Gdańsk–Kraków Forum on Photocatalysis

GKFP 2026

BOOK OF ABSTRACTS

GDAŃSK–KRAKÓW
FORUM
ON PHOTOCATALYSIS
– GOLD STANDARDS –

DATE

8–11 September 2026

VENUE

Jantar, Poland

gkfp2026.ug.edu.pl

ORW Bursztyn | Gdańska 4, 82-103 Jantar, Poland

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Programme

Tuesday, 8 September

16-18	Registration and accommodation
18-19	Social activities
19-22	Welcome BBQ

Wednesday, 9 September

8-9	Breakfast	
I lecture session (chair: prof. dr hab. inż. Adriana Zaleska-Medynska)		
9	Welcome (prof. dr hab. inż. Adriana Zaleska-Medynska)	
9-9:15	Activity presentation (dr inż. Anna Malankowska, dr inż. Emilia Gontarek-Castro)	
9-10	L1	*Photocatalysis as a part of photochemistry* (prof. dr hab. Wojciech Macyk, Jagiellonian University)
10-11	L2	*Characterisation of photomaterials – structural methods 1* (prof. dr hab. inż. Tomasz Klimczuk, Gdańsk University of Technology)
11-11:30	coffee break	
11.30-12.30	L3	*Characterisation of photomaterials – spectroscopic methods* (prof. dr hab. Wojciech Macyk, Jagiellonian University dr Joanna Macyk, InPhoCat Innovative Photocatalytic Solutions Sp. z o.o.)
12.30-13.30	L4	*Characterisation of photomaterials – electron traps' determination methods* (dr Marcin Kobielusz, Jagiellonian University)
13:30-15	Lunch	
15-17.00	young researchers' presentations (chair: dr inż. Aleksandra Pieczyńska)	

- P1 *Facet-dependent photocatalytic reduction of nitroaromatics using tailored $SrTiO_3$ crystals* (Wiktoria Adamowicz, Jagiellonian University)
- P2 *Shape-controlled cuprous oxide@titania composites with facet-dependent activity* (Xin Yue, Jagiellonian University)
- P3 *Role of the {010} facet in photocatalytic reactions over bismuth vanadate photocatalysts decorated with noble metals* (Limeng Wu, Jagiellonian University)
- P4 *Morphology-controlled Au/$InVO_4$ photocatalysts: facet-dependent activity* (Qiansu Ma, Jagiellonian University)
- P5 *On the origin of enhanced activity of gold-modified titania photocatalysts* (Fitri Rizki Amalia, Jagiellonian University)
- P6 A*ction spectrum mapping of blue-edge slow-photon enhancement in gold/titania films* (Lei Wang, Jagiellonian University)
- P7 *Polymer photocatalysts for hydrogen peroxide production* (Marta Kowalkińska, University of Gdańsk)
- P8 *Fabrication and characterization of hybrid NU-1000 surmof thin films on FTO/GO substrates for photocatalytic hydrogen generation* (Adrian Koterwa, Gdańsk University of Technology)
- P9 *Porphyrin surmof (surface coordinated metal organic framework)* (Marta Grota, Gdańsk University of Technology)

- P10 *Photocatalytic NOx oxidation over cements plates modified with an amorphous TiO_2 intermediate and TiO_2 SiO_2 mixtures* (Dominika Dudek, West Pomeranian University of Technology)

17-18 free time
18-19 dinner
19-21 Social activities

Thursday, 10 September

8-9 Breakfast

II lecture session (chair: prof. dr hab. Wojciech Macyk)

9-10	L5	*Characterisation of photomaterials – photoelectrochemical methods* (dr Joanna Kuncewicz, Jagiellonian University)
10-11	L6	*Reliability in scientific studies: set-ups and methodology in heterogenous photocatalysis* (prof. dr hab. inż. Adriana Zaleska-Medynska, University of Gdańsk)
11-11:30	coffee break	
11.30-12.30	L7	*Photoreactors and light sources – how to measure activity under visible light* (dr inż. Ewa Kowalska, prof. UJ, Jagiellonian University)
12:30-13:30	L8	*Time-resolved methods* (dr Marcin Kobielusz, Jagiellonian University)

13:30-15 lunch
15-17 young researchers' presentations (chair: dr inż. Zuzanna Bielan)

- P11 T*hree-dimensional TiO_2-based photocatalytic matrices for selective pharmaceutical removal from aqueous solutions* (Marta Jaruga, Adam Mickiewicz University)
- P12 *Designing g-C_3N_4 photocatalysts through soft templating: synthesis effect on structure and activity* (Maria Adamska, Jagiellonian University)
- P13 *Cyameluturate salts inspired carbon nitride for photocatalytic applications* (Fabian Bumbul, Jagiellonian University)
- P14 *Efficient WO_3 photoelectrodes obtained by liquid phase deposition* (Paweł Wyżga, Jagiellonian University)
- P15 L*iquid phase deposition of photocatalytic thin films: from morphology-controlled TiO_2 toward visible-light-active oxides* (Gülsüm Efsun Tekneci, Jagiellonian University)
- P16 Innovative carbon nitride-based coatings on FTO for photocatalytic hydrogen evolution (Krzysztof Sidur, Jagiellonian University)
- P17 *Synthesis and Characterization of Photoactive Si-Based Materials for Treatment of Emergent Contaminants* (Adugna Abera Ayu, University of Gdańsk)
- P18 *Degradation of diclofenac using Janus microparticles in the photo-Fenton-like process under visible light irradiation* (Natalia Wyźlic, University of Gdańsk)
- P19 *NU-1000@PCN-22X MOF heterostructures for photoconversion of CO_2 into useful chemicals* (Maciej Hiller, University of Gdańsk)
- P20 *Properties and photocatalytic activity of materials obtained by thermal treatment of metal-organic frameworks* (Damian Makowski, University of Gdańsk)

17-18/19	free time	
19-20	dinner	
20-23	party (80s theme)	

Friday, 11 September

8-9	breakfast	
III lecture session (chair: dr inż. Ewa Kowalska, prof. UJ)		
9-10	L9	*From promise to practice: challenges in photocatalytic water disinfection* (prof. dr hab. inż. Agata Markowska-Szczupak, West Pomeranian University of Technology in Szczecin)
10-10:45	L10	T*hermo-photocatalysis induced by light* (prof. dr hab. inż. Beata Tryba, West Pomeranian University of Technology in Szczecin)
10:45-11:30	L11	*Application of action spectra in photocatalytic reactions* (dr inż. Paweł Mazierski, University of Gdańsk)
11:30-11:45	coffee break	
11.45-12.30	Panel discussion *Current Challenges in Photocatalysis* (moderator: dr Amin Muhammad Faisal)	
12:30-13:00	Closing remarks	
13:00	Lunch	

PHOTOCATALYSIS AS A PART OF PHOTOCHEMISTRY

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The goal of the opening presentation at the Gdańsk-Kraków Forum on Photocatalysis is to present photocatalysis as part of the broader branch of chemistry known as photochemistry. Particular attention will be paid to the fundamental laws of photochemistry, also applicable to photocatalysis, that define the limits of photocatalyst applicability in environmental protection, energy conversion, and the transformation of organic compounds.

What is the difference between a thermal and a photochemical reaction? How should the efficiency of such reactions be defined? What is the cost of a mole of photons? What is the difference between a photocatalyst and a photosensitizer? How should the appropriate photocatalyst be selected? Is the planned photocatalytic process even possible? These and other questions are worth asking before beginning work on using photocatalysis to achieve your goals. Examples of basic calculations in photocatalysis will also be presented.

Acknowledgements: The author acknowledges the support of the National Science Centre within the M-ERA.NET project (2024/06/Y/ST4/00227).

