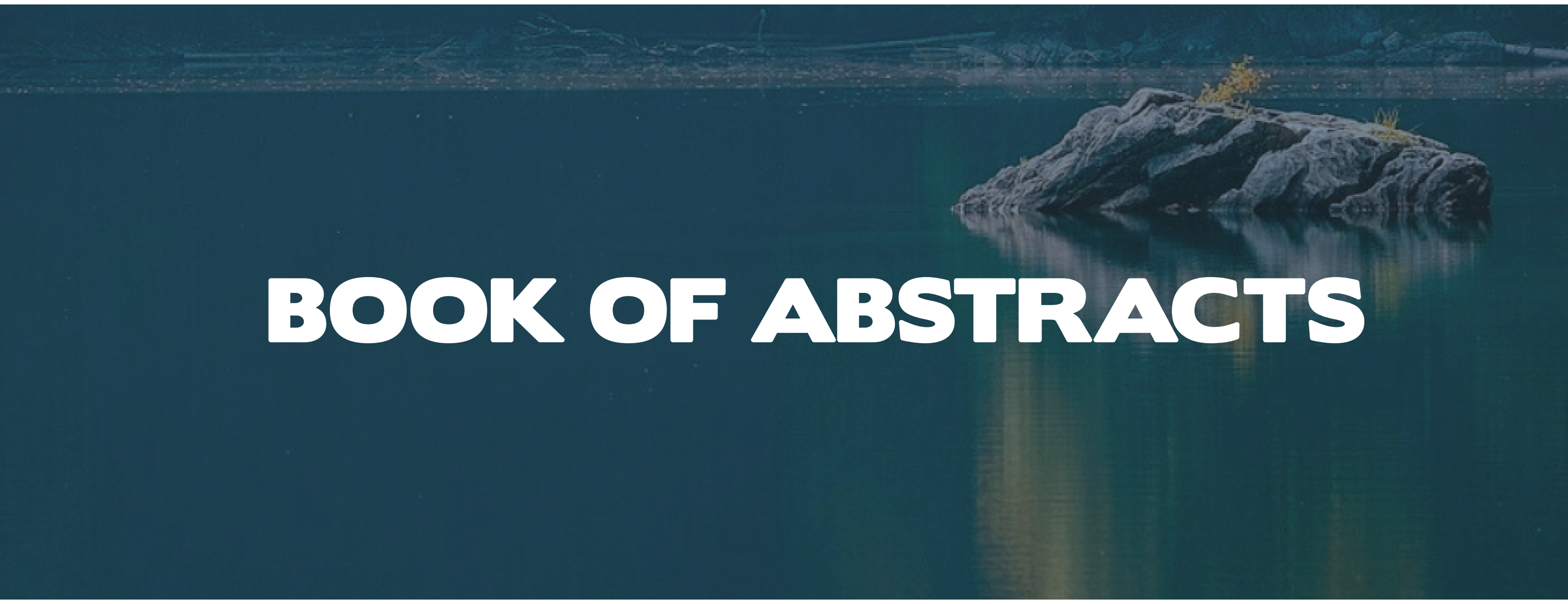
Złoty Potok, May 16-18, 2025

INTERDISCIPLINARY DOCTORAL SYMPOSIUM



BOOK OF ABSTRACTS

RADA DOKTORANTÓW
Politechniki Wrocławskiej

Wrocław University
of Science and Technology

RAJD DOKTORANTA
2025

INTERDISCIPLINARY DOCTORAL SYMPOSIUM

BOOK OF ABSTRACTS

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Wrocław University of Science and Technology Publishing House
Wrocław 2025

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Wrocław University of Science and Technology Publishing House
Wybrzeże Wyspiańskiego 27, 50-370 Wrocław
http://www.oficyna.pwr.edu.pl
e-mail: oficwyd@pwr.edu.pl; zamawianie.ksiazek@pwr.edu.pl

ISBN 978-83-7493-909-6
http://doi.org/10.37190/rado2025

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Feeding Robots

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Keywords: feeding robots, Arduino, the elderly, healthcare, social robot

As the global population ages, the demand for innovative tools to support individuals dependent on caregivers steadily increases. It is essential to promote and ensure the accessibility of such solutions for all who require them. While assistive technologies already exist, they are often financially out of reach for those who need them most. One of the everyday challenges elderly individuals face is eating, as they usually rely entirely on others for assistance. To address this issue and help restore a sense of independence during meals, a feeding robot was developed as part of a master's thesis, serving as a prototype for a widely affordable and accessible solution.

The project focused on designing and building a cost-effective, functional, and easy-to-manufacture feeding station. The robot was primarily produced using additive manufacturing (3D printing) and is operated via an Arduino Uno microcontroller. The system includes four servomechanisms: a bowl, a spoon, a card reader, a temperature sensor, an RGB LED, a battery, control buttons, and a main switch. Notable features include a temperature sensor for monitoring meal conditions and a card reader that stores patient-specific settings to optimize arm movement.

The prototype was tested using food products of varying consistencies, such as water, thick cream soup, and kissel, in both hot/liquid and cold/semi-solid forms. Tests confirmed the robot's ability to consistently retrieve a food sample and deliver it safely to the user's mouth without losing its contents.

However, particular challenges emerged during testing. Specific movement sequences were more effective for liquid or semi-liquid foods, while solid foods required different approaches. Sticky substances, such as kissel, demanded additional motions to remove excess from the spoon and ensure clean transport. Despite these limitations, the initial phase demonstrated the viability of creating a low-cost and practical solution using widely available materials.

Due to the complexity of trajectory optimization, the project has since evolved into a doctoral research topic. The current phase focuses on developing a more reliable robot capable of handling various food textures effectively. A second prototype has been designed using a simplified, more rigid metal component resembling a channel bar. This advancement introduced the need to consider user safety more seriously. As a result, the new prototype includes friction-based joints that allow controlled slippage in case of collisions. The integration of collision sensors remains a subject for future development.

The first prototype and the improved version currently under development are shown in Fig. 1.

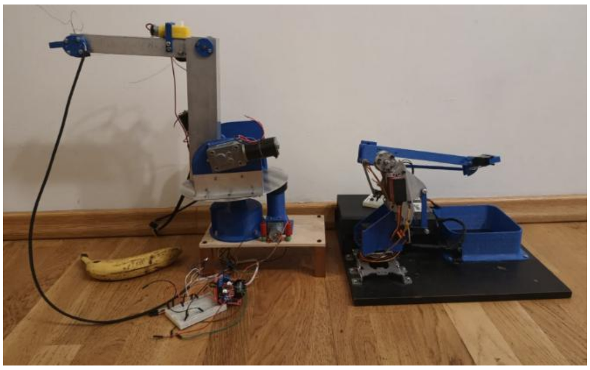

Fig. 1. The feeding robot currently developed during my doctoral studies (left) and its prototype created as part of my master's thesis (right) [own study]

Evaluation of Oxime Ethers: Cytotoxicity and Cell Viability in THP-1 Cells

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Keywords: oxime ethers, cytotoxicity, cell viability, THP-1 cells, fragrance safety

The ability to serve multiple functions is essential for novel chemical compounds, particularly in the field of fragrances, where enhancing product appeal, user satisfaction, and regulatory compliance is crucial. Compounds containing the oxime ether group are highly regarded not only for their diverse and versatile chemical properties but also for their significant biological activities. The oxime ether motif is considered a privileged structure in chemistry, as it is found in numerous medicinal frameworks exhibiting a wide range of biological and pharmaceutical effects, such as antifungal, antibacterial, anticancer, and antitumor activities [1], which may also influence immune cells like macrophages. These cells are critical in the skin, playing a dual role in maintaining homeostasis and defending against microbial threats. Depending on their activation state, they can either support healthy skin function or contribute to inflammation. This makes them particularly relevant when evaluating substances like fragrances, which, while beneficial, can sometimes trigger allergic or irritant skin reactions [2, 3].

To assess the cytotoxic potential of newly synthesized compounds, 90 oxime ethers (at a concentration of 200 µM) were subjected to preliminary cytotoxicity testing using human leukemia monocytes differentiated into macrophage-like cells (THP-1), during exposure time 24–72 h. THP-1 cells were differentiated into macrophages using 10 nM PMA and seeded in 96-well cell culture plates at a density of 100,000 cells per well in 100 µL of RPMI 1640 medium supplemented with 10% FBS, 2 mM L-glutamine, 100 units/mL penicillin, and 10 mg/L streptomycin. Cytotoxicity was evaluated using both the MTS assay, which measures cellular metabolic activity, and the LDH assay, which detects membrane integrity and cell damage.

The results showed that oxime ethers generally exhibited significantly lower cytotoxicity. Oxime ethers with longer or branched alkyl groups tended to exhibit lower cytotoxicity and higher cell viability. Most oxime ethers maintained cell viability above 70%, often exceeding 85%, indicating low toxicity to healthy cells. Several oxime ethers demonstrated both low cytotoxicity and high viability, positioning them as promising candidates for further development in the field.

References

[1] Mirjafary Z. et al., Oxime ethers as versatile precursors in organic synthesis: a review, *RSC Advances*, 2015, 5, 79361–79384.
[2] Nakai K., Multiple Roles of Macrophage in Skin, *Journal of Dermatological Science*, 2021, 104, 2–10.
[3] Tang H. et al., Characterization of Dendritic Cells and Macrophages in Irritant Contact Dermatitis, *Journal of Dermatological Science*, 2010, 57, 216–218.

Investigating the Role of Macrophages in Spinal Cord Regeneration in Zebrafish

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Keywords: developmental biology, regenerative medicine, molecular biology

The immune system has been shown to play a crucial role in the response to tissue damage in many organisms, including zebrafish (*D. rerio*), a species characterized by exceptional regenerative capacity. Macrophages were found to not only remove dead cells but also to transmit signals that activated progenitor cells and initiated regenerative processes. In the absence of macrophages, regeneration did not occur – cells did not divide.

Confocal time-lapse microscopy revealed that macrophages establish prolonged physical interactions with glial cells, sometimes even engulfing viable cells. These contacts precede regenerative events and may suggest a direct regulatory role.

To investigate the molecular basis of this macrophage influence, we performed single-cell RNA-seq and ATAC-seq one day post-injury, comparing injured animals with and without macrophages. While no major shifts in gene expression were observed at this early time point, chromatin accessibility analyses identified macrophage-dependent open regions enriched for AP-1 transcription factor motifs, including FOSL2, JDP2, and ZNF148.

Among 20 candidate enhancers identified from these regions, one drove injury-specific GFP expression in neurons, enabling real-time visualization of regenerative activation in transgenic lines. These results support a model in which macrophages orchestrate regeneration not only through debris clearance and cytokine release, but by modulating chromatin accessibility and activating gene regulatory programs in progenitor cells. Our findings establish a framework for dissecting macrophage-driven regeneration and may inform future regenerative medicine strategies.

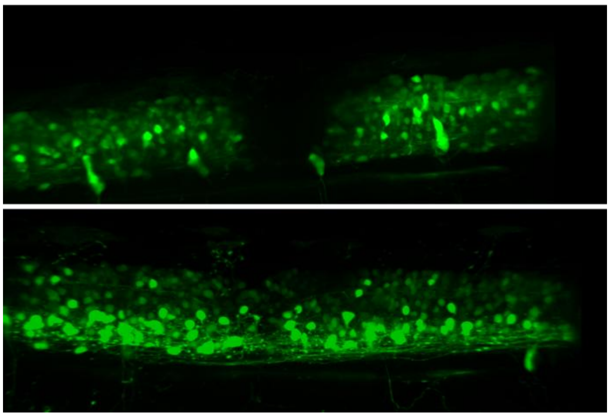

Fig. 1. Process of zebrafish spinal cord regeneration – right after injury (top panel) and 3 days after injury (bottom panel). Neurons are labeled in green

Acknowledgments

The author gratefully acknowledges Fulbright Poland, as well as the support of members of the Wattrus Lab and the Galloway Lab for their valuable assistance and guidance.

Review of Sizing Methodologies for Hydropower-Based Hybrid Energy Systems: A Techno-Economic Perspective

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Keywords: hybrid power systems, techno-economic analysis, pumped hydro storage, renewable energy

Hybrid energy systems emerge as an irreplaceable approach to enhancing grid resilience and speeding up the power system transformation [1]. Hydropower, validated in commercial and industrial contexts, serves as a promising complementary energy source for inherently variable solar and wind sources [2]. However, realizing its complementary potential depends on proper system configuration. Most existing reviews on this topic focus primarily on wind and solar energy, leaving a gap in hydropower-based hybrid energy systems (HBHES) sizing studies [3]. In light of this, this work reviews HBHES from a techno-economic perspective, examining system configurations, uncertainties, techno-economic indicators and optimization methods. A total of 189 research articles were retrieved and categorized from the Web of Science and Scopus databases using the keywords "capacity configuration" and "hydropower/pumped hydro storage," covering complementary energy sources such as solar, wind, electrochemical, hydrogen, biomass, and thermal. Some key conclusions are as follows: (1) The three most influential factors are runoff, electricity prices, and initial investment costs, which affect optimal sizing by 34%, 21%, and 14%, respectively. (2) Wind and solar should account for 40% of the total capacity in HBHES, with storage capacity – such as PHS – constituting 10–20% to achieve optimal technical and economic performance. (3) Accelerated marketization intensifies the impact of natural resources and energy demand on electricity prices, potentially reshaping the landscape of HBHES sizing research. This work aims to offer optimal sizing strategies for hybrid energy systems centered on hydropower, as well as provide in-depth insights into their techno-economic aspects.

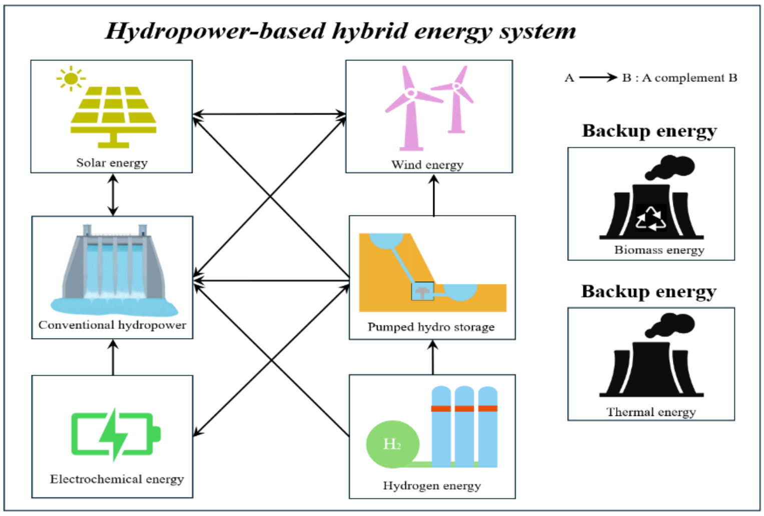

Fig. 1. Hydropower-based hybrid energy system complementary relationships

References

[1] Cui Y. et al., Capacity configuration of cascaded hydro-wind-photovoltaic complementary systems considering comprehensive benefits based on a synergetic-orderly framework, *Energy Convers Manage*, **2024**, 319, 118916.

[2] Jurasz J. et al., A review on the complementarity of renewable energy sources: Concept, metrics, application and future research directions, *Solar Energy*, **2020**, 195, 703–724.

[3] Lian J. et al., A review on recent sizing methodologies of hybrid renewable energy systems, *Energy Conversion And Management*, **2019**, 199.

Zoonotic Capnocytophaga in Wrocław's Dogs: Prevalence and Identification Study

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Keywords: *Capnocytophaga canimorsus, Capnocytophaga cynodegmi, Capnocytophaga* spp., dog, microbiome

Capnocytophaga species are Gram-negative, facultatively anaerobic bacteria that naturally inhabit the oral cavities of dogs and cats. Within this group, *Capnocytophaga canimorsus* and *Capnocytophaga cynodegmi* are known zoonotic agents, with *C. canimorsus* posing a particular threat to individuals with weakened immune systems [1, 2]. This study aimed to determine the prevalence of these bacteria in dogs from the Lower Silesia region of Poland and explore potential factors influencing their presence. Statistical analysis was conducted using Pearson's chi-square test and Fisher's exact test. $P \leq 0.05$ was considered to indicate a statistically significant association. Statistical analysis was performed using PQStat (v. 1.8.6). Due to the exploratory nature of this pilot study and the limited sample size, multivariate analysis was not performed.

Oral swabs were collected from 105 dogs and analyzed using PCR-based molecular techniques. The study assessed possible links between the presence of *C. canimorsus* and *C. cynodegmi* and a variety of variables, including oral health condition, prior antibiotic use, age, chronic illness, and dietary habits, particularly the use of dog chews. Findings revealed that 55.2% of the samples contained at least one *Capnocytophaga* species, with *C. cynodegmi* detected in 45.7% and *C. canimorsus* in 39% of cases, as shown in Fig. 1.

Statistical analysis showed a significant correlation between *C. cynodegm*i presence and factors such as oral cavity health ($p = 0.019$), the location from which the swab was taken ($p = 0.015$), and the use of dog chews ($p = 0.015$). While a significant association between the use of dog chews and the presence of C. cynodegmi was observed, this does not imply a causal relationship. Further research is needed to explore potential mechanisms. No significant associations were identified for *C. canimorsus* with the factors investigated. Interestingly, among multi-dog households, bacterial transmission was not consistent, indicating the potential involvement of additional, unidentified factors that merit further study.

These results emphasize the importance of *Capnocytophaga* species as constituents of the canine oral microbiome and reinforce the need for ongoing research into their implications for both canine and human health. Considering the zoonotic risks associated with these bacteria, it's essential to raise awareness among dog owners and veterinary professionals, particularly concerning oral hygiene practices and preventive measures.

