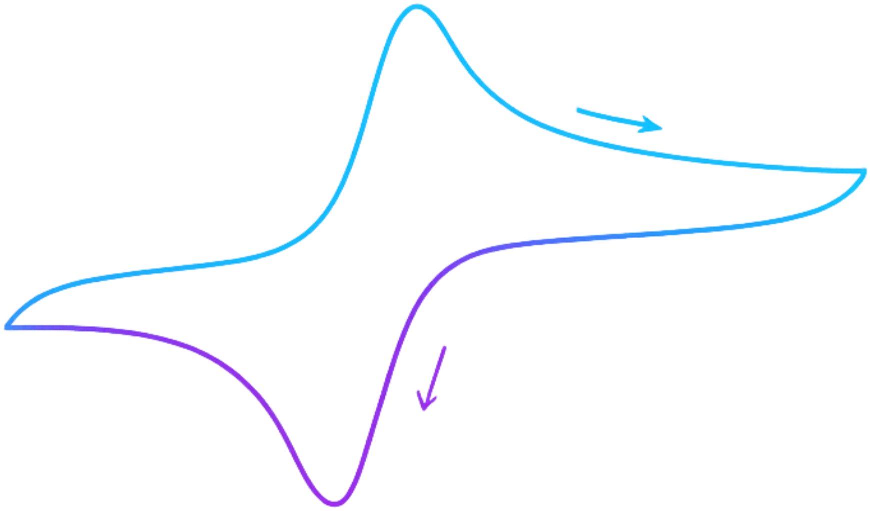
15th ISE Satellite Student Regional Symposium on Electrochemistry

June 19, 2026

Faculty of Chemical Engineering and Technology, Zagreb, Croatia

BOOK OF ABSTRACTS



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Text prepared by:
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Preface

It was a great privilege and pleasure to host the 15th ISE Satellite Student Regional Symposium on Electrochemistry (15th ISE-SRSSE), held on June 19, 2026, at the Faculty of Chemical Engineering and Technology, University of Zagreb, Croatia.

Organized under the auspices of the International Society of Electrochemistry, the symposium continued its mission of supporting the scientific and professional development of young researchers, postgraduate students and PhD candidates by providing a stimulating and collaborative environment for the presentation and discussion of their research results.

The symposium gathered student participants from several countries, fostering international scientific exchange and interdisciplinary collaboration within the field of electrochemistry. The presented contributions covered a wide spectrum of topics, including electrochemical energy storage and conversion, electrocatalysis, corrosion science, environmental electrochemistry, electroanalytical chemistry and advanced functional materials.

We sincerely thank all participants for their excellent presentations, fruitful discussions and valuable scientific contributions that contributed to the success of the symposium. Special appreciation is extended to the International Society of Electrochemistry for its continuous support and encouragement of early-career scientists. Their support has enabled young researchers to share their work internationally, strengthen scientific networks and establish collaborations that will contribute to the future development of electrochemical science.

Organizing Committee

Lana Brkić
University of Zagreb Faculty of Chemical Engineering and Technology, Zagreb, Croatia

Dr.sc. Nikola Zdolšek
Ruđer Bošković Institute, Zagreb, Croatia

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Marija Simić

Institute of nuclear sciences „Vinča“, National institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

Ivana Šoić

Faculty of Chemical Engineering and Technology, University of Zagreb, Zagreb, Croatia

ReCorrTech d.o.o, Zagreb, Croatia

Electrochemical advanced oxidation processes for degradation of bisphenol a mechanisms, transformation products, and toxicity assessment

Marija Simić[1]

[1] Institute of nuclear sciences „Vinča“, National institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa, 12-14, Belgrade, Serbia

*marija.simic@vin.bg.ac.rs

The increasing occurrence of Bisphenol A in aquatic environments has highlighted the urgent need for efficient water treatment technologies capable of its complete removal due to its persistence, endocrine-disrupting properties, and adverse effects on ecosystems and human health, while particular emphasis is placed on achieving a detailed understanding of the mechanisms underlying its degradation. This study investigates the degradation of bisphenol A (BPA) using electrochemical advanced oxidation processes (EAOPs), including electro-Fenton and anodic oxidation, employing an SS/SnO_2–MWCNT anode, with emphasis on degradation mechanisms, transformation products, and toxicity evolution. GC/MS analysis enabled the identification of nine degradation intermediates formed during different stages of BPA oxidation. Based on the detected compounds, two main degradation pathways were proposed. The first pathway involves β-fragmentation of the phenoxy radical, leading to the formation of single-ring compounds such as hydroquinone, 4-isopropenylphenol and benzoic acid, which are further oxidized into aliphatic acids and finally mineralized to CO_2 and H_2O. The second pathway involves hydroxylation of the aromatic ring by ·OH radicals, producing hydroxylated BPA derivatives and quinone-like intermediates prior to ring opening and complete degradation. Toxicity assessment performed using the T.E.S.T. software showed that several intermediates exhibited temporary increases in acute toxicity compared to BPA; however, prolonged treatment significantly reduced both toxicity and bioconcentration factors. The obtained results demonstrate that EAOPs employing the anode facilitate efficient degradation of Bisphenol A through hydroxyl radical (·OH) mediated pathways and contribute to a significant reduction in environmental toxicity [1].

REFERENCES

[1] M. D. Simić, T. P. Brdarić, B. G. Savić Rosić, L. Švorc, D. J. Relić, D. D. Aćimović, Degradation of bisphenol A via the electro–Fenton process using nanostructured carbon-metal oxide anodes: Intermediates and reaction mechanisms study, Journal of Environmental Chemical Engineering 12(5) (2024) 113369.