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CHARACTERISATION OF PHOTOMATERIALS – STRUCTURAL METHODS 1

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X-ray powder diffraction is one of the most accessible and relatively simple methods for characterizing materials. A prerequisite for applying this method is that the material exhibits long-range order in its crystal structure.
In this lecture, I will present the fundamentals of X-ray powder diffraction and then focus on technical aspects, including methods for the qualitative and quantitative analysis of XRD patterns. I will discuss the limitations associated with the analysis of nanopowders and present commonly used methods for determining crystallite size, including the Scherrer and Williamson–Hall methods.

CHARACTERIZATION OF PHOTOMATERIALS – SPECTROSCOPIC METHODS

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Spectroscopic methods are commonly used to characterize photomaterials and the reactions occurring in their presence. This also refers to semiconductor photocatalysts, whose electronic structure is closely related to their spectroscopic properties in the UV-vis-NIR range. This presentation focuses on the use of spectroscopy in this energy range, using both absorption and emission techniques, to describe the electronic properties of semiconductors. Typical errors when interpreting spectroscopic measurement results will be discussed, including errors in determined band gap values, excited-state lifetimes, and deactivation pathways.

The use of absorption spectroscopy in the study of photocatalytic reactions will also be discussed separately. Here, too, significant errors can easily be made, which can translate into incorrect interpretation of results.

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CHARACTERISATION OF PHOTOMATERIALS – ELECTRON TRAPS' DETERMINATION METHODS

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Photocatalytic activity is determined not only by the positions of the semiconductor band edges, but also by a variety of electronic states located within the band gap or below the band edges. Among these states, surface states can play a particularly important role. In photocatalytic reactions, such states may ultimately mediate the transfer of photogenerated electrons to molecules adsorbed on the semiconductor surface. They can therefore influence the effective redox potential of a photoexcited semiconductor under reaction conditions. Consequently, surface states may play a key role in determining photocatalytic activity and selectivity.

The first part of the presentation will focus on the role of surface and sub-band-gap states in photocatalysis, together with an overview of experimental techniques that enable their energy distribution to be characterised. Particular attention will be given to photoacoustic spectroscopy and related spectroscopic approaches that provide information beyond the conventional description based solely on band-edge positions.

The second part will provide a general overview of best practices for investigating charge-transfer mechanisms in semiconductor heterojunctions, with particular emphasis on the experimental evidence needed to distinguish among different charge-transfer pathways.[1]

Acknowledgment

This work was supported by the National Science Centre within the OPUS23 project [2022/45/B/ST5/04087].

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CHARACTERISATION OF PHOTOMATERIALS – PHOTOELECTROCHEMICAL METHODS

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Photoactive materials, predominantly based on semiconductors, constitute a broad group of materials employed in heterogeneous photocatalysis, photovoltaic energy conversion, optoelectronic devices, and chemical sensing. The performance of these materials is intrinsically governed by their interaction with light - specifically, the generation, separation, transport, and recombination of photogenerated charge carriers. While numerous spectroscopic and microscopic techniques exist for determining the structural and electronic properties of photomaterials, a comprehensive assessment of their photoactivity requires complementary approaches that directly couple optical excitation with electrical response. Photoelectrochemistry provides such an approach, offering a unique and powerful toolkit for the characterisation of photomaterials under operational conditions. Photoelectrochemical and photoelectrical techniques based on photocurrent, IPCE, OCP, and surface photovoltage measurements enable the determination of both the efficiency of photoinduced processes and the energetic and spectral range of materials' photoactivity. Moreover, they allow for the characterization of the dynamics of light-induced processes, including trapping, de-trapping, and recombination of charge carriers across the material. In the present work, the basics of photoelectrochemistry will be presented. We will discuss the mechanisms of photocurrent and (surface) photovoltage generation, and how to interpret the time evolution of the signals. Additionally, examples of specific experiments will be presented, together with methods for the determination of quantum efficiency, onset potentials, quasi-Fermi levels, and related parameters.

RELIABILITY IN SCIENTIFIC STUDIES: SET-UPS AND METHODOLOGY IN HETEROGENOUS PHOTOCATALYSIS

A. Zaleska-Medynska

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The lecture will discuss the main aspects of research methodology in heterogeneous photocatalysis and will address several important questions related to the accuracy, reliability, and comparability of photocatalytic measurements:

1. Is it easy to make mistakes/errors into photocatalytic measurements?
2. Do seemingly minor experimental errors affect the quality and reliability of the results?
3. What are the main sources of error in photocatalytic measurements?
4. To what extent can photocatalytic results obtained in different laboratories be reliably compared?

Using a basic model reaction for evaluating the oxidation properties of photocatalysts, the lecture will examine the key experimental factors that can influence photocatalytic measurements, including:

1. Geometry of the photocatalytic setup
2. Photolysis and adsorption steps
3. Optical filters
4. Position of the photoreactor
5. Stirring and aeration of the reaction mixture
6. Cooling and temperature effects
7. Sampling frequency
8. Irradiation flux

The lecture will highlight how these factors can influence the measured photocatalytic performance and will discuss the importance of careful experimental design, standardized procedures, and proper reporting to ensure reliable and reproducible results.

PHOTOREACTORS AND LIGHT SOURCES – HOW TO MEASURE ACTIVITY UNDER VISIBLE LIGHT

E. Kowalska

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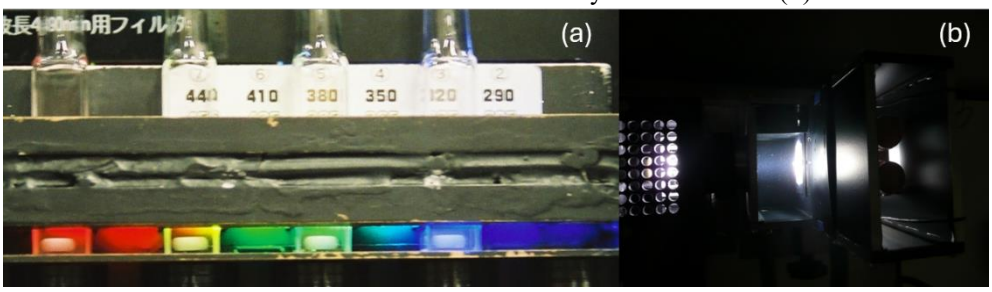
Although photocatalysis is considered one of the best solutions for environmental and energy problems, reliably estimating the photocatalytic effect is challenging because many aspects of light-matter interactions must be accounted for.[1]
Recently, the most interesting feature of photocatalysis is the efficient use of natural solar energy for various purposes, and though the application of sunlight is important for commercialization, the estimation of photocatalytic efficiency and mechanism clarification should be carefully planned and measured. Some aspects of the appropriate design of irradiation/reaction systems (Fig. 1), considering light sources, filters, target pollutants, mass transfer limitations, and efficient light penetration, will shortly be discussed during this presentation.[2-6] The possible methods of photocatalytic activity comparison, including: (i) estimation of apparent quantum efficiency,[7-8], and (ii) an application of a standard photocatalyst,[8-9] will also be shortly presented.

Figure 1. Photographs of exemplary irradiation setups for action spectrum analysis (a) and vis-activity measurements (b).



Acknowledgements

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TIME-RESOLVED METHODS

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Photocatalytic processes depend strongly on the efficiency of photogenerated charge-carrier generation, separation, and transport, as well as on the lifetimes of these carriers. Therefore, understanding the dynamics of photogenerated electrons and holes is essential for establishing relationships between the properties of photocatalytic materials and their activity. A variety of time-resolved spectroscopic and conductivity-based techniques have been developed to monitor these processes, although they probe different stages and aspects of charge-carrier dynamics.

