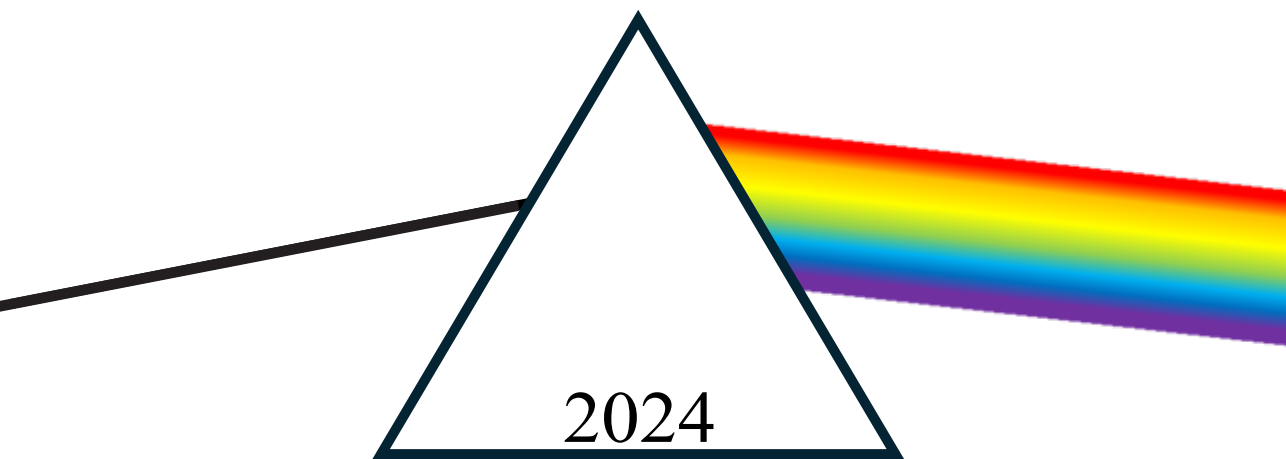


BOOK OF ABSTRACTS



PANIC

The 16th International Annual Conference
of Nanophotonics

May 16–17, 2024
Wrocław, Poland



**PhoBiA Annual Nanophotonics
International Conference**

PANIC 2024

Book of Abstracts

16–17 May 2024, Wrocław, Poland



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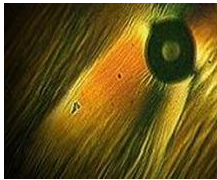
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PANIC 2024 Programme

Thursday – 16.05.2024	
D-21, room 007	
Hours	Activity
8:00–8:30	Registration
8:30–8:45	Opening Ceremony
8:45–11:15	Session I
8:45–9:40	Invited lecture I (Prof. Frank Cichos)
9:45–10:45	Presentation session I
10:50–11:15	Shotgun session I
11:15–11:30	Coffee break
11:30–15:20	Session II
11:30–12:25	Invited lecture II (Prof. Paulina Plochocka-Maude)
12:30–13:30	Presentation session II
13:30–14:00	Lunchbreak
14:00–14:20	Shotgun session II
14:25–15:20	Invited lecture III (Dr hab. Piotr Fita, Prof. UW)
SKS, C-18	
16:00–17:00	Poster session
19:00	Banquet on a boat

Friday – 17.05.2024	
D-21, room 007	
Hours	Activity
8:00 – 10:05	Session III
8:00–8:55	Invited lecture IV (Dr Sylwia Zięba)
9:00–10:05	Presentation session III
10:05–10:20	Coffee break
10:25 – 12:25	Session IV
10:25–11:20	Invited lecture V (Dr Marco Deiana)
11:25–12:25	Presentation session IV
12:25–12:55	Lunchbreak
13:00 – 15:30	Session VI
13:00–13:55	Presentation session V
14:00–14:55	Invited lecture VI (online) (Prof. Vanderlei S. Bagnato)
15:00–15:30	Closing Ceremony
16:45–18:00	Excursion to the Hydropolis Museum

Invited Lectures

Thursday – 16.05.2024	
8:45–9:40	Invited lecture I (Prof. Frank Cichos)
11:30–12:25	Invited lecture II (Prof. Paulina Plochocka-Maude)
14:25–15:20	Invited lecture III (Ph.D. D.Sc. Piotr Fita, Prof. UW)
Friday – 17.05.2024	
8:00–8:55	Invited lecture IV (Ph.D. Sylwia Zięba)
10:25–11:20	Invited lecture V (Ph.D. Marco Deiana)
14:00–14:55	Invited lecture VI (Prof. Vanderlei S. Bagnato)

Prof. Frank Cichos



Prof. Frank Cichos – head of the Molecular Nanophotonics Group at Leipzig University. He has recently co-authored a paper in Nature communications on the use of active microparticles for artificial intelligence. His research group works on, inter alia, microswimmers, thermophoretic trapping as well as thermofluidics.

Thermofluidics – Moving colloids, molecules and liquids with local temperature fields

Prof. Frank Cichos

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In recent years, new techniques have emerged for manipulating nano-objects and flows in a fluidic environment using remote control through light. These methods go beyond the force generation capabilities of optical tweezers and employ plasmonic structures. By generating temperature gradients with plasmonic structures at the boundaries between liquids and solid surfaces in simple fluidic slit pores, local flow patterns can be created to guide, manipulate, and separate suspended objects without the need for external pressure differences. This new field is termed thermofluidics and comprises new rapid developments [1].

We show in this contribution how optically heated plasmonic nanostructures can induce complex hydrodynamic flow fields and molecular concentration gradients. The flow fields arise from forces generated in an ultrathin boundary layer of a few nanometers thickness at the liquid-solid interface and are termed thermo-osmotic flows [2]. Such thermo-osmotic flows can be combined with van der Waals and electrostatic forces to dynamically generate controlled plasmonic structures using gold nanoparticles. The large thermal diffusivity at these length scales further ensures that complex temperature fields may be generated by multiplexing in time and space, which allows additional control on the cluster formation. We present applications of local heat generation to the study of protein aggregation [3], the on-demand formation of photonic crystals and the controlled aggregation of plasmonic clusters on mirrors.

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Prof. Paulina Płochocka-Maude



Prof. Paulina Płochocka-Maude – researcher working simultaneously at the Faculty of Fundamental Problems of Technology of Wrocław University of Science and Technology, as well as Laboratoire National des Champs Magnétiques Intenses of the French National Centre for Scientific Research (CNRS). Her recent publications concern 2D perovskites and properties of crystalline materials. In 2020 prof. Płochocka-Maude was awarded the Polish Smart Development Award for research into perovskites for photovoltaic applications. More about this esteemed guest can be found in a short news piece published on our University website in 2021 (PL).

Organic-inorganic metal halide perovskites: semiconductor different than the others

Prof. Paulina Plochocka

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In recent decades, organic and inorganic metal-halide perovskites have emerged as revolutionary semiconductor materials for energy harvesting, light emission and scintillator applications. The unique synergy of soft lattice and optoelectronic properties is often invoked to explain the superior characteristic of perovskite materials in applications. At the same time, such unique synergy creates a fascinating playground for exciton physics which challenges our understanding of this elementary excitation. In this talk, I will demonstrate that even after a decade of intense investigation the notation “unique” so often used in the case of perovskites deserves serious scrutiny. Here I will discuss certain aspects of excitonic physics in bulk perovskites and their 2D forms which makes these materials so particular. First, I will demonstrate how the seemingly trivial problem of exciton binding energy in bulk semiconductors became a challenge in the case of metal-halide perovskites. Secondly, I will highlight controversy related to exciton fine structure in perovskite compounds. Finally, I will discuss how the soft nature of perovskite control and can be exploited to tune the effective mass – a crucial parameter for any semiconductor.

Ph.D. D.Sc. Piotr Fita



Ph.D. D.Sc. Piotr Fita – team leader at the Ultrafast Phenomena Laboratory of the University of Warsaw. His recent research activity is dominated by bioimaging via linear and nonlinear optical phenomena. This includes a 2022 paper on two-photon excitation for the detections of amyloids. An extended bio of our guest from Warsaw can be found on his division's website.



Time-resolved optical spectroscopy and its applications in chemistry and biology

Ph.D. D.Sc. Piotr Fita

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Ultrafast time-resolved optical spectroscopy, which earned Ahmed Zewail the Nobel Prize 25 years ago, has now become a well-established discipline. Various time-resolved techniques can be employed not only in fundamental research on the properties of matter but also as an advanced analytical tool in chemistry and biology. These techniques aid in the detection and study of species that are challenging to analyze using other methods.

In the presentation, I will delve into the photophysical processes that occur in matter following optical excitation and elucidate how they can be observed using various time resolved absorption and emission spectroscopy methods. Subsequently, I will showcase selected examples of their successful applications in chemical and biological systems.

Ph.D. Sylwia Zięba



Ph.D. Sylwia Zięba – researcher at the Department of Molecular Crystals of the Institute of Molecular Physics of the Polish Academy of Sciences. The department researches proton conductors for applications in energy technology. Doctor Zięba has recently studied temperature expansion and compressibility of an imidazolium benzoate salt and proposed a model explaining the observed properties. Her findings were published in Scientific Reports.

Helical model of compression and thermal expansion

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Negative linear compressibility (NLC) is a rare type of crystal deformation in which one or two dimensions expand with increasing hydrostatic pressure. A similar phenomenon is negative temperature expansion (NTE), where one, two, or three dimensions decrease with increasing temperature. Negative pressure expansion is often observed in compounds with negative temperature expansion. One example is imidazolium benzoate salt, where NLC and NTE behavior were observed. It has a helical structure resulting from ions linked by $N^+ - H \cdots O^-$ hydrogen bonds. X-ray diffraction and vibrational spectroscopy were used to analyze interactions in the crystal. The Quantum Theory of Atoms in Molecules (QTAIM) approach was applied to analyze the hydrogen bonds.

Imidazolium benzoate crystallizes in a monoclinic system and space group $P2_1/n$. Two of the three parameters of the unit cell, namely a and c , and the β angle, exhibit constant elongation (increase) as the temperature rises, whereas the parameter b decreases. The coefficients of linear temperature expansion are equal to: $-54.6(2)$, $47.8(8)$ and $193.2(5)$ $10^{-6} \cdot K^{-1}$ for the X1, X2 and X3 principal directions. The coefficients of linear compressibility are equal to $-4.2(6)$, $12.2(7)$, and $25.2(9)$ TPa^{-1} . Figure 1 shows the relative changes in principal axis lengths as a function of temperature and pressure.

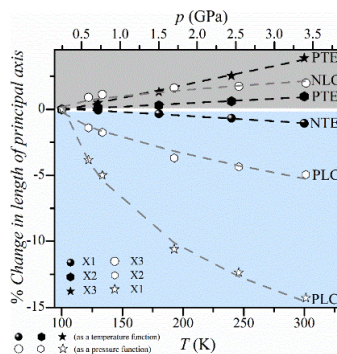


Fig. 1. Relative changes in principal axes lengths as a function of temperature and pressure

We have proposed a helical model to explain the negative linear thermal expansion and compression of imidazolium benzoate crystals. In a helical system with decreasing temperature and increasing pressure, the helix pitch increases while the value of the semi-major axis decreases. The correlation between negative linear behavior and structural distortions of helices is manifest.

The research was financed from budget funds for science in 2020–2023 as a research project under the “PRELUDIUM-18” program (National Science Centre, Poland, 2019/35/N/ST5/03324) and supported by the Foundation for Polish Science (FNP) (START 098.2022).

Ph.D. Marco Deiana



Ph.D. Marco Deiana – Assistant Professor in the Institute of Advanced Materials of Wrocław University of Science and Technology. A scientific globetrotter who has worked at MIT and Umeå University (Sweden) currently investigating G-quadruplex DNA structures as targets of photodynamic therapy. Dr Deiana is closely collaborating with PhoBiA's supervisor and former members employed at the institute, we are all exceptionally happy to welcome him at our conference. You can read more about his scientific journey in this news piece from 2023 (PL).

