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International School of Electrocatalysis 2025 (ISECAT2025)

23-25 July 2025
PADOVA

Organized by:

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The School Chairmen
Prof. Vito Di Noto, *University of Padova, Italy – Coordinator of ACee*
Prof. Enrico Negro, *University of Padova, Italy*

Welcome to the International School of Electrocatalysis 2025 (ISECAT2025)

23-25 July 2025, Padova, Italy

Società
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The "*Gruppo Interdivisionale di Chimica per l'Accumulo e la Conversione Elettrochimica dell'Energia*" **(ACee)** of the **Italian Chemical Society (SCI)** organizes the **first edition** of **the International School of Electrocatalysis** in Padova, Italy on **23-25 July 2025.**

ISECAT2025 aims at **offering to students and newcomers** the ***state of art***, the ***very recent progress*** and ***the future targets*** in the field of electrocatalysis for application in electrochemical energy conversion and storage devices by **top-notch national and international scientists** as **instructors**.

The School Chairmen
Prof. Vito Di Noto, *University of Padova, Italy – Coordinator of ACee*
Prof. Enrico Negro, *University of Padova, Italy*

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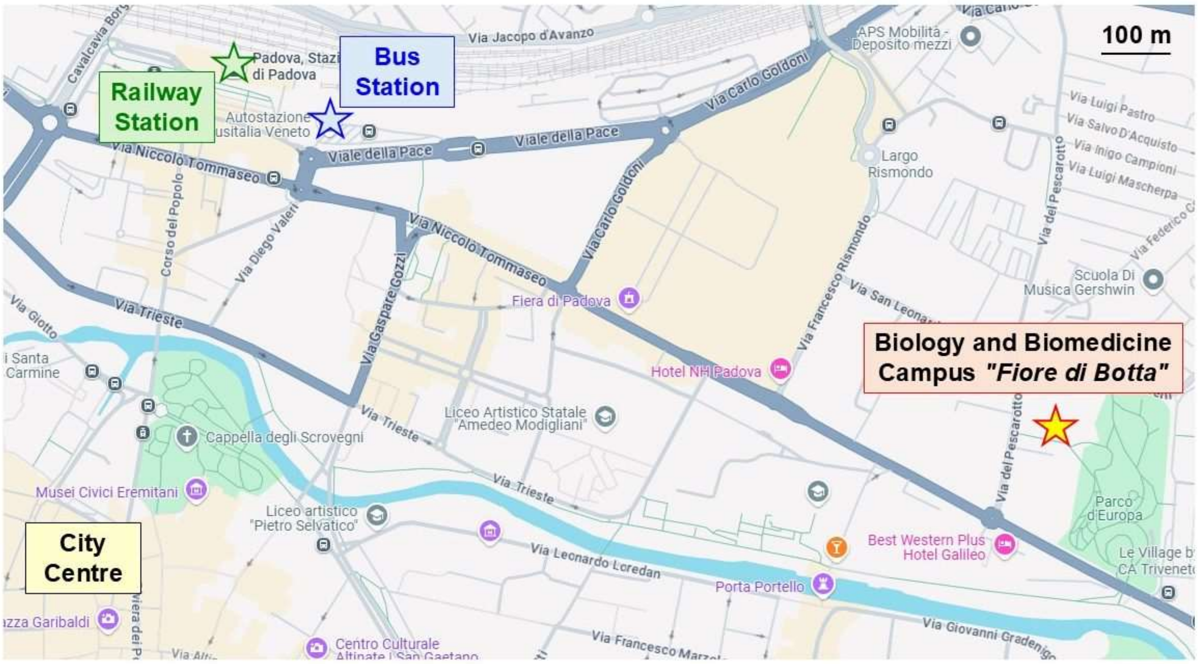
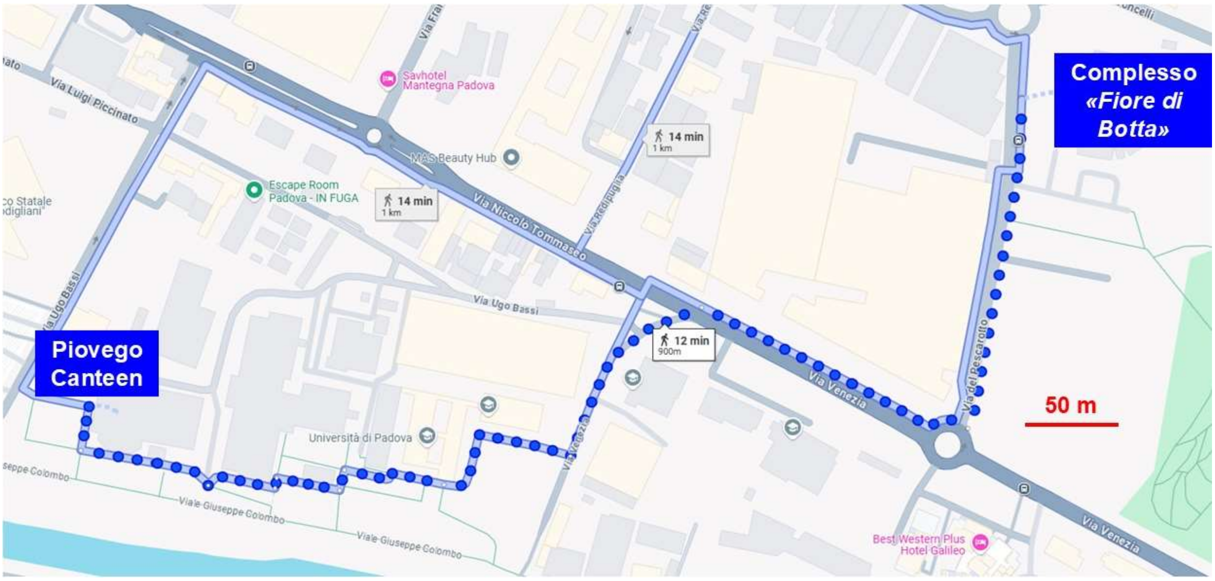
CONFERENCE INFORMATION

ISECAT2025 will be held in one of the most prestigious and modern buildings of the University of Padova, Italy – **the Biology and Biomedicine Campus *"Fiore di Botta"***. The address of the **Biology and Biomedicine Campus *"Fiore di Botta"*** is: Via del Pescarotto, 8, 35131 Padova (PD), Italy. Additional information on the venue can be retrieved at the following link: https://heritage.unipd.it/en/storia/il-fiore-di-botta/.

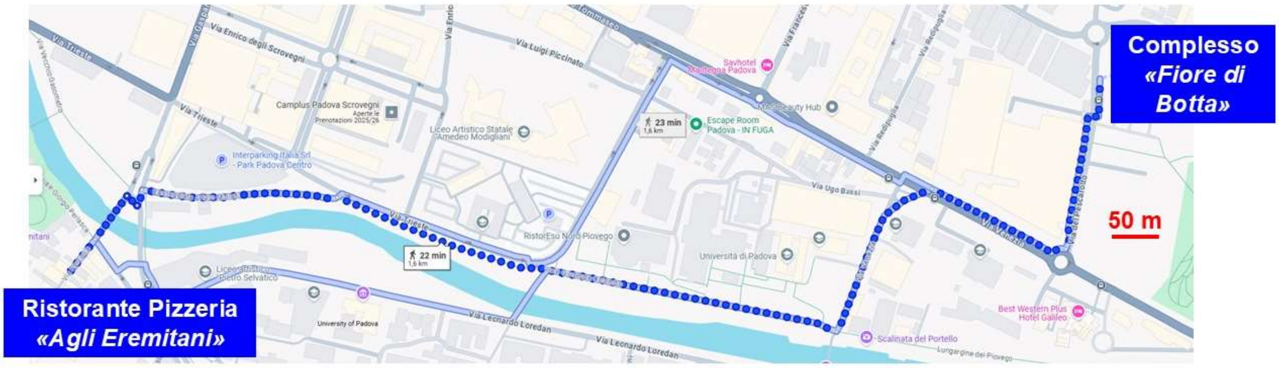
The Biology and Biomedicine Campus *"Fiore di Botta"* is easy to reach from the city center, the railway station and the bus station (see the map below)



Lunches will take place at the Piovego Canteen (Viale Giuseppe Colombo 1, 35131 Padova PD).



The dinner of ISECAT2025 will take place at *"Ristorante Pizzeria Agli Eremitani"* (Via Porciglia 29, 35121 Padova PD), URL: https://www.aglieremitani.it/



ACKNOWLEDGEMENTS

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Project: **DURALYS**
Italy-Germany Call for
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PROGRAM OF THE SCHOOL

Time	Wednesday	Thursday	Friday
	23 July 2025	24 July 2025	25 July 2025
9:00 - 10:15		Nicolas Alonso-Vante	Sven Jovanovic
10:15 - 10:45		Coffee Break	
10:45 - 12:00		Fabrice Micoud	Alessandra Sanson
12:00 - 12:30		Q&A	
12:30 - 13:15		Lunch	
13:15 - 13:30	Opening Remarks		
13:30 - 14:45	Marian Chatenet	Plamen Atanassov	Stephen Paddison
14:45 - 16:00	Piotr Zelenay	Lior Elbaz	Chiara Maurzio
16:00 - 16:30	Coffee Break		
16:30 - 17:30	Peter Strasser	Pawel Kulesza	Final Test
17:30 - 17:45			Closing Remarks
17:45 - 18:15	Q&A		
18:15 - 19:45	Posters		
19:45 - 20:45		Dinner	

WEDNESDAY, 23 JULY 2025

13:15 – Opening Remarks – Conference Chairs

13:30 – Lecture delivered by Prof. Marian Chatenet: *“Oxidation of complex molecules (borohydrides, glucose) in alkaline environment”*

14:45 – Lecture delivered by Prof. Piotr Zelenay: *“Performance Durability of Electrocatalysts for Clean Energy Applications”*

16:00 – Coffee Break

16:30 – Lecture delivered by Prof. Peter Strasser: *“Perspectives on the electrocatalytic oxygen evolution reaction”*

17:45 – Questions and Answers session

18:15 – Poster session

THURSDAY, 24 JULY 2025

9:00 – Lecture delivered by Prof. Nicolas Alonso-Vante: *“What parameters are key in identifying and quantifying the performance of electrocatalysts?”*

10:15 – Coffee Break

10:45 – Lecture delivered by Dr. Fabrice Micoud: *“Manufacturing and testing of membrane-electrode assemblies for PEMFCs”*

12:00 – Questions and Answers session

12:30 – Lunch at Piovego Canteen

13:30 – Lecture delivered by Prof. Plamen Atanassov: *“Perspectives of electrocatalysts for oxygen reduction reaction in fuel cells”*

14:45 – Lecture delivered by Prof. Lior Elbaz: *“Advanced Electrochemical Methods for the Study of PGM-free Electrocatalysts’ Performance in situ PEMFCs”*

16:00 – Coffee Break

16:30 – Lecture delivered by Prof. Pawel Kulesza: *“Structure and Reactivity of Catalysts during Electroeduction of Inert Reactants: Carbon Dioxide, Nitrogen and Nitrates”*

17:45 – Questions and Answers session

19:45 – Dinner at *“Ristorante Pizzeria Agli Eremitani”*, URL: https://www.aglieremitani.it/

FRIDAY, 25 JULY 2025

9:00 – Lecture delivered by Dr. Sven Jovanovic: *“On the challenges, pitfalls and opportunities of in operando analytics for electrocatalytical systems: a practical guide”*

10:15 – Coffee Break

10:45 – Lecture delivered by Dr. Alessandra Sanson: *“The role of ceramic materials in electrochemical devices”*

12:00 – Questions and Answers session

12:30 – Lunch at Piovego Canteen

13:30 – Lecture delivered by Prof. Stephen Paddison: *“Structure/Transport Relations in Electrolytes: What have we learned from modelling in the past Quarter Century?”*

14:45 – Lecture delivered by Prof. Chiara Maurizio; *“Synchrotron radiation experiments to shed light on electrocatalysts”*

16:00 – Coffee Break

16:30 – Final Test

17:30 – Closing Remarks

EVENTS

Questions and Answers sessions

During the *"Questions and Answers"* sessions distributed in **ISECAT2025**, the participants to the School will have the opportunity **to discuss the contents of the lectures with the instructors**. This will allow to clarify the doubts, at the same time improving the understanding and insight on the subject-matter covered by the lectures.

Poster session

One of the core aims of **ISECAT2025** is **to promote direct interactions** between the School's instructors and the participants, **fostering dialogue and the exchange of ideas**. In this spirit, **ISECAT2025** also includes a Poster session, during which the participants will enjoy the opportunity to **share and discuss their findings** both with their peers and with the instructors of the School.

Final Test

The participants to **ISECAT2025** will have the opportunity **to reinforce their learning experience** with a **short final test at the end of the School**. The test will be delivered **online** and will consist **of multiple-choice questions** covering the subject-matter discussed by the instructors during the lectures.

CONTENTS OF THE LECTURES

Oxidation of complex molecules (borohydrides, glucose) in alkaline environment

Lecture delivered on **23 July 2025, 13:30** by **Prof. Marian Chatenet**, Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, France, E-mail: Marian.Chatenet@grenoble-inp.fr

The oxidation of strong reductants like sodium borohydride ($NaBH_4$) or glucose finds applications in metal deposition, energy harvesting in direct fuel cells or electrosynthesis. These reactions have in common to involve multiple steps and intermediates, and their mechanisms strongly depend on the electrocatalytic materials and operating conditions used to promote them. While in some cases (sodium borohydride, for energy harvesting in direct fuel cells) the complete reaction is targeted, in others, it might be interesting to selectively stop the reaction at a desired state (*e.g.* selective glucose oxidation into gluconic acid, a value-added product). Being capable to target the desired reaction pathway of course requires to have a deep knowledge of the reaction mechanisms and to make the proper selection/shaping of the electrocatalyst/electrode.

