
# ABSTRACTS BOOK

8th International Conference InterNanoPoland
16th-17th October 2024
Katowice, Poland

nanonet

SILESIAN NANO CLUSTER

KEY NATIONAL CLUSTER

KATOWICE
*for a change*

# ABSTRACTS BOOK

8th International Conference InterNanoPoland 2024
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Katowice, Poland

CHAIR Adam Szatkowski PhD, MBA

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# AGENDA | 16th-17th October 2024

# Day 1 - 16th October 2024

| Time | Title of the speech | Speaker |
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| **8:15 - 9:00** | **Registration opens** | |
| 9.00 - 9:15 | Welcoming words | Dr inż. Adam Szatkowski, MBA, President in NANONET Foundation<br>Maciej Biskupski, Vice President in Katowice City |
| **9:15 - 10:30** | **Plenary lecture** | **Moderator: Dr inż. Michał Macha, NANONET Foundation** |
| 9:15 - 10:00 | Design of optoelectronic properties in covalent organic frameworks | Prof. Dmytro F. Perepichka, McGill University, Canada |
| 10:00 - 10:30 | Opportunities and trends in modern Nanotechnology | Dr Denis Koltsov, Director in Brec Solutions |
| **10:30 - 11:00** | **Coffee break / Poster session: Research and technologies for the development of the nanotechnology industry** | |
| **11:00 - 12:40** | **Nanotechnology in medicine \| by University of Silesia** | |
| 11:00 - 11:20 | Nanotechnology in medicine: innovative coatings for stents and other cardiovascular implants | Prof. dr hab. n. med. Wojciech Wojakowski, Medical University of Silesia in Katowice |
| 11:20 - 11:40 | The water-soluble fullerene nanomaterials for anti-cancer treatment | Dr hab. inż. Maciej Serda, University of Silesia in Katowice |
| 11:40 - 12:00 | Resorbable amorphous-nanocrystalline calcium-based alloys | Dr hab. inż. Rafał Babilas, Prof. PS, Silesian University of Technology |
| 12:00 - 12:20 | Commercializing R&D case study based on NanOX transplantation system | Mgr inż. Julia Zakrzewska, Nanogroup S.A. , Łukasz Paciorkowski A4BEE, Macieja Gaika A4BEE Sp. z o.o. |
| 12:20 - 12:40 | Cancer treatment with magnetic hyperthermia using nanoparticles | Mgr inż. Adam Czempik, University of Silesia in Katowice |
| **12:40- 13:30** | **Lunch / Poster session: Research and technologies for the development of the nanotechnology industry** | |
| 13:30 - 14:45 | Organic, carbon and hybrid nanoelectronics \|by Silesian University of Technology | |
| 13:30- 13:50 | Tetrazines and heptazines. Remarkable electron-poor aromatics with outstanding properties | Prof. Pierre Audebert, ENS Paris-Saclay, France |
| 13:50 - 14:10 | Recent advances in electrochromic materials and devices | Prof. Igor Perepichka, Silesian University of Technology |
| 14:10 - 14:30 | Heavy-metals-free blue light-emitting quantum dots for color conversion and emissive display application | Prof. dr hab. inż. Artur Podhorodecki, QNA Technologies S.A. |
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| 15:30 - 15:45 | Fluorene-based solid additives for high-performance non-fullerene-based organic solar cells | Dr Manohar Reddy Busireddy, Silesian University of Technology |
| 15:45 - 16:00 | Photoactive covalent triazine framework for CO2 reduction | Dr Sebastian Raja, Silesian University of Technology |
| **16:00 - 16:10** | **Coffee break / Poster session: Research and technologies for the development of the nanotechnology industry** | |
| 16:10 - 17:40 | **Discussion Panel \| Nanotechnology: opportunity or danger \| by University of Silesia**<br>Moderator: Dr hab. Anna Bajorek, prof. US, Institute of Physics,University of Silesia in Katowice, Prof. dr hab. Maria Augustyniak, University of Silesia in Katowice, Prof. dr hab. Robert Musioł, University of Silesia in Katowice, Dr hab. Sławomir Boncel, prof. PŚ, Silesian University of Technology, Dr Sławomir Sułowicz, University of Silesia in Katowice, Dr Anna Nowak, University of Silesia in Katowice | |
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# AGENDA | 16th-17th October 2024

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|---|---|---|
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| **10:55 - 11:20** | **Coffee break / Poster session: Research and technologies for the development of the nanotechnology industry** | |
| **11:20 -12:00** | **Discussion Panel \| Circular economy: chances and opportunities (GOZ:szanse i możliwości - panel w języku polskim)** | **Dr Agnieszka Piekara - Wrocław University of Economics, & Agnieszka Brejdak - CEO ECOLOOP** |
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# DESIGN OF OPTOELECTRONIC PROPERTIES IN COVALENT ORGANIC FRAMEWORKS

D. F. Perepichka (1)
1. Department of Chemistry, McGill University, Monreal, Canada
E-mail: dmytro.perepichka@mcgill.ca

Covalent Organic Frameworks (COFs) are covalent two- (2D) and three-dimensional (3D) polymers with a well-ordered structure and precisely controlled porosity, pioneered by Omar Yaghi in 2005. The combination of high accessible surface area (often >1000 m2/g) and strong electronic coupling in COFs creates new opportunities for applications in sensing and energy. Furthermore, 2D COFs constructed with π-conjugated monomers and linkers can combine 2D electron confinement properties (famous in graphene) with a tuneable band structure and semiconducting behaviour.[1]

In this presentation, I will summarize the achievements of the field of optoelectronically functional COFs and present our own work in molecular design of COFs with phosphorescent, semiconducting and magnetic properties.[2,3]

References:
[1] D. F. Perepichka, F. Rosei, Science 2009, 323, 216.

[2] G. Galeotti et al. Nat. Mater. 2020, 19, 874. V. Lakshmi et al. J. Amer. Chem. Soc. 2020, 142, 2155.

[3] E. Hamzehpoor et al. Nat. Chem. 2023, 15, 83.

# OPPORTUNITIES AND TRENDS IN MODERN NANOTECHNOLOGY

Dr Denis Koltsov (1, 2)
1. BREC Solutions, Turzyn, Poland
2. ISO/TC229 (Nanotechnologies), Geneva, Switzerland
E-mail (denis@brec-solutions.com)

Nanotechnology has captured several generations of academics, investors and policy makers. Since the official launch of US National Nanotechnology Initiative many countries followed. Maor investments flowed into this horizontal area of innovation. Many Nobel prises later and billions of Euros spent on fundamental research and commercialisation it is time to take stock of developments but also describe where the whole field is moving to and what are the threats and pitfalls we have seen along the way.

Having spent many years in nanotechnology innovation area it is important to note the hype bubbles and resulting ups and downs of investment, commercialisation and even regulatory trends. How much more innovation is there in this large field? Have we seen it all in terms of wonder materials and high impact novel applications?

I will present a few case studies where nanotechnology really made an impact. I will outline the trends in nanotechnology moving forward. Will there be more commercial applications and discoveries? What does investment and funding community make of this? How can we start new businesses and spinouts in this dynamic field?

# NANOTECHNOLOGY IN MEDICINE: INNOVATIVE COATINGS FOR STENTS AND OTHER CARDIOVASCULAR IMPLANTS

prof. Wojciech Wojakowski, MD, PhD,
Katowice, Poland
Email: wwojakowski@sum.edu.pl

The use of new biomaterials and nanocoating technologies in cardiovascular devices, particularly coronary stents, drug-eluting balloons (DEBs), and heart valves, represent transformative advancements in interventional cardiology. These innovations aim to enhance device performance, improve patient outcomes, and address the limitations of traditional materials and methods.

Biomaterials play a crucial role in the design and functionality of cardiovascular devices. Advanced materials such as biodegradable polymers, medical-grade metals, and biologically derived substances are engineered to improve biocompatibility and reduce inflammatory responses. For instance, drug-eluting stents (DES) utilize these biomaterials to facilitate controlled drug release, preventing restenosis by inhibiting smooth muscle cell proliferation while minimizing systemic toxicity. The integration of biomaterials also promotes tissue regeneration and angiogenesis, essential for long-term device success.

Nanotechnology further enhances the effectiveness of these devices through the application of nanocoatings and nanoparticles. Nanocoatings can improve the surface properties of stents and DEBs, enhancing drug retention and release profiles. Nanoparticles serve as targeted drug delivery systems, allowing for localized treatment of atherosclerotic lesions while reducing adverse effects. This precision in drug delivery is particularly beneficial in the context of DEBs, where antiproliferative agents are directly applied to arterial walls to prevent restenosis without leaving permanent implants.

In heart valve applications, nanotechnology contributes to the development of bioprosthetic valves with improved durability and reduced thrombogenicity. Nanocoatings can enhance the hemocompatibility of valve surfaces, decreasing the risk of clot formation and improving overall patient outcomes.

Overall, the incorporation of new biomaterials and nanocoating technologies in cardiovascular interventions not only addresses existing challenges but also opens new avenues for personalized medicine. As research continues to evolve, these innovations hold the potential to significantly improve the safety and effectiveness of treatments for cardiovascular diseases, ultimately enhancing patient care and quality of life.

# THE WATER-SOLUBLE FULLERENE NANOMATERIALS FOR ANTI-CANCER TREATMENT

Dr hab. inż. Maciej Serda
Insitute of Chemistry, University of Silesia in Katowice
maciej.serda@us.edu.pl

Pancreatic ductal adenocarcinoma (PDAC) is an extremely aggressive type of cancer with a poor prognosis and a five year survival rate of less than 5%. Unfortunately, traditional chemotherapy, which is usually based on gemcitabine is not effective. Although new therapies are vigorously sought after in this field, no efficient remedy is available as yet, including novel drug design strategies, such as nanomedicine, immuno- or gene related therapies. The main goal of our studies was to develop a fullerene-based nanoplatforms for treatment and diagnosis of pancreatic tumor. The first line of chemotherapeutic drugs that were modified in that study were gemcitabine and EGFR inhibitor Erlotinib.

Here we used three different strategies to create novel anti-cancer fullerene derivatives, mainly via Bingel Hirsch reaction and direct amination of fullerene core. The developed synthetic protocol was able to produce a highly water-soluble[60]fullerene nanoconjugate with gemcitabine in good yields. The physio-chemical characteristics of the fullerene nanomaterial confirms that two gemcitabine units are attached to the [60]fullerene scaffold via formation of amide bonds. In the second approach we synthesized triazole derivative of Erlotinib, which was further conjugated aminofullerenes (Gd@C82, C70 and C60). In the third approach we discovered that created sugar derivatives of [60]fullerene could inhibit non-receptor kinases Fyn A and BTK and therefore maybe be useful as anti-cancer agents [1-3].

We characterized modified buckyballs using NMR, FT-IR, UV-VIS and XPS spectroscopy; each step of synthesis was also monitored using ESI and MALDI mass spectrometry. The size and morphology of synthesized fullerene nanomaterials were analyzed using dynamic light scattering methodology followed by TEM analysis, confirming formation of fullerene aggregates. For gadolinium containing fullerene derivative Gd@C82, both relaxation times T1 and T2 were measured, confirming it's high potential for using as MRI-contrast agent. For all synthesized fullerene nanomaterials photochemical studies (singlet oxygen phosphorescence and EPR-spin trapping) were also carried out to measure generation of singlet oxygen and superoxide which are important when studying fullerenes phototoxicity. All tested fullerene nanomaterials were tested for their cytotoxicity effects on pancreatic cancer cell lines (Pan-01, PAN-2 and AsPC-1) studying in depth their cellular mechanisms of action, in particular cell death, cell cycle and autophagy.

This work was supported by National Science Centre (Poland) Grant OPUS (UMO-2019/35/B/NZ7/02459) awarded to Dr. Maciej Serda.

# RESORBABLE AMORPHOUS-NANOCRYSTALLINE CALCIUM BASED ALLOYS

Rafał Babilas
Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Konarskiego 18a St., 44-100 Gliwice, Poland
E-mail: rafal.babilas@polsl.pl

Resorbable alloys are a promising class of biomedical materials that have received great attention due to their use as temporary medical implants [1]. The dominant class of materials used for such implants are magnesium and calcium alloys [2]. Moreover, Ca-Mg-Zn alloys are a new family of bioresorbable materials that can be applied as potential orthopaedic implants. Corrosion activity may be controlled by the introduction of alloying elements such as ytterbium, boron and gold [3]. Therefore, the objective of the investigation is to study the effect of the addition of B and Au on the ability and active behavior of Ca-Mg-Zn-Yb metallic glasses in Ringer's solution.

New resorbable Ca32Mg12Zn38Yb18-xBx (x=1,2,3 at.%) and Ca32Mg12Zn38Yb18-2xBxAux (x=1,2) alloys were designed and cast in a form of plates by using pressure copper die-casting method. Microstructural investigations showed that the alloys were mainly amorphous, while small reflections from the nanocrystals were observed. The biocorrosion behavior of the plates was tested by hydrogen evolution measurements, electrochemical polarization tests, and electrochemical impedance spectroscopy in Ringer's solution at 37 °C. The corrosion analysis was also supplemented by X-ray diffraction and photoelectron spectroscopy.

Electrochemical polarization and immersion tests in Ringer's solution at 37 °C revealed that the CaMgZnYbB alloys had significantly higher corrosion resistance than CaMgZn alloys. Corrosion resistance measurements revealed that the alloys manifest improved corrosion resistance. The corrosion current density for the Ca32Mg12Zn38Yb18-2xBxAux alloys (x = 1, 2) was 18.46 and 8.79 μA/cm2, which is lower than for pure Mg (47.85 μA/cm2) and Zn (33.96 μA/cm2). The amount of evolved hydrogen as a function of immersion time was also measured, and the results showed that Ca32Mg12Zn38Yb17B1, Ca32Mg12Zn38Yb16B2, Ca32Mg12Zn38Yb15B3 Ca32Mg12Zn38Yb16B1Au1 and Ca32Mg12Zn38Yb14B2Au2 alloys each released non-toxic volumes of hydrogen (<1 ml/h). The corrosion mechanism of the alloys includes an anodic dissolution, a precipitation of hydroxides, the formation layer of the corrosion product, and the corrosion propagation stage.

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# COMMERCIALIZING R&D CASE STUDY BASED ON NANOX TRANSPLANTATION SYSTEM

J. Zakrzewska, M. Gaik, Ł. Paciorkowski, W. Frąckowiak
NanoSanguis S.A., Rakowiecka 36, 02-532, Warszawa, Poland
A4BEE Sp. z o.o. ul. Muchoborska 8, 54-424 Wroclaw, Poland
A4BEE Sp. z o.o. ul. Muchoborska 8, 54-424 Wroclaw, Poland
NanoSanguis S.A., Rakowiecka 36, 02-532, Warszawa, Poland
Email: j.zakrzewska@nanogroup.eu

Organ transplantation is a life-saving procedure, performed when other treatment methods fail or cannot be used. Due to the worldwide donor shortage, the number of transplants performed is still limited, which leads to the death of many waiting recipients. In search of a solution that would expand organs' pool, medicine turns to higher-risk donor categories. Transplanted organs are categorized into two main groups, depending on whether they were retrieved from the living donor or after his death. In the first case, organs are mostly in good condition due to the short period of the ex-vivo storage. Retrieval from the deceased donors is far more complicated and hazardous. Medicine distinguishes two categories of deceased donors- after confirmed brain death (Donation after Brainstem Death, DBD) and after irreversible cardiac arrest (Donation after Circulatory Death, DCD). Organs retrieved from both of these donor categories are more susceptible to severe injury due to the prolonged ischemia time and hypoxia. To increase chances of the successful transplantation, every category of the retrieved organ demands strict storage and transport conditions. Worldwide standard techniques- Static Cold Storage (SCS) and Hypothermic Machine Perfusion (HMP) are commonly used and well-tried, but lack the organ's condition improvement effect. In contrast to mentioned methods, it was proven that perfusion temperature elevation to 37 Celsius degrees with simultaneous oxygen supplementation can induce organs' self- recovery mechanism and restore organs metabolism.

System NanOx, which consists of the acellular perfusion fluid and mobile perfusion apparatus, would not only maintain the organ in a stable condition during its transport to the recipient, but would also improve its parameters owing to perfusion physiological conditions and proper supplementation. The device is designed for 12 hours of kidney perfusion in the whole temperature range, from 4 to 37 Celsius degrees, with pulsatile fluid flow, which mimics natural body conditions and with oxygen supplementation. Device is provided with sensors, which allow constant control of the crucial physicochemical perfusion parameters. Until now our company performed a number of experiments on isolated porcine kidneys. Gained experience let us perform successful autotransplantation of the porcine kidney after 12 hours of the oxygenated subnormothermic perfusion with NanOx fluid in the designed device.

The transition of the NanOX system from concept and research and development (R&D) to commercialization presents a multifaceted challenge, requiring a holistic approach that integrates clinical, technical, and business objectives. Beyond R&D, the success of innovative medical devices like NanOX relies on assembling the right team and strategic partnerships to address critical aspects such as technical platform development, product design, manufacturing scalability, procurement, logistics, and vendor management. This presentation will outline the journey from conceptualization to the R&D phase, focusing on identifying key partners for product development, and will provide insights into the commercialization roadmap and go-to-market strategies. By sharing our experience, we aim to highlight the complexities involved in bringing groundbreaking medical technology to market and the strategic considerations necessary for a successful launch.

# CANCER TREATMENT WITH MAGNETIC HYPERTHERMIA USING NANOPARTICLES

A. Czempik, A. Bajorek
August Chełkowski Institute of Physics, University of Silesia in Katowice,
40-007 Katowice, Poland
E-mail (corresponding author): adam.czempik@us.edu.pl

Cancer is one of the leading causes of death worldwide. It is treated by traditional methods, including chemotherapy and radiotherapy. Although these methods continuously improve, they still cause multiple side effects resulting from harmful effects on healthy cells. Hyperthermia is a therapeutical method for treating different diseases, including cancer, by artificially increasing the temperature of the whole body or some part of it [1]. Using nanocompounds, the hyperthermia process can improve cancer treatment, for example, by concentrating the heat in a tumour region so that the tumour can be reduced or eliminated without significantly affecting the surrounding tissues [2].

Our research investigates magnetic nanocomposites of different types based on spinel ferrite [3]. The chemical composition and obtaining methods can significantly influence their structure and properties. Therefore, we are testing the nanocomposites in multiple ways, specifying their size, shape and crystal structure. Then, we test their behaviour in a magnetic field. The aim is to understand the physics of such magnetic nanocompounds and to choose the ones with the best properties for hyperthermia.

In my presentation, I would like to shed more light on the issue of cancer treatment and explain how nanocompounds can improve this process using magnetic hyperthermia. It will then be discussed which properties of nanocompounds are crucial for this purpose and why the spinel ferrites are suitable candidates. Finally, I will mention some methods for determining the properties mentioned above.

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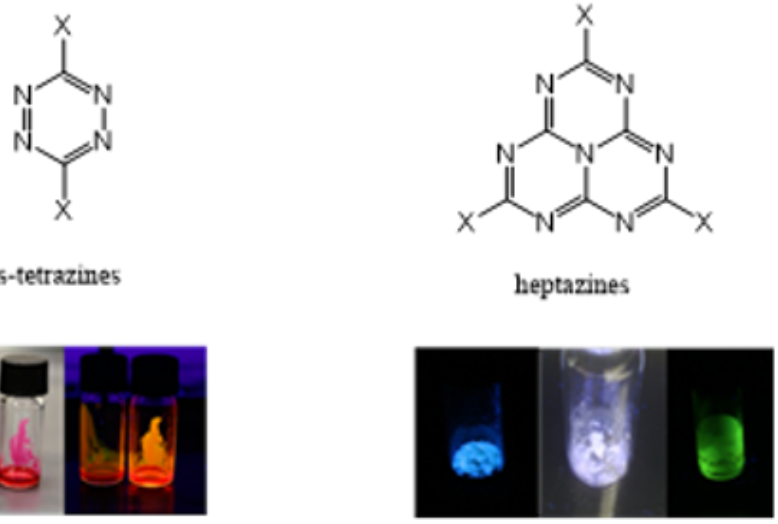
20473-20494.

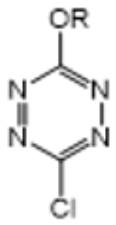
# TETRAZINES AND HEPTAZINES. REMARKABLE ELECTRON-POOR AROMATICS WITH OUTSTANDING PROPERTIES

Pierre Audebert (1,2)
1. Photophysique et photochimie supramoléculaires et macromoléculaires (PPSM – Université Paris-Saclay, ENS Paris-Saclay, CNRS),
2. Institut de recherche XLIM (CNRS, Université de Limoges), France

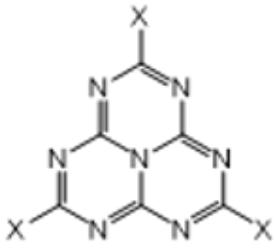
s-Tetrazines1, and more recently heptazines2,3, which count much less reported examples, belong to the small family of the most electron deficient, high-nitrogen content, though stable aromatic heterocycles (Fig. 1). This peculiarity confers them original properties, among which delayed fluorescence (the case of heptazines), a high electrochemical reduction potential, and a high oxidation potential regarding organic photocatalysis. In addition, some heptazines can lead to enhanced electron transport in OPV devices4. However, their synthetic approach, especially for heptazines, is still demanding. We will present new strategic synthetic procedures involving heptazines, and introduce recent results obtained with new derivatives of both families.