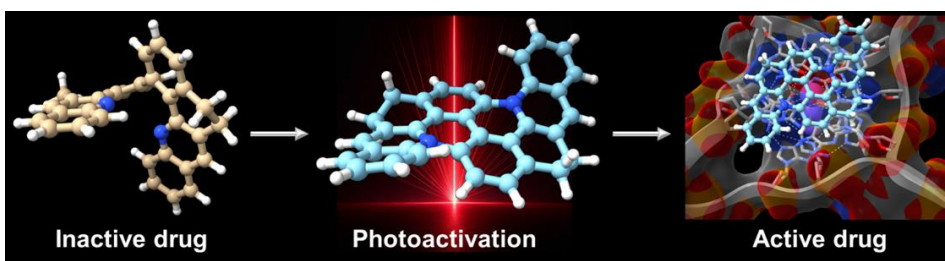
From Darkness to Light: G-Quadruplex as a Molecular Target in Light-Activated Therapy

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Molecular targeted therapies that utilize small molecule inhibitors to disrupt signal transduction pathways have become foundational to precision medicine in cancer treatment. These agents, when endowed with light-responsive properties, facilitate precision dosing – enabling the targeted delivery and activation of therapeutics directly at tumor sites. Among the most promising targets in this domain are G-quadruplexes (G4s), guanine-rich DNA sequences that fold into compact and stable structures. When these G4 structures are stabilized by specific ligands, they can effectively obstruct DNA processes such as replication and transcription. This blockade creates potential avenues for inducing synthetic lethality, either as standalone treatments or in combination with DNA-damaging agents or DNA damage response inhibitors. Additionally, G4s are particularly significant in the context of photodynamic therapy due to their capacity for low-energy photoionization. This property can be harnessed to selectively optimize oxidative DNA damage at the tumor site, enhancing therapeutic efficacy while minimizing off-target effects. This presentation will delve into the biology of G4s, emphasizing their potential as molecular targets within the framework of molecular recognition. I will discuss the development and application of fluorescent probes, light-activated compounds, and photosensitizers that are specifically designed to target these DNA structures. The session will explore molecular design strategies and their translation into cellular applications, highlighting ongoing projects that aim to improve the selectivity and effectiveness of G4-targeting compounds against cancer cells. This comprehensive overview will not only detail the molecular intricacies of G4s but also showcase innovative techniques that are revolutionizing the field of targeted cancer therapy through the use of light-activated molecular recognition mechanisms.



Prof. Vanderlei Salvador Bagnato



Prof. Vanderlei Salvador Bagnato – member of the Group of Optics of exceptionally scientifically prolific São Carlos Institute of Physics at the University of São Paulo. An expert in photodynamic therapy. His recent publications regard photodynamic and sonophotodynamic therapies of bacterial infections and cancer.



Photodynamic therapy: from cancer to microbiological control using light processing of living materials

Prof. Vanderlei Salvador Bagnato

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Photodynamic therapy has been an excellent option for the treatment of skin cancer, and cervix and also for the control of infections, especially those resistant to antibiotics. In this presentation, we will explain how we have been acting with the development of protocols that today reach a success rate of 95% of tumor elimination as well as the approval of the treatment by the unified public health system. For that important materials issues as soluble microneedles, functionalization of materials as well as drug delivery are important. The advantages of using photodynamic therapy for countries with an emerging economy should be discussed. In the microbiological control part, we will explore the problem of bacterial resistance as well as the opportunities created by photodynamic inactivation in different types of infections, including pneumonia. Breaking down bacterial resistance to antibiotics will also be addressed, an issue that is guide urgent and necessary.

Presentation Sessions

Thursday – 16.05.2024	
9:45–10:45	Presentation session I
9:45–10:05	Marek Adaszyński “The spectroscopic properties of Mg ₂ Al ₄ Si ₅ O ₁₈ : Eu ²⁺ , Cr ³⁺ and its possible applications”
10:05–10:25	Fengchan Zhang “A fluorescence nanothermometer for reliable monitoring of intracellular temperature”
10:25–10:45	Magdalena Dudek „Photon avalanche emission in fluoride nano, micro and bulk materials doped with lanthanide ions”
12:30–13:30	Presentation session II
12:30–12:50	Radosław Szymon “The (Al/Hf)O _x partial coatings towards relaxation, protection, and enhancement of GaN nanowires”
12:50–13:10	Ewelina Cybula “Monolayers of transition metal dichalcogenide fabrication and strain engineering on GaAs nanomembranes”
13:10–13:30	Maja Wasiluk “Quantifying spin coherence: Hanle effect measurements in single InAs/InP quantum dots”
Friday – 17.05.2024	
9:00–10:00	Presentation session III
9:00–9:20	Adrian Kowaliński “Sandglass-like nonanuclear rare-earth molecular cluster aggregates for alkaline-earth manganite oxide nanomaterials doping”
9:20–9:40	Wiktoria Zacheja “The influence of plasmonic excitation on the dynamics of photoswitching of molecules”
9:40–10:00	Michał Wnuk “Construction of mobile and compact Raman spectrometer with utilization of 3D printing technologies”
11:25–12:25	Presentation session IV
11:25–11:45	Michał Kopacz “Improvement of electrical conductivity of electrospun PVDF fibers by controlled CNT electrophoretic deposition”
11:45–12:05	Olga Kochanowska “Control of optical modes excited in hyperbolic nanoresonators”
12:05–12:25	Maksymilian Szatko “Exploring Solvent Influence on Sequence-Defined Polymer Helical Structures”

13:00–13:55	Presentation session V
12:55–13:15	Martyna Polak “Advancing core-shell fiber design for biomedical application: polymer diffusion alters fiber’s attributes and cellular responses”
13:15–13:35	Karolina Krautforst “Photoactive chlorophylls from algae encapsulated in novel liquid crystalline nanocarriers effective in anticancer Photodynamic Therapy”
13:35–13:55	Aleksandra Szarwaryn “Applying Solvatochromism to the Investigation of Emulsions systems: Enhancing Optimization for Potential Eco-Friendly Formulations”

The spectroscopic properties of $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$: Eu^{2+} , Cr^{3+} and its possible applications

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Europium is a metal coming from the f-block of the periodic table and belongs to the lanthanides family. It is noteworthy that unlike most lanthanides, which are stable in the +3 oxidation state, europium can also be present as Eu^{2+} ions in the +2 oxidation state [1]. In such case, it possesses the possibility to perform 5d-4f transition, which is observed as a broad, spin-allowed band in the emission spectra. The maximum of the emission can be easily tuned by changing the ligands surrounding the emitting ion thus influencing crystal field splitting. These properties made a significant impact on modern technologies such as LED lighting [1].

Chromium (III) ions are considered as one of the best emitters for red and NIR emission. Cr^{3+} ions provide a partially filled d-shell with $3d^3$ configuration, which causes strong absorption of light in the VIS range. Usually, two different transitions are possible in photoluminescence spectra: spin-allowed ${}^4T_2 \rightarrow {}^4A_2$ and spin-forbidden ${}^2E \rightarrow {}^4A_2$, which makes its ideal red-NIR emitter in applications such as biological detection and night vision imaging [2].

In this work, a novel silicate $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$ doped with both Eu^{2+} and Cr^{3+} is presented. The sol-gel method of synthesis was applied and optimized. The absorption spectra of the achieved samples consist of a broad band from 250 to 450 nm corresponding to Eu^{2+} transition and a weaker band with a maximum at around 550 nm contributed to Cr^{3+} transition. The emission spectra were measured using multiple excitation wavelengths and in a function of temperature to investigate the possible energy transfer mechanism, that can occur. While 375 nm excitation was used, the emission spectra were characterized by a broad, spin-allowed emission band with a maximum at around 475 nm assigned to Eu^{2+} ions and a spin-forbidden emission line at around 687 nm contributed to Cr^{3+} ions. Moreover, it was observed that Eu^{2+} ions can occupy another site in the crystal lattice which is causing asymmetrical broadening of the main peak at around 600 nm. Finally, the possible application of the material, e.g., in luminescence thermometry and as a phosphor for pc-LEDs will be discussed.

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A fluorescence nanothermometer for reliable monitoring of intracellular temperature

Fengchan Zhang^{1,2*}, Álvaro Artiga¹, Jaume Ramon Otaegui³, Claudio Roscini³, Daniel Ruiz-Molina³, Patricia Haro González^{1,2}, and Daniel Jaque^{1,2}

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Intracellular temperature sensing plays an important role in understanding the biological reactions and physiological conditions inside live cells. A considerable amount of works about intracellular thermometer has been published [1]. Among them, fluorescence thermometers have been widely used due to their non-contact and non-invasive characteristics. However, the reliability of their intracellular thermal readouts is still a question of debate. The change in the compositional properties of intracellular medium can induce changes in the fluorescence signal that can be erroneously interpreted as thermal variations [2]. To overcome it, we proposed an inert thermal probe where the fluorescence nanoparticles are encapsulated with a silica shell to isolate them from the environment.

We used the thermochromic nanoparticles as a ratiometric nanothermometer for measuring the intracellular temperature (Fig. 1a). The fluorescence dye in nanoparticle achieves the fluorescence modulation through the solid-liquid transition of phase change materials. The phase change temperature is 38 °C, which results in a high temperature sensitivity within physiological temperature range. Figure 1b is the emission spectra of the suspension of nanoparticles under 20 °C to 65 °C. We experimentally demonstrated that its green-red fluorescence ratio and phase change temperature is not sensitive to pH, viscosity, ionic strength, and the physical change of the cells. The intracellular temperature calibration is consistent with the extracellular results (Fig. 1c). The proposed ratiometric fluorescence nanothermometer is reliable for live cells temperature sensing.

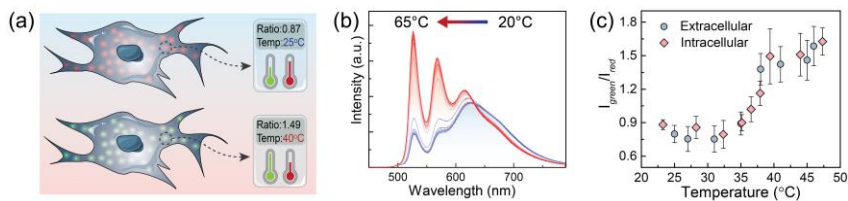


Fig. 1. (a) Schematic diagram of the intercellular ratiometric nanothermometer,

(b) Evolution of emission spectra with temperature from 20 °C to 65 °C,

(c) Temperature dependence of the extracellular and intracellular fluorescence intensity ratio.

I_{green} : fluorescence intensity before 600 nm, I_{red} : fluorescence intensity after 600 nm

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Photon avalanche emission in fluoride nano, micro and bulk materials doped with lanthanide ions

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Photon avalanche (PA) is a kind of an energy up-conversion process characterized by highly non-linear increase of luminescence intensity (I_L) in a response to a minute rise of photo-excitation pump power density (I_P). This relationship follows a “S” shape like dependence, with distinct pump power threshold (I_{TH}) at which PA begin, followed by rapid luminescence rise (according to pump power law $I_L = (I_P - I_{TH})^S$), and becomes saturated at larger pump powers. PA was first observed in 1979 in Pr³⁺ doped LaCl₃ quantum counters [1]. Only recently PA was reported in nanomaterials, namely NaYF₄ nanocrystals doped with Tm³⁺ as well as co-doped with Pr³⁺ and Yb³⁺ ions [2], [3]. The studies presented here concern PA in LiYF₄ (bulk crystal, microcrystals and nanocrystals) doped with Tm³⁺ ions as well as sensitized PA in NaYF₄ nanocrystals co-doped with Pr³⁺ and Yb³⁺ ions [4], [5]. Crystals LiYF₄ doped with Tm³⁺ ions were investigated in response to rising power of 1064 nm photoexcitation corresponding ³F₄ → ³F_{2,3} transition. PA emission was observed at 800 nm (³H₄ → ³H₆). The PA_{TH} increased proportionally to decrease of crystal size. The observed slopes (S) were in the range from 6 to 12. Sensitized PA was presented in Pr³⁺ and Yb³⁺ co-doped NaYF₄ nanocrystals, which were synthesized in a core and core-shell architecture by thermal decomposition of lanthanide salts. The materials were investigated under 852 nm photoexcitation (Pr³⁺: ¹G₄ → ³P_{0,1}) and PA emissions were observed at 482 nm (³P₀ → ³H₄) and 607 nm (³P₀ → ³H₆). Comparing with cores, core-shell nanocrystals showed higher slopes and lower PA_{TH}. The highest slopes, around $S = 9$ and the lowest PA_{TH} around 280 kW/cm² were observed for core-shell nanocrystals co-doped with 0.5 % Pr³⁺ and 15% Yb³⁺ ions for both emissions. Investigations under 852 nm were performed also for nanocrystals singly doped with Pr³⁺ ions, however no emission was present. The essential role of Yb³⁺ ions was additionally confirmed by theoretical modeling. The presented results provide a solid foundation for further development and applications of new optimized PA materials.

Acknowledgements

The research was supported by projects: 2018/31/B/ST5/01827 and 2021/43/B/ST5/01244 funded by the National Science Centre, Poland.

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The (Al/Hf)O_x partial coatings towards relaxation, protection, and enhancement of GaN nanowires

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Gallium nitride (GaN) nanowires owe their great application potential in optoelectronics to exceptional structural quality, high luminescence efficiency, stress elimination, and thermal stability. However, their advantages become irrelevant when structures undergo photodegradation. The proposed solution to this problem involves employing core-shell GaN-AlO_x/HfO_x nanowires grown by molecular beam epitaxy on Si substrates and further coated using atomic layer deposition (Fig. 1a).