Quantitative evaluation of protective coating stability through portable low-frequency impedance analysis and water uptake monitoring

Ivana Šoić[1,2]*, Sanja Martinez[1,2]

[1] Fakultet kemijskog inženjerstva i tehnologije, Trg Marka Marulića 19, Zagreb,Croatia
[2] ReCorrTech d.o.o.,Domobranska ulica 4 , Zagreb, Croatia;

*isoic@fkit.unizg.hr, ivana.soic@recorrtech.com

Reliable assessment of protective coating durability requires methods capable of detecting early degradation phenomena before visible damage occurs. Conventional exposure testing and visual inspection often fail to distinguish between temporary environmental effects and irreversible barrier deterioration.

This work presents a practical methodology for quantitative evaluation of coating stability based on portable low-frequency impedance measurements combined with accelerated water uptake assessment. The approach utilizes a surface-mounted two-electrode configuration with a quasi-solid-state electrolyte, enabling non-destructive measurements directly on dry coatings and complex industrial structures without surface preparation or coating damage.

Special attention is given to interpretation of low-frequency impedance response in relation to coating permeability, dielectric behavior, water sensitivity, and environmental influences such as humidity and temperature fluctuations. By integrating rapid impedance measurements with controlled short-term water uptake testing, the method enables differentiation between reversible impedance variations and progressive degradation associated with porosity development, electrolyte penetration, and loss of barrier performance.

Laboratory investigations demonstrate effective ranking of coating systems and application quality, while long-term field monitoring confirms that recovery of impedance after environmental exposure correlates with improved coating durability. Additionally, machine-learning-assisted spectral analysis enables identification of characteristic degradation trajectories and grouping of coatings according to their barrier stability behavior.

The proposed methodology provides a rapid and mechanistically grounded framework for coating qualification, inspection, and durability prediction under both laboratory and field conditions.

Mechanistic investigation of visible-light-driven emerging contaminant degradation over band-tuned Fe-SrTiO3

Suresh Kumar Pandey[1, *], Sandra Romac[1], Marin Kovacic[1], Marijana Kraljic Rokovic[1], Hrvoje Kusic[1]

[1]Faculty of Chemical Engineering and Technology, University of Zagreb, Marulićev trg 19, 10000 Zagreb, Croatia

*skpandey@fkit.unizg.hr

Perovskite photocatalysts are promising materials for environmental remediation due to their tunable electronic structure and efficient charge-carrier dynamics[1,2]. In this study, pristine $SrTiO_3$ and Fe-doped $SrTiO_3$ (FeSK) were synthesized via a facile hydrothermal method and characterized using spectroscopic and electrochemical techniques. Fe doping introduced mid-gap states and narrowed the band gap, enhancing visible-light absorption and charge separation.

The photocatalytic activity of the materials was evaluated for the treatment of ciprofloxacin (CIP) and perfluorooctanoic acid (PFOA). Among all samples, 3% Fe-doped $SrTiO_3$ (FeSK-0.03) showed the best performance, achieving 95% CIP degradation within 120 min under visible light. The enhanced activity was attributed to optimized band-edge positions and suppressed charge recombination. Radical trapping experiments identified $O_2^{\cdot-}$ as the dominant reactive species, with additional contributions from h^+ and $^{\cdot}OH$ radicals.

Environmental applicability was further assessed through biodegradability, TOC, and aquatic toxicity analyses using *Vibrio fischeri* and *Daphnia magna*. The treated samples exhibited improved biodegradability, TOC removal, and significantly reduced toxicity after prolonged irradiation.

These findings demonstrate the potential of band-engineered Fe-$SrTiO_3$ as an efficient and environmentally safer visible-light photocatalyst for water treatment applications.

REFERENCES

[1] G.A. Batarni, F. AlMomani, Z. Elkahlout, A.S. Bano, Towards sustainable hydrogen production: A critical review of perovskite photocatalysts and their energy conversion pathways, Separation and Purification Technology 379 (2025) 135035.

[2] D. Zhang, W. Pan, A.M.T. Oo, Advances in perovskite-based photocatalysts: Mechanisms, materials design, and applications, in: Semiconductors and Semimetals, Elsevier, 2025: pp. 105–156.

Structure-property correlations in alkali phosphate glasses containing TM ions

Suzon Laroye[1,2*], Sara Marijan[1], Marta Razum[1], T. Hostinský[3], P. Mošner[3], L. Koudelka[3], Ž. Skoko[4], J. Pisk[4], Luka Pavić[1]

[1] Ruđer Bošković Institute, Zagreb, Croatia
[2] National Graduate School of Engineering and Research Center, Caen, France
[3] University of Pardubice, Faculty of Chemical Technology, Pardubice, Czech Republic
[4] University of Zagreb, Faculty of Science, Zagreb, Croatia

*suzon.laroye@ecole.ensicaen.fr

This study examines alkali phosphate glasses containing transition metal (TM) ions, focusing on how composition influences structure, thermal behaviour, and electrical properties. Glasses are prepared via the conventional melt-quenching technique, while the glass-forming region is explored by systematically varying the content and ratio of the constituent oxides. Thermal stability and glass transition temperatures are determined using differential thermal analysis (DTA), while structural features are examined using ATR-FTIR and Raman spectroscopy. Electrical properties are evaluated through Solid-State Impedance Spectroscopy (ss-IS) over a wide temperature and frequency range. By correlating structural, thermal, and electrical properties, this study aims to clarify the role of TM ions in governing transport behaviour in phosphate-based glass systems, highlighting their potential for electrochemical energy storage applications.

