-0'  
 [7\_ "Qtj cp. "Ĥ0'Uēpnq'Ĥ0'U'Q' wtm'P0'Egēkē"Ĥ0'C0'Rwnt. 'C0' ( 'Mcp. \ 0'Rj { vēj go kēcn'eqpvēpv'cpf'gp { o g'kēj kēkē { 'cpf "cpvkzĳ cpv'r tqr gtvēgu'qh' Cpgĵ wo 'i tēxgqrgpu'N0\*f km+ūco r ngū'ēwēkēcvēgf 'vpf gt' qti cplē'cpf "eqpxgpv'qēcn'ēi tēwēwtcn'eqpf kēqpu0Ĥqf 'cpf 'Ej go kēcn'Vqzēqni { '7; .; 86 325' %4235-0'

**VJ G'RJ QVQUVCDKNI 'QHEf Ugl pUEQQJ 'S WCP VVO 'F QVU'P''  
CS WGQWUCPF 'DIQNQI KECN'O GF IC''**

Go krlc'lepwmekv<sup>3</sup>. 'Quxerf cu'Xknwku<sup>3</sup>. 'Ci p 'Merpckv v<sup>3,4</sup>"

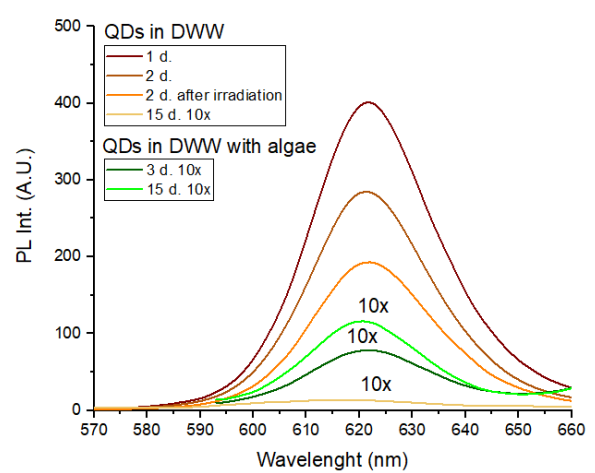
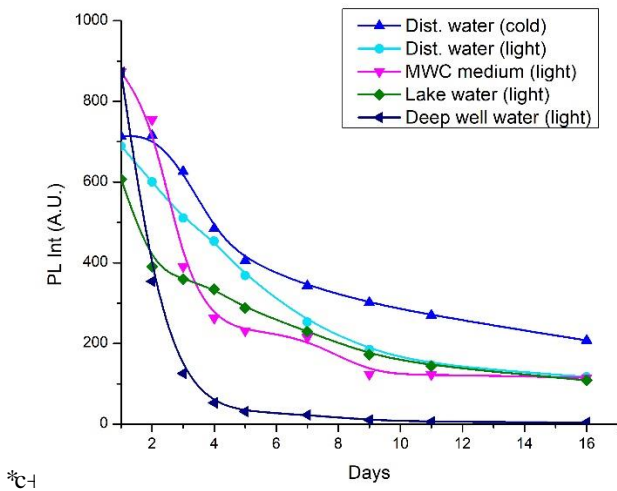
<sup>3</sup>Dlqr j qvpleu'I tqwr "qh'Ncugt'Tgugctej 'Egpytg. 'Xkpkwu'Wpksxtuks'. 'Ucwn vgnkq'cxg0; . 'KKKdrf 0'NV'6'32444.'  
Xkpkwu. 'Nkij wcpk"

<sup>4</sup>Kpukwng'qh'Geqmi { . 'P cwtg'qh'Tgugctej 'Egpytg. 'Cnrf go kqu'ut04.'NV/2: 634. 'Xkpkwu. 'Nkij wcpk"  
go krlc'lepwmekvB Hnwaf 0w0w'

S wcpwo 'F qu'F u'ctg'hwatgugpvlgo leqpf wevqtu.'3/322'po 'lp'uk' g. 'y kj 'wpls wg'qr vclnc'p'f "grgvt'lecn'r tqr gt'vku'  
]3\_00 qtgqxt. 'f wg'v'ugpukxkx' qh'S F u'ur gevtn'r tqr gt'vku'v'g'p'xk'q'po gpv. 'k'ku'cf xcp'ci gqu'v'q'wug'S F u'cu'dkq'ugpuqtu'  
]4\_0Cnuq. 'cu'S F u'ctg'cf { 'ctg'wug' 'lp'o cp { 'ctgcu. 'k'ku'r quukdng'v'j cv'v'j g { 'o c { 'rgcm'lp'v'j g'y cvgt' c { u'c'p'f "gpvt'v'j g'iq'f"  
ej c'kp']5\_0Uq. 'k'ku'lo r qt'v'p'v'q'c'p'cn' | g'v'j g'S F u'r j qv'qu'cdk'k'x' 'lp'cs wg'qu'v'q't'dk'q'ni lecn'o gf'lc'v'q'w'p'f g'w'c'p'f 'j qy 'f'k'ht'g'p'v'  
eqpf k'k'p'u'gh'g'ev'v'j g'k'lc'v'g'lp'v'j g'p'xk'q'po gpv0"

Kp'v'j ku'w'w'f { . 'b' gcuwt'k'p'i 'cp'qr vclnc'f gpuk'x' 'c'p'f 'hwatgugpeg'qh'Ef Ugl pU/EQQJ 'S F u'847'po 'k'p'xk'q'ni gp+'lp'x'ct'k'q'w'  
cs wg'qu'v'c'p'f 'dk'q'ni lecn'o gf'lc'v'q'w'p'f g'f'k'ht'g'p'v'ri j v'eqpf k'k'q'p'c'p'f 'vgo r gtcw't'g'y cu'cu'gu'ug'f 'v'j g'r j qv'qu'cdk'k'x' 'qh'S F u'  
ur gevtn'r tqr gt'vku'0'v'j g'uco r rgu'qh'S F u'y kj '6'pO 'eqpeg'p'v'c'k'q'p' y g't'g'r t'g'r c't'g'f 'lp'f k'k'ng'f. 'f ggr 'y gm'c'p'f 'w'ng'y cvgtu.  
lp'O Y E' b' gf'k'wo 'h'qt'i t'qy k'p'i 'c'ni cg. 'c'p'f 'y kj 'w'p'leg'm'w'ct' h'g'uj y cvgt'i t'ggp' 'U'eg'p'g'f' g'uo w'u'ur'0'c'p'f 'E'j r'q't' g'nc' 'ur'0'c'ni cg'eg'm'0'  
C'ht'g'r t'g'r c't'c'k'q'p'qh'uco r rgu. 'v'j g'f 'y g't'g'n'g'r v'c'v'f'k'ht'g'p'v'eqpf k'k'p'u'v'j g'f'c't'n'v'v'- 6 'vgo r gtcw't'g. 'c'nuq'lp'f'c't'n'c'p'f'w'p'f'g'  
eq'p'v'p'w'qu'y j k'g'ri j v'v'Qu'co 'F w'w'z' 'U'ct. '33Y 1: 49+'cv'cd'q'w'- 42 'vgo r gtcw't'g'0'v'j g'uco r rgu'y kj 'c'ni cg'eg'm'y g't'g'  
r t'g'r c't'g'f 'y kj 'k't'c'f'k'c'v'g'f 'x'k'q'ng'v'ri j v'f'k'q'f'g. '626'po . '52o Y' k'o 4. '342'o k'p+'S F u'lp'f'g'gr 'y gm'y cvgt' 'F Y Y '+'c'p'f 'n'g'r v'lp'  
k'p'f'k'g'ev'w'p'ri j v'0"

F gur k'g'v'j cv.'j qwt'c'ht'g'v'j g'r t'g'r c't'c'k'q'p'qh'S F u'uco r rgu. 'v'j g'r j qv'qu'w' k'p'g'eg'p'g'RN+'lp'v'p'uk'x' 'qh'S F u'lp'f'g'gr 'y gm'y  
y cvgt'y cu'i t'g'c'v'ur'eqo r c't'g'f 'qh'S F u'uco r rgu'lp'q'v'j g't'w'w'f'k'g'f 'o gf'lc'0'f'w'k'p'i 'v'j g'r g't'k'q'f'qh'38'f'c' { u.'v'j g'RN'lp'v'p'uk'x' 'y cu'  
v'j g'ig'c'v'w'cd'ng'lp'F Y Y . 't'g'i c't'f' r'gu'v'q'w'at'k'p'i 'eq'p'f'k'k'p'u'v'j g'f'k'03'c'+0'v'j g'S F u'j g'f'w'p'f'g'f'v'j g'y j k'g'ri j v'j c'f 'f'get'g'c'ug'f'  
RN'lp'v'p'uk'x' 'c'p'f 'v'j k'ng'f 'v'j g'r g'm'q'q'ur gev't'c'v'q'v'j g't'g'f 'u'k'f'g'q'h'y cv'g'g'p'i v'j 'c'ht'g'c'f'c'f'eqo r c't'g'f 'y kj 'uco r rgu'n'g'r v'lp'v'j g'  
f'c't'm'y j g't'g'v'j g'ug'ur gev't'c'v'epi g'u'c'r r g'c't'g'f 'r'c'v'g'0'v'j k'u'i k'x'g'u'c'p'lp'f'k'c'v'k'q'p'v'j cv'ri j v'o k'i j v'c'c'eg'g't'c'v'g'v'j g'c'i i t'g'i c'v'k'q'p'qh'  
QF u'0T'g'i c't'f'k'p'i 'v'j g'h'c'v'v'j cv'ri j v'j c'f 'v'j g'v'ut'q'p'i g'u'v'p'k'k'c'v'g'h'g'ev'q'p'ur gev't'c'v' t'qr gt'vku'qh'S F u'lp'w'ng'y cvgt' 'v'j g'h'w'v'j g'u'  
v'j k'w'qh'RN'ur gev't'c'v'q'v'j g't'g'f 'u'k'f'g+'v'j g'f 'y g't'g'o q't'g'uc'd'ng'w'p'f'g'f'v'j g'eq'p'v'p'w'qu'ri j v'v'j c'p'lp'f'c't'n'q'x'g't'v'j g'v'o q'h'  
g'z'r g't'k'o gpv0"



Hki 030'c+v'j g'RN'lp'v'p'uk'x' 'c'v'ur gev't'wo 'r g'm'c'd'q'w'843'po +'qh'S F u'uco r rgu'lp'f'k'ht'g'p'v'o gf'lc'g'z'r qu'g'f'v'j'  
eq'p'v'p'w'qu'y j k'g'ri j v'c'p'f 'v'j g'S F u'lp'f'k'w'ng'f 'y cvgt'v'ut'g'f 'lp'f'c't'n'v'v'- 6 'vgo r gtcw't'g'f'w'k'p'i '38'f'c' { u'v'j g'RN'  
lp'v'p'uk'x' 'qh'S F u'lp'f'g'gr 'y gm'y cvgt'v'j kj 'c'p'f 'y kj q'w'c'ni cg'eg'm'0'G'z'ek'c'v'k'p'y cv'g'g'p'i v'j '627'po 0"

Vj g'RN'lp'v'p'uk'x' 'qh'S F u'uco r rgu'lp'f'g'gr 'y gm'y cvgt'c'ht'g'k't'c'f'k'c'v'k'q'p'd' { 'x'k'q'ng'v'ri j v'v'j kj '438'Leo 4'f'q'ug'f'get'g'c'ug'f'  
o qu'v'it'ng'ni 'f'wg'v'q'v'j g'r c't'v'cl'nc'f'k'k'p'v'g'i c'v'k'q'p'qh'S F u'eq'c'v'p'i . 'c'p'f 'n'g'r v'f'get'g'c'uk'p'i 'f'w'k'p'i '37'f'c' { u'v'j g'RN'  
lp'v'p'uk'x' 'qh'v'j g'ug'S F u'lp'et'g'c'ug'f'c'ht'g'c'f'f'k'k'q'p'qh'c'ni cg'eg'm'1'eqo r c't'g'f 'v'j g'RN'lp'v'p'uk'x' 'k'o o gf'lc'v'g'ni 'c'ht'g'k't'c'f'k'c'v'k'q'p'  
k'v'g'go u'v'j cv'v'w'v'c'p'eg'u'y kj 'c'ni cg'eg'm'1'c'f'c'r'c't'v'cl'nc'f'g'u'at'k'p'i 'g'h'g'ev'q'p'v'j g'S F u'eq'c'v'p'i . 'y j k'ej 'y cu'c'h'g'ev'g'f'd' { 'v'j g'ri j v'0'  
Vj ku'y q't'n'ly cu'w'p'f'g'f'd' { 'v'j g'T'gug'ctej 'Eq'w'p'ek'q'h'N'k'ij w'c'p'k'. 'R't'q'lg'ev'P'q'0U/O'R/42/440"

]3\_00C'p'g'p'g.'J 0T'w'k' /I c't'ek'g'v'c'ni'0'c'f'x'c'p'eg'f'k'o ci k'p'i 'V'g'ej'p'q'ni k'g'u.'T'g'w'p'. '355/372'84235-0'  
]4\_0C'ni'q'. 'Z'01' c'q'0'c'r'r' n'c'v'k'p'u'qh'S w'c'p'wo 'F'q'u'lp'D'k'q'lo ci k'p'i 'c'p'f'D'k'q'c'uc' { '8423; +'  
]5\_0'J' 0'G'0'G'ni' q't'n'p'f'. '0'0'c' 'H'k'i j c'k'g'v'c'ni'G'eq'q'z'k'eq'ni { 'k'o r'c'ev'q'h'v'k'k'c'ec'q'c'v'g'f'Ef'U'gl p'U's'w'c'p'wo 'f'q'u'lp'v'g't'p'c'k'g'f'lp'E'j'p'o { f'q'o'q'p'cu't'g'k'p'j'c't'f'w'k'  
c'ni'c'r'ie'g'm'. 'U'el'g'peg'qh'v'j g'v'q'v'c'ni'G'p'x'k'q'po gpv'8423; +'

**EQPUVTWEVKQP'QH'V[ RG'KKK'ETKURT/ECU'GHHGEVQT''**  
**EQO RNgZ'HQT'VTCPURQTVCVKQP'KPVQ'VJ G\ GDTCHKUJ 'PWENGWU'**

F cpcu'Mko cXk ku<sup>3</sup>. 'F cnc'Uo cncm\ v<sup>3</sup>. 'Cdj kuj gniRcvgtk<sup>4</sup>.  
O cwj ku'Dqej vgt<sup>4,5</sup>. 'I kpcwcu'Vco wrcku<sup>3</sup>"

"

<sup>3</sup>Kpukwag'qhDkqvej pqrni { . 'Nkg'Uelpegu'Egpgvt. 'Xkpkwu'Wpkxgtukf. 'Ucwre'vgnk'cx09.'32479'Xkpkwu.'Nksj wcpk"  
<sup>4</sup>Kpvtpcvkpcn'Kpukwag'qh'O qrgewt'cpf'EgmiDkqrni { . 'Vtqlf gpc'6.'24/32; 'Y ctucy . 'Rqrcpf "  
<sup>5</sup>Kpukwag'qhDkqej go kut { 'cpf'Dkqr j { uku'RCU.'Rcy kpunki q'7c.'24/328'Y ctucy . 'Rqrcpf "  
mko cXkkuwuf cpcuB i o cktqo "

"

TPC'hpqenf qy p'ku'c'ry gthwngzr gtlo gpvcn'gej pls wg'vq'uwf { 'i gpg'hwpevkq'cpf'k'ku'eqo o qpn' 'o gf kcvf 'y tqwi j "  
TPC'kpvthgtgpeg'J qy gxgt.'uqo g'qti cpluo u'uwej 'cu' gdtchkuj 'ecppqv'vqrgcv'j g'cf f kkpvcn'ncf "qp'vj gk'kpvthgtkpi "  
TPC'o cej kpgt { " ]3\_0' Qw" i tqwr " r tqr qugf " vj cv' v' r g' KKK'ETKURT/Ecu' ghgevt " eqo r ngz " Euo " htqo " Utgrvqegeewi "  
vj gto qvj kwi" \*UeUo -'eqwf " dg'wugf " hqt " TPC'hpqenf qy p'cu'c'r tqi tco o cdrg'tkdqpwergcug'k'vj ku'o qf gniqti cpluo 0Y g' "  
f go qpvtcvf " i tgcvt " vj cp " 72' " ghkkgpe { " qh'UeUo " k' " TPC'hpqenf qy p'cpf " j gpeg' r tqxkf gf " c' r tqqh'qh' r tkpek ng " qh' "  
r tqi tco o cdrg'bo TPC'f gi tcf cvkq' d { 'UeUo 'k'p'gwnt { qvq' ]4\_0'

Tgepvt' 'k'v' cu'uj qy p'vj cv'v' r g'KETKURT/Ecu'ghgevt'eqo r ngz'Ecuecf g.'y j lej 'ku'qh'uko kct'uk' g'v' Euo . 'eqwf " dg' "  
uweeguhnt' " vtcpur qtvgf " kvq' " vj g' pwegwu' d { " cwcej kpi " vj g' pwegwu' nqecik' cvkq' " ugs wpeg " \*P NU" ]5\_0' Upeg' FPC "  
vtcpuetk vkq' qeewu'k'vj g' pwegwu. 'u { p'vj guk' gf " vtcpuetk u'eqwf " dg'engcxgf " ko o gf kcvn' " dg'htg'vtcpur qt'kpi " vj go " kvq' "  
vj g'e { vqr cuo 0k' qtf gt " vq' hwtj gt' ko r tqxg'vtcpuetk v'f gi tcf cvkq' ghkkgpe { 'y g'f gekf gf " vq'f grkxgt " UeUo 'kvq' vj g' pwegwu' "  
qh'c'egm0k' vj ku'uwf { 'y g' r' tguqpv'eqpvtwvkq' qh'UeUo 'xctkcvu'qr vko k' gf " hqt " vtcpur qt'cvkq' kvq' | gdtchkuj 'pwegwu0'

"

---

[3\_ 'Nkw'Y 0'Y cpi 'I 0'Uwp' I 0'Y cpi 'I 0'Y cpi 'I 0'Ej gp'UO\ j w\ 0\*4227+GhhegpvTPC'kpvthgtgpeg'k'p' gdtchkuj "go dt { qu'vukpi "ukTPC'u'f p'vj guk' gf "  
y kj 'UR8'TPC'r qn' o gtcug'0F gxnqro gpv' I tqy vj 'c'pf 'F hhtg'gpvk'vkq'.'69\*7+'r 05456553"  
[4\_ 'Hkeng'V0'Uo cncm\ v'F0'Ncr kpunk'O0'Revgtk'CO'Y gli g'E0'Rcuqt'O0'Mjrepq'CO'Y kpcvc'E0'Ukmp { u'X0'Vco wrcku'I 0'Dqej vgt "O0\*4242+ "  
Vcti gvgf 'TPC'hpqenf qy p'd { 'V { r g'KKK'ETKURT/Ecu'Ego r ngz'k'p' \ gdtchkuj 0Vj g'ETKURT'Lvtpcn'5\*6+'r 04; /535 "  
[5\_ 'Fqrcp'CO'J qw\ 0'Zlekq' I 0'I tco gnr cej gt'O0'J gq'LO'J qy f gp'UO'Hg'gf f qnkq'R0'Mg'CO\ j cpi 'I 0\*423; +k'pvtqf welpi 'c'Ur gewto 'qh'Nqpi /Tcpi g' "  
I gpqo k'F grg'kpu'k'p'J wo cp'Go dt { qple'Ugo 'Egmi'Wukpi 'V { r g'KETKURT/Ecu'0'qrgewt' 'Egm'96\*7+'r 0; 58; /720 "

# APPLICATION OF MARCUS THEORY TO ANALYSIS OF GLUCOSE OXIDASE CATALYZED REDUCTION REACTION

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Oxidoreductases are enzymes that catalyze oxidation and reduction reactions in biochemical processes. They participate in glycolysis, citric acid cycle, oxidative phosphorylation, amino acid metabolism and in other vital biochemical transformations. Many of these reactions are interesting both from theoretical and practical perspectives. In industry, oxidoreductases are used as catalysts for synthesis of valuable products, biodegradation of pollutants, fabrication of biofuel cells and biosensors. Therefore, a better theoretical understanding of processes such as electron transfer (ET) catalysis of oxidoreductases provide routes for practical implementations.

Here we used glucose oxidase from *Aspergillus niger* (GOx) as a model enzyme to study ET between the active center of enzyme and a set of artificial electron acceptors. GOx catalysis cycle involves two separate reactions. In the first reaction,  $\beta$ -D-glucose is oxidized to D-glucono- $\delta$ -lactone. In the second reaction, molecular oxygen, the natural second substrate of the enzyme, is reduced to hydrogen peroxide. According to the literature, the rate of this reaction is limited by ET [1, 2]. In addition, GOx can reduce a wide range of artificial electron acceptors, and in this study we investigated which process is the rate-limiting of reduction of these compounds.

According to Marcus theory [3], when the reaction rate is ET-limited, then a parabolic relationship between natural logarithm of the reaction rate and free Gibbs energy exists [4,5]. However, this relationship is expected to hold only for a series of homologous substrates. A more generalized version of Marcus theory predicts a parabolic relationship between free energy of activation and free energy of a reaction (Fig. 1. B), without any assumptions about similarity of substrates. We measured these thermodynamic parameters for GOx catalyzed reduction reactions of 12 non-homologous artificial electron acceptors (Fig. 1. A, blue dots) and found a completely different relation than it is predicted by assuming ET as a reduction rate-limiting step. These observations could be explained by consecutive electron and proton transfer mechanism. In the case of this study, the reduction rate constants measured consist of both electron and proton transfer rate parameters. If ET is very fast, then the reaction rate is limited by proton transfer rate, and vice versa, if ET is slow, the reaction rate is limited by ET rate.

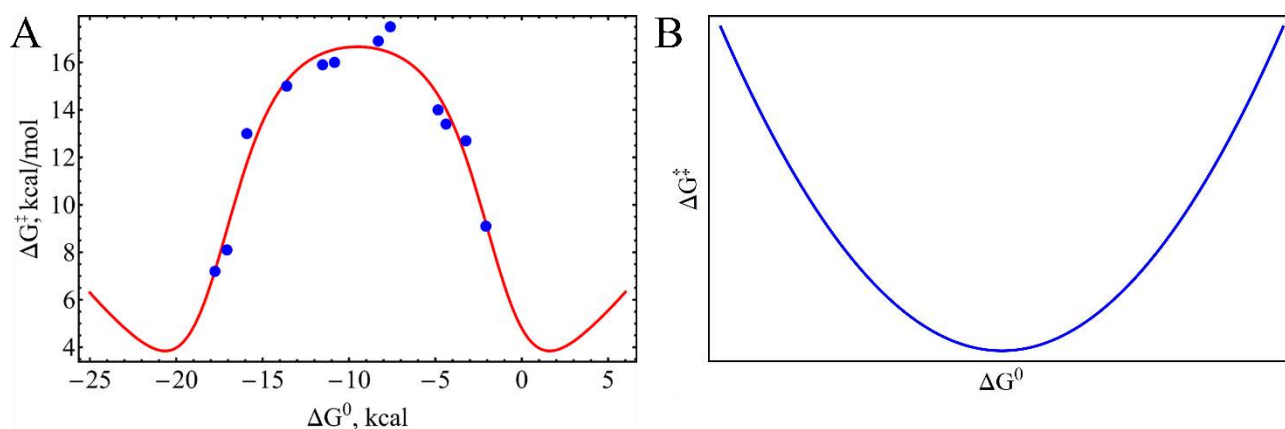


Fig. 1. A – The dependency of reaction activation energy on free Gibbs energy of substrates. Blue dots – experimental result, red line – mathematical model. B – Theoretical dependency of reaction activation energy on free Gibbs energy of substrates

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# PREPARATION OF IMMOBILIZED MICROBIAL LIPOLYTIC ENZYMES APPLICABLE FOR THE SYNTHESIS OF FLAVOR ESTERS

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At present, enzymes are the key players in different industrial processes with microbial lipolytic enzymes being one of the most widely used in biocatalysis, both at academic and industrial levels. However, for the industrial implementations, especially in organic synthesis, immobilized enzymes are preferred over their soluble forms because of their reusability, greater activity, specificity, stability, resistance to inhibitors and in some cases even purity [1]. Immobilized preparations are more suitable for the biocatalysis in organic media. Immobilization may improve enzymes rigidity which can lead to higher stability in organic media and, therefore, such enzyme preparation maintains not only high residual activity, but also can exhibit improved thermostability and substrate specificity [2]. Unfortunately, ready-to-use immobilized preparations of lipolytic enzymes suitable for the synthesis of the desired compounds do not always exist and/or usually have a high cost. Therefore, in the present study, we aimed to find effective way of immobilization of different lipolytic enzymes for the use in organic media. So far, two enzymes were selected for the study: a novel recombinant Lip4 carboxylesterase from *S. saprophyticus* AG1 and a chimeric lipolytic enzyme (made of *Theromyces lanuginosus* lipase and *Fusarium oxysporum* phospholipase A1) Lecitase Ultra (Novozymes). The former enzyme-coding gene (*lip4*) was cloned and expressed in *E. coli* C41 (DE3) and purified using affinity chromatography. Lip4 and Lecitase Ultra were immobilized utilizing adsorption immobilization on octylsepharose (OS). Adsorption immobilization was chosen since lipolytic enzymes have a hydrophobic lid domain and this unique structural feature can be used to “lock” the enzyme in active form by immobilization on hydrophobic supports, which mimic the hydrophobic substrates of enzymes [3] (Fig. 1). Immobilization of Lip4 and Lecitase Ultra on OS have shown that compared to free enzymes, both Lip4 and Lecitase Ultra possessed higher activities indicating their hyperactivation upon immobilization. However, for the further synthesis of valuable flavor esters (2-phenylethylbutanoate and 2-phenylethylpropanoate) immobilization requires further studies in selecting the optimal conditions for each enzyme.

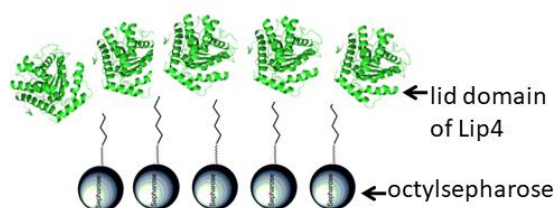


Fig. 1. Schematic representation of how lid-containing lipolytic enzymes can be “locked” on the surface of the hydrophobic OS resulting in the hyperactivation of the enzyme. Model of recombinant Lip4 was used for the visualization.