Electron microscopy imaging in both scanning and transmission modes revealed that shells with nominal thickness below 5 nm exhibit a non-uniform morphology (Fig. 1b). Despite this, an improvement in the properties of the core-shell nanowires was observed. Namely, partial coverage results in GaN core crystal lattice relaxation, as indicated by Raman spectroscopy, photoluminescence, and X-ray diffraction measurements. This conclusion was supported by statistical analysis, which revealed the statistically significant differences in the calculated strain. Photo- and cathodoluminescence measurements showed that the partial coverage provides to enhancement of luminescence efficiency (Fig. 1c-d). Finally, photoluminescence measurements confirmed that partial coverage effectively protects nanowires against photodegradation.

It was hypothesised that the shells grow in the Stranski-Krastanov mode, where a monolayer is deposited prior to the formation of islands. Consequently, crystal lattice relaxation could be explained by nucleation driven by strain. Additionally, luminescence enhancement might result from the passivation of surface states by the monolayer [1]. Therefore, further investigation is required to determine the presence of the monolayer in the system and whether the proposed mechanisms are responsible for the observed effects.

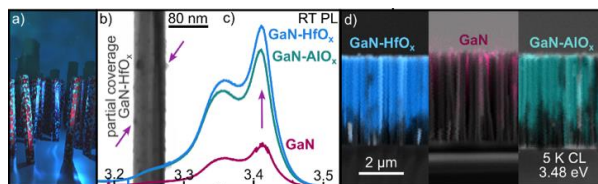


Fig. 1. The characteristics of the bare and core-shell GaN-AlO_x/HfO_x nanowires a) the visualization of the nanowires ensemble, b) the scanning electron microscope image captured in transmission mode showing the GaN-HfO_x nanowire, c) the room temperature photoluminescence spectra, d) the cathodoluminescence maps

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Monolayers of transition metal dichalcogenide fabrication and strain engineering on GaAs nanomembranes

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Recent research in material science physics has extensively focused on layered materials also known as van der Waals materials (vdW) [1]. Their properties, such as weak interlayer bonds and strong intralayer bonds, facilitate the peeling off of layers from a bulk material using adhesive tape (see Fig. 1a). This straightforward method enables the creation of two-dimensional layers, including monolayers. Despite its simplicity, this technique can produce samples with the highest optical quality. This presentation will illustrate the simplicity of the exfoliation process, thereby convincing you of its practicality. Additionally, I will describe the method for transferring exfoliated layers onto a substrate.

Layered materials such as transition metal dichalcogenides (TMD) exhibit intriguing optical properties that can be tuned in various ways. One of the most popular method of tuning is controlling the number of layers. This discussion will concentrate on tuning properties of monolayers (see Fig. 1b) using high-quality GaAs nanomembranes. These nanomembranes apply stress to the monolayers, which in turn modifies their properties. Through the application of photoluminescence spectroscopy, I will show that TMD monolayers, when deposited on GaAs nanomembranes, effectively funnel carriers towards the potential minima corresponding to strain. In other words, by applying strain, I modify the material's energy gap. TMDs possess an excellent mechanical robustness and flexibility withstanding strains as high as 10% before breaking.



Fig. 1. a) Photograph of layered material on adhesive tape,
b) micrograph of TMDs monolayer c) monolayer on GaAs nanomembranes substrate

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Quantifying spin coherence: Hanle effect measurements in single InAs/InP quantum dots

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Significant interest among researchers in exploring carrier spins in semiconductor nanostructures through optical orientation techniques is caused by the potential of this area for the development of quantum information processing and spintronic devices. Quantum dots (QDs) stand out as particularly promising candidates for quantum spin memory due to three-dimensional confinement of carriers, which significantly suppresses spin relaxation processes. Consequently, spin relaxation times in QDs are expected to be considerably longer compared to those observed in bulk semiconductors or two-dimensional structures [1]. Moreover, QDs offer compatibility with well-established semiconductor technology and thus show potential for on-chip integration of different functionalities.

This study explores the properties of symmetric, low-density InAs/InP QDs grown using ripening process-assisted molecular beam epitaxy and emitting within the telecom spectral range (1.55 μm). The QDs were grown on the top of a distributed Bragg reflector, resulting in 6.8% photon extraction efficiency for the planar sample and 13.3% for QDs in cylindrical mesas [2]. High single-photon purity ($g^{(2)}(0) < 0.01$) [3] and low fine structure splitting [4] show prospects for generating non-classical light. Such a material system can be also used for optically driven spintronics, compatible with telecom infrastructure.

Our investigations involved magneto-optical polarization-resolved measurements in Voigt configuration. We determined g-factors of trions within the range of 0.5-1.3 out-of-plane of the dots, which make them promising for electrical tuning of the g-factor sign, required for schemes of single spin control in qubit applications [5]. We observed the negative circular polarization (NCP) [6] under quasi-resonant excitation for emission lines identified as trions. The degree of circular polarization (DOCP) of emission reaches up to 40%. Finally, the decrease of DOCP under the influence of external magnetic field, the so called Hanle effect, reveals the spin coherence time of carriers within the QD [1], which occurs to be in the range of recombination time of trions in these structures. Determining the factors causing decoherence enables optimization of existing sources and verification of the application potential of the studied system.

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Sandglass-like nonanuclear rare-earth molecular cluster aggregates for alkaline-earth manganite oxide nanomaterials doping

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Over the past few decades, lanthanide molecular cluster aggregates (MCAs) composed of multinuclear metal core encapsulated by organic ligands have garnered much attention because of their interesting solid-state structures and versatile application in the field of single molecular magnetism [1], magnetic refrigeration systems [2], luminescent sensors/probes [3], and catalysis [4]. Recently, MCAs are being considered as the new generation of highly efficient optical materials that can unify the properties of lanthanide nanoparticles (NPs) and molecular complexes. Because of the chemical similarities of Ln(III) ions, the easy modification of the chemical composition and, consequently, the energy transfer processes using MCAs are similar to those observed for NPs. The molecular architecture of the lanthanide clusters allows for a precise determination of the Ln(III) local symmetry, leading to higher homogeneity in the optical properties, which is not entirely possible for NPs. Lanthanide complexes can also be used as molecular precursors for the low-temperature synthesis of functional organic materials [5]. Because of that, we decided to use $[\text{RE}_9(\mu_4\text{-OH})_2(\mu_3\text{-OH})_8(\text{L})_{16}]^+$ clusters (RE = Y, Eu, Dy, Tm, Yb, Lu, L = methyl or ethyl salicylate) as a single-source of rare-earth ions for doping bimetallic oxide nanomaterials (CaMnO_3 and BaMnO_3) obtained from thermal decomposition of manganese $[\text{Mn}_2(\mu\text{-OME})_2(\text{L})_4]$ and calcium $[\text{Ca}(\text{L})_2]_n$ or barium $[\text{Ba}(\text{L})_2(\text{THF})]_n$ clusters, as shown in *Figure 1*. The research conducted proved that:

- thermal decomposition of manganese and calcium compounds together with rare-earth metal complexes led to the formation of CaMnO_3 as the main phase and small amounts of CaMn_2O_4 doped with RE^{3+} ions;
- thermal decomposition of manganese and barium compounds together with rare-earth metal complexes led to the formation of BaMnO_3 doped with RE^{3+} ions;
- REMnO_3 crystallites are present in the $\text{BaMnO}_3\text{:RE}$ materials.

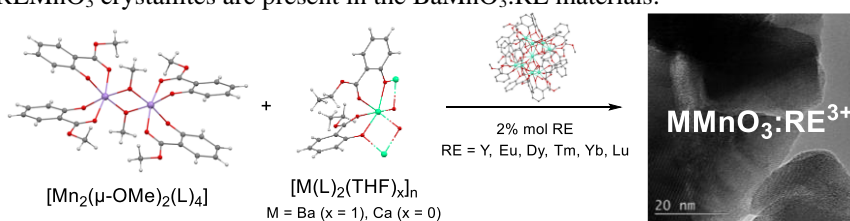


Fig. 1. Thermal decomposition of complexes to $\text{MMnO}_3\text{:RE}^{3+}$ (M = Ba, Ca)

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The influence of plasmonic excitation on the dynamics of photoswitching of molecules

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Metallic nanoparticles, such as gold nanorods (AuNRs), have unique optical properties that enable efficient absorption and scattering of light. Illumination of AuNRs with light of the same or higher frequency than the vibrational frequency of free electrons on the surface of metallic nanostructures, leads to collective oscillations of these electrons, known as localized surface plasmon resonance (LSPR) [1]. The aim of this study was to investigate the effect of localized surface plasmon resonance of gold nanorods (AuNRs) on the photoswitching dynamics of 1,2-bis[2-methyl-5-(4-pyridyl)-3thienyl]perfluorocyclopentene (DTE-py2). For this purpose, AuNRs nanorods with controlled optical properties were synthesized using the seed-growth method [2]. Then, after mixing the nanorods with DTE-py2, such a hybrid structures were illuminated with two wavelengths ($\lambda = 630 \text{ nm}, 535 \text{ nm}$).

It was found that for DTE-py2 molecules placed in the close vicinity of AuNRs the fluorescence intensity is strongly enhanced. Moreover, it was found that, depending on the optical properties of AuNRs nanorods and the wavelength of light used to irradiate this hybrid nanostructure, both the efficiency of photoswitching and fluorescence enhancement can be affected. In summary, this study demonstrates that the localized surface plasmon resonance (LSPR) in AuNRs has a significant impact on the photoswitching dynamics of DTE-py2 and on its fluorescence intensity.

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Construction of mobile and compact Raman spectrometer with utilization of 3D printing technologies

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We presents the development and testing of the mobile Raman spectrometer, which was based on the design by Raji *et.al.* of a low-cost Raman spectrometer [1]. The design presented in the article was modified to use the constructed device on the Scorpio 7 mobile research platform, which the OFF-ROAD Unconventional Vehicles Student Association constructed for the Rover Challenge series.

The modifications made to the device's original design consisted of changing the housing of the device used and adapting it to the operating conditions of the Scorpio mobile research platform.

The presentation will include the various stages of the spectrometer's design work, the test results from the various prototypes of the device, and the results of the in-situ spectral measurements made during the University Rover Challenge 2023 competition.



Fig. 1. Scorpio 7 mobile research platform with installed Raman spectrometer (spectrometer is located under black, round cover)

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Improvement of electrical conductivity of electrospun PVDF fibers by controlled CNT electrophoretic deposition

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As smart electronic devices and self-powered technologies continue to evolve, there is a growing research interest in piezoelectric polymers [1]. Electrospun polyvinylidene fluoride (PVDF) fibers have emerged as a promising energy harvesting candidate [2]. This is attributed to their flexibility, porosity, and higher piezoelectric coefficient, making them a focal point in the pursuit of efficient solutions for current energy consumption challenges [2]. Electrophoretic deposition (EPD) enables the precise deposition of nanomaterials, such as carbon nanotubes (CNTs), to enhance the conductivity of the fibers. Therefore, in this study, we investigate the use of EPD of CNTs on electrospun PVDF fibers to obtain porous, flexible mats with enhanced electrical conductivity.

Firstly, the solution containing CNTs was prepared with the required concentration of 7–8% in isopropanol. Next, the EPD parameters such as deposition time and voltage were optimized to obtain uniform coatings. The morphology of the resulting fiber mats was characterized using scanning electron microscopy (SEM), and the electrical conductivity was measured using a two-point probe setup. EPD allowed to cover the entire surface of electrospun fibers while maintaining a high porosity of mats [2]. Notably, a uniform coating maximizes the contact area between CNTs and polymer fibers, thereby improving its conductivity.

As a result, the EPD layer of CNTs on PVDF fibers significantly reduced the resistivity of the electrospun mats. This research facilitates the development of flexible smart textiles for sensing and energy harvesting applications.

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Control of optical modes excited in hyperbolic nanoresonators

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Optical metamaterials open new possibilities in photonics. Playing with the distribution and size of their subwavelength-scale components, so-called meta-atoms, we can design a structure to interact with light in a specific way. Especially promising are highly anisotropic hyperbolic metamaterials (HMMs), whose dielectric permittivity tensor has two principal elements of opposite sign to the third one. This leads to a hyperbolic dispersion relation and high confinement of light, as HMMs support light with infinitely large wavevectors. Thanks to their unique anisotropic properties, HMMs interact with light in an unusual way, resulting in such effects as negative refraction. HMMs can be applied in subwavelength imaging, enhancing spontaneous emission, optical sensors or perfect absorbers.

