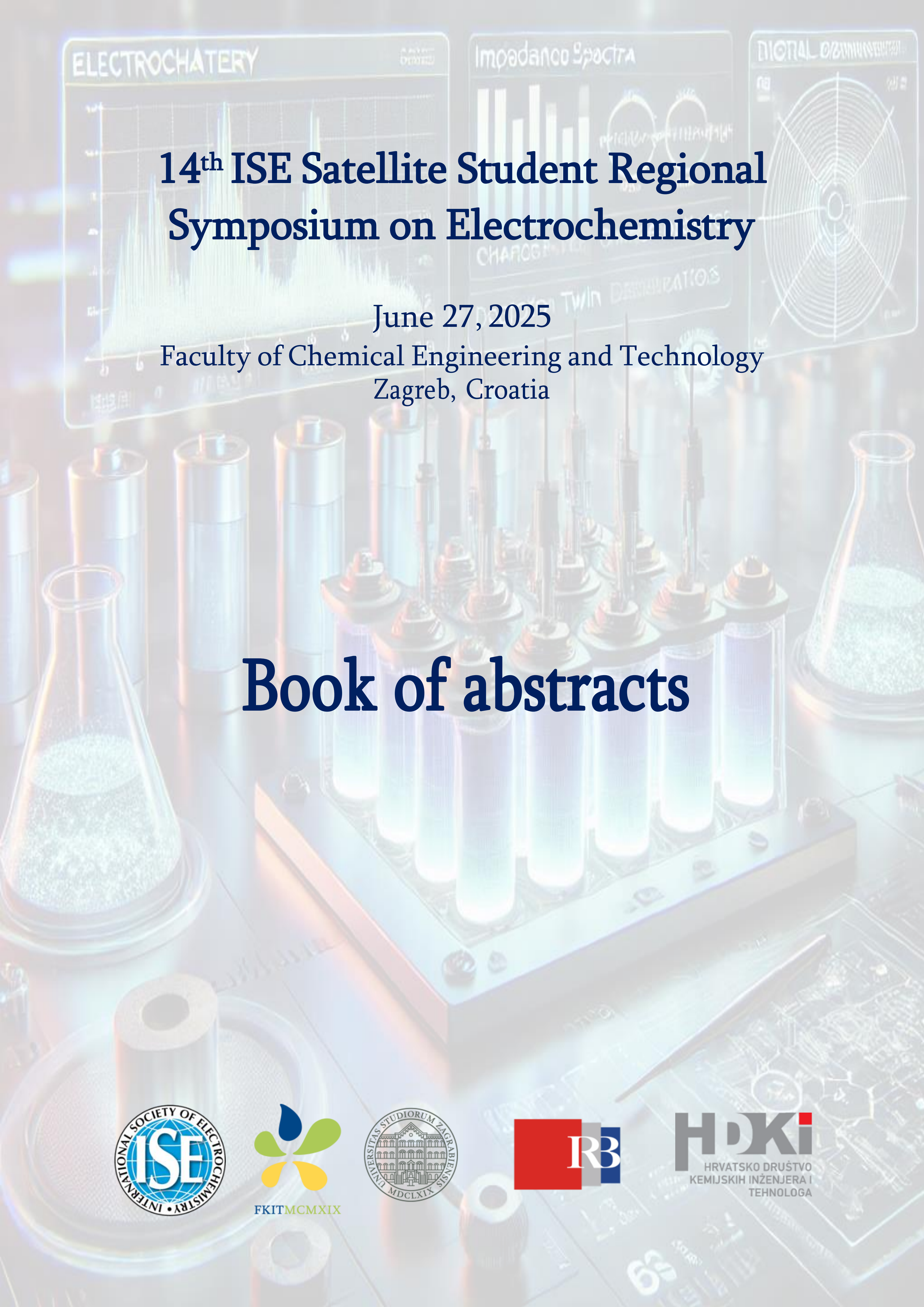

14th ISE Satellite Student Regional Symposium on Electrochemistry

June 27, 2025
Faculty of Chemical Engineering and Technology
Zagreb, Croatia

Book of abstracts

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Croatian Society of Chemical Engineers

14th ISE Satellite Student Regional Symposium on Electrochemistry

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Preface

It was a distinct honor and pleasure to host the 14th ISE Satellite Student Regional Symposium on Electrochemistry (14th ISE-SRSSE) on June 27, 2025, held in a hybrid format at the Faculty of Chemical Engineering and Technology, University of Zagreb, Croatia.

Organized under the auspices of the International Society of Electrochemistry (ISE), the symposium was dedicated to fostering the professional development of young scientists, postgraduate researchers, and PhD students by providing an inclusive and collegial environment for presenting their work.

The symposium brought together 27 student participants representing Croatia, Austria, Bosnia and Herzegovina, Slovenia, Serbia, Algeria, and Spain. Their contributions spanned a broad range of electrochemical disciplines, including electrochemistry of materials, corrosion science, environmental electrochemistry, electroanalytical chemistry and electro-organic synthesis.

We extend our heartfelt thanks to all participants for their engaging presentations and valuable scientific contributions. We are especially grateful to the International Society of Electrochemistry for its generous financial support, which enabled early-career researchers to present their work, gain experience, and establish meaningful scientific connections that may evolve into future collaborations.

We also sincerely thank our sponsors—BioLogic, Emus, ReCorrTech and Labena—for their continued support in making this event a success.

