FULL PROGRAMME &
BOOK OF ABSTRACTS

[HYCELTEC 2026]

X Symposium on Hydrogen, Fuel Cells and Advanced Batteries

8-11 June 2026, Alicante (Spain)

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CONTENT

[HYCELTEC 2026] X Symposium on Hydrogen, Fuel Cells and Advanced Batteries

8-11 June 2026, Alicante (Spain)

GENERAL INFORMATION

X Symposium on Hydrogen, Fuel Cells and Advanced Batteries

Hyceltec 2026 is the tenth International Symposium on Hydrogen, Fuel Cells and Advanced Batteries. The Symposium is organized by the Materials Institute of the University of Alicante (IUMA) and will be held in Alicante, Spain.

Hyceltec 2026 will be an interdisciplinary forum for those researchers interested in topics related to hydrogen, fuel cells, batteries, supercapacitors and other energy storage devices, bringing together from academia, technological centers, and industry.

Topical areas include: (i) hydrogen production, storage and transportation, its integration with renewable energy sources, and its environmental social impact, etc; (ii) fuel cells, development of components and materials, device integration, degradation mechanisms, applications, etc; (iii) advanced batteries, liquid-, fused, solid-state and polymeric batteries, redox flow batteries, supercapacitors, electrochromic energy storage devices, sustainability and recyclability, etc.

This conference is expected to stimulate fruitful discussion, new ideas, and collaborations between specialists from various domains. As in preceding meetings, the conference aims at bringing together the scientists, engineers, and technologists working on these topics and intends to provide a forum for discussion on fundamental and technological scientific aspects of Hydrogen, Fuel Cells, and Advanced Batteries.

We hope you will enjoy the Symposium and that you will have time to interact with other researchers and colleagues and to visit our host city. Alicante is a seaside, cozy, and sunny city with pleasant weather and a nice atmosphere.

The Local Organizing Committee

Language

All lectures are in English. There will be no facilities for simultaneous translation.

Communication certificates

Attendance certificates, as well as certificates for oral and poster presentations, can be downloaded from the conference website (user area) once the congress has ended.

Internet

The conference venue will have open-access wireless networks available for all conference participants.

Remember that the electric current in Spain is 220V and plugs are two-pin continental sizes.

Meeting Room

A meeting room will be available to all conference participants within the conference venue (Lecture theatre A2/D02).

Advice to presenters

Oral Presenters

Duration

Plenary Talks: 60 min (50 min + 10 min Q&A)

Keynote Talks: 30 min (25 min + 5 min Q&A)

Oral Presentations: 15 min (12 min + 3 min Q&A)

Information

Presentations must be prepared in either PowerPoint 2016/2019/2021/365. Presenters are advised to use standard Office fonts and embed videos in the slides.

Please bring your widescreen slides in either PowerPoint or PDF form on a flash drive well in advance and before your presentation day.

There will be a chair in the room to introduce each presenter, moderate the Q&A for each talk and ensure you keep to the time. Practice your timing to stay within your time as the chairs will cut you short if you are not finished in this time.

Please arrive at least 15 minutes earlier to your session.

Poster Presenters

Format

The poster format is: Size A0 Portrait (841mm wide × 1189 mm high)

Information

Your poster board will be numbered by the ID of your contribution from the Conference Program.

Poster(s) should be readable at a distance of at least 1 meter.

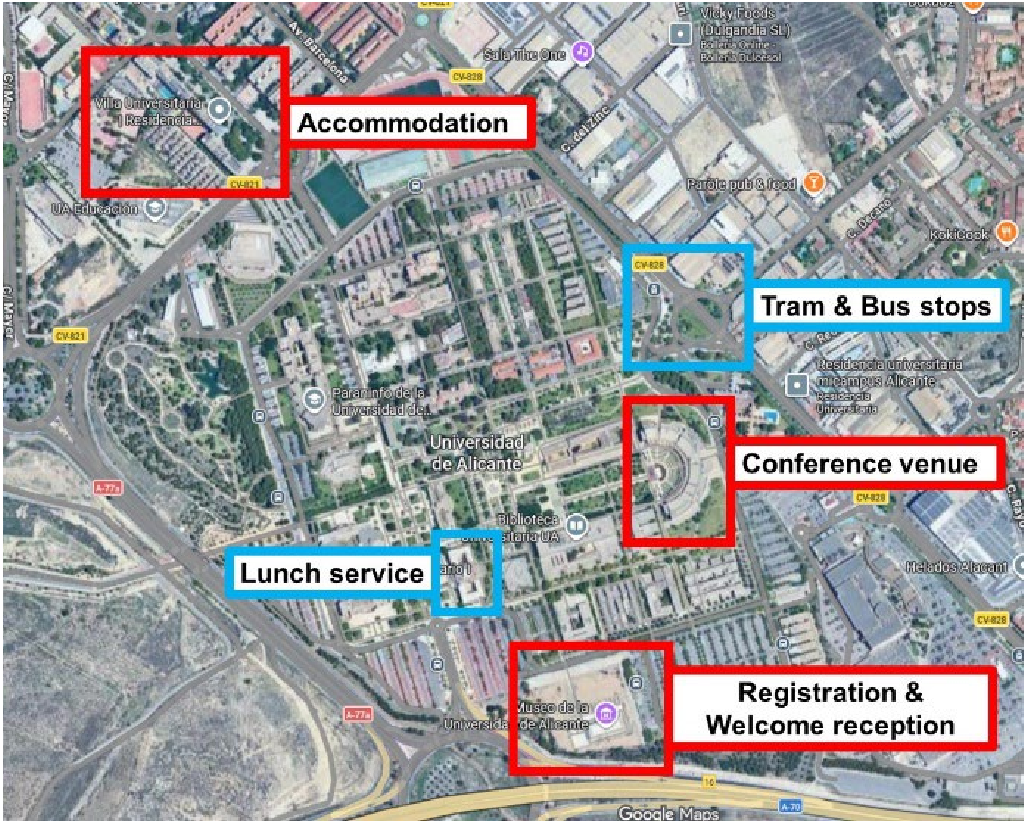
Information on the day and time of your poster session is available in the Conference Program, but your poster will be displayed during the three days of the conference. Please make sure you attach your poster to the correct board.

Materials to pin up your poster will be available.

You will be expected to print and bring your poster with you to the conference. Printing will not be available at the conference.

CONFERENCE VENUE

Aulario II – Universidad de Alicante
Carretera de San Vicente del Raspeig, s/n
03690 San Vicente del Raspeig, Alicante (ES)



CONFERENCE OFFICE

The Conference Area will be located on the ground floor of the Aulario II building (conference venue).
Outside the lecture theatre, in the central access area, the Conference Office will be permanently established next to the Hospitality Desk. Sponsors stands will be located on the 1st floor.

From the Conference Office room:

- You may access the Club Social II building, where work lunches will take place.
- Make coffee breaks, although they could also be carried out on the 1st floor, depending on the availability.
- Access the 1st floor where the poster sessions will take place.

SCIENTIFIC PROGRAM
TIME SCHEDULE

Hydrogen

Salón de actos - Aulario II Building

	Monday June 8	Tuesday June 9	Wednesday June 10	Thursday June 11
8:30		**Opening Ceremony**		
9:00		**Plenary 1**	**Plenary 2**	**Plenary 3**
9:30				
10:00		**Oral Session 1 (2 keynotes, 2 orals)**	**Oral Session 7 (1 keynote, 4 orals)**	**Oral Session 11 (2 keynotes, 2 orals)**
10:30				
11:00				
11:30		**Coffee Break**	**Coffee Break**	**Coffee Break**
12:00		**Oral Session 2 (2 keynote, 2 orals)**	**Oral Session 8 (1 keynote, 4 orals)**	**Oral Session 12 (1 keynote, 4 orals)**
12:30				
13:00				
13:30		**Lunch**	**Lunch**	**Closing ceremony**
14:00				**Lunch**
14:30				
15:00				
15:30		**Oral Session 3 (1 keynote, 4 orals)**	**Poster Session 2 (Coffee)**	
16:00				
16:30				
17:00	**Registration**	**Poster Session 1 (Coffee)**		
17:30				
18:00				
18:30				
19:00	**Welcome Reception**			
19:30				
20:00				
20:30		**Cocktail**	**Conference Banquet**	
21:00				
21:30				
22:30				

Fuel cells, Advanced Batteries and Supercapacitors

Lecture theatre A2/D01 - Aulario II Building

	Monday June 8	Tuesday June 9	Wednesday June 10	Thursday June 11
8:30		Opening Ceremony		
9:00		Plenary 1	Plenary 2	Plenary 3
9:30				
10:00		Oral Session 4 (1 keynote, 4 orals)	Oral Session 9 (1 keynote, 4 orals)	Oral Session 13 (1 keynote, 4 orals)
10:30				
11:00				
11:30		Coffee Break	Coffee Break	Coffee Break
12:00		Oral Session 5 (1 keynote, 4 orals)	Oral Session 10 (1 keynote, 4 orals)	Oral Session 14 (1 keynote, 4 orals)
12:30				
13:00				
13:30		Lunch	Lunch	Closing ceremony
14:00				Lunch
14:30				
15:00				
15:30		Oral Session 6 (1 keynote, 4 orals)	Poster Session 2 (Coffee)	
16:00				
16:30				
17:00	Registration	Poster Session 1 (Coffee)		
17:30				
18:00				
18:30				
19:00	Welcome Reception			
19:30				
20:00				
20:30		Cocktail	Conference Banquet	
21:00				
21:30				
22:30				

DAILY SCIENTIFIC PROGRAM

Monday, 8th June 2026

The Museum of the University of Alicante (MUA)

17:00-19:00 Registration

19:00-20:30 Welcome Reception

8:30-9:00 OPENING CEREMONY. Salón de Actos – Aulario II

9:00-10:00 PLENARY LECTURE 1. Salón de Actos – Aulario II

Design of Nanostructured Catalysts for Sustainable Energy and Environmental Uses

Prof. Hiromi Yamashita. The University of Osaka, Japan

Hiromi Yamashita has been a full professor at the University of Osaka since 2004. He received his PhD degree from Kyoto University in 1987. He was an assistant professor at Tohoku University (1987-1992), an assistant professor and associate professor at Osaka Prefecture University (1992-2003). He was an invited professor at the University Pierre and Marie Curie (UPMC), Shanghai University of Electronic Power, and Shanghai Normal University. He was a visiting research fellow at the Pennsylvania State University (1992), the University of Texas at Austin (1993), California Institute of Technology (1998-1999). He was the president of the Asia and Pacific Association of Catalysis Societies (2019-2023), the president of Catalysis Society of Japan (2019-2020), a member of Academia Europea (2019-), and the editor of Applied Catalysis B (2012-). He received awards from several societies, such as the Chemical Society of Japan, Catalysis Society of Japan, International Mesostructured Materials Association, etc. He has published more than 650 papers. His research interests include the design of single-site photocatalysts and nanostructured catalysts.

Chairperson: José Rodríguez-Mirasol

Oral Session 1: Hydrogen

Chairperson: Elena Pastor

10:00 **K1** (Id.1)
In Situ Time-Resolved X-ray Absorption Spectroscopy Unveils Partial Re-Oxidation of Tellurium Cluster for Prolonged Lifespan in Hydrogen Evolution
*Pang Kanglei, **Jiayin Yuan**, Uguz Neli Özlem*

10:30 **S1-1** (Id.35)
Development of Carbon Nitride-Supported Copper Electrocatalysts: An Operando X-ray Absorption Spectroscopy Study
***Sara Álvarez Parejo**, Gabriel Alemany Molina, Elisa Borfeccia, Emilia Morallón Núñez, Diego Cazorla-Amorós*

10:45 **S1-2** (Id.103)
Strategies to maximize the density of active sites in Ni-N-C catalysts for AEM electrolysis
*Carlos Serrano Alcalde, Sara Pérez Rodríguez, María Jesus Lázaro Elorri, **David Sebastián del Río***

11:00 **K2** (Id.118)
Operando Insights into Transition Metal Phosphides during the Oxygen Evolution Reaction
*David Ríos Ruiz, Pablo Arévalo Cid, Armando Ibraliu, Verónica Celorrio, Sandra Drev, Cecilia Gómez-Sacedón, Antonio de Lucas-Consuegra, **María Victoria Martínez Huerta***

11:30 **Coffee break**

Tuesday, 9th June 2026 A2/D01 – Aulario II

Oral session 4: Advanced batteries and capacitors

Chairperson: Ana Arenillas

10:00 **K6** (Id.68)
3D carbon electrodes manufactured by Direct Ink Writing for all-iron redox flow batteries
Victoria García Rocha*, Pablo Rodríguez Lagar, Alejandro Concheso Álvarez, Daniel Barreda, Zoraida González Arias, Miguel Montes-Morán, J. Ángel Menéndez, Clara Blanco, Ricardo Santamaría*

10:30 **S4-1** (Id.14)
Determination of the diffusion coefficient of vanadium ions in practical redox flow batteries
Ignacio Ortiz de Landazuri Suárez, Manuel Montiel Argaiz, Antonio Lozano Fantoba, ***Felix Barreras Toledo***

10:45 **S4-2** (Id.29)
Beyond Solubility Limits: Quinone Mediators for Redox-Mediated Aqueous Flow Batteries.
Antonio Martínez Bejarano*, Giu A. Silva Testa, Vikram Singh, Nagaraj Patil, Paula Navalpotro, David Arnáiz-Gil, Gimena Martín-Tajadura, Edgar Ventosa, Evan Wenbo Zhao, Rebeca Marcilla*

11:00 **S4-3** (Id.80)
Towards Physically-Consistent Overpotential Decomposition in VRFB Stacks: A PINN-Based Modelling and Benchmarking Approach
Andrés Bernabeu Santisteban, ***Alejandro Clemente****, Yonca Belce, Lluís Trilla*

11:15 **S4-4** (Id.74)
Beyond the Membrane: Enhancing Stability through Interphase Insights in Aqueous Biphasic Flow Batteries
Paula Navalpotro*, Carla Santana Santos, Murilo L. Alcantara, Vanesa Muñoz-Perales, Santiago Enrique Ibañez, Antonio Martínez-Bejarano, Nomnotho Jiyane, Catarina M.S.S. Neves, Rubén Rubio-Presa, Thomas Quast, Wolfgang Schuhmann, Joao A.P. Coutinho, Rebeca Marcilla*

11:30 **Coffee break**

Oral Session 2: Hydrogen

Chairperson: Juana María Rosas

12:00 **K3** (Id.25)
H_2 production via photo(thermo)reforming of organic compounds on hybrid carbon/semiconductor catalysts
Alberta Genco, Alicia Gomis-Berenguer, Elisa Garcia-Lopez, Giuseppe Marci, ***Conchi Ania***

12:30 **S2-1** (Id.18)
Enhanced CO_2 reduction through thermo-photocatalysis over modified TiO_2 systems
Piotr Patulski, ***Nicolás García-Pérez****, Ángel Berenguer-Murcia, Diego Cazorla-Amorós*

12:45 **S2-2** (Id.58)
Design and evaluation of MoS_2-CdS heterostructures for hydrogen production via the photoreforming of lactic acid
Juan Manuel Rives*, María Carmen Román, María Ángeles Lillo*

13:00 **K-4** (Id.87)
Modeling High-Pressure Hydrogen Uptake by Nanoporous Materials
Rafael Morales Ospino*, Alain Celzard, Vanessa Fierro*

13:30 **Lunch**

Oral session 5: Fuel Cells

Chairperson: Paula Navalpotro

12:00 **K7** (Id.54)
High Fe(III) Content Molecular Electrocatalyst in Fuel Cell Applications
Federico Tasca

12:30 **S5-1** (Id. 38)
Effect of the Sulfur Incorporation in Single Atom Catalysts as Electrocatalyst for PEMFC-Type Devices
***José Luis Pérez**, María Karla López, Javier Narciso, Roberto Gómez, Andrés Parra*

12:45 **S5-2** (Id.120)
Tracking the evolution of winery-waste derived single atom Cu-N-C electrocatalysts during the CO_2 to CO conversion
***Ana Cristina Giménez Rubio**, Manuel Gutierrez-Roa, Irene Vela, Andrea Zitolo, María Jesús Lázaro, Sara Perez-Rodríguez*

13:00 **S5-3** (Id.122)
Single-atom and MOF-derived catalysts for the electroreduction of O_2 and CO_2
Elena Pastor

13:15 **S5-4** (Id.13)
Silica coating of PEM fuel cell Pt/carbon electrocatalysts to enhance durability upon operation
***Lucas Elvira**, Ali Haider, Loïc Noumbi, Nathalie Job, Sophie Hermans*

13:30 **Lunch**

Oral Session 3: Hydrogen / Fuel Cells

Chairperson: Raúl Berenguer

15:30 **K5** (Id.119)
Microbial Electrochemical Technology for sustainable wastewater treatment and simultaneous hydrogen production
Ana J. Vega de Armas, Marti Aliaguilla, Pau Bosch-Jimenez, Eduard Borràs, Lidia Zulema Borjas, Abraham Esteve-Núñez, ***Juan Manuel Ortiz***

16:00 **S3-1** (Id.114)
Study of the effect of configurational parameters on the performance of a microbial desalination cell
Sahar Abdolbaghi*, Vânia Oliveira, Alexandra Rodrigues Pinto*

16:15 **S3-2** (Id.56)
Doped-tin oxide electrocatalysts as anode in water electrolysis
Javier García de Quirós*, Emilia Morallón, Diego Cazorla-Amorós*

16:30 **S3-3** (Id.89)
Neural-network-based strategies for computational modeling of hydrogen fuel cells: from data-driven surrogates to physics-informed approaches
Raúl Losantos*, Radu Mustata, Manuel Montiel, Luis Valiño*

16:45 **S3-4** (Id.48)
Use of unmanned vehicles in intensive olive cultivation (OLIVARIA Project)
Fernando Isorna Llerena*, Diego Tejada Guzmán, Matías Díez Pérez, Rubén Cuesta Zurita, Eduardo López González*

17:00 -19-00 **Poster Session 1 and coffee break**

Tuesday, 9th June 2026 A2/D01 – Aulario II

Oral session 6: Advanced batteries and capacitors

Chairperson: David Sebastian

15:30 **K8** (Id.20)
Intrinsic Electronic Limitations in Carbon Electrodes for Electrochemical Capacitors
Hirotomo Nishihara

16:00 **S6-1** (Id.23)
Investigation of the surface composition of carbon xerogels used in carbon-carbon composites for sodium-ion batteries
Zoé Deckers*, Berke Karaman, Hélène Tonnoir, Bryan Carré, Alexandre Léonard, Jimena Castro-Gutiérrez, Driélle Müller, Alain Celzard, Vanessa Fierro, Da Huo, Raphaël Janot, Nathalie Job*

16:15 **S6-2** (Id.104)
Lead the Charge: Modern Solutions for Battery Material Characterization
César del Río, *Gonzalo Anguera Pujadas, Carlos Gracia*

16:30 **S6-3** (Id.71)
Polymer-Stabilized Ammoniate Electrolytes for Sodium Batteries
Pablo Hiller*, Carmen Miralles, Roberto Gómez*

16:45 **S6-4** (Id.9)
Co-intercalation electrolyte enabling sodium ion batteries at low temperaturas
Yu Zhang

17:00 -19-00 **Poster Session 1 and coffee break**

Tuesday, 9th June 2026 Salón de Actos – Aulario II

9:00-10:00 PLENARY LECTURE 2. Salón de Actos – Aulario II

Exploring the electrode/electrolyte interface of carbon-based supercapacitors

Dr. Encarnación Raymundo-Piñero. CNRS, Orléans, France

Encarnación Raymundo-Piñero is Research Director at the CEMHTI-CNRS UPR3079 laboratory at Orléans (France). She got a PhD in Materials Science at the University of Alicante (Spain) in 2000, and after a post-doc in the USA, she moved to France in 2002 with a Marie Curie fellowship and joined the CNRS as permanent staff in 2006. In 2009, she was awarded the CNRS bronze medal. Her research focuses on the investigation of carbon-based materials and their composites as electrodes for supercapacitors, micro-supercapacitors, and batteries. A particular emphasis is placed on the development of novel functional carbon-based materials for electrochemical energy storage, the design of high-energy and high-power supercapacitors using environmentally friendly electrolytes, and exploring the electrode/electrolyte interphase. This is achieved through the development of new in situ/operando techniques based on solid-state NMR, Raman spectroscopy, and gas spectrometry. She holds 13 patents related to electrode materials and energy storage devices, and her publications have received over 15500 citation.

Chairperson: Diego Cazorla-Amorós

Oral Session 7: Hydrogen

Chairperson: María Carmen Román-Martínez

10:00 **K9** (Id.78)
Steam reforming of biomass pyrolysis liquids using Ni supported on activated carbons obtained from biomass pyrolysis solids
*Paula Cabrera-Reyes, María Nerea Rivas Márquez, Paula Riquelme-García, **Ramiro Ruiz Rosas**, Miriam Navlani-García, Juana María Rosas, Diego Cazorla-Amorós, José Rodríguez-Mirasol, Tomás Cordero*

10:30 **S7-1** (Id.86)
Biomass Gasification with Air: Integration of Gas Cleaning and CO_2 Valorization for Enhanced Process Performance
***Paulo Brito**, Bruna Rijo, Roberta Panizio, José Copa*

10:45 **S7-2** (Id.109)
Hydrogen and nanostructured carbon from methane pyrolysis using locally sourced metallurgical iron waste
***Daniel Torres**, Jaime López-de los Ríos, José Luis Pinilla, Isabel Suelves*

11:00 **S7-3** (Id.128)
Improving SOEC and tri-reforming efficiencies in the integration of SOEC and Gasification for H_2, methanol and dimethyl ether production
***Giulia Balestra**, Andrea Fasolini, Micaela Calzone, Nicola Boccagni, Elena Marchetti, Andrea Brigliadori, Francesca Bagioni, Elisa Mercadelli, Angela Gondolini, Nikolaos Dimitratos, Alessandra Sanson, Francesco Basile*

11:15 **S7-4** (Id.125)
Effect of Ni incorporation route on Ni-Al aerogel thermo-photocatalysts for CO_2 methanation
***Haritz Etxeberria Altuna,** Daniel Estevez, Laura Barrio*

11:30 **Coffee break**

Oral session 9: Fuel cells / hydrogen

Chairperson: Carmelo lo Vecchio

10:00 **K11** (Id.97)
Tuning the pore structure of Fe-N-C electrocatalysts for high ORR activity and stability
Giulia Gianola, Mirtha A.O. Lourenço, Tiago Morais, Luís Mafra, Juqin Zeng, ***Stefania Specchia***

10:30 **S9-1** (Id.92)
Degradation of Fe-N-C fuel cell catalysts in a gas diffusion electrode system
Miguel Coca-Arroyo, Beatrice Ricciardi, María Jesús Lázaro, David Sebastián, ***Cinthia Alegre***

10:45 **S9-2** (Id.90)
Influence of Fan Power, Geometry and Speed on the Performance of an Open-Cathode PEMFC Stack
Miguel N. Moreira*, Daniela S. Falcão, Alexandra M.F.R. Pinto, Rui B. Ferreira*

11:00 **S9-3** (Id.70)
Modeling and numerical simulation of a solid oxide fuel cell stack using an iterative multi-scale approach
Cristina Raga*, Santiago Lain, David Parra, Blanca Isabel Arias*

11:15 **S9-4** (Id.124)
Enhancing Spanish Electric System Resilience Through The Characterization Of Intermittent Renewable Surpluses For Large-Scale Green Hydrogen Storage
David Bermejo Plana*, Genís Casanova Palomar, Laura Martí Ferré*

11:30 **Coffee break**

Oral Session 8: Hydrogen

Chairperson: Felix Barreras

12:00 **K10** (Id.12)
On the heating during refueling of a hydrogen-powered vehicle
*Ana González-Espinosa, **Antonio Lozano**, Juan Stehr, Jorge Barroso, Félix Barreras*

12:30 **S8-1** (Id.101)
Spatial planning of RFNBO electrolyzers through GIS–MCDA regulatory framework and statistical robustness analysis
***Jorge Cuevas Moreno**, Jordi Renau, Fernando Sanchez*

12:45 **S8-2** (Id.111)
Digital twins for green hydrogen plants: balancing efficiency, generation, and degradation
***Andrés Bernabeu Santisteban**, Héctor del Pozo González, Tolga Yalçin, Francisco Díaz-González, Lluís Trilla*

13:00 **S8-3** (Id.120)
Modeling the Voltage Response of Anion Exchange Membrane Water Electrolyzers with Different Electrode Materials for Power Electronics Design
***Hector del Pozo Gonzalez**, Andrés Bernabeu-Santisteban, Andres Alberto Garcia-Blanco*

13:15 **S8-4** (Id.106)
Design and validation of modular hydrogen range extenders for electric mobility: A methodological study
*Alberto Aguilar Asensio, **Javier Tobajas Blanco***

13:30 **Lunch**

15:30 -17-30 **Poster Session 2 and coffee break**

Wednesday, 10th June 2026 A2/D01 – Aulario II

Oral Session 10: Fuel cells / hydrogen

Chairperson: David Salinas-Torres

12:00 **K12** (Id.26)
Warped Graphene Layers Control ORR Activity of Carbon Catalysts via Configurational Entropy
Jun-ichi Ozaki, *Rieko Kobayashi*

12:30 **S10-1** (Id.45)
Development of hollow bimetallic catalysts supported on nanostructured carbons for sustainable PEM fuel cell electrodes
Ali Haider*, Lucas Elvira, Loïc Noumbi, Nathalie Job, Sophie Hermans*

12:45 **S10-2** (Id.88)
Tailoring Active and Stable Electrodeposited Ni-Based Catalysts for HER in Alkaline and Alkaline-Saline Media
María González Ingelmo, ***Lucia Muñiz Muñoz****, Clara Blanco, Ricardo Santamaría, Victoria García Rocha*

13:00 **S10-3** (Id.123)
Methanol Oxidation as a Diagnostic for OH Adsorption on Pt
Rubén Rizo, *Enrique Herrero*

13:15 **S10-4** (Id.85)
Engineering Nickel Catalysts for High-Efficiency Urea Electrolysis and Sustainable Hydrogen Production
María Cuartero-González

13:30 **Lunch**

15:30 -17-30 **Poster Session 2 and coffee break**

9:00-10:00 PLENARY LECTURE 3. Salón de Actos – Aulario II

Hybrid Electrochemical Energy Storage: Integrating Saline Electrolysis and CO_2 *Capture for Next-Generation Renewable Systems*

Prof. Manuel A. Rodrigo. University of Castilla-La Mancha, Spain

M.A. Rodrigo is Professor in Chemical Engineering at the University of Castilla-La Mancha (UCLM), with a career marked by pioneering contributions to electrochemical engineering. He graduated with honors in Industrial Chemistry from the University of Valencia in 1993 and earned his PhD in 1997, focusing on the automation of biological nutrient removal processes. Since joining UCLM in 1996, he has developed a robust research program in electrochemical technologies, initially targeting industrial wastewater treatment. His postdoctoral work at EPFL (Switzerland) introduced him to conductive diamond electrodes, which became central to his research. Over the years, he expanded his interests to include electrocoagulation, PEM fuel cells, electrocatalysis, electrokinetic soil remediation, and bioelectrochemical systems. More recently, he has explored innovative areas such as electro-refinery, reactive absorption, redox flow batteries and 3D-printed electrochemical cells. Rodrigo has published over 660 scientific articles, with a strong international collaboration rate and high impact (h-index 84, over 32000 citations). He has supervised 29 PhD theses and led numerous competitive projects and industry collaborations. He is deeply committed to mentoring young researchers and fostering international partnerships, particularly in Latin America. He has held leadership roles in major scientific societies and editorial boards and currently serves as Dean of the Faculty of Chemical Sciences and Technologies at UCLM. His work has been recognized with prestigious awards, including the 2020 Career Award from the Spanish Royal Society of Chemistry and the 2021 Research and Innovation Award from Castilla-La Mancha. In 2025, he was named Fellow of both the International Society of Electrochemistry and the Spanish Royal Academy of Sciences.