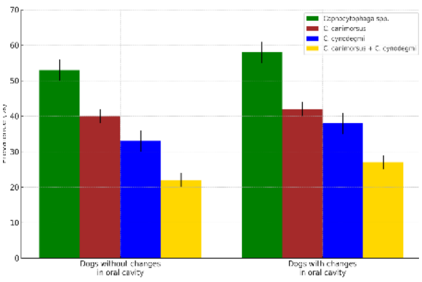

Fig. 1. Prevalence of Capnocytophaga species in healthy and sick dogs

References

[1] Dilegge S.K. et al., Presence of the oral bacterium Capnocytophaga canimorsus in the tooth plaque of canines, *Veterinary Microbiology*, **2011,** 149, 437–445.

[2] Holt C.S., Capnocytophaga, [in:] B.W. Whitman (ed.), Bergey's Manual of Systematics of Archaea and Bacteria, John Wiley & Sons, Inc., **2015,** 4, 168–176.

Architectural Research of Carolath Castle

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Keywords: architecture, Silesia, heritage, conservation

The aim of this research is to reconstruct and discuss the architectural development and transformation processes of the Carolath Castle in Siedlisko. Residence was originally constructed at the turn of the 16th and 17th century on the initiative of Georg von Schönaich. It was built in the type of palazzo in fortezza, which was intended to combine the functions of comfortable palace and a fortress. Over time, it was expanded form l-shaped to six wing with representative and a service courtyards [1]. It became one of the largest early modern residential complexes in the historical region of Silesia. Residence remained in the hands of the Schönaich family until its partial destruction in 1945 [2]. The work focuses on a detailed historical and architectural analysis of the building. Its main objective is to fill existing research gaps and to systematise knowledge on the evolution of the residence in the context of Central Europe, Poland and Silesia. The present work will be based primarily on an in-depth analysis of source and historical material, as opposed to research papers in which hypotheses and research questions are used to verify specific theories. In this case, the key objective is to describe and understand specific architectural transformations in relation to changing historical and cultural realities. The study employs a combination of archival analysis, architectural research, and non-invasive survey methods. A key component of the methodology is the use of modern digital documentation techniques, including 3D laser scanning and photogrammetry with the use of a drone. The architectural research involves construction and material analysis to determine building phases.

Preliminary results reveal a multi-stage development process: the identification of at least three major construction phases (c. 1600, mid-17th century, and early 19th century), differences in materials, masonry techniques. The chapel in the eastern wing, the only surviving interior is described by researchers as the greatest achievement of Protestant church architecture of the Reformation age in Silesia [3, 4]. Although palace chapels appear at the turn of the 16th and 17th centuries in many residences of varying status in Silesia, e.g., in Brzeg, Pruszków, Żyrowa, Gorzanów, none of them presents a similar layout and level of ornamentation. The findings contribute to a more precise understanding of the architectural evolution of early modern Silesian residences and support conservation planning for partially preserved heritage sites.

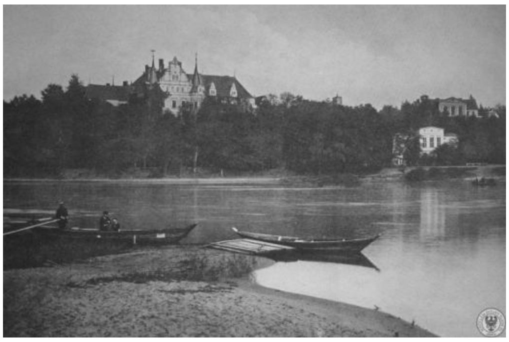

Fig. 1 Siedlisko - Carolath. Castle on the right bank of the Oder, https://polska-org.pl/865598, foto.html?idEntity=511612

References

[1] Kąsinowska R., Architektura Rezydencjonalna Powiatu Nowosolskiego, *Muzeum Miejskie w Nowej Soli*, **2003**.
[2] Andrzejewski T. et.al., Siedlisko poprzez wieki – z dziejów zamku Karolat, *Wydawnictwo Reklamowe MARTINUS*, **2014**.
[3] Harasimowicz J., Protestanckie budownictwo kościelne wieku reformacji na Śląsku, *Kwartalnik Architektury i Urbanistyki XXVIII*, **1983**.
[4] Świdrak M., Valentin von Saebisch i rozbudowa zamku w Siedlisku (1612-1619). Uwagi o nowatorstwie w architekturze śląskiej początku XVII w., *Roczniki Sztuki Śląskiej*, **2023**, XXXII, 39–76.

Multi-Criteria Risk Assessment Method Focused on Building Resilience in Global Supply Chains

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Keywords: supply chain resilience, risk assessment, global logistics, disruptions, anthropotechnical systems

The increasing complexity of global supply chains (SCs), intensified by COVID-19 disruptions, emphasizes the urgent need to strengthen supply chain resilience (SCRES) [1, 2]. A systematic review of 110 sources using the PRISM methodology revealed a research gap concerning integrated approaches to resilience assessment within internal anthropotechnical logistics systems – critical for sustaining material flows. The literature reveals a gap in assessment methods focused on viability. Although resilience assessment methods exist, with most described as of 2024, there is still a need to develop a comprehensive assessment method specifically aimed at building resilience in global supply chains.

Preliminary empirical research, including expert interviews and document analysis in a leading FMCG company, identified key disruptions and assessed their impacts on inventory, delivery lead times, and service levels. A case study demonstrated a pandemic-related drop in service levels from 98% to below 35%, with recovery extending over four years. These results underline limited resilience and a lack of tailored risk assessment tools [2, 3]. The analysis suggests that resilience-building requires the integration of proactive and reactive strategies with long-term operational planning. Resilience should be embedded in organizational strategy to foster adaptability to dynamic market conditions and the ability to transform crises into growth opportunities. The preliminary results provide a foundation for the development of the proposed method and for further recommendations on risk mitigation and supply chain redesign.

The contribution of this research lies in the forthcoming development of a formalized resilience assessment method incorporating both organizational and technological dimensions. This study aims to develop a multi-criteria risk assessment method that integrates managerial and engineering perspectives to support SCRES. This method is expected to support managerial decision-making and foster digital transformation in Industry 4.0 logistics. Future work will focus on the model's development, implementation guidelines, and validation through supply chain flow simulations.

Acknowledgments

"Implementation Doctorate" program; cooperation with Cedo Sp. z o.o.

References

[1] Ozdemir D. et al., Supply chain resilience during the COVID-19 pandemic, *Technology in Society*, **2022**, 68, 101847.
[2] Van Hoek R., Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice, *International Journal of Operations & Production Management*, **2020,** 40, 341–355.
[3] Pereira R. et al., Achieving supply chain resilience: the role of procurement, *Supply Chain Management: An International Journal*, **2014**, 19, 626–642.

Fotogrametry in Architectural Research on the Temple of Hatshepsut in Egypt

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Keywords: ancient Egypt, history, Hatshepsut, New Kingdom

Historical architectural monuments, due to natural and human-related factors, are constantly at risk of degradation and eventual loss. This raises an important research question: how can modern digital documentation techniques support the preservation of such structures for future generations? One of the key challenges in contemporary archaeology is therefore the effective digitalization of historical sites.

I am a member of a Polish-Egyptian archaeological and conservation expedition working under the auspices of the Polish Centre of Mediterranean Archaeology at the University of Warsaw. Our work is centered on the Temple of Hatshepsut in Deir el-Bahari, southern Egypt – also known as the "Temple of Millions of Years." It served as the mortuary temple of Queen Hatshepsut, one of only four women to rule as pharaoh. The construction of this monument dates back to the New Kingdom period, a time of great power and architectural achievement in ancient Egypt.

In my role as a member of a mission, I focus on the documentation of architectural elements. In my presentation, I will explore what daily archaeological work looks like on-site, and, most importantly, how modern documentation methods are being applied to protect and preserve ancient heritage.

Fig. 1. Temple of Hatshepsut, 2024

Scalable Fault Diagnosis System for AC Motors

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Keywords: electric motors, fault diagnosis, artificial intelligence, signal analysis

Electric motors have been widely used in drive systems in both industry and electromobility. The reliability of these systems has been crucial to maintaining production continuity and ensuring operational safety. Early fault detection has been recognized as a key factor in minimizing the risk of failure and reducing maintenance costs.

Despite structural similarities, motors used in different applications vary significantly in design and rated parameters. Current diagnostic methods have mostly been tailored to specific machines, limiting their scalability and general applicability. This has highlighted the need to develop diagnostic systems that allow the identification of various types of faults across motors with diverse characteristics.

The planned research has focused on the development of a scalable diagnostic system based on the analysis of easily measurable electrical signals. Special attention has been given to signals that allow noninvasive and practical data acquisition, such as the axial flux and stator current. To identify fault-related features that are consistent across motors of different power levels, classical signal processing methods and selected artificial intelligence techniques have been proposed.

The expected results of the research include the development of a scalable diagnostic system capable of effectively detecting faults in motors with various rated parameters. The findings will advance knowledge of the relationships between fault symptoms and motor parameters with varying power levels, allowing better adaptation of diagnostic methods to a variety of electric machines. The results of the research are intended to form the basis for further scientific studies focused on expanding diagnostic approaches to a wider range of motor types and fault categories.

Design and Evaluation of Electromagnetic Metasurfaces for Microwave Energy Harvesting

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Keywords: metasurfaces, microwave energy harvesting, wireless power transfer

The growing interest in microwave energy harvesting technologies has driven the development of advanced systems capable of wireless power transfer and ambient energy recovery [1]. Electromagnetic metasurfaces, characterized by engineered subwavelength structures, offer promising solutions due to their ability to achieve high absorption levels and tailor electromagnetic responses beyond the limits of natural materials [2].

This research focuses on the numerical design and optimization of metasurfaces dedicated to efficient energy harvesting in the microwave frequency range (1.7–5 GHz). Full-wave electromagnetic simulations have been conducted to investigate the influence of unit cell geometry and output pad integration on energy absorption and extraction efficiency. Artificial intelligence methods were additionally employed to optimize the unit cell designs [3]. The designed metasurface concepts contribute to sustainable development by promoting energy-efficient technologies, minimizing reliance on conventional power sources, and enabling compact, low-impact energy harvesting systems. Future work includes fabrication of prototypes and experimental validation. The presented approach contributes to the development of compact, integrated systems for powering IoT devices, microsatellites, and wearable electronics.

Acknowledgments

This work was supported by the Rector's Grant of the West Pomeranian University of Technology in Szczecin, 2025 Edition

References

[1] Góra P. et al., Metamaterials' application in sustainable technologies and an introduction to their influence on energy harvesting devices, *Applied Sciences*, **2023**, 13, 7742.

[2] Zheludev N.I. et al., From metamaterials to metadevices, *Nature materials*, **2012**, 11, 917–924.

[3] Góra P. et al., Proposal for an Artificial Neural Network Tool for the Process of Generating Metasurface Unit Cell Geometries, *Applied Sciences*, **2024**, 14, 11549.

Application of OxiTop® Respirometry for Monitoring Fungal Growth and Enzymatic Potential

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Keywords: OxiTop® respirometry, *Fusarium culmorum*, biocatalyst, culture conditions

The OxiTop® method is a respirometric approach used for the quantification of Biochemical Oxygen Demand (BOD). This technique operates on the principle of monitoring pressure changes within a sealed system, which occur as a consequence of microbial oxygen consumption and carbon dioxide production. The generated carbon dioxide is absorbed by an alkaline medium, resulting in a measurable decrease in pressure that correlates directly with the BOD value. [1] The OxiTop® system is applicable in a wide range of environmental and biotechnological analyses [2, 3], including the assessment of effluents from wastewater treatment facilities, investigations of soil respiration dynamics, and evaluations of chemical biodegradability. Moreover, it has been demonstrated as a viable tool for monitoring the growth and metabolic activity of fungi [4].

From a biocatalytic perspective, it is well established that the enzymatic properties of a biocatalyst can be modulated through the careful optimization of culture conditions. Considering this, the present study investigated various cultivation media – specifically Czapek-Dox Medium (CDM), Potato Dextrose Broth (PDB), Maltose Glucose Medium (MG), and Maltose Glucose Yeast extract Peptone Medium (MGYP) – for their influence on the growth of *Fusarium culmorum*. Particular attention was given to assessing the fungus's respiratory activity as an indirect indicator of its biocatalytic potential, with the ultimate aim of identifying conditions conducive to the production of an active enzymatic system for further investigation.

The study showed different growth rates on the mediums depending on their complexity – the richer they were, the faster fungi grew. Thus, for the full MGYP medium, entry into the logarithmic phase occurred after just 1 day and into the stationary phase 24 hours later, while for the minimal medium (CDM) the logarithmic phase lasted longer, 48 hours, but also started later, on day 2 after inoculation. And although these results by themselves do not speak directly to the enzymatic activity of the biocatalyst, they allow the selection of optimal culture conditions for further biotransformation studies.

References

[1] Su T., WTW OxiTop® for Biodegradation Determination, *Xylem*, **2022**

[2] Takekoshi S. et al., Establishing a ready biodegradability test system using OxiTop® to evaluate chemical fate in realistic environment, *Journal of Pesticide Science*, **2022**, 47, 35–42.

[3] Vähäoja P. et al., Studies of biodegradability of certain oils in forest soil as determined by the respirometric BOD OxiTop® method, *International Journal of Environmental Analytical Chemistry*, **2005,** 85, 1065–1073

[4] Pineda-Vásquez T. et al., Biogeneration of silica nanoparticles from rice husk ash using Fusarium oxysporum in two different growth media, *Industrial and Engineering Chemistry Research*, **2012,** 53, 6959–6965

Photoinduced Astrochemical Synthesis of Benzonitrile

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Keywords: astrochemistry, photochemistry, quantum chemistry, benzonitrile, interstellar medium

The recent detection of benzonitrile in the interstellar medium (ISM) is one of the most important discoveries of modern astrochemistry [1]. Benzonitrile is not only ideally suited for studying the evolution of aromatic compounds in the ISM but it can also be a precursor in the synthesis of aromatic molecules of biological importance [2]. Therefore, it is very important to study and understand how this compound is formed in such an environment. Experimental work indicates the possible synthesis of benzonitrile inside astronomical ice grains containing benzene and hydrogen cyanide (HCN) or acetonitrile (ACN) molecules, but the exact chemical mechanism of this process remains unknown [3]. To investigate it we performed a series of quantum-chemical calculations. The vertical excitation spectrum, calculated using the ADC(2)/cc-pVTZ method, indicates the presence of a high-energy excited state in the benzene-acetonitrile system describing the electron transfer from benzene to acetonitrile. This state can be relaxed by conical intersection with the ground state leading to the formation of a cyclic product in a [2+2] cycloaddition reaction. Subsequent excitations of this product with photons can lead to its opening and rearrangement. As a result, it is possible to form a benzonitrile molecule from a mixture of benzene and acetonitrile. The reaction paths leading to conical intersections were obtained from the RI-CASPT2 (10/10) method in the def2-TZVP basis set.

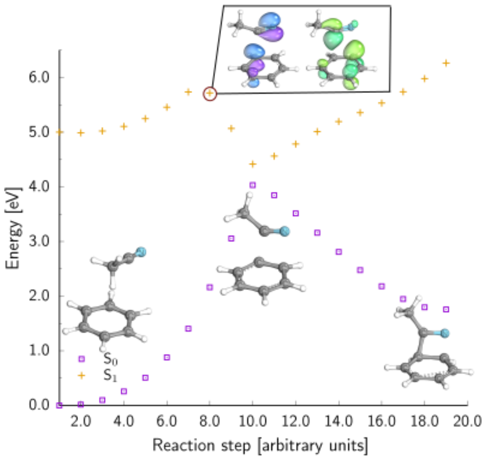

Fig. 1. Pathway of photoinduced cycloaddition of acetonitrile to benzene with HOMO (blue) and LUMO (green) orbitals shown

Acknowledgments

Presented results were created as a part of a research project financed by the Polish National Science Centre (2022/47/D/ST4/03244 for R. S.). We gratefully acknowledge Poland's high-performance Infrastructure PLGrid ACK Cyfronet AGH for providing computer facilities and support within computational grant no PLG/2024/017359.
Created using resources provided by Wroclaw Centre for Networking and Supercomputing (http://wcss.pl).

References

[1] McGuire B.A. et al., Detection of the aromatic molecule benzonitrile (c-C_6H_5CN) in the interstellar medium, *Science*, **2018**, 359, 202–205.
[2] Gagonova M.Y. et al., Radiation-Induced Transformations of an Isolated $C_6H_6\cdots$HCN Complex: Possible Way to Synthesis of Interstellar Benzonitrile, *The Journal of Physical Chemistry A*, **2025**, 129, 282–287.
[3] Maksyutenko P. et al., Formation of c-C_6H_5CN Ice Using the SPACE TIGER Experimental Setup, *The Astrophysical Journal.*, **2022**, 940, 113–126.

In Vivo Metabolite and Neurotransmitter Measurements in Molecular Major Depressive Disorder Correlates: How to Quantify Stress?

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Keywords: astrocytes, glucocorticoids, metabolomics, major depression disorder, translational psychiatry

Astrocytes play a crucial role in regulating the number and functioning of synapses. Specifically, these cells are responsible for brain energy metabolism and neurotransmitter homeostasis – two processes that are tightly linked at the molecular level and subject to systemic hormonal control. Disturbances in astrocyte-specific processes can lead to abnormal synaptic structure and function. For example, clinically confirmed phenotypes in depression include disrupted glucose metabolism in the prefrontal cortex and altered glutamate to glutamine (Glx) ratio. Both parameters are directly related to astrocyte function. The main glutamate metabolism pathway involves its uptake by specific transporters, which activates glucose metabolism. Glutamate is then converted to glutamine by the astrocyte-specific enzyme glutamine synthetase (GluL), or it can enter the Krebs cycle as an energy substrate. Current understanding of astrocyte physiology suggests that these processes are regulated by circadian metabolic hormones, particularly glucocorticoids, under chronic stress conditions in mice [1]. The main goal of this study is to determine how chronic stress affects astrocyte-dependent metabolic and neurotransmitter pathways in a time-of-day-dependent (circadian) manner. This will be achieved by monitoring approximately 120 selected, polar metabolites (e.g., lactate, BCAA, aminoacids, intermediate metabolites) and key neurotransmitters (e.g., Glu, GABA, serotonine) using a targeted metabolomics approach combined with NextGenMicrodialysis in rodent models [2]. The focus will be on brain regions involved in the integration of the stress response, such as the prefrontal cortex. The expected outcome of this study is the identification of circadian disruptions in energy metabolism and neurotransmitter cycling – particularly within glutamate-glutamine related pathways – in response to chronic stress. These changes are hypothesized to contribute to dysfunctional neurotransmission observed in stress-related psychiatric disorders. Ultimately, the project aims to identify novel astrocyte-related molecular targets for future pharmacological interventions in the treatment of mood disorders.