Ivana Šoić, mag.appl.chem.
Ivana Šoić

Narda Stipanović, mag.chem.

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Grgur Mihalinec

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Application of Ionic Liquids as Electrolytes in Batteries

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Ionic liquids (ILs) have emerged as promising alternatives to conventional organic electrolytes in battery systems due to their unique physicochemical properties, including wide electrochemical stability windows, negligible vapour pressure, high thermal stability and tunable solvation characteristics. These features make ILs particularly attractive for next-generation batteries that operate under demanding conditions, such as high temperature or high voltage. This work presents a comprehensive overview of the recent advances in the application of ionic liquids as electrolytes in various battery chemistries, with a focus on zinc- and calcium-based systems. Special emphasis is placed on the interaction of ILs with electrode materials, ion transport mechanisms and the impact of IL composition on electrochemical performance. Additionally, we discuss the challenges associated with viscosity, cost and long-term stability, as well as strategies to overcome these limitations through molecular design and the use of IL-based mixtures. The findings support the growing potential of ionic liquids to improve the safety, efficiency, and sustainability of modern battery technologies.

ACKNOWLEDGMENT

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Development of the calcium SEI: Toward researchable calcium battery

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Lithium-ion batteries highlight the current state of the art of energy storage technology. The demand of the present industry exceeds far more than what lithium-ion theoretically can offer. The low availability of lithium metal and general safety concerns of lithium-based batteries induced the rise of the novel technology based on multivalent ions. Among potential candidates, calcium possesses a considerable amount of favourable properties such as high abundance, low redox potential, and a high capacity due to the two-electron charge transfer. However, calcium batteries are still in the research phase due to complex interactions of the calcium electrode and organic electrolyte which results in the passivation of the electrode disabling calcium transport. To achieve a rechargeable calcium battery, it is necessary to generate a calcium solid electrolyte interface (SEI), which protects the electrode from further passivation and enables calcium diffusion throughout the layer, similar to one that lithium forms. In this research, the phenomenon of passive layer formation is investigated to achieve a reversible calcium metal battery. It is shown that the amount of the parameters, such as concentration and composition of electrolyte, etc. significantly influence the composition of the calcium SEI layer, enabling the reversibility of calcium metal anode.

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NATO OTAN

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Use of a carbon-based electrode modified with TiO_2 nanoparticles to determine voltammetric properties of polyphenols in wine

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The aim of the study is to develop and characterize a carbon paste electrode (CPE) modified with TiO_2 nanoparticles to be used to determine voltammetric properties of polyphenols in natural wine samples. To find the suitable composition of carbon material/binder/modifier, we examined physicochemical and electrochemical properties of the electrode material changed depending on the type and amount of binder and nanoparticles used.

The results showed that increasing the binder content improves the compactness of the electrode, while the TiO_2 nanoparticles are fairly evenly distributed on the surface. Optimal results were obtained with a carbon electrode containing 40 vol.% paraffin oil and 8-10 wt.% TiO_2 nanoparticles, which exhibited the lowest resistivity and the most pronounced degree of reversibility of the electrochemical processes [1]. In addition, the electrochemical properties of five selected model polyphenolic compounds were investigated on MCPE and CPE, determining the kinetic parameters of oxidation, the detection and quantification limits, and the stability and repeatability of the measurement. The results showed that MCPE allows a precise detection of polyphenols and the determination of their electrooxidation potential based on the catalytic effect of nanoparticles [2]. Finally, an electrochemical characterization of seven selected commercially available wine samples was performed, including white, rosé and red wine varieties. Investigations have shown that white wines have the lowest concentration of polyphenols compared to red and rosé wines. The MCPE of the above composition has proven to be reliable and repeatable in the characterization of gallic acid, which can be useful in winemaking and is essential for quality control and research into the organoleptic properties of wine. Based on the results obtained, a mathematical data processing algorithm was proposed for a better interpretation of the voltammograms and a more precise estimation of the polyphenol content in wines.

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Defect Engineering in 2D-Based Core@Shell Nanostructures for Hydrogen Evolution Reaction: Comparative Study of Au@MoS_2 and Au@Mo(W)S_2 Systems

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Two-dimensional (2D) materials, such as MoS_2 and WS_2, have emerged as promising catalysts for electrochemical processes like the hydrogen evolution reaction (HER) [1,2]. In this study, we investigate the influence of heteroatom incorporation and thermal treatment on the structural and HER properties of these hybrid nanostructures. Core@shell nanostructures, exemplified by Au@MoS_2 systems, demonstrated enhanced HER properties attributed to charge transfer effects.[2] In addition, the plasmonic properties of gold makes it an interesting proposal in photoelectrocatalysis [3].For Au@MoS_2 systems, thermal treatment under reducing conditions is employed to enhance structural and HER properties. Our comprehensive characterization, including ex-situ and in-situ aberration-corrected scanning transmission electron microscopy (STEM), Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS), reveals a decrease in the number of external MoS_2 layers with increasing temperature. Notably, annealing at 800°C under H_2 atmosphere results in the highest HER performance, with an overpotential of 203 mV vs RHE at 10 mA/cm^2 and a Tafel slope comparable to that of edge sites in MoS_2. Furthermore, plasmonic-assisted HER performances under LED illumination demonstrate an enhancement in current density by about 10%, depending on the wavelength used [3].

