September 20-24, 2026, Prague, Czech Republic

10th Regional Symposium on Electrochemistry

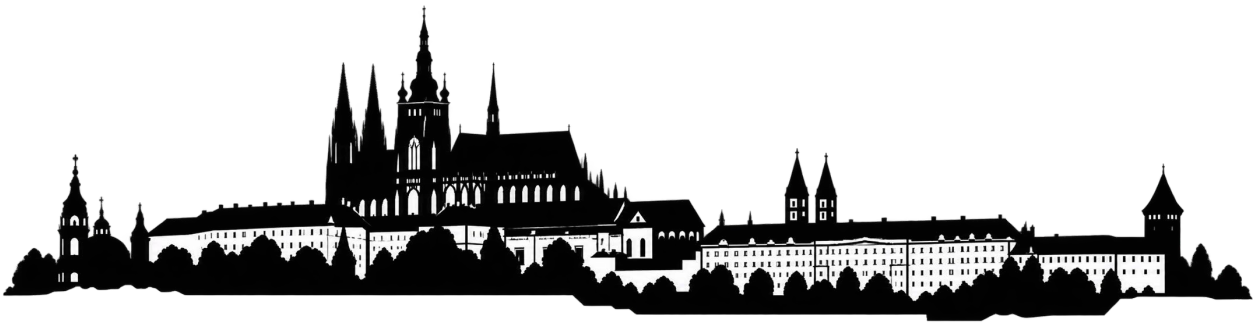
RSE-SEE

South-East Europe

10th Regional Symposium on Electrochemistry – South East Europe

BOOK OF ABSTRACTS

RSE-SEE10



Hotel Krystal, Prague, Czech Republic

September 20-24, 2026

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Association of South-East European Electrochemists

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PROGRAMME

Sunday September 20

13.00 – 18.30 **Registration in the entrance hall of the Krystal Hotel**
18.30 – 20.00 **Welcome Drink**

Monday September 21

8.45 – 9.00 **RSE-SEE10 Conference Opening, Welcome Address**

PLENARY TALK (Chairman Magdaléna Hromadová)	
9.00 – 9.40	**Electrochemically Controlled Single-Protein Electronics** *Ismael Díez-Pérez*
ORAL TALK (Chairman Magdaléna Hromadová)	
9.40 – 10.00	**From Molecular to Protein Junctions: Computational Approaches to Charge Transport** *Zdenek Futera*
10.00 – 10.20	**Length-Dependent Spin Polarization in Single α-Helical Peptide Junctions** *Wenzhu Kuang*

10.20 – 10.50 **COFFEE BREAK**

KEYNOTE TALK (Chairman Evelina Slavcheva)	
10.50 – 11.20	**Calcium/Oxygen Batteries: Challenges and Perspectives** *Zoran Mandić*
ORAL TALK (Chairman Evelina Slavcheva)	
11.20 – 11.40	**Phosphoric Acid Modified Silica-Based Composite Additive of Lead Dioxide Electrodes for Automotive Battery Applications** *Albena Aleksandrova*
11.40 – 12.00	**Cathode-Free Li-Sulphur Batteries: Catalysts for Polysulphide Conversion** *Ladislav Kavan*

12.00 – 12.45 **LUNCH A**
12.45 – 13.30 **LUNCH B**

KEYNOTE TALK (Chairman Zoran Mandić)	
13.30 – 14.00	**Low Temperature Electrolyser Research: Taking the Step beyond State of the Art** *Merit Bodner*
ORAL TALK (Chairman Zoran Mandić)	
14.00 – 14.20	**Construction of Well-Curated Battery Material Database and Cycling Stability Prediction by Time-Series Machine Learning** *Lyuben Borislavov*
14.20 – 14.40	**Interface-Engineered Transition-Metal Oxide Cathodes for High-Performance Aqueous Zinc-Ion Batteries** *Monaam Benali*

14.40 – 15.00	**A Controlled Monitoring of Ni Coarsening and Depletion through Electrochemical Testing Methods** *Aslam Hossain*
15.00 – 15.30	**COFFEE BREAK**
	KEYNOTE TALK ***(Chairman Merit Bodner)***
15.30 – 16.00	**Designing Robust Transition Metal Catalysts for Alkaline Water Electrolysis under Industrially Relevant Conditions** *Jelena D. Gojgić*
	ORAL TALK ***(Chairman Merit Bodner)***
16.00 – 16.20	**Electrochemical Performance of Supercapacitors Based on Modified Montmorillonite Electrodes** *Borislava Mladenova*
16.20 – 16.40	**Electrodeposition and Characterization of Amorphous Ni-Mo Coatings** *Veselina Chakarova*
16.40 – 17.00	**Exploration of Malva Sylvestris L., an Albanian Medicinal Plant, as a Promising Green Corrosion Inhibitor for Mild Steel MS 235 in Aggressive Acidic Media: A Machine Learning-Assisted Predictive Study** *Alketa Lame*
17.00 – 17.20	**Influence of Mo and Ta Additions and Heat Treatment Process on the Corrosion Properties of AlCoCrFeNi High-Entropy Alloy** *Hüseyin Zengin*
	POSTER SESSION
17.30 – 19.00	**Poster Session I (poster P1 to P19)**
19.00 – 20.00	**Concert**

Tuesday September 22

	PLENARY TALK ***(Chairman Romana Sokolová)***
9.00 – 9.40	**Integrating Electrochemistry and Optical Imaging to Probe Liposomes: Emerging Paradigms in Fluorescence and Electrochemiluminescence Studies** *Olivier Buriez*
	ORAL TALK ***(Chairman Romana Sokolová)***
9.40 – 10.00	**Enhanced Electrochemical Performance of Boron-Doped Diamond Electrodes via e-Beam-Evaporated Platinum Nanoparticles** *Oleksandr Matvieiev*
10.00 – 10.20	**Development of a Voltammetric Method for Dicamba Determination at Boron-doped Diamond Electrodes and Investigation of its Electrooxidation** *Lenka Janíková*
10.20 – 10.50	**COFFEE BREAK**

	KEYNOTE TALK ***(Chairman Francesco Paolucci)***
10.50 – 11.20	**Advanced Aptasensors: Towards Precision in Cancer Marker Detection** *Miroslav Gál*
	ORAL TALK ***(Chairman Francesco Paolucci)***
11.20 – 11.40	**Ferrocene Modified MIPs for (Redox Probe)-Free Electrochemical Sensing** *Maciej Cieplak*
11.40 – 12.00	**Molecularly Imprinted Polymer-Based Electrochemical Sensor for Sensitive Bisphenol A Detection** *Sabrina State*
12.00 – 12.45	**LUNCH A**
12.45 – 13.30	**LUNCH B**
	KEYNOTE TALK ***(Chairman Miroslav Gál)***
13.30 – 14.00	**Solid-State Electrochemical Sensors: Challenges and Opportunities** *Federico Maria Vivaldi*
	ORAL TALK ***(Chairman Miroslav Gál)***
14.00 – 14.20	**Electrocatalytic Biomass-Derived Carbon Cathodes for Selective Two-Electron Oxygen Reduction and Efficient Electrochemical Hydrogen Peroxide Generation** *Erika Bustos*
14.20 – 14.40	**Coupled Model of Acid-Base Equilibria and Charge Transport in Pulsed Electric Fields** *Táňa Sebechlebská*
14.40 – 15.00	**NIR-Based Temperature Measurement in Pulsed Electric Field Systems** *Gregor Mydla*
15.00 – 15.30	**COFFEE BREAK**
	ORAL TALK ***(Chairman Győző G. Láng)***
15.30 – 15.50	**Influence of Temperature and Water on Phosphonium-based Protic Ionic Liquids for Intermediate Temperature PEMFCs** *Tommaso Bertolin*
15.50 – 16.10	**Influence of Transition Metals on Ni Sulfide-based Electrocatalysts for Alkaline Urea Oxidation Reaction** *Jesper T.N. Knijnenburg*
16.10 – 16.30	**On the Incorporation of Zeolites into Oxide Coatings During Plasma Electrolytic Oxidation Processing** *Rastko Vasilic*
16.30 – 16.50	**Use of Magneto-Electropolishing and Electropolishing in the Preparation of TiO_2-Modified Stainless Steel Electrodes to Reveal the Impact of TiO_2 Grain Boundaries on the CO_2 Photoconversion to Ethanol in an Acidic Aqueous Medium** *Juan Manríquez*
16.50 – 17.10	**Electrodeposition of Nanostructured Multilayer Protective Coatings with Controlled Phase Composition from Polyligand Electrolytes** *Antonina Maizelis*

POSTER SESSION	
17.30 – 19.00	**Poster Session II (poster P20 to P37)**

Wednesday September 23

PLENARY TALK (Chairman Jiří Ludvík)	
9.00 – 9.40	**Mechanistic Insights of Electrogenerated Chemiluminescence for Enhanced Bioanalytical Applications** *Francesco Paolucci*
ORAL TALK (Chairman Jiří Ludvík)	
9.40 – 10.00	**Optimization of Some Important Parameters of Electrochemical Ferrate Production Using Dual Dynamic Voltammetry** *Győző G. Láng*
10.00 – 10.20	**Spectroelectrochemical Monitoring of pH Changes in the Pulsed Electric Field** *Viliam Kolivoška*

10.20 – 10.50 COFFEE BREAK

KEYNOTE TALK (Chairman Soma Vesztergom)	
10.50 – 11.20	**Role of in-situ Spectroelectrochemistry in the Redox Mechanism Determination** *Romana Sokolová*
ORAL TALK (Chairman Soma Vesztergom)	
11.20 – 11.40	**Elucidating the Mechanism of Initial Hydroxide and Oxide Formation on a Polycrystalline Nickel Surface** *Ožbej Vodeb*
11.40 – 12.00	**Insight into Degradation Mechanism of PFAS on Ti_6O_{11} Electrodes** *Aleksandra Janošević Ležaić*

12.00 – 12.45 LUNCH A
12.45 – 13.30 LUNCH B

KEYNOTE TALK (Chairman Jelena D. Gojgić)	
13.30 – 14.00	**Workforce Needs and Training Opportunities for the European Hydrogen Sector: Insights from the GreenSkills4H2 Project** *Evelina Slavcheva*
ORAL TALK (Chairman Jelena D. Gojgić)	
14.00 – 14.20	**From Molecular Electrochemistry to Functional Nanomaterials: Advanced Electrocatalysts for Sustainable Hydrogen Production** *Ayman Nafady*
14.20 – 14.40	**Influence and Interfacial Kinetics of Binary Protic Ionic Liquid Electrolyte Mixtures on Intermediate-Temperature Polymer Electrolyte Membrane Fuel Cells** *Yang Tang*
14.40 – 15.00	**Nickel Sulfide Electrocatalysts via Chemical Bath Deposition for Urea-assisted Hydrogen Production** *Kaewta Jetsrisuparb*

15.00 – 15.30 COFFEE BREAK

ORAL TALK (Chairman Alketa Lame)	
15.30 – 15.50	**Chronoamperometric Oxidation of High-Entropy Alloys Dedicated to Electrooxidation of Methanol** *Katarzyna Skibińska*
15.50 – 16.10	**Perforated Microporous Layers for Flooding Mitigation in High-Current-Density CO_2 Electroreduction** *Eva Vaněčková*
16.10 – 16.30	**Derivatization-Based HPLC Ammonia Quantification and Time-Resolved Analysis of Lithium-Mediated Nitrogen Reduction** *Primož Jovanović*
16.30 – 16.50	**Computationally Efficient Catalyst Agglomeration Model Based on Scaling Relations of Particle Size Distribution** *Ambrož Kregar*

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PLENARY TALK (Chairman Maciej Cieplak)	
9.00 – 9.40	**Impedance Spectroscopy of Hydrogen Underpotential Deposition on Platinum** *Rafał Jurczakowski*
ORAL TALK (Chairman Maciej Cieplak)	
9.40 – 10.00	**A Shot Noise Based Approach to Constant Phase Behaviour in Electrochemical Impedance Spectroscopy – the Concept of Frequency Dependent Charge Transfer Impedance** *Gábor Mészáros*
10.00 – 10.20	**Reference Potential for Non-Ideal Media** *Jiří Janata*

10.20 – 10.50 COFFEE BREAK

KEYNOTE TALK (Chairman Magdaléna Hromadová)	
10.50 – 11.20	**Adaptive IR Compensation and Multi-Nodal Electrometry Control Concepts for Electrolysers: An Instrumentation Roadmap** *Soma Vesztergom*
ORAL TALK (Chairman Magdaléna Hromadová)	
11.20 – 11.40	**Phase Transformations in Zirconia upon Electroreduction** *Christian Rodenbücher*
11.40 – 12.00	**Electrodeposition from Ionic Liquids and Deep Eutectic Solvents: Co, Ni and Co-Ni Systems** *Shamsa Khalid*

12.00 – 12.10 Closing remarks
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PLENARY LECTURES

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Integrating Electrochemistry and Optical Imaging to Probe Liposomes: Emerging Paradigms in Fluorescence and Electrochemiluminescence Studies

Olivier Buriez[a]
[a] *Laboratoire Chimie Physique et Chimie du Vivant—CPCV, UMR8228, Département de Chimie, Ecole Normale Supérieure, PSL University, Sorbonne Université, CNRS, Paris 75005, France, olivier.buriez@ens.psl.eu*

Understanding lipid membrane dynamics at the microscale remains a major challenge in biophysical chemistry, particularly for deciphering key processes such as permeabilization, rupture, and molecular transport. Liposomes, as well-defined biomimetic systems, offer a versatile platform to investigate these phenomena under controlled conditions. However, accessing both chemical reactivity and spatiotemporal evolution requires the integration of complementary analytical methodologies.

In this lecture, recent progress in coupling electrochemistry with optical imaging to investigate liposome behavior will be presented, with particular emphasis on fluorescence and electrochemiluminescence (ECL) approaches. Building on a series of studies [1, 2], we will first show that redox-controlled fluorescence can be implemented in giant unilamellar vesicles and directly visualized at the single-vesicle level, thereby establishing a new paradigm for electrochemical control in soft, biomimetic systems. Notably, fluorescence modulation is shown to be strictly leaflet-selective, occurring exclusively for probes located in the membrane leaflet accessible to the electrode. This provides direct experimental evidence, at the single-object scale, of the insulating character of lipid bilayers. In addition, the role of membrane surface charge in modulating the efficiency of fluorescence response will be discussed.

We will then highlight the emergence of ECL microscopy as a powerful tool for probing liposome systems. By converting electrochemical reactions into light emission without external optical excitation, ECL offers high sensitivity and intrinsically low background. This enables the visualization of individual liposome opening events and the spatiotemporal mapping of released species [3-8].

Highlighting recent advances and perspectives, this lecture will illustrate how the convergence of electrochemistry and optical imaging is transforming our ability to probe soft interfaces, with implications for drug delivery, artificial cells, and bioanalytical applications.

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Electrochemically Controlled Single-Protein Electronics

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In this short seminar, I will present our latest efforts on understanding and control charge transport in a single-protein junction, with an emphasis on how to harness enzymatic activity electrically in an individual enzyme. Our approach relies on trapping individual redox proteins in an electrochemically controlled tunneling junction to characterize their main electrical signatures. The method can capture very fine details of the charge transport mechanisms across proteins in an aqueous environment [1,2].

I will first introduce the methodology with a couple of examples of electrochemically controlled single-molecule wires with synthetic backbones, then introduce our studies on a benchmark redox protein model such as a bacterial blue Cu-Azurin. We will show first the main observed electrical signatures of these systems that make them particularly efficient in transporting charge. We then bioengineer the outer protein surface using point-site mutagenesis as a mean to get a more detailed picture of possible electron pathways through the protein backbone [2,3].

Finally, I will switch to our very recent charge transport studies on redox enzymes. Using the above electrochemically controlled single-protein methodologies, we demonstrate that when an individual redox enzyme is trapped on a nanoscale junction, a distinct telegraphic noise can be directly correlated to the enzymatic activity of the enzyme during the active bioelectrocatalytic conditions (see TOC Fig.) [4]. The last study opens a new door for the fundamental studies of redox enzymatic catalysis and brings prospects to the high-resolution electrical detection of an enzymatic reactions.

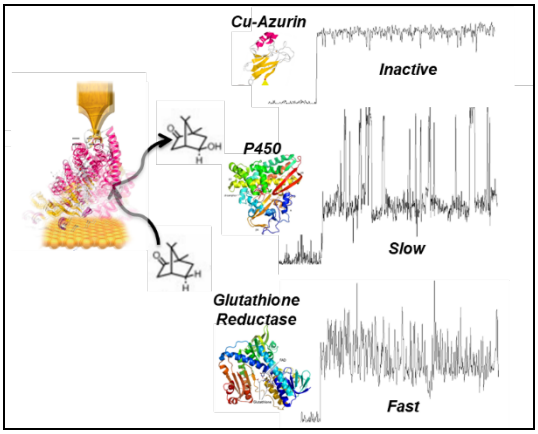


Fig. 1 Electrical transduction of redox enzymatic catalysis in a single-protein junction.

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Impedance Spectroscopy of Hydrogen Underpotential Deposition on Platinum

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Hydrogen sorption kinetics play a central role in heterogeneous catalysis, energy conversion, and hydrogen storage. Platinum-group metals that strongly interact with adsorbed hydrogen atoms exhibit hydrogen chemisorption at potentials positive of the hydrogen evolution reaction via the underpotential deposition (UPD) mechanism. The kinetics and thermodynamics of this process for a given metal strongly depend on the crystallographic orientation of the substrate.

Polycrystalline platinum and Pt(111) are particularly intriguing due to their exceptionally high electron transfer kinetics in this process. Electrochemical impedance spectroscopy (EIS) can provide valuable insights into the mechanisms and kinetics of electrode processes, as well as the structure of the double layer at the interface. However, studies on H-UPD kinetics on Pt and Pt(111) using EIS in a standard three-electrode setup are not feasible due to the slow response of the potentiostat at high frequencies. Additionally, the charge transfer resistance (R_{ct}) is significantly smaller than the resistance of the solution (R_s).

To address these challenges, EIS has been conducted using a twin-electrode and hanging meniscus configuration, covering a wide frequency range up to 1 MHz (Fig.1). The impedance between the twin electrodes was measured directly using a frequency response analyzer (FRA), while the potentiostat was utilized solely for DC polarization. This presentation will discuss the kinetics and thermodynamics of hydrogen electrosorption on platinum, comparing it with other platinum-group metals. It will also explore the challenges associated with measuring fast electrode processes, highlighting the factors that influence frequency dispersion and observed CPE-like behaviour.

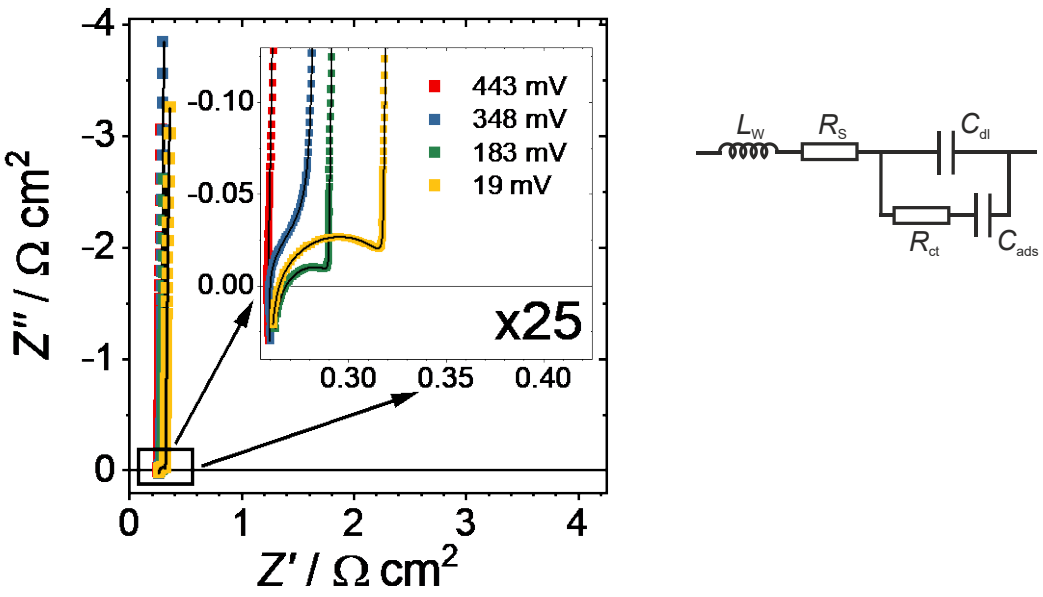


Fig. 1. (left) Complex plane plot of impedance spectra for Pt(111) in 0.5 M H_2SO_4. Symbols represent experimental data; solid lines are fits of equivalent circuit (right). L_W – inductance of the electrical connections, R_S – solution resistance, C_{dl} – double layer capacitance, R_{ct} and C_{ads} – hydrogen electrosorption charge transfer resistance and capacitance.

Mechanistic Insights of Electrogenerated Chemiluminescence for Enhanced Bioanalytical Applications

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Electrogenerated chemiluminescence (ECL) is a phenomenon of light emission at electrodes in electrochemical cells caused by energetic electron transfer (redox) reactions of electrogenerated species in solution. The ECL process is intrinsically surface-confined with concomitant steps involved in the generation of the analytical signal. Rate determining factors, affecting the overall ECL efficiency, include the heterogeneous electron transfer kinetics, the electrogenerated radicals stability and the spatial luminophores distribution and the optimization of the ECL signal has largely been focused on materials, either luminophores, coreactants or electrodes, aiming at identifying the best candidates for an ultra-bright ECL emission [1].

Because ECL is limited in space and time, imaging the ECL emission add further information on the system under investigation. The spatiotemporal resolution permits to develop multiplexing analysis platforms, locate micro-objects and imaging cells, organelles, single proteins and single entities, or visualizing chemical reaction, especially useful in mechanistic investigations [2].

Herein we will present general strategies aimed at the intensification of the ECL signal in view of its application in sensing and imaging, encompassing from fundamental research to foreseeable applications [3-4].

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KEYNOTE LECTURES

(ALPHABETICAL LIST)

Low Temperature Electrolyser Research: Taking the Step beyond State of the Art

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Hydrogen is a key compound for both a variety of chemical processes, as well as for energy storage and conversion, with annual production approaching 100 Mt [1]. The vast majority of used hydrogen originates from fossil fuels. Water electrolysis is a viable alternative that allows for the carbon neutral or lean production of hydrogen electrochemically from electricity. In particular low-temperature water electrolysis offers clear advantages due to its relatively high tolerance towards fluctuations. However, the technology faces several challenges, in particular in terms of costs and susceptibility towards harsh operating conditions and water impurities [2], [3]. Furthermore, there are few easily accessible metrics from which general conclusions about the functionality of materials can be drawn.

In our recent work, we assess the open circuit voltage (OCV) as such a metric. OCV is strongly impacted by gas crossover, catalyst layer and porous transport layer composition and structure. Values for two different materials are compared over an initial 120 s OCV hold. The data is complimented by 100 h of constant operation, electrochemical analyses, fluoride and fluorine emission rate assessment. The collective results show that while not giving a mechanistic direction for failure, OCV monitoring is a suitable metric to quickly assess material functionality and give an indication for the need of further investigation [4].

This approach also promises better transferability towards pending material transitions. With the outlook to replace per- and polyfluorinated alkyl substances (PFAS) such as perfluorosulfonic acid (PFSA) with non-fluorinated alternatives [5], [6], other early metrics for degradation detection such as fluoride emission monitoring become obsolete. Thus, OCV monitoring is explored as future-proof alternative.

Acknowledgement
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Advanced Aptasensors: Towards Precision in Cancer Marker Detection

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In contemporary clinical oncology, early and precise diagnostics are important factors for therapeutic success and improving patient prognosis. Various types of markers play a significant role in this process, reflecting dynamic changes within the tumor microenvironment. Among them proteins involved in extracellular matrix (ECM) remodelling such as fibronectin and periostin are closely associated with processes such as epithelial-mesenchymal transition, angiogenesis, and tumor metastasis [1-5].

Traditional diagnostic methods, like ELISA and HPLC provide valuable clinical data. However, their practical application is often limited by being time-consuming, requiring expensive reagents, and involving complex sample preparation. Consequently, the focus of modern bioanalytical and bioelectrochemical research has shifted toward the development of advanced biosensors, specifically aptasensors. These devices utilize aptamers – short, synthetic single-stranded nucleic acid sequences as highly specific biorecognition elements. They bind to the targets with high affinity, overcoming the stability and manufacturing limitations of antibodies. The integration of aptamers into various physicochemical platforms allows for versatile and robust applications in cancer diagnostics [6-13].

Within our research, we primarily focus on electrochemical aptasensors, which excel in high sensitivity, rapid response, and a great potential for miniaturized POC testing. In parallel, we utilize QCM based aptasensors, which enable label-free, sensitive, real-time monitoring of marker binding kinetics through mass changes on the sensor surface. A complementary approach in our work involves ELISA for control purpose and imaging via fluorescence microscopy, where fluorescently labelled aptamers serve as selective probes to directly visualize the spatial distribution of these markers within cellular structures. Our ongoing efforts have concentrated on developing these specific aptamer-based platforms for the detection of various proteins and miRNAs, as both groups show high potential as reliable indicators of tumour presence.

To conclude, the presentation will briefly introduce our latest results from the preparation and characterization of a novel electrochemical aptasensor specifically designed for the precise quantification of fibronectin, demonstrating excellent analytical performance and confirming that electrochemical aptasensors represent a promising pathway toward accessible precision oncology.

Acknowledgments

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Designing Robust Transition Metal Catalysts for Alkaline Water Electrolysis under Industrially Relevant Conditions

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Nickel is one of the most commonly used cathode materials in alkaline water electrolysis due to its good catalytic activity, relatively low cost, and favourable corrosion stability in alkaline media. However, during prolonged hydrogen evolution, particularly at high current densities, gradual deactivation of nickel may occur. This phenomenon is often associated with hydrogen absorption and the formation of nickel hydrides, leading to local changes in the electronic structure of the electrode. To overcome this limitation and improve catalytic performance, alloy or composite catalytic coatings can be deposited onto nickel electrodes, thereby increasing the electrochemically active surface area and/or enhancing the intrinsic catalytic activity. For this purpose, transition metal-based alloy coatings were electrodeposited from a pyrophosphate-glycine bath while varying the deposition parameters. The obtained coatings were subjected to comprehensive physicochemical characterization (SEM, EDX, XPS, XRD, TEM), providing insights into morphology, elemental distribution, chemical composition, and phase composition of the coatings, as well as electrochemical characterization, based on which the optimal deposition parameters were defined. [1,2] To assess their industrial applicability, a scale-up procedure was conducted in order to deposit coatings onto larger electrodes, which were subsequently evaluated in a zero-gap flow electrolyzer under industrially relevant conditions (30 wt.% KOH, 70 °C). [2,3] The overall catalyst development pathway, from laboratory-scale optimization to application-oriented testing, is schematically illustrated in Figure 1.