ACKNOWLEDGMENT
This work is supported by the ERASMUS+ Student mobility for traineeships programme and the Croatian Science Foundation (CSF) through the ECLECTIC GLASS project IP-2025-02-7124.

Electrochemical determination of vancomycin on printed carbon based electrodes

Nina Meštrović[1, *], Željka Boček[1], Petar Kassal[1]

[1] University of Zagreb, Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, 10000 Zagreb

*nmestrov1@fkit.hr

Vancomycin is a glycopeptide antibiotic widely used for the treatment of severe infections caused by Gram-positive bacteria, including MRSA. Due to its narrow therapeutic window, accurate monitoring of vancomycin concentrations is essential to minimize the risk of nephrotoxicity, treatment failure and antibiotic resistance. Conventional analytical techniques, such as liquid chromatography and immunoassays, are often expensive, time-consuming and require complex instrumentation. Electrochemical sensors could be a promising alternative due to their potential for rapid, sensitive and cost-effective detection of vancomycin [1]. In this work, the electrochemical determination of vancomycin using printed carbon based working electrodes was investigated. Screening and optimization of method parameters were performed in 50 µM vancomycin in phosphate buffer at pH 7 with 0,1 M KCl using differential pulse voltammetry (DPV) and square-wave voltammetry (SWV), yielding optimized DPV parameters: scan rate of 20 mV/s, t_{pulse} = 0.01s and E_{pulse} = 0.1 V. Using DPV with optimized method parameters, the pH dependence was tested in phosphate buffer solutions pH 5-8. Repeatability was assessed at pH 7 in 50 µM vancomycin solutions. Calibration curves were constructed at pH 7 over a concentration range of 1 µM to 10 mM to evaluate linearity. Finally, to assess applicability in real samples of vancomycin infusions, measurements were conducted in 3.365 mM solutions of vancomycin prepared with 0.9% NaCl and 5% glucose.

REFERENCES

[1] Gaber, A. M., Emara, H. M. and Allam, N. K. Electrochemical biosensors for vancomycin monitoring in blood: advances, strategies, and future perspectives. RSC Advances 15 (2025) 41418–41431.

ACKNOWLEDGMENTS

This research was funded by the NextGenerationEU funded Institutional research project ADFABSENS (112103).

WO_3 for photoelectrochemical hydrogen production

Tadea Lažeta[1, *], Marijana Kraljić Roković[1], Mustapha EL Cadiri[2]

[1]University of Zagreb, Faculty of chemical engineering and technology, Marulićev trg 19, Zagreb, Croatia
[2]University Cadi Ayyad (UCA), IMED-Lab / FSTG, 40 000, Marrakech, Morocco

*tlazeta@fkit.unizg.hr

Photoelectrochemical hydrogen production is one of the promising approaches for converting solar energy into sustainable fuel. In this work tungsten (VI) oxide (WO_3) was used as a photoanode material for hydrogen production in a 0.5M Na_2SO_4. The experiments were perfomed in a two compartment cell (Fig 1.) with LED light source. Special attention was given on influence of different hole scavengers on hydrogen production. Hole scavengers that were used were 0,1 M ascorbic acid and 20% v/v ethylene glycol, methanol or ethanol in 0.5M Na_2SO_4. Addition of organic compounds enables more efficient utilization of photogenerated charge by reducing electron – hole recombination thereby enhancing the production of hydrogen. WO_3 was confirmed as efficient photoanode material for hydrogen production by applying bias 0.5 V vs. saturated calomel electrode.

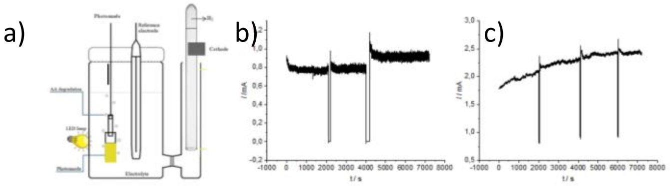

Fig. 1. a) The two-compartment cell for the photoelectrochemical hydrogen generation [1]. Current obtained during hydrogen production in b) Na_2SO_4 and c) ascorbic acid/Na_2SO_4 solution.

REFERENCES

[1] G. Radić, T. Krnić, M. Lovrić, K. Perović, F. Radovanović Perić, B. Genorio, H. Kušić, Ž. Petrović, M. Kraljić Roković, New insight into photoelectrochemical hydrogen production and photocorrosion inhibition by ascorbic acid, Electrochimica Acta 539 (2025) 147050.

ACKNOWLEDGMENTS

We are grateful for the supports from the project Tailored solar-active materials for photocatalytic degradation of contaminants of emerging concern (SOL-MAT-CLEAN) (IP-2025-02-8507).