This presentation will focus on three complementary approaches: time-resolved emission spectroscopy, transient absorption spectroscopy, and time-resolved microwave conductivity measurements. Time-resolved emission spectroscopy provides information on the deactivation pathways of excited states and charge-carrier recombination, while transient absorption spectroscopy enables the observation of transient species and their evolution over a broad range of timescales. Time-resolved microwave conductivity, in turn, provides information on the mobility and lifetime of photogenerated charge carriers via changes in the material's conductivity.

The presentation will introduce the fundamental principles of these techniques, discuss what information each method can and cannot provide, and demonstrate their application to the characterisation of photocatalytic materials. Particular attention will be paid to the interpretation of kinetic data, comparison of results obtained using different techniques, and common experimental and conceptual pitfalls that may lead to incorrect conclusions about charge-carrier lifetimes and recombination dynamics. The complementary nature of these approaches will also be highlighted to provide a more comprehensive picture of photogenerated charge-carrier dynamics in photocatalytic systems.

Acknowledgment

This work was supported by the National Science Centre within the OPUS23 project [2022/45/B/ST5/04087].

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FROM PROMISE TO PRACTICE: CHALLENGES IN PHOTOCATALYTIC WATER DISINFECTION

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Photocatalytic water disinfection has attracted considerable attention as a sustainable alternative to conventional disinfection technologies due to its ability to inactivate a broad range of microorganisms without the formation of hazardous disinfection by-products. Although decades of research have demonstrated remarkable antimicrobial and antiviral performance under laboratory conditions, the transition of photocatalytic disinfection into full-scale water treatment remains limited [1, 2].

This submission provides a comprehensive and critical assessment of the scientific and technological challenges that hinder the widespread application of photocatalytic water disinfection. Beyond the mechanisms of microbial inactivation, the critical analysis of problems, operational conditions, and water matrix composition that ultimately determines disinfection performance was presented.

Particular emphasis is placed on insufficient visible-light utilization, and the influence of natural organic matter, inorganic ions, suspended solids, and microbial aggregation. The review further discusses the limitations of methods for microbial detection in water, reactor configurations, photocatalyst immobilization strategies, and scale-up approaches, all of which remain major engineering bottlenecks. It is also addressed increasingly important aspects that have received comparatively less attention, including nanoparticle release, ecotoxicological risks, techno-economic feasibility, life-cycle assessment, and the need for standardized protocols that enable meaningful comparison of disinfection performance across studies.

Finally, key research priorities are identified to accelerate the translation of photocatalytic water disinfection from proof-of-concept studies to reliable engineering solutions. Emphasis is placed on testing under environmentally relevant conditions, pilot-scale validation, realistic water matrices, standardized microbiological assessment, and interdisciplinary integration of materials science, environmental engineering, and process design. Bridging these gaps will be essential for establishing photocatalytic disinfection as a robust, energy-efficient, and sustainable technology for future drinking water and wastewater treatment.

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THERMO-PHOTOCATALYSIS INDUCED BY LIGHT

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Thermal effect induced by absorption of light can enhance photocatalytic reactions. A part of absorbed photons by photocatalyst are converted to heat increasing the local temperature of the photocatalytic system. Moreover solar light or various sources of artificial light generate heat, which generally increase temperature of the surrounding environment. In some cases IR cut-off filters or water cooling systems are applied to reduce distribution of heat when lamp is switched on. However it was proved, that kinetics of the photocatalytic reactions can be accelerated when process is conducted at elevated temperatures. Therefore there are some research studies focused on increasing absorption of IR by photocatalysts through modulation of their optical properties.

Thermo-photocatalysis exploits the synergistic interaction between photon energy and thermal activation. Moderate heating, typically within the range of 50-150 °C, accelerates surface reaction kinetics, enhances the diffusion of gaseous reactants, and promotes the desorption of strongly adsorbed intermediates that may otherwise block catalytically active sites. Consequently, a larger fraction of photogenerated electrons and holes can participate in interfacial redox reactions instead of undergoing recombination [1].

One of the strategies of delivery heat to the photocatalytic system is use of IR irradiation. Upon IR irradiation, materials exhibiting efficient light absorption convert photon energy into heat via non-radiative relaxation processes, resulting in an increase in the catalyst surface temperature. This localized heating accelerates thermally activated surface reactions while preserving simultaneous UV- or visible-light-driven charge generation, thereby enhancing the overall efficiency of the photocatalytic process [2]. The effectiveness of IR-induced heating strongly depends on the optical absorption properties of the photocatalyst and its support. Pristine TiO_2 exhibits only limited absorption in the infrared region; therefore, efficient photothermal conversion is commonly achieved by coupling TiO_2 with materials possessing high IR absorbance, such as plasmonic metals (Pt, Au, Ag), transition-metal oxides (e.g., Fe_3O_4, Co_3O_4, CuO), black TiO_2, or carbon-based materials [3-5].

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APPLICATION OF ACTION SPECTRA IN PHOTOCATALYTIC REACTIONS

P. Mazierski

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Photocatalysis represents a sustainable technology for solar energy conversion, environmental remediation and organic synthesis [1]. Evaluating efficiency and understanding underlying reaction mechanisms remain major challenges. An Action Spectra, which plots reaction efficiency, such as the Apparent Quantum Efficiency (AQE) as a function of incident light wavelength, serves as a fundamental tool in photocatalytic research [2].

This presentation focuses on the practical methodology of determining, calculating and presenting action spectra in heterogeneous photocatalysis. I will detail the experimental measurement of reaction rates under monochromatic illumination and explain the step-by-step calculation of Apparent Quantum Efficiency (AQE) based on photon flux measurements. Furthermore, I will demonstrate how to graphically present action spectra by overlaying wavelength-dependent quantum efficiency directly onto the photocatalyst's photoabsorption spectra. Finally, calculation methods and data interpretation techniques will be illustrated using case studies in water splitting, CO_2 reduction and pollutant degradation.

Acknowledgement

This research was financially supported by Polish National Science Centre (grant No. NCN 2022/45/B/ST4/01138).

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FACET-DEPENDENT PHOTOCATALYTIC REDUCTION OF NITROAROMATICS USING TAILORED $SrTiO_3$ CRYSTALS

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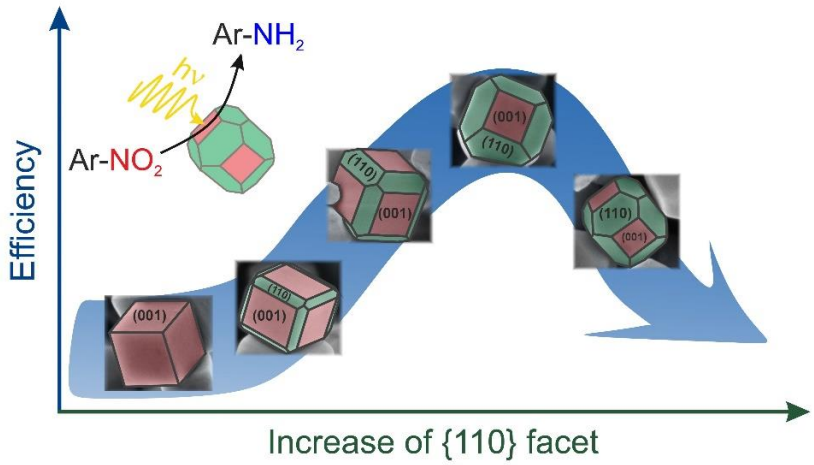
This work presents a selective photocatalytic reduction of nitroaromatics to amines on tailored $SrTiO_3$ crystals. Exploring the role of exposed facets reveals their substantial impact on both the efficiency and selectivity of this type of reduction reaction. A series of uniform $SrTiO_3$ crystals with systematically varied morphologies, differing only in shape and type of exposed facets, were synthesised. Photoelectrochemical measurements and photodeposition experiments demonstrated that reduction reactions preferentially occur on the {001} facets, while oxidation predominantly takes place on the {110} facets. Furthermore, the {110} facets play a key role in enhancing charge separation, thereby significantly boosting photocatalytic activity. The changes in the efficiency of photocatalytic oxidation of terephthalic acid follow the same pattern as photocurrent generation. Using tailored $SrTiO_3$ crystals, the reduction of nitroaromatic compounds was achieved with outstanding conversion rates (up to 40 times higher compared to commercial $SrTiO_3$). Although {110} facets facilitate charge separation, transforming nitroaromatics to amines requires {001} planes.