References

[1] Tertil M. et al., Glucocorticoid receptor signaling in astrocytes is required for aversive memory formation, *Translational Psychiatry*, **2018**, 8, 255.
[2] Anderzhanova E. et al., Brain microdialysis and its applications in experimental neurochemistry, *Cell and Tissue Research*, **2013**, 354, 27–39.

Topological Responsiveness Behaviors Models in Architectural Structures

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Keywords: architectronics, structures behaviors models, topological responsiveness

Structural responsiveness in architecture refers to structures that adapt to external conditions by altering their geometry. This research introduces a new perspective – topological responsiveness – as an alternative to the more common geometric approach. Unlike traditional kinetic systems based on telescoping actuators that can only operate within elongation of bars, author proposes using rotational and translational motion within modular structures that retain a partially rigid skeleton, enabling easier simulation, analysis and more adjustable structure adaptation.

The concept builds on Kinetic Architecture [1], which integrates movement and time into design. While most research focuses on optimizing energy [2] use and geometric transformations [3], this study emphasizes structural changes at a topological level, offering new design and behavioral possibilities in intelligent architecture.

The author presents a methodology for designing a topologically responsive rod module, along with conceptual and geometric models, simulations on various scales, and a physical prototype. Conceptual design has to improve effectiveness in responsive architecture by higher shape adjustability. The structure undergoes basic tests comparing simulated and real-world behavior, allowing the identification of its functional scope and limitations. Test has to highlight structural improvement in comparition with geometrical responsiveness and show structural mass savings against static structures.

Results show radical improvement in calculations speed of domain topology and difficulties in imperfection occurencies possibility that leads to uniaxial forceflow that is ineffective. Results show that protective systems must be involved to reduce connections imperfection impact.

Topological responsiveness can be applicable in domain of high rise buidings and urban footbridges so structures that's one dimention is dominant and wind forces influences structure cross sections dimensions.

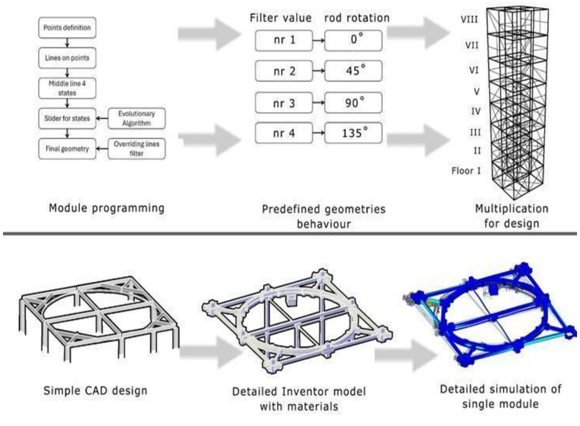

Fig. 1. Development Process of the Generalized Grasshopper Model and the Geometrical CAD Model. Own graphic

References

[1] William Z. et al., *Kinetic Architecture*,Van Nostrand Reinhold Company, **1970**.
[2] Senatore G. et al., Synthesis of minimum energy adaptive structures, *Structural and Multidisciplinary Optimization*, **2019**, 60, 849–877.
[3] Senatore G. et al., Force and Shape Control Strategies for Minimum Energy Adaptive Structures, *Front Built Environ*, **2020**, 6.

Deep Learning Based Motor Misalignment Detection Using Current Signals

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Keywords: electric motor, misalignment, motor current, deep neural networks, fault detection

This work addresses the critical challenge of detecting Parallel Motor Misalignment with Load in industrial settings, a condition known to significantly reduce motor lifespan and cause operational disruptions. Traditional diagnostic methods often rely on vibration analysis, necessitating additional sensors susceptible to environmental noise, or signal processing techniques like Fast Fourier Transform (FFT) which demand large amounts of stationary data. This research proposes an alternative by exploring the diagnostic potential of motor current signatures – specifically utilizing only 600 data probes sampled at 10 kHz – processed directly via Deep Neural Networks (DNNs) to accurately identify misalignment levels. Crucially, leveraging inherent current signals eliminates the need for extra sensors and offers enhanced resilience against common industrial noise compared to vibration-based approaches.

The core methodology involves a DNNs architecture specifically designed to classify raw, unprocessed motor current signals into one of nine distinct parallel misalignment states. Input data, meticulously collected under diverse motor load and supply frequency conditions, is rigorously partitioned into training, validation, and testing sets to ensure robust model development and evaluation. The DNN undergoes training on the designated training set, with performance continuously monitored against the validation set, followed by final performance verification using the unseen test data. This specific DNN-based strategy builds upon previous successful applications in identifying other motor fault types, highlighting its potential advantages over classical algorithms, particularly regarding processing efficiency and minimal data requirements.

The primary contribution of this investigation is the application and validation of this established DNN methodology within the novel context of motor misalignment detection using only current signals. The central objective is to ascertain the effectiveness of the approach in discerning the subtle, yet characteristic, current signal patterns induced by varying degrees of misalignment. The research workflow encompasses systematic data acquisition, tailored DNN model development and training, and comprehensive testing phases designed to thoroughly evaluate the algorithm's diagnostic accuracy, operational advantages, and inherent limitations across a spectrum of simulated industrial scenarios.

Consequently, the anticipated outcome is the development and verification of a novel, robust, and computationally efficient method for detecting motor misalignment using readily available motor current data. This approach promises a significant improvement over the current state-of-the-art by providing a reliable diagnostic tool that functions effectively under varied motor operating conditions without requiring additional, costly sensor installations. Successful implementation offers a pathway to enhanced predictive maintenance strategies, contributing to increased operational reliability and reduced downtime in industrial applications reliant on electric motors.

Acknowledgments

Funded by the European Union under GA no. 101101961 – HECATE. The views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or Clean Aviation Joint Undertaking. Neither the European Union nor the granting authority can be held responsible for them. This project is supported by the Clean Aviation Joint Undertaking and its Members.

Active Disturbance Rejection Control Based on Neural Model Applied for Two-Mass System

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Keywords: Active Disturbance Rejection Control, Radial Basis Function Neural Network, Elastic Coupling, Electric Drives

Electric drives are often used to fulfill strict requirements of modern technological processes. Moreover, in order to face a variety of different technological challenges they are often coupled with sophisticated machinery, which requires high dynamics and control accuracy. A two-mass system is considered one of the most common mechanical extensions of the complex electric drive unit. It is applied in various industrial applications, e.g., wind turbines, positioning systems. The mechanical part of the drive is exposed to different external disturbances (environmental circumstances, overload scenario, changed friction, etc.), which significantly affect the plant response quality. A wide range of possible operating scenarios force scientists to elaborate novel control strategies which can provide increased robustness or adaptation capabilities. The main principle of modern control strategies is to minimize vulnerability of the drive and compensate any kind of uncertainties occurred during operating the drive (e.g. speed/position overshoot, torsional vibrations, etc.). Strict dynamic requirements are also faced with modern automation trends, i.e. reducing the number of measurement sensors (low costs, system reliability). For the sake of scientific research, a two-mass system concept is substituted with two electric motors coupled together with a long (flexible) shaft. The purpose of using the shaft is to introduce additional elasticity and torsional vibrations to the drive model. By doing so, it is possible to analyze the worst potential operating scenario on the test-bench. In order to satisfy abovementioned demands of modern electric drive systems, an Active Disturbance Rejection Control (ADRC) is currently being evaluated. It is based on the assumption that the exact plant model can be described with the use of the multi-integrator concept. By doing so, the mathematical description of the controlled object does not need to be known. Thus, both the internal plant dynamics and the external disruptions can be omitted, as their precise form is estimated on-line in the form of the combined disturbance variable [1]. The actual value of the disruption is estimated with the use of the Extended State Observer (ESO). Described approach ensures high control accuracy and excellent dynamic properties. Moreover, it also satisfies the limited mechanical sensor amount criteria, as it uses the load machine speed feedback only. The main idea of the doctoral dissertation is to make an ADRC strategy more robust to a sudden change of the plant parameters and to increase its resilience on the implementation inaccuracies. The doctoral thesis examines two main approaches. The first one is focused on extending the speed controller with the floating gain parameters adjusted by the Radial Basis Function Neural Network (RBFNN) [2]. The second part of the work improves the control quality by modifying the default form of the ESO. The main goal of the doctoral thesis is to improve the two-mass ADRC system speed precision tracking and vibration damping capabilities in case plant parameters are significantly changed. The general concept of the doctoral thesis involves elaboration of the current state of the art overview, development of a novel ADRC algorithm improvements based on neural network model, carrying out numerical and experimental tests. The elaborated neural extensions will make the ADRC more versatile algorithm capable of controlling the drive in variety of different conditions, no matter what type of flexible connection or electric motor is used. The proposed algorithms will constitute a huge contribution to the field of two-mass control strategies development.

References

[1] Wicher B. et al., Active Disturbance Rejection Control Based Load Side Speed Controller for Two Mass System with Backlash, *IEEE 18th International Power Electronics and Motion Control Conference (PEMC)*, **2018**, 645–650.

[2] Kaczmarczyk G. et al., A neural-enhanced active disturbance load-side speed control of an electric drive with a flexible link, *Archives of Electrical Engineering*, **2025**, 74, 269–289.

Synthetic α-helical PSMα3 as an Inhibitor of Human Amyloid Aggregation

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Keywords: PSMα3, anti-fibrillation effect, molecular modelling

The α-helical peptide PSMα3 belongs to the family of phenol-soluble modulins (PSMs), which are extracellular short amphipathic peptides secreted by the bacteria *Staphylococcus aureus*. PSMα3 is of special recent interest due to its cytotoxicity and highly stable α-helical conformation, which also remains in its amyloid fibrils [1]. The aim of this study was to evaluate the aggregation propensity of synthetic PSMα3, which, due to the features of the synthesis process, lacks the N-terminal formyl groups usually presented in wild-type bacterial peptides.
It has been demonstrated that synthetic PSMα3 does not form amyloid fibrils and maintain α-helical conformation in a soluble monomeric form for days of incubation. Furthermore, using multiple experimental techniques, it has been found that synthetic PSMα3 considerably inhibited the aggregation of particular human amyloids, for example human insulin [2]. It has also been revealed that PSMα3 substantially reduced human islet amyloid polypeptide (hIAPP) aggregation *in vitro*. Particularly, the kinetics assay displayed a considerable elongation in the lag phase with the increase of PSMα3 concentration. Microscopic studies show fewer fibrils in the case of co-incubation of hIAPP with PSMα3, supporting the kinetic data, while the attenuated total reflectance-Fourier transform infrared (ATR-FTIR) analysis indicated that PSMα3 prevents hIAPP transition into β-sheet-enriched structures, disrupting its tendency to fibrillate. Notably, synthetic PSMα3 was not damaging to human endothelial cells, in contrast to wild-type bacterial peptide. It also protects these cells from cytotoxicity caused by hIAPP, hence enhancing their viability and rate of proliferation. Furthermore, it has been shown the anti-fibrillation effectiveness of PSMα3 is highly selective, dependent on the target protein sequence, and extremely sensitive to its terminal alterations. Particularly, PSMα3 was totally ineffective towards the deamidated sample of hIAPP. Moreover, PSMα3 did not modulate the aggregation of the fragment serum amyloid A (SAA27), which is characterised by entirely different amino acid sequences compared to hIAPP. Molecular modelling suggested that PSMα3 could interact with a broader range of amyloidogenic peptides. According to predicted structures, the mechanism of PSMα3 binding to other peptides is probably dominated by hydrophobic interactions between the PSMα3 amino acids Phe, Leu, and Val and the partner protein's Ala, Phe, Ile, Leu, and Val.
In conclusion, it has been demonstrated that synthetic PSMα3 acts as a selective, non-toxic inhibitor of amyloid aggregation of particular human proteins. Its anti-amyloidogenic effect depends on a target protein sequence and is highly sensitive to terminal modifications. The obtained results suggest the therapeutic potential of synthetic PSMα3 in modulating pathological amyloid aggregation.

Acknowledgments
This work was partially supported by the statutory funds of the Wrocław Medical University subsidy with an internal number of SUBK.Z516.24.068 and the National Science Centre, Poland, grant no. 2019/35/B/NZ2/03997.

References

[1] Salinas N. et al., Extreme amyloid polymorphism in Staphylococcus aureus virulent PSMα peptides, *Nature communications*, **2018**, 9, 1–9.
[2] Kalitnik A. et al., Cytotoxic Staphylococcus aureus PSMα3 inhibits the aggregation of human insulin in vitro, *Physical Chemistry Chemical Physics*, **2024**, 26, 15587–15599.

Ignition Spark Stability According to the Spark Plug Tip Geometry and Pressure

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Keywords: combustion engines, electric drives, electronic, NVH, plasma

The research focuses on examining the influence of spark plug tip geometry, gap size, and pressure on the ionization process, plasma channel formation, and spark stability. Parameters such as spark duration, current and voltage waveforms, as well as peak and average values, are being analyzed. Additionally, the effect of multiple attempts to initiate the plasma channel is investigated. The scientific study revealed a strong dependency of the voltage required to initiate the plasma channel on the pressure inside the test chamber. In some cases, particularly for surface-discharge spark plugs, this relationship is not linear. For certain tip designs, multiple attempts to establish the plasma channel were observed before the final spark breakdown occurred. All tests were conducted under negative polarity. Sample graphs from the study are presented in Fig. 1.

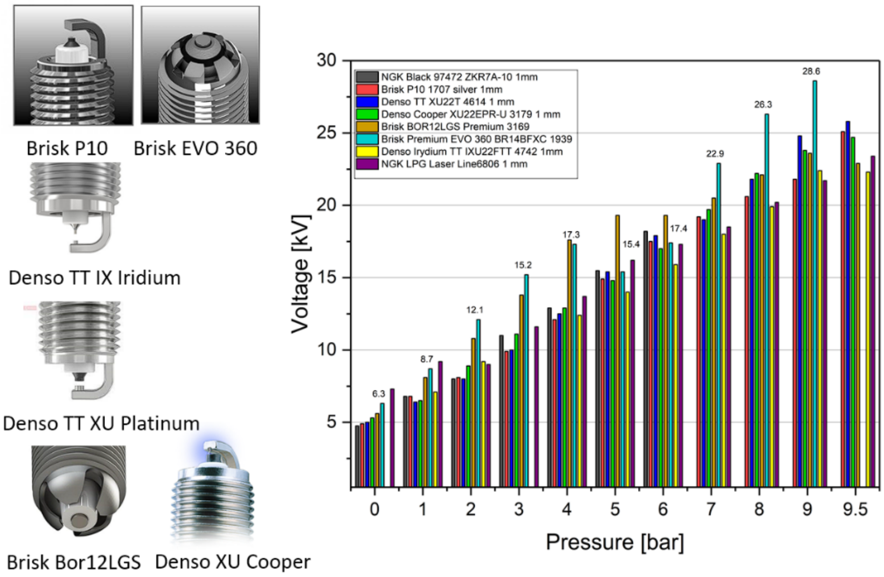

Fig. 1. Behavior of the different spark plug types

For the purposes of the study, a dedicated test rig was constructed. It includes a pressure chamber with adjustable pressure ranging from 0 to 10 bar, a single ignition coil, a coil triggering system with adjustable charging time and firing frequency, and a measurement system based on a resistor with minimal voltage-dependent resistance. The setup also includes two high-voltage probes for the oscilloscope, a PICO oscilloscope adapter, and an Mt Pro 4.1 oscilloscope. For each measurement point, the spark was triggered at least 100 times. Before beginning the tests, each spark plug was operated for 10 minutes to stabilize the breakdown voltage and current values. A uniform 1 mm gap between electrodes was used for all spark plugs. The lowest overall breakdown voltages and the longest spark durations were achieved by the iridium-platinum double TIP spark plug, Denso TT. The highest voltages were recorded on the BRISK EVO spark plug, which is a surface-type plug with an additional coated electrode on the ceramic insulator, resulting in a double spark discharge. At a pressure of 9 bar, the breakdown voltage in ambient air reached as high as 28.6 kV, making this spark plug unsuitable for use in turbocharged and high-performance vehicles. The copper NGK spark plugs exhibited high ignition instability, showing multiple attempts to initiate a plasma channel even at pressures as low as 4 bar.

Innovative Additive Manufacturing Approach to 3D Printing Conformal Cooling Channels for Hot Forging Dies

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Keywords: Hybrid manufacturing, conformal cooling channels, cold metal transfer (CMT) technology

This study presents a novel hybrid method for manufacturing forging tools with conformal cooling channels by integrating 316Ti stainless steel tubes into hardfaced layers using Cold Metal Transfer (CMT) technology. The method was tested on H11 tool steel substrates with three different variants of tube positioning and weld bead geometry. The objective was to achieve full circumferential fusion of the tubes while minimizing thermal distortion and welding defects. Microstructural analysis confirmed effective bonding in all variants, with Method 2 (bevel bead) providing the most consistent results and minimal welding discontinuities. The CMT process produced narrow heat-affected zones and preserved a fine-grained tempered martensitic structure in the substrate. Hardfaced layers exhibited a gradient from tempered bainite at the base to untampered martensite at the surface. Vickers hardness values ranged from ~500 HV1 near the fusion line to ~750 HV1 at the surface, with tubes maintaining ~200 HV1. This method enables the formation of smooth, circular internal channels with good mechanical integrity and thermal properties. Compared to conventional additive manufacturing, it offers greater structural control, improved cooling efficiency, and practical applicability for large-scale industrial forging tools.