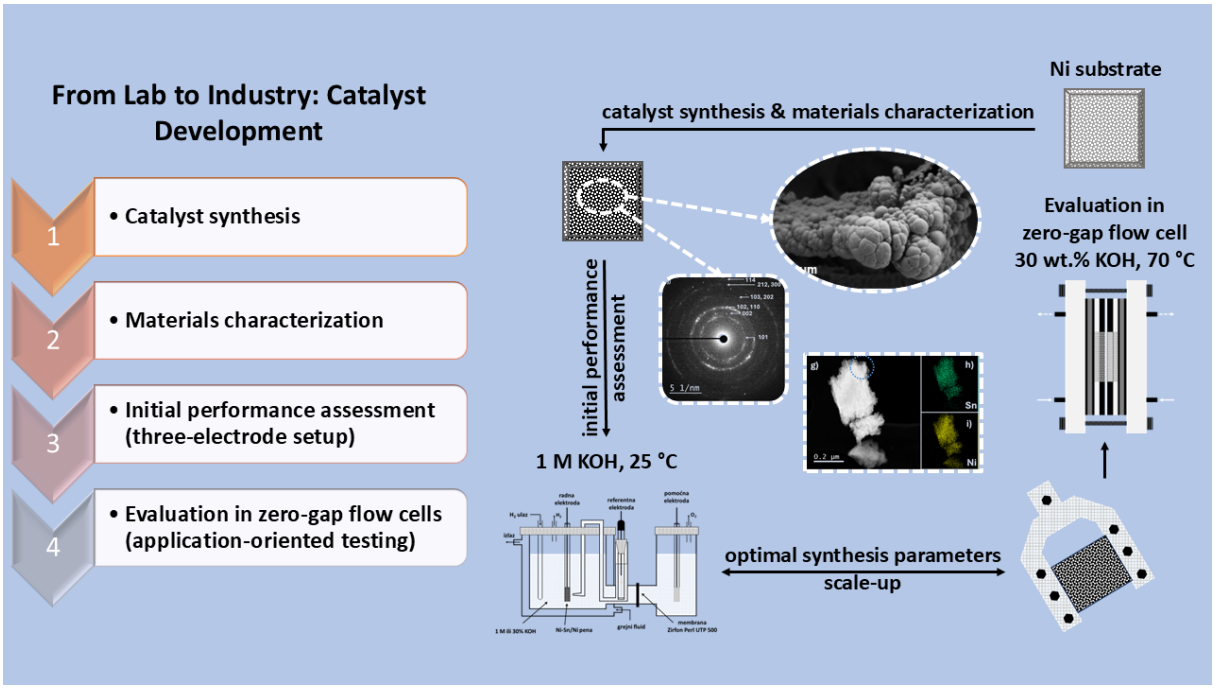


Figure 1 Schematic representation of catalyst development from laboratory-scale to industrial application.

Acknowledgements

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Calcium/Oxygen Batteries: Challenges and Perspectives

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Calcium batteries are attracting increasing attention as potential next-generation energy storage systems beyond lithium-ion technology. Calcium offers several advantages, including high natural abundance, low redox potential, and the possibility of achieving high energy densities. However, the development of rechargeable calcium batteries remains challenging due to issues related to calcium/electrolyte compatibility, reversibility of calcium plating and stripping reactions, and limited permeability of formed passivating layers to multivalent ions.

Among the various calcium battery concepts, calcium–oxygen (Ca/O_2) batteries are particularly interesting because of their very high theoretical energy density and the use of oxygen as an active cathode material. However, oxygen cathodes introduce significant complexities in overall battery chemistry, which are mainly due to oxygen reduction and evolution reactions, formation and decomposition of discharge products and electrolyte degradation.

This talk will discuss the fundamental challenges associated with oxygen electrochemistry in calcium systems, recent progress in electrolyte and cathode design, and current perspectives for advancing Ca/O_2 batteries toward practical applications.

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Workforce Needs and Training Opportunities for the European Hydrogen Sector: Insights from the GreenSkills4H2 Project

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Hydrogen is increasingly recognized as a key pillar of Europe's transition towards a climate-neutral economy. Through initiatives such as the European Green Deal, REPowerEU, and the Hydrogen Strategy for a Climate-Neutral Europe, substantial investments are being directed towards hydrogen production, infrastructure development, and industrial applications. The overarching objective is to accelerate the deployment of renewable and low-carbon hydrogen in order to decarbonize energy-intensive industries, transport systems, and the energy sector.

However, achieving these ambitions requires not only technological innovation and infrastructure investments, but also a highly skilled workforce capable of supporting the development of the entire hydrogen value chain. The rapid expansion of the European hydrogen sector is expected to generate approximately one million highly skilled jobs by 2030 and up to 5.4 million jobs by 2050. While this growth represents a significant economic and environmental opportunity, it also poses considerable challenges for labour markets, education systems, and vocational training providers. Consequently, workforce development has emerged as a strategic priority alongside technological advancement.

Addressing these challenges is the primary objective of the GreenSkills4H2 project (Green Skills for Hydrogen – The European Hydrogen Skills Alliance), one of the most significant European initiatives dedicated to workforce development for the hydrogen economy. Funded under the Erasmus+ programme, the project brings together more than 30 organizations from industry, academia, research institutions, sectoral associations, and training providers across Europe. The consortium is coordinated by the Karlsruhe Institute of Technology and includes major hydrogen stakeholders such as Hydrogen Europe and Hydrogen Europe Research.

Throughout its four-year implementation period, GreenSkills4H2 has investigated the workforce requirements of the European hydrogen sector, identified existing and emerging skills gaps, and evaluated current education and training opportunities. Through extensive consultation with industry experts and stakeholders, the project has mapped occupational profiles, analysed future workforce needs, and defined competency requirements across the hydrogen value chain. Furthermore, it has developed and piloted vocational education and training (VET) programmes tailored to industry demands and produced the European Hydrogen Skills Strategy, one of the first comprehensive frameworks dedicated to hydrogen workforce planning in Europe.

This contribution presents an overview of the project's main achievements, with particular emphasis on the research activities carried out by the Institute of Electrochemistry and Energy Systems at the Bulgarian Academy of Sciences. The findings highlight the critical role of education, training, and skills development in supporting the successful deployment of the European hydrogen economy and ensuring a sustainable and competitive energy transition.

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Role of *in-situ* Spectroelectrochemistry in the Redox Mechanism Determination

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Electrochemical methodologies have been successfully used to explain correlations between chemical structure, oxidation potential, and biological activity of electroactive species as drugs and medicaments. The antioxidant properties of bioactive compounds, allowing them to prevent the formation of reactive oxygen species (ROS) often generated at sites of inflammation and injury, or to neutralize free radicals and minimize the oxidative stress resulting from a variety of insults, are closely related to their redox properties and in particular to their ability to act as electron donors. The online connection of electrochemistry with spectroscopic techniques has large importance in the detection of short living intermediates and determination of detailed reaction mechanism of targeting compound. In this presentation, a role of infrared spectroelectrochemistry (Fig. 1) will be shown on solving of oxidation mechanism of several polyphenolic substances [1-3] with focus on determination of oxidation mechanism of tapinarof, an isopropyl derivative of dihydroxystilbene, serving as an active pharmaceutical substance for the treatment of psoriasis [4]. Thank to infrared spectroscopy a formation of molecules associates in solution was detected, which can explain its therapeutic potential.

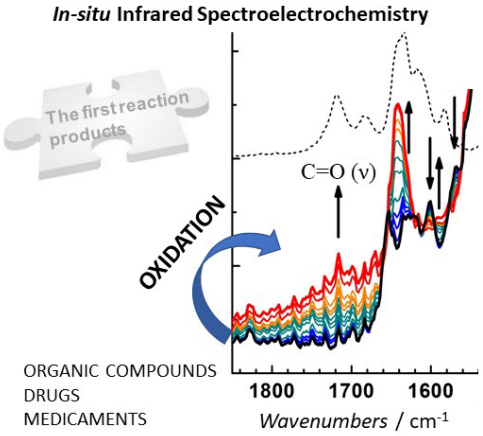


Fig. 1 Oxidative IR-spectroelectrochemistry of Flavonolignan 2,3-Dehydrosilybin [3].

The second example of in-situ spectroelectrochemistry will be focused on in-situ fluorescence spectroelectrochemistry, which significantly helped to explain the mechanism of reduction of new methylene blue derivative QMB^+ [5]. Compound **QMB^+** does not lose its fluorescence properties when irradiated with light of 587 nm even after its reduction. During its catalytic cycle, only a slight shift in the emission maximum occurred. In the contrary, methylene blue loses its emission completely when reduced. Importantly, the pronounced increase in fluorescence intensity of **QMB^+** upon reaction with an electron donor or under reduction conditions, compared to the parent **MB^+**, occurred. This phenomenon can be desirable for applications in light-energy conversions. Also, the increase in photostability of a photosensitising dye results in a longer time of ROS generation, which translates to a stronger therapeutic effect. The enhanced lipophilicity of the new compound **QMB^+** makes it a promising candidate for use in photosensitized membrane permeabilization and photodynamic antimicrobial chemotherapy. The observation that **QMB^+** and its reduced forms remain fluorescent may help overcome a key limitation of **MB^+** in medicine.

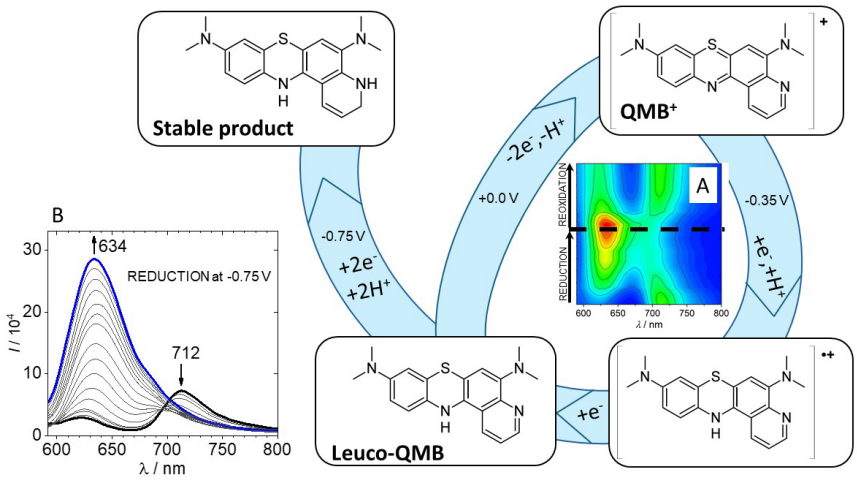


Fig. 2 Scheme of chemical reactions of phenothiazinium derivative QMB⁺ under controlled potential conditions. Inset A: Emission intensity of QMB⁺ during reduction and re-oxidation between 0 V and +0.35 V. Inset B: Emission intensity of QMB⁺ during reduction [4].

Acknowledgement
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Adaptive *IR* Compensation and Multi-Nodal Electrometry Control Concepts for Electrolysers: An Instrumentation Roadmap

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Electrocatalysis is rapidly moving from catalyst discovery toward device-relevant operation, where meaningful benchmarking requires high current densities, long durations, and realistic architectures (membranes, GDEs, flow cells). In this regime, however, a fundamental measurement problem becomes dominant: the electrical quantity we command (applied potential or current) is often not the electrical quantity the catalyst experiences, because significant —and frequently time-dependent— voltage losses occur outside the interface. Uncompensated and drifting solution resistance (IR drop) can therefore obscure activity/selectivity trends, distort integrated charges and Faradaic efficiencies, and compromise reproducibility across laboratories.

We argue that robust electrolyser experimentation requires an instrumentation shift: from single-working-electrode-centred control toward electrolyser-native observability and closed-loop stabilisation. The roadmap begins with adaptive, oscillation-free IR compensation as a prerequisite for high-current potentiostatic studies. We present a fully software-based method that achieves 100% dynamic IR compensation using commercially available potentiostats by continuously monitoring the high-frequency resistance and DC current, then adapting the setpoint so that the IR-corrected electrode potential remains constant throughout electrolysis. Crucially, the control strategy is designed to remain stable even when resistance decreases during operation (e.g., due to Joule heating or evolving multiphase conditions), which is exactly where conventional analogue positive-feedback compensation becomes unstable or forces users to under-compensate. Demonstration in nitrate-to-ammonia electrolysis at high current density shows that static partial compensation can lead to artefact-prone currents and misinterpreted selectivity, while adaptive digital control enables stable operation without oscillations and yields reliable potential-dependent performance metrics under drift.

Adaptive IR control solves one critical “single-electrode” problem, but electrolysers are multi-domain systems in which cathode, separator, and anode jointly set performance and failure. The next step in the roadmap is therefore multi-nodal electrometry: simultaneous measurement of cathode and anode potentials vs local references, separator-associated losses, and full-cell voltage, enabling real-time partitioning of where voltage (and therefore energy) is spent as conditions evolve. Building on this observability, we outline an electrolyser-centric control instrument concept that supports modes aligned with system constraints—including constant-power regulation in addition to constant-current/constant-voltage—so that operation can be stabilised under shifting resistive and transport conditions.
A further enabling element is bias-under-load, frequency-aware diagnostics embedded into the controller: controlled AC (including multi-tone) perturbations superimposed on DC operation to extract rapid impedance-informed signatures during electrolysis, localise emerging bottlenecks, and trigger protective or performance-preserving interventions before catastrophic drift occurs.

Solid-State Electrochemical Sensors: Challenges and Opportunities

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Solid-state electrochemistry has been extensively investigated for applications such as batteries, fuel cells, and energy conversion devices [1]. More recently, increasing attention has been devoted to its application in chemical sensing technologies, particularly for gas sensors. In this field, solid-state electrochemical sensors represent a promising alternative to conventional electrochemical devices, as they offer the possibility to overcome several intrinsic limitations associated with liquid-based systems, including electrolyte leakage, corrosion phenomena, limited operational stability, and restricted operating conditions. These advantages make solid-state platforms especially attractive for gas sensing applications related to energy, environmental monitoring, and industrial safety, where robust and reliable operation is required under variable temperature and humidity conditions. Nevertheless, several scientific and technological challenges still need to be addressed, including the optimization of electrode/electrolyte interfaces, the enhancement of sensitivity and selectivity, the reduction of cross-sensitivity effects, and the achievement of long-term stability.

This contribution discusses the main challenges and opportunities associated with solid-state electrochemical gas sensors, with particular emphasis on hydrogen sensing technologies. As a representative case study, a fully solid-state electrochemical hydrogen sensor developed by our group is presented. The device was specifically designed to eliminate all liquid components, thus improving robustness and enabling operation under conditions that are often problematic for conventional electrochemical sensors (Figure 1A). The sensor response was evaluated for hydrogen concentrations between 0.03–1.6% v/v under different environmental conditions. The results reveal a linear relationship between the sensor output and the logarithm of hydrogen concentration, in agreement the Nernst equation (Figure 1B). Interestingly, the measured sensitivity exceeds the theoretical Nernstian slope, suggesting that additional interfacial phenomena may contribute to signal amplification. Furthermore, the sensor maintains stable operation at elevated temperatures (Figure 1C), demonstrating the strong potential of solid-state electrochemical platforms for reliable sensing in harsh environments.

Overall, the presented results highlight how solid-state electrochemistry can create new opportunities for next-generation sensors for gas technologies and beyond.

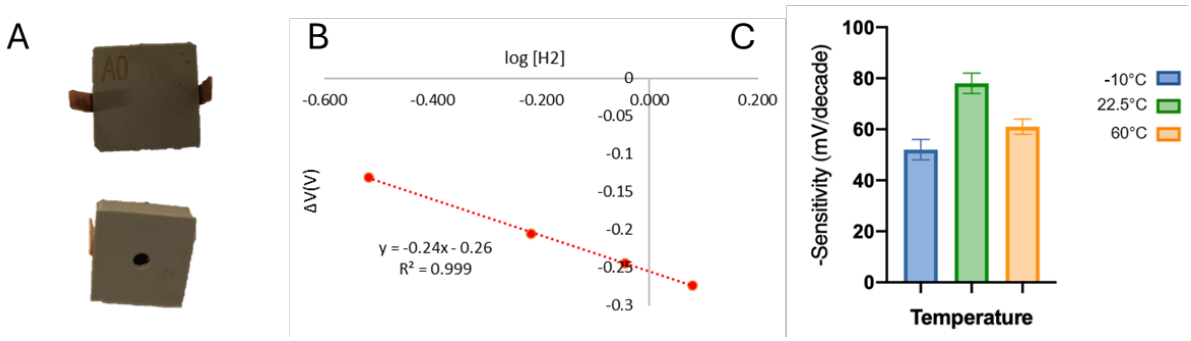


Fig. 1 A) Picture of the solid-state hydrogen sensor. B) Typical calibration curve; the variation of the potential is shown as a function of the concentration of hydrogen. C) Sensitivity of the sensor as a function of the temperature in the range – 10 to 60 °C.

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ORAL PRESENTATIONS

(ALPHABETICAL LIST)

Phosphoric Acid Modified Silica-Based Composite Additive of Lead Dioxide Electrodes for Automotive Battery Applications

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This study investigates the electrochemical performance of lead-acid batteries utilizing a phosphoric acid-modified $85SiO_2$-$9P_2O_5$-$6TiO_2$ additive in the positive active mass (PAM). The ternary oxide system was synthesized via the sol-gel method, modified by addition of different amounts xH_3PO_4(0; 17; 35; 52 mmol) and functionalized to improve proton conductivity and structural stability [1]. The additive was incorporated into the PAM in concentrations of 0.25% and 1.00%, by weight. Electrical characteristics were evaluated through initial C_{20} capacity tests and to simulate modern automotive demands, the batteries were subjected to Partial State-of-Charge (PSoC) testing at a 17.5% Depth of Discharge (DoD) cycling protocol.

Results demonstrate that the addition of silica-based composites in the PAM significantly modifies the specific surface area, pore system and morphology of the PbO_2 crystals. Notably, batteries containing 1.00% of the additive synthesized in 52 mmol H_3PO_4 exhibited a three-fold increase in cycle life compared to blank (additive-free) control samples. This substantial improvement is attributed to the synergistic effect of the TiO_2 framework providing mechanical reinforcement [2] and the phosphoric acid-modified phosphosilicate network facilitating ion transport, which effectively mitigates the growth of insulating lead sulfate layers [3].

These findings indicate that the $85SiO_2$-$9P_2O_5$-$6TiO_2$ system is a promising additive for extending the operational lifespan of lead-acid batteries in high-stress automotive applications.

Keywords
Phosphoric acid-doped SiO_2–$P2O_5$–TiO_2 system, Sol–gel, Lead dioxide electrode, Lead-acid battery, Partial State-of-Charge (PSoC)

Acknowledgements
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Research equipment of the project № BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies" was used for experimental work financially supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021-2027.

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Interface-Engineered Transition-Metal Oxide Cathodes for High-Performance Aqueous Zinc-Ion Batteries

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Aqueous zinc-ion batteries are attracting increasing attention as safe, low-cost, and environmentally friendly energy-storage systems for large-scale applications. However, their practical performance is still limited by slow Zn^{2+} diffusion, structural instability of cathode materials, and interfacial charge-transfer resistance during repeated cycling. In this work, we investigate transition-metal oxide-based cathodes as promising materials for aqueous zinc-ion storage, with a focus on improving electrochemical kinetics and cycling stability through compositional and interfacial engineering.

The cathode materials were prepared using a controlled synthesis approach and characterized by X-ray diffraction, Raman spectroscopy, electron microscopy, and surface-sensitive techniques to evaluate their structure, morphology, and chemical states. Electrochemical performance was studied in aqueous Zn-based electrolyte using cyclic voltammetry, galvanostatic charge–discharge, electrochemical impedance spectroscopy, and cycling tests. The modified oxide electrodes show improved charge-storage behavior, enhanced rate capability, and more stable cycling compared with the unmodified material. These improvements are attributed to better electronic transport, more accessible electroactive sites, and reduced interfacial polarization during Zn^{2+} insertion/extraction.

This study highlights the importance of rational cathode design and interface control in improving the performance of aqueous zinc-ion batteries. The results provide useful insight into the relationship between material structure, electrode/electrolyte interface, and Zn^{2+} storage kinetics, contributing to the development of more reliable and sustainable electrochemical energy-storage devices.

Influence of Temperature and Water on Phosphonium-based Protic Ionic Liquids for Intermediate Temperature PEMFCs

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Polymer electrolyte membrane fuel cells (PEMFCs) are a viable alternative to combustion engines and rechargeable batteries for automotive applications. The operating temperature of PEMFCs utilising sulfonated fluoropolymers as NAFION® is restricted to below 80 °C, as the presence of water is a prerequisite for proton conduction. At temperatures above 100 °C, the use of a non-aqueous protic electrolyte would facilitate significantly the water and heat management. Protic ionic liquids (PILs) can serve as effective substitutes. PILs are molten salts characterised by high thermal stability and high conductivity. Ammonium-based cation PILs have demonstrated a rapid oxygen reduction reaction (ORR) kinetics, namely the main bottleneck of the electrodic redox processes, compared with other electrolytes, such as phosphoric acid. [1-2] These results are attributed to the pronounced proton-donating capability of the acid PIL cations and the enhanced oxygen permeability arising from the more apolar character of the electrolyte bulk. [3]

In this study, phosphonium-based PILs (PPILs) are investigated as electrolytes for the application in future intermediate temperature PEMFCs for a temperature range of 80–160 °C. The PPILs have already shown in previous studies higher thermal stability and oxygen permeability compared to ammonium-based PILs, due to heavier cations and even higher apolar character due to the presence of the aliphatic phosphonic functional group. In this study, three PPILs, comprising superacid anion triflate [TfO] and quaternary acidic phosphonium cations trioctyl(3-sulfopropyl)phosphonium [tOP], tributyl(4-sulfobutyl)phosphonium [tBB] and tributyl-(3-sulfopropyl)phosphonium [tBP], are investigated by linear sweep voltametry (LSV) regarding their ORR performances. The investigations were conducted in the temperature range between 80–120 °C and at different water content at an water partial pressure between 0–15 kPa to simulate the expected operating conditions. The PPILs show higher ORR current densities at increasing temperature and water content than the ammonium-based PIL [2-Sema][TfO], a well-studied electrolyte with promising electrochemical performance. These features of the PPILs are originate from the high acidity of the cation acting as proton donor in the ORR combined with a high oxygen permeability, ensuring a readily accessible oxygen supply for the cathodic reaction and thereby promoting faster reaction kinetics. Additional electrochemical impedance analyses (EIS) have also shown a higher current density associated with the (rate limiting) charge transfer process, in agreement with the LSV results. Moreover, also the areal capacitance of the double layer related process is higher. These results indicate that PPILs are potential candidates for fuel cell applications at elevated temperatures.

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Construction of Well-Curated Battery Material Database and Cycling Stability Prediction by Time-Series Machine Learning

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Over the past few years, the data-driven methods have proven their efficiency for processing large amounts of theoretically-derived or experimental data to uncover trends, which can hardly be grasped by other techniques. The existence of large and well-sorted datasets is essential for the application of such methods. The number of well-structured machine-readable datasets dedicated to lithium- and sodium-metal batteries reported in the literature, on the other hand, is fairly limited [1].

The present study aims to propose a relational database scheme for systematic management of experimental data for metal-ion battery-related materials. To validate the approach, experimental data produced by galvanostatic cycling and cyclic voltammetry of a series of peri-annulated naphthalimide cathode materials [2,3] were imported to the database. The organic cathode materials were chosen as model systems since they are promising materials for metal-ion batteries [4] because of offer gainful properties in terms of energy density per unit of mass, environmental compatibility and structure tunability (i.e., organic compounds can be synthetically modified to attain maximal specific capacity).

Finally, the galvanostatic cycling data imported were analysed with different time-series machine learning algorithms such as echo state networks, random forests and Long Short-Term Memory (LSTM) networks to predict how the state of health of the electrochemical cells under study evolves with time and hence to determine the onset of irreversible degradation processes leading to capacity fade.

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Electrocatalytic Biomass-Derived Carbon Cathodes for Selective Two-Electron Oxygen Reduction and Efficient Electrochemical Hydrogen Peroxide Generation

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The selective electrochemical production of hydrogen peroxide (H_2O_2) through the two-electron oxygen reduction reaction ($2e^-$ ORR) has emerged as a promising alternative for water treatment owing to its low energy demand and in situ generation of reactive oxygen species. Developing efficient, metal-free electrocatalysts capable of promoting the $2e^-$ ORR pathway remains a key challenge for improving H_2O_2 electrosynthesis. In this work, Toray® carbon paper cathodes were modified with electrocatalytic carbon materials derived from the biomass of Phragmites australis and Spergularia rubra. The carbon materials were synthesized by hydrothermal carbonization followed by KOH activation and thermal treatment. Their physicochemical properties were investigated by scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), X-ray photoelectron spectroscopy (XPS), Fourier-transform infrared spectroscopy (FTIR), and Raman spectroscopy.

The structural characterization revealed that the biomass-derived carbons exhibit abundant oxygen- and nitrogen-containing surface functionalities together with a highly defective carbon structure (I_D/I_G > 1), features that are recognized as active sites favoring oxygen adsorption and the selective $2e^-$ ORR pathway. Electrochemical measurements demonstrated that the modified cathodes significantly enhanced H_2O_2 electrogeneration compared with pristine Toray® carbon paper. The influence of dissolved oxygen availability was evaluated under controlled aeration conditions, while cyclic voltammetry performed using a polycrystalline platinum electrode and DigiSim® 3.0 simulations enabled estimation of dissolved oxygen concentration and kinetic parameters associated with oxygen reduction. The improved catalytic performance was correlated with the increased density of structural defects and oxygenated surface groups identified by spectroscopic characterization.

The enhanced H_2O_2 electrogeneration promoted the formation of hydroxyl radicals (•OH) (Figura 1 and Table 1), enabling complete degradation of amoxicillin under the best operating conditions while considerably improving mineralization and reducing solution toxicity (Figura 2). These results demonstrate that biomass-derived carbon materials constitute sustainable and efficient metal-free electrocatalysts for selective H_2O_2 electrosynthesis and highlight the strong relationship between surface chemistry, carbon defect density, and electrochemical activity toward advanced oxidation processes.

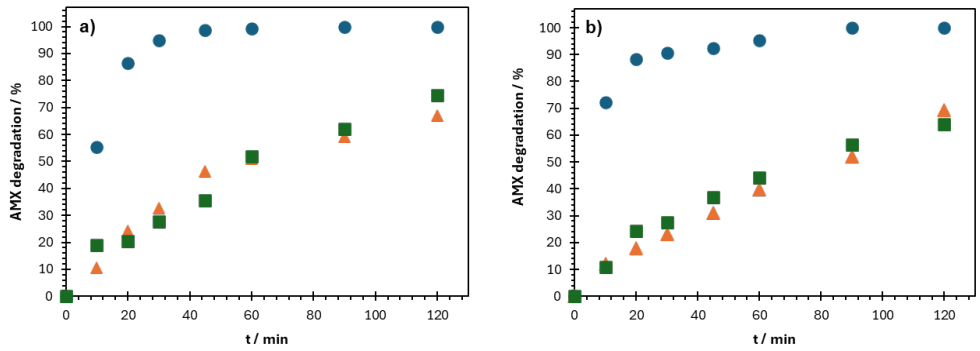


Fig. 1 Influence of tert-butanol and isopropanol as scavengers on the time course of AMX degradation percentage using carbon-based cathodes. Toray® carbon paper cathode modified with (CEM) from PA (a) and SR (b), without scavenger (●), tert-butanol (▲), and isopropanol (■). Current density: 0.85 mA cm-2, supporting electrolyte: Na_2SO_4 0.1 M, 200 rpm, and 24 °C.