Herein, based on examples obtained in the past via multiple collaborative projects, it will be shown how combining a proper design of the electrocatalyst, thorough electrochemical investigations, *in situ* physicochemical techniques (differential electrochemical mass spectrometry, DEMS, Fourier-transform infra-red spectroscopy, FTIR), microkinetic modelling and DFT calculations, one could unveil these complex reaction mechanisms [1-6], thus reach the desired targets of performance, including in real cells [7, 8].

Acknowledgements: The National Research Agency funded this research via the MobiDiC project (ANR-16-CE05-0009-01), the GlucoNiC project (ANR-20-CE43-0005-03) and the "CEMAM" labex (ANR-10-LABX-44-01).

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[2] P.-Y. Olu, A. Bonnefont, G. Braesch, V. Martin, E.R. Savinova, M. Chatenet, Influence of the concentration of borohydride towards hydrogen production and escape for borohydride oxidation reaction on Pt and Au electrodes – experimental and modelling insights, J. Power Sources, 375 (2018) 300-309.

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Performance Durability of Electrocatalysts for Clean Energy Applications

Lecture delivered on **23 July 2025, 14:45** by **Prof. Piotr Zelenay**, Los Alamos National Laboratory, Los Alamos, NM 87544, USA, E-mail: zelenay@lanl.gov

Electrocatalysis plays a fundamental role in clean technologies for energy conversion and storage. It promotes the conversion of fuels to electricity in fuel cells with efficiency which is not limited by that of a heat engine and hydrogen generation from water in electrolyzers that is free of any products and contaminants. In a longer term, electrocatalysis is especially well poised to replace some of the most polluting processes in the chemical industry.

While in quite a few cases the state-of-the-art electrocatalysts offer performance that initially meets requirements their durability under the operating conditions of real-life systems is insufficient for practical applications. Assuring adequate performance durability over the required time typically entails an increase in the catalyst loading, which then leads to a considerable rise in overall cost, if the catalyst expense represents a significant fraction of the overall system expense. Best examples of such systems are fuel cells for automotive applications and polymer electrolyte membrane water electrolyzers, which require high loadings of platinum (Pt) and iridium (Ir) for their cathode and anode, respectively. Inadequate electrocatalyst durability can also require “overbuilding” of the system with corresponding increase in cost associated also with other system components.

In this lecture, we will focus on the durability of electrocatalysts for low-temperature fuel cells (not only for catalyzing the cathodic process of oxygen reduction, abut also selected fuel oxidation processes at the anode) and for electrolyzers operating in both acidic and alkaline environments. We will assess the current state of the art in catalyst durability for these applications versus the requirements of practical systems and established performance targets, before reviewing selected methods of assessing performance of electrocatalysts under real-time and using accelerated stress test (AST) conditions. We will then use available durability data to analyze performance-cost tradeoffs underpinning the choice of preferred operating conditions such as pH and temperature and analyze how such a choice is likely to impact a device performance. In conclusion of this lecture, we will identify main challenges facing the development of electrocatalysts for fuel cell and electrolyzer applications from the performance durability point of view and possible paths of addressing these challenges.

Perspectives on the electrocatalytic oxygen evolution reaction

Lecture delivered on **23 July 2025, 16:30** by **Prof. Peter Strasser,** Department of Chemistry, Technical University Berlin, Berlin, Germany, E-mail: pstrasser@tu-berlin.de

The electrolytic splitting of water into its elements is Reaction No.1 in modern electrochemistry. Discovered by van Troostwijk, Nicolson, Carlisle, and Ritter, water splitting and its half-cell constituents - hydrogen evolution (HER) and oxygen evolution (OER) – later became the most widely explored electrochemical model reactions in works by Bockris, Parsons, Conway, and Gerischer. Over the past decade, advanced characterization methods have offered new molecular insights into the reactive interface of catalyst and electrolyte. Today, water splitting using renewable power is an emerging industrial process technology to generate "green" hydrogen, a versatile energy vector for the decarbonization of power generation, heat, mobility, and industry.

In this presentation, I will share some of our work on the design and characterization of electrocatalytic materials, interfaces and mechanisms of the electrochemical oxygen evolution reaction (OER). Catalytic materials such as Iridium oxide and Nickel oxides along with similarities and differences in their mechanisms in acid and alkaline environments will be discussed.

What parameters are key in identifying and quantifying the performance of electrocatalysts?

Lecture delivered on **24 July 2025, 9:00** by **Prof. Nicolas Alonso-Vante,** College of Smart Energy, Shanghai Jiao Tong University, Shanghai 200240, People's Republic of China, E-mail: nicolas.alonso.vante@sjt.edu.cn

Electrochemistry is an important topic for nanomaterials due to their applications in energy storage and conversion [1]. In addition, the enormous growth of articles on electrocatalysis with new nanomaterials, as well as novel strategies to improve the performance of known nanomaterials, is evident. In this context, we can state that considerable progress has been made in understanding the fundamental processes involved in important electrochemical reactions such as hydrogen evolution (HER), oxygen evolution (OER), oxygen reduction (ORR) and CO_2 reduction (CO2RR). Therefore, fairly comparing the electrocatalytic properties of different nanomaterials for a given reaction has become difficult, thus resorting to a particularly important parameter for electrochemical applications of nanomaterials which is the electrode specific surface area (ECSA). Identification and quantification involve a thorough evaluation of material properties, electrochemical performance and stability.

It should be recalled that electrocatalysis involves several critical steps, such as access of reactants to active sites, adsorption, charge transfer and product release. The efficiency of these processes is mainly influenced by the electronic structure of the active sites, which dictates the adsorption and charge transfer kinetics [2]. Thus, the identification and understanding of active sites are crucial to advance the design of electrocatalysts. Active sites interact optimally with transition states, providing the best catalytic performance [3].

In this lecture, in addition to the usual electrochemical techniques, it will be shown how certain techniques help to understand the morphology, composition and structure of materials. Standardized evaluation methods are also essential for accurate comparison, and factors such as environmental conditions, reference electrodes and electrolytes must be consistent to ensure reliable results [4]. Understanding these factors is essential for developing high-performance electrocatalysts for various applications.

References

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Manufacturing and testing of membrane-electrode assemblies for PEMFCs

Lecture delivered on **24 July 2025, 10:45** by **Dr. Fabrice Micoud,** Commissariat à l’énergie atomique et aux énergies alternatives, Département de l’Electricité et de l’Hydrogène pour les Transports, France, E-mail: fabrice.micoud@cea.fr

Proton Exchange Membrane Fuel Cell (PEMFC) is a promising technology to provide clean energy by the electrochemical conversion of H_2 and O_2 into electricity, water and heat. Commercialization has already started, mainly for transportation and stationary applications but mass-production is still hindered by limited performance/lifetime and high cost. The PEMFC stack is composed of bipolar plates and the Membrane Electrode Assembly (MEA). The MEA is the core component where the electrochemical reactions, namely the Hydrogen Oxidation Reaction (HOR) and the Oxygen Reduction Reaction (ORR), take place. More precisely, the Catalyst Layers (CL), placed on both sides of the membrane, are the exact seats for these reactions. Therefore, the CL are of key importance and must be optimized for both the performance and the durability of the fuel cell. They are composed of electrocatalysts (mostly Pt-based nanoparticles supported on carbon) and ionomer which acts as proton conductor and binding agent. Each catalyst layer is coated from an ink consisting of a dispersion of catalyst and ionomer in one or more solvents. Manufacturing parameters such as catalyst layer composition (type of catalyst, ionomer to carbon ratio), nature of solvents, ink mixing method, deposition process (blade-coating, screen-printing, spray-coating) onto an inert support and then decal transfer conditions onto the membrane have to be carefully set to optimize their intrinsic properties and performance. In this lecture, a review of the main materials, manufacturing processes and quality control techniques will be made to obtain reproducible MEA. Then, cell and stack assembly protocols will be presented. Some guidelines and good practices for break-in phase, performance measurement by polarization curves and durability evaluation will be shared and further insight that can be obtained via complementary characterizations (cyclic voltammetry, impedance spectroscopy, CO_2-online analysis and local current density mapping) will also be addressed. Finally, the choice of experimental settings and data treatment methodology will also be discussed to get and present reliable results to support efficiently future developments of innovative materials and MEA manufacturing processes.

Perspectives of electrocatalysts for oxygen reduction reaction in fuel cells

Lecture delivered on **24 July 2025, 13:30** by **Prof. Plamen Atanassov,** Department of Chemical & Biomolecular Engineering, University of California, Irvine, USA, E-mail: plamen.atanassov@uci.edu

Platinum Group Metal (PGM) and Platinum Group Metal-free (PGM-free) catalysts have been extensively developed as oxygen reduction reaction (ORR) cathode materials for both Proton Exchange Membrane (PEM) and Alkaline Exchange Membrane (AEM) fuel cells aiming automotive, stationary and portable applications. In this lecture we will review the fundamental approaches to maximize their efficiency, activity and durability and will address the critical challenges that the research community is facing on the way to practical application of such catalysts in fuel cells.

For PGM catalysts the critical issue is to maximize activity and selectivity while reducing to the extent possible platinum metal content in the cathode (PGM loafing) and minimizing the thinness of the catalyst layer. At the same time, catalyst design is expected to address issues of “ionomer poisoning” or specific adsorption of sulphonate groups on the platinum catalyst interface as well as the interfacial and structural stability of the catalysts during long-term operation or corresponding cycling protocols. Role of the catalyst support, usually a meso-porous carbonaceous material becomes important and, in some cases, dominant in new PGM catalyst materials design. This includes issues of corrosion resistance, strong catalyst-support iteration, morphological advantages and, ultimately, scalability and manufacturability of the catalysts as a product. Next set of issues arise from ink formulation to correspond to the rheological and deployment specifications of high throughput membrane electrode assembly (MEA) manufacturing processes. Challenges set by mass-production of fuel cells lead to a shift in MEA manufacturing from intermittent production (by spray coating or digital printing) to roll-to-roll manufacturing based predominantly on thin film spreading/coating and gravure printing technologies.

PGM-free ORR catalysts continue being developed and are in search for its market application. The makeup and structure of the active site/sites of the PGM-free ORR electro-catalysts, including geometry (coordination) and chemistry (composition and oxidation state) remain contentious even after 50 years of research. There is an emerging agreement that iron (or other transition metal) and nitrogen functionalities, displayed on the surface if the carbonaceous substrate/support, govern ORR activity. This is often combined with a broadly accepted hypothesis that micro-porous surface area plays a critical role forming the active site. Candidate structures participating in ORR include multitudes of nitrogen defect motifs in the carbon matrix of different degrees of graphitization, with metal incorporated as metal nano-particles, corresponding (native) oxides and/or as atomically dispersed, oxidized metal species, linked (coordinated) to nitrogen defects in carbonaceous matrix in a variety of possible configurations. This lecture will attempt to address rational design metrics of transition metal-nitrogen-carbon (M-N-C) electrocatalyst based on a broad experimental set of data. This lecture will review the applications of this class of PGM-free electrocatalyst across several fuel cell applications: from automotive to microbial and from regenerative electrolyzer/fuel cell units to water purification and desalination devices.

Advanced Electrochemical Methods for the Study of PGM-free Electrocatalysts' Performance *in situ* PEMFCs

Lecture delivered on **24 July 2025, 14:45** by **Prof. Lior Elbaz,** Bar-Ilan University, Israel, E-mail: lior.elbaz@biu.ac.il

Platinum group metal-free (PGM-free) catalysts have shown increasing performance and durability and are considered as viable candidates for replacing PGM catalysts for the oxygen reduction reaction (ORR) in fuel cells. Yet, their relatively low intrinsic turn over frequency, which is two orders of magnitude below that of PGMs, and low active site density, requires high loadings of the PGM-free catalysts to obtain reasonable performance in fuel cells. Consequently, the resulting high catalyst loadings induce several interesting and opposing phenomena, namely, lower ORR kinetic losses due to an increase in the number of active sites and much higher mass and charge transport losses. In this talk I will present the application of Fourier-transformed ac voltammetry (FTacV) in fuel cells, explain the theory and data analysis using this method and show some examples from my research in recent years.[1-3] These will include the use of FTacV to systematically deconvolute the gains and losses to the activity due to the high loading of PGM-free catalysts and relate the underlaying processes to the observed fuel cell performance, as well as to understand the fundamental reactions and the limiting thermodynamic and kinetic parameters in the ORR, to enable the production of advanced PGM-free catalysts. To complement FTacV, I have also been using electrochemical impedance spectroscopy (EIS). The EIS is analyzed via extraction of the distribution of relaxation times (DRT), obtaining a model-free analysis of the physical processes in the cell. Combined with FTacV measurements I will explain how one can extract the optimal catalyst loading from a mechanistic point of view.[4, 5] The combined use of advanced ac techniques for analysis of operating fuel cells is an important step towards rational design of the catalysts and catalyst layers.

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Structure and Reactivity of Catalysts during Electroeduction of Inert Reactants: Carbon Dioxide, Nitrogen and Nitrates

Lecture delivered on **24 July 2025, 16:30** by **Prof. Pawel Kulesza,** Faculty of Chemistry, University of Warsaw, Poland, E-mail: pkulesza@chem.uw.edu.pl

There has been growing interest in the electrochemical reduction of carbon dioxide, a potent greenhouse gas and a contributor to global climate change. In this respect formation of simple fuels and utility chemicals is of interest. Formation of ammonia is one of the most important chemical synthetic processes. Development of low-temperature synthetic (e.g., electrochemical) methodology is tempting both from the practical and fundamental reasons. Given the fact that both N_2 and CO_2 molecule are very stable, their electroreduction processes are characterized by large over-potentials.