Selection of a Cyanobacterial Biocatalyst Based on Production of Exopolysaccharides for Later Application of Biomass in Bioremediation and Plant Biostimulation

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Keywords: cyanobacteria, exopolysaccharides, biomass, bioremediation, plant stimulation

Cyanobacteria are known biocatalysts and due to their photoautotrophic metabolism, they are able to utilize carbon dioxide as a carbon source and light as energy. This renders them sustainable candidates for performing especially redox-based transformations with chemo-, regio- and enantio-selectivitity under mild conditions (physiological pH, ambient temperature and pressure) and generate less waste than conventional chemical routes. Additional advantage is application of biomass after biocatalysis further reducing waste and using it for bioremediation of heavy metals from the environment or stimulating plant growth.

One of the key components of cyanobacterial biomass are exopolysaccharides (EPS). Beyond their role in shielding cells from environmental stresses and contributing to biofilm formation, EPS exhibit a broad spectrum of biological activities, including antibacterial, antioxidant, and anticoagulant properties. The inherent negative charge of EPS facilitates the sequestration of metal cations, which is an attribute crucial for cellular growth and particularly advantageous in the context of bioremediation of heavy metals from contaminated environments. Additionally, they have shown potential as biostimulants in agriculture, aiding in the mitigation of both biotic and abiotic stresses and functioning as elicitors of plant defense responses, as well as contributing to soil stabilization.

Using phenol-sulfuric-acid assay, the amount of EPS was established in various cyanobacterial species *Kaptonema animale* (36.50 mg/L EPS eq. glucose), *Leptolyngbya foveolarum* (70.95 mg/L EPS eq. glucose), *Nodularia moravica* (21.04 mg/L EPS eq. glucose), *Nodularia sphaerocarpa* (45.26 mg/L EPS eq. glucose), *Nostoc cf-muscorum* (33.84 mg/L EPS eq. glucose), *Synechococcus bigranulatus* (93.46 mg/L EPS eq. glucose), *Limnospira maxima* (222.7 mg/L EPS eq. glucose), *Limnospira indica* (166.5 mg/L EPS eq. glucose), which allowed to select an appropriate species to further conduct research on its biocatalytic abilities. *Limnospira maxima* and *Limnospira indica* were preliminarily chosen as a biocatalysts with the highest concentration of EPS.

Heterometallic Rare Earth-Zinc Aryloxides for Polymer Synthesis

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Keywords: heterometallic complexes, rare earth elements, catalysis, polymer synthesis

Over the past three decades, heterometallic rare earth metal-zinc coordination compounds have gained attention as valuable molecular materials due to their remarkable magnetic, photochemical, catalytic, and structural characteristics [1-4]. The synthesis of RE^{III}-Zn^{II} complexes presents a promising approach to enhancing catalytic performance, offering improved reaction efficiencies and selectivity in various chemical transformations. In polymer and resin synthesis, these complexes can facilitate controlled polymerization processes, leading to advanced materials with tailored properties such as enhanced stability, mechanical strength, or thermal resistance.

In our work, we developed a simple synthetic route to RE^{III}-Zn^{II} coordination compounds by reacting homoleptic or heteroleptic zinc aryloxides, $[Zn_4(\text{sal-Me})_8]$ and $[Zn_4(\mu_3\text{-OMe})_2(\text{sal-Me})_6]$ (Hsal-Me = methyl salicylate) with 2 equiv of $RECl_3$ [5]. Depending on the zinc aryloxide precursor used, the formation of either trinuclear heterometallic clusters $[REZn_2(\text{sal-Me})_4Cl_3(H_2O)]$ (RE^{III} = Y, Ho, Er) using the first one or hexanuclear clusters $[RE_2Zn_4(\mu_3\text{-OH})_2(\mu\text{-OMe})_2(\text{sal-Me})_6Cl_4]$ (RE^{III} = Y, Ho, Er) using the second one was observed. The catalytic activities of homometallic and heterometallic compounds were investigated in the ring-opening polymerization (ROP) of pentadecanolide (PDL) and hexadecanolide (HDL), leading to the synthesis of low molecular weight materials, as pictured in Fig. 1. Although a direct comparison with homometallic analogs was limited due to solubility constraints in the monomers, the Y^{III}-Zn^{II} complexes showed the most consistent catalytic performance, attributed to their favorable solubility in the reaction environment.

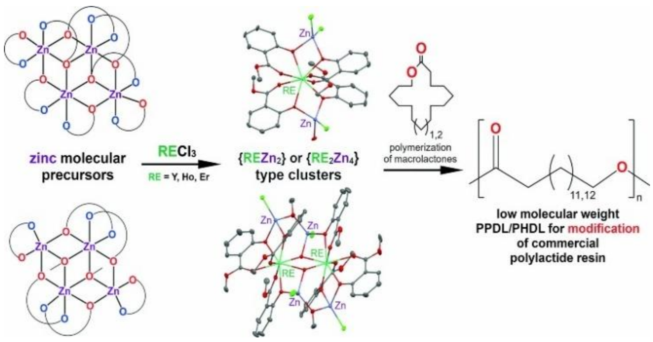

Fig. 1. Synthesis of $\{REZn_2\}$ and $\{RE_2Zn_4\}$ type clusters for polymerization of macrocyclic lactones.

The low molecular weight polyesters (PPDL and PHDL) were examined as modifying agents for commercial polylactide resin (PLLA 2003D) and used to create PLLA/PPDL and PLLA/PHDL blends. From an application standpoint, blending PLLA with PPDL or PHDL resulted in lower thermal stability and faster degradation, suggesting potential utility in biodegradable packaging or transient biomedical materials.

Acknowledgments

The authors thank the Polish National Science Center for financial support, grant number 2017/26/D/ST5/01123.

References

[1] Zheng B. et al., Rare-Earth Doping in Nanostructured Inorganic Materials, *Chemical Reviews*, **2022**, 122, 5519–5603.
[2] Boulkedid A.-L. et al., Synthesis, Structure and Magnetic Properties of a Series of Dinuclear Heteroleptic Zn^{2+}/Ln^{3+} Schiff Base Complexes: Effect of Lanthanide Ions on the Slow Relaxation of Magnetization, *Dalton Transactions*, **2019**, 48, 11637–11641.
[3] Li Y.-L. et al., Lanthanoid Hydrogen-Bonded Organic Frameworks: Enhancement of Luminescence by the Coordination-Promoted Antenna Effect and Applications in Heavy-Metal Ion Sensing and Sterilization, *Chemical Engineering Journal*, **2023**, 451, 138880.
[4] Yin C.-L. et al., Single Molecule Magnet Behaviors of Zn_4Ln_2 (Ln = Dy^{III}, Tb^{III}) Complexes With Multidentate Organic Ligands Formed by Absorption of CO_2 in Air Through In Situ Reactions, *Dalton Transactions*, **2019**, 48, 512–522.
[5] Kowaliński A., et al., Synthesis of Heterometallic Rare Earth-Zinc Aryloxido Complexes and Their Application in Macrocyclic Lactones Polymerization, *Applied Organometallic Chemistry*, **2025**, 39, e70017.

ProSorb-C4P1a for the Removal of Phosphorus from High-Phosphorus Wastewater: Laboratory Studies and Industrial Implementation Prospects

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Keywords: sorption, wastewater purification, elemental analysis, circular economy

High phosphorus concentrations in industrial wastewater represent a significant environmental and technological challenge, as they preclude direct discharge into sewer systems and contribute to eutrophication of receiving surface waters. The commercial sorbent *ProSorb-C4P1a*, obtained by modifying natural aluminosilicate, was chosen for its characteristic porous structure and abundance of active sites, enabling effective phosphorus removal; once saturated, it can be used as a fertilizer, thus closing the nutrient loop. Although aluminosilicates are widely used to treat waters with low to moderate contaminant loads, their sorption capacity under conditions of extremely high phosphorus concentrations remains poorly characterized. In this study, the mineralogical composition of the *ProSorb-C4P1a* sorbent was determined by energy-dispersive X-ray fluorescence (ED-XRF), and the pH and electrical conductivity of a 1% suspension were measured. All aqueous samples were analyzed for phosphorus content by inductively coupled plasma optical emission spectrometry (ICP-OES). The effect of a 1% (w/v) sorbent addition on phosphorus removal was evaluated in both synthetic model solutions and actual industrial effluents. Adsorption isotherms were obtained over a range of 0–1000 mgP/L and fitted to both Langmuir and Freundlich models, yielding a maximum adsorption capacity (Q_{max}) of 37 mgP/g for the Langmuir model, while the Freundlich model provided the best fit (K_F = 1.123, n = 1.656), indicating potential multilayer adsorption at higher initial concentrations. Sorption kinetics were also determined. A subsequent pilot-scale experiment, in which 1% (w/v) sorbent was placed in a tank periodically charged with real wastewater containing 1540 mgP/L, a reduction in phosphorus concentration exceeding 50% was achieved. Future work will evaluate the agronomic potential of the phosphorus-laden *ProSorb-C4P1a* sorbents as a sustainable fertilizer source.

Mechanical Investigation of Ultrathin Membranes Based on $Mo(S_XSe_{1-X})_2$ alloys

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Keywords: TMD alloys, Young's modulus, mechanical properties, transition metal dichalcogenides membranes

2D materials such as transition metal dichalcogenides (TMDs) and their alloys are being intensively investigated for future applications in electronics and sensors. 2D TMDs exhibit new properties that differ from their bulk counterparts. In the present study, the mechanical properties of monolayer and bilayer membranes based on $Mo(S_XSe_{1-X})_2$ crystals were investigated. The samples were prepared using mechanical exfoliation and the dry transfer method [1]. To characterize the number of layers, Raman spectroscopy and atomic force microscopy (AFM) measurements were carried out, which prove that mono- and bilayer atomic thicknesses were obtained. Specialized substrates with etched holes of 2.4 μm diameter, coated with a gold layer (150 nm Au/10 nm Cr/297 nm SiO_2/Si), were used to fabricate the structures. Membrane deflection as a function of applied force was measured for each of the materials investigated using AFM. In the case of the monolayer structure, $MoSe_2$ showed the lowest deflection, while MoS_2 showed the highest, as shown in the figure below [2]. The magnitude of deflection of membranes fabricated from $MoS_{1.44}Se_{0.56}$ is between $MoSe_2$ and MoS_2. The thickness of the membrane also significantly affects its deflection. The thinner the membrane, the greater the deformation. One of the mechanical properties that was determined by force-distance (F–z) spectroscopy was Young's modulus (E). The highest Young's modulus was determined for MoS_2 and is 247.96 ± 1.8 GPa. In comparison, the E of the most mechanically strong material, graphene, is 1.02 ± 0.03 TPa [3]. For monolayers, the smallest Young's modulus was obtained for $MoS_{1.44}Se_{0.56}$ – 101.23 ± 31.01 GPa, which is 26.37 GPa lower than $MoSe_2$. In addition, for the $MoS_{1.44}Se_{0.56}$ bilayer, E was obtained four times lower than the result obtained for the single layer.

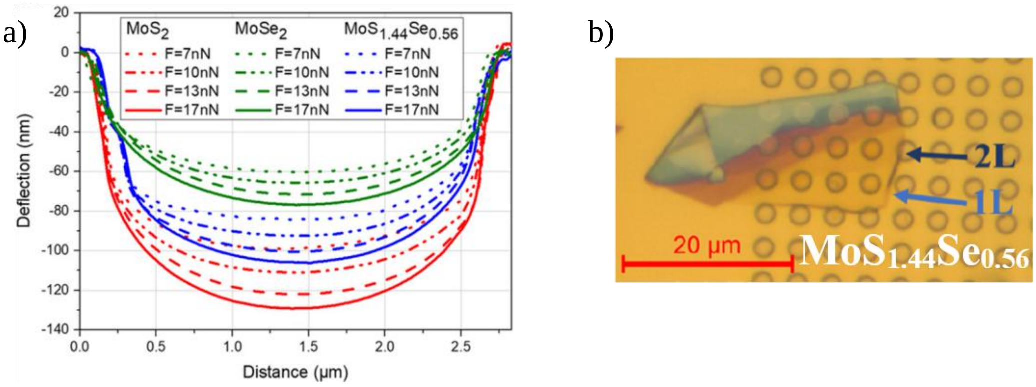

Fig. 1. (a) Deflection of membranes fabricated from MoS_2, $MoSe_2$, and $MoS_{1.44}Se_{0.56}$ as a function of the applied forces. Images of the membrane made of (b) $MoS_{1.44}Se_{0.56}$ [2]

Acknowledgments

This research was funded by the National Science Centre Poland OPUS (grant no. 2021/41/B/ST5/04328).

References

[1] Castellanos-Gomez A. et al., Deterministic transfer of two-dimensional materials by all-dry viscoelastic stamping, *2D Materials*, **2014**, 1, 011002.
[2] Piejko A. et al., Mechanical and Kelvin Probe Force Microscopy Investigations of Ultrathin Membranes Based on MoS_2 and $MoSe_2$, *Physica Status Solidi B*, **2024**, 4, 2300352.
[3] Lee C. et al., Measurement of the Elastic Properties and Intrinsic Strength of Monolayer Graphene, *Science*, **2008**, 321, 385–388.

Hybrid Power Unit for Patrol Drone Application

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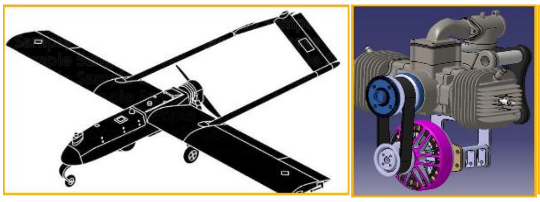
Keywords: Gears design, Gears manufacturing, propulsion systems, UAV.

The increasing use of Unmanned Aerial Vehicles (UAVs), fueled by recent military conflicts and expanding civilian applications, has created a demand for innovative propulsion systems with expanded operational capacity. The purpose of this study was to evaluate a hybrid propulsion unit concept with a system power of 30 kW for an observation drone with a takeoff weight of 200 kg and a flight time of more than 2 hours, and to determine its flight performance for two flight scenarios. The shape of the airframe resulting from the conceptual design is shown in Figure 1. The proposed architecture consisted of a 20 kW counter-rotating internal combustion engine and a 10 kW electric motor, connected by a mechanical clutch and belt system developed by Gear Research Laboratory, shown in Fig. 1. The main requirements for the design of such a gearbox are its compact size, low weight, allowing each engine to operate separately or work together. The electric motor was configured to operate in three modes: starter, booster and generator. A flight profile analysis was conducted to verify the ability of the propulsion system to meet operational requirements. Using the energy method for determining power requirements during flight [1, 2], two flight scenarios were simulated for the adopted mission profile: flight without battery charging and flight with simultaneous charging. Both scenarios maintained a cruising speed of 36 m/s and propulsion power delivered to the propeller of 11 kW. In the first case, the electric motor did not operate in generator mode, coaxing only the energy stored in the battery. The drone achieved a total flight time of 182 minutes, with 31 seconds of quiet operation in "ghost mode" using pure electric propulsion. In the second scenario, the internal combustion engine was additionally loaded with an electric motor operating in generator mode at 7 kW of charging power. This resulted in a slight reduction in flight time to 180 minutes but significantly increased the ability to operate in ghost mode to 432 seconds. The results of the analysis are shown in Table 1. The results of the conceptual work have confirmed stable operation in all modes, with an expected flight duration of 180 minutes, surpassing the initial assumption of a 2-hour mission. In addition, the hybrid system provides the ability to control the energy cycle on board the UAV, increasing the reliability of the aircraft and enabling low-noise reconnaissance with purely electric propulsion (it was shown that electric flight is possible in excess of 5 minutes after operation in generator mode). This research presents a novel propulsion concept that integrates mechanical and electrical subsystems to meet the changing tactical requirements of modern UAV missions.



Flight trajectory	V[m/s]	Nn[kW]	Ns[kW]	Nel[kW]	D[min]	GhostMode [s]
Flight without charging	36	8	11	0	182	31
Flight with charging	36	8	11	-7	180	432

Fig. 1. Isometric view of the analyzed UAV and hybrid propulsion system, Table with parameters of flight analyzed UAV

References

[1] Fillippone A., Advanced aircraft flight performance, *Cambridge University Press*, USA, **2012**.
[2] Kuźniar M., Wielokryterialna ocena doboru napędów lotniczych nowej generacji z wykorzystaniem metod energetycznych, Doctoral thesis, **2021**.

Impact of RNA Template on DNA Self-Replication Process

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Keywords: DNA, RNA, self-replication, nonenzymatic, molecular dynamics

In the last forty years, considerable research has focused on the nonenzymatic self-replication of RNA, revealing that imidazolium-bridged dinucleotides likely play a crucial role in this process. Such findings reinforce the idea that RNA was important to the origin of life [1–3]. By contrast, DNA primer extension occurs at a much slower rate, which makes it less relevant to prebiotic chemistry, though it might provide an alternative route for DNA synthesis [4]. While common techniques like solid-phase synthesis and PCR are often employed to produce DNA, they come with several drawbacks, such as high enzyme costs, procedural complexity, and heavy solvent usage. Notably, recent research indicates that DNA synthesis proceeds more efficiently on RNA templates than on pure DNA, potentially due to RNA's A-form helical structure [5]. Main object of these studies is to fully understand mechanism of the process and impact of RNA template on DNA self-replication.

In this work, we present molecular dynamics simulations of RNA, DNA, and DNA/RNA hybrid systems, considering both protonated and deprotonated 3′ ends of the primer. These simulations help clarify the limited efficiency of DNA primer extension and show how RNA template force DNA to adopt A type helicity. Additionally, they reveal the essential role of magnesium ions in facilitating nonenzymatic primer extension.

