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Book of abstracts

7TH CONFERENCE OF DOCTORAL STUDENTS OF THE PAS

October 13-15th
2023 WROCLAW

Contents

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Schedule:

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10:15 – 10:30	03	**Wiktoria Morawska** Inequalities which we don't see. Experiences of young successful Polish women.
10:30 – 10:45	04	**Sebastian Sosnowski** How does data travel? Datafication and its consequences for public services provision – the case of Electronic Care Services (ECS) system
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12:15 – 12:30	09	**Marek Adaszyński** Methods of composite preparation for white LEDs

12:30 – 12:45	10	**Mohammad Ali Haghighat Bayan** Nano-fabrication of polymer-based antibacterial textiles for biomedical applications

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10:30 – 10:45	19	**Ved Prakash Dubey** An Experimental Investigation of Initial and Subsequent Yield Surfaces of Ti-Cu Bimetallic Structure Under Complex Loadings
10:45 – 11:00	20	**Weronika Bodylska** Synthesis of a novel EuBTC@hydroxyapatite hybrid material with luminescent properties

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11:30 – 12:30 Talk Session V

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Antimicrobial activity of halogenated COSAN derivatives

13:45 – 14:00 29 **Dawid Drozdowski**
Flexible solar cells and other phenomena – the world of hybrid perovskites

14:00 Closing ceremony

General Information:

The conference Venue:
Institute of Low Temperature and Structure Research
Polish Academy of Sciences
ul. Okólna 2 50-422 Wrocław

The Institute is located in the Przedmieście Oławskie district, across the Oder river from the famous zoological garden (ZOO Wrocław) and the Centennial Hall (Hala Stulecia). Parking lot, as well as bike racks will be waiting for the participants.

Integration meeting places:

Integration meeting (Friday):	PINTA Wrocław Podwale 83, 50-414 Wrocław
Integration meeting (Saturday):	HALA Świebodzki - bar & food court plac Orląt Lwowskich 20B, 53-605 Wrocław

Presenting Authors

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Abstracts

Talk session I-III

October 14th 2023 :

How do you kill microbes with sunlight? The Visible to UVC upconversion phenomenon.

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Upconversion is a fascinating phenomenon that enables the transformation of low-energy photons into higher-energy ones [1]. While the phenomenon itself has been known for some time, its full understanding and practical applications have evolved over the years. This process, driven by special materials called upconverters, has far-reaching applications. It enhances solar panel efficiency by converting low-energy sunlight into high-energy light [2]. Moreover, in medicine, upconversion nanoparticles aid in deep-tissue imaging and drug delivery [3].

One of the most recent breakthroughs in upconversion involves the transformation of visible (Vis) light into ultraviolet C (UVC) light [4]. UVC radiation is highly effective at disinfecting and killing microorganisms, making it valuable in several fields, i.e., water and air purification, surface disinfection, and sterilization of medical instruments and equipment.

Only a limited number of compounds exhibiting visible-to-UVC upconversion have been reported so far. This work explains the fundamentals of the upconversion phenomenon and introduces novel luminescent materials that emit UVC radiation when excited by blue light. Their properties are discussed in the context of potential applications in the fields of disinfection and sterilization.

This research was funded by the Polish National Science Centre (project No. UMO-2021/41/B/ST5/03792).

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Inequalities which we don't see. Experiences of young successful Polish women.

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The aim of the lecture is to present research devoted to the analysis of inequalities in social allocation due to gender in the lives of young, advancing women: professionals and entrepreneurs. Women from this group internalize the social structure and have an ambivalent attitude towards the implementation or the attempt to reject gender roles. This tension – what I call invisible inequalities – may be a fundamental source of further perpetuation of gender inequalities, which is especially evident in this research group that theoretically has all the resources to make equality possible. In my speech, I will talk about the autonomy of gender structures in relation to the changing legal and economic structures in the context of the image of a contemporary Polish woman.

The speech will be a presentation of the results of preliminary research conducted using the technique of 32 biographical interviews, analyzed using MAXQDA, and started proper research using techniques such as FGI, dyads.

This research was funded by the Ministry of Science and Higher Education in Poland, as part of the "Pearls of Science" program (project No. PN/01/0319/2022).

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How does data travel? Datafication and its consequences for public services provision – the case of Electronic Care Services (ECS) system.

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This presentation aims to present the author's planned research project, which explores our comprehension of how datafication and its consequences impact daily practices in welfare provision, using ECS system in Poland as a case study.

Public institutions frequently emphasize the advantages of datafication, claiming that data-driven systems are more rational, impartial, and reliable [4]. However, the datafied welfare state introduces privacy risks, selective data collection leading to biased outcomes, and potential discrimination against marginalized social groups, exacerbating existing inequalities [5-6]. Moreover, human experiences through datafication are reduced to quantifiable variables, leading to diminished reliance on experience-based professional knowledge of social workers.

The study seeks to answer research questions on data practices, stakeholders' influence on the system and its impact on everyday practices. The following are presented through research questions: How are data on social service beneficiaries produced, processed, used, and shared within ECS system? How do stakeholders, particularly beneficiaries and caregivers, influence these data practices within ECS system and its development? How does datafication influence the everyday practices of public servants (caregivers, social workers) and citizens in the context of ECS system?

The research draws upon the data journeys approach developed by Bates, Lin, and Goodale [1], rooted in critical data studies [2-3]. This approach examines how data move through time and space, revealing data fractures and emphasizing that data are not neutral but influenced by unequal dynamics. It aims to enhance the explainability of data-based automated decision-making systems, empowering data subjects.

The presented research project is a part of the AUTO-WELF project. Project AUTO-WELF (2021/03/Y/HS5/00263) is supported by Austrian Science Fund: [I 6075-G], Austria; Independent Research Fund, Denmark; BMBF, Germany; National Science Centre, Poland; FORTE, Sweden, under CHANSE ERA-NET Co-fund programme, which has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 101004509.