Effect of tailored $SrTiO_3$ crystal on the efficiency of photocatalytic reduction of nitroaromatics.

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SHAPE-CONTROLLED CUPROUS OXIDE@TITANIA COMPOSITES WITH FACET-DEPENDENT ACTIVITY

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The heterojunction composites have attracted large attention due to an efficient charge carriers' migration (preferably via Z-scheme mechanism) and thus enhanced photocatalytic activity. In this study, nine shape-controlled Cu_2O particles with a gradual evolution from cubic to octahedral morphologies were synthesized and then modified with NPs of commercial titania (P25) via electrostatic adsorption to construct Cu_2O@P25 composites. The photocatalysts exhibited pronounced morphology-dependent photocatalytic activity towards organic pollutants' degradation, with rhombicuboctahedral Cu_2O showing the best performance, likely owing to its multiple exposed facets, abundant edges, facet junctions, and enhanced Cu_2O–P25 interfacial contact. Time-resolved microwave conductivity (TRMC), incident photon-to-current efficiency (IPCE), and finite-difference time-domain (FDTD) simulations correlate with photocatalytic activity, indicating that morphology is a key factor of charge-carrier dynamics, photoresponse and local electromagnetic-field distribution.

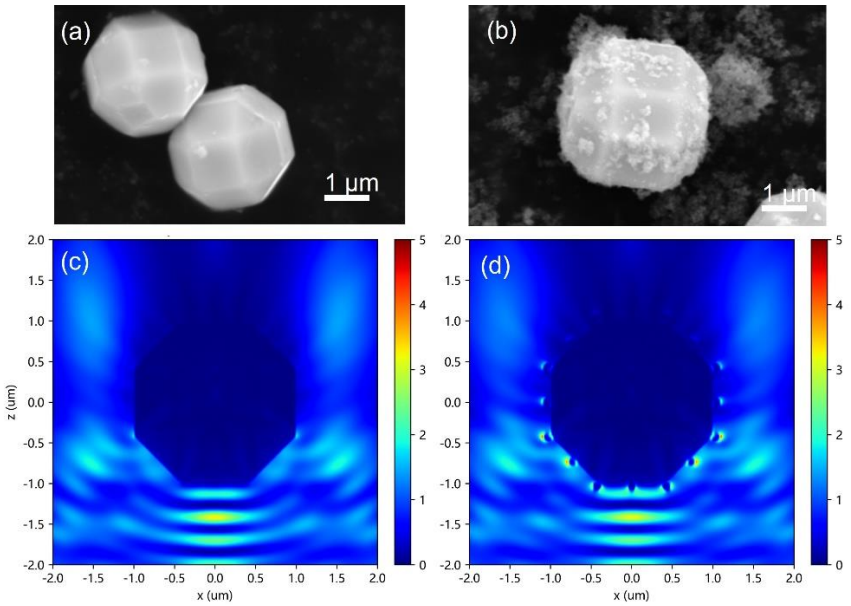

Figure 1. (a-b) SEM images and (c-d) FDTD-simulated electric-field distributions of: rhombicuboctahedral Cu_2O (a, c) and Cu_2O@P25 (b, d).

Acknowledgements
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ROLE OF THE {010} FACET IN PHOTOCATALYTIC REACTIONS OVER BISMUTH VANADATE PHOTOCATALYSTS DECORATED WITH NOBLE METALS

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Although the design of special crystal facets and cocatalyst loading are crucial to enhance photocatalytic efficiency,[1-2] their synergistic effect on the reaction dynamic remains unclear. Herein, taking monoclinic $BiVO_4$ as a target,[3] the morphology of $BiVO_4$ has been controlled from octahedron, via decahedron, and finally to octa-decahedrons, with precise modulation of the content of {010} facets, as shown in Figure 1. The selective deposition of different noble metals (Au, Pt, Ag and Pd; working mostly as cocatalysts) on the facets has been observed. It has been found that the exposed {010} facet not only enhances photocatalytic activity but also affects the cocatalyst properties. Based on Kelvin Probe Force Microscopy (KPFM) and Finite-Difference Time-Domain (FDTD) analyses, it has been proposed that enhanced photocatalytic activity must be caused by the spatial separation of charge carriers in different facets.

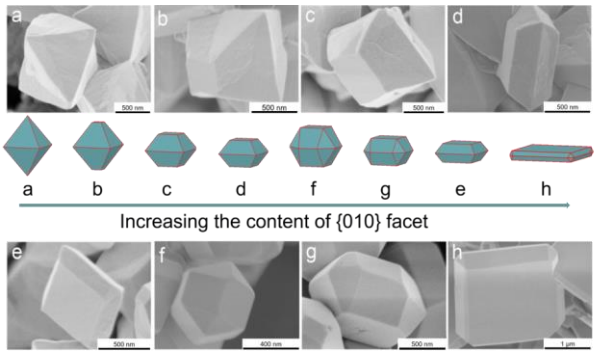

Figure 1. SEM images with respective drawings of faceted $BiVO_4$ photocatalysts.

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This work has been supported by National Science Centre, Poland (2023/51/B/ST4/01935 and 2025/57/B/ST4/03883).

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MORPHOLOGY-CONTROLLED $Au/InVO_4$ PHOTOCATALYSTS: FACET-DEPENDENT ACTIVITY

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Visible-light-driven H_2 evolution is an attractive route for solar-to-chemical energy conversion, and the rational design of oxide-based photocatalysts remains an important challenge. Indium vanadate ($InVO_4$) is a promising material, owing to its visible-light response, chemical stability, and low cost[1]. To improve its activity, morphology control and surface modification with gold has been proposed in this study, since the well-designed structure improves the surface properties (specific surface area, crystallinity, crystallite size, porosity, and exposed surface structures), whereas gold deposition enhances visible-light harvesting and interfacial charge separation[2]. To clarify how the oxide structure governs gold deposition and the resultant photocatalytic behavior, $Au/InVO_4$ photocatalysts have been investigated.

Morphology-controlled $Au/InVO_4$ photocatalysts have been prepared by pH-controlled hydrothermal synthesis followed by Au photodeposition. The formed structures of 2D thin-layered, flower-like, and spherical morphologies have been confirmed by SEM and XRD analyses. High-magnification SEM has further revealed Au crystallites on the $InVO_4$ surface. Texture-coefficient and BET analyses have shown morphology-dependent exposed facets, surface area, and porosity. Similarly, photoelectrochemical measurements have confirmed structure-dependent activity, indicating that the response to gold modification is strongly affected by the initial morphology of $InVO_4$.