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**GHHGE VU'QH'E QNF 'RNCUO CQP 'VJ G'CO QWP V'QHUVGXQN'  
I N[ EQUK GU'K' STEVIA REBAUDIANA'DGT VQP KNGCXGU''**

Vqo cu'O qemckku<sup>3</sup>. 'Xkf c'O krf cflkpp<sup>3</sup>. 'Tcuc'fi mkgp<sup>3</sup>

<sup>3</sup>Hewm{ "qh'P cwtcrn'Uelgpegu 'X{ vwwcu'O ci pwa'Wpkxgtuks{ 'Xkrgknq'ut0: . 'NV/66626'Mewpcu. 'Nkj wcpk." vqo cuO qemckkuB xf wOy"

"

Ugxlc" tgdwfw kpc" Dgtv' \*Dgtvqpk" j cu" cwtcevgf " yj g' cwgpvqpp" qh' uelgpkwu" cpf " kpf wut { "kp" tgegpv { gctu" hqt" ku" r tqr gtvku. 'pcwtcrncpf "ny /ecmtkg'uy ggvgpgtu. 'uxgkqni n' equkf gu" UI u: 'y j lej 'ctg'cp'cngtpcvkxg'vq' uwi ct0Vj g'bo ckp'UI u' ctg'uxgkqkf g' \*Ugx+ 'cpf 'tgdwfw kqkf g' C' \*TgdC+0Vj g' 'eqo r qug'wr 'vq'62" 'qh'vj g'f t { 'y gki j v'qh'vj g' hqch'cpf 'ctg'522'vko gu" uy ggvgf 'vj cp'uwetqug. 'cnuq'vj g' { 'ctg'vj g' to qucdng'bo cnkpi 'vj go 'hcxqtdng'kp'vj g' hqf 'kpf wut { 'j3. '4\_0TgdC'j cu'dgwgf 'y cvgt' uqndkksf "cpf "c"o krf gt"cvug. 'enqugt"vq"uwetqug. "vj cp"Ugx0'Uggf "v'gcv' gp'v'd { "eqrf "r'ncuo c' \*ER+ 'ku'cp" gp'xktqpo gp'wcmf " h'lgpf n' "o gy qf "wugf 'vq'lo r tqxg'xctkqwu'r ncpv'r tqr gt'vku'cpf "vko wcvg'ugeqpf ct { 'o gvcdrksgu'u { pyj guku"j5\_0'

Vj g'c'ko "qh'vj ku'uwf { 'y cu'vq'f g'vgt'o kpg'vj g'ghge'v'qh'eqrf "r'ncuo c' \*ER+ 'uggf "v'gcv' gp'v'4. "7. "qt"9"o kp+ 'qp"Ugx"cpf " TgdC"ceewo wcvkpp'kp'uxgk' h'cxgu'cvf k'htgtpv'i tqy vj 'y ggmu'\*. : '34. '36'cpf '42+0Qvj gt' d'kqej go lecn'v'cku'wvej 'cu'co qwpv' qh'v'v'cn'r j gp'q'ku. "v'q'v'cn'r'xqpp'kf u'cpf "cp'v'ctf lecn'uecxgpi kpi "cevkxkf "y gtg'cnuq'f g'vgt'o kpgf 0'

Vj g'nci gu'vej cpi g'kp'UI u'eqpegp'v'cvkpp'cv'y ggm: 'y cu'kpf weg'f 'd { 'ER'4"o kp'cpf 't'gcej gf '363"o i li . 'cu'eqo r ctgf "vq" 325"o i li "kp"eqp'v'q'0C'v'y ggm'34'cpf "36. "vj g'nci gu'v'kpetgcug'kp'UI u'eqpegp'v'cvkpp'y cu'q'dugtxgf "kp"ER'7"o kp"i tqw'0C'v' y ggm'34. 'k'v'kpetgcug'f 'h'qo '345"o i li 'kp"eqp'v'q'v'383"o i li . 'cpf 'cv'y ggm'36'k'y cu'553"o i li 'cu'eqo r ctgf "vq"442"o i li "kp" eqp'v'q'0C'v'y ggm'42. 'vj g'UI u'eqpegp'v'cvkpp'f getgcugf "vq"372"o i li 'cpf 'ER'j cf 'pq'ghge'v'0Vj g'co qwpv'qh'UI u'kp'vj g' h'cxgu' kpxgtugn' "eqttgr'v'gf "y kj "vj g'uecxgpi kpi "cevkxkf "cpf "vj g'v'v'cn'r'co qwpv'qh'r j gp'q'ku'cpf "h'cxqpp'kf u'0K'ecp"dg"eqpenw'gf " vj cv'vj g'ghge'v'qh'eqrf "r'ncuo c'j cf "c"r'qukkxg"ghge'v'qp"vj g'ceewo wcvkpp'qh'uxgkqni n' equkf gu'cv' h'cxgu'wp'v'ki'y ggm'36'qh' xgi gcvkpp0'

"

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[3\_Dgti u'F'0'Dwi j qh'D0'Lqgi pem'O'0'O'ctv'p. 'I'0' ( 'Uej go dgengt. 'I'0'4234+0H'cu'v'cpf "kuqetv'le"J RNE/o gyj qf 'hqt'uxgkqni n' equkf gu'cpcn'uku' h'qo "Ugxlc'tgdwfw kpc'h'cxgu'0Lqwt'pcn'h'x'gtdt'v'ej g'tuej w' 'w'p'f 'h'gd'g'p'uo k'vgn'lej g'tj gk'v'9\*4+ '369/3760'f qk'3208229 h'22225/234/2982/7"

[4\_Lgr r gupg. 'R'D0'I' tgi g'tugp. 'UO' 'C'ncw'r. 'MMO' ( 'J' g'to cp'ugp. 'M'0'4224+0Ugxkqkf g'k'p'f weg'v'cp'v'j { r g'ti n' ecgo le. 'k'p'w'k'p'q'v'qr le"cpf "i' n'v'eci q'p'q'v'v'le" ghge'v'v'k'x'q'<'uwf' l'gu'lp'vj g'f' k'cd'g'v'le" 'I' q'v'q/M'cn'k' cnk' \*I' M+ 't'v'v'0Rj { v'qo g'f' l'ek'p'g. ; \*3+; ; 6360'f qk'3208374 k'lr g'p'f q'0255304227"

[5\_L'k'cpi . 'L'OH'D'J' g. 'Z'0'Nk' 'NO'Nk' 'L'OI' 0'Uj c'q. 'J' 0N0'Z'w' 'S'0N0' 'I' g. 'J' 0T0' ( 'F' q'pi . 'I' 0J' 0'4236+0G'ghge'v'qh'eqrf "r'ncuo c'v'gcv' gp'v'qp'uggf "i' g'to k'p'v'kpp' cpf "i' tqy vj "qh'vj g'v'v'cn'r'cu' c'uekpeg'g'v'ej p'q'q'j { . '38\*4+ '7667: 0'

"

**RQNCTKO GVTĒ 'PQP NĒ GCT' O KĒTQUEQRĪ 'Y KĀJ 'VGZVWT'G'  
CPCNĪ UK'ĤQT'EQNQP 'ECPEGT'FKCI PQUVĒU'**

Xkmaqtcu'O cflgknc<sup>3</sup>. 'O { nqrcu'O c kwrk<sup>3</sup>. 'O ctv{pcu'Tkwcnc<sup>3</sup>. 'Nwncu'Mqpvpgku<sup>3,4</sup>. 'Gf xctf cu'fi wtcwncu<sup>5</sup>. "  
Xkti kpkwu'Dct| f c<sup>3,6,7</sup>"

<sup>3</sup>Hcewn{ "qh'Rj { uleu.'Ncugt'Tgugctej 'Egvtg.'Xkpkwu'Wpkxgtuk{ . '32'Ucwn vgnkq'Cxg0'NV/ 32444.'Xkpkwu.'Nksj wcpkc"

<sup>4</sup>Nki j vEqpxgtukq. '4D'Mgtco kmw'x0'NV/32455.'Xkpkwu.'Nksj wcpkc"

<sup>5</sup>F gr ctvo gpv'qh'Rcy qmī { . 'Ĥtgpule'O gf lekpg'cpf 'Rj cto ceqmī { . 'Hcewn{ 'qh'O gf lekpg.'Xkpkwu'Wpkxgtuk{ . 'O MD' Ekwtkqpkq'Uv'43'49.'NV/25323.'Xkpkwu.'Nksj wcpkc"

<sup>6</sup>F gr ctvo gpv'qh'Rj { uleu.'Wpkxgtuk{ 'qh'Vqtqpvq.'82'U0I gati gu'x0'Vqtqpvq.'QP 'O 7U'3C9.'Ecpfc c"

<sup>7</sup>F gr ctvo gpv'qh'Ej go lecn'cpf 'Rj { ulecn'Uekgpegu.'Wpkxgtuk{ 'qh'Vqtqpvq'O kuukucwi c.'557; 'O kuukucwi c'Tf 0P 0" O kuukucwi c'N7N'3E8.'QP . 'Ecpfc c"

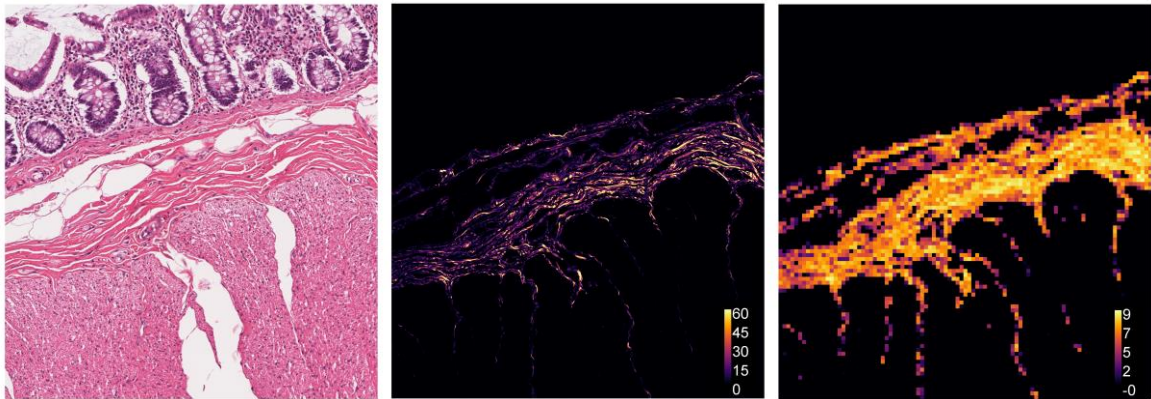
xkmaqtcu0 c| gkncB Hkx0w'

"

P qprkpgct'o letqueqr { "o gj qf u.'uwej 'cu'o wnrk j qvpp'gzekcvkqp'hwqtguepegg\*O RGH+.'ugeqpf /j cto qple'i gpgtcvkqp" \*U I +." cpf " j kf /j cto qple" i gpgtcvkqp" \*VJ I +." o letqueqr lgu." j cxg" dggp" uweeguuhwn{ " cr r rkgf " hqt" j kvqr cyj qmī { " ko ci kpi "J3\_0'U I " o letqueqr { " ku' r ctvkwrcn{ " kpvgtgukpi " dgecwug" qh' ku' ecr cdkk{ " hqt" rcdgn'htgg" ko ci kpi " qh' pqp/ egptqu{ o o gtle'utwewtgu.'uwej 'cu'eqmī gp'hdgtu'lp'j g'gzvtegmwrc' b cvtkz0Cu'eqmī gp'utwewt'g'ku'hpqy p'vq'wvf gti q" ej cpi gu'f wtkpi " ectelpqi gpguku" J4\_." U I " o letqueqr { " ecp" dg" c" wughwn'vqnn' hqt" lpxguki cvkpi " j g" tguwnkpi " utwewtci' f khtgtpgegu'Vgzwtg'cpcn{ uku'ecp'dg'r gthqto gf "qp'j g'ces wktgf' ko ci gu'xk'j g'i tc { /rgxgn'leq/qeewtgppeg'o cvtkz \*I NEO +." y j lej 'eqpvcvku'j g'pwo dgtu'qh'qeeewtgpgegu'qh'pki j dqtkpi 'r kzm'j cvkpi 'r ctvkwrc'xcnwu0I NEO 'ecp'dg'wugf 'vq'ecrncwv'g" ugxgtcn'ucvku'ecnr' cto gvgtu'f guetkdkpi 'j g'ko ci g.'uwej 'cu'eqpvcu'eqttgmvkqp.'cpf 'gpvtqr { 0k'cf f kkp'vq'U I 'kpvpuks{ " ko ci gu.'I NEO 'ecp'cnuq'dg'wugf 'vq'cpcn{ | g'o cr u'qh'xctkqwu'r qrtk'ko gtle'r cto gvgtu.'hqt'gzco r ng.'U I 'ektewrc'f lej tqkuo " \*U I /EF +."cpf 'cej kcn'uwuegr vdkk{ 'tcvq'T0Uwej " o cr u'ecp'dg'qdvckpgf "d{ 'r gthqto kpi 'r qrtk'ko gtle"o gcuwgo gpwu'cu" r qrtk'cvkqp'qh'j g'i gpgtcv'U " f gr gpf u'qp'r qrtk'cvkqp'qh'pki'gpv'ki j v'c'p'qp'uco r ng'ej ctcevt'ku'eu"J5\_0Wug'qh'I NEO " hqt'ecpegt'f kci pquvku'j cu'dggp'kpxguki cvg'lp"o wnrk ng'uwf lgu.'cpf 'lp'uo g'ecugu'k'y cu'gxgp"uj qy p'vq'f khtgtpvcv'g" dgvy ggp'f khtgtpv'uci gu'qh'ecpegt"J5.'6\_0

Kp'j ku'y qtm'U I 'r qrtk'ko gtle'o letqueqr { 'ku'wugf 'vq'kpxguki cvg'eqmī gp'utwewt'g'lp'p'qto cnc'p'f "ecpegtqwu"j wo cp" eqmī"j kvqmī lecn'uco r ngu'0I NEO "ku"go r nq {gf "vq'cpcn{ | g'j g'qdvckpgf "o cr u'qh'r qrtk'ko gtle"r cto gvgtu'0T guwnkpi " vgz wrcn'f cv'ku'wugf 'vq'eqo r ctg'p'qto cnc'p'f "ecpegtqwu'eqmī"kuuwg0

"



"

Hki 030Rqrtk'ko gtle'U I " o letqueqr { "cpf 'vgzwtg'cpcn{ uku'qh'p'qto cnc'eqmī'kuuwg0J ( 'G'vckp'g'f'j kvqmī lecn'urk' g'ng'hw+." U I 'kpvpuks{ 'ko ci g'o kf f ng'+."cpf 'cp'U I 'kpvpuks{ 'gpvtqr { 'o cr "h'ki j v0Uk' g'qh'ko ci gu'c' 22" " 22" o 0'

"

J3\_'COVwgt'gv'cn'0'p qprkpgct'o wneqpv'cu'v' letqueqr { "qh'j go cvqz { nq/ cpf /gqulp/ucv'kpgf' j kvqmī lecn'ugev'ku'p'0'10Dlqo gf 0Qr v037\*4+.'24823: \*4232-0 J4\_'E0E0Ng'gv'cn'0'5'Hpvev'qpcn'kpvtr'nc' 'Dgy ggp'Eqmī gp'P gy qmī'cpf 'Egn'Dgj cvkqt'Y ksj lp'Vwo qt'O letqgp'xkqpo gpv'lp'Eqmī'g'v'cn'Ecpegt.0'Hi qpv'0' Qpeq'032.'749\*4242-0

J5\_'C0I qrtcgk'gv'cn'0'6'Rqrtk'ko gtle'ugeqpf /j cto qple'i gpgtcvkqp'o letqueqr { "qh'j g'j kgtetej lecn'utwewt'g'qh'eqmī gp'lp'uci g'Kkkk'qp/uo cnc'egnt'wpi " ectelpqo c.0'Dlqo gf 0Qr'0Gzrt'gu'33.'3: 73/3: 85\*4242-0

J6\_'P 0Hwko c'gv'cn'0'v'j g'wkrk{ 'qh'O TKj kvqī tco 'cpf 'vgzwtg'cpcn{ uku'ht'j g'r tgf'levkqp'qh'j kvqmī lecn'f kci pquku'lp"j gcf "cpf "pgem'0 c'ki pcpelgu.0" Ecpegt'ko ci kpi '3; .7\*423; -0

# PHYTOCHEMICAL ANALYSIS OF *ARTEMISIA DUBIA* WALL. SECONDARY METABOLITES AND ITS SOLID PELLET CALORIFIC VALUE

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Secondary metabolites exert significant pharmacological and toxicological effects and their efficient antioxidant activity has led these compounds being used as nutraceuticals [1]. *Artemisia dubia* Wall. exhibits many of these natural compounds, such as flavonoids, phenolics and alkaloids. Aside from the pharmacological aspect, the plant is also a prosperous energetic plant, obtaining significant heating value and large growth rate, yearly reaching up to 11,10 t/ha [2]. The aim of the research is to investigate *A. dubia* Wall. methanol/water extraction fractions phytochemical properties and the solid phase residue heating value before and after the extraction. In the research *A. dubia* Wall. was harvested from 3 different areas on 2018 July 27 and dried for lower enzymatic activity. The areas differed one from each other by different level of nitrogen fertilizers: no fertilization, N90 and N180. Extraction was performed using distilled water and 3 concentrations of methanol: 50%, 75 % and 100 %. Phytochemical capabilities were measured using spectrophotometric analysis methods according to Stankevičius et al. (2011) to evaluate the total amount of phenolic compounds using Folin-Ciocalteu reagent and the total amount of flavonoids using AlCl<sub>3</sub> reagent. Antioxidant activity was evaluated using DPPH reagent. The lower calorific value (LHV) of the dry basis for the solutions was measured by an IKA C5000 calorimeter in accordance with the LST EN ISO 18125:2017 adiabatic method for automated bomb calorimetry. Extraction influence on *A. dubia* Wall. calorific value and comparison of increasing polarity solvent effect on total phenolic content, flavonoid content and antioxidant activity has yet not been published.

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- [1] G. Velu, V. Palanichamy, and A. P. Rajan, Phytochemical and Pharmacological Importance of Plant Secondary Metabolites in Modern Medicine, Bioorganic Phase Nat. Food An Overv., 135–156 (2018).
- [2] J. Slepetyš, Z. Kadziulienė, L. Sarunaite, V. Tilvikiene, and Kryzeviciene Aldona, Biomass Potential Of Plants Grown For Bioenergy Production, Renew. Energy Energy Effic. Proc. Int. Sci., 64–72 (2012).
- [3] M. Stankevičius, I. Akuāeca, I. Jākobsone, and A. Maruška, Comparative analysis of radical scavenging and antioxidant activity of phenolic compounds present in everyday use spice plants by means of spectrophotometric and chromatographic methods, J. Sep. Sci., vol. 34, no. 11, 1261–1267, (2011).



**EQNNCI GP 'WNVTCUVTWEVWTG'EJ CPI GUKP 'NGP VK IPQWU'  
O GNCPQO C'EJ CTCEVGTK GF 'D| 'UGEQPF/J CTO QP KE"  
I GPGTCVKQP 'O KETQUEQR| "**

O ctv|pcu|Tkwne<sup>3</sup>. "Xkmtcu'O c| gkne<sup>3</sup>. 'O { nqrcu'O cekwku<sup>3</sup>. "  
"Gf xctf cu\ wtewwne<sup>4</sup>. "Nwnru"Mpvgpk<sup>3,5</sup>"cpf "Xki kplwu"Dct| f c<sup>3,6</sup>"

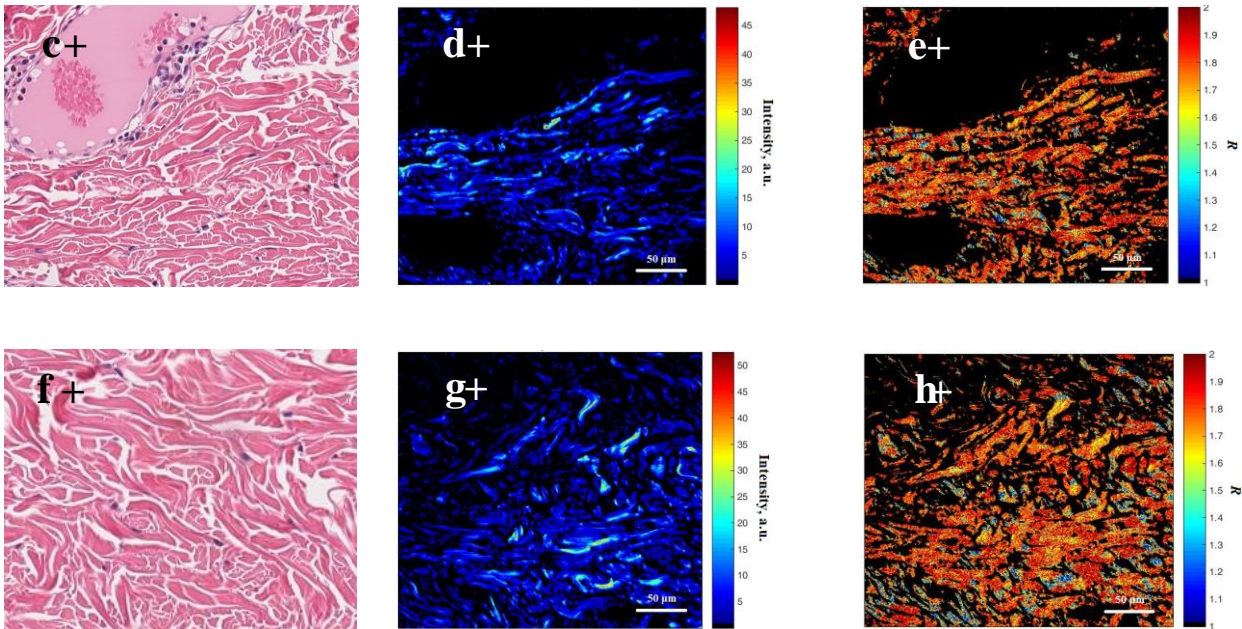
<sup>3</sup>Ncugt "Tgugctej "Egptg. "Hewnw| "qh'Rj { uleu. "Xkpkwu" Wpkxgtukv|. "Ucwgvgnu" Cxgpgw<sup>5</sup>. "NV/32444. "Xkpkwu. "Nkj wpcle"  
<sup>4</sup>F gr ctwo gpv'qh'Rcvj qmji { . "Hqtgpule" O gf kelpg"cpf "Rj cto ceqni { . "Hewnw| "qh'O gf kelpg. "Xkpkwu" Wpkxgtukv|. "O OM"  
Ekwnkqpkq "Uv'43 I49. "NV/25323. "Xkpkwu. "Nkj wpcle"  
<sup>5</sup>Nki j v'Eapxgtukp. "Mgtco kmw'u"4D. "NV/32456. "Xkpkwu. "Nkj wpcle"  
<sup>6</sup>F gr ctwo gpv'qh'Rj { uleu. "F gr ctwo gpv'qh'Ej go lecn'cpf "Rj { ulecn'Uelgpegu. "Wpkxgtukv| "qh'Vqtqpvq. "557; "O kuukuwci c "Tf "  
P qtvj . "O kuukuwci c. "N7N'3E8. "Ecpfc c"  
o ctv|pcu|kwneB HkxwH|"

F gxgnr o gpv'cpf "ur tgcf "qh'ecpegt "ctg"npqy p "v"ecwug"ej cpi gu"lp"vj g"utweww g"qh'gz tcegnwrt "o ctkz "GEO +0C"  
uudwvpcn'r qt vqp "qh'GEO "ku'eqo r tkvgf "qh'eqmci gp. "y j lej "ku" c"pqpepvtqu{ o o gtle "utweww g0F wg"vq"vj ku. "k'ku"npqy p "  
v" r tqf weg "ugeqpf /j cto qple" i gpgtcvkqp " \*U I + "uki pcnu" Hwtv j gto qtg. "vj g" U I " uki pcnu. " r tqf wegf "lp" eqmci gp. "ctg"  
utqpi n| "f gr gpf gpv'qp"vj g" cpi rg"dgvy ggp"vj g" eqmci gp "hdtu"cpf "vj g" kpego kpi "rki j v'r qrtk c vqpp. "j gpeg"vj g" utwewwcn'  
ej cpi gu'qh'eqmci gp "ecp"dg'uwf lgf "wukpi "r qrtklo gtle "ugeqpf /j cto qple" i gpgtcvkqp "o letqueqr { "J3\_0"

C "tgf wegf" r qrtklo gtle " U I " o letqueqr { " vgej pls wgu. " pco gn| " rkpget" r qrtk c vqpp/kp. " r qrtk c vqpp/qw" \*RRRQ+  
o letqueqr { . "ku"cr r rkgf "hqt"unlp "kuuwg"ko ci kpi O'kp "RRRQ"ecug. "hqt"gej "qtlgpcvqpp"qh'rkpgetn| "r qrtk gf "kpego kpi "rcugt"  
tcf kvqpp" c'ugv'qh'rkpgetn| "r qrtk gf "ucvgu'qh'qwi qkpi "ugeqpf "j cto qple"uki pcnku"o gcuwgf "J4\_0"

Kp"vj ku"y qtm "RRRQ"vgej pls wgy"cu"cr r rkgf "v"q"qdvclp"vj g"kpvgpukv|. "cej kcn'uwuegr vdkkx| "tcvkq" T"cpf "eqmci gp" hdtg"  
qtlgpcvqpp" cpi rg" f kntkdwkqpu"kp" r V3d"uci g" rnpvki kpwu"o gnpqo c"j kxqni lecn'ugevqpu0Vj g" r ctco gvgf "f kntkdwkqpu"  
y gtg"gz tcevgf "d| "r gthto kpi "c" r kzgn'd { "r kzgn'kxkpi "r tqegf wtg"qh'vj g"kpvgpukv| "xctkdwkqpu"kp"vj g"ko ci g"wukpi "vj g" U I "  
kpvgpukv| "gs wcvqpp" hqt"vj g" RRRQ"ecug" J4\_0Vj g"uco g"uco r rkgf "eqpvcvqpp"pqto cni"kpvgtugevqpp"dgvy ggp"j gcmj { "gr kf gto ku"  
cpf "f gto ku"cpf "ecpegtqwu"kuuwg"kpvgtugevqpp"dgvy ggp"wo qt "kuuwg"cpf "f gto ku"vj gthgtg"vj g"ug" r ctco gvgu"y gtg"uwgf "  
v"lpvgukv c v"vj g" utwewwcnf khtgpgegu"dgvy ggp"vj g"y q"ecug0"

RRRQ" f cv" cpcn| uku'tgxgrcf "vj g" f khtgpgegu"kp"eqmci gp "hdtg"qtlgpcvqpu"cu"y gni'cu" kpetgcug"kp" T"tcvkq"cpf "f getgcug"  
kp" U I "kpvgpukv| "kp"ecpegtqwu"kuuwg. "y j lej "uwi i guu" c"o qf khtg" eqmci gp "utweww g0Vj gthgtg. "vj g" f khtgpgegu"kp"vj g"  
r qrtklo gtle" r ctco gvgu"qh'eqmci gp "ecp"dg"cr r rkgf "hqt"o gnpqo c"tuguctej "cpf "f kci pquku0"



Hki 030P qnrkpgct "o letqueqr { "qh'o gnpqo c"lp"J ( G'j kxqr cvj qmji { "uco r ngu0J ( G'luclpgf "ecpegtqwu" c"  
cpf "pqto cni" f +kuuwgu"y kj "eqttgur qpf kpi "U I "kpvgpukv| "cpf "T"tcvkq" f kntkdwkqpu"o cr u'lp"ecpegtqwu" d. "e"  
cpf "pqto cni" g. "h"kuuwgu0