Despite the fact that the processes are complex and kinetically slow, electrochemical approaches are generally suitable for the low-temperature conversions of carbon dioxide (to carbon-based simple organic fuels or utility chemicals) and nitrogen (typically to ammonia). Remembering that N_2 molecule is electrochemically more inert (during reduction) than CO_2, as well as being aware that hydrogen evolution is a competitive and complicating process in aqueous media, different concepts of utilization, including nanostructuring, hybridization, alloying admixing, preconditioning, modification or functionalization of various catalytic systems for electroreduction of CO_2 and N_2 are elucidated. Experimental conditions, including a choice of solvent and electrolyte, its acidity, as well as presence of certain cations and anions are of importance as well. In a case of N_2-reduction, low yields and possibility of contamination require rigorous procedures and careful analytical approaches. A promising approach to synthesize NH_3 involves lithium or calcium mediated reduction of nitrogen in organic solvents.

While some progress in the N_2-reduction catalyst development has been made, the low NH_3 production rates limit its widespread application. The nitrate anion is considered as an alternative to N_2-reduction due to its lower dissociation energy of the N=O bond, which promises much better reaction kinetics for NH_3 production. Nevertheless the trigonal nitrate(V) molecular anion is still a stable molecule, certainly electrochemically much more inert than the partially reduced nitrate(III), i.e., nitrite (NO_2^-) analogue.

To optimize the hydrogenation-type electrocatalytic approaches, nanostructured metallic centers (e.g. Pd, Pt or Ru) in a form of highly dispersed and reactive nanoparticles generated within supramolecular compounds containing distinct nitrogen, sulfur or oxygen-coordination sites are also proposed. Recent studies clearly demonstrate that coordinatively stabilized iron catalytic sites, e.g. iron-centered heme-type porphyrins or iron phosphide, FeP and Fe_2P phases, have been found to act as efficient catalysts not only for CO_2-reduction in moderately acidic media but also for the formation of NH_3 in alkaline and semi-neutral media.

Among important issues are specific interactions between coordinating centers and metallic sites. For example, the copper-based metal organic frameworks (MOFs) are of importance in this respect. Another possibility to enhance the electroreduction processes is to consider metal oxides as active matrices and co-catalysts. The hydrous behavior of such systems, which favors proton mobility and affects overall reactivity, reflects not only the oxide's specific chemical properties and morphology but influences the overall activity and selectivity.

On the challenges, pitfalls and opportunities of *in operando* analytics for electrocatalytical systems: a practical guide

Lecture delivered on **25 July 2025, 9:00** by **Dr. Sven Jovanovic,** Juelich Research Centre, Institute of Energy Technologies (IET), Germany, E-mail: s.jovanovic@fz-juelich.de

In operando methodology is often regarded as the "final step" for the characterization of electrochemical and electrocatalytic systems, as it enables the study of reactions and transformations that only occur under so-called true catalytic conditions. While such opportunities often arise, the adaptation of spectroscopy, microscopy and tomography techniques towards an *in operando* methodology brings challenges and limitations that researchers should be aware of. This lecture aims to present a general framework for the development and design of *in operando* experiments, while recognizing that each technique presents unique issues that have to be overcome.

Therefore, the implementation of *in operando* setups for the study of electrocatalytic systems will be explored by discussing a number of representative analytical techniques: i) magnetic resonance spectroscopy with a focus on NMR, ii) Raman spectroscopy, iii) electron microscopy, and iv) x-ray tomography. For each field, the lecture will elucidate the unique aspects that need to be considered, focusing on pragmatic tips and tricks. This includes application examples for several electrochemical systems, *i.e.* PEM water electrolysis, CO_2 electroreduction and lithium-ion batteries. This practical guide intends to endorse the opportunities and unique experiments enabled by the presented *in operando* studies while also addressing their limitations, and – maybe most importantly – when it may be actually better to revert to the classical *ex situ* approach.

The role of ceramic materials in electrochemical devices

Lecture delivered on **25 July 2025, 10:45** by **Dr. Alessandra Sanson,** National Research Council, ISSMC – Institute of Science, Technology and Sustainability of Ceramic Materials, Italy, E-mail: alessandra.sanson@issmc.cnr.it

A fully decarbonised society strongly relay on the development of efficient and robust materials. Ceramics plays a central role in electrocatalysis devices such as the one for power to X, conversion of CO_2 and N_2 in valuable products, electrocatalytic membranes and many more related applications. The intrinsic structural and compositional flexibility as well as the possibility to tailor morphology and microstructure, impart to this important class of materials different very important and even multifunctional properties.

The lecture will give an insight on some of these applications (photoelectrochemical devices, membranes, piezophototronic devices, solid oxide, etc) looking in details at the potentiality and drawbacks related to the use of these materials from their synthesis to the final application.

Modelling of Soft Materials: PEMs and AEMs for Energy Storage and Conversion

Lecture delivered on **25 July 2025, 13:30** by **Prof. Stephen Paddison,** University of Tennessee, Knoxville, Department of Chemical and Biomolecular Engineering, USA, E-mail: spaddison@utk.edu

The development of highly efficient energy conversion devices that utilize sustainable fuel sources with components that are thermally stable, chemically robust, and economically and environmentally feasible and sensible is an important research trust. The electrolyte in low temperature fuel cells is typically an ion containing polymer: either a proton exchange membrane (PEM) or an anion exchange membrane (AEM). Of the many properties that are critical to the effective function of a membrane as the electrolyte and separator in a fuel cell none is more important than the ionic conductivity. The hydrated morphology of either a PEM or an AEM determines many aspects that govern the transport of species (i.e., H_2O, $H^+(H_2O)$, and/or $OH^-(H_2O)$). Transport mechanisms in these soft materials are complex as they involve interactions of the cations and anions, the mobile and tethered ions with the water, and the relaxation dynamics of the polymeric backbones and side chains.

Over the past 30 years, numerous theoretical and computational studies have been undertaken with a focus of understanding ion and water transport in PEMs and AEMS. This talk will attempt to review what has been learned over the past 25 years from modelling and simulation on the connections, correlations, and relations of polymer structure and architecture to transport properties.

Synchrotron radiation experiments to shed light on electrocatalysts

Lecture delivered on **25 July 2025, 14:45** by **Prof. Chiara Maurizio,** University of Padova, Department of Physics and Astronomy, Italy, E-mail: chiara.maurizio@unipd.it

Understanding the intimate structure of complex materials such as nanostructued electrocatalysts is nowadays mandatory to design effective strategies to boost their performances. Synchrotron radiation is a powerful probe for matter, allowing us to get detailed information down to the atomic structure of materials. This lecture will introduce the basic concepts related to synchrotron radiation and will give an overview on a variety of experiments, especially tailored to understand the behavior of electrocatalysts, including in working conditions.

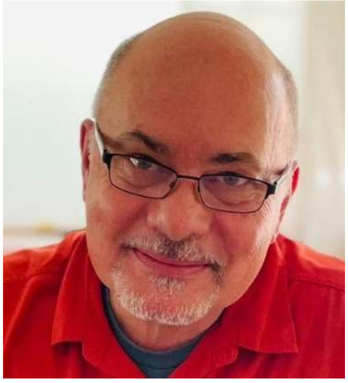
THE INSTRUCTORS OF ISECAT2025

Prof. Nicolas Alonso-Vante

College of Smart Energy, Shanghai Jiao Tong University, Shanghai 200240, People's Republic of China, E-mail: nicolas.alonso.vante@sjt.edu.cn

Nicolas Alonso-Vante is a Chair Professor at the College of Smart Energy of Shanghai Jiao Tong University (SJTU), Shanghai, China. He earned his MS (1978 -MX), Diplôme d'études Approfondies (1979-FR), PhD (1981-FR), Docteur ès Science (1984 -FR) from the University of Strasbourg-FR. He did his postdoctoral research (2 years) in Germany supported by the Alexander von Humboldt Foundation at the Hahn-Meitner-Institut-Berlin, where he stayed as senior scientist till 1997. He moved to Poitiers, France as University Professor at the University of Poitiers, where he remained till 2024. He has coauthored more than 300 journal papers. His research group in Germany and France has been devoted to photoelectrocatalytic and electrocatalytic systems on supported and not supported nanostructured transition metals (based on non-precious-, and precious-metals) electrocatalysts to investigate the oxygen reduction reaction and on the bifunctional hydrogen and oxygen reactions processes.

Prof. Plamen Atanassov



Department of Chemical & Biomolecular Engineering, University of California, Irvine, USA, E-mail: plamen.atanassov@uci.edu

Plamen Atanassov graduated *University of Sofia* (1987) with MS in Chemical Physics & Theoretical Chemistry and received PhD in Physical Chemistry from the *Bulgarian Academy of Sciences.* He moved to the US in 1992 and joined *University of New Mexico (UNM)* where he founded UNM *Center for Emerging Energy Technologies* (CEET), was Associate Dean for Research of Engineering and later served as director of UNM *Center for Micro-Engineered Materials* (CMEM). In 2018 Atanassov joined *University of California Irvine* (UCI) where he is a Chancellor's Professor *of Chemical & Biomolecular Engineering,* and *Materials Science & Engineering*. His educational efforts are directing towards creating an interdisciplinary program in *Electrochemical Science & Engineering*.

At present his research is focused on new electrocatalysts for fuel cells, electrolyzers, CO_2 electroreduction and valorization, as well as ammonia and urea electrosynthesis. He has published more than 475 peer-reviewed papers (with 43K+ citations and forming an h-index of 106). He supervised 50 doctoral dissertations and 30 postdoctoral fellows. He holds 64 issued US patents, substantial number of which have been licensed and are at the core of several catalyst products. Atanassov is on the leadership team of *Alliance for Renewable Clean Hydrogen Energy Systems* (ARCHES) – the California DOE Hydrogen Hub. Atanassov is a fellow of *National Academy of Inventors* (NAI), *The Electrochemical Society (ECS)* and the *International Society of Electrochemistry* (ISE) of which he is currently president.

Prof. Marian Chatenet

Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, France, E-mail: Marian.Chatenet@grenoble-inp.fr

Marian Chatenet holds a master in electrochemistry and an engineer degree in materials sciences (1997 - Grenoble Institute of Technology, Grenoble INP), obtained his PhD in Electrochemistry (2000, Grenoble INP), then made a post-doc at the University of Minnesota (2000-2002). He was appointed associate professor in electrochemistry (2002), then professor in Grenoble INP/Phelma (2011). He studies electrocatalysis of complex reactions and electrocatalysts' activity/durability in fuel cells/water electrolyzers within the laboratory of electrochemistry and physical-chemistry of materials and interfaces (LEPMI). Best young scientist in Electrochemistry (French Chemical Society, 2009), he received the Oronzio and Niccolò De Nora Foundation Prize of the International Society of Electrochemistry on Applied Electrochemistry (ISE, 2010). He has published 200+ papers in scientific journals, given 250+ communications in (inter)national conferences (ca. 60 invited/keynotes/plenary), 55+ invited seminars and filed 9 patents (*h-index* = 60, 11500+ citations – Scopus, January 2025).

After having led the team of Interfacial electrochemistry and processes (EIP) of LEPMI for 10 years, he initiated a joint laboratory between LEPMI and Michelin and has built multiple collaborations with industrial partners and laboratories in France and abroad. Co-head of the mobility axis of the "French Research Network on Hydrogen" (FRH_2, research federation n°2044 from CNRS), he leads PEMFC95, a research program on PEMFC for heavy-mobility applications within the ANR-sponsored PEPR-H2 (10 partners, ca. 9 M€ funding, ANR-22-PEHY-0005).

Prof. Lior Elbaz

Bar-Ilan University, Israel, E-mail: lior.elbaz@biu.ac.il

Lior Elbaz is Full Professor for Electrocatalysis and Sustainable Energy in the Department of Chemistry, Bar-Ilan University, Israel. He is the head of the Israeli Fuel Cells Consortium (IFCC), composed of 17 leading Israeli labs, the Israeli representative to the International Energy Agency's Advanced Fuel Cells Executive Committee, a member of the Israeli Presidential Climate Forum, and was recently appointed as the director of the hydrogen technologies center (H2Tech) in the framework of the National Institute for Sustainable Energy (NISE). He is the co-

Founder of two Israeli start-up companies, developing reversible fuel cells and fuel cells for stationary power supply. Lior has been involved in the development of advanced catalysts for hydrogen technologies for the past 22 years, focusing on platinum group metal-free catalysts. He developed methodologies for synthesis of 3D covalent aerogel frameworks of catalysts, reaching ultra-high electrochemically active site densities, which allow overcoming some key challenges relating to this family of catalysts. He has also designed and utilized high surface area ceramic catalysts' supports for increased system durability, and advanced electrochemical methods to allow in situ study of catalyst degradation and to decipher complex reactions in electrochemical devices.

Dr. Sven Jovanovic

Juelich Research Centre, Institute of Energy Technologies (IET), Germany, E-mail: s.jovanovic@fz-juelich.de

Dr. rer. nat. Sven Jovanovic is a designated group leader for NMR and Raman spectroscopy in the Spectroscopy department of the Institute of Energy Technologies – Fundamental Electrochemistry (IET-1) inside the Research Center Jülich. He received his Bachelor's and Master's degree in chemistry from the RWTH Aachen University. His PhD was conducted at the IET-1 and involved Raman as well as *in operando* NMR studies of the catalytic CO_2 electroreduction.

In his postdoctoral studies, Sven Jovanovic intensified his research focus on the application of NMR and Raman techniques on electrochemical systems by collaborating in national and international projects, often joined by industry. These include the systematic design and method development of *in operando* NMR studies for CO_2 electroreduction and PEM water electrolysis [1,2], solid-state and pulsed-field-gradient NMR for the education of transport and degradation mechanisms in battery electrolytes, ionomers and redox active organic materials [3], and cell & method development for *in operando* Raman studies of battery components and electrocatalysts [4, 5]. Currently, Sven Jovanovic is supporting Prof. Vito di Noto in the coordination of the DURALYS project on next generation anion exchange membrane water electrolyzers.