Chairperson: Francisco Montilla

Oral Session 11:Hydrogen

Chairperson: Cinthia Alegre

10:00 **K13** (Id.49)
Poly-Terphenyl-Piperidinium Anion Exchange Membranes for Next-Generation Hydrogen Technologies
Vincenzo Baglio, *Carmelo Lo Vecchio, Irene Gatto, Gioacchino Bucca, Cataldo Simari, H.M. Ur Rehman, Martina De Bonis, Isabella Nicotera*

10:30 **S11-1** (Id.53)
Experimental validation of operational strategies and decision support tools for renewable hydrogen production in PEM and AEM multi-stack electrolyzers
Eduardo López, *Alberto Monterroso, Miguel A. Ridao, Diego Tejada*

10:45 **S11-2** (Id.73)
Online identification of a semi-empirical reduced-order model for health monitoring of PEM electrolyser stacks
Diego Tejada Guzmán, Alberto Monterroso Muñoz, Víctor García Peñas, Eduardo López González, ***Jordi Renau Martínez***

11:00 **K14** (Id.62)
Stability Assessment of Commercial Membranes for AEM Water Electrolysis
Daniela Falcao, *Vasco Lopes, Alexandra Pinto, Rui Ferreira*

11:30 **Coffee break**

Oral Session 13: Advanced batteries and capacitors

Chairperson: María Jesús Lázaro

10:00 **K16** (Id.82)
Carbon Strategies for Rechargeable Batteries
Quan-Hong Yang

10:30 **S13-1** (Id.10)
Novel nitrogen-based solid polymeric electrolytes for next-generation Zinc batteries: An environmental impact analysis using Life Cycle Assessment methodology
Miguel Ángel González Lara, *Ángel Galán-Martín, Daniel Brandell, Pedro Navarrete-Segado, Manuel Merguizo, Antonio Peñas-Sanjuán*

10:45 **S13-2** (Id.24)
Novel Polyperylenediimide-Based Organic Polymers as Cathode Materials for Secondary Calcium Organic Batteries: A Green Chemistry Approach
Belén Martínez*, Ruben Cruz, Juan Pedro Merino, Celeste García, Antonio Peñas*

11:00 **S13-3** (Id.40)
High-Purity Recovery and Structural Restoration of Anode Graphite from NMC-Type Batteries using a Mild Citric Acid-Based Hydrometallurgical Route
Pedro Navarrete-Segado*, M. Luz Godino-Salido, Abhishek Khaimar, David Anguera, Stephan Stuhr, Antonio Peñas-Sanjuán*

11:15 **S13-4** (Id.76)
Development of Software for Energy Management and Cost Minimization in Electrochemical Plant Operation Using Renewable Energy and Battery Support
Miguel Ángel Rodríguez Cano*, Alberto Rodríguez Gómez, Justo Lobato Bajo, Manuel A Rodrigo Rodrigo*

11:30 **Coffee break**

Oral Session 12: Hydrogen

Chairperson: Daniel Torres

12:00 **K15** (Id.115)
Single-atom M-N-C catalysts for the electrochemical CO_2-to-CO conversion
***Sara Pérez Rodríguez**, Manuel Gutiérrez Roa, Ana Cristina Giménez Rubio, Irene Vela, David Sebastián del Río, María Jesús Lázaro Elorri*

12:30 **S12-1** (Id.50)
Activity and Stability of $NiFe_2O_4$ Catalysts in PiperION® Based AEM Electrolysers
***Carmelo Lo Vecchio**, Irene Gatto, Mairaj Ahmad, Riccardo Dollenz, Angelo Mondello, Assunta Patti, Gioacchino Bucca, Vincenzo Baglio*

12:45 **S12-2** (Id.72)
Unraveling the effect of high-entropy in layered hydroxides for oxygen evolution reaction catalysis and durability
***Gabriel Alemany-Molina**, Youssra Youssra Diouane, Raúl Serna-Guijarro, Álvaro Seijas-Da Silva, Gonzalo Abellán*

13:00 **S12-3** (Id.75)
Engineering NiFe-LDH-Based Composites with Molybdenum Chalcogenides for AEM Water Electrolysis
***Beatrice Ricciardi**, Cinthia Alegre, Carlos Serrano, María Jesús Lázaro, David Sebastián.*

13:15 **S12-4** (Id.79)
Direct seawater electrolysis for hydrogen production
***Gabriel Melle**, Alejandro Ortega-Murcia, María Porcel-Valenzuela, Marta García-Pellicer*

13:30 **CLOSING CEREMONY**

14:00 **Lunch**

Thursday, 11th June 2026 A2/D01 – Aulario II

Oral Session 14: Advanced batteries and capacitors

Chairperson: Marta Sevilla

12:00 **K17** (Id.99)
Post-treatments on carbon xerogels to improve their performance as negative electrodes of Na-ion batteries
Berke Karaman*, Hélène Tonnoir, Da Huo, Jimena Castro Gutiérrez, Bryan Carré, Alexandre F. Léonard, Marion Bermont, Zoé Deckers, Alain Celzard, Vanessa Fierro, Carine Davoisne, Raphaël Janot, Nathalie Job*

12:30 **S14-1** (Id.42)
A simple and effective method to synthesize ZnS@C composites for use as anode materials in Na-ion batteries
Raúl Gimeno Ferrero*, Noel Díez Nogués, Marta Sevilla Solís*

12:45 **S14-2** (Id.64)
Exploring Fast Parameterization of P2D Models in Commercial Sodium-Ion Batteries via Intermittent Current Interruption
Martin Roitegui*, Oier Arcelus, Emanuele Gucciardi*

13:00 **S14-3** (Id.105)
Chemical design of sustainable materials for the anode of high-performance sodium-ion battery anodes
Julia Trojaola*, David García, Nuria Cuesta, Natalia Rey-Raap, Ana Arenillas, Belén Lobato, Ignacio Cameán*

13:15 **S14-4** (Id.108)
Pore Size Engineering in Sustainable Materials for Enhanced Sodium-Ion Battery Capacity
David García Pérez*, Julia Trojaola, Nuria Cuesta, Belen Lobato, Ana Beatriz García, Ana Arenillas, Natalia Rey-Raap, Ignacio Cameán*

13:30 **CLOSING CEREMONY**

14:00 **Lunch**

POSTER SESSION

HYDROGEN AND FUEL CELLS

P1 (Id.5)

Co_3O_4 and Cr_2O_3 Particles Supported Biomass–Derived Nitrogen-Doped Carbon as an Electrocatalysts for Hydrogen Evolution Reaction

Karina Vjūnova, *Loreta Tamašauskaitė-Tamašiūnaitė*

P2 (Id.8)

Preliminary assessment of hydrogen production via solar-driven biomass gasification

Diogo Canavarro, *Bruna Rijo, Paulo Brito*

P3 (Id.21)

Production of H_2 from formic acid by tuning palladium-based catalysts supported on N-doped activated carbon

Paula Riquelme García, *Jerónimo Juan Juan, David Salinas Torres, Miriam Navlani García, Diego Cazorla-Amorós, Alina Skorynina*

P4 (Id.22)

Biomass-derived nitrogen-doped Pd/C catalysts: tuning nitrogen groups for hydrogen storage and production

María Bernal-Vela, *Miriam Navlani-García, Diego Cazorla-Amorós*

P5 (Id.32)

Methodology for MEA characterization

Joël Martín Dalmas, *Adrián Martín Pintos, Marcos Castrillo Cuevas, Jose Ignacio Domínguez Carrero*

P6 (Id.47)

Highly porous carbons from hydrochar by means of a controlled physical activation process and their hydrogen storage performance

Marta Sevilla, *Ana Fernández-Lera, María Dolores Casal, Stephen Otieno, Leo Scott Blankenship, Robert Mokaya, Teresa Valdés-Solís*

P7 (Id.51)

Aqueous-phase catalytic ammonia decomposition for hydrogen production at moderate temperature

Manuela Sanchez Barbon, *Cristina Ruiz-Garcia, Jose Alberto Baeza, Luisa Calvo, Miguel Angel Gilarranz*

P8 (Id.52)

Techno-economic analysis of the integration of biomass-based processes and water electrolysis for hydrogen and renewable fuels production

Eduardo López, *Diego Tejada, Adrián Castro, Bruna Rijo, Cecilia Mateos-Pedrero, Paulo Brito, Jose I. Domínguez, Ángel Álvarez, Jimena Incer, Fausto Posso*

P9 (Id.55)

Electrooxidation of glycerol catalyzed by low-temperature heat-treated NiO-based catalysts in alkaline media

Raúl Ligero Peralta, *David Salinas Torres, Diego Cazorla-Amorós, Emilia Morallon*

P10 (Id.57)

Low-coated Pt/graphene electrocatalysts for her: synthesis, optimization and characterization in acidic and alkaline media

Javier García de Quirós, *Sara Rodríguez, Emilia Morallón, Diego Cazorla-Amorós*

P11 (Id.59)

Lactic acid photoreforming over CdS: influence of crystallinity on activity under UV and solar irradiation

Juan Manuel Rives López, *María Carmen Román Martínez, María Ángeles Lillo Ródenas*

P12 (Id.60)

Boosting hydrogen production via photoreforming of the aqueous phase from hydrothermal carbonization of olive stones: effect of reaction conditions

Manuel Peñas-Garzón, María J. Valero-Romero, Ramiro R. Ruiz-Rosas, Juana M. Rosas, ***Jose Rodríguez-Mirasol***, *Tomás Cordero*

P13 (Id.61)

H_2 production by glycerol photoreforming under UV and solar light using TiO_2-Cu photocatalyst

Juan Carlos Maciá Barrios, *Macarena Espinosa Agulló, María Carmen Román Martínez, María Ángeles Lillo Ródenas*

P14 (Id.65)

Hydrogen production via steam gasification of char obtained from slow pyrolysis of lignocellulosic biomass

María Nerea Rivas Márquez, *Ramiro Ruiz Rosas, Juana María Rosas, José Rodríguez Mirasol, Tomás Cordero*

P15 (Id.66)

Hydrogen production through the water – gas shift reaction using sustainable Cu and Cu/ZnO – based catalysts

María Nerea Rivas Márquez, *Paula Riquelme García, Ramiro Ruiz Rosas, Miriam Navlani, Juana María Rosas, Diego Cazorla-Amorós, José Rodríguez Mirasol, Tomás Cordero*

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Alberto Aguilar Asensio, ***Javier Tobajas Blanco***

P17 (Id.77)

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Francisco Manuel Soria López, ***Miguel Ángel Rodríguez Cano***, *Pablo Cañizares, Justo Lobato, Jesús Rodríguez-Ruiz, Carmen M. Fernández Marchante*

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Paula Arias Cuberas, *Alejandro Clemente Leon, Levon Gevorkov, Lluis Trilla*

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Design of ionic liquid-based ionogel membranes as alternatives to PFSA-based membranes in PEM fuel cells

Eduardo Iniesta-López, *Adrian Hernandez-Fernandez, Pranav Sharda, Josh Bailey, Antonia Perez-de-los-Rios, Francisco Jose Hernandez-Fernandez*

P20 (Id.93)

Role of pore structure in the stability of Fe–N–C catalysts based on carbon xerogels for fuel cells

Cinthia Alegre, *Miguel Coca-Arroyo, Beatrice Ricciardi, Laura Álvarez-Manuel, María Jesús Lázaro, David Sebastián*

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Maria Camila González, *Francisco Huerta, Francisco Montilla, Andrés Quintero*

P22 (Id.98)

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Abraham Castilla Silvestre, *Elena Pastor, Sergio Díaz Coello, Julia Kunze Liebhäuser, Rubén Rizo*

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Tiago Sanros, *José Sousa, Frederico Relvas, Adélio Mendes*

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Lidia Garcia Santos, *Mario García-Rodríguez, Samuel Calabuig-Mompó, Diego Cazorla-Amorós, Emilia Morallón*

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Evaldo B. Carneiro-Neto, Kelvin Costa de Araújo, Roger Gonçalves, ***Ernesto Chaves Pereira de Souza***

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ADVANCED BATTERIES AND CAPACITORS

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Sustainable functionalization of carbon materials with nitrogen via mechanochemistry for energy storage applications

Joel Gran-García, Jorge Sánchez-Carrasco, ***Jessica Alejandra Chaparro-Garnica****, David Salinas-Torres, Emilia Morallón, Diego Cazorla-Amorós*

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Óscar Jareño Amorós*, Jessica Chaparro Garnica, Emerson Vega Ramírez, David Salinas Torres, Emilia Morallón, Diego Cazorla-Amorós*

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Can sodium carbonate be a sustainable electrolyte for activated carbon–based supercapacitors?

Laia Figueres-Fernández*, Cristian Jaimes-Páez, David Salinas-Torres, Diego Cazorla-Amorós, Emilia Morallón*

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Influence of Oxygen Functional Groups on Iron Phthalocyanine–Graphene Interactions for Enhanced ORR Electrocatalysis

Samuel Calabuig Mompó, *Gabriel Alemany Molina, Diego Cazorla-Amorós, Emilia Morallón*

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Ricardo Hincapié-Ocampo*, Cristian Jaimes-Páez, Emilia Morallón, Ángel Berenguer-Murcia, Diego Cazorla-Amorós*

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Dual-Phase High-Entropy Oxide (CrMnCoNiCu)xOy as a High-Performance Anode for Lithium-Ion Batteries

Dávid Csík*, Lenka Oroszová, Gabriela Baranová, Róbert Džunda, Beáta Ballóková, Zuzana Molčanová, Karel Saksl*

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High-Entropy Oxide $(CrMnFeCoNi)_3O_4$ as an Electrocatalyst for High-Performance Lithium-Sulfur Batteries

Lenka Oroszová*, Dávid Csík, Gabriela Baranová, Róbert Džunda*

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Activated Carbon from Peach Pits with Chicken Feather Keratin for Supercapacitor Electrodes.

Ofelia Marilú Arias Pinedo*, Vitor L Martins, David Salinas Torres, Angélica M Baena-Moncada*

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TEMPO immobilized on magnetic silica nanoparticles as electrocatalyst for energy storage applications.

Francisco José Lloret-Mateo*, César Quijada, Raúl Berenguer*

P36 (Id.113)

Valorization of grape pomace residues into N-doped activated carbons as electrochemical capacitor electrodes

Diego Lobato, Irene Vela, Sara Pérez Rodriguez, Cinthia Alegre, ***María Jesús Lázaro Elorri***

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Protocols for evaluating advanced bio-sourced gel polymer electrolytes (GPEs) for sustainable zinc-air battery (ZAB) applications

Barbara Belza*, Luca Bargnesi, Maria Martinez-Ibañez, Nagore Ortiz Vitoriano, Mattia Felice Palermo*

P38 (Id.130)

Binder-free and self-standing porous carbon fabric for flexible supercapacitors

Angel Del Blanco García*, Marta Sevilla, Noel Diez, Antonio José Paleo*

SOCIAL PROGRAM

Participants and accompanying persons of HYCELTEC 2026 are invited to all the activities detailed in this social programme.

Monday, 8th June 2026

Welcome reception at the Museum of the University of Alicante (MUA). It will take place from 19:00 to 20:30 h.

Tuesday, 9th June 2026

Cocktail at Dársena Restaurant (Address: Perfecto Palacio de la Fuente, Muelle Pte., 6, 03003 Alicante; Panoramis Life & Business)

- From San Vicente del Raspeig to Dársena Restaurant:

Two buses will leave from Residencia Villa Universitaria (Avda. Vicente Savall Pascual, 16, San Vicente del Raspeig) at 20:00 h.

- From Dársena Restaurant to San Vicente del Raspeig:

Two buses will leave from Dársena Restaurant at 23:00 h.

Wednesday, 10th June 2026

Conference Banquet at Meliá Hotel (Address: Plaza del Puerto 3, Alicante)

- From San Vicente del Raspeig to Meliá Hotel:

Two buses will leave from Residencia Villa Universitaria (Avda. Vicente Savall Pascual, 16, San Vicente del Raspeig) at 20:00 h.

- From Meliá Hotel to San Vicente del Raspeig:

Two buses will leave from Meliá Hotel at 23:00 h.

HYCELTEC 2026

X Symposium on Hydrogen,
Fuel Cells and Advanced Batteries

8-11 June 2026, Alicante (Spain)

BOOK OF ABSTRACTS

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PLENARY LECTURES

Plenary Lecture 1

Design of Nanostructured Catalysts for Sustainable Energy and Environmental Uses

Hiromi YAMASHITA (1)

[1] Division of Materials and Manufacturing Science, Graduate School of Engineering, The University of Osaka, 2-1 Yamada-oka, Suita, Osaka 565-0871, Japan

Type of abstract: Plenary speakers
Subject area: Hydrogen

The utilization of unique reaction fields such as nanoporous spaces in zeolites, mesoporous silica, and metal-organic frameworks (MOFs), as well as thin film interfaces, has been applied for solid-catalyst design. By employing innovative catalyst preparation techniques, distinctive catalytic structures and surface active sites have been designed, including single-site photocatalysts (isolated metal ions and photo-functional metal complexes), ultra-fine semiconductor photocatalysts, plasmonic catalysts, non-equilibrium alloy nanoparticle catalysts, high-entropy alloy nanoparticle catalysts, and porous metal catalysts. Advanced surface structure analysis using cutting-edge spectroscopic and microscopic methods, such as synchrotron operando XAFS and aberration-corrected STEM, along with theoretical calculations, has enabled the elucidation of mechanisms and the design of new catalytic materials and reaction fields. The developed unique reaction fields and catalytic active sites have been applied to environmentally friendly reactions, including hydrogen cycle reactions (hydrogen production from water and hydrogen carrier molecules, hydrogen peroxide synthesis), carbon dioxide fixation reactions (synthesis of CO, formic acid, methanol, methane), and purification of air and water. By precisely controlling the structure of complex solid catalysts and their surrounding reaction fields at the nanoscale, and applying advanced operando spectroscopic analysis and thorough theoretical calculations, a new catalyst design method, “nanoscale design”, has been established.

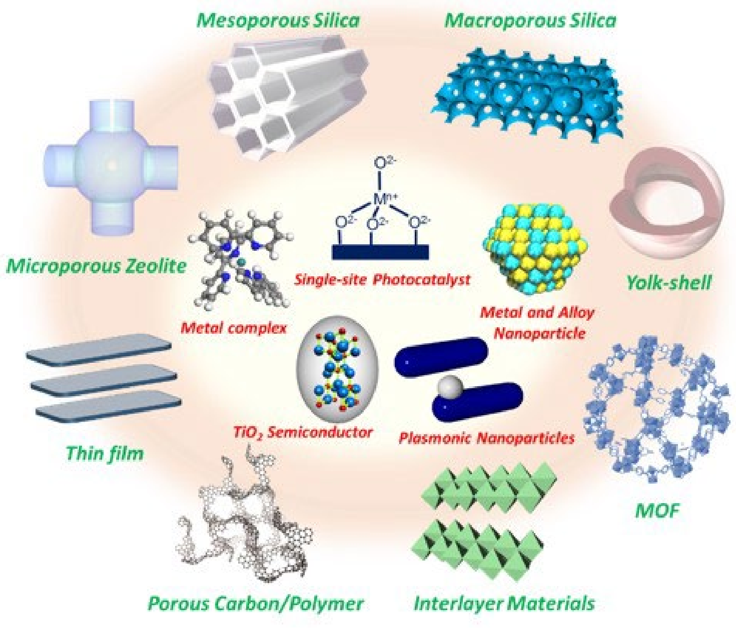

Figure 1. Design of mesostructured catalysts and photocatalysts using porous materials.

References:

1. H-J. Kim, H. Yamashita, et al. Nature Comm. 16, 2025, 2697.

2. H. Yamashita, et al. Chem. Soc. Rev. 47, 2018, 8072-8096.

3. Y. Kuwahara, H. Yamashita, et al. J. Am. Chem. Soc. 140, 2018, 9203-9210.

4. K. Mori, H. Yamashita, et al. J. Am. Chem. Soc. 140, 2018, 8902-8909.

Plenary Lecture 2

Exploring the electrode/electrolyte interface of carbon-based supercapacitors

RAYMUNDO PIÑERO Encarnacion (1), E. Salager (2), M. Deschamps (2) (1)

CEMHTI-CNRS Orléans. France, (2) RS2E, France.

Type of abstract: Plenary speakers
Subject area: Advanced batteries and capacitors

Supercapacitors owe their existence to the extraordinary physico-chemical properties of porous carbon. Without the high specific surface area, exceptional electrical conductivity and outstanding (electro)chemical stability of carbon, these devices would not be developed. By complementing batteries, which are known for their high energy density, supercapacitors have unlocked new possibilities in power applications for electrochemical energy storage.

The most common type of supercapacitor is the electric double-layer capacitor (EDLC). Using carbon electrodes with an adequate porous texture in organic electrolytes enables voltages of up to 2.9 V to be achieved. However, these electrolytes pose some safety and environmental risks. In response to societal demands for sustainability and security, aqueous electrolytes offer a more environmentally friendly alternative. Nevertheless, the stability potential window of water, i.e. 1.23 V, results in low energy density. Overcoming this scientific and technical challenge requires careful electrolyte selection and modulation of carbon surface functionality, as this has a direct impact on enhancing energy storage through pseudocapacitive effects while preventing irreversible reactions that compromise device performance [1].

This presentation highlights that, no mater the electrolyte, understanding the electrode/electrolyte interface is key to developing high-performance supercapacitors. Advanced techniques such as NMR spectroscopy (ex-situ, in-situ) and operando electrochemical mass spectrometry enable us to investigate charge storage mechanisms at the carbon/electrolyte interface (Figure 1) and detect undesirable side reactions during ageing [2,3]. This insight is crucial for designing new carbon materials tailored to specific electrolytes, which can enhance the energy density of supercapacitors while maintaining high power density and long cycle life.

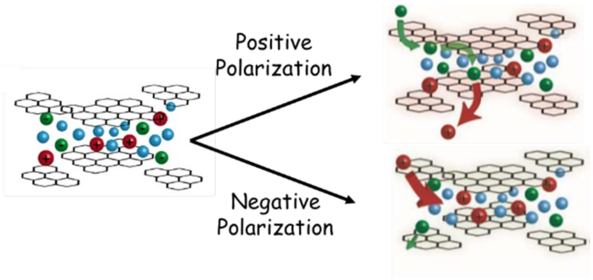

Figure 1. Charge storage mechanism of a nanoporous carbons operating in an organic electrolye determined by NMR measurements [2].

References

[1] A. Gomis Berenguer, M. Weissmann, R. Omnee, E. Raymundo-Piñero. Carbon 234, 2025, 119927. [2] G. Oukali, E. Salager, M.R. Ammar, C.E. Dutoit, V. SarouKanian, P. Simon, E. Raymundo-Piñero, M. Deschamps. ACS Nano 13, 2019, 12810-12815. [3] C. Neto, H. T. T. Pham, R. Omnée, A. Canizarès, A. Slodczyk, M. Deschamps, E. Raymundo-Piñero. ACS Applied Materials & Interfaces 14, 2022, 44405-44418.