Cempqy ngf i go gpw<Vj g"y qtmly cu"uwr r qtvgf "d| "i tcpvP q03040NO V/M/93: /24/22380"

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o qngewrt "utwewwgu. \$10Qr v0Uqe0C o 0D'54. 673/683\*4237-0"  
"J4\_ "C0I qrtcgk" Rqrtklo gtle "ugeqpf /j cto qple" i gpgtcvkqp "o letqueqr { "hqt" j kxqr cvj qmji { 0Rj F "vj guku. "Wpkxgtukv| "qh'Vqtqpvq. "423: 0"

**IPXGUVK CVKQP UQHDKQNQI KECN'GHHGE VUQHI TCRJ GP G'QZKF G'  
PCPQUVTWEVWTGUQP'DTQY P'VTQW'\*SALMO TRUTTA+'**

I { uku O ct wugxk kwu<sup>3,4</sup>. "I kpvct "Ucwkw<sup>3</sup>. "Lcplpc'Rcflwukg<sup>3</sup>. "fikkn "Lwti gn p<sup>3</sup>. "Ugti gl<sup>TM</sup>go wñ<sup>5</sup>.  
O kf c"Ucprngxk k v<sup>3</sup>"

<sup>3</sup>P cwtg" Tgugctej "Egpgt. "Cnrf go kqu"U04. "NV/2: 634"Xkpkwu. "Nkj wcpk"

<sup>4</sup>Xkpkwu" Wpkxgtukf. "Nkg"Uekpegu" Egpgt. "F gr ctwo gpv'qhi" Dkqej go knt { "cpf "O qrgewt" Dkqmi { ". "Ucwn vnkq" cx09. "32445"  
Xkpkwu. "Nkj wcpk"

<sup>5</sup>UTKEgpgt "hqt" Rj { ulecn'Uekpegu" cpf "Vgej pqmi { ". "Ucxpqt" cx0453. "NV/24522" Xkpkwu. "Nkj wcpk"  
i { uku O ct wugxlekuB i o eUwf Uwñ'

I tcr j gpg" qz kf g" \*I Q+ "pcpqr ct wergu" ctg" wughwi" cpf " r tqo kulpi " o cvgtkri" hqt" i tcr j gpg/ dcugf " cr r rkecvkpu" kp"  
grgvtqple. "qr vleu. "ej go knt { ". "gpgti { "uqtci g. "cpf "dkqmi { "O T gegpwl " f gxrgr gf " o gvj qf u" hqt" r tgr ctvkvq" qh" i tcr j gpg"  
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eqo r qpgpu. "kpenf kpi " y g" r nuu c' o go dtcpg. "e { vq r nuu le" qti cpngnu" cpf "pwegwu" ]4\_0' Hqt" y g" g' tgcucpu" I Q' o c { "ecwug"  
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Vj g' cko "qh" y ku" uwf { " y cu" vq" f gvtgto kpg" i gpqvzlek" t gur qpugu" pwerct "cdpqtto crkxgu" cuuc { "+cpf " o gvcnyj kqpgku"  
\*O V+ " r xgn" kp" Ucw g" r mwc" rtxc g" gzr qugf " vq" i tcr j gpg" qz kf g" pcpqutwewtgu" \*I QP + " o gvcn' o kwwtg" \*O KZ + " cpf "  
I QP - O KZ 0' Vqzlek { "qh" o gvcn' o kwwtg" \*O KZ + " cv' 62/ hqn" \*62 + " lpetgcugf " o czko wo / r gto kuukng/ eqpegpvtcvkpu" \*O RE + "  
ugv' hqt" " GW" kprpf " y cvgtu" vq" " Uwt mwc" rtxc g" y g" g" xcnwcvf " wukpi " y g" y j qrg/ o kwwtg" cr r tqcej O' kpf wvkvq" qh" o letqpwergk"  
\*O P + " pwerct " dwf u" \*P D+ " pwerct " dwf u" qp" hkr o gpv" \*P Dh+ " dk' pwegcvf " gt { y tge { vgu' y kj " pwegqr nuu le" dtkf i gu" \*DP d+ "  
cpf " dngddg" pwegk" \*DN+ " egm" y g" g" cuugugf " cu" i gpqvzlek { " gpv r qkpw0' Vj g" vqcn' i gpqvzlek { " \* I gpvz+ " r xgn" y cu"  
cuugugf " cu" y g' uwo " qh" hts wpekgu" qh" y g" cpcn' ugf " i gpqvzlek { " \*O P - P D- P Dh- DP d- DN+ " gpv r qkpw0' o gvcnyj kqpgku"  
kpf wvkvq" y cu" o gcuwgf " d { " eqmkt o gtle" tgcwkvq" wukpi " Gw cp' tgc i gpv0'

T guwmu" uj qy gf " y cv' chgt " gzr quwtg" vq" I QP 62 . " y g' co qwpv' qh" O V" kp" " Uwt mwc" rtxc g" lpetgcugf . " cu" y gmi' chgt " y g"  
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huj " rtxc g' Vj g" i gpqvzlek { " cuuc { " uj qy gf " y cv' y g" j ki j guv' hts wpekgu" qh" cpcn' ugf " gpv r qkpw" y g" g" hqwpf " kp"  
I QP 62 - O KZ 62 " gzr qugf " rtxc g' Uwt mwc " rtxc g" gzr quwtg" vq" I QP 62 - O KZ 62 " tguwngf " kp" c" uki pl' htecpv' grgxcvkvq" qh"  
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y g' O V' cpcn' uku" o c { " kpf kecvg" y g' r qv' p' vkn' qh" I QP " vq" d' kpf " j gcx { " o gvcn' kp" " Uwt mwc " rtxc g' 0'

**Cempy rgi o gpw'**

Vj ku' y qtnly cu' hwpf gf " d { " y g" Tgugctej " Eqwpeki" qh" " Nkj wcpk. " Rtqlgev" P q0U/O KR/42/440'

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[4]\_C0M0F cuo c' j cr ctc. "VOR0U0F cuctk" R0D0Vej qwpy qw" I tcr j gpg/ Dcugf " P cpqo cvgtknu" Vqzlek { " kp" Huj 0' Tgx" Gpxkq" Eqpvco " Vqzleqn" 469. "367: "  
\*423; +0'  
[5]\_P 0O cij qtc. "Q0D0Xlnc" hqtgu" I 0Cwf ktc. "R0Uk gi ct. "L/ U0Ngg. "V/ T0I gt. "E/ F" J ukq. "Vqzlek { " uwf kgu" qp" i tcr j gpg/ dcugf " pcpqo cvgtknu" kp" cs wvle"  
qti cpluo u' c' wvt gpv' wpf gtucpf kpi . " O qrgewt" 47\*38+ 583: " \*4242+0'

**IO RCEV'QHT'GF 'ENQXGT'UGGF 'EQNQT'QP'I GTO KPCVKQP."**  
**O QTRJ QO GVT[ . 'CPF 'TQQV'P QF WNCVKQP 'CHVGT'UGGF "**  
**VTGCVO GPV'Y K'J 'EQNF 'RNCUO C'CPF 'GNGE VTO QO CI PGVKE 'HKGNF "**  
Cpcvqrkk'Kcpmxx<sup>3</sup>. 'Tcuc'fi wnkgp <sup>3</sup>. \ kc'P cw kgp <sup>3</sup>. 'Nco c'F gi w\ w/Hqo kpu<sup>3</sup>. 'Kkpc'Hkrcvxc<sup>4</sup>. "  
Xgtqpknc'N{ wuj ngxlej <sup>4</sup>. "Xkf c'O kf cflkgp <sup>3</sup>, "

<sup>3</sup>Hcewmx'qh'P cwtcn'Uelgpegu. 'X{ vewcu'O ci pwa'Wpkxgtuk\'. 'Nkj wcpke"  
<sup>4</sup>D0K0Ugr cpqx 'Kpukwg'qh'Rj { uleu. 'P cvkppcn'Cecf go { 'qh'Uelgpegu. 'Dgrtwu'  
cpcvqrkk'KcpmxxB xf w0n'

"  
K'j cu'dggp'uj qy p'd{ "pwo gtqwa'uwf lgu"]3/5\_ 'v' cv'gzr quwtg'qh'r rcpw'v'q' gpxktqpo gpvcn'utguu'ecp"lpetgcug'uggf " i gto kpcvkqp'cpf 'r tqo qvg'o qtr j qo gvkcn'ej cpi gu'lp'r rcpw'v'j ku'uwf { 'clo gf 'v'gxcnvc'v'j g'ghgevu'qh'uggf "eqcv'eqmt" qp'v'j g'uggf "i gto kpcvkqp'qh'tgf 'emxgt' "Vt ktrkwo 'r' tcvpug'NO' 'uggf npi 'f gxmqr o gpv.'cpf 'v'j g'co qwpv'qh'hrcxqpqkf u'cpf " tqqv'pqf wrcvkqp'lpf wegf 'd' 'grgevtqo ci pgvke'hgrf "GO H'cpf 'eqrf 'r rcuo c' "ER+0Vj g'gzr gtko gpw'y gtg'r gthqto gf 'qp'uggf u' qh'tgf 'emxgt'ewnkxct'-'Ucf ' pck0Dghqtg'uqy kpi. 'tgf 'emxgt'uggf u'qh'f kthgtgpv'uggf 'eqmtu' "gmy 'cpf 'f ctnlr wtr rg+y gtg' v'gcv'g' y kj 'y q'v' r gu'qh'r j { ulecn'utguuqtu'ER'ht'7"cpf '9'o kpwgu' "ER7"cpf 'ER9+'cpf 'GO H'ht'32'o kpwgu' "GO H2+0 Vj g'ghgevu'qh'v'gco gpv'qp'uggf "i gto kpcvkqp'y cu'guko cv'gf "d{ 'lp'xktq" i gto kpcvkqp'v'gu'0Vj g' nkgvke"r ctko gvgtu'qh' i gto kpcvkqp'y gtg'f gvto kpgf 'Xk'/'v'j g'hpcn'i gto kpcvkqp'r gtegpvc' g. "O g'/'v'j g'o gf kcp"i gto kpcvkqp'v'ko g. "S w'0's wctv'rg" f gxcvkqp. 'wplh'qto k\ 'i gto kpcvkqp'lp'uggf 'r qr wrcvkqp'0Vj g'o qtr j qo gvkcn'ej cpi gu.'ej cpi gu'lp'v'j g'co qwpv'qh'hrcxqpqkf u' cpf 'v'j g'pwo dgt'qh'tqvp'pqf wrgu'ht'v'j g'ewnkxct'v'j cv'y cu'i tqy kpi 'lp'v'j g'udwutcv'g'ht'7'y ggm'y gtg'o gcwtf 0""

Vj g'tguwu'j cxg'uj qy p'v'j cv'v'j g'ghgevu'qh'uggf "v'gco gpv'y kj "ER'cpf "GO H'qp'v'j g' i gto kpcvkqp'nkgvke. "uggf npi " f gxmqr o gpv'qh'tgf 'emxgt'uggf u'uki pkl'ecpv' "f gr gpf u'qp'v'j g'eqmt'qh'v'j g'uggf u'0E'apvtqn'uggf u'qh'dqy 'eqmtu'uj qy gf " Xk'322' . 'v'j gthqtg. 'v'gco gpv'qh'uggf u'y kj 'utguuqtu'eqw'f 'pqv'j cxg'c' r qukxg'ghgevu'qp'v'j ku'lpf lcvqt0J qy gxt. "ER7" tgf wegf "Xk'qh' { gmy 'uggf u'd{ '39' 0P qpgv' gguu. 'v'j g'utguu'lpf wegf 'ej cpi gu'lp'v'j g'O g'lpf gz 'y gtg'f kthgtgpv'ht' " { gmy " cpf 'f ctnlr wtr rg'uggf u'0Utguu'v'gco gpv'f kf 'pqv'j cxg'c'uki pkl'ecpv'ghgevu'qp'O g'lpf gz 'ht' " { gmy 'uggf u.'dw'v'j g'v'gco gpv' qh'r wtr rg'uggf u'y kj "ER7. "ER9'tgf wegf "O g'd{ '46' "cpf '78' . 'tgur gev'xgn'0V'v'gco gpv'y kj "GO H2'f kf "pqv'chgevu'v'j g' i gto kpcvkqp'tcv'g'qh'gkj gt' { gmy 'qt' r wtr rg'uggf u'0""

GO H2'uggf "v'gco gpv'j cf 'r qukxg'ghgevu'38' +qp'v'j g'j gki j v'qh'v'j g'cdqxi tqwpf 'r ctv'qh'uggf npi 'i tqy p'htqo 'v'j g' { gmy 'uggf u'cpf 'v'j g'gpi v'j 'qh'v'j gk'tqqv'0P qpg'qh'v'j g'qy gt' utguuqtu'j cf 'c'uki pkl'ecpv'ghgevu'qp'v'j gug'r ctko gvgtu'0GO H2" r tqo qvg'cdqxi tqwpf 'r ctv'y gki j v'i clp'd{ '52' . 'cmj qwi j 'k'f kf "pqv'j cxg'c' tgrkcdng'ghgevu'qp'tqqv'y gki j v'0ER9'j cf "c" pgi cv'xg'ghgevu'qp'tqqv'y gki j v'y j lej 'f getgcugf 'd{ '72' 0Vj g'GO H2'cpf 'ER7'gzr quwtg'f kf 'pq'v'ecw'g'wej 'c'uki pkl'ecpv' f kthgt'pge'0Utguu'v'gco gpv'f kf 'pqv'ej cpi g'v'j g'pwo dgt'qh'uggf npi 'rgcxgu. 'dw'ER7'cpf 'GO H2'lpetgcugf 'v'j g'pwo dgt' qh'pqf wrgu'd{ '80'cpf '330'v'ko gu. 'tgur gev'xgn'0V'j g'j gki j v'qh'v'j g'cdqxi tqwpf 'r ctv'qh'v'j g'eqpvtqnl' tqw' qh'uggf npi u'i tqy p' htqo 'v'j g'r wtr rg'uggf u'y cu'42' . 'v'j g'y gki j v'y cu'4; ' 'j k j gt. 'v'j gug'r ctko gvgtu'ht'v'j g'uggf npi u'qh'v'j g'ER9'i tqw' 'y gtg'cu' o wej 'cu'4: ' 'cpf '62' 'j k j gt'eqo r ctgf 'v'j g'v'j g'uggf npi u'i tqy kpi 'htqo 'v'j g'tgur gev'xg'i tqw' u'0V'v'gco gpv'qh'r wtr rg'uggf u' y kj 'ER7'tgf wegf 'v'j g'j gki j v'qh'v'j g'cdqxi tqwpf 'r ctv'qh'uggf npi u'd{ '42' 0Utguu'v'gco gpv'qh'r wtr rg'uggf u'j cf 'pq'tgrkcdng' ghgevu'qp'tqqv'gpi v'j . 'v'j g'pwo dgt'qh'rgcxgu. 'cpf 'v'j g'pwo dgt'qh'pqf wrgu'0""

Uggf "v'gco gpv'y kj "ER'cpf "GO H'lpf wegf 'ej cpi gu'lp'v'j g'co qwpv'qh'hrcxqpqkf u' "gze'gr v'nwq'rkp'+lp'tqqv'gz'wf cv'gu'0 Rctv'kwctn' 'utqpi 'y cu'ghgevu'qh'ER9'/'v'j g'co qwpv'qh'j gur g'v'kp. 's wte'g'v'p. '9/j { f tqz { r j r'cxqpg. 'f ckl' gkp'lpetgcugf "4/5" v'ko gu'0Vj g'qdv'clp'gf "tguwu'eqph'ko "v'j g'j { r qy guku'v'j cv'v'j g'ej cpi gu'lp'tgf "emxgt'pqf wrcvkqp'cev'xkv' 'ecw'gf "d{ "uggf " v'gco gpv'utguuqtu'o c{ 'dg'f w'v'g'cp'cev'xg'lpv'gtcev'kp"y kj 'tj k qdcev'tk'f w'v'v'j g'ej cpi gf 'ej go lecn'eqo r qukxqp'qh' tqqv'gz'wf cv'gu'0""

Vj g'uwf { 'uj qy gf 'v'j cv'r'tg/uqy kpi 'v'gco gpv'qh'tgf 'emxgt'uggf u'y kj 'eqrf 'r rcuo c'cpf 'cp'grgevtqo ci pgvke'hgrf 'ecp" lpf wegf'uggf "eqcv'eqmt/f gr gpf gpv'ej cpi gu'lp"i gto kpcvkqp. "o qtr j qo gvkcn'r ctko gvgtu. 'pqf wrcvkqp. 'cpf 'v'j g'co qwpv'qh' hrcxqpqkf u'0"

j3\_Uctk. "R0'Xqi gn'O kmw-'M0'O q' gk. 'O 0( 'Lxpnet. "K'Ghgevu'qh'P qpj gto cni'Rcuo c'qp'O qtr j qm' { 'I gpgv'eu'cpf "Rj { ukq'qi { 'qh'Uggf u'c' " Tgx'gy 0R'rcpu'; .3958'4242+0"

j4\_ "Xwdqx". T'0'gv'c'0Gxcnvc'v'j g'k'o r cev'qh'Eqrf 'C'vo qur j g'ke 'Rtguu'g'Rcuo c'qp'Uq { dgcp'Uggf 'I gto kpcvkqp'0R'rcpu'32. '399'4243+0""

j5\_ 'O kf c' l'kgp. 'X'0'gv'c'0Uggf 'v'gco gpv'y kj 'eqrf 'r rcuo c'cpf 'grgevtqo ci pgvke'hgrf 'lpf wegf'ej cpi gu'lp'tgf 'emxgt'v'q'v'j tqy 'f { pco leu. 'hrcxqpqkf " g'z'wf cv'kp. 'cpf 'cev'xg'u'pqf wrcvkqp'0R'rcuo c' "Rt'qegu'0R'rcuo c' 0'4242+0

CPCN[ UKU'QH'UGEQPF CT[ 'O GVCDDQNKGUQH'O GF KECN'RNCPVU'  
*Levandula N0'CPF 'Helichrysum N0''*

*Mctqrkpc'Ncpmekv . 'T w' O lenkpg . 'Xkm c' Mc-nqpkpg . 'Cwf tkwu' Uki kcu' O ctw-m'*

" Hcewm\ 'qh'P cwtcn'Uelgpegu. 'Kpwt wo gpvcrn' Cpcn\ uki' Qr gp' Ceeuu' Egptg. 'X { wvuw' O ci puw' Wpkxgtuk\ . ''  
Xkrgknqu' ut0: . 'NV66626. 'Mcvpcu. 'Nkj wcpk''

nctqrkpc: 2: 2: B i o ckrfgo "

Ncxgpf gt \*Ncxcpf wr' cpi waktqrk +guugpvkrn' qkn' ku' apg' qh' yj g' o quv' r qr wrt' cpf' ecp' dg' eqpukf' gt gf' "qpg' qh' yj g' dguv' ugnkpi' guugpvkrn' qkn' hqt' cpzkgv\ . 'ut' guu' cpf' f' gr' tguakp0' k' vgt' pcvkqpcn' qti' cpk' cvkpu' uwe' j' cu' yj g' Y' qtrf' 'J' gcnj' 'Qti' cpk' cvkq' \*Y' J' Q+ . 'yj g' Gwt' qr' gcp' 'Uelgpkw' 'E' qqr' gtc' wkg' hqt' 'Rj' { vqj' gtr' { '\*GUEQR+' qt' 'yj g' Gwt' qr' gcp' 'O' gf' kelpgu' 'Ci' gpe' { '\*GO C+' xcnk' cvg' 'yj g' r' tqr' g' t' vku' qh' 'yj' ku' o' gf' kelpcn' r' npx' . 'uwe' j' cu' cpzkgv\ ' cpf' ' ut' guu' t' g' r' gh' ]3\_0' Cnuq. 'kp' vgt' guv' 'kp' 'J' grkej t f' uwo' 'N0' guugpvkrn' qkn' ku' i' tqy' kpi' ' tcr' k' n' f' 'O' J' grkej t f' uwo' 'N0' guugpvkrn' qkn' ku' cu' dgpp' 'uj' qy' p' 'vq' 'j' cxg' 'cp' v' k' p' h' r' o' o' cvqt' { 'r' tqr' g' t' vku' 'kp' t' g' e' p' v' f' gecf' gu' 0' k' p' 'cf' f' k' k' p' . 'ux' g' t' cn' u' w' f' k' u' j' cxg' 'uj' qy' p' 'v' j' cv' u' g' e' p' f' ct' { 'o' g' c' d' q' r' k' s' u' q' h' 'J' grkej t f' uwo' 'N0' 'cev' cu' c' 't' g' g' t' cf' k' e' c' n' i' u' e' c' x' g' p' i' g' t' 'y' j' cv' e' p' 't' g' u' q' t' g' e' g' m' w' r' t' 't' g' f' q' z' 'd' c' m' p' e' g' 'c' p' f' 'u' n' y' 'w' o' q' t' 'e' g' m' i' t' q' y' 'j' 'c' p' f' 'e' c' p' 'd' g' 'w' u' g' f' 'k' p' 'e' c' p' e' g' t' 'y' j' g' t' c' r' { ' ]5\_0'

Guugpvkrn' qkn' ctg' o' cf' g' w' r' qh' r' e' t' i' g' t' c' t' q' o' c' v' e' 'c' p' f' 'x' q' r' v' k' g' 'e' q' o' r' q' w' p' f' u' 'h' q' w' p' f' 'p' c' w' t' c' m' l' 'k' p' 'c' m' i' r' c' t' w' i' q' h' 'y' j' g' r' n' e' p' v' 0' N' l' n' g' ' o' g' f' k' e' l' p' g' u' . 'e' q' u' o' g' v' e' u' 'c' p' f' 'h' q' q' f' 'r' t' g' u' g' t' x' c' v' k' g' u' 'y' j' g' { 'c' t' g' 'y' k' f' g' n' l' 'w' u' g' f' 'k' p' 'f' k' h' g' t' g' p' v' e' q' w' p' t' k' u' 0' V' q' f' c' { . '5.222' guugpvkrn' qkn' v' r' g' u' ctg' n' p' q' y' p' . 'c' p' f' 'y' j' g' t' g' 'c' t' g' 'c' d' q' w' '522' 'e' q' o' o' g' t' e' k' n' i' v' i' r' g' u' ]7\_0' F' g' o' c' p' f' 'h' q' t' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'k' u' 'i' t' q' y' k' p' i' . 'f' w' g' 'v' q' 'y' g' k' t' 'x' c' t' k' q' w' i' y' j' g' t' c' r' g' w' l' e' 'r' t' q' r' g' t' v' k' u' 0' J' grkej t f' uwo' 'N0' c' p' f' 'N' g' x' c' p' f' w' r' 'N0' guugpvkrn' qkn' ctg' y' k' f' g' n' l' 'w' u' g' f' 'c' m' l' q' x' g' t' 'y' j' g' y' q' t' r' f' 'k' p' 'e' q' u' o' g' v' e' u' . 'c' t' q' o' c' v' j' g' t' c' r' { . 'r' g' t' h' w' o' g' t' { . 'r' j' c' t' o' c' e' { . 'g' v' e' 0: 'y' j' g' t' g' h' q' t' g' . 'y' j' k' u' 'p' c' w' t' c' n' l' e' q' o' r' q' u' k' k' q' p' 'q' h' i' r' t' q' f' v' e' w' i' k' u' g' t' { 'k' o' r' q' t' w' p' v' p' q' y' c' f' c' { u' 'c' u' ' p' c' w' t' c' n' i' t' g' c' v' o' g' p' u' 'c' t' g' 'd' e' g' e' q' o' k' p' i' 'o' q' t' g' 'c' p' f' 'o' q' t' g' 'r' q' r' w' r' t' 0'

Qpg' qh' yj g' o' quv' eqo o' qp' y' c' { u' v' q' q' d' v' c' l' p' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'k' u' 'u' g' c' o' 'f' 'k' u' k' m' e' v' k' p' 'q' t' 'j' { f' t' q' f' k' u' k' m' e' v' k' p' 0' V' j' k' u' o' g' y' q' f' 'k' u' 'w' u' g' f' ' y' j' g' p' . 'k' p' 'y' j' g' r' t' g' u' e' p' e' g' 'q' h' 'c' 'j' k' i' j' 'e' q' p' v' g' p' v' q' h' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'k' p' 'y' j' g' t' c' y' 'o' c' v' g' t' k' e' n' 'g' z' r' q' u' w' g' 'q' 'y' c' v' g' t' 'x' c' r' q' t' 'c' p' f' 'f' 'k' u' k' m' e' v' k' p' ' v' g' o' r' g' t' c' w' t' g' . 'y' j' g' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'f' q' 'p' q' v' e' j' c' p' i' g' 'y' j' g' k' t' 'e' q' o' r' q' u' k' k' q' p' c' n' i' r' t' q' r' g' t' v' k' u' 0' C' n' u' q' . 'u' g' c' o' 'f' 'f' 'k' u' k' m' e' v' k' p' 'k' u' 'd' c' u' g' f' 'q' p' 'y' j' g' r' t' q' r' g' t' v' k' u' q' h' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'x' q' r' v' k' s' { . 'k' o' o' k' u' e' k' d' k' r' k' s' { 'y' k' j' 'y' c' v' g' t' + ]8\_0'

I' cu' e' j' t' q' o' c' v' q' i' t' c' r' j' { 'q' h' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'l' u' c' o' r' r' g' u' . 'q' p' g' 'q' h' 'y' j' g' 'v' e' u' v' o' g' y' q' f' u' . 'y' c' u' e' j' q' u' g' p' 'd' g' e' c' w' u' g' 'u' g' r' e' v' k' s' g' 'v' u' v' o' g' y' q' f' u' 'c' t' g' ' x' g' t' { 'k' o' r' q' t' w' p' v' h' q' t' 'f' g' v' g' t' o' k' p' k' p' i' 'y' j' g' 'e' q' o' r' q' u' k' k' q' p' 'q' h' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 0' I' c' u' e' j' t' q' o' c' v' q' i' t' c' r' j' { ' / 'o' c' u' u' 'r' g' e' t' q' o' g' t' { '\*I' E' 'T' O' U' k' u' ' p' p' g' 'q' h' 'y' j' g' o' q' u' v' k' o' r' q' t' w' p' v' o' g' y' q' f' u' 'h' q' t' 'y' j' g' f' g' v' g' t' o' k' p' c' v' k' p' 'q' h' i' r' w' k' s' { ' ]4\_0'