Here, I present numerically calculated optical response of type II hyperbolic nanodisks consisting of alternating metal (Ag) and dielectric (SiO₂) layers. Such a material behaves like a diluted metal in the plane of the layers, and like a dielectric in direction parallel to the optical axis of the HMM disk. This way, even simple disk-like particles can support both electric and magnetic resonances. In the optical response of a hyperbolic nanodisk (HND) two resonances dominate: a highly radiative electric dipole (ED) mode and non-radiative magnetic dipole (MD) coupled with electric quadrupole (EQ). By modifying the shape and dimensions of the nanoresonator, one can tune the spectral position, width and intensity of resonances induced in extinction spectra. In particular, the ED and MD modes can overlap, leading to directional scattering of light described as generalized Kerker effect. For other applications, such as optical sensors, it is beneficial to spectrally shift apart the two resonances in extinction spectrum. As both ED and MD modes exhibit sensitivity to the change of refractive index of the surrounding medium, HNDs can act as refractometric sensors, as proven in numerical modelling.

The aim of our work is to design optimal hyperbolic metamaterials for applications in refractometric sensors and tunable reflectors. Engineering of the optical response of HMMs requires full understanding of the character of induced resonances. Previously derived resonance conditions for hyperbolic nanoparticles connect the resonance energy of the ED and MD modes with the geometry and/or material of the resonator [1, 2]. None of them, however, accounts for the effect of surrounding medium, which indeed influences the spectral position of the resonances. Here, I would like to derive ED and MD resonance conditions dependent also on refractive index of surrounding medium.

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Exploring Solvent Influence on Sequence-Defined Polymer Helical Structures

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Sequence-defined polymers (SDPs) stand as versatile macromolecules distinguished by their uniform structure and precisely defined monomeric sequence [1]. This characteristic, akin to biopolymers, empowers SDPs to display advanced functionalities, including the capacity for folding and selective binding to target ligands [2]. The extensive library of abiotic monomers further amplifies the potential of SDPs, enabling precise adjustments to polymer properties tailored for diverse applications, particularly within non-biological contexts.

In our investigation, we explore the influence of solvents on the helical structure of oligocarbamates, employing both theoretical methods and experimental validation. Utilizing a Molecular Dynamics approach, we evaluate the conformational behavior of oligourethanes in various solvent environments. Experimental verification is carried out using Nuclear Magnetic Resonance (NMR) spectroscopy. Our results indicate a strong correlation between solvent parameters and the conformational state of oligourethanes. Specifically, we observe that the presence of nonpolar solvents promotes the folding of a helical structure, suggesting a potential avenue for mimicking the functionality of natural polymer.

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Advancing core-shell fiber design for biomedical application: polymer diffusion alters fiber's attributes and cellular responses

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Electrospun polymer scaffolds stand as promising candidates for a myriad of biomedical applications, spanning from tissue engineering to drug delivery systems [1, 2]. Leveraging the versatility of core-shell fibers emerges as a compelling strategy, offering control over mechanical attributes, material and drug selection, encapsulation efficiency, and regulated drug release mechanisms.

This study delves into a pivotal challenge in the realm of core-shell fiber design, specifically addressing the intricate blending phenomena between core and shell polymers during the co-axial electrospinning process. By electrospinning polymethyl methacrylate (PMMA) and polycarbonate (PC), we produced PC-PMMA core-shell fibers. Notably, co-axial electrospinning facilitated the diffusion of PC into the PMMA shell, causing alterations in the surface chemistry of the resultant fibers [3]. Subsequent scrutiny of surface properties unveiled variation in surface potential among PC-PMMA fibers, significantly impacting cellular responses *in vitro*. Scaffold surface chemistry and potential were validated through X-ray photoelectron spectroscopy (XPS) and Kelvin probe force microscopy (KPFM), respectively. The observed differences between PMMA and PC-PMMA scaffolds prompted further investigation employing confocal laser scanning microscopy (CLSM) coupled with the AiryScan technique, enabling focal adhesion point analysis [4].

Our comprehensive analysis emphasizes the interfacial dynamics inherent in core-shell fiber design and its consequences in the interplay between fiber properties and cellular attachment to scaffolds, thus fostering advancements in biomedical applications.

Acknowledgments

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Photoactive chlorophylls from algae encapsulated in novel liquid crystalline nanocarriers effective in anticancer Photodynamic Therapy

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Drug delivery into pancreatic tumor cells is a huge challenge due to the limitations resulting from its complex microenvironment, rich in various obstructive physical and biochemical components [1]. The development of nanotechnology brings increasingly more solutions, including lipid-based liquid crystalline nanocarriers – cubosomes characterized by high stability and bioavailability [2]. Photoactive pigments largely found in green marine algae, such as chlorophylls, can be employed as photosensitizers in Photodynamic Therapy (PDT) for anticancer applications, although their use is strongly limited by instability and insolubility after administration into the body [3]. Therefore, these pigments need to be encapsulated in biocompatible and stable nanocarriers to be protected, properly delivered, and released in pathological tissues in their effective bioactive form. To develop an efficient nanosystem useful against pancreatic tumors, herein we present a comparison between two types of cubosome formulations loaded with chlorophylls extracted from green algae biomass (*Ulva rigida*). The microwave-assisted extraction, a green technique, was used for the photoactive extract preparation, due to its high efficiency and short processing time. Such extract was then loaded into traditional cubosomes stabilized with Pluronic F108 and a novel, less toxic, Pluronic-free cubosome nanocarriers stabilized with Span 80/sodium taurocholate combination. These two formulations were thoroughly characterized from a physicochemical point of view by SAXS, Cryo-TEM, DLS, and ELS measurements, as well as investigated for the production of Reactive Oxygen Species (ROS), while their biocompatibility, cytotoxicity, and phototoxicity features were evaluated *in vitro* on human pancreatic cancer cell lines (BxPC-3). Finally, the bioimaging and F-actin cytoskeleton oxidation studies proved the significant effectiveness of the novel cubosome formulation loaded with photoactive chlorophylls against pancreatic tumor cells when combined with PDT.

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Applying Solvatochromism to the Investigation of Emulsions systems: Enhancing Optimization for Potential Eco-Friendly Formulations

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Natural items often possess rare and valuable qualities that people directly use or draw inspiration from to develop modern technologies. For example, pearls, which come in various shapes and colors, are most prized when perfectly round and regular. Similarly, in modern drug delivery systems, nanocarriers must possess specific features to effectively solubilize drugs and ensure their stability. Some of the most commonly used formulations are microemulsions and nanoemulsions, both composed of surfactants, oil, and water in appropriate proportions, often with an additional stabilizing agent in the case of microemulsions [1, 2]. Depending on the size, microemulsions are usually transparent, while nanoemulsions can be translucent or opaque, akin to pearls.

Following the principles of Green Chemistry and drawing inspiration from nature, microemulsion and nanoemulsion systems were developed. A surfactant derived from coconut oil with ethoxylation degrees of 15 moles and unsaturated fatty acids - oleic and linoleic acid as the oil phase in both systems were used. The samples were then processed using ultrasounds. By using dynamic and electrophoretic light scattering the size and ζ -potential of the emulsions were obtained. The most stable and homogeneous formulations were chosen based on monitoring changes in hydrodynamic diameter, polydispersity index, and charge over time. Additionally, a solvatochromic probe was incorporated to investigate the internal environment of the nanocarriers. UV-Vis spectrophotometric measurements revealed potential differences in solubilization between micro- and nanoemulsions.

Monitoring micropolarity leads to the development of better drug-specific nanocarriers. Drug delivery systems are constantly being optimized and sometimes even completely redefined. The use of nature-inspired agents is not only beneficial but also essential due to their ecological significance. Therefore, changing the composition, not the environment, is crucial.

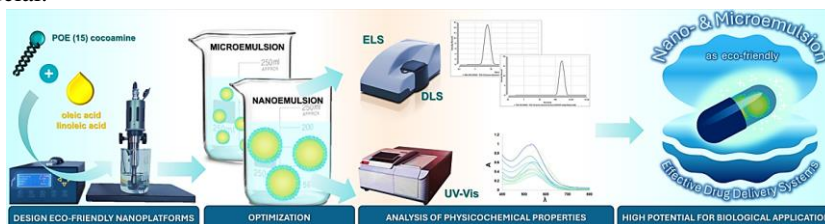


Fig. 1. Schematic idea of the eco-friendly emulsion type formulations for potential drug delivery

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Shotgun Sessions

Thursday – 16.05.2024	
10:50–11:15	Shotgun session I
10:50–10:55	Aleksandra Dupla “Synthesis of FONs and studying the influence of the surfactant on their physicochemical properties”
10:55–11:00	Paulina Musolf “Investigation of the activity of enzymes involved in mRNA metabolism”
11:00–11:05	Mikołaj Tkotz “Application of aPDT in the treatment of diabetic feet”
11:05–11:10	Natalia Szyperska “The effect of age of biofilm on their sensitivity to light-induced eradication”
11:10–11:15	Anna Zdubek “5-aminolevulinic acid based photodynamic inactivation of bacteria enhanced by organophosphorus compounds”
14:00–14:20	Shotgun session II
14:00–14:05	Katarzyna Gdula “Highly self-assembling poly(<i>p</i> -phenylene vinylene) as donor in organic solar cell”
14:05–14:10	Marek Czyszczoń “Incorporation of carbon nanodots into poly(<i>N</i> -isopropylacrylamide) hydrogel structure”
14:10–14:15	Patrycja Wilczewska “Synthesis and characterization of composites containing graphene quantum dots and polypyrrole nanoparticles”
14:15–14:20	Julia Goszyk “Deep UV and blue lasing of new organic emitters based on a fluorene core”

Synthesis of FONs and studying the influence of the surfactant on their physicochemical properties

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Fluorescent organic nanoparticles (FONs) represent a broad category of nanostructures made from organic materials that can emit light across various spectral ranges when excited, thanks to organic fluorophores within their composition. The versatility of FONs, in terms of their composition, shape, surface modifications, and optical characteristics, makes them highly valuable for a wide range of applications in biology and medicine. These multifunctional FONs offer the potential to employ a single type of nanoparticle for both diagnostic and therapeutic purposes. This research focuses on the development of an organic fluorophore (5-(2-ethylhexyl)-1,3-di(thienyl-2-yl)-4H)-thieno[3,4-c] pyrrole-4,6(5H)-dione), that is used in the fabrication of fluorescent organic nanoparticles [1, 2].

After obtaining our product, we started to fabricate FONs in various ways. Samples were prepared, each one contained 5-(2-ethylhexyl)-1,3-di(thienyl-2-yl)-4H-thieno[3,4-c]pyrrole-4,6(5H)-dione, specific surfactant, and water, which was added up to 5ml. One of the samples didn't contain any surfactant. We used three different surfactants (triton, trimethyloctadecylammonium bromide, dodecyltrimethylammonium bromide) to observe and compare the results. Different approaches were used to optimize the process of fabrication. To examine the FONs, we used a fluorescent microscope, DLS device for particle size measurements, spectrofluorometer for measuring lifetimes, absorbance, and fluorescence. After a week, we repeated the experiments, this time using a higher concentration of surfactant.

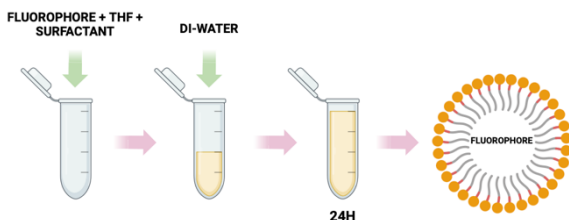


Fig. 1. Sample preparation scheme

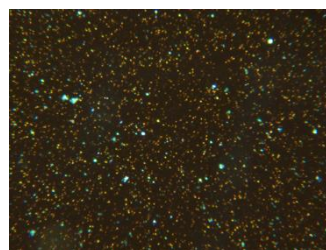


Fig. 2. FONs under fluorescent microscope

We obtained FONs of varying sizes from 90–400 nm. Considering the conditions of the conducted experiments, we can conclude that the amount of surfactant used significantly influences the size of nanoparticles. The more surfactant used, the larger the nanoparticles. However, the absence of surfactant greatly affects the stability of FONs. Further studies will be conducted to investigate the morphology and applications of FONs.

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Investigation of the activity of enzymes involved in mRNA metabolism

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Expression of genetic information encoded in DNA is a multi-stage process, in which mRNA plays a key role. Subsequent stages of the metabolism of these particles are regulated by the activity of enzymes. Their proper function determines the maintenance of homeostasis. Abnormalities in enzymatically controlled mRNA metabolism processes may result in the development of various diseases, including cancer [1]. Therefore, it is important to study the activity of enzymes involved in mRNA metabolism and to precisely understand the processes they control.

An interesting method of examining the activity of enzymes involved in the mRNA metabolism is the Förster Resonance Energy Transfer (FRET). Using advanced fluorescence techniques, it is possible to analyze the processes occurring even between a single enzyme and fluorescently labeled mRNA molecules in real time as well as to image these processes directly in living cells or model organisms [2].