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2. Hepp, A., Jarke, J., & Kramp, L. (Eds.). (2022). *New Perspectives in Critical Data Studies: The Ambivalences of Data Power*. Springer International Publishing. https://doi.org/10.1007/978-3-030-96180-0
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Luminescence thermometry based on hybrid organic-inorganic perovskites containing Cr^{3+} ions

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Hybrid compounds described with the general formula ABX_3, where A represents organic cation (e.g. $CH_3NH_3^+$), B is a metal cation (e.g. Mn^{2+}) and X stands for the anion (e.g. $HCOO^-$), have attracted increasing attention due to their multifunctional properties. [1,2] The perovskite-like compounds create the three-dimensional framework, containing metal cations and anionic linkers, while organic cations are localized inside the framework's voids. Hybrid materials may exhibit a number of extraordinary physical phenomena, such as dielectric and magnetic properties as well as interesting optical properties, especially temperature-dependent luminescence. [1,2]

Among various compounds, the group of formate-based hybrid perovskites exhibits particularly interesting relationships between the structure and optical properties. The composition of the material is a crucial parameter affecting the luminescence of the Cr^{3+} ions. The crystal field strength (Dq/B) induces the main emission type of the chromium trivalent ions: narrow spin-forbidden $^2E_g \rightarrow {}^4A_{2g}$ or broad spin-allowed $^4T_{2g} \rightarrow {}^4A_{2g}$ transitions. The luminescence of the Cr^{3+} ion in the investigated structures is strongly dependent on the temperature. The increase in this parameter induces the thermal population of the higher $^4T_{2g}$ energetical level. The temperature-dependent luminescence has been a basis for the thermometric model determination. The obtained results confirm the great potential of the sensing materials based on the hybrid perovskite materials containing Cr^{3+} ions. [1,2]

The presentation will contain the spectroscopic analysis of the investigated materials, with particular emphasis on their implementation as a highly sensitive luminescent thermometer. Additionally, the influence of the crystal field strength on the optical characteristics will be described in detail.

This research was supported by the National Science Center (Narodowe Centrum Nauki) in Poland under the project SONATA 16 no. 2020/39/D/ST5/01289

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Cellular senescence in anticancer therapy

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Cellular senescence is a state of cell cycle arrest, which can be induced with telomere attrition, chemotherapy, radiation, oncogene activation, or oxidative stress. Senescence is also known as a tumor-suppressing mechanism, which not only ceases the proliferation of transformed cells but also promotes an immune response, maintaining tissue homeostasis. Senescent cells remain metabolically active and exhibit characteristic morphological and metabolic features accompanied by senescence-associated secretory phenotype (SASP). The molecules secreted by senescent cells can recruit immune cells to promote inflammation, which contributes to wound healing, tissue repair, and morphogenesis. However, SASP may also induce immune exhaustion and chronic inflammation, which results in the persistence of senescent cells in the cancer microenvironment. In such cases, SASP promotes further senescence, cancerogenesis, and metastasis[1]. Thus, anti-proliferative and pro-senescence therapy followed by senolysis (eradication of senescent cells) can be a valid and promising approach to anti-cancer therapy[2].

Natural Killer cells are the first line of defense mechanism when it comes to cancer. Unlike cytotoxic T-cells, they are part of the innate immune system and do not require co-activation but respond directly to the signals from the target cell and the environment. The NK cells were often found in the proximity of the senescent cells and suspected to be naturally engaged in the senescent cells' removal[3-5]. It makes them an excellent candidate for a senolytic tool.

To determine the senolytic potential of NK cells towards chemotherapy-induced senescent cancer cells, we induced senescence in cancer cell lines with low-dose etoposide treatment, and then tested them for senescence markers. We found that senescence induction did not change the expression of NK cell-response ligands on the cancer cell's surface. Accordingly, no differences in cytotoxicity were observed in the co-culture of NK-92 cells with target cells relative to untreated versus senescent cancer cells. However, after exposure of NK-92 to the untreated and senescent cancer cells' conditioned media, the NK cells exhibited a decline in their cytotoxic function. It correlates with upregulated NKG2A inhibitory receptor expression on NK cells. Interestingly, exposure to the senescence microenvironment downregulated the expression of 2B4 activating receptor.

Our data suggest that senescence does not necessarily stimulate NK cells' cytotoxicity. On the other hand, both tumor and tumor-senescence microenvironment decrease NK-92 cells' cytotoxic activity.

The research was financed with statutory funds of Hirszfeld Institute of Immunology and Experimental Therapy.

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Why are *Euchromia* wasp moths so special?

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The wasp moths from the genus *Euchromia* possess a few interesting features. Firstly, they just arouse aesthetic impressions with their bright body colouration, which combined with their body shape and behaviour, makes them resemble large hornets. Interestingly, the metallic blue colour present in many species is an effect of structural colouration caused by the nanostructure of scales covering their body. Additionally, these moths exhibit pharmacophagy, i.e. imbibing toxic substances from plants and accumulating them in their bodies, to obtain an even stronger predator deterrent effect [1, 2].

However, the most interesting thing about *Euchromia* moths is perhaps their zoogeography. This genus certainly derives from the Neotropical (South American) realm, but it is the only member of its group present solely in the Old World tropics [3]. The Neotropical lineage of tiger moths they belong to, called Euchromiina, evolved around 25 million years ago at the earliest [4]. The arrangement of the continents at that time was already very similar to the current one. Thus, the ancestor of *Euchromia* must have arrived in the Old World via Long Distance Dispersal, through the Pacific or Atlantic Ocean. Currently, there are around 40 *Euchromia* species, distributed from Africa to Fiji (Southwest Pacific). This distributional pattern makes *Euchromia* a suitable object of zoogeographical research on the "out-of-Neotropics" events of colonisation and dispersal in the Old World. In my talk, I will present the main objectives of my project concerning zoogeography of *Euchromia*.

This research is funded by the Polish National Science Centre (project No. UMO-2021/41/N/NZ8/03334).

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POLY(LACTIDE) ON THE PATH TO SUSTAINABLE DEVELOPMENT: INTRODUCING FUNCTIONAL ACETALS INTO THE POLYESTER CHAIN

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Recently, the growing ecological awareness of society and the need to protect the environment led to a growing interest in biodegradable materials. In this context, among many bio-based polymers, polylactide (PLA) has emerged as a sustainable, environmentally friendly material. [1] However, despite many advantages, PLA has properties that limit its broader applications. Due to the absence of reactive side groups in the repeating units that form the PLA chain, further polymer post-modification is considerably challenging. Our research aimed to introduce acetal units with functional groups into the PLA backbone to enable the functionalization of the resulting copolymers. Importantly, acetal units, which are labile under acidic conditions, also enhance the chain's degradation capability.[2] To obtain functionalized polylactide, we employed cationic copolymerization of selected functional cyclic acetals:[(4-chloromethyl-1,3-dioxolane, 4-[(allyloxy)methylo]-1,3-dioxolane)] with lactide (*Fig. 1*). The presented results demonstrate the influence of reaction condition on the molecular weight and composition of the copolymers. Additionally, the capability of the obtained copolyesters for modification was demonstrated through reactions with azide, propargyl alcohol, mercaptopropanol, or thioglycolic acid.