Comparative analysis of chemical properties of rhodamine B and bisphenol A as organic pollutants

Katarina Stojanović[1]*, Marija Simić[1] , Marija Kovačević[1], Danka Aćimović[1],
Branislava Savić Rosić[1], Tanja Brdarić[1], Marija Ječmenica Dučić[1]

[1] University of Belgrade, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Belgrade, Serbia

*katarina.stojanovic@vin.bg.ac.rs

Organic pollutants represent a significant challenge for environmental protection due to their persistence and potential toxicity. This study presents a comparative analysis of the chemical properties of Rhodamine B and Bisphenol A, as representatives of synthetic dyes and industrial organic pollutants. The interaction of the pollutants with three prospective electrode materials, lead dioxide (PbO_2), carbon felt (CF), and iridium oxide (IrO_2), was examined. Each material was immersed in sulfate-based aqueous solutions containing Bisphenol A or Rhodamine B, adjusted to pH values of 2, 4, 7, and 11, and aliquots were collected to monitor the time-dependent uptake or surface binding of the target compounds by UV-Vis. Rhodamine B, a xanthene-based dye characterized by an extended conjugated π-system and a carboxyl functional group responsible for lactonization, exhibits a pH-dependent equilibrium between its cationic and lactone forms: under acidic conditions, the soluble and colored cation predominates, whereas under alkaline conditions, a less soluble, colorless lactone is formed [1]. In contrast, due to the presence of hydroxyl groups in its structure, Bisphenol A remains relatively stable at low pH values, with its phenolic groups in the protonated form, rendering the molecule less polar and predominantly neutral. Under alkaline conditions, these phenolic groups undergo deprotonation, resulting in a significantly more polar species with increased solubility in aqueous solutions. The observed changes in ionization and molecular structure at different pH values have a significant impact on their electrochemical reactivity and behavior at the electrode surface. The results indicate that pH significantly influences the mobility, stability, and degradation pathways of these pollutants, which is crucial for the development of effective strategies for their removal from the environment.

REFERENCES

[1] E. Birtalan, B. Rudat, D. K. Kölmel, D. Fritz, S. B. L. Vollrath, U. Schepers, S. Bräse Investigating rhodamine B-labeled peptoids: scopes and limitations of its applications, PeptideScience 96(5) (2011) 694-701.

Spectroelectrochemical investigation of oxygen reduction reaction in calcium-based DMSO electrolytes

Mia Božiković[1,*], Nikola Zdolšek[2], Zoran Mandić[1]

[1] Faculty of Chemical Engineering and Technology, University of Zagreb, Marulićev trg 19, 10000 Zagreb, Croatia
[2] ˝Vinča˝ Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Serbia

*mbozikovi@fkit.hr

The oxygen reduction reaction (ORR) in aprotic electrolytes is of significant interest due to its relevance in metal–air battery systems and oxygen redox chemistry. In this work, spectroelectrochemical investigation of ORR processes in DMSO-based electrolytes containing calcium salts was performed using a combination of chronoamperometry and in situ UV–VIS spectroscopy. The applied approach enabled simultaneous monitoring of electrochemical processes and spectral changes associated with oxygen reduction intermediates and modifications in the electronic environment of the system. Changes in UV–VIS absorption during electrochemical measurements were correlated with ORR/OER behavior observed by cyclic voltammetry, providing insight into intermediate formation and oxygen redox pathways. This work contributes to a better understanding of oxygen electrochemistry in calcium-based non-aqueous electrolytes and demonstrates the applicability of UV–VIS spectroelectrochemistry for mechanistic studies of ORR processes.

REFERENCES

[1] Yu, Q.; Ye, S. In Situ Study of Oxygen Reduction in Dimethyl Sulfoxide (DMSO) Solution: A Fundamental Study for Development of the Lithium–Oxygen Battery. Journal of Physical Chemistry C, 119 (22) (2015) 12236–12250.
[2] Lu, Y.-T.; Neale, A. R.; Hu, C.-C.; Hardwick, L. J. Trapped Interfacial Redox Introduces Reversibility in the Oxygen Reduction Reaction in a Non-Aqueous Ca2+, Chemical Sciences 12 (2021) 8909-8919.

Protection of bronze with wax-phosponic acids composite coating

Helena Otmačić Ćurković[1], Lucija Blažinić[1*]

[1] Faculty of Chemical Engineering and Technology, University of Zagreb,
Marulićev trg 19, 10000 Zagreb, Croatia

Bronze is one of the most widely used materials in cultural heritage objects, however, its stability is significantly compromised by long-term exposure to atmospheric conditions, particularly acid rain. In conservation practice, wax coatings are commonly applied as protective barrier layers for bronze artefacts. Nevertheless, their resistance to moisture and aggressive ion penetration is often limited, leading to gradual metal degradation.

The aim of this study was to investigate whether the durability of protection can be improved by applying a composite coating system on CuSn6 bronze. These systems involved chemical modification of the bronze surface with thin films of long-chain phosphonic acids before wax application. The corrosion behaviour of unprotected bronze, bronze protected solely with wax coatings (Renaissance Wax or Cosmoloid H80), and composite coating systems combining two long-chain phosphonic acids (12-phosphonododecyl phosphonic acid and 1-dodecylphosphonic acid) with two types of waxes was investigated. Samples were exposed to simulated acid rain solution (pH 5) over an extended period, accompanied by periodic electrochemical characterization. Open circuit potential (OCP), electrochemical impedance spectroscopy (EIS), and linear and potentiodynamic polarization measurements were employed to determine polarization resistance and corrosion kinetic parameters. Based on the obtained results, the kinetics of corrosion processes, the stability of the protective layers, and their barrier efficiency over time were assessed. The obtained results contribute to a better understanding of corrosion protection mechanisms in bronze materials and to the optimization of protective systems for cultural heritage conservation.

REFERENCES

[1] E. K. Mioč, H. Otmačić Ćurković, Protective films of stearic and octadecylphosphonic acid formed by spray coating, Journal of Electrochemical Science and Engineering 10(2) (2020) 161-175.