I' E' / 'O' U' c' p' c' n' u' k' i' y' c' u' 'w' u' g' f' 'h' q' t' 'J' grkej t f' uwo' 'k' e' r' k' e' w' o' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 0' V' j' g' u' w' f' { 'u' j' q' y' g' f' '89' 'e' q' p' u' k' w' g' p' u' 'k' p' 'y' j' g' 'g' u' u' g' p' v' k' r' n' ' q' k' n' 'c' e' e' q' w' p' v' k' p' i' 'h' q' t' ' ; : 046' 'q' h' 'y' j' g' 'v' q' v' c' n' 'q' k' 0' 'G' u' u' g' p' v' k' r' n' 'q' k' n' 'k' u' 'e' j' c' t' c' e' v' g' t' k' f' g' f' 'd' { 'y' j' g' r' t' g' f' q' o' k' p' e' p' e' g' 'q' h' 'q' z' { i' g' p' / e' q' p' v' k' l' p' i' ' u' g' u' s' v' k' g' t' r' g' p' g' u' 'c' p' f' ' ' q' z' { i' g' p' / e' q' p' v' k' l' p' i' ' ' o' q' p' q' v' g' t' r' g' p' g' u' 0' V' j' g' o' c' k' p' 'e' q' p' u' k' w' g' p' u' 'q' h' 'y' j' g' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'c' t' g' ' / e' g' f' t' g' p' g' . ' / e' w' t' e' w' o' k' p' . 'i' g' t' c' p' { n' i' c' e' g' v' e' g' . 'h' k' o' q' p' p' g' . 'p' g' t' q' r' k' 'p' g' t' { n' i' c' e' g' v' e' g' 'c' p' f' ' ' / r' k' p' p' g' ]5\_0'

I' E' / 'O' U' c' p' c' n' u' k' i' y' c' u' 'w' u' g' f' 'q' f' g' v' g' t' o' k' p' g' 'y' j' g' e' j' g' o' k' e' c' n' l' e' q' o' r' q' u' k' k' q' p' 'q' h' i' r' x' g' p' f' g' t' 'q' k' n' 0' C' u' 'g' z' r' g' e' v' g' f' . 'y' j' g' o' c' k' p' 'e' q' o' r' q' p' p' g' u' ' y' g' t' g' 'h' k' p' c' m' q' n' i' c' p' f' 'h' k' p' c' n' i' n' i' c' e' g' v' e' g' . 'c' e' e' q' w' p' v' k' p' i' 'h' q' t' '5407' ' 'c' p' f' '6505' ' 'q' h' 'y' j' g' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 't' g' u' r' g' e' v' k' s' g' n' l' ' ]6\_0'

Ceeq' t' f' k' p' i' 'q' 'y' j' g' 'c' p' c' n' u' k' i' y' q' h' 'y' j' g' 'h' k' g' t' c' w' t' g' . 'y' j' g' 'x' q' r' v' k' g' 'e' q' o' r' q' w' p' f' u' 'q' h' 'J' grkej t f' uwo' 'k' e' r' k' e' w' o' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'c' t' g' 'd' c' u' g' f' ' q' p' 'v' g' t' r' g' p' g' u' < p' g' t' k' e' g' v' e' g' . ' / R' k' p' p' g' . 'p' g' t' q' r' k' ' / e' c' t' { q' r' j' { n' e' p' p' g' . 'd' l' u' c' d' q' r' e' p' g' . 'c' l' w' r' e' p' g' . 'c' p' f' 'y' j' g' f' q' o' k' p' c' p' v' e' q' o' r' q' w' p' f' u' f' g' t' k' x' g' f' ' h' t' q' o' 'N' g' x' c' p' f' w' r' 'c' p' i' w' a' k' t' q' r' k' 'k' p' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'c' t' g' 'h' k' p' c' m' q' n' i' c' p' f' 'h' k' p' c' n' i' n' i' c' e' g' v' e' g' 0'

[3\_ 'Nqr' gl' 'X0' P' k' n' g' p' 'D0' U' q' n' u' 'O' 0' T' c' o' 'f' g' l' 'O' 0' 0' 'L' @' g' t' 'C' 0' 0' 'M' %4239+0' G' z' r' n' q' t' k' p' i' 'R' j' c' t' o' c' e' q' n' j' i' l' e' c' n' i' 0' g' e' j' c' p' k' u' o' u' q' h' 'N' e' x' g' p' f' g' t' \*' N' c' x' c' p' f' w' r' 'c' p' i' w' a' k' t' q' r' k' -' ' G' u' u' g' p' v' k' r' n' 'Q' k' n' i' q' p' 'E' g' p' v' c' n' i' P' g' t' x' q' u' u' 'U' f' u' g' o' 'V' c' t' i' g' u' 0' F' g' r' c' t' w' o' g' p' v' q' h' 'R' j' c' t' o' c' e' { . 'H' c' e' w' m' \ 'q' h' 'J' g' c' n' j' 'U' e' l' g' p' e' g' u' . 'W' p' k' x' g' t' u' k' f' c' f' 'U' c' p' 'L' q' t' i' g' . \ 'c' t' c' i' q' l' c' . 'U' r' c' k' p' 0' ]4\_ 'D' w' e' m' g' 'L0' %4225+0' E' r' i' k' p' l' e' c' n' i' C' t' q' o' c' v' j' g' t' c' r' { < 'G' u' u' g' p' v' k' r' n' 'Q' k' n' 'k' p' 'R' i' c' e' v' e' g' 0' U' g' e' q' p' f' 'G' f' k' k' a' p' 0' R' e' i' g' '94/960' ]5\_ 'I' k' u' o' q' p' f' k' e' 0' 'O' c' t' e' q' I' 0' 'E' c' p' l' k' C' 0' %4242+0' J' g' r' e' j' t' f' u' w' o' 'k' e' r' k' e' w' o' 'T' q' y' +I' 0' F' q' p' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'E' q' o' r' q' u' k' k' q' p' 'c' p' f' 'r' q' v' e' p' v' k' i' c' l' e' p' v' k' p' g' q' r' n' e' u' k' e' 'g' h' t' g' e' v' 0' U' q' w' j' ' ' C' h' l' e' e' p' 'L' q' w' t' p' c' n' i' q' h' 'D' q' w' c' p' { 'X' q' n' o' g' '355' . 'R' e' i' g' u' '444/4480' ]6\_ 'F' 'C' w' t' k' 'H' F' 0' 'V' g' e' e' c' 'O' 0' 'U' t' k' r' r' q' i' k' 'X' 0' 'U' c' n' e' v' q' t' g' I' 0' 'D' e' w' l' p' g' n' k' 'N' 0' 'O' c' l' | c' p' w' T' 0' %4227+0' C' p' v' k' h' p' i' c' r' i' c' e' v' k' s' { 'q' h' 'N' e' x' c' p' f' w' r' 'c' p' i' w' a' k' t' q' r' k' 'e' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'c' i' c' l' p' u' 'E' c' p' f' k' f' c' 'c' n' i' l' e' c' p' u' 'f' g' c' u' v' c' p' f' 'o' { e' g' r' i' c' n' i' h' q' t' o' 0' 'O' g' f' l' e' c' n' i' 0' { e' q' n' j' { . 'X' q' n' o' g' '65' . 'K' u' w' g' '7' . 'R' e' i' g' u' '5' : 365 ; 80' ]7\_ 'D' j' e' x' c' p' t' e' o' { c' 'U' 0' 'X' k' i' j' p' w' r' t' k' c' 'U' 0' 'U' c' n' j' C' n' 'C' d' q' q' { d' 'O' 0' 'X' k' i' c' { c' m' w' c' i' 'T' 0' 'D' e' u' n' i' t' e' p' 'F' 0' %423 ; +0' T' q' n' g' 'q' h' 'g' u' u' g' p' v' k' r' n' 'q' k' n' 'k' p' 'h' q' q' 'u' c' h' g' v' < 'C' p' k' o' l' e' t' q' d' k' n' i' c' p' f' 'c' p' v' k' z' k' f' c' p' v' c' r' n' e' c' v' k' p' u' 0' i' t' c' l' p' ( ' 'Q' k' i' U' e' l' g' p' e' g' 'c' p' f' 'V' e' j' p' q' n' j' { . 'X' q' n' o' g' '4' . 'K' u' w' g' '4' . 'R' e' i' g' u' '6' ; /770' ]8\_ 'J' c' p' f' c' 'U' 0' 'y' c' o' k' e' v' U' 0' %422 : +0' G' z' t' e' c' v' k' p' 'V' e' j' p' q' n' j' k' u' h' q' t' 'O' g' u' l' e' p' c' n' i' c' p' f' 'C' t' q' o' c' v' e' 'R' e' r' p' u' 0' k' p' v' g' t' p' c' v' k' p' c' r' i' e' g' p' v' t' 'h' q' t' 'U' e' l' g' p' e' g' 'c' p' f' 'j' k' i' j' 'v' e' j' p' q' n' j' { 0' R' e' i' g' ' 660'

**CPCN[ UKU'QH'VJ G'DKQE QP UQNK' CVKQP 'RQVGP VKCN'QH'  
STAPHYLOCOCCUS UR0J 8"**

Ncw{ pcu'Xc-ngxk kwu<sup>3</sup>. 'Xkku'O cn pcxk kwu<sup>3</sup>. 'O ctklc' lcpmwpe<sup>4</sup>. 'T gpcvc' I wf kwækv<sup>3</sup>"

<sup>3</sup>Xkpkwu'Wpkxgtuk{. 'Egpyt' qh'Nkhg'uelgpegu. 'Kpukwag' qh'Dkuelgpegu 'Xkpkwu. 'Nkj wcpk'

<sup>4</sup>Xkpkwu'Wpkxgtuk{. 'Egpyt' qh'Nkhg'uelgpegu. 'Kpukwag' qh'Dkuej go krt{. 'Xkpkwu. 'Nkj wcpk'

rcw{ pcu'XcungxlekwB i o eQwfw'kwB

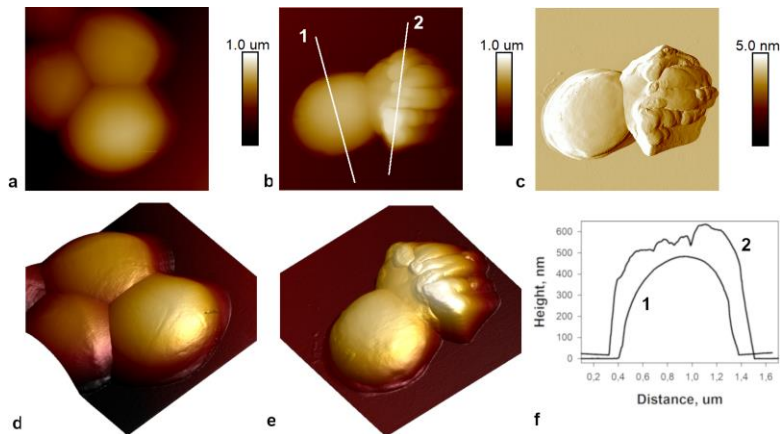
O letqdkm{ 'lpf wegf "ecrekq" r tgekr kcvkqp "O KER+" hqt "uqkl'dkqepuqrkf cvkqp" ku'c' tgrvkvgn{ 'tgegpw{ 'f gxgnr gf "uchg." ghgevkxg' cpf "geq/ltkpf n{ "vej pls wg" vq" lo r txxg" vj g" i gpgtcl' r tqr gtvku' qh' uqku' cpf "uqrxg" ugxgtcl' qh' vj g" o quv' eqo o qp" i gqgpxktqpo gpcnr' tqdrgo u. "kq'0'gtqkqp. 'r qmwkqp' cpf "EQ<sub>4</sub>" ugs wguvcvkqp0Vj ku' r tqegu' wklk' gu' vj g" o gvcdqne' r cvj y c{ u' qh' dcevtk" vq" hqto "ecrekgu" \*EcEQ<sub>5</sub>+ vj cv' dlpf "uqkl' r ctvlegu" vqi gvj gt. "rgcf kpi "vq" kpetgcuqf "uqkl' utgpi vj "cpf "ukhpgu" dgecvwg' qh' vj ku' r j { ukecl' eqppgevkqp0Vj g' r tgekr kcvkqp' qh' ectdpcvku' xlc' wgc' j { f tqn' uku' d{ "wtgnf ve" dcevtk' ku' vj g" o quv' utckl j vhty ctf "cpf "gcukl' "eqpwqngf "o gej cpluo "qh' O KER' y kj "r qvppkcl' vq" r tqf weg" rti g" co qwpw' qh' ectdpcvku' k' c" uj qtvr' gkqf "qh' vko g<sup>3</sup>0"

Vj ku' uwf { " r tggpwa" vj g" cpcn{ uku' qh' Ucrj { nqegewu' ur 0' J 8" cu' c" r gtur gevkvxg' dkqrqi kecl' vqqr' vq" r gthqto " dkqepuqrkf cvkqp' qh' ucpf "xlc' O KER' f wg' vq" ku' j ki j "wtgnf ve" cevkxk{ 0Vq' qw' npqy ngf i g. 'y g' cnuq' r tggpva' vj g' hktv' tgr qtvgf " cvqo le' hqteg' o letqueqr { "CHO + cpcn{ uku' qh' cp' kpkclni' tqy vj "cpf " r tgekr kcvkqp' qh' "ecrekq" qp' dcevtkcl' utv' hcego'

Y g' eqpf wegf "vj g' cpcn{ uku' qh' Ucrj { nqegewu' ur 0J 8" utv' hcego' vq' qi tcr j { "ej cpi gu' chgt' vtgevo gpv' y kj "ego gpcvkqp" o kzwtg' wukpi "CHO 0Vj g' qdvcvpgf "tguwmu' kpf kecvgf "vj cv' vj g' vq' qmji { "qh' Ucrj { nqegewu' ur 0J 8" ewwvtg' cttgcf { "ej cpi gu' chgt' 3' j qvt' u' kpevdcvkqp' y kj "vj g' ego gpcvkqp" o kzwtg' \*Hi 03-0K' y cu' qdugt' xgf "vj cv' vq' qi tcr j kecl' ej cpi gu' dgi k' hqto kpi " hqto "qpg' r riq' qh' vj g' egm' \*Hi 03d. "Hi 03e. "Hi 03g+ j" qy gxgt' vj ku' ecp' dg' f wg' vq' egm' ko o qdkk' cvkqp' k' vj g' o qpqr' { gt0K' y cu' j { r qv' guk' gf "vj cv' co qtr j qwu' EcEQ<sub>5</sub>' r tgekr kcvku' y g' hqto kpi "qp' vj g' egm' 0"

Vq' vgu' vo cm' uecrq' ucpf "dkqepuqrkf cvkqp. "wtgcu' cevkxk{ 'f gr gpf gpeg' qp' i' tqy vj "tcvg' qh' Ucrj { nqegewu' ur 0J 8" y cu' hktv' kpxgunki cvgf 0Vj g' uo cm' uecrq' r kqv' uwf lgu' qh' Ucrj { nqegewu' ur 0J 8" cr r rkecvkqp' k' dkqepuqrkf cvkqp' k' p' kecvgf "vj cv' chgt' "g' zr quwg' qh' ucpf "y kj "Ucrj { nqegewu' ur 0J 8" ewwvtg' uqrl' ucpf "eqwv p' utveww' tu. "qt' k' uqo g' ecugu' qpn' " r r' vgrw' y g' hqto gf 0Vj g' utveww' tu' qdvcvpgf "d{ "wukpi "20B' 0" wgc' c' p' "20B' 0" EcEn' f kur r' { gf "j ctf kpgu' ci c' kpuv' j 4Q' c' p' "ecp" ugt' xg' v' enqi " r qtu' k' vj g' uqkl' c' p' "tgf weg' uqkl' r' gto g' cdkk' { 0"

Vj ku' tgr qt' v' j ki j rki j vu' c" uqkl' cdw' p' cpv' Ucrj { nqegewu' ewwvtg' cu' c" r tqo kuki " o letqti cpluo " hqt" O KERO' Ucrj { nqegewu' ur 0' J 8" f go qpwt' cvgf " cwt' cevkxg' " ej ctcevtk' ku' hqt" EcEQ<sub>5</sub>" r tgekr kcvkqp" c' p' " hqt" ucpf " r ctvleg' dkqepuqrkf cvkqp' 0"



Hi 030Ej cpi gu' k' p' dcevtkcl' n' o qtr j qmji { "chgt' 3' j k' p' evdcvkqp' y kj "ego gpcvkqp' uqmwkqp04F' c' p' "5F" CHO " vq' qi tcr j { "lo ci gu' qh' Ucrj { nqegewu' ur 0J 8" egm' p' qv' chgevgf "c. "f + c' p' "chgevgf "d. "g+ y kj "ego gpcvkqp" o kzwtg= e+ "

Co r rkwf g' uki p' en' v' vj qy "vj g' vq' qi tcr j { "d+ f' cv' k' p' o qtg' f' gvcl' h+ ugevkqp' c' p' n{ uku' qh' h' k' p' 3' c' p' "4' r tggpvgf "k' "d- 0"

Ucp' uk' g' 4" o "z" 4" o 0"

[3] Cpdw' R0' M' pi . 'EOJ 0' Uj k' p' . 010( "Uq. '10 U0Hqto cvkpu' qh' "ecrekwo "ectdpcvgo" kpgtcl' d{ "dcevtkcl' c' p' "ku' o wkl' r' cr r rkecvkqp' u' t' t' pi g' tr' nu' 7." \*4238-0'

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DID NOT PARTICIPATE

# CONCENTRATION QUENCHING OF ZINC-PHTHALOCYANINE IN SOLUTIONS

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Concentration quenching, or aggregation-induced quenching, occurs when the fluorescence quantum yield of fluorophores is significantly reduced upon increase of fluorophore concentration. This phenomenon is encountered in many systems [1]. From biological point of view, a particularly interesting case is quenching in chlorophyll solutions, which has been examined from the middle of previous century to this day [2,3].

In this work, we experimentally examine concentration quenching of Zinc 2,9,16,23-tetra-tert-butyl-29H,31H-phthalocyanine (TB-ZnPC). While phthalocyanine molecules are interesting in their own right [4], their similarity to chlorophyll makes them excellent model systems. It is often argued that formation of H-aggregates is responsible for fluorescence quenching. In Fig. 1a we present the fluorescence spectra of TB-ZnPC in ethanol for a few concentrations. The relative increase of the longer wavelength transition upon increasing concentration demonstrates formation of aggregates for TB-ZnPC molecules. The monomer transition demonstrates redshift upon increasing concentration, also consistent with aggregate formation. Meanwhile, in Fig. 1b the fluorescence decay kinetics are shown and only a minimal dependence upon concentration can be observed. This suggests that no simple relation exists between the mean excitation lifetime and the quantum yield which will be discussed in the presentation.

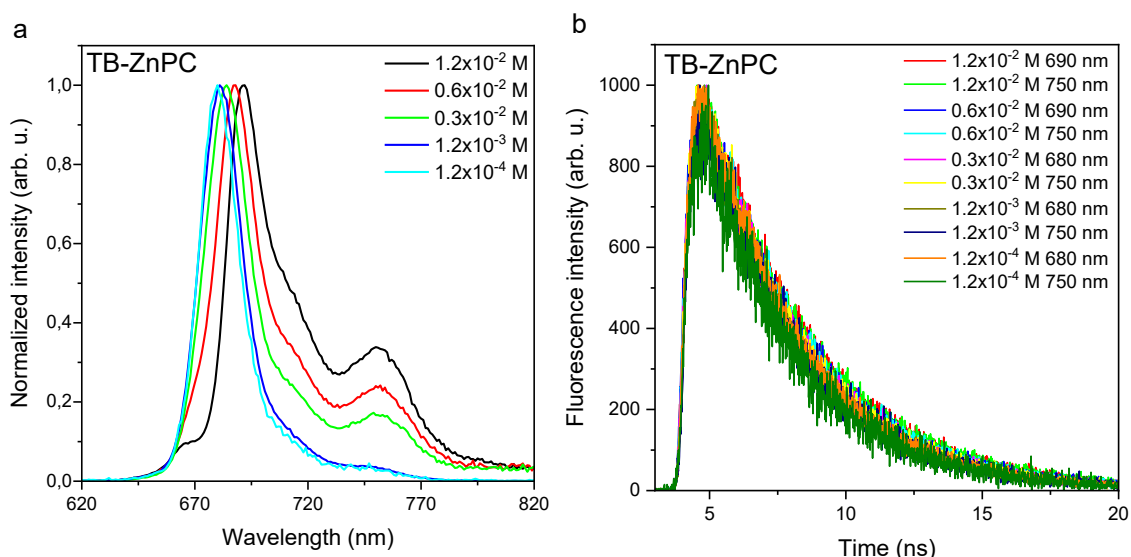


Fig. 1. a) Normalized fluorescence spectra of TB-ZnPC in ethanol at several different concentrations. b) Fluorescence kinetics of the main bands of fluorescence spectra in panel a.

[1] A. I. Burshtein, Concentration of noncoherent excitation in solutions, *Sov. Phys. Usp.* **27**, 579-606 (1984).

[2] W. F. Watson, R. Livingston, Self-Quenching and Sensitization of Fluorescence of Chlorophyll Solutions, *J. Chem. Phys.* **18**, 802-809, 1954.

[3] W.-J. Shi, J. Barber, Y. Zhao, Role of Formation of Statistical Aggregates in Chlorophyll Fluorescence Concentration Quenching, *J. Phys. Chem. B* **117**, 3976-3982 (2013).

[4] J. Mack, N. Kobayashi, Low Symmetry Phthalocyanines and Their Analogues, *Chem. Rev.* **111**, 281-321, 2011.

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DID NOT PARTICIPATE



**VJ G'RQVGP VKCN'QH'BACILLUS PSEUDOFIRMUS'CU'J GCNKP I 'CI GPV'  
QH'DKQNQI KECN'UGNH/J GCNKP I 'EQPETGVG'K'P QTVJ 'GWTQRG'  
TGI KQP'''**

Cwi wuc'Lcpmw<sup>3,4</sup>.Uko qpc'I wqdwfckv<sup>3,4</sup>.Tqpcrf cu'Lcmwqxunku<sup>4</sup>.Xkmqt'I tdkpckf.Lcwplku'  
Wdqpcxk kw<sup>3</sup>"

<sup>3</sup>F gr ctwo gpv'qh'Ej go kwt { 'cpf 'Dkqgpi kpggtkpi . 'Xkpkwu'I gf ko kpcu'Vgej plecn'Wpkxgtuks{ . 'Xkpkwu. 'Nkj wcpk'"  
<sup>4</sup>Ncdqtcvqt { 'qh'kppqxcvkg'Dwrf kpi 'Utwewtgu. 'Xkpkwu'I gf ko kpcu'Vgej plecn'Wpkxgtuks{ . 'Xkpkwu. 'Nkj wcpk'"  
cwi wuc'LcpmwB xkpkwugej Oiw'

Eqpetgv'ku'j g'o quv'y kf gn{ "wugf "dwrf kpi "o cvgtkcn'kp"j g'y qtrf OJ qy gxgt. "etcemu'kpgxkcdn{ "qr gp'wr "kp"eqpetgv'  
utwewtguO letqdkqmi lecm{ "kpf wegf "ecreksg"r tgekr kcvkp"bO KER+ecp'dg'wugf "v'hn'letcemu'ctkukpi "kp"eqpetgv'OHqt'j g'  
hqto cvkqp'qh'dkqmi lecn'ugrh'j gcnkpi "eqpetgv'ur gekkle'cmcrkr j kle'ur qtg/hqto kpi "dcevgtkc. 'y j lej 'ecp'uwtxkg'gzvgo g'r J "  
xcnwgu'cpf "j ctuj "eqpf kkpku'kp"eqpetgv'o cvtkz. "cpf "o kpgtcr'rtgewtuq't'eqo r qwpf u'wvej "cu'ecrekwo "rcevvg'ctg'pggf gf O'Kp"  
vj ku'uwf { . "j g'xkcdkks{ "qh'Deckmu'r rugvf qht o wu'lp'uwf/| gtq'vgo r gtcwttgu'cpf "kp"eqpetgv'o cvtkz "eqpcklpi "ugxgcn'  
v{r gu'qh'ego gpv'y kj "f hgtgpv'o gcnkqp'eqpegpvcvku'p'y cu'kpxguki cvgf O'

Cp" gzcrcpf gf "erc { " \*GE+ "y cu" wugf " cu" c" ecttktg" hqt " y q/eqo r qpgpv' ugrh'j gcnkpi " ci gpv' eqpukwpi " qh' Deckmu'  
r rugvf qht o wu'ur qtgu'cpf "ecrekwo "rcevvg'OHgt "94" f c { u'qh'kpedwcvkp'qh'GE "r ctv'ergu'cv'vgo r gtcwttgu'dgruy "2" AE "\*/42"  
AE+ "j g'pwo dgt "qh'xkcdrg'ur qtgu'tgo clpgf "cm quv'eqpuvcv'v32" EHWI "qh'GE+eqo r ctgf "v'eqpvtqnr'ur geko gpu'uwqgf "cv'  
vj g'tqqo "vgo r gtcwttg'OVj cv'kpf lecvgu'j cv'DO'r rugvf qht o wu'j cu'c'r qv'pvcn'vq'dg'wugf "kp"dkqmi lecn'ugrh'j gcnkpi "eqpetgv'  
hqt "j g'P qt vj gtp'Gwtqr g'tgi kqp'y kj "j ki j "pwo dgt "qh'htggj g/vj cy "e{ ergu'OVj g'eqpetgv'o kz'y cu'qdvckpgf "d { "o kz kpi "GE."  
ego gpv'ucpf "cpf "y cvgt'Qw'qh'hqwt'ego gpv'v{r gu'eqo o qpn{ "wugf "kp"Nkj wcpk. "j g'dgu'uwtxkcn'tcv'g'y cu'qdvckpgf "kp"eqpetgv'o kz'wukpi "y j ksg'EGO "Kego gpv'OVj g'pwo dgt "qh'xkcdrg'DO'r rugvf qht o wu'ur qtgu'chgt'j tgg'f c { u'qh'eqpetgv'ewt kpi "  
xctkfg "htqo "4066" "325"v"807; " "326" EHWI "qh'eqpetgv'"J3\_0'Vj gug't guwmu'f go qpuxtcv'j cv'cf f kkpvcn'eqcvkpi "qh'GE"  
ci i tgi cvgu'ku'pggf gf "v'ko r tqxg'vj g'xkcdkks{ "qh'dcevgtkc"kp"j g'eqpetgv'o"

J3\_ Lcmwqxunku. T0'Lcpmw . "C0'Wdqpcxk kwu. L0'I tdkpckm"X0'42420' Cpcn{uku'qh'o gej cplecn'r gthqto cpeg'cpf "f wcdkks{ "qh'ugrh'j gcnkpi "dkqmi lecn'  
eqpetgv'OE qput wewkqp'cpf "Dwrf kpi "O cvgtkcnu."482. Rcr gt'K <33; : 44."3/370

# THE ROLE OF TRPV4 CATION CHANNELS IN SMOOTH MUSCLE CONTRACTILE ACTIVITY IN RATS WITH PARKINSON'S DISEASE

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Constipation and motility dysfunction are the most common non-motor gastrointestinal (GI) symptoms in Parkinson's disease (PD) patients [1]. Transient receptor potential vanilloid-type 4 (TRPV4) are expressed in the intestine and can control GI motility [2]. But the specific role of this channels in PD remains largely unknown.

The aim of the study was to test the action of transient receptor potential vanilloid-type 4 selective agonist GSK1016790A on smooth muscle cells contraction in rat's colon with experimental Parkinson's disease.