We anticipate that plasmonic nanostructures may be helpful for studying the enzymatic activity when controlling mRNA metabolism. Our preliminary investigations show that silver nanowires (AgNWs) are suitable for this purpose. First of all, their surface is suitable for chemical binding of FRET probes. Secondly, emission intensity of such probes can be enhanced via the electromagnetic field associated with plasmonic resonance in AgNWs. Therefore, we expect that the enhancement of both fluorescence intensity and FRET efficiency provided by AgNW opens the way to study enzymatic activity in mRNA metabolism for highly diluted samples, presumably down to single-molecule level.

The research was financially supported by the National Science Center (Poland), OPUS 25 no. 2023/49/BST4/01450.

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Application of aPDT in the treatment of diabetic feet

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Antibacterial photodynamic therapy is one of the method of choice in the treatment of diabetic feet ulcers. Bacteria are one of the major cause of skin infections in humans, with a reported increase in drug-resistant pathogens in infections occurring in diabetic foot ulcers. This reinforces the need to develop new antimicrobial agents and alternative therapies to eradicate sources of inflammation in chronic wounds. Photodynamic therapy (PDT) is a form of treatment that uses a light source and a chemical compound (photosensitizer) as well as oxygen. The light-activated photosensitizer reacts with oxygen to generate reactive oxygen species and oxygen free radicals, which, upon accumulation in bacterial cells, cause oxidative stress and ultimately directly destroy bacterial cells. Currently, in the course of most photodynamic therapy, either not well controlled ordinary lamps or expensive laser technologies are used as light sources. In contrast, the goal of our research is to use Organic Light Emitting Diodes (OLEDs), which can be manufactured as small or large, depending on the area of the irradiation, thin and lightweight wearable devices while providing a uniform and efficient light output that can be used as a light source for PDT.

The effect of age of biofilm on their sensitivity to light-induced eradication

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The growing resistance of microorganisms to classic antibiotics poses a huge threat to humanity. A particularly important issue is the resistance of biofilms to antimicrobial drugs. It is known that bacteria that form biofilms may be more resistant to antibiotics. This important problem has forced scientists to look for new strategies to combat bacterial pathogens that form biofilms on abiotic surfaces.

Antimicrobial photodynamic therapy (aPDT) is a promising, modern method involving the use of a light-activated chemical compound (photosensitizer) that is non-toxic to cells [1]. These compounds exposed to light of a specific wavelength in the presence of oxygen generate reactive oxygen species (ROS), which have a cytotoxic effect on microorganisms [2].

The aim of this study was to determine the effect of the age of biofilms formed by the *S. aureus* strains isolated from the natural environment on their sensitivity to light-induced eradication. The effectiveness of Methylene Blue (MB)-based protocols in photoelimination of biofilms formed on stainless steel discs by *S. aureus* MRSA isolates was compared using a diode laser with a peak power wavelength of $\lambda = 638$ nm.

The obtained results showed that MB alone had a limited photo-bactericidal activity and the cell death rate did not exceed $65,8 \pm 1.2\%$. The age of the bacterial biofilm influenced the effectiveness of photodynamic therapy. For most strains tested, older biofilms showed greater resistance to photodynamic therapy.

It was possible to enhance the photo-biocidal effect of MB by using gold nanoparticles of similar sizes 15 ± 3 nm / 20 ± 3 nm but differing in the method of their synthesis and stabilization.

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5-aminolevulinic acid based photodynamic inactivation of bacteria enhanced by organophosphorus compounds

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The rapid spread of antibiotic-resistant bacteria is a major problem worldwide. As a consequence, antibiotics are becoming ineffective against bacterial infections. Antimicrobial photodynamic inactivation (aPDI) is a promising approach to eradicate microorganisms. This method involves photosensitizer (PS) in combination with visible light to produce cytotoxic singlet oxygen as well as free radicals, which are harmful to bacteria [1].

Recently, there has been considerable interest in using 5-aminolevulinic acid (5-ALA) in photodynamic elimination, but its utilization has some limitations. At physiological pH, 5-ALA is identified as a hydrophilic ion that has difficulty passing through biological barriers and reaching the appropriate organelle in the cytoplasm [2]. For this reason, chemical substances are being developed to enhance the transport of this compound inside cells and at the same time allowing its conversion to porphyrins (intracellular PS) [3].

The purpose of this research was to evaluate the synergistic effect of 5-ALA, phosphoric acids and light on the photosensitization of bacteria.

The study was carried out with bacterial strain *Proteus mirabilis*. 5-ALA was used as a precursor to porphyrins (active PS). As a source of light single-mode diode lasers with a peak power wavelength of 404 nm and 630 nm were applied. The viability of bacteria was determined using the drop plate method [4].

The results obtained indicate that the use of 5-ALA, particularly in combination with phosphoric acids, has a positive impact on the effectiveness of antimicrobial photodynamic inactivation of *Proteus mirabilis*. The combination of 5-ALA with an adjuvant that affects the fluidity of the bacterial membrane is a promising strategy for improving the effectiveness of its transport to cells.

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Highly self-assembling poly(*p*-phenylene vinylene) as donor in organic solar cell

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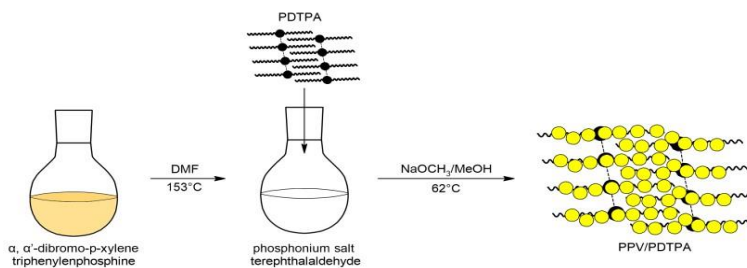
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Polyphenylene vinylene (PPV) belongs to the group of conductive polymers. Its structure has conjugated π bonds, thanks to which it is characterized by unique physicochemical properties, i.e. high electrical conductivity, excellent optical properties and chemical stability [1]. It is also widely used in organic solar cells due to its desirable HOMO-LUMO energy gap.

The scientific research aimed to modify poly(*p*-phenylene vinylene) (PPV) with a self-assembling material 2,5-bis(pentadecyloxy)terephthalic acid (PDTPA).

A new photoactive material (PPV/PDTPA) was obtained and applied to organic solar cells. The PPV/PDTPA was characterized via infrared and Raman spectroscopy, atomic force microscopy, scanning transmission electron microscopy, dynamic light scattering, and zeta potential measurement. A highly ordered PDTPA was introduced to force the orientation of the PPV chains, enabling efficient electron transport. The distribution of energy levels in PDTPA relative to the PPV energy bands also allows charge exchange between the components, favouring charge separation. Microscopic characterization confirmed the organized morphology of PDTPA and the PPV/PDTPA.

During the research, a clear improvement in the operating parameters of a solar cell containing a PPV/PDTPA composite as a photoactive material was observed compared to the parameters obtained in a cell-based only on pristine PPV. For organic solar cells based on the PPV/PDTPA composite, a power conversion efficiency of 2.66% was achieved.



Scheme 1. Synthesis of PPV/PDTPA

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Incorporation of carbon nanodots into poly(N-isopropylacrylamide) hydrogel structure

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Hydrogels are crosslinked polymers compatible with aqueous solutions. Poly(N-isopropylacrylamide) (PNIPAM) is a thermoresponsive polymer with a lower critical solution temperature (LCST). When PNIPAM hydrogel is heated above its LCST it expels the aqueous solution from its matrix. PNIPAM is biocompatible and can be used in controlled-release devices [1, 2].

Carbon nanodots (CNDs) are nearly spherical nanomaterials with a predominant carbon core and size smaller than 10 nm. Their inherent property is intense and color-tunable fluorescence. Multiple functional groups on CND surface may provide broad emission spectra. The prominent properties of CNDs are photostability and biocompatibility [3].

Our carbon nanodots (PG CNDs) were fabricated by thermal decomposition of phloroglucinol in ethanol. They demonstrate a solvatochromic effect, with the emission color varying from blue (in water), through cyan (in methanol) to green (in DMSO). The fluorescence also depends on stimuli like temperature and pH value [4].

In this work, we decided to combine PNIPAM hydrogels with CNDs in order to create a hydrogel with the controlled release properties of PNIPAM and bright fluorescence of the dots. CNDs' carboxylic groups were activated with EDC (1-Ethyl-3-(3-dimethylamino-propyl)carbodiimide) and added to the reaction mixture used to synthesize crosslinked PNIPAM. FTIR spectroscopy confirmed that the reaction's product formed new chemical groups when compared with free PNIPAM, including carbonyl moieties, characteristic for CNDs. These findings allowed us to confirm the successful incorporation of carbon nanodots into the structure of the hydrogel.

In further studies, we would like to focus on applying the synthesized material, e.g., using the environment-dependence of the dots for distinguishing the cargo of the hydrogel.

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Synthesis and characterization of composites containing graphene quantum dots and polypyrrole nanoparticles

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Polypyrrole (Ppy) is one of the most important conducting polymers due to a number of advantages, such as simplicity of synthesis, high electrical conductivity, excellent biocompatibility, and chemical and thermal stability towards environmental factors. The possibility of obtaining nanometer-sized morphological forms of Ppy such as polypyrrole nanoparticles (PpyNPs) is attracting increasing attention due to their applications in sensor and capacitor devices.

Carbon nanostructures recently have been frequently introduced into composites to improve electrochemical properties. One of them is graphene quantum dots (GQDs), which are distinguished from others by their excellent solubility in a wide range of solvents, ensuring their even distribution in the composite material.

The aim of the presented research was the optimization of synthesis conditions and physicochemical characterization of composites containing PpyNPs and GQDs.

PpyNPs were synthesized by chemical polymerization from pyrrole in the presence of surfactant and strong oxidant [1]. GQDs were obtained by pyrolysis of citric acid [2]. The synthesis of the composite was conducted by introducing GQDs into a solution of polymerized PpyNPs. The physicochemical characterization of the obtained material included spectroscopic (FTIR, Raman, DLS) and microscopic analysis (SEM, TEM), as well as electrochemical properties (CV) was tested. The obtained results confirmed that composites have promising properties as an electrode material and can potentially be used in supercapacitors.

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Deep UV and blue lasing of new organic emitters based on a fluorene core

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Over recent years, UV and blue emitters have attracted extensive study due to their potential application in plant lighting, sterilization, excitation sources, sensing, or high-density information storage [1]. Although ongoing comprehensive research in the field, there is still a high demand for the introduction of new organic light sources in the range of 200–495 nm, that will overcome existing difficulties, especially in achieving both high quantum efficiency and sufficient stability. Moreover, organic lasing faces in particular the challenge of stability, as the short-wavelength pumping of gain material usually results in quick photodegradation [2]. Therefore, achieving thermal, morphological, and photophysical stability in studied materials is extremely important.

Recently, fluorene molecule has been presented in the literature as prosperous organic precursor, with tunable optical properties. In fact, the unique combination of high photoluminescence efficiency, excellent charge transport properties, and chemical stability, makes fluorene-based moieties suitable for stimulated emission. Furthermore, the π -conjugated structure of its molecules, facilitates efficient energy transfer and exciton formation, leading to enhanced emission in the UV and blue spectral regions. Consequently, the fluorene family is well-developed and is utilized in applications such as two-photon microscopy [3] and OLED devices [4].

Here we show the experimental results of synthesis of new quadrupolar derivatives of 9,9-diheptyl-9H-fluorene including spectroscopic and one-photon lasing studies. The obtained results demonstrate the significant potential of this family of compound as a source of blue light, generated through one-photon absorption.