MXene modification by alkyl phosphonic acids

Karla Stjepanović[1*], Augustin Brzić[1], Marijana Kraljić Roković[1]

[1] University of Zagreb Faculty of chemical engineering and technology, Marulićev trg 19, Zagreb, Croatia2

* kstjepano@fkit.hr

MXenes are transition metal carbides and nitrides. They are characterized by a layered structure, high electrical conductivity, and the presence of surface functional groups. Due to these properties, they are being investigated for applications in various fields, including energy storage and conversion, sensors, catalysis, separation membranes, and biomedical systems. [2] Surface modification allows for further tailoring of their properties, such as hydrophilicity or hydrophobicity, and reduction of agglomeration. The aim of this work was to delaminate multilayer MXene, modify its surface surface, and conduct structural and electrochemical characterisation. The delamination was performed using tetramethylammonium hydroxide (TMAOH). The surface modification was performed with two phosphonic acids: 12-aminododecylphosphonic acid hydrochloride (AP) and 1-dodecylphosphonic acid (P). Electrochemical characterization included cyclic voltammetry and electrochemical impedance spectroscopy techniques, while structural characterization included FTIR and Raman spectroscopy techniques.

REFERENCES

[1] M. Mozafari Soroush M., Surface functionalization of MXenes, Materials Advances 2(22) (2021) 7277-7307.

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Electrochemical evaluation of electron-beam crosslinked fatty acids on stainless steel

Helena Biljanić[1, *], Marta Walo[2], Urszula Gryczka[2], Katarina Marušić[1]

[1] Ruđer Bošković Institute, Bijenička cesta 54, Zagreb,
[2] Institute for Nuclear Chemistry and Technology, Dorodna 16, Warszaw, Poland

*hbachroj@irb.hr

Stainless steel is widely used in biomedicine because of its favourable combination of biocompatibility, corrosion resistance, and mechanical durability, although its performance in physiological environments remains limited. Surface functionalization with fatty acids offers a promising strategy to improve biocompatibility and corrosion protection, and gamma irradiation-induced crosslinking has already been shown to further stabilize these properties. Electron beams are an attractive alternative because they enable precise, scalable processing without radioactive sources, offering a safer and more sustainable approach.

This study investigates the conditions for low-energy electron-beam-induced crosslinking of behenic acid on a stainless steel surface. The effects of irradiation dose and atmospheric conditions were systematically examined to determine parameters that promote stable coating formation. Protective performnce of the resulting surfaces was evaluated using electrochemical impedance spectroscopy and Tafel extrapolation. The results showed that electron-beam irradiation effectively crosslinks behenic acid and improves corrosion resistance under selected conditions. Compared with gamma irradiation, low-energy electron-beam treatment achieved greater improvement, with the high dose rate eliminating the need for oxygen removal. These findings demonstrate a promising environmentally friendly method for protective biomedical coatings on stainless steel.

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Recent advances in electrochemical lab-on-chip biosensors for bisphenol monitoring in water systems

Gjino Šutić[1,*], Ines Šiško Markoš[2], Ivana Tomac[3]

[1] UR Institute, Bleiweisova 15, Zagreb, Croatia
[2] Catholic University of Croatia, School of Medicine, Ilica 244, Zagreb, Croatia;
University Hospital Centre Sestre Milosrdnice, Vinogradska cesta 29,Zagreb,Croatia
[3] Sveučilište Josip Juraj Strossmayer Osijek, Prehrambeno-tehnološki fakultet Osijek, F. Kuhača 18, Osijek, Croatia

*gjino.sutic@gmail.com

The increasing presence of endocrine-disrupting compounds (EDCs) in aquatic systems is a significant environmental and public health concern. Among these pollutants, bisphenols are widely detected in water due to their extensive industrial use and persistence[1]. Conventional analytical methods for bisphenol detection are often labour-intensive, time-consuming, and require sophisticated instrumentation, limiting their suitability for rapid in situ monitoring. Consequently, electrochemical biosensors integrated with lab-on-chip (LOC) technologies have emerged as promising analytical platforms for sensitive, selective, and real-time detection of EDCs in water samples. Electrochemical biosensors offer advantages such as low detection limits, portability, rapid response, and cost-effective analysis, while LOC systems enable miniaturisation, automation, and reduced sample and reagent consumption. The integration of these technologies supports the development of compact and highly efficient devices suitable for environmental monitoring. Recent advances in nanomaterials, microfluidics, and biorecognition elements have significantly enhanced the analytical performance of electrochemical LOC biosensors for bisphenol detection. This study aims to review the literature over a five-year period on the potential application of electrochemical lab-on-chip biosensors for detecting bisphenols in water samples, with emphasis on their sensitivity, selectivity, and suitability for rapid environmental monitoring. This approach offers considerable potential for continuous water quality assessment and early identification of hazardous contaminants, contributing to environmental protection and sustainable water resource management.

REFERENCES

[1] Lao, X. et al. Distribution and risk assessment of antibiotic and bisphenol compounds residues in drinking water sources of Guangdong. Environmental Earth Sciences 83(16) (2024) 475.