Plenary Lecture 3

Hybrid Electrochemical Energy Storage: Integrating Saline Electrolysis and CO_2 Capture for Next-Generation Renewable Systems

Manuel Andrés Rodrigo Rodrigo (1), Miguel Angel Rodríguez Cano (2), Alberto Rodríguez-Gómez (2), Rafael Granados-Fernández (2), Carmen María Fernandez Marchante (2), Engracia Lacasa Fernández (2), Cristina Sáez (2), Justo Lobato (2)

(1) University of Castilla La Mancha. Department of Chemical Engineering. Spain, (2) University of Castilla La Mancha , Spain

Type of abstract: Plenary speakers
Subject area: Hydrogen
Keywords: Hybrid energy storage systems; Saline electrolysis; Electrochemical CO_2 capture; Renewable energy integration; Hydrogen-based sustainability technologies

The need for efficient energy storage systems capable of regulating renewable energy by aligning generation and consumption has become increasingly critical. This urgency emerges as both the number and diversity of applications grow, from mobility solutions to grid-support technologies that enhance flexibility and network stability. Despite significant progress, no large-scale definitive solution exists, prompting extensive research to explore technological niches and propose alternative approaches.

Hydrogen has long been considered a strong candidate and benefits from mature technologies at TRL 9, including PEM and SO electrolysis and fuel cells. However, many sectors, particularly automotive, have prioritized conventional batteries. At larger scales, replacing pumped hydropower with electrochemical options remains challenging; even advanced systems like redox flow batteries struggle with scalability. Difficulties in water management and process integration have contributed to a preference for simpler yet less efficient technologies.

In this context, recent research has focused on integrating saline electrolyzers into energy storage schemes. When properly operated, these systems not only generate hydrogen through water electrolysis but also capture carbon dioxide via electrochemically assisted reactive absorption. This dual functionality enables more sustainable applications than current alternatives, including hybrid solar engines, although these remain at low TRL levels.

This presentation provides an overview of the key components required to implement this technology and describes several successful case studies, such as genuinely hybrid automotive and agricultural-irrigation engines, as well as ongoing developments aimed at improving water and energy management in photovoltaic solar-plant environments.

KEYNOTE
LECTURES

Keynote Lecture 1 (Id.1)

In Situ Time-Resolved X-ray Absorption Spectroscopy Unveils Partial Re-Oxidation of Tellurium Cluster for Prolonged Lifespan in Hydrogen Evolution.

Pang kanglei (1), Jiayin Yuan (1), Uguz Neli Özlem (1)
(1) Stockholm University. Sweden

Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords: Catalysts; Hydrogen evolution reactions; semimetal

Efficient and long-lasting electrocatalysts are one of the key factors in determining their large-scale commercial viability. Although the fundamentals of deactivation and regeneration of electrocatalysts are crucial for understanding and sustaining durable activity, little has been conducted on metalloids compared to metal-derived ones. Herein, by virtue of in situ seconds-resolved X-ray absorption spectroscopy, we discovered the chemical evolution during the deactivation-regeneration cycles of tellurium clusters supported by nitrogen-doped carbon (termed Te-ACs@NC) as a high-performance electrocatalyst in the hydrogen evolution reaction (HER). Through in situ electrochemical reduction, Te-ACs@NC, which had been deactivated due to surface phase transitions in a previous HER process, was reactivated and regenerated for the next run, where partially oxidized Te was found, surprisingly, to perform better than its nonoxidized state. After 10 consecutive deactivation-regeneration cycles over 480 h, the Te-ACs@NC retained 85% of its initial catalytic activity. Theoretical studies suggest that local oxidation modulates the electronic distribution within individual Te clusters to optimize the adsorption energy of water molecules and reduce dissociation energy. This study provides fundamental insights into the rarely explored metalloid cluster catalysts during deactivation and regeneration and will assist in the future design and development of supported catalysts with high activity and long durability.

References

[1] K. Pang, C. Long, Y. Zhang, M. Zhang, J. Chang, Y.-L. Wang, H. Zhang, R. Liu, S. Saeedi Garakani, Ö. Uguz Neli, J. Yuan; J. Am. Chem. Soc. 2025, 147, 17, 14359–14368.

Keynote Lecture 2 (Id.118)

Operando Insights into Transition Metal Phosphides during the Oxygen Evolution Reaction

David Ríos Ruiz (1), Pablo Arévalo Cid (1), Armando Ibraliu (2), Verónica Celorrio (3), Sandra Drev (4), Cecilia Gómez-Sacedón (5), Antonio de Lucas-Consuegra (5), Maria Victoria Martinez Huerta (1)

(1) Instituto de Catálisis y Petroleoquímica, CSIC. Spain, (2) Diamond Light Source Ltd. United Kingdom, (3) Diamond Light Source Ltd. Spain, (4) Center for Electron Microscopy and Microanalysis. Slovenia, (5) Universidad de Castilla La Mancha. Spain

Type of abstract: Keynote speakers
Subject area: Hydrogen
Keywords: oxygen evolution reaction; metal phosphide; Ni2P; Fe2P;operando XAS;

The increasing energy demand and environmental deterioration have driven the development of clean and renewable energy technologies. Hydrogen production by water electrolysis is a promising strategy, although its efficiency is limited by the sluggish OER. Earth-abundant phosphide catalysts have emerged as alternatives to noble-metal systems due to their high activity and stability [1]. Here, we reveal the structure-activity relationship in Ni_2P/Fe_2P catalysts via operando XAS and their evaluation in an AEM water electrolyzer, providing insight into their structural evolution under OER conditions.

A series of Ni-Fe-based catalysts with varying Ni:Fe ratios (1.4-7) were synthesized via solvothermal carbonization [2], using dopamine as C and N precursor and $NH_4H_2PO_4$ as P source, to identify the optimal composition for OER. A clear dependence of activity on the Ni:Fe ratio was observed, with the NiFeP 6 catalyst showing the best performance, with an overpotential of 290 mV at 10 $mA\cdot cm^{-2}$ and a Tafel slope of 38 $mV\cdot dec^{-1}$ (1M KOH). XRD and XPS analyses confirm the formation of Ni_2P and Fe_2P phases, associated with enhanced activity and stability. The P-doped catalysts exhibit hollow spheroidal morphologies, whereas P-free samples form intermetallic Ni_3Fe structures with collapsed morphologies. The P-doped material also showed superior performance at 100 $mA\cdot cm^{-2}$ in AEM water electrolyzer tests.

Operando XAS studies revealed the outstanding structural robustness of the Ni_2P and Fe_2P phases under OER conditions, with preferential oxidation of Fe relative to Ni. XANES analysis demonstrated the evolution of Fe^0 to Fe^{3+} during operation, providing insight into the catalyst's structural dynamics. These results stablish a clear structure-activity relationship, where Fe-centered oxidation and phosphide preservation underpin the enhanced activity and durability. Overall, N,P-doped NiFebased catalysts emerge as promising candidates for efficient OER electrocatalysis.

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Keynote Lecture 3 (Id.25)

H_2 production via photo(thermo)reforming of organic compounds on hybrid carbon/semiconductor catalysts

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Type of abstract Keynote speakers
Subject area: Hydrogen

Many semiconductors are capable of splitting water into H_2 under adequate illumination, but most of them present a poor activity in the full solar spectrum [1,2]. To overcome this, we have investigated the production of H_2 by photo(thermo)reforming of aqueous solutions of organic compounds. Our approach is based on carbon/semiconductor heterojunctions that combine the optical properties of the semiconductors with the strong light absorbing features and thermal conductivity of the carbon material. A series of photo(thermo)catalysts were prepared using semiconductors (Nb_2O_5, C_3N_4, TiO_2) and various loading ratios of carbon materials (graphene oxide, reduced graphene oxide, carbon foams). The photoreforming tests were performed in aqueous solutions of methanol, ethanol or glycerol as organic substrates, and irradiating with UV (LEDs) or natural solar light. The photothermal response of the carbon materials showed a direct correlation with their surface chemistry, with all of them displaying a fast temperature increase upon illumination (up to 25-50ºC). Data showed a dependence of the reaction rate with the temperature of the photoreforming assays, showing a predominance of photothermal effects over the photochemical reaction. The final temperature of the photoreforming assays depended on the composition of the carbon material, demonstrating the important role of the photothermal effect (Figure 1). Data on H_2 productivity (ca. 10-30 mmol H_2/h g), showed better results obtained with the heterostructures synthesized with ca. 10 wt.% of carbon material, with slightly better performances for the photoreforming of methanol and ethanol.

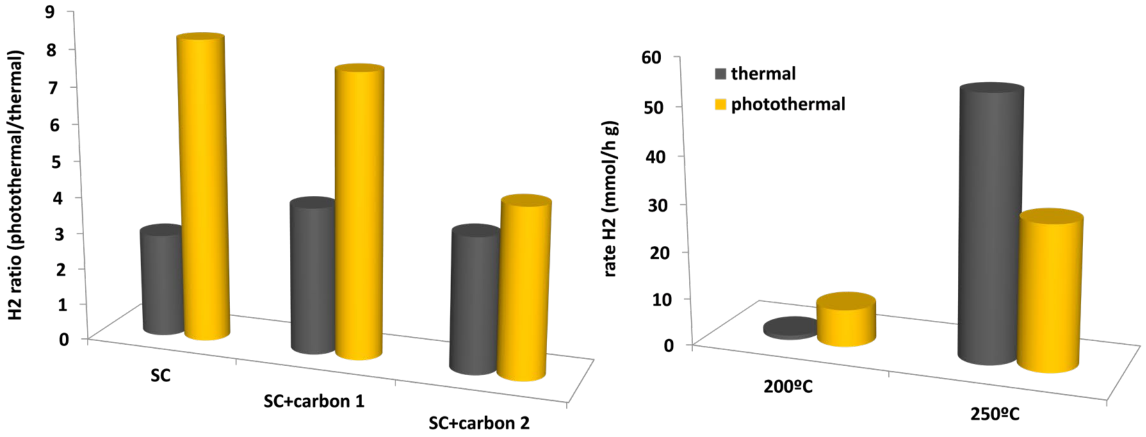

Figure 1. Dependence of the (left) photothermal/thermal H_2 production ratio with the composition of the catalysts and (right) H_2 productivity (mmol/hg) at various temperatures.

Acknowledgments. The authors thank the financial support of CET co-funded Partnership (HORIZON-CL5-2021-D3-01-04) through the grant CLYOSPHERE.

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Keynote Lecture 4 (Id.87)

Modeling High-Pressure Hydrogen Uptake by Nanoporous Materials

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Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords: Hydrogen adsorption; Isotherm modeling; modified Dubinin–Astakhov (MDA) equation; Hydrogen storage prediction.

Cryogenic hydrogen storage pressures can be significantly reduced by incorporating microporous materials (pore diameter < 2 nm), which enhance adsorption at 77 K and pressures below 10 MPa. Compared to conventional compression (≈70 MPa), this approach enables the use of lower-strength materials, leading to lighter and more compact storage systems.

Hydrogen adsorption in nanoporous materials has been modeled using the Sips, Toth, and modified Dubinin–Astakhov (MDA) equations. The MDA model accurately reproduces adsorption isotherms over a wide range of conditions (50–300 K, 0.1–14 MPa). Correlations between MDA parameters (m, n_{max}, α, β, P_o, V_a) and textural properties were established for activated carbons [1] and metal–organic frameworks [2], based on fitting 11 isotherms (11 points each) per material over 77–213 K and up to 14 MPa. Unlike previous approaches that assume a constant pseudo-saturation pressure, we introduce two refinements in this study: (i) treating the exponent m, which reflects the pore-energy heterogeneity of the adsorbent, as an adjustable parameter, and (ii) expressing the pseudo-saturation pressure as a temperature-dependent function, analogous to the Antoine equation. This formulation significantly improves the accuracy of the fits and reveals an exponential correlation between the pseudo-saturation pressure and the specific surface area derived from NLDFT, thereby enhancing both the physical interpretability and the predictive capability of the model.

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Keynote Lecture 5 (Id.87)

Microbial Electrochemical Technology for sustainable wastewater treatment and simultaneous hydrogen production

Ana J. Vega de Armas (1), Marti Aliaguilla (2), Pau Bosch-Jimenez (2), Eduard Borràs (2), Lidia Zulema Borjas (3), Abraham Esteve-Núñez (4), Juan Manuel Ortiz (1)

(1) IMDEA Water Institute. Spain, (2) LEITAT Technological Center. Spain, (3) SORIGUÉ. Spain, (4) Universidad de Alcalá. Spain

Type of abstract: Keynote speakers
Subject area: Hydrogen
Keywords: Microbial electrolysis cell; environmental biotechnology; wastewater treatment; green hydrogen; water technology

Wastewater treatment plants are energy intensive infrastructures based on biological degradation of the sewage. In conventional treatment plants, air is pumped in bioreactors to supply oxygen for degradation of organic matter (60-70% of the energy cost in these plants).

Bioelectrochemical systems (BES) combine electrochemistry with electroactive microorganisms for energy production. In Microbial Electrolysis Cells (MECs), electroactive bacteria grow building a biofilm on the surface of a conductive anode, which acts as electron acceptor. The microorganisms oxidize organic matter under anaerobic conditions and the electrons obtained in the process are transferred from the anode to the cathode through an electrical circuit [1]. The cathodic reaction is the H_2 formation through H_2O reduction under alkaline conditions. The saline compartment is filled with $NaHCO_3$ in order to avoid acidification of the biofilm (limitation) in the anodic chamber, as bicarbonate migrates from saline compartment due the electric field in the bioelectrochemical system.

In this work, we present the BES-BioH_2 system, a laboratory scaled reactor based on a MEC system [2] with the purpose of obtaining biohydrogen with lower energy requirements than conventional electrolysis, using the energy produced by electroactive microorganisms and employing urban wastewater as organic matter source. The electrochemical operation of the BES-BioH_2 reactor is analysed to obtain the potential diagram of the system and its energy analysis is performed.

Additionally, the microbial population is assessed and correlated to the microbial electrochemical behaviour of the system. The results obtained allow us to determine the optimal operational conditions that would allow us to obtain H2 and remove COD from wastewater with lower energy requirements than conventional processes (<20 kWh kg^{-1} H^2).

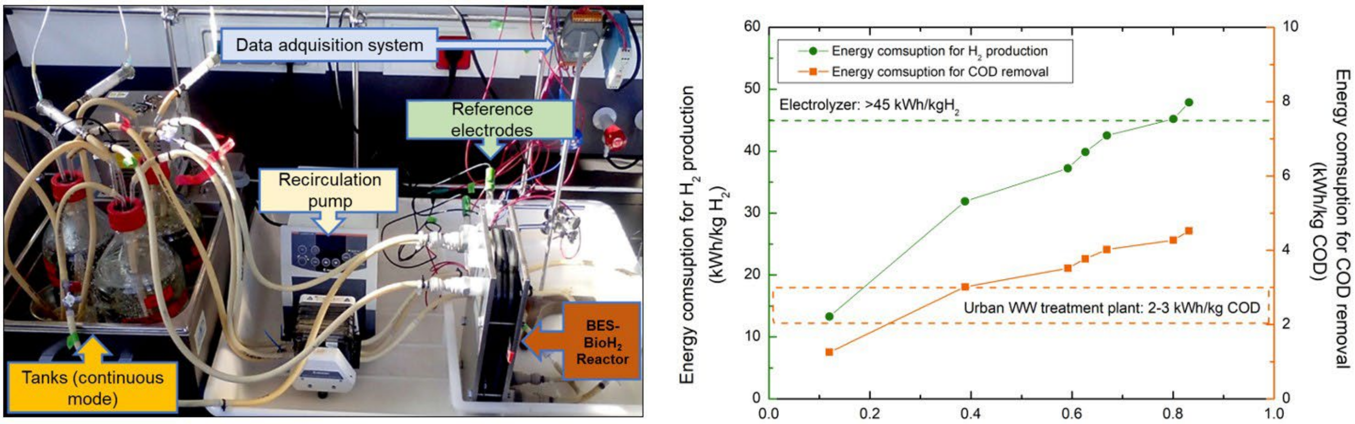

Figure 1. Experimental setup and potential diagram for the BES-BioH_2 system using synthetic wastewater.

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Keynote Lecture 6 (Id.68)

3D carbon electrodes manufactured by Direct Ink Writing for all-iron redox flow batteries

Victoria García Rocha (1), Pablo Rodriguez Lagar (1), Alejandro Concheso Álvarez (1), Daniel Barreda (1), Zoraida González Arias (1), Miguel Montes-Morán (1), J. Ángel Menéndez (1), Clara Blanco (1), Ricardo Santamaría (1)

(1) Instituto de Ciencia y Tecnología del Carbono, CSIC. Spain

Type of abstract: Keynote speakers
Subject area: Advanced batteries and capacitors

The rich chemistry and natural abundance of iron make it a strong candidate for developing sustainable all-iron redox flow batteries (RFBs), offering an alternative to established systems, such as all-vanadium RFBs. However, the inherently slow kinetics of iron plating/stripping and the parasitic hydrogen evolution reaction (HER) at the negative electrode limit battery performance and durability. Commercial carbon felts are commonly used as electrodes in RFBs, but their low wettability, limited catalytic activity, and disordered structure make their performance improvement challenging. Direct Ink Writing (DIW) enables the manufacture of complex 3D architectures using a wide range of materials by formulating shear-thinning inks or pastes. Formulating printable materials that can be shaped and used as-printed (or with minimal post-processing) is a promising approach to tailoring the composition of 3D electrodes with high surface area, efficient mass transport, and low pressure drop.

In this work, highly conductive carbon-based pastes processed by DIW and thermal post-processing enabled the fabrication of mechanically strong 3D electrodes. Formulation of the carbon pastes was based on different ingredients, with proportions tuned to maximize the performance of the anode of an all-iron RFB. Among the formulations studied, those containing high graphite loadings consolidated through a graphitizable binder showed the highest overpotential towards HER. Hydrogen evolution was quantified by operando mass spectroscopy coupled to a three-electrode cell. In addition, battery tests with the
3D electrode yielded coulombic (CE) and voltage efficiencies (VE) around 80% after more than 50 h of cycling. Notably, the VE obtained with the 3D all-carbon electrodes exceeded that of the same system but using a commercial carbon felt anode.

Keynote Lecture 7 (Id.54)

High Fe(III) Content Molecular Electrocatalyst in Fuel Cell Applications

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Type of abstract: Keynote speakers
Subject area: Fuel cells
Keywords: Electrocatalysis; Oxygen reduction reaction; Fe phthalocyanines, fuel cell, penta-coordination.

Fe phthalocyanine (FePc) axially coordinated to 4-amino-pyridine (Py) or 4-amino-3-nitropyridine (NPy) shows drastically high Fe(III) content associated with high performance for the ORR. The electrocatalytic studies of the oxygen reduction reaction (ORR) in alkaline media show better performances than the commonly used Pt/C 20% electrocatalyst in terms of overpotential (ΔE0'= [E0'onset Fe-NPy-CNT - E0'onset Pt0] = 35 mV) and similar TOF rates at 0.9 V vs. RHE (~1.00 e− site−1 s−1). The NPy axial ligand exerts a high electron-withdrawing power on the Fe centre, causing a shift to a more positive value of E0'Fe(III)/(II) contrasted to FePc-CNT with a ΔE0'= [E0'FePc-NPy-CNT(III)/(II) - E0'FePc-CNT(III)/(II)] = 56 mV. The decrease in electron density at the metal centre and higher concentrations of Fe(III) in the catalyst lead to weaker interactions with O_2. DFT calculations show that the FePc-NPy-CNT catalyst has propitious interactions with O2, with an adsorption energy of -0.37 eV and high O_2 -Fe bond distance, explaining the superior performance. Theoretical overpotential calculations corroborate the simulations and the experiments. Anion exchange membrane fuel cell experiments confirm the extremely high activity of the electrocatalyst with a maximum OCV of 0.98 V and peak current density of 151 mWcm-2 and the feasibility of employing molecular catalysts in real conditions.

Keynote Lecture 8 (Id.20)

Intrinsic Electronic Limitations in Carbon Electrodes for Electrochemical Capacitors

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Type of abstract Keynote speakers
Subject area: Advanced batteries and capacitors
Keywords: Supercapacitors, Graphene, Quantum capacitance, Carbon defects

Electrochemical capacitance in carbon electrodes is traditionally interpreted through specific surface area, pore size distribution, and ion accessibility. According to the electric double-layer model, increasing accessible surface area and optimizing ion–carbon distance should enhance capacitance. However, experimental observations often show that capacitance does not scale proportionally with these factors remains inconsistent across different carbon materials. These empirical observations suggest the presence of intrinsic limitations beyond the well-established factors.

In this presentation, it is proposed that electrochemical capacitance can be partially limited by the intrinsic electronic property of carbon itself. The total capacitance can be conceptually divided into electrolyte-side and carbon-side contributions, independent of the effects of surface area and ion accessibility. While the former is governed by ion confinement and desolvation, the latter is associated with the electronic density of states and charge carrier response within the carbon framework. In graphene-based or highly graphitized carbons, the relatively low electronic density of states near the Fermi level can make the carbon-side contribution rate-limiting within certain potential ranges.

Recent studies on activated carbons reveal correlations between structural disorder and areal capacitance, indicating that disorder influences not only pore geometry but also electronic properties. Modifications in π-electron delocalization and local electronic states can alter the carbon-side contribution to capacitance, highlighting disorder engineering as a potential design strategy.

Three-dimensional graphene frameworks are discussed as model systems to examine how intrinsic carbon properties govern electrochemical response. This perspective moves beyond a purely surface-area-driven paradigm toward integrated structural and electronic optimization of carbon electrodes for advanced capacitors.

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Keynote Lecture 9 (Id.78)

Steam reforming of biomass pyrolysis liquids using Ni supported on activated carbons obtained from biomass pyrolysis solids

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Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords:steam reforming; activated carbon; pyrolysis; carbon nanotubes; nickel catalysts

Steam reforming (SR) of biomass-derived pyrolysis liquids (bio-oil) for hydrogen production using carbon-supported Ni catalysts has gained increasing attention. In this context, biochars generated during pyrolysis can be valorized as precursors for activated carbons, which can subsequently be used as catalyst supports. However, these catalytic systems suffers of deactivation at long time on streams by coke deposition and/or gasification of the carbon support.

To address these challenges, we have systematically investigated several strategies to tune the surface properties of carbon supports for the SR of model bio-oil compounds. These approaches are grounded in established principles of carbon materials science, including: (i) modification of the activation method to tailor porosity, (ii) functionalization of the surface to introduce specific chemical groups, and (iii) adjustment of the treatment temperature to increase structural order.

These studies have enabled us to elucidate key relationships between pore structure and coke-induced deactivation. Also, the incorporation of surface phosphorus groups significantly enhances catalyst stability by suppressing both coke formation and support gasification, albeit at the expense of reduced H_2 selectivity. Increasing the structural order of the carbon support improves resistance to gasification; however, the resulting lower surface polarity hinders the dispersion of the nickel active phase, thereby reducing catalytic activity. Furthermore, highly microporous supports with large surface areas tend to promote support gasification. Interestingly, nickel particles dispersed on microporous supports also facilitate the formation of carbon nanostructures, leading to a catalyst that exhibits both high activity and stability during SR.

Acknowledges

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Keynote Lecture 10 (Id.12)

On the heating during refueling of a hydrogen-powered vehicle

Ana González-Espinosa (1), Antonio Lozano (1), Juan Stehr (2), Jorge Barroso (2), Félix Barreras (1)

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Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords:hydrogen refueling, hydrogen vehicles

Filling an empty tank with hydrogen stored in a high-pressure reservoir causes gas heating due to two combined effects: Joule-Thomson heating during the initial expansion, and further heating caused by the compression as the tank pressure increases [1]. It has been established that the refueling process of a standard light duty car must comply with the SAE J2601_202005 “Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles” Technical Information Report [2], that limits the maximum allowed in-tank temperature to 80°C (353 K). Under normal circumstances, considering a final tank pressure of 700 bar, this temperature is exceeded if the filling is simply accomplished by a free expansion from a higherpressure storage vessel (e.g. 800 bar). The compression process occurring inside the vehicle tank entails an additional heating.

While compression-induced heating is unavoidable, expansion-related heating can be mitigated. Unlike most gases, hydrogen heats up when expanding through an orifice to lower pressure at typical ambient temperatures. This behavior is governed by the Joule-Thomson coefficient µJT, defined as the variation of temperature with pressure at constant enthalpy:

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_h$$

This effect can be mitigated by reducing the enthalpy of the hydrogen that expands from the refueling station reservoir. Currently, this is accomplished by pre-cooling the hydrogen to a temperature that prevents in-tank temperature does not exceed 80°C during the refueling. As this is an energy-consuming and quite expensive procedure, the hydrogen is typically cooled only to the value to satisfy this requirement, which is -40°C.

In this work, numerical simulations were performed using the EES computer software to analyze how the hydrogen temperature increases during the tank refilling [3]. Different strategies are considered in order to reduce the expansion heating, such as gas pre-cooling to different temperatures, staged expansion to reduce the pressure difference, or other alternative approaches such as turboexpanders or vortex tubes.