Photocatalytic tests under visible-light irradiation have confirmed that modification with gold is beneficial for H_2 evolution, and the response depends on $InVO_4$ structure. Additionally, DFT calculations, evaluated Au adsorption on selected facets, charge-density difference (CDD), work function (W_F), and hydrogen adsorption energy relevant to H_2 formation, have indicated: (i) the preferable facet for gold adsorption, (ii) interfacial charge transfer, and (iii) the interaction of hydrogen species with the surface via adsorption-energy calculations. Concluding, it has been found that morphology engineering is crucial for controllable gold deposition, interfacial charge transfer, and H_2 evolution in $Au/InVO_4$ photocatalysts.

Acknowledgements. Supported by Jagiellonian University's Strategic Programme Excellence Initiative and the National Science Centre, Poland (2023/51/B/ST4/01935).

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ON THE ORIGIN OF ENHANCED ACTIVITY OF GOLD-MODIFIED TITANIA PHOTOCATALYSTS

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Gold nanoparticles (Au NPs) are well known for their ability to improve activity of semiconductor photocatalysts under UV and/or vis. Despite various reports on the effect of photocatalyst properties, the role of Au NPs in the photocatalytic mechanism has not been fully elucidated yet.[1-4] Here, the function of gold and photocatalysts' properties have been investigated in the formation of hydroxyl radicals and photocurrent under UV and/or vis. Five commercial titania samples with different properties were modified with gold by photodeposition. The effect of Au NPs and titania properties on photocatalytic activity was investigated under UV and/or vis. It has been found that: (i) gold enhances photocatalytic activity under both UV and vis irradiation (e.g., Fig. 1), (ii) the properties of titania and gold are the primary factor influencing the photocatalytic response under UV and vis, respectively, (iii) the electron traps might be involved in the mechanism of plasmonic photocatalysis.

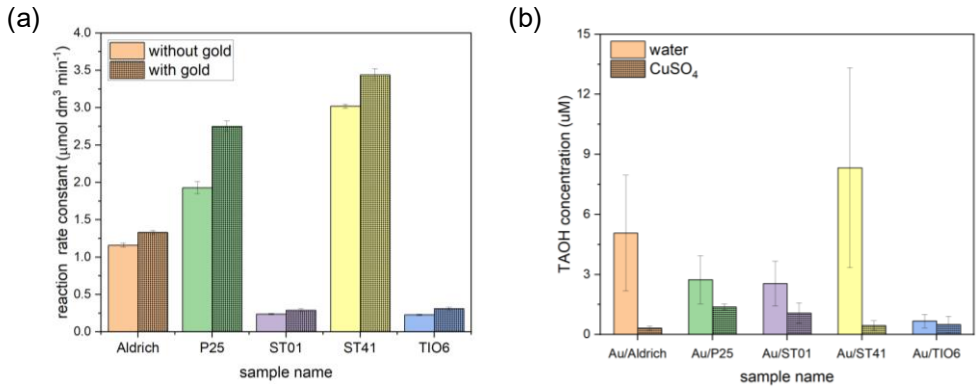

Figure 1. Hydroxyl radicals' generation on bare and gold-modified commercial titania (rutile: Aldrich, P25, TIO6; anatase: P25, ST01, ST41; fine TiO_2: ST01, TIO6, large TiO_2: Aldrich, ST41) under: (a) UV/vis and (b) vis (water or $CuSO_4$ as an IR filter).

Acknowledgements

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ACTION SPECTRUM MAPPING OF BLUE-EDGE SLOW-PHOTON ENHANCEMENT IN GOLD/TITANIA FILMS

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Photonic crystals, especially inverse opals, might cause an efficient light harvesting through slow photons near the edges of the photonic bandgap (PBG), but experimental identification of the contribution of slow photons for photocatalytic enhancement remains challenging. In this study, the action spectrum has been used for identifying exact enhancement positions arising from blue-edge slow photons. To achieve vis-activity, localized surface plasmon resonance (LSPR) has been introduced by modification of inverse opal titania films with gold nanoparticles (NPs).

The gold-modified inverse opal titania (Au/IOT) films has been successfully (the inset of Figure 1) fabricated by three-phase co-assembly of polystyrene (PS), Au NPs, and titania source, followed by removal of PS opal template at 500 °C, similarly to the procedure used for IOT films' preparation.[1]

For the activity evaluation, the generation of hydroxyl radicals ($HO^{\bullet}$), probed by hydroxylation of terephthalic acid (TA), was measured under monochromatic irradiation (λ = 450, 500, 530, 545, 575, 600 and 650 nm). The highest activity at 545 correlates well with the blue-edge of PBG, providing direct evidence that the slow photon effect causes enhanced photocatalytic activity. Consequently, the action spectrum directly shows the contribution of slow photons in the amplified activity.

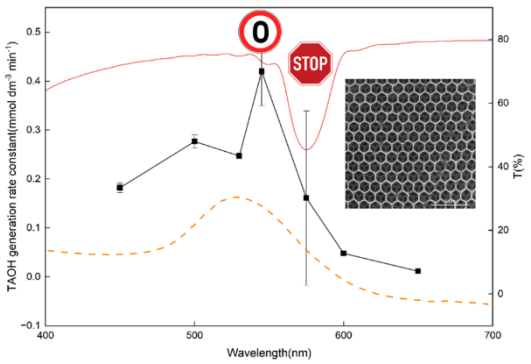

Figure 1. The action spectrum (black dots) and transmittance spectrum (red line) of Au/IOT measured in TA solution, LSPR of gold colloids (the dash curve), and SEM image of the surface of an inverse opal titania film (the inset).

Acknowledgements: This work was supported by NAWA (BPN/PPO/2021/1/00037) and NCN (2022/01/1/ST4/00026, 2023/51/B/ST4/01935 and 2025/57/B/ST4/03883).

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POLYMER PHOTOCATALYSTS FOR HYDROGEN PEROXIDE PRODUCTION

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Hydrogen peroxide (H_2O_2) is a widely used compound in disinfection, medicine, chemical industry, and aerospace. Currently, industrial H_2O_2 is synthesized through the anthraquinone (Riedl–Pfleiderer) process, an energy-intensive and multistep method requiring noble-metal (Pd) catalysts and high-pressure H_2, which contributes to high production costs and environmental pollution[1,2]. Therefore, the development of more sustainable, energy-efficient, and environmentally friendly H_2O_2 production methods is highly desirable.

Recently, solar-driven photocatalytic H_2O_2 production has attracted considerable research interest because it requires only water and oxygen as substrates, a light source, and a photoactive semiconductor to initiate the reaction. The overall efficiency of this process is mostly determined by the activity of the photocatalyst employed. Among the various materials investigated for this purpose, research attention has been focused on polymer photocatalysts due to their structural diversity and highly tunable properties. Their molecular architecture can be tailored through the rational selection of organic building blocks, and even a slight structural modification can lead to remarkable variations in materials properties, including electronic structure, pore size and light absorption range[3]. This tunability makes polymer photocatalysts promising candidates for H_2O_2 production, potentially reducing reliance on noble-metal-based catalysts.

The main goal of this study was to evaluate the performance of selected polymer photocatalysts for H_2O_2 production in air atmosphere. Their photocatalytic activity was compared with that of graphitic carbon nitride (g-C_3N_4), one of the most widely studied metal-free photocatalysts. These preliminary studies aimed to select the most promising polymer photocatalysts for more detailed investigations.

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FABRICATION AND CHARACTERIZATION OF HYBRID NU-1000 SURMOF THIN FILMS ON FTO/GO SUBSTRATES FOR PHOTOCATALYTIC HYDROGEN GENERATION

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Photocatalytic water splitting and hydrogen generation using solar energy represent one of the most promising strategies in addressing the energy crisis and advancing sustainable energy conversion. However, a key challenge in designing efficient photoheterojunctions remains ensuring a high specific surface area, appropriate band edge positions, and efficient charge transport that minimizes unwanted electron-hole pair recombination. In this context, mesoporous metal-organic frameworks (MOFs), such as zirconium-based NU-1000, have attracted particular interest due to their exceptional chemical stability, high porosity, and ability to absorb UV radiation.