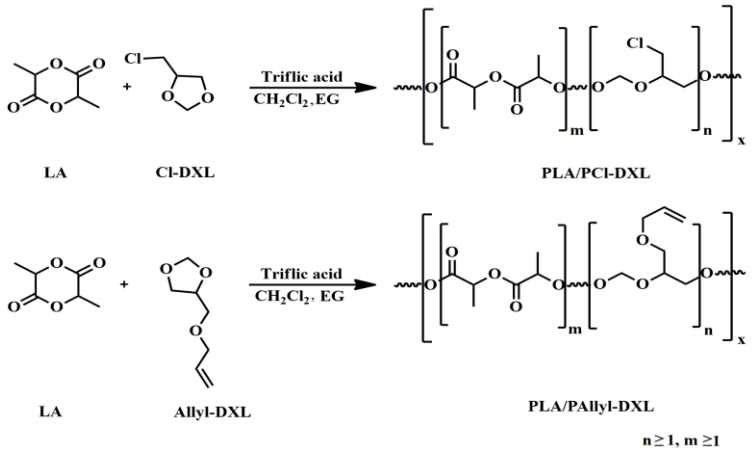

Fig. 1 Cationic copolymerization of lactide with cyclic acetals.

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Methods of composite preparation for white LEDs

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Light emitting diodes (LEDs) have emerged as one of the most revolutionary technologies in lighting and display systems. Their energy efficiency is significantly greater than for other traditional technologies such as incandescent lamps or fluorescent lighting [1]. There are different approaches to achieve white light emission in LED system. One of the most common is based on the blue emitting chip, which is covered with the layer of the yellow emitting phosphor usually containing Ce^{3+} or Eu^{2+} ions. The total emission spectra from such device consist of a narrow blue peak and a broad yellow emission band, which appears as a white color. Despite the high energy efficiency, this construction does not provide high quality white light [2]. Another type of construction is based on a UV-emitting chip, which then excites a mixture of broadly emitting phosphors in the visible light region. This solution provides a better quality of light and a higher color rendering index (CRI). Another possible white LED system is based on red, green, and blue (RGB) diodes, which gives the possibility to dynamically change the emission color [2].

The phosphor material used in LEDs is applied after dispensing it in a polymer matrix. First, the appropriate amounts of polymer resin and a hardener are weighed, and then phosphor is added. Depending on the type of polymer it can be used only in the specified limited time before it will be fully cured and become a solid [1]. The mixture can be dispensed in many different ways. The most simple method, which does not require advanced equipment, is drop casting. In this case, the mixture is cast on a substrate by drops coming from a dispenser or a pipette. However, it is not easy to control the thickness and achieve uniform layers [3]. Another possible preparation method for composite layers is spin coating. In this method, the material is applied on the substrate which is spinning at the precisely chosen speed. The centrifugal force spreads the mixture uniformly and removes the excess material. As a result, the thickness of the layers can be strictly controlled by the rotation speed of the device. However, some of the material is wasted during spin coating and ejected from the substrate [4].

In this work, the results of the different composite preparation methods and protocols will be presented. The analysis is based on the chosen mixture of phosphors: silicate and borate doped with Eu^{2+} ions. As a matrix for composites silicone resin is used. The comparison between drop casting and spin coating layers will be performed to find the most optimal method for composite preparation.

This research was funded by the National Centre for Research and Development (LIDER/19/0103/L-12/NCBR/2021).

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Nano-fabrication of polymer-based antibacterial textiles for biomedical applications

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The demand for advanced textiles with inherent antibacterial properties has grown significantly in recent years, driven by the increasing need for effective infection control measures in biomedical settings.[1] Electrospinning, a versatile and scalable technique, has emerged as a promising method for fabricating antibacterial textiles with precise control over fiber morphology and surface characteristics.

Electrospinning involves the application of an electric field to a polymer solution, leading to the formation of ultrafine fibers through a jetting and stretching mechanism. These fibers exhibit a high surface area-to-volume ratio, conducive to efficient functionalization with antibacterial agents. Various polymers, including biocompatible and biodegradable materials, can be employed as the electrospinning matrix, allowing for the developing of diverse textile formats, such as nonwovens, membranes, and scaffolds. [2]

Electrospun textiles are often modified with antibacterial agents, such as nanoparticles, enzymes, or antimicrobial peptides, to confer antibacterial properties. The controlled release of these agents from the electrospun fibers imparts long-lasting antibacterial activity to the textiles, making them suitable for applications in wound dressings, implants, personal protective equipment, and hospital linens.

Furthermore, the tunability of the electrospinning process allows for the optimization of fiber diameter, porosity, and surface roughness, all of which play a critical role in the overall antibacterial performance of the textiles. Recent advancements in electrospinning technology have incorporated multiple antibacterial agents into a single textile, providing a multifunctional approach to combat a broad spectrum of pathogens.

In conclusion, electrospinning offers a versatile and efficient platform for fabricating antibacterial textiles tailored to meet the specific requirements of biomedical applications. These textiles promise to enhance infection control, promote wound healing, and improve patient care in healthcare settings. Further research and development efforts in this field are expected to yield innovative solutions that address the evolving challenges of antibacterial textile fabrication for biomedical purposes.

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Philosophy in Poland after II World War. Ideologies and politics.

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The aim of this research is the influence of science policy on philosophy in Poland from 1945 to 1956. The "science policy" is concened which influences of the communism party and goverment to the freedom of research and teaching as well as the organizational autonomy of scientific institutions and societies [1]. In Poland after the Second World War when the The Polish Workers' Party formed the goverment the concept of science policy took on a new meaning. It became an instrument for building the communist system as part of the so-called "ideological offensive".

I intent to explain why philosophy in Poland survived in those years? How developed an policy on philosophy? Which people brought on the marxism method? Who was a decision-maker? What was the role of marxist's philosophers? Last, but not least, why stalinism ideology in 1956 disappeared. Thus, I approach to those problems form different ways.

I'm going to answer by filling existing research gaps. Over the last several years, be published a few studies on the related humanities, mostly the history [2–4]. Also Piotr Hübner wrote a few important studies about science policy [5–7]. In the recent years published the book firmed by the Institute for the History of Science of the Polish Academy of Sciences [8]. Moreover, John Connelly, professor at the University of California, Berkeley, wrote a great book about Sovietization of higher education in East German, Czech, and Polish [9].

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Profiling of the *Helicobacter pylori* redox switch HP1021 regulon using a multi-omics approach

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Helicobacter pylori is a Gram-negative, microaerobic, pathogenic bacterium that has been intensively investigated since its discovery in 1982. *H. pylori* living in a severe environment of the human stomach has evolved many mechanisms to survive combating many stress factors, including reactive oxygen species (ROS) [1]. Our studies focus on HP1021 - atypical orphan response regulator, i.e., response regulator not regulated by phosphorylation. We have recently discovered that it acts as a redox switch protein responding to redox imbalance of the *H. pylori* cell and plays an important role in the bacterial response to oxidative stress [2]. Here, we further investigated and characterised the regulon of HP1021. We performed transcriptome (RNA-seq), proteome (MS/LC-MS) and DNA-protein interaction (ChIP-seq) analyses for *H. pylori* N6 wild-type (WT) and HP1021 deletion mutant (ΔHP1021) under oxidative stress (21% O_2) and optimal microaerobic growth (5% O_2) conditions. The data were validated through RT-qPCR, ChIP-qPCR, EMSA and phenotype experiments for selected processes. The expression of 411 genes was affected by oxidative stress in stressed wild-type cells (WTS) compared to non-stressed cells (WT). Interestingly, ΔHP1021 did not respond to oxidative stress. A comparison of genes expressed in the ΔHP1021 and WT strains under optimal growth conditions revealed 190 differently expressed genes. Moreover, transcriptional changes and overall final protein levels correlated across multiple genes. Our studies proved that HP1021 decides about *H. pylori* response to oxidative stress and directly controls both typical ROS response pathways and less canonical ones, i.e. DNA uptake and metabolism [3].