Table 1 Pseudo-first-order kinetic constants of reactive species in AMX degradation.

	Without Scavenger	***Tert-butanol***	***Isopropanol***
Phragmites australis	*0.0977*	*0.0127*	*0.0112*
Spergularia rubra	*0.1118*	*0.0091*	*0.0091*
Platinum	*0.0075*	*0.0075*	*0.0075*

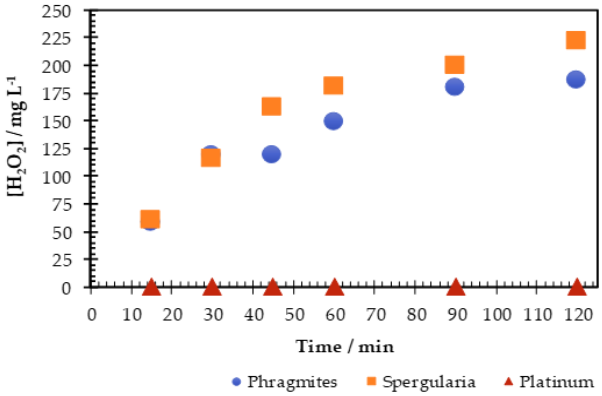


Fig. 2 H_2O_2 generation over 120 minutes for the functionalized cathodes (CEM) of Phragmites (●) and Spergularia (■) with j = 5.08 mA cm^{-2}.

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Electrodeposition and Characterization of Amorphous Ni-Mo Coatings

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Nickel is alloyed with many metals, such as molybdenum, resulting in alloys with improved corrosion resistance, exceptional high-temperature strength, shape memory, low coefficient of thermal expansion, and other properties.

This study focuses on the preparation and characterization of amorphous Ni-Mo (~50 wt% Mo) coatings with the aim of improving their performance properties. The coatings were obtained by electrochemical deposition from weakly acidic citrate-based aqueous electrolytes containing nickel and molybdenum salts at two current densities. The influence of these parameters on the composition, morphology, structure, and electrocatalytic properties of the coatings was thoroughly investigated.

The characterization of the obtained coatings was performed using X-ray diffraction (XRD), differential thermal analysis (DTA/TG/MS), scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and X-ray photoelectron spectroscopy (XPS). The results show the formation of an amorphous structure depending on the deposition conditions and the molybdenum content.

The electrocatalytic activity of the alloy coatings with respect to the hydrogen evolution reaction (HER) was investigated using electrochemical methods. A relationship was established between the chemical composition and the catalytic properties of the coatings.

Acknowledgments

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Ferrocene Modified MIPs for (Redox Probe)-Free Electrochemical Sensing

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Molecularly imprinted polymers (MIPs) are bio-mimicking recognizing materials used for sensors fabrication [1, 2]. Analytical parameters of these chemosensors, such as sensitivity, selectivity, and detectability, are almost as high as those of biosensors. MIP-based chemosensors are superior concerning their ease of fabrication, durability, and tolerance to harsh experimental conditions, including elevated or decreased temperature, high ionic strength, extreme pH values, the presence of heavy metal ions and organic solvents. Therefore, MIP-based chemosensors found numerous applications in environmental analysis [3], food quality control [4] and clinical analysis [5].

For the electrochemical determination of non-electroactive analytes, some external redox probe is usually added to the test solution [6, 7]. In our works we have proven that it is possible to immobilize redox probe inside of the MIPs' polymer matrix by co-polymerization of monomers containing ferrocene groups [8, 9], or to introduce ferrocene moieties into MIP molecular cavities via post-imprinting modification [10]. Obtained redox active MIPs' were characterized with electrochemical methods, including, cyclic voltammetry, differential pulse voltammetry, electrochemical impedance spectroscopy, scanning electrochemical microscopy and capacitive impedimetry as well as E-QCM (quartz-crystal microbalance) and E-SPR (surface plasmon resonance spectrometry).

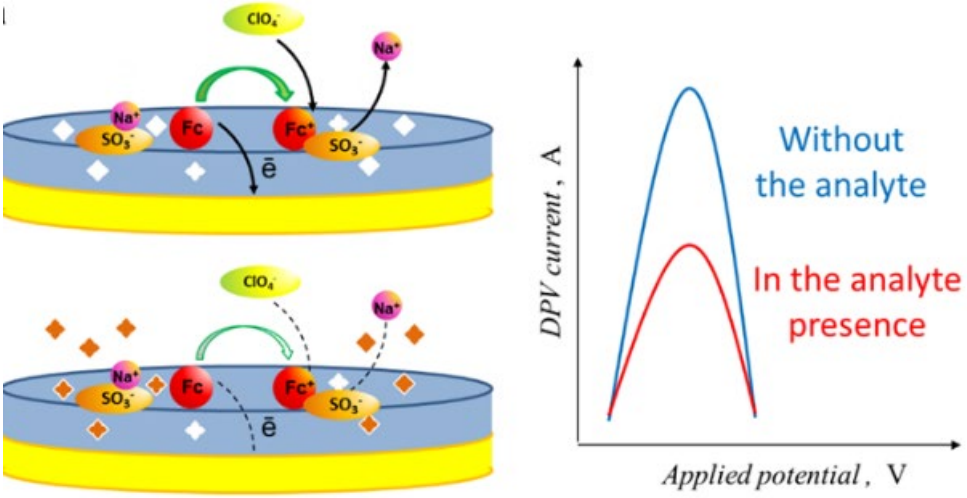


Fig. 1 Application of ferrocene containing MIP in chemosensing.

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From Molecular to Protein Junctions: Computational Approaches to Charge Transport

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Charge transport in molecular and biomolecular junctions depends on structural motifs, chemical bonding, redox-active sites, environmental effects, thermal fluctuations, and the alignment of molecular and metallic electronic states. As a result, the dominant transport mechanism can change markedly between environments. For instance, native redox proteins typically mediate electron transfer by an incoherent hopping mechanism, but they can facilitate electron tunneling when they are attached between metallic electrodes [1-5], as it is typical for scanning tunneling microscopy (STM) and molecular nanoelectronics applications.

For interpreting experimental data and elucidating the details of the transport mechanism, computational studies that provide atomistic and electronic structure are essential. Conventionally, Landauer formalism and non-equilibrium Green's function (NEGF) methods based on electronic-structure calculations within density functional theory (DFT) are applied. However, relatively high computational cost limits such calculations to relatively small systems. For larger biomolecular junctions, including peptides and proteins, more approximate yet reliable methods are required [6]. These include simplified electronic-structure models, band-alignment correction schemes, approximate treatments of electrode coupling, and linear-response descriptions of external fields. In this contribution, we will discuss the applicability and accuracy of such approaches using model molecular and protein junctions (Fig. 1) that were previously studied experimentally.

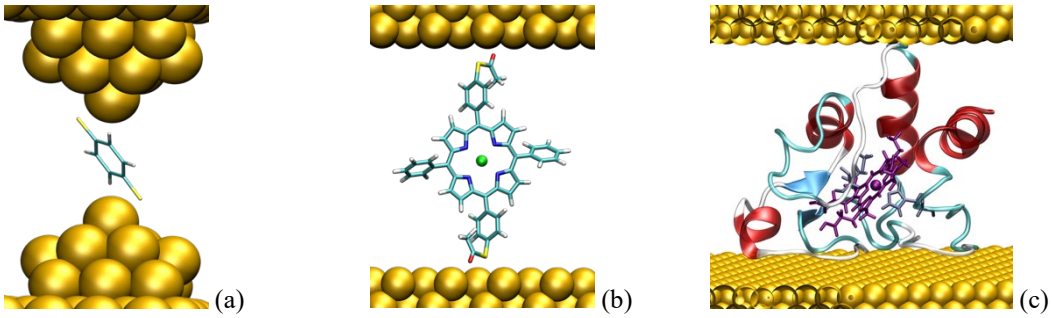


Fig. 1 Atomistic models of (a) benzene-1,4-dithiolate bridge (BDT), (b) Zn-porphyrin junction (ZnTPP), and (c) cytochrome c between two flat gold contacts used for electron transport calculations.

Acknowledgment
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A Controlled Monitoring of Ni Coarsening and Depletion through Electrochemical Testing Methods

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For the development of high-performance and durable Solid Oxide cells (SOCs), an in-depth study of degradation mechanisms is critically important. In this regard, the problem solving approach lies in the artificial aging of the fuel electrode where the Redox cycling has served as a tool. Based on this approach an accelerated stress testing (AST) protocol is developed and verified in terms of applicability and reproducibility. A quantitative match of artificially induced degradation with the calendar aging of the cell is presented that proves the reliability of the results which can be used for any improvement strategy.

The electrochemical testing methods are the primary tools used to identify and quantify the performance loss in SOCs as well as in other electrochemical devices. While *i-v* curves give a qualitative and integral picture of degradation, the electrochemical impedance spectroscopy (EIS) presents a wider view of different degradation mechanisms at a defined working point. In this work the degradation in fuel electrode as the coarsening of Ni particles and Ni depletion due to volatilization and migration, is explored through *i-v* curves and EIS, in combination with an advanced method, differential impedance analysis (DIA), providing a deeper insight into the electrode processes and degradation mechanisms.

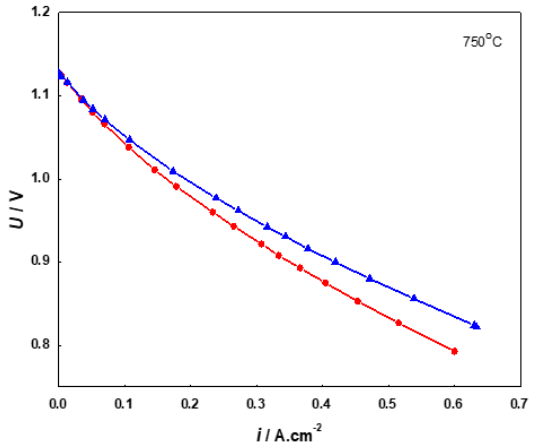


Fig. 1 Current-voltage (i-V) curves of the aged cell before 20 redox cycles (▲) and after 20 redox cycles (●).

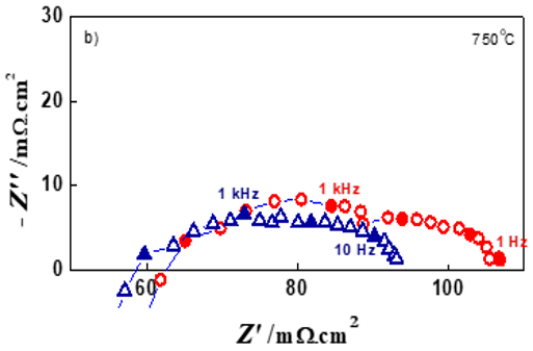


Fig. 2 EIS diagram: before degradation (▲) and after degradation (●) under load of 0.5Acm^{-2}.

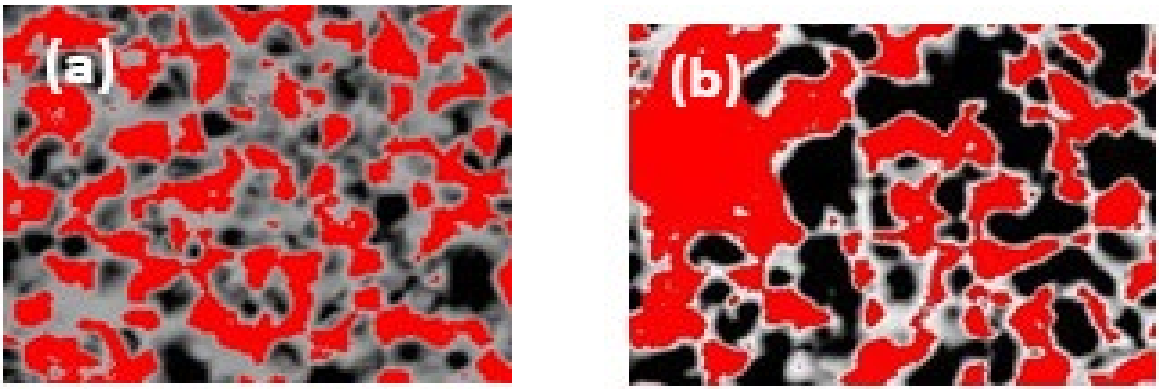


Fig. 3 SEM-BSE images: a) pristine cell b) cell after 20 redox cycles) (red – Ni; black – pores; grey – YSZ) (2μm resolution).

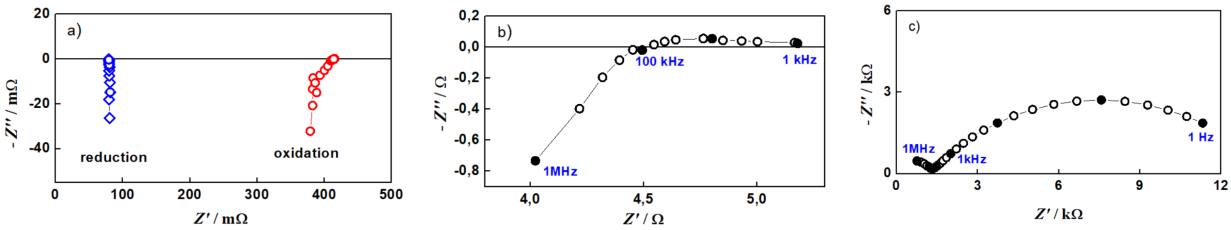


Fig. 4 Oxidized and reduced states of bare anode at 750^{o}C (a), 2 min. oxidation/24 min in N2 flow (b), 5 min. oxidation/270 min in N2 flow (c).

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Reference Potential for Non-Ideal Media

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Hydrogen scale of electrochemical potentials is based on Faradayic reaction:

$$2H^+(solv) + 2e^-(solv) = H_2(solv) \qquad (1)$$

It is realized by normal hydrogen electrode (NHE) consisting of platinized/platinum electrode immersed in aqueous acid of hydrogen ion activity $a_{H+} = 1$, under 1 atm pressure of H_2, at 25 ^{0}C and pressure of 1 atm of hydrogen, so called *ideal medium*. Most electrochemical experiments are done in *non-ideal medium.* That is depicted in Fig. 1, in which the ideal medium is shown as black bar at corner A. Any other point X in the triangle ABC is a non-ideal.

Because use of NHE in electrochemical experiment is impractical, *secondary reference electrode* is used for measurement of cell voltage E_{cell}. The two electrodes are separated by ionic liquid junction (//). For example, popular silver-silver chloride electrode is used in the cell:

$$Pt/H_2\ (1\ atm)/H^+(H_2O)(a = 1)\ //\ 0.1M\ KCl(H_2O)Ag/AgCl \qquad (2)$$

Therefore, experimentally accessible cell voltage is:

$$E_{cell} = \pi_H - \pi_{Ag/AgCl} + \pi_{LJ} \qquad (3)$$

Inclusion of secondary reference electrode generates *liquid junction potential* π_{LJ} which has its origin in the different *mobilities* of all ionic and neutral species present in the junction. It has to be included in the measured cell voltage. If the chemical potential gradients of all these species are zero, the liquid junction potential is also zero. In experiments performed in water the liquid junction potential is *assumed* to be small. Under those conditions the measured voltage of the cell shown in Eq. 2 is +0.288 V, on hydrogen scale.

However, most electrochemical experiments are done in media which are far from ideal (Fig. 1). Mobilities of the solvated species in an arbitrary non-ideal medium are unknown. That introduces an unknown, irreproducible and unstable liquid junction potential, which can introduce an error of hundreds of millivolts in some experiments.

Metallocenes have been investigated[1] as a possible reference, in an attempt to mitigate this problem. However, until now all such experiments had failed to link the potentials of metallocenes in non-ideal media to NHE in water. The goal of this presentation is to show how the hydrogen scale of potentials for experiments performed in a non-ideal medium can be created[2]. It is done by measuring the cell voltage between *universal reference electrode (URE)* and a *metallocene electrode (ME)*[3]. By such procedure the error caused by the liquid junction potential is eliminated.

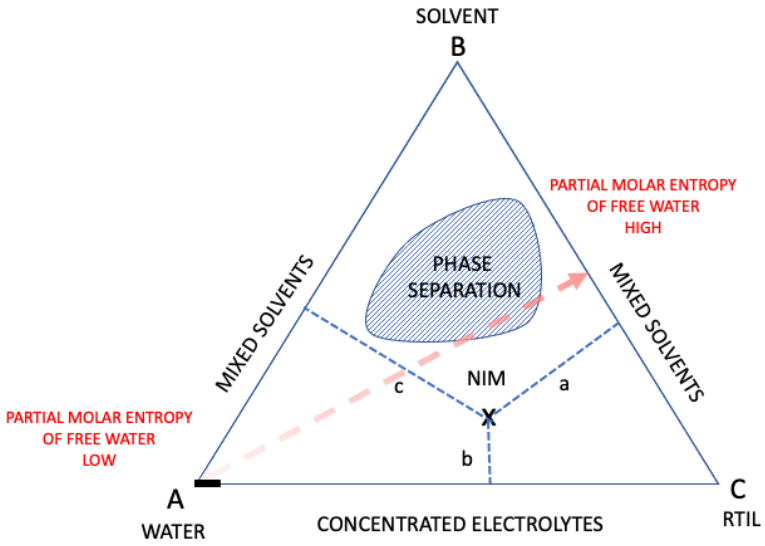


Fig. 1 Realm of experimental electrochemistry. Corners of the triangle represent ideal aqueous medium (A), miscible organic solvents (B) and ionic liquids (C). Phase separation may take place at certain compositions. Entropy of free water (dashed red arrow) increases from point A to line BC.

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Development of a Voltammetric Method for Dicamba Determination at Boron-Doped Diamond Electrodes and Investigation of its Electrooxidation

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Dicamba (3,6-dichloro-2-methoxybenzoic acid; DCB) is a widely used systemic herbicide for protecting diverse crops such as corn and cotton [1]. The increased use of pesticides generally requires reliable, effective analytical tools to control their use or monitor them in the environment. The main targets of the present work were to develop a simple voltammetric approach for the detection of DCB in model and real samples and to describe the mechanism of its electrooxidation on a boron-doped diamond electrode (BDDE). Based on the literature survey, the voltammetric behaviour of DCB has not been described previously; thus, our work provides a first insight into this topic.

The experiments were carried out in a classic three-electrode setup, with BDDE as the working electrode, and on a screen-printed sensing three-electrode platform with BDDE as the working electrode (SP/BDDE) as well. In both cases, DCB provided a well-developed signal in acidic supporting electrolytes at high potential (+1.9 V vs Ag/AgCl/KCl (sat.) (BDDE) and +1.5 V vs. pseudo-reference Ag/AgCl electrode (SP/BDDE)), and a poorly developed reduction response. The anodic peak was stable and suitable for analytical purposes. The oxidation mechanism was studied using GC-MS, and decarboxylation was identified as the most probable reaction pathway. More attention was devoted to the development of a voltametric approach for DCB determination. The experimental parameters of differential pulse and square-wave voltammetry at the BDDE were optimized. Both methods provided excellent repeatability of measurements (RSD_{11} < 3%), wide linear dynamic range (LDR) and low limit of detection (LOD). Finally, DPV was chosen for further experiments due to lower LOD (2.7×10^{-7} mol/L) and wider LDR (from 0.5 to 70×10^{-6} mol/L). The developed DPV method was also applied to SP/BDDE, providing comparable results. The proposed method was verified by the analysis of model samples and real samples of two commercially available agrichemicals containing DCB with excellent repeatability of determination (RSD_5 < 5%) and high accuracy, confirmed by comparative HPLC analysis. The proposed method enabled the successful determination of DCB also in spiked natural water (5×10^{-9} mol/L) samples after prior ion-exchange preconcentration.

Acknowledgements
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Insight into Degradation Mechanism of PFAS on Ti_6O_{11} Electrodes

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Electrochemical oxidation of PFAS compounds on a Ti6O11, Magnéli phase layer deposited on a titanium mesh, was carried out under under a potentiostatic regime at 7 V for 5 h, with UPLC-MS/MS analysis confirming high degradation efficiency. PFOS removal reached 94%, while PFOA degradation achieved 67%, indicating faster oxidation kinetics for PFOS. Kinetic analysis showed that the degradation process could be described by both pseudo-first-order and pseudo-second-order models, with a better fit obtained for the pseudo-second-order model, suggesting the dominant role of radical species in the oxidation process. UPLC-MS/MS analysis identified short-chain transformation products during PFOA degradation, including PFHxA, PFHpA, PFPeA, and PFBA, confirming the stepwise shortening of the perfluoroalkyl chain. All detected intermediates remained below the limit of quantification due to the low initial PFOA concentration. In contrast, no stable transformation products were detected during PFOS degradation, indicating nearly complete mineralization. Ion chromatography further confirmed successful defluorination through the increase in fluoride ion concentration during treatment. In river water containing a mixture of PFAS compounds, very high removal efficiency was achieved for long-chain PFAS molecules (~95%), while lower degradation efficiencies were observed for short-chain species. These results demonstrate that Ti_6O_{11} is an efficient and stable anodic material for the electrochemical treatment of PFAS contaminants at environmentally relevant concentrations.

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Nickel Sulfide Electrocatalysts via Chemical Bath Deposition for Urea-Assisted Hydrogen Production

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The urea oxidation reaction (UOR) offers a sustainable pathway for coupling wastewater treatment with clean hydrogen production. However, its application is hindered by sluggish anodic kinetics and high overpotentials resulting from the complex six-electron transfer process. In this work, nickel sulfide (NiS) electrocatalysts were synthesized directly onto nickel foam (NF) using chemical bath deposition method. The influence of the number of deposition cycles (5, 10, 15, and 30 cycles) on the UOR performance was systematically investigated under alkaline conditions (1 M KOH + 0.33 M urea), and showed that 15 deposition cycles was optimal as evidenced by the lowest required potential at 50-200 mA/cm^2 (Figure 1). When comparing the electrocatalytic performance of 15-NiS@NF under UOR and oxygen evolution reaction (OER, 1 M KOH without urea) conditions, a current density exceeding 400 mA/cm^2 was achieved at 1.52 V vs RHE while the OER was almost completely suppressed, demonstrating a high selectivity for UOR. This high selectivity was further confirmed by a detailed investigation of the UOR and OER using electrochemical impedance spectroscopy (EIS) at different potentials. This study presents a facile synthesis technique for highly active and selective UOR electrocatalysts, offering promising potential for the simultaneous advancement of energy conversion and urea-rich wastewater treatment.

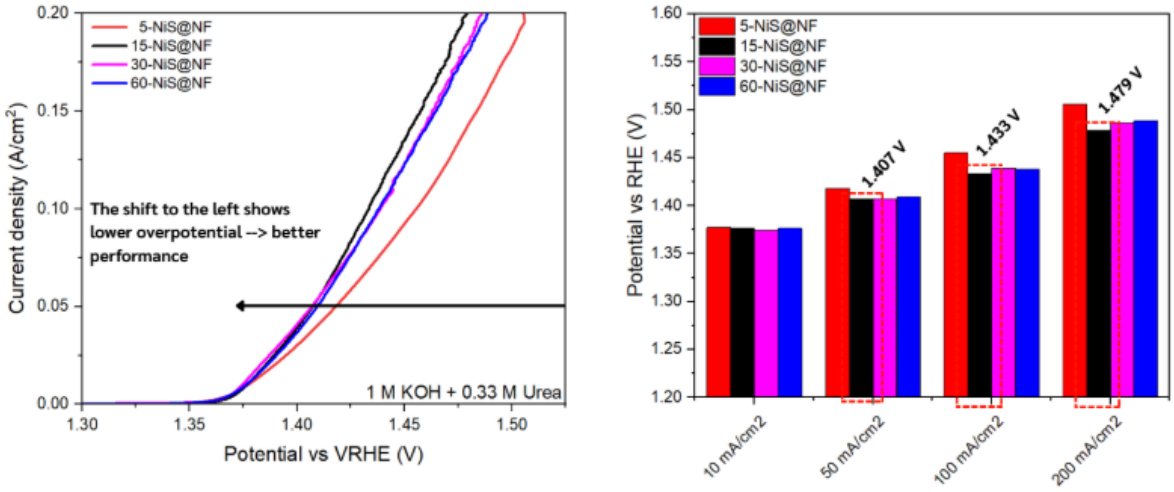


Fig. 1 Required potential at different current densities for NiS@NF electrocatalysts prepared with different number of chemical bath deposition cycles. Conditions: 1 M KOH + 0.33 M urea.

Derivatization-Based HPLC Ammonia Quantification and Time-Resolved Analysis of Lithium-Mediated Nitrogen Reduction

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Lithium-mediated electrochemical nitrogen reduction (LM-NRR) has emerged as the only credible electrochemical route for decentralized ammonia production from atmospheric nitrogen [1–3]. However, further progress is strongly limited by insufficient mechanistic understanding of the dynamically evolving solid electrolyte interphase (SEI), as well as by challenges associated with reliable ammonia quantification.

In the first part of this work, I will introduce a novel derivatization strategy for ammonia detection based on the condensation of gaseous ammonia with benzaldehyde, yielding three products—phenylmethanimine (monomer), a dimer, and hydrobenzamide (trimer)—which can be adequaltely analyzed by high-performance liquid chromatography (HPLC). The developed HPLC method was subsequently validated against ion chromatography during LM-NRR experiments conducted in LiTFSI/diglyme electrolytes. The obtained Faradaic efficiencies (FE_{NH3}) agree within 20%, confirming the reliability of the proposed approach while providing a more accessible alternative for ammonia analysis.

In the second part, I will focus on the dynamic behaviour of LM-NRR under quasi time-resolved conditions, with particular emphasis on the influence of EtOH as the proton donor. Our quasi time-resolved LM-NRR measurements revealed a pronounced dependence of ammonia formation on EtOH concentration, with intermediate EtOH content consistently yielding the highest FE_{NH3}. Temporal analysis further demonstrated that LM-NRR performance evolves dynamically during operation rather than remaining in a steady state. Open-circuit potential decay measurements suggested that the passivation capability and transport properties of the SEI strongly depend on proton donor concentration and continuously change during cycling. Potentiostatic electrochemical impedance spectroscopy revealed substantial differences in lithium accessibility, interfacial reaction resistance, and Li^+ transport through SEI as a function of EtOH concentration. At low EtOH concentrations, inactive SEI-protected lithium accumulates on the electrode surface, whereas excessive EtOH concentrations lead to severe transport limitations through increasingly clogged SEI structures. These findings support the existence of an optimal intermediate SEI morphology balancing lithium accessibility, reactant transport, and suppression of parasitic reactions. Overall, these findings provide both a practical analytical platform for ammonia quantification and new mechanistic insight into the dynamic role of proton donors and SEI evolution in LM-NRR systems.