In parallel, the integration of W-based heteroatoms into Au@MoS_2 nanostructures is explored. The synthesis yields core@shell structures with a single Mo(W)S_2 layer enveloping the metallic Au core. Characterization using XPS and aberration TEM confirms the presence of tungsten, while electrochemical analyses reveal reduced overpotential and Tafel slope compared to counterparts lacking W-based heteroatoms. The synergistic effects of thermal treatment and heteroatom incorporation offer promising avenues for advancing the efficiency of core@shell nanostructures in hydrogen production applications, contributing to the pursuit of sustainable energy solutions.

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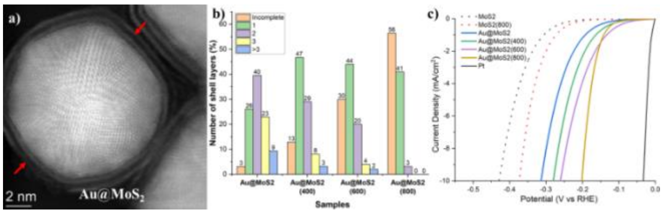

Figure 1: Aberration-corrected STEM image of the initial Au@MoS_2 sample, b) Evolution of the number shell layers with the temperature c) LSV curves obtained in 0.5 M H_2SO_4 at 10 mV·s^{-1}

Graphene-like Carbon Derived from Hazelnut Shells for High-Performance Supercapacitors

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Abstract

Biomass-derived carbon materials offer a sustainable route to high-performance energy storage systems [1-2]. In this study, graphene-like carbon was synthesized from hazelnut shell biochar via KOH activation and catalytic graphitization using ferrocene under controlled pyrolysis. The resulting material exhibits excellent structural and electrochemical characteristics, making it an ideal candidate for next-generation supercapacitor electrodes. Nitrogen adsorption-desorption analysis showed a high specific surface area of 1217 m²/g, supporting efficient electrolyte access and charge accumulation. Thermogravimetric analysis confirmed thermal stability, with over 90% material retention at 800 °C. Raman spectroscopy indicated a low ID/IG ratio (≈ 0.3), reflecting a low defect density and well-ordered graphitic domains. SEM imaging revealed a porous structure that is optimized for ion transport, while EDS confirmed high carbon content with minimal residual metal. Electrochemical characterization using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge-discharge (GCD) in 1 M $TEABF_4$/ACN electrolyte yielded a specific capacitance of 26 F/g, demonstrating stable capacitive behavior in an organic system. This study demonstrates the potential of engineered biomass-derived graphene-like carbon for scalable, eco-friendly, and high-performance electrochemical energy storage.

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Electrical transport in silver phosphate glasses containing V_2O_5 and MoO_3

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Petr Mošner[3], Ladislav Koudelka[3], Ana Šantić[1]

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Oxide glasses containing alkali or silver oxides in combination with transition metal oxides (TMO) have recently emerged as promising candidates for cathode materials in battery technologies. Such glasses can exhibit mixed ion-polaron conductivity or the increase in ionic conductivity due to the facilitating effect of the glass network modified by TMO. Generally, ionic conductivity depends on the concentration and mobility of alkali/silver ions, whereas polaronic (electronic) conductivity follows the small polaron hopping mechanism and depends on the amount of TMO and a relative fraction of TM ions in different valence states.

In this study, we report the influence of V_2O_5 and MoO_3 on the transport of silver ions in phosphate glasses. Two series of glasses of molar composition $50Ag_2O$-xV_2O_5-$(50-x)P_2O_5$, $x = 0$-30 mol% and $50Ag_2O$-$10V_2O_5$-$xMoO_3$-$(40-x)P_2O_5$, $x = 5$-30 mol%, were prepared by melt quenching. Electrical properties of glasses were measured by impedance spectroscopy over a wide temperature and frequency range. The conductivity of glasses changes non-linearly as P_2O_5 is gradually replaced by V_2O_5 exhibiting maximum at 10 mol% V_2O_5. The observed trend in conductivity can be attributed to the changes in the glass-network structure which influence the dynamics of Ag^+ ions. In these glasses, the contribution of polaronic conductivity is negligible, if any, which is confirmed by the scaling of the conductivity spectra using Summerfield scaling procedure. On the other hand, with the addition of MoO_3 to silver vanadate glasses the conductivity remains nearly constant which also suggests the absence of the polaronic transport in these materials.

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I would like to thanks Erasmus program which gives me the opportunity to study abroad. Thank you to my supervisor, Dr. Ana Šantić, for providing guidance and feedback throughout this project.

Plant extracts as metal corrosion inhibitors

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Corrosion inhibitors have been used to protect metals from corrosion for a long time, and we are familiar with many compounds with inhibitory properties. With time and research it is now known that some of the existing inhibitors are not environmentally friendly or are harmful to health and should be replaced with greener corrosion inhibitors. Therefore, new compounds are being researched that have inhibitory effects on metal corrosion. One of the alternatives are inhibitors from natural sources such as plant extracts. Plant extracts are easily available, sustainable, and environmentally friendly, and like classic inhibitors, they create a protective film on the metal surface and thus protect the metal from corrosion. In this research orange peel extract and olive leaf extract have been examined as corrosion inhibitors of carbon steel in 1M HCl. Electrochemical methods were used along with gravimetry to collect information on the corrosion inhibition efficiency of the extract. Experiments were conducted for different extract concentrations and through time to detect any possible degradation of the extract. Also, different solvents were used in the extraction to determine whether the solvent affected the effectiveness of the extract. FTIR spectrum was also recorded to determine the functional groups in the extract itself that play a role in protecting the metal from corrosion.