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Investigation of theranostic properties of silicate-substituted hydroxyapatite

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Synthetic hydroxyapatites (HAps) exhibit similar characteristics to naturally occurring hydroxyapatites found in mammalian bones and teeth. HAps find widespread application in medicine, serving as a filler for bone fractures, a dental material, and a replacement for tissue in compact bones. Moreover, in recent years, there has been extensive research into utilizing hydroxyapatite in theranostics, which is a combination of therapy and diagnostics.

One of the key attributes that renders HAps highly appealing as theranostics biomaterials is their ability to easily undergo ion replacement within their crystal lattice. This substitution allows for the modification of biological properties, such as osteoconductive and osteoinductive properties, but also physicochemical properties, such as morphology, texture, and structural characteristics. The substituents play a crucial role in mineral homeostasis and the metabolic processes of the cells and tissue surrounding hydroxyapatite-based implants. As an example, introducing silicate ions leads to enhanced osteoclastic and osteoblastic responses, as well as an increase in bioactivity. What is more, doping with lithium ions (Li^+) enhances the osteogenesis, toughness, and strength of HAp implants, while substituting with rare element ions such as Eu^{3+} and Gd^{3+} results in luminescent and magnetic properties, respectively.

Given this understanding, we introduce a new, versatile silicate phosphate nanohydroxyapatite, co-doped with Li^+, Eu^{3+}, and Gd^{3+} ions. By incorporating these ions into a single compound, we have developed a biocompatible biomaterial suitable for cell and tissue engineering applications. Co-doping of Li^+, Eu^{3+}, and Gd^{3+} ions allows for concurrent cell treatment and bone repair, coupled with *in vivo* imaging or magnetic guidance.

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G-quadruplexes - structures from the influenza A virus genome and their biological function

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Influenza A virus (IAV) causing pandemic outbreaks became an important research subject. Despite the high variability of the IAV genome, its viral RNA (vRNA) structure possesses features that remain constant between strains. Previous research demonstrates the significance of the vRNA secondary structure in the viral life cycle, thus structural motifs can represent novel therapeutic targets. We know from the literature that RNA structures called G-quadruplexes (G4s) are present within the viral genomes, where they play an essential role during biological processes. G4s can be formed within guanine-rich sequences called potential quadruplex forming sequences (PQSs). We investigated the influenza A virus genome for the presence of PQSs, their ability to fold into G-quadruplexes, and their potential role in the viral life cycle.

Using bioinformatics methods we identified twelve PQS motifs and estimated their conservation level across the H1N1 subtype. Then, by biophysical methods, we determined their propensity to form G4s. To this end, we used spectroscopic techniques and methods based on the native polyacrylamide gel electrophoresis. Additionally, we performed biological studies of the influence of G4-specific ligands on the IAV replication.

Our results revealed that three of the selected PQS oligomers from the IAV genome form RNA G-quadruplexes. We also discovered that these PQS motifs are present within segments encoding viral proteins. Moreover, polyacrylamide gel analysis showed that G4-specific ligands can stabilize G-quadruplex structures. The biological studies demonstrated that the same ligands effectively inhibit virus replication.

Taking into consideration the obtained results, we concluded that G-quadruplex structures are present within the IAV genome and can be targeted by specific ligands. What is more, via G4 stabilization, viral replication can be effectively inhibited. All our findings suggest that selected PQS motifs from the IAV genome can serve as potential novel anti-viral therapeutic targets.

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Cell culture monitoring with electrochemical sensors

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Cell culture research are essential in pharmaceutical industry, especially in predictions of drug activity, metabolism and toxicity *in vivo*[1]. However, two-dimensional monolayer of cells, which are used all over the world, are not exactly reflect tissue-specific architecture, mechanical and biochemical cues and cell–cell communication[2]. They are lost under such simplified and highly biased conditions. *Animal models* commonly used in various stage in drug development do not meet expectation many scientist, therefore one of the solution is to create 3 dimensional cell cultures or even organoids, small human tissues on-chip. This technology would have allow better understanding of malfunctions of diseases in organs and tissues.

Electrochemical methods enable real-time in vitro analysis. Moreover they allow measurement at different places of the culture by placing electrodes throughout the cell culture scaffold. Oxygen and glucose consumption measurements provide us with a lot of information about cell viability and can be translated to toxicity during tests of new drugs[3].

The research was focus on the oxygen sensors, which can be used in cell culture applications, the aim was to find an electrode modification, which effectively reduce the potential value for oxygen sensing in neutral pH, most suitable for cell culture. The second direction of research was to prolonged (at least 3-4 weeks) measurements within cell culture matrix and the surrounding medium, where biofouling is a major issue. Through the several major antifouling layers: polymers (e.g. Nafion®), hydrogels (e.g. polyhydroxyethyl methacrylate), protein (e.g. albumin), polyethylene glycol and poly-L-lactic acid have been tested against cell culture medium and later directly in the HeLa cell culture.

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Abstracts

Talk session IV-VI

October 15th 2023

Interactome studies of an orphan histidine kinase CpkM from *Streptomyces coelicolor* A3(2)

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Presented study focuses on the interaction partner search of an orphan histidine kinase CpkM from *Streptomyces coelicolor* A3(2). *Streptomyces* are soil-dwelling, Gram positive bacteria of critical industrial importance for antibiotic and chemical therapeutics production. On the genetic level, specialized metabolites production is governed by a variety of regulatory systems including two-component systems that consist of histidine kinases (HKs) and cognate response regulators (RRs). Diverse environmental stimuli can trigger HKs to autophosphorylate and subsequently transfer the phosphoryl group to RRs. This post-translational modification changes RRs properties, e.g. activates DNA binding activity, therefore regulates transcription activation [1].

HKs in *Streptomyces* influence both specialized metabolites production, as well as morphology development and cell survival response. CpkM is a putative NarX-like HK. The acquired data suggest that CpkM could respond to a change in cellular redox state caused by antibiotic or hypoxia stress. Oxygen depletion triggers dormancy state activation, which from the pharmaceutical industry perspective it is an antibiotic production limiting issue. Research on genetic regulatory pathways in *Streptomyces* can contribute to construction of a suitable microbial hosts for the medical metabolites production.