This lecture will start recalling a few striking results on tetrazines obtained some time ago; for example, we will describe very low-viscosity tetrazine-based fluorescent liquids, as well as tetrazine dyads displaying tunable intense fluorescence. The presentation will then treat with more recent results on the exceptionnal family of molecular heptazines. At the origin, a new synthetic procedure of heptazines using mechanochemistry, elaborated in the PPSM laboratory, will be presented. The original delayed fluorescence of some heptazines, which are the first organic species to present sometimes a singlet-triplet inversion, will be detailed, and notably one example of singlet-triplet inversion will be presented (Scheme below). First results in photocatalysis will be introduced. Finally, the synthesis and properties of a new type of heptazine-porphyrin bi-functional dyad will be presented.

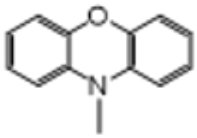



s-tetrazines for electrofluorochromism




heptazines

X = Pyrazoles, Imidazoles,

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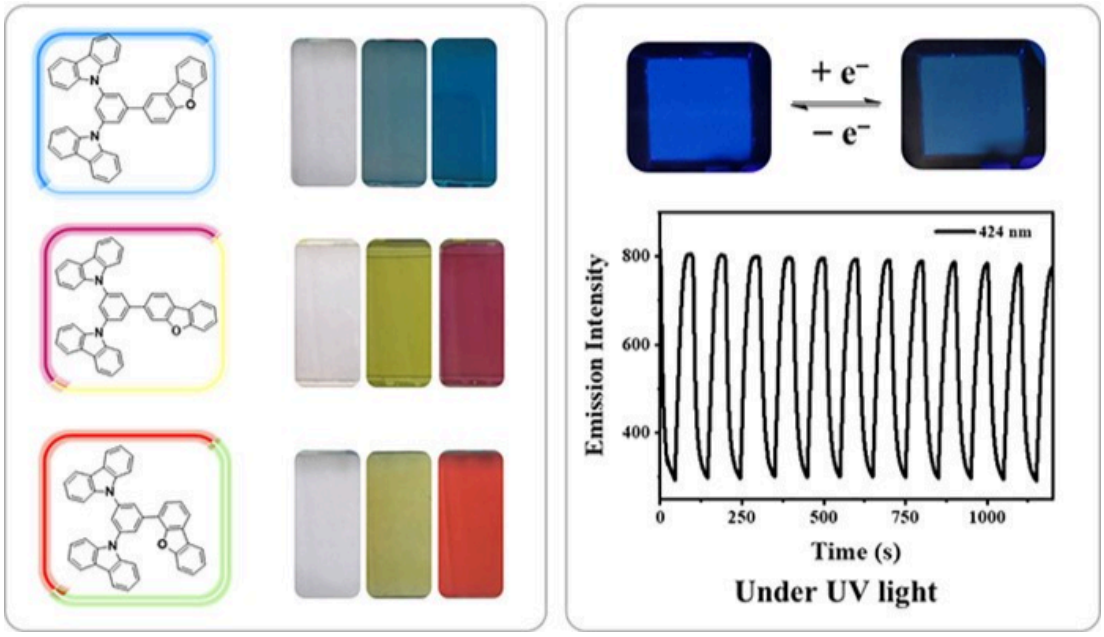
# RECENT ADVANCES IN ELECTROCHROMIC MATERIALS AND DEVICES

Igor F. Perepichka
Department of Physical Chemistry and Technology of Polymers, Faculty of Chemistry,
and Centre for Organic and Nanohybrid Electronics,
Silesian University of Technology, Konarskiego 22b, 44-100 Gliwice, Poland
E-mail: igor.perepichka@polsl.pl

Electrochromism, the phenomenon displayed in some electroactive materials of reversible color change in response of applied voltage due to electrochemical redox reaction is widely studied for decades and electrochromic materials have already found many applications in smart windows, sunglasses, displays, thermal control and energy storage devices. In this presentation, I will discuss recent advances in electrochromic materials and devices highlighting some our research as well as literature data. I will particularly focus on such aspects of electrochromic material applications as neutral black electrochromic materials for smart windows,[1] multicolor electrochromism[2] and engineering of dual electrochromic/thermochromic devices[3] to achieve an absolute private state in device operation. Some other aspects of development of electrochromic materials and devices will also be discussed (e.g. electrofluorochromism, electrochromic textile for camouflage applications[4]).



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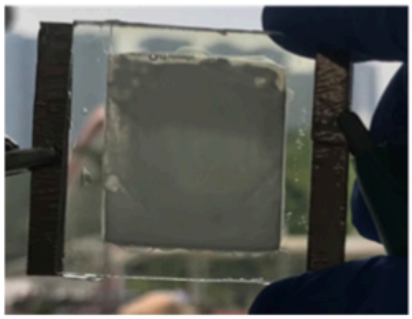

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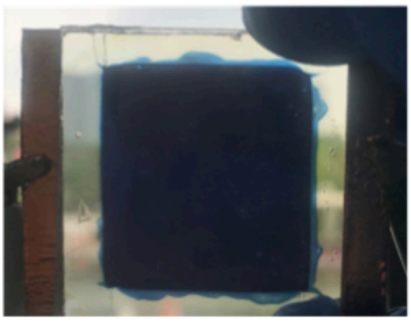

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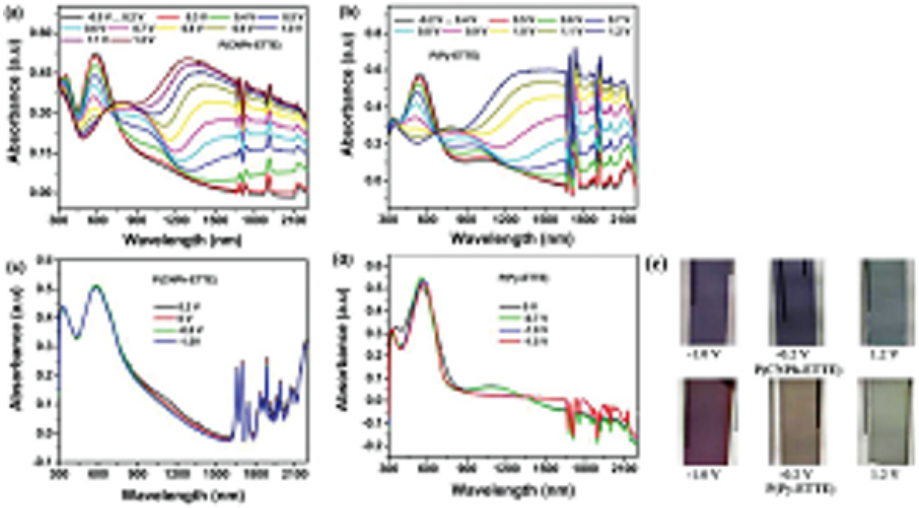

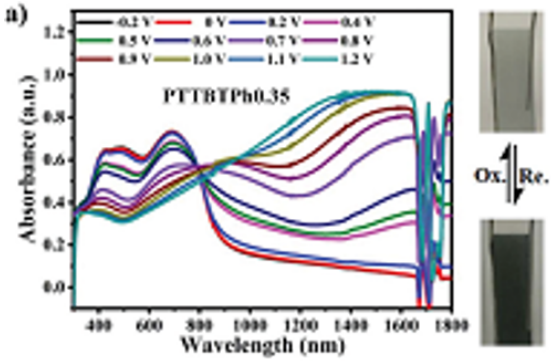


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# HEAVY-METALS-FREE BLUE LIGHT-EMITTING QUANTUM DOTS FOR COLOR CONVERSION AND EMISSIVE DISPLAY APPLICATION

Artur Podhorodecki – presenting author
QNA Technology S.A., ul. Duńska 9, 54-427 Wroclaw, Poland
E-mail (corresponding author): artur.podhorodecki@qnatechnology.com

One of the intriguing yet largely unexplored technological approaches to fabricating microLED displays involves utilizing UV micro LEDs alongside colloidal quantum dots as light-converting materials. A main difference from traditional blue LEDs backlighting lies in the necessity of integrating hard-to-make and hard-to-get blue QDs in addition to red and green QDs. Despite this challenge, this approach offers several significant advantages, such as the lack of blue light leakage or better absorption efficiency of red and green QDs in the UV range as to name the most important ones.

In this presentation, we will show the properties of our UV curable inks, which are based on heavy metal-free, blue light-emitting QDs known as PureBlue.dots, which can be used for UV light conversion to high quality 455 nm blue light which can be used in microLED displays. Furthermore, we will showcase our recent findings obtained from electroluminescent devices utilizing PureBlue.dots as the active material.

Many thanks to all of the members of QNA Technology team working on the development of Pure Blue dots.


QNA Technology S.A. implemented an R&D project co-financed by European Funds: "Innovative PureBlue.dots' limited-toxicity synthetic technology for high quality blue light sources" under the Intelligent Development Operational Program 2014-2020, Priority I "Support for R&D by enterprises", Sub-measure 1.1.1., project number: POIR.01.01.01-00-1698/20-05.

# UV-CURABLE INKS BASED ON ACRYLATE OLIGOMERS FOR SECURING DOCUMENTS

M. Adamczyk (1), K. Skupień (1), A. Stępień (1), K. Twardosz (1), K. Leśniewska-Matys (2), M. Kukielski (2)

1. 3D-nano Krzysztof Skupień, Cracow, Poland,

2. Łukasiewicz Research Network - Institute of Microelectronics and Photonics, Warsaw, Poland

E-mail (corresponding author): madamczyk@3d-nano.com

UV-curing is regarded as a broadly developing technology in printing due to its significant advantages, such as instant drying, low space and capital requirements for curing equipment. Additionally, the possibility of preparing a wide range of ink formulations can enhance their parameters, like long-term stability and chemical resistance to various bleaching agents and atmospheric conditions. The implementation of these material specifications may lead to the beginning of new directions to further expand their applications.As far as is known, the development of methods to enhance protection of the documents and reduce the cost of security inks remains a challenge.

In this work, the correlation between ink compositions, rheological properties, adhesion and the printability on selected substrates (security paper and polycarbonate foil) was systematically investigated. The presented studies involve crucial criteria for preparing inks by optimizing various combinations of the main substances (oligomers, photoinitiators, and monomers) to develop inks suitable for the defined requirements.

The final aim of the present work is to formulate a unique anticounterfeiting inks dedicated to three different printing techniques (flexographic, screen and offset printing) by mixing prepared inks with taggants. However, the future perspectives and potential of these components in detecting forged copies of documents require extensive research.

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# INFLUENCE OF DIFFICULT TO QUANTIFY PARAMETERS ON PROCESS REPEATABILITY IN CASE OF SOLID STATE SYNTHESIS

M. Kukielski (1), A. Pantoł-Boczoń (1), K. Leśniewska-Matys (1), A. Kozłowska (1), A. Malinowska (1), M. Adamczyk (2), A. Stępień (2)
1. Łukasiewicz Research Network, Institute of Microelectronics and Photonics, Warsaw, Poland
2. 3D-nano Krzysztof Skupień, Cracow, Poland
E-mail (corresponding author): michal.kukielski@imif.lukasiewicz.gov.pl

Consistency is one of the most important factors when trying to introduce a new process to the industry. Having process that is highly repeatable helps reduce waste during production (as faulty products need to be discarded or in best case, if possible, remade) increases safety during production and quality of the final product. This is doubly important for fields that require highly specific parameters like for example security materials. In this case high variance in characteristics of obtained materials between product batches may result in relaxation of the verification conditions, which in turn makes them easier to counterfeit. Otherwise some products could have been recognized as counterfeited despite being legit (if the verification conditions are more stringent than the variance between samples).

Unfortunately, many processes are prone to outside and human factors, that quite often are difficult to quantify. That is doubly true during R&D period, when the production is not fully automated. Another time when presence of unquantified process parameters can be an issue is during the upscaling, when procedures need to be adjusted to fit larger equipment and human element is reduced. Thus it is important to recognise and limit influence of such variables on the process.

In this presentation process of solid state synthesis will be analysed in order to identify possible difficult to quantify factors. Furthermore, influence of such factors on phase purity of ceramic powders will be discussed. Possible solutions to remove or limit impact of those factors will also be proposed.

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# WIDE COLOR GAMUT LUMINESCENT THERMAL INDICATORS BASED ON AN ORGANIC ENERGY DONOR-ACCEPTOR SYSTEM

P. Ślęczkowski (1), F. A. Soares (1), G. Martinez-Denegri (1)
1. International Centre for Research on Innovative Biobased Materials (ICRI-BioM) – International Research Agenda, Lodz University of Technology, Lodz, Poland
E-mail (corresponding author): piotr.sleczkowski@p.lodz.pl

Excited state intramolecular proton transfer (ESIPT) molecules have demonstrated unique fluorescent properties including large values of Stokes shift [1]. However, their application in thin films and related technologies is limited and mainly focused on the realization of efficient white light organic light-emitting diodes (WOLEDs) [2]. In frame of exploring new applications for ESIPT compounds, we have designed and synthesized two benzothiazole isomers with tailored optical properties in thin films.

First, we have demonstrated that tuning of fluorescence emission wavelength and fluorescence quantum yield for those compounds resulted from modified (inter)molecular interactions in thin films. The latter were achieved by optimization of several parameters, including selection of solvent used for deposition and by studying the effect of the annealing temperature [3]. Basing on this approach, we have also elaborated more advanced materials in form of thin films incorporating ESIPT molecules. It was achieved by doping the ESIPT analogues with a novel far-red fluorescent dye, thus realizing organic Förster resonance energy transfer (FRET) systems. We have explored the role of their molecular interactions by studying their morphology and fluorescent properties. Such analysis enabled us to develop unique FRET temperature indicators, which are air-stable, capable of detecting multiple temperature ranges, and compatible with naked eye inspection under UV illumination. The application of the thin films as thermal indicators is demonstrated for simple visual inspection and for ratiometric sensing, showing noticeable color changes every 20 °C and remarkable sensitivities of up to 14 % C-1.

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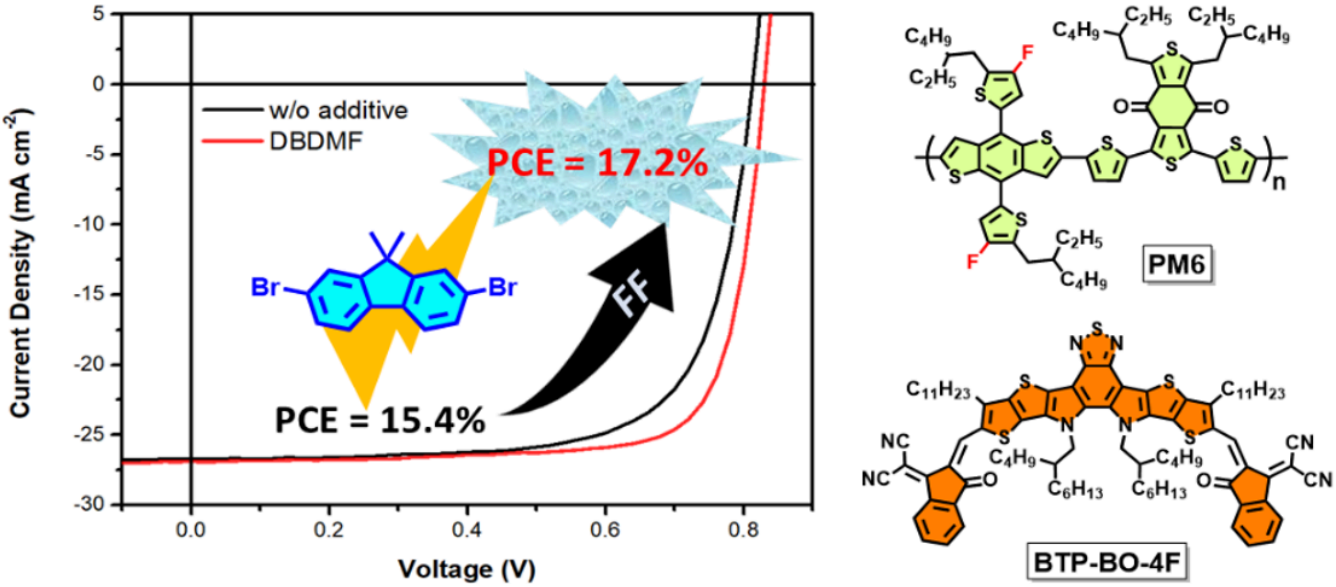
# FLUORENE-BASED SOLID ADDITIVES FOR HIGH-PERFORMANCE NON-FULLERENE-BASED ORGANIC SOLAR CELLS

Manohar Reddy Busireddy, (1,2) Sheng-Ci Huang, (2) Chain-Shu Hsu, (2) Igor F. Perepichka (1)

1. Department of Physical Chemistry and Technology of Polymers, Faculty of Chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland.
2. Department of Applied Chemistry, and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, 1001 University Road, Hsinchu 30010, Taiwan.

E-mail address (corresponding author): busireddymanohar90@gmail.com

Organic solar cells (OSCs) have drawn more attention because of their rapid development and great potential in large-area flexible electronics.1 Recently, volatile solid additives have been widely used in optimizing morphologies of active layers and improving device performances for non-fullerene (NF)-based OSCs.2-3 Most solid additives, however, still suffer severe problems such as unsuitable volatile temperatures and the requirement of extra solvent additives.4 In this work, we design a new solid additive 2,7-dibromo-9,9-dimethylfluorene (DBDMF) with a high crystallinity and suitable volatile temperature as an additive for NF-based OSCs, is designed. DBDMF can suppress the over-aggregation of the NF acceptors (NFAs) and improve the material rearrangements after thermal annealing because of the good miscibility with the NFAs. As a result, DBDMF-treated OSC devices display more favorable film morphologies and phase separation, well-balanced charge mobilities, higher electron transfer rates, and better device stability. Consequently, the PM6:BTP-BO-4F binary system shows an outstanding PCE of 17.2% from 15.3% with a simultaneous increase in fill factor (FF) from 71.4 to 77.1%. Additionally, DBDMF has been applied to two other photoactive layers, manifesting the general applicability. This study demonstrates a feasible and promising approach to develop volatilizable solid additives for improving the performance and stability of NF-based OSCs. Authors acknowledge the supporting actions from EU's Horizon 2020 ERA-Chair project ExCEED, grant agreement No. 952008.

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# PHOTOACTIVE COVALENT TRIAZINE FRAMEWORK FOR CO2 REDUCTION

Sebastian Raja (1, 2), Igor F. Perepichka (1, 2), Eduardo A. Reis (3) Caue Ribeiro (3)
1. Department of Physical Chemistry and Technology of Polymers, Silesian University of Technology, Marcina Strzody Street 9, Gliwice 44-100, Poland
2. Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego Street 22b, Gliwice 44-100, Poland
3. National Nanotechnology Laboratory for Agribusiness (LNNA), Embrapa Instrumentação, São Carlos-SP, 13560-970, Brazil
E-mail (corresponding author): Raja.Sebastian@polsl.pl.

Global warming, driven by rising CO2 levels, demands urgent solutions. Fossil fuels are the main contributors to CO2 emissions, spurring research into alternative energy and CO2 reduction strategies. Photo and electrochemical CO2 conversion to chemicals and fuels has gained interest, but developing catalysts with high selectivity, stability, and suppression of hydrogen evolution reactions (HER) remains a challenge [1]. While inorganic catalysts show promise, they face issues like high costs and resource scarcity. Covalent triazine frameworks (CTFs) offer a viable alternative, with high surface areas, tunable electronic properties, and stability, making them strong candidates for CO2 reduction via photo and electrocatalysis [2]. We recently demonstrated highly conductive carbonaceous supports derived from covalent organic frameworks, employed as effective metal-doped electrocatalysts for CO2 conversion [3]. Herein, we synthesized a CTFs incorporating perylenediimides (PDIs) and triazine precursors via green hydrothermal approach. This metal-free catalyst with rich in nitrogen content demonstrated excellent optical properties and showed the capability of converting CO2 to methanol with high efficiency. Detailed results will be presented at the conference.

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# RESEARCH POSSIBILITIES OF NANOMATERIALS USING XRD AND FTIR TECHNIQUES

K. Urbański (1), B. Puhr (2), A, Jones (2)
1. Anton Paar Poland Sp. z o.o., Warszawa, Polska
2. Anton Paar GmbH, Graz, Austria
E-mail: kamil.urbanski@anton-paar.com

Powder X-ray diffraction (pXRD) is one of the fundamental research methods for nanomaterial investigation. The results of XRD diffraction studies can provide useful information about the phase composition, crystal structure, lattice parameters, interplanar distances, degree of crystallinity and amorphous phase content of the tested sample. Thanks to modern design solutions, the XRD technique significantly increases measurement accuracy and sensitivity, and also push forward to the possibility of performing high quality low-angle X-ray scattering (SAXS) measurements. Thanks to the use of low-angle precision methods, it becomes possible to determine the shape, internal structure, size distribution and porosity of the nanomaterial samples.

A useful analytical method complementing XRD and SAXS studies is Fourier transform infrared spectroscopy (FTIR). Thanks to technique using attenuated total infrared reflection (ATR), it is possible to easily and quickly identify substances, without requiring prior mundane sample preparation. Based on the interpretation of the spectrum and the characteristic absorption bands present, it is possible to identify functional groups complementing the structural information obtained from X-ray methods.

XRD and FTIR methods are an extraordinarily valuable source of information helping to characterize the properties and parameters of the tested nanomaterials. Thorough understanding of the research capabilities of these techniques can provide invaluable assistance in developing and testing new materials.