Development of a UV-Vis-based calibration model for SoC determination of vanadium redox flow battery

Leda Kolarek[1], Srečko Herceg[1], Nenad Bolf[1], Zoran Mandić[1]

[1] Faculty of Chemical Engineering and Technology, University of Zagreb,
Marulićev trg 19, 10000 Zagreb, Croatia

*lkolarek@fkit.unizg.hr

One of the most significant and destructive environmental problems, which worsens every year, is climate change. To address this issue, there has been increased investment in industries that use renewable energy sources such as solar, wind, hydropower and low-carbon energy from nuclear reactors. However, energy production from most renewable sources is inconsistent and unpredictable. These technical challenges can only be addressed by implementing efficient energy storage systems (ESS) that balance energy production and consumption. Among the available energy storage systems, vanadium redox flow batteries (VRFBs) represent one of the most promising large-scale solutions due to their scalability, long cycle life and flexible design. For efficient VRFBs operation, it is necessary to determine the state of charge (SoC), as a key parameter in the ESSs, which directly depends on the concentration ratios of vanadium oxidation states present in the electrolyte. In this work, a calibration method based on UV-Vis spectroscopy was developed for monitoring vanadium species and determining the SoC of VRFB. Three binary mixtures of vanadium oxidation states, V(II)/V(III), V(III)/V(IV) and V(IV)/V(V), were prepared in different concentration ratios (1:9, 2.5:7.5, 5:5, 7.5:2.5 and 9:1) and their absorption spectra were recorded. The resulting spectral data were used to develop a calibration model capable of determining the concentrations of individual vanadium species in electrolytes of unknown composition. To evaluate the applicability of the method under real operating conditions, UV-Vis spectra of VRFB electrolytes were recorded during battery charging at different cell voltages. The developed model enables the construction of a SoC versus cell voltage profile for the laboratory-scale VRFB system. The proposed approach demonstrates the potential of UV-Vis spectroscopy as a rapid and non-destructive tool for real-time electrolyte analysis and operational monitoring of VRFB systems.

REFERENCES

[1] A. A. Maurice, A. E. Quintero, and M. Vera, A comprehensive guide for measuring total vanadium concentration and state of charge of vanadium electrolytes using UV-Visible spectroscopy, Electrochimica Acta 482 (2023) 144003.

Development of a dynamic model for the simulation of redox flow battery systems

Teo Smolej[1,*], Leda Kolarek[1], Srečko Herceg[1], Nenad Bolf[1], Zoran Mandić[1]

[1]Sveučilište u Zagrebu Fakultet kemijskog inženjerstva i tehnologije, Trg Marka Marulića 19, 10 000 Zagreb, Croatia

*tsmolej@fkit.unizg.hr

The increasing share of renewable energy sources in power systems requires the development of efficient electrical energy storage technologies. The Vanadium Redox Flow Battery (VRFB) is considered one of the most promising technologies for large-scale electrical energy storage due to its ability to scale power and capacity independently, its long operational lifetime and the use of the same active species in both half-cells, which prevents irreversible electrolyte contamination. Despite its many advantages, the wider commercialisation of VRFB systems is still limited by their relatively low energy density and the complexity of process optimisation. The development of mathematical models describing the dynamic behaviour of such systems is a crucial tool for improving process understanding, predicting charging and discharging characteristics, and optimising geometrical and operational parameters without extensive experimental investigations. In this study, a dynamic model of a VRFB system based on the Plug Flow Reactor (PFR) approach, commonly used to describe flow cells in VRFB systems, was developed. Each half-cell was discretised into N consecutive segments and a material balance equation was formulated for each segment. The cell voltage was calculated using the Nernst equation accounting ohmic, activation and concentration overpotentials. The diffusion of vanadium ions through the membrane, i.e., crossover, was described using Fick's laws of diffusion. The developed model was validated by comparing simulation results with experimental data from a laboratory-scale VRFB system under different current densities. Additionally, a comparison with a previously developed lumped-parameter model was performed to evaluate the influence of cell discretisation on the accuracy of predicting the system's dynamic behaviour.

REFERENCES

[1] Y. Li, M. Skyllas-Kazacos and J. Bao, A dynamic plug flow reactor model for a vanadium redox flow battery cell, Journal of Power Sources 311 (2016) 57–67.

Competing activation and catalytic restructuring pathways govern pore accessibility in phosphorus-containing porous carbon frameworks

Chekwube Ginika Nwodika[1, *], Grgur Mihalinec[1], Zoran Mandić[1]

[1] Fakultet kemijskog inženjerstva i tehnologije, Sveučilište u Zagrebu, Trg Marka Marulića 19, HR-10000 Zagreb, Croatia

*cnwodika@fkit.hr

In this study, phosphorus-containing porous carbon frameworks derived from phosphoric-acid-activated hazelnut shells were subjected to ferrocene-assisted thermal treatment with and without simultaneous ZnCl2 activation in order to investigate the interplay between catalytic restructuring and secondary activation. Structural, chemical, textural, and electrochemical evolution were evaluated using XRD, Raman spectroscopy, nitrogen physisorption, SEM, FTIR, XPS, TGA, cyclic voltammetry, and electrochemical impedance spectroscopy. Catalytic treatment reduced the BET surface area from 1343 to 810 $m^2\ g^{-1}$ and promoted partial carbon-layer restacking while maintaining a predominantly disordered structure. Simultaneous ZnCl2 activation produced a non-monotonic evolution of porosity and accessibility. Moderate ZnCl2 loading further decreased the external surface area to 330 $m^2\ g^{-1}$ despite increased microporosity, whereas higher loading partially restored surface area and pore accessibility. Electrochemical measurements showed lower equivalent series resistance for treated samples (2.0–2.5 Ω) compared to the parent carbon (4 Ω), indicating improved charge transport. The results demonstrate that competing activation and restructuring pathways govern pore accessibility within the carbon frameworks.