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Novel inhibitors of influenza virus and emerging coronaviruses entry

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Emerging viruses, such as influenza viruses (FluV) and severe acute respiratory syndrome coronavirus 2 (SARS-CoV2), pose a constant threat to animal and human health. Identification of host cell factors which are necessary for viral replication cycle but dispensable for cellular survival might define novel, attractive targets for therapeutic intervention. One of the most crucial step of viral infection is the proteolytic activation of viral surface glycoprotein, i.a. FluV hemagglutinin (HA) and SARS-CoV-2 spike protein (S), mediated by the type II transmembrane serine proteases (TTSPs), e.g. TMPRSS2.

In our research, we defined the secondary structure of TMPRSS2 mRNA in vitro and designed TMPRSS2-specific antisense oligonucleotides (ASOs). We tested ASOs in different types of cells. Experimental data showed that the TMPRSS2-specific ASOs led to the TMPRSS2 gene silencing and consequently, to a significant decrease in the influenza replication. In addition, we found that the TMPRSS2-specific ASOs significantly blocked the entry of emerging coronaviruses, i.e. SARS-CoV-2. To sum up, we established the TMPRSS2 mRNA secondary structure and designed the TMPRSS2-specific antisense oligonucleotide with antiviral activity.

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Temperature dependence of avalanche photon emission in nanocrystals of $NaYF_4$ doped with Pr^{3+} Yb^{3+}

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In lanthanide ions, a very particular energy conversion process can occur – Photon Avalanche (PA) emission. A characteristic feature of PA is a steep, highly nonlinear relationship between the power density of the pumping laser (Ip) and luminescence intensity (I_L), where $I_L=(Ip)^S$, observed with S > 10, which occurs above a certain critical excitation power density (PA threshold). At this point, the luminescence intensity versus power density graph exhibits a distinctive S-shaped curve. One of the key requirements for observing PA emission is to pump the material with photons corresponding to excited state absorption but far from resonance with ground state absorption. Although this phenomenon has been studied in bulk crystals, it has only recently been demonstrated in nanocrystals [1-3].

This study presents research on the PA phenomenon in $NaYF_4$ nanocrystals doped with praseodymium and ytterbium ions. The nanocrystals were excited at a wavelength of 852 nm, leading to multicolor emission with prominent peaks at 610 nm and 482 nm. The relationship between the power density of the excitation laser and luminescence intensity was examined, revealing the characteristic S-shaped dependence. Furthermore, these dependencies were explored at different temperatures ranging from -175°C to 175°C. Interestingly, strong temperature dependencies were found for significant parameters describing PA, such as intensity, slope, and threshold power. Relative temperature sensitivities were calculated, reaching values of up to 7.5% per degree Celsius. The presented research highlights the potential of PA nanostructures in luminescence thermometry, including temperature detection based on a novel thermometric parameter - PA threshold power.Celsius. The presented research highlights the potential of PA nanostructures in luminescence thermometry, including temperature detection based on a novel thermometric parameter - PA threshold power.

This research was funded by the Polish National Science Centre 2021/43/B/ST5/01244

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An Experimental Investigation of Initial and Subsequent Yield Surfaces of Ti-Cu Bimetallic Structure Under Complex Loadings

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Advanced composite materials, such as bimetallic structures formed from two dissimilar constituent materials, offer unique properties ideal for high-tech applications, including aerospace, automobiles, and biomedicine [1]. Conventional mechanical tests conducted under simple stress conditions fail to replicate the real-world engineering applications. Relying solely on the uniaxial testing methods provides only limited results, that are not sufficient to capture all aspects of materials like texture or anisotropy introduced during manufacturing [2]. In this work, an experimental and theoretical investigations are presented to discover the physical mechanisms behind the plastic deformation in titanium-copper bimetal subjected to complex mechanical loading, employing the yield surface method. The complex loadings were executed by the simultaneous application of uniaxial tension with cyclic torsion.

The material characteristics of bi-metal (Ti-Cu) showed a decrease of the yield point under these loading conditions, Fig. 1. Yield surfaces were determined through sequential probes along 17 strain-controlled paths in the plane stress state. The material exhibited slight anisotropic behaviour in the as-received state for the plastic offset strain defined. Such anisotropy could be potentially induced during production or specimen manufacturing processes. Yield surface sizes in the pre-deformed state were primarily reduced in the axial direction, especially for the compression. This indicates significant softening due to the plastic anisotropy introduced by complex loading, potentially contributing to a defect initiation and its subsequent growth in the bimetal tested.

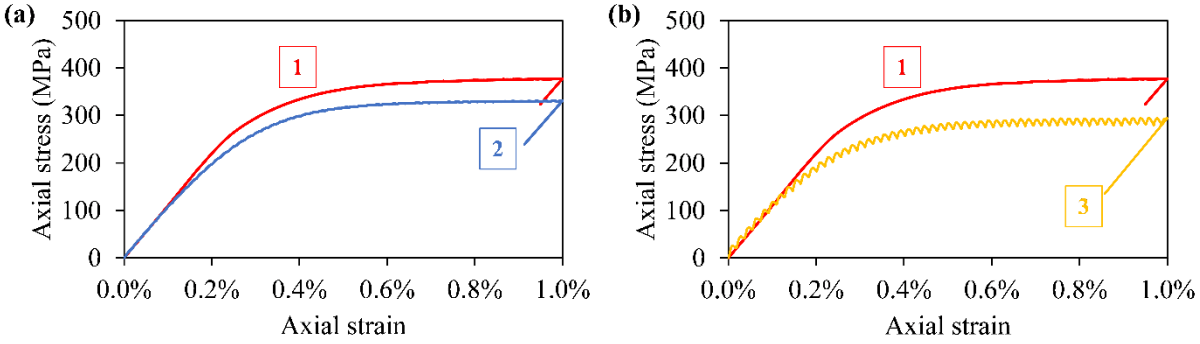

Fig. 1 Material characteristics of Ti-Cu bimetal under monotonic tension only (1); simultaneous monotonic tension with cyclic torsion of strain amplitude values equal to 0.1% (2) and 0.15% (3) at 0.5 Hz frequency.

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Synthesis of a novel EuBTC@hydroxyapatite hybrid material with luminescent properties

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Currently, materials chemistry is developing towards the synthesis of composites and hybrid materials. Combining the properties of the components allows for a synergistic effect and, consequently, for obtaining a more functional material. An interesting approach to the fabrication of novel multifunctional materials can be achieved through the interface of biomaterials, such as hydroxyapatite (HA), with coordination polymers and MOFs [1].