The PD was induced by single unilateral stereotaxic injection of 12 µg 6-OHDA. The percentage of destroyed dopaminergic neurons was evaluated in apomorphine test (0.5 mg/kg, i.p.) at 1 and 2 weeks after surgery. The water content in faeces was evaluated on the 1<sup>st</sup> day, then at the 3<sup>rd</sup> week and 7<sup>th</sup> month of the experiment. The daily volume of water consumption and GI transit time were evaluated at the 3<sup>rd</sup> week and 7<sup>th</sup> month after surgery. The expression of TRPV4 channels was evaluated by qRT-PCR in muscles and mucosal layer of colon. The action of TRPV4 agonist GSK1016790A (0.3 mmol) on smooth muscle cells of colon was estimated by isometric tension recording.

The apomorphine test showed a progressive increase in the number of turns between the 1<sup>st</sup> and 2<sup>nd</sup> week after inducing 6-OHDA-PD. The water content in faeces was increased at the 3<sup>rd</sup> week ( $P < 0.05$ ) vs. 1<sup>st</sup> day of the experiment. The rats with 6-OHDA-PD drank less water vs. placebo and intact groups. We observed a 17% delayed GI transit time in 6-OHDA-PD rats ( $P < 0.01$ ) vs. intact and 21% vs. sham-lesioned group of rats 3 weeks after the 6-OHDA treatment. 7 months after the surgery GI transit time was increased more than twice in all studied groups. In 6-OHDA rats, we observed changes in TRPV4 mRNA levels, 50 fold decrease in muscle layer and 2,3-fold increase in mucosa vs sham lesioned rats. TRPV4 agonist action on smooth muscle cells of 6-OHDA-PD rats was reduced by 21% compared to intact group and by 46% in sham-lesioned group ( $P < 0.05$ ).

Pharmacological activation of TRPV4 ion channels by their selective agonist GSK1016790A decreased the contractile activity of colon smooth muscle cells in 6-OHDA rats' model of Parkinson's disease.

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[1] Carrasco, A. J. P., Timmermann, L. & Pedrosa, D. J. Management of constipation in patients with Parkinson's disease. *NPJ Parkinsons Dis.* 4, 6, 2018.

[2] Luo J, Qian A, Oetjen LK, Yu W, Yang P, Feng J, et al. TRPV4 Channel Signaling in Macrophages Promotes Gastrointestinal Motility via Direct Effects on Smooth Muscle Cells. *Immunity.* 2018; 49: 107-119.

**ET[ UVCNKC VKQP 'QHETKURT/ECUTGNCVGF 'VQZK"**

Mqpuvcv' Mgf c<sup>3</sup>. 'I kfg tg'Vco wrckkpg<sup>3</sup>. 'Ko cpvcu'O qi kr<sup>3</sup>."

Xkti kplwu'Ukmp{u<sup>3</sup>. 'I kpcwcu'Vco wrckku<sup>3</sup>"

<sup>3</sup>'kpukwg'qh'Dkqvej pqmji { . 'Nhg'Uelgpeg'Egpvt. 'Xkpkwu'Wpkxgtukv. 'Nkj wpcle'  
nuvcv' hgf cB i o eUwf kxwv'

"

V{r g"KKETKURT/Ecu'u{ ugo "r tqxf gu'r tqnet { qvu"y kj "cf cr vxg" f ghgpeg"ci clpuv'xkwgu'K'y cu't gegpv{ "pqvf " y cv' yj gug" u{ ugo u" go r m{ "ur gekrk gf " egm'uki pcmkpi "r cvj y c{ u" vq" eqo dcv' kphgcvkpu'Y j gp" ETKURT/Ecu" ghgvt " eqo r ngz "tgeqi pk gu'htgk p"TP C"kv'uctw'vq"u{ pyj guk g"e{ erke"qri qcf gp{ rvgu'htqo "CVR"}3\_0Vj gug"o qngwgu'cevxcvg" f kxgtug"ETKURT"cpkmt { "r tqvklpu"y j lej "epukuv'qh'uki pcm'tgeqi pklqp" f qo clp"cpf "ghgvt" f qo clp<"TP cug."F P cug." CVRCug. "r tqvcug"qt"qj gt u"}4\_0Hwpevkpu"cpf "utwewtgu'qh'ugxgtcn'ghgvt" f qo clpu'j cxg'dggp"gwel' cvgf <"ht"gzco r ng." yj g"TP cug"cevxcv' "qh'J GRP "f qo clpu"}5."6\_ "cpf "y j"FP cug"cevxcv' { "qh'tgwel'vkp" gpf qpwercug/rkng" ghgvtu"}7."8\_0 J qy gxgt."o cp{ "qj gt"ghgvt" f qo clpu'j cxg"pqv' { gv'dggp"uwf kfg O'T gegpv'ugs wpeg"cpn'uku't gxgrgf "y cv'c"i tqwr "qh' uvej "ghgvtu"ctg"uko kct"vq"t cpurvkp/kpj kklkpi "vzku'htqo "dcevtkcn'vzku'cpvkzku"u{ ugo u"}4\_0'k" y ku'uwf { "y g" r tguvp'et { ucnk' cvkq' t guwu'ht "vzku' t grv'vq" ETKURT/Ecu'u{ ugo "cpf "f kwuu'r qukdng"hwwtg"ut cvgi kgu' "

- 13\_ "Mc| r wunlpgg."O 0" Mqukw" I 0" Xgpenxcu." 0" Vco wrckku." I 0" cpi "Ukmp{u." X0\*4239+C" e{ erke"qri qpweqv' g'uki pcmkpi "r cvj y c{ "lp"v{ r g"KK ETKURT/Ecu'u{ ugo u'Uelgpeg."579\*8573+T 0827/82; 0'
- 14\_ "O cnetqxc."MUU" Vlo kpuncu."C0"Y qih"l (00" I wuqy ."C0D0"Ukmp{u."X0"Xgpenxcu." 0" cpi "Mqppk."G0X0\*4242+0Gxqnvkqpc{ "cpf "hwpevkpci' erucukle'vkp'qh'y g"ECTH" f qo clp'wv' gthco kx' .hg{ 'ugpuqtu'lp' t tqnet { qle'cpv'kku'f ghgpeg'OPwengke' celf u't gugctej .':6: \*38+':0: : 4: /: : 690
- 15\_ "Uo crn' v'g."F 0"Mc| r wunlpgg."O 0"HOJ cxgnpf."L0" Twn- pckv ."C0" Tko ckg."C0" Vco wrckkpg."I 0" H ti go cp."P (L0" Vco wrckku." I 0" cpi "Ukmp{u."X0 \*4242+V{r g"KKC"ETKURT/cuqekv'g" r tqvklp"Eu0 8" f gi tcf gu"e{ erke"j gzc/cf gp{ rvg"cevxcvt" wtkpi "dqj "ECTH" cpi "J GRP "f qo clpu'OPwengke" celf u't gugctej .':6: \*38+':0: 426/; 4390
- 16\_ "I cteke/F qxcn" E0"Uej y gf g."HD" Dgtm" E0" Tquān" L0W0" P kgy qgj pgt."Q0" Vglgtq."Q0" J cm" L0" O cttcHpk" NC0" cpi "Lkpgm" O 0\*4242+ "Cevxcv'kq" cpi " ugrh'kpcev'cvkq" o' gej cpluo u'qh'y g' e{ erke"qri qcf gp{ rvg' f gr gpf gp'VETKURT" i kdpwercug' Eu0 80P cwt g' eqo o wplecvkpu."33\*3+':03/; 0"
- 17\_ "O eO cj qp."UC0" \ j w" Y 0" Tj co ."U0" Tco dq."T0" Y j kg."O (H0" cpi "I nuqgt."V0 0\*4242+ "Utwewt g' cpi "o' gej cpluo "qh'c" V{r g"KKETKURT" f ghgpeg" F P C" pwegcug'cevxcv'g' d{ 'e{ erke"qri qcf gp{ rvg'0P cwt g' eqo o wplecvkpu."33\*3+':03/330"
- 18\_ "Tquān" L0W0" Zkg."Y 0" Mwt { cx { k" X0" O ci wkp."R0" Mcq."M0" Hqqo ."T0" Rcvgn" F L0" cpi "O cttcHpk" NC0\*4243+Vj g' Ectf 3" pwegcug' r tqxf gu' f ghgpeg" f wtkpi "v{ r g"KKETKURT" lo o wplk'OP cwt g.'r 0/; 0'

"

**IPXGUVK CVIQP 'QH'GARDNERELLA SPP. 'EP C'RTQVGR 'WUKPI ' IO O WPQNQI KECN'O GVIJ QF U'**

Tco kpc' Tg-mgk k v. 'Ipf t 'F cri f kgp . 'Cwtgrlc'fik drkgp . 'O kfc' Rrg nckv v "

Xkpkwu'Wpkgtukv. 'Nhg'Uelpegu'Egpvt. 'Ipkwkw'qh'Dkqvej pqm{ . "  
F gr ctvo gpv'qh'ko o wpqm{ { 'cpf 'EgmDkqm{ } "  
tco kpc' gumpxlekwgB i o e'xv'v'

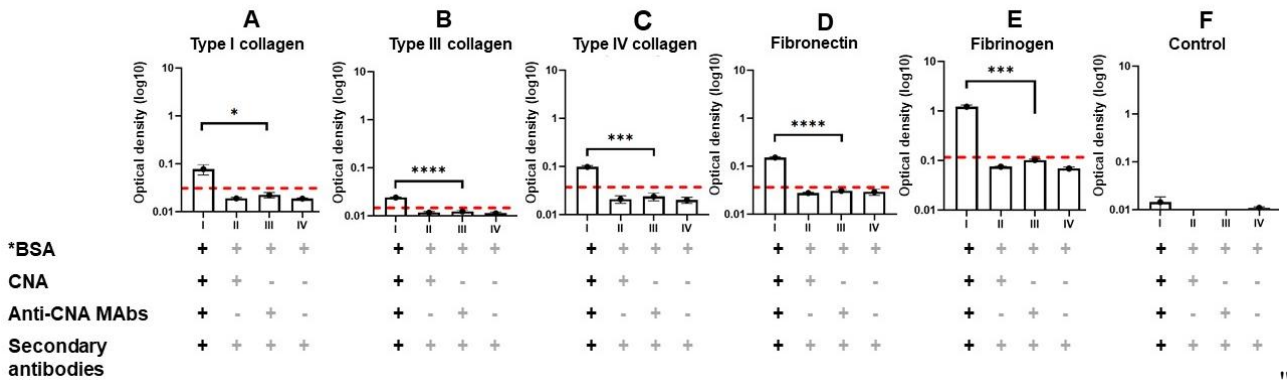
"

Dcevtkrc'xci kpkuku'DX+ku'qpg'qh'yj g'o quv'eqo o qp'xci kpcn'lphevkpu'cuuqekvcf 'y kj 'ko r cktgf 'xci kpcn'o letqhrtc' yj cv'chgevu'yo gp'qh'ej krf dgctkpi 'ci g0DX'ku'cuuqekvcf 'y kj 'xctkqwu'cf xgtug'qweqo gu'pqv'qpn' 'tgrw'kpi 'vq'y go gpa' hgt'wkv. 'tgr tqf wexg'j gcnj . 'qt'r tgi pcp{ . 'dw'cnu'y qo gpa'o gpvcn'j gcnj 'j3\_0I ctfpgt gmc'urr0ku'yj g'o quv'cuuqekvcf " dcevtkwo 'y kj 'DX'cpf 'j cu'dggp'f gvev'f 'k'cm quv'cm'xci kpcn'uco r rgu'ht qo 'y qo gp'uw'htkpi 'ht qo 'DX'j4\_0'

Cf j gulkpu'ctg'egm'uw'hc'eg'eqo r qpgp'u'yj cv'ctg'g'tgur qpukdg'ht'v'j g'tgeqi p'k'q'qh'j quv'egm'cpf 'cf j g'kpi 'vq'yj go 0' Uwf lgu'qp' 'qy' g' dcevtk' 'uj qy ' 'y' cv'xctkqwu'cf j gulkpu'ctg'r tqxgp'xktw'p'eg'hcevtu' 'y' cv'ctg'uki p'ht'ecp'v'k' dcevtk'ca' r cv'qi gpguku'j5.'6\_0J qy g'xgt. 'y' g'cf j gulkpu'qh'dcevtkwo 'I ctfpgt gmc'urr0ctg'xgt { 'k'w'g'uw'f l'g'f 'cpf 'f' g'uetldgf 0'

Chgt' 'y' g'co k'p'cek' 'ugs'w'peg'qhi' 'I ctfpgt gmc'urr0'eqmci gp'cf j gulk'EP C+r tqv'k'f'v'g'to k'p'cv'k'p.'c'j { r qj g'uku'y cu' r tqv'k'p' 'y' cv'EP C'cmqy u'I ctfpgt gmc'urr0'v'k' d'k'p' 'v'q'j quv'gz'v'cegm'w'ct'o cv'kz 'GO' +r tqv'k'p'u'

Vj g'k'p'v'k'c'v'k'p' 'd'gy ggp' 't'geqo d'k'p'c'p'v'I ctfpgt gmc'urr0'EP C'cpf 'u'gr'ge'v'f 'GO' r tqv'k'p'u'y cu'k'p'x'g'uki cv'g' 'd' { 'xctkqwu' GNKUC'o g'v' qf 'xctk'v'k'p'u'c'p'f 'q'j g't'ko o w'p'q'j go k'ec'n'o g'v' qf u'00 q'p'q'ec'p'c'n'c'p'v'k'q'f l'gu' \*O Cdu' +ci c'k'p'u'v'geqo d'k'p'c'p'v'EP C' r tqv'k'p' 'y' g't'g'et'g'v'f 'w'uk'pi 'j { d'k'f'qo c' 'v'g'j p'q'm{ { 0C'p'w'EP C' 'O Cdu'y g't'g'w'ug' 'v'q'k'p'x'g'uki cv'g' 'y' g'k'p'v'k'c'v'k'p' 'd'gy ggp' 'y' g' EP C'cpf 'GO' r tqv'k'p'u'v'k' r g'K'K'K'K' 'eqmci gp'u. 'h'k't'q'p'g'v'k'p' . 'cpf 'h'k't'k'p'qi gp'0'W'uk'pi 'k'p'f'k'g'v'GNKUC'o g'v' qf 'y' g'f' g'v'g'v'f " yj cv'EP C'k'p'v'k'c'v'k'p' 'y' kj 'c'm'GO' r tqv'k'p'u'w'ug'f 'k'p' 'y' g'z'r g't'ko gp'v' \*H'ki 03+0'



H'ki 0'30'Vj g'k'p'x'g'uki cv'k'p' 'qh'k'p'v'k'c'v'k'p' 'd'gy ggp' 'I ctfpgt gmc'urr0'EP C' r tqv'k'p' 'cpf 'u'gr'ge'v'f 'GO' r tqv'k'p'u' 'C' 'o' 'v'k' r g'K' 'eqmci gp'='D' 'o' 'v'k' r g'K' 'eqmci gp'='E' 'o' 'v'k' r g'K' 'eqmci gp'='F' 'o' 'h'k't'q'p'g'v'k'p'='G' 'o' 'h'k't'k'p'qi gp'='H' 'o' 'eq'p'v'q'n' 'p'q' 'GO' r tqv'k'p'u' y' g't'g' 'cf u'q't'd'g'f 0'Vj g'v' 'g'v'v'y cu' 'c'r r'k'g'f . 'y' j g't'g' , r '>'2027. , , , r '>'20223. , , , r '>'20223'p'?' '6+0'Vj g't'g'f 'h'p'g'k'p'f k'ec'v'u'yj g'o g'cp' qh'c'p'qr 'v'k'c'n'f' g'p'uk'v' { 'r n'u' 'y' t'g'g' 'u'c'p'f c't'f 'f' g'x'k'v'k'p'u'0' , DUC 'o' 'd'q'x'k'p'g' 'u'g't'wo 'c'n'l'wo k'p'0'

T'gu'w'u'c'p'f 'et'g'c'v'f 'o' q'rg'ew'ct' 'v'q'mu' 'c'p'w'EP C' 'O Cdu' . 't'c'k'ug' 'p'gy 's' w'g'v'k'p'u'c'p'f 'j { r qj g'ugu'0'k'p' 'y' g' 'h'w'w't'g' . 'y' g' 'u'g'g'n'v'q' 'w'ug' 'o' q't'g' 'eqo r n'g'z' 'o' q'f g'n'u'f 'u'v'go u' 'v'q'k'p'x'g'uki cv'g' 'y' g'k'p'v'k'c'v'k'p' 'd'gy ggp' 'p'c'v'k'g'EP C' 'cpf ' 'g'r k'j g'r'k'c'n' 'eg'm' 'k'p' 'x'k't' q'0'Vj k'u' 'y' q'w'f 'c'm'qy 'v'q'k'p'x'g'uki cv'g' 'cpf 'w'p'f'g't'ux'c'p'f 'o' q'rg'ew'ct' 'I ctfpgt gmc'urr0'f' cv'j qi gpguku' 'o' g'ej c'p'k'uo u'0'

"

[30] "Iqpgu.'C0%423; +Dcevtkrc'xci kpkuku'c'Tgxly 'qh'v'tgcvo gpv.'Tgewtgpeg.'cpf 'Fkur ctkk'gu.'Lpr/Lqwtpcn'lyt'Pwtug'Rtcevkqpgt'037.'642/6450  
[40] "Uej y gdnq.'L0T0'O w'p'p' . 'E0C0( 'Iqg{ . 'Y 0G0%4236+Tqrq'qh'I ctfpgt gmc'xci kpcru'lp' 'y' g' 'Rcv'j qi gpguku'qh'Dcevtkrc'xci kpkuku'c'E'q'p'eg' w'cn'  
O qf gn'Lqwtpcn'qh'k'p'v'k'c'v'k'p'u'F'k'g'c'ug'0432.'55: /5650  
[50] "Tj go . 'O 0P0'Ngej . 'G0O 0'R'ekw'L0'O 0'O eF g'x'k'w.'F 0'J qqm'O 0'Iqpgu.'F 0'D0( "Y kj gm wu.'M0T0%4222+'Vj g'eqmci gp/d'k'p'f'k'pi 'cf j gulk'ku'c'  
xktw'p'eg' 't'cevt'k'p' 'Ucr j { n'q'ec'ew'u'c'w'g'u'ng't'c'v'k'ku.'k'p'v'k'c'v'k'p' 'cpf 'k'o o w'p'k'f'08: . '5998/599: 0'  
[60] "G'w'uk' 'O 0Q0'Vj qo cu.'L0T0'U'h'p'p'g't.'T0C0'D'g'x'k'p'u.'L0U0'D'g'g'p'ng'p.'M0G0'P'g'u'p' . 'E0N0( 'Uo gn'gt.'O 0U0%4224+'Ucr j { n'q'ec'ew'u'c'w'g'u'ng't'c'v'k'ku' gp'  
cf j gulk'eq'p'v'k'w'g'u'v'q'yj g'r cv'j qi gpguku'qh'q'ug'qo { g'r'k'ku.'D'q'p'g'052.'497/4: 20'

**RJ 'F GRGP F GP V'UGNH/CUUGO DNŦPI 'QH'J 4VRRU6'ŦP 'CS WGQWU'  
UQNWWKQP U'**

**Mqtprkic'Dwkw { f ckv }<sup>3.4</sup> . 'O ctklwu'Rrg nekku<sup>3.4.5</sup> . 'Tk ctf cu'Tqwo unku<sup>3.5</sup>'''**

<sup>3</sup>"Dkqo gf leclnRj { uleu'Ncdqtcvt { . 'P cvkqpcn'Ecpegt 'Kpukswg. 'R0Dcwndkq'ut05d. 'NV/2: 628'Xkpkwu. 'Nkj wcpkc"

<sup>4</sup>"Nhg'Uelpegu'Egpygt. 'Xkpkwu'Wpkxgtukv{. 'Ucwn vgnkq'cx09. 'NV/32479'Xkpkwu. 'Nkj wcpkc"

<sup>5</sup>"Dkqr j qvqpleu'i tqwr 'qh'Ncugt'Tgugctej 'Egpygt. 'Xkpkwu'Wpkxgtukv{. 'Ucwn vgnkq'cx0; . 'NV/32444'Xkpkwu. 'Nkj wcpkc"

mqtprkicDwkw { f ckgB i o eUwfw 0xwŦn"

Tgepwn{. 'uwr tco qrgewrct'cuugo drkgu'qh'r qtr j { tlpu'j } cxg'dggp'qh'i tqy kpi "kpvtggu'dgecwug'vj g'ci i tgi cvg'r cenkpi " utwewtge'ecp'dg'gculkl' wpgf 'vj tqwi j 'kqple'kpvtcevkqpu'co qpi 'vj g'ecvqple'eqtg. 'ej cti gf 'uwdukswgpcu'cpf kqt'vj g'pcwtg'qh' yj g'"kpqti cple"cpkqp0'Eqpvtqmkpi "vj g'r cenkpi "utwewt g'qh'hwpevkqpcn'f { g'o qrgewgu'd { "uwr tco qrgewrct"o g'j qf u'ku" c" ej cmgpi kpi "cumihqt'ckkqtkpi 'hwpevkqpcn'o cvgtkc'u'y kj 'f guktgf 'r tqr gt vku0"

Vj g'cuuqekvqpp "lp"cs vgwau'ugnwkpku'vgtcuqf kw "7.32.37.42/vgtcnku\*6/uwrhqpvcvqj j gp { nr' r qtr j { tlp' \*j 4VRRU6+ " y j lej 'y cu'f gvgevgf 'd { 'xkukdn'ur gevte'j } cu'dggp'p'qv'emctkkgf 0k' cefk'le' b' gf k'kv' cu'dggp'f guetkdgf 'vj cv'pgy 'ur geku'cr r gct" y kj 'cduqtr vkqpu'cv'6; 2'cpf '928'po 0Vj ku'dg'j cxkqwt'lp'vj g'cek'le' t'gi kqj'j } cu'gxgp'dggp'f guetkdgf 'cu'xgt { 'eqo r n'ecvfg 0Cu" c'tguwn'qhlkpvtej tqo q'r j q'le'kpvtcevkqpu. r g'wt'dcvkqpu'lp'vj g'cduqtr vkq'cpf 'hwqtguegpeg'ur gevte'qh'f { gu'q'eew0k'v'gto u' qh'g'zekvqple'eqwr nkpi . 'ci i tgi cvgf 'f { gu'y kj 'dnwg' /cpf 'tgf /uj khwg' cduqtr vkq' dcpf u'ctg' t'ghgtgf 'v'cu'J / /cpf 'L'ci i tgi cvgu0 F wg'v'vj g'f k'v'p'v'q' r v'ec'n'r tqr gt vku. 'eqpvtq'qh'vj g' hqto cvkq'qh'J / /cpf 'L'ci i tgi cvgf 'uvcv'g'qh'f { gu'j } cu'cwtcevgf 'o wej " t'gugctej 'kpvtggu0"

J 4VRRU6'ku"cy cvgt/ugnwdr'v'g'tcr { ttqrg'o qrgewr' \*y kj 'hw'w'uw'w'q' i tqwr 'uwdukswgu+ 'kpvtgeqppgevgf 'cv' 'cvqo 'xlc" o g'j k'p'gd'f' i gu'J 4VRRU6'o qrgewr' hqto 'ej cpi gu'cee'qt'f kpi n' { 'v'q'vj g'r J "qh'vj g'ugnwkp0k' c'm'c'k'p'g'ugnwkpku'J 4VRRU6" ku'kp'v'g'tc' /cpkqp' hqto 'y kj 'pq'cf'f' k'k'q'pc'n'r tqv'pu'cw'cej gf 'v'q'vj g' 'h'g'g'p'k'tq'i gp'cvqo u'lp'vj g'egpygt0J qy g'xgt. 'kp'cek'le" ugnwkqpu'k'v'ecp' hqto 'L'ci i tgi cvgu'cu'k'v'uc'w'u'ugr'h'cuugo drkpi "h'qto 'ku'" y kwgtkqple' hqto 0Vj g'J /L'ci i tgi cvgu' hqto 'y j gp" r qu'k'k'x'gn' 'ej cti gf 'r qtr j { tlp'kpi u'cpf 'p'gi cvk'x'gn' 'ej cti gf 'uwrh'q' i tqwr u'dgi kp'v'q'kpvtce'v0"

Kp'vj ku'uwf { . 'y g'lx'x'g'w'ki cvgf 'j qy 'f' h'gt'gp'r' J 'c' h'g'ew'vj g' hqto cvkq'qh'k'qple'ur geku'qh'J 4VRRU6'o qrgewgu. 'vj g'k' cduqtr vkq'cpf 'hwqtguegpeg'ur gevte'0Vj g'ugnwkpku'y g'g'b' cf'g'd' { 'f' k'w'k'p' i 'J 4VRRU6'lp'f' g'k'p'k' gf 'y cvgt'cpf 'vj gp'ej cpi kpi " r J 'cee'qt'f kpi n' . 'y kj 'cs vgwau'P cQJ ' \*h'qt'vj g'r J '9+ J En' \*h'qt' r J '6'v'q' r J '3+ 'qt' J 4UQ6' \*h'qt' r J '3+ ugnwkqpu'0C' v'j g'r J '9" v'g'tc' /cpkqp' hqto "qh'J 4VRRU6" y cu'q'dugt'x'gf " y kj "Uqt'g'v' dcpf "cv'866"po "cpf "S" dcpf u'cv'738. "775. "7; 6'cpf "856"po . " t'g'ur' ge'v'x'gn' 0'W'p'f' gt'636"po "g'z'ek'c'v'k'p. 'hwqtguegpeg' y cu'q'dugt'x'gf "cv'866"po "cpf "924"po 0D { 'ny' g'tkpi "v'q'vj g'r J '6. 'vj g' J 4VRRU6" ej cpi gf "v'q'f' k'ek'f " hqto "cu'v'y q'cf'f' k'k'q'pc'n'r tqv'pu'cw'cej gf "v'q'vj g' 'h'g'g'p'k'tq'i g'pu'cv'vj g'egpygt' qh'J 4VRRU6" o qrgewgu'0D'cv'j qej tqo le'uj k'v'q'h'vj g'Uqt'g'v'dcpf "657"po +y cu'q'dugt'x'gf 'lp'vj g'cduqtr vkq'ur gevte'wo "cpf 'vj g'S' dcpf u'y g'tg" t'g'f' weg' "v'q'867"po "y kj 'vj g'uj' q'w'f' g'tu'ct'q'w'p'f "772"po . "7; 6"po 0J 4VRRU6'f' k'ek'f " hqto "w'p'f' gt'657"po "g'z'ek'c'v'k'p" j cf "c" hwqtguegpeg'r g'm'c'v'892"po 0D { 'ny' g'tkpi "vj g'r J "gxgp'o q'tg'cv'r J '3'vj g'J 4VRRU6' hqto gf 'vj g' y kwgtkqple' hqto 'y kj 'p'q'v' q'p'n' 'vj g'egpygt' p'k'tq'i g'pu' d'm'q'engf "y kj "r tqv'pu. "dw'v'y q' uwdukswg' uwrh'q" i tqwr u'cu' y g'n0' k'p' 'vj ku' hqto "vj g' J 4VRRU6" o qrgewgu' u'ct'v'q' c'v'x'gn' 'ugr'h'ci i tgi cvg' hqto kpi 'L'ci i tgi cvgu' y kj "c'f' k'v'k'p'i w'k'j' gf "cduqtr vkq'ur gevte'wo "cpf "Uqt'g'v'dcpf " cv'6; 2"po . "cpf "S" dcpf "cv'92: "po 0'W'p'f' gt'6; 2"po "g'z'ek'c'v'k'p. 'vj g'hwqtguegpeg'r g'm'c'v'892"po 0D { 'ny' g'tkpi "vj g'r J "gxgp'o q'tg'cv'r J '3'vj g'J 4VRRU6' hqto gf 'vj g' y kwgtkqple' hqto 'y kj 'p'q'v' q'p'n' 'vj g'egpygt' p'k'tq'i g'pu. 'dw'v'y q' uwdukswg' uwrh'q" i tqwr u'q'h'J 4VRRU6' y g'tg' d'm'q'engf 'd { 'r tqv'pu'0Vj ku' h'g'f' "v'q" cp'cduqtr vkq'ur gevte'wo 'y kj 'vj g'Uqt'g'v'dcpf "cv'65: "po "cpf "S" dcpf "cv'86; "po " \*d'cv'j qej tqo le'uj k'v'q' h'eqo r c'tgf "v'q'vj g'f' k'ek'f" hqto "qh'vj g' J 4VRRU6+cpf 'hwqtguegpeg' \*w'p'f' gt'656"po "g'z'ek'c'v'k'p+r' g'm'c'v'8: 4"po 0"