In this work, the synthesis and photocatalytic properties of thin-film NU-1000 SURMOFs grown on graphene oxide (GO)-modified FTO substrates were investigated. Oriented NU-1000 structures were synthesized by solvothermal procedures to obtain FTO/GO/NU-1000 films on substrates modified with hydroxyl groups. The successful formation of the crystalline SURMOF structure and the retention of open mesoporous channels were confirmed by X-ray diffraction (XRD), DRIFT-FTIR spectroscopy, and BET analysis. Photoelectrochemical measurements (including Mott-Schottky analysis) revealed that the presence of the GO interlayer significantly accelerates electron transfer from the MOF matrix to the conductive substrate. Consequently, in the presence of ascorbic acid as a sacrificial agent and a platinum co-catalyst, the FTO/GO/NU-1000 system exhibits a significant enhancement in hydrogen photogeneration performance under UV-Vis irradiation.

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PORPHYRIN SURMOF (SURFACE COORDINATED METAL ORGANIC FRAMEWORK)

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According to the latest data, global GHG emissions in 2024 reached 53.2 Gt CO_2eq. This marks an increase of 1.3%, or 665 Mt CO_2eq, compared to 2023.[1] The overproduction of carbon dioxide necessitates the development of technologies capable of reducing this amount. Heterogeneous photocatalysis with the use of semiconductors appears to be a promising solution. One of the promising semiconductor materials is MOF (Metal Organic Framework). A MOF is a hybrid material consisting of organic linkers and inorganic metal centers. Compared to powder MOFs, SURMOFs (Surface Coordinated Metal Organic Frameworks) offer several advantages. The main advantages include easier processability, greater control over the MOF structure, and higher photocatalytic activity. To obtain a SURMOF, a substrate must be functionalized with appropriate functional groups to ensure the formation of a uniform and stable film. The functionalization of a substrate can be carried out using various methods, such as solvothermal synthesis, electrochemical treatment, or plasma treatment. In the present work, copper foam was functionalized electrochemically.[2] As a result, the color of the copper foam changed from orange to blue. XRD results and SEM images confirmed the presence of –OH groups, which serve as anchoring sites for MOF growth. The growth process was conducted via LPE LBL (Liquid Phase Epitaxy Layer-by-layer) method. As a result, the substrate color changed from blue to purple.[3]

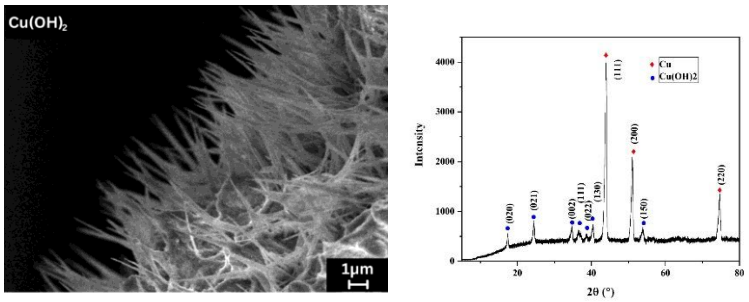

Fig. 1. SEM images and XRD pattern for $Cu(OH)_2$

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This work was supported by The National Science Centre (Poland) under project OPUS 29, UMO-2025/57/B/ST11/00206

PHOTOCATALYTIC NOx OXIDATION OVER CEMENTS PLATES MODIFIED WITH AN AMORPHOUS TIO_2 INTERMEDIATE AND TIO_2-SIO_2 MIXTURES

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The aim of this study was to develop a low-cost method for producing photoactive cements. Cement clinker was heated to 700 °C, and then a mixture of amorphous TiO_2 suspension (an intermediate product in the production of TiO_2 by the sulfate method) together with micro-SiO_2 (TiO_2:SiO_2 molar ratios of 1:1, 1:2, and 2:1, with 1–5 wt.% TiO_2) was added while the clinker was cooling. The modified clinker was then ball-milled with the addition of 5 wt.% flue gas desulfurization (FGD) gypsum. Pure TiO_2 without micro-SiO_2 was also tested (1–5 wt.%). Photocatalytic activity was assessed by NO decomposition in a continuous flow photoreactor (0.5 ppm NO, UV) at temperatures of 4, 20, and 40 °C. The reference sample (clinker + 5 wt.% FGD gypsum) showed negligible activity (2.0% at 20°C), confirming the photocatalytic origin of the NO removal process. The sample with 5 wt.% TiO_2:SiO_2 (1:2) showed the highest NO decomposition (16.1% at 20 °C, 23.7% at 40 °C, and 9.8% at 4 °C). The addition of SiO_2 improved the activity by 32% compared to pure TiO_2 at 20°C. The optimal ratio was found to be 1:2. For most samples, photocatalytic activity increased with temperature, which is consistent with literature reports that elevated temperatures promote water desorption, releasing active sites for NO photooxidation [1, 2]. The concept of incorporating TiO_2 production residues into photocatalytic cement composites has been previously described in the literature [3]. In the present study, a locally sourced, amorphous TiO_2 intermediate was uniquely utilized together with micro-SiO_2, clinker, and FGD gypsum. These results are consistent with previous findings that the addition of 5 wt.% TiO_2 to clinker at 700 °C provides the highest activity [4]. Adding amorphous TiO_2 with micro-SiO_2 without prior calcination to the clinker during its cooling may be a sustainable way to produce photoactive cements.

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THREE-DIMENSIONAL TiO_2-BASED PHOTOCATALYTIC MATRICES FOR SELECTIVE PHARMACEUTICAL REMOVAL FROM AQUEOUS SOLUTIONS

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Titanium dioxide (TiO_2) is one of the most widely used photocatalytic materials due to its chemical stability, non-toxicity, and strong oxidative properties. However, its powdered form presents several limitations, including difficult recovery, agglomeration, and limited active surface area, which reduce its practical applicability [1]. Designing TiO_2 as three-dimensional (3D) structures, such as sponge-based matrices, addresses these challenges by improving catalyst handling, light penetration, mass transfer, and effective surface area [2,3]. Inspired by the hierarchical porous architectures found in nature, this study investigates biomimetic sponge matrices as templates for TiO_2 deposition [4,5]. Although sponge materials have previously been used as supports, no comprehensive comparison of different sponge matrices has been reported, and the influence of sponge architecture on TiO_2 deposition and photocatalytic performance remains largely unexplored. The resulting 3D materials exhibited uniform TiO_2 coatings, enhanced light absorption, improved charge separation, and increased photocatalytic activity. Their properties were evaluated using SEM, XRD, and UV-Vis spectroscopy to establish the relationship between structure and performance. The developed photocatalysts showed superior efficiency in the degradation of ketoprofen in wastewater compared with conventional TiO_2 powders and also demonstrated potential for solar-driven hydrogen production. Overall, biomimetic sponge matrices represent a promising approach for designing next-generation photocatalysts for environmental remediation and sustainable energy applications.

Acknowledgments

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DESIGNING g-C_3N_4 PHOTOCATALYSTS THROUGH SOFT TEMPLATING: SYNTHESIS EFFECT ON STRUCTURE AND ACTIVITY

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In response to growing energy challenges, hydrogen is considered a promising energy carrier that could replace fossil fuels. It can be produced photocatalytically through water splitting or the photoreforming of simple organic compounds[1]. Although graphitic carbon nitride (g-C_3N_4) is a promising photocatalyst, its performance is limited by rapid charge-carrier recombination and low specific surface area, caused by its denced structure in its bulk form. Therefore, structural modifications and coupling with other materials are being explored to enhance photocatalic properties[2,3].