# NANOIMPRINT LITHOGRAPHY (NIL) – FROM NICHE TO HIGH VOLUME MANUFACTURING

A. Duduś (1), P. Schuster (1)
1. EV Group, DI Erich Thallner Strasse 1, 4782 - St. Florian am Inn, Austria
E-mail: a.dudus@EVGroup.com

Nanoimprint lithography (NIL) made its way from university laboratories (utilizing soft-UV NIL fabrication technique) to a key technology that supports fabrication of novel devices and applications in semiconductor, photonics, and biomedical industries [1]. Up to now expensive direct writing technologies needed to be used to fabricate complex structures. However, nanoimprinting offers an alternative fabrication technique that uses a transparent soft stamp material to transfer structures into matching resist. NIL has shown to be precise and well-suited patterning method of structures with challenging complex geometries with resolution down to sub-100nm [2]. NIL as flexible and low-cost imprinting method is being wider used in fabrication of micro-lenses, meta-type lenses [3] (Fig. 1), silicon photonic application or augmented reality waveguides (Fig. 2). So far only single devices were fabricated by direct writing fabrication due to high cots. NIL offers competitive cost-effective technology that allows to upscale from single device to multidevice wafer level scale by utilize Step and Repeat (S&R) imprint lithography replication technique. Next, such fully populated with devices wafer (S&R master) can be used for high volume manufacturing by applying highly efficient "SmartNIL" or wafer level replication (WLO) method. SmartNIL and WLO allow over a large area parallel structuring of multiple devices in a single step, with a high fidelity in respect to critical dimensions, residual layer, roughness and TTV. Additionally, such nanoimprint devices can be applied on various substrates shapes and sizes by using dedicated coatings such as spin coating, spray coating or inkjet coatings. Inkjet coating as well allows to actively control the residual layer within the device while using different structures height enhancing device (optical) performance. Hence, the NIL achievements, trends, and new developments towards imprinting of various structure types towards high volume manufacturing will be reviewed.

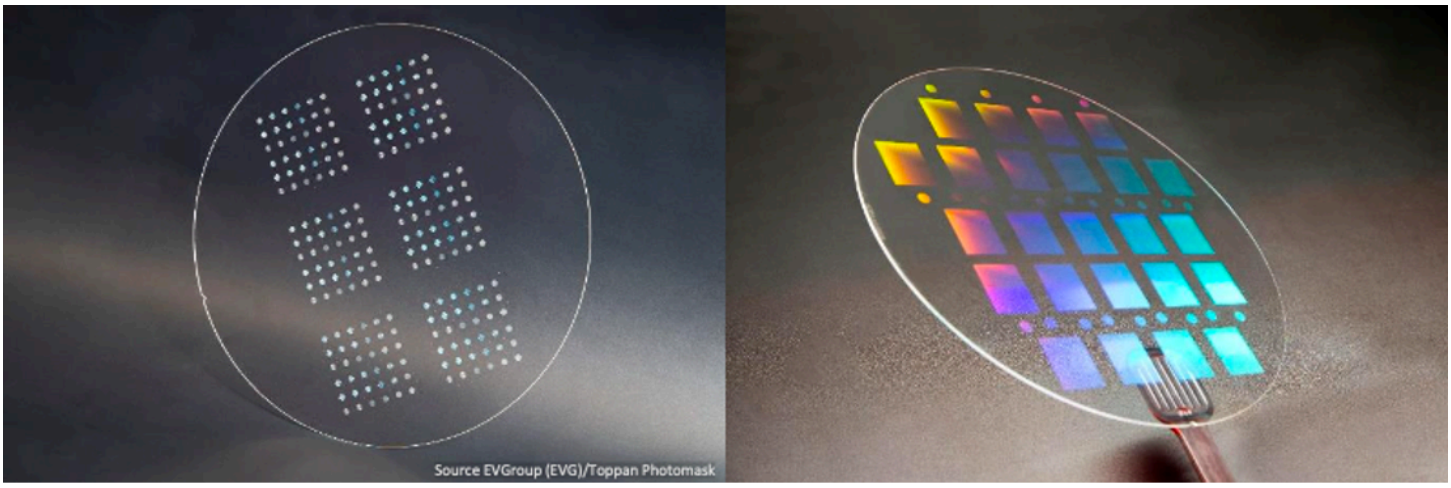


Fig.1 SmartNIL Imprint with meta-type lenses Fig 2. S&R master with augmented reality waveguides

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# METAL ADDITIVE MANUFACTURING: A VERSATILE SOLUTION FROM HEAVY INDUSTRY TO SPACE EXPLORATION

**A.**Kukofka (1), R. Bardo (1), K. Fryzowicz (1), A. Wrona (2)
1. Progresja S.A. Katowice, Poland
2. Sieć Badawcza Łukasiewicz – Instytut Metali Nieżelaznych, Gliwice, Poland
akukofka@progresja.co

In recent years, Progresja S.A. has concentrated its efforts on advancing material science and metal additive manufacturing (AM) technologies, aiming to address challenges across diverse sectors—from heavy industry to space exploration. Research and development activities have led to the acquisition of valuable knowledge on alloy modification for AM applications, process parameter optimization for Laser Powder Bed Fusion (LPBF), and the recyclability of critical materials. Progresja S.A. has also taken significant steps toward contributing to Poland's space sector, collaborating with leading national universities and research institutes.

Progresja's commitment to the space industry began in 2016 with a grant from the Polish Space Agency for advisory services, followed by two successful projects for the European Space Agency (ESA), focusing on additive manufacturing technologies in simulated space environments. These initiatives have equipped Progresja S.A. with substantial experience in applying metal additive manufacturing to both heavy industrial and aerospace applications.

This presentation focuses on the encountered challenges and solutions developed by Progresja's team during R&D projects, such as addressing structural discontinuities in 15–5PH tool steel, mitigating hot cracking in aluminum alloys, optimizing powder manufacturing processes using production waste, and fine-tuning additive manufacturing parameters for refractory metals. Additionally, we will explore the potential of laser additive manufacturing with consumable feeding in different forms for space applications, including novel LPBF technology designed for use in vacuum and zero-gravity environments.

Progresja's work demonstrates that both material science research and technological development prove a high degree of versatility of metal additive manufacturing in a wide range of applications.

# CHARACTERISATION OF NOVEL NANO/COMPOSITES INTENDED FOR TISSUE ENGINEERING APPLICATIONS

K. Haraźna (1), D. Träger (2), K. Lis (2,3), D. Słota (3), K. Niziołek (3), A. Sobczak-Kupiec (1)

1. Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
2. Smart-Mat Students Scientific Association Group, The Bio-Mat Section, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
3. Doctoral School of Cracow University of Technology, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland

E-mail: katarzyna.harazna@pk.edu.pl

Osteoarthritis (OA) is a degenerative condition affecting the joints and is a significant contributor to disability in older adults. This disorder involves the gradual deterioration of joint tissues and the underlying bone. Presently, the primary focus of OA treatment is on managing pain; however, there remains a deficiency in effective, clinically validated therapies that not only relieve pain but also mitigate ongoing inflammation and promote tissue regeneration. Throughout the progression of OA, various components of the joint, including cartilage, subchondral tissue, and bone can undergo degradation over time. Consequently, contemporary materials designed for osteochondral tissue engineering should replicate the joint's layered architecture. In this context, a notable area of current research is the development of hierarchical and gradient materials. [1]

In this study, the objective was to evaluate the physicochemical, structural, morphological and mechanical properties of nano/composites made from calcium phosphates, modified polysaccharide (PS-mod), and other natural macromolecules. A detailed analysis has shown that the resulting nano/composites are promising materials for applications in osteochondral tissue regeneration. However, to confirm this, in vitro studies on, for example, a mouse pre-osteoblast cell line (MC3T3-e1) are needed.

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# EU INITIATIVE ON ADVANCED MATERIALS: STEP TOWARDS EUROPE'S INDUSTRIAL AND SOCIETAL LEADERSHIP

Jarosław Piekarski (1)
1. National Center for Research and Development,
National Contact Point for Horizon Europe,
Warsaw, Poland
E-mail (corresponding author): jarolsaw.piekarski@ncbr.gov.pl

The EU Initiative on Advanced Materials1 aims at consolidating Europe's leadership in advanced materials, crucial for industrial and societal prosperity. This initiative focuses on developing innovative materials that are safe, sustainable, and circular, aligning with the European Green Deal's goals of climate neutrality by 2050. The initiative encompasses the entire lifecycle of materials, from discovery and development to manufacturing and recycling, ensuring they meet high standards of performance and environmental safety.

The implementation of the EU Advanced Materials Initiative involves a coordinated effort between the European Union and its Member States. The EU sets the overarching strategy and provides funding through various programs, such as Horizon Europe, to support research and innovation in advanced materials. Member States are invited to contribute by aligning their national research and innovation policies with the EU's strategic goals. They also may co-fund projects and initiatives, fostering collaboration between national research institutions, universities, and industries. This alignment will help to create a cohesive and dynamic ecosystem for advanced materials research and development across Europe.

The EU Initiative on Advanced Materials will significantly impacts the European industry by enhancing its competitiveness and resilience. By fostering innovation in advanced materials, the initiative supports the development of new, high-performance products and more efficient processes. This is crucial for sectors like energy, mobility, construction, and electronics, which are key to achieving the EU's twin green and digital transitions.

The initiative also aims to fast-track the commercialization of advanced materials, reducing the time from lab to market. This accelerates the adoption of cutting-edge technologies, giving European companies a competitive edge globally. Additionally, it promotes sustainability and circularity, ensuring that new materials are environmentally friendly and contribute to the EU's climate goals.

The Horizon Europe Innovative Materials for EU (IM4EU) partnership2,3 is expected to become a key component of the EU's Advanced Materials Initiative. This co-programmed partnership will focus on the research, development, and integration of advanced materials that are safe, sustainable, and designed for circularity.

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# BUILDING MATERIALS: NEW PERSPECTIVES, NEW CHALLENGES, NEW TECHNOLOGIES

Artur Miros
Łukasiewicz Research Network – Warsaw Institute of Technology, Katowice, Poland
E-mail (corresponding author): artur.miros@wit.lukasiewicz.gov.pl

In the changing world of construction, innovations are key not only to improve the technical parameters of materials, to keep up with changing regulatory requirements [1], but also to support sustainable development. In the Center for New Technologies in Construction, Łukasiewicz Research Network - Warsaw Institute of Technology efforts are being made to to implement the goal of providing building materials that respond to the functional and technological challenges of modern times. The presentation will showcase several works and projects (both completed and ongoing) focused on new or improved construction materials based on broad recycling concepts, reducing the carbon footprint, or improving energy efficiency.

One of the materials developed by Łukasiewicz-WIT is lightweight artificial aggregate produced from sewage sludge, which offers an innovative solution in waste management and can be used as an additive in concrete, road construction, or in agriculture. Another technology to be presented is a thermal insulation material for timber wood construction, produced using synthetic fibers from recycling, such as from used clothing. To reduce the carbon footprint and address the problem of waste from wind turbine blades, a building board with a filling made from processed wind turbine blades will be introduced. Another project, addressing the need to reduce the carbon footprint, is a high-performance fire-resistant board designed for the fire protection of reinforced concrete structures. The presentation will cover both the prospects for large-scale implementation and the challenges related to their production and application.

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# PREFABRICATED WOODEN PARTITIONS FILLED WITH WASTE MATERIALS

JB Balcerowska [1], MW Włodarczyk [2]
[1] Joanna Balcerowska, Ekoinbud, Gdańsk, Poland
[2] Monika Włodarczyk, Ekoinbud, Gdańsk, Poland,
E-mail: m.wlodarczyk@ekoinbud.pl

Ekoinbud, a company specializing in modular wooden construction, has developed prefabricated, eco-friendly wooden partitions with enhanced insulation properties, using filling made from waste materials. The project's aim was to develop an insulating mixture containing waste materials and to create a system of prefabricated wooden frame partitions along with the technology for their production.

As part of the project, a new insulating material was created from naturally derived materials that are by-products of other production processes. The mixture was subjected to a series of tests, including:

a. Fire resistance: In accordance with the PN-EN 13051-1:2019-02 standard, the partitions were tested using the SBI method according to the PN-EN 13823:2020 standard, achieving a classification of D-s2, d1.

b. Acoustic insulation: Partitions with the new mixture achieved R'A1 = 43 dB for the thinnest wall.

c. Thermal transmittance: The U-value for the external partition ranged from 0.16 to 0.178 $W/m^2K$.

d. Building airtightness: The average air exchange rate (n50) for different partitions and structural systems ranged from 1.06 to 1.73 air exchanges per hour at pressure differentials.

e. Fire resistance class: According to the PN-EN 1365-1 method, the partitions met the REI 30 criteria.

f. Insulation blowing technology: A device was developed for mixing, dosing, and blowing insulation into single-sided closed partitions.

The project also required the development of technology for the automation of partition production. Technological research was conducted to improve partition positioning, minimize dimensional deviations, speed up the production process, and enhance the quality of structural connections, contributing to increased airtightness and acoustic insulation.

As a result of the work, a production system for partitions with enhanced thermal, acoustic, and airtightness properties was launched. A system of prefabricated wooden partitions with improved parameters was developed, achieved through the use of industrial wood and cellulose waste, as well as a new, automated production technology. The improved technology, alongside the use of new materials, contributed to better insulation and airtightness of the partitions, which directly impacted the energy efficiency of buildings.

The project outcome positively influenced the implementation of sustainable development principles by utilizing wood and cellulose waste as insulation filling, reducing the carbon footprint, and supporting environmental protection. The automation of production processes increased energy efficiency, streamlined partition production, and improved the quality of the final product.

# EXPANDED PERLITE: THE KEY TO HIGH-PERFORMANCE AND SUSTAINABLE BUILDING SOLUTIONS

P.A. Bolimowski, PhD
SYSTEM 3E S.A. Warsaw, Poland
WSB Merito University, Warsaw, Poland
E-mail: patryk.bolimowski@system3e.com

Sustainable architecture has become a mainstream approach in the construction industry as the world faces increasing environmental challenges. Architects and builders are turning to innovative materials and technologies to minimize environmental impact while maximizing efficiency and performance. One such material gaining prominence is perlite, particularly expanded perlite, and a pioneering technology that leverages its benefits – SYSTEM 3E.

Perlite is a naturally occurring volcanic glass, mined and processed globally. Its unique properties make it valuable in various industries, including construction. Perlite is amorphous, lacking a defined crystalline structure, contributing to its lightweight and insulating characteristics when expanded. Compared to other construction aggregates, perlite is notably lightweight, reducing the load on structural components. Its microcellular structure provides excellent thermal insulation, reducing energy consumption in buildings. Perlite is non-combustible, enhancing fire safety, and its porous nature offers sound absorption, making it ideal for acoustic insulation. Expanded perlite is used in various forms, such as loose fill, insulating lightweight materials, plaster, and base materials to manufacture building elements like SYSTEM 3E. SYSTEM 3E is an innovative construction technology leveraging expanded perlite to create sustainable, high-performance building materials. Developed with a focus on environmental sustainability, SYSTEM 3E addresses key challenges in modern construction. It is a groundbreaking technology for constructing ecological, energy-saving, and economic walls in all types of buildings.

Expanded perlite, combined with the innovative SYSTEM 3E technology, offers a powerful solution for sustainable architecture. Their unique properties provide significant benefits in thermal and acoustic insulation, fire resistance, and overall environmental impact. As the construction industry continues to prioritize sustainability, adopting advanced materials and technologies like SYSTEM 3E will play a crucial role in shaping the future of green building practices.

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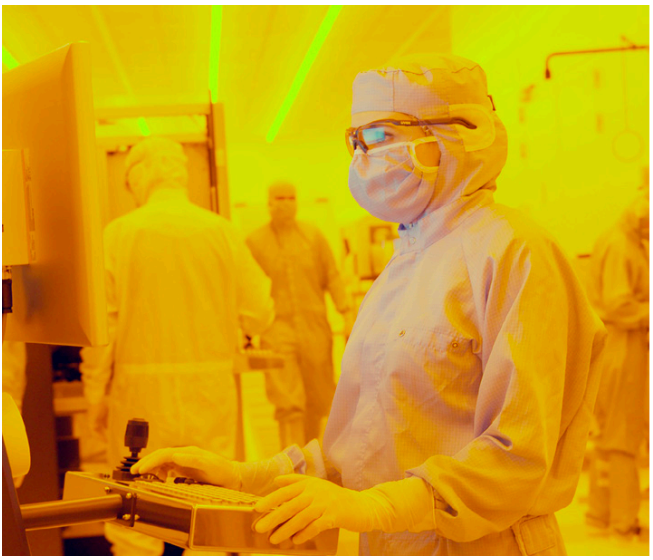

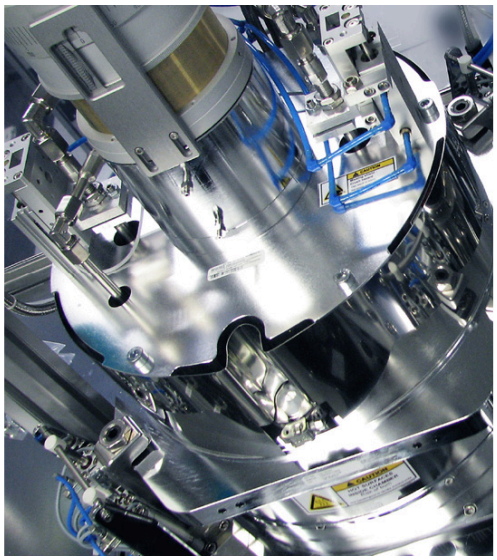

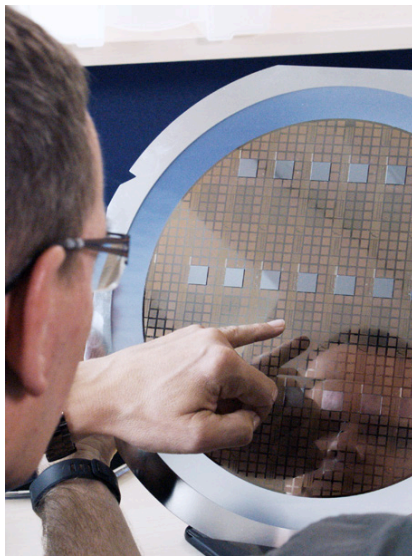

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Prezes Axelon Sp. z o.o. Doświadczony partner w zarządzaniu projektami związanymi z innowacjami, technologią i zrównoważonym rozwojem.

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Nasza siła tkwi w naszych ludziach. Grupa doświadczonych profesjonalistów, każdy członek naszego zespołu wnosi do stołu unikalną mieszankę wiedzy.

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Współwłaścicielka Axelon Sp. z o.o. Z funduszami unijnymi związana od 10 lat. Specjalizuje się w pozyskiwaniu i rozliczaniu projektów B+R oraz inwestycyjnych.

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# 1.

## BIOACTIVE POLYMER COMPOSITES WITH NANOCERAMICS

Julia Sadlik, Edyta Kosińska, Karina Niziołek, Kamila Lis, Agnieszka Sobczak-Kupiec
Dagmara Słota
1 Cracow University of Technology, Faculty of Materials Engineering and Physics Department of Materials Engineering, 37 Jana Pawla II ave, 31-864 Cracow, Poland
E-mail:julia.sadlik@doktorant.pk.edu,pl

Bioactive ceramic-polymer materials are currently being intensively researched for bone tissue reconstruction materials. Polymeric materials are gaining an advantage over ceramic and metallic materials due to their ease of manufacture and wide range of physical as well as mechanical properties. The addition of bioactive ceramics, on the other hand, is an essential component of implants to ensure properties similar to human bone thus faster osteointegration. One of the best known is hydroxyapatite, which belongs to the apatite phosphate family. It is widely used in orthopedics and dentistry. Due to its brittleness, it cannot be used on a large scale, so combining it with a polymer provides ideal conditions for applications in regenerative medicine [1]. The formation of the bioactive ceramic in nano form greatly facilitates dispersion in the polymer matrix and this has a positive effect on tissue-polymer interactions and also its properties can be significantly improved.

The aim of this work is to select a suitable ceramic and polymer phase that will provide patients with rapid regeneration after implantation. Furthermore, being able to obtain the ideal composition for 3D printing will not only speed up the wait for surgery but also offer the possibility of using the product in aesthetic medicine, which will also improve people's quality of life and self-esteem. This paper reviews the latest developments in the field of inert polymer-ceramic composites, which are additionally bioactive and thus promote bone regeneration [2].

The authors gratefully acknowledge the financial support of the project: “"Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

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2.

# ASSESSING THE PERFORMANCE OF PHYTIC ACID-ENHANCED HYDROGELS FOR HEAVY METAL ADSORPTION

J. Skubalski (1), P. Filipczak (2), M. Kozanecki (2)

1. Lodz University of Technology Faculty of Chemistry, Students Association NANO, Łódź, Poland

2. Lodz University of Technology Faculty of Chemistry, Department of Molecular Physic, Łódź, Poland

E-mail (corresponding author): 249673@edu.p.lodz.pl

Given the growing problem of freshwater scarcity affecting approximately 40% of the global population in over 80 countries, pollution of water bodies with heavy metals poses a serious threat to public health and the environment [1]. Therefore, there is an urgent need to develop effective methods for removing contaminants, including heavy metals, from water. In this context, adsorption techniques appear particularly promising due to their efficiency, low cost, and ease of use [2]. In our study, we focused on the synthesis of polymeric hydrogels based on acrylic acid, which were modified with natural additives such as phytic acid and hydroxyethyl cellulose. Phytic acid, a natural metal chelator found in grains, is characterized by its high phosphate group content, making it an attractive additive for hydrogels [3]. We investigated the water-swelling properties and metal-binding capacities for $Co^{2+}$, $Cu^{2+}$, and $Fe^{3+}$ across various ranges of water hardness and pH levels. Our findings demonstrate that the developed hydrogels effectively bind metal ions, and incorporating both phytic acid and hydroxyethyl cellulose significantly enhances their adsorption properties, especially for cobalt ions sorption.