Vj g't'guwmu'uj qy gf 'vj cv'cv'egt'v'k'p'cek'le'eqpf' k'k'q'pu'J 4VRRU6'ecp' hqto 'L'ci i tgi cvgu'f' wg'v'q' r qu'k'k'x'g' g'rg'evt'qu'v'c'le" kpvtcevkqpu. 'j qy g'xgt' k'k'r J 'i gu'v'q'q'ny . 'cm'UQ5' i tqwr u'ctg' d'm'q'engf 'cpf 'vj g'ci i tgi cvgu'ecp'p'q' h'qpi gt' hqto 0"

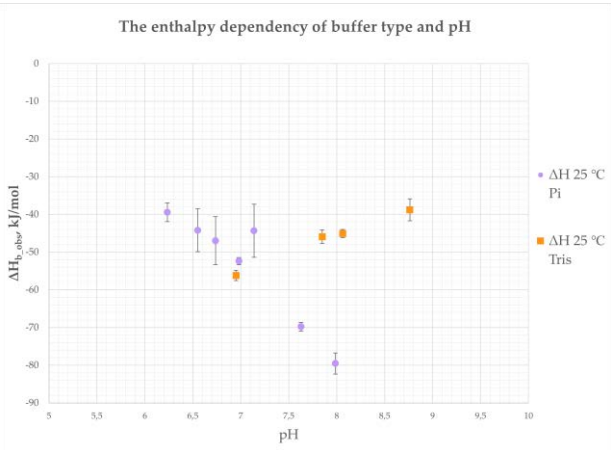
**'KPVTKPUE'VJ GTO QF [ PCO KE'RCTCO GVGTVQHJ WO CP'ECTDQPK'  
CPJ [ FTCUG'KKCPF'CEGVC\ QNCO KF G'KPVGTCEVKQP''**

Gi n "Xkm pckv"cpf "Nkpc"Detcpwunkgp "

F gr ctvo gpv'qh'Dkqvj gto qf { pco leu'cpf 'F twi 'F guki p. 'Kpukwag'qh'Dkqvgej pqrqi { . 'Nkpg'Uekgpegu'Egpygt. 'Xkpkwu'  
Wpkxgtukv{ . 'Xkpkwu.'Nkj wcpkc"  
gi ng0kmpckvB i o e0uwf 0xw0v'

\*\*\*\*\*Ectdqple'cpj { ftcugu\*ECu+ctg'o gvcmqgp| {o gu'y j lej 'ecvnc' ug'tgxgtukdrg'tgcevkap'qh'ectdqpf'kqzlf'g'j' { ftcvkap'kp''  
xkxq]3\_<

\*\*\*\*\*EQ4- 'J 4Q'=> J EQ5'- 'J -' \*\*\*\*\*3+''  
\*\*\*\*\*Vj gtg'ctg'y gnxg'ecvnc' vccm' 'cevkg' /EC'kuqhato u'lp'j wo cpu0Uqo g'qh'yj go 'ctg'cuuqekcvf'y kj 'j wo cp'f kugcugu''  
uwej "cu" i rweqo c." qgf go c." gr kgr u{." ecept0' /EC' kuqhato u' lpj kdkkqp" y kj "uo cni' o qrgewg" f twi u." eqpvcklpi''  
wpuwukwagf'uwhtpco kf g'i tqwr . 'ku'wugf 'v'eqpwtqnuqo g'qh'yj gwg'f kugcugu0P qpgvj gnguu.'ppqg'qh'yj g'ewttgpw' 'wugf 'f twi u''  
ku'ur gekkle' hqt'cp { qpg'vcti gv'EC'kuqhato . "cpf" 'lpj kdkkqp'qh'yj gtu. 'qh'vcti gv'ECu'ecwugu'wpf guktgf "cf xgtug'ghgevu0'  
Vj gtghqg. 'y j g'f guki p'qh'pgy 'kuqhato /ugrgevkg'EC'lpj kdkkqtu'ku'wuk'c'ej cmgpi kpi 'vcun0'  
\*\*\*\*\*J wo cp'EC'KKu'c'e { vquqre'kuqhato "y j lej "j cu'y j" ki j guv'gp| {o cve'cevkv'qh'cmj' wo cp'ECu'cpf 'ku'y kf gn''  
f kwtkwg'f 'lp'f khtg'gpv'qti cpu'cpf 'kuwgu0K'cf f kkkp'v'ko r qvcpeg'cu'f twi 'vcti gv'j EC'KKu'qh'wgp'wugf 'cu'c'o qf gn'f tqvklp''  
hqt'cpcn' uku'qh'r tqvklp' rki cpf 'lpvgtcevkapu'j4\_0j EC'KKu'c'uo cm"o qpqo gtle. 'ppq/i n' equ' r wgf "r tqvklp. 'y j lej "ku'tgcf kn''  
cxckwdg'cpf 'j cu'c'y gmouwf kcf '5F' 'utwewtg0Cpcn' uku'qh'EC'dl'p'f kpi 'v'ku'ri cpf u'ku'p'v'utck' j vhty ctf "o'EC'dl'p'f kpi''  
v'ku'uwhtpco kf g'i tqwr 'dgctkpi' 'eqo r qwpf 'ku'rkp'ng'f'v'ugxgtcn'eqpeqo kcpv'tgcevkapu'y j lej "qeew'lp'cf f kkkp'v'q'dl'p'f kpi''  
kugr0Vj g'dl'p'f kpi' 'b gej cpkuo 'kpenf gu'f tqvpcvkap'cpf 'f gr tqvpcvkapu'tgcevkapu0Vj gtghqg. 'y j g'v'ugxgt'f' dl'p'f kpi' 'chh'p'v'k''  
cpf "gpvj crr { 'f gr gp'f u'q'p'tgcevkap'eqpf kkkp]6\_0j qy gxgt. 'qpn' 'lpv'k'pule'yj gto qf { pco le'r ctco gvgtu. 'k0'g0'k'p'f gr gp'f gp'v'q'p''  
tgcevkap' eqpf kkkp. "ecp" dg' f k'gevn' 'rkp'ng'f' v'q' et { uvcmj tcr j k' l'p'hto cvkap. "cpf" 'v'j gp' uwej "tguwuu' qh' utwewtg/  
yj gto qf { pco leu'tgrvkapuj kr u'cpcn' uku'ecp'dg'wugf 'hqt'cevkap'cn'f twi 'f guki p'j5\_0'  
\*\*\*\*\*K'p'j ku'uwf { 'y g'hw'uw'q'p'lpv'k'pule'yj gto qf { pco le'r ctco gvgtu'qh'j EC'KK'c'egvc| qmco kf g'lpvgtcevkap0Y g'wugf 'y q''  
dkr j { ulecn'0 gvj qf u'ku'v'j gto cnc'cm'kto gt { 'v'k'cevkap'cpf 'hw'qt'guegpeg'yj gto cni'j kh'cuuc { 0Y g'cpcn' ugf 'y ku'tgcevkap'd {''  
r gthqto kpi 'gzr gtko gp'u'lp'xctk'q'w'f' J . 'dwh'gtu'cpf 'vgo r gtcw'g0Ceeq'f kpi 'v'q'f gr gp'f gpeg'qh'q'dugtxgf 'dl'p'f kpi' 'r ctco gvgtu''  
qp'tgcevkap'eqpf kkkp'u'y g'ecrew'v'v'f 'y j g'lpv'k'pule'dl'p'f kpi' 'r ctco gvgtu' \*M'. " J . "Er+0"



Hki 030Vj g'f gr gp'f gpeg'qh'q'dugtxgf 'gpvj crr { 'qh'j EC'KK'cpf'cegv'c| qmco kf g'lpvgtcevkap'qp'dwh'gt'v' r g'cpf 'r J 0Vj g'gzr gtko gp'u'y g'g'r gthqto gf 'cv'47''  
'vgo r gtcw'g'lp'2027'O 'r j qur j cv'g'dwh'gt'y kj '20'0 'P cEn' r w'ng'ek'eng'q'2027'O 'V'ku'dwh'gt' \*qt'cpi g'us wctgu+ 'y kj '20'0 'P cEn0''

13\_ E0NONqo g'rlpq. 'L0V0Cpf tkpi . "cpf" 'T00 eMgppc. "Et { uvcmj tcr j { 'cpf' 'Ku'k' r cev'q'p' Ectdqple' Cpj { ftcug' T'gugctej a' 'Kpvt'p'cvkap'cn' Lqwt'p'cn' qh''  
O gf kelp'cn' E'j go knt { . 'xq'0423: . 'r r 03643. 'Ugr 0423: . 'f qk'3208377423: 1; 63; 7430'  
14\_ X00 0M'ku'j pco w'vj { 'gv'c'n' Ectdqple' Cpj { ftcug' cu'c' O' qf gn'ht' Dkq'j { ulecn' c'p' R'j { ulecn' Q'ti c'p'le' U'w'f l'gu'qh' R't'q'v'k'p'u' c'p'f 'R't'q'v'k'p' N'ki c'p'f''  
Dl'p'f kpi a' 'E'j go 0T'gx0' xq'032: . 'pq05. 'r r 0; 6863273. 'O ct0422: . 'f qk'3208243 let272484r 0'  
15\_ X0N'k'p'w'k'p' 'gv'c'n' V'j gto qf { pco le. 'h'p'g'v'k' . 'cpf' 'utwewtcn' r ctco gvgtu'k' cvkap'qh'j wo cp'ectdqple' cpj { ftcug' lpvgtcevkapu'v'qy ctf 'gpj cpegf''  
lpj kdkkqt' f' guki p' a' 'S w'c'v'0T'gx0Dkq'j f u' xq'073. 'f 0g32. '423: . 'f qk'3208239 l'22557: 573; 2222: 40'  
16\_ X00 qtm pckv 'gv'c'n' K'p'v'k'pule'yj gto qf { pco leu'qh'uwhtpco kf g'lpj kdkkqt' dl'p'f kpi 'v'q'j wo cp'ectdqple' cpj { ftcugu' K'cpf 'K'k' Lqwt'p'cn' qh' Gp| {o g''  
K'p'j kdkkqp' c'p'f 'O gf kelp'cn' E'j go knt { . 'xq'052. 'pq04. 'r r 04266433. 'O ct04237. 'f qk'320532; 136978588042360 2: 4; 30'  
''  
''

# ONFLOW: A SOFTWARE TOOL THAT PREDICTS LATERAL FLOW ASSAY PARAMETERS

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Lateral flow assay (LFA) tests are becoming more popular each year because of their ability to rapidly and cheaply detect small amounts of analyte[1]. However, straightforward questions, for instance, the appropriate concentration of capture sites and optimal test line location can be answered only by experimentation. Thus, the development of LFA tests is very tedious and can exhaust the most valuable resources – time and money. To facilitate the development process of LFA strip tests we have created a universal software tool – onFlow. Our software can accurately predict where to spray probes in order to obtain the most visible results on the strip. onFlow is easy to use as we have provided detailed documentation, default values and integrated an existing molecular interactions platform KOFFI to facilitate user experience as well as an API that makes it accessible to other workflows.

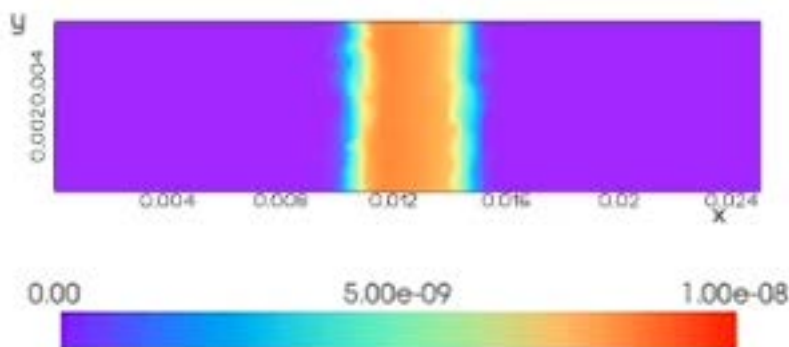


Fig. 1. Simulation of the advection-diffusion-reaction PDE for the concentration of the complex of analyte, detection probe and capture probe throughout the membrane.

The software is based on the mathematical LFA test model that provides a basis for a fast and open-source application that gives recommendations for the design of lateral flow assays. The backbone is a simulation and optimisation of a system of diffusion-advection-reaction partial differential equations[2]. The model uses the finite element method platform FEniCS[3] to simulate a partial differential advection-convection-reaction equation system Eq. (1) and predicts the optimal location of a test line and the required concentrations of reactants to provide a visible signal (Fig. 1).

$$\begin{cases} \frac{\partial[A]}{\partial t} = D_A \Delta[A] - V(t) \cdot \nabla[A] - k_1[A][P] + k_{-1}[C], \\ \frac{\partial[P]}{\partial t} = D_P \Delta[P] - V(t) \cdot \nabla[P] - k_1[A][P] + k_{-1}[C], \\ \frac{\partial[C]}{\partial t} = D_C \Delta[C] - V(t) \cdot \nabla[C] + k_1[A][P] - k_{-1}[C], \\ \frac{\partial[R]}{\partial t} = -k_2[R][C] + k_{-2}[S], \\ \frac{\partial[S]}{\partial t} = +k_2[R][C] - k_{-2}[S] \end{cases} \quad (1)$$

[1] Gasperino, D., Baughman, T., Hsieh, H. V., Bell, D. & Weigl, B. H. Improving Lateral Flow Assay Performance Using Computational Modeling. *Annual Rev. Anal. Chem.* **11**, 219–244 (2018).

[2] Qian, S. & Bau, H. H. A mathematical model of lateral flow bioreactions applied to sandwich assays. *Analytical Biochemistry* **322**, 89–98 (2003).

[3] Alnæs, M. et al. The FEniCS Project Version 1.5. *Archive of Numerical Software* **3**, (2015).

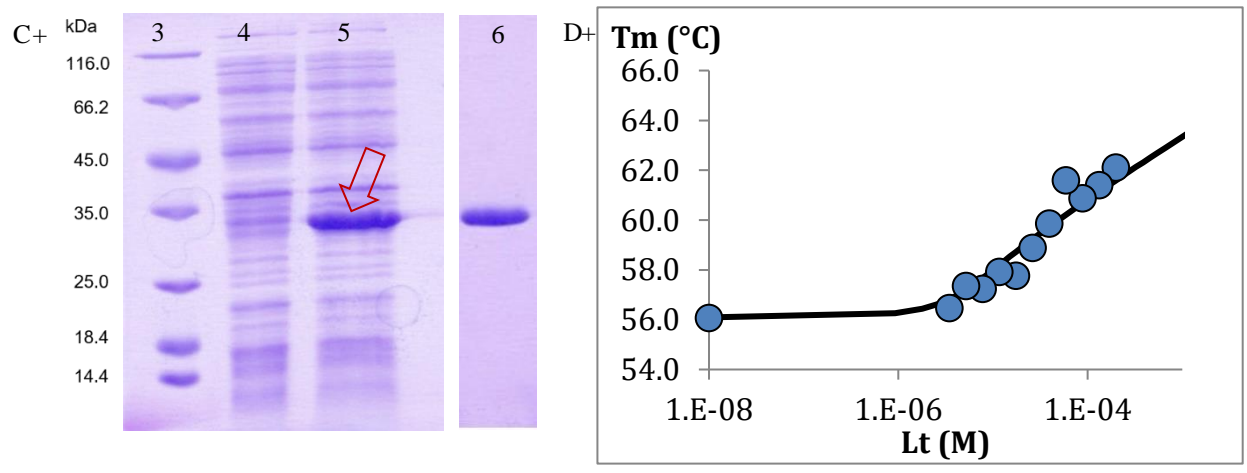
**RTQF WEVKQP 'QHTGEQO DRP CP V'O QWUG'ECTDQP KE 'CP J [ F T CUGU' Ect 'KEct 'KK'Ect 'KK'Ect 'XKKCP F 'Ect 'ZKK'**

**Gf xctf cu'vlo q- gpne. 'Cwtgrkle' O lengxk k v. 'Nlpc' Dctcpcwunlpg "**

F gr ctvo gpv'qh'Dlqvj gto qf { pco leu'cpf 'F twi 'F guki p. 'Kpukwag'qh'Dlqvgej pqrqi { . 'Nhg'Uelgpegu'Egpygt. 'Xlprkwu' Wpkxgtukf. 'Nkj wcpk" *gf xctf cu'vlo quegpne B i o e'lvlu'*

Tgxgtdrg'j { ftcvq'q'hdctdqp'f'kz'kf'g'v'q'dlectdpcv'k'ue'cwn'ugf'd'{'c'ho'kn'q'hdctdqp'epj { ftcug'EC+gp| { o'gu'0'k'p'o'co'o'ciu.'y'g'q'hg'p'gz'kv'lp'o'wnr'ng'kuq'hto'u'cpf'r'ct'v'ek'c'v'g'lp'xct'k'wu'r'j { ukqrqi'lecni'r'tqeguugu.'kpenf'kpi 'EQ.'cpf' J EQ'/'w'cpur'qt'v'lp'dmqf.'t'gi'w'v'k'p'q'h'r'J' 'cpf'g'g'v'q'n'v'g'j'q'o'g'v'uc'uku.'cpf' 'u'q'o'g'o'g'v'cd'q'le'r'c'v'y'c'c' { u'0'D'g'ec'w'g'q'h'y'g't' j'k'j' 'lp'x'q'x'go'gp'v'lp'r'j { ukqrqi'lecni'r'tqeguugu.'j'wo'cp'ect'd'q'p'le'cpj { ftcugu'ct'g'cu'q'ek'v'f'y'k'j' 'u'g'x'g't'c'if'k'ug'c'ugu.'g'0' 'EC' 'K' ku'h'p'ng'f' 'v'j' 'c'go'q'n'v'e'c'p'c'go'k'c.' 'cpf' 'EC' 'KK'6' 'v'q' 'i' r'w'eq'o'c.' 'co'q'p'i' 'q'j'g't'u'j'3\_0'V'j'g't' 'k'p'j'k'k'q'u't'g'w'ug'f' 'v'q' 'e'q'p't'q'u'q'o'g'q'h' 'y'g'g'f'k'ug'c'ugu'0'H'q't' 'o'g'f'lecni'r'g'ug'ct'ej' 'r'w'r'q'ug'u' 'ECu'ct'g'ej'c'm'g'p'i'k'p'i' 'v'ct'i'g'u'f'v'g'v'q'j'k'j' 'j'q'o'q'r'qi' { 'cpf' 'u't'w'w't'c'r'i'ku'k'ct'k'f' 'd'g'y'g'g'p' 'ku'q'hto'u'0'V'j'g' 'EC' 'ku'q' { o'g'u'j'c'x'g'f'k'h'g't'g'p'v'ng'x'm'q'h' 'n'p'g'v'e' 'c'e'v'x'k'f' . 'u'w'r'j'q'p'c'o'k'f'g' 'k'p'j'k'k'k'q'p' ]4\_ 'cpf' 'ct'g' 'g'z'r't'g'u'g'f' 'k'p'f'k'h'g't'g'p'v'ku'w'g'u'0'Q'h'r'c't'v'e'w'r'c't' 'k'o'r'q't'v'e'p'eg'c't'g'e' 'v'q'u'q'le' 'ECu'd'g'ec'w'g' 'y'g' { 'ct'g' 'y'g' 'o'q'u'v'c'd'w'p'f'c'p'v'e'rc'u'q'h' 'ku'q'hto'u'0'V'j'g'z'r'c'p'f' 'e'q'o'r't'g'j'g'p'u'k'g'x'k'g'y'u'q'p' 'o'c'o'o'c'r'k'c'p' 'EC.' 't'g'ug'ct'ej' 'q'p' 'o'k'eg' 'EC' \*Ect+ 'cpf' 'r'ki'c'p'f' 'k'p'v't'c'e'v'k'p'u'ku' 'r'g't'q'hto'g'f'0'k'p'q'hto'c'v'k'p' 'c'd'q'w' 'Ect' 'c'p'f' 'u'o'c'm'i'o'q'rg'ew'g' 'r'ki'c'p'f' 'd'k'p'f'k'p'i' 'e'q'w'f' 'e'q'p't'k'd'w'g' 'v'q' 'h'k'g'f' 'q'h' 'y'g'f' 't'w'i' 'f'g'x'g'r'q'o'g'p'v' 'h'q't' 'u'r'g'ek'le' 'ECu'0'

J'gt'g'y'g'y'k'n'i'r't'g'ug'p'v'e' { v'q'u'q'le' 'Ect' 'em'p'l'k'p'i' 'u't'c'v'g'i' { . 'g'z'r't'g'u'k'q'p.'r'w't'h'k'ec'v'k'p.'c'p'f' 'u'o'c'm'i'o'q'rg'ew'g' 'd'k'p'f'k'p'i' 'g'z'c'o'k'p'g'f' 'd' { 'y'g' 'h'w'q't'g'ue'g'p'v'j'g't'o'c'n'i'uj'k'h'v'c'u'c' { 0'V'j'g' 'em'p'l'k'p'i' 'q'h'c'm'i' 'Ect' 'r't'q'v'g'k'p'u' 'u'c't'v'g'f' 'y'k'j' 'c'o'r'k'h'k'ec'v'k'p' 'q'h' 'F'P'C' 'u'g's'w'g'p'eg' 'd' { 'RET.' 'et'g'c'v'k'p' 'q'h' 'u'k'el' 'g'p'f' 'u'y'k'j' 't'g'u't'k'ev'k'p' 'd' { 'g'p'f'q'w'eng'c'ugu.'r'ki'c'v'k'p' 'k'p'v'q' 'r'GV/37'd' 'r'nc'u'k'f' . 'c'p'f' 'u't'c'p'u'q't'o'c'v'k'p' 'q'h' 'G'ue'j'g't'k'ej'k'c' 'e'q'r'k' 'd'c'e'v't'k'c'0'I' 't'q'y'k'p'i' 'e'q'p'f'k'k'q'p'u' 'h'q't' 'c' 'u'w'h'k'el'g'p'v'c'o'q'w'p'v'q'h' 't'g'eq'o' 'd'k'p'c'p'v' 'Ect' 'y'g't'g' 'q'r'v'k'o'k'f' 'd' { 'u'j'w'h'k'p'i' 'y'g' 'G'0'e'q'r'k' 'u't'c'k'p' 'c'p'f' 'x'c't' { k'p'i' 'y'g' 'r' 't'q'v'g'k'p' 'g'z'r't'g'u'k'q'p' 'e'q'p'f'k'k'q'p'u.'g'0' 'c'o'q'w'p'v'q'h' 'c'f'f'g'f' 'K'V'R'I' 'q't' 'w'uk'p'i' 'f'k'h'g't'g'p'v' 'n'p'f' 'u'q'h' | 'k'p'e' 'u'c'n'u'0'V'j'g' 'r' 't'q'v'g'k'p'u'y'g't'g' 't'w'h'k'g'f' 'w'uk'p'i' 'k'o'o'q'd'k'k'g'f' 'p'l'eng'ni'k'q'p' 'c'h'k'p'k'f' 'e'j' 't'q'o'c'v'q'i' 't'c'r'j' { 0'V'j'g' 'h'w'q't'g'ue'g'p'v'j'g't'o'c'n'i'uj'k'h'v'c'u'c' { 'y'c'u'w'ug'f' 'v'q' 'c'u'g'u'u' 'y'g' 'r' 't'q'v'g'k'p' 'y'g't'o'c'n'i' 'u'c'd'k'k'k' 'c'v'k'p' ]5\_ 'd' { 'd'k'p'f'k'p'i' 'u'o'c'm'i'o'q'rg'ew'g' 'r'ki'c'p'f' 'u'0' 'H'k'i' 'w't'g' '3'C' 'r' 't'g'ug'p'w' 'q'r'v'k'o'k'f' 't'g'u'w'u'q'h' 'Ect' 'Z' 'KK'z'r't'g'u'k'q'p' 'c'p'f' 'r'w't'h'k'ec'v'k'p.'y'j'k'g' '3'D' 'u'j'q'y' 'u'k'u'd'k'p'f'k'p'i' 'v'q'f' 'l'ej' 'n'q't'q'r'j'g'p'c'o'k'f'g'd' { 'h'w'q't'g'ue'g'p'v'j'g't'o'c'n'i'uj'k'h'v'c'u'c' { 0'



**Hk 030Ect 'Z'KKz'r't'g'u'k'q'p.'r'w't'k'f' 'c'p'f' 'h'w'p'ev'k'q'p'c'n't'c'v'k'k'f' 0'C+'UF'U'RC'I' G'q'h'Ect'Z'KK'c'p'g'3'6'O'Y' 'o'c't'ng't'u.'4'6'd'c'e'v't'k'c'n'h' 'u'c'v'g' 'd'g'h'q't'g'k'p'f'w'v'k'p.'5'6'd'c'e'v't'k'c'n'h' 'u'c'v'g'c'h'g't'k'p'f'w'v'k'p.'6'6'r'w't'h'k'g'f' 'Ect'Z'KK'0D+'h'w'q't'g'ue'g'p'v'j'g't'o'c'n'i'uj'k'h'v'c'u'c' { 't'g'u'w'u'q'h' 'Ect'Z'KK'k'p'f'k'p'i' 'v'q'f' 'l'ej' 'n'q't'q'r'j'g'p'c'o'k'f'g'o' 'u' { o' 'd'q'u' 'e'q't't'g'ur'q'p'f' 'v'q' 'g'z'r'g't'k'o'g'p'v'c'n'f'c'v'c' 'c'p'f' 'h'k'p'g'r't'g'ug'p'v' 'h'w'k'p'i' 'w'uk'p'i' 'M'f'g't'o'k'p'c'v'k'p' 'o'q'f'g'r'0'**