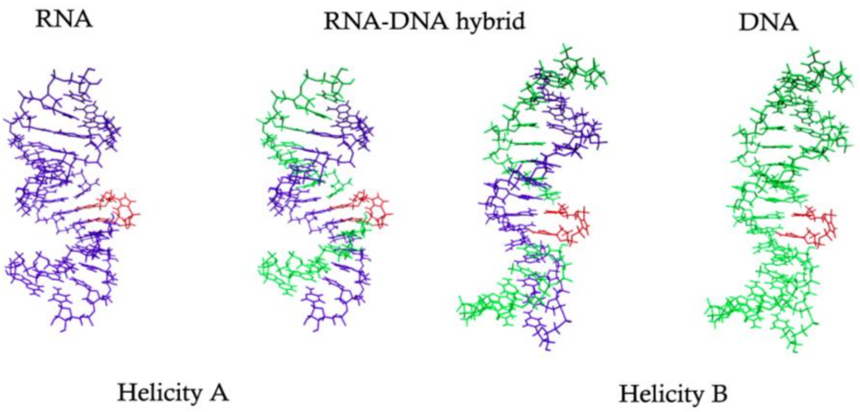

Fig. 1. Investigated structures

Acknowledgments

This work has been supported by a grant from the National Science Centre, Poland (2022/46/E/ST4/00377 to R. S.). Calculations were performed in Poland's high-performance Infrastructure PLGrid.

References

[1] Crick F.H.C., The origin of the genetic code, *Journal of Molecular Biology*, **1968**, 38, 367–379.
[2] Inoue T. et al., Oligomerization of (guanosine 5′-phosphor)-2-methylimidazolide on poly (C): an RNA polymerase model, *Journal of Molecular Biology*, **1982**, 162, 201–217.
[3] Zhang W. et al., Crystallographic observation of nonenzymatic RNA primer extension, *eLife*, **2018**, 7, e36422.
[4] Andrews B.I. et al., Sustainability challenges and opportunities in oligonucleotide manufacturing, *Journal of Organic Chemistry*, **2021**, 86, 49–61.
[5] Park S.J. et al., Role of helicity in the nonenzymatic template-directed primer extension of DNA, *Organic & Biomolecular Chemistry*, **2023**, 21, 6702–6706.

Synthesis and Characterization of Polyurethanes for Thermal Energy Storage Applications: Investigation on Chain Extenders

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Keywords: polyurethane chemistry, material engineering, phase change materials, polyurethane crystallinity, segmented polyurethanes

Phase change materials (PCMs), among fatty acids, paraffins, and eutectic mixtures, represent a wide range of materials that can be used for thermal energy storage due to their cyclic ability to undergo phase transitions. One of the materials that can store thermal energy is polyethylene glycol (PEG), a crystalline polyol, which, combined with an isocyanate and chain extender, can form part of the segmented structure of polyurethane materials. The presentation covers the influence of the type of chain extender on the thermal energy storage capacity of the polyurethane material based on petrochemical polyethylene glycol. In this work, three polyurethane materials were obtained based on petroleum PEG, 4,4'-diphenylmethane diisocyanate (MDI), and three chain extenders – diethanolamine (DEA), 1,4-butanediol (BDO), and 1,3-propanediol (PDO). The correlation between PEG and chain extender was investigated utilizing thermal, mechanical, and chemical analysis. The addition of an amine-based extender caused the formation of a higher interconnected domain structure in comparison to alcohol-based chain extenders. An increase in hydrogen bond strength results in a melting point shift into higher temperature regions, reaching 37.1°C for PUxPCM DEA sample and the highest latent heat value – 68.15 J/g. In comparison, alcohol-based chain extenders caused poorer interaction-network, and melting temperature and latent heat for BDO and PDO were 31.8°C/55.39 J/g and 34.2°C/42.34 J/g, respectively (Fig. 1). Thermal stability was determined by $T_{5\%}$ parameter and the sample's value of stability with diethanolamine was the highest (Fig. 2).

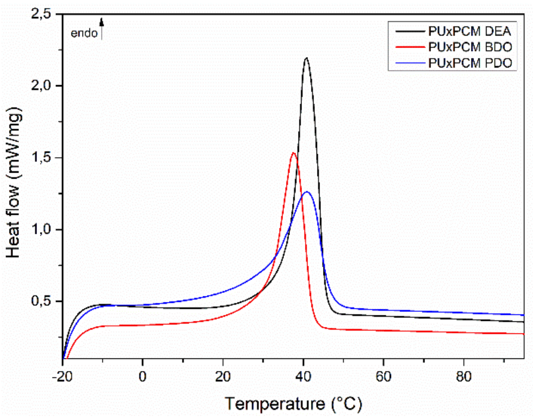

Fig. 1. Heat flow of obtained materials as a function of the temperature

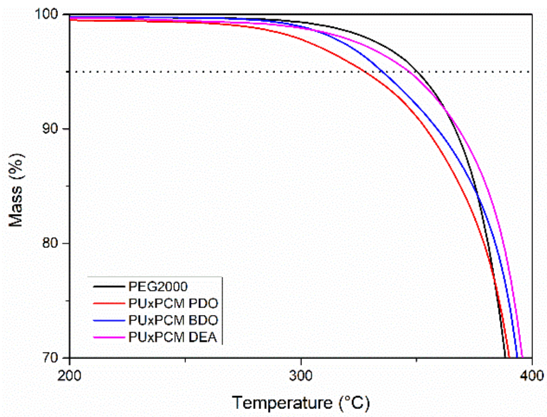

Fig. 2. Thermal degradation of polyurethane materials

Acknowledgments

This work was supported by the National Science Centre (NCN, Poland) project - Investigation of the processing capability, compatibility, and stability of Phase Change Materials (PCM) in polyurethane materials for thermal energy storage.

Hydrogen Combustion Simulation in a Spark Ignition Engine with Prechambers

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Keywords: hydrogen combustion, combustion engine, prechamber, combustion modelling, simulation

The combustion of a hydrogen-air mixture in an internal combustion engine is a complex phenomenon, however worthy of thorough research and technological development taking into account the potential benefits of using hydrogen as an alternative fuel [1]. Its usage can significantly contribute to the reduction of harmful emissions, supporting global efforts towards sustainable development and environmental protection [2]. In the context of hydrogen engines, where the burning rate of hydrogen is relatively high, the two stage combustion system allows for more precise control of the combustion process, which is key to ensure the stability and safety of engine operation [3]. The main objective of the research was to determine the influence of the volume of prechamber on the course of the combustion process in a spark ignition engine fueled by hydrogen. The used research object was a 1.4 TSI engine of the Volkswagen Group designated as EA111. The scope of the carried research includes the analysis of the principle of the two stage combustion system and its applications in engines, as well as the influence of the geometry of prechamber on the combustion process. The simulation part of the work focuses on the comparison of three prechamber volumes: 3%, 5% and 10% of the main combustion chamber volume, based on the literature review, using the CFD modeling software - AVL Fire. The simulation results were then compared and interpreted to identify the optimal solution.

Table 1. Amount of heat released in a single cycle for different ignition advance angles and prechamber volumes

Ign. Advance [°CA]	Q_{max} V = 0% [J]	Q_{max} V = 3% [J]	Q_{max} V = 5% [J]	Q_{max} V = 10% [J]
9	628.8	**640.9**	630.5	629.1
7	628.4	**640.8**	633.6	639.4
5	627.5	**640.5**	635.4	653.3

Simulations were carried out for a rotational speed n =1500 rpm and ignition advance angles of 9.7 and 5 degrees before top dead centre. In the course of the analysis, it was determined that chambers with a volume of 3% have optimum properties considering the effect of its volume on the reduction of compression ratio.

References

[1] Falfari S. et al., Hydrogen Application as a Fuel in Internal Combustion Engines, *Energies*, **2023**, 16, 2545.
[2] Atanu R., A review of the hydrogen fuel path to emission reduction in the surface transport industry, *International Journal of Hydrogen Energy*, **2024**, 49, 792–821.
[3] Xinlei L. et al., Hydrogen pre-chamber combustion at lean-burn conditions on a heavy-duty diesel engine: A computational study, *Fuel*, **2023**, 335.

Explainable Machine Unlearning

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Keywords: machine learning, machine unlearning, explainable ai

Machine learning models may inadvertently memorize sensitive, unauthorized, or malicious data, which poses risks of privacy breaches, security vulnerabilities, and performance degradation. To address these issues, a new group of algorithms, called machine unlearning [1], has emerged, whose main goal is to remove the influence of specific data fragments on previously trained models. As this technique develops, many questions have arisen aimed to understand the unlearning. The most challenging of these involves determining the impact of individual data points on the machine learning model and the possibility of fairly comparing different machine unlearning methods based on various model architectures. Explainable Artificial Intelligence techniques can be used to increase the transparency and explainability of complex models, making the relationship between training data and model predictions clear. This intricate relationship between explainability and machine unlearning could be used to impact both branches of artificial intelligence. In this seminar we will present my achievements in the unexplored field of explainable machine unlearning. My current research is focused on usage of already existing instance-level explanation methods like Shapley Additive Explanations (SHAP) [2], Local Interpretable Model-Agnostic Explanations (LIME) [3] or saliency map [4] as evaluation metric for machine unlearning methods. This study is the first one to use such approach in assessments of forgetting algorithms. Results showed that there is a connection between existing machine unlearning metrics and proposed solution. Based on the number of active pixels in the SHAP method before and after unlearning operation, we observed a significant drop in feature importance in the class forgetting task on unlearned datasets across all tested machine unlearning algorithms—from 20.89% in the original model to between 16.71% and 4.71%. This results are the first milestone in order to understand how deletion of selected data affected machine learning model. Future studies may include going deeper into the problem of explainability in machine unlearning with the usage of other existing explain- ability algorithms on less complex model architectures.

References

[1] Xu J. et al., Machine Unlearning: Solutions and Challenges, *IEEE Transactions On Emerging Topics In Computational Intelligence*, **2024**, 8, 2150–2168.
[2] Binder A. et al., Layer-Wise Relevance Propagation for Neural Networks with Local Renormalization Layers, *Lecture Notes in Computer Science*, **2016**, 9887, 63–71.
[3] Ribeiro M.T. et al., "Why should I trust you?": Explaining the Predictions of Any Classifier, *Association for Computing Machinery*, **2016**.
[4] Simonyan K. et al., Deep Inside Convolutional Networks: Visualising Image Classification Models and Saliency Maps, *arXiv* , **2016**.

On Track for Biodiversity: Making Rail Transport Environmentally Friendly

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Keywords: rail transport, biodiversity, habitat fragmentation, wildlife protection, mitigation measures, sustainable development

The environmental impacts of rail transport have long remained underrepresented in discussions of biodiversity conservation. Although railways are often considered more sustainable than road transport, they have been shown to contribute significantly to habitat fragmentation, wildlife mortality, and ecological barrier effects [1]. To address these challenges, a comprehensive review of mitigation strategies has been conducted, covering both peer-reviewed studies and applied cases across Europe and North America. Particular attention has been given to the integration of these strategies into planning and development processes under the framework of sustainable development. The research has identified a variety of technical and ecological measures, including wildlife crossings, fencing systems, early warning and detection devices, and habitat restoration. Their effectiveness has been evaluated in relation to different landscape types, traffic intensities, and species-specific needs. It has also been demonstrated that the timing and scale of mitigation implementation are critical to success, and that strategic environmental assessments (SEA) and environmental impact assessments (EIA) can serve as key instruments in guiding these processes. By framing biodiversity protection not as a limitation but as a strategic component of sustainable infrastructure, the study has contributed to the development of an integrated model for environmentally responsible rail expansion. This approach has highlighted the importance of interdisciplinary collaboration, early-stage planning, and the alignment of ecological objectives with transportation policies at multiple governance levels.

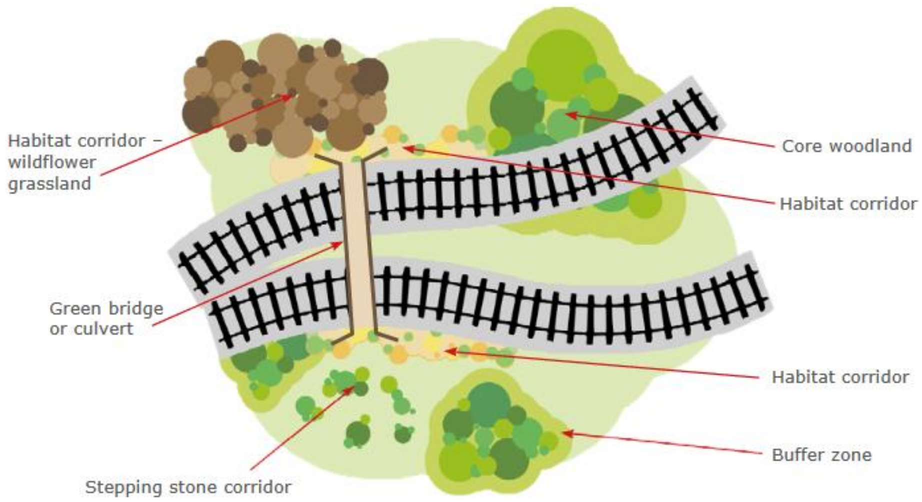

Fig. 1 Examples of protecting and enhancing the lineside environment by habitat creation as biodiversity off-setting and managing habitat corridors to link core habitats (adapted from Network Rail Biodiversity Action Plan in UK) [2]

References

[1] Borda-de-Água L. et al., Railway Ecology, *Springer International Publishing*, **2017**.
[2] International Union of Railways, European Railways: Strategy and Actions for Biodiversity. *rEvERsE Final Report*, **2022**.

Finite Field Method with Harmonic Potential

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Keywords: quantum chemistry, polarizability, electric field

The purpose of this work is to introduce a modification of the finite field method [1]. In the original method the energy of the molecule is differentiated with respect to the intensity of the electric field. The Hamiltonian in these calculations is unlimited from below and so are the spectra of its eigenvalues. Proposed modification consists in replacing the homogeneous electric field with the harmonic potential:

$$V(x) = \frac{1}{2} k \sum_{i=1}^{n} x_i^2 - k X_0 \sum_{i=1}^{n} x_i + \frac{1}{2} k X_0^2 \tag{1}$$

and the second one that uses the dependence of the response to harmonic perturbation upon X_0(2). Auxiliary X_A variable is introduced in this approach:

$$V(x) = \frac{1}{2} k \sum_{i=1}^{n} (x_i - X_A + X_A - X_0)^2 = \frac{1}{2} k \sum_{i=1}^{n} [(x_i - X_A)^2 + 2(X_A - X_0)(x_i - X_A) + (X_A - X_0)^2 \ . \tag{2}$$

Concerning numerical tests, the properties of water, lithium hydride and the helium atom were calculated in aug-pc-2, aug-pc-3 and Hy-pol basis sets with MP2 and HF-SCF method. Obtained values of dipole moment μ, dipole polarizability (α) and dipole hyperpolarizability (β) are close to the cited literature [2–4], which proves that the modification is indeed correct. However, several problems appear in calculations, mainly with numerical precision of the hyperpolarizability due to lack of numerical control of calculations of the energy, and in algorithm that employs extrapolation of results.

References

[1] Piela L., Idee chemii kwantowej, PWN, **2011**.
[2] Rice J.E. et al., The determination of accurate dipole polarizabilities α and γ for the noble gases, *The Journal of Chemical Physics*, **1991**, 94, 4972–4979.
[3] Góra R.W. et al., Electric dipole (hyper)polarizabilities of spatially confined LiH molecule, *The Journal of Chemical Physics*, **2012**, 137, 094307.
[4] Maroulis G. et al., Hyperpolarizability of H_2O, *The Journal of Chemical Physics*, **1991**, 94, 1182–1190.

An Analysis of the Impact of the Use of Virtual Reality During Health and Safety Training

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Keywords: virtual reality, BIM, OHS, construction industry

The construction industry is one of the largest sectors in the world in terms of workforce size. It offers a wide range of job opportunities across the entire lifecycle of a building – from design and construction to maintenance [1], as well as the development of new materials for structural and finishing purposes. Within this process, the construction phase presents the greatest risk to worker safety. Despite years of improvements in training programs and raising awareness among workers, the industry continues to face a high number of accidents and fatalities [2]. The aim of this research is to analyze the current state of knowledge regarding the use of virtual reality (VR) and augmented reality (AR) technologies in health and safety training within the construction industry. In Poland, many initiatives have emerged to reduce workplace accidents in construction, aligning with the nationwide "zero accidents" campaign led by major construction companies under the "Agreement for Safety in Construction" initiative. Previous market research has shown a strong interest among construction workers in new technologies and innovative solutions, particularly in the field of occupational health and safety training [3]. One possible response from the construction sector to improve the quality and effectiveness of training is the use of virtual reality (VR). Studies have demonstrated that before undergoing personalized VR-based safety training, construction workers were able to identify only 42% of potential hazards at the workplace, whereas after training, they were able to recognize up to 77% [4]. Currently implemented VR solutions place participants in a virtual environment where they must complete tasks related to workplace safety. VR can also be integrated into Building Information Modeling (BIM) technologies, for example, in planning assembly processes using CLT (Cross-Laminated Timber) panels [5]. In this scenario, the worker is immersed in a BIM-based virtual environment to perform assembly tasks. During the simulation, the worker's movements are tracked – such as their exact locations, areas where they spent the most time, and zones they merely passed through. Based on this data, safe and high-risk zones are defined.

This practical use of VR not only enhances the skills and knowledge of the participant but also provides valuable insights for the researchers conducting the training. Current research indicates that most studies involving VR are conducted with students, while construction workers – who are the primary target group for these solutions – are rarely involved [6]. This highlights the direction that future studies should take. The subject of the research is VR technology in OSH and the developed virtual environment created to conduct the research. The objective of this paper is to determine whether: the use of VR-based training systems effectively minimizes the risk of accidents and hazards on construction sites. And if the application of various VR tools and techniques (such as visual presentations, gamification, and experiential learning) impacts participant engagement in the training process.