Following this research line, a new hybrid material containing HA nanoparticles coated with a layer of luminescent coordination polymer EuBTC (where H_3BTC = 1,3,5-benzenetricarboxylic acid) was proposed. EuBTC@HA was prepared by a layer-by-layer approach (Figure 1) and characterized using various techniques such as PXRD, IR, EDS, and TEM. Due to its photoluminescent properties, EuBTC@HA was tested for selective detection of iron(III) ions in a wide concentration range.

Detection of Fe(III) is crucial since it is one of the most important micronutrients in the human body. Moreover, the detection of Fe(III) is also essential from an environmental point of view. The harm of Fe(III) ions has not attracted enough attention for a long time, although they are widespread in industrial wastewater [2]. In this context, it is significant that EuBTC@HA can be reused for at least five Fe(III) detection applications without a significant change in the emission intensity.

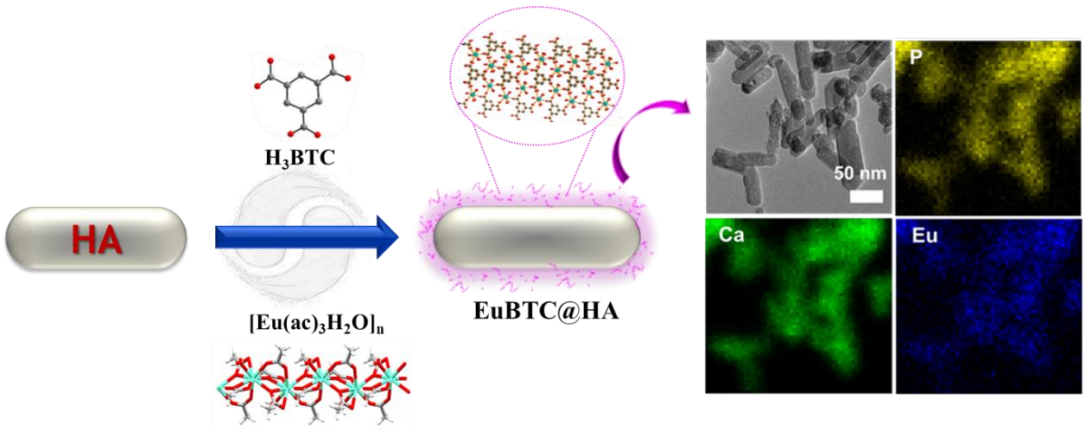

Fig. 1 Synthesis scheme of EuBTC@HA along TEM image and EDS elemental mapping of Eu, Ca, P.

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Polarization doped p-cladding layer InGaN laser characterization

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Nitride semiconductors (AlInGaN)-based optoelectronic devices play a crucial role in modern optoelectronics, especially in solid-state lighting. All semiconductor light emitters, including light-emitting diodes and laser diodes, operating in the visible part of the spectrum rely on this group of materials. For all these devices, the realization of low-resistance p-type GaN/AlGaN layers is a critical task. Magnesium (Mg) acceptor doping is currently the only effective method for these materials. However, Mg doping has several drawbacks. First, it has a high ionization energy, approximately 160-200 meV for GaN and 630 meV for AlN, resulting in a low number of free hole carriers. The hole concentration also changes significantly with temperature, limiting the cryogenic temperature performance of the devices.

Nitride-based semiconductors exhibit spontaneous and piezoelectric polarization due to their wurtzite structure. These polarization properties create a fixed polarization charge in the composition gradient and a three-dimensional free carrier gas with the opposite polarization, which behaves as either n-type or p-type doping. This phenomenon is referred to as polarization doping. Thanks to polarization doping, the carrier concentration can be easily adjusted by the layer's thickness and composition gradient. Furthermore, the carrier concentration remains unaffected by temperature, making these devices suitable for cryogenic applications.

In this study, a laser diode with a polarization-doped p-cladding layer demonstrated a low threshold current and minimal optical losses. The laser structure was designed using a symmetrical gradient-cladding layer. For the electron blocking layer (EBL), a conventional Mg-doped AlGaN layer was employed. To enhance injection efficiency between the EBL and p-cladding layer, a low-content AlGaN:Mg layer was added. The subcontact layer was also doped with Mg to reduce the metal-semiconductor Schottky barrier for the top metal contact. After mirror coating, the laser diode's threshold current ranged from 54 mA to 88 mA, and the slope efficiency varied from 0.77 W/A to 0.87 W/A with temperature in continuous wave (CW) mode. Following the gain measurement, the internal loss was found to be approximately 5–6 cm^(-1).

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The photosensitization of giant unilamellar vesicles as biomimetic model of bacterial cell membrane

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Photoinactivation of pathogens called also Antimicrobial Photodynamic Therapy (APDT), is recently an intensively explored alternative to fight bacterial infections. The main motivation is the growing problem of antibiotic resistance.[1] Chemically, APDT is based on the light activation of a chemical compound, called photosensitizer (PS), and the production of reactive oxygen species through the transfer of absorbed energy. From a biological point of view, it is well-known that the main consequence of photoinactivation is the widespread oxidation of biological structures, however, the exact mechanism is still unknown.

The aim of my research is to investigate whether changes in lipid composition influence bacterial vulnerability to APDT. The main hypothesis assumes the importance of bacterial lipids in antimicrobial photodynamic therapy, and modification their chemical structure and the ratio of specific lipids affects the level of bacterial reduction. To study the photoinactivation mechanism we self-assembled from bacterial lipid giant unilamellar vesicles (GUVs), cell-sized lipid bilayer capsules widely used as biomimetic models of cellular membranes. [3]

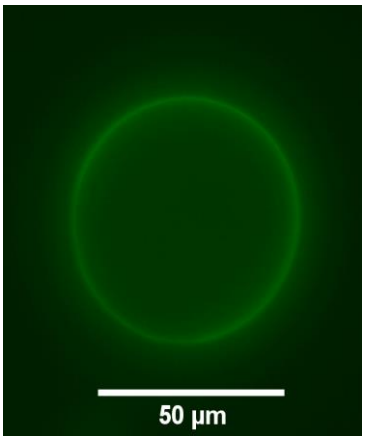

Fig. 1 GUVs enriched with fluorescence NBD assembled from Escherichia coli lipid extract.

GUVs were prepared using lipids extracted form *Escherichia coli*, and their photosensitization and observation was performed under contrast and confocal microscopy. Methylene blue was chosen as the photosensitizer, and activated directly during observation under the microscopes. Additionally, observations with NBD (1,2-dioleoyl-sn-glycero-3-phosphoethanolamine-N-(7-nitro-2-1,3-benzoxadiazol-4-yl)) to visualize the GUVs 2D and 3D structures were performed (*Fig. 1*). Liquid chromatography-mass spectrometry and gas chromatography-mass spectrometry were used to investigate changes in the lipid composition and saturation. The photosensitization effect was found to be dependent on GUV lipid composition.