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Cathode-Free Li–Sulphur Batteries: Catalysts for Polysulphide Conversion

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Cathode-free lithium-sulphur (Li-S) batteries offer a promising route toward maximizing practical energy density by eliminating pre-fabricated sulphur/carbon composite cathodes. Here, the solution-based lithium polysulphides (Li_2S_6 or Li_2S_8) undergo reversible in-situ electrochemical conversion on inert carbon substrates, removing the need for bulk sulphur host matrices, binders, and auxiliary additives, such as TiO_2, TiO_xN_y or $Li_4Ti_5O_{12}$ [1-4]. A practical embodiment involves, e.g., catalytic carbon nanofibers containing Fe, Co, and Ni, synthesized via pyrolysis of filter paper impregnated with the corresponding metal chlorides [5]. This so-called medium-entropy catalytic alloy is a variant of high-entropy oxychloride catalysts, which accelerate the redox reactions of polysulphides [6]. Another polysulphide catalyst is based on bismuthene [7]. A commercial carbon buckypaper is a promising substrate for polysulphide conversions in the CR2032 coin cells assembled with a lithium metal anode, a glass fiber separator and a LiTFSI-based electrolyte solution. Polysulphide catholytes were prepared either via preparative electrolysis of the S/C composites or by prolonged stirring of stoichiometric mixtures of Li_2S and S_8 in a 1:1 (v/v) mixture of 1,3-dioxolane and 1,2-dimethoxyethane. Advantages of the cathode-free design are demonstrated through comparison with conventional sulphur/carbon composite cathodes prepared either by mechanical mixing or by melt-impregnation with elemental sulphur (S_8). Cyclic voltammetry, galvanostatic charge/discharge cycling, and electrochemical impedance spectroscopy consistently confirm the reversible conversion of soluble polysulphides (Li_2S_6 or Li_2S_8) to Li_2S during discharge, followed by sulphur regeneration upon charging, without the necessity of a bulk sulphur composite cathode. While elimination of the traditional sulphur/carbon composite cathode reduces inactive mass and improves theoretical energy density, it also keeps challenges such as incomplete sulphur utilization, polysulphide shuttling, and limited cycle life. Overall, cathode-free Li–S battery is a promising pathway toward high-energy-density storage systems for next-generation electric vehicles and grid-scale applications.

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Electrodeposition from Ionic Liquids and Deep Eutectic Solvents: Co, Ni and Co-Ni Systems

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The growing demand for environmentally sustainable electrochemical technologies has driven the development of alternative electrolytes for the metal deposition process. Deep eutectic solvents (DESs) have emerged as promising alternatives due to their low volatility, nonflammability, broad electrochemical stability window, and tunable physicochemical properties [1]. DESs outperform conventional aqueous electrolytes in terms of metal deposition control while also lowering environmental impact. Ethaline-based DESs have received a lot of attention for electrodeposition applications due to their high metal salt solubility and excellent electrochemical performance [2].

This study aims to analyze the electrochemical behaviour and electrodeposition of Ni, Co, and Co-Ni systems using ethaline-based deep eutectic solvents, including $NiCl_2$ and $CoCl_2$. Cyclic voltammetry and galvanostatic electrodeposition are used to investigate the effect of temperature and electrolyte composition on deposition kinetics, electrochemical stability, and coating morphology in DES electrolytes. Experiments are conducted with inert glassy carbon electrodes in a three-electrode electrochemical setup. This study emphasizes the considerable influence of temperature and electrolyte composition on metal electrodeposition in DES systems and illustrates the viability of using ethaline-based electrolytes for long-term electrochemical processing of transition metals and alloys. The findings contribute to advance electrodeposition technologies and serve as a platform for future research on Co-Ni alloy production in deep eutectic solvents.

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Influence of Transition Metals on Ni Sulfide-Based Electrocatalysts for Alkaline Urea Oxidation Reaction

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Nickel (Ni) sulfides have emerged as promising electrocatalysts for the alkaline urea oxidation reaction (UOR), and their performance may be further improved through combinations with other transition metals [1]. In this work, we synthesized a series of bimetallic Ni-based sulfides (with Cr, Mn, Fe, Cu, or Zn) deposited onto nickel foam (NF) electrodes. The electrocatalytic performance for the UOR was evaluated in a three-electrode configuration in 1 M KOH with 0.33 M urea [2]. Linear sweep voltammetry (LSV) measurements indicated that at a low current density (10 mA/cm^2), NiMnS/NF exhibited the highest activity and required a potential of only +1.363 V vs RHE (Figure 1). This was followed by NiFeS/NF (+1.370 V) and NiCrS/NF (+1.377 V), whereas Cu and Zn addition negatively affected UOR performance (+1.407 V both). The electrochemical impedance spectroscopy (EIS) measurements confirmed that NiMnS/NF exhibited a lower charge-transfer resistance towards UOR than the other electrodes. The highest electrochemically active surface area (ECSA) was obtained for NiFeS/NF, despite the actual Fe incorporation as measured by EDX analysis was lower than other metals. X-ray diffraction did not detect crystalline metal sulfides, suggesting the deposits were either amorphous or present in small amounts. These results demonstrate that bimetallic sulfide modification of NF is an effective approach for enhancing the UOR performance under alkaline conditions.

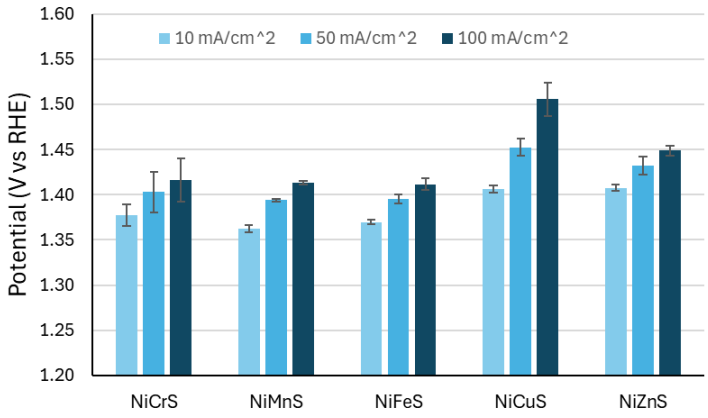


Fig. 1 Required potential at different current densities for transition metal containing Ni sulfide electrocatalysts on Ni foam under alkaline UOR conditions (1 M KOH + 0.33 M urea).

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Spectroelectrochemical Monitoring of pH Changes in the Pulsed Electric Field

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Pulsed electric field (PEF) has rapidly growing applications in medicine, food industry or biotechnology. PEF acts on biomolecules via several interwoven mechanisms, being far from completely understood. [1,2] In electrically conductive samples, charge transfer reactions occur at electrode/sample interfaces, having diverse chemical consequences including pH changes. Here, we develop a spectroelectrochemical (SEC) approach to track pH changes at the anode and cathode in PEF based on the employment of colorimetric indicators.

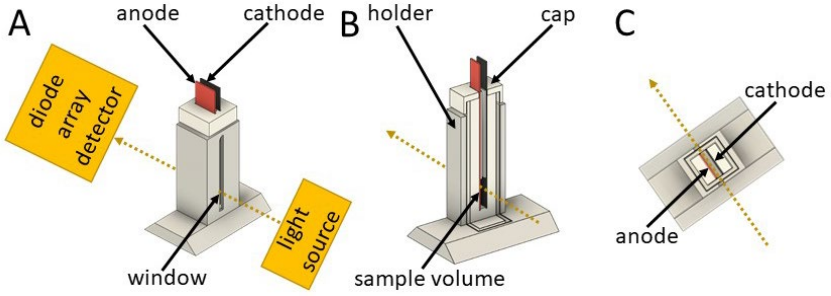


Fig. 1 SEC cell for measurements of pH changes induced by PEF developed and applied in this work. Overall arrangement (A), vertical (B) and (C) horizontal cross-section of the cell.

The proof-of-concept is demonstrated for the PEF cell filled with originally neutral (pH = 6.8) PIPES buffer and phenol red (pK_a = 7.9) selected as the indicator. At the cathode (OH^- is electrogenerated), the parent indicator band is diminished, while a new band reporting alkaline pH emerges, in line with expectations. At the anode (H^+ is formed), no profound shifts are observed. Changes of pH are completely suppressed when bipolar (alternating cathodic and anodic pulses) are applied. Thus, we demonstrate that pulse architecture has decisive influence on the pH changes in the sample subjected to PEF.

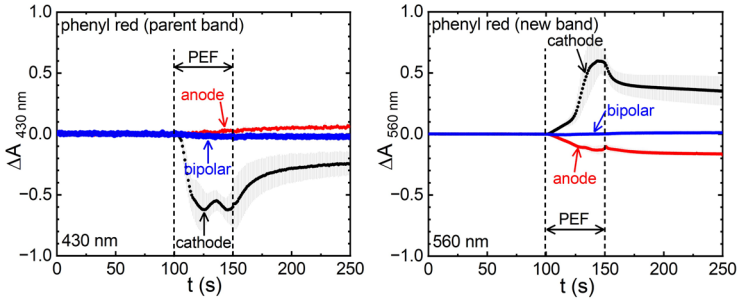


Fig. 2 Absorbance transients (mean values and standard deviations) obtained for parent (left) and new (right) absorption bands of phenyl red for cathode and anode in unipolar pulses and for bipolar pulses.

Acknowledgments
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Computationally Efficient Catalyst Agglomeration Model Based on Scaling Relations of Particle Size Distribution

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Despite significant improvements in recent years, degradation of carbon supported Pt catalysts, used in proton exchange membrane fuel cells, remains a significant limiting factor in their wider adoption. Catalyst particle agglomeration is an important factor in irreversible loss of electrochemically active surface area of catalyst layer. Agglomeration is initiated by electrochemical corrosion of carbon support in presence of water at high electric potentials. Modelling studies suggest that corrosion is additionally accelerated in the vicinity of Pt particles due to interaction between electrochemical reactions on Pt and carbon surface [1]. Corrosion of carbon support leads to loss of contact area between Pt nanoparticles and carbon support structure, which leads to detachment and attachment of particles to the neighbouring particles.

Mathematical modelling of this process is typically approached by applying particle size distribution (PSD) functions [2] using Smoluchowski coagulation equation [3], which can account for detailed dynamics of size-dependent particle detachment and agglomeration processes. However, the use of this method is computationally demanding, especially in large spatially resolved models of fuel cell operation and degradation.

To address this challenge, we performed a detailed numerical analysis of solutions of Smoluchowski coagulation equation, applied to the process of corrosion-initiated agglomeration of particles. Size-dependent coagulation kernel function was calculated based on Pandy model [1] of oxidation and radical species diffusion between Pt and carbon surface, as shown in Figure 1. Using these results, we demonstrate that for the case of agglomeration process in fuel cell catalyst layer, PSD functions follow a simple scaling law which allows PSD to be expressed solely as a function of mean particle size, as shown in Figure 2. Based on these findings, we have developed a first order differential equation which governs the evolution of mean particle size. We further demonstrate that this newly developed method represents a computationally efficient approach for calculation of particle size evolution in realistic fuel cell operating conditions.

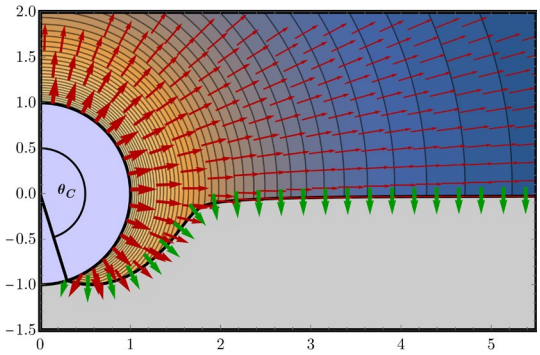


Fig. 1 Carbon corrosion simulation.

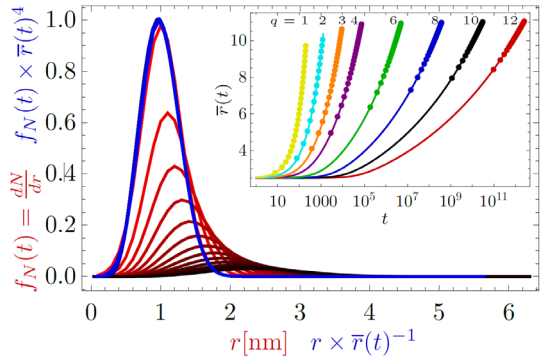


Fig. 2 PSD and mean particle size evolution.

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Length-Dependent Spin Polarization in Single α-Helical Peptide Junctions

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Chiral-induced spin selectivity (CISS) enables chiral molecules to act as efficient spin filters, yet the molecular parameters that govern the magnitude and limits of spin polarization remain poorly understood. Here we investigate spin-dependent charge transport through single α-helical peptide junctions with systematically varied lengths using spin-polarized scanning tunnelling microscopy break-junction (STM-BJ) measurements. All peptides adopt α-helical conformations, as determined from circular dichroism (CD) spectroscopy, providing a well-defined chiral framework for transport. We directly measure spin-up and spin-down conductance and observe a pronounced length dependence of the spin polarization. For short peptides, spin polarization increases rapidly with molecular length, whereas for longer peptides it saturates at values approaching ~0.6. Analysis of the spin-resolved conductance decay reveals that this crossover originates from the evolution of the spin-dependent attenuation factors, which differ strongly at short lengths but converge as molecular length increases. A theoretical model incorporating the helical structure and dephasing parameters reproduce the experimentally observed transition from a CISS-dominated regime to a dephasing-limited regime in which further length extension does not enhance spin selectivity. These results identify molecular length as a key control parameter governing both the efficiency and fundamental limits of spin polarization in chiral molecular junctions, with direct implications for spin-selective charge transport in biomolecular systems.

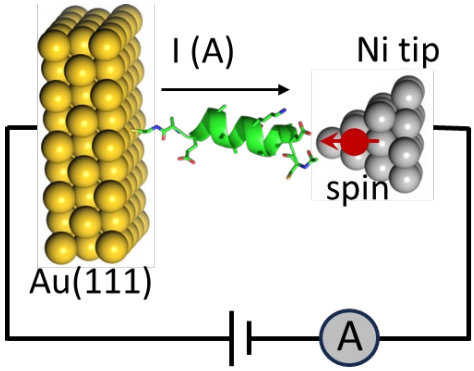


Fig. 1 Schematic illustration of a single-molecule scanning tunnelling microscopy break-junction (STM-BJ) setup, where an α-helical peptide bridges an Au(111) substrate and a magnetic Ni tip for spin-dependent charge transport measurements.

Exploration of Malva Sylvestris L., an Albanian Medicinal Plant, as a Promising Green Corrosion Inhibitor for Mild Steel MS 235 in Aggressive Acidic Media: A Machine Learning-Assisted Predictive Study

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Albanian *Malva Sylvestris L.* (MSL.) as part of traditional medicine, uses only the flowering tops, while traditional world medicine uses all parts of the plant: roots, leaves, flowers and fruits. Bioactive substances such as coumarins, polyphenols, flavonoids, terpenes and tannins are reported to have strong antioxidant, anti-inflammatory, antimicrobial, antiseptic properties and good protective effects related to cardiovascular, respiratory, infectious, digestive and cancer diseases. [1], [2] The characterization of polyphenols and flavonoids in Albanian MSL. alcoholic extract, was analysed by spectral methods UV-VIS and ATR-FTIR. Total phenolic content (TPC) at MSL. alcoholic extract, results to have 41,33; 47,19 and 13,39 mg GAE/g DEx, respectively at leaves, flowers and roots. This amazing plant, because of these bioactive compounds, can be used as an eco-friendly inhibitor for the protection of mild steel: MS 235 against extremely aggressive mix acidic conditions (0.5 $molL^{-1}$ H_2SO_4 / 0.5 $molL^{-1}$ HCl). Corrosion inhibition efficiency of MSL. extract was tested by weight loss, electrochemical techniques, as potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS). The optimal values of the inhibition efficiencies (IE%) of MSL. extract from WL, PDP and Rp were found to be in good correlation respectively 79.8% (referred 100 hours immersing time at 298 K), 80.41% and 77.93, at the concentration 600 mg/L of the inhibitor. Thermodynamic analysis showed that the adsorption mechanism of the inhibitor at 298K followed the Villamil isotherm with K_{ads} = 35.382 L/g and ΔG^0_{ads} = -25.95kJ/mol, which suggests a multilayer adsorption with a spontaneous mixed chemo-physisorption mechanism. The anodic shift of OCP, indicates an anodic inhibitor. At higher temperature 308K and 318K, the adsorption mechanism followed the Temkin isotherm with $\Delta G^0_{ads} \approx$ -28.00kJ/mol which suggests a mixed chemo-physisorption mechanism on the active zone of the heterogeneous metal surface, influenced by lateral molecular interaction. The WL method data, for different inhibitor concentrations, in different temperatures with different testing times were used for machine learning prediction. The results are in line with the experimental findings. In addition, the mild steel MS 235 surface was examined post immersion, using Fourier Transform Infrared spectroscopy (FTIR), scanning electron microscopy (SEM), energy dispersive x-ray spectroscopy (EDX), and contact angel (CA) techniques. It turns out that the alcoholic extract of MS leaves, is a green inhibitor very effective, while being quite sustainable and eco-friendly with the environment.

Keywords
MSL. plant, eco-friendly inhibitor, machine learning, adsorption isotherm.

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Optimization of Some Important Parameters of Electrochemical Ferrate Production Using Dual Dynamic Voltammetry

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One of the most used techniques for producing ferrate ions (FeO_4^{2-}) is electrochemical. This method can yield a very pure product and doesn't require expensive chemicals. In this process an iron-containing sacrificial electrode is oxidized in a highly alkaline solution during the electrochemical generation of ferrate ions. [1]. However, in the relevant potential region, vigorous oxygen evolution diminishes current efficiency, complicating the quantification of produced ferrate ions from the electrochemical data. Moreover, the inherent instability of ferrate ions renders conventional analytical methods for their determination, which rely on sampling, unreliable and characterized by low temporal resolution.

The rotating ring-disk electrode (RRDE) is a common example of generator-collector systems made up of two electron conducting components: the ring (collector) surrounding the centrally located disk (generator). The operating principle of RRDEs is that products of the disk electrode reaction – the rate of which may be influenced by rotation – move to the ring by forced convection, where they participate in an additional electrochemical reaction and will thus be detected. In contrast to classical RRDE experiments, where potentiostatic control is applied to at least one of the electrodes, new techniques were developed in the past decade that utilized dynamic potential control of both electrodes at the same time. E.g. the method of "dual dynamic voltammetry" (DDV) [2] has been applied to study the mechanism of electrochemical formation of ferrate ions during the electrochemical dissolution of pure and white cast iron in the "transpassive" potential region [3,4].

During the experiments presented in this study the electrochemical synthesis of ferrate ions was performed from high-purity iron electrode in a 45 % (*m*/*m*) aqueous NaOH solution. The synthesis process was investigated using dual dynamic voltammetry (DDV) using a rotating Pt-ring – Fe-disk electrode setup. This method enables the real-time determination of the quantity of ferrate ions formed at the disk electrode. The effects of temperature, the electrode potential and the current density on the rate of ferrate ion formation were examined. By using the RRDE-DDV method the optimal potential range and current density at various temperatures were determined to maximize ferrate ion production and current efficiency.

The results obtained indicate that dual dynamic voltammetry is an effective technique for investigating challenging electrochemical systems. In addition to producing ferrate ions, the procedures followed in this work can be extended to other industrial-scale syntheses.

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Electrodeposition of Nanostructured Multilayer Protective Coatings with Controlled Phase Composition from Polyligand Electrolytes

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The electrochemical formation of multilayer coatings with alternating layers of different composition and phase structure is of interest for the creation of surface materials with enhanced protective and mechanical properties [1, 2]. This work proposes an approach for obtaining nanostructured multilayer coatings from polyligand electrolytes, which ensure sufficient reduction of the difference between the potentials for the co-deposition of metals and allow the phase composition of the layers to be controlled over a wide range of electrolysis conditions.

The key idea lies in using a single electrolyte for the sequential deposition of layers with different not only elemental but also phase compositions, while programmatically varying the potential or current density. This allows for the formation of coatings of the $[(M_1\text{-}M_2)_{base}/(M_1\text{-}M_2)_{add}]_n$ type, in which the base layers correspond to the composition and quality of traditional single-layer coatings, while the additional layers create new conditions for nucleation, promote structural refinement, increase the proportion of interlayer boundaries, and form regions enriched with intermetallic phases.

To optimize the electrodeposition processes, new methods have been developed for determining the parameters of kinetics of contact exchange using model polarization dependencies obtained by the method of nonlinear polarization corresponding to a change in the stationary potential of a metal surface [3], as well as for determining the chemical and phase composition of multiphase alloy films using stripping voltammetry [4], the results of which have been confirmed by X-ray phase and X-ray fluorescence analysis with a successive increase in layer thickness.

It is shown that the properties of multilayer coatings are determined not only by their composition but also by their architecture: the thickness of the bilayer and the ratio of the thicknesses of the base and additional layers.

It is established that the coatings $[(Cu\text{-}Zn)_{base}/(Cu\text{-}Zn)_{add}]_n$, $[(Cu\text{-}Sn)_{base}/(Cu\text{-}Sn)_{add}]_n$, $[(Cu\text{-}Ni)_{base}/(Cu\text{-}Ni)_{add}]_n$, and $[(Zn\text{-}Ni)_{base}/(Zn\text{-}Ni)_{add}]_n$, compared to single-layer coatings of the corresponding alloys, are characterized by higher microhardness, lower porosity, and higher corrosion resistance. The results obtained confirm that polyligand electrolytes can be considered an effective tool for the targeted electrochemical design of coatings with specified structures and properties [5].

The practical significance of this approach lies in the potential to increase the durability of coatings while reducing their material consumption, as well as in the promising applications of such materials in mechanical engineering, the energy sector, and surface engineering. Of additional interest is the fact that the same principles of electrochemical design were subsequently extended to the Zn-Ni-Cu and Ni-Cu functional systems to produce catalytically active surfaces, which underscores the versatility of the proposed concept.

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Use of Magneto-Electropolishing and Electropolishing in the Preparation of TiO_2-Modified Stainless Steel Electrodes to Reveal the Impact of TiO_2 Grain Boundaries on the CO_2 Photoconversion to Ethanol in an Acidic Aqueous Medium

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Photocatalytic CO_2 conversion to alcohols in acidic aqueous media represents an electrochemical research approach having a strong potential for application in the development of technologies based on the circular economy fundamentals. In this sense, the preparation of TiO_2-based photoanodes with an effective control of the photoactive area of TiO_2 electrodes is crucial to better understand the reaction mechanism and the overall conversion efficiency of CO_2 photoreduction to aliphatic alcohols [1]. In this investigation, stainless steel (AISI-304) mesh electrodes were electrophoretically modified by nanoparticulate TiO_2 films to carry out the photocatalytic conversion of CO_2 in a pH 2 sulfates aqueous buffer solution, when the stainless-steel (SS) substrates were polished (mirror-like finishing) utilizing three different techniques: magneto-electropolishing (MEP), electropolishing (EP), and the typical manual polishing (MP, as a control system). MEP and EP techniques were galvanostatically conducted (800 mA/cm^2) when immersing the SS substrates (2 cm-height, 1 cm-width) in an aqueous electrolyte containing 10.24 M H_3PO_4 and 2.09 M H_2SO_4 at 25 °C. Particularly, a magnetic field of 500 gauss intensity was additionally applied to the SS-electrolyte interface to carry out the MEP. For comparison purposes, the MP of the SS substrates was obtained utilizing SiC sandpapers with grits of 200 and 600 grain/in^2. Once the SS substrates (polished by MEP, EP, or MP) were electrophoretically modified (2 V/cm-electric field) by TiO_2 films, the as-prepared SS|TiO_2 photoanodes were employed to perform the CO_2 photoconversion to ethanol under UV illumination (365 nm). Our results demonstrated that, despite the electrophoretically deposited amount of TiO_2 being practically the same for SS substrates polished with MEP (1.90±0.39 mg/cm^2), EP (1.33±0.29 mg/cm^2), or MP (1.96±0.07 mg/cm^2), the final concentrations of ethanol were significantly different: 0.045±0.002, 0.108±0.003, and 0.159±0.005 %V/V, for SS|TiO_2 photoanodes prepared with SS substrates polished by MEP, EP, and MP, respectively. Photo-Electrochemical Impedance Spectroscopy (PEIS) experiments showed that the charge transfer resistance (R_{ct}) values associated with the CO_2 photoreduction in SS|TiO_2 photonodes prepared with SS substrates polished by MEP (1943 ± 34 kΩ cm^2), EP (584 ± 18 kΩ cm^2), and MP (488 ± 6 kΩ cm^2), confirmed that the highest ethanol concentrations were obtained on the SS|TiO_2 photonodes having the highest photochemical reactivity (i.e., the smallest R_{ct} value). Consequently, it was demonstrated that the reactivity of the SS|TiO_2 photoanodes can be efficiently controlled according to the technique employed to polish the SS substrates before the electrophoretic deposition of TiO_2.

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Enhanced Electrochemical Performance of Boron-Doped Diamond Electrodes via e-Beam-Evaporated Platinum Nanoparticles

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Boron-doped diamond (BDD) have become highly attractive electrochemical materials owing to their exceptional physicochemical and electrochemical properties, including a wide potential window, low background currents, remarkable chemical stability, corrosion resistance, and resistance to surface passivation [1]. These characteristics make BDD electrodes particularly suitable for advanced electroanalysis, electrocatalysis, and environmental monitoring applications [2]. Nevertheless, the inherently low electrocatalytic activity of pristine BDDE surfaces toward selected redox systems still limits their broader practical utilization.

Herein, we report a novel strategy for the fabrication of nanostructured modified screen-printed BDD platforms based on the direct e-beam evaporation of platinum nanoparticles (PtNPs). The developed deposition procedure enables precise control over nanoparticle morphology, surface coverage, and particle distribution, resulting in highly homogeneous and mechanically stable Pt nanostructures firmly anchored to the diamond surface. The proposed approach provides a rapid, reproducible, and scalable route for the preparation of advanced BDDE-based electrochemical materials with enhanced interfacial properties.

The morphology and structural properties of the prepared PtNP/BDD materials were investigated by scanning electron microscopy and Raman spectroscopy, confirming the successful formation of a highly developed nanostructured surface. Electrochemical characterization was carried out using cyclic voltammetry, electrochemical impedance spectroscopy in the presence of both inner-sphere and outer-sphere redox probes and Mott-Schottky analysis. PtNP modification significantly accelerated electron transfer kinetics, decreased charge-transfer resistance, and increased the electroactive surface area compared with bare BDD electrodes. Importantly, the modified materials exhibited excellent repeatability and reproducibility, with relative standard deviation values below 3.2% and 2.6%, respectively, demonstrating high fabrication reliability and operational stability.

The practical potential of the developed PtNP/BDD platform was demonstrated in two distinct application areas: electrochemical detection of Hg(II) ions and electrocatalytic hydrogen evolution reaction in acidic media. In both cases, the PtNP-modified electrodes exhibited substantially enhanced electrochemical responses and catalytic activity compared with unmodified BDD. The presented results highlight the strong potential of e-beam-fabricated PtNP/BDD nanostructures as versatile electrochemical materials for future sensing and energy-related applications.

Acknowledgements
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A Shot Noise Based Approach to Constant Phase Behaviour in Electrochemical Impedance Spectroscopy – the Concept of Frequency Dependent Charge Transfer Impedance

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The constant phase behaviour (CPE) is the most frustrating feature in electrochemical impedance spectroscopy (EIS). It is usually attributed to surface inhomogeneity, porous structure of the surface, or - following the analogy of dielectric spectroscopy – to the distribution of the time constants present in the investigated system. However, when it comes to the point to set up a model or equivalent circuit in order to fit the obtained spectra the constant phase behaviour is completely passed over to the capacitive components, *i.e.* to the double layer capacity or supposed geometric capacities, *etc*. The reason is very simple. Most of electrochemists using EIS are rather interested in kinetics and not in the capacitive behaviour of the interface. Consequently, electrochemists – including the author of the present work – insist on the inevitable presence of an ideal charge transfer resistance. We are so much addicted to that concept that we tend to neglect the origin of the charge transfer resistance itself. However, the constant phase elements in place of capacitors puzzles those who are interested in interfacial capacitances.