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Poster Session

Thursday 16.05.2024	
SKS C-18	
16:00 - 17:00	Poster session
1	Konrad Widaj "Exploring the Optical and Magnetic Properties of a Two-Dimensional Magnetic Semiconductor – CrSBr"
2	Sunday Samson "Biocatalysis in the synthesis of valuable substances from cyanobacterial cells"
3	Msanif Msanif "The influence of the NMR pulse sequence on the metabolomics analysis"
4	Akshay Kallikkunnath "Spontaneous Symmetry Breaking of Microdroplets Filled with Heat Releasing Particles"
5	Oliwia Janikowska "Exploring the Optoelectronic Properties of CsPbBr ₃ Nanowires"
6	Marcin Kozak "Photochromism - from science to art"
7	Jan Pytel "Fe ₃ O ₄ magnetic nanoparticles: single- and two-photon absorption and prospective use in controlling myeline figure growth"
8	Grzegorz BękarSKI "The influence of upconverting nanoparticles chemical architecture on Förster resonant energy transfer to the organic dye"
10	Katarzyna Kołodzińska "Luminescent biocompatible electrospun fibers"
11	Laura Zeidler "Towards deterministic positioning of InAs/InP quantum dots in photonic structures"
12	Agnieszka Siomra "Two-photon active cadmium-free colloidal nanomaterials for applications in fluorescencebased sensing"
13	Mikołaj Polaszek "Personalized LED illuminator for photodynamic therapy studies"
14	Emilia Olbińska "Numerical simulations of an optically active gate-defined quantum dot"
15	Weronika Andrzejczak "New fluorescent markers of amyloids"
16	Adam Kabański "Single- and double hybrid perovskites containing Cr ³⁺ for highly sensitive luminescent thermometry"
17	Maciej Fryckowski "Photophysical properties of single chiral gold nanoclusters"
18	Wiktoria Sienkiewicz "Chiral gold nanoclusters as amyloid-modulating agents"
19	Anita Polewska "Optimization of structure of germanium-doped M-type silica optical fiber for third-harmonic Generation"
20	Robert Matysiak "Optical Properties of Nanohole In _{0,1} Ga _{0,9} Sb/Al _{0,3} Ga _{0,7} Sb Quantum Dots"
21	Jakub Tracz "Development of a New Synthesis and Characterization of Silver Sulfide Quantum Dots"

Exploring the Optical and Magnetic Properties of a Two-Dimensional Magnetic Semiconductor – CrSBr

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Magnetic semiconductors are garnering significant interest in both technological and theoretical fields due to the interplay between their electronic structure and magnetism, which facilitates spintronic and magnetoelectric phenomena. Such properties allow for applications in spin injection, the development of magneto resistive devices, and direct-read magnetic memory technologies. Additionally, if a magnetic semiconductor possesses a direct band gap or undergoes optically allowed crystal field transitions, it may exhibit photoluminescence, broadening its utility to include light-emitting and processing technologies. The rules governing optical transitions in these materials are shaped by their overall symmetry, which is a composite of the crystal lattice's symmetry, the symmetry of electronic orbitals, and the spin/magnetic order inherent in the material. Therefore, controlling the magnetic order, for instance, through temperature adjustments or external magnetic fields, could significantly affect the optical properties of a magnetic semiconductor, offering novel avenues for manipulating material characteristics [1].

CrSBr is a two-dimensional orthorhombic layered material known for its unique electronic and magnetic properties. It features strong ferromagnetic intralayer interactions and antiferromagnetic interlayer coupling, making it an A-type antiferromagnet. CrSBr exhibits a direct band-gap of around 1.5 eV and is known for its highly anisotropic electronic and optical properties. This material has shown significant potential for applications in spintronics and magnetoelectronics due to its ability to maintain magnetic properties even in monolayer form. The magnetic order in CrSBr can be controlled through temperature or external magnetic fields, impacting its optical properties and offering new avenues for material control.

In the experimental approach undertaken on the sample, a series of detailed photoluminescence and reflectance measurements were conducted, with a particular focus on their variation with respect to polarization, temperature, and the influence of high magnetic fields. The study also extended to evaluating the dependency of photoluminescence characteristics on the excitation power and wavelength, offering a more nuanced understanding of the sample's optical response under various excitation conditions.

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Biocatalysis in the synthesis of substances from cyanobacterial cells

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The robust catalytic potential of cyanobacterial cells for organic redox reactions and/or enzymatic hydrolysis of complex substances known as substrates (Fig. 1) and transforming them into valuable optically pure compounds has remained largely unexplored. Selected substrates are known to be unyielding and exhibit competitive inhibitors to several biocatalysts [1, 2]. Photobiocatalytic methods were performed with cyanobacterial strains (Fig. 1) under sterile, gentle and suitable physicochemical conditions. Performed experiments proved that the biocatalysts allowed biodegradation (Fig. 1a) and the synthesis of high value compounds (Fig. 1b, c) – “green methods” which are good alternative to the chemical synthesis due to environmental safety reasons. The obtained products could present a platform for further applications in agrochemicals, flavors, cosmetic and pharmaceutical industries.

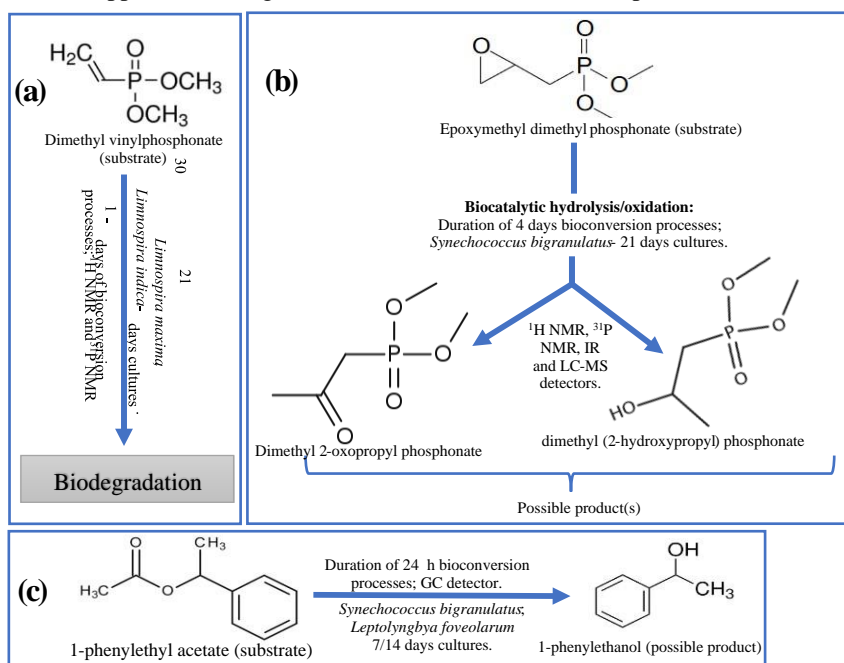


Fig. 1. Possible sequences of photobiocatalytic reactions - methods and analysis (a, b, and c). [NMR= Nuclear magnetic resonance; LC-MS = Liquid chromatography with mass spectroscopy; IR = Infrared spectroscopy; GC = Gas chromatography.]

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The influence of the NMR pulse sequence on the metabolomics analysis

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Metabolomics (together with genomics, transcriptomics, and proteomics) belongs to the systemic sciences and plays a critical role in understanding metabolic changes associated with diseases. It explores metabolic variations between samples, which can provide valuable insights into disease mechanisms [1]. Metabolomics, as a scientific study, involves a thorough examination of small-molecular compounds (<1.5 kDa) known as metabolites, which are commonly present in biological samples. This analysis is typically conducted using profiling techniques such as nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry (MS) combined with chromatography [2]. Metabolomics involves the thorough and simultaneous systematic examination of various metabolite concentrations [3]. NMR-based analysis offers reproducible metabolomics fingerprinting, allowing for the relative quantification of biological samples. This technique provides a reliable method for profiling and comparing the metabolic composition of samples, contributing to the understanding of their biochemical composition [4]. Despite the NMR spectroscopy plays a vital role in metabolomics, the impacts of the results significantly come from the choice of the pulse sequences [5]. The main aim of this study was to compare the results for biological samples measured with different pulse sequences. Ten samples of chicken breast and liver were extracted with methanol and water (80:20, v/v) and subjected to two distinct NMR pulse sequence measurements: *noesypr1d* and *cpmgpr1d* (according to the Bruker notation). After the measurement, the metabolites were identified: for the liver, 24; and for the breast samples, 22. The results showed that the metabolomics profiles yielded varied differently according to pulse sequences, affecting the quantification of metabolites. Finally, this study has shown that the outcome of metabolic analysis is profoundly affected by the choice of NMR pulse sequence. *Noesypr1d* (according to the Bruker notation) pulse sequences enhanced the visibility of specific metabolites, while the other provided better overall resolution. Those results indicate that the metabolomics data obtained from the NMR spectroscopy must be compared only where the same pulse sequences are conducted. Researchers must carefully select pulse sequences based on the specific goals of their study and the nature of the samples being analyzed. Understanding the strengths and limitations of each pulse sequence is crucial for the accurate interpretation of metabolomics data.

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Spontaneous Symmetry Breaking of Microdroplets Filled with Heat Releasing Particles

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Self-propulsion of microscopic objects require symmetry breaking, which is often achieved by preparing geometrically asymmetric particles, e.g., Janus particles [1]. Self-propulsion can, however, also be achieved with symmetric particles like droplets, where the symmetry is broken dynamically, e.g., by a chemical reaction that induces Marangoni fluxes at the interface to the surrounding medium [2]. Here, we show the self-propulsion of water-in-oil microdroplets encapsulated with symmetric iron oxide particles upon widefield laser illumination. The heat released by the particles close to the boundary of the droplet induces strong Marangoni flows that reshape the distribution of particles inside the droplet. The dynamics of the particles and hydrodynamic flow fields also couple to other particles to create collective motion and cohesive behavior. Our results provide insight into complex collective behavior of micro-particles in confinements and provide new directions for future research in the engineering of such actively propelled micromachines.

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Exploring the Optoelectronic Properties of CsPbBr₃ Nanowires

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Metal-halide perovskites (MHPs) have brought a revolution in the field of photovoltaics due to their simple production process and unique optoelectronic properties. They are not only used in solar cells but also in light-emitting diodes, photodetectors, and lasers. Simultaneously they constitute an interesting material system for fundamental photo-physics investigation in bulk and quantum confined regimes. So far the investigation of perovskite nanostructures has been dominated by the studies of their 0D [1] and 2D [2] forms however quasi-1D nanowires can also be obtained [3]. These nanowires can be used as potential components in various applications, showing properties such as low threshold lasing and polarity-dependent photodetection. Moreover, the CsPbBr₃ nanowires, are more stable than bulk forms. Here we show our investigation of the optical properties of stable, single-crystal CsPbBr₃ nanowires grown by surface-guided chemical vapor deposition [3], which reflect the symmetry or morphology of their sapphire substrates. These horizontal CsPbBr₃ nanowires, guided on surfaces, present unusually large size dependent emission blue shifts, significantly beyond the quantum confinement regime, related to substantial and uniform lattice distortion due to heteroepitaxial strain and lattice relaxation. Such wires provide a great opportunity to study the continuous evolution of the band-structure parameters due to strain in metal halide perovskites. We will show detailed photoluminescence, time-resolved photoluminescence and reflectance characterization of CsPbBr₃ nanowires characterized by the strong change of their optical response along the wire length. We will show how the strain modulation impacts the structural phase transition of CsPbBr₃ nanowires and how the 1D form affects the polarization of the emitted light.

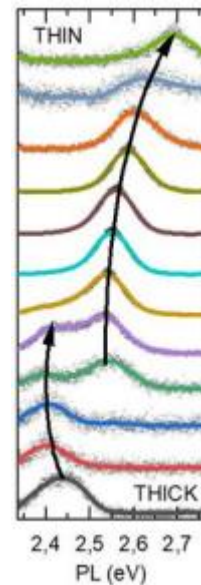


Fig. 1. Normalized PL spectra of photoluminescence emission taken at different points along the nanowire

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Photochromism – from science to art

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Phenomenon discovered in 1899 as “phototropy”, renamed to “photochromism” in the 1950s, is a reversible transformation of a chemical species induced in one or both directions by the absorption of light between two forms having different absorption spectra [1], which is nowadays widely studied all over the world by many research groups. The reversibility and light-dependence of photochromic materials make them attractive not only for numerous photonic applications, such as optical data processing, optical switches and memories, but also for commercial ones, like production of colour-changing dyes, pigments and lenses.

In a popular science way, we want to show how we carried out fundamental research on photochromic materials in our lab. Our investigation is focused on the novel azobenzene and azo pyridine based compounds, in which UV-light induces the reversible *trans-cis-trans* isomerization. We measure their absorption spectra and their changes due to the photochromic reaction using UV-Vis spectroscopy, the kinetics of the photochromic reaction (the reaction time constant, efficiency, parameters that are crucial from the perspective of future applications).



Fig. 1. Agata di Masternak “Histology of the soul” nb15, photochromic paint on canvas

Additionally, we present a successful application of photochromism phenomenon in real life-painting prepared with colour-changing dyes and pigments. Photochromic paints and dyes, and going further, fabrics and materials colored by them, are used to create spectacular paintings (Fig. 1), as well as entire fashion collections, which change their colour after irradiation with UV light- an object which appears to be all-white, suddenly becomes brightly coloured. Despite an immense amount of research, knowledge about photochromism, its mechanisms and aspects affecting is still not sufficient. In this case, photonic applications must wait, until all or most of details become discovered and described.