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A bitter-sweet story of one gene: the role of *RAP2-7* transcription factor in the regulation of alkaloid biosynthesis in narrow-leafed lupin (*Lupinus angustifolius* L.)

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Due to their high protein content there is an increasing interest in using lupin seeds in nutrition. However, this usage may be significantly hampered due to lupins ability to store toxic alkaloids. Therefore, from a breeding perspective, it is crucial to understand the molecular background of their biosynthesis[1]. In the past decade, considerable progress has been made in research endeavours aimed at identifying genes involved in the lupin alkaloids' synthesis. A culmination of these efforts led to the identification of the APETALA2/ethylene response transcription factor, *RAP2-7*, proposed as a pivotal regulator of the pathway in narrow-leafed lupin[1]. Subsequent work has concentrated on gaining a deeper understanding of the role *RAP2-7* played in this biological process. The complete sequencing of *RAP2-7* revealed the presence of a single, conservative missense mutation in the sequence of the fourth exon, discriminating bitter and sweet forms. Leveraging this discovery, a molecular marker has been developed, allowing for 100% accurate differentiation between high- and low-alkaloid accessions within a pool of 198 genotypes[2]. A subsequent step of research involved the expression analysis of *RAP2-7* and several other genes from this pathway, across all organs of one sweet and one bitter narrow-leafed lupin accession, employing qPCR assay. This analysis confirmed that the transcription factor exhibited higher expression in organs of bitter accession associated with alkaloid synthesis, i.e. leaves, stems, and pods. Furthermore, its expression displayed a strong positive correlation with the expression of genes encoding the initial enzymes of the alkaloid synthesis pathway. Collectively, these findings constitute additional evidence of *RAP2-7* involvement in regulating this pathway. For the sweet accession *RAP2-7* expression was lowered in leaves, but it was still relatively high in its stems and pods. At the same time, expression of other alkaloids biosynthesis genes was maintained low throughout the whole plant. These observations may suggest the existence of additional regulatory layers in the alkaloid synthesis pathway of narrow-leafed lupin[3]. The conducted research has provided further insights into the pivotal role of *RAP2-7* in regulating alkaloid content in lupin seeds. Simultaneously, it has identified additional research gaps warranting future exploration and clarification.

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The role of electron-electron interactions in electron emission from nanotube materials

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Nanotubes and nanorods have recently been recognized as highly effective materials for serving as electron sources in a process known as field emission (FE). These materials are characterized as one-dimensional (1D), and it is anticipated that interactions between electrons will have a significant impact on their physical behaviour. In our study, we answer precisely this question: how electron-electron interactions influence field emission.

The focus is on the low-energy regime thus it is required to move away from the anti-adiabatic approximation and instead to derive the tunneling amplitude for a finite duration of the tunneling process.

This research identifies the specific conditions under which it is possible to provide an exact analytical expression for the tunneling current.

The formalism is developed that allows us to simultaneously account for both the collective effects arising from electron-electron interactions and thermionic emission.

These results highlight that the various types of nanotubes and their minigap/compressibility parameters can be easily distinguished based on FE measurements on these materials.

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Hybrids of haloantimonates (III) and halobismuthates (III) and their possible application in optoelectronic devices

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Organic-inorganic hybrids with a perovskite-like structure are currently the subject of intensive research. The widespread popularity of these materials can be attributed to their remarkable properties, which enable applications across various industrial sectors. The narrow energy bandgaps and broadband absorption make them suitable for applications in solar cells. Lead-iodide compounds incorporating methylamine [1] are well-known examples, featuring a perovskite crystal structure and superior energy absorption.

Despite evident advantages, these materials are chemically unstable when exposed to average humidity and light. Conducting additional research is essential to obtain materials that are both chemically stable and capable of retaining the specified properties. Additionally, the investigation and consideration of viable alternatives to lead, which is a hazardous and toxic elemental substance, necessitate scientific inquiry. Organic-inorganic perovskites are being also investigated as potential semiconducting and photoluminescent materials.

Halometallates like haloantimonates(III) and halobismuthates(III) constitute an important class in the field of hybrid, organic-inorganic materials. They appear to be a promising alternative to the previously mentioned lead-based compounds. These substances exhibit lower toxicity when compared to lead-based derivatives and demonstrate greater resistance to atmospheric conditions. Additionally, they offer straightforward deposition methods suitable for large-scale production. The family of haloantimonates(III) and halobismuthates(III) is continually growing through the discovery of novel compounds that incorporate small amine cations such as formamidinium, pyrrolidinium, and guanidinium into their structural composition [2-4]. Many crystallize in polar space groups exhibiting non-linear optical, piezo-, and ferroelectric properties. For that reason, they can be used as sensors, transistors, or other electronic devices.

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Anticalcification effect of human adipose tissue-derived mesenchymal stem cells (HATMSC2) secretome in calcification model of vascular smooth muscle cells (VSMC)

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Every year, over 250 000 heart valve transplant are performed worldwide. This is mainly due to calcification of the heart valves, which is present in approximately 20-30% of individuals aged over 65 years and in 48% of patients over 85 years. There are two types of aortic heart valve implants. First group consists mechanical implants made of synthetic materials. Their main advantage is durability. However, they increased risk of a blood clot, therefore require anticoagulant therapy. An alternative to mechanical valves are implants made of biological materials, which in turn are less resistant and require chemical preservation. Their limited durability exposes the patient to the risk of aortic valve reintervention [1]. Glutaraldehyde (GA) is frequently used for tissue fixation to extend life of bioimplant, but may contribute to cytotoxicity. Recently, mesenchymal stem cells (MSC) have emerged as a promising approach for regenerative medicine including cardiological intervention. MSCs are non-hematopoietic, multipotent cells which are located in almost every organ and tissue. MSC should also be able to differentiate into chondrocytes, adipocytes and osteocytes [2]. MSCs secretome is a cocktail of growth factors and cytokines which may be used as an alternative for cell therapy. The aim of the study is to optimize methods for testing the *in vitro* biocompatibility of bovine tissue from the jugular vein fixed with GA (hereinafter referred to as biomaterial) against immortalized human aortic smooth muscle cells (VSMC) and to determine anti-calcification effect of HATMSC2 secretome in cellular model of VSMC calcification.