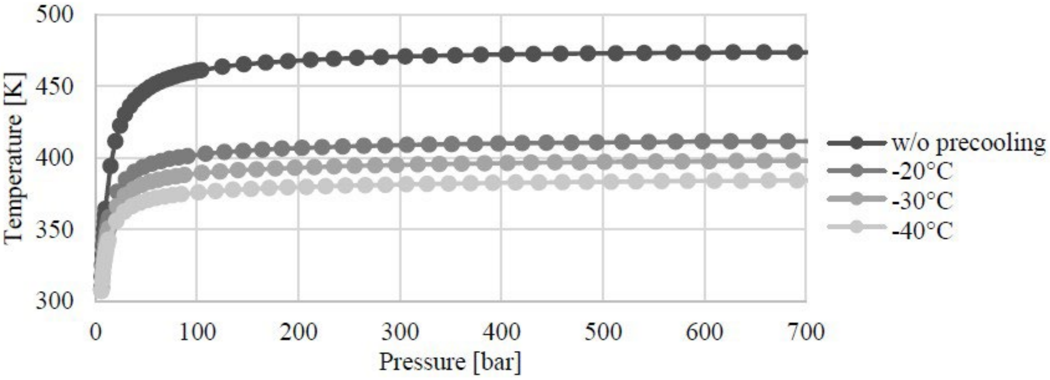

Fig. 1 Temperature increase as a function of pressure in a single stage tank filling for different pre-cooling levels.

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Keynote Lecture 11 (Id.97)

Tuning the pore structure of Fe-N-C electrocatalysts for high ORR activity and stability

Giulia Gianola (1), Mirtha A.O. Lourenço (2), Tiago Morais (2), Luís Mafra (2), Juqin Zeng (3), Stefania Specchia (3)

(1) Istituto Italiano di Tecnologia . Italy, (2) University of Aveiro. Portugal, (3) Politecnico di Torino. Italy

Type of abstract Keynote speakers
Subject area: Fuel cells
Keywords: Mesoporous carbons; hard template; oxygen reduction reaction; Fe-N-C electrocatalysts; acid and alkaline electrolyte

Hydrogen fuel cells offer a low-carbon option to conventional energy systems to generate electricity directly from electrochemical reaction between hydrogen and oxygen. However, their commercialization is still hindered by the performance and cost of the electrocatalyst layer at the cathode side, due to the sluggish kinetic of oxygen reduction reaction (ORR). As alternative to Pt-based electrocatalysts, Fe-N-C electrocatalysts have gained attention due to their favorable activity, durability, and cost-effectiveness. In this study, hard-templating with tailored silica scaffolds (SBA-15, KIT-6, and a dual SBA-15/KIT-6 template) were used to tune the pore structure of Fe-N-C materials. All electrocatalysts initially followed a quasi-4e– ORR pathway, but their behavior diverged during the long-term testing. Fe-N-CMK-3 exhibited the highest ORR activity due to its well-defined mesoporous structure, balancing mass transport and active site accessibility, while Fe-N-CMK-8, showing unexpected microporosity, enhanced selectivity and active site density but limited mass transport. The dual-templated Fe-N-CMK-3/8 catalyst combined 2D and 3D porosity for intermediate performance. Durability tests revealed media- and porosity-dependent stability: Fe-N@CMK-8 excelled in ORR activity in acidic conditions due to the confinement conferred by its microporous framework. Conversely, Fe-N-CMK-3 maintained high ORR activity in alkaline media along with a slight shift of reaction pathway. In comparison, the dual porous Fe-N-CMK-3/8 shows the best stability particularly in terms of selectivity in both acid and alkaline media. These findings establish pore engineering as a powerful tool to tailor Fe-N-C electrocatalysts for specific operational environments, contributing to the development of highperformance non-precious metal catalysts for ORR in proton exchange membrane and alkaline fuel cell applications.

Keynote Lecture 12 (Id.26)

Warped Graphene Layers Control ORR Activity of Carbon Catalysts via Configurational Entropy

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Type of abstract: Keynote speakers
Subject area: Fuel cells
Keywords: Carbon catalysts; Oxygen reduction reaction; Warped graphene layers; Configurational entropy; Density functional theory

Carbon materials are widely used as catalyst supports in fuel-cell electrodes, but their intrinsic catalytic activity for the oxygen reduction reaction (ORR) is generally considered limited. However, recent studies have shown that some disordered carbons exhibit measurable ORR activity even in the absence of metal active sites, indicating that structural factors may influence catalytic performance.

In our previous work, we introduced a structural descriptor L/L_a, defined as the density of bending vertices in warped graphene layers (WGL). Across a series of carbon catalysts, ORR activity was found to correlate with $\log(L/L_\mathrm{a})$. Kinetic analysis suggested that this dependence mainly arises from variations in activation entropy, while no explicit dependence of the enthalpic term on L/L_a was assumed in the present model[1].

To explore the microscopic origin of this entropy contribution, density functional theory (DFT) calculations were performed using corannulene and coronene as model fragments of curved and planar graphene layers. The calculations evaluate the interaction landscape and accessible configurations of O_2 near the carbon surface.

Convex graphene fragments allow a broader range of molecular orientations for oxygen adsorption, whereas planar or concave surfaces restrict these orientations. Consequently, more O_2 configurations become accessible near curved graphene surfaces. This increase in configurational multiplicity is related to activation entropy via the Boltzmann relation $\Delta S^\ddagger \propto \ln \Omega_\mathrm{total}$, where Ω_total denotes the number of accessible configurations, primarily those involving adsorption sites (Ω_site) and molecular orientations (Ω_θ).

Within this framework, the observed correlation between ORR activity and $\log(L/L_\mathrm{a})$ can be attributed to configurational entropy arising from graphene-layer curvature. These findings suggest that curvature engineering of carbon structures offers a strategy for designing metal-free ORR catalysts.

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Keynote Lecture 13 (Id.49)

Poly-Terphenyl-Piperidinium Anion Exchange Membranes for Next-Generation Hydrogen Technologies

Vincenzo Baglio (1), Carmelo Lo Vecchio (1), Irene Gatto (1), Gioacchino Bucca (1), Cataldo Simari (2), H.M. Ur Rehman (2), Martina De Bonis (2), Isabella Nicotera (2)
(1) CNR-ITAE. Italy, (2) Università della Calabria. Italy

Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords: Hydrogen production; water electrolysis; anion exchange membrane.

Anion exchange membranes (AEMs) are key components in electrochemical devices such as fuel cells and electrolyzers, enabling the use of platinum-group-metal-free catalysts and lower-cost materials. In this work, a new family of p-terphenyl piperidinium AEMs was developed via an acid-catalyzed Friedel–Crafts polycondensation, offering a scalable and durable synthesis route. Their ether-free, hydrophobic aryl backbone improves mechanical strength, while quaternized piperidinium groups provide high anion conductivity and strong alkaline stability.

Extensive structural, mechanical, and electrochemical analyses demonstrated excellent performance, even in harsh alkaline environments (6 M KOH). The incorporation of nanofillers further enhanced hydroxide conductivity and dimensional stability.

Nuclear Magnetic Resonance (NMR) spectroscopy was used to probe molecular dynamics and ion transport, including selfdiffusion and relaxation behavior. The membranes were also evaluated in a complete water electrolysis cell, demonstrating high performance and durability. Overall, these p-terphenyl piperidinium AEMs, especially when reinforced with nanofillers, show strong potential for next-generation hydrogen energy systems due to their balance of conductivity, stability, and mechanical robustness.

Acknowledgments

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Tomorrow's Energy", under the project DURALYS (DURAble, Scalable, and Recyclable Components and Cell Designs for Next Generation Alkaline Exchange Membrane Water Electrolysis).

Keynote Lecture 14 (Id.62)

Stability Assessment of Commercial Membranes for AEM Water Electrolysis

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Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords:AEM Water Electrolysis, Anion-exchange membranes, Performance, Stability

Anion Exchange Membrane Water Electrolysis (AEMWE) is a promising technology for green hydrogen production, combining the possibility of using low-cost and non-noble materials, similarly to conventional alkaline electrolysis, while targeting the high performance and compact design typically associated with Proton Exchange Membrane Water Electrolysis (PEMWE). However, its large-scale implementation is still limited by the durability of membrane-electrode assemblies (MEAs), particularly due to the chemical and mechanical stability of commercial anion exchange membranes under operation [1].

This work aims to evaluate the performance and stability of commercial membranes for AEMWE. A 5 cm^2 single-cell AEMWE is assembled using membranes preconditioned in 1.0 M KOH and commercial Catrode® electrodes (Ni-Fe-based), together with titanium bipolar plates with single-serpentine flow fields and stainless-steel end plates. Stability tests are performed for approximately 100 h at a constant current of 0.5 A cm^{-2} with continuous voltage monitoring, and polarization curves are recorded before and after testing to assess performance variation.

So far, results are available for the PNB-R45 membrane. This membrane shows good electrochemical performance, with cell voltage close to 2.2 V at 1.8 A cm^{-2}. During the galvanostatic hold of approximately 100 hours, a voltage increase rate of around 0.7 mV.h-1 was observed through continuous monitoring. However, the polarization curves recorded before and after the stability test reveal only a slight decrease in performance, indicating that irreversible degradation is limited under the tested conditions. These findings suggest that the observed voltage drift is mainly associated with reversible operational effects rather than permanent degradation of the MEA. Additional commercial membranes are currently being tested to establish a broader comparative stability assessment, and all results will be presented during the conference.

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Keynote Lecture 15 (Id.115)

Single-atom M-N-C catalysts for the electrochemical CO_2-to-CO conversion

Sara Pérez Rodríguez (1), Manuel Gutiérrez Roa (1), Ana Cristina Giménez Rubio (1), Irene Vela Murillo (1), David Sebastián del Río (1), María Jesús Lázaro Elorri (1)

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Type of abstract Keynote speakers
Subject area: Hydrogen
Keywords:CO2 electroreduction, syngas, M-N-C, rotating ring-disc electrode

The electrochemical reduction of CO_2 (CO_2RR) offers a promising route to convert surplus renewable energy into fuels and value-added chemicals. Among the possible products, CO is a key intermediate for the synthesis of energy-dense fuels. While noble metals such as Au, Ag, and Pd have shown high CO selectivity at low overpotentials [1], their scarcity and high cost hinder large-scale deployment. Recently, metal-nitrogen-carbon (M-N-C) catalysts featuring single atom M-Nx sites have emerged as alternatives for selective CO2-to-CO conversion [2,3].

Herein, we explore a series of M-N-C catalysts (M = Fe, Ni, Cu, Co) using different nitrogen-doped carbon materials as porous matrixes: a resorcinol-formaldehyde-urea-derived carbon xerogel and activated carbons obtained from winery wastes. The electrochemical performance for CO2RR was assessed in CO_2-saturated 0.1 M $KHCO_3$ using a rotating ring-disc electrode (RRDE). This configuration, rarely applied to CO_2RR, enables direct detection of the products formed at the catalyst-coated disc directly by monitoring the oxidation signals at the ring [3]. Complementary product analysis was carried out in an H-type electrochemical cell coupled to gas chromatography.

The results confirm that the RRDE setup is a viable alternative for CO detection during CO_2RR. Cu-N-C catalysts derived from carbon xerogels exhibited selective CO production with high Faradaic efficiency at -0.65 V vs RHE. At higher overpotentials, the competitive water reduction led to syngas formation. Moreover, catalysts synthesized from biomass carbon precursors displayed enhanced CO production, which would provide additional advantages in terms of cost and sustainability.

Acknowledgements: The authors acknowledge support from project CNS2023-144433 to MICIU/AEI/10.13039/501100011033 and the European Union Next Generation EU/PRTR.

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Keynote Lecture 16 (Id.82)

Carbon Strategies for Rechargeable Batteries

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Type of abstract Keynote speakers
Subject area: Advanced batteries and capacitors
Keywords: Carbon, Lithium-ion batteries, Lithium-sulfur batteries, Sodium-ion batteries.

Carbon materials are central to rechargeable battery chemistry, serving as both active materials and key structural components across lithium-ion and next-generation battery systems, including sodium batteries and conversion-type sulfur batteries. For future energy storage, several requirements are particularly critical, including high energy density, safety, compactness, resource sustainability, and low cost. This presentation highlights recent representative studies from our group, published in Nature, Nature Synthesis, Nature Sustainability etc., on carbon materials from the perspectives of carbon networks, carbon interfaces, and carbon pores, with a focus on their roles in dense energy storage for lithium-ion batteries, catalytic sulfur conversion in lithium-sulfur batteries, and ion-sieving architectures for sodium-ion batteries. Together, these studies demonstrate how rational carbon design can simultaneously enhance both volumetric and gravimetric battery performance, and thereby accelerate the development of advanced energy storage devices.

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Keynote Lecture 17 (Id.99)

Post-treatments on carbon xerogels to improve their performance as negative electrodes of Na-ion batteries

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Type of abstract Keynote speakers
Subject area: Advanced batteries and capacitors
Keywords: Hard carbon, carbon xerogels, CO2 activation, Na-ion batteries

Energy storage through batteries is essential for a sustainable future, but growing demand requires improved strategies for critical material use and manufacturing. Challenges include limited lithium availability and the use of electrode materials that are difficult to recycle. This study focuses on hard carbons as negative electrodes for Na-ion batteries, processed via water-based route using a biosourced binder (xanthan gum).

Hard carbons are promising due to Na^+ insertion within nanopores, tunable structure, and relatively simple synthesis. Although capacities up to 300 mAh g^{-1} can be achieved, performance is limited by excessive SEI formation arising from high surface area. Previous work demonstrated that carbon xerogels with larger nodule sizes show improved performance, as their inner micropores are less accessible to the electrolyte while still enabling reversible Na^+ storage.

Here, carbon xerogels with ~2 µm nodules were synthesized via pyrolysis of phenolic resins. After, CO_2 activation applied to increase microporosity, followed by the deposition of a carbon layer using Chemical Vapor Deposition (CVD). Electrochemical testing showed that activation alone significantly degrades performance (ICE: from 80% to 18%, reversible capacity: from 248 to 62 mAh g^{-1}), due to excessive electrolyte-accessible surface area. However, combining activation with CVD yielded optimal performance (ICE 88%, reversible capacity 294 mAh g^{-1} at C/20), along with improved plateau capacity, rate capability, and cycling stability.

Cyclic voltammetry in a supercapacitor configuration revealed that BET surface area does not directly reflect the effective electrode–electrolyte interface. Materials with similar BET values showed different ICE and irreversible capacities, indicating that many micropores remain inaccessible unless activation sufficiently increases pore volume. Precise control of electrolyte access to micropores is key to optimizing hard carbon performance in Na-ion batteries.

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ORAL PRESENTATIONS

Oral Presentation S1-1 (Id.35)

Development of Carbon Nitride-Supported Copper Electrocatalysts: An Operando X-ray Absorption Spectroscopy Study

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords:operando XAS, bimetallic electrocatalyst, copper

XAS techniques are essential for unveiling the coordination and electronic structure of metal-based electrocatalysts. While most studies focus on ex-situ measurements, the potential-driven dynamic evolution of active sites is often only addressed theoretically. This work performed operando XAS measurements to analyze Cu supported on carbon nitride (C3N4)/activated carbon materials used as electrocatalysts for the Oxygen Reduction Reaction (ORR) and Hydrogen Evolution Reaction (HER). Three systems were compared: highly dispersed Cu, a bimetallic Pd/Cu system, and a Cu phthalocyanine (CuPc) sample.

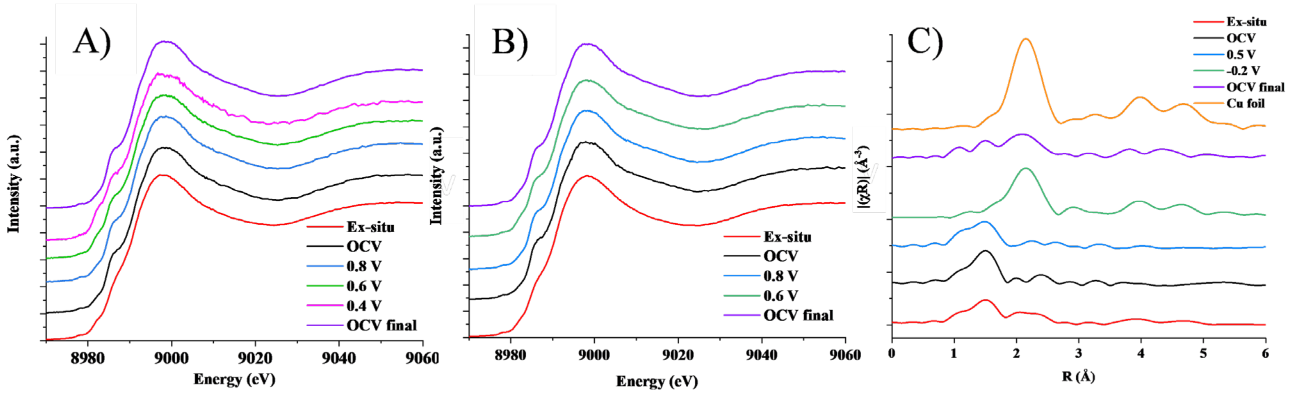

Fig. 1. Cu K-edge XANES spectra for A) Cu-C3N4/C and B) Pd/Cu-C3N4/C, and Cu K-edge Fourier Transform of k2-weighted FT-EXAFS for C) Pd/Cu-C3N4/C.

Measurements at ALBA Synchrotron revealed a critical dependence of the Cu structure on applied potential and chemical environment. For dispersed Cu and the bimetallic Pd-Cu system during ORR (Fig. 1A and B), a progressive reduction from the initial Cu (II) state to Cu(I) species was observed. In the PdCu/C3N4 sample under an inert atmosphere (HER) (Fig. 1C), EXAFS showed the formation of metallic phases at lower potentials, which persisted even after reaching the open circuit potential. The Cu K-edge exhibited characteristic 1s → 4p transitions, allowing for the identification of changes in coordination geometry and active site symmetry. In contrast, the CuPc system demonstrated superior structural stability, retaining its square-planar configuration and oxidation state across a wide potential range. These findings highlight the significance of metal-support interactions and molecular architecture in the evolution of active sites during ORR and HER.

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Oral Presentation S1-2 (Id.103)

Strategies to maximize the density of active sites in Ni-N-C catalysts for AEM electrolysis

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Carbon nanofibers (CNF), Ni-N-C, Electrocatalysis, AEM, Oxygen evolution reaction (OER)

The development of efficient oxygen evolution reaction (OER) catalysts is crucial for improving anion exchange membrane (AEM) water electrolysis, a technology that combines the advantages of both alkaline and proton exchange membrane (PEM) systems for green hydrogen generation [1]. Carbon nanofibers (CNFs) offer high conductivity, stability, and surface area, making them ideal supports for M–N–C catalysts hosting atomically dispersed transition metals [2]. In particular, nickel is recognized as one of the most active non noble metals for OER [3].

In this work, CNFs were engineered to maximize the density of Ni–N active sites. Controlled oxidative treatments were applied to tune their defect concentration: hydrogen peroxide (H_2O_2) generated moderate and homogeneous defects, while potassium permanganate ($KMnO_4$) induced partial exfoliation and an increase in the surface roughness of the CNFs [2]. Subsequent nitrogen doping and nickel incorporation yielded catalysts with Ni loadings below 2 wt%, but oxidation and exfoliation increased the uptake of atomically dispersed Ni accessible to the OER. Structural and chemical characterization (XRD, TEM, XPS, ICP OES) confirmed the presence of nickel dispersed at the atomic level throughout the carbon nanofibers and its coordination with nitrogen.

Electrochemical characterization in 1 M KOH demonstrated that defect engineering increased the density of accessible active sites, resulting in higher OER activity. These findings confirm that combining defect-modulated CNFs with atomically dispersed Ni–N sites is a highly effective strategy to achieve a high density of active sites and enhance catalytic activity in AEM electrolysis.

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Oral Presentation S2-1 (Id.18)

Enhanced CO_2 reduction trough thermo-photocatalysis over modified TiO_2 systems

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Thermo-photocatalysis, structured reactor, TiO2, CO2 reduction, fuels

Among all greenhouse gases that contribute to climate change, CO_2 is considered the most critical due to the massive amounts of this gas that are constantly being emitted to the atmosphere by human activities [1]. In response to this issue, the scientific community is developing novel methods to mitigate this global crisis, being the conversion of CO_2 to solar fuels one of the most promising [2].

In this context, this study investigates the thermo-photocatalytic reduction of CO_2 to methane over copper-modified TiO_2 (P25) and TiO_2/g-C_3N_4 catalysts. Physicochemical characterisation of the catalysts, including ICP-OES, XPS, FT-IR, UV–Vis DRS, UPS, and PL spectroscopy was conducted.

Thermo-photocatalytic tests were carried out from room temperature up to 70°C under UV irradiation (368 nm), evidencing a methane production maximum at mid-range temperatures. For 0.5%Cu-TiO_2 the maximum rate of production was ~1010 µmol/g·h at 50ºC, whereas for 1%Cu-TiO_2/g-C_3N_4 the figure was ~720 µmol/g·h at 60ºC, significantly exceeding those at room temperature. Moderate heating enhanced charge carrier mobility, ethanol functioned effectively as a hole scavenger, and CO_2 reduction kinetics were accelerated. Beyond the optimal temperature, performance declined due to a decrease in reactant adsorption counterbalancing previous improvements [3-4]. In turn, copper species performed a critical role in methane production by enhancing CO2 adsorption and increasing charge-transfer processes. This synergistic effect allowed the catalysts to far surpass pristine P25 performance [5-6].

These findings demonstrate the potential of combining photonic and thermal energy inputs to improve sustainable CO_2 conversion technologies.

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Oral Presentation S2-2 (Id.58)

Design and evaluation of MoS_2-CdS heterostructures for hydrogen production via the photoreforming of lactic acid

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Type of abstract: Oral presenters
Subject area: Hydrogen

The aim of this work is to prepare efficient photocatalysts for H_2 production by photoreforming biomass-derived compounds. MoS_2 and CdS were synthesized by hydrothermal treatment (HT), as well as two MoS_2-CdS hybrids containing 6 wt% MoS_2, obtained by two routes: (1) mixing with ultrasounds CdS and MoS_2 suspensions, both prepared by HT, followed by filtration, drying, and grinding, named MoS_2-CdS, and (2) prepared in a single step by addition of CdS precursor during the hydrothermal synthesis of MoS_2, named MoS_2-CdS-1P.

X-ray diffraction showed that MoS_2 has low crystallinity and contained the 1T (tetragonal) and 2H (hexagonal) phases, with predominance of 2H. CdS showed high crystallinity and contained both cubic and hexagonal phases, the latter being dominant. N_2 adsorption at -196 °C revealed a very low surface area for MoS_2 and slightly higher porosity for CdS (1 and 18

$m^2\cdot g^{-1}$ respectively). Photoluminescence results showed that both hybrids exhibit lower e^-/h^+ recombination than CdS, particularly lower for the 1P sample. UV-Vis DRS spectra confirmed higher absorbance for the hybrids, especially in the visible region, with 1P being the most absorbing.

Tests performed in the absence of photocatalyst showed a high amount of CO_2 and almost no H_2 was detected, suggesting photodegradation and/or photodecarboxylation. In the photocatalytic tests, CdS showed moderate H_2 production (3.9 $mmolH_2\cdot g_{cat}^{-1}\cdot h^{-1}$), whereas MoS_2 produced much lower one (1.4 $mmolH_2\cdot g_{cat}^{-1}\cdot h^{-1}$). By contrast, the hybrids clearly increased H_2 production (11.2 and 10.6 $mmolH_2\cdot g_{cat}^{-1}\cdot h^{-1}$ for MoS2-CdS and MoS_2-CdS-1P respectively, consistent with a synergistic effect between MoS_2 and CdS. This is attributed to improved charge separation and/or electron transfer to active MoS2 sites that promote hydrogen evolution. Both hybrids gave similar overall H_2 and CO_2 results and, due to their optical properties, are promising candidates for operation under solar irradiation.

Oral Presentation S3-1 (Id.114)

Study of the effect of configurational parameters on the performance of a microbial desalination cell

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: Fuel Cell, Microbial desalination cell, MDC, desalination

The rapid increase in global population has been demonstrated to have a significant impact on demand for natural resources, resulting in increased waste production and intensification of climate change. Water scarcity has emerged as a critical global challenge, reinforcing the need for sustainable technologies aligned with the United Nations 2030 Agenda. Conventional desalination technologies are effective, but their high energy demand and environmental impacts compromise long-term sustainability. Microbial Desalination Cells (MDCs) emerged as a promising alternative because they integrate desalination, wastewater treatment, and electricity generation in a single process without an external energy input. MDCs may operate as standalone systems or in combination with other technologies, such as reverse osmosis pre-treatment. However, large-scale implementation remains limited by membrane high capital costs, and lower performances. This work presents the evaluation of an air-cathode MDC with a cross-sectional area of 12.6 cm², operated under ambient conditions. A pure culture of Lactobacillus pentosus was used as biocatalyst in a nutrient-rich medium, while NaCl solutions, ranging from 14 to 35 g/L, were employed to evaluate the effect of salinity on desalination and electrochemical performance. Each test lasted 15 days with polarization measurements performed every 48 h, after which 20 mL of anolyte was replaced with fresh medium. The results demonstrated a maximum salt removal of 79% and a power density of 28.25 mW/m² at 35 g/L NaCl when the anion exchange membrane (AEM) was activated in 1 M KOH. When the AEM was activated in 2 M NaCl, salt removal increased to 88%, whereas maximum power density decreased to 17.74 mW/m². These findings demonstrate that membrane activation conditions strongly affect the balance between desalination efficiency and energy recovery. Overall, the proposed MDC shows potential as a sustainable and energy-efficient desalination technology.