An easy approach to manipulate the structure of g-C_3N_4 was proposed. Modified materials were synthesized *via* thermal polycondensation under air and inert conditions to deposit urea-based semiconductors on different soft s-triazine templates, in order to study their impact on structure and photocatalytic performance of graphitic carbon nitride.

Characterization of the materials was performed to evaluate their structure, morphology, and both thermal and surface properties. Photocatalytic and photoelectrochemical tests, including hydroxyl radical generation and methanol photoreforming in different conditions were performed to evaluate the activity of the obtained materials. The degree of template condensation influenced the thermal stability and band gap of photocatalysts, while the synthesis conditions affected their specific surface area and active sites.

Structurally modified graphitic carbon nitrides exhibit distinct photocatalytic performance, indicating that synthesis conditions influence photocatalytic mechanisms of obtained materials. Lower template condensation favored activity in oxygen-containing systems, whereas reaction conditions reversed the activity trend based on the synthesis atmosphere. Selection of particular template enables to control reaction paths in certain conditions determining defined application possibilities.

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CYAMELUTURATE SALTS INSPIRED CARBON NITRIDE FOR PHOTOCATALYTIC APPLICATIONS

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Carbon nitride (g-C_3N_4) is known to be a photocatalytically active material under visible light irradiation but suffers from a high recombination rate of photoexcited charges[1]. This drawback can be surmounted by structural modifications and coupling with other materials. For example, hydroxyl groups can be incorporated to increase photocatalytic activity[2]. The hydroxylated g-C_3N_4 resembles the structure of cyameluric acid, which can create coordination salts. It was found that potassium cyamelurate can photocatalytically photodegrade tetracycline[3]. Therefore, the question arises: can hydroxylated g-C_3N_4 also coordinate metals, thereby improving photocatalytic efficiency?

A new approach for surface modification method has been proposed. The g-C_3N_4 has been treated with KOH under mild conditions, either under reflux or in a microwave. Then the possibility of copper incorporation was verified. The obtained materials were analyzed by infrared spectroscopy (IR), X-ray diffraction spectroscopy (XRD), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), Brunauer-Emmett-Teller analysis (BET), and diffuse reflectance spectroscopy (DRS). The photocatalytic activity of the obtained materials was investigated in tetracycline decolorization.

It was found that the incorporation of hydroxyl groups and copper into the carbon nitride structure enhances its photocatalytic properties.

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EFFICIENT WO_3 PHOTOELECTRODES OBTAINED BY LIQUID PHASE DEPOSITION.

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Tungsten (VI) oxide photoelectrodes on transparent substrates are usually synthesized by the hydrothermal method, which requires deposition temperatures above 80°C. On the other hand, a successful deposition of metal oxide films at room temperature, including WO_3, was reported for the liquid phase deposition (LPD) method, in which metal-fluorine complexes serve as precursors and H_3BO_3 is used to control the reaction rate[1]. The WO_3 coatings deposited by LPD are composed of thin vertical plates, similar to hydrothermally synthesized films[2]. Such a morphology promotes better separation of photogenerated charges. Moreover, enhanced photoelectrochemical efficiency was reported in multilayer WO_3 electrodes[3].

In this study, we have optimized the LPD synthesis of compact WO_3 films, paying special attention to the deposition temperature (30–80°C) and to the number of consecutive layers. The deposition followed by calcination resulted in the formation of the single γ-WO_3 phase. Elevated deposition temperature, coupled with magnetic stirring, yielded compact WO_3 films, composed of densely packed plates organized into desert-rose-like aggregates. In multilayer samples, the consecutive layer (i) partially grew inside the pores of the preceding one (reducing its porosity), (ii) recrystallized into larger blocks at the interface between layers, and (iii) formed a densely packed plate structure on top.

The single-layer electrodes revealed a similar optical band gap E_g = 2.87(2) eV, whereas a smaller value of 2.78(2) eV was determined for the 2-layer sample. The incident photon-to-current efficiency (IPCE) of single-layer photoanodes correlated with their surface coverage, and the highest value of 23% (360 nm, 1.2 V *vs*. RHE) was observed for the most compact film deposited at 60°C. The enhanced IPCE of 33% was found for the 2-layer electrode. The higher efficiency of the latter can be explained by its lower band gap energy, improved charge separation (a higher surface photovoltage was measured in the multilayer sample), reduced charge-transfer resistance (as indicated by a smaller semicircle in electrochemical impedance spectra), and higher specific surface area. Photocatalytic activity towards hydroxyl radical generation was highest for the 2-layer sample. However, when comparing only single-layer electrodes, those with the lowest surface coverage were in fact the most photocatalytically active.

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LIQUID PHASE DEPOSITION OF PHOTOCATALYTIC THIN FILMS: FROM MORPHOLOGY-CONTROLLED TiO_2 TOWARD VISIBLE-LIGHT-ACTIVE OXIDES

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Thin-film photocatalysts are attractive alternatives to powder systems due to their mechanical stability, reusability, and ease of integration into photoelectrochemical and environmental applications.[1] Liquid phase deposition (LPD) offers a simple, low-cost, and scalable route for fabricating oxide coatings under mild conditions.[2,3]

In this work, LPD was employed to synthesise anatase, rutile TiO_2 and α-V_2O_5 thin films. For anatase TiO_2, deposition and calcination temperatures were used to tailor film morphology, promoting a transition from compact grains to nanorod-like structures. These morphological changes were accompanied by enhanced photocurrent response, indicating improved charge separation and transport. Surface voltage measurements revealed only minor changes in work function, suggesting that morphology-driven effects dominate the observed performance enhancement.

Furthermore, a low-temperature route for direct formation of rutile TiO_2 was developed, avoiding the harsh thermal treatments typically required for rutile synthesis.

To extend the applicability of LPD toward visible-light photocatalysts, V_2O_5 thin films were synthesised and characterised. Preliminary XRD results confirmed the formation of crystalline orthorhombic α-V_2O_5 and demonstrated that precursor concentration influences film crystallinity and structural ordering.

Overall, the results demonstrate the versatility of LPD as a morphology-controlled synthesis platform for photocatalytic oxide thin films and provide insight into the relationship between film structure and photo(electro)catalytic performance. Further details and a comprehensive discussion of the results will be presented.

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INNOVATIVE CARBON NITRIDE-BASED COATINGS ON FTO FOR PHOTOCATALYTIC HYDROGEN EVOLUTION

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Graphitic carbon nitride (g-C_3N_4), due to its ability to absorb visible light, is considered a promising material for photocatalytic applications, i.e., hydrogen generation.[1,2] Typically, g-C_3N_4 is used in powder form, as g-C_3N_4 films appear challenging to synthesize. Herein, the conventional approach involves direct synthesis on the substrate (bottom-up), primarily through thermal vapor condensation and surface condensation. However, the relatively weak adhesion forces hinder the fabrication of high-quality and durable coatings, which remains a current research challenge.[3]

In this work, a novel method for the synthesis of g-C_3N_4 coatings on FTO glass was developed. The synthesis procedure was based on coating the FTO surface with a paste composed of melamine and an organic tin precursor, followed by thermal condensation in a specially designed reactor in an atmosphere of nitrogen or air. The obtained g-C_3N_4 coatings were characterized using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), and diffuse reflectance spectroscopy (DRS). The evaluation of the chemical structure reveals the incorporation of Sn and SnO_2 in coatings obtained in N_2 and air atmospheres, respectively.

The photocatalytic activity of the obtained coatings was verified through hydrogen evolution in the presence of methanol, revealing the highest efficiency for the created heterojunction between g-C_3N_4 and SnO_2.