There are several ways to approach the concept of the charge transfer resistance one of them being the theory of shot noise. There are several misconcepts about shot noise namely that shot noise is present whenever a net current is flowing in a circuit, and shot noise is connected to a non-zero net current. Sometimes it is also claimed that shot noise is a non-thermally activated phenomenon since it is considered to be an intrinsic property of the flowing current. This is also a complete misunderstanding of shot noise.

In reality, shot noise takes place at such interfaces where the charge transfer is hindered. Even in thermodynamic equilibrium at such interfaces the shot noise is the noise generating process since elementary charge transfer steps take place both direction. The shot noise generation does not depend on the direction of those elementary steps, just on the corresponding elementary charge and on the frequency of those events.

Shot noise is strongly correlated to the dynamic resistance of the interface thus in electrochemistry the charge transfer resistance can be derived from the shot noise itself. The basic equation of shot noise is the Schottky Equation which corresponds to that case when there is no correlation between the individual elementary charge transfer steps. The ideal charge transfer resistance can be derived from that situation. However, if we assume that at high frequencies there can be a strong correlation between the elementary charge transfer events the conclusion is a frequency dependent element which may give an alternative explanation to the constant phase behaviour at higher frequencies.

The proposition of that work is to turn upside down our way of thinking in composing the impedance models. As for the charge transfer process such a frequency dependent element should be used the low-frequency limit of which can provide the value of the classical charge transfer resistance while an ideal capacitor can be applied for the double layer capacitance.

Example and fit results will be shown to demonstrate the applicability of the theory.

Electrochemical Performance of Supercapacitors Based on Modified Montmorillonite Electrodes

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The development of modern supercapacitor systems is focused on the use of low-cost, environmentally friendly, and high-performance electrode materials with good cycling stability. Supercapacitors are promising energy storage devices due to their high power density, fast charge–discharge processes, and long operational lifetime. In this context, clay minerals such as montmorillonite are of significant interest as structural platforms for the integration of electrochemically active components.

The present study is focused on the electrochemical behaviour of composite materials based on montmorillonite K10 with incorporated active additives – carbon material (YP80F), manganese dioxide (MnO_2), and silver nanoparticles (YP80F/AgNPs). The investigation of different additives synthesized via different methods aims to evaluate their electrochemical behaviour and determine their influence on electrical conductivity, capacitive performance, and electrode stability.

The electrodes were prepared by casting method, followed by thermal treatment to improve mechanical stability and adhesion properties. Electrochemical tests were carried out in a Swagelok-type cell, using an Aquivion® membrane pre-soaked in a sodium sulfate (Na_2SO_4) electrolyte solution.

The electrochemical characterization includes cyclic voltammetry at scan rates from 1 to 40 mV/s, galvanostatic charge–discharge measurements, electrochemical impedance spectroscopy (EIS), and cycling stability tests. Additionally, the contact angle was determined to evaluate the surface hydrophilicity of the electrodes.

The obtained results indicate that the montmorillonite matrix represents a suitable eco-friendly platform for the integration of electrochemically active components, providing good electrochemical stability and promising potential for application in supercapacitor systems. It was found that the structure of the composites and the interactions between individual components have a significant influence on the electrochemical response and transport processes within the electrodes.

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NIR-Based Temperature Measurement in Pulsed Electric Field Systems

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Pulsed electric field (PEF) treatment is based on the application of short electrical pulses between two electrodes. The sample is exposed to a defined electric field for a limited period of time, typically using pulses in the microsecond-to-millisecond range. Depending on the applied field strength, pulse duration, and number of pulses, PEF can induce changes in biological membranes, influence mass transport, or modify the physicochemical properties of the studied system. In conductive solutions, the passage of electric current is also accompanied by Joule heating, which may significantly affect the experimental conditions and should therefore be monitored. Monitoring thermal effects is important in biomedical, veterinary, and food-related applications of PEF [1,2].

The aim of this study was to develop and evaluate an apparatus for pulsed electric field experiments and to assess the applicability of UV-Vis-NIR spectrophotometry for monitoring PEF-induced temperature changes in solution. The availability of 3D printing with its advantages such as rapid design customization has contributed to the increasing use of 3D printing in chemistry [3] and other scientific fields. It is for these reasons we chose to develop the apparatus utilizing 3D printing. Customized 3D printed insert, lid were designed to hold electrodes in place and provide thermal insulation inside a quartz cuvette. Quartz cuvette was placed inside this specially designed stand with integrated aperture. Thin aluminium electrodes were utilized as they represent a standard in the community. Cuvette was filled with solution of KCl as model system and temperature was monitored using 3 separate methods. First method was monitoring absorbance of the sample at 970 nm where near infrared spectrum of water shows a peak. Second method was monitoring the shift in position of this peak with temperature. Third method was monitoring the current passing through the system during pulsing.

All three methods were verified as functioning. However, varying degree of accuracy was observed.

Acknowledgments
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From Molecular Electrochemistry to Functional Nanomaterials: Advanced Electrocatalysts for Sustainable Hydrogen Production

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Electrochemical water splitting has emerged as a cornerstone technology for the sustainable conversion of solar energy into hydrogen, a clean and high-energy-density fuel that underpins the future hydrogen economy. The development of efficient, robust, and earth-abundant electrocatalysts remains a central challenge in advancing this technology toward practical implementation. In this presentation, we report integrated chemical, electrochemical, and photochemical strategies for the rational design and fabrication of a diverse class of micro- and nanostructured functional materials. These include metal–TCNQ coordination polymers, transition metal-based compounds, such as hydroxides, oxides, phosphides, and sulfides (M = Mn, Fe, Co, Ni), and metal-free electrocatalysts based on heteroatom (N/P) co-doped crystalline carbon and tailored metal–organic frameworks (MOFs). Particular emphasis is placed on controlling composition, morphology, electronic structure, and interfacial properties to optimize catalytic activity and stability. The structure–property relationships governing the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) are systematically discussed, with attention to key parameters such as active site density, conductivity, charge-transfer kinetics, and durability under operational conditions. Advanced nanocomposite architectures and hybrid systems are highlighted as effective approaches to overcoming intrinsic limitations of single-component catalysts. Beyond water splitting, the multifunctional performance of these materials in sensing, energy storage, and other electrochemical applications is also explored, demonstrating their versatility across a wide range of energy-related technologies. Furthermore, the presentation addresses the redox chemistry of metal–carbonyl complexes and other technologically relevant organometallic systems in mild media containing large and weakly coordinating (TFAB) anions, offering new insights into their stability, reactivity, and potential roles in catalytic and electrochemical processes. Overall, this work provides a comprehensive perspective on the design principles of next-generation electrocatalysts and highlights emerging opportunities for bridging molecular electrochemistry with functional nanomaterials to enable efficient, scalable, and sustainable hydrogen production.



Fig. 1 Molecular electrochemistry and functional nanomaterials for rational design of efficient electrocatalysts.

Keywords
metal-TCNQ coordination polymers; weakly coordinating anions, MOFs, energy applications, nanomaterials

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Phase Transformations in Zirconia upon Electroreduction

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Electroreduction in yttria-stabilised zirconia (YSZ) represents a long-standing scientific challenge with direct implications for both the reliability of solid oxide electrolysis cells and the processing of advanced ceramics through flash sintering. Under sufficiently high electric fields and reducing conditions, transparent and purely ionic conducting YSZ undergoes dramatic electrocoloration and eventually transforms into a mixed ionic-electronic conductor with metallic-like behaviour. Despite decades of research, the microscopic mechanisms governing this transition and the associated structural evolution remain unresolved.

Here, we present a comprehensive investigation of electroreduction in single-crystal YSZ by combining operando electrical characterisation with microscopy and spectroscopy. The results reveal a sequential transformation process consisting of three distinct stages [1,2]. The first stage involves a reversible electrocoloration accompanied by the emergence of characteristic blackening fingers propagating through the crystal. In the second stage, electroreduction accelerates through the formation of mixed ionic-electronic conducting pathways. Finally, a runaway-type reduction process occurs, driving irreversible morphological transformations and filamentary phase formation near the cathode surface.

High-resolution scanning transmission electron microscopy coupled with energy-dispersive X-ray spectroscopy uncovers previously unreported oxygen-deficient phases in the heavily reduced regions [3]. Belt-shaped features beneath the sample surface exhibit a stoichiometry close to $(Zr,Y)_{8.6}O$ and are embedded within a surrounding oxygen-depleted matrix approximated as $(Zr,Y)_2O$. In addition, a chequerboard-like surface morphology is observed and is attributed to strain relaxation mediated by dislocation glide during extreme reduction.

These findings provide new insight into the progression from electrocoloration to heavy electroreduction in YSZ and establish a direct link between electrochemical loading, defect evolution, and phase instability. The results further demonstrate that harsh operating conditions relevant to steam electrolysis can induce irreversible degradation of the electrolyte, ultimately compromising ionic transport efficiency and long-term device performance.

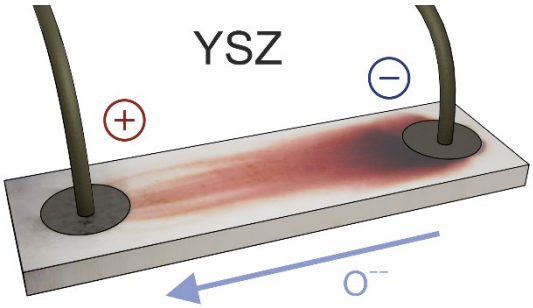


Fig. 1 Illustration of the blackening process in YSZ upon electric polarization.

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Coupled Model of Acid-Base Equilibria and Charge Transport in Pulsed Electric Fields

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Pulsed Electric Field (PEF) technology is widely utilized in the food industry for non-thermal pasteurization and in biomedicine for electroporation and tumor ablation. While PEF minimizes thermal stress, it is inevitably accompanied by undesirable electrochemical reactions at the electrode-solution interface, primarily water electrolysis. [1] This leads to the generation of reactive oxygen species and extreme local pH gradients, which can cause protein denaturation, aggregation of biomolecules, and ultimately compromise the biocompatibility of the treatment. Due to the microsecond time scales and close proximity to the electrodes, real-time experimental monitoring of these drastic pH shifts is challenging.

To address this, we developed a numerical 1D model in COMSOL Multiphysics to simulate water electrolysis in a buffered solution under PEF conditions. The model successfully couples diffusion-driven mass transport with the kinetics of acid-base buffer equilibria, monitoring the generation of H^+ and OH^- ions at the electrodes and their subsequent neutralization in the bulk. We evaluated different pulsing regimes with pulse durations of 100 and 0.3 µs while maintaining an equal total charge across all simulations.

The simulation results demonstrate that pulse duration significantly impacts the spatial and temporal distribution of pH. Longer pulses generate extreme local pH spikes because the rapid ion generation temporarily overwhelms the buffering capacity during the pulse. Conversely, shorter pulses generate a smaller amount of ions per pulse, providing sufficient time for the acid-base equilibrium to stabilize during the intervals. This results in significantly smaller pH gradients and smoother transitions. Consequently, adopting a regime with shorter pulses provides a milder, more biocompatible environment for biological samples, minimizing electrochemical damage.

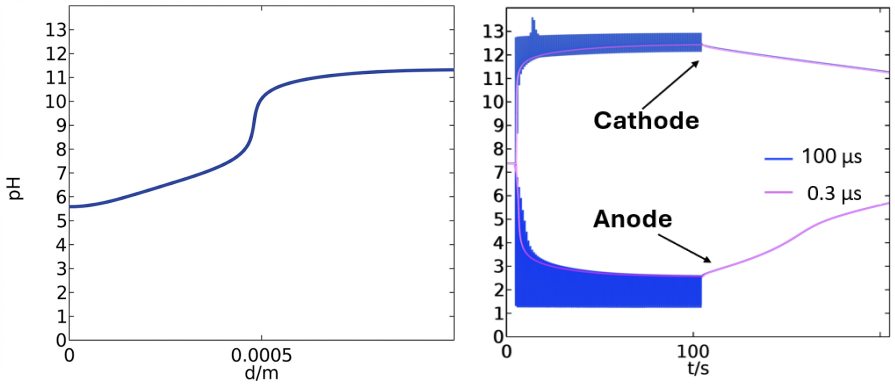


Fig. 1 Spatial distribution of pH across the electrochemical cell at the end of the experiment (i.e., 5 s pre-pulsing, 100 s pulsing, and 100 s post-pulsing period). (Right) Time evolution of pH at the anode and cathode surfaces during water electrolysis in a buffered solution (pKa = 6.94).

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Chronoamperometric Oxidation of High-Entropy Alloys Dedicated to Electrooxidation of Methanol

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High-entropy alloys (HEAs), defined as multicomponent systems containing five or more metallic elements at equal or near-equal molecular ratios ave attracted considerable attention due to their unique properties compared with well-known binary and ternary alloys. Their catalytic behavior is driven by four core effects: the high-entropy effect, lattice distortion, sluggish diffusion, and the cocktail effect [1]. As a result, HEAs exhibit enhanced electrochemical stability, numerous possible combinations, and synergistic interactions among components, often surpassing the performance of conventional electrocatalysts. To avoid the use of high-cost catalysts based on platinum group metals, first row transition metals, such as Ni, Fe, Co, Cu, and Mn, have been widely explored due to their favorable electronic structures and accessibility. Meanwhile, the addition of Ti and Al in HEAs has been predominantly investigated in the context of improving mechanical strength, wear resistance, and corrosion resistance. Current research focuses mostly on the electrooxidation of methanol using HEAs containing mainly platinum group metals, e.g., CuAgAuPtPd [2] or PdPtCuAgAu [3]. The development of non-noble electrocatalysts for methanol electrooxidation is a key issue to reduce the costs in fuel cells based on methanol.

In this work, high-entropy alloys (HEAs) based on transition metals (Ni, Co, Fe, and Mn), with Ti and/or Al additions, were electrochemically oxidized in 1 M H_2SO_4 via chronoamperometry. The novelty of this research was to investigate the effect of Ti and/or Al addition on the catalytic performance of noble metal-free HEAs. Electrochemical activity was determined before and after oxidation toward the oxygen evolution reaction (OER) and methanol electrooxidation. Any changes in morphology and surface composition caused by Ti and Al addition, both before and after oxidation, were analyzed.
The results demonstrate a significant influence of Ti and/or Al additions in the alloys on their catalytic activity in OER and methanol oxidation.

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Molecularly Imprinted Polymer-Based Electrochemical Sensor for Sensitive Bisphenol A Detection

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The extensive use of synthetic polymers in food packaging and consumer products has raised growing concerns regarding the release of hazardous chemical additives into the environment and the human body. Among these substances, bisphenol A (BPA) is of particular concern because it can migrate from polymer-based materials during normal use and storage conditions. BPA is recognized as an endocrine-disrupting compound, and even trace-level exposure has been associated with adverse biological effects and potential long-term health risks. In response to these concerns, the European Commission has established strict regulations limiting BPA migration from food-contact materials, including a specific migration limit of 0.05 mg kg^{-1}, highlighting the need for sensitive, selective, and reliable analytical methods for BPA monitoring [1].

Electrochemical sensors have gained considerable attention as efficient analytical tools because of their fast detection capability, ease of miniaturization, cost-effectiveness, and suitability for on-site analysis. To improve selectivity toward specific analytes, molecularly imprinted polymers (MIPs) have been extensively incorporated into sensing platforms [2]. Among the conducting polymers employed for MIP synthesis, polypyrrole (PPy) is widely utilized owing to its intrinsic electrical conductivity, simple electrochemical polymerization process, and strong adherence to electrode substrates.

In this work, a molecularly imprinted electrochemical sensor for bisphenol A (BPA) detection was developed using gold screen-printed electrodes (Au-SPEs) modified with sulfur-doped graphene. The graphene was incorporated either by drop-casting onto the electrode surface or during electropolymerization of polypyrrole (PPy). Molecular imprinting was achieved by electropolymerizing PPy in the presence of BPA as the template molecule. Key parameters, including electropolymerization conditions, template concentration, template removal, and rebinding conditions, were optimized to improve sensor performance. Preliminary results obtained with electrochemical sensors fabricated in-house are also presented.

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Influence and Interfacial Kinetics of Binary Protic Ionic Liquid Electrolyte Mixtures on Intermediate-Temperature Polymer Electrolyte Membrane Fuel Cells

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Operation of polymer electrolyte membrane fuel cells (PEMFCs) at elevated temperatures above 100 °C has attracted increasing attention. Compared to conventional low-temperature and high-temperature fuel cell technologies, there are advantages due to due to an accelerated electrode kinetics, improved tolerance toward fuel impurities, and a simplified thermal and water management [1]. However, suitable electrolytes for operation above 100 °C at low-humidity or anhydrous conditions are still lacking, motivating increasing interest in ionic liquids as promising candidates, due to their high thermal stability and tunable transport properties. Nevertheless, the coupling between proton transport, oxygen transport, interfacial charge transfer, and local ionic environment during the oxygen reduction reaction (ORR) remains insufficiently understood [2]

Herein, a binary protic ionic liquid electrolyte mixture system composed of acidic [DESPA][TfO] and neutral [Dema][TfO] is systematically investigated to elucidate how the local ionic environment governs the interplay between electrochemical kinetics and mass-transport processes during ORR. Linear sweep voltammetry combined with temperature-dependent Tafel analysis reveals that increasing [DESPA][TfO] content substantially lowers the charge-transfer barrier and accelerates proton-coupled electron-transfer kinetics (PCET). However, electrochemical impedance spectroscopy demonstrates that enhanced interfacial kinetics do not necessarily correlate with improved ionic transport, indicating a decoupling between bulk conductivity and ORR activity. Chronoamperometric analysis further shows that oxygen diffusion coefficient, oxygen concentration, and overall oxygen transport capability exhibit pronounced composition-dependent behavior, with mixed ionic liquid systems exhibiting significantly enhanced oxygen transport compared with the neat electrolytes. Notably, this work demonstrates that ORR activity in protic ionic liquid electrolytes cannot be interpreted solely by charge-transfer kinetics or ionic conductivity, but instead arises from the coupled contributions of electron transfer, oxygen diffusion, oxygen solubility, ionic transport, and solvent structural dynamics. The present study provides a mechanistic framework for rationally designing ionic liquid electrolytes for operation at elevated temperatures.

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Perforated Microporous Layers for Flooding Mitigation in High-Current-Density CO_2 Electroreduction

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Electrochemical CO_2 reduction (CO_2RR) on gas diffusion electrodes (GDEs) offers a promising route for converting CO_2 into value-added chemicals while enabling operation at commercially relevant current densities. However, long-term operation is frequently limited by electrolyte flooding of the microporous layer (MPL), which restricts CO_2 transport to the catalyst layer and promotes the competing hydrogen evolution reaction.[1-3]

Here, we introduce a simple strategy for controlling electrolyte transport by micromechanical perforation of an originally compact MPL. A commercial gas diffusion layer (GDL) with a crack-free MPL was perforated using a microneedle roller equipped with 50 µm diameter needles. Silver nanoparticles were subsequently deposited as the catalyst, and the resulting GDEs were tested for CO_2RR in 2 M KOH at current densities of 100, 200, 300, and 400 mA cm^{-2} for up to 10,000 s. The perforated GDEs were compared with the unmodified compact GDE and with a commercial GDE featuring naturally formed MPL cracks.

Micromechanical perforation substantially improved the stability and CO selectivity of the GDEs. At 100 mA cm^{-2}, the Faradaic efficiency for CO, FE(CO), remained at approximately 80–90% throughout electrolysis for the perforated GDE, whereas the compact GDE exhibited a continuous decline. At 200 mA cm^{-2}, the final FE(CO) reached approximately 55% for the perforated GDE, compared with less than 10% for the compact GDE. Significant improvements were also observed at 300 and 400 mA cm^{-2}. Perforation additionally suppressed H_2 formation and reduced product losses associated with severe flooding.SEM analysis revealed a median equivalent diameter of 47 ± 9 µm for the engineered holes, whereas naturally formed cracks exhibited a median width of 9 ± 2 µm. Despite comparable relative area and number density of drainage features, naturally cracked GDEs showed somewhat higher FE(CO), particularly at higher current densities. This difference is attributed to the elongated and partially interconnected geometry of the cracks, which may provide more efficient electrolyte drainage than isolated circular holes.

The results demonstrate that controlled micromechanical perforation of the MPL is a simple and reproducible approach to improving electrolyte management in GDEs. Unlike naturally occurring cracks, engineered perforations allow the size, density, spatial distribution, and potentially the shape of drainage features to be controlled. This approach therefore provides a promising route toward rational GDE design for stable CO_2 electrolysis at high current densities.

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On the Incorporation of Zeolites into Oxide Coatings During Plasma Electrolytic Oxidation Processing

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The formation of mixed-oxide coatings by plasma electrolytic oxidation (PEO) proved itself as a valuable tool in many applications [1]. PEO processing enables the incorporation of electrolyte components (including particles) into coatings, providing the pathway for tailoring the properties of such composite coatings [2]. A wide range of functional additives has therefore been explored in PEO electrolytes. Among them, so-called nanocontainers, such as zeolites, layered double hydroxides, and metal organic frameworks, are of particular interest because they possess well-defined internal structures that allow them to act not only as structural fillers but also as carriers of functional ions or compounds.

Addition of particles to PEO processing electrolyte usually results in either reactive or inert incorporation of particles into PEO oxide coatings. The presence of locally high temperatures and pressures inherent to PEO processing is detrimental for the preservation of zeolite structure during the incorporation of zeolites into oxide coatings and one can expect only reactive incorporation of zeolites. Previous investigations have demonstrated that zeolites can be successfully incorporated into oxide coatings during PEO processing on Al and Mg alloys. In particular, coatings containing Ce-loaded zeolites have shown notable photocatalytic performance, while simultaneously improving resistance to degradation in aggressive environments [3]. Nevertheless, the mechanism by which zeolites become incorporated, whether through inert embedding or reactive participation in the coating growth, has remained unclear. Some evidence suggests that inert incorporation occurs under so-called soft-sparking conditions during the PEO process [4].

Presented research result clearly reveal that inert incorporation of Y zeolite into oxide coatings occurs during PEO processing of Mg alloy AZ31 in aqueous electrolyte solution comprised of 4 g/dm^3 Na_3PO_4 + 1 g/dm^3 KOH with applied current density of 200 mA cm^{-2}. High resolution x-ray analysis of formed PEO coatings with incorporated zeolites served as a direct evidence that it is possible to achieve inert incorporation of zeolite structures into PEO coatings which is highly beneficial for their multifunctional properties.

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Elucidating the Mechanism of Initial Hydroxide and Oxide Formation on a Polycrystalline Nickel Surface

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Nickel is a promising material for an alkaline water-splitting electrolyzer. For maintaining and optimizing such machines, knowing how a material behaves under potential control is crucial. However, not much is known about nickel's fundamental electrochemical behavior. Currently, it is known that bare nickel surfaces in alkaline and especially acidic media transform into nickel hydroxides and oxides almost immediately. Both of which have been extensively studied over the years.

There does appear to be a lack, however, in the fundamental understanding of how a nickel surface begins its oxidation journey. While in acidic media, the oxidation occurs almost immediately, there is a small potential window in alkaline conditions that allows for such fundamental studies. Thus, we have studied nickel voltammetry between -0.1 and 0.6 V vs. RHE to understand the initial formation of the hydroxide layer. We hypothesize that the hydroxide layer begins to penetrate the bulk metal after surface oxide formation via place-exchange and that such an oxide follows a different reduction path. We then attempted to develop and fit a mean-field microkinetic model to our data to confirm our suspicions. The model we obtained was then further verified with DFT calculations and TOF-SIMS, both proving our hypothesis of place-exchange happening between adsorbed species and nickel atoms.

Influence of Mo and Ta Additions and Heat Treatment Process on the Corrosion Properties of AlCoCrFeNi High-Entropy Alloy

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In the present study, the corrosion behaviour and passivation characteristics of AlCoCrFeNi and AlCoCrFeNiX0.5 (X = Mo, Ta) high entropy alloys after casting and heat treatment were investigated. The alloys were produced by vacuum arc melting, followed by heat treatment at 1200 °C for 5 h and rapid cooling in water. Electrochemical corrosion tests were conducted using cyclic potentiodynamic polarization and electrochemical impedance spectroscopy, focusing on corrosion resistance and passive film behaviour in 3.5 wt% NaCl solution. The results revealed a dendritic BCC microstructure in the as-cast AlCoCrFeNi alloy while heat treatment promoted FCC phase formation. Furthermore, Mo and Ta additions resulted in the formation of Cr-rich σ and Laves phases, respectively. All alloys exhibited pitting corrosion with limited re-passivation. Heat treatment improved re-passivation in the base and Mo-containing alloys due to microstructural evolution and Mo–Cr synergy, whereas the Ta-containing alloy, despite improved pitting resistance, showed higher corrosion rates after heat treatment due to porous Al oxide formation and possible enhanced micro-galvanic interactions.

POSTER PRESENTATIONS

(ALPHABETICAL LIST)

Rechargeable Metal Hydride-Air Battery Under Deep-Discharge and Accelerated Operating Modes for Energy Storage

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The growth in energy production from renewable energy sources (RES) in the context of the green transition is driving the demand for new batteries and/or the further development of existing ones that can play a role in the future energy system. The two most widely used rechargeable batteries in the world with the largest market share - lithium-ion and lead-acid batteries, can be used for stationary energy storage, but the drawbacks of this approach outweigh the benefits.

Another widely used battery, commercialized in the early 1990s, is the nickel-metal hydride (Ni-MH) battery. As an alternative, we investigated the cycle stability of an MH-Air battery in which the heavy Ni electrode was replaced with a bifunctional oxygen gas diffusion electrode (GDE). The advantages of this battery are that it uses a negative (MH) electrode, which is the most durable metal electrode in a strongly alkaline environment, with satisfactory capacity (~300 mAh g^{-1} for AB_5-type alloys) and good cyclic stability. The main limitation of the system remains the GDE, which, due to the polarization of the oxygen reduction and evolution reactions, currently operates at a current density of 10 mA cm^{-2}.

The electrodes applied in the battery configuration were developed in our previous studies and further scaled for the present work. After activation, the cells were tested under two operating modes: "deep discharge" (C/2.5) and "accelerated" (C/0.5), selected to simulate the operating conditions associated with RES-based energy storage applications. The results shown are satisfactory, and work on the system continues primarily in two areas: improving the cycling stability of the two electrodes and increasing the current density of the GDE.