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Oral Presentation S3-2 (Id.56)

Doped-tin oxide electrocatalysts as anode in water electrolysis

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Hydrogen Electrocatalyst OER

The growing demand for sustainable energy and propulsion technologies has reinforced the strategic role of PEM water electrolysers, which operate using water as a safe and non-toxic feedstock. However, their large-scale deployment is limited by the high cost and scarcity of IrO_2, the state-of-the-art anode catalyst for the oxygen evolution reaction (OER) in acidic media. Developing efficient and stable alternatives with reduced noble-metal content is therefore essential, particularly for aerospace applications under harsh conditions.

This work explores Sb-doped SnO_2 (13 at.% Sb, ATO) as a conductive and corrosion-resistant support for OER in acidic conditions. Porous Ti mesh was employed to increase surface area and facilitate gas release. The ATO matrix was modified with Ru (3 and 13 at.%) and, in the most promising composition, co-doped with Pt (3 and 10 at.%) to enhance catalytic activity while minimizing precious-metal loading. The electrodes were benchmarked against commercial IrO_2/Ti.

Characterization (XRD, XPS, SEM/EDX) confirmed Sb incorporation into the SnO_2 lattice and the formation of RuO_2-like surface species, together with an increased concentration of oxygen vacancies. Electrochemical evaluation in 0.5 M H_2SO_4 included cyclic voltammetry, electrochemical surface area analysis, Tafel slope determination, and temperature-dependent OER studies (10–50 °C).

Ru incorporation significantly enhanced OER performance, decreasing the Tafel slope from 120 $mV \cdot dec^{-1}$ (ATO/Ti) to 57 $mV \cdot dec^{-1}$ (ATO-Ru13/Ti), and to 47 $mV \cdot dec^{-1}$ in the Ru–Pt co-doped electrode, which outperformed IrO_2/Ti under identical conditions. Increasing temperature further improved current density.

These results demonstrate that Ru- and Ru–Pt-doped ATO on Ti mesh is a competitive, low-iridium alternative for acidic OER in advanced PEM electrolysers.

Acknowledgements: The authors acknowledge financial support from project PID2022-137566OB-I00 funded by MCIN/AEI/10.13039/501100011033 and ERDF/EU.

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Oral Presentation S3-3 (Id.89)

Neural-network-based strategies for computational modeling of hydrogen fuel cells: from data-driven surrogates to physics-informed approaches.

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: HT-PEMFC, 3D Simulation, ANNs, PINNs

Computational modeling plays an important role in understanding the coupled transport, thermal and electrochemical processes governing a hydrogen fuel cell operation [1]. However, detailed 3D CFD simulations remain too costly computationally for design sweeps and control-oriented studies. In this work, we present two complementary neural-network approaches that accelerate PEMFC simulations while maintaining physical consistency.

First, we develop artificial neural network (ANN) surrogates trained on detailed 3D CFD generated from a validated HT-PEMFC stack model. The surrogates predict key operating quantities: stack voltage, total heat generation, and three-dimensional fields of temperature, current density, and oxygen concentration to within the intrinsic uncertainty of the CFD simulations, enabling rapid evaluation across operating conditions [2].

Second, we implement Physics Informed Neural Networks (PINNs) that enforce the governing equations for mass,
momentum, and species transport together with electrochemical relations directly in the training process. In line with recent PEM studies [3], we construct a 3D PINN defined on a channel-scale domain, which learns solutions consistent with the governing physics without precomputed CFD data.

ANN surrogates and PINNs offer complementary tools that cut computation times and adapt to different modeling needs. ANNs enable fast predictions based on CFD simulated data, while PINNs provide physics-based detail, together improving understanding and prediction of fuel cell behavior.

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Oral Presentation S3-4 (Id.48)

Use of unmanned vehicles in intensive olive cultivation (OLIVARIA Project)

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: FUEL CELLS, HYDROGEN, UAV, UGV

OlivarIA is a research project co-financed with EDF funds by the Spain-Portugal Cross-Border Cooperation Program (POCTEP) 2021-2027 (0067_OLIVAR_IA_5_E). With participating entities from the public and private sectors of Spain and Portugal, the project is coordinated by the University of Huelva.

The solution proposed in OlivarIA is based on the autonomous collection of olive grove data through the use of aerial and ground robotic platforms powered by green hydrogen and equipped with specialized sensors. Specifically, sensors capable of extracting spectral information representative of the water and nutritional status of the olive grove, as well as the harvest quantity and the ripening stage of the fruit, will be selected. The platforms will also integrate equipment for the transmission and processing of information. Ultimately, artificial intelligence algorithms capable of interpreting the data in terms of the aforementioned agronomic parameters will be developed, thereby providing farmers with objective, real-time information that supports their decision-making and promotes optimal use of resources.

The final manuscript to be presented during the Symposium describes the design, construction and evaluation of an autonomous aerial vehicle, controlled by Artificial Intelligence and equipped with sensors capable of autonomously, accurately, and efficiently monitoring the water and nutritional status of olive groves from a top-down perspective. Its highautonomy propulsion system is based on fuel cells powered by hydrogen generated from renewable energy sources.

Also an unmanned ground vehicle powered by hydrogen and fuel cells will be presented as a complement of the integrated system. It collects agronomic data from the ground, while the unmanned aerial system transmits the data collected from the air. Both platforms operate in sync with the data collection and processing system.

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EVALUACIÓN DE UN VEHÍCULO TERRESTRE NO TRIPULADO (UGV) CON PILA DE COMBUSTIBLE.

Oral Presentation S7-1 (Id.86)

Biomass Gasification with Air: Integration of Gas Cleaning and CO_2 Valorization for Enhanced Process Performance

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Biomass gasification, gas cleaning, CO2 valorization, renewable energy

This study, developed within the framework of the Interreg AIHRE project, focuses on the thermochemical gasification of residual biomass (olive and forestry residues) using air as the gasifying agent (Configuration A), aiming at the production of syngas and its subsequent valorization through gas cleaning and CO_2 utilization. A downdraft gasifier was coupled with a dedicated gas cleaning system, including cyclone separation, water scrubber, and zeolites and activated carbon adsorption.

The gas cleaning system proved effective in removing contaminants, particularly tears, as confirmed by the observed color change (orange) in the washing water, indicating the transfer of condensable compounds from the gas phase to the liquid phase. This highlights the importance of integrating scrubbing stages to improve syngas quality and ensure process reliability.

Additionally, CO2 capture and valorization were assessed as a key strategy to enhance process sustainability and economic performance. CO2 capture using CaO at 700 °C was successfully demonstrated, with efficiencies up to 42%, and quantified through thermogravimetric analysis based on normalized mass loss. The potential sale of captured CO_2 (assumed at €1.20/kg) was incorporated into the techno-economic model.

Results show that CO2 valorization significantly improves financial performance, enabling positive net present value (NPV) and internal rate of return (IRR) values above 10%, while reducing the payback period. Although Configuration A produces lower hydrogen yields compared to alternative setups, the combination of effective gas cleaning and CO2 utilization enhances its viability. In general, this work demonstrates that integrating gas cleaning and CO2 valorization is essential to improve both the environmental and economic performance of biomass gasification systems.

Oral Presentation S7-2 (Id.109)

Hydrogen and nanostructured carbon from methane pyrolysis using locally sourced metallurgical iron waste

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Hydrogen production; Methane pyrolysis; Iron waste catalysts; Nanostructured carbon

The transition towards low-emission energy systems has intensified interest in hydrogen as an alternative energy vector. Conventional production routes, particularly steam methane reforming, are associated with significant CO^2 emissions.

Methane pyrolysis has emerged as a promising alternative, enabling hydrogen generation without direct CO^2 emissions, as carbon is recovered in solid form and can be obtained as nanostructured materials with added value. The viability of this process strongly depends on the development of cost-effective catalysts with adequate activity and stability. Iron-rich residues from the metallurgical industry are particularly attractive due to their high content of metallic iron or easily reducible phases, which provide active sites for methane decomposition without complex synthesis steps. This intrinsic catalytic functionality, combined with their low cost, wide availability and potential for waste valorization, makes them especially promising materials for sustainable hydrogen production. This work investigates hydrogen production via methane pyrolysis using locally sourced metallurgical iron residues, mainly GG25 cast iron. The influence of activation treatments, including acid washing and/or air calcination, as well as reaction conditions on hydrogen production and nanostructured carbon formation were systematically evaluated. Experiments were conducted in a quartz fixed-bed reactor after catalyst reduction under H_2 at 750 ºC for 1 h (10 ºC min^{-1}). Reactions were carried out at 800-950 ºC for 3 h, varying the space velocity between 2 and 19 $L·h^{-1}·g_{cat}^{-1}$. Methane conversion and hydrogen production were quantified by gas chromatography analysis of the outlet stream. Under optimal conditions (950 ºC, WHSV = 2 $L·h^{-1}·g_{cat}^{-1}$), methane conversions up to 60% and hydrogen concentrations of 75 vol.% were achieved, together with the formation of graphitic nanostructured carbon exhibiting mixed laminar and filamentous morphology.

Oral Presentation S7-3 (Id.128)

Improving SOEC and tri-reforming efficiencies in the integration of SOEC and Gasification for H_2, methanol and dimethyl ether production

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Type of abstract: Oral presenters
Subject area: Hydrogen

Biomass gasification is typically carried out using air as the oxidant, which results in a diluted syngas that is not ideal for fuel production. In this context, the GeniusFuels project aims to enhance sustainable fuel synthesis by integrating a solid oxide electrolysis cell (SOEC) with a biomass gasifier. The oxygen generated during water electrolysis is utilized as the oxidant in the gasification process, while the produced hydrogen is used to adjust the H_2/CO ratio to values suitable for fuel production, thereby eliminating the need for a water–gas shift reaction.

Additionally, tri-reforming is implemented, increasing the gasification temperature to 900 °C. The resulting waste heat is recovered by the SOEC, which operates at 700 °C to improve heat exchange efficiency. However, this lower operating temperature, compared to the conventional 800–850 °C range, negatively impacts ionic conductivity and therefore requires electrolyte doping. Effective integration with the gasification process also necessitates modifications to SOEC operating conditions, including replacing air with oxygen, potentially mixed with CO_2 and H_2O. This change exposes the oxygen electrode to a more corrosive environment. Thus, in this project innovative SOEC materials and solutions are being explored such as doping and cation substitution to increase the resistance under harsh conditions. Pr1-xCaxFeO3-δ (PCF) compositions were investigated, in which Pr is partially substituted by Ca on the A site, while only Fe occupies the B site. Appropriate cation substitution and controlled redox treatments modify the structural and surface properties of these perovskites.

In addition, the tri-reforming reaction needs highly stable catalysts able to convert the gas produced by the oxygen-fed gasification which also contains tars and H2S, which can lead to deactivation. On this side, Ce-based catalysts were produced and optimized to yield high conversions in tri-reforming, with high stability.

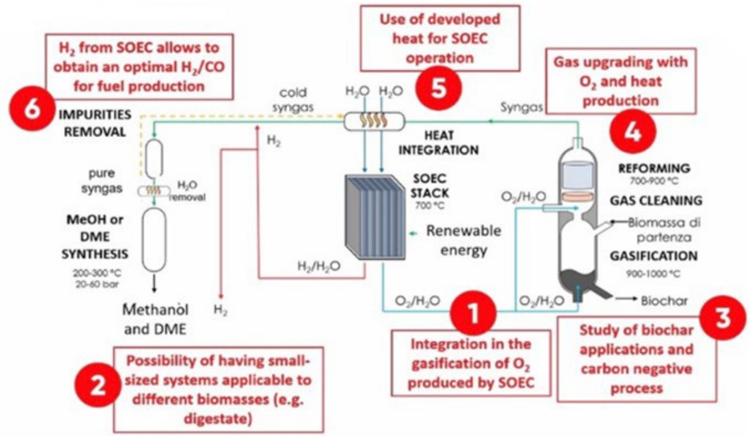

Figure 1: The GeniusFuels project.

Acknowledgements

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Oral Presentation S7-4 (Id.125)

Effect of Ni incorporation route on Ni-Al aerogel thermophotocatalysts for CO_2 methanation

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: CO2 methanation; Sabatier reaction; nickel; alumina; aerogels; supercritical drying; photocatalysis; greenhouse gas; power-to-gas

Thermo-photocatalytic CO2 methanation is an attractive route to valorize renewable H2 and store energy as synthetic methane [1] to obtain carbon neutrality. Ni-based aerogels have shown to be promising catalysts because their high surface area and porosity can favour metal dispersion and light-assisted activity [2]. In this work, two Ni incorporation routes in alumina aerogels were compared: one-pot sol-gel synthesis of Ni-Al aerogels [3] and post-synthesis Ni impregnation of preformed Al aerogels. Both families were dried under supercritical CO2, calcined and characterized by ICP-OES, N2 physisorption, XRD, H2-TPR, TEM, XPS and UV-Vis DRS. Activity tests were performed in a photoreactor at 300-450 °C and 10 bar under dark, visible and UV irradiation (λ = 365 nm, λ = 470 nm). The one-pot route shows surface areas up to 492 m2 g-1 with high porosity, and favouring high Ni loadings and dispersions, giving the best performance under visible light. AG
1/3 reached 82% CO2 conversion with 100% CH4 selectivity at 450 °C and improving conversion values at lower temperatures. In contrast, Ni impregnation reduced the surface area of the substrate Al aerogel to 187-209 m2 g-1. Therefore, impregnated aerogels showed lower activity, although the sample with the highest Ni loading still approached 80% CO2 conversion at 450 °C under visible light. These results indicate that the method used to introduce Ni strongly determines metal-support interaction, reducibility and catalytic activity, and one-pot incorporation appears more effective than impregnation for developing Ni-Al aerogel thermo-photocatalysts for the Sabatier reaction.

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Oral Presentation S8-1 (Id.101)

Spatial planning of RFNBO electrolyzers through GIS–MCDA regulatory framework and statistical robustness analysis

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords:RFNBO compliance; certification-ready siting; regulatory-first planning; GIS–MCDA; non-compensatory screening; Monte Carlo robustness

Renewable hydrogen deployment depends not only on technology and cost, but also on whether a location can satisfy certification requirements from the outset. This is especially critical for Renewable Fuels of Non-Biological Origin (RFNBO), where sites that appear attractive in terms of resource availability may still prove non-certifiable. This study proposes a regulatory-centered framework based on Geographic Information Systems and Multi-Criteria Decision Analysis (GIS–MCDA), together with an Integrated Regulatory-Criteria Index (IIRC), for the spatial planning of RFNBO-based electrolyzers. Its key contribution is to translate RFNBO requirements into a non-compensatory ex ante Gate applied before ranking any site. In practice, sites are excluded when they cannot demonstrate additional renewable energy, sufficient temporal and geographic matching, or reliable traceability through Measurement, Reporting and Verification [1,2]. This avoids false optima and narrows the decision space to certifiable sites [3,4].

The framework evaluates ten technical, environmental and infrastructural criteria, applies a transparent and robust scoring method, and quantifies uncertainty through Monte Carlo–based robustness analysis. [5,6]. In Aragón, at 250 m resolution, the ex ante Gate excludes 27.4% of the sites primarily due to RFNBO non-compliance, insufficient grid capacity, and severe water stress, while the remaining high-suitability clusters (IIRC ≥ 0.80) show strong ranking stability, [1,2,7,8]. Water availability [7] and grid capacity emerge as the most sensitive territorial constraints. Limitations concern data quality and the partial incorporation of climate, hydrological, permitting, and social-acceptance scenarios [7,9,10].

RFNBO compliance fundamentally reshapes hydrogen siting: regulatory feasibility must come before cost or resource potential, providing a reproducible, certification-aligned tool for early project screening.

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Oral Presentation S8-2 (Id.111)

Digital twins for green hydrogen plants: balancing efficiency, generation, and degradation

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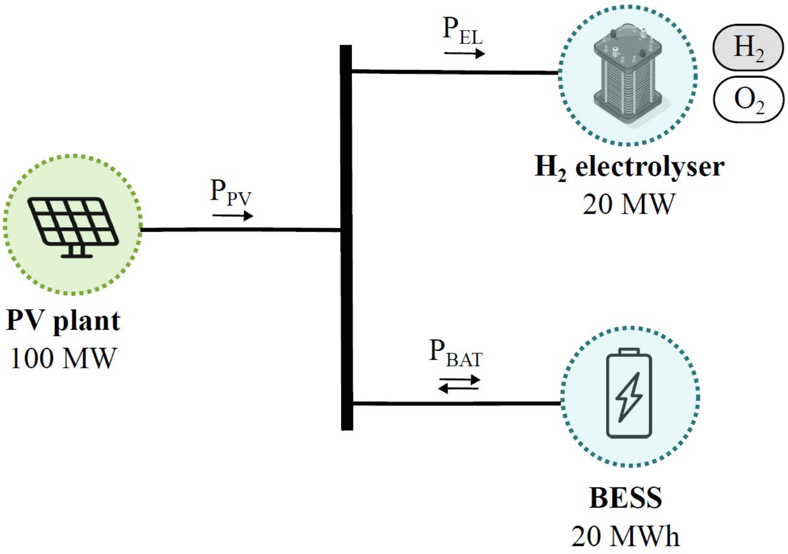
Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Green hydrogen generation; Digital twin; PEM electrolysis; Models; Optimization;

Integrating renewable power generation sources with electrolysis plants is vital for green hydrogen production. However, managing these diverse energy systems is a complex task, often leading operators to rely on simplified and conservative approaches. Cloud-based Digital Twins (DT) offer a practical solution to this current challenge, enabling informed decisions to optimize plant management.

This study investigates the potential of DT solutions when applied to a MW-scale facility comprising a 20 MW PEM electrolyzer, a 100 MW photovoltaic (PV) installation, and a 20 MWh Lithium-ion Battery Energy Storage System (BESS). These principal assets are represented by individual models, creating a virtual replica of the system, which enables a deeper understanding of internal insights as well as forecasting its performance under a given scenario.



The PV System utilizes a data-driven model that estimates power generation, depending on weather forecasts. The PEM electrolyzer employs a physics-based lumped model capturing internal stack dynamics, temperature evolution, hydrogen and oxygen generation, and storage, while also accounting for peripheral equipment influence. Additionally, the BESS is represented by a physics-based model with coupled degradation mechanisms to track battery capacity fade over time.

Following this architecture, three operational scenarios are evaluated over a 24h window: (i) directing maximum PV energy to the electrolyzer while minimizing BESS energy storage, (ii) maximizing electrolyzer efficiency, and (iii) optimizing power distribution to minimize BESS degradation.

Finally, a comparative analysis evaluates overall system efficiency and total hydrogen generation, and examines how the different scenarios might impact BESS and electrolyzer degradation. The study highlights the contributions that DTs can provide in green hydrogen generation plants and their potential in optimizing factors such as hydrogen generation, energy efficiency, and plant lifespan.

Oral Presentation S8-3 (Id.110)

Modeling the Voltage Response of Anion Exchange Membrane Water Electrolyzers with Different Electrode Materials for Power Electronics Design

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Anion Exchange Membrane Water Electrolyzers (AEMWE); Hydrogen; Power Electronics

As Anion Exchange Membrane Water Electrolyzers (AEMWE) emerge as a cost-effective solution for green hydrogen production, their integration into localized microgrids requires specialized power electronics capable of handling diverse electrochemical behaviors. This study presents a preliminary approach for electrolyzer power converter design by modeling and validating five different electrode materials at the cell level. Two distinct modeling methodologies are proposed: a physics-based electrochemical approach and an Equivalent Circuit Model (ECM) derivation.

By analyzing polarization curves with a lab-scale AEMWE with 5cm^2 cells, we demonstrate how material selection significantly shifts the operating point and dynamic response of the cell. The electrochemical model is utilized to calibrate the ECM parameters, ensuring that the resulting circuits maintain physical interpretability rather than being simple mathematical fits. These results are important for defining power electronics requirements, such as ripple tolerance, voltage regulation range, and efficiency optimization, tailored to specific AEMWE configurations. The findings provide a foundation for developing robust, adaptive converters that can accommodate varying stack impedances and degradation profiles in a microgrid context, balancing model complexity with experimental accuracy.

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Oral Presentation S8-4 (Id.106)

Design and validation of modular hydrogen range extenders for electric mobility: A methodological study

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: hydrogen, fuel-cell, pallet truck, range extender, power-pack, electric vehicles

Background

Transport represents roughly one-third of global final energy use and about one-quarter of CO_2 emissions, underscoring the urgency to decarbonize the sector [1]. Battery-electric vehicles (BEVs) appear as main option to decarbonize, offering high efficiency and zero tailpipe emissions but face range and recharging-time constraints, while fuel-cell electric vehicles (FCEV) provide long range and fast refueling but depend on still-nascent hydrogen infrastructure.

Objective

We present a replicable methodology to design and integrate modular HRE systems into existing BEVs across multiple duty cycles and platforms, from light-duty to heavy applications.

Methods

The workflow comprises:
Concept definition: We define vehicle concept, target range and the operating strategy.
Sizing: A first hydrogen and electrical pre-sizing is necessary as starting point.
Component selection: Taking into account mobility-grade constraints (power density, compactness, mass).
3D packaging and vehicle integration: With volume and weight-distribution limits, this is essential in order to optimize the equipment distribution on the vehicle.
Assembly and commissioning: As an on-vehicle installation or stand-alone power-pack, it is necessary to assembly as the 3D model determine
Homologation: An accredited entity has to homologate the vehicle in order to use the vehicle on public road

Results

As a representative case, a modular power-pack had been developed for a MAXUS EV80 on the H2Login project. The powerpack was equipped with a 16 kW fuel cell with a 103 L, 700-bar tank storing 4.1 kg H_2. After implementing this module, the vehicle delivering a 205.9% range increase with refueling times <5 min.

Conclusions

The proposed methodology enables rapid HRE deployment, leveraging ubiquitous BEV charging while providing fast-refuel extended autonomy with smaller batteries than BEVs and lower hydrogen system power than FCEVs—reducing system complexity and accelerating adoption across heavier use-cases.

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Oral Presentation S11-1 (Id.53)

Experimental validation of operational strategies and decision support tools for renewable hydrogen production in PEM and AEM multi-stack electrolyzers

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Hydrogen production, PEM electrolyzer, AEM electrolyzer, operating strategies, renewable energy

The intermittency of renewable energy sources strongly affects the operating conditions of electrolyzers for hydrogen production, when they are directly coupled to renewable energy generation plants. Relevant Key Performance Indicators (KPIs) of water electrolysis-based renewable hydrogen production systems, such as produced hydrogen, efficiency, durability and cost are directly related to these operating conditions [1].

Single electrolyzers and large hydrogen production plants can benefit from modular and flexible architectures that enhance energy efficiency and extend operational lifetimes, considering, for example, multi-stacks configurations [2]. Commercially available electrolyzers require AC/DC converters to supply power to the individual stacks or assembly of them. Depending on the number of stacks, they can be connected in series to a single power converter, which manages the operating conditions of all the stacks in the chain. These chains are usually connected in parallel to increase the flexibility of the operation with variable power supply conditions, increasing on the other hand the complexity of the control system [3].

Different operating strategies can be applied to the management of individual stacks and the AC/DC converters to optimize the whole performance of the system, but they could also be extrapolated to the management of large plants based on several electrolyzers, deciding the number of them into operation and the load. This work addresses the simulation and experimental validation of suitable operating strategies for three multi-stack systems based on PEM and AEM technologies, with different configurations and number of stacks, in order to analyze how the most suitable strategies could be implemented by an AI based tool to support the decision of the control system of the electrolyzer, depending on the operating criteria defined by the end-user. The work will also analyze how this tool could be applied to large hydrogen plants.

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Oral Presentation S11-2 (Id.73)

Online identification of a semi-empirical reduced-order model for health monitoring of PEM electrolyser stacks

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Modelling PEMEL; State-of-Health; Degradation

PEMEL are a key technology for green hydrogen production, yet their long-term reliability remains a major barrier to largescale deployment. Estimating their State-of-Health and Remaining Useful Lifetime is therefore an active scientific [1,2] and industrial [3] topic. Degradation manifest as an increase in cell voltage during operation. Modelling the stack voltage is thus essential for tracking degradation. Existing approaches follow three directions: analytical electrochemical models [4,5], datadriven methods [6,7], and hybrid or semi-empirical formulations [8,9].
Semi-empirical models are promising for Health Monitoring because they retain physical structure while remaining compatible with operational data. Unlike most models that avoid temperature, ours uses current density and stack-average temperature, which limits parameter extraction but improves fitting to real operating data.

The proposed model is derived from physical electrochemical expressions and simplified through sensitivity analysis, resulting in four identifiable fitting parameters: three describing activation overpotentials and one describing ohmic losses. These parameters allow the direct estimation of the corresponding activation and ohmic voltage components, used here as indicators of stack health and performance.

The model was first applied to a large experimental dataset obtained under controlled laboratory-like conditions, where current, temperature and pressure were intentionally varied to map the full operating range of each cell. This revealed clear degradation differences linked to cell position in the stack. The model was then applied to normal plant operation data recorded in 2019 and 2025, where the electrolyser was producing hydrogen under standard PLC control. Across these datasets, representing 1480 h of accumulated service time, the estimated degradation rate is 74 µV/h, consistent with values reported in the literature.