References

[1] Plebankiewicz E. et al., Life cycle cost modeling of buildings with consideration of the risk, *Archives of Civil Engineering*, **2016**, 2, 149–166.
[2] Drozd W. et al., Analiza wypadków budowlanych jako zdarzeń niezamierzonych, *Przegląd Budowlany*, **2022**, 9–10, 84–89.
[3] Szóstak M. et al., Analiza możliwości zastosowania wirtualnej rzeczywistości w szkoleniach BHP w budownictwie, *Przegląd Budowlany*, **2022**, 9–10, 138–140.
[4] Jeelani I. et al., Development and Testing of a Personalized Hazard-Recognition Training Intervention, *Journal of Construction Engineering and Management*, **2017**, 143.
[5] Getuli V. et al., BIM-based immersive Virtual Reality for construction workspace planning: A safety-oriented approach, *Automation in Construction*, **2020**, 114.
[6] Rokooei S. et al., Virtual reality application for construction safety training, *Safety Science*, **2023**, 157, 105925.

The Importance and Influence of the State Policy on Housing Construction in Wrocław, Including the Activity of Housing Cooperatives in the Period of the Weimar Republic

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Keywords: architecture, modernism, social architecture, housing estates

The starting point of this research is a discussion of the housing situation after the First World War in Germany, with particular emphasis on Silesia. Housing conditions were tragic; there was a quantitative and qualitative lack of housing for the poorest class. In the first post-war years, the Weimar Republic began activities to solve the housing problem, the country made an effort to build new social housing estates, which became a model of modern housing solutions, and significant changes in the architectural form took place. Thanks to the introduction of Charles Gates Dawes' plan (foreign capital supplied the German economy), from April 1924, the phase of economic improvement began. New architectural trends spread in Germany more than in any other European country.

In 1926, the State Research Society for the Economics of Construction and Housing was established to carry out and finance research on rational development and to support model housing projects. It dealt with the internal layouts of apartments and their surface, new materials and technologies. At the beginning of the 1920s, Wrocław was perceived as a unique place on the map of Europe because of new ways of solving housing problems. Housing estate cooperatives and housing associations of general utility greatly impacted new housing estates. The research will aim to show the impact of mentioned institutions and companies on the development of modern housing. The last point is to examine the influence of the interwar period's architecture on residential architecture after the Second World War.

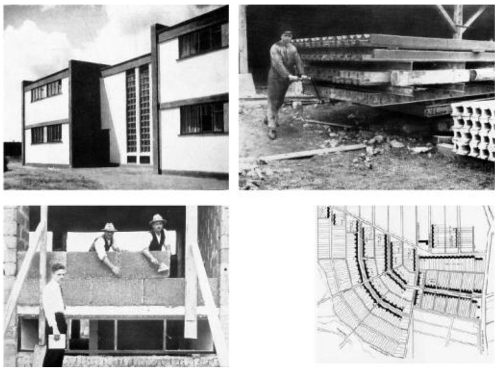

Fig. 1 Dessau, Töerten housing estate, arch. W.Gropius, 1926-1928. Bericht über die Versuchssiedlung in Dessau, Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen, Sonderheft 7, vol. 2, April 1929, pp. 5, 41, 84, 137

Operation and Microscopic Sets

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Keywords: *operation, microscopic sets, Cantor space, porous sets

This work delves into the intricate relationships between various classes of sets in Cantor space, focusing on their structural properties under the $*$-operation, measure-theoretic characteristics, and interactions with ideals. Central to the study is the exploration of the $*$-operation, defined for a family $F \subseteq P(X)$ as

$$F^* = \{A \subseteq X \colon \forall F \in F \; A + F \neq X\}.$$

Key results include the equivalence of conditions for $F = F^{**}$ and implications for translation-invariant σ-ideals.

Results also contains examples of families F, such that $F = F^*$ in $Z \wedge \{\omega\}$ or $2 \wedge \{\omega\}$.

Next we will present he Galvin–Mycielski–Solovay Theorem extended to the Cantor space, establishing that a set $X \subseteq 2 \wedge \{\omega\}$ is strong measure zero if and only if $X + H \neq 2 \wedge \{\omega\}$ for every meager set H. Dually we can define strongly meager sets as: X is strongly meager if and only if $X + H \neq 2 \wedge \{\omega\}$ for any null set H. This bridges the study of strong measure zero (SMZ) and strongly meager (SM) sets with the $*$-operation, revealing SMZ = M^* and SM = N^*, where N is the family of null sets and M is the family of meager sets.

The work further demonstrates that under the Borel Conjecture (saying that every strong measure zero set is countable), $M \neq M^{**}$, similar with dual Borel Conjecture (saying that every strongly meager set is countable) which implies $N \neq N^{**}$.

Next we will present microscopic sets (Micro) and porous sets (P) and how they look like in the real line and in Cantor space. Key result in this section is showing how related with respect to *-operation are microscopic and porous sets. It turns out that we have $\sigma - P^* \neq M$ and $M^* \neq \sigma - P$, where $\sigma - P$ sets are countable unions of porous sets but we have implication that set X is microscopic if for every porous set H we have $X + H \neq 2 \wedge \{\omega\}$.

Deposition of TiO_2-Based Photocatalytic Coatings Using Plasma Spray Methods: Potential and Challenges

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Keywords: plasma spraying, photocatalysis, coatings, titanium dioxide, thermal spraying

In recent years, interest in photocatalysis and photocatalytic materials has intensified. Photocatalysis, defined as the induction of redox reactions under light irradiation [1], is regarded as a promising solution to various environmental challenges. Its applications include air purification, water treatment, microplastic degradation, and green hydrogen production [2]. However, broader implementation is hindered by limitations in the manufacturing methods of photocatalysts. The most commonly employed technique is sol-gel processing, which is a time- and energy-intensive, multistep process that poses significant challenges for industrial scalability [3].

An alternative strategy involves the use of thermal spray techniques for the deposition of photocatalytic coatings from powder, suspension, or solution precursor feedstocks. These methods offer several advantages over conventional approaches, particularly in terms of scalability and the potential for single-step deposition [4]. Despite these benefits, the application of plasma spraying for the fabrication of photocatalytic coating remains underdeveloped, with many underlying challenges yet to be explored.

This presentation addresses the key aspects of the fabrication and characterization of TiO_2-based photocatalytic coatings produced via plasma spraying. The deposition process is discussed in detail, with emphasis on substrate preparation and importance of stability of process conditions. The critical role of feedstock materials is also highlighted. The issues related to characterization of both mechanical and photocatalytic properties are also presented. Furthermore, the relationships between process parameters and evaluation methodologies are disclosed and discussed.

Acknowledgments

The research was founded by the National Center of Science, grant no. 2022/47/O/ST8/01066 Preludium BIS.

References

[1] Fusjihima A. et al., Electrochemical Photolysis of Water at a Semiconductor Electrode, *Nature*, **1972**, 238, 37–38.
[2] Wang Y. et al., Photocatalytic materials applications for sustainable agriculture, *Progress in Material Science*, **2022**, 130, 100965.
[3] Guo Q. et al., Fundamentals of TiO2 Photocatalysis: Concepts, Mechanisms, and Challenges, *Advanced Materials*, **2019**, 31
[4] Zhai M. et al., Efficient suspension plasma spray fabrication of black titanium dioxide coatings with visible light absorption performances, *Ceramics International*, **2019**, 45, 930–935.

Experimental Investigation of Aggregation and Cross-Interactions Involving Bacterial Proteins and Peptides Implicated in Neurodegenerative Disorders

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Keywords: amyloid, humane microbiome, Alzheimer's disease, *Helicobacter pylori*, histidine-rich protein

Amyloids are ordered, typically fibrillar protein or peptides aggregates, characterized by a cross-β structure. While traditionally linked to neurodegenerative diseases (NDDs), such as Alzheimer's disease (AD), involving the amyloid beta (Aβ) and tau proteins aggregation, and Parkinson's disease (PD), associated with α-synuclein [1], recent research has uncovered their broader biological roles. These so-called functional amyloids are involved in processes such as biofilm formation, gene expression regulation, and immune system responses across both eukaryotic and prokaryotic organisms.

Recent discoveries have suggested that some components of the human microbiome may influence amyloid-associated NDDs, potentially mediated *via* the gut-brain axis. In this context, bacterial proteins or peptides could encounter and interact with amyloids in the brain, thereby contributing to the development of various NDDs [2]. One bacterium implicated in neurodegeneration is *Helicobacter pylori*, a widespread gastric pathogen. Among the proteins expressed by *H. pylori*, the histidine-rich Hpn (*H. pylori* nickel-binding) protein has been recognized for its metal-binding properties, and more recently, for its ability to form amyloid-like structures [3, 4].

The aim of the present study has been to experimentally verify the aggregation propensity and cross-interaction potential between selected protein/peptide pairs, namely Hpn (and its fragments) and Aβ. A combination of spectroscopic techniques (Fourier-Transform InfraRed (FTIR) and Circular Dichroism (CD) spectroscopies), microscopic methods (Atomic Force Microscopy (AFM) and Transmission Electron Microscopy (TEM)), and fluorescence-based test (Thioflavin T (ThT) assay) has been employed [5]. Our results, obtained using the aforementioned techniques, have demonstrated that the Hpn(4–38) fragment exhibits amyloidogenic properties; however, the full-length Hpn protein has not formed amyloid fibrils, contrary to findings reported by *R. Ge (2011)* [4]. Moreover, our preliminary results using the ThT assay have indicated a potential interaction between Aβ and Hpn. Given the growing body of evidence linking *H. pylori* infection with an increased risk of AD, there is a clear need for in-depth investigation of cross-interaction mechanisms between microbial and host amyloids. Confirmation that Hpn influences Aβ aggregation would suggest that *H. pylori* infection is not neutral to human health and may contribute to the pathogenesis of AD. Understanding these interactions may provide new insights into the role of the microbiome in neurodegeneration and aid in identifying novel therapeutic targets.

Acknowledgments

This work was supported by the National Science Centre, Poland [grant number 2019/35/B/NZ2/03997].

References

[1] Hampel H. et al., The amyloid-β pathway in Alzheimer's disease, *Molecular Psychiatry*, **2021**, 26, 5481–5503.
[2] Friedland R.P. et al., The role of microbial amyloid in neurodegeneration, *PLoS pathogens*, **2017**, 13, e1006654.
[3] Iwasaki T. et al., In vitro transcytosis of *Helicobacter pylori* histidine-rich protein through gastric epithelial-like cells and the blood–brain barrier, *Bioscience, Biotechnology, and Biochemistry*, **2022**, 86, 321–330.
[4] Ge R. et al., Histidine-rich protein Hpn from Helicobacter pylori forms amyloid-like fibrils in vitro and inhibits the proliferation of gastric epithelial AGS cells, *Biochimica et Biophysica Acta*, **2011**, 1813, 1422–1427.
[5] Housmans J.A.J. et al., A guide to studying protein aggregation, *The FEBS Journal*, **2023**, 290, 554–583.

Effectiveness of Stabilization of Semi-Cohesive Soil by Geopolymerization Method Using Fly Ash as Pozzolanic Material

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Keywords: geopolymeryzation, expansive soils

Geopolymerization is the process of producing stable aluminosilicate materials by activating aluminosilicate powders in a highly alkaline environment, resulting in a three-dimensional Si–O–Al copolymer network stabilized by sodium or calcium cations. Clays with a high plasticity index (IP > 40%) can undergo volumetric expansion of up to 25% when exposed to moisture fluctuations, which may lead to damage of foundations and pavements. Fly ash, an industrial by-product rich in amorphous SiO_2 and Al_2O_3, serves in geopolymerization as an aluminosilicate precursor, replacing part of the cement while substantially reducing the carbon footprint. Eliminating cement – which accounts for approximately 5% of global anthropogenic CO_2 emissions – makes this method more environmentally sustainable.

In this study, two variants of stabilizing a base soil (a bentonite – kaolin blend in a 20:80 ratio) were compared, each activated with a 6% NaOH solution and amended with either 16% or 24% fly ash by mass. The objectives were to assess the influence of fly ash content on unconfined compressive strength (UCS), Atterberg limits (liquid limit, LL; plasticity limit, PL), and free-swelling behavior. After 14 days of curing at 20°C, the 16% fly-ash mixture achieved a UCS of 15.04 MPa and the 24% mixture 19.83 MPa, whereas the unstabilized base material exhibited UCS values of only 1.27 MPa and 1.44 MPa, respectively. The plasticity index of the soil mixtures decreased by 52.5 p.p. (from 77.0% to 24.5%) and 33.5 p.p. (from 57.5% to 24.0%) after geopolymerization process. Free swelling was reduced by 95% and 99%.

These results confirm that geopolymerization with 16% and 24% fly ash is an effective alternative for stabilizing expansive soils. The markedly improved resistance to swelling (95%–99% reduction) minimizes deformation and cracking of pavement layers, which is particularly important under variable moisture conditions that induce cycles of swelling and shrinkage.

Ultrasonic Atomization for Metal Powder Production

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Keywords: metal powders, ultrasonic atomization, additive manufacturing, thermal spraying

Ultrasonic atomization is emerging as a promising alternative technique for the production of metal powders, offering unique advantages over conventional methods such as gas and water atomization [1]. This process utilizes high-frequency vibrations to fragment molten metal into fine droplets, which solidify into spherical powders with narrow particle size distributions. The ability to precisely control droplet size through vibration frequency enables tailored powder characteristics, making this method particularly attractive for advanced manufacturing applications [2]. Additionally, ultrasonic atomization can be performed in compact, laboratory-scale setups, allowing for cost-effective small-batch production ideal for research and development [3]. The primary objective of this study is experimentally evaluate a laboratory-scale ultrasonic atomization system for the production of metal powders. Stainless steel 316L was used as a reference material to validate atomization behavior and optimize process parameters. The system integrates a high-frequency ultrasonic transducer (20 kHz) with a arc melting unit and a controlled delivery mechanism, allowing for the continuous feeding of molten material onto the vibrating surface. In this study, the influence of key process parameters was investigated, such as:

- the distance between the spray gun and the ultrasonic atomization plate, in a range of 100 mm to 300 mm;
- the tilting angle of the atomization plate, in a range of 0° to 45°;
- the RMS power of the atomization system, in a range of 10% to 40%.

This study demonstrates the feasibility of producing high-quality, defect-free powders suitable for use in additive manufacturing and other precision applications. It should be highlighted that regardless of the tested parameters in this study, the as-produced powders were known by dv50 size in range of 42 μm to 91 μm, which made it possible to prove that the process is stable,, but it is possible to change the distribution of the obtained powders, mainly by changing the angle of inclination of the atomizing plate.

Acknowledgments

The work was created within the framework of the research project entitled “Ultramizer, a system for manufacturing powder materials” No. 0230/L-10/2018 funded by the National Centre for Research and Development under the LIDER X program.).

References

[1] Żrodowski Ł. et al., Novel Cold Crucible Ultrasonic Atomization Powder Production Method for 3D Printing, *Materials*, **2021**, 14, 2541.
[2] Priyadarshi A. et al., New Insights into the Mechanism of Ultrasonic Atomization for the Production of Metal Powders in Additive Manufacturing, *Additive Manufacturing*, **2024**, 83, 104033.
[3] Kustron P. et al., Development of High-Power Ultrasonic System Dedicated to Metal Powder Atomization, *Applied Sciences*, **2023**, 13, 8984.
[4] Sajbura A. et al., Ultrasonic Atomization as a Novel Route for the Metal Powder Development, *ASM International*, **2023**, 735–741.

Vegetated Kinetic Façades

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Keywords: vegetated kinetic façades, kinetic green façades, vertical green façades, kinetic façades

The study aims to assess the potential of vegetated kinetic façades, which incorporate vertical green façades with kinetic shading mechanisms to enhance their environmental benefits. The state-of-the-art has been systematically reviewed, integrating concepts such as vegetated kinetic façades, kinetic green façades, and dynamic living walls, with a scope encompassing peer-reviewed articles and conference papers published in the last 15 years. The findings of the study demonstrated that the implementation of vegetated green façade modules on windows can result in a reduction of heat transfer through window glass by up to 64.8% [1]. The application of kinetic external green wall louvres has reduced the cooling load by 30.09% and the heating load by 17.74% [2]. The research emphasizes the significance of specifying lightweight substrates, sustainable yet durable materials, sensor-controlled irrigation systems, and control technologies that enable user interaction when necessary to align the façade function with the design stage. This approach is intended to optimize the performance of these systems. Furthermore, the study demonstrates that while promising, the scope of existing research is limited, and further work is needed to comprehensively analyze environmental benefits and improve system designs for wider applications. This study provides valuable insights to support designers in the early development of vegetated kinetic façades, aiming to promote innovative, sustainable and adaptable architectural solutions for urban environments.

References

[1] Zheng X. et al., An experimental study of vertical greenery systems for window shading for energy saving in summer, *Journal of Cleaner Production*, **2020**, 259, 120708.
[2] Hany Na. et al., Dynamic vertical green walls & shading systems integration to enhance energy efficiency & thermal comfort: A case of educational building skin retrofit in a Mediterranean city [version 1; peer review: awaiting peer review]. *F1000Research*, **2025**, 14:445.

Machine Learning Approaches for Uncovering Neurophysiological and Behavioral Markers of Chronic Stress in Preclinical Studies

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Keywords: machine learning, EEG, chronic stress, social behavior, preclinical studies

Chronic stress is one of the main risk factors for the development of mental disorders, including depression, which is a major medical challenge and it is estimated that about one-third of patients are resistant to drug treatment [1]. Preclinical studies using animal models are an integral part of testing new pharmaceutical agents for psychiatric diseases [2]. The project aims to develop artificial intelligence methods, such as deep learning, that will be applied to the analysis of neurophysiological and behavioral symptoms of chronic stress. Using a mouse model, the research project will conduct electroencephalographic (EEG) signal recording by wireless devices, which will enable monitoring of circadian brainwave rhythm and sleep architecture, excluding contact with a sleeping animal that could affect the results obtained [3]. Moreover, the wireless recording of the EEG signal will be connected to the already existing "Social Box" system, which is based on video recording of mice and allows analysis of their social behavior without the presence and influence of an experimenter [4, 5]. The integration of these technologies will allow a more accurate assessment of the impact of stress on the social behavior of mice and test whether antidepressant drugs can modify these changes. Including in a single model data from EEG recordings during sleep as well as those recorded during a specific behavior may contribute to better identification of potential biomarkers of depressive disorders, which in turn may affect the efficiency of diagnosis and precise selection of pharmacotherapy [6].