Behenic acid-based nanocoatings for corrosion-resistant stainless steel surface

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Fatty acids, such as behenic acid, have the ability to form self-assembled monolayers (SAMs) on metallic substrates, including stainless steel. Due to their excellent biocompatibility, they represent a great canditate for enhancing the corrosion resistance of medical-grade stainless steel implants. Although SAMs initially provide protection against corrosion, their long-term stability is limited due to desorption over time. To address this issue, fatty acid SAMs can be irradiation-crosslinked to form polymer nanocoatings (PNCs), thereby improving stability and providing enhenced long-term corrosion resistance.

In this work, we investigated the optimal conditions for forming behenic acid SAMs on stainless steel 316L surface, aiming to achieve homogeneous and stable PNCs upon crosslinking. Gamma irradiation was utilized to crosslink the behenic acid SAMs, resulting in the formation of robust PNCs. Electrochemical techniques, including potentiodynamic polarization and electrochemical impedance spectroscopy (EIS), were employed to assess the corrosion resistance of the modified stainless steel 316L surfaces.

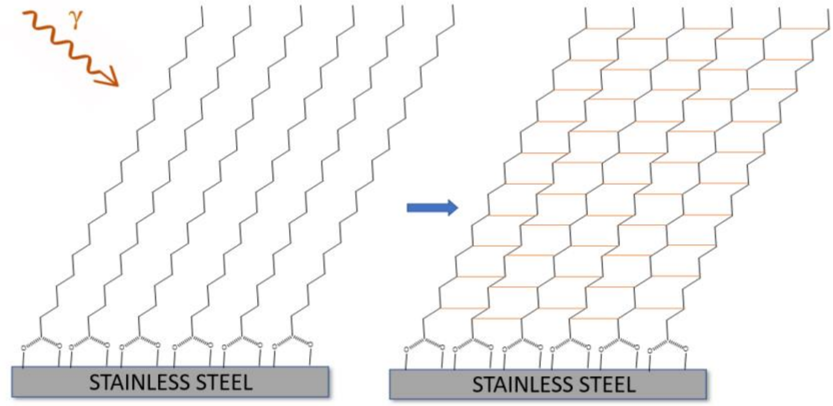

Figure 1. Radiation crosslinking of behenic acid SAM on stainless steel 316L surface.

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Correlation of Mass Loading and Active Material Layer Thickness with the Electrochemical Performance of Graphite Electrodes

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Li-ion batteries are currently the most widely used type of battery. High energy density, low self-discharge rate, and fast charging capabilities are some of the advantages of Li ion batteries over conventional batterie cells. Still there are many challenges regarding Li-ion batterie performance and longevity. For this reason, intensive efforts are being made to improve and develop them further.

In this work mass loading and active material layer thickness was correlated with changes in capacity and impedance before and after several charge-discharge cycles. Several electrodes with mass loading ranging from 0.9 – 4 mg/cm^2 were prepared. Commercial batterie grade graphite was used as active material while PVDF and carbon black were used as binder and conductive additive respectively. Graphite and along with additives were dispersed in NMP to form a slurry. Prepared slurry was applied to copper current collector via doctor blade method. Differing mass loadings were achieved by varying weight ration of dry ingredients to NMP as well as blade gap. Wet electrodes were dried in vacuum oven for 24 hours. After drying mass loading and thickness of resulting layers were measured. Electrochemical characterisation was performed on graphite-Li half-cells by potentiostatic electrochemical impedance spectroscopy (PEIS) and galvanostatic cycling with potential limitation (GCPL) techniques. Further analysis was performed by modelling equivalent circuits.

Findings demonstrate notable influence of mass loading and active material layer thickness on capacity and cycling stability as well as contributions of different reaction and charge transfer mechanisms.

ACKNOWLEDGMENT

This work was financially supported by the project NPOO.C3.2.R3-I1.04.0187: Advanced innovative materials and technologies for lithium-ion batteries production.

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Laboratory Characterization of Coating Systems by Real-Time Impedance Monitoring

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This paper presents a laboratory characterization of protective coating systems using Electrochemical Impedance Spectroscopy (EIS) by the innovative electrochemical setup and method that measures water uptake. The objective was to examine the low-frequency impedance and water uptake of different coatings through real-time impedance measurements. Four different coating systems (A, B, C, and D) were analyzed, with A and B being water-based, and C and D solvent-based. The applied method provides insights into coating barrier efficiency, which is essential for optimizing protective systems. Coatings were applied on metal plates and their thickness was measured using the PosiTector device.

EIS measurements were conducted using a QCQ device over three separate days, to repeatedly assess impedance and percentage of water absorbed into the coating. The thinnest coating (A) showed the highest water absorption (~3.76%) and the lowest impedance. Coating C demonstrated the highest impedance, with the lowest water absorption (~0.31%) and remained stable over time. Water-based systems (A and B) exhibited higher water absorption compared to solvent-based systems (C and D), due to less pronounced protective barrier performance of the dispersion-type coatings as compared to chemically curing-type coatings.

The EIS method proved reliable for monitoring coating condition, water uptake and barrier behavior over time. The composition and thickness of the coating significantly influenced its barrier effectiveness.