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Oral Presentation S12-1 (Id.50)

Activity and Stability of $NiFe_2O_4$ Catalysts in PiperION® Based AEM Electrolysers

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: AEM electrolysis; $NiFe_2O_4$ Catalysts; hydrogen generation

Hydrogen plays a pivotal role in enabling Europe's transition toward net-zero carbon emissions. Among the various hydrogen production routes, water electrolysis powered by renewable energy sources represents the most sustainable pathway, as it generates no direct carbon emissions. In recent years, anion-exchange membrane (AEM) electrolysis has attracted growing attention as a cost-effective alternative to proton-exchange systems that rely on expensive acidic membranes such as Nafion®. Furthermore, the alkaline environment of AEM devices enables the use of earth-abundant transition-metal catalysts, offering a viable path to reduce system costs while maintaining high performance.

In this study, $NiFe_2O_4$ catalysts were synthesized via a modified oxalate route [1]. Nickel and iron nitrates, in stoichiometric proportions, were sequentially added to an oxalic acid solution, followed by hydrogen peroxide as an oxidizing agent. The resulting precipitate was filtered, dried, and calcined at 350 °C to obtain nickel ferrite. The catalyst was then deposited onto a PiperION® (40 µm, Versogen) anion-exchange membrane using a spray technique, paired with a Pt-based cathode, and evaluated in a 5 cm^2 single-cell AEM electrolyser. Various $NiFeO_x$ loadings were tested and benchmarked against literature data to assess their activity and stability toward water splitting.

These results support the development of low-cost, high-efficiency catalyst–membrane assemblies for next-generation AEM electrolysers, contributing to the broader deployment of renewable hydrogen technologies.

Acknowledgments

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Oral Presentation S12-2 (Id.72)

Unraveling the effect of high-entropy in layered hydroxides for oxygen evolution reaction catalysis and durability

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: High entropy, layered hydroxides, oxygen evolution reaction, AEM water electrolysis, in situ Raman

Among 2D materials, layered hydroxides of transition metals have emerged as one of the most attractive materials for energy conversion catalysis. The general formula is $M^{II}_{1-x}M^{III}_{x}(OH)_2A_x^{-}.xH_2O$, where M represents divalent and trivalent transition metals arranged with interlaminar anions (A_x^{-}) [1,2]. Electrodes based on NiFe layered double hydroxides (LDHs) are currently the state-of-the-art for the oxygen evolution reaction (OER) process in anion exchange membrane water electrolyzers, and our group has recently reported the first scalable synthesis strategy for their preparation [1]. The formation of multiple-metal LDHs can boost the conductivity, increase the active sites exposure, induce phase stability and modulate the formation of high valence Ni species (NiOOH), which are the most active catalytic site [3,4]. High entropy (HE) layered hydroxides offer almost infinite possibilities to regulate the catalytic performance and stability of the structure. In this work, we have studied novel compositions (M^{II}: Ni, Co, Zn; M^{III}: Fe, Cr, V) and the effect of high entropy in the catalytic activity and durability. Due to the high complexity of these materials, understanding the interaction among the multi-metal components remains a major gap. The combination of in situ Raman spectroscopy with DFT+U modelling has allowed a high comprehension of the active phase. Fig. 1 contains the X-ray photoelectron spectroscopy spectra of 2p Ni, showing higher presence of Ni^{3+} on the surface for the HE catalyst compared to NiFe-LDH, and OER polarization curves at 70ºC, indicating comparable performance. 100 h durability tests in a zero-gap cell at 1 A cm^{-2} revealed lower degradation rates of HE catalysts.

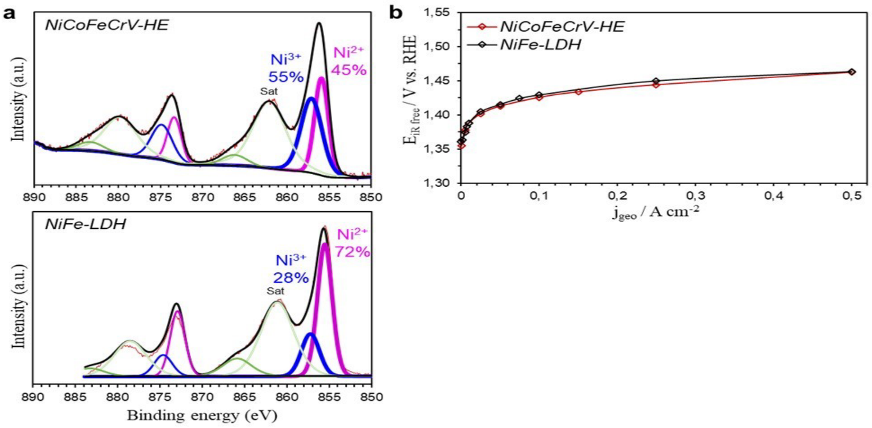

Figure 1: (a) 2p Ni XPS spectra of the layered hydroxides and (b) HFR-corrected polarization curves (Ni-fiber substrate, KOH 1 M, 70ºC).

Acknowledgements: SEAL HYDROGEN (GA-101137915), European Research Council (ERC PoC 2D4H2 No. 101101079, ERC PoC Roll-E No. 101213941), MICINN (PID2022-143297NB-I00, PDC2022-133997-I00, CNS2024-154959), Excellence Unit María de Maeztu (CEX2019-000919-M) and AVI (INNEST/2024/564).

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Oral Presentation S12-3 (Id.75)

Engineering NiFe-LDH-Based Composites with Molybdenum Chalcogenides for AEM Water Electrolysis

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: NiFe-LDH, Molybdenum chalcogenides, Electrocatalysis, AEM, Oxygen evolution reaction (OER), Hydrogen evolution reaction (HER)

Layered Double Hydroxides (LDHs) are a class of lamellar materials extensively investigated as electrocatalysts for water electrolysis in Anion Exchange Membrane (AEM) systems, owing to their high density of catalytically active sites and tunable surface chemistry. Among them, NiFe-LDH systems are considered among the most effective catalysts for the Oxygen Evolution Reaction (OER), where the interaction between nickel and iron species promotes efficient charge transfer and facilitates the adsorption of reaction intermediates in alkaline media.

In this work, we investigate the integration of NiFe-LDH with molybdenum-based chalcogenides to expand their electrocatalytic functionality toward overall water splitting. Molybdenum chalcogenides are known for their favorable electronic properties and intrinsic activity toward the Hydrogen Evolution Reaction (HER), making them suitable candidates to complement the OER performance of NiFe-LDH. In addition, a conductive carbon support was introduced to improve electrical conductivity and facilitate the dispersion and accessibility of active sites.

The resulting composite materials were systematically characterized by electrochemical techniques, including rotating disk electrode (RDE) measurements, to evaluate their activity in alkaline conditions. Particular attention was focused to assessing catalytic performance and stability under prolonged operation.

The results suggest that combining NiFe-LDH with molybdenum chalcogenides and conductive supports enhances electrocatalytic activity and improves stability, outperforming the individual components. These results demonstrate the potential of these hybrid systems as efficient catalysts for alkaline water splitting, offering valuable insights for the rational design of advanced electrocatalytic materials.

Oral Presentation S12-4 (Id.79)

Direct seawater electrolysis for hydrogen production

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Seawater Electrolysis, Hydrogen Production, Oxygen Evolution, Alkaline Electrolytes, Electrocatalysis.

Seawater electrolysis is a promising alternative for hydrogen production due to the abundance of the resource and the elimination of purification steps. The main challenge is the oxygen evolution reaction (OER) at the anode, which exhibits slow kinetics, high overpotential and the formation of adsorbed intermediates. In addition, the presence of chloride ions competes with the oxidation reaction, reducing selectivity and causing corrosion. To overcome these limitations, highly active and selective catalysts have been developed. Recent studies show that nickel-based modified electrodes, especially in alkaline electrolytes simulating seawater, exhibit high catalytic activity, lower overpotential, and increased corrosion resistance. Fig.1 compares the voltammetric profile of nickel foam (Ni/NF) and nickel-iron (NiFe/NF) electrodes, indicating that iron modification reduces the potential required to initiate the OER, improving efficiency.

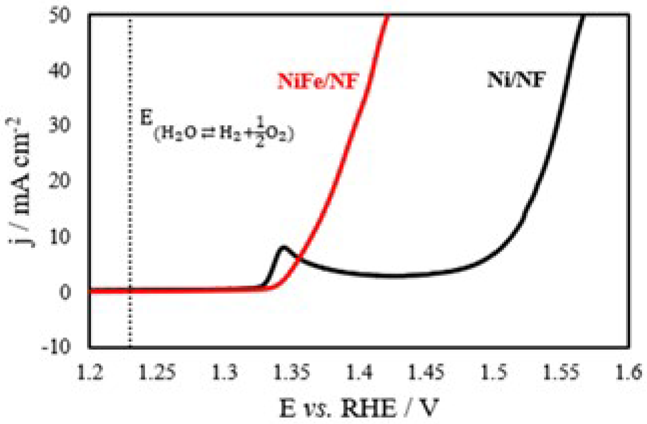

Fig. 1 Voltammetric profile of the NF and NiFe/NF electrode, obtained at 5 mV s^{-1} in 1.0 mol L-1 KOH.

The catalytic behavior of modified nickel electrodes will be analyzed, highlighting their activity and stability in alkaline seawater electrolysis and showing that these modifications enhance efficiency and durability, thereby contributing to more sustainable systems. Their performance will be evaluated through experiments ranging from three-electrode cells with 1 cm² electrodes to electrolyzers with 25 cm² electrodes, integrating insights from fundamental studies to practical applications.

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Oral Presentation S4-1 (Id.14)

Determination of the diffusion coefficient of vanadium ions in practical redox flow batteries

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Vanadium redox flow battery, diffusion coefficients, crossover, digital twin, inverse optimization, energy storage, ion-exchange membrane

The increasing penetration of intermittent renewable energy sources in power grids requires robust and scalable solutions for stationary high-capacity long-term energy storage. In this context, vanadium redox flow batteries (VRFBs) have emerged as one of the most promising technologies due to their ability to decouple power and energy sizing, their long lifespan, high cycle efficiency, and ease of modular scaling [1]. The performance of a VRFB is strongly influenced by ionic and mass transport phenomena of the four vanadium ions (V^{2+}, V^{3+}, VO^{2+}, and VO_2^+) across the polymer membrane separating the two half-cells. This phenomenon is known as crossover, and the diffusion coefficient of vanadium species is a key parameter determining its magnitude. Unwanted diffusion of redox species between half-cells (self-discharge) causes capacity loss, decreased Coulombic efficiency, and increased complexity of electrolyte management [2]. Therefore, the accurate quantification of diffusion coefficients across the membrane allows not only the characterization of the cell performance but also the realistic estimation of the system degradation and its long-term behavior [3].

Traditionally, the characterization of properties such as the diffusion coefficient has been performed in lab-scale cells under highly controlled conditions. However, the experimental validation of physicochemical properties in large stacks is a critical point for the reliable scaling of VRFB systems. In particular, determining the diffusion coefficient in these stacks requires tailored methodologies that consider the inherent complexity of the system: dead zones, cumulative thermal effects, SoC heterogeneity, and the impracticality of using invasive techniques.

In this research, experimental measurements are combined with numerical simulations using a full electrochemical model implemented in a digital twin (DT) with a genetic algorithm (GA). An inverse modeling strategy was selected based on the numerical simulation of the open-circuit voltage (OCV) decay curve. During the experimental campaign, 10 tests were conducted with different SoC combinations for the posolyte and negolyte. Here, the temporal evolution of the OCV exclusively reflects the self-discharge processes induced by diffusive transport through the membrane due to the concentration gradients between the half-cells.

The results obtained confirm the capability of the DT model to accurately reproduce the self-discharge behavior of the VRFB. The excellent agreement observed between simulated and experimental OCV decay profiles (see Fig. 1) demonstrates that the model effectively captures the essential dominant diffusion-controlled dynamics governing the system under open-circuit conditions. The optimization procedure therefore provides not only a rigorous numerical validation of the modelling framework, but also a consistent and physical meaningful set of transport parameters capable of describing the actual diffusion processes occurring within the stack.

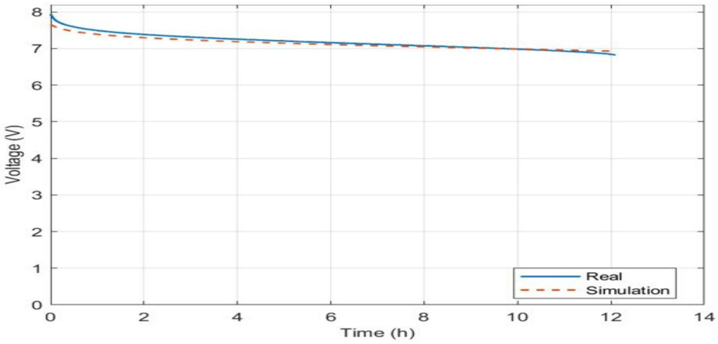

Figure 1. Experimental and numerical simulation results of the OCV for one of the tests

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Oral Presentation S4-2 (Id.29)

Beyond Solubility Limits: Quinone Mediators for Redox-Mediated Aqueous Flow Batteries.

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Organic Redox Flow Battery, Redox-Mediated Flow Battery, Redox Active Polymer, Energy Storage,

Redox-mediated flow batteries (RMFBs) have emerged as a promising strategy to overcome the solubility-limited energy density of conventional redox flow batteries. In these systems, dissolved electroactive molecules (redox mediators) act as charge transferrers that shuttle charge between the electrochemical reactor and high-capacity solid redox-active materials (boosters) stored in external reservoirs. By decoupling charge transfer from energy storage, RMFBs enable the use of solid boosters with significantly higher capacity, reducing the dependence of cell energy density on mediator solubility[1].

In this work, the negolyte side is studied for the redox mediation process by using a mixture of quinone-based organic redox mediators, 2,6-DHAQ and 1,5-DHAQ for targeting the charge and the discharge, respectively, combined with an anthraquinone-based conjugated microporous polymer booster (IEP-11)[2]. Efficient redox mediation requires a suitable thermodynamic match between the redox potentials of redox mediator and solid booster to enable spontaneous charge transfer during cycling. This required that redox compatibility between redox mediators and the solid booster is first evaluated by cyclic voltammetry. After confirming favourable redox alignment, redox mediation is demonstrated using specially designed static cells that enable rapid and controlled screening of the charge-transfer process. Finally, full aqueous redox-mediated flow battery systems are assembled to evaluate the concept under realistic operating conditions. The mechanism and interaction between redox mediators and the polymer booster are further investigated by in situ NMR and UV–Vis spectroscopy. This work demonstrates the feasibility of quinone-mediated charge transfer with sustainable redox polymer boosters, proving an effective methodology to demonstrate mediation, highlighting that dual-mediated RMFB is an alternative to single-molecule RMFB.

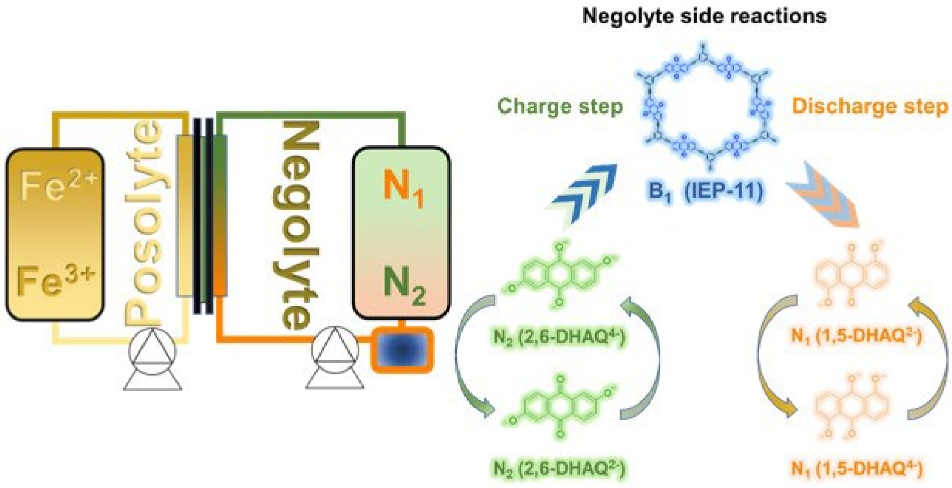

Figure 1. General scheme of the redox mediated flow system

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Oral Presentation S4-3 (Id.80)

Towards Physically-Consistent Overpotential Decomposition in VRFB Stacks: A PINN-Based Modelling and Benchmarking Approach

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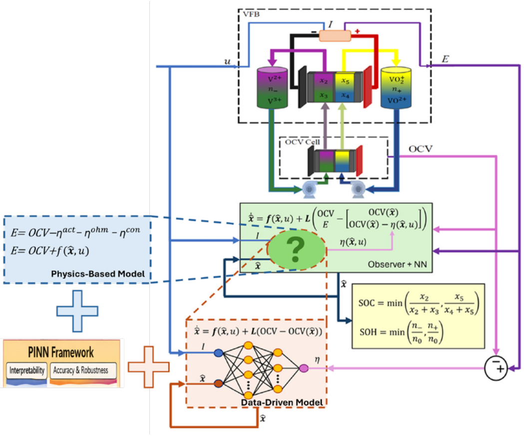
Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Physics-Informed Neural Networks; Vanadium Redox Flow Batteries; Overpotential Decomposition; Stack-Level Modeling; Hybrid Modeling; Model Benchmarking

Vanadium redox flow batteries (VRFBs) have emerged as a promising solution for large-scale energy storage applications due to their scalability, long cycle life, and operational flexibility. However, their performance is strongly influenced by electrochemical losses, including activation, ohmic, and mass transport overpotentials, whose accurate identification remains a major challenge, particularly at stack level where multi-cell interactions introduce additional complexity[1].

This work proposes a Physics-Informed Neural Network (PINN) framework for the identification and explicit decomposition of overpotential contributions in VRFB systems. The approach integrates experimental measurements with governing electrochemical equations, enabling the estimation of individual polarization components while preserving physical consistency. The proposed formulation extends previous observer-based and data-driven voltage modelling strategies towards a unified physics-informed learning paradigm[2].

The methodology has been experimentally validated using data from VRFB stacks with different numbers of cells, allowing the analysis of how overpotential contributions evolve with system scale and operating conditions[3]. Furthermore, a systematic comparison has been conducted between three modelling approaches: a classical physics-based model, a purely data-driven neural network, and the proposed PINN framework.

The results demonstrate that the PINN approach achieves an improved balance between accuracy, robustness, and physical interpretability. In addition, it provides enhanced insight into stack-level behaviour and enables a more consistent characterization of electrochemical losses across operating regimes. These features make the proposed framework a promising tool for advanced modelling, analysis, and real-time monitoring of VRFB systems.



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Oral Presentation S4-4 (Id.74)

Beyond the Membrane: Enhancing Stability through Interphase Insights in Aqueous Biphasic Flow Batteries

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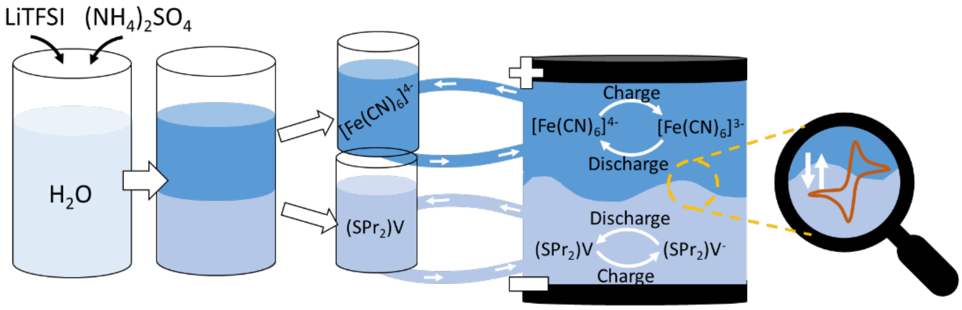
Type of abstract: Oral presenters

Subject area: Advanced batteries and capacitors

Keywords: Redox Flow Batteries; Membrane-free Flow Batteries; Liquid-Liquid interphase; Aqueous redox electrolytes

The transition toward a decarbonized global energy infrastructure scalable and stationary energy storage. Electrochemical devices offer high efficiency and reliability. Besides, Redox flow batteries (RFBs) present a highly flexible solution by decoupling power and energy density. Though, their commercial deployment is hindered by the use of costly ion-exchange membranes, which can account for ~40% of the total battery price, and the reliance on critical raw materials like Vanadium. Membrane-free flow batteries based on aqueous biphasic systems (ABS) aim to bypass these limitations through the thermodynamically driven separation of immiscible electrolytes. Nevertheless, early prototypes[1] struggled showing low power density due to high viscosity and poor mass transport, alongside low coulombic efficiencies caused by self-discharge at the liquid-liquid interphase.

To address these challenges, we present a novel aqueous membrane-free flow battery utilizing a dual-salt ABS composed of LiTFSI and $(NH_4)_2SO_4$) that drastically enhances ionic conductivity and lowers viscosity. By pairing highly compatible redox species, potassium ferrocyanide and a sulfonated viologen derivative, we achieved effective thermodynamic partitioning (a tenfold higher concentration in their respective electrolytes) across all oxidation states. Crucially, this mutual compatibility enabled the first in situ scanning electrochemical microscopy (SECM) analysis of the liquid-liquid interphase, successfully unraveling local concentration gradients and self-discharge mechanisms (Figure 1). The optimized transport properties of the electrolytes expanded the battery open-circuit voltage to 1.1 V and enhanced the battery power density by 3.5 times when compared to previous membrane-free architectures[2]. The flow battery achieved an 80.2% energy efficiency and demonstrated remarkable long-term stability, maintaining performance over 400 cycles (one month) without capacity fading[3].



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Oral Presentation S5-1 (Id.38)

Effect of the Sulfur Incorporation in Single Atom Catalysts as Electrocatalyst for PEMFC-Type Devices

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: SACs; ORR; catalysts; Polymer Electrolyte Fuel Cells; H2

Moving towards more renewable and resilient energy sector the integration of solar and wind energy requires the development of efficient energy storage and conversion technologies. Electrochemical energy storage systems (Li-ion, Naion and Redox Flow Batteries [RFBs]), together with chemical storage as hydrogen (H_2) have gained considerable attention. Excess electricity from renewables can be used to produce green H_2 via water electrolysis, used as energy vector[1] to generate electricity on demand[2]. In this respect, Polymer Electrolyte Membrane Fuel Cells (PEMFCs) play a critical role[3], although their full implementation in the actual energy sector is limited because the high loading of Pt (critical raw material) required for the cathode due to the sluggish kinetics of the oxygen reduction reaction (ORR)[4]. As an alternative, combining the fast kinetics of RFBs (catholyte) and PEMFCs (anode) in a device called regenerative fuel cell (RFC), can reduce the utilization of Pt, thus favoring its use for energy storage[5]. Developing catalysts based on abundant transition metals is critical for reducing cost and facilitate PEMFCs implementation in the energy sector[6]. In this context, Single-Atom catalysts (SACs) have gained much attention in recent years because of their significant activity for the O_2 and H_2 reactions (using transition metals)[7].SACs are efficient for ORR, even in acid media, approaching the Pt activity[8]. Here, we present the effect of sulfur incorporation into the SACs, which consists in enhancing their ORR activity and stability as well as their performance for the H_2 reactions[9].

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Oral Presentation S5-2 (Id.120)

Tracking the evolution of winery-waste derived single atom Cu-NC electrocatalysts during the CO_2 to CO conversion

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: CO2 electroreduction, Cu-N-C, operando X-ray absorption spectroscopy, biomass-derived activated carbons

Controlling selectivity in the electrochemical CO2 reduction reaction (CO2RR) remains challenging due to the complex network of competing intermediates. Carbon monoxide (CO) is a key species, as it can be further converted into fuels and chemicals via established routes. Metal-nitrogen-carbon (M-N-C) catalysts with atomically dispersed M-Nx (M = Fe, Ni) sites have attracted special attention for CO production[1]. Although selective CO formation in Cu-N-C analogues is challenging since Cu-N_x moieties tend to form Cu nanoparticles under CO_2 electrolysis[2], we recently demonstrated that Cu-N_4 sites enhance CO_2-to-CO turnover frequency[3]. Motivated by the sustainability and low cost of biomass-derived materials, this work explores single-atom Cu-N-C catalysts from abundant winery residues.

Six N-doped activated carbons with tailored textures and N contents were synthesized from grape pomace or stems via three routes with different numbers of steps. The resulting Cu-N-C catalysts (0.1-0.3 wt.% Cu) were obtained by mixing with the metal precursor, followed by pyrolysis and acid treatment[3]. Electrochemical tests in a CO_2-saturated 0.1 M $KHCO_3$ H-type cell confirmed selective CO production for all catalysts, with the materials obtained by the simplest route yielding the highest CO production. Given the instability of Cu-Nx moieties under CO_2RR, operando X-ray absorption spectroscopy (XAS) was employed. XAS spectra at the Cu K-edge confirmed isolated Cu-N4 sites in all samples. Operando measurements revealed the transformation of Cu-Nx sites into Cu nanoparticles during CO2RR. The results provide valuable insights into the valorization of abundant residues into sustainable electrocatalysts for CO2-to-CO conversion.

Acknowledgements: The authors acknowledge support from project CNS2023-144433 to MICIU/AEI/10.13039/501100011033 and the European Union NextGenerationEU/PRTR and thanks synchrotron SOLEIL for providing beamtime at the SAMBA beamline (20250635).