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Fe₃O₄ magnetic nanoparticles: single- and two-photon absorption and prospective use in controlling myeline figure growth

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Magnetic nanoparticles (MNPs) are being widely used in a variety of biomedical applications, most notably as contrast agents in magnetic resonance imaging, as well as in magnetic hyperthermia [1]. To further develop those implementations and to design new ones, imaging methods of MNPs in biological systems need to be employed. Reports are available of two-photon microscopy being used to image a type of MNPs called: ultrasmall superparamagnetic iron oxide nanoparticles (USPIO NPs) either via their interaction with a fluorescent label [2], or by having a fluorescent dye grafted onto them [3]. However the underlying optical properties of iron oxide MNPs are underreported.

In the presented work we characterize the single- and two-photon absorption of different sized Fe₃O₄ MNPs in aqueous suspension. The two-photon absorption was measured utilizing the Z-scan technique across a wide range of wavelengths. The obtained results will help us propose and optimize a method for imaging of MNPs in aqueous systems. One such system which is of particular interest to us are myeline figures – bioinspired, self-organizing, phospholipid bilayer structures. In our future work we plan to introduce Fe₃O₄ MNPs into myeline figures in order to control their growth via an external magnetic field.

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The influence of upconverting nanoparticles chemical architecture on Förster resonant energy transfer to the organic dye

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Upconverting nanoparticles (UCNPs) based on a NaYF₄ matrix doped with lanthanide ions are able to emit photons with higher energy than the energy of excitation photons. As a result of forbidden $f \rightarrow f$ electronic transition, lanthanide ions exhibit long luminescent lifetimes. Sharpness of the observable absorption and emission peaks is caused by screening of 4f electrons and splitting of energy levels. Moreover, these nanoparticles offer no photobleaching, efficient anti-Stokes emission and low toxicity [1]. Due to that, UCNPs can serve as energy donors to organic dyes in a process known as Förster Resonance Energy Transfer (FRET)^[2]. Even though there were many achievements in this field, some challenges still remain. One of these challenges is finding perfect composition and chemical architecture of nanoparticles for which FRET would be most efficient. Although similar study was performed to understand the influence of nanoparticles architecture on energy transfer from lanthanide ions to Rose Bengal dye [2] in the present work we investigated the effect of lanthanide-doped nanoparticle architecture on energy transfer to the ATTO dye. Three types of nanoparticles were obtained and next functionalized with the dye: NaYF₄:20% Yb, 2%Er core-only and NaYF₄@ NaYF₄:20% Yb, 2%Er, NaYF₄:50% Yb@ NaYF₄:20% Yb, 2%Er core-shell nanoparticles.

The nanoparticles were synthesized by thermal decomposition method, which is well described in literature [3]. Structure and morphology of obtained UCNPs were investigated using transmission electron microscopy (TEM) and X-Ray diffraction analysis (XRD). Subsequently, absorption and upconversion emission spectra were measured for nanoparticles, for ATTO dye and for an UCNPs-ATTO complex. Our goal is to study FRET at single nanoparticle level and get quantitative information on number of molecules attached to single UCNP as well as sensitivity of dye detection using spectral and luminescence decay measurements.

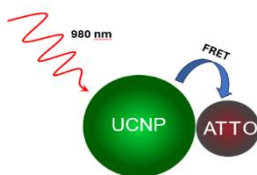


Fig. 4. Schematic FRET from UCNP to ATTO dye

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Luminescent biocompatible electrospun fibers

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According to current environmental challenges and circular economy approaches, biopolymeric materials are intensively developed in a growing range of fields of study. Natural polymers have the possibility to replace some petrochemical-derived polymers due to their significant structural and functional diversity. Furthermore, a variety of biopolymers like proteins, polysaccharides, and nucleic acids show great potential in the creation of functionalized materials [1]. The present study is focused on creating biocompatible, non-toxic, natural-derived matrixes doped with luminescent dyes for photonic applications, such as optical sensors or light systems.

The various structures of materials on micro and nanoscales can be adjusted using the electrospinning process. The technique allows the control of morphology, diameters, orientation of the fibers, and their distribution. Moreover, the unique optical properties of biomolecules and the possibility to tailor the degree of disorder of electrospun fibers and mats have prospects in the fabrication of novel types of luminescent materials [2].

Here, electrospun fibers based on two different biopolymers are presented: DNA and globular protein-bovine serum albumin (BSA). The fabricated materials were doped with low-toxic luminescent dyes like berberine chloride and rhodamine B, which show interactions with used biopolymers – DNA intercalation or binding to proteins. The presented results are focused on morphological studies with a wide range of microscopy techniques (TEM, AFM, fluorescence microscopy, confocal microscopy) and preliminary studies of luminescence properties. The findings show the promising potential for further investigation of fabricated natural-derived materials in photonic applications.

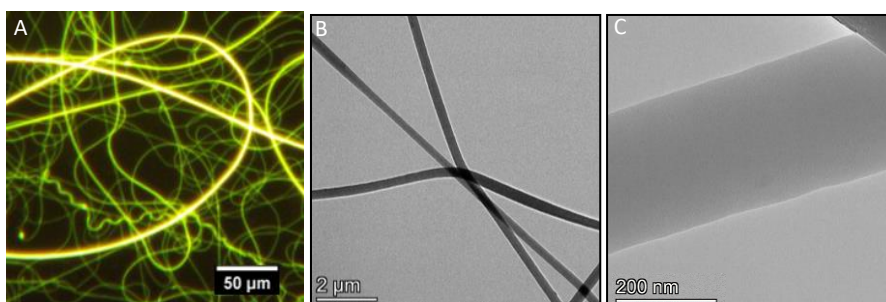


Fig. 1. Morphologies of electrospun fibers: A. DNA/PEO (fluorescence microscopy); B, C. BSA/PEO (TEM)

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Towards deterministic positioning of InAs/InP quantum dots in photonic structures

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Photonic structures with embedded single quantum emitters are in scientific research of high demand due to their high potential for utilizing in quantum technologies, especially in the field of on-chip integrated quantum photonic circuits [1]. To create a high quality photonic structures in deterministic manner it is required to know accurate position of a suitable emitter. Quantum dots are perfect example of nanostructures which can be applied as on-demand quantum emitters, i.e. single photon sources, polarization entangled pairs or indistinguishable photons and can be used for this purpose.

In the presented work we use quantum dots obtained by metalorganic chemical vapor deposition (MOCVD) growth method in the Stranski-Krastanov mode, i.e., nanostructures typical geometry is an in plane size of ~ 10 nm and height of 2–4 nm sitting on a 1–2 monolayers thick wetting-layer. The QDs surface density is low, on the order of 10^{-8} cm $^{-2}$. This allows to apply 2D luminescence mapping with a set of spectral filters to find single QD emitting in the given range (we focus mainly around 1.55 μ m wavelength). In order to create photonic structure we performed the grid of alignment markers on the sample surface. They allow us to align the observation field and then to specify the position of the QD within the field. The photoluminescence signal is used to determine the position, as shown schematically below. The reflected laser is filtered out from the detection path with long pass filtering system. We use a dedicated computer software which is based on pixels contrast criterion to find brightest region of interest and to specify its center position of a quantum dot.

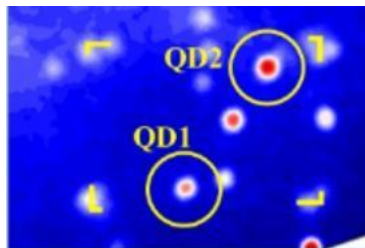


Fig. 1. A photoluminescence map showing bright spots on a planar sample indicating the position of suitable quantum dots for deterministic processing of photonic microstructures

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Two-photon active cadmium-free colloidal nanomaterials for applications in fluorescencebased sensing

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Quantum dots (QDs) are widely used in research and industrial fields due to their exceptional optical and electronic properties, which can be tailored by adjusting size and chemical composition of these nanomaterials. However, conventional QDs usually incorporate cadmium or lead, along with selenium, both of which raise significant concerns regarding human health and environmental safety. In contrast, for example, molybdenum sulphide (MoS_2) QDs, vanadium disulfide (VS_2) QDs, and carbon nanodots (CNDs) offer desirable optical properties, coupled with low toxicity, good biocompatibility and excellent water dispersibility, making them attractive candidates for a wide range of applications [1–3].

In this study, we investigate the optical properties of MoS_2 QDs, VS_2 QDs and CNDs, focusing on their potential applicability as two-photon active fluorescence sensors. The nonlinear optical (NLO) properties were explored in a broad spectral range with the two-photon excited emission technique using tunable femtosecond laser pulses. The nonlinear absorption properties are presented as appropriate cross sections normalized per molecular weight which allows comparison of the NLO properties of the studied quantum dots with various nanosystems or organic dyes.

All investigated nanomaterials exhibit notable optical properties suitable for sensing applications in both one- and two-photon regime. The findings of the study also highlight the promising outlook for employing novel and emerging cadmium-free nanomaterials in various fields, including bio-related ones, as they could be an interesting alternative to nonlinear absorbers currently used, for example, as markers for nonlinear microscopy.

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Personalized LED illuminator for photodynamic therapy studies

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Photodynamic therapy uses photosensitizing agents to kill the tumor. It may be necessary to use metabolic synthesis, also known as pro-drug, followed by activation of a specific agent with radiation of a specific wavelength in the presence of oxygen. Thanks to a sequence of photochemical and photobiological processes, reactive oxygen species (ROS) are generated, cancer cells are irreversibly destroyed. This type of therapy can be used in the treatment of many skin cancers, or the treatment and palliative care of internal cancers [1, 2].

In this paper, a brief literature review and results are presented in an attempt to construct a personalized LED illuminator for photodynamic therapy trials and to test its effectiveness when it is irradiated with methylene blue in the form of a solution of various and hydrogel by studying the change in the methylene absorption spectrum. Trials were conducted using LEDs with different emitted wavelengths in order to find a perfect match to the blue.

By using an LED with an emission wavelength of 660 nm, the change in absorption in the solution as well as in the hydrogel was successfully achieved, confirming the effectiveness of illuminating the blue with the illuminator used.

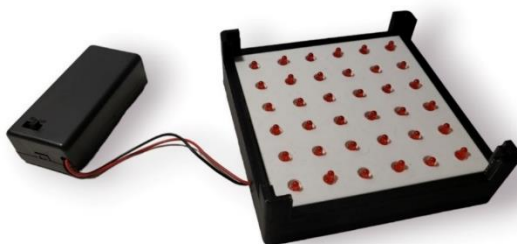


Fig. 1. Actual appearance of the constructed illuminator

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Numerical simulations of an optically active gate-defined quantum dot

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Self-assembled quantum dots (QDs) have a plethora of applications thanks to their ability to confine both electrons and holes and thus couple with light. However, the characteristic randomness of their arrangement and defining features (size, shape) makes their properties hard to control. Gate-defined QDs can be much easier to adjust just by manipulations of the potentials applied to the electrodes defining a QD. Yet, dots of this kind cannot directly couple with light as they can typically only confine one type of carrier simultaneously. Creating a QD that would combine the advantages of both kinds of dots, i.e., easily adjustable properties and controlled coupling between QDs with optical activity would be desirable.

Here we propose the simplest geometry of circular electrodes whose combined potential would be able to confine both holes and electrons. By numerical simulation, we are able to show a theoretical possibility of creating an optically active gate-defined QD with the proposed geometry.

Our calculations are executed by numerically solving the Schrödinger equation in cylindrical coordinates. An improved discretization [1] of the problem was implemented as direct discretization would lead to carrier wave functions exhibiting a non-physical behavior near the origin. We calculate the overlap integral of the electron and hole wave functions, with a non-zero result implying a theoretical possibility of both carriers being found in the same volume. This overlap is a requirement for the dot's optical activity. After achieving a non-zero result we carry out an optimization of the dot-defining parameters, i.e., dimensions of the system and potentials applied to the electrodes. A key step of the optimization process is rejecting parameters that result in not well-localized electron wave functions, meaning that in the real system the carrier would not get confined in the dot. For the optimized QD, we attain an overlap of ~ 0.2 which is a very promising result.

Our results can be an introductory step in creating optically active gate-defined QD. We expect the potential for optical activity to turn out to be even higher after including the electron-hole interaction in the model. If this kind of dot was added to a linear array or a matrix of standard gate-defined QDs it could act as an interface with light for such a device. This additional component could open the door for long-distance quantum communication between gate-defined QD matrices.