A Fundamental Mechanistic Perspective on the Electrochemical Behaviour of Gallic Acid at Carbon Nanotube Electrodes via Cyclic Voltammetry

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Due to their remarkable properties, carbon nanotubes, especially single-walled carbon nanotubes (SWCNTs), represent a highly attractive class of nanomaterials used in a variety of electrochemical applications, including energy storage and sensing technologies. Nevertheless, the electrochemistry of these materials is still poorly understood, mainly due to the complex interplay between their morphology, kinetics, mass transport and electrical properties. In general, electrodes modified with SWCNTs show an improved electrochemical response compared to unmodified electrodes. This behaviour is often attributed to their "electrocatalytic" properties. However, due to the porous morphology of SWCNTs, the mass transport phenomena in the SWCNT layer can exhibit complex behaviour that can affect the overall electrochemical response in the same way. Accordingly, the distinction between mass transport processes within the SWCNT layer, adsorption phenomena and "improved" kinetics remains a major challenge [1]. To clarify this, the electrochemical behaviour of gallic acid (GA) with SWCNT-modified glassy carbon electrodes (SWCNT/GCE) was systematically investigated. A comprehensive cyclic voltammetry (CV) study was performed under conditions where the contribution of mass transport by diffusion from solution was considered negligible, allowing the evaluation of redox processes limited by the SWCNT layers. A detailed analysis of the voltammetric profiles at different scan rates from 12 mV s^{-1} to 400 mV s^{-1} in Britton-Robinson buffers of the different ionic strengths allowed deeper insights into the occurring phenomena and governing redox processes.

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Exploring Ca electrolytes based on weakly coordinating anion salts

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Calcium (Ca) batteries offer a promising alternative to lithium-ion systems due to calcium's natural abundance and low reduction potential (–2.87 V vs. SHE). However, their development is limited by the lack of electrolytes that enable reversible Ca plating/stripping without surface passivation and offer a wide electrochemical window. A key advancement was development of Ca electrolytes based on weakly coordinating anions (WCAs), such as $Ca[B(hfip)_4]_2$.[1]

In this study, we explore the effect of different WCA-anions on the electrochemical performance of Ca electrolytes. A series of fluorinated alkoxyborate and alkoxyaluminate salts -$Ca[B(hfip)_4]_2$, $Ca[B(tfe)_4]_2$, $Ca[BH(pftb)_3]_2$, $Ca[B(pfp)_4]_2$, and $Ca[Al(hfip)_4]_2$ - was synthesized and characterized using NMR and IR spectroscopy. Electrochemical evaluation via cyclic voltammetry, revealed that Ca plating/stripping performance is highly dependent on the specific WCA. At the same time, we observe that the type of current collector significantly influenced electrochemical behavior, even with the same electrolyte, indicating important considerations for future development and characterization of Ca electrolytes.

ACKNOWLEDGMENTS

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Surface modification of tempered martensitic steels: Role of shot peening in hydrogen embrittlement behavior

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In recent years, with the global rise in energy demand, hydrogen has emerged as a promising clean energy carrier. However, high-strength steels utilized for hydrogen infrastructure experience performance degradation, primarily due to their increased sensitivity to hydrogen embrittlement (HE). Surface modifications offer a potential approach to enhance the resistance of the steels exposed to the hydrogen environment. Shot peening (SP) imparts compressive residual stresses and promotes the formation of hydrogen traps within the plastically deformed surface layer. Conversely, laser oxidation (LO) creates protective oxide films that act as barriers to hydrogen uptake. While both techniques are well established, the knowledge regarding their influence in terms of HE is very limited.

This study examines the impact of SP and LO on the hydrogen embrittlement behaviour of two high-strength martensitic steels. Hydrogen trapping and diffusion characteristics were assessed through Electrochemical Permeation Testing and Thermal Desorption Spectroscopy (TDS). To evaluate mechanical behavior under hydrogen exposure, Slow Strain Rate Tests (SSRT) were conducted on electrochemically charged specimens subjected to SP and LO. Microstructural modifications and fracture surface features were analyzed using Scanning Electron Microscopy (SEM) and Electron Backscatter Diffraction (EBSD).

SP increased dislocation density and subsequently the quantity of the trapping sites in the plastically deformed layer. Grain refinement reduced the transport of hydrogen, resulting in a decreased effective diffusion coefficient. Residual compressive stresses inhibited the initiation and propagation of the cracks. TDS analysis implied a low-temperature peak for both SP and LO. SSRT tests in a hydrogen-rich environment exhibited enhanced mechanical performance of the SP and LO specimens compared to the steels in base condition.

Comparison of six coating systems in reference and exposed state using Electrochemical Impedance Spectroscopy

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In this study, the protective performance of six coating systems (A–F) on steel substrates was evaluated under reference (REF) and exposure (EXP) conditions. Measurements were conducted using a QCQ device and included open circuit potential (OCP), impedance at 0.1 Hz, water absorption and impedance at elevated temperatures (30, 40 and 50°C) using one and two-electrode configurations. All coatings showed a stable OCP without the values approaching the potential of the steel substrate. The impedance loss due to exposure indicated irreversible damage in the dry state. After conditioning at 100 % relative humidity, coatings D, E and F showed the greatest impedance loss, while A, B and C showed better barrier performance, with B (the thickest coating) performing best. Water absorption was low for all samples (<0.5 %), confirming the effective barrier properties. The impedance decreased with temperature, with the reference samples showing a faster decrease than the exposed ones. The results emphasize the importance of coating thickness and composition for effective protection.