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Prof. Pawel Kulesza

Faculty of Chemistry, University of Warsaw, Poland, E-mail: pkulesza@chem.uw.edu.pl

Pawel J. Kulesza is a distinguished professor at University of Warsaw, Poland. He obtained his M.Sc. from University of Warsaw, Ph.D. from Southern Illinois University (USA), and he held postdoctoral research associate positions and, later, visiting professorships at University of Illinois (with Larry R. Faulkner), Fritz-Haber Institut der Max-Planck-Gesellschaft (with Karl Doblhofer and Gerhard Ertl - 2007 Noble Prize Laureate), EPFL -Swiss Federal University of Technology (with Michael Graetzel), and University of North Carolina (with Royce W. Murray). He also served as Dean of Faculty of Chemistry, University of Warsaw. He is a full member of Polish Academy of Sciences and, currently, functions in its Presidium. He was Associate Editor of *Electrochimica Acta* (Elsevier) for many years (2010-2024) and, presently, he is a member of Editorial Boards of *Journal of Solid State Electrochemistry*, *Russian Journal of Electrochemistry Electrocatalysis* (Springer), and *Catalysts* (MDPI). He is a Fellow of The Electrochemical Society (USA) where he has also served as Chair of Physical Analytical Electrochemistry Division and Chair of European Section. He received A. Volta Award from The Society in 2024. He was a National Representative of Poland to Inorganic Chemistry Division of International Union of Pure and Applied Chemistry.

Pawel J. Kulesza has significantly contributed to fundamental studies of importance to the technology of low temperature fuel cells (reduction of oxygen, oxidation of simple organic fuels). His research has led to better understanding of the role of the metal oxide nanostructured additivities that affect the catalytic performance of noble metal nanoparticles with respect to adsorption, desorption and catalytic steps during oxidation of simple organic fuels. He demonstrated and emphasized the importance of interactions with the metal oxide support and emphasized its chemical state and activity toward removal of undesirable hydrogen peroxide intermediate during the oxygen reduction reaction. His research has also led to the development of new electroanalytical methodology and to advances in diagnostic measurements based on ultramicroelectrodes. More recently, his attention has centered on the development of hybrid materials for electrochemical energy conversion with special emphasis on electrocatalysis and photoelectrochemistry (solar energy conversion, water splitting, CO_2-reduction, N_2-fixation, and generation of fuels). He has published more than 300 refereed papers in journals of international circulation.

Prof. Chiara Maurizio

University of Padova, Department of Physics and Astronomy, Italy, E-mail: chiara.maurizio@unipd.it

Associate professor in Physics of Matter at the Physics and Astronomy Department, UNIPD, since 2017. Researcher at UNIPD (2010-17) and CNR at the European Synchrotron-ESRF (2002-10). PhD in Physics in 2002 (UNIPD). The experimental research activity is on the nucleation and growth of multielement nanostructures for catalytic and optical properties relating their atomic structure with the macroscopic and technologically relevant properties, especially through synchrotron radiation-based experiments. Author of >100 papers in international peer-review journals, presented in several international congresses and in invited presentations. Some of the results have been awarded. Part of the research has been funded by projects, of which the most recent ones are funded by PNRR. H-index: 30 (Google Scholar). ASN (I fascia, PHYS-03/A), valid until 7/2029. Member of the Senato Accademico (UNIPD) since Oct 2019.

Dr. Fabrice Micoud

Commissariat à l'énergie atomique et aux énergies alternatives, Département de l'Electricité et de l'Hydrogène pour les Transports, France, E-mail: fabrice.micoud@cea.fr

Fabrice MICOUD is a research engineer and expert on PEMFCs at CEA LITEN. He holds a PhD in electrochemistry and has been working on the development of PEMFC and PEMWE technologies for 15 years at CEA LITEN. His work focuses on the electrochemical characterization of PEMFCs at all scales, from raw materials for electrocatalysis to the single-cell PEMFC configuration and up to the stack, in order to link the properties of the membrane-electrode assembly (MEA) with its electrochemical performance and durability. He was awarded the "Young Scientist Award" for the "Transport Pillar" by Hydrogen Europe Research in 2019 for his involvement as coordinator, WP leader, and/or his scientific contributions to several European projects. He is co-author of more than 20 publications and 9 patents related to the electrochemical characterization of PEMFC components and the optimization of PEMFC stack operation and systems.

Prof. Stephen Paddison

University of Tennessee, Knoxville, Department of Chemical and Biomolecular Engineering, USA, E-mail: spaddison@utk.edu

Stephen J. Paddison received a BSc (Honours) in Chemical Physics and a PhD (1996) in Physical/Theoretical Chemistry from the University of Calgary, Canada. He was, subsequently, a postdoctoral fellow and staff member in the Materials Science Division at Los Alamos National Laboratory where he undertook both experimental and theoretical investigations of sulfonic acid based polymer electrolyte membranes. This work was continued while he was part of Motorola's Computational Materials Group in Los Alamos, New Mexico.

He joined the Department of Chemical and Biomolecular Engineering at the University of Tennessee in August of 2007. He was a Visiting Fellow of Fitzwilliam College at the University of Cambridge, UK in 2003 and 2015; a guest scientist at the Max Planck Institute for Solid State Research in Stuttgart in 2004; and a Visiting Scientist at the University of Padova, Italy in 2013, 2015, and 2017.

Dr. Alessandra Sanson

National Research Council, ISSMC – Institute of Science, Technology and Sustainability of Ceramic Materials, Italy, E-mail: alessandra.sanson@issmc.cnr.it

Alessandra Sanson gained her master degree in Industrial Chemistry at University of Padua and her PhD in materials science at Cranfield University (UK) in 2003. She then joined the Institute of Science and technology for Ceramics (ISTEC) (now Institute of Science, Technology and Sustainability of Ceramics, ISSMC) in 2004, where since 2008 she is leader of the Group of Materials and Processing for Energetics in charge of regional, national and european projects related to the energy production and storage. In 2021 she became director of the Institute. Her main activities concern the development of materials and devices for energy applications such as Solid Oxide Cell, solid state batteries and supercapacitors, solar conversion devices (photovoltaics and photoelectrochemical cells). She is co-authors of more than 130 international peer-reviewed papers, three book chapters and inventor of two patents. She had projects with several energy-related companies such as Edison, ENI, FIAMM. From 2011 to 2017 she was CNR representative in the EERA Joint Program "Energy Storage". Since 2016 she is Italian Focal Point in Mission Innovation for the challenge "Conversion of sunlight to fuels and other forms of chemical energy storage". She is supervisor of MSc as well as PhD students of Parma, Bologna and Padua. She contributed to the definition of the Smart Specialization Strategy of the Emilia Romagna Region regarding energy. Since 2018 she is member of the Coordination and "Innovation Research and Development" Groups in the Chemistry Observatory of the Ravenna Province for the re-qualification of the chemistry industrial hub. Since April 2023 she is member of the Permanent Scientific Operational Structure of the Italian Chemical Society and CNR representative in the technical groups of the Italian National Cluster "Fabbrica Intelligente". She is She is member of the NAO-Italy for IUPAC and Associate member of the Division II of the Union.

Prof. Peter Strasser

Department of Chemistry, Technical University Berlin, Berlin, Germany, E-mail: pstrasser@tu-berlin.de

Peter Strasser is a chaired professor of Electrochemistry in the Department of Chemistry at the Technical University Berlin. Prior to this, he served as Assistant Professor in the Department of Chemical and Biomolecular Engineering at the University of Houston. Before moving to Houston, he worked at Symyx Technologies as a postdoctoral associate and Senior Staff Scientist. He studied Chemistry at Tübingen University, Stanford University and the University of Pisa and received his PhD in Physical Electrochemistry under Gerhard Ertl at the Fritz-Haber-Institute of the Max-Planck-Society in Berlin. Electrocatalysis is a central theme in his career. His interests have been ranging from electrocatalytic oscillations to high throughput catalyst discovery to fundamental understanding of electrified catalytic interfaces for clean energy and decarbonization technologies.

Recognitions of his work include the 2023 ECS Carl Wagner Memorial Award, 2022 *F-cell award*, the EFCF *Christian Schönbein Gold Medal award*, the RSC *Faraday Medal,* the ISE *Brian Conway Prize*, the IAHE *Sir William Grove award*, the *Otto-Roelen medal in Catalysis* from the German Catalysis Society, and the *Otto-Hahn Medal* from the Max-Planck Society. He is Fellow of the International Society of Electrochemistry (ISE) and a Fellow of the Electrochemical Society (ECS). He is member of the European Science Academy, Academia Europaea.

Together with his team, Peter has authored more than 400 Journal publications and edited the book *High-Throughput Screening in Chemical Catalysis*. He is a named inventor on more than 20 issued U.S. and European patents. He has mentored spin-off companies such as "DexLeChem" and more recently "Liquid Loop" that commercialized technology from his labs.

Prof. Piotr Zelenay

Los Alamos National Laboratory, Los Alamos, NM 87544, USA, E-mail: zelenay@lanl.gov

Dr. Piotr Zelenay, Professor of Chemistry, received his Ph.D. and D.Sc. ("habilitation") degrees in Chemistry from the University of Warsaw, Warsaw, Poland. He was a faculty member in the Department of Chemistry, the University of Warsaw until 1997, when he accepted research position at Los Alamos National Laboratory (LANL). He has been associated with LANL for the past 28 years. He is currently one of ca. 15 highest-level scientists at LANL, a laboratory of more than 16,000 employees, and in the top 25 most cited Los Alamos researchers of all time listed on Google Scholar. His research focuses on electrocatalysis of oxygen reduction reaction, methanol, and dimethyl ether oxidation in polymer electrolyte fuel cells, hydrogen and oxygen evolution reactions in water electrolyzers, and electrochemical reduction of CO_2 to value-added products. Dr. Zelenay has received numerous awards and recognitions, most recently Lifetime Achievement Award from the United States Department of Energy (US DOE) in 2024 and Outstanding Researcher Award from International Association for Green Energy (IAGE) in 2022 for “outstanding research and advancement of knowledge in fuel cells, electrochemical energy, and green energy systems”. He is a fellow of Los Alamos National Laboratory, The Electrochemical Society, and International Society of Electrochemistry.

LIST OF THE POSTERS

P-01

Pt nanoparticle electrocatalysts manufactured by magnetron sputtering for HER under AEM conditions

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P-02

Photoelectrocatalysis of water-splitting: mechanisms, catalysts and challenges

Amaro Ferreira Miguel

P-03

Exploring Crystalline (Ni_xFe_xO) for Efficient Oxygen Evolution Reaction in AEM Water Electrolysis

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ABSTRACTS OF THE POSTERS

P01 – Pt nanoparticle electrocatalysts manufactured by magnetron sputtering for HER under AEM conditions

Alba Alonso[1*], Villamayor Antía [1], Mendizabal Lucia[1] and Gutiérrez Eva G.[1]

[1] TEKNIKER, Basque Research and Technology Alliance (BRTA), Parke Teknologikoa, Calle Iñaki Goenaga 5, 20600, Éibar (Guipúzcoa), Spain
[*]email: alonso.alba@tekniker.es

The future of ‘green’ hydrogen production lies in the further development of low-temperature Anion Exchange Membrane water electrolysis technology [1]. Catalysts, essential to facilitate semireactions, are often manufactured by chemical methods that involve high energy consumption and generation of undesirable by-products. This work proposes an alternative technique, magnetron sputtering, with the advantage of being a one-step automated industrial process [2]. Pt nanoparticle electrodes are developed for the Hydrogen Evolution Reaction (HER).

The magnetron sputtering process is carried out in a gas aggregation chamber where the Pt target is located. This chamber is connected to an industrial vacuum chamber where the multiporous layer carbon paper that will serve as electrode support is located. The same process is repeated for different times (2.5, 5, 10 and 15 minutes) to obtain different samples. Field Emission Scanning Electron Microscope (FESEM), X-ray Photoelectron Spectroscopy (XPS) and Inductively Coupled Plasma (ICP) are used for morphological, surface chemical species and Pt loading analysis, respectively. Different electrochemical measurements are carried out in a three-electrode cell configuration, at room temperature and in a 1M KOH alkaline solution.

Nanoparticle layers are observed, with a proportional relationship between processing time and layer thickness. XPS shows poorer coating performance in shorter processes. The ICP measurements reflect loadings of 0.003, 0.007, 0.014 and 0.018 mg/cm^2 for the samples from the shortest to the longest process time. From the Cyclic Voltammetries (CVs) in Ar-saturated atmosphere the characteristic peaks of Pt are obtained, and electrochemical active surface areas (ECSA) of 33.08, 27.36, 16.55, 25.83 and 6.21 m^2/g are measured for the 2.5, 5, 10, 15 min samples and a 0.300 mg/cm^2 Pt/C commercial sample, respectively (Figure 1a), showing an ECSA on average 4 times more active in the sputtering samples compared to the commercial one. The catalytic activity is measured by Linear Sweep Voltammetries (LSVs) in H2-saturated atmosphere reaching overpotentials at -10 mA/cm^2 of 198, 151, 113, 65 and 35 mV for the 2.5, 5, 10, 15 min and commercial samples (Figure 1b), but with the latter having almost seventeen times more Pt loading. When normalising with the area with respect to the area of a theoretical monolayer of Pt values, it is observed that commercial sample shows a worse performance (Figure 1c). The Tafel slopes show that in all cases the reactions occur by the same mechanism, the Potentio Electrochemical Impedance Spectroscopy (PEIS) exhibits electrical behaviour consistent with the rest of the results seen and the durability tests reflect a good stability of the catalytic activity and the quality of the coatings.