Using these modified materials may represent an innovative approach to water purification, contributing to increased efficiency in contaminant removal processes in the context of sustainable development.

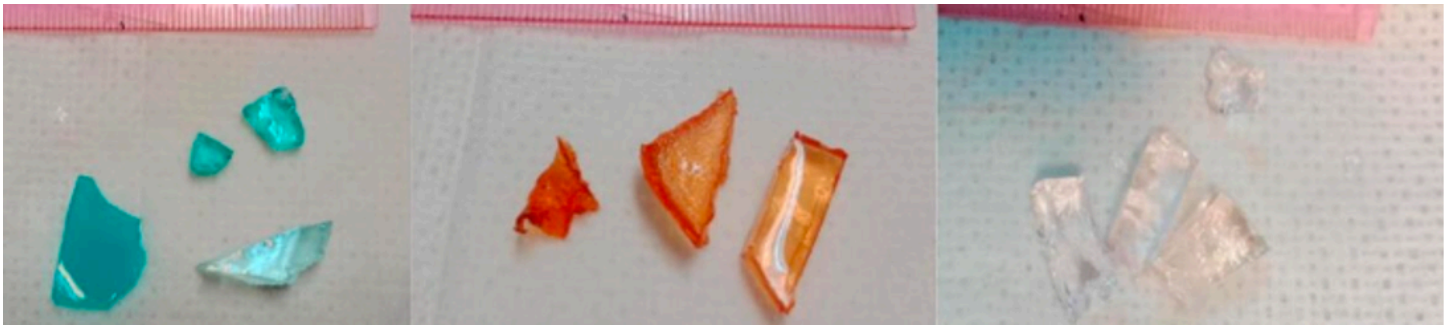

Figure 1 Hydrogels after the absorption of ions (from left to right) of copper, iron, and cobalt. A noticeable color change in the hydrogel is clearly visible due to the presence of the metal.

The research was financed from the project entitled “Automation and modification of the synthesis process of environmentally friendly hydrogels for capturing heavy metals from water” carried out by the Student Science Association NANO operating at the Faculty of Chemistry of the Lodz University of Technology, as part of the “Student Science Associations Create Innovations” program financed by the Ministry of Education and Science (reg. no.: SKN/SP/571454/2023).

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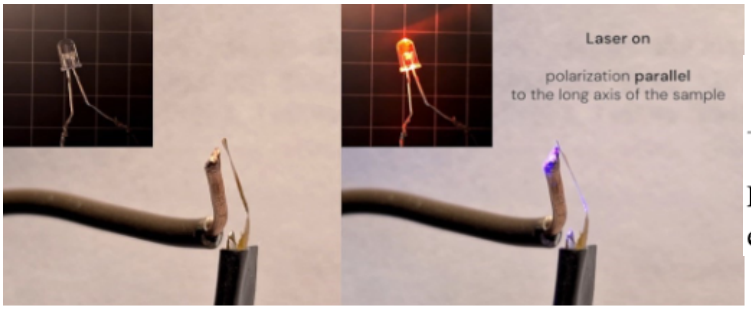
3.

# ON/OFF ELECTRICAL CIRCUIT BASED ON THE PHOTOMECHANICAL EFFECT OF AZOPOLYIMIDE

J. Konieczkowska, M. Siwy
Centre of Polymer and Carbon Materials, Polish Academy of Sciences, Zabrze, Poland
E-mail (corresponding author): jkonieczkowska@cmpw-pan.pl

Azopolyimides are a wide group of amorphous, thermostable materials [1]. Exposure of the azopolymer cantilever to a polarized light beam leads to multiple and reversible cycles of trans-cis-trans isomerization and reorientation of azomolecules. This allows the generation of optical anisotropy in the material, allowing for the study of dichroism, birefringence, or the recording of diffraction gratings [1,2]. In recent years, azopolymers have been used as advanced photosensitive materials in photomechanical studies [3], which opens new possibilities for their applications. Multiple acts of trans-cis isomerization and reorientation of azomolecules induced by laser light resulted in the mechanical bend of the polymer cantilever.
The photomechanical effect was used for the fabrication of an ON/OFF electrical circuit controlled by polarized 405nm light. We used linear azopolyimide with two azo groups (N=N) in the repeating unit as a photoactive material (Fig. 1a). Thin 20 μm foil was prepared from synthesized azomaterial. Then, a ca. 200 nm layer of platinum was evaporated onto the prepared foil. The material prepared in this way showed both photoactive and electrically conductive properties. The incorporation of azomaterials into an electrical circuit allows ON or OFF the charge flow in a circuit using laser light. Irradiation of material by the linear polarized light to the long axis of polymer foil resulted in bending of the cantilever towards the light source “close” the circuit (Fig. 1b). Change the polarization of the light towards to unbending the foil and “open” the electrical circuit.



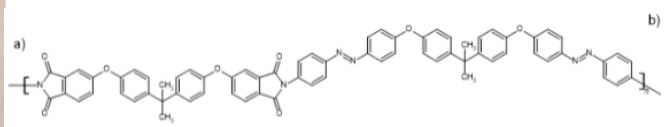




Fig. 1. (a) chemical structure of azopolyimide, (b) electrical circuit based on azopolyimide foil.

This research was funded by the National Science Centre, Poland, grant number UMO-2019/35/D/ST5/00533.

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# 4.

# HIGH THERMALLY STABLE ANTHRACENE-BASED POLYIMIDES WITH LOW DIELECTRIC CONSTANTS AND DISSIPATION FACTORS

Manohar Reddy Busireddy,(*,1,2) Jin-Wei Lin, (2) Chain-Shu Hsu, (2) Igor F. Perepichka (1)

1. Department of Physical Chemistry and Technology of Polymers, Faculty of Chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland.

2. Department of Applied Chemistry, and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, 1001 University Road, Hsinchu 30010, Taiwan.

E-mail address (corresponding author): busireddymanohar90@gmail.com

At present, high-performance polymers with low dielectric constants (Dk) and low dissipation factors (Df) have gained much attention with the rapid evolution of microelectronic and 5G communication technologies.1–2 Due to their excellent thermal stabilities, heat resistance, mechanical strengths, and dielectric properties, polyimides (PIs) have attracted much attention in recent years.3 In this work, a series of anthracene (An)-based PIs are synthesized from an ester-functionalized anthracene diamine (An-NH2) monomer and four kinds of commercial dianhydrides such as BDTA, DSDA, 6FDA, BPADA, ODPA by a two-step process i.e., the chemical polyaddition followed by thermal imidization. As a result, all An-based PI films display excellent thermal properties with thermal decomposition temperatures of 450–530 °C (Td5% weight loss) and glass transition temperatures (Tg) of 270-410 °C. In addition, these PI films exhibit decent optical transparency, flexibility, coefficient of thermal expansion (CTE), and mechanical properties. Remarkably, all An-based PI films show excellent dielectric properties with low Dk of 2.540-3.388 and Df of 0.0059-0.0240 at high frequency (10 GHz). In particular, the An-based PI films with ether linkages (AnOD-PI and AnBPA-PI) and a high fluorine content (An6F-PI) show low Dk and Df values compared with those with keto (AnBT-PI) and sulfone (AnDS-PI) linkages. Authors acknowledge the supporting actions from EU's Horizon 2020 ERA-Chair project ExCEED, grant agreement No. 952008.


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5.

# PORPHYRIN SENSITIZERS FOR DYE-SENSITIZED SOLAR CELLS

Jonnadula Venkata Suman Krishna (1,2), Lingamallu Giribabu (2), Igor F. Perepichka (1)
1. Department of Physical Chemistry and Technology of Polymers, Faculty of chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland
2. Polymers and Functional Materials Division, CSIR-Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad- 500007, India.
E-mail (corresponding author): Venkata.Suman.Krishna.Jonnadula@polsl.pl

In Dye Sensitised Solar Cells (DSSCs) the photovoltaic parameters are modulated by the photo sensitizers1. Ru (II) polypyridyl complexes (CYC-B11) achieved a certified efficiency of 11.5%2, but its synthesis and practical applications has limited to due its high cost. The investigation on porphyrins have been attracted much attention in the field of DSSCs, since it mimics the role of chlorophyll in photosynthesis. Porphyrins has ease of tuning the molecular structure at meso and β pyrrole positions towards light-harvesting. In 2014, M. Grätzel and coworkers adopted the D-π-A approach and achieved a power conversion efficiency of 13%3. To understand D-π-A approach, porphyrin was linked with fluranthene through acetylene bridge with different acceptors (LG8-LG10) and achieved an efficiency of 2.91% in LG8. Later, porphyrins with triphenylimidazole group (LG15-LG18) as donor has achieved PCE of 10.5% in LG18. Afterwards, 4-(10-ethynylanthracen-9-yl)-N,N-diphenylaniline as donor and increased the alky chain length from octyloxy to dodecyloxy chains with various acceptors (LG19-LG21) and achieved the efficiency of 10.0% in LG20. The detailed synthesis, characterization, and its applications will be presented.

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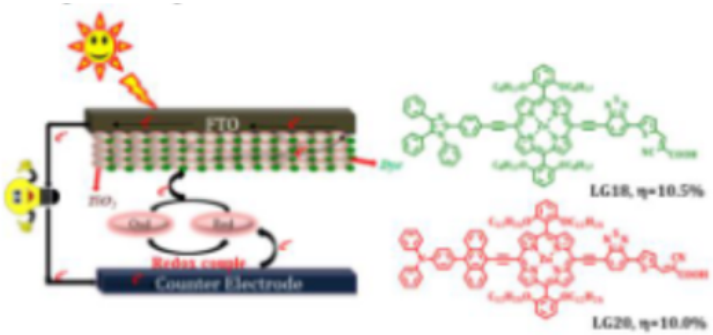


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6.

# Ni–PORPHYRIN AS ELECTROCATALYST FOR ELECTROCHEMICAL CONVERSION OF WATER INTO DIOXYGEN

Jonnadula Venkata Suman Krishna (1,3), Dhavale Vishal Mahesh (2), Lingamallu Giribabu (3), Igor F. Perepichka (1)

1. Department of Physical Chemistry and Technology of Polymers, Faculty of chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland

2. CECRI Department, CSIR- Madras Complex, Taramani, Chennai - 600 113, India.

3. Polymers and Functional Materials Division, CSIR-Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad- 500007, India.

E-mail (corresponding author): Venkata.Suman.Krishna.Jonnadula@polsl.pl

In view of renewable energy, water oxidation is an significant reaction for engendering fuel and oxidants, depending on the catalyst used and the operational conditions.1 To date, iridium and ruthenium oxides have been considered as standard electro catalysts for water oxidation, but cost is a major stumbling block for their widespread use.2–4 In this context, the electrochemical water oxidation of complexes 5,15-diphenylporphinatonickel(II) (A) and 5,15-bis(3,5-di-tert-butylphenyl)porphinatonickel(II) (B) in oxygen evolution reaction (OER) have been investigated in an alkaline medium. Complex B was found to be kinetically and thermodynamically more active than complex A. Also, 3,5-di-tert-butylphenyl substituent in B plays a decisive role in achieving a better OER onset potential and current than that of A, which is a result of the modulation of the structural parameters of B. Furthermore, the measured OER activities of A and B have been correlated with their molecular arrangement as well as differences in their bonding characteristics and dipole moments.

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7.

# SUPERHYDROPHOBIC HYDROGENATED NANOCARBONS

M. Małecka (1), A. Marek (1), E. Korczeniewski (2), A. P. Terzyk (2), S. Boncel (1)
1. Silesian University of Technology, NanoCarbon Group, Gliwice, Poland,
2. Nicolaus Copernicus University in Torun, Physicochemistry of Carbon Materials Group, Toruń, Poland
E-mail (corresponding author): magdalena.malecka@polsl.pl

Superhydrophobicity is the sine qua non characteristic of anti-icing, anti-fogging, anti-wetting, and water-oil separation materials. Intrinsic anti-wetting properties of nanocarbon materials can be further enhanced by numerous approaches. The fundamental methods of the nanocarbon extra-hydrophobization involve covalent and non-covalent functionalization, in situ or post factum alignment of pristine or functionalized materials, coating by other (super)hydrophobic surfaces, and formation of hybrid/composite materials. One of the most prospective modifications of pristine nanocarbons toward superhydrophobicity is hydrogenation [1]. During this process,
the nanocarbon is purified from iron-based compounds and amorphous carbons [2], the chemical structure of the C-framework changes (to a varied extent) from sp2- to sp3-hybridization, and morphology of the product can adopt a re-ordered geometry.

Here, hydrogenation of various carbon nanomaterials, i.e., carbon nanotubes (CNTs) of a different morphology, graphene, and single-walled carbon nanohorns (SWCNHs), was performed via two methods [3]. The first method was based on the electrochemical reduction in the optimized H2O/MeOH media. The second approach involved scalable, high-pressure hydrogenation in an autoclave, at elevated temperature. The products were cros characterized by SEM, TEM, elemental analysis, TGA, XPS, Raman and FT-IR spectroscopy. The wetting properties of hydrogenated versus non-hydrogenated nanocarbons were evaluated by water contact angle (WCA) measurements of the isotropic coatings obtained under fully reproducible protocols.

The hydrogenated carbon nanomaterials, due to their tunable morphology and surface physicochemistry accompanied by the excellent anti-wetting properties, including superhydrophobicity with WCA as high as >160°, emerge as promising candidates in numerous applications, such as anti-fogging and anti-icing surfaces or technologies for oil separation from the spillages.

Acknowledgements
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# 8.

# EFFECT OF THE ADDITION OF AN AZOBENZENE DERIVATIVE TO THE ELECTROLYTE ON THE PHOTOVOLTAIC PERFORMANCE OF A DYE-SENSITIZED SOLAR CELL

Paweł Gnida (1), Jolanta Konieczkowska (1), Muhammad Faisal Amin (1,2), Ewa Schab-Balcerzak (1,3)

1. Centre of Polymer and Carbon Materials, Polish Academy of Sciences, 34 M. Curie-Skłodowska Str., 41-819 Zabrze, Poland

2. Joint Doctoral School, Silesian University of Technology, Akademicka 2a, Gliwice, 44-100, Poland

3. Institute of Chemistry, University of Silesia, 9 Szkolna Str., 40-007 Katowice, Poland

*pgnida@cmpw-pan.pl

Photovoltaics (PV) is one of the most promising technologies for obtaining energy. The most noteworthy is the direction related to solar cells using organic materials. Among these types of PV devices, dye-sensitized solar cells (DSSCs) have received much attention. The undeniable advantages of these solar cells include their ability to operate at wide incident angles and low irradiance, their ability to change colour and transparency, and their relatively uncomplicated preparation methods [1]. In general, work around DSSCs focuses on improving the efficiency of radiation conversion to electricity. Therefore, modifications are made to the structure of the device, as well as to the selection of appropriate preparation methods. This modification often involves many aspects such as the use of blocking layers, scattering layers, new dyes, conductive polymers. Also important is the selection of appropriate conditions for the preparation of the various components of the device (photoanode, electrolyte and counter-electrode) [2].

Among the numerous modifications, an interesting one is the use of azobenzene derivatives to improve cargo transport efficiency by locally increasing the temperature due to changes in cis-trans isomerism [3]. The effect of this modification can mainly be seen by an increase in the value of the short-circuit current density (Jsc) and, consequently, the solar cell efficiency (PCE) increases.

This study investigated the effect of using an azobenzene derivative additive on the photovoltaic performance of DSSCs under varying illumination. The variation of incident light intensity is intended to simulate the different operating conditions of the device, specifically both externally, where electricity is obtained from sunlight conversion, and internally, artificial light conversion. The effect of the concentration of azobenzene additive in the electrolyte on the photovoltaic response of the devices was also investigated.

Acknowledgements: This research was funded by the National Science Centre, Poland, grant number UMO-2019/35/D/ST5/00533.

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9.

# INNOVATIVE BIOMEDICAL MATERIALS IN CHRONIC WOUND THERAPY

A. Piekarniak (1), M. Bańkosz (2), B. Tyliszczak (1), M. Kędzierska (3)
1. Cracow University of Technology, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
2. Cracow University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
E-mail: anna.piekarniak@student.pk.edu.pl

Chronic, difficult-to-heal wounds are a major challenge for today's healthcare systems. The rising cost of wound treatment resulting from recurrent infections and prolonged healing process, as well as the growing number of patients with diabetes, obesity, and an aging population, further increase the need for the development of new, more effective therapeutic methods. This poster reviews innovative biomaterials that can support the treatment of chronic wounds. In particular, materials such as multifunctional hydrogels, bioactive glasses, immunomodulating nanostructures, and intelligent nanofibrous membranes produced by electrospinning were discussed.

Hydrogels create a moist environment, their form and shape allows for direct application of substances supporting the treatment in areas affected by disease lesions, depending on the specificity and complexity of the wounds observed in patients, it is possible to plan individually adapted therapy. Bioactive glass containing minerals such as calcium, zinc, and silver support angiogenesis, antibacterial action, and hemostasis, which accelerates the healing process. Immunomodulatory nanostructures can be used as carriers for drugs, peptides, and other bioactive compounds, increasing stability, precise delivery, and immunomodulatory efficiency. Inteligent nanofibrous membranes, due to their porosity and similarity to extracellular matrix, support wound healing, and integration with artificial intelligence technologies enables real-time wound monitoring and tailoring therapy to individual patient needs.

The project is financed with funds from the state budget granted by the Minister of Science within the framework of the "Student Scientific Clubs Create Innovations" (SKN/SP/601893/2024) "Application of Biohydrogels Containing Adaptogens in Innovative Chronic Wound Therapy" .The research work was carried out within the SMART-MAT Functional Materials Science Club (section Smart-Mat) at the Faculty of Materials Engineering and Physics of the Cracow University of Technology.

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10.

# PREPARATION OF HIERARCHICAL SCAFFOLDS FOR THE TREATMENT OF OSTEOPOROSIS

A. Sobczak-Kupiec (1),K. Haraźna (1), D. Träger (1), D. Słota (1), K. Niziołek (1)
Department of Materials Engineering, Cracow University of Technology, 31-155 Krakow, Poland
E-mail: agnieszka.sobczak-kupiec@pk.edu.pl

Current treatments for osteoporosis are effective in managing pain but do not effectively suppress progressive inflammation or stimulate tissue regeneration. Using commercially available implants carries the risk of rejection, so scientists focus on developing new biomaterials for constructing implants and scaffolds for tissue regeneration. There is a demand for biomaterials that can simultaneously regenerate three different tissues - cartilage, subchondral tissue, and bone. To meet this demand, researchers are working on hierarchical and gradient materials. Moreover, it is crucial to keep within certain parameters in order to develop effective scaffolds for osteochondral tissue engineering. These scaffolds must be capable of recreating a three-dimensional microenvironment that mimics native tissue, featuring a connected, porous architecture ideal for cell growth. Furthermore, the scaffolds should exhibit mechanical properties compared to native cartilage or bone tissue. Utilizing suitable polymers with precise geometry and micro-/macromolecular organization is a promising approach to achieving this goal. The solvent casting/porogen leaching and freeze-drying are a methods that enables the production of scaffolds characterized by a certain porosity.[1,2]

This study assessed the possibility of combining solvent casting, particulate leaching, and freeze-drying methods to produce tissue engineering scaffolds based on calcium phosphates, polyesters, and polysaccharides. In the long term, these materials may be helpful in the treatment of osteochondral tissue.

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# 11.

# OPTICAL AND ELECTROCHEMICAL PROPERTIES OF DONOR-ACCEPTOR POLYMERS WITH A D-A1-A1/A2-D STRUCTURE DERIVED FROM 1,3,4-OXADIAZOLE AND 1,3,4-SELENADIAZOLE ACCEPTOR UNITS

Andualem Merga Tullu*, Wojciech Domagala
Silesian University of Technology, Department of Physical Chemistry and Technology of Polymers, 9 M. Strzody street, 44-100 Gliwice, Poland
∗Corresponding Author: Andualem Merga Tullu, (Andualem.Merga.Tullu@polsl.pl)

Organic donor-acceptor (D-A) semiconductors are at the forefront of research in the field of organic electronics due to their tuneable optoelectronic properties, flexibility and potential for low-cost production. These materials are essential for devices such as organic photovoltaics (OPVs), organic field-effect transistors (OFETs) and organic light-emitting diodes (OLEDs). Current research is focused on the development of novel donor-acceptor molecules by combining new donor electron-rich moieties of fused heterocyclic systems or extended π-conjugated structures and acceptor moieties that can potentially replace the traditional fullerene derivatives, the so-called non-fullerene acceptors (NFAs), such as thiadiazole, oxadiazole and selenadiazole moieties.