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Exploring Oxygen Reduction Reaction (ORR) in DMSO-based electrolytes for Ca-O_2 battery applications

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Calcium-oxygen batteries are emerging as a promising solution for energy storage due to the abundance of calcium, its low cost, and its beneficial electrochemical properties. Calcium exhibits a high theoretical volumetric capacity (2,7 mAh/cm^3), high gravimetric capacity (1,335 mAh/g) and relatively low standard redox potential of -2,87 V, making it a promising anode material for high-voltage battery systems. On the other hand, use of oxygen as the cathode reactant enables high energy density through the oxygen reduction reaction (ORR) which is the key to the battery's discharge mechanism.

One of the main challenges in developing this technology is determining a suitable electrolyte that can support efficient and reversible oxygen reduction reaction (ORR), while remaining chemically stable in the presence of reactive oxygen species and calcium metal.[1,2]

This study focuses on investigating the ORR activity in DMSO-based electrolytes containing various calcium salts and the ionic liquid EMIM-FSI (1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide), aiming to optimize electrolyte formulations for future calcium-oxygen battery applications.

ACKNOWLEDGMENTS

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Electrochemical and spectroscopic characterization of the Cu-SA system

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Salicylaldoxime (SA) is a bidentate organic ligand known for its ability to form complexes with transition metals, especially copper(II). Due to its selectivity and sensitivity, it is often used to determine the stability constants of copper in seawater. UV-Vis spectroscopy confirms the formation of a stable complex by shifting the characteristic peaks that correspond to the electronic $\pi \rightarrow \pi^*$ transitions. The copper binds via the deprotonated phenol and oxime groups and forms a chelate structure. Electrochemical studies carried out using cathodic stripping voltammetry (CSV) show the presence of two important features. When the pH of the solution is varied, it becomes clear that the complex between mercury (formed durring the dissolution of Hg electrode at the positive potentials with respect to the Ag/AgCl) with SA is formed. The second feature reffers to the exchange of copper with mercury in an already formed Hg-SA complex, indicating a substitution reaction at the electrode surface. This cognition is important for the interpretation of the analytical results as it can influence the quantification of copper if the interaction with the electrode is not taken into account. Overall, the combination of spectroscopic and electrochemical methods enables a detailed characterisation of the Cu-SA complex/s, providing insights into the nature of the coordination bonds and the redox behaviour of copper in complex natural samples such as seawater.

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Kinetics and Mechanism of Zinc Electrodeposition from Sulfuric Acid bath onto Graphite Electrode

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Along with the increase of the production of zinc metals, Zinc quantities in the environment have increased which poses a threat to society due to its high toxicity and cumulative properties. It has been found that 83% of industrial discharges contain zinc or one of its compounds. This data present a critical environmental problem and underline the importance of removing this pollutant from wastewaters. On the other face, treating these industrial wastewaters with the aim of regenerating water and recovering zinc is therefore of primary interest. Various conventional methods are used to remove heavy metals from wastewater. The electrodeposition process is usually applied for the recovery of Zinc, this process is considered of great importance for reducing environmental emissions and for substantial savings.

In the present work, Potentiostatic Zinc electrodeposition at a graphite electrode from synthetic solution of 0.05M Zinc (II) sulfate was studied at pH3. Cyclic voltammetry, electrochemical impedance spectroscopy and chronoamperometry were used to characterize the kinetics of nucleation and electroplating of Zinc deposits. Zinc was deposited potentiostatically at -1300 mV on a graphite electrode. Characterization of the deposits formed was done by scanning electron microscopy (SEM), and X-ray diffraction (XRD).

Excellent efficiency zinc recovery was achieved. In the first time of deposition, Zinc deposits reveal a very compact growth, well adhered to the electrode surface. with the increase of the deposition time, the morphology of zinc deposits changes and deposits less attached to the electrode was presented which facilitates the zinc deposits recovery, fig.1.

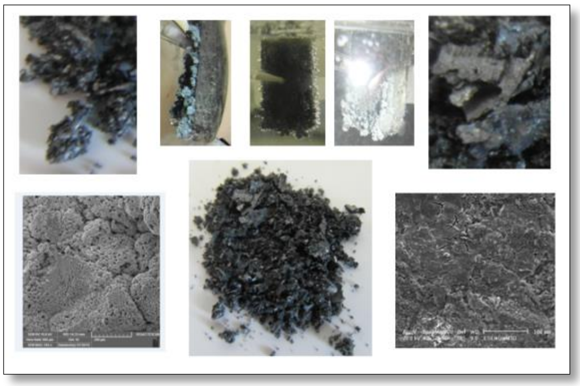

Fig.1 : Morphological structure of Zinc deposits.

Anti-corrosion protection of copper by polyelectrolyte multilayer nanofilms

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Metal corrosion is one of the main problems of technological development, hence the need for new, effective methods of protecting metals from corrosion is extremely important. Polyelectrolyte multilayers (PEMs) are a new class of thin films formed by alternating deposition of positively and negatively charged polyelectrolytes on different substrates [1]. The properties of PEMs can be precisely controlled by changing the preparation conditions. Moreover, further improvements of PEM properties can be achieved by post-fabrication methods such as thermal annealing [2]. In this study, surface morphology of a copper sample and thickness of its oxide layer were determined using atomic force microscopy and ellipsometry, respectively. After that, nanofilms were fabricated on copper surface by layer-by-layer assembled poly(allylamine hydrochloride) and poly(acrylic acid). Ellipsometry was used to monitor film growth. After preparation, the films were thermally cross-linked. The films, both before and after annealing, were characterized by atomic force microscopy and ellipsometry. Finally, polyelectrolyte coatings were examined by electrochemical impedance spectroscopy and enhanced corrosion protection effectiveness was observed.