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Oral Presentation S5-3 (Id.122)

Single-atom and MOF-derived catalysts for the electroreduction of O_2 and CO_2

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: Oxygen reduction reaction, carbon dioxide electroreduction, MOF, single-atom catalyst, DEMS

The oxygen reduction reaction (ORR) is a key process in electrochemical devices such as metal–air batteries and fuel cells; however, its sluggish kinetics require the use of efficient catalysts. Although noble metals exhibit high activity, their high cost and limited availability hinder their widespread application. Therefore, the development of efficient, low-cost alternative catalysts is essential to advance sustainable energy technologies.

This work presents the synthesis and evaluation of a high-performance ORR catalyst based on a manganese - metal-organic framework (MOF) ZIF-67 supported on S- and N-doped reduced graphene oxide (MnZIF/SN-rGO). The material was obtained via a simple coprecipitation method followed by pyrolysis, resulting in a porous hybrid structure with abundant active sites and enhanced electrical conductivity [1].

On the other hand, the electrochemical conversion of carbon dioxide into value-added chemicals and fuels represents a major challenge for the sustainable energy transition. Current research strategies focus on the development of advanced materials capable of maximizing CO_2 interaction (adsorption-reaction). In this context, atomically dispersed catalysts (also known as single-atom catalysts, SACs) have emerged as one of the most promising approaches to achieve highly selective CO_2 conversion while minimizing the use of noble metals. Results for a Fe SACs will be described [2].

Additionally, catalysts obtained via thermal decomposition of preformed MOFs dispersed on carbide supports have demonstrated selective CO_2 reduction. This enables the use the combinatios of electrochemical techniques, such as rotating ring–disk electrode (RRDE) and differential electrochemical mass spectrometry (DEMS), for rapid product detection and evaluation of the faradaic efficiency of the process.

Acknowledgements

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Oral Presentation S5-4 (Id.13)

Silica coating of PEM fuel cell Pt/carbon electrocatalysts to enhance durability upon operation

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords:PEMFC, Catalysis, Carbon, Electrochemistry, Platinum, Silica-coating

Proton Exchange Membrane Fuel Cells (PEMFCs) are promising electrochemical devices to handle the challenges of the production of zero emission electricity. Platinum supported on carbon black (Pt/CB) is the primary catalyst used in practical PEMFC applications due to its high activity. However, the harsh operating conditions accelerate the catalyst degradation which compromises the catalyst stability and reduces the long-term efficiency of the fuel cell[1].

As a possible solution, the use of silica-coating method to increase the stability of the catalyst has been reported in the literature[2,3]. By covering the Pt/C material with a porous silica layer, one could prevent the particles from dissolution and sintering by forming a protective barrier, while the porosity of the layer ensure access to the underlying Pt particles for the reactants. As catalysts support, Carbon Xerogels (CXs) are promising candidates as it is possible to control their meso/macroporosity. This control enables optimization of the mass transport properties of the catalysts[4].

This project aims to develop silica-coating methods for Pt/CX catalysts, with a focus on achieving controlled layer thickness, uniform coatings and pores structure, thanks to statistical analysis and optimization of synthesis parameters. The catalysts are characterized for their electrochemical and surface properties using nitrogen physisorption, mercury porosimetry, electron microscopy, and accelerated stress tests (ASTs) on Rotating Disk Electrode systems. Ultimately, the most promising catalysts will be integrated into a membrane-electrode assembly (MEA) for performance evaluation.

Acknowledgements
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Oral Presentation S6-1 (Id.23)

Investigation of the surface composition of carbon xerogels used in carbon-carbon composites for sodium-ion batteries

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors

The negative electrode of sodium-ion batteries remains a challenge because graphite, the classical material of lithium-ion systems, does not efficiently intercalate sodium[1]. Other carbonaceous materials such as hard carbons are promising and have shown capacities of 300 mAh/g[2]. However, their specific surfaces are usually high, leading to significant Solid Electrolyte Interphase (SEI) formation at the 1st cycle[3]. In previous studies[4,5], carbon xerogels (CX), *i.e.* micro-mesoporous hard carbons with a controllable pore texture[6], were synthesized by the pyrolysis of a phenolic resin. A secondary carbon layer was then deposited by chemical vapor deposition (CVD), using ethylene as a precursor, to cover the micropores and reduce SEI formation[6]. The study of those carbon-carbon composites showed that the closed micropores inaccessible to the electrolyte are beneficial to sodium ion storage[4,5].

In this work, the study of the composites was further developed by investigating the impact of the surface composition of the CX on the electrochemical performance, in particular on the SEI formation. More precisely, the effect of the presence of oxygen at the CX surface was studied *via* two post-treatments: (i) oxidation under air (variable time)[7] and (ii) reduction under diluted hydrogen (variable temperature). The treated CX were then covered by a secondary carbon layer using CVD to close the microporosity. The different samples were then characterized by physicochemical and electrochemical techniques.

The electrochemical results showed that oxidation increases the irreversible capacity at 1st cycle while maintaining an identical initial coulombic efficiency whereas reduction does not modify the results significantly. Strikingly, the CVD treatment allows to homogenize the performance for CX with different surface compositions, meaning that, in addition to closing the micropores, the secondary carbon layer also gets rid of any influence of surface composition fluctuations.

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Oral Presentation S6-2 (Id.104)

Lead the Charge: Modern Solutions for Battery Material Characterization

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords:batteries, microcalorimetry, rheology, slurries, thermal analysis, electrochemical cycling, impedance, thermal stability, hyphenated techniques

As battery technologies advance toward higher performance, improved safety, and faster development cycles, robust and realistic material characterization is essential. This talk highlights recent innovations from TA Instruments supporting battery research from electrode slurry formulation to cell-level analysis. Battery Cycling Microcalorimetry (BCMS) provides unique insight into heat generation during electrochemical cycling, while Rheo-IS and advanced rheology reveal structure–property relationships in complex slurries. Emerging characterization concepts will also be introduced, offering a glimpse of what is next in thermal and multi-modal analysis for batteries. Together, these integrated measurement approaches help accelerate materials optimization and lead the charge toward next-generation energy storage.

Oral Presentation S6-3 (Id.71)

Polymer-Stabilized Ammoniate Electrolytes for Sodium Batteries

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords:ammoniates;polimer additive; sodium battery electrolytes;

In recent years, growing concerns over the environmental and economic impact of lithium-ion batteries (LIBs) have driven interest in sodium-ion batteries (SIBs) as a sustainable alternative. The development of high-performance SIBs requires not only advanced electrode materials but also electrolytes with wide electrochemical stability windows (ESWs), high thermal stability, and high ionic conductivity. Currently, most SIB electrolytes rely on organic salts dissolved in carbonate or ether solvents; however, these systems suffer from low thermal stability and limited electrochemical robustness due to the formation of fragile and non-uniform solid–electrolyte interfaces. Ammoniate-based electrolytes have emerged as a promising alternative, offering attractive physicochemical properties compared to conventional organic systems.

Ammoniates are simply ammonia solvates of inorganic or hybrid salts. Similar to ionic liquids (ILs), liquid ammoniates exhibit high ionic conductivities, with the added advantage of having relatively low viscosities and densities[1]. Their use suppresses SEI formation on sodium metal, promoting uniform and dendrite-free deposition. This leads to highly reversible electrochemical behavior, with coulombic efficiencies approaching 100%, not only for sodium metal but also for other current collectors such as copper. Such performance enables the development of anode-free battery systems.

Despite these advantages, their practical application is limited by high volatility and moderate electrochemical stability. In this work, we explore the incorporation of polymeric additives into NaI·3.3NH3 liquid ammoniate. These polymers are expected to promote intermolecular interactions that stabilize ammonia and expand the ESW. This strategy provides a rational pathway toward the for the development of new sodium-based batteries.

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Oral Presentation S6-4 (Id.9)

Co-intercalation electrolyte enabling sodium ion batteries at low temperatures

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Sodium ion batteries, Electrolyte, Low temperature

Sodium ion batteries (SIBs) are emerging as promising candidates for large-scale electrochemical energy storage due to the natural abundance and low cost of sodium resources.[1] However, at low temperatures, sluggish desolvation and the formation of thicker solid electrolyte interphase (SEI) on hard carbon (HC) negative electrode hinder the ion transport, resulting in severe performance degradation, especially below -30 °C. Here, we introduce a co-intercalation electrolyte (CIE) strategy that enables Na^+ to bypass the sluggish desolvation process and achieve efficient diffusion in both the electrolyte and the HC simultaneously. Meanwhile, regulated anion participation in the solvation sheath promotes the formation of a thin, inorganic-rich SEI, thereby facilitating rapid ion transport across SEI. Benefiting from this synergistic design, the CIE extends the operational temperature window of SIBs down to -50 °C. The Na||HC cell delivers 93.5% capacity retention after

200 cycles at -50 °C. And Ah-level HC||$NaNi_{1/3}Fe_{1/3}Mn_{1/3}O_2$ pouch cells achieve a specific energy of 107 Wh kg^{-1} at -50 °C.[2] The results provide a practical electrolyte design for enabling SIBs operation in extreme low-temperature environments.

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Oral Presentation S9-1 (Id.92)

Degradation of Fe-N-C fuel cell catalysts in a gas diffusion electrode system

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: gas diffusion electrode (GDE), oxygen reduction reaction (ORR), Fe-N-C catalyst, fuel cells

Facing the challenge of the energy transition, one of the most promising options is fuel cells (FCs), which use green hydrogen to generate electricity through electrochemical reactions. Fe-N-C catalysts have shown similar activity to that of current reference catalysts containing noble metals for the oxygen reduction reaction (ORR), which is the rate-limiting step of the process [1]. However, one of the main challenges of this technology is the durability of the catalyst [2,3].

The aim of this work was to investigate the activity and durability of an Fe-N-C catalyst for the ORR using an accelerated stress test (AST) method. For this purpose, a gas diffusion electrode (GDE) system was employed in an alkaline medium (1 M KOH). This setup represents an intermediate configuration between the basic electrochemical characterization using rotating disk electrode (RDE) and the fuel cell (FC), thereby enabling the performance of the catalysts to be analyzed in an environment closer to realistic operating conditions.

Various accelerated stress methodologies were investigated to assess degradation phenomena of the Fe-N-C catalysts, deposited on carbon gas diffusion layer and using a Gaskatel FlexCell test cell. Preliminary studies considered an accelerated stress method based on the Fuel Cell Commercialization Conference of Japan's (FCCJ) method, simulating load-cycle and start-up/shutdown conditions, which was adapted to investigate different aspects of catalyst degradation [4].

The most striking results indicate greater degradation of the material during the first cycles of the AST (approximately 60% of the total degradation during the initial cycles). This highlights the need to direct mitigation strategies towards improving this critical stage. For this reason, post-test characterizations of the electrodes at different stages of the AST are important to gain deeper insight into the mechanisms and structural changes responsible for the observed degradation.

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Oral Presentation S9-2 (Id.92)

Influence of Fan Power, Geometry and Speed on the Performance of an Open-Cathode PEMFC Stack

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: PEM fuel cells; Open-cathode; Thermal management; Fan; Efficiency.

Effective thermal management is essential for optimal performance of open-cathode proton exchange membrane fuel cells (PEMFCs). Cooling fans are particularly relevant, as they supply oxygen and remove the heat generated during operation [1, 2]. However, they often represent the most energy-demanding auxiliary component [3]. This study evaluates the impact of fan power, geometry, and operating speed on the performance of a 3-cell open-cathode PEMFC stack with an active area of 25 cm^2.

The results show that the values of the I-V and power curves at any given current density are independent of the fan and speed used, differing only in their maximum current density and power. Higher fan power or speed results in better heat removal capability and thus in a lower temperature at any given current. This helps mitigate drying and allows the stack to operate at higher current and power levels.

From a system perspective, higher cooling capability often increases the operational range but reduces efficiency due to increased fan energy consumption. Conversely, configurations with lower cooling power may achieve higher efficiencies at low current densities but cannot achieve significant net power output.

Among the tested configurations, 7W_4×4×2.8 (7 W rated power, 4×4 cm cross section and 2.8 cm depth) fan provides the best compromise, achieving the highest net power output of 23.2 W with 40.6% system efficiency, outperforming 11W_5×5×2.8 fan in terms of net power. Tests indicate that 2W_4×4×2.0 fan appears to be undersized, only performing reasonably well at its maximum speed. In contrast, the 50W_4×4×2.8 fan seems to be oversized, yielding prohibitively lower efficiency and/or net power at medium to high-speed levels.

These results demonstrate that fan selection strongly influences the thermal profile and performance of an open-cathode PEMFC. They further highlight that net power output and net efficiency are essential metrics for proper fan selection and system optimization.

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Oral Presentation S9-3 (Id.70)

Modeling and numerical simulation of a solid oxide fuel cell stack using an iterative multi-scale approach

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: SOFC Stack, Numerical Modeling, CFD Simulation

SOFCs stand out among fuel cell technologies due to their high electrical efficiency and versatility. Their high operating temperature enables fast electrochemical kinetics, internal reforming and the direct use of various fuels, such as H_2, biogas, NH_3 or syngas-derived mixtures. In industrial systems, several cells are assembled into a stack to reach the required power output. These systems involve a strong coupling between fluid flow, heat transfer, mass transport and electrochemical reactions, leading to highly complex multiphysics interactions. In this scenario, CFD has emerged as a fundamental tool for understanding the behaviour of SOFC systems [1], enabling the investigation of local gradients, limiting phenomena and design strategies that are difficult or impossible to assess experimentally.

Applying CFD modeling directly to SOFC stack entails extremely high computational cost, as it requires solving multiple repeating cells, each with complex internal processes, limiting the feasibility of parametric studies or long-term performance analyses. To overcome this, we have developed an iterative multi-scale modeling tool to decouple electrochemical and thermal phenomena. Electrochemical and transport phenomena are solved in independent single-cell domains [2], representing the repeating unit of the stack. Meanwhile, the full stack geometry is used solely to solve the temperature field and the thermal interactions between cells and interconnectors. The two levels exchange information iteratively until convergence is achieved.

The proposed multi-scale methodology, previously applied to HT-PEMFC stacks [3], is here successfully extended to SOFC, enabling to drastically reduce computational cost while preserving the physical fidelity required to analyse overall performance and thermal distribution, thus providing a robust framework for SOFC stack design, optimisation and thermal management.

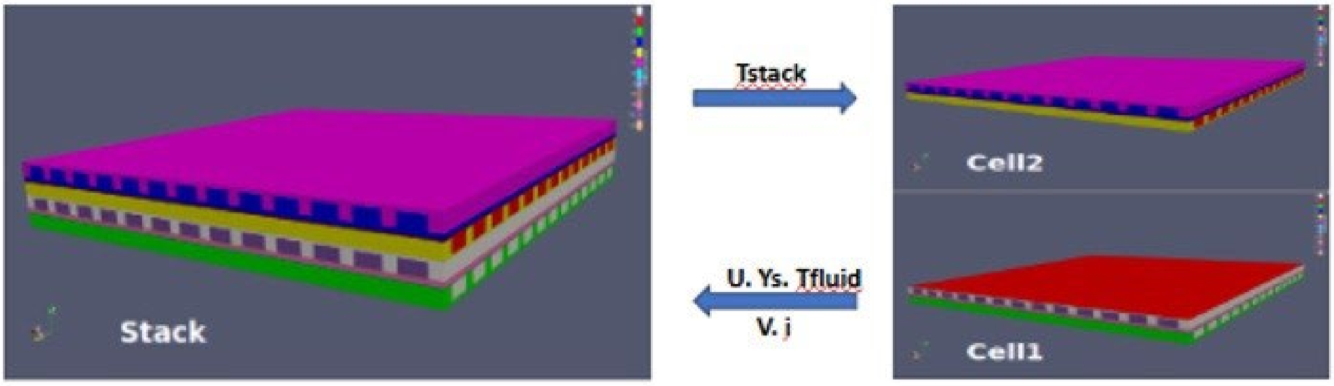

Figure 1. Information flow diagram between the two simulation domains.

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Oral Presentation S9-4 (Id.124)

Enhancing Spanish Electric System Resilience Through The Characterization Of Intermittent Renewable Surpluses For LargeScale Green Hydrogen Storage

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Green Hydrogen, Intrinsic Intermittency, Energy Utilisation Capacity, Market Surpluses, Generalized Extreme Value Theory, Hybrid Energy Storage.

This study addresses the integration of renewable energy sources under the UN 2030 Agenda, focusing on the challenges posed by wind and solar intermittency to grid stability. It evaluates national electricity market dynamics to identify surplus energy specifically for green hydrogen production.

Drawing on Suchet et al. (2020), intermittency is defined as an intrinsic physical property of a power source, independent of the energy mix or predictive capacity. It is quantified by the spread of relative power deviations across intervals from 30 minutes to 72 hours, distinguishing it from variability, dispatchability, and foreseeability. Using 2023-2025 hourly data from the national operator (OMIE), a custom algorithm identifies unmatched energy bids as physical manifestations of source intermittency. To provide a location-agnostic baseline, the study utilizes the Energy Utilisation Capacity (EUC) framework, reflecting actual resource variability rather than equipment-limited capacity factors.

Temporal and frequency analyses reveal significant cyclical patterns in surplus generation. While spatial aggregation reduces variability at a national scale, intermittency remains significantly higher than demand fluctuations. By applying generalized extreme value (GEV) theory, the study characterizes "mutation events"—sudden power shifts—enabling the calculation of return periods for specific intermittency thresholds.

The findings highlight green hydrogen as an optimal seasonal storage vector to mitigate high-amplitude intermittency. Unlike fast-response batteries, hydrogen addresses long-duration energy shortfalls. This research optimizes electrolysis facility sizing by quantifying surpluses, utilizing specific mass consumption values (e.g., 65 MWh/t H2). Ultimately, this provides a scalable methodology to convert intermittent surpluses into persistent energy reserves, enhancing power system resilience.

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Oral Presentation S10-1 (Id.45)

Development of hollow bimetallic catalysts supported on nanostructured carbons for sustainable PEM fuel cell electrodes

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: proton exchange membrane fuel cell, carbon xerogel, hollow PtCo NPs, oxygen reduction reaction

Proton Exchange Membrane (PEM) fuel cells offer an efficient method to convert hydrogen and oxygen into electricity and water, making them a promising solution for clean energy production. The catalytic layers of a PEM fuel cell are typically composed of Pt nanoparticles (NPs, ~3 nm in size) supported on carbon black and mixed with a polymer ionomer (Nafion®)[1,2]

However, upon operation, both the carbon support and the Pt nanoparticles degrade : carbon undergoes oxidation, while Pt particles coalesce or dissolve and redeposit elsewhere, resulting in performance decay.

To enhance catalyst efficiency and lifetime, our research has focused on developing hollow PtM (M=Co, Ni, Fe *etc.*) nanoparticles, as their voided architecture increases Pt utilization, provides more accessible active surface area, and can reduce the extent of Pt coalescence compared to solid nanoparticles. In particular, large (10–50 nm) hollow PtCo nanoparticles degrade more slowly, which helps maintain catalytic activity over time [3]. Alloying Pt with transition metals such as Co or Ni contracts the Pt lattice, which leads to widening the d-band and lowering the reaction activation energy [4].

PtCo/CX catalysts have been synthesized in previous work [3], but the 14-step procedure is too complex and requires simplification. The main goal of this work is to rationalize and optimize the synthesis route for hollow PtCo/CX catalysts. Several synthesis parameters were systematically investigated to identify which variables influence the nanoparticle size, morphology, and composition, and which steps can be simplified to improve the manufacturing procedure.

The electrochemical performance of the hollow PtCo/CX catalysts was assessed in 0.1 M $HClO_4$ on a rotating disk electrode. The catalysts exhibited higher mass and specific activities than the commercial Vulcan Pt/C material, confirming the beneficial effect of alloying and hollow nanostructuring on ORR performance.

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Oral Presentation S10-2 (Id.88)

Tailoring Active and Stable Electrodeposited Ni-Based Catalysts for HER in Alkaline and Alkaline-Saline Media

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Type of abstract: Oral presenters
Subject area: Hydrogen

The growing demand for green hydrogen is driving the development of efficient water-splitting technologies, with alkaline electrolysis standing out for its compatibility with non-noble metal catalysts. In alkaline media, the hydrogen evolution reaction (HER) is slowed by the required water dissociation step, making catalyst design crucial for improving reaction rates. Ni-based catalysts have become an attractive option for alkaline HER, as their activity can be enhanced by incorporating additional species. Among these approaches, bimetallic NiMo alloys are known to improve hydrogen adsorption [1], while the incorporation of CeO_2 has been associated with facilitated water dissociation and increased surface stability [2]. Moreover, extending HER catalysts to alkaline-saline media is particularly relevant for future seawater electrolysis as a strategy to reduce freshwater consumption. However, chloride ions can accelerate degradation and diminish catalytic activity, highlighting the importance of identifying Ni-based catalysts capable of sustaining performance under such demanding conditions.

To explore these aspects, Ni-based catalysts were prepared by electrodeposition onto carbon paper (TCP) (Figure 1a), incorporating species such as Mo or CeO_2 to assess their impact on HER performance. Preliminary results indicate that Cecontaining coatings exhibit enhanced activity and that the catalysts retain stable performance in alkaline-saline conditions (1 M KOH + 0.5 M NaCl) (Figure 1b). Ongoing efforts focus on refining the electrodeposition parameters, including electrolyte composition and electrochemical conditions, to further modulate catalyst dispersion, surface morphology, and coating thickness, together with comprehensive structural and chemical characterization to directly correlate catalyst structure with HER performance.

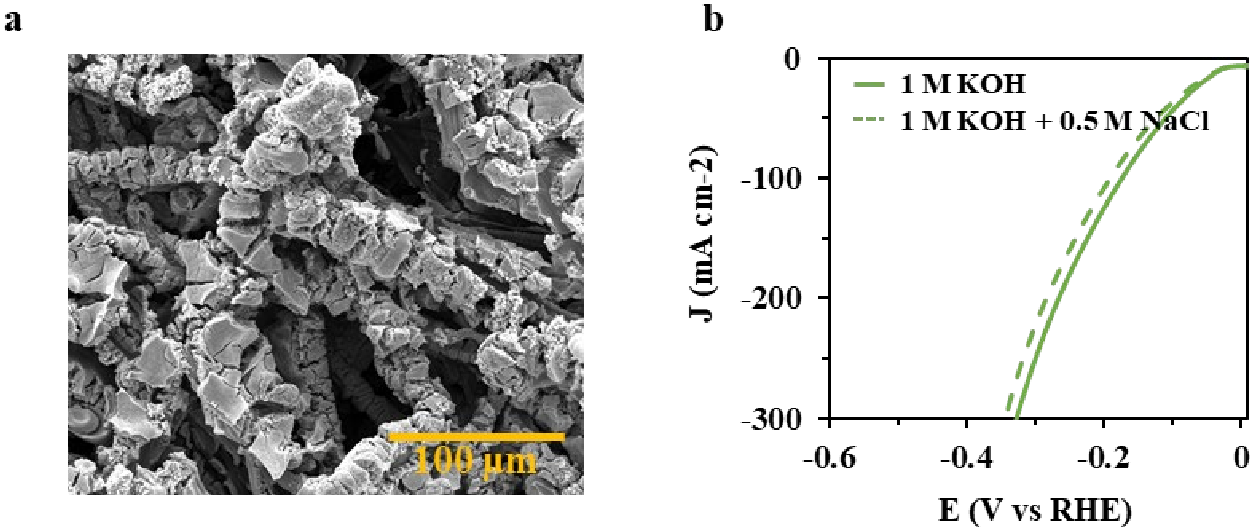

Figure 1. a) SEM image of $NiCeO_2$@NiMo /TCP and b) HER polarization curves of the same sample in 1 M KOH and in 1 M KOH + 0.5 M NaCl.

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Oral Presentation S10-3 (Id.123)

Methanol Oxidation as a Diagnostic for OH Adsorption on Pt

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Type of abstract: Oral presenters
Subject area: Fuel cells
Keywords: Pt, methanol oxidation, electrochemistry, OH adsorption

The electrochemical oxidation of methanol (MOR) is a benchmark reaction in electrocatalysis, yet its fundamental study is often hindered by experimental irreproducibility and the complex nature of the Pt-electrolyte interface. This presentation integrates two key studies that redefine how we prepare, measure, and interpret the early stages of alcohol oxidation on platinum surfaces.

First, we resolve the chronic irreproducibility in alcohol oxidation by demonstrating that experiments often start before we think via vapor-induced pre-poisoning [1]. Even before immersion or potential control, volatile alcohol vapors in the cell atmosphere adsorb and decompose on Pt at open circuit. This process forms CO-like intermediates that mask the catalyst's true initial response. By preventing this pre-exposure, we recover pristine voltammetric signatures and identify a characteristic low-potential dehydrogenation.

Building on this refined experimental control, we propose a paradigm shift. Using the MOR as a spectroscopy-free diagnostic tool for detecting OH adsorption [2]. While OH species are essential for methanol activation, their direct identification typically requires advanced spectroscopic techniques. By analyzing the initial voltammetric cycles across a comprehensive set of Pt surfaces spanning the entire stereographic triangle, we show that the MOR provides a direct readout of surface coordination. Our results confirm that OH adsorption occurs at unusually low potentials on low-coordination sites (steps and kinks), regardless of terrace width. The systematic shift in the position and intensity of these dehydrogenation features serves as a structural fingerprint, allowing us to map reactive surface motifs.