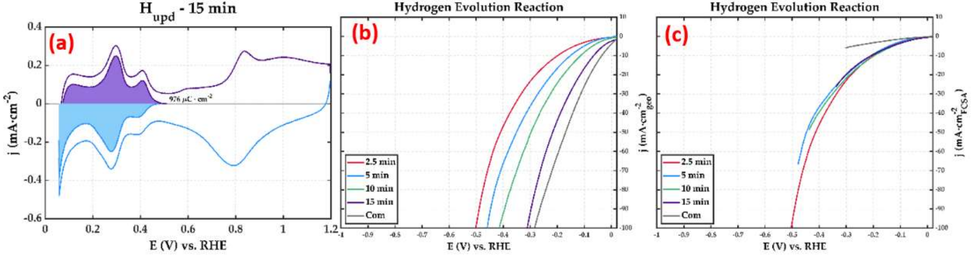

Fig. 1. (a) Example of a CV at 50 mV/s with the integrated charge to obtain the ECSA (b) LSVs normalised by geometrical area (c) LSVs normalised by active area

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P02 – Photoelectrocatalysis of water-splitting: mechanisms, catalysts and challenges

Amaro Ferreira Miguel

DISAT, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129 Torino TO, Italy
**email: miguel.amaro.ferreira@gmail.com*

Photoelectrocatalysis of water-splitting offers a promising pathway for sustainable hydrogen production using solar energy.[1] Among the various photoanode materials studied, $BiVO_4$, WO_3, and Fe_2O_3 have emerged as leading candidates due to their suitable band gaps, earth-abundance, and photostability. [2] $BiVO_4$ exhibits high visible light absorption and favourable band alignment but suffers from poor charge transport and surface recombination.[3] WO_3 demonstrates excellent charge mobility and stability in acidic media, though its narrow light absorption range limits efficiency, while Fe_2O_3 is cost-effective and stable yet constrained by slow charge kinetics and short hole diffusion lengths.[4] Mechanistically, these oxides facilitate the oxygen evolution reaction (OER), water-splitting's bottleneck, through surface-adsorbed intermediates, where surface states and charge carrier dynamics play critical roles.[5] To enhance the performance of these semiconductors, strategies such as doping, heterojunction formation, and surface co-catalyst integration have been widely implemented.[6] However, despite progress, challenges remain in overcoming intrinsic material limitations and achieving scalable, unbiased and efficient systems for practical solar water splitting applications.[7]

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P03 – Exploring Crystalline (Ni_xFe_xO) for Efficient Oxygen Evolution Reaction in AEM Water Electrolysis

Atta Muhammad[1], Rodriguez Tatiana[1], Nisticò Roberto[1], Di Fonzo Fabio[2], Santoro Carlo[1]

[1] *Electrocatalysis and Bioelectrocatalysis Laboratory, Department of Materials Science, University of Milano-Bicocca, Building U5 Via Cozzi 55, 20125 Milan, Italy.*
[2] *X-nano s.r.L Via Rubattino 81, 20134 Milan, Italy*
**email: carlo.santoro@unimib.it*

Although anion exchange membrane water electrolyzers (AEMWEs) offer various advantages, their large-scale commercial adoption remains restricted, due to the slow and complex oxygen evolution reaction (OER) at the anode, which involves multi-electron transfer and high kinetic barriers. This challenge is commonly addressed using PGM based catalysts; however, their scarcity and excessive cost significantly hinder the practical scalability of AEMWE technology. In this work we present a scalable and economical, homogeneous precipitation method to synthesize nanostructured NiFe oxides crystallite with different Ni/Fe ratios, thus reducing the dependence on expensive and scarce noble metal-based electrocatalysts. The effect of Ni/Fe ratios in the synthesized (Ni_xFe_xO), along with morphological and surface chemical characteristics, on catalytic performance was thoroughly investigated with half-cell measurements using the rotating disk electrode (RDE) technique. Furthermore, critical electrode design factors, such as ink composition, choice of additives, and catalyst loading on the rotating disk electrode (RDE) were scientifically investigated and optimized. Among the explored compositions, amorphous $Ni_{0.28}Fe_{0.72}Ox$ and crystalline $Ni_{0.39}Fe_{0.61}Ox$ exhibited superior OER activity, achieving low overpotentials of 354 mV and 359.5 mV at 10 mA cm^{-2}, respectively. This superior activity was attributed to a higher concentration of Ni^{3+} (NiOOH), a highly active species for the OER. These high-performing materials have been selected for integration as anode electrodes in a lab-scale AEMWE configuration, laying the groundwork for future device-level testing and long-term stability assessment.

Keywords: AEM-WE; NiFe oxide; Alkaline media; RDE; OER; PGM-free electrocatalysts.

P04 – Dry Plasma Synthesis of Nanohybrids and Nanofluids for Water Electrolysis: Toward CRM-Free, Green and Efficient Catalytic Materials

Chandraiahgari Chandrakanth Reddy[1*], Gottardi Gloria[1], Dalessandro Domenico[1], Speranza Giorgio[2], Muzzi Beatrice[3], Pedrielli Andrea[2], Micheli Victor[1], and Testi Matteo[1]

[1] Center for Sustainable Energy, Fondazione Bruno Kessler (FBK), Trento, 38123, Italy
[2] Center for Sensors and Devices, Fondazione Bruno Kessler (FBK), Trento, 38123, Italy
[3] ICCOM, National Research Council (CNR), Sesto Fiorentino, Florence, 50019, Italy.
**email: cchandraiahgari@fbk.eu*

This work presents a dry and green synthesis approach using RF magnetron sputtering, a physical vapor deposition (PVD) technique, to develop nanohybrids (catalyst-coated powders) and nanofluids (nanoparticles suspended in liquids) catalysts for water electrolysis.[1,2] The method eliminates hazardous chemicals and multi-step processes, enabling sustainable and scalable catalyst production. For nanohybrids, copper-coated multi-walled carbon nanotubes (Cu/CNTs) are synthesized by O_2 plasma treatment of CNTs followed by RF sputtering of Cu.[1] A vibrating deposition stage ensured uniform nanoparticle coating. XPS confirmed enhanced surface functionality, while dynamic light scattering (DLS) and thermogravimetric analysis (TGA) revealed improved dispersion and material loading. Finally, the produced nanohybrids exhibited hydrogen evolution reaction (HER) activity. For nanofluids, gold nanoparticles (AuNPs) were sputtered directly into polyethylene glycol (PEG) and transferred into a Nafion ionomer to fabricate a catalyst-coated membrane (CCM).[2] Characterization using UV-VIS, TEM, SEM, XPS, and AFM confirmed the preservation of nanoscale morphology and uniform dispersion. The resulting CCM exhibited excellent HER activity, with an onset potential of 50 mV and a Tafel slope of 38 mV/dec. This work demonstrates RF magnetron sputtering as a clean, scalable, dry synthesis technique for producing CRM-free, high-efficiency catalysts for sustainable hydrogen production through water electrolysis.

Acknowledgments

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P05 – Copper-intercalated-tungsten-oxide-cocatalytic-additive for oxygen reduction at low-Pt-content systems

Chmielnicka Anna[1*], Kostuch Aldona[1], Negro Enrico[2], Pagot Gioelle[2], Di Noto Vito[2],
Rutkowska Iwona[1], Kulesza Paweł[1]

[1] *Faculty of Chemstry, University of Warsaw, Pasteura 1, 02-093 Warsaw, Poland*
[2] *Department of Industrial Engineering, Universit`a degli Studi di Padova in Department of Chemical Sciences, Via Marzolo 1, Padova, (PD) 35131, Italy*
[*]*email: achmielnicka@chem.uw.edu.pl*

Among important strategies is the hybridization, activation, and stabilization of carbon-supported Pt catalysts (for oxygen reduction) through admixing with certain nanostructured and typically substoichiometric metal oxides. Special attention is paid to such features as porosity, hydrophilicity, and degree of graphitization of carbon components, in addition to the existence of metal–support interactions, high electrochemical active surface area, electronic structure of interfacial Pt, and the feasibility of adsorptive or activating interactions with oxygen molecules. Hybrid supports, which utilize metal oxides have been demonstrated to stabilize Pt and carbon nanostructures and diminish their corrosion while exhibiting high activity toward the four-electron (most efficient) reduction of oxygen. In the present work, we explore and demonstrate usefulness of copper-intercalated hexagonal tungsten oxide as cocatalyst or additive to the Vulcan supported Pt and PtCu nanoparticles. Based on XPS measurements, specific interactions between Pt and hybrid metal oxide centers can be postulated.

P06 – Ni-Doping Strategies for Composite Fuel Electrodes of Solid Oxide Fuel Cells

Cornale Michela*, Panunzi Anna Paola, Duranti Leonardo, Di Bartolomeo Elisabetta

Department of Chemical Science and Technologies, University of Rome Tor Vergata, Via della Ricerca Scientifica, 00133, Rome, Italy
**email: michela.cornale@uniroma2.it*

Solid oxide fuel cells (SOFCs) are a well-established technology for energy storage and conversion. Operating at elevated temperatures (>650°C), SOFCs benefit from enhanced reaction kinetics and reduced activation losses. The current state-of-the-art fuel electrode materials are cermets based on nickel and yttria-stabilized zirconia (Ni-YSZ). However, these materials are prone to degradation due to coking, as well as nickel coarsening and agglomeration, particularly in carbon-rich environments. According to the literature, the primary strategy to mitigate these issues involves replacing Ni-YSZ cermets with nickel-doped fluorite and/or perovskite-structured materials as alternative fuel electrodes [1].

This study investigates two composite fuel electrodes. The first comprises an A-site deficient perovskite, $La_{0.40}Ca_{0.40}TiO_3$ (LCT), combined with Ni-doped gadolinium-doped ceria (NiGDC), a fluorite-structured material. The second consists of a Ni-doped perovskite titanate, $La_{0.4}Ca_{0.4}Ti_{0.95}Ni_{0.05}O_3$ (LCTN), also combined with GDC. Among perovskite oxides, titanates are favored due to their structural stability in reducing atmospheres [2]. Additionally, A-site deficiency facilitates the formation of oxygen vacancies, thereby enhancing ionic conductivity. Moreover, Ni doping improves electrocatalytic performance through the exsolution phenomenon [3].

An innovative synthetic approach is developed for LCT and LCTN, enabling a substantial reduction in the calcination temperature to 700°C, a significant decrease from the 1400°C typically reported in the literature [4]. This temperature reduction results in an increase in the surface area, thereby enhancing the electrochemical performance of the titanates. GDC is synthesized via a co-precipitation method and fluorite phase is being obtained prior to the calcination step. The crystalline structure of the as-synthesized powders is analyzed using X-ray Diffraction (XRD) analyses and the specific surface area is determined by N_2 adsorption/desorption. The structural stability under reduction conditions is also assessed. The Area Specific Resistance (ASR) of LCT and LCTN is measured under reducing conditions using symmetrical cells, with YSZ pellets serving as electrolytes. Morphological characterization of the powders and cells is performed using a field emission scanning electron microscope (FE-SEM).

Cell tests in hydrogen are conducted using the following composite fuel electrodes: LCT-NiGDC and LCTN-GDC, with $La_{0.4}Sr_{0.6}Fe_{0.8}Co_{0.2}O_3$+GDC used as the conventional air electrode. A comparative analysis of cell performance is then presented, with a focus on the effects of Ni doping.

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P07 – Cerium transport and its effect on PEM fuel cell performance

Cultrera Livio*, Verducci Francesco, Colombo Elena, Baricci Andrea, Casalegno Andrea

MRT Fuel Cell & Battery LAB, Department of Energy, Politecnico di Milano, via Lambruschini 8, 20156, Milan, Italy
email: livio.cultrera@polimi.it

To mitigate membrane degradation in Polymer Electrolyte Membrane Fuel Cells (PEMFCs), cerium-based radical scavengers are used to neutralize free radicals responsible for ionomer decomposition [1]. However, cerium mobility and its interactions with the PFSA backbone compromise both fuel cell performance and scavenging effectiveness [1,2]. A combined experimental and modelling study was conducted to better understand cerium transport, identifying heterogeneous cation concentration, ionic potential and water content as key drivers of cation redistribution. Data from literature [3–5] and tailored experiments were used to quantify cerium mobility under various operating conditions and to develop a model framework able to simulate radical scavenger redistribution during real PEMFC operation. Results revealed also the negative impact of cerium ions on proton conductivity and oxygen mass transport properties, especially at low relative humidities. Future studies will focus on evaluating the role of cations on electrochemical surface area (ECSA) loss under different electrode potentials and operating conditions.

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P08 – Development of Porous Transport Electrode (PTE) for Low Temperature Electrolysis

Faiz Uzma, Testi Matteo, Ercolano Giorgio

Department of Industrial Innovation, University of Trento, FBK, Trento, Italy
**email: ufaiz@fbk.eu*

The transition to sustainable hydrogen production requires the development of efficient and durable electrode materials for proton exchange membrane Water electrolysis (PEMWE). My proposed PhD research aims to engineer Titanium dioxide (TiO_2) nanotube arrays (TNAs) as advanced catalyst supports For PEMWE anodes. The approach will focus on tailoring the structural and surface properties of TNAs, such as tube length, pore morphology, and wettability, to enhance iridium catalyst dispersion and facilitate gas bubble formation and release. A series of controlled electrochemical synthesis and post-treatment strategies will be employed to optimize the nanotube architecture for high conductivity, mechanical stability, and acid resistance. The project is guided according to recent literature and aligned with industrial standards for PEM electrolyzer durability and performance. This research is expected to contribute to the scalable fabrication of high-efficiency porous transport electrodes and support the broader goal of accelerating green hydrogen technologies. The poster presents the research motivation, proposed methodology, and anticipated impact.