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Enhancing ionic conductivity in lithium phosphate-based glasses: the role of Nb_2O_5 and mixed glass-former effect

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Lithium phosphate-based glasses are being actively explored as solid electrolytes for all-solid-state lithium batteries because of their low melting points, glass transition temperatures, and strong glass-forming ability. Although they offer moderate ionic conductivity, their transport properties still fall short of those required for high-performance battery systems [1].

In this study, the stepwise substitution of P_2O_5 with Nb_2O_5 in Li_2O-P_2O_5-Nb_2O_5-(V_2O_5/Al_2O_3) glasses system was investigated. The samples were prepared via a conventional melt-quenching method, and their amorphous nature was confirmed by PXRD. Structural and thermal analyses were performed using IR spectroscopy and DTA, while the electrical properties were evaluated using solid-state impedance spectroscopy (ss-IS) over a broad frequency and temperature range. The results revealed a conductivity enhancement with increasing Nb content, attributed to the mixed glass-former effect (MGFE) [2, 3] and the formation of P–O–Nb linkages with a more open network structure. On the other hand, the addition of intermediates V_2O_5 and Al_2O_3 also show positive effect on conductivity through improved network connectivity. This study provides key insights into structure-property relationships and highlights the importance of compositional fine-tuning in developing efficient solid-state electrolytes.

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Hydrated Deep Eutectic Solvents as Electrolytes for Zinc-Ion Batteries: Dendrite Suppression and Plating/Stripping Stability

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The growth of zinc dendrites remains a major challenge for the long-term performance and safety of Zn-ion batteries. In this study, hydrated deep eutectic solvents (DES) were investigated as alternative electrolytes for Zn-ion battery applications. A DES composed of choline chloride and ethylene glycol was prepared and $ZnCl_2$, $ZnSO_4$ and zinc acetate were each added at a concentration of 0.3 M. The electrochemical behaviour of these electrolytes was evaluated using cyclic voltammetry and galvanostatic cycling with potential limitation (GCPL), with a focus on zinc plating/stripping performance and dendrite suppression. Among the tested systems, the DES containing zinc acetate demonstrated the most stable and prolonged zinc plating/stripping behaviour. These results suggest that the DES with zinc acetate is a promising electrolyte candidate for Zn-ion battery applications.

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Development of the New Sulfate Ion-Selective Electrode Modified with Fe_3O_4 Nanoparticles

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Potentiometric ion-selective electrodes (ISEs) are among the most rapidly developing sensors [1]. They offer numerous advantages, including high selectivity and sensitivity, low detection limits, small size, ease of use, portability, and low cost. They are used in the food industry, agriculture, environmental analysis and medicine [2]. The ion-selective membranes were prepared by pressing a mixture of barium sulfate, graphite, and polytetrafluoroethylene (PTFE) in a 2 : 1 : 1 mass ratio and modified with addition of 0.2 - 0.8 % of magnetite nanoparticles (NPs). The measurements were performed in sodium sulfate solutions at pH = 2, 4, 6 and 8, and barium nitrate solutions at pH = 2 and 4. The electrochemical sensor incorporating 0.2 % magnetite NPs exhibited a linear potential response with a slope of 29.38 mV per decade, closely approximating the theoretical Nernstian slope for divalent ions (29.6 mV dec^{-1}) with a regression coefficient of R^2=0.9660. Notably, none of the prepared membranes responded to barium ions, confirming the high selectivity of the potentiometric sensors toward sulfate ions. Furthermore, membranes without the addition of magnetite NPs exhibited no significant performance. The results showed that the incorporation of graphite instead of previously used silver sulphide [3] as a charge transferer showed effective results. Additionally, we investigated 3D-printed ion-selective electrodes fabricated using the same base composition, with PTFE replaced by industrial ABS in a 3:1:96 mass ratio. Among the 3D-printed membranes tested, only one containing 0.6% magnetite NPs at pH = 4 showed a response to sulfate ions, with a slope of 27.06 mV per decade and a regression coefficient of R^2=0.9497. This indicates that there is still room for improvement, and our ongoing work is focused on further optimizing the process of 3D printed membranes.

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Design and characterization of electron donating organic semiconductors for photovoltaic application

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When designing electron donors for photovoltaic application, it is important to consider the key parameters which govern charge carrier transport inside a bulk heterojunction that plays a pivotal role in the functioning of a thin film solar cell. In this work, ten novel squaraine derivatives were synthesized and methods of their preliminary characterization are discussed. These include their bandgap and HOMO/LUMO energy levels and the influence they have on the performance of assembled solar cells based on their respective compounds. Moreover, a brief overview of other photovoltaic and physical properties will be discussed. UV-Vis spectroscopy and cyclic voltammetry were utillized to obtain the bandgaps and HOMO/LUMO energies for each compound while supporting characterization was obtained by microscopy methods, such as profilometry, AFMandFIB-SEM.