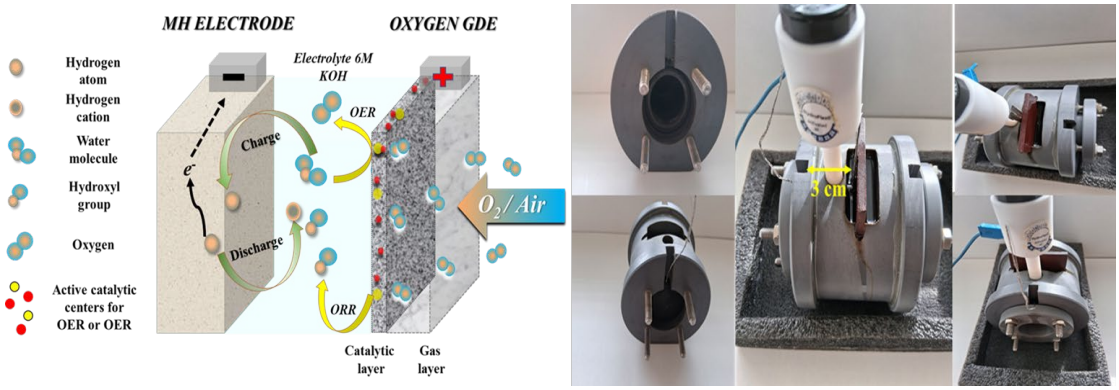


Fig. 1 Schematic representation of the MH-Air battery, the reactions taking place within it, and a photo of its prototype

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Synthesis of Nano-Architectonics Nanorods of Bismuth Telluride/rGO Pseudocapacitive Materials for High Performance Energy Storage Application

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Energy shortage and environmental degradation lead to the two main issues over the worldwide exploration for novel materials useful for energy storage and environmental protection. Pseudocapacitors abstain recently from gaining the attention of energy experts owing to their superior energy and power density and elongated life cycle. The investigation on finding an appropriate electrode material with extraordinary specific capacitance, stability, and high efficiency required for the progressive energy storage application. At present, metal selenides are elaborate in significant consideration due to their exceptional physical and chemical characteristics. Herein, the Bismuth telluride (Bi2Te3) with reduced graphene oxide (rGO) Bi2Te3/rGO-x (x = 0-0.5) nanoarchitectonics nanorods through the hydrothermal technique for pseudocapacitors electrode materials has been studied. The comparative investigation of the prepared electrodes materials exhibited that higher specific capacitance response was observed for theBi2Te3/rGO-x (x = 0.3) electrode than the pure Bi2Te3 electrode owing to its high conductivity. All nanoarchitectonics electrodes showed the pseudocapacitive response with well-defined cyclic voltammetry (CV) plateaus and clear oxidation and reduction. The specific capacitance (SC) for Bi2Te3 electrode 784.95 F g -1 increases to 1396.34 F g -1 at 5 A g-1 for Bi2Te3/rGO-x (x = 0.3) nanoarchitectonics electrode, which identifies that rGO has enhanced the electrochemical performance of pure Bi2Te3. These consequences cooperatively suggest that Bi2Te3/rGO nanoarchitectonics nanorods have broad application for supercapacitor.

Influence of Diamond Particles on the Properties of NiP and NiCoP Composite Coatings

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Composite coatings on nickel base containing diamond particles have attracted considerable interest due to their improved mechanical, electrochemical and catalytic properties. In this study, NiP-D and NiCoP-D composite coatings were prepared and comparatively investigated in terms of their surface morphology, elemental composition, structural characteristics, electrocatalytic activity towards the hydrogen evolution reaction (HER) and corrosion resistance.

The morphology and composition of the obtained coatings were investigated using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The depth distribution of the elements was determined by glow discharge optical emission spectroscopy (GDOES).

The electrochemical behavior of the obtained materials was evaluated by polarization measurements in a model corrosion medium and under hydrogen evolution reaction conditions.

The results show that the incorporation of cobalt and diamond particles influences the electrochemical characteristics and corrosion resistance of the coatings.

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NiCoP–hBN Composite Coatings: Preparation and Electrochemical Characterization

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Chemical and electrochemical nickel plating processes are among the most widely used methods for producing functional coatings on metallic and non-metallic substrates. The incorporation of dispersed particles into a metallic matrix enables the formation of composite materials with enhanced physical, chemical, and electrochemical properties.

Nickel–cobalt–phosphorus (NiCoP) coatings modified with hexagonal boron nitride (hBN) represent a potential class of functional materials with possible applications in electrocatalysis, protective coatings, and tribological systems.

In the present work, the electrocatalytic activity of chemically and electrochemically deposited alloy and composite coatings of the NiCoP and NiCoP–hBN types has been investigated. The morphology, elemental composition, and electrochemical properties of the obtained materials were analyzed using scanning electron microscopy and energy-dispersive X-ray spectroscopy (SEM/EDS), X-ray photoelectron spectroscopy (XPS), electrochemical and polarization techniques.

The obtained results indicate that the incorporation of hBN particles influences the structure and electrocatalytic properties of the coatings.

Acknowledgments

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Behavior of the Electrolyte–Electrode Interface

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Understanding how electrolytes interact with metal (electrode) surfaces, specifically regarding wettability, is critically important across various industrial and chemical technology fields. This is especially true in contexts such as metal corrosion, electrochemical synthesis [1], and oil industry processes, such as water-oil separation [2,3], among others. Numerous studies have examined wettability in water-metal systems [4]; however, their findings often contradict each other, a point highlighted by Schrader [5].

White [6] attributes the difference in the wetting behavior of oxide films with uncertain composition and thickness during surface cleaning to incomplete wetting. Conversely, in typical water-metal interfaces, the contact angle (Θ) is often around 60°, a value supported by Erb's experimental observations on noble metal surfaces [7].

A universal equation that accurately predicts either the wettability of metals by electrolytes or the adhesion energy in metal-electrolyte systems is needed.

The objective of our study is to measure the contact angles of both polar and non-polar liquids across a broad selection of metal surfaces and to establish a relationship between these contact angles and the intrinsic properties of the metal substrates based on our experimental data.

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Reaction of *in situ* Generated Oxygen Radicals with Bioactive Phenethylamine Derivative, Electrochemical and Spectroelectrochemical Study

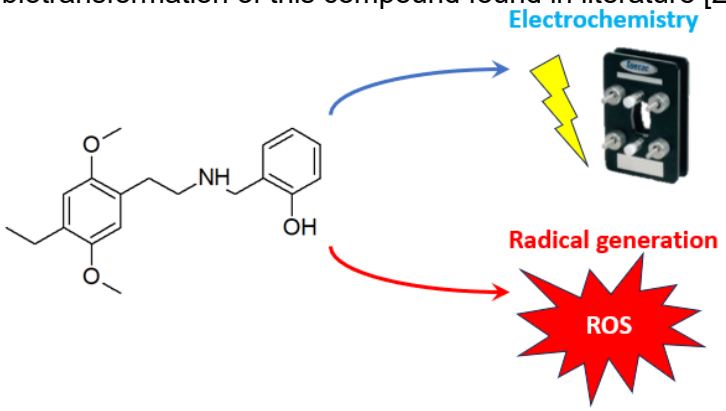
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The electrochemical oxidation of the bioactive compound 25E-NBOH was investigated using electrochemical, spectroelectrochemical, and chromatographic techniques. Cyclic voltammetry was applied to characterize the redox behaviour and elucidate the overall reaction mechanism. To identify the reaction products, UV-Vis and IR spectra were monitored *in situ* during the voltametric cycle. Solution of the compound was also oxidatively electrolyzed in presence and absence of dissolved air oxygen and analysed via HPLC-DAD. Because proton and electron transfers are fundamental to phase 1 metabolic biotransformation, electrochemical oxidation can be used to mimic a biological transformation. Additionally, the compound's reactivity was tested in presence of *in situ* electrochemically generated reactive oxygen species (ROS) [1]. Finally, the resulting chemical oxidation products were compared to those obtained through pure electrochemical oxidation and to biological studies of biotransformation of this compound found in literature [2].



Scheme 1. Chemical structure of studied compound 25E-NBOH and applied methods of research

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Synergistic Effect of Fe_3O_4 of Chemical and Residual Origin on $TiO_{2,nt}$| Tias Photoelectrocatalytic Cathodes for Toluene Removal

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Air pollution by volatile organic compounds (VOCs) is an environmental and health problem of global scope due to its high toxicity and its participation in the formation of secondary pollutants, such as tropospheric ozone and secondary organic aerosols. Among the VOCs, toluene is one of the most representative pollutants of industrial and urban emissions. In this context, photoelectrocatalysis has emerged as an advanced oxidation technology capable of increasing degradation efficiency through the synergy between light irradiation and the application of an electric potential, favoring the generation of reactive oxygen species and reducing the recombination of electron-hole pairs.

The present work evaluates the synergistic effect of Fe_3O_4 nanoparticles obtained from chemical precursors and high-iron residues on titanium-supported TiO_2 self-organized nanotubes ($TiO_{2,nt}$|Ti), used as cathodes in a photoelectrocatalytic system for the degradation of toluene in the gas phase. The incorporation of Fe_3O_4 seeks to improve electronic transfer, increase the separation of photogenerated charges and promote the formation of oxidizing species responsible for the mineralization of the pollutant, in addition to exploring the potential for the recovery of iron-rich waste under a circular economy approach. $TiO_{2,nt}$|Ti were synthesized by anodic oxidation and subsequently modified with Fe_3O_4 of chemical and residual origin. Characterization includes morphological, structural, chemical, optical, and electrochemical analyses using scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), UV-Vis spectroscopy, anodic resolution voltammetry (LSV), controlled potential electrolysis (CPE), and electrochemically active area determination. Subsequently, the photoelectrocatalytic performance of the cathode was evaluated by determining the degradation efficiency of toluene in the border area of Tijuana. It was shown that the modification of $TiO_{2,nt}$|Ti with Fe_3O_4 generates a synergistic effect that increases photoelectrocatalytic activity with respect to unmodified materials, and that nanoparticles obtained from residues with high iron content have a performance comparable to those synthesized from conventional chemical reagents.

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The Effect of Current Desity on the Electrolytic Cu Coating Layer on Polyurethane Foam

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Metal foams attract considerable attention because of their distinctive characteristics, including a high surface-area-to-weight ratio, excellent thermal conductivity, and strong potential for recycling. These materials are widely applied as energy-absorbing structures, filtration media, sound-dampening components, catalytic reactors, and flow control filters. Among the available fabrication techniques, electrolytic deposition is commonly used for producing open-cell metal foams. In this method, polyurethane foam with 10 PPI (Pores Per Inch) serves as the template and is coated with metals such as copper or nickel. Since electroplating requires the substrate to be electrically conductive, adequate conductivity of the polymer template is essential.

In this study, polyurethane foam was selected as the substrate for manufacturing open-cell copper foam. Because polyurethane is inherently non-conductive and cannot be electroplated directly, an electroless copper plating process was first applied. This technique is a standard approach for creating a conductive metallic layer on polymer surfaces, enabling subsequent electrochemical metal deposition. The influence of current density on copper deposition and pore morphology was examined. The findings indicate that increasing the current density leads to a greater amount of deposited copper, as well as higher solid fraction and improved electrical conductivity of the porous structure.

The resulting coatings were characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS).

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Effect of Electrolyte Composition on the Electrodeposition of Ni-Co Alloys from Aqueous Electrolyte

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Nowadays, the production of metal alloys relies on technologies that are highly costly, energy- and time-consuming. However, the pursuit of sustainable development necessitates the modernization of these technologies. Based on electrochemical methods, an efficient approach can be developed that enables the formation of alloys directly from their natural forms in a single step, involving the dissolution of the raw materials followed by their deposition onto the cathode surface using an external electric current. In this way, the method provides a more economical and resource-efficient process [1]. Currently, the design of electrochemical alloy production is guided by the well-known rule of thumb stating that binary systems can be co-deposited if the difference between the deposition potentials of the metals is less than 200 mV [2,3]. However, this approach pays less attention to the role of the mixing enthalpy between the two components.

The aim of our research is to create and experimentally validate electrochemical phase diagrams which, under conditions of constant temperature, pressure, and low current density, provide information about the phases and composition of the alloy deposited on the cathode surface. During the experiments, binary alloys of Ni-Co system are produced from aqueous electrolytes using metal salts, primarily chlorides, and deposited onto an inert glassy carbon cathode surface. The research investigates the effect of electrolyte concentration on the composition, morphology, and phase structure of the deposited alloy.

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A Green Approach to Uric Acid Detection Using Reduced Graphene Oxide-Decorated Medium Entropy Alloy Electrodes

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Uric acid (UA) is an important biomarker, and its reliable quantification is essential for biomedical and clinical applications. Electrochemical sensing offers a rapid and sensitive approach for UA detection; however, the development of highly active and conductive electrode materials remains crucial. In this study, a Ni–Cr–Fe–Cu medium entropy alloy (MEA) was synthesized and investigated as a non-enzymatic electrochemical sensor for UA detection [1]. To enhance the sensing performance, MEA particles were decorated on reduced graphene oxide (rGO), forming a conductive multicomponent alloy–carbon composite. The MEA–rGO composite was synthesized through a mechanochemical route involving high-energy mechanical milling of graphite with metallic powders, followed by sonication-assisted exfoliation. The structural and morphological characteristics of the prepared composites were investigated using X-ray diffraction, Raman spectroscopy, scanning electron microscopy, transmission electron microscopy, and X-ray photoelectron spectroscopy. Electrochemical sensing performance was evaluated using cyclic voltammetry and differential pulse voltammetry. Among the investigated compositions, the MEA–rGO composite containing a 50:50 weight ratio exhibited the most favorable electrochemical response. The optimized electrode demonstrated a linear current response toward UA over a concentration range of 100–1000 μM and achieved a high sensitivity of 27 μA μM^{-1} cm^{-2}. The enhanced sensing performance is attributed to the synergistic interaction between electrochemically active MEA particles and the conductive rGO network, facilitating charge transfer and increasing accessible active sites. These results demonstrate the potential of MEA–rGO composites for sensitive non-enzymatic UA detection.

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Confinement Effects of Copper and Gold Nanoparticles in Porous Carbon for Enhanced and Selective CO_2 Electroreduction

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The electrochemical reduction of carbon dioxide (CO_2RR) into value-added chemicals enables energy storage while simultaneously contributing to climate change mitigation [1,2]. Among metallic electrocatalysts, copper stands out because of its unique ability to produce a wide range of reduction products, including multicarbon compounds [3,4]. However, its application is limited by poor operational stability. Under cathodic polarization, the catalyst surface reconstructs, particles agglomerate, and metal dissolves. We synthesized the materials by incipient wetness impregnation followed by thermal treatment, promoting the preferential nucleation of Cu and Au nanoparticles within the porous structure rather than on the external carbon surface. Structural characterization by X-ray diffraction indicated the formation of Cu nanoparticles confined within the carbon matrix. The electrochemical properties of the materials were investigated by cyclic voltammetry and electrochemically active surface area (ECSA) measurements. CO_2 reduction activity was evaluated by linear sweep voltammetry in N_2- and CO_2-saturated electrolytes using a catalyst loading of 150 µg cm^{-2}. For XE2B containing 10 wt% Cu, the onset potential shifted positively from -0.80 V under N_2 to -0.56 V under CO_2. The Cu/Vulcan catalyst exhibited a similar shift, from -0.73 V under N_2 to -0.51 V under CO_2. These positive shifts in the onset potential, together with the distinct current responses observed in the presence of CO_2, indicate enhanced CO_2 reduction activity relative to the competing hydrogen evolution reaction. The operando dissolution of copper and gold was monitored using inductively coupled plasma mass spectrometry (ICP-MS) coupled to a chamber flow cell (CFC). Cu dissolution dropped substantially for the pore-confined material, indicating that spatial confinement limits catalyst degradation. These results demonstrate that pore confinement is an effective strategy for minimizing copper degradation during CO_2RR and provide valuable insights into the design of durable electrocatalysts for long-term electrochemical CO_2 conversion.

Acknowledgments

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Prospective of Ti_4O_7@Ti Mesh in Environmental Application

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Titanium suboxide (TSO) electrodes based on Magnéli phases have emerged as promising materials for electrochemical advanced oxidation processes due to their wide potential window, stability, and ability to generate reactive oxygen species [1]. Herein, surface titanium suboxides were synthesized directly on titanium mesh substrates through thermal reduction in 5% H_2/Ar atmosphere at temperatures between 630 and 950 °C, producing bifunctional electrodes suitable for pollutant degradation applications. Structural evolution of the surface layer was investigated using SEM, micro-Raman spectroscopy, and XPS analysis, confirming the gradual transformation of TiO_2 toward oxygen-deficient Magnéli phases, particularly Ti_4O_7, at higher treatment temperatures. Electrochemical characterization in neutral 1 M Na_2SO_4 electrolyte revealed a significant widening of the operational potential window and enhanced catalytic activity for both oxygen and hydrogen evolution reactions. Samples treated at 850 and 950 °C exhibited nearly tenfold higher current densities compared to lower-temperature-treated electrodes, while maintaining high Tafel slopes characteristic of suppressed parasitic oxygen evolution. The onset potentials for oxygen evolution (~3.3 V vs. RHE) approached the potential region required for OH^* and SO_4^{*-} radical generation, indicating favorable conditions for electrochemical pollutant degradation with reduced energy losses. Simultaneously, cathodic potentials around −1.2 V vs. RHE enabled the formation of reactive H^* species relevant for reductive dehalogenation processes. Impedance spectroscopy demonstrated low and comparable charge-transfer resistances (~29 Ω) for highly reduced samples, while potentiostatic testing confirmed good electrochemical stability under harsh anodic conditions. The results demonstrate that surface-engineered TSO@Ti mesh electrodes combine anodic and cathodic functionality, high stability, and scalable preparation, making them attractive candidates for advanced electrochemical wastewater treatment and degradation of persistent pollutants.

Acknowledgment
Research was funded by the Science Fund of the Republic of Serbia (Grant No 17990, Advanced electrochemical treatment of PFAS contaminated water: Novel Materials and Mechanisms–ALTER) and supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No: 451-03-137/2025-03/200146, 451-03-136/2025-03/200146, 451-03-137/2025-03/200161).

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Is the Lignin Content the Key Factor for Enhancing the Electrochemical Na-Ion Storage into Hard Carbon Derived from Lignocellulosic Materials?

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Hard carbons (HCs) derived from various lignocellulosic-based raw materials have become widely recognized and implement as negative electrode materials with excellent properties, mainly with regard to reversible sodium storage. In recent years, numerous research has been conducted on the influence of different factors on the electrochemical properties of hard carbons — including the type of raw materials (fresh or waste), the synthesis procedure, the effect of mineral content [1] etc. Nevertheless, the question of how individual lignocellulosic components (hemicellulose, cellulose, and lignin) affect the properties of the resulting carbon materials remains a matter of debate.

Herein, we study the effect of the lignin content in the raw materials on the electrochemical performance of the resulting carbon materials. To this purpose, we selected four types of waste lignocellulosic materials, with lignin content ranging from 6% to 97%. The synthesis procedure was selected to ensure the complete removal of the accompanying hemicellulose and cellulose components, specifically a two-stage pyrolysis under argon. The final temperature at which all hard carbons were obtained was 1300 °C. The textural and morphological characteristics were examined using BET analysis and HR-TEM. The electrochemical properties of HCs were carried out in model half cells consist of sodium metal as a counter electrode and carbonate-based sodium electrolyte, i.e. 1 M $NaPF_6$:PC. To quantify the Na-storage performance of the hard carbons, we determined four parameters: first sodiation capasity, first irreversible capacity, cycling stability and cycling retention. We went even further by investigating the effect of lignin content on the sodium storage mechanism. Therefore, electrochemical tests were conducted not only in a galvanostatic "constant current" mode but also in a "constant current - constant voltage" mode, which allows for an assessment of the contribution of sodium intercalation and sodium pore filling. The results unequivocally confirm that the electrochemical sodium storage performance of HCs increases with increasing lignin content in the raw materials.

Acknowledgment

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Fluorescence and Electrochemistry of Leucomethylene Blue

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Methylene blue (MB) can be readily converted to leucomethylene blue (LMB) by chemical reducing agents, however, the presence of additional reagents and reaction by-products may complicate subsequent spectroscopic analysis, particularly when multicomponent spectral data are evaluated chemometrically [1]. Electrochemical reduction offers a cleaner alternative, enabling LMB to be generated directly in the measurement cell without introducing chemical reductants. At the same time, spectroelectrochemistry allows such redox species to be monitored in real time, which is especially useful for LMB because of its susceptibility to oxidation under ambient conditions. Despite this potential, fluorescence spectroelectrochemistry remains experimentally demanding due to the limited availability of suitable measurement cells that simultaneously satisfy electrochemical and optical requirements [2].

In this work, a fluorescence spectroelectrochemical platform based on a quartz cuvette and a custom-designed 3D-printed PLA/carbon black working electrode with an integrated optical window is presented. The design enables simultaneous electrochemical control and fluorescence monitoring while maintaining reproducible electrode positioning and straightforward fabrication by fused deposition modeling.

The platform was applied to the methylene blue/leucomethylene blue redox system. Chronoamperometric measurements revealed a decrease in fluorescence intensity in the spectral region characteristic of oxidized methylene blue during reduction, followed by fluorescence recovery after switching the applied potential to 0 V. This reversible response is consistent with the reduction and subsequent reoxidation of the dye. To determine spectral regions suitable for LMB detection, excitation-emission matrix measurements of chemically generated LMB were performed. LMB was prepared by reducing methylene blue with ascorbic acid under acidic conditions. Preliminary experiments indicate that optical excitation during electrochemical measurements may influence the redox equilibrium through photoinduced regeneration of methylene blue in the presence of residual oxygen, highlighting an important challenge in fluorescence spectroelectrochemical investigations of redox-active fluorophores.

The presented approach demonstrates the potential of additive manufacturing for low-cost spectroelectrochemical instrumentation and provides a basis for future studies aimed at reliable fluorescence characterization of electrochemically generated leucomethylene blue under controlled conditions.

Aknowledgements
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Synthesis and Structural Characterization of Functional Montmorillonite Composites for Electrochemical Applications

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Improving the performance of modern energy devices requires the development of new electrode materials with high structural stability and optimized electrochemical activity. Clay minerals such as montmorillonite have attracted increasing attention due to their layered structure, high surface area, ion-exchange capacity, and environmental compatibility, making them promising matrices for functional composite materials.

In the present study, two approaches for modifying a montmorillonite matrix (K10) have been developed and compared in order to obtain functional composite materials for electrochemical applications. The main focus is on the incorporation of active additives into the structure of a clay matrix.

Two synthesis methods have been used: a two-step method, in which the functional components are synthesized in advance and subsequently incorporated into the montmorillonite matrix under controlled conditions, and a direct *in-situ* method, in which the formation of the active phase occurs directly on the surface and in the interlayer space of the montmorillonite. The obtained materials have been characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and X-ray fluorescence analysis (XRF).

The results show that the synthesis method has a significant impact on the morphology, dispersion and accessibility of the active phase, which is critical for the potential application of the materials as electrode structures in energy systems. Furthermore, the enhanced interaction between the clay matrix and the incorporated active components suggests promising opportunities for the design of stable and efficient electrode materials for next-generation electrochemical devices.

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Gold Nanoparticle-Enhanced Electrochemiluminescence for Sensing Applications

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Electrochemiluminescence (ECL) is a highly sensitive detection technique in which electrochemically generated excited states emit light. Gold nanoparticles (AuNPs) represent attractive surface modifiers for ECL platforms owing to their large effective surface area, favorable electron-transfer properties, and unique optical characteristics associated with localized surface plasmon resonance. Depending on the distance between luminophores and nanoparticles, AuNPs can either enhance ECL through plasmonic and electrocatalytic effects or quench emission via energy transfer. In this work, AuNPs with diameters of approximately 100 nm were electrodeposited on glassy carbon electrodes using a double-pulse deposition strategy comprising a short nucleation pulse (10 ms, −1.3 V) followed by a growth pulse (10-300 s, 0.4 V). Spectral measurements confirmed AuNPs of this diameter exhibit substantial spectral overlap with the $Ru(bpy)_3^{2+}$ emission band, a prerequisite for efficient plasmon-mediated enhancement of ECL. The resulting nanoparticle layers were further characterized by scanning electron microscopy and cyclic voltammetry. To investigate the influence of AuNPs on ECL generation, surface-confined $Ru(bpy)_3^{2+}$ luminophores were immobilized via thiolated PEG linkers. A spacer length of approximately 10 nm was selected to position the luminophore within a distance regime where plasmon-assisted enhancement is expected while minimizing quenching effects. ECL measurements demonstrated enhanced emission from AuNP-modified electrodes compared with standard gold electrodes. Notably, an approximately two-fold increase in ECL intensity was observed even after correction for surface area differences, indicating that the enhancement cannot be explained solely by increased luminophore loading. Preliminary bipolar ECL measurements further demonstrated localized light emission from AuNP-modified sheet electrodes at the $Ru(bpy)_3^{2+}$ redox potential. These results highlight the potential of electrodeposited AuNP architectures as versatile platforms to enhance ECL performance and provide insight into the interplay between nanostructured electrode surfaces and luminescent redox systems in sensing applications.

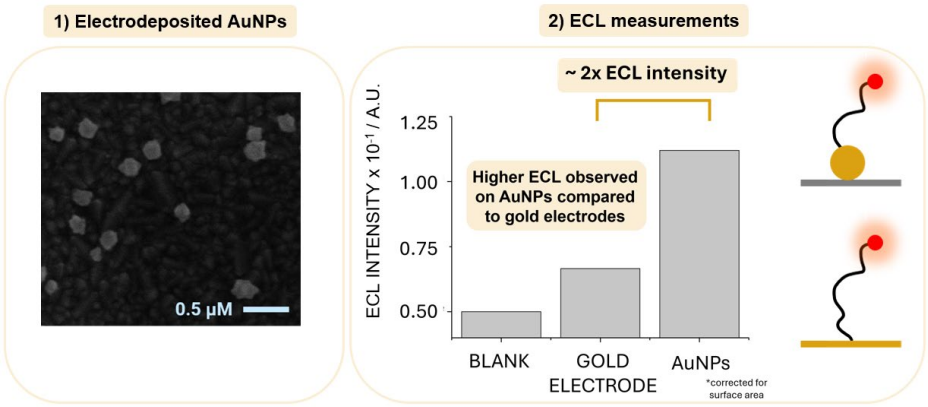


Fig. 1 SEM image of electrodeposited AuNPs. 2) ECL measurement of immobilized $Ru(bpy)_3^{2+}$ luminophores.

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Enhancing the Electrochemical Performance of Hard Carbon by Texture Tuning through Synthesis Procedure

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Since hard carbon materials emerged as negative electrode materials with real potential for application in sodium-ion batteries, research on them has increased significantly. Despite progress in research on hard carbons, their main drawback remains the initial very high irreversible capacity, which ultimately affects both the specific capacity and the capacity retention during prolonged cycling.

Our recent research revealed that slight changes during synthesis procedure such as removing the mineral content [1] or increasing pyrolysis temperature [2] could dramatically impact electrochemical performance of hard carbon in respect of sodium-ion storage.

Herein, we evaluate another approach to the synthesis procedure, namely the application of a preliminary acid treatment of the raw materials. For the purposes of our study, we selected raw material with an approximately equal content of the three main lignocellulosic components (hemicellulose, cellulose, and lignin, each at about 33%), i.e., walnut shells. For the acid treatment, we selected two types of acids – strong and weak – and additionally the soaking time in the weak acid was varied. After rinsing and drying, the pre-treated walnut shells were pyrolysed in an argon atmosphere at 1300°C. BET surface analysis and HR-TEM reveal a significant change in the textural and morphological characteristics of the hard carbons, depending on the type of acid and the soaking time. Electrochemical performance in terms of Initial Coulombic Efficiency (ICE), specific capacity and cyclic stability was evaluated in sodium half cell. For monitoring the sodium-ion insertion mechanism *ex-situ* EPR spectroscopy was employed [2] and discussed concerning acid pre-treatment. The results show that the electrochemical properties of hard carbon materials can be improved by tuning their texture and morphology through controlled acid pre-treatment of the raw material.