Acknowledgments

This work was funded by Industry PhD Grant - Martyna Skuła (DWD/8/0125/2024) from Polish Ministry of Science and Higher Education.

References

[1] Malhi G.S. et al., Depression, *Lancet*, **2018**, 392, 2299–2312.
[2] Abi-Dargham A. et al., Candidate biomarkers in psychiatric disorders: state of the field, *World Psychiatry*, **2023**, 22, 236–262.
[3] Čukić M. et al., Classification of Depression Through Resting-State Electroencephalogram as a Novel Practice in Psychiatry: Review, *The Journal of Medical Internet Research*, **2020**, 22, 19548.
[4] Pereira T.D. et al., Fast animal pose estimation using deep neural networks, *Nature Methods*, **2019**, 16, 117–125.
[5] Bordes J. et al., Automatically annotated motion tracking identifies a distinct social behavioral profile following chronic social defeat stress, *Nature Communications*, **2023**, 14, 4319.
[6] Watts D. et al., Predicting treatment response using EEG in major depressive disorder: A machine-learning meta-analysi, *Translational Psychiatry*, **2022**, 12, 332.

Method of Assessing the Safety of Human-Machine Interaction in Autonomous Logistic Systems

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Keywords: Human error, Automated guided vehicle (AGV), safety

Safety assessment methods were developed about fifty years ago to analyze undesirable events, including human errors, and to develop strategies to prevent them. Initially, they were used in high-risk sectors such as aviation, the chemical industry, and the nuclear industry. With technological advances and increased human-machine interaction, the number of these methods has increased significantly, especially in the 1990s.

Purpose of the article is to show the process of developing the method of assessing the safety human-machine interaction in automatic logistic systems.

Based on two hypotheses: H1: The functioning of autonomous logistic systems generates changes in human-machine cooperation affecting the safety of the human-machine-environment system and H2: Currently, there is a lack of safety assessment methods for complex autonomous logistic systems that take into account the new conditions of human-machine interaction and the specificity of the functioning of logistics systems.

A two-stage literature review was conducted, including an analysis of the interaction between Automated Guided Vehicles (AGVs) and human operators [1] and a review of methods for assessing human errors [2]. Based on the obtained results, two levels of security were distinguished: First – operational level: cooperation based on human-machine interactions. Second – system level: assessment of the security of the entire system operation.

On this basis, appropriate assessment criteria were selected and a method of assessing the risk associated with human error for Logistics 4.0 systems was created, considering the new conditions of human functioning in cyber-physical systems, dedicated to two levels of safety.

The method of assessing the safety human-machine interaction in automatic logistic systems is still in the process of development.

References

[1] Tubis A. et al., Interaction between a Human and an AGV System in a Shared Workspace – A Literature Review Identifying Research Areas, *Sustainability*, **2024**, 16, 974.
[2] Stanton N.A. et al., Human Factors Methods A Practical Guide for Engineering and Design, *CRC Press*, **2013**.

Temperature Measurements in Liquids with the Use of Optical Fiber Sensors

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Keywords: heat transfer, optical fiber sensors, distributed optical fiber sensor, Rayleigh scattering

Fiber optic sensors are widely used for temperature monitoring due to their high sensitivity, electromagnetic immunity, and ability to operate under harsh environmental conditions. They can be categorized as point sensors (e.g., Bragg gratings), which can measure the response from a single selected point [1], quasi-distributed sensors (multiple gratings at different wavelengths), and fully distributed sensors [2]. Distributed fiber optic sensors, utilizing phenomena such as Rayleigh, Brillouin, and Raman scattering, enable continuous measurements along the entire fiber length with high spatial resolution.

Optical fibers are coated with materials such as polyimide, acrylate, copper, or other metals to protect the glass fiber against mechanical damage and environmental factors. The coating material is often selected based on expected operating conditions, including temperature range, liquid exposure, and mechanical stress [3].

In liquid or humid environments, the absorption of surrounding substances by the fiber protective coating can significantly affect the measurement result and its accuracy. Swelling of the coating material due to absorption of surrounding liquids and/or vapors can cause stretching or exert stress on the fiber core. This can lead to apparent temperature changes that are not related to actual environmental changes.

The aim of this study is to investigate the effect of fiber coating material absorption on the performance of distributed temperature sensors. Key factors include stabilization time, interaction with temperature variations, and long-term reliability. A commercial OFDR-based Rayleigh sensor system was used, offering 0.65 mm spatial resolution, ±0.1°C temperature accuracy, and an operating range of –40°C to 200°C [4]. Fibers with polyimide and acrylate coatings were tested in water and alcohol environments. Results show that polyimide coatings exhibit better stability in liquids. In methanol and water, stabilization occurred within approximately 3000 minutes (2 days) and 300 minutes (5 hours), with maximum spectral shifts of –31 GHz and –8.5 GHz, respectively. Acrylate-coated fibers stabilized faster (up to 500 minutes) but showed poor long-term compatibility with the tested liquids. Understanding these interactions is essential for improving sensor reliability in applications involving immersion in fluids.

Acknowledgments

The work was supported by the project Minigrants for doctoral students of the Wrocław University of Science and Technology.

References

[1] Chen S. et al., Marine Structural Health Monitoring with Optical Fiber Sensors: A Review, *Sensors*, **2023**, 23, 1877.
[2] Luna, Inc., High-Definition Distributed Fiber Optic Sensing, https://lunainc.com, **2024** [date of access: 28.04.2025].
[3] Soller B.J. et al., High resolution optical frequency domain reflectometry for characterization of components and assemblies, *Optica Publishing Group*, **2005,** 13, 666–674.
[4] Luna, Inc, ODiSI 6000 Series Optical Distributed Sensor Interrogator, https://lunainc.com/product/odisi-6000-series [date of access: 28.04.2025].

Helical Conformations of Sequence-Defined Oligourethanes Uncovered via 2D ROESY NMR and Molecular Dynamics

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Keywords: stereocontrolled polymers, molecular dynamics, 2D NMR

Recent breakthroughs in polymer chemistry have enabled significant progress in emulating the molecular architecture of natural biopolymers, driven by innovations in the design of sequence-defined polymers [1]. Unlike conventional polymers, these synthetic heteropolymers feature precisely engineered chain sequences, eliminating structural variability. A critical attribute of these polymers is their ability to adopt folded conformations, mirroring the functional behaviour of biomolecules such as ligand-binding proteins [3]. Sequence-defined polymers acquire tailored functionalities by integrating synthetic monomers into their backbones, expanding their utility in biomedical engineering, nanotechnology, and adaptive materials. Their folding behaviour enables sophisticated applications, including enzyme-mimicking catalysts and programmable drug delivery systems [2].

This study aims to identify solvent conditions that induce stable folding in sequence-defined oligourethanes – a promising class of abiotic foldamers – and to correlate their structural behaviour with potential functional applications. We use molecular dynamics simulations and nuclear magnetic resonance (NMR) spectroscopy to investigate how solvent polarity governs conformational transitions. Molecular dynamics simulations quantified the stability of folded states, revealing a >60% population of helical conformations in nonpolar media. Computational insights aided in interpreting 2D ROESY NMR spectra, which provided interproton spatial correlations that confirmed the folded architectures. Remarkably, ROESY data identified a distinct 2.6_{14} helical conformation exclusively in nonpolar solvents, whereas polar solvents failed to promote ordered structures. These findings highlight the potential of sequence-defined oligourethanes as versatile platforms for applications requiring programmable folding, from molecular sensing to supramolecular assembly.

Acknowledgments

The authors thank the Polish National Science Centre (2018/31/D/ST5/01365, 2021/43/I/ST4/01294) for financial support. Calculations have been carried out using resources from the Wrocław Centre for Networking and Supercomputing (http://wcss.pl). NMR measurements and characterisation were performed by Dr Rafał Konefał.

References

[1] Szweda R., Sequence- and stereo-defined macromolecules: Properties and emerging functionalities, *Progress in Polymer Science*, **2023**, 145, 101737.
[2] Laurent E. et al., Synthetic Polymers with Finely Regulated Monomer Sequences: Properties and Emerging Applications, *Macromolecular Engineering*, **2022**.
[3] Szatko M. et al., Revealing the Effect of Stereocontrol on Intermolecular Interactions between Abiotic, Sequence-Defined Polyurethanes and a Ligand, *ACS Biomaterials Science & Engineering Journal*, **2024,** 10, 3727–3738.

From Table to Soil: Sustainable conversion of HoReCa food waste into high-nutrient fertilizers

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Keywords: food waste management, nutrient recovery, sustainable fertilizers, circular economy, waste valorization

The management of food waste is a pressing global issue, with the Hotel, Restaurant, and Catering (HoReCa) sector being a substantial contributor. This study developed a method for converting the waste stream from the HoReCa sector into high-nutrient organo-mineral fertilizers. The primary focus was on optimizing nutrient recovery and minimizing the environmental consequences associated with conventional food waste disposal. The developed method comprises four key stages: (1) acid hydrolysis of food waste to break down organic matter and release bound nutrients, (2) neutralization to stabilize pH and enhance nutrient availability, (3) granulation to produce a solid fertilizer product, and (4) drying to ensure product stability and usability. These steps were designed to maximize the retention of essential nutrients while minimizing losses. Analysis of the obtained fertilizer showed high concentrations of key nutrients, including nitrogen (1.41%), potassium (7.22%), and organic carbon (44.0%). Cucumber seed germination tests demonstrated significantly improved plant growth compared to control groups and commercially available fertilizers, as evidenced by increased stem length, enhanced root development, and greater biomass accumulation. The study also addressed challenges associated with the inherent variability in food waste composition and potential contamination by heavy metals, proposing strategies to ensure consistent product quality. This scalable method demonstrates distinct advantages over conventional food waste disposal techniques. Converting HoReCa food waste into organo-mineral fertilizers offers a sustainable solution aligned with the principles of a circular economy. This approach effectively reduces environmental impact while simultaneously recovering valuable nutrients. Future research should focus on refining processing techniques, validating results through large-scale field trials, and ensuring the long-term safety and consistent quality of the product.

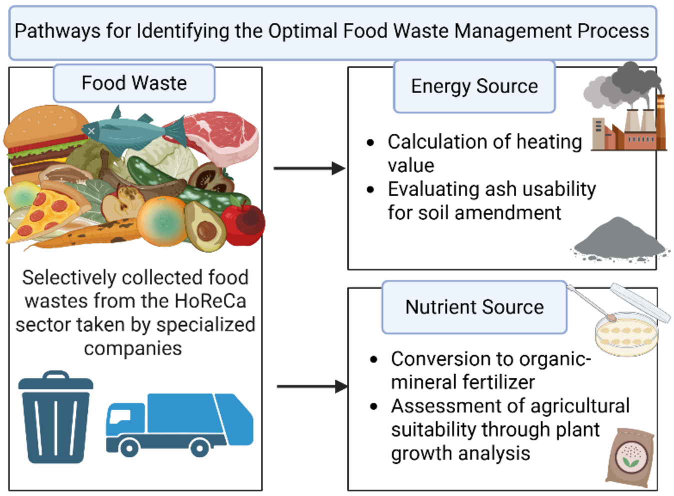

Fig. 1. Pathways for identifying the optimal food waste management process

Acknowledgments

This work was financed by the Horizon2020 Research & Innovation Program of the Europe-an Union under grant agreement No. 696356 and from the Executive Agency for Higher Ed-ucation. Research. Development and Innovation Funding, UEFISCDI (Romania). the Nation-al Center for Research and Development, NCBR (Poland). Agenda Estatal de Investigation AEI (Spain). and the Ministry of Agriculture and Forestry – MMM (Finland).

The common dandelion will tell you the truth. Application of bioindication to assess the effectiveness of roadside green belts along expressways – a case study from the S5 expressway

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Keywords: bioindication, *Taraxacum officinale*, roadside vegetation, soil pollution, expressways

The development of road infrastructure, despite its undeniable economic importance, poses serious environmental challenges. Expressways are significant sources of atmospheric pollution, including heavy metals (Pb, Zn, Cd) and suspended particulate matter, which accumulate in soils and vegetation along roadsides [1, 2]. One of the methods for monitoring the scale of this impact is the use of bioindicator plants capable of accumulating harmful substances [3].

Taraxacum officinale (Common dandelion) is characterized by a wide distribution, high tolerance to environmental stress, and the ability to accumulate heavy metals in its tissues [2, 4]. It frequently colonizes areas transformed by human activity, including roadside zones, which makes it an accessible and practical bioindicator of environmental contamination.

The aim of this study was to assess the effectiveness of roadside green belts in limiting the spread of traffic-related contaminants, based on the analysis of heavy metal accumulation in common dandelion. Plant and soil samples were collected along a fragment of the S5 expressway, between the Kleszczewo and Poznań East junctions, at two distances from the road: 10 meters from the road edge before the green belt and 20–25 meters beyond the green belt. The analyzed sites varied in the structure of the green belts – they included areas dominated by herbaceous vegetation, single and double rows of shrubs, tree plantings, and sections with acoustic barriers.

Field observations and literature analysis indicate that the presence of green belts helps reduce the spread of traffic-related contaminants into the soil environment [2, 5]. Measured concentrations of Pb, Cd, Zn, Cu, Cr, Ni, and As were significantly higher at 10 meters from the road, confirming strong pollutant input from traffic. Green belts reduced heavy metal levels by up to 80–90%, particularly for Pb, Zn, Cr, and Ni. Sites S.2, S.3, and S.5 – which featured shrubs, trees, or noise barriers – proved most effective in reducing contamination, whereas S.1, a site without vegetation, showed minimal protective function. This confirms that herbaceous vegetation alone is insufficient to act as an effective barrier.

The conclusions are based on complete dataset analysis and confirm the usefulness of *Taraxacum officinale* as an effective, low-cost bioindicator of traffic pollution. The study also highlights the important role of well-designed green belts as natural protective barriers along expressways.

References

[1] Kabata-Pendias A., Trace Elements in Soils and Plants, *CRC Press*, **2011**.
[2] Gworeket B. et al., Heavy metal contamination in Taraxacum officinale and soils collected from different land use areas of three representative cities, *Environmental Science and Pollution Research*, **2021**, 28, 11145–11158.
[3] Vural A., Trace element accumulation behavior, ability, and propensity of Taraxacum officinale F.H. Wigg (Dandelion), *Environmental Science and Pollution Research*, **2024**, 31, 16667–16684.
[4] Altaf R. et al., Heavy metal accumulation by roadside vegetation and implications for pollution control, *PLOS ONE*, **2021**, 16, e0249147.
[5] Malawska M. et al., Influence of traffic activity on heavy metal concentrations of roadside soils and plants, *Environmental Monitoring and Assessment*, **2001**, 75, 75–87.

Direct Growth of Carbon Nanostructures on Carbon Cloth: Toward Binder-Free Air Electrodes for Zn–Air Battery

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Keywords: carbon materials, electrocatalysis, Zn-air battery

One of the most promising groups of carbon materials are carbon nanostructures (CNSs), such as carbon nanotubes (CNTs) and carbon nanofibers (CNFs). They exhibit unique physicochemical properties, which make them of great interest for use in electrochemical energy storage and conversion systems. However, their practical use is limited by the fact that they are usually obtained in powder form, which hinders their direct application in devices and often necessitates the use of binders or polymer matrices, which can significantly degrade electrochemical properties.

An engaging solution to this problem is the direct synthesis of CNSs on conductive substrates, such as carbon cloth (CC). This material exhibits excellent electrical conductivity, chemical and thermal stability, mechanical flexibility, and textile-like structure, making it an ideal substrate for building flexible and freestanding electrode materials. This approach makes it possible to produce coherent, binder-free, and mechanically durable electrodes which can be used, for example, as air electrodes in flexible zinc-air batteries. The battery technology is gaining increasing attention due to its high energy density, environmental friendliness, and potential applications in wearable electronics [1].

The most common method for the synthesis of CNTs and CNFs directly on CC is catalytic chemical vapor deposition (CCVD). A key element of this process is the presence of a catalyst, typically transition metal nanoparticles such as Fe, Co, or Ni. Although many catalyst deposition strategies have been developed, most of them rely on expensive precursors, toxic solvents, or complicated procedures, limiting their scalability [2].

This work presents a simple, rapid, and environmentally friendly method for catalysts impregnation on carbon cloth using a dip-coating technique from aqueous solutions of transition metal inorganic salts. This method minimizes the use of harmful solvents and provides a readily available pathway to prepare catalysts for the direct synthesis of CNSs on conductive substrates. Furthermore, the resulting materials were also tested as oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) electrocatalysts. The studies showed that the materials exhibit excellent ORR/OER activities, making them highly suitable as air electrodes in Zn-air batteries.

Acknowledgments

The research was founded by the National Science Centre, Poland under the research project Preludium-Bis 2021/43/O/ST5/01996.

References

[1] Gacem A. et al., Recent Advances in Methods for Synthesis of Carbon Nanotubes and Carbon Nanocomposite and their Emerging Applications: A Descriptive Review, *Journal of Nanomaterials*, **2022**, 7238602.
[2] Li Y. et al., Metal–Organic Framework as Catalyst Precursor of Floating Catalyst Chemical Vapor Deposition for Single-Walled Carbon Nanotube Manufacture, *ACS Sustainable Chemistry & Engineering*, **2023**, 11, 13122–13131.