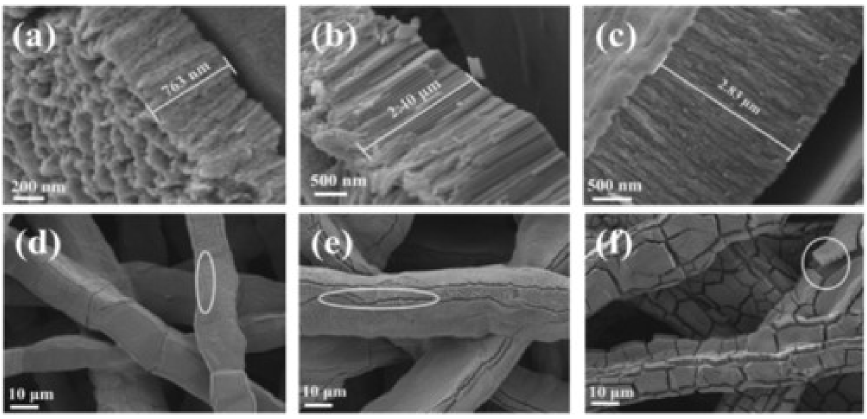

Figure 1. SEM images of cross section and surface morphology of TiO_2 prepared at 20V (a and d), 40V (b and e), 60V (c and f) for 30 minutes.
(Adapted from Lv et al., Int. J. Hydrogen Energy, 2024 [1]).

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P09 – Anode catalyst layer composition in PEM water electrolysis: An in-depth electrochemical analysis

Froehlich Kristina[1]*, Liu Jialiang[1,2], Hilche Tobias[1], Bartoli Francesco[1], Karl André[1], Jodat Eva[1],
Eichel Rüdiger-Albert [1,2,3]

[1] Institute of Energy Technologies, Fundamental Electrochemistry (IET-1), Forschungszentrum Jülich, D-52428, Jülich, Germany
[2] Institute of Physical Chemistry, RWTH Aachen University, D-52074, Aachen, Germany
[3] Faculty of Mechanical Engineering, RWTH Aachen University, D-52062, Aachen, Germany
**email: k.froehlich@fz-juelich.de*

Proton exchange membrane (PEM) water electrolysis is a technology for large-scale hydrogen production.[1,2] The oxygen evolution reaction (OER) at the membrane electrode assembly (MEA) is the rate determining step dominating the overall cell performance. The choice of the OER catalyst and deposition procedure significantly affect the reaction kinetics, chemical stability and electronic conductivity.[3] To maintain a high and long-term consistent cell performance, manufacturing and performance control of the MEA is indispensable.

Electrochemical analysis is a powerful tool for MEA evaluation providing information about catalytic activity, kinetics and electrochemically active surface area (ECSA). In addition, scanning electrochemical microscopy and eddy current measurements give insights into the micro- and macroscopic homogeneity of catalyst layers and MEAs.[4,5]

In this study, we clarify the significance of electronic conductivity focusing on Ir-based anodes of customized MEAs. The effect of catalyst material and loading on the in-plane MEA resistance, OER performance and ECSA was investigated.

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P10 – Investigation of the Cathode–Electrolyte Interface in Spent Symmetrical SOCs Devices

Ippolito Marta[1*], Tedesco Costanza[1], Vecino-Mantilla Sebastian[2], Matos de Oliveira Fabiana[2], Lo Faro Massimiliano[2], Giannici Francesco[1]

[1] DIFC, UNIPA, Viale delle Scienze Ed.17, 90128-Palermo, Italy;
[2] ITAE, CNR, Via Salita S. Lucia sopra Contesse 5, 98126-Messina, Italy
**email: marta.ippolito01@unipa.it*

The energy transition towards sustainable and clean energy sources is a critical global challenge. Intermediate Temperature Solid Oxide Cells (IT-SOCs) in electrolysis or fuel cell mode are promising technologies for high energy conversion efficiency, fuel flexibility and environmental friendliness. The long-term chemical and crystallographic stability of the electrode/electrolyte interface remains a major limitation. In this work, we investigate the solid-solid processes at the cathode-electrolyte interface in symmetrical spent cells employing $Ce_{0.9}Gd_{0.1}O_2$ (CGO) as the electrolyte and $SrFeO_3$ perovskite doped with different amounts of Ba, Ca and Mo as the cathode. Micro-XRF and micro-XANES techniques were employed post-mortem to spatially resolve elemental distributions and oxidation state changes across the cathode/electrolyte interface[1,2]. By correlating spectroscopic evidence with interfacial chemistry and microstructure, this study provides new insights into degradation mechanisms in realistic electrochemical environments. This approach proves to be a powerful diagnostic tool for post-operando SOC analysis and highlights critical aspects for the rational design of stable and high-performing electrode materials in solid-state energy systems employing green fuels [1,2].

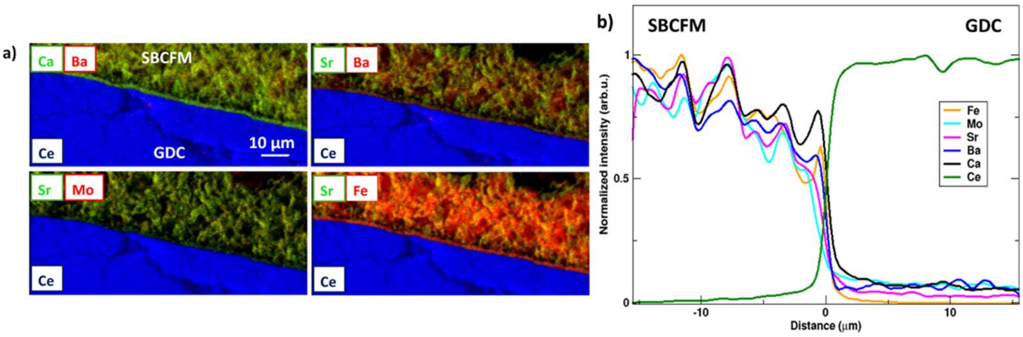

Fig. 1. *a) Concentration map from micro-XRF analysis at the Fe K-edge, showing the different quantified cation. b) Concentration profiles (arb. u.) of Ba, Ca, Ce, Fe, Mo at the interface between electrode-electrolyte.*

Acknowledgement
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P11 – Unraveling Degradation Phenomena within Proton Exchange Membrane Electrolytic Cells through Modeling

Karyofylli Violeta[1*], Raman K. Ashoke[1], Hammacher Linus[1,2], Kungl Hans[1], Jodat Eva[1], Karl André[1], Eichel Rüdiger-Albert[1,2,3]

[1] Institute of Energy Technologies, Fundamental Electrochemistry (IET-1), Forschungszentrum Jülich GmbH, 52425, Jülich, Germany
[2] Institute of Physical Chemistry, RWTH Aachen University, 52062, Aachen, Germany
[3] Faculty of Mechanical Engineering, RWTH Aachen University, 52062, Aachen, Germany
Department, Institution, Street and number, Postal Code, City, Country
**email: v.karyofylli@fz-juelich.de*

Proton exchange membrane (PEM) electrolytic cells (ECs) have gained significant attention in the realm of hydrogen production. With the increasing demand for commercializing PEMECs, there is a pressing need for enhancing their performance and durability. In addition to experiments, macro-scale modeling plays a pivotal role in comprehending the multi-physics processes within PEMECs.

This poster aims to highlight the implementation of physics-based[1] and data-driven models[2] tailored for PEMECs. They serve as the basis for further investigating degradation phenomena within PEMECs[3], aiming to prolong their lifespan and improve their efficiency for a quick technology ramp up. These models explore the electrochemical processes and transport phenomena occurring within the porous transport layers (PTLs), catalyst layers (CLs), and the PEM. The high-aspect-ratio PEMECs are well-suited for one-dimensional (1D) analysis[4,5]. The 1D analysis is implemented in Python, with COMSOL also utilized for 2D and 3D simulations.

Acknowledgment

Financial support was provided by the German Federal Ministry of Education and Research (BMBF) within the H2Giga project DERIEL (grant number 03HY122C).

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P12 – Mechanistic Insights into NiFe Nanoparticle Formation for AEM Fuel Cells

Levy Niv*, Zitoun David

Department of chemistry, Bar-Ilan University, Anna Max Webb St., 5290002, Ramat-Gan, Israel
*email: levy.niv@biu.ac.il

In a previous work we have presentd a platinum-group-metal-free catalyst based on NiFe nanoparticles synthesized from bis(cyclooctadiene)nickel(0) which is a common precuser for Ni based nanoparticles[1,2] and iron pentacarbonyl.

These nanoparticles have been successfully integrated and operated in Anion-exchange membrane fuel cells, exhibiting effective hydrogen oxidation reaction (HOR) activity under alkaline conditions. Despite this functional validation, the mechanistic pathway underlying nanoparticle formation remains poorly understood. Preliminary evidence suggests that CO released from $Fe(CO)_5$ modulates the reactivity of the Ni precursor, yet the nature and dynamics of the resulting intermediates are unresolved.

In this work, we apply a comprehensive analytical strategy—NMR, IR spectroscopy, XRD, and TEM—to elucidate the formation mechanism and correlate structural evolution with catalytic performance. These insights aim to guide the rational design of PGM-free HOR catalysts for next-generation, low-cost fuel cell technologies.

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P13 – Comparative study of various metal oxides for the Electrochemical Reduction of Nitrate to Ammonia (NO_3^-RR)

Lombardi Simone[1*], Rodriguez-Flores Tatiana[1], Nisticò Roberto[1], Viscardi Rosanna[2], Muhyuddin Mohsin[1], Santoro Carlo[1]

[1] *Electrocatalysis and Bioelectrocatalysis Laboratory, Department of Materials Science, University of Milano-Bicocca, Via Roberto Cozzi 55, 20125 Milan, Italy*
[2] *ENEA Casaccia Research Center, Via Anguillarese 301, Rome 00123, Italy*
**email: s.lombardi22@campus.unimib.it*

Ammonia, the basic building block of fertilizers and an essential industrial reagent is synthesized globally at a scale exceeding 150 million tons annually, making it the world's second most commonly produced chemical after sulfuric acid (H_2SO_4). However, its production is typically based on the Haber Bosch process, an energy-intensive process (>600 KJ mol^{-1} ammonia), which entails demanding conditions of high pressures and high temperatures (150-350 atm, 350-550 °C). Moreover, in this process, H_2 is entirely produced through steam-reforming natural gas, which consumes 3-5% of the global natural gas supply and is responsible for 450 million metric tons of CO_2 emission annually. In addition to the challenges associated with conventional NH_3 production, nitrate pollution is engendering severe threats to the whole ecosystem. On the other hand, the electrochemical reduction of nitrate to ammonia (NO_3^-RR) is emerging as an efficacious method to synthesize NH_3 under ambient conditions and remove nitrates from the environment while avoiding the limitations and problems involved in the conventional synthesis pathways. Besides, if electricity is provided through renewable energy, this process can be considered totally green and could contribute to electrifying, at least partially, an industrial sector such as NH_3 production, which is crucial to reaching the complete decarbonization set by the EU in 2050. [1] However, the sluggish kinetics of NO_3^-RR and competitive hydrogen evolution reaction (HER) are the main bottlenecks of the given technology and demand urgent scientific endeavors. Therefore, the development of efficient electrocatalysts with specific structures capable of suppressing competitive reactions *i.e.* HER is the need of the hour. To this end, the aim of this work was to compare the electrochemical performance of various metal oxides: ZnO, CuO and Co_3O_4 to identify which electrocatalyst exhibit higher efficiency for the selective reduction of nitrate to ammonia between them. Each material was characterized using SEM, XRD, XPS, HR-TEM and XRF to evaluate its morphology and crystalline structure. The electrochemical performance were then tested in nitrogen-saturated (oxygen-free) phosphatebuffered solution (PBS) containing potassium nitrate through Linear Sweep Voltammetry (LSV) using a rotating disk electrode (RDE), and by Chronoamperometry (CA) in a H-type cell. Following the chronoamperometric tests, the concentrations of NH_4^+ formed during the electroreduction were quantified by ion chromatography (IC). Among the various synthesized materials, Co_3O_4 nanoparticles obtained via an optimized co-precipitation synthesis route exhibited the best performance, achieving a Faradaic Efficiency (FE) of above 94% and an ammonia production rate of roughly 150 µmol h^{-1} cm^{-2} at -0.8 V vs Reference hydrogen electrode (RHE), providing a simple synthesis approach that can lead to high-performing, Pt-free electrocatalyst for the NO3 -RR.

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P14 – Solar-powered CO_2 reduction to value added products

Magliocco Alberto[1*], Axel Guinart Guillem[2], Carolina Gimbert Suriñach[2], Stefano Caramori[1],
Serena Berardi[1]

[1] *Department of Chemical Pharmaceutical and Agricultural, University of Ferrara, Via Luigi Borsari 46, 44121, Ferrara, Italy*
[2] *Departament de Química, Facultat de Ciències - C7/417, 08193 Bellaterra, (Cerdanyola del Vallès), Barcelona, Spain*
[*] *email: alberto.magliocco@unife.it*

The SOREC2 (SOlar Energy to power CO_2 REduction towards C_2 chemicals for energy storage), EU-funded project, is committed to the design and fabrication of a photoelectrochemical (PEC) device able to carry out the standalone solar-driven CO_2 conversion to ethanol and ethylene.