Source discrimination of atmospheric carbohydrates in the central Adriatic: episodic events assessed by HPAEC–PAD biomarker analysis

Andrea Milinković[1,*], Suzana Sopčić[2], Dora Crmarić[1], Slađana Strmečki[1]

[1] Ruđer Bošković Institute, Bijenička cesta 54, Zagreb, Croatia
[2] Institute for Medical Research and Occupational Health, Ksaverska cesta 2, Zagreb, Croatia

*amilink@irb.hr

Atmospheric carbohydrates are important constituents of organic aerosols, but their sources in Mediterranean coastal environments remain understudied. This study investigates episodic atmospheric carbohydrate deposition in the central Adriatic associated with pollen outbreaks, Saharan dust intrusions, and regional wildfire events during spring and summer 2024. Dry deposition of atmospheric aerosols with aerodynamic diameter ≤ 10 μm (PM_{10}), wet deposition, and total deposition samples were analysed for water-soluble organic carbon, carbohydrate biomarkers, and total dissolved carbohydrates (TDCHO). TDCHO were measured spectrophotometrically, while carbohydrate biomarkers were determined using high-performance anion-exchange chromatography coupled with pulsed amperometric detection (HPAEC–PAD) on gold working electrode. Distinct differences in carbohydrate composition and deposition fluxes were observed among episodic events. Airborne pollen outbreaks were identified as a dominant source of primary sugars, while biomass burning, including residential heating and wildfires, produced the highest levels of anhydrosugars and significantly increased TCHO. In contrast, Saharan dust did not significantly contributed to atmospheric organic carbon levels, including carbohydrates. These results demonstrate the applicability of HPAEC–PAD for atmospheric carbohydrate source apportionment in wet, dry, and bulk deposition samples, and highlight the importance of pollen-derived inputs in Mediterranean coastal environments.

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The development of fully printed flexible sodium-selective electrodes

Dea Hladek[1]*, Sara Krivačić[1], Petar Kassal[1]

[1]University of Zagreb, Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, Zagreb, Croatia

* dhladek@fkit.hr

The main focus of this study was to fabricate solid-state potentiometric sensing platforms for on-site sodium ion detection using printing techniques. Fabrication steps were optimized for achieving fabrication repeatability on a flexible surface. Automatically deposited silver ink and inkjet printed graphene ink were examined as working electrode materials. Additionally, intense pulse light (IPL) was investigated as means of achieving greater electrode capacitance to ensure a fast and reversible potentiometric signal transduction [1]. Electrochemical characterization of fabricated graphene electrodes was done before and after IPL treatment using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The effect of automatically deposited ion-selective membrane thickness on the potentiometric signal was analyzed on both electrode materials. The results show that IPL treatment considerably increases the capacitance of the graphene electrodes, which then results in greater stability of the potentiometric signal. The electrode capacitance before and after IPL treatment determined form the CV-s shows a 5 times greater value after IPL treatment. The optimized ion-selective electrode showed a near-Nernstian sensitivity of 56.7±1.3 mV/pNa.

REFERENCES

[1] Shao, Y., Ying, Y., Ping, J., Recent advances in solid-contact ion-selective electrodes: functional materials, transduction mechanisms, and development trends, Chemical Society Reviews 49 (2020) 4405-4465.

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Correlating slurry composition with electrochemical impedance spectra of NMC cathode slurries

Hrvoje Tašner[1], Grgur Mihalinec[1], Zoran Manić[1]

[1] Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, Zagreb

*htasner@fkit.hr

In this study, a correlation between the impedance spectra of the individual components and the slurry for NMC cathodes was established. The objective was to demonstrate that EIS is a suitable, rapid, and simple method for monitoring the mixing process of electrode slurries, as well as for tracking slurry condition during storage. For the purposes of the investigation, seven mixtures of ingredients for NMC electrode slurry were prepared. For EIS measurements, the mixtures were filled into standard 2032 coin cells. The cells were sealed using a hydraulic press at a pressure of 5 MPa. Impedance was measured over the frequency range from 0.1 Hz to 7 MHz. Measurements were performed immediately after cell assembly and again after several days. The measured spectra showed characteristic, reproducible responses of the individual components as well as of the mixtures used in NMC cathode slurries. The study demonstrated that EIS is a fast and simple method suitable for monitoring the quality of electrode slurries during preparation and storage.

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Ionic liquid-derived Ni/C for alkaline water splitting

Jelena Georgijević[1], Stefan Mitrović[1]*, Ivana Perović[1] , Snežana Brković[1] ,
Milena Pijović Radovanović[1] , Petar Laušević[1] , Biljana Šljukić[2]

[1] Department of Physical Chemistry, “Vinča” Institute of Nuclear Sciences—National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12–14, 11351 Belgrade, Serbia
[2] University of Belgrade, Faculty of Physical Chemistry, Studentski trg 12-16, Belgrade, Serbia