The biocompatibility of the biomaterial was tested using cell metabolic activity assay (MTT) or cell cytotoxicity (LDH release) after 24 h of VSMC cultured directly on biomaterial or in biomaterial extracts. Biomaterial extracts has been obtained after 24 h incubation of biomaterial in the culture medium. To achieve calcification model of VSMCs a culture medium with 2mM of phosphates (Pi) was used and cells were cultured up to 14 days. At 3rd, 9th, 11th and 14th day of experiment, cells were fixed with 10% formalin and stained with 2% solution of Alizarin Red. Then quantification of calcium deposition was performed using cetylpyridinium chloride. HATMSC2 secretome was produced as previously described [3]. To determine anti-calcification properties of HATMSC2 secretome the calcification medium with 50% of secretome was used. Direct culture of VSMCs on the biomaterial showed inhibition of cell proliferative activity and cytotoxicity confirmed by light microscopy. The MTT assay using biomaterial extracts confirmed that the tested biomaterial has strong cytotoxic properties similar to 10% DMSO control. Therefore, this biomaterial requires further modifications. A pilot stydy showed that the presence of 50% of the HATMSC2 secretome in the culture medium reduced calcium deposition by 95% in an *in vitro* VSMC calcification model, indicating a potent anti-calcification effect of the HATMSC2 secretome. Anti-calcification properties o HATMSC2 secretome will be explored as part of my doctoral thesis.

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Photon avalanche in Pr^{3+}, Yb^{3+} co-doped crystals – experimental and simulated results

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Photon avalanche (PA) is one of kinds of photoluminescence processes. Simultaneously, PA is an energy up-conversion phenomenon, where emitted photon has higher energy than absorbed. PA is unique due to highly non-linear increase of luminescence intensity in response to very tiny increase of excitation source pump power density. This dependence has characteristic s-shape. The PA process is characterized by slope (S) of the s-shape curve and PA threshold (PA_{TH}) indicating the pump power density above which PA exists. PA first was observed in a quantum counters doped with Pr^{3+} ions [1], and then in many bulk crystals, fibers and waveguides doped with different lanthanide ions [2]. However, obtaining PA in smaller scale was a challenge, but it was recently achieved for Tm^{3+} ions doped $NaYF_4$ nanocrystals [3], Tm^{3+} ions doped $LiYF_4$ micro- and nanocrystals [4] as well as Pr^{3+}, Yb^{3+} ions co-doped $NaYF_4$ nanocrystals [5], [6]. In a present work β-$NaYF_4$ nanocrystals doped with Pr^{3+} as well as co-doped with Pr^{3+} and Yb^{3+} ions were synthesized by thermal decomposition of lanthanide salts. The samples were investigated under excitation with 852 nm, which is resonant with excited state absorption (ESA) of Pr^{3+} ions and simultaneously far from the resonance with ground state absorption (GSA) of these ion, what is one of the key conditions necessary to observe PA. Multicolor emission was successfully observed in Pr^{3+}, Yb^{3+} co-doped crystals, while singly Pr^{3+} doped have shown no emission. PA features were demonstrated for two the most intense emission peaks: at 482 nm and 607 nm. Higher S and lower PA_{TH} values were observed for core-shell nanocrystals, comparing with cores. The biggest S: 8.6 and 9.0 and the lowest PA_{TH}, namely 286 kW/cm^2 and 281 kW/cm^2 for emissions 607 and 482 nm, respectively, were obtained for core-shell nanocrystals co-doped with 0.5% Pr^{3+},15% Yb^{3+} ions. Moreover, simulated calculations were performed and the key role of Yb^{3+} ions, which are necessary to observe PA emission from Pr^{3+} ions in such excitation conditions was confirmed.

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Antimicrobial activity of halogenated COSAN derivatives

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Antibiotic resistance is one of the biggest global health problems. Infections caused by bacteria from the ESKAPE group are difficult to treat due to their resistance to numerous antibiotics. Thus, new antimicrobial agents are diligently needed [1].

COSAN is a representative of metallacarboranes that has unique physicochemical properties (e.g. σ-aromaticity, an ability to form dihydrogen bonds, 3-center-2-electrons bonds). A wide group of COSAN's derivatives demonstrate antimicrobial activity [2]. I_2-COSAN holds a prominent position among them. Its biological and physicochemical properties have been extensively studied [3-5]. However, the properties of other halogenated derivatives of COSAN remain unexaminated.

The aim of the research was to investigate the effect of halogen substitution on the antimicrobial activity of obtained derivatives. For selected derivatives, time-kill kinetics were determined to assess the antimicrobial effect over time. Furthermore, the antimicrobial activity was correlated with the lipophilicity of the compounds.

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Flexible solar cells and other phenomena – the world of hybrid perovskites

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In the vast realm of materials science, a class of compounds known as hybrid organic-inorganic perovskites (HOIPs) has garnered significant attention from researchers and industry. The three-dimensional (3D) lead halide HOIPs of the ABX_3 formula with methylammonium and formamidinium A-site cations have recently revolutionised the field of photovoltaics. HOIP-based solar cells demonstrate power conversion efficiencies near 26% (comparable to traditional silicon-based cells) while being produced as thin, semi-transparent, and flexible foils. Beyond photovoltaics, HOIPs also demonstrate potential in various optoelectronic devices, including LEDs, lasers, and photodetectors, exhibiting, e.g., high photoluminescence quantum yields (PLQY) and emission colour adjustability [1 – 3].

A limitation of the applications of these materials is their sensitivity to moisture and chemical degradation. To enhance stability, new 3D HOIP analogues are constantly sought through chemical substitution. In this regard, the methylhydrazinium (MHy^+) based HOIPs are worth attention, revealing a tendency to adopt noncentrosymmetric structures and therefore demonstrating non-linear optical effects, ferroelectricity, dielectric switching, etc. Enhanced stability of HOIPs may be also attained by reducing their dimensionality to layered (2D) structures (general formula of A_2BX_4), where the octahedra slabs are separated by organic spacers. In 2D HOIPs, octahedra layers are separated by organic spacers, creating a quantum well effect that results in a larger band gap and higher PLQY in comparison to 3D counterparts. Regardless of the structural alignment and chemical composition, HOIPs reveal great potential for everyday-life applications, especially in the optoelectronic scope [4, 5].

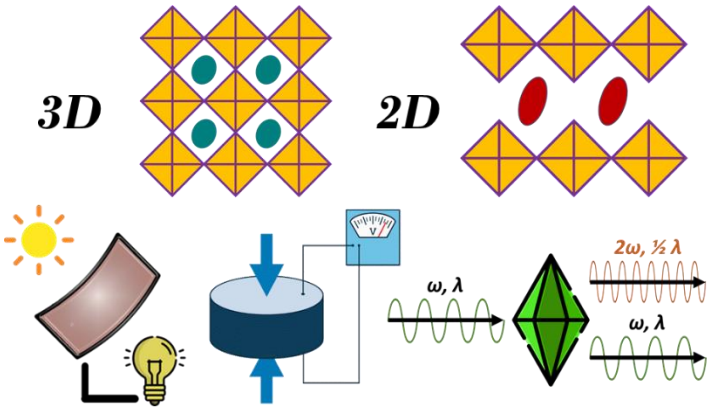

Fig. 1 Hybrid organic-inorganic perovskites (HOIPs) and their properties and applications.

This research was funded by the Polish National Science Centre (project No. 2019/35/B/ST5/00043).

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