Particularly, copper metal-based electrodes were proven to be catalytically active in the electrochemical CO_2 reduction, leading to a plethora of different molecules [3], Thus, selective formation of targeted product(s) is a pivotal aspect to be pursued, e.g. by tuning the stability of the reaction intermediates. [4]

In this contribution, we will report on the modification of copper electrodes with an electrodeposited organic film, which allows for enhanced CO_2 electroreduction to C_2 products in aqueous media. The use of these cathodes in combination with a bismuth vanadate-based photoanode for water oxidation will be also presented as the proof-of-concept stand-alone PEC device of the SOREC2 project.

Acknowledgements

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P15 – Green Hydrogen Production via Alcohol Electroreforming: Toward Clean and Sustainable Energy Solutions

Ahmad Mairaj*, Lo Vecchio Carmelo, Mondello Angelo, Dollenz Riccardo, Baglio Vincenzo

CNR-ITAE, Via Salita S. Lucia sopra Contesse 5, 98126 Messina, Italy
*email: ahmad@itae.cnr.it

Alcohol electroreforming (AER) is a promising electrochemical method for hydrogen production, coupling alcohol oxidation at the anode with proton reduction at the cathode, using a polymer electrolyte membrane. Compared to conventional water electrolysis, AER offers improved energy efficiency due to the lower oxidation potentials of short-chain alcohols (e.g., 0.016 V for methanol), resulting in reduced energy consumption (~18.5 kWh/kg H_2). In this study, 50% Pt_1Ru_1/C anodic catalysts were synthesized via a platinum sulfite complex route with Ketjenblack carbon and a ruthenium precursor. The catalysts were characterized by X-ray diffraction (XRD), X-ray fluorescence (XRF), and S/TEM-EDX to assess structural and morphological properties. Electrochemical performance was evaluated using rotating disc electrode (RDE) tests and full electroreforming (ER) cells under acidic and alkaline conditions. The study demonstrates the catalysts' effectiveness in enhancing alcohol oxidation activity, hydrogen generation, and system stability, highlighting their potential for efficient and scalable green hydrogen production.

Acknowledgments

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P16 – Mechanistic Insights into the Reversible NAD^+/NADH Interconversion Catalyzed by Cp*Ir(Pyrazine-2-Amidate) Complexes

Menendez Rodriguez Gabriel*, Macchioni Alceo

Department of Chemistry, Biology and Biotechnology and CIRCC, Università degli Studi di Perugia, Via Elce di Sotto 8, 06123-Perugia, Italy
**email: gabriel.menendezrodriguez@unipg.it*

Reversible electrocatalysis is an electrochemical process in which a catalyst facilitates both the forward and reverse reactions with minimal energy loss.[1] Electrocatalysts capable of such bidirectional activity are termed *reversible* and are essential for advancements in energy storage, conversion, and sustainable chemical processes. However, designing truly reversible molecular electrocatalysts remains a significant challenge, with only a few examples reported to date.

Among these rare systems, we recently disclosed the reversible electrocatalytic interconversion between NAD^+ and NADH mediated by [Cp*Ir(pyza)Cl] (pyza = pyrazineamidate).[2] This complex efficiently catalyzes both NAD^+ reduction and NADH oxidation with high selectivity in response to subtle changes around the equilibrium potential.

In this study, we report another member of the [CpIr(pyza)Cl] family, namely Cp*Ir(N-methyl-2-pyrazineamidate)Cl, that also exhibits reversible NAD^+/NADH electrocatalysis. A detailed mechanistic analysis is presented, combining electrochemical techniques with NMR spectroscopy. As illustrated in Figure 1, the redox-active form of the catalyst (**I**) undergoes a ligand-centered, two-electron/one-proton proton-coupled electron transfer (PCET) to form intermediate **II**. This is followed by a metal–ligand proton tautomerism (MLPT) step, generating intermediate **III**, which subsequently transfers a hydride to NAD^+, forming NADH and regenerating the initial catalyst.

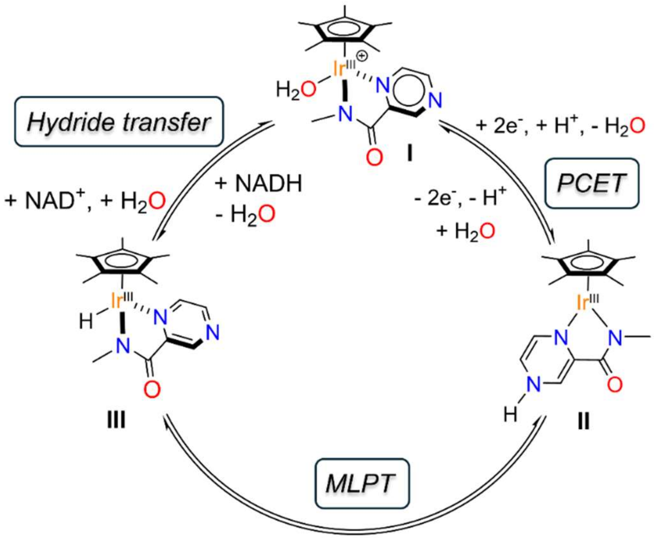

Fig. 1. Proposed mechanism for the electrocatalytic NADH/NAD^+ interconversion.

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P17 – $SnSe_2/TiO_2$ Heterostructure as a Novel Photoanode for the Oxygen Evolution Reaction

Ricci Vittorio, Mohammadi Ehsan*, Natarajan Thirugnanam, Piccirilli Daiana, Paolucci Valentina, Cantalini Carlo

Department of Industrial and Information Engineering and Economics, P.le Pontieri, 1 Monteluco di Roio, University of L'Aquila, I-67100 L'Aquila, Italy
**email: ehsan.mohammadi@graduate.univaq.it*

Introduction

Photoelectrocatalytic Oxygen Evolution Reaction (PEC-OER) describes the process of oxygen production at the anode of an electrolytic cell, where $O_{2(g)}$ generation is enhanced by UV-Visible light [1]. Up to now many different heterojunctions, and specifically TMDs/TiO_2 heterostructures [2] have been validated as PEC-OER materials. Based on these premises, a novel photoanode composed of a $SnSe_2/TiO_2$ heterostructure is investigated in this work.

Materials and Methods

The two-step synthesis starts from commercial FTO conductive substrates and involves deposition of a thin mesoporous TiO_2 film by sol-gel [3], followed by an overlaying solvothermal growth of $SnSe_2$ platelets. The morphology, chemical composition and optical properties of the electrode have been studied by SEM, XPS, Raman, XRD and UV-VIS analyses. The electrode with an area of 7.5 cm^2 has been tested in Na_2SO_4 0.5 M electrolyte and by illuminating with Xe lamp and monochromatic LEDs during Linear Sweep Voltammetry (LSV).

Results

The SEM images of **Fig. 1a** show the presence of $SnSe_2$ platelets with approximately 10 µm lateral size over the underlying TiO_2 film. Regarding PEC-OER performance, LSV of **Fig. 1b** shows an increase from 0.1 mA/cm^2 to 0.8 mA/cm^2 from dark to solar simulation illuminated conditions.

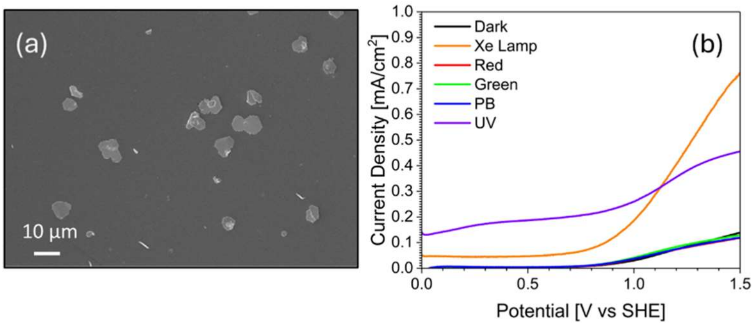

Fig. 1. (a) SEM image of the $SnSe_2/TiO_2$ heterostructure. (b) LSV curves at a scan speed of 200 mV/s and different illumination conditions of the $SnSe_2/TiO_2$ heterostructure.

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P18 – Characterization of LFP Batteries Ageing from Automotive Applications via Single Cell Testing, Physical Modeling and Ex-Situ Analyses

Nicosia Giorgia[1*], Callegari Daniele[2], Quartarone Eliana[2], Casalegno Andrea[1], Rabissi Claudio[1]

[1] *Department of Energy, Politecnico di Milano, Via Lambruschini 8, 20156, Milan, Italy*
[2] *Department of Chemistry, Università di Pavia, Via Taramelli 16, 27100, Pavia, Italy*
[*] *email: giorgia.nicosia@polimi.it*

This work presents the development of a diagnostic methodology, able to assess the degradation state of lithium-ion batteries, and its application to the case study of LFP cells from hybrid-buses with a residual capacity of 50%-80%. The method combines electrochemical techniques, as quasi-OCP discharges, differential voltage analyses and electrochemical impedance spectroscopy (EIS), with ex-situ analyses, such as SEM and XRD. Electrochemical characterization highlighted a strong heterogeneity among cells in the same parallel, mainly caused by the uneven operating temperature. Then, with a quasi-OCP model[1], the primary degradation modes were identified as the loss of lithium inventory (LLI) and the loss of active material of the negative electrode (LAMn). Post-mortem SEM images showed a dense layer on graphite, that may hinder lithium intercalation, additionally XRD analyses on the cathode confirmed lithium depletion with ageing. Therefore, this diagnostic approach successfully correlates electrochemical results with ageing, offering valuable insights into possible second-life applications.

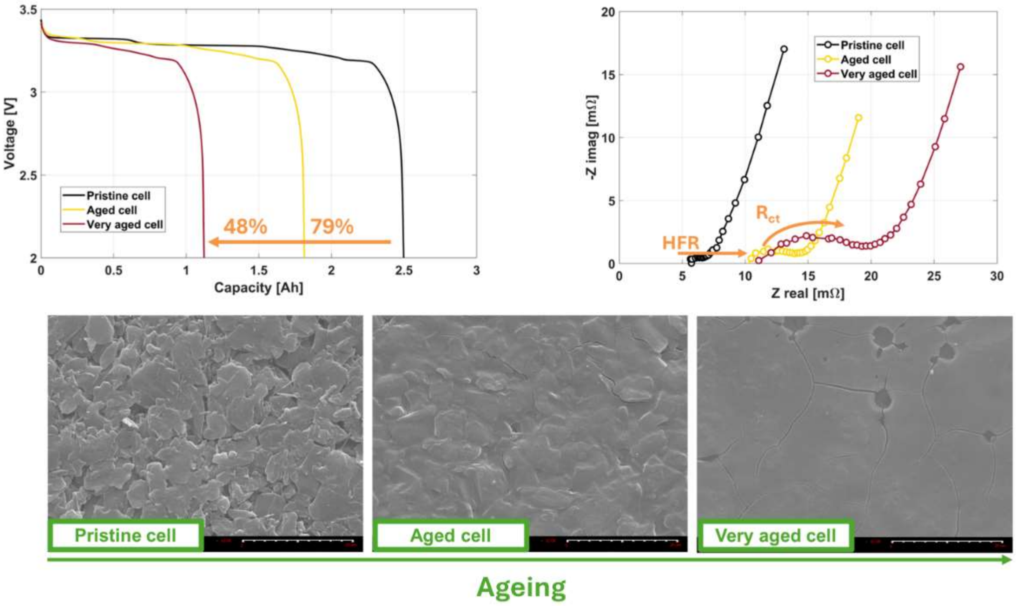

Fig. 1. *Top left*: quasi-OCP discharges of the analyzed cells. *Top right*: Nyquist plot of the EIS at SoC = 100% and T = 25°C. *Bottom*: SEM top-view of the graphite electrodes of the analyzed cells.

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P19 – A 1-D Electrolysis Physics-based Model Combining Steady-State and EIS Analyses

Oriani Sara Samantha*, Colombo Elena, Casalegno Andrea, Baricci Andrea, Zago Matteo

Department of Energy, Politecnico di Milano, Via Lambruschini 8, 20156, Milan, Italy
**email: sarasamantha.oriani@polimi.it*

Understanding the fundamental processes in PEM water electrolysis is crucial to enable large-scale renewable hydrogen production. In this study, a one-dimensional physics-based steady-state electrochemical model has been developed to rigorously reproduce experimental data, specifically polarization curves and Electrochemical Impedance Spectroscopies (EIS) obtained in collaboration with the University of Connecticut. The steady-state model solves the coupled mass transport, electrochemical kinetics, and ohmic losses to provide detailed profiles of physical quantities, including current density, potential, and water content. An AC perturbation is integrated to simulate EIS, capturing typical capacitive and resistive behaviors. Preliminary simulations show an inductive feature at low frequencies, which could be associated with the water content profile. Further investigation is ongoing to understand this phenomenon. Overall, the model supports the interpretation of experimental data and offers insights into the coupled phenomena governing PEM water electrolysis.

Acknowledgements

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P20 – One-Pot Synthesis of $LaNiO_3$ for Enhanced Oxygen Evolution Reaction Activity in Alkaline Media

Pagano Giorgio*, Panunzi Anna Paola, Duranti Leonardo, Di Bartolomeo Elisabetta

Department of Chemical Science and Technologies, University of Rome Tor Vergata, Via della Ricerca Scientifica, 00133, Rome, Italy
email: giorgio.pagano@uniroma2.it

Water electrolyzers powered by renewable energy offer an environmentally sustainable approach to hydrogen production [1]. The oxygen evolution reaction (OER) is the rate determining step of water electrolysis and expensive platinum group metal (PGM) oxides such as RuO_2 and IrO_2 are the state-of-the-art OER electrocatalysts [2]. In alkaline water electrolyzers [3], perovskite oxides such as $LaNiO_3$ have emerged as excellent PGM-free electrocatalysts thanks to their stability and high activity [4].