*stefan.mitrovic@vin.bg.ac.rs

Nickel-on-carbon (Ni/C) electrocatalysts were obtained by direct carbonization of Ni-containing ionic liquids (ILs), where choline and imidazolium-based ILs served as single-source precursors. The use of different IL structures allowed simultaneous formation of metallic Ni nanoparticles and heteroatom doped carbon matrices, leading to significant differences in the physicochemical properties of the resulting materials. Characterization by nitrogen sorption, XRD, Raman spectroscopy, SEM/EDS, TEM, and XPS confirmed the successful synthesis of mesoporous Ni/C composites composed of face-centered cubic Ni nanoparticles well dispersed throughout the carbon matrix. Their electrocatalytic activity was assessed for both HER and OER in alkaline medium. Ni/C(Hm) exhibited the highest HER efficiency, which was associated with its defect-rich carbon structure, high surface area, low charge-transfer resistance, and favorable Tafel behavior. In contrast, Ni/C(Ch) proved to be the most active OER catalyst, displaying the lowest onset potential, the lowest overpotential at 10 mA cm^{-2}, the smallest Tafel slope, and remarkable long-term stability. The results clearly show that precursor selection strongly influences the charge transfer kinetics and interfacial properties of Ni/C electrocatalysts, providing an effective way to tailor their bifunctional activity. These findings highlight ionic liquids as versatile precursors for the rational design of noble-metal-free catalysts for efficient alkaline water electrolysis.

Electrochemical insights into the reactions of sulfide and elemental sulfur at a mercury electrode in seawater condition: A case study of Rogoznica lake

Nikola Zdolšek[1,*], Irena Ciglenečki[1]

[1] Division for Marine and Environmental Research, Ruđer Bošković Institute, Bijenička Cesta 54, Zagreb, Croatia

*nizdolsek@irb.hr

Understanding the electrochemical behavior of reduced sulfur species (RSS) in natural aquatic systems is essential for both RSS determination and the interpretation of RSS speciation in anoxic environment. In this study, the interactions of sulfide (HS^-) and elemental sulfur (S^0) at a mercury (Hg) electrode were investigated using cyclic voltammetry in seawater as the supporting electrolyte, with particular emphasis on conditions relevant to Rogoznica Lake, a stratified marine system. Special attention was devoted to the behavior of S^0, whose extremely low solubility in water represents a major limitation for electrochemical as well as other analytical investigations. Despite this challenge, CV measurements enabled the observation of characteristic responses associated with HS^- and S^0 interactions at the Hg electrode surface. Analysis of the dependence between the logarithmic of the reduction current and scan rate revealed distinct electrochemical behaviors. In the case of S^0, the slope value was close to 1, indicating an adsorption-controlled process, whereas HS- exhibited a slope value of approximately 0.5, characteristic of diffusion-controlled electrochemical behavior.

Additionally, seawater samples collected from anoxic water column of Rogoznica Lake were analyzed to investigate weather similar electrochemical experimental conditions (i.e., different scan rate and accumulation time) would enable the separation of reduction peaks and the quantification of S^0 and HS^- presence in natural samples.

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Electrochemical determination of surface-active substances under different tidal and salinity regimes

Nikola Zdolšek[1*], Rajna Marija Jozić[1], Luka Andrijanić[1], Paolo Palijaga[2] and Irena Ciglenečki[1]

[1] Division for Marine and Environmental Research, Ruđer Bošković Institute, Bijenička Cesta 54, Zagreb, Croatia
[2] Faculty of Natural Sciences, Dobrila University of Pula, Zagrebačka 30, 52100 Pula, Hrvatska

*nizdolsek@irb.hr

Surface-active substances (SAS) are an important subgroup of organic matter (OM) present in the marine environment, where they are considered good indicators of changes. SAS are formed as a result of biological activity, particularly phytoplanktonic and bacterial primary production, as well as zooplankton grazing, and include various organic compounds (biosurfactants) such as lipids, proteins, polysaccharides and humic substances. SAS can be present in dissolved, particulate or colloidal forms, making them key components in the transformation of dissolved organic matter (DOM) into particulate organic matter (POM).

For the determination and characterization of SAS, AC voltammetric method was applied, based on the measurement of adsorption effects of SAS at the surface of a hanging mercury drop electrode as the working electrode. This method was further applied for the analysis of samples from the unique Palud swamp environment (Istria, Croatia). Samples were collected during different seasons 2025/2026, under different tidal and salinity conditions (low and high tides). The highest SAS concentrations were recorded during low tides in summer 2025.

The study demonstrates the applicability of the AC voltammetry for SAS determination in very complex environmental samples.

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Influence of reduction method on charge storage mechanism of biographite derived reduced graphene oxide

Grgur Mihalinec[1]*, Chekwube Ginikanwa Nwodika[1], Zoran Mandić[1]

[1]Fakultet kemijskog inženjerstva i tehnologije, Trg Marka Marulića 19, Zagreb,Croatia

*gmihaline@fkit.unizg.hr

Supercapacitors are considered promising energy storage systems due to their high-power density, fast charge-discharge capability, and excellent cycling stability. Although carbon-based materials remain the most widely used electrode materials, ongoing research focuses on developing and optimizing carbon structures to improve the electrochemical performance of supercapacitor devices. In this study, graphene oxide (GO) was synthesized from biographite using the modified Tour method and subsequently submerged in three different reduction pathways. These included chemical reduction using ascorbic acid, thermal reduction at 700 °C, and a combined thermal-chemical reduction approach. The influence of the reduction pathway was electrochemically examined using a standard three-electrode system with a carbon paste electrode as the working electrode, Hg/HgO as the reference, and platinum as the counter electrode in 6 M KOH aqueous electrolyte. Electrochemical characterization was performed using cycling voltammetry at different scan rates alongside galvanostatic charge-discharge at commonly used current densities over 100 cycles. The obtained results present a clear difference in electrochemical response depending on the reduction method used. This study confirms supercapacitive performance is significantly influenced by the reduction pathway of graphene-based material and highlights potential for further development of materials.

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