Acknowledgements

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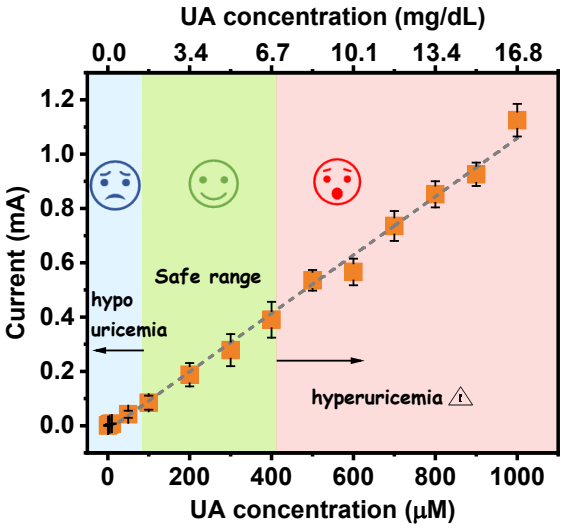
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Nickel-Doped $MnWO_4$-Based Electrochemical Sensor for Non-Invasive Uric Acid Detection from Sweat

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Uric acid (UA) is an important biomarker associated with metabolic disorders such as gout, hypertension, and kidney dysfunction, and its non-invasive monitoring through sweat using flexible electrochemical sensors is highly desirable for personalised healthcare.[1] However, the development of highly sensitive, stable, and cost-effective electrode materials for wearable UA sensing remains challenging. This study investigates the potential of nickel-doped manganese tungstate (Ni-$MnWO_4$) as an efficient electrode material to enhance non-enzymatic UA detection. Ni-$MnWO_4$ was synthesised via a simple reflux method followed by annealing and used to fabricate wearable electrodes.[2] The morphological, structural, and physicochemical properties of the synthesised material were systematically investigated using various physical characterisation methods and electroanalytical techniques. Doping is an effective method for tuning the electrochemical activity of $MnWO_4$ to develop efficient sensors. The incorporation of nickel into the $MnWO_4$ lattice enhances charge transfer characteristics and increases the number of electrochemically active sites, thereby facilitating efficient UA oxidation. The enhancement in electrochemical charge transfer efficiency is verified with the help of advanced distribution of relaxation (DRT) analysis. The Ni-$MnWO_4$ modified electrode exhibited comparitively good electrochemical sensing performance, including high sensitivity, a wide linear detection range covering both hypouricemia and hyperuricemia conditions, and a low limit of detection (LOD) of 0.2 µM. These results demonstrate the strong potential of the Ni-$MnWO_4$ based flexible electrode for wearable and non-invasive UA monitoring applications.



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Sodium-Ion Diffusion in Carbon Decorated $Na_4Fe_3(PO_4)_2P_2O_7$ Electrode Material: Studies by Different Electrochemical Methods

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Sodium-ion batteries (SIBs) offer an efficient energy storage solution for large-scale application. Finding high-performance electrode materials is crucial for the commercialization of SIBs. $Na_4Fe_3(PO_4)_2P_2O_7$ (NFPP) is recognized as an promising candidate for positive electrode material in SIBs. It is characterized by a NASICON-type of structure that allows up to 3 moles of Na ions to be reversibly intercalated with a theoretical capacity of 129 mAh/g. The main disadvantage of this material is its very low electronic conductivity, which hinders the Na-ion mobility, so that capacities close to the theoretical value could be achieved at low cycling charge/discharge rates. To increase NFPP conductivity and thus to overcome the sluggish Na^+ diffusion kinetics, conventional strategy involves its coating with various carbonaceous materials in amount about 10-15 wt. %. However, the presence of large amount of electrochemically inactive carbonaceous additives in the electrode composition is a major contributor to the lower overall energy density of the battery cells, which is one of the most important characteristics for practical application.

To overcome the reduced energy density, the purpose of the present contribution is to decorate NFPP with carbon additives (carbon black and reduced graphene oxide (rGO)) with a minimal amount of 1 wt. %. Carbon black and rGO are conductive and porous additives which not only increase the electronic conductivity of the electrodes, but they help the penetration of the electrolytes to the electrode, thus promoting better charge transfer. The composites NFPP/C and NFPP/rGO have been prepared by a dry-coating method using a high-speed planetary mixer. This simple and very fast method ensures homogeneous distribution of the carbon black and rGO over the phosphate particles. The electrochemical tests in galvanostatic and potentiostatic regime have been performed at 20 and 40 °C in sodium half-cells using 1M $NaPF_6$ in propylene carbonate as electrolyte. Electrochemical performance of the carbon composites has been evaluated in terms of capacity and cycling stability, while the origin of the kinetic response is studied by electrochemical impedance spectroscopy (EIS). The contributions of the Faradaic and capacitive reactions in NFPP/C and NFPP/rGO have been compared. The effect of the carbon additive on the Na-ion diffusion has been studied by three electrochemical methods: EIS, cyclic voltammetry (CV) and galvanostatic intermittent titration technique (GITT). The difference in the electrochemical behaviour of NFPP/C and NFPP/rGO has been discussed based on the data for the electrolyte resistance (R_e), electrolyte/electrode interfacial resistance (R_{SEI}), and charge-transfer resistance (R_{ct}). The results show a clear distinction in the role of two types of carbon additives.

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Diamagnetic Ordering of Graphite Electrode Grains for Electroanalytical Applications

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Graphite exhibits a high diamagnetic anisotropy $\Delta\chi$ (=$\chi_{\parallel}-\chi_{\perp}$), where $\chi_{\parallel}$ and $\chi_{\perp}$ are the magnetic susceptibilities of a grain along the parallel (-3.3×10^{-8} emu/mol) and perpendicular (-1.9×10^{-6} emu/mol) axes, respectively (Figure 1). Therefore, the diamagnetic ordering $\langle m\rangle = \frac{1}{2}\langle 3\cos^2\theta - 1\rangle$ of grains in graphite electrodes (GE) would be promoted by a magnetically induced energy U on the electrode material (in erg/gauss/grain) based on the equation $U = -\frac{NH^2}{2}\left(\chi_{\perp} + \Delta\chi\cos^2\theta - 1\right)$, where θ is the angle between the magnetic field lines H (in gauss) and the grain plane, and *N* is the carbon content per grain (in mol C/grain) [1]. In this investigation, EGs were magnetically processed with magnetic fields of 0, 125, 250, 500, 1000, and 2000 gauss (15 min each), to diamagnetically orient their grains and control their electron-transfer (ET) properties. The EGs thus processed were used to study: (a) the ET kinetics of the $Fe(CN)_6^{3-}|Fe(CN)_6^{4-}$ pair in EG systems, and (b) the detection of aqueous H_2O_2 using Prussian blue-modified EGs (EG/PB systems). Table 1 shows the effects of magnetic processing on EGs: (a) the voltammetric ΔE_p (=E_{ap}-E_{cp}) for the $Fe(CN)_6^{3-}|Fe(CN)_6^{4-}$ couple using the EGs, where E_{ap} and E_{cp} are the anodic and cathodic peak potentials, respectively, and (b) the electrochemical quantification limits (QL) of aqueous H_2O_2 using the EG/PB. [2] In conclusion, magnetic processing of EGs at 250 gauss maximized the TE kinetics of the $Fe(CN)_6^{3-}|Fe(CN)_6^{4-}$ pair (lowest ΔE_p value) in EG systems, thereby improving the QL for H_2O_2 detection in EG/PB systems.

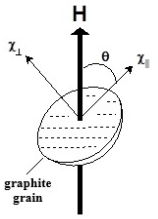


Fig. 1 Diamagnetic ordering of a graphite grain.

Table 1 Selected electrochemical results

H (gauss)	ΔE_p (mV)	QL (ppm)
0	225	149.10±0.08
125	175	189.19±0.15
250	75	95.29±0.13
500	100	147.28±0.14
1000	125	116.52±0.21
2000	200	185.16±0.23

Acknowledgments

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High-Rate Organic Li/Na Electrodes Based on Peri-Annulated Diselenides

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The utilisation of organic electrode materials (OEMs) as versatile redox-active hosts for lithium- and sodium-ion batteries is a recent development. The molecular tunability, sustainability, and ability to support both cation and anion storage within a single structural framework of these materials are the key factors behind their popularity. The structural flexibility inherent to these substances renders them far less sensitive to the ionic radius of the charge carrier in comparison to conventional inorganic intercalation hosts. This quality positions them as a particularly attractive proposition for use in sodium-ion batteries, where the larger size of Na^+ frequently limits both diffusion and structural stability.

Here, we investigate the mechanism of bipolar redox reactions in naphthalimide (NI) derivatives when used as cathodes in lithium and sodium half-cells with ionic liquid electrolytes. To increase the low electronic conductivity, we made composites of NI with rGO. Electrochemical tests were conducted in potentiostatic and galvanostatic modes within a range of potential windows spanning from 1.0 to 4.6 volts. The results of the cyclic voltammetry experiments demonstrate the bipolar nature of the studied naphthalimides. The objective of the cyclic stability experiments is to ascertain the influence of the incorporated groups at the imide nitrogen and the halogen substituent in the naphthalimide core. The results demonstrate that the specific capacity of lithium cells stabilises after the 20th cycle, whereas that of sodium cells stabilises after the 5th cycle, irrespective of the halogen substituent. Furthermore, long-term cycling tests were conducted under conditions of high current loads. The investigation revealed that the specific capacity of the sodium electrolyte at a current load of 500 mA/g decreased marginally from 45 mAh/g to 35 mAh/g. This finding suggests that the cathode material exhibited consistent high-rate performance.

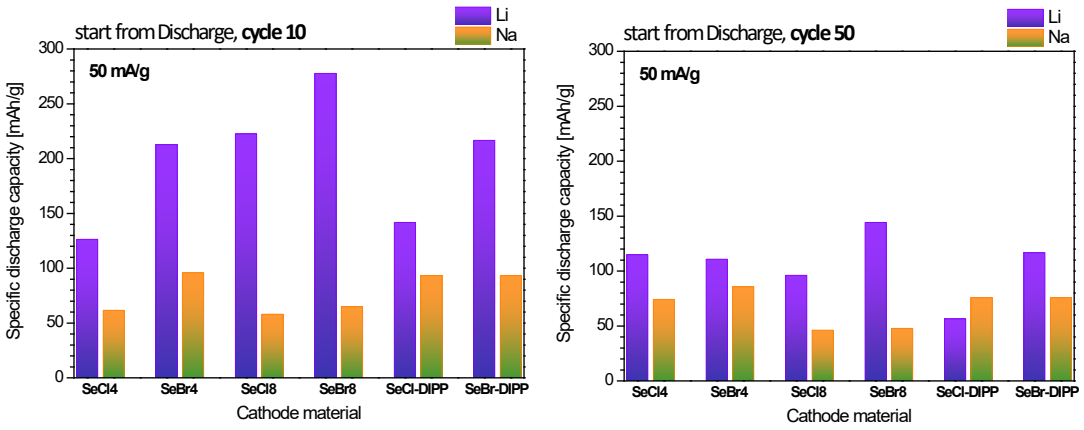


Fig.1 Discharge capacity of NIs cycled in lithium half-cells (blue bars) and sodium half-cells (orange bars) for the 10th and 50th cycle, starting from a discharging mode at current load 50 mA/g.

Acknowledgements
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Clay Mineral-Doped Positive Electrode for Lead-Acid Batteries

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The positive active material (PAM) of lead-acid batteries features a hierarchical structure, where PbO_2 particles form agglomerates and aggregates that define the electrode's reaction and transport pores. These particles consist of gel and crystalline zones, providing proton and electron conductivity, respectively. Additionally, PAM comprises alpha- and beta-PbO_2 polymorphs, each exhibiting distinct morphologies and electrochemical characteristics.

This study investigates the effect of clay mineral doping on the electrochemical performance of positive electrodes. To address limitations such as low utilization and limited cycle life under partial state-of-charge (PSoC) conditions, natural clay minerals were incorporated into the positive paste. Structural and morphological changes were characterized using Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), the BET method for specific surface area (SSA), and Hg-porosimetry. Electrical characteristics were evaluated through initial C_{20} capacity tests and a specific automotive protocol at 17.5% Depth of Discharge (DoD) to simulate PSoC conditions.

The results demonstrate that the addition of 1% Halloysite nanoclay (HNC) significantly enhances porosity and ionic conductivity by acting as an acid reservoir and facilitating electrolyte diffusion. Batteries with 1% HNC-doped electrodes exhibited increased SSA and a prolonged cycle life compared to the control samples. Furthermore, the doping inhibited the shedding of active material, leading to enhanced structural stability. These findings suggest that clay minerals are a cost-effective and environmentally friendly additive for improving the energy density and durability of lead-acid batteries in automotive applications.

Keywords
Lead-acid batteries; Positive electrode; Clay minerals; Doping; Energy storage.

Acknowledgements
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Tuning the Electronic Structure of TiO_2 via Sputtering Deposition of Ti to Enhance Electron Transfer in Dye Sensitized Solar Cells

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Dye-sensitized solar cells (DSSCs) still generate considerable research interest due to their green and inexpensive technology of production, as well as easy fabrication and flexibility. In recent years, the particular significance of these photoelectrochemical devices has been evident in rising energy conversion efficiency under low-solar-light and indoor diffuse-light conditions.[1] The most important and complex part of every DSSC is the photoanode, the initial point for the injection of photogenerated electrons from the dye molecule to the oxide semiconductor. The relative position of energy levels of a semiconductor, commonly TiO_2, and a dye molecule plays a crucial role in the efficient electron transfer and thus efficient photon to current conversion. Doping TiO_2 with nonmetals and metals is considered a promising way for tuning the conduction band edge of TiO_2 to improve the photovoltaic performances of DSSCs.[2]

In this research, we have doped TiO_2 by sputtering Ti atoms directly on the top of the mesoporous layer of TiO_2 paste. Radio-frequency (RF) sputtering allows precise control over the amount and uniformity of the dopant distribution, which is otherwise challenging when metals are incorporated into the paste via alternative methods.[3] A series of samples has been fabricated by varying the RF sputtering power and the deposition time. The samples have been exposed to the elevated temperatures during the subsequent process of sintering in the inert atmosphere of Ar. As the intercalation of Ti atoms in the TiO_2 structure depends on temperature, we have also investigated the impact of the sintering process on the characteristics of the doped layers. The change in the electronic structure of Ti-doped TiO_2 is investigated by observing the difference in the work function shift between doped and non-doped samples using Kelvin probe force microscopy. Atomic force microscopy provided insights into the morphology of doped layers. Finally, doped TiO_2 samples that showed a significant change in the work function were used for the fabrication of DSSCs, with N719 dye as the sensitizer, I^-/I_3^- redox electrolyte, and Pt as the counter electrode. Voltammetric and impedance spectroscopy measurements of the prepared solar cells enabled us to explore the changes in the photovoltaic performances of solar cells caused by the presence of dopants and identify the DSSC with the highest efficiency.

Acknowledgments

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Metallomic Analysis of Biological Samples from Patients with Malignant Tumors Using Electrochemical Methods

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Introduction. According to available statistical data, the incidence of cancer in industrialized countries shows an increasing trend. Among the most frequently occurring malignant tumors, prostate cancer ranks highest in men, while breast cancer is the most common in women. A wide range of methods, such as magnetic resonance imaging, positron emission tomography, ultrasound, and others, are used in diagnostics. However, such methods are costly and require highly specialized personnel. Therefore, new, faster, and more economically favorable approaches, such as chemical and biochemical markers, are being sought. It is known that a wide range of molecules show an association with cancer, including the metallomic approach. Cancer metallomics evaluates the relationships between levels of metal ions (zinc, copper, cobalt, manganese, or selenium), regulatory proteins (thiol compounds such as metallothioneins or glutathione), and malignant tumors. The large amounts of data obtained require the use of more advanced mathematical data processing methods. The aim of the study was to investigate the levels of selected metal ions and biochemical parameters in patients with cancer. Furthermore, the objective was to evaluate the levels of thiol compounds and utilize mathematical data evaluation based on neural networks.

Methods. Blood serum and urine were obtained from probands included in the study and stored at −20 °C until processing. Biochemical analysis was performed using the Atellica CH930. Metal analysis was performed using AAS. Electrochemical analyses (Cu, Zn, Pb, Cd, and thiols) were performed using a Metrohm potentiostat. Samples for the determination of thiols were prepared according to our proposed procedure. The obtained data were stored and processed in the QUINSLAB laboratory information system.

Results. The observed group of evaluated data covered the period 2000–2026. A total of 300 probands were analyzed, 57% women and 43% men. The age range was from 16 to 81 years, with a mean age of 59 years (median 62 years). The selected cohort showed a clear shift toward higher age categories. In our pilot study, urine and serum were analyzed during routine biochemical examination. Zinc ion levels were 0.1–43.4 μmol/l and copper ion levels were 0.3–10.9 μmol/l. Electrochemical determination of MT was performed using the Brdička reaction. The electrochemical study yielded MT voltammetric curves with typical signals (Cat1, Cat2, and Cat3). An average amount of MT in the range of 8–35 μg/l was found in the group. In the distribution of MT values, three significant clusters can be observed around the values of 5 μg/l, 15 μg/l, and 30 μg/l. The obtained curves were evaluated in detail using machine learning methods and Fourier transform. For each proband, an average curve was mathematically calculated and the area under the curve (AUC) was determined for the individual studied analytes.

Conclusion. In the ongoing study, new insights were obtained through metallomic analysis of urine in patients with cancer.

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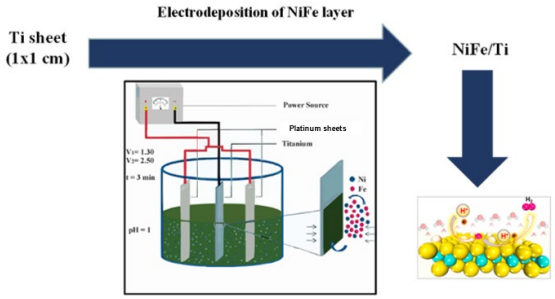
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Three-Dimensional Nickel–Iron/Titanium Bimetallic Electrocatalysts for Efficient Hydrogen Evolution in Acidic Media

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Aiming to develop efficient and low-cost electrocatalysts for the hydrogen evolution reaction (HER), bimetallic systems have attracted considerable attention due to their tunable intrinsic properties and potential synergistic effects. This study focuses on Fe/Ni bimetallic layered coatings as efficient electrocatalysts for the HER in 0.5 M H_2SO_4. The catalysts were electrochemically deposited onto a titanium substrate (1 × 1 cm^2) using a hydrogen bubble template-assisted method, which is a simple, cost-effective, and easily controllable method. The HER electrocatalytic performance of the synthesized catalysts was evaluated by linear sweep voltammetry at 298 K. The morphology and composition were characterized using scanning electron microscopy and inductively coupled plasma optical emission spectroscopy. Fe^{3+}/Ni^{2+} molar ratios of 1:1 and 1:2 were employed to prepare FeNi/Ti-1 and FeNi/Ti-2 electrocatalysts, respectively. Both catalysts exhibited excellent HER activity under acidic conditions, requiring overpotentials of only 106 and 247 mV, respectively, to achieve a current density of 10 mA cm^{-2}. Furthermore, both electrocatalysts maintained remarkable stability during chronoamperometric and chronopotentiometric measurements performed for 2 and 10 h, demonstrating their durability under HER operating conditions. Overall, these results demonstrate that Fe/Ni bimetallic systems are promising, robust, and highly efficient electrocatalysts for the HER and may contribute to the development of sustainable hydrogen production technologies.



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Theoretical Modeling of Titanium Suboxides for Advanced Environmental Electrochemical Applications

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Titanium suboxides containing Magnéli phases have emerged as highly attractive electrode materials for electrochemical advanced oxidation processes because of their favorable electronic conductivity, chemical stability, and ability to promote reactive oxygen species formation. To gain insight into the influence of oxygen deficiency on electrochemical behavior, density functional theory (DFT) calculations were performed on representative rutile TiO_2 and Magnéli-phase surfaces. Particular attention was devoted to the Ti_6O_{11} phase, whose conductivity remains sufficiently high to support efficient pollutant oxidation while exhibiting thermodynamic stability comparable to Ti_4O_7 with respect to rutile formation. The calculations revealed that oxygen-vacancy formation and the emergence of Ti^{3+} states increase electronic conductivity and modify the surface electronic structure, facilitating charge transfer and adsorption of reactive intermediates involved in oxygen evolution and radical generation processes. In contrast to rutile TiO_2, Ti_6O_{11} and Ti_4O_7 exhibit occupied Ti 3d states near the Fermi level, with Ti_6O_{11} showing a broader distribution of these states, indicating enhanced electronic delocalization and stronger hybridization effects. These features suggest favorable properties of Ti_6O_{11} for adsorption and electrooxidation of PFAS contaminants. Furthermore, DFT analysis of PFAS degradation pathways demonstrated that oxidation-induced radical formation leads to redistribution of spin density and weakening of key chemical bonds. In PFOA, strong destabilization of the carboxyl group promoted decarboxylation, whereas PFOS exhibited destabilization of the sulfonate moiety, consistent with its experimentally observed faster degradation. Bond order and Fukui function analyses further indicated that radical localization governs the initial bond cleavage pathways during electrochemical oxidation. Overall, the theoretical results demonstrate that surface-engineered titanium-suboxide electrodes possess tunable electronic structure, high stability, and promising electrocatalytic properties for advanced electrochemical wastewater treatment and degradation of persistent pollutants.

Acknowledgment
Research was funded by the Science Fund of the Republic of Serbia (Grant No 17990, Advanced electrochemical treatment of PFAS contaminated water: Novel Materials and Mechanisms–ALTER), and supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No: 451-03-137/2025-03/200146, 451-03-136/2025-03/200146, 451-03-137/2025-03/200161 and AIRES project number 003417039).

Electrocatalytic Hydrodeoxygenation of Aldehydes in Pd@CNT-Stabilized Pickering Emulsions

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The global transition toward a sustainable chemical industry requires processes to shift from fossil to renewable carbon and energy sources. Many important platform molecules contain carbonyl functionalities such as aldehydes (e.g. furfural, HMF, vanillin, etc.), which need to be hydrodeoxgenated to produce bio-derived intermediates for the production of fuels and value-added chemicals. [1,2] High temperatures and pressures are typically needed for conventional thermal catalytic processes, and these harsh conditions can also promote side reactions such as polymerization and coke production, which can reduce yield and selectivity.[3]

With the ability to fine-tune electron transfer and redox transformations under moderate conditions without the need of stoichiometric oxidants or reductants, electrocatalysis and organic electrosynthesis have lately become attractive approaches.[4,5] One direct and atom-efficient method for removing oxygen from carbonyl substrates is electrochemical deoxygenation; yet, direct hydrodeoxygenation (HDO) of these substrates is still a major obstacle due the high bond dissociation energies (BDEs) of C−O and C=O bonds.[6]
Building on a concept recently established by our team,[7] this study investigates the electrocatalytic HDO (ECHDO) of aldehydes using a Pd@CNTs catalyst within a Pickering emulsion system. The unique properties of this Pickering emulsion system, such as enhanced mass transfer and optimized interactions between the catalyst, organic phase and electrolytes, provides a conducive environment for complex catalytic reactions enabling effective dissociation of C−O and C=O bonds to tolyl products with higher selectivity and Faradaic efficiency than previously reported (Figure 1b). The hydrophilic carboxylated-CNTs stabilize the aqueous phase, while hydrophobic Pd NPs generate adsorbed hydrides (H_{ads}) at the interface and drive selective C–O bond cleavage in the organic phase (Figure 1a). This integrated catalytic–emulsion platform enables the selective hydrodeoxygenation of C=O bonds to alkanes, effectively overcoming the limitations of traditional hydrogenation pathways.

This method demonstrates a synergistic integration of electrocatalysis and emulsion chemistry for the sustainable upgrading of biomass-derived carbonyl compounds, advancing the frontier toward a green chemistry-energy nexus.

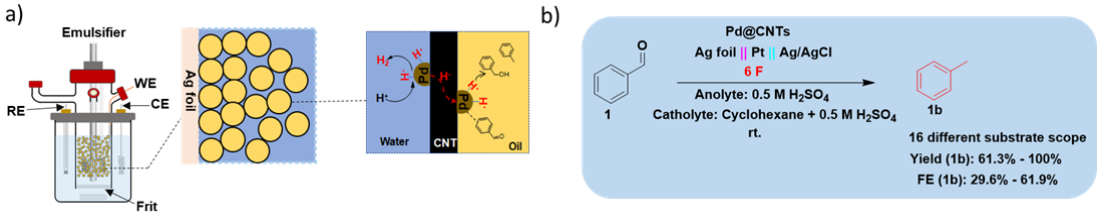


Fig. 1 a) Pickering emulsion system, with CNT-stabilized oil-in-water emulsion on Ag electrode (WE: Working Electrode) enabling interfacial ECHDO of aromatics (where; CE: Counter Electrode, and RE: Reference Electrode). b) Optimized conditions for aldehyde ECHDO across substrates.

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Interfacial Engineering of ZIF-8/CNF Hybrid Architectures for Flexible Electrochemical Energy Storage

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The increasing demand for sustainable and flexible energy-storage technologies has accelerated the development of multifunctional electrode materials with high conductivity, structural stability, and efficient charge transport. In this work, an in-situ synthesized ZIF-8/cellulose nanofiber (ZIF-8/CNF) hybrid architecture was developed as a flexible supercapacitor electrode. The in-situ growth of ZIF-8 nanocrystals within the interconnected cellulose nanofiber network enabled uniform nanoparticle dispersion, resulting in a porous and mechanically stable structure with improved interfacial contact and electrochemical accessibility.

The optimized ZIF-8/CNF electrode exhibited enhanced electrical conductivity (2.083 S cm^{-1}) and demonstrated excellent electrochemical performance in flexible supercapacitor devices. The symmetric device achieved a specific capacitance of 155.3 F g^{-1} with an energy density of 49.6 Wh kg^{-1} and maintained 88% capacitance retention after 10,000 charge–discharge cycles. In addition, the asymmetric ZIF-8/CNF‖CNF device showed stable electrochemical behavior under repeated bending conditions, confirming its mechanical flexibility and structural robustness.

The improved electrochemical performance is attributed to the interconnected porous architecture and effective integration of ZIF-8 nanocrystals within the CNF framework, which facilitated efficient ion transport and charge-transfer pathways. These results highlight the potential of ZIF-8/CNF hybrid materials as sustainable and flexible electrode platforms for next-generation electrochemical energy-storage.

Development of a Polypyrrole/Activated Carbon-Based Electrochemical Sensor for Pb^{2+} Detection in Water

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Heavy metal contamination in water, particularly by Pb^{2+}, poses significant environmental and health risks due to toxicity and bioaccumulation. This work aims to develop a sensitive, low-cost, and sustainable electrochemical sensor for Pb^{2+} detection. A composite sensing platform was designed by combining polypyrrole (PPy) with activated carbon derived from recycled polyethylene terephthalate (PET). Activated carbons were obtained via pyrolysis at 700–900 °C and characterized by FTIR, SEM, nitrogen physisorption, and Raman spectroscopy, confirming porous structures (133 m^2g^{-1}) with moderate disorder (ID/IG = 0.78). The sensor was fabricated by electropolymerizing pyrrole onto a modified glassy carbon electrode in 0.1 mol L^{-1} H_2SO_4 at a scan rate of 100 mV s^{-1}.