In this work, a one-pot solution combustion route is presented as a fast and practical method to enhance $LaNiO_3$ OER activity descriptors. The synthesis is based on a combination of low-cost fuels: glycine (Gly) and citric acid (CAM), which has not been previously explored for $LaNiO_3$ to the best of our knowledge. Compared to other wet-chemistry methods, the Gly + CAM synthesis yielded powders with superior textural properties, optimal Ni^{3+}/Ni^{2+} ratio and high intrinsic OER activity.

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P21 – Electrochemical Evaluation of Fe–N–C and Co–N–C Catalysts in Acidic and Alkaline Media: Insights from CV and LSV Analyses

Rosella Ettore*, Lo Vecchio Carmelo, Bucca Gioacchino Davide, Baglio Vincenzo, Gatto Irene

CNR-ITAE, Salita Santa Lucia Sopra Contesse, 5, 98126 Messina ME, Italy.
**email: ettorerosella@cnr.it*

The development of efficient and sustainable catalysts for the oxygen reduction reaction (ORR) is a key challenge for electrochemical energy technologies such as fuel cells and metal–air batteries. Among non-precious metal catalysts (NPMCs), iron- and cobalt-based M–N–C materials have attracted considerable attention due to their promising activity and cost-effectiveness [1,2]. In this study, Fe–N–C and Co–N–C catalysts were synthesized by impregnating ZIF-8, a nitrogen-rich metal-organic framework, with transition metal precursors, followed by high-temperature pyrolysis. Ketjenblack was also added to enhance the electrical conductivity and surface dispersion. The resulting materials were evaluated through electrochemical testing in both acidic ($HClO_4$ 0.1 M) and alkaline (KOH 0.1 M) media. The electrochemical characterization was carried out using cyclic voltammetry (CV) and linear sweep voltammetry (LSV), with the aim of comparing the behavior of the two catalysts under different pH conditions. While the data collection has been completed, a detailed analysis of the CV and LSV curves is still ongoing. This work is part of a broader effort to understand how electrolyte environment influences the activity and stability of MOF-derived M–N–C catalysts.

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P22 – Electrochemical fixation of nitrogen to ammonia at iron-phosphide-based electrocatalytic systems

Rytelewska Beata[1*], Chmielnicka Anna[1], Emin Saim[2], Eder Dominik[3], Naghdi Shaghayegh[3], Rutkowska Iwona A.[1], Kulesza Pawel J.[1]

[1] *Faculty of Chemistry, University of Warsaw, Pasteura 1, 02-093, Warsaw, Poland*
[2] *Materials Research Laboratory, University of Nova Gorica, Vipavska 13, SI-500 Nova Gorica, Slovenia*
[3] *Institut für Materialchemie, Technische Universität Wien, Getreidemarkt 9, 1060, Wien, Austria*
**email: b.rytelewska@uw.edu.pl*

Electrocatalytic systems based on iron phosphides (Fe_2P, Fe_3P) have exhibited electrocatalytic activities toward N_2-reduction reaction in alkaline (NaOH) and semi-neutral (phosphate buffers) media. The results are consistent with the view that the interfacial reduced-iron (Fe^0) centers within Fe_2P, while existing within the network of P sites, induce activation and reduction of nitrogen, parallel to the water splitting (reduction) to hydrogen. The catalytic system exhibits certain tolerance with respect to the competitive hydrogen evolution; namely, during electrolysis at -0.4 V vs. RHE, the molar efficiency toward production of NH_3 is on the level of 60%. Furthermore, by supporting iron phosphides (e.g. Fe_3P) onto hexagonal tungsten nanowires (capable of controlling hydrogen evolution), electroreduction of nitrogen has been feasible in the semi-acid medium (pH=4.6). Finally special attention has been paid to the determination and verification of the identity of the nitrogen-electroreduction products. Potential advantages of electroanalytical approaches will be mentioned.

P23 – Tuning Electron Poorness and Basicity of Cobalt Corroles for Identifying the Optimal Performing Electrocatalyst

Saini Azad*, Gross Zeev

*Schulich Faculty of Chemistry, Technion Israel Institute of Technology, 3200003 Haifa, Israel **
**email: azad.saini@campus.technion.ac.il*

Cobalt corrole complexes are constantly introduced as electrocatalysts for reactions of prime importance for sustainable processes, like the reduction of CO_2 and the hydrogen evolution reaction (HER).[1,2] Chelation of cobalt by electron-poor corroles has a large effect on formal redox potentials but also decreases the basicity/nucleophilicity required for the activation of CO_2 and protons. One most recent study uncovered the importance of the last aspect, which came into play by a change in the reaction mechanism of electrocatalytic HER catalyzed by the cobalt complexes performed with the parent corrole (Figure 1). We are now in the process of preparing a series of compounds depicted in the Figure, which differ in the number of CF_3 groups at their meso-C positions. This series will first be tested as HER catalysts for identifying optimal conditions regarding overpotential and reactivity. In follow-up studies, we will focus on the CO_2 reduction reaction. Once established, these will be used for other electrocatalytic reactions.

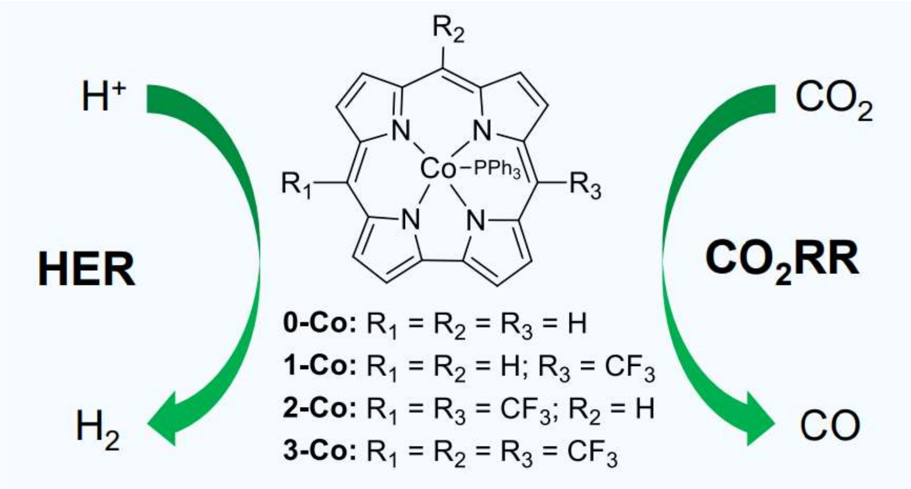

Fig. 1. Cobalt corrole complexes that differ in the number of CF_3 groups for optimal HER and CO_2RR electrocatalysts.

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P24 – Photo-Electrocatalytic Capabilities of a Green-Synthesized MoS_2–WO_3 Composite

Šarapajevaitė Gabrielė[1,2], Milda Petrulevičienė[1], Jurga Juodkazytė[1]

[1] *Laboratory of Electrochemical Energy Conversion, Center for Physical Sciences and Technology (FTMC), Sauletekio al. 3, LT-10257, Vilnius, Lithuania*
[2] *Department of Silicate Technology, Kaunas University of Technology, Radvilenu pl. 19, LT-50254, Kaunas, Lithuania*
**email: gabriele.sarapajevaite@ftmc.lt*

Molybdenum disulfide (MoS_2) is an n-type semiconductor with a versatile layered structure that supports a wide range of multifunctional applications, e.g., green hydrogen production and the degradation of organic pollutants in wastewater [1,2]. However, its standalone use is often limited by rapid charge recombination and photocorrosion, which can hinder its photo(electro)chemical performance [1,2]. To overcome these challenges, the formation of a heterostructure with tungsten oxide (WO_3) is a well-established strategy to enhance the functional efficiency of MoS_2. In addition, the aim of this work was to synthesize MoS_2-WO_3 composite and to investigate its potential as a photo(electro)catalyst.

A sustainable synthesis approach was employed, using ascorbic acid as a green reducing agent for MoS_2 production. The samples were characterized by XRD, SEM and XPS, while electrochemical performance was evaluated using cyclic voltammetry and chronoamperometry.

The findings of this research revealed that under the applied hydrothermal conditions, defect-rich 2H MoS_2 was formed. The MoS_2–WO_3 composites exhibited enhanced photo(electro)chemical responses, attributable to the synergistic interaction within the heterostructure (Fig. 1). In addition, the obtained results demonstrated the synergistic effect of the MoS_2-WO_3 heterostructure, highlighting its promising potential for efficient and sustainable photo(electro)catalytic applications.

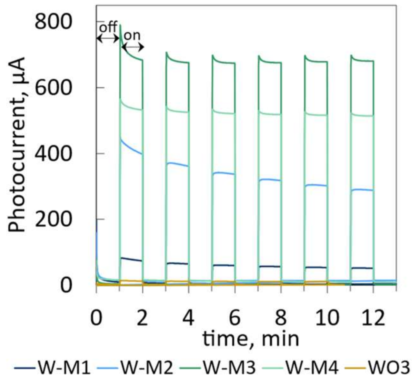

Fig. 1. Chronoamperograms of different WO_3-MoS_2 composite samples recorded in the dark and under irradiation of light

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P25 – Nanocomposite Co_3O_4-CeO_2 catalytic systems in oxygen electrochemistry

Siamuk Olena[1*], Chmielnicka Anna[1], Rytelewska Beata[1], Janiszewska Claudia[1], Yang Jingxia[2],
Rupprechter Günther[2], Rutkowska Iwona A.[1], Kulesza Pawel J.[1]

[1] *Faculty of Chemistry, University of Warsaw, Pasteura 1, 02-093 Warsaw, Poland*
[2] *Institut für Materialchemie, Technische Universität Wien, Getreidemarkt 9, 1060 Wien, Austria*
[*]*email: o.siamuk@student.uw.edu.pl*

Catalytic systems based on nanostructures of carbon-supported platinum, Pt/C (catalytic centers), and certain metal oxides (cocatalytic sites), have been investigated under electrochemical conditions toward both the reduction of oxygen as well as the oxidation of water to oxygen. Evidence has been provided that specific interactions between the oxide and noble metal (Pt) nanoparticles should improve the stability and activity of the metal catalytic sites due to modification of the Pt electronic structure. In the present study, we have demonstrated that Co_3O_4-modified CeO_2 additive (to Pt/C) synthesized in a form of intermixed oxides with homogenously dispersed cobalt ionic sites enhance activity of Pt centers during oxygen reduction in acid medium. Furthermore, the Co_3O_4-CeO_2 nanocomposites have occurred to exhibit high stability and promising activity under anodic conditions, namely during electrooxidation of water (water splitting) in acid medium.

P26 – B-site mixed $LaNiO_3$ perovskite oxide as a catalyst for acid-stable oxygen evolution

Tubul*, Kama, Barad

Department of chemistry, Bar-Ilan university, 5290002, Ramat Gan, Israel
**email: tubulno@biu.ac.il*

Fossil fuels are the main cause of global climate change, urging a shift to clean and renewable energy sources. Electrocatalytic energy conversion reactions can produce clean energy with low activation energy and without any catalyst consumption. Perovskite oxides (ABO_3) are catalysts of interest due to their structural flexibility, and high ionic conductivity. The research goal is to tailor $LaNiO_3$, a perovskite oxide, which is highly conductive and perform remarkably in alkaline conditions, to be acid-stable for the oxygen evolution reaction (OER) by mixing its B-site with Mo. The doped-$LaNiO_3$ is prepared by pulsed laser deposition. The material properties and electrocatalytic activity are determined through various methods including XRD, HR-SEM, EDS, and electrocatalytic measurements. We found that $LaNiO_3$ forms a stable perovskite of $LaNi_xMo_{1-x}O_3$ that shows high and long-term OER activity.

P27 – Performance Comparison of Aquivion®-Based PEMFCs Using Catalyst-Coated vs. Decal-Transferred Membranes

Zekri Mohamed[1*], Carbone Alessandra[1], D'Agostino Roberto[1], Librizzi Flavio[1], Saccà Ada[1], Messaggi Mirko[2], Facchi Daniele[2], Baglio Vincenzo[1], Gatto Irene[1]

[1] CNR-ITAE, Via Salita S. Lucia sopra Contesse 5, 98126 Messina, Italy
[2] SYENSQO, Viale Lombardia 20, 20021 Bollate (MI), Italy
**email: mohamed.zekri.etud@fss.usf.tn*

This study compares the electrochemical performance of proton exchange membrane fuel cells (PEMFCs) to analyze two membrane electrode assembly (MEA) fabrication processes: the spray catalyst-coated membrane (s-CCM) and the decal-coated membrane (d-CCM). In the s-CCM procedure, the catalyst ink is applied directly onto the membrane surface by spray coating procedure, followed by drying and hot pressing with the GDLs. In the d-CCM process, the catalyst ink is first deposited onto a PTFE substrate, which is then hot-pressed onto the membrane (decal); the PTFE substrate is subsequently removed, leaving the catalyst layer transferred to the membrane. Gas diffusion layers (GDLs) are then applied during final assembly. Polarization curves were recorded under various operating conditions, including temperatures ranging from 80 to 95 °C, relative humidity between 50% and 100%, and pressure from 1.5 to 3 bar, using hydrogen and air as reactant and oxidant gases. Under all test conditions, the d-CCM-MEA outperformed the s-CCM-MEA. This performance improvement is attributed to better catalyst–membrane interfacial contact, improved layer uniformity, and reduced mass transport resistance provided by the decal transfer process. These results highlight the significant influence of MEA fabrication on PEMFC performance and efficiency during operation. Keywords: Proton Exchange Membrane Fuel Cell (PEMFC), Membrane Electrode Assembly (MEA), Catalyst-Coated Membrane (CCM), Decal Method, Electrochemical Performance, Power Density, Polarization Curve

Keywords: Proton Exchange Membrane Fuel Cell (PEMFC), Membrane Electrode Assembly (MEA), Catalyst-Coated Membrane (CCM), Decal Method, Electrochemical Performance, Power Density, Polarization Curve.

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