The developed synthesis method enables the preparation of highly durable g-C_3N_4 coatings, whose properties can be tailored by the reactor architecture and applied atmosphere during synthesis.

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SYNTHESIS AND CHARACTERIZATION OF PHOTOACTIVE Si-BASED MATERIALS FOR TREATMENT OF EMERGENT CONTAMINANTS

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The application of photocatalytic materials in batch and continuous-flow systems is a high-priority for tackling environmental emerging contaminants. So, developing silica-based material as destructive technologies for remediations of PFAS and other recalcitrant substances from different contaminant sources is crucial nowadays. The other study also relies on silica-based TiO_2 nanocomposite material with the addition of nucleophiles ($Na_2S_2O_3$) in a packed column reactor system showed a great efficiency on photocatalytic degradation of PFAS[1].

This research fills the gap in the use of photocatalytic nanocomposite materials based on silica and titanium dioxide, where the formation of oxane-bridges (Si-O-Ti) is expected to ensure chemical stability and overcome the kinetic barriers to complete degradation emerging contaminants such as PFAS and PFSA precursors. Additionally, modification of these materials with MOF structures is planned to enhance their sorption properties and photocatalytic activity.

Nowadays, experimental research activity started by synthesizing Ti-O-Si through sol-gel process and calcinated in different temperature conditions. The characterization of obtained materials with SEM (to identify the porous morphology), BET (absorption surface area), FTIR and XRD were performed. For the coming experimental activity, and forwarded objectives of research see Figure 1, as a full scheme and it shows the simulation of synthesis of nanocomposite materials based on surface functionalized ZIF-MOF in Si-Ti matrix, through the molecular transition from a liquid mixture to a solid ceramic cage.

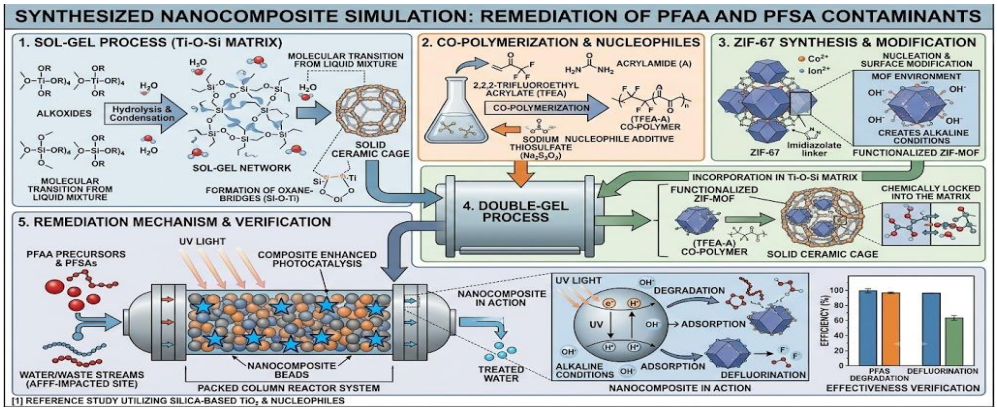

Fig. 1. AI-generated full schemes of synthesis process, characterization and application of the nanocomposites

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DEGRADATION OF DICLOFENAC USING JANUS MICROPARTICLES IN THE PHOTO-FENTON LIKE PROCESS UNDER VISIBLE LIGHT IRRADIATION.

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Diclofenac sodium is an anti-inflammatory drug commonly used to cure pain in various treatments, which leads to its excessive use and, therefore, a persistent water contamination. Its presence in aqueous bodies is hazardous for a range of aquatic species, causing, among other things, abnormal reproduction and development, but also affecting humans, leading to serious health problems.[1]

Herein, we present a comparative study of the new Janus microparticles Fe_3O_4-Au and Fe_3O_4-AuPt as photocatalysts for the degradation of diclofenac sodium in photo-Fenton like reaction under visible light irradiation. Janus particles enable the development of hybrid bimetallic or trimetallic structures that exhibit enhanced catalytic activity due to the integration of different components within a single structure, which allows for the free and effective transfer of electrons.[2] Two-step synthesis of Janus microparticles was presented. The first step involves the solvothermal synthesis of Fe_3O_4 microparticles, followed by the nucleation of gold nanoparticles, or gold and platinum nanoparticles, at a single site on the surface of the Fe_3O_4 microparticles, resulting in an asymmetric Janus structure. Moreover, Fe_3O_4 microparticles exhibit magnetic properties[3-4], which means that separating them from the treated water does not require additional or complex filtration processes, and the separated Janus particles can be used in subsequent photodegradation processes.

Fe_3O_4-Au and Fe_3O_4-AuPt microparticles demonstrated the ability to photodegrade approximately 50% of diclofenac sodium in the presence of hydrogen peroxide and under visible light irradiation.

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NU-1000@PCN-22X MOF HETEROSTRUCTURES FOR PHOTOCONVERSION OF CO_2 INTO USEFUL CHEMICALS

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The increasing concentration of atmospheric CO_2 has intensified the need for sustainable CO_2 utilization technologies. Photocatalytic CO_2 reduction offers a promising approach for converting this greenhouse gas into value-added chemicals and fuels using UV–Vis irradiation. Porous metal-organic frameworks (MOFs) are good candidates as photocatalysts for this process due to their high gas absorption capacity and tunable structures. Combining different MOFs into composite materials can create synergistic effects that enhance their performance [1]. This research focuses on the synthesis and characterization of NU-1000@PCN-22X (X=2,3 and 4) composite materials for the photoconversion of CO_2 into useful chemicals. The NU-1000@PCN-222, NU-1000@PCN-223 and NU-1000@PCN-224 composites were synthesized using a two-step procedure. First, the NU-1000 was synthesized by solvothermal method and purified [2, 3]. Then, in a second step, the PCN frameworks were synthesized directly on the surface of the NU-1000. The morphology and structure of obtained materials were confirmed using various characterization techniques (e.g. SEM, XRD). The obtained composites were tested for CO_2 photoreduction using a 1000W Xenon lamp with a >420 nm cut-off filter over a 4-hour reaction period. HPLC and GC methods were used for the analysis of CO_2 photoreduction products.

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PROPERTIES AND PHOTOCATALYTIC ACTIVITY OF MATERIALS OBTAINED BY THERMAL TREATMENT OF METAL-ORGANIC FRAMEWORKS

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Progressive climate change and the need to reduce greenhouse gas emissions are making alternative energy sources increasingly important. Particular attention is being paid to the use of hydrogen, which, due to its high energy density and lack of emissions during use, is considered a promising energy carrier of the future[1]. However, the widespread use of hydrogen is limited by the costs and efficiency of currently used production methods.

Therefore, intensive research is being conducted on new technologies for producing hydrogen from renewable sources. One area of research focused on renewable methods of hydrogen production is the photocatalytic hydrogen evolution reaction, which uses UV-Vis radiation to initiate processes occurring on the surface of the photocatalyst. The key factor influencing the efficiency of this process is the properties of the photocatalytic material used; therefore, considerable attention is currently being devoted to the design and study of new systems based on, among other things, semiconductors, metal nanoparticles, quantum dots, and metal-organic frameworks (MOFs)[2].

In presented study, a series of composite photocatalysts based on materials derived from metal-organic frameworks was prepared. The precursor was bimetallic MOF containing nickel and zinc in the metal center, which, after thermal treatment, were transformed into a ZnO/NiO-based composite. The surfaces of the materials were then modified using varying concentrations of NiS_2 quantum dots. The properties of the resulting photocatalysts were analyzed using structural, morphological, and optical characterization methods, while their application potential was assessed based on the efficiency of photocatalytic hydrogen generation.

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