Enhancing Supercapacitor Performance Using MXene Electrodes and Ionic Liquid Electrolytes

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Supercapacitors are promising energy storage devices due to their high power density, fast charge/discharge capability and long cycle life, but their low energy density remains a key limitation. To address this, we combined delaminated MXene electrodes with ionic liquids as electrolytes to improve both capacitance and the electrochemical window. Three ionic liquids were tested—[BMIM][PF_6], [BMIM][Sal] and [Ch][Sal], and compared to aqueous 0.5 M Na_2SO_4. MXene in Na_2SO_4 showed the highest capacitance (67 F/g at 5 mV/s), but a narrow potential window (0.9 V). In contrast, ionic liquids enabled a wider window (1.6 V) with slightly lower capacitance values (37.5–54 F/g). Trasatti analysis indicated that pseudocapacitance dominates the charge storage. Among the tested systems, the MXene/[Ch][Sal] pair showed the best overall balance, highlighting its potential for next-generation supercapacitors.

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Electrochemical Impedance Spectroscopy characterization of bioimplant Ti-6Al-4V alloy using an innovative cell with electrolytic paste

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In this study, electrochemical characterization was performed on the material and component of a hip implant made from the titanium alloy Ti-6Al-4V. Although this alloy exhibits excellent corrosion resistance, under certain conditions it may be susceptible to Mechanically Assisted Crevice Corrosion (MACC). A press-on cell was used, in which the working electrode was the sample, while the counter electrode consisted of conductive rubber embedded with a pseudo-reference electrode made of stainless steel (SS316L). Instead of a standard liquid electrolyte, an innovative electrolyte paste was applied. This setup enabled an in vitro simulation of MACC corrosion through successive cathodic polarization at various potentials. The harmful effects of polarization were assessed using Electrochemical Impedance Spectroscopy (EIS).

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Engineering High-Capacity Silicon–Graphite Composite Anodes for Advanced Lithium-Ion Battery

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The growing issues related to greenhouse gas emissions are accelerating the transition from fossil fuels to renewable energy sources. While such sources are essential for a sustainable future, their main drawback lies in the need for efficient energy storage systems. One of the promising solutions for energy storage is the lithium-ion battery. They represent the most advanced technology due to their high energy and power density. The most used anode material in lithium-ion batteries is graphite, which provides reversible lithium-ion intercalation capability that leads to excellent cycling stability and a theoretical capacity of 375 mAh/g. However, with the increasing demand for improvement, graphite alone can no longer meet the performance requirements of the battery industry. Silicon presents itself as a promising addition due to its extremely high theoretical capacity of 4200 mAh/g. Nevertheless, despite its high capacity, silicon underperforms on its own due to significant volumetric changes during cycling, leading to electrode degradation. The solution is to combine graphite and silicon into composite anodes in optimized ratios, which makes achieving high capacity without compromising electrode stability possible. In this work, the goal was to make hybrid anode materials with varying graphite-to-silicon ratios. The electrodes were prepared by formulating slurries of a graphite and silicon blend as an active material, carbon black as a conductive additive and PVDF as the binder, with NMP serving as the solvent. After coating, drying and cutting the electrodes were assembled into Swagelok test cells and posed as a working electrode while lithium was used as both counter and reference electrode. The electrodes were tested electrochemically, using cyclic voltammetry and galvanostatic charge-discharge, and physically, using contact angle and scanning electron microscopy. The results suggest that a small addition of silicon can significantly enhance the capacity of graphite-based electrodes without causing structural degradation. In contrast, higher silicon contents lead to reduced cycling stability.

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Influence of electrode slurry composition and electrode thickness on the electrochemical performance of NMC cathodes

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Excessive reliance on fossil fuels creates severe environmental problems, facilitating the transition to sustainable energy sources is a global imperative. In this context, batteries are crucial as they enable the storage of intermittently generated energy from renewable sources. Currently, lithium-ion (Li-ion) batteries are leading technologies in energy storage. Their advantage is attributable to the unique properties of lithium – it has a small atomic radius, the lowest reduction potential, and a low atomic mass – all of which contribute to their impressive energy density and efficiency. Because of this, Li-ion batteries are often hailed as the "state of the art" in energy storage. Among the various chemical compositions, lithium nickel manganese cobalt oxide (NMC) materials are the preferred material for positive electrodes, due to an excellent balance of performance, including high energy density, solid power output, and long cycle life. However, the production of Li-ion batteries is a demanding process involving multiple stages. Each step in the manufacturing process must be closely monitored, as the preparation parameters can significantly affect the final properties of the battery, such as capacity, durability, and safety. Therefore, optimization of the production processes is essential to achieve the desired performance and ensure the quality of the lithium-ion batteries. In this study, we explored how the dry matter ratio in the electrode paste and the thickness of the electrodes impact their structure and electrochemical properties. Variation in proportions of dry matter and the thickness of the electrode slurry applied to the current collector were systematically implemented. Positive electrode performance was evaluated electrochemically using galvanostatic charge-discharge cycling, electrochemical impedance spectroscopy and galvanostatic intermittent titration technique. The physical properties were further characterized using scanning electron microscopy, contact angle measurements and B.E.T. adsorption analysis to fully understand the results of electrochemical performance. The findings demonstrate that adjusting initial parameters significantly improves electrode quality and electrochemical properties, producing promising results that encourage further investigation.

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