Organic donor- acceptor semiconductors derived from bithiophene donor units and chalcogenodiazoles (oxadiazole, thiadiazole and selenadiazole) as acceptor units exhibit a number of physicochemical properties that are essential for their performance in optoelectronic devices. The 2,5-sigma bonding combination between these donor and acceptor moieties ensures that the system remains conjugated, allowing the delocalization of π-electrons across
the donor-acceptor backbone. This combination also favours a planar geometric arrangement that enhance the π-π stacking interactions of the molecules in the solid state. The application of binary acceptor units in the donor-acceptor scaffold, in the form of symmetric (D-A1-A1-D) or asymmetric (D-A1-A2-D) arrangement, allow fine tuning of optical, electronic and charge transport properties.
In this study, a series of donor-acceptor monomers were chemically synthesized using alkylbithiophene donor units symmetrically attached to a central bis(1,3,4-oxadiazole), bis(1,3,4-selenadiazole), and (1,3,4-oxadiazole-1,3,4-selenadiazole) acceptor motifs. The corresponding polymers were produced via the oxidative electropolymerization technique. Electrochemical, spectroscopic, and spectroelectrochemical properties were examined. The resul revealed that the compounds undergo a reversible reduction process and irreversible oxidation, which leads to the formation of a polymer film through α-α coupling. The obtained polymer film potentially hosts paramagnetic polaron and diamagnetic polaron-pair charge carriers. Summarising, easily polymerizable ambipolar low-band gap organic semiconductor molecules were synthesized by combining alkylbithiophene and chalcogenodiazole motifs, their physicochemical properties are a function of their structural framework of the central acceptor units.

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# 12.

# COMPACT X MINIATURE, LOW-POWER X-RAY SOURCE FOR SPECIAL APPLICATIONS

K. Gryboś, P. Kunicki
1. Compact X sp. z o.o. sp.k., Bierutowska 57-59, 51-317, Wrocław, Poland
E-mail (corresponding author): piotr.kunicki@compactx.pl

With the advent of innovations like the Compact X, new possibilities for X-ray technology are emerging, particularly in areas that were previously difficult or impossible to implement. This technology can be utilized in a variety of applications and conditions, including specific and demanding situations such as working at heights, in mine shafts, or even in space, as well as in home medical diagnostics, where it facilitates rapid and effective imaging to assess a patient's condition.

The Compact X features high mechanical resistance, which is essential for X-ray sources used in industrial applications and non-laboratory conditions. Its ability to modulate radiation intensity allows it to be applied to various uses and materials without the need for complicated modifications. Additionally, the miniature design of the Compact X significantly reduces the cost of the device while enhancing its mechanical durability and expanding its range of applications. Finally, its mobility enables broader use of X-ray technology in locations and situations where it was previously challenging or impossible.

The development of X-ray technology — from Roentgen's discovery to contemporary innovations — has transformed numerous fields, including medical imaging, quality control and security screening. The introduction of the Compact X has further expanded the possibilities for X-ray usage in demanding environments, thanks to its robust design, adaptability, and enhanced safety features. In the future, the Compact X source is planned to be adapted to security applications, such as scanning for harmful, hazardous or prohibited materials, as well as in the field of dentistry.

We pursued the project within instrument Fast Track 4/1.1.1/2018 about „Miniature, low-power x-ray source for special applications”, funded by the European Union from European Regional Development Fund under Smart Growth Operational Programme 2014-2020.

# 13.

# HIGHLY CONDUCTIVE PATHS IN DIAMOND AND THEIR APPLICATION IN HIGH PRESSURE MEASUREMENTS

Mateusz Gramala (1,2) *, Andrzej Sikora (3), Aleksandra Chudzyńska (1,4), Łukasz Gelczuk (2), Filip Dybała (2), Paweł Modrzyński (1,2) and Robert Kudrawiec (2) **

1 Nanores Sp. z o.o. Sp. k., Bierutowska 57-59, 53-317 Wrocław, Poland

2 Department of Semiconductor Materials Engineering, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland

3 Department of Nanometrology, Faculty of Electronics, Photonics and Microsystems, Wrocław University of

Science and Technology, Janiszewskiego 11-17, 50-372 Wrocław, Poland

4 Department of Optical Spectroscopy, W. Trzebiatowski Institute of Low Temperature and Structural Research

of the Polish Academy of Sciences, Okólna 2, Wroclaw 50-422, Poland

Email (corresponding author):* mateusz.gramala@nanores.pl, ** robert.kudrawiec@pwr.edu.pl

Diamonds are renowned for their remarkable properties, including impressive mechanical strength, excellent thermal conductivity, and significant electrical resistance, which makes them ideal for applications in high-power and opto-electronics. Nevertheless, the creation of conductive structures within diamond remains a notable technological hurdle. During this project, we have introduced a method for the precise fabrication of amorphous conductive pathways in monocrystalline diamond utilizing focused ion beam (FIB) technology. We have precisely determined the resistivity and thickness of these fabricated structures and conducted a thorough morphological characterization. Our findings revealed that the optimal charge dose for achieving minimal resistance was 1017 ions/cm$^2$. The resulting structures displayed an amorphous morphology, and elemental analysis confirmed the incorporation of gallium ions into the modified material. The resistivity measured for these conductive paths was an impressive 30 μΩm, which is significantly lower than results from prior studies and only 1-2 orders of magnitude greater than that of metals. Furthermore, we showed the potential applications of this technology in high-pressure chambers and in the development of high-pressure sensors using diamond anvils. This research offers meaningful insights into the fabrication of conductive structures in diamonds using FIB technology and paves the way for new advancements in diamond electronics.

We pursued the project within instrument Fast Track 1/1.1.1/2015 about „ Development of sensors for extreme pressure measurements”, funded by the European Union from European Regional Development Fund under Smart Growth Operational Programme 2014-2020.

# 14.

## HYDROGEL MATERIALS AS CARRIERS OF ACTIVE SUBSTANCES

Wiktoria Wrzesińska (1), Magdalena Bańkosz (2), Magdalena Kędzierska (3),Bożena Tyliszczak (1)
1. Cracow University of Technology, Faculty of Materials Engineering and Physicis, Department of Material Engineering
2. Cracow University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physicis, Department of Material Engineering
3. Departament of Chemotherapy, Copernicus Memorial Hospital of Lodz, Medical University of Lodz
E-mail (corresponding author): wiktoria.wrzesinska@student.pk.edu.pl

Hydrogel materials, due to their three-dimensional, cross-linked polymeric structure, are capable of absorbing and retaining significant amounts of water or other fluids. Due to their distinctive properties, including biocompatibility, biodegradability and the capacity for regulated release of assorted substances, they are increasingly employed as carriers of active substances. In recent years, there has been a surge in interest in hydrogel materials as carriers for these substances, primarily due to a number of distinctive properties and the potential for utilisation in a multitude of fields. In the field of medicine and pharmacology, these materials facilitate precise and controlled drug delivery, thereby enhancing the efficacy and efficacy of therapy while reducing the adverse effects associated with traditional forms of treatment. In the domain of cosmetology, they are employed in moisturising or anti-wrinkle products due to the gradual release of active substances, such as hyaluronic acid.

Active substances are defined as chemical compounds that possess specific biological, pharmacological, or chemical properties. They have the capacity to influence biological processes in organisms, including antimicrobial, anti-inflammatory, and therapeutic effects. A special advantage of the hydrogels are their ability to respond to various stimuli, such as pH or temperature changes [1]. Despite the numerous advantages of hydrogel materials, there are some limitations associated with the long-term storage of active substances in hydrogel structures, which require further investigation. However, hydrogel materials as carriers of active substances demonstrate a wide range of applications and represent an innovative element in the development of various scientific and industrial fields.

The project is financed with funds from the state budget granted by the Minister of Science within the framework of the "Student Scientific Clubs Create Innovations" (SKN/SP/601893/2024) "Application of Biohydrogels Containing Adaptogens in Innovative Chronic Wound Therapy" .The research work was carried out within the SMART-MAT Functional Materials Science Club (section Smart-Mat) at the Faculty of Materials Engineering and Physics of the Cracow University of Technology.

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15.

# KAOLIN – A NOBLE RAW MATERIAL IN CERAMICS AND INDUSTRY

H. Bogusz-Koziarska (1), K. Urbański (1), M. Dworczak (1)
1. Anton Paar Poland, Warsaw, Poland
E-mail: helena.bogusz@anton-paar.com

Clay minerals serve as filler materials in a variety of applications. Technical kaolin is a commercially sold kaolin of relatively low purity, often used as a filler in paints, paper and ceramics. Kaolin is a clay mineral, which belongs to the group of layered silicates. The main component is kaolinite with the chemical composition Al2Si2O5(OH)4. The structure of kaolinite may be represented by hexagonal platelets with predominantly negatively charged faces (SiO2) and positively charged edges (Al2O3). The platelet structure and the non-uniform charge distribution enhance the probability of particle aggregation [1,2,3].

The poster presents comprehensive solutions using different measurement technologies. In order to obtain detailed information on the quantitative and qualitative composition, as well as crystallographic and structural information, kaolin was subjected to XRD, FTIR studies, particle size analysis using laser diffraction methods and dynamic image analysis. The studies were supplemented with the density value obtained from the measurement with a gas pycnometer.

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16.

# MICROSTRUCTURE, MECHANICAL PROPERTIES, AND TRIBOLOGICAL BEHAVIOR OF CU-NANO TIO2-MWCNT COMPOSITE SINTERED MATERIALS

A. Marek (1), S. Boncel (1), A. Piasecki (2)
1. Silesian University of Technology, NanoCarbon Group, Gliwice, Poland
2. Poznan University of Technology, Poznań, Poland
E-mail: adam.a.marek@polsl.pl

The pursuit for new materials with tribological properties is burning from the point-of-view of practical and economic applications. Tribological wear is one of the most common causes of material wear, leading to damage of the machine parts or tools. This phenomenon has a large economic effect related to the downtime of the devices and a period of time required for the replacement of parts. Therefore, the search for new materials with a higher wear resistance is particularly important, allowing for the longer operational stability [1].

Here, we present the results of microstructure, mechanical, and tribological tests of copper matrix sinters with the addition of nano-TiO2 and Cu-decorated multi-walled carbon nanotubes (MWCNTs) [2]. A powder metallurgy was used to produce composite materials. The aim of the work was to determine the properties and wear mechanism of the produced sinters with single additives and to investigate the synergistic interaction of TiO2 and CNTs. The main wear mechanisms of the friction pairs tested at room temperature and 600 °C were adhesive, abrasive, and oxidation wear. Furthermore, at the test temperature of 600 °C, the formation of a tribofilm was observed on the surface of the friction pairs, which reduced the friction wear. The introduced additions to the copper matrix increased its hardness, stiffness, work of axial deformation, and the wear resistance. Moreover, the additions decreased the relative value of the thermal expansion coefficient of the sintered copper. It has been shown that the friction pair (Cu + 1 wt.% MWCNTs – Inconel®625) was characterized by the lowest coefficient of friction at room temperature and 600 °C, of approximately 0.62 and 0.56, respectively. The sintered composite material of Cu – 10 wt.% nano-TiO2 – 1 wt.%. MWCNTs was characterized by the highest mechanical properties and the lowest wear.

Acknowledgements
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17.

# CHEMICAL ACTIVITY OF NANOCRYSTALLINE IRON IN AMMONIA SYNTHESIS AND DECOMPOSITION – MODEL STUDIES

R. Pelka, K. Klimza
West Pomeranian University of Technology in Szczecin, Department of Inorganic Chemical Technology and Environment Engineering, 10 Pułaskiego Str., 70-322 Szczecin, Poland
E-mail (corresponding author): rpelka@zut.edu.pl

The iron catalyst with different sizes of iron nanocrystallites used for the study was obtained using the method described in [1] and then impregnated in an aqueous solution of KOH. The activity of the tested samples in the ammonia synthesis reaction was determined at a pressure of 10 MPa, at temperatures of 500oC, 450oC, 400oC and 350oC, based on measurements of ammonia concentration in the post-reaction gases. The catalytic activity was characterized using the reaction rate constant calculated using the Tiemkin-Pyzhev equation. The rate of catalytic decomposition of ammonia was measured at a temperature of 500oC and a pressure of 0.1 MPa. The samples were characterized using X-ray diffraction (XRD; size of iron nanocrystallites), inductively coupled plasma (ICP; chemical composition) and thermal desorption (specific surface area) methods.

It was observed that after impregnation of the catalyst with potassium compounds (in order to supplement the promoter losses in the etching process), its activity increased and exceeded the activity of catalysts produced by the world's leading producers of hydrogenation catalysts. By adding appropriate amounts of potassium compounds as a promoter, the relationship observed for non-impregnated samples can be reversed and the activity increases with the increase in the average size of iron nanocrystallites in the samples (the increase in the active surface area with the increase in potassium concentration in the samples compensates to some extent for the decrease in the specific surface area of the catalysts).

It was also found that the obtained modified samples with a narrow nanocrystallite size distribution are much more active in the catalytic decomposition of ammonia than the unmodified sample (with a wide range of iron nanocrystallite sizes), and their activity is inversely dependent on the average size of nanocrystallites in the sample (and thus directly proportional to the specific surface area of the samples).

The observed relationships were interpreted using numerical modelling of the crystal structure of iron nanocrystallites. The Avogadro program [2] was used for this purpose.

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18.

# EFFECT OF MORPHOLOGY ON PHOTOCATALYTIC PROPERTIES OF Ag-MODIFIED TITANIUM DIOXIDE NANOSTRUCTURES

N. Shakeel (1), I. Piwoński (2), A. Kisielewska (3), M. Krzywiecki (4)
1. University of Łódź, Faculty of Chemistry, Department of Materials Technology and Chemistry, Pomorska 163, 90-236 Lodz, Poland
2. Silesian University of Technology, Institute of Physics - CSE/Department of Applied Physics, Konarskiego 22 B, 44-100 Gliwice, Poland
E-mail (corresponding author): nasir.shakeel@edu.uni.lodz.pl

Nanoparticle-based photocatalysis exhibits potential for diverse applications, such as solar energy conversion, water electrolysis, and environmental pollutant remediation [1]. Titanium dioxide (TiO2) is an efficient and chemically stable photocatalyst commonly employed in both fundamental research and commercial applications. This study aims to improve the photocatalytic properties of titanium dioxide nanorods (TNRs) by modifying them with silver nanoparticles (AgNPs). This modification is performed using two separate methods: sol-gel combined with dip-coating deposition and the hydrothermal method. The synthesis of AgNPs was achieved using the photoreduction of Ag+ ions. The research investigates the impact of various growth conditions on the morphological evolution of TiO2 nanorods. This study synthesized several TiO2 nanostructures by modifying (i) the chemical composition specifically the water to acid ratio—and (ii) the precursor concentration during the hydrothermal process. The nanocomposite's morphology was analyzed using scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS), revealing essential structural components crucial for photocatalytic performance. The findings indicate that modifying the parameters resulted in several morphological shapes, including thin nanorods, thick nanorods, nanoflowers, and nanoballs. The photocatalytic effectiveness of the TNRs and Ag-coated TNRs was assessed by measuring the degradation of the organic dye rhodamine B (RhB) under ultraviolet (UV) and visible light irradiation. The UV-Vis spectroscopy technique was employed to investigate the changes in the RhB spectrum during photocatalytic processes. The findings clearly indicate that UV light causes the decolorization of the RhB solution, while visible light promotes the conversion of RhB into rhodamine 110, indicating a successful photocatalytic transformation. The treatment of nanoball-like structures with active metal silver (TNRs 4 Ag) exhibited considerable photocatalytic efficiency under both ultraviolet (UV) and visible light across diverse chemical composition parameters. Concerning the precursor amount parameter, the TNRs 2 Ag (nanorod structure) display enhanced efficiency under UV light, whereas the TNRs 6 Ag sample shows improved efficacy in visible light photocatalysis. The findings highlight the potential of TiO2-based nanocomposites, especially TNRs augmented with AgNPs, in improving photocatalytic technologies for environmental remediation and energy conversion purposes.

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# 19. COVALENT TRIAZINE FRAMEWORK: A HIGHLY CONDUCTIVE CARBON SUPPORT FOR CO2 ELECTROCATALYSIS

Sebastian Raja, (1,2,3,4) Gelson T. S. T. da Silva (1,2), Eduardo A. Reis (1), Jean C. da Cruz (1,2), Anelisse Brunca Silva (2), Igor F. Perepichka, (3,4) Lucia Helena Mascaro (2), and Caue Ribeiro (1,2)

1. National Nanotechnology Laboratory for Agribusiness (LNNA), Embrapa Instrumentação, São Carlos-SP, 13560-970, Brazil

2. Department of Chemistry, Federal University of São Carlos (UFSCar), 13565-905, São Carlos, São Paulo, Brazil

3. Department of Physical Chemistry and Technology of Polymers, Silesian University of Technology, Marcina Strzody Street 9, Gliwice 44-100, Poland

4. Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego Street 22b, Gliwice 44-100, Poland

E-mail (corresponding author): Raja.Sebastian@polsl.pl

The accumulation of CO2 drives global warming, creating an urgent need to reduce emissions. Converting CO2 into value-added products through electrocatalytic CO2 reduction reactions (CO2RR) offers a promising solution, producing C1 and C2/C2+ products like methanol and ethylene [1]. However, improving selectivity and suppressing the competing hydrogen evolution reaction (HER) remains a challenge. Single-atom catalysts (SACs) show great potential for CO2RR due to their high atom utilization and HER suppression [2]. Carbon-based supports like graphene, MOFs, CNTs, and covalent triazine frameworks (CTFs) enhance SAC performance with their unique electronic properties and conductivity. CTFs, in particular, offer tunable heteroatom content and strong covalent bonds [3].

We synthesized Cu single-atom catalysts (Cu-SACs) using a CTF based on perylenediimide (PDI) and triazine precursors. This conductive carbon support enabled the selective electroreduction of CO2 to methanol, achieving a faradaic efficiency (FE) of 72.6% at 0.2 V vs. RHE. The CTF-Cu-SACs demonstrated strong stability, maintaining performance over 20 hours of continuous electrolysis. Nitrogen doping within the PDI-CTF further enhanced product selectivity, likely due to the combined effect of the conductive pyrolyzed CTF and nitrogen-chelating ligands, which provided abundant active sites. Our findings indicate that PDI-CTF-based Cu-SACs improve CO2 adsorption and ion/charge transport, enabling efficient CO2 reduction to methanol in aqueous systems.

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# 20.

## TRANSFERSOMES: A PROMISING INNOVATION IN TARGETED SKIN CANCER THERAPY

D. Wanat (1), K. Sala (2), M. Bańkosz (1), B. Tyliszczak (2)
1. Cracow University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
2. Cracow University of technology, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
E-mail (corresponding author): dominika.wanat@doktorant.pk.edu.pl

Skin cancers, including melanoma, pose significant therapeutic challenges due to their complex biology and the difficulty in delivering drugs to affected areas. One innovative approach to targeted therapy is the use of transfersomes – flexible lipid carriers that enable efficient drug penetration through the skin barrier [1]. Transfersomes, thanks to their unique structure, can pass through the stratum corneum, making them a promising solution for skin cancer treatment. The mechanism of action of transfersomes, their application in delivering anticancer drugs, and research results on their efficacy indicate that they can significantly improve the effectiveness of skin cancer therapy [2]. The advantages and limitations of this technology compared to other drug delivery systems, such as liposomes and nanoemulsions, have also been analyzed. Transfersomes stand out for their ability to enhance drug bioavailability while simultaneously reducing systemic toxicity, leading to an improved safety profile of the therapy. The findings indicate that transfersomes can significantly enhance the bioavailability of anticancer drugs while reducing systemic toxicity, thus improving the safety profile of the therapy [3]. Further research on optimizing transfersome composition and integrating them with photodynamic therapies and immunotherapy may open new avenues for treating skin cancer patients. Transfersomes show great potential as a tool in targeted therapy, contributing to a more precise and effective fight against cancer.

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21.

# TRANSFERSOMES IN TARGETED SKIN CANCER THERAPY: ENHANCING TREATMENT EFFICACY AND SAFET

K. Sala (1), D. Wanat (2), M. Bańkosz (2), B. Tyliszczak (1)
1. Cracow University of Technology, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
2. Cracow University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
E-mail (corresponding author): katarzyna.sala@student.pk.edu.pl

Chronic wounds pose a significant challenge to global healthcare systems, affecting approximately 1.5% of the population in developed countries and leading to high treatment costs. Infections complicate wound healing, prolong recovery times, and can result in severe outcomes such as amputations or life-threatening conditions. Additionally, the overuse of antibacterial agents, particularly antibiotics, contributes to the emergence of resistant bacterial strains, which further complicates treatment. To address these issues, this project proposes the development of advanced hydrogel dressings incorporating plant-derived adaptogens, known for their ability to modulate immune responses, reduce oxidative stress, and support tissue regeneration. The innovative hydrogel dressings aim to provide controlled, localized release of active adaptogenic substances, offering a personalized treatment approach for chronic wounds. By optimizing the composition and properties of the polymer matrix, we can regulate the release rate of the adaptogens, thereby enhancing their therapeutic effects while minimizing potential side effects. This project focuses on the synthesis and formulation of hydrogel systems, determination of the release profiles of active substances, and evaluation of the physicochemical and mechanical properties of the dressings. Furthermore, the ecological aspects of the materials used and the potential for reducing the environmental impact of chronic wound treatment are considered, contributing to the sustainability of the proposed solution. These dressings offer a novel approach to improve wound healing outcomes, reduce healthcare costs, and address the global issue of antibiotic resistance.