The Impact of Photovoltaic Glass on the Building - Selected Aspects

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Keywords: renewable energy sources, semitransparent and transparent PV modules, thermal and visual comfort, building energy performance, carbon footprint

The ongoing climate change and international commitments such as the UN Sustainable Development Goals (SDG, 2015) [1] and the European Green Deal (2019) underline the urgent need to implement sustainable energy solutions. Buildings account for almost 40% of the total primary energy consumption in Europe, while also being a significant source of greenhouse gas emissions [2]. Considering that people spend about 90% of their lives indoors, improving energy efficiency cannot be at the expense of the quality of the indoor environment of buildings [2].

One promising direction is the integration of renewable energy sources directly into the building envelope. This presentation focuses on the use of photovoltaic panels in glazing systems, which allow the simultaneous use of the surface for generating electricity, illuminating interiors and regulating thermal conditions. PV panels integrated with façades are an example of a multifunctional approach, in line with the idea of BIPV (Building-Integrated Photovoltaics). They offer the potential to reduce operational energy consumption, reduce CO_2 emissions and improve indoor comfort.

The presentation includes a review of selected aspects of the current state of knowledge regarding the use of PV panels in glazed building facades. Particular attention is paid to the impact of these solutions on the energy performance of the building and user comfort.

References

[1] United Nations, Transforming our world: The 2030 Agenda for Sustainable Development, United Nations, **2015**, https://sdgs.un.org/2030agenda [accessed: April 22, 2025].
[2] Cao X. et al., Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade, *Energy and Buildings*, **2016**, 128, 198–213.

Chelidamic Acid as a Ligand: Synthesis and Properties of its Copper(II) Coordination Compounds

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Keywords: chelidamic acid, copper(II) ions, coordination compounds, crystal structures, physicochemical properties

Chelidamic acid (chel, H_3cda) is a multifunctional ligand of growing interest due to its versatile coordination properties. Its ability to coordinate metals ions through nitrogen, two carboxylate oxygen atoms, and a phenolic oxygen makes it suitable for constructing a wide range of mono- and polynuclear complexes, including coordination polymers and metal-organic frameworks. Chelidamic acid typically coordinates metal ions via tridentate (O, N, O′) chelation, and can furthermore function as a bridging ligand through its carboxylate groups and deprotonated phenolic oxygen atoms [1, 2]. In aqueous solutions, it interconverts between enol and keto tautomeric forms and exists in multiple protonation species (H_3cda, H_2cda^-, $Hcda^{2-}$, cda^{3-}), depending on the pH. These factors significantly influence its coordination behavior [3]. The introduction of co-ligands, such as 2,2′-bipyridine, enables precise modification of complex geometry and properties [4]. Consequently, it becomes feasible to engineer structures with interesting magnetic and optical properties [5].

The research focuses on the synthesis and characterization of new copper(II) coordination compounds based on chelidamic acid and co-ligands such as 1,10-phenantroline (phen) and imidazole (imid). Special attention is given to the influence of reaction conditions, particularly pH and stoichiometry, on the resulting crystal structures and physico-chemical properties. A combination of crystallographic techniques (single-crystal and powder X-ray diffraction) and spectroscopic methods (UV-Vis-NIR, IR/Raman, EPR, fluorescence) is employed to characterize the obtained compounds. The variation in reaction parameters led to the formation of both mononuclear ([Cu(Hcda)(phen)(H_2O)]·H_2O (1), [Cu(Hcda)(imid)(H_2O)]·H_2O (2)) and trinuclear ([Cu_3(μ-O-cda)(cda)$(phen)_4$]·13H_2O (3), [$Cu_3(cda)_2(imid)_2(H_2O)_6$] (4)) copper(II) complexes with different coordination modes and protonation species of chelidamic anions (Fig. 1). In monomeric compounds, the Cu(II) center is coordinated by tridentate (O, N, O′) $Hcda^{2-}$ anion. Whereas in trinuclear structures, the Cu(II) centers are linked via bridging carboxylate groups or phenolic O atoms of cda^{3-} anions. The results contribute to a deeper understanding of the design principles for multifunctional coordination materials.

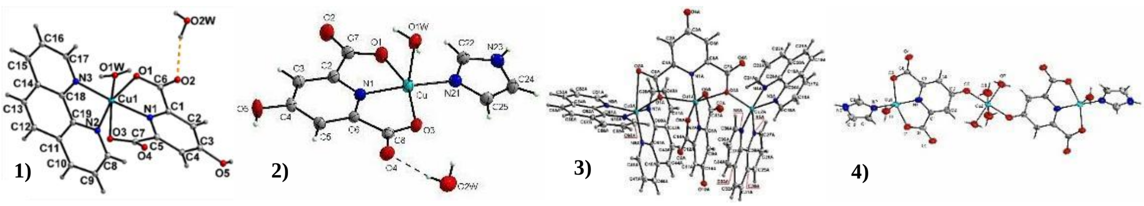

Fig. 1. Structures of copper(II) complexes with chelidamic acid and: a) 1,10 -phenanthroline (1,3); b) imidazole (2,4)

References

[1] Mahjoobizadeh M. et al., Coordination Behavior of Chelidamic Acid With V^{V}, Ni^{II}, Fe^{III}, and Ca^{II}: Syntheses, X-ray Characterization and DFT Studies, *ChemistrySelect*, **2016**, 1, 1556–1566.

[2] Yasodha V. et al., New Metal–Organic Framework Solids Built from Barium and Isoelectronic Chelidamic and Chelidonic Acids, *Journal of Chemical Crystallography*, **2011**, 41, 1988–1997.

[3] Chen B. et al., Protonation of Chelidamic Acid: Thermodynamic Analysis and Crystal Structure, *Journal of Solution Chemistry*, **2022**, 51, 1187–1198.

[4] Wojciechowska A. et al., Chelidamic acid tautomers in copper(II) compounds. One-pot synthesis, crystal structure, spectroscopic and DFT studies, *Polyhedron*, **2023**, 230, 116210.

[5] Zou J.P. et al., A novel heterometal–organic coordination polymer with chelidamic acid: nonlinear optical and magnetic properties, *CrystEngComm*, **2009**, 11, 972–974.

Optimization of the Gasochromic Response of WO_3 Thin Films

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Keywords: gasochromic properties, optical properties, WO_3

Hydrogen renewability, and environmentally friendly properties make it a promising candidate for the development of new technologies and research related to energy production and storage [1]. Hydrogen, undetectable by human senses due to its lack of color, odor, or taste, presents a unique challenge. Tungsten oxide (WO_3), an intriguing metal oxide, has significant utility in various sectors. The optical properties of tungsten oxide are changed upon interaction of the film and hydrogen, which is known as the gasochromic effect [2]. The gasochromic effect can only occur in the presence of a catalyst and is strongly dependent on the structure and morphology of the WO_3 film. Ongoing efforts to further enhance gas detection capabilities and create sensors with better performance include the use of different manufacturing methodologies and post-processing of WO_3 [2].

Fabrication of WO_3 thin films was achieved through electron beam evaporation. The study aimed to explore the effects of postprocess thermal modifications, as well as the thickness and type of catalysts, on the gasochromic properties of tungsten oxide WO_3. Gasochromic properties were determined from transmission changes during 30-minute colouring and bleaching cycles for films annealed at different temperatures (Fig. 1a). It was determined that the biggest change, and therefore the highest sensor response, was achieved for the film annealed at 673 K. Further investigations into the influence of thickness and catalyst type were conducted for the films after postprocess modification at 673 K (Fig. 1b). It was found that, for low hydrogen concentrations, the use of thin palladium as a catalyst reduces the response time and thus speeds up the gasochromic process.

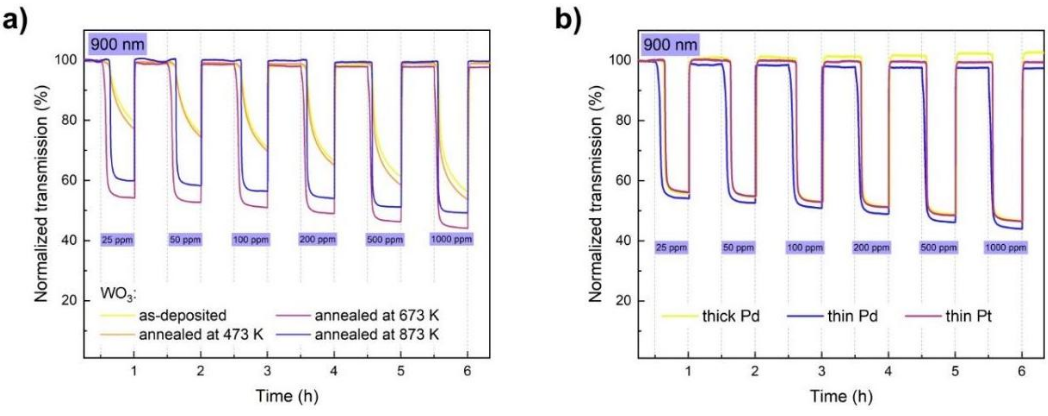

Fig. 1. Variation in transmittance at 900 nm during colouring/bleaching cycles of WO_3 thin films (a) annealed at various temperatures (b) annealed at 673 K with different catalyst upon exposure to H2 concentrations of 25 to 1000 ppm

The gasochromic effect was observed in all samples, irrespective of the annealing temperature or the type and thickness of the catalyst. Enhancing the sensor characteristics of the tested films involved optimizing the annealing temperature and application of a suitable catalyst.

References

[1] Mirzaei A. et al., Gasochromic WO_3 Nanostructures for the Detection of Hydrogen Gas: An Overview, *Applied Sciences*, **2019**, 9.
[2] Gao C. et al., A review on WO_3 gasochromic film: Mechanism, preparation and properties, *Int. J. Hydrogen Energy*, **2023**, 48, 2442–2465.

Fabrication of Flexible Semiconductor and Piezoelectric Films by Laser Assisted Zone Casting Method

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Keywords: coating methods, polymer science, scanning probe microscopy, organic piezoelectric

Laser-Assisted Zone Casting (referred to as LAZEC) is a novel method for fabricating ultrathin (ranging from several nanometers to a few hundred nanometers in thickness) films of polymers and small-molecule organic substances. LAZEC is based on moving a laser-induced temperature gradient zone on a substrate pre-coated with the coating solution. The absorption of laser radiation leads to localized heating of the substrate, and the resulting temperature gradient induces surface tension variations in the coating solution, initiating Marangoni flow. Moving the laser spot guides the directional flow of the solution on the substrate. The transported solution leaves a thin wet film on the substrate, which is immediately dried due to laser heating. The evaporation of the solvent leaves an ultrathin film of the solute behind the heated zone. Film formation under flow conditions combined with immediate solvent evaporation and annealing enables the fabrication of films with unique physicochemical properties.

Experiments performed in recent months have demonstrated that, by adjusting key coating parameters (substrate wettability, solution viscosity, casting speed, and evaporation rate) it is possible to control the structure and morphology of the resulting solid film. The LAZEC method was successfully employed to fabricate coatings of small-molecule semiconductors and synthetic polymers on both flat substrates (e.g., mineral glass, ITO) and curved surfaces (e.g., plastic optical lenses), which may find application in modern organic electronic.

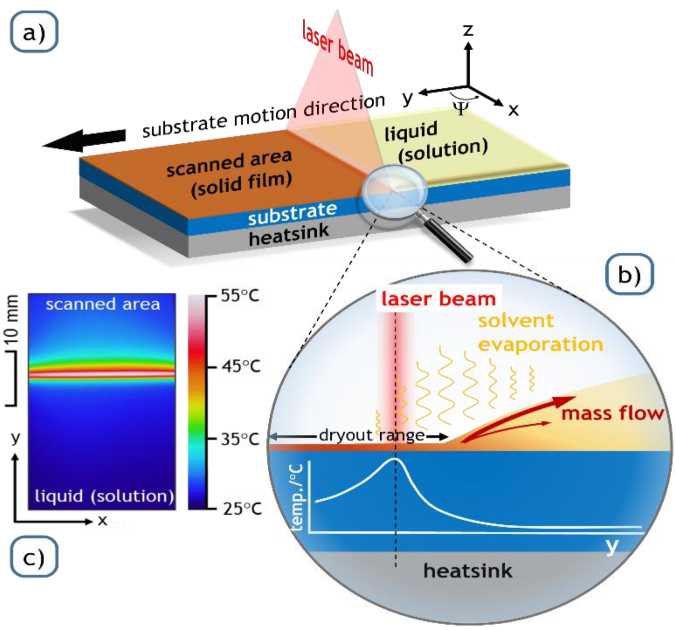

Fig. 1. (a) Component layout in Laser-Assisted Zone Casting (LAZEC), (b) heating, evaporation and flow in the proximity of the laser-heated area, (c) exemplary thermal image for toluene on glass scanned with a 28W laser

Acknowledgments

This work was funded by National Science Centre – Poland through grant UMO-2017/25/B/ST5/02869.

From Roads to Public Realms: Rethinking Street Design for Inclusive and Resilient Cities

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Keywords: inclusive street design, people-centred planning, active mobility, participatory design

Throughout the second half of the twentieth century, the paradigm of urban planning and street design was shaped by modernist ideologies and increasing industrialisation, which facilitated the adoption of zoning policies. These approaches physically separated residential, industrial, and commercial areas, encouraging suburbanisation. Rapid motorisation, supported by automobile propaganda, offered individuals the promise of spatial freedom, reinforcing the logic of car-centric development. In response, the developing then field of road engineering introduced the Functional Classification system – originating in the United States and subsequently exported globally – which framed streets primarily as conduits for traffic flow. This system became a dominant tool in automobile-based planning, contributing to the spatial separation of life functions and eroding social cohesion by discouraging spontaneous, local interaction.

In recent decades, technological shifts (smartphones, e-commerce, e-mobility, remote work) and demographic changes (EU 65+ share rising from 16% to 21% between 2002–22 – Eurostat) have laid bare the shortcomings of car-focused street design. The COVID-19 pandemic further accelerated remote lifestyles and contributed to a 25% increase in anxiety and depression worldwide – exacerbating both physical inactivity and mental-health pressures (W.H.O. 2022). Sedentary lifestyles now double premature-death risk (2× overall; 2.7× for cardiovascular disease – HUNT Study, ESC 2020) and cost Europe € 80 billion annually (152 000 deaths, 2.1 million lost healthy years – EC Health Promotion Knowledge Gateway), while mental-health disorders consume ~4% of EU GDP (EESC). Elderly citizens, individuals with disabilities, children, youth, and caregivers are frequently marginalised in street design, despite their diverse needs for physical accessibility, independence, and social interaction.

Today, many streets remain designed for traffic efficiency rather than human connection. Children often lack the freedom to play or travel independently, confined to designated "safe" areas or transported by car – limiting opportunities to build resilience and develop social skills. Similarly, weak inter-neighbourhood ties and reduced public interaction contribute to growing levels of social isolation and loneliness. A sedentary lifestyle, compounded by low rates of active mobility and limited public realm engagement, is increasingly linked to physical and mental health issues. For instance, Dr Bruce Appleyard's research [1] demonstrates, residents of low-traffic streets report approximately three times more local acquaintances than those on high-traffic streets, highlighting the powerful role of street environments in shaping social connection. Moreover, heavy traffic not only suppresses street life but also discourages walking and other forms of active mobility, diminishing access to communal spaces and reinforcing both physical inactivity and social withdrawal.

Addressing these challenges requires rethinking streets as public, multifunctional realms that enable spontaneous interaction, social cohesion, and community. Walkable, human-scaled environments also support active transportation, build social capital, and improve public health. The social dimension of street design underpins my PhD's theoretical framework, and the next phase is a case study of a street transformation project – using spatial analysis and stakeholder interviews – to examine how temporary interventions can drive lasting, systemic change.

References

[1] Appleyard B., Livable Streets 2.0, *Elsevier*, **2020**.

Artificial Intelligence in Behavioral Studies: A Tool for Preclinical Research Improvement

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Keywords: automatization, behavioral studies, artificial intelligence, 3Rs

Nowadays, the demand for more precise and reliable behavioral assessment in laboratory animals is growing, particularly in the context of preclinical studies. Automated or semi-automated systems that maintain etiologically relevant environmental conditions offer a significant improvement over classical, mostly manual methods by enabling the detection of subtle behavioral changes in mice. These alterations are often crucial for identifying the effects of genetic modifications, pharmacological agents or complex therapeutic strategies. The integration of Artificial Intelligence tools into behavioral studies further not only enhances the accuracy and efficiency of data analysis, allowing for more detailed interpretation of behavioral patterns, but also helps eliminate the human factor as a source of subjective data interpretation.

Presented experimental setup for automated tracking of mice cohorts in semi-naturalistic conditions was designed to be both user-friendly and broadly applicable, particularly for studies involving mouse models of neurological disorders. System is based on AI-tools, such as SLEAP [1], used for markerless pose-estimation of mice and DeepOF [2], applied for supervised behavioral classification and deep phenotyping of the tested animals, with a particular focus on social interactions (eg., nose to nose-, side by side-behavior). Furthermore, the volume and quality of data produced within the analysis support the 3Rs principle – Replacement, Reduction, and Refinement, by reducing the number of animals used and promoting higher standards of animal welfare during conducting experiments.

Acknowledgments

1. This project is part of industrial PhD programme (DWD/6/00191/2022, Industrial PhD Programme VI Edition - Ministry of Science and Higher Education, Poland).
2. This project has received funding from the Horizon Europe Research and Innovation Funding Programme, under grant agreement project 101079181 – SAME NeuroID.
3. Project financed by the National Science Centre based on decision no. Dec-2021/41/b/nz3/04099 entitled "Do astrocytes control synaptic connections in neural networks relevant to psychiatric diseases?"

References

[1] Pereira T.D. et al., SLEAP: A deep learning system for multi-animal pose tracking, *Nature Methods*, **2022**, 19, 486-495.

[2] Miranda L. et al., DeepOF: A Python package for supervised and unsupervised pattern recognition in mice motion tracking data, *Journal of Open Source Software*, **2023**, 8(86), 5394.

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ISBN 978-83-7493-909-6

https://doi.org/10.37190/rado2025