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New fluorescent markers of amyloids

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Amyloids are improperly folded proteins associated with more than 30 disease entities (including neurodegenerative diseases) [1]. Despite remarkable advances in modern science, their role in disease pathology is not fully understood. Since the beginning of research on amyloids, various types of dyes have been used to detect them. These markers display differences in spectroscopic properties when they bind to amyloid fibrils. They are usually aromatic heterocyclic compounds [2]. The dyes do not interact with all amyloid intermediate forms – such as toxic oligomers or protofibrils [3]. This makes them less suitable and useful in the context of labeling amyloid structures. It is therefore necessary to construct new selective dyes for amyloid detection. New organic fluorophores with structures based on BODIPY and Thioflavin T dyes were designed and synthesized [4, 5]. Two new dyes, which differ by the groups of diphenyl (DPA) and dimethyl (NMe₂), were studied, showing AIE (Aggregation Induced Emission) and AIQ (Aggregation Induced Quenching) properties. The singlephoton optical properties of these dyes were compared in the presence of both incubated bovine serum insulin amyloids, and the A β (16-22) peptide fragment, and without them. The obtained results were compared with the reference dye – Thioflavin T. Depending on the dye motif and the amyloids used, different changes in the spectrum and fluorescence intensity were observed. The emission maximum of the dye exhibiting the properties of AIE (with a diphenylamine group) with the addition of amyloids, was shifted towards the red, which may be more favorable in the context of using this fluorophore for bioimaging. The emission maximum of the fluorophore exhibiting AIQ (with a dimethylamine group) with the addition of amyloids was comparable to the emission maximum of the reference dye (Thioflavin T). The study showed that the affinity for amyloids of the newly synthesized fluorophores is higher compared to the standard dye for both insulin and A β (16-22) amyloids. The results confirm that the newly synthesized dyes can serve as potential amyloid markers.

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Single- and double hybrid perovskites containing Cr³⁺ for highly sensitive luminescent thermometry

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Luminescent thermometry, a novel approach to temperature sensing, has been extensively investigated recently. Due to the remote readout, the variety of the sensing ranges depending on the used material as well as the possibility of performing plunge measurements, luminescence thermometry may overcome the limitation of the conventional contact sensing solutions.

The materials containing Cr³⁺ ions have attracted increasing attention due to their significant luminescence properties, strongly dependent on the host material [1, 2]. The potential of the chromium trivalent ions as luminescent temperature sensors can be seen in hybrid perovskites. The group organic-inorganic (hybrid) perovskites with the general formula [A]BX₃, where A represents an organic cation (e.g., EA⁺), B is a metal cation (e.g., Mn²⁺) and X stands for the anion (e.g., HCOO⁻), exhibit a variety of useful properties. Such compounds create a three-dimensional framework, containing metal cations and anionic linkers. Organic cations, in turn, are localized inside the framework's voids. The usefulness of the hybrid materials may be increased by implementing a double perovskite structure, such as formate-based materials with a formula [EA]₂M^IM^{III}(HCOO)₆, where M^I and M^{III} stand for mono- (e.g., Na⁺) and trivalent metal ions (Al³⁺) [1, 2].

The presence of the Cr³⁺ ions in hybrid perovskites provides a sufficient luminescent condition for luminescent thermometry. The coexistence of two types of temperature-dependent emission: narrow spin-forbidden ²E → ⁴A_{2g} or broad spin-allowed ⁴T_{2g} → ⁴A_{2g} transitions, is strongly dependent on the type of the material and Cr³⁺ ions concentration. By comparing the intensities of these two types of emission, it is possible to obtain a luminescence thermometer with high sensitivity and a wide range of usefulness.

The poster will present a comparison of the two types of hybrid Cr³⁺ compounds: single and double perovskites. Particular attention will be paid to the structural and luminescent properties of representative materials used as highly sensitive luminescent thermometers.

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Photophysical properties of single chiral gold nanoclusters

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Materials exhibiting dependence of their optical characteristics on the handedness of circular polarized excitation light are known as chiral materials. Recent interest in chirality at the nanoscale has been motivated by a broad range of possible applications in, e.g., enantioselective separation [1], catalysis [2], bioimaging [3], sensing [4], and theranostics [5]. Gold nanoclusters (AuNCs) have entered this field also, as their sensitivity to the polarization state of the excitation light can be controlled by attaching chiral molecules on their surface. To this point, the focus of the research has been on quantum efficiency tuning/improvement or two-photon excitation chirality [6]. However, details of their photophysics upon attaching chiral ligands still require experimental effort.

We present spectroscopic studies concerning the AuNCs exhibiting chirality and two-photon chirality. Samples were stabilized by the attached ATT (6-aza-2-thiopyrimidine) ligand, and chirality was enabled by D-Arg and L-Arg (D- and L-arginine, respectively) attached as outer layers to the AuNCs [6]. Experiments were carried out using wide field fluorescence microscopy for layers of single AuNCs embedded in a polyvinyl alcohol (PVA) matrix. Timetraces of emission intensity of individual AuNCs were acquired for several excitation wavelengths and as a function of the excitation power.

Statistical analysis of fluorescence timetraces indicate peculiar behavior for single AuNCs as a function of the excitation wavelength. We believe that the results provide new insight on the fundamental photophysical processes associated with the emissive state of the AuNCs.

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Chiral gold nanoclusters as amyloid-modulating agents

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Gold nanoclusters (Au NCs) have shown great potential in medical fields such as drug delivery systems, photothermal therapy, or bioimaging [1]. Gold, as a core material, offers several advantages, including biological inertness, and exceptional electro-optical properties. AuNCs (<2 nm) exhibit molecule-like optical properties including fluorescence, and multiple visible absorption peaks. Moreover, AuNCs possess a large specific surface area and the capacity to penetrate the blood–brain barrier [2].

Amyloid fibrillation is a process initiated by misfolding of some peptides and proteins leading to the formation of fibrillar aggregates [3]. The presence of amyloid aggregates is associated with several disorders, e.g., Alzheimer’s disease. Therefore, inhibition of fibrillization is essential for the prevention and treatment of these amyloid-related disorders. Several studies have shown that AuNCs have a considerable impact on fibrillization processes [4]. They can either inhibit or promote amyloid fibrillation depending on their physicochemical properties such as morphology or charge of the particle. Nevertheless, chirality has seldom been considered in the recognition of amyloid aggregates and modulation of fibril formation.

In this work, we investigated and compared the effect of gold nanoparticles surface chirality on the fibrillization kinetics of bovine insulin, a widely used model protein for the study of amyloid formation. Here, we prepared D-Acetylcysteine and L-Acetylcysteine-stabilized gold nanoclusters, denoted as Au₂₅(D-AcCys)₁₈ and Au₂₅(LAcCys)₁₈, respectively). The fibrillization kinetics of bovine insulin was tested using a Thioflavin T (ThT) assay which is a standard method to monitor fibril formation. To examine the effect of D-AcCys and L-AcCys on the fibrillation process, incubation of insulin (2mg/mL) with the addition of ThT (20 μM) was conducted in the absence and presence of the AuAcCys-NCs. The process was monitored by ThT fluorescence measurements, and morphology was investigated by recording AFM images. The results revealed, that both two chiral AuNPs inhibited insulin fibrillation, but the inhibitory effect Au₂₅(D-AcCys)₁₈ was more effective than that of Au₂₅(L-AcCys)₁₈ when comparing to the insulin incubated in absence of AuAcCys-NCs.

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Optimization of structure of germanium-doped M-type silica optical fiber for third-harmonic generation

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Third-harmonic generation (THG) in optical fibers has been studied for over 30 years and is still discussed in literature [1–3]. In this study, we investigate the feasibility of THG in germanium-doped M-type fibers. Our research is motivated by a notable gap in the existing literature regarding THG in such fiber structures.

In this presentation we demonstrate the relevance between geometric parameters of fiber and matching the pump mode and third-harmonic mode. The possibility of achieving third-harmonic generation within germanium-doped M-Type silica optical fiber highly depends on geometrical parameters of fiber and doping concentration contrast between core, ring and cladding of fiber.

Our calculations show the theoretical possibility of THG in germanium-doped M-Type fibers. Mode calculations were performed for 1560 nm pump and its corresponding 520 nm third-harmonic wave. The Finite Element Method (FEM) was used to analyze mode generation in M-type structure for both wavelengths.

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Optical Properties of Nanohole $\text{In}_{0.1}\text{Ga}_{0.9}\text{Sb}/\text{Al}_{0.3}\text{Ga}_{0.7}\text{Sb}$ Quantum Dots

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The security of the quantum cryptography is guaranteed by the fundamental laws of quantum mechanics. For achieving functional and secure transmission of quantum information, using e.g. the widely known BB84 protocol for quantum key distribution, non-classical sources of single photons (SPS) are needed. Additionally, their emission wavelength has to match the third transmission window to take advantage of the low-loss transmission via existing fiber-based infrastructure. The most promising option for this purpose is the usage of epitaxial semiconductor quantum dots (QDs) [1]. Over the last two decades, droplet-epitaxy etched almost strain-free GaAs/AlGaAs QDs have been shown to provide unmatched optical quality (e.g., QD ensemble homogeneity, purity and indistinguishability of Fourier-limited single-photons, photon pair entanglement fidelity), but emitted photons are not at telecom wavelengths [2]. Recently, (In, Ga)As QDs have been suggested as potential SPS at telecom C-band frequencies [3]. We propose alternative material platform for 3rd telecom window, namely type I GaSb QDs on AlGaSb surface grown in the same droplet-epitaxy etching scheme. Thus combining QDs growth proven advantageous for QD optical quality at shorter wavelengths and maturity of GaSb platform in terms of methodology for device integration on the Si platform. There are strong indications that such QDs may serve as high-quality SPS working at the third transmission window [4]. To obtain the theoretical predictions of the QDs' optical properties, we use a custom state-of-the-art software employing a multi-band theoretical $k\cdot p$ framework [5]. We present numerically obtained optical properties of Indium doped $\text{In}_{0.1}\text{Ga}_{0.9}\text{Sb}/\text{Al}_{0.3}\text{Ga}_{0.7}\text{Sb}$ QDs based on experimental data.

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Development of a New Synthesis and Characterization of Silver Sulfide Quantum Dots

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Enhancing the manufacturing process of quantum dots stands as a pivotal endeavor, offering a pathway to finely tune their spectroscopic attributes through meticulous adjustments in reaction parameters like temperature, duration, pH levels, choice of capping agent, and concentration of reagents. Among these, silver sulfide quantum dots (Ag_2S QDs) emerge as a beacon of promise, especially within the realm of theranostics, owing to their profound potential. These attributes are owed to their advantageous features, such as low toxicity, elevated quantum yield, two-photon absorption properties [1], robust photostability, biocompatibility, and emission residing within the near-infrared (NIR) spectrum, facilitating cutting-edge imaging capabilities. While traditional organic fluorescent dyes have excellent optical properties, they face challenges such as autofluorescence from inherent fluorophores in biological systems. Innovations in silver sulfide quantum dots, especially those emitting in the NIR II window (1000–1400 nm), offer a promising solution to these challenges. Their emission properties in the second NIR window provide unique advantages, including reduced light scattering and minimal autofluorescence, facilitating deep-penetration imaging with exceptional clarity and precision.

In this research, we introduce an enhanced synthesis technique for Ag_2S quantum dots, fortified with an inventive stabilizing shell. Furthermore, our investigation thoroughly examines these quantum dots, clarifying their emission and excitation spectra, and delving into the complexities of their lifetime dynamics.

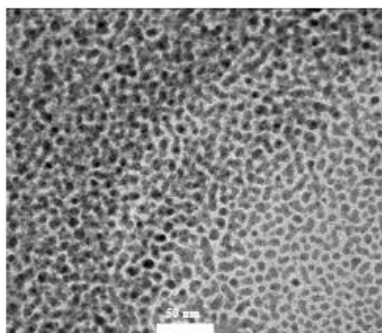


Figure 1. TEM image of Ag_2S QDs

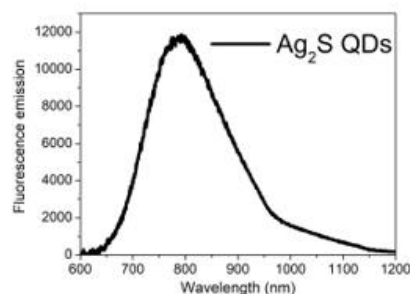


Figure 2. Fluorescence emission spectrum Ag_2S QDs

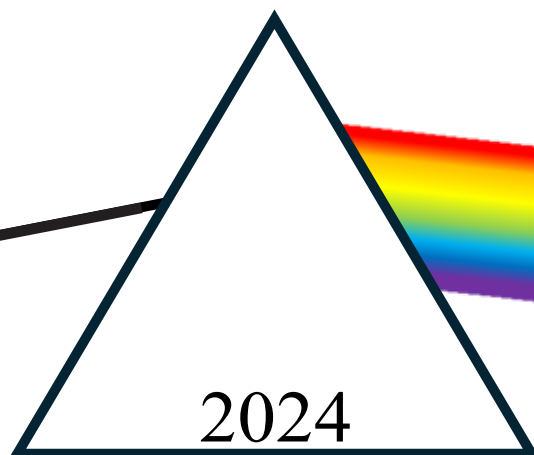
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