Acknowledgments: The project is financed with funds from the state budget granted by the Minister of Science within the framework of the "Student Scientific Clubs Create Innovations" (SKN/SP/601893/2024) "Application of Biohydrogels Containing Adaptogens in Innovative Chronic Wound Therapy" .The research work was carried out within the SMART-MAT Functional Materials Science Club (section Smart-Mat) at the Faculty of Materials Engineering and Physics of the Cracow University of Technology.

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# 22.

## PHARMACOLOGICAL AND CLINICAL POTENTIAL OF ADAPTOGENS

Oliwia Grzywacz (1), Magdalena Bańkosz (2), Magdalena Kędzierska (3), Bożena Tyliszczak (1)

1. Cracov University of technology, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracov, Poland
2. Cracov University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracov, Poland
3. Department of Chemotherapy, Copernicus Memorial Hospital of Lodz, Medical University of Lodz, Lodz, Poland

E-mail (corresponding author): oliwia.grzywacz@student.pk.edu.pl

Adaptogens have been present in medicine for centuries. Adaptogens are a group of plant substances that exhibit properties that regulate the body's response to various types of stressors. The four most common adaptogens found in the scientific literature are ashwagandha, panax ginseng and rhodiola rosea [1]. They have been popular for centuries due to their natural plant origins and the lack of side effects from their use. They are distinsguished by their lack of specific action and their ability to adapt to the changing needs of biological systems. The increased incidence of 21st century diseases suggests that stressors are on the rise. It has been proven that many adaptogenic plants, when supplemented individually in the form of capsules with powdered plant material, improve the condition of patients suffering from anxiety and depression, which belongs to the 21st century diseases. This proves that the use of adaptogens as a supplement has desirable effects which proves at the same time that adaptogens used as an active substance show potential to combat the negative effects of the stresses of daily life on humans [2,3].

The research was carried out as part of the SMART-MAT Functional Materials Scientific Circle operating at the Faculty of Materials Engineering and Physics of the Cracow University of Technology. The project is financed with funds from the state budget granted by the Minister of National Education within the framework of the “Student Scientific Clubs Create Innovations” program.

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# 23.

## NANOSYSTEMS BASED ON POLY(2-OXAZOLINES) FOR ANTIBACTERIAL APPLICATIONS

Marcelina Bochenek (1), Barbara Mendrek (1), Wojciech Wałach (1), Aleksander Foryś (1), Jerzy Kubacki (2), Łukasz Jałowiecki (3), Jacek Borgulat (3), Grażyna Płaza (4), Agnieszka Klama-Baryła (5), Anna Sitkowska (5), Agnieszka Kowalczuk (1), Natalia Oleszko-Torbus (1)

1. Centrum Materiałów Polimerowych i Węglowych Polskiej Akademii Nauk, ul. M. Curie-Skłodowskiej 34, 41-819 Zabrze
2. Wydział Nauk Ścisłych i Technicznych, Uniwersytet Śląski w Katowicach, u. 75 Pułku Piechoty 1, 41-500 Chorzów
3. Instytut Ekologii Terenów Uprzemysłowionych, ul. Kossutha 6, 40-844 Katowice
4. Wydział Organizacji i Zarządzania, Politechnika Śląska, ul. Roosvelta 26-28, 41-800 Zabrze
5. Centrum Leczenia Oparzeń im. Dr. Stanisława Sakiela w Siemianowicach Śląskich, ul. Jana Pawła II 2, 41-100 Siemianowice Śląskie

E-mail (corresponding author): noleszko@cmpw-pan.pl

The study yielded a nanosystems of a 2-oxazoline-based copolymer and a chelating compound that can complex the ions responsible for stabilizing the bacterial outer cell membrane. The proposed strategy demonstrates a new approach to the synthesis of antibacterial polymers and redefines the possibilities of their interaction with bacteria.

The 2-ethyl- and 2-(3-butenyl)-2-oxazoline copolymer (POx) was modified with a DOTA chelating agent, which generated the ability to complex ions (POx-DOTA) in the macromolecule. The obtained conjugate was characterized using gel chromatography techniques and nuclear magnetic resonance spectroscopy. POx-DOTA has been shown to form nanostructures in aqueous solutions and exhibit the ability to complex Ca2+ ions. These properties were used to study the conjugate's interaction with gram negative bacteria, whose cell membrane is known to be rich in Ca2+ ions.

Interactions between POx-DOTA and a model strain of E. coli bacteria were visualized using TEM microscopy. The study showed that the conjugate was capable of destroying the bacterial cell membrane, leading to its disintegration. At the same time, the number of colonies in the presence of POx-DOTA did not increase throughout the culture, indicating that the studied polymeric nanosystem exhibited bacteriostatic properties.

Nanostructures based on 2-oxazolines functionalized with chelates, capable of interacting with and destroying bacterial cell membranes, may be an effective solution for obtaining new materials with antibacterial activity.

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24.

# FLUORENE AND CARBAZOLE DERIVATIVES AS ELEMENTS OF INORGANIC-ORGANIC SOLAR CELLS

A. K. Pająk (1), S. Kotowicz (2), E. Schab-Balcerzak (1,2)
1. Centre of Polymer and Carbon Materials PAN, 34 M. Curie-Skłodowskiej Str., 41-819 Zabrze, Poland
2. Institute of Chemistry, University of Silesia, 9 Szkolna Str., 40-006 Katowice, Poland
E-mail (corresponding author): apajak@cmpw-pan.pl

Nowadays, there is an intensive research trend towards searching for a new generation of processable organic semiconductors that can transport positive charges for applications as solid electrolytes in dye-sensitized cells (DSSCs) and perovskite solar cells (PSCs).
In the development of charge-transporting materials, it is crucial to understand the correlation between the chemical structure and their properties which are important in application. Deepening the knowledge of the relationship between the organic materials' chemical structure and selected properties important for application will allow obtaining organic compounds with assumed properties and improving optoelectronic systems.

Fluorene and carbazole derivatives possess interesting optical and electronic properties that are perfect in many applications. The derivatives' both of these structures are characterized by high thermal stability, good solubility, high photostability, good layer-forming properties, intensive luminescence, and the ability to transport positive charges [1].

The presented research results are intended to analyze the examined compounds' thermal, absorption properties in the UV-Vis range, photoluminescence, and electrochemical properties, as well as to determine the ability to transport positive charges, which was verified in inorganic-organic, i.e. perovskite solar cells. The investigated fluorene and carbazole derivatives were characterized by high thermal stability (T5% = 356–432 °C).
These compounds were molecular glasses with high Tg from 123 to 133 °C,
and electrochemically active, with Eg ranging from 2.15 to 3.88 eV. The derivatives absorbed with a maximum absorption band from 244 to 367 nm in solution, and in the solid state from 257 to 403 nm. The compounds emitted light from the violet to blue-green color range
in solution, and in a layer and powder the yellow-orange (with a fluorene group) and violet
(with a carbazole). The highest power conversion efficiency (PCE = 4.72%) was obtained for the PSC of the fluorene derivative with a phenyl substituent [2, 3].

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25.

# FUNCTIONALIZED CARBON NANOMATERIALS AS ENHANCEMENT COMPONENTS FOR INDUSTRIAL LUBRICANTS

I. Scudło (1), J. Woch (1), S. Boncel (2)
1. Łukasiewicz Research Network - Institute of Heavy Organic Synthesis “Blachownia“, Kędzierzyn-Koźle, Poland
2. Silesian University of Technology, Faculty of Chemistry, Gliwice, Poland
E-mail (corresponding author): ilona.scudlo@icso.lukasiewicz.gov.pl

The poster presents the results of stability studies of chemically modified carbon nanomaterials for use as components in industrial lubricants.

Commercially available lubricants composed of base oil and conventional additives do not always provide the required performance, as some issues related to insufficient friction reduction and rapid wear of machine components are being observed.
Carbon nanomaterials show the potential to improve the lubricating properties of the media in which they are homogeneously dispersed [1, 2].

The research presented here focuses on the use of analytical methods using the light scattering phenomenon in assessing the stability of industrial lubricants.
Analytical methods using light scattering (LS) a useful instrument for characterizing the microstructure of colloidal systems and assessing their stability over time useful in evaluating the quality of lubricants and performance product [3].

Dynamic light scattering (DLS) non-invasively enables measurement of particle size in dispersion. The interaction parameters of dynamic and static light scattering (SLS) are helpful in quickly determining and comparing the stability of dilute colloids. Observation of changes in the intensity of light scattered by particles at different sample heights informs about the nature of the occurring dispersion stability loss.

This work is supported by State Budget under the "IMPLEMENTATION DOCTORATE" Programme

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# 26.

# PHTHALIMIDE AND 1,8-NAPHTHAL-PHTHALIMIDE DERIVATIVES – CHARACTERIZATION AND APPLICATIONS

Sonia Kotowicz (1), Ewa Schab-Balcerzak (1,2), Sebastian Maćkowski (3 0,
1. Institute of Chemistry, University of Silesia, 9 Szkolna Str., 40-006 Katowice, Poland
2. Centre of Polymer and Carbon Materials, Polish Academy of Sciences, 34 M. Curie-Sklodowska Str., 41-819 Zabrze, Poland
3. Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, 5 Grudziadzka Str., 87-100 Torun, Poland

Phthalimides and 1,8-naphthalimides are still interesting to investigate by many groups of scientists. These structures are often used as acceptors (via electron-withdrawing elements) in organic electronics as n-type semiconductors [1]. The study of the thermal and electrochemical properties and a wide-ranging study of the optical properties are crucial to designing the structure of devices [2]. An important aspect is also initial application research (pilot studies), during which we can simulate the conditions in the surrounding environment in real time.

The presented research results show the two groups of compounds – strong blue emitters phthalimide derivatives [3] and weak blue emitters 1,8-naphthal-phthalimide derivatives. The compounds were subjected to comprehensive physicochemical measurements: thermal, optical and electrochemical. Presented compounds were thermally stable up to 380 ºC, and seven of the them were molecular glasses. 1,8-Naphthal-phthalimide derivatives have shown low ionization potentials (below -6.76 eV) and an energy band-gap below 3.37 eV, whereas the phthalimide derivatives have shown an energy band-gap below 3 eV. The photoluminescence studies in the solution, films and blends with a two-component matrix poly(vinylcarbazole):2-tert-butylphenyl-5-biphenyl-1,3,4-oxadiazol (PVK:PBD) showed their ability to emit light from blue to green spectral region. Moreover, the blends with a conducting polymer poly[2,5-bis(2-octyldodecyl)pyrrolo[3,4-c]pyrrole-1,4(2H,5H)-dione-3,6-diyl)-alt-(2,2';5',2'';5'',2'''-quaterthiophen-5,5'''-diyl)] (PDPP4T) with 1,8-naphthal-phthalimides were also investigated. The application possibilities of the obtained compounds were analyzed. The phthalimide derivatives were used as a component of the active layer in OLEDs. The obtained OLEDs (ITO/PEDOT:PSS/phthalimide derivatives:PVK:PBD/Al) emitted light from blue spectral region and started to emit under external voltage of about 10 V. The 1,8-naphthal-phthalimide derivatives effectively quenched the emission of the PDPP4T polymer, which may be useful in the chemical structure of the active layers of photovoltaic cells.

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27.

# MXENS AS POTENTIAL BONE IMPLANT COATINGS

E.Kosińska (1), J.Sadlik (1) A.Tomala (1)
1. Cracow University of Technology, Faculty of Materials Engineering and Physics
Department of Materials Engineering, 37 Jana Pawla II ave, 31-864 Cracow, Poland
E-mail (corresponding author): edyta.kosinska@doktorant.pk.edu.pl

Nowadays, the demand for bone implants is expanding. The reason for this is the increasingly rapid aging of the population, and with it the increasing number of bone injuries associated with osteoporosis, which usually occurs in old age. For this reason, more and more research is focusing on bone implants coated with coatings that can have a significant impact on the bone-implant connection.

MXEne are among the relatively newly discovered nanostructures that bring new properties to many applications, including biomedical. MXENs are two-dimensional (2D) materials characterized by a layered structure in which the individual sheets are connected by weak hydrogen and van der Waals bonds [1]. MXENs have excellent properties when it comes to tribology.Studies indicate, the nanostructures in discussion will ideally serve as beneficial tribophilms that can be used as lubricants and as a reinforcing additive for composites. MXenes' potential was brought to the limelight because of their large surface area, size tunability, drug loading capacity, biocompatibility, and non-toxic nature in living entities.
Nanostructures containing especially elements such as Ti, Ta and Nb are inert to biological systems. Therefore, these elements are non-toxic, biocompatible and biodegradable [2].

The review literature indicates the combination of titanium alloy-based implants along with applied MXEN coatings can introduce properties such as biocompatibility and increased levels of control over tribological properties.

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# 28. STUDY OF PLASMONIC HEATING IN GOLD NANORODS

G. Opiła (1,2), A. Pietrzyk (3), E. Gumieniczek-Chłopek (1), Sz. Zapotoczny (3), Cz. Kapusta (1,2)

1. AGH University of Krakow, Faculty of Physics and Applied Computer Science, Mickiewicza Av. 30, 30-059 Krakow, Poland

2. AGH University of Krakow, Space Technology Centre, Mickiewicza Av. 30, 30-059 Kraków, Poland

3. Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387 Krakow, Poland

E-mail (corresponding author): gopila@agh.edu.pl

Plasmonic effects, such as Localised Surface Plasmon Resonance (LSPR), prove useful in multiple applications in various fields of science, medicine, technology, and engineering. Examples of benefits of plasmonic effect include boosting photocatalytic degradation of toluene, [1] photothermal induction of pyroptosis in malignant glioma spheroids [2] and others, both industrial and biomedical. As those examples demonstrate, plasmonic properties open way for innovative methods of taking care of health and environment. Plasmonic properties of nanoparticles are determined by their size, shape and material, and noble metals such as gold and silver are typical materials in which LSPR can be induced. Moreover, plasmonic responsive gold nanoparticles can be synthesized using upcycled e-waste, therefore contributing to the idea of circular economy. [3]

We have synthesized gold nanoparticles in the shape of nanorods using a modified seedless growth technique. The nanorods were characterized using UV-VIS, STEM and Cryo-TEM to find the relationship between their aspect ratio and their spectra. Using laser beam, we exposed a dispersion of the nanorods to a wavelength of 808 nm, selected due to its ability to penetrate skin. With a setup consisting of a high-resolution thermographic camera and a macro lens, plasmonic heating was observed and its dynamic was analyzed. Such a setup allows for both an in vitro and an in vivo study.

Thermography study of gold nanorods samples as obtained from the synthesis, as well as in various concentrations and with anionic capsules investigated in an in vitro environment will be presented. The results show that the samples of undiluted dispersion achieve more than 42 degrees Celsius in 60 seconds, proving that the material is a promising one for e. g. inducing apoptosis of undesirable (tumour) cells.

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# 29.

## BIOHYDROGELS WITH ADAPTOGENS IN TISSUE REGENERATION

C. Garbowska (1), M. Bańkosz (2), M. Kędzierska (3), B. Tyliszczak (1)
1. Cracow University of Technology, Faculty of Materials Engineering and Physics Department of Material Engineering. Cracow, Poland
2. Cracow University of Technology, CUT Doctoral School, Faculty of Materials Engineering and Physics Department of Material Engineering, Cracow, Poland
3. Department of Chemotherapy, Copernicus Memorial Hospital of Lodz, Medical University of Lodz, Lodz, Poland
E-mail (corresponding author): claudia.mordaka@student.pk.edu.pl

Biohydrogels with adaptogens are an innovative solution in regenerative medicine that integrates the ability of hydrogels to release bioactive substances in a controlled manner with the broad therapeutic effects of adaptogens such as Withania somnifera (ashwagandha), Panax ginseng (ginseng) or Rhodiola rosea (mountain rhodiola). Adaptogens are particularly valued for their antioxidant, anti-inflammatory and immunomodulating properties, which support the body's natural repair processes, including tissue regeneration. They reduce the oxidative stress that often accompanies injury, regulate the inflammatory response and promote cell proliferation and migration, which is crucial in the healing process.

Hydrogels, being biocompatible polymers, have a dual function: they serve as a scaffold for cells, enabling their adhesion and growth, and act as carriers for adaptogens, ensuring their gradual release at the site of injury. This makes it possible to prolong the action of the adaptogens and to precisely dose the bioactive substances at the site needed for regeneration.

The use of biohydrogels with adaptogens is particularly important in the treatment of chronic wounds that are difficult to heal and in the regeneration of tissues such as muscle, skin or cartilage. Panax ginseng, for example, supports collagen synthesis, which accelerates skin regeneration, while Rhodiola rosea reduces inflammation and protects cells from oxidative stress. Withania somnifera, on the other hand, improves the regeneration of muscle and nerve tissue, promoting their recovery from damage.

Promising research results indicate that biohydrogels enriched with adaptogens may become a future tool in the treatment of tissue damage, especially in the context of the treatment of hard-to-heal wounds and degenerative diseases.

The research was carried out as part of the SMART-MAT Functional Materials Scientific Circle operating at the Faculty of Materials Engineering and Physics of the Cracow University of Technology. The project is financed with funds from the state budget granted by the Minister of National Education within the framework of the “Student Scientific Circles Create Innovations” program.

# 30.

## CROSS-LINKING OF CARBON NANOTUBES USING S-TETRAZINE DERIVATIVES

Anna Blacha (1), Szymon Ruczka (1), Pierre Audebert (2), Aleksandra Cyganiuk (3), Emil Korczeniewski (3), Artur Terzyk (3), Sławomir Boncel (1)

1. Silesian University of Technology, Department of Organic Chemistry, Bioorganic Chemistry and Biotechnology, NanoCarbon Group, Gliwice 44-100, B. Krzywoustego Street 4, Poland

2. Université Paris-Saclay, ENS Paris-Saclay, CNRS, 4 Avenue des Sciences, 91100 Gif sur Yvette, France

3. Nicolaus Copernicus University in Toruń, Faculty of Chemistry, Physicochemistry of Carbon Materials Research Group, Toruń 87-100 Gagarin Street 7, Poland First author's affiliation, City, Country

E-mail (corresponding author): anna.blacha@polsl.pl

Carbon nanotubes (CNTs), due to their quasi-aromatic structure, cylindrical shape, and small individual sizes, are characterized by excellent electrical, thermal, mechanical, and optical properties [1]. Since their discovery, they have become a promising subject of research, in which CNTs are finding many applications, ranging from electronics through materials engineering to medicine. Functionalization of that materials ensure their better dispersibility in solvents and increased physicochemical compatibility with polymer matrices, typically by the anchored functional groups. Therefore, there is a constant need to develop modified nanomaterials, and "controlled" functionalization makes CNTs processable designed for the target application. On the other hand, "assembling" CNTs into desired forms and geometries with excellent electrical, thermal, and mechanical properties would require "infinitely" long CNTs. This function could be achieved, for example, by cross-linking CNTs. In this paper, we present a method of covalent cross-linking of carbon nanotubes using s-tetrazine derivatives [2,3]. We have selected several specially designed s-tetrazine structures containing aromatic and aliphatic substituents. The obtained functionalized CNTs (f-CNTs) were examined using analytical techniques such as thermogravimetric analysis (TGA), scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman spectroscopy and infrared spectroscopy (FTIR). Then, new nanocomposites and electroconductive pastes were produced from f-CNTs, and their electrical and thermal properties were tested for use.

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31.

# NEW BEAMLINES (CIRI AND POLYX) AT THE NATIONAL SYNCHROTRON RADIATION CENTRE SOLARIS

M. Gołuński (1)
1. National Synchrotron Radiation Centre SOLARIS, Jagiellonian University, Krakow, Poland
E-mail (corresponding author): industry.solaris@uj.edu.pl

Synchrotron radiation (also called synchrotron light) is produced in a synchrotron and then directed to beamlines with experimental end-stations. Each beamline and end station is unique and provides specific solutions to serve scientists and their measurements. The SOLARIS National Synchrotron Radiation Centre stands as a beacon of scientific advancement, being the largest scientific research device in Poland and the first and only synchrotron light source in Central Europe. It is a third-generation light source operating at an electron energy of 1.5 GeV and has been serving synchrotron radiation to users since 2018. In the second half of 2024, SOLARIS feeds seven beamlines operating in the range of radiation from IR to hard X-rays, enabling experiments with multiple experimental techniques. Apart from that, the SOLARIS Centre hosts two cryo-electron microscopes of the latest generation: Titan Krios G3i and Glacios.

Two of the synchrotron beamlines are new additions since the last InterNanoPoland conference, showcasing the continuous growth and development of the SOLARIS Centre. The recently opened POLYX beamline, a compact beamline for X-ray microimaging and X-ray microspectroscopy in the 4-15 keV energy range, has transitioned from a commissioning mode to regular operation, becoming a fully operational beamline. The CIRI beamline, which uses infrared radiation suitable for chemical analysis on the microscale and investigation of intramolecular interactions, has recently switched to synchrotron radiation, opening up new possibilities for everyone interested in testing its capabilities.

In the poster, I present both beamlines and sample experiments that can be done with them. I also discuss the advantages of synchrotron-based research over conventional radiation sources.

32.