[3]\_U'w'c'p' 'E'0'H'q'u'v'T'q'd'g'r'v'O'e'M'g'p'p'c'0'E'c't'd'q'p'le' 'C'p'j' { ftcug<O'gej'c'p'k'u'o' . 'T'gi'w'v'k'p' . 'N'k'p'm'u'v'q' 'F'k'ug'c'ug.'c'p'f' 'k'p'f'w'u't'k'n'i'c'r'r' 'd'ec'v'k'p'u'0' F'Q'K'320229I; 9: /; 6/229/957; /40'  
 [4]\_Ect'v.' 'H'ed't'k'k'q'0'C' 'em'u'u'q'h' 'u'w'r'q'p'c'o'k'f'g'ect'd'q'p'le' 'c'p'j' { ftcug'k'p'j'k'k'q'u't'u'y'k'j' 'p'g'w't'q'r'c'v'k' 'e'r'c'k'p' 'o'q'f'w'v'k'p'i' 'g'h'g'ew'0'F'Q'K' 320238I'0'lo'e'04237'04249'  
 [5]\_T'g'f'j'g'c'f' 'O'0'U'c'v'ej'g'm'i'0'0'q't'm'p'c'k'v' 'X'0'U'y'k'h'v'F'0'R'g'v't'c'w'u'n'u'X'0'I'q'r'f'k'p'i' 'G'0'Q'p'l'q'p'u'U'0'O'c'w'w'k'u'F'0'W'p'k'v'U'0'C' 'e'q'o' 'd'k'p'c'v'q't'k'n'i' 'd'l'q'r'j' { 'u'lec'n'i'r' 'r'q'q'ej' =H'V'U'C' 'c'p'f' 'U'R'T' 'h'q't' 'k'f'g'p'v'k'h'k'p'i' 'u'o'c'm'i'o'q'rg'ew'g' 'r'ki'c'p'f' 'u'c'p'f' 'R'C'K'p' 'u'0'L'w'p'g'4237.'C'p'c'r'0'D'k'q'ej'g'o' . '856950'





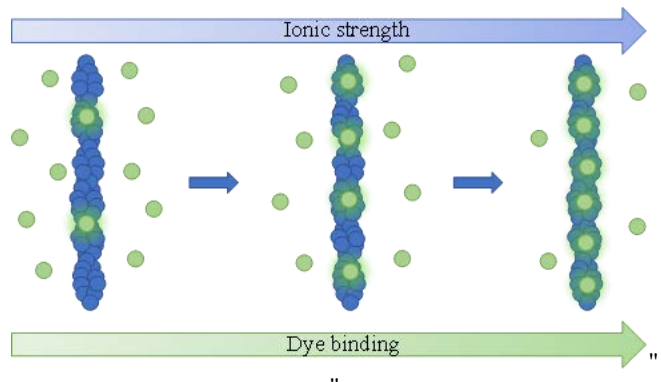
**GHHGE V'QH'KQP Æ'UVTGPI VJ 'QP'VJ KQHNCXKP/V'CHHKP KV[ 'VQ''  
CO [ NQKF 'HDTKNU'CPF 'KVUHNWQT GUEGPE'GP VGP UKV[ ''  
Meo kg'O knrcwunckg<sup>3</sup>. 'O cpvcu\ kcp{ u<sup>3</sup>. 'Vqo cu'Upgkf gtku<sup>3,4</sup>. 'X{ wvcu'Uo ktpqxcu<sup>3</sup>**

<sup>3</sup>Kpukwng'qh'Dkqvej pqrqi { . 'Nhg'Uelgpegu'Egpygt. 'Xkpkwu'Wpkxgtukv{ . 'NV/32479'Xkpkwu.'Nsj wcpkc'  
<sup>4</sup>F gr ctvo gpv'qh'Ej go kvt { . 'Wpkxgtukv' 'qh'Eco dtkf i g.'Eco dtkf i g'ED4'3GY . 'WM'  
neo kg(b) knrcwunckgB i o cktkqo "

Eqphqto cvkqpcr'ej cpi gu'lp'r tqvklpu'cpf 'vj gk'ci i tgi cvkqp'lp'vj g'hqto "qh'co { nqkf "hdtku'j' cxg'dggp" ko r rkecvgf "kp" o cp { 'bgwtqf gi gpgtcvkx'f kuqtf gtu. 'uwej 'cu'Ci j glo gtu. 'Rctmkuqppa'f kugcugu'qt' o co o ctkp'lr qpi hqto "gpegr j cqr cvj { " ]3\_0Ewtgpnv. 'vj g'g'ku'c'nv'qh'tgugctej "ecttkgf "qww'p'qtf gt'vq'gzco kpg'j qy 'ci i tgi cvkqp'qh'co { nqkf 'r tqvklpu'qeevtu'cpf " j qy "xctkqwu'gpxktqpo gpwri'fcevtu'o c { 'kphwvpeg'vj g'r tqeguugu'qh'r tqvklpu'ci i tgi cvkqp'0K'ku'qdugtxgf "vj cv'go r gtcwtg." r J . 'kqple'utgpi vj 'cpf 'v' r g'qh'lj ctkpi 'ej cpi g'pqv'qpn' 'vj g' h'p'g'v'e' r tco gvtu'qh'ci i tgi cvkqp. 'dw'cmaq'vj g'eqphqto cvkqpcr' utwewtg'qh'vj g'r tqvklpu. 'vj wu'hqto kpi 'hdtku'qh'f h'htg'gpv'utckpu']4.5\_0Vj g' h'wqtguegpv'f { g'vj kqhncxkp/V'ku'qpg'qh'vj g'o quv' y kf gn' 'wugf' f { gu'lp'co { nqkf 'r tqvklpu'uwf lgu']6\_0K'vj ku'y qtm'k'y cu'lp'xguki cvgf 'y j gvj gt'kqple'utgpi vj 'qh'vj g' uqmwkqp' chgevu'vj g'dkpf kpi 'qh'vj kqhncxkp/V'vq'co { nqkf 'hdtku'wukpi 'cduqtdcepeg'cpf 'h'wqtguegpeg'ur gev'queqr { 0

Kpuwkp "422" O 'r tqvklpu'f kuqrxgf 'lp'322'o O 'P cEn'322'o O 'r j qur j cvg'dw'htg' "r J "406+ 'kpedcvkqp'46'j . '82"AE+." n' uq| { o g'"422" O 'r tqvklpu'f kuqrxgf 'lp'4'O 'I w' En'72'o O 'r j qur j cvg'dw'htg' "r J "8+ 'kpedcvkqp'46'j . '82"AE. 'y kj 'uj ctkpi . " wukpi 'i rnu'dgcf u+." o qwug' r tkp/r tqvklpu'"20"o i lo n'r tqvklpu'f kuqrxgf 'lp'2.7"O 'I w' En'72'o O 'r j qur j cvg'dw'htg' "r J "8+." kpedcvkqp'46'j . '82"AE. " /u { pwenglp'"422"UO 'r tqvklpu'f kuqrxgf 'lp'RDU.'kpedcvkqp'46'j . '82"AE. 'y kj 'uj ctkpi . 'wukpi 'i rnu' dgcf u+co { nqkf 'hdtku'y g'g'r tgr ctgf 0Chgt'ci i tgi cvkqp. 'vj g'hdtku'y g'tg'epv'khw' gf . 'tguur gpf gf 'lp'v'f kungf 'y cvgt'cpf " eqpegp'vcvgf "v'622" O -0Vj g'cduqtdcepeg'qh'vj g'uco r ngu'y cu'o gcuwgf 'chgt'o lzkpi 'vj g'hdtku. 'Vj V'cpf "P cEn' uqmwkqp" \*kpcnr' tqvklpu'eqpe0322"UO +lp'vj g'tcpi g'htqo '522'v'822'po 0Gz'ekcvkqp/go kukqp'o cvtlegu'"GGO +qh'gcej 'uco r ng'y g'g' vj gp'uecppgf 'wukpi 'cp'gz'ekcvkqp'cpf'go kukqp'tcpi g'htqo '657'v'722'po 0Vj g'uco r ngu'y g'g'v'j gp'epv'khw' gf 'hqt'32'o lp' cv; 222'lr o 'cpf 'vj g'uw' g'p'w'p'v'cduqtdcepeg'lp'vj g'tcpi g'htqo '522'v'822'po 'y cu'o gcuwgf 0

C'f k'gev'f gr gpf gpeg'dgy ggp'vj g'co qwpv'qh'Vj V'o qrgewgu'dqwpf "v' hdtku'cpf 'vj g'uqmwkqp-a'kqple'utgpi vj 'y cu' qdugtxgf 0C'vj ki j gt'kqple'utgpi vj . "o qt'f { g'o qrgewgu'ct'g'cwcej gf "v'vj g'co { nqkf 'hdtku. 'y j lej 'kpetgcugu'vj g'uco r ng' h'wqtguegpeg'lp'v'pukv' "Hki 03+0Uko krt'kqple'utgpi vj 'ghgevu'y g'tg'qdugtxgf 'wukpi 'cm'hw'co { nqkf 'r tqvklpu'0



Hki 030J ki j gt'kqple'utgpi vj 'hgcf u'v'kpetgcugf 'h'wqtguegpv'f { g'dkpf kpi 0

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[3\_0Mpqy ngu'VRL'Xgpf tweqm'0. 'F qduqp'EO 0Vj g'co { nqkf 'ucvg'cpf 'ku'cuuqekcvkqp'y kj 'r tqvklpu'o kuh'rf kpi 'f kugcugu'P cvT gx'O qn'Egmi'Dkqr04236' Lxp'45-37\*8+5: 66; 80"  
[4\_0Eco r qu'Tco 'f'g' 'C.'O' a' ts wgl 'O. 'S w'p'c'p'et'N.'Tqlcu/Qej qc'NH0Gh'gev'qh'kqple'utgpi vj 'qp'vj g'ci i tgi cvkqp'h'p'g'v'e'qh'vj g'co kf cvgf 'co { nqkf 'd'gvc' r gr w'f g'C "3/62+lp'cs w'g'wu'q'w'k'p'p'u'0Dkqr j { u'Ej go 04239'Ugr -44: < : 63290"  
[5\_0Y cy gt'L'U qek un'k'O. 'Qnu' gy un'k'O. 'Rk v'ni'T. 'P cel ni'O. 'M'ic'nu'y k'cm'10'f' h'wv'peg'qh'vj g'kqple'utgpi vj 'qp'vj g'co { nqkf 'hdtk'q'j g'p'g'gi i " y j kg'h'f' uq| { o g'0'f'v'L'Dkqr'0 cetqo qn'0423; 'Lcp-343-856920"  
[6\_0Z w'g'E. 'Nlp'V' . 'Ej cpi 'F. 'I w'q' \ 0Vj kqhncxkp/V'cu'cp'co { nqkf 'f { g'hdtk'is w'p'v'k'ec'v'k'p. 'qr w'o c'ne'q'p'g'p'v'c'v'k'p' b'p'f 'gh'gev'q'p'ci i tgi cvkqp'0T'U'q'e'Qr'gp' Uek04239'Lcp'6-6\*3+3828; 80"

**UGNH/CUUGO DNGF 'P CP QUVT WE VWT GUHQTO GF 'DI 'TGE QO DRP CP V'  
RTQVGR UQH'DCE VGTQRJ CI G'XKTQP U'**

Ncwtc'Mkw-ckv<sup>3</sup>. 'Ncwt {pcu'Crlq-kw<sup>3</sup>. 'Gwi gplwu<sup>3</sup> qrk pcu<sup>3</sup>. 'Cwtgrlc\ clcp n#wunckv<sup>3</sup>. 'O ctv\pcu'  
Umr cu<sup>4</sup>. 'Nkf klc'Vt wpeckv<sup>3</sup>"

3'Xkpkwu'Wpkgtuk\ 'Nkg'Uelgpegu'Egpgt'Ucwn vgnkq'cx09. 'Xkpkwu'NV/32479. 'Nkj wcpk"

4'Egpgt'ht'Rj {ulecni'Uelgpegu'cpf'Vgej pqm {'. 'Ucwn vgnkq'cx05. 'Xkpkwu. 'Nkj wcpk"

nwtc0hkwuckgB i o e0rwf 0kw0h'

"

Dcevtqrj ci gu '\*rj ci gu' ctg' vj g' o quv' y kf gur tgc' f' cpf' f' kxgtug' i tqw' qh' xlt wugu' vj cv' ctg' cdwpf cpv' kp' o letqdkn' gequ\ ugo u' cpf' ur gell' c' m' l' p' h' g' e' v' d' c' e' v' t' k' o' N' k' g' q' v' j' g' t' x' l' t' w' u' g' u' . ' r' j' c' i' g' u' j' c' x' g' c' p' w' e' n' g' l' e' c' e' k' f' i' g' p' q' o' g' r' t' q' v' e' v' g' f' d' { ' v' j' g' r' t' q' v' g' l' p' u' q' h' x' l' t' q' p' o' k' p' p' c' w' t' g' . ' r' j' c' i' g' u' h' e' g' c' y' k' f' g' x' c' t' l' g' v' { ' q' h' r' j' { ' u' l' e' c' n' i' c' p' f' e' j' g' o' l' e' c' n' i' h' e' v' q' t' u' \* W X' t' c' f' k' c' v' k' p' . ' g' z' v' t' g' o' g' h' n' e' w' e' v' k' p' u' q' h' r' j' ' x' c' n' g' c' p' f' ' v' g' o' r' g' t' c' w' t' g' + 0' D' g' e' c' w' u' g' q' h' v' j' c' v' v' j' g' x' k' t' k' p' u' q' h' r' j' c' i' g' u' c' t' g' j' k' i' j' n' { ' t' q' d' w' u' v' c' p' f' ' u' c' d' i' g' o' V' j' k' u' r' t' q' r' g' t' v' { ' k' u' x' g' t' { ' c' w' t' c' e' v' k' g' h' t' v' j' g' f' g' x' g' n' r' o' g' p' v' q' h' u' g' r' h' c' u' u' g' o' d' n' g' f' r' t' q' v' g' l' p' p' c' p' q' u' t' w' e' w' t' g' u' q' t' r' j' c' i' g' r' h' n' g' r' c' t' w' e' n' g' u' o'

Rj ci g' x' k' t' k' p' u' f' g' t' k' x' g' f' ' u' w' r' t' c' o' q' n' g' e' w' r' t' p' c' p' q' u' t' w' e' w' t' g' u' j' c' x' g' c' i' t' g' c' v' r' q' v' p' v' e' n' i' c' u' g' p' x' k' t' q' p' o' g' p' v' h' t' k' e' p' f' n' { ' d' k' q' o' c' v' g' t' k' c' n' i' h' q' t' v' j' g' f' g' x' g' n' r' o' g' p' v' q' h' u' c' h' g' c' p' f' ' g' h' h' e' l' g' p' v' f' g' x' l' e' g' u' v' j' c' v' e' c' p' d' g' w' u' g' f' k' p' v' e' j' p' q' m' i' k' u' c' p' f' o' g' f' k' e' k' p' o' J' q' y' g' x' g' t' . ' v' j' g' c' t' u' g' p' c' n' i' q' h' u' w' k' c' d' i' g' r' t' q' v' g' l' p' u' k' u' t' g' u' t' l' e' v' g' f' v' q' q' p' n' i' y' g' m' u' w' f' l' e' g' f' r' j' c' i' g' u' . ' y' j' k' e' j' v' j' g' t' q' v' p' v' e' n' i' q' h' i' g' u' u' w' f' l' e' g' f' q' p' p' u' t' g' o' c' k' p' u' w' p' n' p' q' y' p' o' o' q' u' v' y' k' f' g' u' r' t' g' c' f' r' j' c' i' g' u' j' c' x' g' e' q' o' r' n' g' z' x' k' t' k' p' u' f' g' u' k' i' p' g' f' v' q' t' g' e' q' i' p' k' g' c' p' f' l' p' h' e' v' j' q' u' v' e' g' m' o' v' j' g' t' g' h' q' t' g' . ' r' t' g' f' k' e' v' k' p' q' h' v' j' g' r' t' q' v' g' l' p' h' w' p' e' v' k' p' w' u' k' p' i' q' p' n' i' d' k' q' l' p' h' q' t' o' c' v' l' e' o' g' v' j' q' f' u' e' c' p' d' g' f' k' h' l' e' w' u' c' p' f' g' z' r' g' t' k' o' g' p' v' e' n' i' e' q' p' h' t' o' c' v' k' p' u' k' u' p' g' g' f' g' f' o'

Kp' vj ku' uwf { . ' r' w' c' v' k' g' u' t' w' e' w' t' c' n' i' r' t' q' v' g' l' p' u' q' h' v' j' g' p' g' y' n' i' ' u' g' s' w' g' p' e' g' f' r' j' c' i' g' u' y' g' t' g' g' z' c' o' k' p' g' f' d' { ' g' p' i' k' p' g' g' t' k' p' i' v' j' g' k' t' t' g' e' q' o' d' k' p' c' p' v' r' t' q' v' g' l' p' u' c' p' f' c' p' c' n' i' k' p' i' v' j' g' u' g' r' h' c' u' u' g' o' d' n' g' f' r' t' q' v' g' l' p' p' c' p' q' u' t' w' e' w' t' g' u' y' k' j' v' t' c' p' u' o' k' u' k' q' p' g' r' g' e' w' t' q' p' o' l' e' t' q' u' e' q' r' g' \* V G O + 0 H q t v j k u . y g e j q u g v j t g g v c k r g f r j c i g u h t q o v j g O { q x k l f c g c p f U r j q x k l f c g h c o k r g u . y j k e j j c x g v j g l e q u e j g f t c n i j g c f u c p f v c k u y k j v j g h d g t u c w e j g f v q v j g o 0 V j g r w c v k x g v c k n i r t q v g l p q h R c p v q g c c i i n q o g t c p u l p h g e v k p i r j c i g x D a R c i U a O G F 3 8 . v j g v c k u u j g c v j r t q v g l p q h x D a R c i O a C C O 4 4 c p f v j g v c k n h d g t r t q v g l p h t q o v j g G u e j g t k e j k e q r k l p h g e v k p i r j c i g x D a G e q O a C r h 7 y g t g z c o k p g f o'

Qwt' t' g' u' w' u' m' l' j' q' y' v' j' c' v' v' j' g' t' g' e' q' o' d' k' p' c' p' v' r' t' q' v' g' l' p' u' q' h' l' j' c' i' g' x' k' t' k' p' u' c' f' q' r' v' e' j' c' t' c' e' v' t' k' u' l' e' h' q' t' o' u' t' g' u' g' o' d' r' k' p' i' v' j' q' u' g' q' h' i' p' c' v' k' g' r' j' c' i' g' u' o' v' j' g' t' g' h' q' t' g' . ' v' j' k' u' o' g' v' j' q' f' q' m' i' { ' k' u' u' w' k' c' d' i' g' h' t' e' q' p' h' t' o' c' v' k' p' u' q' h' v' j' g' r' t' g' f' l' e' v' g' f' u' t' w' e' w' t' c' n' i' h' w' p' e' v' k' p' u' q' h' r' j' c' i' g' g' p' e' q' f' g' f' r' t' q' v' g' l' p' u' o' o' q' t' g' q' x' g' t' . ' v' j' g' t' g' u' w' u' k' p' i' p' c' p' q' u' t' w' e' w' t' g' u' e' c' p' u' g' t' x' g' c' u' d' c' u' k' i' h' q' t' g' p' i' k' p' g' g' t' k' p' i' q' h' i' o' q' t' g' e' q' o' r' n' g' z' f' g' x' l' e' g' u' v' j' c' v' o' c' { ' d' g' w' k' k' g' f' f' g' r' g' p' f' k' p' i' q' p' v' j' g' k' t' u' t' w' e' w' t' c' n' i' c' p' f' d' k' q' e' j' g' o' k' e' c' n' i' e' j' c' t' c' e' v' t' k' u' l' e' u' o'

# POLARIMETRIC SECOND HARMONIC GENERATION RESPONSE OF COMPLEX BIOLOGICAL STRUCTURES IN THE FOCAL VOLUME OF THE MICROSCOPE

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Polarimetric Second Harmonic Generation (SHG) microscopy can provide extra-molecular information from various non-centrosymmetric biological samples. The results of polarimetric SHG measurements require careful interpretation and modeling when the biological sample has a complex structure in the focal volume. In this study, a numerical modeling [1] has been performed to understand how biophysical parameters such as chiral (C) and achiral (R) susceptibility ratios are affected by different organizations of fibrillar structures in the focal volume. Then the results of numerical modeling have been used to interpret the images obtained from collagenous biological tissues and meso-tetra (4-sulfonatophenyl) porphyrin (TPPS4) molecules in giant “sea urchin” (GSU) aggregates using polarization-in polarization-out (PIPO) microscopy technique. The numerical modeling shows that in image plane crossing fibers [2] do not have a significant effect on the C ratio. The effect of crossed fibers on the measured R ratio is different for high and low molecular R ratio of individual fibers. In the case of low molecular R ratio, the effective R ratio increases with increasing the crossing angle between two fibers, while the effective R parameter decreases for high molecular R ratio crossing fibers.

On the other hand, tilting fibers out of the image plane affects both R and C ratios [3]. This geometry increases R and C ratios, and the C dependency has a sinusoidal behavior where the sign shows the direction of tilting. These results are in good agreement with the results obtained using PIPO measurements (Fig. 1).

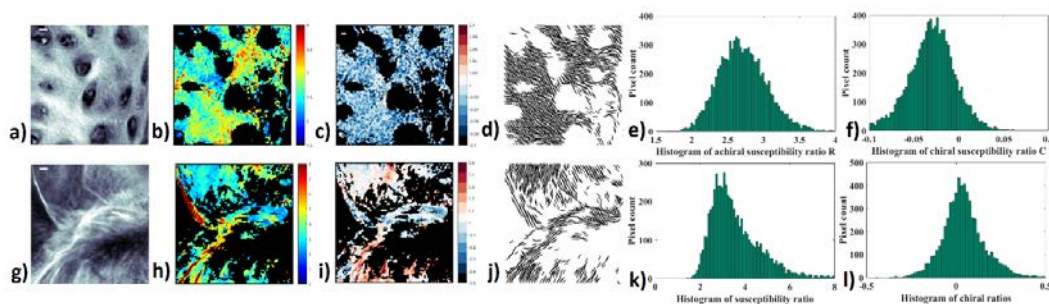


Fig. 1. PIPO microscopy results obtained from cartilage (upper row) and TPPS<sub>4</sub> aggregate (lower row) samples. Logarithmic SHG intensity images (a, g). R ratios, (b, h). C ratios (c, i). Cylindrical axis orientation map (d, j) of data in (a) and (g), respectively. Histograms of R values (e, k). Histograms of C values (f, l). Scale bar is 10  $\mu\text{m}$ .

Fig. 1 a) and g) show the logarithmic scaled SHG intensity images of the collagenous and TPPS<sub>4</sub> aggregate samples, respectively. Fig. 1 b) and h) illustrate the results of R values calculated from Fig. 1 a) and g). The TPPS<sub>4</sub> has a higher R ratio than cartilage collagen. Fig. 1 c) and i) show the C ratios and Fig. 1 d) and j) show the cylindrical orientation maps in the image plane. The histograms of R values are shown in Fig. 1 e) and k). The histograms show a higher R ratio for TPPS<sub>4</sub>. The histograms of C values are shown in Fig. 1 f) and l).

There are some regions of interest in the both samples with C ratio close to 0. In some of these regions, different fiber orientations of crossing fibers can be observed at different linear polarization states. In these areas, the value of R increases for low R sample (cartilage), but it decreases for high R sample (TPPS<sub>4</sub>). Furthermore, there are some regions in the samples without crossing fibers. In these areas, increase in the C values correlates with increase in the R ratio as predicted by the modeling.

In conclusion, biophysical parameters are dependent on the geometry of fibers in the focal volume. PIPO SHG microscopy is a powerful technique to identify different organizations in the focal volume. The results of this study show that PIPO technique enables the reconstruction of complex biological organizations.

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[2] M. Alizadeh, D. Merino, G. Lombardo, M. Lombardo, R. Mencucci, M. Ghotbi, and P. Loza-Alvarez, "Identifying crossing collagen fibers in human corneal tissues using pSHG images," *Biomedical Optics Express* 10, 3875 (2019).

[3] A. Golaraei, K. Mirsanaye, Y. Ro, S. Krouglov, M. K. Akens, B. C. Wilson, and V. Barzda, "Collagen chirality and three-dimensional orientation studied with polarimetric second-harmonic generation microscopy," *J. Biophotonics* 12, e201800241 (2019).