Electrochemical analysis demonstrated the formation of a stable, conductive PPy/carbon film. The synergistic effect between PPy conductivity and high surface area carbon enhanced charge transfer and metal ion preconcentration. The sensor exhibited high sensitivity toward Pb^{2+} with a limit of detection of 1 µmol L^{-1} and good reproducibility in aqueous media. This study presents a cost-effective and sustainable sensing strategy that integrates plastic waste valorization with efficient electrochemical detection, showing strong potential for environmental monitoring applications.

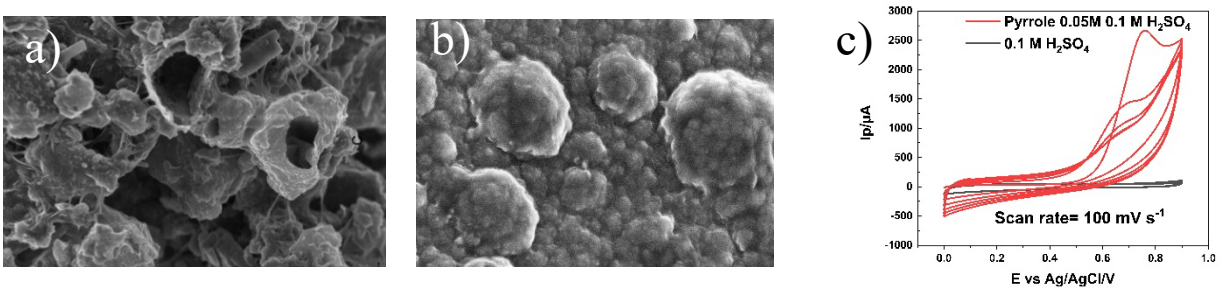


Fig. 1 a) SEM micrograph of the AC; b) SEM micrograph of the Ppy, c) cyclic voltammograms recorded during the electropolymerization of pyrrole on the modified electrode.

Keywords

Electrochemical sensing; Polypyrrole; Activated carbon; PET waste valorization; Pb^{2+} detection; Water analysis.

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Applying Point Defect Thermodynamics to the SIB Cathode Material Prussian Blue – Experiments and Modelling

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Prussian Blue, $Na_{1+\xi}Fe[Fe(CN)_6]$, and Prussian Blue analogues, $Na_{1+\xi}Fe[Me(CN)_6]$ (Me = Mn, Ni, Co, Cu, etc.) are promising low-cost cathode materials for future sodium-ion batteries. Prussian Blue stands out for a high theoretical capacity of 169 mAh g^{-1} and low manufacturing costs, as it can be synthesised in aqueous solution without high temperature processing. Despite the importance of this class of materials, the point defect structure and the range of stoichiometry ξ of these mixed ionic and electronic conducting phases are not reported in detail in literature.

An electrochemical cell is assembled using a sodium metal anode, the solid Na^+ electrolyte NASICON and a (composite) cathode of only iron based Prussian Blue. The course of the cell potential U_{cell} *vs.* ξ is measured by galvanostatic intermittent coulometric titration (GITT). The chemical diffusion coefficient $\tilde{D}_{Na}$ of the component sodium is determined by evaluation of the cell potential transients.

Point defect thermodynamics is used to model relations between ξ, the chemical potential μ_{Na}, U_{cell}, $\tilde{D}_{Na}$ and σ_e-. [1] The thermal equilibrium between high-spin Fe^{3+}, low-spin Fe^{2+}, low-spin Fe^{3+} and high-spin Fe^{2+} is decisive for the electrochemical properties. These defects can be assigned as “electrons” and “holes”. U_{cell} *vs.* ξ and $\tilde{D}_{Na}$ *vs.* ξ exhibit characteristic s-shaped courses. The equilibrium constant K_{el} of the thermally excited electron-hole formation and the charge carrier mobilities $u_{e'}$ and $u_{h\cdot}$ are obtained by fitting the data. The Gibbs free enthalpy ΔG_{el}^0 has a value of 0.3 eV, this is significantly lower than the energy E_{IT} of the optically excited charge transfer process of 1.7 eV. This is in accordance to the Marcus-Hush theory of intervalence charge transfers [2] $\tilde{D}_{Na}$ is in the order of 10^{-8} to 10^{-9} cm^2 s^{-1}, $u_{e'}$ and $u_{h\cdot}$ in the order of 10^{-7} and 10^{-6} cm^2 $(V\ s)^{-1}$, indicating strongly localised small polarons. A full sodiation results in a Prussian White phase with a nominal composition $Na_2Fe[Fe(CN)_6]$, a full desodiation seems to be impossible. It ends up at a limiting composition of about $Na_{0.2}Fe[Fe(CN)_6]$. [3] The results offer valuable insights for a better understanding the electrochemical (cycling) behaviour [4].

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Towards Fluoride-Free Synthesis of MXenes for Electrochemical Applications

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MXenes are two-dimensional nanomaterials with numerous attractive properties for electrochemical devices, discovered by Gogotsi *et al.* in 2011.[1] Modification of synthesis methods and post-processing techniques allows for a variety of controllable parameters: surface terminations on basal planes, electronic structure and band gap, hydrophilicity, conductivity, particle size, mechanical strength, and more may all be tuned to suit a range of applications including: electrocatalysis, sensing, energy storage and conversion, heat and EMI shielding, and fabrication of nanoscale electronic devices.[2-6]

MXenes are made by selective etching of a nanolayered ceramic starting material, the MAX phase. Controlled removal of interlayer metal atoms leaves only metallic carbide nanosheets imparted with surface functionality. Separation into few or single layer nanosheets is possible by adding intercalants and delamination. These 2D particles are typically stored in suspension, and may then be formed into a membrane, drop-cast onto an electrode, or used to construct nanodevices.[2,6]

Despite their rich chemistry, MXenes are limited by synthesis methods that rely on risky and inconvenient fluoride-producing methods, and/or very harsh conditions. Additionally, MXenes often exhibit marked degradation due to oxidation, both during synthesis and use. Therefore, scalability of these exciting materials is limited by lengthy and dangerous production.[5-8]

Here, we examine the use of mild conditions during MAX phase etching in order to develop a facile method to produce MXene membranes. Combining hydrothermal, UV, or electrochemically assisted processes with added reagents to limit water activity and therefore oxidation allows for a neat, one-pot process combining the etching and delamination steps, reducing the need for complicated work-up.[9-12] These porous membrane deposits are then applied for electrocatalysis: here we investigate the conversion and separation of aqueous nitrate waste streams into ammonia, a process that presents an electrifiable, low-carbon alternative to the historically significant Haber-Bosch process.[13-15]

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Modulating Bipolarity in Naphthalimide Electrode Materials via Dichalcogenide Bridging

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In recent years, organic electrode materials have become a good alternative to inorganic materials, as they have high energy density, low cost, and are environmentally friendly. They are distinguished by a unique multi-electron redox mechanism for energy storage. Their diversity of compositions and flexible structure make them more resistant to structural stress in oxidation-reduction reactions.

Here, we investigate the mechanism of redox reactions in naphthalimide (NI) derivatives when used as cathodes in lithium half-cells with ionic liquid electrolytes. NI derivatives consist of three building blocks: an aromatic naphthalene core, an N-alkylated imide unit, and a peri-dichalcogenide bridge. The main building block in their molecular structure is the chalcogenide bridge, in which S is sequentially replaced by Se and Te. Their only drawback is the low electronic conductivity, for this purpose, we made composites of NI with rGO. In Fig. 1, the morphology of the pure compositions SCl8 to SeCl8 and TeCl8, and composites with rGO, is presented, which changes progressively from small, tightly connected rods to rod-shaped particles and to wire-like particles with needle-like ends.

Electrochemical tests were performed in potentiostatic and galvanostatic regimes. In the entire potential window (i.e., between 1.0 and 4.3 V), where both reduction and oxidation are activated, the charge-discharge curves adopt almost the same profiles, regardless of the nature of the chalcogenide. Among the pure compounds, SCl8 provides the highest capacity and after 15 cycles, the capacity decreases in the order SCl8 > SeCl8 > TeCl8. A dramatic improvement in the specific capacity is achieved after the addition of rGO to the pure compounds: after 15 cycles, the discharge capacity increases from 82 to 183 mAh/g for SCl8; from 61 to 252 mAh/g for SeCl8; and from 29 to 62 mAh/g for TeCl8. This is directly related to the improved electronic conductivity of the NI derivatives by the addition of rGO.

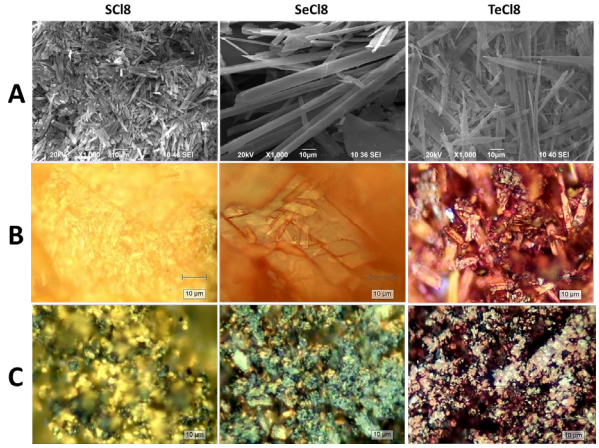


Fig. 1 SEM images of SCl8, SeCl8, and TeCl8 (A), color images (B) and their composites with rGO (C).

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Oxygen Reversible Gas Diffusion Electrode with Single-Layer Structure for Rechargeable Metal-Air Batteries

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The development concerns a single-layer gas-diffusion electrode (GDE) designed for operation in rechargeable Metal-Air battery. It has a single-layer structure, in which no distinction is made between a gas and a catalytic layer – they are united in a monolithic composite structure. The main advantage of the single-layer GDE is the elimination of the need for separate application of a catalytic layer, which significantly reduces the complexity, time and cost of the production process. The developed technology given the agility to move from lab-based concepts to industrially scalable product and can be adapted by changing the type and quantities of starting materials, as well as the location of the current collector. It is also possible to configure it with other types of metal electrodes in a rechargeable Metal-Air battery. In addition, the developed electrode demonstrates significantly improved electrochemical stability, maintaining stable performance for over 1000 charge–discharge cycles.

The matrix of the basic structure of the electrode is teflonized MWCNT in which the catalysts for the two oxygen reactions are evenly distributed: reduction (ORR) and evolution (OER). There are also certain amounts of zeolite to wet the electrode on the electrolyte side and to increase gas permeability on the opposite side. To increase the mechanical stability of the structure and bond of individual materials, PTFE powder is used as an additional binder. Within conducted research, the results of the structural (SEM, EDS, XRD, BET, etc.) and electrochemical (potencio/galvano static modes) studies of electrode samples have been shown and analyzed. Some post-mortem analyses have also been made to give a clearer understanding of the causes of the degradation processes occurring in the GDE.

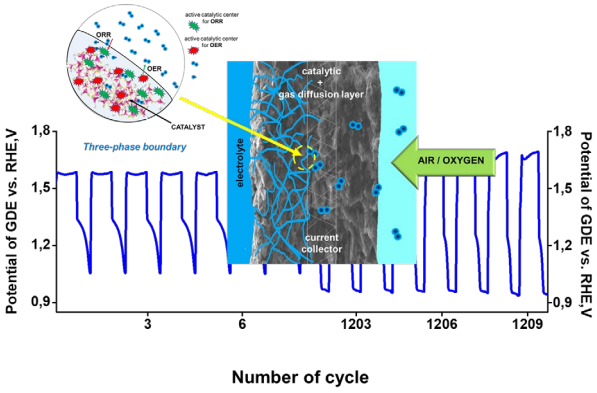


Fig. 1 Schematic figure of the single-layer GDE and cyclic stability test.

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The Perspective of Tandem PVDF-HFP/SWCNT/Bi_2O_3 Platform for Advanced Electrochemical Applications

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PVDF-HFP (poly(vinylidene fluoride-co-hexafluoropropylene)) is a highly versatile fluoropolymer widely used in modern sensor technologies. Due to its superior flexibility, high piezoelectric properties, and excellent chemical resistance, its potential application in the fabrication of polymeric membranes has recently gained significant attention. The membrane mixture (MM) was prepared from PVDF-HFP and Aliquat 336 in THF using two methods: heating at 40 °C with magnetic stirring, and using an ultrasonic bath. A comparison of the thermal properties of the membranes prepared by these two methods was conducted using differential scanning calorimetry (DSC).

The aim of this work was to investigate the possibilities of applying the advantages of the MM for electroanalytical purposes and to confirm its ion-exchange properties as a selective film for electrode modification. The MM was evaluated in presence of transition metal ions, carbonates, thiocyanate, and glucose, proving to be a effective barrier for positively charged particles as well as a protective anti-fouling layer.

Furthermore, the prepared MM was used as a matrix in the preparation of a bismuth-based single-walled carbon nanotube electrode. The electrode films were examined using cyclic voltammetry, chronoamperometry and electrochemical impedance spectroscopy (EIS). In addition, a study on the redox properties of the films toward gallic acid was performed. The tandem use of SWCNTs and Bi_2O_3 within the MM matrix emerged as the optimal configuration. Due to its unique structure, the MM significantly improves mechanical properties, acts as a smart barrier and enhances stability of modification.

The SWCNT/Bi_2O_3/MM electrode was optimised and applied for the qualitative and quantitative analysis of gallic acid in real samples using square-wave (SW) voltammetry. The response stability, excellent mechanical stability, reproducibility, and reliability demonstrate the outstanding performance of the developed sensor. This work provides a new perspective on the simplified design and integration of robust, multifunctional, and flexible sensors.

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Potentiometric Sensors Based on Calix[4]arene Derivatives for the Detection of New Psychoactive Substances

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In 2023, an estimated 316 million people worldwide had used illegal drugs at least once a year [1]. Aminoindane (2-AI) first emerged on the United Kingdom's illicit drug market around 2010 [2]. Their popularity spread rapidly following the ban on mephedrone [3]. Chile, for instance, reported the emergence of tryptamines (TRY) in its market in 2013 [4].

On-site rapid detection technologies, such as electrochemical sensors, offer core advantages including rapid response, ease of operation, and portable equipment, which align with the timeliness requirements of law enforcement settings. Potentiometric sensors are capable of measuring AI and TRY as cations. This is an intrinsic advantage of the potentiometric measurement of 2-AI/TRY, as the negative influence of the main anionic interferents in fluids is eliminated. Another advantage of the potentiometric approach is its non-destructive character, which is particularly important for measurements at low concentrations. In contrast to other electrochemical sensors, potentiometric sensors offer a response across a wide concentration range.

In this study, 4-tert-butylcalix[4]arene-tetraacetate (C4), 4-sulfocalix[4]arene (SC4), and sodium tetraphenylborate (TPBNa) were applied and compared as recognition components of the potentiometric sensors. Analytical parameters, including sensitivity, selectivity, and the limit of detection, were evaluated in parallel. The advantages and disadvantages of the potentiometric detection of 2-AI/TRY are discussed. The experimental potentiometric sensors demonstrated a near-Nernstian response in a wide concentration range from 1.00×10^{-5} to 1.00×10^{-2} mol l^{-1}. The C4-based potentiometric sensor demonstrated stable and repeatable sub-Nernstian responses towards 2-AI: 44.3 ± 3.1 mV $decade^{-1}$ (RSD = 2.8 %). The SC4-based sensor demonstrated high sensitivity towards 2-AI/TRY in both model systems and in oral fluids. Unlike the C4-based sensor, the SC4-sensor showed an ability to discriminate primary amines and inorganic cations. It should be noted that primary amines are potential interferents in the determination of 2-AI/TRY. According to reported cases of intoxication, blood concentrations of AI and TRY are in the range of 0.101 to 26.3 mg l^{-1} and 0.01 to 2.0 mg l^{-1}, respectively. The present work showed the ability of potentiometric sensors to determine 2-AI and TRY in both model and saliva samples at a concentration of 1.00×10^{-5} mol l^{-1}, corresponding to 1.70 mg l^{-1} for 2-AI and1.97 mg l^{-1} for TRY.

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Electrochemical Deposition of Polymethylene Blue and Ni-Based Composite Films for Sensor Applications

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This study investigates the optimization of electrodeposition parameters for the fabrication of polymethylene blue (PMB) and $Ni(OH)_2$/NiOOH composite materials for non-enzymatic electrochemical glucose sensing applications. PMB is a conductive polymer with excellent electrocatalytic and photoelectrochemical properties, high electrical conductivity, and good long-term stability, making it a suitable matrix for composite sensor materials [1]. In alkaline media, the $Ni(OH)_2$/NiOOH redox couple exhibits strong electrocatalytic activity toward glucose oxidation through the reversible transition between Ni^{2+} and Ni^{3+} species, enabling efficient electron transfer and enhanced sensing performance. Nickel-based nanomaterials have also demonstrated high catalytic activity toward small molecules such as hydrogen peroxide, methanol, and formaldehyde [2, 3].

Screen-printed electrodes consisting of a gold working electrode and a platinum counter electrode were modified with conductive polymer layers combined with nickel-based materials. PMB films were synthesized by electropolymerization using cyclic voltammetry in the potential range from −0.4 V to 1.1 V under alkaline conditions to obtain stable and uniform polymer coatings. Subsequently, different concentrations and compositions of $Ni(OH)_2$/NiOOH were electrodeposited onto the PMB-modified electrodes to form composite sensing layers. The morphology and structural properties of the prepared composites were characterized by scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FTIR). In addition, the influence of scan rate on the electrochemical behavior of the modified electrodes was investigated. Sensor stability, sensitivity, and electrocatalytic activity toward glucose oxidation were systematically evaluated. The analytical performance of the fabricated sensors was assessed through calibration measurements at different glucose concentrations. The obtained results demonstrate that PMB/$Ni(OH)_2$/NiOOH composite electrodes exhibit promising electrochemical properties and significant potential for sensitive and stable glucose sensing applications.

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Operando Thermography-Assisted Mapping of Interfacial Current Distribution in Electrochemical Batteries

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Mapping the spatial distribution of interfacial current is important for understanding reaction heterogeneity, local polarization, and uneven electrode utilization in electrochemical batteries. However, conventional electrochemical measurements usually provide only area-averaged current responses and cannot directly resolve local current-density variations across the electrode surface. Here, we propose an operando thermography-assisted strategy[1] to reconstruct the apparent two-dimensional current-density distribution of cathodes in aqueous Zn batteries.

In this work, infrared thermography is combined with chronoamperometry to monitor the transient thermal response of working battery electrodes under constant-voltage polarization. MnO2/Al foil and graphite/stainless-steel cathodes paired with Zn anodes are selected as model battery configurations. The heat generation in the electrochemical cell is considered to originate from ohmic heating, electrochemical-reaction-related heat, and polarization-associated thermal contributions. To isolate the electrochemical thermal signal, a no-electrolyte control cell is used to establish the baseline background heating, which is then subtracted from the total thermal response measured in the electrolyte-containing cell. The early-stage temperature-rise rate is employed as the thermal descriptor because it is closely related to local current flow. After background correction, the obtained spatial thermal signal is converted into a relative current-distribution map and further calibrated by the simultaneously recorded chronoamperometric current to generate an absolute current-density map.

This experiment-guided thermographic method provides a direct and visual approach to evaluating non-uniform interfacial current distribution in battery electrodes. By linking operando thermal imaging with electrochemical current response, the proposed strategy bridges macroscopic electrochemical measurements and local interfacial reaction behavior. This approach may provide useful insight into electrode heterogeneity, current localization, and structure–performance relationships in aqueous Zn batteries and other electrochemical energy-storage systems.

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CULTURAL EVENTS

mixed chambre choir

CANTIO ANTIQUA



Monday September 21, 2026

Conference room, 7:00 PM

Renaissance songs as a living language with which we can talk to the past, comfort those present, sing our own sorrows and express joyful vibrations, outbursts of love, indignation, fighting tensions as well as satisfaction and peace. The eight-part vocal ensemble ***Cantio antiqua*** *focuses on European Renaissance music, not disdaining the overlaps into Gothic, early Baroque and sometimes even into the present. The ensemble approaches this so-called old music with youthful enthusiasm in the sense of the motto: back then, music was still young. In this so-called serious music, Cantio antiqua finds humor, irony, and even titillating images from the life of secular society, which was certainly not too different from our own world. And so, where perhaps the song originally sounded too serious and noble, we do not hesitate to involve our own imagination and, in the spirit of Renaissance puns, underpin the music with a new text. We connect musical samples with a story about Renaissance society or with period poems.*

CRUISE ON THE VLTAVA RIVER

An experience in the heart of Prague with all your senses

You can enjoy great food and great views of the most important landmarks on both sides of the "Moldau-Vltava" river.



Na Františku (starting point) is a historical district in Prague 1, named after the Church of St. Francis of Assisi within the grounds of the **Agnes Convent**. The origins of the district date back to the 12th century, with significant development following the founding of the St. Clare's Convent by King Wenceslas I in 1233. The area was also home to other monasteries and hospitals, including the present-day Hospital Na Františku, whose history dates back to the 17th century. The area was an important transport hub connecting Old Town with Lesser Town.
Cruise will take you on a journey where you can enjoy views of the **Agnes Monastery, Charles Bridge** with views of **Kampa, Hradčany, the panorama of Prague Castle, Sovovy Mlýny, Straka Academy, Dancing House** and other attractions.

Charles Bridge is Prague's oldest bridge over the Vltava River, built by Charles IV in the 14th century on the site of the older Judit Bridge. It served as an important trade route and connects Old Town with Lesser Town. It is famous for its thirty Baroque statues and statuary groups, the most well-known of which is the **statue of St. John of Nepomuk**.
Sovovy mlýny on Kampa is a historical complex of buildings, originally a Renaissance watermill from 1589, which underwent reconstruction in the 19th century. After a major fire in 1896, the mill was abandoned and the buildings fell into disrepair until the Jan and Meda Mládek Foundation renovated them in 2002 and transformed them into gallery spaces for Museum Kampa. Today, it is a significant monument with a rich history.



Sponsor



Exhibitors

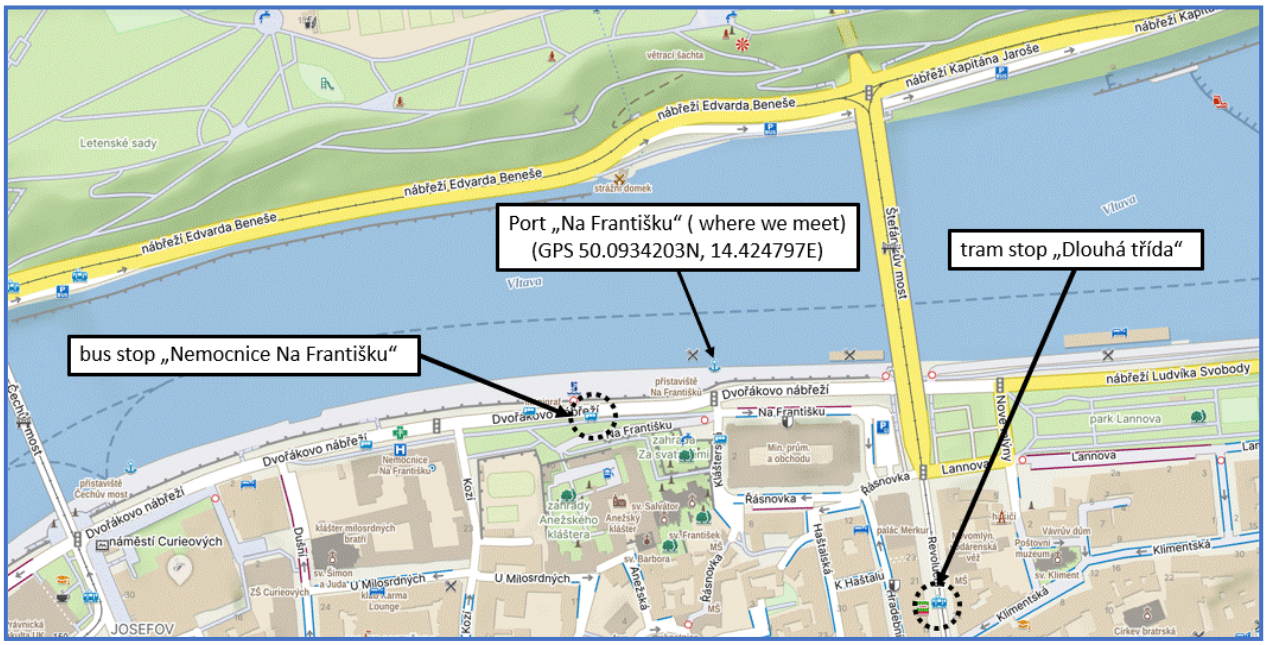




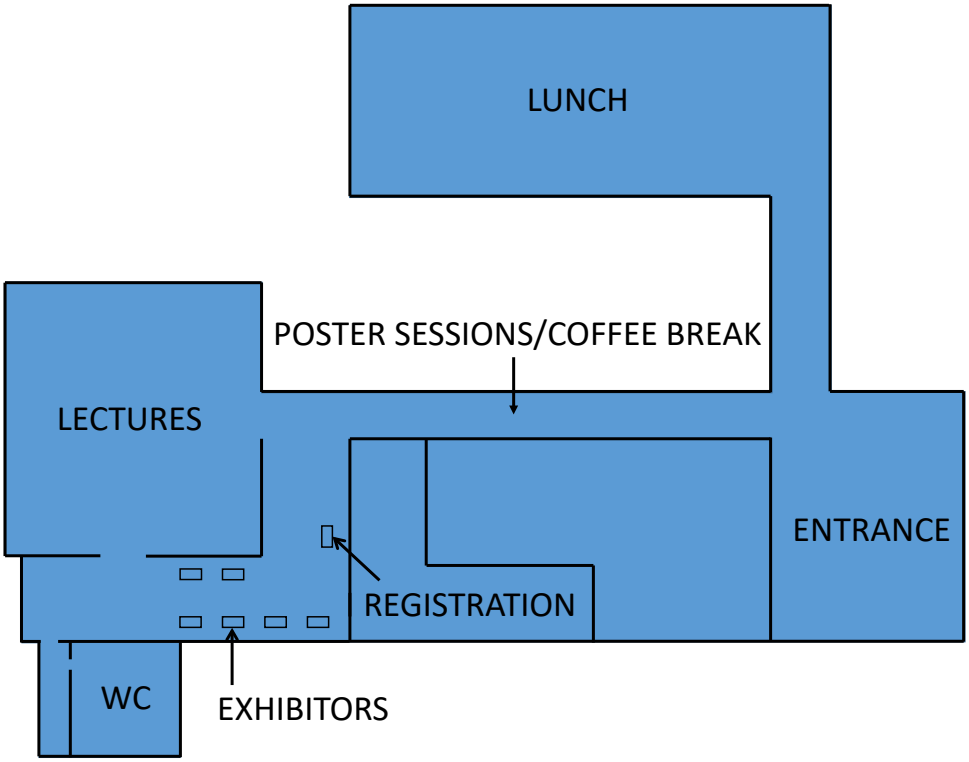




CRUISE ON THE VLTAVA RIVER (Conference Dinner):



Map of the embarkment point for the Cruise on the Vltava (Moldau) river
Address: Dvořákovo nábřeží – quay Na Františku, dock number 10



Sketch of the Conference Center Krystal: José Martího 407/2, 16200 Prague 6

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