# GRAPHENE ON SIC AS A PROMISING PLATFORM FOR MAGNETIC FIELD DETECTION UNDER NEUTRON IRRADIATION

Jakub Jagiełło (1), Artur Dobrowolski (2), Tymoteusz Ciuk (3)
1. Łukasiewicz Research Network – Institute of Microelectronics and Photonics,Warsaw, Poland
E-mail (corresponding author): jakub.jagiello@imif.lukasiewicz.gov.pl

Controlled nuclear fusion is a long-term goal for a sustainable energy supply on a global scale [1][2]. Current and future projects, including the International Thermonuclear Experimental Reactor (ITER) and the Demonstration Power Plant (DEMO), demand several technological advancements to operate effectively. Among them are magnetic field detectors able to operate under extreme neutron radiation and high temperatures (190–350 ◦ C). In such reactors, plasma is confined by the magnetic field, which makes reliable magnetic diagnostics an important issue for the stability of the fusion. Commercially available semiconductor Hall sensors were found to be incompatible with the extreme conditions of ITER. Hence, current pursuits are based predominantly on thin sensing layers made of chromium and bismuth, while gold and antimony solutions are also being considered. All prospects have some advantages. However, they also suffer from intrinsic drawbacks like low sensitivity or sharp temperature dependence of their electrical parameters. Furthermore, the investigated systems have a relatively high cross-section for neutrons as the layers are three-dimensional bulk structures comprising heavy elements. Thus, the statistical probability of neutrons colliding with atoms in the crystal structure is high even at moderate flux. Consequently, sensors with a smaller cross-section for neutrons could prove superior. The adoption of two-dimensional (2D) layered materials would minimize the collision probability. However, not all 2D sheets will be suitable. A high Hall coefficient is also required. This makes graphene a particularly promising platform as the sheets can be fabricated into exceptionally sensitive Hall effect sensors. We demonstrate on the first experimental study [3] on the impact of neutron radiation on quasi-free-standing (QFS) graphene. For this purpose, we have fabricated hydrogen-intercalated QFS graphene on semiinsulating high-purity 4H-SiC(0001), passivated it with an Al2O3 layer, and exposed it to a fast-neutron fluence of ≈ 6.6 × 1017 cm−2. The results have shown that the graphene sheet is only moderately affected by the neutron radiation with the estimated defect density of ≈ 4 × 1010 cm−2. The low structural damage allowed the Al2O3/graphene/SiC system to maintain its electrical properties and an excellent sensitivity to magnetic fields characteristic of QFS graphene. Consequently, our findings suggest that the system may be a promising platform for magnetic diagnostics in magnetic-confinement fusion reactors. However, the scope of its use should be a subject of further study. In this context, we have explored possible modes of damage and have concluded that the main factor that affects the electrical parameters of the structure is the impact of neutrons on the layer of hydrogen atoms saturating the SiC(0001) surface.

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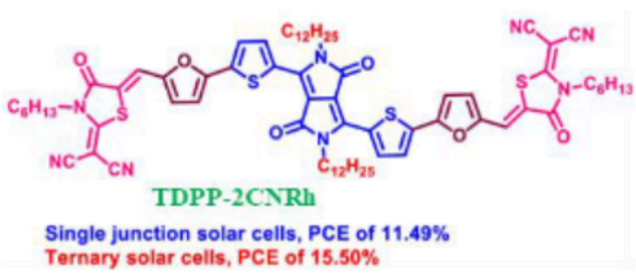
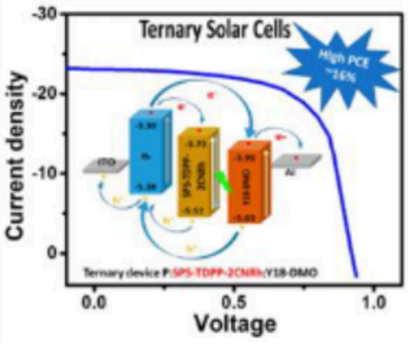
33.

# MEDIUM BANDGAP ELECTRON ACCEPTOR BASED ON DIKETO PYRROLOPYRROLE FOR TERNARY ORGANIC SOLAR CELLS

Bommaramoni Yadagiri (1, 2), Surya Prakash Singh (2), and Igor F. Perepichka (1)
1. Department of Physical Chemistry and Technology of Polymers, Faculty of chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland
2. Polymers and Functional Materials Division, CSIR-Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad- 500007, India.
E-mail (corresponding author): Yadagiri.Bommaramoni@polsl.pl

Organic solar cells (OSCs) with bulk-heterojunction (BHJ) architecture are more suitable for flexible and lightweight solution processing fabrication.[1-2] Recently, a significant leap in the power conversion efficiencies (PCEs) of non-fullerene acceptors (NFAs) of more than 19% has been reported with novel developments in NFAs.[3] In this work, we report the design of novel medium bandgap NFA, SPS-TDPP-2CNRh, consists of a strong electron-accepting unit thiophene-diketopyrrolopyrrole as central unit, which is attached to the dicyanomethylene-3-hexylrhodanine (CNRh) acceptor via a furan as π-spacer unit. The incorporation of CNRh and furan enhance the light absorption by extending π-conjugation and is anticipated to improve the VOC. Binary BHJ-OSCs constructed with polymer P as the donor and SPS-TDPP-2CNRh as the acceptor resulted in a PCE of 11.49%. Additionally, a ternary OSC device based on Y18-DMO and SPS-TDPP-2CNRh as acceptors having complementary absorption profiles and polymer P as the donor, resulting in a high PCE of 15.50%. The ternary OSCs with SPS-TDPP-2CNRh as the host acceptor in the P:Y18-DMO binary film were shown to have improved PCE values, which is mainly attributed to the effective photoinduced charge transfer through multiple networks and the use of excitons from SPS-TDPP-2CNRh and Y18-DMO. These results demonstrate that combining medium bandgap and narrow bandgap NFAs with a wide bandgap polymer donor is a successful route to increasing the overall PCE of the OSCs.

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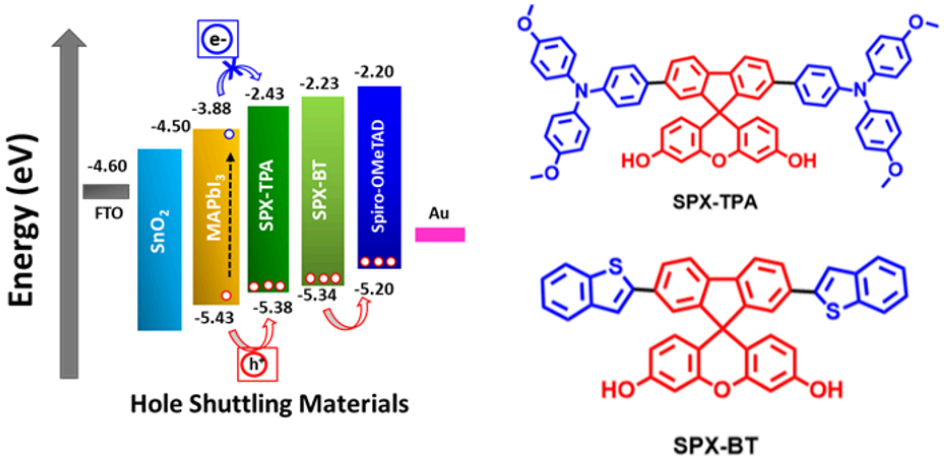
34.

# SPIRO[FLUORENE-9,9′-XANTHENE]-BASED MATERIALS FOR EFFECTIVE DEFECT PASSIVATION IN PEROVSKITE SOLAR CELLS

Bommaramoni Yadagiri (1, 2), Jae-Joon Lee (2), and Igor F. Perepichka (1)
1. Department of Physical Chemistry and Technology of Polymers, Faculty of chemistry, and Centre for Organic and Nanohybrid Electronics, Silesian University of Technology, Konarskiego 22b, Gliwice 44-100, Poland
2. Department of Energy & Materials Engineering, Dongguk University, Republic of Korea
E-mail (corresponding author): Yadagiri.Bommaramoni@polsl.pl

Perovskite solar cells (PSCs) have attracted wide interest in both academia and industry due to their high efficiency, low cost, and great application potential.[1] The certified efficiency of PSCs has recently surpassed 26%.[2] Interfacial engineering between the perovskite layer and hole transporting layer has become an effective approach to enhance both the performance and stability of PSCs.[3] Herein, cruciform-shaped dual functional organic materials, SPX-TPA and SPX-BT, are employed as surface passivation and hole transporting interfacial layers in MAPbI3-based PSCs. The rigid three-dimensional conjugated spiro(fluorene-9,9′-xanthene) (SPX) core can effectively adjust the HOMO level and inhibits intramolecular π-π stacking to extract holes from the adjacent perovskite layer. The hydroxyl (-OH) group in the SPX unit forms hydrogen bonds with undercoordinated iodide (I) and methyl ammonium (MA+) ions, suppressing the related defects. Lewis bases (O, N and S) in TPA and BT units can promote the passivation of undercoordinated Pb2+ and MA+ via Lewis's acid-base interactions (Pb-S/O/N). As a result, the PSCs with SPX-TPA and SPX-BT exhibit significantly improved PCEs of 20.03% and 18.51%,

respectively, while the PCE of the control device is 17.77%. The enhanced PV performance of SPX-TPA treated PSCs is ascribed to the well-aligned energy levels, superior hole mobility, and favorable film morphology.

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35.

# PRODUCTION AND CHARACTERIZATION OF THIN FILMS OF ZINC OXIDE

K. Wojtasik (1), N. Nosidlak (1), K. Matus (2), C. Garbowska (1), O. Grzywacz (1), W. Wrzesińska (1), M. Czajka (1), J. Hrywna (1), M. Mrowczyk (1), M. Wojtasik (3)

1. Department of Physics, Faculty of Materials Engineering and Physics, Cracow University of Technology, Kraków, Poland

2. Materials Research Laboratory, Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland

3. Oil and Gas Institute – National Research Institute, Kraków, Poland

E-mail (corresponding author): katarzyna.wojtasik@pk.edu.pl

Zinc oxide (ZnO) is one of the most popular materials with a variety of properties, such as photocatalytic, electrical, optical and biological properties. It is an n-type semiconductor with high exciton binding energy (60 meV at room temperature) and wide band gap (Egdir=3.37 eV), which is why it shows high absorption in the UV range of electromagnetic radiation and transparency in the visible range. It is also characterized by high conductivity, due to oxygen vacancies. It is a chemically stable, available and non-toxic material. These features make it an attractive material for applications in optoelectronics, electronics, optics, biomedicine and sensors [1].

ZnO thin films can be produced by physical and chemical methods. One of them is the sol-gel method. The sol-gel method is a chemical method of producing materials from the liquid phase and its greatest advantage is the possibility of controlling the structure of the produced material in a wide range. By selecting the sol synthesis parameters, such as the precursor, stabilizing agent, solvent, surfactant, synthesis time or sol ageing time, we can influence the structure of the ZnO layer and at the same time its properties [2]. The sol can be applied to various substrates, and the most popular methods are: spray-coating, dip-coating and spin-coating. In the dip-coating method, the most important parameter influencing the thickness of the produced layers is the speed of emergence of the substrate from the sol, while in the spin-coating method it is the speed of rotation of the substrate [3].

The aim of the presented work was to investigate the effect of nonionic surfactants added during the synthesis of sols on the optical properties and surface morphology of thin films ZnO produced by the sol-gel method and spin-coating technique. The effect of the amount of added surfactant was also investigated.

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# 36.

# APPLICATION OF GOLD NANOPARTICLES TO STIMULATE COLLAGEN PRODUCTION IN THE SKIN

K. Lis (1,2), K. Haraźna (3), D. Słota (1), K. Niziołek (1), A. Sobczak-Kupiec (3)
1. Doctoral School of Cracow University of Technology, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
2. Smart-Mat Students Scientific Association Group, The Bio-Mat Section, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
3. Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
E-mail (corresponding author):kamila.lis@doktorant.pk.edu.pl

Nanotechnology is a field that plays an important role in the biomedical sector. Nanoparticles (NPs) are widely used in applications such as delivery systems for active substances, wound dressings, targeted therapies, etc. NPs are particles with a size between 1-100 nm, and thanks to their small size, they are able to penetrate the membranes and cell walls of pathogens [1]. One of the most widely used metal nanoparticles is colloidal gold (AuNPs). AuNPs have excellent biological properties. Studies show that it has anti-inflammatory, anti-bacterial, anti-angiogenic effects and has good biocompatibility [1].

Interestingly, AuNPs can help increase collagen production in the skin [1]. Collagen enables cell migration and proliferation to accelerate tissue regeneration, which is why stimulating collagen production is important in regeneration. If wound healing is too slow, it promotes bacterial infection, which can lead to tissue defects. Therefore, important that the skin is regenerated quickly and correctly, as it is the first protective covering for the body against various harmful substances and microorganisms. Therefore, the development of an AuNPs-modified hydrogels may result in improved performance. Hydrogels can absorb vast amounts of aqueous solutions. They are biocompatible, biodegradable and enhance bioavailability. Applying an AuNPs-enriched polymeric material directly to the skin may result in faster wound healing by providing the appropriate factors needed for regeneration and stimulation of collagen expression [2,3].

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37.

# ASSESSING THE PERFORMANCE OF SMALL CONCRETE BEAMS REINFORCED WITH STEEL AND FIBER REINFORCED POLYMER BARS

Abel A. Belay (1), Julita Krassowska (1), Marta Kosior-Kazberuk (1)
1. Białystok University of Technology
Wiejska 45A 15-351, Białystok, Poland
abel.belay@sd.pb.edu.pl

This research investigates the performance of small concrete beams reinforced with glass fiber reinforced polymer (GFRP), basalt fiber reinforced polymer (BFRP), and traditional steel bars. It addresses limitations of steel reinforcement and explores alternative strategies for better infrastructure solutions. FRP materials offer benefits like lightweight properties, cost-effectiveness and corrosion resistance. The study analyzes strength, load-bearing capacity, failure modes, and deflection of concrete beams reinforced with these materials.

Concrete beams were prepared with CEM I 42.5R Portland cement, a water-cement ratio of 0.5, sand, aggregates, and super-plasticizer. Reinforcements included 6 mm diameter S-500 steel bars, 6 mm BFRPs, and 8 mm GFRPs, all 940 mm long. An experimental program assessed the ultimate load-bearing capacity, mid-span deflection, average deformation, and failure modes. Specimens' concrete were mixed, cured, and tested per Eurocode. Six beams (120 x 80 x 1100 mm) with steel, GFRP, and BFRP reinforcements were used.

GFRP-reinforced beams supported higher ultimate loads than BFRP and steel-reinforced beams. BFRP beams, despite early crack initiation, had higher ultimate load-bearing capacity than steel beams.

Steel reinforced concrete beams failed at 20 KN and 21.8 KN with mid-span deflections of 4.76 mm and 4.65 mm. GFRP reinforced concrete beams failed at 32 KN and 40 KN, with deflections of 14.01 mm and 14.61 mm. BFRP reinforced concrete beams failed at 26 KN and 30 KN, with deflections of 16.17 mm and 21.50 mm. GFRP reinforced concrete beams had significant deformations and larger crack widths. Failure modes differed: steel beams had flexural tension failure, GFRP beams had diagonal tension leading to shear tension failure, and BFRP beams had combined diagonal tension and flexural failure.
This research highlights a shift towards using GFRP and BFRP materials in concrete beams, comparing their mechanical characteristics and effectiveness against traditional steel reinforcement under concrete beams

Keywords: BFRP, GFRP, Steel bars and Concrete beams

# 38. FOCUSED ION BEAM BASED TECHNOLOGIES FOR GEMSTONES

A. Zięba (1), K. Hreczycho (1,2), P, Kunicki (1)
1. Nanores sp. z o.o. sp.k., Bierutowska 57-59, 51-317, Wrocław, Poland
2. Mathematical Institute, University of Wrocław Joliot-Curie 15, 50-383, Wrocław, Poland
E-mail (corresponding author): aneta.zieba@nanores.pl

Focused ion beam microscopy is known mostly by its applications in microelectronics industry, but its nano scale precision can be also valuable for gemstones processing. We present three solutions: NanoPatterning for changing visual impressions by changing colors of a desired area (or whole facets), NanoIndividualization for engraving images on a gemstone table and NanoMarking for fabricating invisible to the human eye marks for ensuring their authenticity. Each of those structures have depth of up to 200 nanometres, so gemstone weight and value is not lowered.

Focused ion beam (FIB) microscope is a device used for imaging and processing material with precision up to tens of nanometres. It is used mostly in manufacturing of semiconductors and transmission electron microscopy sample preparation (lamellas), but its possibilities make it useful in many different industries. On this poster we present FIB technology applied to fabricating micro and nano scale solutions on gemstones.

Value of the most desired gemstones (e.g., rubies and diamonds) comes from their qualities like clarity, carat weight and cut. Those parameters are visually assessed before the gemstone is introduced to the market, so it is important to mark it beforehand. Common methods like laser marking produce symbols visible to the naked eye, so their counterfeits are easy to fabricate. On the other hand, FIB can fabricate patterns with details smaller that wavelength of the light.

In conclusion we developed three technologies for gemstones' modification and security. NanoPatterning focuses on increasing diamond brilliance by fabricating a diffractive grating on its table. NanoIndividualization focuses on engraving unique images on gemstone tables, so that they can be seen by the naked eye. NanoMarking combines simple patterns with data stored in a database. By containing 25-bit word (which gives us more than 2 billion possible sequences) in 5x5 μm area, which coordinates are stored in the database, we fabricate mark close to impossible to find.

We pursued the project within instrument Fast Track 1/1.1.1/2015 about „Development of NanoPatterning, NanoMarking and NanoIndividualization services together with innovative technology of ion sources for Focused Ion Beam.", funded by the European Union from European Regional Development Fund under Smart Growth Operational Programme 2014-2020.

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# 39.

# CHARACTERISATION OF NOVEL NANO/COMPOSITES INTENDED FOR TISSUE ENGINEERING APPLICATIONS

K. Haraźna (1), D. Träger (2), K. Lis (2,3), D. Słota (3), K. Niziołek (3), A. Sobczak-Kupiec (1)

1. Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
2. Smart-Mat Students Scientific Association Group, The Bio-Mat Section, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland
3. Doctoral School of Cracow University of Technology, Department of Materials Engineering, Cracow University of Technology, 31-864 Kraków, Poland

E-mail: katarzyna.harazna@pk.edu.pl

Osteoarthritis (OA) is a degenerative condition affecting the joints and is a significant contributor to disability in older adults. This disorder involves the gradual deterioration of joint tissues and the underlying bone. Presently, the primary focus of OA treatment is on managing pain; however, there remains a deficiency in effective, clinically validated therapies that not only relieve pain but also mitigate ongoing inflammation and promote tissue regeneration. Throughout the progression of OA, various components of the joint, including cartilage, subchondral tissue, and bone can undergo degradation over time. Consequently, contemporary materials designed for osteochondral tissue engineering should replicate the joint's layered architecture. In this context, a notable area of current research is the development of hierarchical and gradient materials. [1]

In this study, the objective was to evaluate the physicochemical, structural, morphological and mechanical properties of nano/composites made from calcium phosphates, modified polysaccharide (PS-mod), and other natural macromolecules. A detailed analysis has shown that the resulting nano/composites are promising materials for applications in osteochondral tissue regeneration. However, to confirm this, in vitro studies on, for example, a mouse pre-osteoblast cell line (MC3T3-e1) are needed.

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# 40.

## ICEPHOBIC AND SELF-HEALING HYDROXY-NANOCARBON COMPOSITES

M. Tarnowska (1), E. Korczeniewski (2), A. P. Terzyk (2), S. Boncel (1)
1. Silesian University of Technology, NanoCarbon Group, Gliwice, Poland
2. Nicolaus Copernicus University in Torun, Physicochemistry of Carbon Materials Group, Torun, Poland
E-mail (corresponding author): monika.tarnowska@polsl.pl

The last two decades have witnessed a rapid development of new icephobic coatings. This interest was translated into the improvement in the fields of nanomaterials, including novel coating methods and an in-depth understanding of ice nucleation and ice adhesion. Anti-icing properties of carbon nanotubes (CNTs), graphene(s), and its oxide(s) are well-known, and seem to be the most promising in the field of icephobic coatings [1]. Never applied before, but promising for this purpose, modern carbon nanomaterials like pristine and hydrogenated single-walled carbon nanohorns (SWCNHs), nanosized graphane, or fluorographane, exhibit high hydrophobicity. At the same time, formation of surface cracks and scratches cannot be neglected during design and manufacturing of the ice-repellent coatings. Nature-inspired, self-healing materials represent a promising solution for this problem [2]. For instance, polydimethylsioxane vitrimers combined with boric acid were proven to act as a prospective component of recovering materials.

Here, we have synthesized self-healing and icephobic composites based on polydimethylosiloxane (PMDS) vitrimers combined with, the thereto embedded, carbon nanomaterials, such as single-walled (SW-), multi-walled (MW-) CNTs, SWCNHs, and/or carbon nanofibers. As the initial modification of carbon nanomaterials, Fenton hydroxylation was applied [3], for which quantification of oxygen functionalities was performed by Boehm titration, thermogravimetric analysis, and Raman spectroscopy. As a result, the highest level of functionalization was obtained for SWCNTs (7.8 mmol g–1), while for SWCNHs 3.0 mmol g–1. Summing up, all carbon nanomaterials were successfully hydroxylated and may undergo further processing aimed at the self-healing and icephobic composites.

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# 41.