P8-41

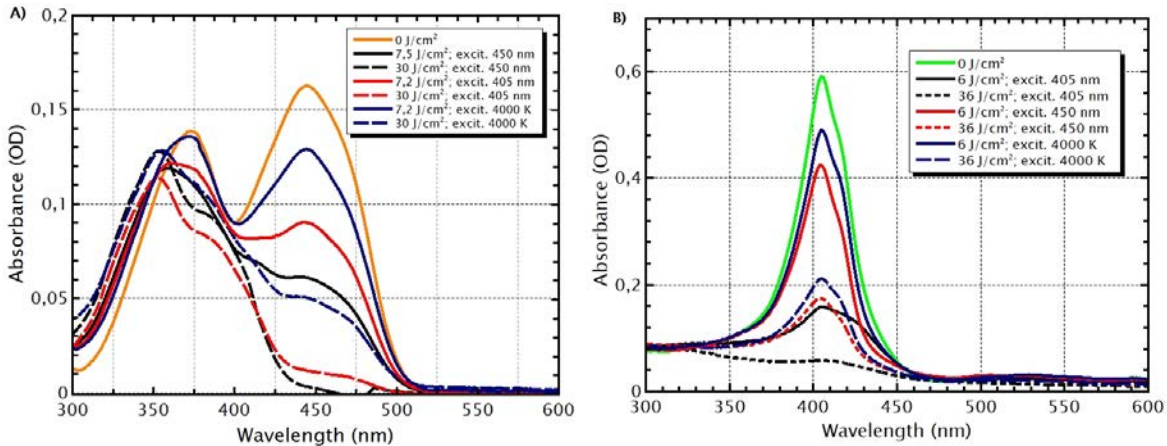
DID NOT PARTICIPATE

**QRVĖCN'UVWF [ 'QHRJ QVQCEVĖG'CP VĖDCEVGTĖCN'CI GPVU' ]**  
**TĖDQHNCXĖP 'CPF'EJ NQTQRJ [ NNĖP'0**  
**Twi kn 'Dctgkncv<sup>3</sup>.F gko cpv 'Rwt { v<sup>3</sup>. 'KĖpc'Dvej qxge<sup>3</sup>'**

<sup>3</sup>"Ėpukwv'qh'Rj qvqpleu'cpf "Pcpqvej pqrqi { 'Hcwm' { 'qh'Rj { ukeu 'Xkpkwu'Wpkxgtuks { 'Nkj wpcle "  
twi kgŃlct gkncvkgB ĤŃwvŃ ŃxwŃv"

Dcevtk'ecp'dg'hqwpf'gxgt { y j gtg<lp'j qur kcnu.'lpf wutkcn'r megu.'hqf 'hcekvku'cpf'gxgp'ur cegetchŃVj g'go gti gpeg'qh' cpvdkvĖ/tgukvpep'co qpi uv'dcevtk'ku'qpg'qh'v'g'o quv'r tgułpi "y qtrf y kf g'kuwguŃQpg'qh'v'g'r tqo kulpi "cr r tqcej gu'v'q" vĖcvkpi "uvej "dcevtk'ku'cpvko letqdkn'r j qvqĖcvkcvkqp" \*CRKŃ'CRK'ku'cp'ghĖkegpv'dkqr j qvqple"vgej pqrqi { "dcugf" qp"v'j g' kĖgtcvkqp"qh'r j qvqgpukv'gt "RU:" o qrgewct"qz { i gp."cpf "ny "f qugu'qh'ri j v'qh'uwkcdrg"y cxgrpi v' "v"o cvej "v'j g'RU' cduqr vqp'r genl]3\_ŃVj g'kĖgtcvkqp'qh'RU'cpf'ri j v.'lp'v'g'r tgupeg'qh'qz { i gp'tguwv'lp'c'r rĖj qtc'qh'Ė { vqzke'tgcevkqp'cpf" eqpugs wgpv'f. 'lpf wegu'ugrĖvkg'f gvt wvkv'qh'v'g'v'cti gv'dcevtk'ŃCPvdkcevtk'ri'ghĖkepe { 'qh'v'g'CRK' gr gpf u'qp'Ń cp { 'hcvtu." dw'o quv'uki pĤkecpv'qp"v'j g'r j qvqr j { ukecn'r tqr gtvku'qh'wuf "RUŃVj ku'wvf { "hewugu'qp'pcwtcn'RU'/"tkdqhrxkp"\*TH'cpf " ej mqr j { nkp"\*Ej nŃVj g { "ctg'npqy p'cu"j wo cp'pqp/vzke'cpf "uchg'ht"gpv'xkqpo gpv'r j qvqcvk'g'eqo r qwpf u'wuf "cu'hqf" eqnwtcpw'G/323"cpf "G/362k'tgur gevkgn' "J4\_ŃTH"y cvgt/uqndrg'Xkv'D4+'ku'c'eqo r qwpf "v'cv'ku's wem' "f gi tcf gu'd { 'ri j v'Ń Ceeqt'kpi "v'Ĥkgtcwtg.'TH'cduqr vqp'Ń czko wo u'tcg'cv'445.'489.'595'cpf '666'po ŃVj g'ri j v'lpf wv'f 'TH'cvkcvkqp'ecp'uj qy " r qv'p'v'e { vqzke' { "cpf "ugrĖvkg' "f co ci g'f kĤgtgpv'dcevtk'ŃEj n'ku'npqy p'cu"y cvgt/uqndrg."i tggp."pgi cvkgn' "ej cti gf " eqo r qwpf "y kj "v'j g'o clp'cduqr vqp'Ń czko wo "cv'627'po ŃVj gtghgtg."c'NGF/dcugf'ri j v'v'qwtg'qh'ri j v'v' cxgrpi v' "627'po " y cu'wuf "lp'g'zr g'ko gpv'ht'v'j g'qr vko cn'gzekcvkqp'qh'Ej n'Ń'ku'c'ugo k'u'p'v'g'v'e "r qtr j { tkp'qdvk'p'f "Ĥqo "ej mqr j { m'v'cv' i gp'gtcv'g'cevk'g'qz { i gp'ur gelgu'y kj "cpvko letqdkn'cevk'v' "chgt'g'zr quwt'g'v'x'k'kdrg'ri j v'Ń"

Dqj "RU'ctg'npqy p'v'ej cpi g'v'j g'qr v'cn'cduqtdcep'g'chgt'cevkcvkqp'd { "ri j v'ŃVj gug'ej cpi gu'uj qy "v'j g'cevkcvkqp" f gr gpf gpeg'qp'gzekcvkqp'f qug'cpf "ecp'dg'wuf "v'eqo r ctg'v'j g'ktcf kcvkqp'ghĖkepe { "d { "f kĤgtgpv'ur gev'cn'eqo r qp'gpv'Ń Vj gtghgtg."v'j g'cduqr vqp'ur gev'c'qh'TH'cpf'Ej n'v'gtg'lp'xgunk'cv'f "chgt'knwo Ĥcvkqp'y kj "672'po ."627'po ."6222'M'ri j v' \*Ĥki Ń-Ń



Ĥki Ń'Ń'Ńj qvqwdk'v' "cu'qr v'cn'cduqtdcep'ur gev'c'qh'3.3 32/7"Ń "TH'Ń'c'cpf"3 32/7"Ń "Ej n'Ń'D'chgt'v'g'v' gpv'qh'f kĤgtgpv' ktcf kpep'f quguŃ

Vj g'r j qvqf gi tcf cvkqp'ghĖgef' gr kev'f "lp'Ĥki Ń3C'uj qy u'v'cv'TH'ecp'dg'gzek'f "d { '672'po "cu'qr vko cn'cpf "d { '627'po "cpf " 6222'M'ri j v'v' kj "tgrv'kg'ghĖkepe'ku'qh'2.5"cpf "2.45."tgur gevkgn'ŃVj g'r j qvqf gi tcf cvkqp'g'zr g'ko gpv'j gr g'f "cuwv'v'j g'TH' ucdk'v' "r'xgn'cpf "t'g'g'gr'f "ku'r'j qvqf gi tcf cvkqp'r tqf wv'chgt'ur gek'le'knwo Ĥcvkqp'g'zr quwt'g'Ń'ku'npqy p'v'cv'v'j g'cs w'q'w' uq'w'v'qp'qh'Ej n'ctg'cnq'ugpuk'v'v'ri j v'ŃQw'g'zr g'ko gpv'uj qy gf "v'cv'cm'v'j tgg'ktcf kpep'v'qwt'g'u"627'po ."672'po "cpf " y j kg'6222'M'gzek'g'Ej n'dw'r j qvqcvkcvkqp'ghĖkepe { "ku'f kĤgtgp'ŃVj g'r j qvqf gi tcf cvkqp'ghĖgef' gr kev'f "lp'Ĥki Ń3D'uj qy u' v'cv'Ej n'ecp'dg'gzek'g' "d { '627'po "cu'qr vko cn'cpf "d { '672'po "cpf "6222'M'ri j v'v' kj "tgrv'kg'ghĖkepe'ku'qh'2.64"cpf "2.37." tgur gevkgn'ŃCnq."uq'v'ci g'ucdk'v' { "cpf "r j qvqwdk'v' "qh'dqj "RU'lp'v'j g'o k'zwt'g'cpf "ugr'ct'v'g'uq'w'v'qp'y gt'g'cpcn' { gf ŃVq" eqp'w'f g.'TH'cpf'Ej n'ctg'r tqo kulpi 'pcwtcn'RU'v'v'cv'ecp'dg'y kf gn' "cr r n'cedrg.'dw'v'j g'ht'v'j gt'lp'xgunk'cvkqp'Ń w'v'd'g'r g'ht'qo gf Ń

13\_ " Dvej qxge." K' gv' cnŃ "4242-Ń' Cp'vko letqdkn' Rj qvqĖcvkcvkqp" Crrtqcej " Dcugf" qp" Pcw'cn' Ci gpv' ht' " Eqpvtqn' qh' Dcevtk' Dq'k'ko u' lp' " Ur cegetchŃVj g'kĖgtcvkqp'cn'l'qwt'pcn'l'q'Ń' qrgewct' u'ek'p'egu."43'3: -Ń  
14\_ "ŃŃŃ c'k'v' "g'v'c'Ń'Ń'Ĥcu'v'cpf "ghĖv'kg'r j qvqf { pco k'lp'cevkcvkqp'qh'o wnt'guk'v'p'v'dcevtk' "d { "ec'v'k'ple' 'tkdqhrxkp'f g'k'v'k'v'g'u.Ń'RNq'U'Qpg.'xqrŃ; ."pqŃ34." 4236Ń

**O KETQDKCN'DKQHWGN'E GNN'DCUGF 'QP'DCMGT AU[ GCUV'VTGCVGF "'  
D[ ' ; . '32/RJ GP CP VJ TGP GS WKP QP G"**

Vlo cu'O gtngrku<sup>3</sup>. 'Mcur ctcu'Mk { u<sup>4</sup>. 'Cpvcpcu\ kpxxleku<sup>5</sup>. 'Lwug'Tql gpg<sup>5</sup>. 'Kpi c'O qtmxgpckg/  
Xkmqpekgp<sup>4,5</sup>. 'Ctwpcu'Tco cpcxleku<sup>3,5</sup>

<sup>3</sup>'Xkpkwu'Wpkxgtuk\ . 'Hewm\ 'qh'Ej go km { 'cpf 'I gquekgpegu 'P cwi ctf vnu<sup>4</sup>6. 'Xkpkwu 'Nkj wcpk "  
<sup>4</sup>'Xkpkwu'I gf ko kpcu'Vgej plecn'Wpkxgtuk\ . 'Hewm\ 'qh'O gej cpleu. 'L0'Dcucpcxk kcu'i 04: . '25446'Xkpkwu. 'Nkj wcpk "  
<sup>5</sup>'Egpgvt'ht' 'Rj { ukecn'Uelkgpegu'cpf 'Vgej pqm { . 'Ucwn vgnk<sup>5</sup>. '32479'Xkpkwu. 'Nkj wcpk "  
vlo cuO gtngrkuB ej i hnwf kvwv"

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# IDENTIFICATION OF A NOVEL FAMILY OF BACTERIAL LIPOLYTIC ENZYMES

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Lipolytic enzymes belong to a large class of enzymes called serine hydrolases that are distinguished by a presence of a nucleophilic serine (nSer) in their active site. Most of the bacterial lipolytic enzymes have the nSer located in a conservative GX SXG pentapeptide (X – any amino acid residue), GD SL motive or less frequently in a motive specific to lipolytic enzymes structurally resembling  $\beta$ -lactamases / DD-peptidases [1]. Conservative amino acid motives and biochemical properties of bacterial lipolytic enzymes are used for their classification [2]. In this work, a putative carboxylesterase (EstAG1) from *Staphylococcus saprophyticus* AG1 [3] with previously uncharacterized pentapeptide and nSer location motive was identified. Enzyme having no close homologues had unconventional GDGTG pentapeptide and nSer located in a SPXYD (Y – hydrophobic residue) sequence previously unspecified for the bacterial lipolytic enzymes. The putatively catalytic nSer and other amino acids related to catalytic function were investigated and validated by site-directed mutagenesis and activity analysis of the mutant recombinant enzymes. Phylogenetic analysis revealed that EstAG1 homologues are found in the other *Staphylococcus* spp. as well. Based on the low amino acid sequence identities, unique conservative amino acid motives and phylogenetic analysis results, EstAG1 belongs to a new family of bacterial lipolytic enzymes.

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# RAMAN LIGHT SCATTERING FROM THE LEAVES PLATES OF AQUATIC MACROPHYTE ELODEA CANADENSIS (MICHX. 1803) UNDER THE INFLUENCE OF MULTILEVEL SALINITY IN VIVO.

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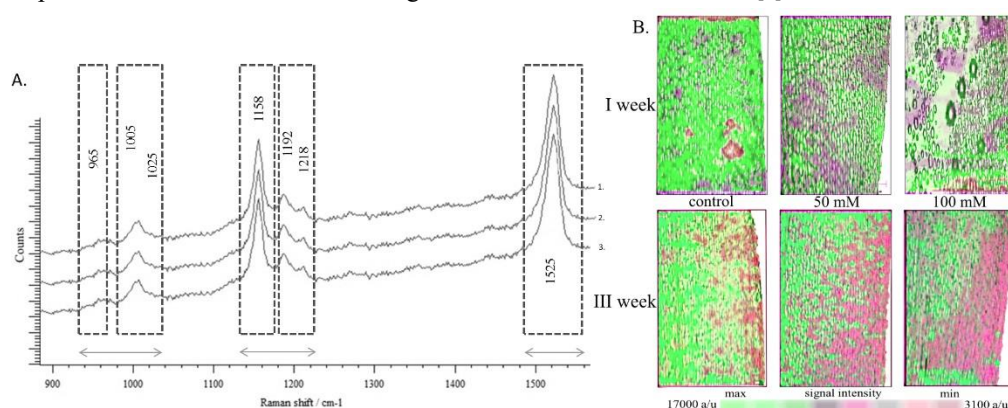
An important ecological and physiological parameter for assessing the influence of different salinity levels on plants' growth and development are the changes occurring in the photosynthetic apparatus, significantly the changes of chlorophyll and carotenoid content in the leaves of the plant under the influence of different environmental aspects. Salinity is recognized as one of the leading environmental factors that limit the productivity and development of plants. In general, investigations of the effect of salinity on crops are being studied more actively than other plants. Still, aquatic plants may also experience the adverse effects of NaCl and may be more sensitive to these types of changes or, vice versa, have specific adaptive mechanisms. Therefore, studies in this direction are interesting and promising to clarify this issue and help draw the right conclusions for assessing the effect on plants [2].

During the Raman spectroscopy, the whole leaf-plates of the invasive aquatic plant *Elodea canadensis* (Michx.) were examined. It was found that cells exhibit non-uniform distribution of the chlorophyll and carotenoid molecules, which is associated with the different photosynthetic activity rates perhaps caused by various salt concentrations in water. Canadian waterweed was grown in aquarium-tanks with nutrients and various NaCl concentrations: 0 mM, 50 mM, 100 mM in a climate chamber, photoperiod (16 h day / 8 h night, 16°C, relative illumination 2500 Lux).

The Raman spectra were obtained by using the British Renishaw inVia Reflex system at shortened Raman shift range: 1590–850 cm<sup>-1</sup> (Fig.1.A) and micro-mapping (Fig.1.B), excitation by Ar-ion laser  $\lambda = 514.0$  nm (~9.2–26.5 mW power at the sample). Obtained Raman spectra were performed with the WiRE 3.3 program, and spectra final correction was carried out using the software package OriginPro 9.2.

The presence of a positive correlation between an increase of NaCl concentration and a decrease of the Raman signal intensity of chlorophyll *a* and chlorophyll *b* (due to overlapping signals of close peaks in some cases, it isn't easy to separate the peaks of Chl *a* from Chl *b*). The 100 mM concentration of NaCl negatively impacted the photosynthetic apparatus's functioning, and at the third week, photosynthetic efficiency decreased significantly [1], [3].

The Raman band's intensity of carotenoids depends on the level of salinity. The peak intensity of the signal of carotenoids was in the range: 395 –16800 a.u. Spectra were similar in general peaks but differ from control samples by the level of shifts signal intensity. Due to the decrease of the total intensity of all peaks in samples (100mM), an increase in the number of low-intensity peaks over the entire length of the spectrum was observed. The band in the region of 1525 cm<sup>-1</sup> characterizes the stretching vibrations of the double –C=C bonds of the carotenoid molecule and shifts to the high-frequency region when the configuration of the carotenoid molecule changes, the band 1158 cm<sup>-1</sup> characterizes the stretching vibrations of single C–C bonds. (Fig.1.) The simultaneous shift of the 1525 cm<sup>-1</sup> band towards lower frequencies and band 1158 cm<sup>-1</sup> towards higher frequencies may decrease the number of double conjugated bonds in the molecule and processes associated with the changes in the carotenoid molecules. [3]



**Fig. 1.** **A** The short-range Raman spectra of plant leaves measured directly from leaf surface (--- Chl *a*, Chl *b*, total carotenoids) **B** - Spatial 2D images of *Elodea canadensis* leaf plate surface with micro-Raman signal intensity maps

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**QRVIO K CVKQP 'QHI GP QO G'RTKO G'GF KVP I 'K' O WTKP G'  
GO DT[ QP KE 'EGNNU'**

Tcf xkræUdgpft { u<sup>3</sup>. "Dgtpcf gvc'O cukwkp { v<sup>3</sup>. "Dgcvtk "O kfc "Dcrk- { v<sup>3</sup>. "  
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<sup>3</sup>F gr ctvo gpv'qh'Dkqmi leci'F P C'O qf kkecvkp. "kpuvwg'qh'Dkqvej pqmi { . "Nke"Uelgpegu'Egpvt. ""  
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j3\_ "Eqpi . "N0"Tcp. "H0C0"Eqz. "F0"Nkp. "U0"Dcttgwq. "T0"J cdld. "P0" j cpi . "H0"O wkr ngz. "I gpqo g'Gpi kpggtkpi "Wulpi "ETKURT IEcu"U{ ugo u0Uelgpeg. "  
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# **PALMITOXYACETONE, A PRODUCT OF FREE RADICAL LYSOPHOSPHOLIPIDS DESTRUCTION, REGULATES H<sub>2</sub>O<sub>2</sub> PRODUCTION BY NEUTROPHILS**

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Lysophospholipids are formed as a result of hydrolysis of glycerophospholipids localized in biological membranes and lipoproteins catalyzed by phospholipases A<sub>2</sub> (PLA<sub>2</sub>) [1]. The products of PLA<sub>2</sub> functioning regulate the processes of signal transduction in response to external stimuli. PLA<sub>2</sub> plays an important role in the development of pathological conditions associated with oxidative stress formation caused by reactive oxygen species (ROS) hyperproduction. It has been previously shown that ROS induce lysophospholipids destruction. The interaction of lysophosphatidylcholine with ROS is accompanied by lipid molecule fragmentation with the formation of predominantly palmitoxyacetone and stearoxyacetone. The formation of such products from lysophospholipids is possible only through the free radical pathway since the enzymatic systems leading to the accumulation of these compounds have not been found in the human body.

ROS are produced mainly by neutrophils as a result of the enzymes NADPH oxidase and myeloperoxidase activation, which generate superoxide radical anions and hypochlorous acid, respectively [2]. Palmitoxyacetone, formed in the inflammatory focus as a result of ROS-induced free radical fragmentation of lysophospholipids, can change the functional activity of neutrophils, and thus regulate the inflammatory process, which makes this work relevant.

Neutrophils were isolated from the peripheral blood of healthy people in a Histopaque-1077 density gradient according to a standard technique. Cell survival was studied using propidium iodide ( $\lambda_{ex} = 530$  nm,  $\lambda_{em} = 640$  nm). ROS generation by neutrophils was determined by the fluorescent method using the H<sub>2</sub>DCF-DA probe ( $\lambda_{ex} = 488$  nm,  $\lambda_{em} = 530$  nm). The cells were stimulated to phagocytosis with the chemotactic peptide fMLP. The measurements were carried out at T = 37 ° C, pH = 7.2.

It has been shown that palmitoxyacetone in the concentration range of 0.1–100  $\mu$ M doesn't have a toxic effect on cells. It was found that cells incubation with palmitoxyacetone at a concentration of 100  $\mu$ M for 30 min leads to a decrease, and at a concentration of 1 and 10  $\mu$ M, to an increase in H<sub>2</sub>O<sub>2</sub> production by fMLP-stimulated neutrophils, while 0.1  $\mu$ M palmitoxyacetone does not affect this process.

Thus, palmitoxyacetone can regulate ROS generation by neutrophils.

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# THE EFFECT OF INDOLE-CONTAINING STEROIDS ON THE MITOCHONDRIAL MEMBRANE POTENTIAL OF C6 GLIOMA CELLS

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Mitochondria are key cellular organelles that play an essential role in various functions such as regulation of cellular metabolism, redox signaling, ionic homeostasis, and cell death [1]. Since tumorigenesis requires flexibility for the tumors to adapt to cellular and environmental alterations, it is not surprising that mitochondria serve a key role in this process [2].

Previously, a series of indole-containing steroids were synthesized: N-(2-(3-indolyl)ethyl)-3 $\beta$ -hydroxyandrost-5-en-17 $\beta$ -amine (IS-1), N-(2-(3-indolyl)ethyl)-3-hydroxyestra-1,3,5(10)-trien-17 $\beta$ -amine (IS-2) and two 20-epimers of N-(2-(3-indolyl)ethyl)-3 $\beta$ -hydroxypregn-5-en-20-amine (IS-3). These compounds were shown to decrease C6 glioma cell proliferation in 10  $\mu$ M concentration [3], as abiraterone acetate (Abi) anticancer agent did. To examine indole-containing steroid intracellular effects, we investigated the mitochondrial membrane potential (MMP) of C6 glioma cells.

Cells were cultured in DMEM/F-12 medium at 37°C in a humidified 5% CO<sub>2</sub> and 95% air atmosphere. On the third day of growth cells in suspension in HEPES-buffer were incubated with tetraethylbenzimidazolylcarbocyanine iodide (JC-1, 2  $\mu$ M) for 30 min at 37°C, membrane potential was measured by spectrofluorimetry. Mitochondrial inhibitors Rotenone (Rot) or Antimycin A (Ana) were added after incubation with JC-1.

We found that Abi at 10  $\mu$ M decreases the MMP by 62 $\pm$ 15%, whereas IS-3R does so by 40 $\pm$ 25% (Fig.1 A). IS-1, IS-2, and IS-3S did not affect the MMP. Simultaneous treatment with complex I inhibitor rotenone (Rot) and Abi, IS-1 or IS-3R led to an additional decrease of MMP (Fig.1 B). IS-1 and IS-3R lead to the minor recovery of MMP after inhibition of the third complex by Ana (Fig.1 C).

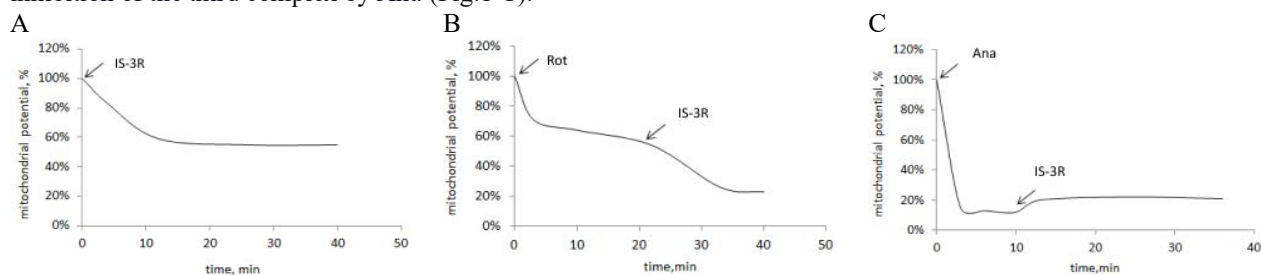


Fig.1. Typical kinetics of MMP changes under the action of IS-3R and complex I (Rot) and complex III (Ana) inhibitors

Although IS-1 is an effective inhibitor of glioma cell proliferation [3], we did not detect it to influence the MMP, contrary to abiraterone, a known apoptosis inducer [4]. The observed effect of the indolesteroid IS-3R on MMP could be related to its interaction with mitochondria on complex III level. Further investigations are underway to examine if apoptosis is involved in indolesteroids' effect on C6 glioma proliferation.

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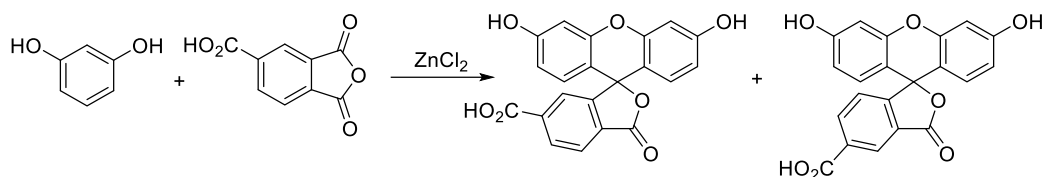


# ADOMET ANALOGUES WITH FLUORESCENT MOIETIES. RESEARCH ON SYNTHESIS OF FLUORESCINE CARBOXY MOIETY POSSESSING ALKYNE AND PREPARATION OF 6-AZIDOHX-2-YN-1-YL NOSYLATE

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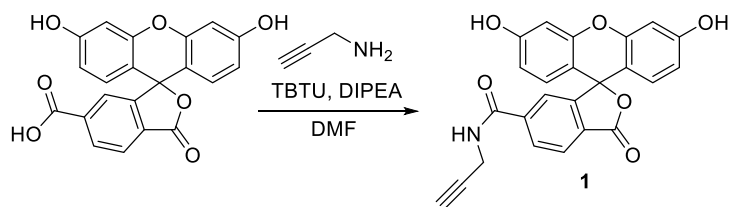
Fluorescent dyes have been a topic of discussion for several decades. Development of new fluorophores has improved sensitivity of biomolecule detection. Some of the most widely used fluorophores are fluorescein and its analogues. Depending on pH fluorescein can exist in “open” or “closed” forms, monoanionic form shifts UV (ultraviolet) spectra in the blue wave direction, comparing with its dianionic form, which has a strong fluorescent emission [1]. Also, fluorescein synthesis has been a topic of debate due to lack of selectivity of Friedel-Crafts acylation (*Fig. 1*). Products that form are structural isomers, their separation requires preparative HPLC (high-performance liquid chromatography) and for this reason pure carboxyfluorescein and its derivatives are costly [2].



**Fig. 1.** Synthesis of fluorescein derivatives.

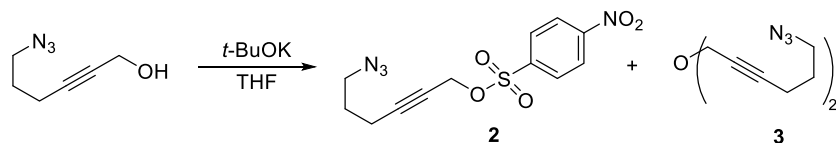
S-Adenosyl-L-methionine (AdoMet) is a commonly used cofactor, which participates in numerous methyl group transfer reactions occurring in living organisms. Sulphur-bound methyl group is transferred onto biomolecules via  $S_N2$  reaction. While methyl group transfer is simple and is catalysed by native methyltransferases (MTases), it has no utility for biomolecule tagging. Despite that, other transferable groups together with engineered MTases are usually applied for tagging in biological systems [3].

In our laboratory, synthesis of fluorescein-6-carboxamide (**1**) has been developed. 6-Carboxyfluorescein, TBTU (2-(1H-Benzotriazole-1-yl)-1,1,3,3-tetramethylammonium tetrafluoroborate), DIPEA (N,N-diisopropylethylamine) and propargyl amine are stirred in N,N-dimethylformamide (DMF). Desired product forms in 78% yield (*Fig. 2*).



**Fig. 2.** 6-Carboxyfluorescein reaction with propargyl amine.

Another prerequisite component for the synthesis of AdoMet cofactor analogue has been obtained from 6-azidohex-2-yn-1-ol, 4-nitrobenzenesulfonylchloride and a strong base potassium *tert*-butoxide (*Fig. 3*). Synthesis of 6-azidohex-2-yn-1-yl-4-nitrobenzenesulfonate (**2**) is accompanied by the formation of ether side product (**3**).



**Fig. 3.** Synthesis of 6-azidohex-2-yn-1-yl-4-nitrobenzenesulfonate.

In the near future we are preparing to synthesise an AdoMet analogue, which, instead of a methyl group, would contain a alkynylazide group. The produced versatile cofactor with a reactive azido group would then be reacted with fluorescein-6-carboxamide (**1**) to form cofactor possessing a fluorescein tag.

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[2] Y. Duan, M. Liu, W. Sun, M. Wang, S. Liu, Q. Li. *Mini. Rev. Org. Chem.* **2009**, 6 (1), 35–43.

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