# NANOLENSCONNECTION FOCUSED ION BEAM MICROSTRUCTURING OF OPTICAL FIBERS

P.Kunicki (1), K.Hreczycho (1,2)
1. Nanores sp. z o.o. sp.k., Bierutowska 57-59, 51-317, Wrocław, Poland
2. Mathematical Institute, University of Wrocław Joliot-Curie 15, 50-383, Wrocław, Poland
E-mail (corresponding author): piotr.kunicki@nanores.pl

Here, we present the process of milling Fresnel lenses on faces of optical fibers by using focused ion beam (FIB) technology. One of the most important requirements for effective FIB usage is the high surface conductivity of the sample. Samples not satisfying that requirement accumulate charge and deflect the ion beam, resulting in low milling precision. Due to most optical fibers consisting of glass, special preparation process is needed.
It was found in testing that gold coating is essential for the process to succeed. Additionally, optical fibers need to be mounted in a dedicated holder with grooves and a clamping plate for efficient charge dissipation. Proper preparation allowed us to use FIB on optical fibers for a prolonged period of time without charge accumulation and the resulting loss of precision. Due to FIB versatility, we were able to develop lenses of a wide range of shapes and sizes with modifications taking place in any part of the optical fiber face (or on the whole optical fiber face).

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42.

# NEXT-GEN CARBON NANOTUBE COMPOSITES: UNLOCKING SUPERIOR THERMAL PERFORMANCE

Sz. Ruczka (1), A. Blacha (1), G. Dzido (2), S. Boncel (1,3), K. Cwynar (4), M. Dzida (4)
1. Silesian University of Technology, Faculty of Chemistry, Department of Organic Chemistry, Bioorganic Chemistry and Biotechnology, NanoCarbon Group, Gliwice, Poland
2. Department of Chemical Engineering and Process Design, Faculty of Chemistry, Silesian University of Technology, Gliwice, Poland
3. Silesian University of Technology, Centre for Organic and Nanohybrid Electronics (CONE), Gliwice, Poland
4. Institute of Chemistry, University of Silesia in Katowice, Katowice, Poland
E-mail (corresponding author): slawomir.boncel@polsl.pl

Energy is finite and its availability is limited by our processing capabilities. Facing the climate changes challenges, humanity is improving their abilities in transmission and storage energy across all scales from small-scale devices to large-scale power systems. Effective storage and transfer of energy is one of the crucial topics for achieving EU's climate and energy targets. These goals could be reached within research area of nanotechnology.

In the last decades nanotechnology revolutionized our daily lives with plenty of implementations in consumer products [1]. One of the promising nanomaterial which can be implemented in this area could be carbon nanotubes (CNTs) due to their excellent electrical and thermal properties. However, nanoscale properties do not simply translate into macroscale. As it can be seen, there are rather a few implementations of carbon nanotubes into commercial application, while modifying nanostructure of CNTs, one can change their interactions toward real-life application.

A commercially available option for the researchers is to disperse CNTs in different solvents using surfactants. Such a non-covalent approach results in higher dispersibility of CNTs. The second method involves covalent bonding of moieties and functionalities to the CNT surface. Functionalization of CNTs modifies properties and change the surface interactions in the absence of "free floating" additives. One of the name reactions of nanocarbons is a 1,3-dipolar cycloaddition introduced by Maurizio Prato and applied for CNTs by Georgakilas [2]. This modification, however, might yield loses of conductivity and mechanical strength while remediation is covalent by cross-linking the CNTs using bifunctional functionalizing agents.

Here, we present that cross-linked CNTs applicable in, e.g. paraffin composites, display enhanced both thermal conductivity and specific heat capacity, while previous results indicated an improvement in thermal conductivity solely [3]. Hence, our results represent a new opening in superior thermal performance of the CNT-based composites.

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43.

# THE UNIVERSAL OPTICAL SYSTEM FOR MONITORING AND CONTROL THE LASER DEPOSITION PROCESS

T. Kałmuczak, P. Kunicki
Nanores sp. z o.o. sp.k., Bierutowska 57-59, 51-317, Wrocław, Poland
E-mail (corresponding author): piotr.kunicki@nanores.pl

Laser deposition is one of the methods used to apply functional coatings. The critical parameter that should be monitored in this process is the distance between the laser head nozzle and the processed material (stand-off parameter). Currently used systems do not monitor the mentioned parameter during deposition, which often results in the presence of defects in the manufactured coatings.

We present a universal optical system for real-time monitoring and control of the laser deposition process that is based on a confocal chromatic sensor. In our solution the determination of the stand-off parameter is possible thanks to the developed algorithm to process the spectral signal. In order to get clear signal it was crucial to use specific intensity of the measurement beam. The required power was achieved by creating an original broadband source and increasing the light coupling efficiency of the used sensor. Using a focused ion beam (FIB) microscope the tips of the optical fibers were modified to form a Fresnel microlens.

Validation tests of the system were carried out using coatings that differed in height and chemical composition. The operation of the system for various deposition trajectories was also checked. The results confirmed the usefulness of the developed solution in controlling laser deposition process and compatibility with commercially available laser heads.

We pursued the project within instrument Fast Track 1/1.1.1/2021 about „The universal optical system for monitoring and controlling the laser metal deposition process.”, funded by the European Union from European Regional Development Fund under Smart Growth Operational Programme 2014-2020. This project was carried out in cooperation with Wroclaw University of Technology.

44.

# WHITE CARBON INNOVATIVE ENDOSCOPY LIGHT SOURCE BASED ON CARBON MATERIALS

P. Kunicki (1), M. Sikora (1, 2)
1. Nanores Sp. z o.o. sp.k., Bierutowska 57-59, 51-317, Wrocław, Poland
2. Faculty of Electronics, Photonics and Microsystems, Wroclaw University of Science and Technology, Janiszewskiego 11/17, 50-372 Wroclaw, Poland
E-mail (corresponding author): piotr.kunicki@nanores.pl

For years, carbon has continued to astonish scientists with its extraordinary properties. As one of the most fascinating elements, it consistently reveals new dimensions of its potential. While commonly associated with its black color, recent scientific reports demonstrate that carbon-based materials exhibit the ability to emit white light. When graphene materials are excited by a focused near infrared laser diod, they generate efficient radiation emission within the visible spectrum (VIS). This emitted light is broad-spectrum, covering a range from 360 to 900 nm.

Research has shown that this method offers higher energy efficiency than conventional tungsten or halogen bulbs, while maintaining a high quality of light comparable to natural sunlight. The quality of this light is characterized by parameters such as the color rendering index (CRI) and color temperature. For the studied light source, these values
exceed 99 and approximately 4000 K, respectively (for comparison, sunlight, the best source for color rendering, has a CRI of 100). These features make this light source competitive with current energy-efficient lighting technologies, such as LEDs and fluorescent lamps, which are typically associated with a lower CRI (around 80) and a cooler color temperature. The high CRI and sunlight-like color temperature provide a significant advantage, especially in applications such as endoscopy, where accurate color revealing, particularly in the red spectrum, is crucial for effective diagnostic procedures and endoscopic surgeries.

The research and development work undertaken was aimed at developing graphene-based carbon materials, nanodiamonds and their composites and their use as a novel light source in an endoscopic illuminator. One challenge related to light emission from graphene-based active materials is the high emission threshold. Thus, reducing this threshold was a key objective of the project. Structural and morphological factors of carbon materials, including graphene oxide, nanodiamonds, and composite materials, were investigated to assess their impact on emission intensity, spectroscopic properties, and emission stability. These studies allowed for the selection of a group of materials with optimal properties for use as novel white light sources, currently unavailable on the market. The final outcome of the project is an endoscopic illuminator utilizing an innovative white light source based on carbon materials.

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45.

# COVALENT FUNCTIONALIZATION OF 1D AND 2D sp2-CARBON NANO-ALLOTROPES – TWELVE YEARS OF PROGRESS (2011–2023)

Z. Amjad (1), A.P. Terzyk (2), S. Boncel (3)
1. Silesian University of Technology, Faculty of Chemistry, Department of Organic Chemistry, Bioorganic Chemistry and Biotechnology, Gliwice, Poland
2. Nicolaus Copernicus University in Toruń, Faculty of Chemistry, Toruń, Poland
3. Silesian University of Technology, Centre for Organic and Nanohybrid Electronics (CONE), Gliwice, Poland
E-mail (corresponding author): slawomir.boncel@polsl.pl

Over the past decade, carbon nano-allotropes have attracted significant attention in materials science due to their unique physicochemical and biological properties. One-dimensional (1D) and two-dimensional (2D) sp2-carbon nano-allotropes, including carbon nano-horns (CNHs), carbon nanotubes (CNTs), and graphene, are at the forefront of technological advancements. Covalent functionalization of these nanostructures enhances their processability and performance by attaching functional groups or molecules via linkers of varying strengths, enabling precise control over their physical, chemical, biological, and electronic properties.

This approach allows for the tailored modification of solubility, dispersibility, reactivity, and interactions with other materials. Recent advancements have paved the way for applications in nanoelectronics, energy storage, sensing, and biomedicine. This presentation provides a comprehensive review of state-of-the-art developments in the covalent functionalization of 1D and 2D sp2-carbon nano-allotropes from 2011 to 2023, highlighting significant strategies, methodologies, and breakthroughs in the field. Furthermore, it discusses the implications of these advancements and future research opportunities.[1]

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# 46.

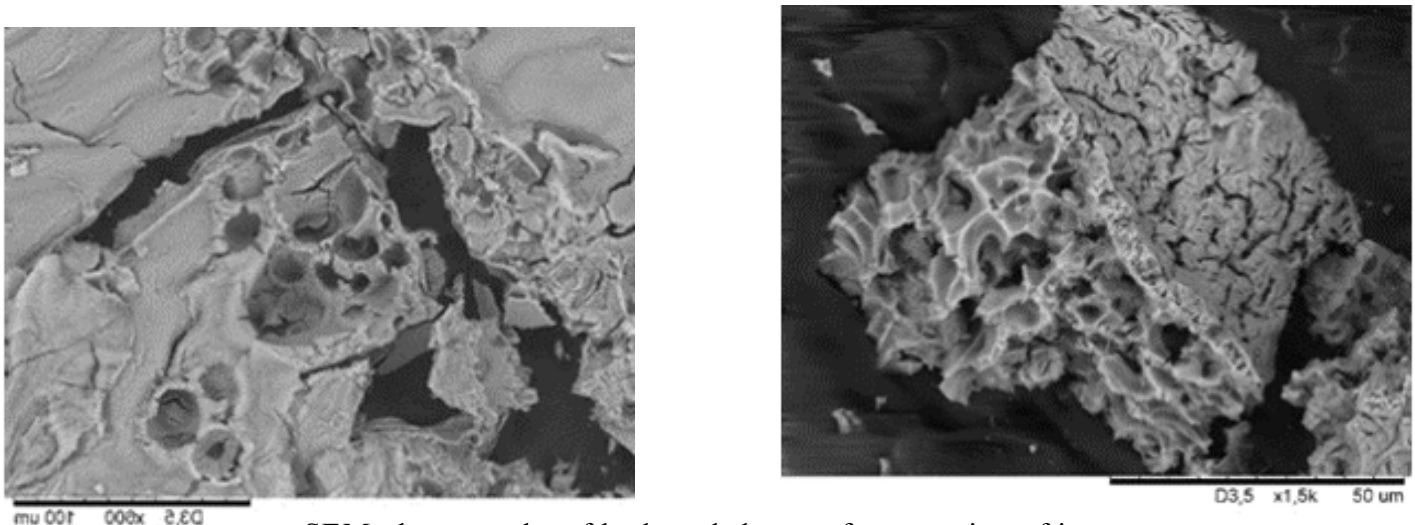
# ANALYSIS OF METAL OXIDES RECOVERED BY THERMAL DEGRADATION OF HYDROGELS AFTER METAL ION SORPTION

O. Czerwińska (1), J. Skubalski (1), J, M. Olejniczak (1), W. Łukasiuk (1), M, Kozanecki (2), P. Filipczak (2)

1. Lodz University of Technology Faculty of Chemistry, Students Association NANO, Łódź, Poland
2. Lodz University of Technology Faculty of Chemistry, Department of Molecular Physic, Łódź, Poland

E-mail (corresponding author): 237620@edu.p.lodz.pl

Groundwater contamination with heavy metals is a severe environmental problem, contributing to water scarcity in over 80 countries [1]. Several water purification methods are available to address this, including chemical precipitation, ion exchange, membrane filtration, and adsorption. Among these, adsorption stands out as an effective, fast, and cost-efficient solution [2]. Polymer hydrogels, as adsorbents, have gained attention for their ability to capture various heavy metals from contaminated water. However, one major limitation is the difficulty in recovering the metals once they are bound to the hydrogel, which reduces the overall sustainability of the process [3]. In this study, we developed hydrogels based on poly(acrylic acid), hydroxyethyl cellulose, and phytic acid as an effective adsorbent for heavy metal removal. We propose a new procedure for metal recovery using thermal degradation of metal-loaded hydrogels, enabling efficient and straightforward retrieval of the adsorbed metals. The thermal stability of these hydrogels was examined using Thermogravimetric Analysis (TGA) to establish optimal degradation conditions. The composition and morphology of the residues were further characterized using X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), and Raman spectroscopy to assess the quality of the recovered materials. The results show that thermal degradation produces pure metal oxides with a highly developed surface area and nanometric crystallite sizes. These attributes make the recovered materials suitable for applications in catalysis and sensing, adding significant value to the process.




SEM photography of hydrogels burnt after sorption of iron

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47.

# ELECTRICAL, DIELECTRIC, I-V AND ANTIMICROBIAL BEHAVIOR OF COBALT INCAPACITATED PRUSSIAN BLUE GRAPHENE FERRITES COMPOSITE

Ammara Aslam (1,2*), Przemyslaw Ledwoń (1)*, Muhammad Danish Ali (2,3),
1. Department of Physical Chemistry and Technology of Polymers, Faculty of Chemistry, Silesian University of Technology, 44-100, Gliwice, Strzody 9, Poland
2. PhD School, Silesian University of Technology, 2a Akademicka str., 44-100 Gliwice, Poland
3. Institute of Physics Center for Science and Education, Silesian University of Technology, Krasińskiego 8A, Katowice, 40-019 Poland
E-mail (corresponding author): amaraaslam09@gmail.com, przemyslaw.ledwon@polsl.pl

In today's modern era, human-technology is reliant on energy sources that are inexpensive, cost-effective, reliable, and energy-efficient. The material was synthesized using the Hummers method, coprecipitation method, and hydrothermal technique. X-ray diffractometry was used to confirm the material's formation. The UV-Vis. spectroscopy was used to explain the $\pi - \pi^*$ transition, which affects the material's properties. PL spectroscopy was used to analyze the material's crystallinity, and it revealed that delocalized electrons move between Fe2+, Fe3+, CO, and Prussian blue nanoparticles. The capacitance and energy dissipation were calculated using the material's dielectric constants (both real and imaginary). Grain boundaries have high resistivity at lower frequencies, requiring a large amount of energy to move charge from one grain to another. An increase in AC conductivity value was observed with increasing applied frequency. The electrical properties were determined using impedance spectroscopy, which also characterizes the interfaces of the conducting electrodes, both electronic and ionic. The four-probe method showed that as the voltage increases, the current also increases, and at 20 V a current value of $6 \times 10{-}4$ A was detected, demonstrating the sample's electrical conductivity behavior. The result of GO showed a small inhibition zone, while CO-PBGF showed a high inhibition zone, confirming the high antibacterial activity of CO-PBGF compared to GO.

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48.

# LINEAR POLY(IONIC LIQUID)-CLOXACILLIN CONJUGATES: A NOVEL DRUG DELIVERY SYSTEM

S. Keihankhadiv (1) and D. Neugebauer (1)
1. Department of Physical Chemistry and Technology of Polymers, Faculty of Chemistry, Silesian University of Technology, 44-100, Gliwice, Poland
Shadi.keihankhadiv@polsl.pl

In recent years, breakthroughs in polymer science have led to the creation of materials with precisely tunable characteristics, making them highly adaptable for various biomedical applications. One of the most transformative areas impacted by these advancements is polymer-based drug delivery systems (DDSs). These systems are engineered to not only improve the bioavailability of therapeutic agents but also enable targeted and sustained release, minimizing side effects and enhancing patient compliance [1,2].

This study focused on the synthesis of monomeric ionic liquids by replacing the chloride counterion in [2-(methacryloyloxy)ethyl]trimethylammonium chloride (TMAMA/Cl) with cloxacillin anion from its sodium salt (CLXNa), resulting in the formation of [2-(methacryloyloxy)ethyl]trimethylammonium cloxacillin (TMAMA/CLX). Afterward, the modified monomer was copolymerized with methyl methacrylate (MMA) via the atom transfer radical polymerization (ATRP) method yielding CLX based copolymers P(TMAMA/CLX-co-MMA). The release of the drugs is facilitated by an exchange mechanism induced by phosphate anions present in the phosphate buffer saline (PBS), with simulating the natural environment of physiological fluids with a pH of 3.7 at 37°C.

The compositions of polymers were controlled by the total monomer conversion (X= 40–75%) resulting in a variable degree of polymerization (DPn = 160–299) and contents of pharmaceutical anions (DC= 67–80%). In aqueous solution, particles of the polymer achieved nanoscale sizes by utilizing dynamic light scattering (DLS), the hydrodynamic diameters (Dh = 274–380nm) of polymer nanoparticles and their polydispersity index (PDI = 0.006–0.01) were determined. In addition, in vitro studies demonstrated the release of 58-76% (10.5–13.6 μg/mL) of drug within 72 hours.

In conclusion, these copolymers have proven effective in developing drug delivery systems, showcasing their potential for preventing and treating various bacterial infections.

Keywords:poly(ionic liquid); polymeric carrier; cloxacillin; ATRP; drug delivery system.

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# 49.

# DARK GREEN LUBRICANTS - CAN THEY BE EFFICIENT SUBSTITUTE FOR PETROLEUM-BASED LUBRICANTS?

R.G. Jędrysiak (1), S. Ruczka (1), Ł. Wojciechowski (2), M. Skrzypek (2), S. Boncel (1)
1. Silesian University of Technology, Faculty of Chemistry, CONE, NanoCarbonGroup, (Poland),
2. Poznan University of Technology, Institute of Machines and Motor Vehicles (Poland)
E-mail (corresponding author): rafal.jedrysiak@polsl.pl

The attempts to use alternative to petroleum fuels energy sources continue to expand. In the automotive or, generally, the machinery industry, hydrocarbons obtained from crude oil are not used solely as propellants, the petrochemically born lubricants are widely used in gear boxes and other elements exposed to wear as a result of friction of moving elements.

This application probably will last in the case of entirely electric cars, in which it will enable the reduction of electricity consumption and overcome the fundamental problem of the limited range.

For automatic gear boxes, spermaceti oil was used. However, the ban on a sperm whale hunting introduced in the 1970s [1] made it necessary to replace it with other media. The use of mineral oils did not bring the expected results – the number of automatic transmission failures in the United States alone increased in late ’70 from less than 1M to 8M per year. The solution was modified jojoba oil – the first step in the replacement of mineral and animal oils with products of plant origin.[2]

In our research, we indicate the possibility of using vegetable oils in combination with carbon nanotubes and their chemically modified derivatives in the preparation of lubricating oils. Such a combination is beneficial as extending the operation time of the lubricant by capturing free radicals,[3] increases thermal conductivity, and improves lubricating properties in metal-metal and metal-polymer tribo-pairs.

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50.

# SULFUR K-EDGE XANES SPECTRA OF METHYL AND PHENYL COMPOUNDS: BREAKING NEW GROUND IN ORGANIC COMPOUND RESEARCH AT THE ASTRA BEAMLINE

Ryszard Stekla (*1,2), Alexander Prange (3), Josef Hormes (4), Henning Lichtenberg (3), Alexey Maximenko (1)

1. NSRC SOLARIS 30-392 Krakow, Poland,

2. AGH University of Krakow, 30-059 Krakow, Poland,

3. Niederrhein University of Applied Sciences, 47805 Krefeld, Germany,

4. University of Bonn, 53113 Bonn, Germany

*correspondence E-mail:stekla@student.agh.edu.pl

ASTRA is an X-ray absorption spectroscopy beamline specially constructed for measurements in the tender energy range of X-rays. Investigating the atomic environment of sulfur atoms in different materials, especially the local bond structure, plays an important role in petrochemistry and polymer science. Sulfur can form up to six bonds by donating, and up to two bonds by accepting electrons due to vacant 3p orbitals. The strength of these chemical bonds is influenced not only by its electronegativity difference but also by surrounding ligands. This work is a stepping stone for ASTRA's beamline users conducting similar studies about organic compounds, providing the beamline with a XANES library of unique sulfur-containing compounds.

# 51.

## PASSIVE RADIATION DETECTORS WITH SURFACE MODIFIED BY METAL NANOPARTICLES

Kacper Połuszejko (1), Weronika Kwiatosz (1), Kinga Mycek (1), Julia Potempa (1), Łukasz Ruba (1), Aleksandra Jung (1), Jan Michalik (1)
1. AGH University of Krakow, 30-059 Krakow, Poland

Passive thermoluminescence radiation detectors (TLDs) are essential for dosimetry and radiological protection in various areas that make use of ionizing radiation.

Recently, studies highlighted dosimetric properties of passive detectors with the addition of metallic nanoparticles (Nps-M). We investigated this topic by performing dosimetric measurements on MCP-N (Magnesium, Copper, and Phosphorus doped Lithium Fluoride) TLDs, that we modified by depositing Ag and TiO2 nanoparticles on their surface. Furthermore, we examined another group of MCP-N detectors with Cu and Ag nanolayers applied to their surface using a magnetron sputtering system. Afterwards, we compared dosimetric properties of both sets of detectors to the control group.

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