In summary, this presentation will not only resolve historical discrepancies in electrocatalytic data but will also offer a powerful electrochemical tool to probe the reactive state of Pt surfaces and their specific site-dependent activity toward
MOR

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Oral Presentation S10-4 (Id.85)

Engineering Nickel Catalysts for High-Efficiency Urea Electrolysis and Sustainable Hydrogen Production

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Type of abstract: Oral presenters
Subject area: Hydrogen
Keywords: Urea, electrolysis, nickel-based electrocatalysts, hydrogen production, energy consumption

Hydrogen technologies are becoming a cornerstone of sustainable energy systems. Among the emerging approaches, urea electrolysis offers a promising pathway to simultaneously reduce the energy demand for hydrogen production while enabling the valorization of nitrogen-rich wastewater streams[1]. Nickel-based materials have been widely studied as electrocatalysts due to their high efficiency and stability in alkaline media. In this work, three nickel-based catalytic systems with different structures and electronic environments, $Ni(OH)_2$, $Ni_2Fe(CN)_6$, and NiFe layered double hydroxide, were systematically evaluated as catalysts for urea oxidation reaction (UOR). A preliminary screening was conducted under highly alkaline conditions, followed by a deeper electrochemical characterization in the presence of urea in order to investigate catalyst activity and stability. Particular attention was given to the role of Fe incorporation and the modification of the Ni coordination environment, which are expected to influence the formation and stabilization of the active NiOOH phase and thus affecting the catalytic performance of urea. After identifying the most active material, full-cell electrolysis experiments were performed using an electrolyte containing 0.33MUrea and 5MKOH at current densities of 37.5 and 75$mAcm^{-2}$. The system demonstrated stable operation and a significant reduction in energy consumption, reaching a specific energy demand of

46.5$kWhkg^{-1}H_2$. Overall, this work provides a comparative evaluation of nickel-based catalytic systems for urea electrolysis and highlights the structural factors governing their electrocatalytic activity, contributing to the development of more energy-efficient hydrogen production.

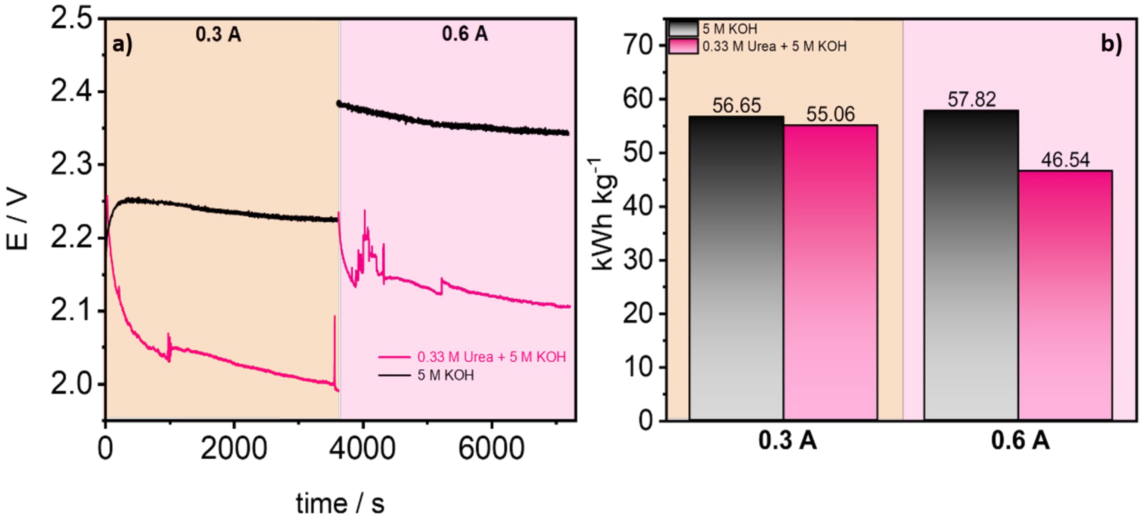

Figure 1. **a)** Chronopotentiometric curves obtained at constant currents of 0.3A (orange) and 0.6A (pink) in 0.33M Urea+5M KOH for $Ni(OH)_2$ **b)** Specific energy consumption ($kWhkg^{-1}H_2$) at the two applied currents for 5M KOH (black) and 0.33M Urea+5M KOH (pink) for $Ni(OH)_2$

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Oral Presentation S13-1 (Id.10)

Novel nitrogen-based solid polymeric electrolytes for next generation Zinc batteries: An environmental impact analysis using Life Cycle Assessment methodology.

Miguel Ángel González Lara (1), Ángel Galán-Martín (1), Daniel Brandell (1), Manuel Merguizo (1), Antonio PeñasSanjuán (1),
Pedro Jesús Navarrete Segado (1)
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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Life cycle assessment (LCA), batteries beyond Li-Ion, organic batteries, polymer electrolytes, carbon footprint.

The transition toward low-carbon energy systems and the widespread electrification of economic activities have intensified the demand for efficient, scalable, and environmentally sustainable battery technologies. Consequently, increasing attention is being directed toward post-lithium systems, such as multivalent metal-ion batteries (e.g., magnesium, calcium, and zinc). These systems offer superior theoretical volumetric capacities and utilize more abundant, less toxic elements. However, the inherent reactivity of multivalent ions (e.g., Ca2+ or Zn2+) with these solvents often triggers the formation of passivating interphases, ultimately impeding electrode functionality. Over the past decade, solid polymer electrolytes (SPEs) have emerged as promising candidates for enhancing the safety and cycling stability of these batteries. However, despite their potential, reliable SPEs for multivalent ion systems remain in their infancy and their comprehensive environmental performance has yet to be fully evaluated.

This research focuses on the development of a new concept of a SPE based on nitrogen-type structures, which can address the current limitations of multivalent-ion rechargeable batteries. In particular, we investigated an innovative solid-state polymer electrolyte, characterized by good mechanical stability, low heat transfer, high ionic conductivity, and high stability, based on aminotriazole-type repeating units. This material has demonstrated promising properties for use in multivalent-ion batteries, particularly zinc ion batteries. Subsequently, the polymer electrolytes were mixed with zinc salts (concentrations ranging from 80% to 50% polymer) to produce thin-film membranes, which were validated for zinc secondary batteries by using Electrochemical Impedance Spectroscopy (EIS). Finally, a Life Cycle Assessment (LCA) was performed to evaluate the environmental impact of the manufacturing process, revealing a promising carbon footprint.

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Oral Presentation S13-2 (Id.24)

Novel Polyperylenediimide-Based Organic Polymers as Cathode Materials for Secondary Calcium Organic Batteries: A Green Chemistry Approach

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(1) University of Jaen. Spain, (2) University of Jaen. Spain

Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Secondary Calcium Organic Batteries, Organic electrode materials, Polymer cathode, Polyimide, Green Chemistry Approach

The twin green and digital transitions, together with the profound transformation of the European economy, industry, and society required to achieve climate neutrality by 2050, represent a major challenge. Addressing this challenge is not possible without the development of new energy storage technologies, essential for enabling sustainable energy strategies based on renewable sources such as wind and solar power. Conventional energy storage systems predominantly rely on lithium-based materials and transition metals, whose extraction and utilization entail significant environmental, social, and economic impacts. Consequently, there is an urgent need to identify innovative and sustainable energy storage alternatives.

In this context, calcium-based batteries have emerged as promising transition-metal-free candidates, expected to be safe, efficient, and cost-effective, though their development remains hindered by a lack of high-performance cathode materials. Organic electrode materials (OEMs) have emerged as an interesting alternative, with research exploring active polymers, organosulfur compounds, and carbonyl-based systems. Despite strategies such as structural engineering, polymerization, and amorphization, the application of OEMs in multivalent batteries remains underdeveloped, with low operating voltage, poor electronic conductivity, and electrolyte dissolution still posing critical challenges.

In this study, we present our latest advancements in developing organic cathodes based on polyperylenediimide redoxactive materials using a novel, cost-effective, reproducible, and sustainable approach, eliminating the need for expensive and environmentally harmful solvents such as DMF and DMSO. The hybrid materials were structurally characterized via NMR, EA, XRD, and IR spectroscopy. Subsequently, their electrochemical properties were assessed using techniques such as cyclic voltammetry and electrochemical impedance spectroscopy.

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Oral Presentation S13-3 (Id.40)

High-Purity Recovery and Structural Restoration of Anode Graphite from NMC-Type Batteries using a Mild Citric Acid-Based Hydrometallurgical Route

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Type of abstract: Oral presenters

Subject area: Advanced batteries and capacitors

Keywords: Lithium-ion battery recycling, spent graphite purification, citric acid leaching, structural restoration of graphite, electrochemical validation

Introduction

This study investigates the effectiveness of citric acid, for the high-purity purification and structural upcycling of spent graphite (SG) derived from end-of-life lithium-ion batteries (LiBs). Amid the global energy transition and strategic constraints on critical raw material supply chains, recovering anode graphite is essential to advancing a circular economy.[1] End-of-life graphite typically suffers from structural defects, reduced crystallinity, and contamination by residual metals and solid electrolyte interphase (SEI) byproducts. By employing a mild hydrometallurgical approach based on organic acids, this work provides a sustainable alternative to conventional inorganic acid treatments, mitigating associated environmental impacts. [2], [3]

Methodology and Key Findings

Metal extraction (Li, Ni, Co, Mn) was quantified by ICP-MS. Process optimization employed a 3^3 factorial design evaluating temperature (60–90 °C), citric acid concentration (0.10–0.30 $mol \cdot L^{-1}$), and solid-to-liquid ratio (1:30–1:70). Optimal conditions (90 °C, 0.20 $mol \cdot L^{-1}$ citric acid, 1:50 ratio) delivered exceptional purification, achieving >95% lithium removal and substantial reduction of Ni, Co, and Mn impurities. XRD and Raman spectroscopy demonstrated restoration of the graphitic crystalline structure.

Validation and Material Revalorization

Comprehensive characterization (XRD, Raman, SEM, XPS) confirmed recovery of battery-grade graphite without structural degradation. Electrochemical validation in CR2025 coin cells showed high specific capacity (>300 $mAh\ g^{-1}$) and stable performance over 100+ cycles, demonstrating the feasibility of a closed-loop, material-to-material recycling pathway.[4] Acknowledgements

This research was funded by the European Union (EU) under the Horizon Europe research and innovation programme (grant agreement No 101193032 “BeyondBattRec”) and Junta de Andalucía (grant agreement No. EMC21-00293 “EMERGIA PolyBatt”)

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Oral Presentation S13-4 (Id.76)

Development of Software for Energy Management and Cost Minimization in Electrochemical Plant Operation Using Renewable Energy and Battery Support

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords:renewable energy, vanadium redox flow battery, energy storage, simplex linear programming, optimization cost

Renewable energy generation is becoming increasingly important, and integrating it with energy storage systems is crucial for improving energy management and overall efficiency. In this scenario, energy flows must be managed to achieve the lowest possible cost.

In our case, an electrochemical plant must operate using solar and wind power, a supporting vanadium redox flow battery, and electricity grid. Given the complexity of the system, software integrating different tools has been developed for two main purposes: predicting renewable energy availability and managing the energy flows to minimize costs.

The software incorporates four main tools: (1) a one-day weather forecast providing temperature, solar radiation, and wind speed profiles; (2) a renewable energy power estimation module for solar and wind generation; (3) a battery management system; and (4) a linear-programming-based optimization tool for cost minimization, which includes the price of grid electricity and the amortization of the equipment.

In order to operate the software, several input values were required: the number and nominal power of the solar panels and wind turbines; the battery characteristics; and, finally, the date. The model predicted the weather conditions, then it estimated the renewable power generation. Finally, the optimization tool minimized the total cost.

The results of the energy cost minimization are shown in Figure 1. The orange line represents the cost when the energy was supplied directly from the grid, whereas the blue line represents the cost when the software optimized the use of renewable energy.

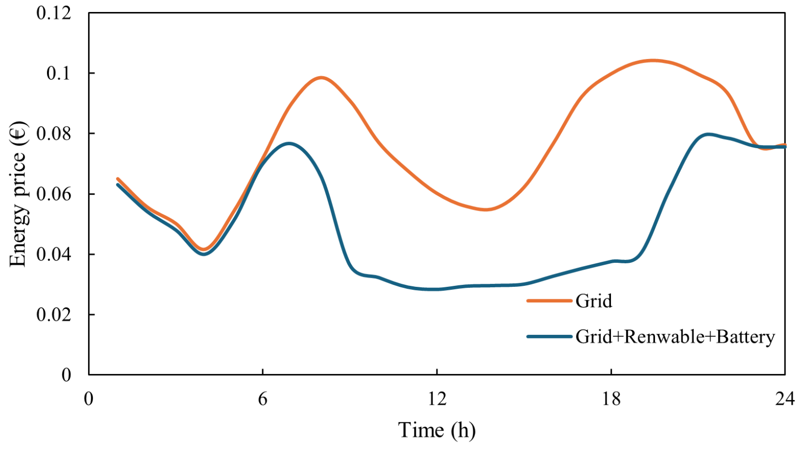

Figure 1. Total energy cost from Grid (orange) and optimized (blue).

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Oral Presentation S14-1 (Id.42)

A simple and effective method to synthesize ZnS@C composites for use as anode materials in Na-ion batteries.

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: Nanotechnology, Oxides and sulfides, Electrochemistry, Nanostructures, Nanoparticles

Energy storage has become essential to sustain modern life, and to enable the decarbonization of the energy and transport sectors. Li-ion batteries have driven some of the most transformative advancements in energy storage. However, lithium scarcity and its geopolitical constrains have stimulated growing interest in alternative chemistries, where sodium stands out for being a more abundant, economic and geographically well-distributed material with comparable electrochemical properties. Hard carbon materials are already implemented as the negative electrode in commercial Na-ion batteries.

However, they suffer from low initial Coulombic efficiency, moderate specific capacity (~ 300 mAh g^{-1}) and poor performance at fast charge and discharge rates. In the search for high energy density and excellent electrochemical performance, transition metal sulfides, specifically ZnS, have attracted great attention due to nontoxic nature, inexpensive raw materials and abundant elements. Despite its high theoretical capacity (610 $mAhg^{-1}$), there are some serious issues related to its low electronic and ionic conductivities, and large volumetric changes during Na insertion/deinsertion which compromise its electrochemical performance. Herein we propose its hybridization with carbon to overcome its limitations by using a simple, sustainable and potentially scalable method. The resultant ZnS@C composite is able to provide a capacity of 530 $mAhg^{-1}$ at

0.05 A g^{-1} and still preserving a large value of 300 $mAhg^{-1}$ at 2 A g^{-1}. A battery was assembled to support the applicability of the material by using commercial sodium vanadium phosphate as cathode material, obtaining a full cell device that exhibited a capacity of 528 $mAhg^{-1}$ (based on the anode mass) at 0.05 A g^{-1} and 266 $mAhg^{-1}$ at 0.5 A g^{-1}, as well as a stable cyclability (ca. 70% retention after 250 cycles at 0.2 A g^{-1}).

Oral Presentation S14-2 (Id.64)

Exploring Fast Parameterization of P2D Models in Commercial Sodium-Ion Batteries via Intermittent Current Interruption

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Type of abstract: Oral presenters

Subject area: Advanced batteries and capacitors

Keywords: Sodium-ion batteries Intermittent Current Interruption (ICI) Parametrisation of OCV, Diffusion Coefficient and Internal Resistance Pseudo-two-dimensional modeling (P2D)

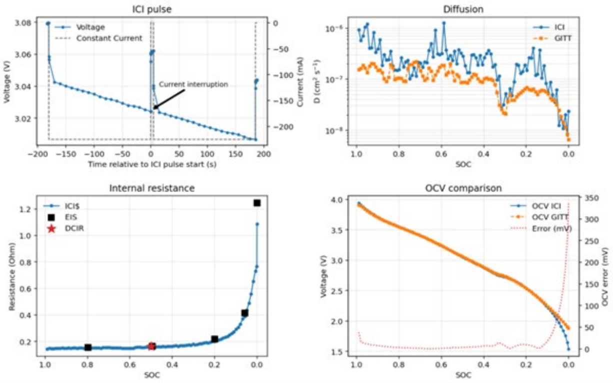
Physics-based models such as the pseudo-two-dimensional (P2D) framework are powerful tools for understanding and predicting the behavior of sodium-ion batteries. However, their predictive capability, depends also on accurate parametrization of transport and kinetic properties which practical implementation is both experimentally demanding and time-consuming, as it typically relies on techniques such as galvanostatic intermittent titration technique (GITT) or electrochemical impedance spectroscopy (EIS). In this context, there is a clear need for faster and more efficient methodologies that can deliver comparable parameter sets without compromising reliability.

Here, we propose Intermittent Current Interruption (ICI) as a rapid and reliable alternative for extracting key transport and kinetic parameters in commercial sodium-ion cells.

ICI measurements were performed using three protocols varying the number of pulses and relaxation times. Voltage responses during short current interruptions were analyzed to extract internal resistance and sodium-ion diffusion-related parameters across the full state-of-charge window. In addition, the relaxation behavior enables determination of the cell open-circuit voltage (OCV), providing thermodynamic information without long equilibration steps.

Comparison with GITT, EIS, and DCIR shows strong agreement, even with short relaxation times (5 s) and pulse intervals of 1% state of charge. Under these conditions, a full cycle can be characterized by a total relaxation time of ~6 minutes at C/10 or even C/5 rates, demonstrating a significant reduction in experimental time while maintaining robustness.

The extracted parameters, including resistance, diffusion-related properties, and OCV profiles, can be implemented in P2D models to simulate full-cell behavior. This approach enables accelerated model-based development and diagnostics of sodium-ion batteries, particularly in industrial and high-throughput environments.



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Oral Presentation S14-3 (Id.105)

Chemical design of sustainable materials for the anode of high performance sodium-ion battery anodes

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: sodium-ion batteries, anodes, sol-gel, sustainable carbon gels

Sodium ion-batteries (SIBs) represent a promising alternative to the currently widespread lithium ion-batteries (LIBs), as they do not rely on critical raw materials and operate through analogous electrochemical principles. Among the different anode materials, hard carbons have proven to be the most suitable anode materials in SIBs due to the wide range of available precursors and synthetic routes, which leads to a large variability in material properties.1 Synthetic routes, such as sol-gel methodology, allow the production of highly reproducible carbon materials with well-controlled chemistry and tailored properties, making them well suitable for this specific application.

Herein, we present an efficient and scalable process to obtain sustainable synthetic aerogels to be used as anodes in SIBs. The proposed synthesis is based on sol-gel methodology assisted by microwave heating, shortening the time of reaction considerably. Instead of using resorcinol and formaldehyde, which are reagents frequently used in this type of synthesis2, less toxic options such as tannins (a green precursor) and glyoxal are employed. Remarkably, and just by simple modulation of the tannins/glyoxal ratio, both physicochemical properties and electrochemical performance of the resulting materials can be finely adjusted.

This allowed the synthesis of carbon aerogels with excellent electrochemical performance as anodes for SIBs. Thus, specific capacity values of ~ 300 mAh g-1 were achieved at 30 mA g-1 with a capacity retention of 97 % after 35 cycles. In addition, the initial coulombic efficiency was > 70 %, achieving values of ~ 100 % in cycle 5. These results are consistent with those reported for hard carbons in literature3 and highlight the crucial role that chemical design has in the final physicochemical properties of the material and their impact on the anode performance in sodium-ion batteries.

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Oral Presentation S14-4 (Id.108)

Pore Size Engineering in Sustainable Materials for Enhanced Sodium-Ion Battery Capacity

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Type of abstract: Oral presenters
Subject area: Advanced batteries and capacitors
Keywords: sodium-ion batteries, anodes, sol-gel, tannins, sustainable carbon gels.

El almacenamiento de energía es esencial para lograr un uso eficiente tanto de la energía proveniente de fuentes renovables como de la movilidad eléctrica. En este contexto, las baterías de iones de sodio (SIBs) están surgiendo como una alternativa viable a las baterías de iones de litio debido a la abundancia y el bajo costo del sodio, a la vez que reducen la dependencia de materiales críticos. Las SIBs suelen utilizar ánodos basados en carbonos desordenados, en particular carbonos duros, capaces de proporcionar capacidades de alrededor de 300 mAh g^{-1} [1]. Sin embargo, los carbonos duros generalmente se obtienen de biomasa, lo que genera problemas de reproducibilidad tanto en las propiedades de los materiales como en su rendimiento como ánodos en las SIBs. En este sentido, la síntesis sol-gel asistida por microondas emerge como una ruta sostenible que permite controlar las propiedades fisicoquímicas del carbono con el objetivo de optimizar su aplicación como ánodos en las SIBs [2].

En este trabajo, se empleó una síntesis sol-gel asistida por microondas, utilizando taninos como precursor sostenible, para obtener aerogeles de carbono, los cuales se evaluaron como ánodos para baterías de iones de sodio (SIB). Este estudio revela que la variación del pH durante la síntesis modifica el tamaño de poro, el área superficial, la morfología nodular y la incorporación de grupos funcionales que afectan el rendimiento electroquímico de los aerogeles de carbono como ánodos en SIB. Al ajustar estos parámetros, se lograron preparar aerogeles de carbono capaces de proporcionar capacidades de aproximadamente 310 mAh g^{-1} a 50 mA g^{-1} con una retención de capacidad superior al 90 % después de 50 ciclos. Además, la eficiencia coulómbica inicial fue > 70 %, alcanzando valores de ~ 100 % en el ciclo 5. Los resultados son excelentes, reproducibles y comparables a los carbones duros comerciales, lo que confirma que esta ruta sol-gel asistida por microondas derivada de taninos es un método robusto y escalable para producir ánodos de SIB sostenibles y competitivos.

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POSTER PRESENTATIONS

Poster Presentation P1 (Id.5)

Co_3O_4 and Cr_2O_3 Particles Supported Biomass–Derived Nitrogen-Doped Carbon as an Electrocatalysts for Hydrogen Evolution Reaction

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Hydrogen Evolution Reaction, Fuel Cells, Non-Noble Metal-Based Electrocatalysts

Electrochemical water splitting is a sustainable method of producing hydrogen on a large-scale, which is crucial for hydrogen-based energy technologies, such as fuel cells. However, the high cost and scarcity of the noble metal-based electrocatalysts used limit its practical application, highlighting the need for efficient, low-cost, earth-abundant, non-noble metal alternatives. In this study, Co_3O_4, Cr_2O_3, and mixed Co_3O_4–Cr_2O_3 particles were synthesized via a hydrothermal method to investigate their potential as non-noble metal-based electrocatalysts. The structural, morphological, and crystalline properties of the synthesized materials were characterized using scanning electron microscopy (SEM) and X-ray diffraction (XRD) methods. The synthesized Co_3O_4, Cr_2O_3, and Co_3O_4-Cr_2O_3 particles were also combined with nitrogen-doped carbon (NC) to enhance electrocatalytic activity. The performance of the resulted materials toward the HER was investigated using linear sweep voltammetry (LSV). The results showed that the Co_3O_4 and Co_3O_4–Cr_2O_3 particles supported on NC exhibit significantly higher electrocatalytic activity for the HER compared to the pure Co_3O_4 and Co_3O_4–Cr_2O_3 particles. Importantly, the Cr_2O_3 particles and/or Cr_2O_3/NC electrocatalyst were inactive for the HER, indicating the beneficial role of cobalt-based oxides in promoting HER kinetics. The electrocatalytic activity of the prepared Co_3O_4/NC and Co_3O_4-Cr_2O_3/NC electrocatalysts toward HER was remarkable. The onset potential (E_{onset}) and the overpotential at a current density of 10 mA cm^{-2} were approximately -0.189 and -0.350 V, respectively, for Co_3O_4/NC, and approximately -0.360 and -0.476 V, respectively, for Co_3O_4–Cr_2O_3/NC. These findings highlight the potential of cobalt-based non-noble metal oxides as cost-effective electrocatalysts for sustainable hydrogen production and future use in fuel cells.

Poster Presentation P2 (Id.8)

Preliminary assessment of hydrogen production via solar-driven biomass gasification

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Hydrogen; Solar-driven processes; Biomass gasification

Solar-driven biomass gasification enables the production of energetically upgraded syngas by supplying the endothermic heat demand through concentrated solar power (CSP). Building upon a previously established techno-economic assessment of solar-driven syngas production [1], this work quantifies the hydrogen fraction contained in the syngas and estimates the corresponding levelized cost of hydrogen (LCOH) using identical methodological assumptions. Typical syngas compositions from the literature are used to determine hydrogen yields as a fraction of total syngas output, while the economic analysis preserves the same CAPEX, OPEX, project lifetime and financial parameters as the reference syngas study.

The results indicate that hydrogen production costs derived from solar-driven syngas generally remain above the European target under the considered baseline assumptions. Nevertheless, the analysis highlights a clear potential for cost reduction if higher hydrogen fractions are achieved, for instance through the use of alternative gasification agents such as steam or oxygen-enriched media. These findings suggest that solar-driven gasification could evolve into a competitive complementary hydrogen pathway, particularly when coupled with biomass residue valorization and process optimization strategies aimed at increasing hydrogen yield.

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Poster Presentation P3 (Id.21)

Production of H_2 from formic acid by tuning palladium-based catalysts supported on N-doped activated carbon

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Type of abstract: Poster Presenters
Subject area: Hydrogen

Conventional physical hydrogen storage methods present safety concerns, which have led to the search for alternatives such as chemical storage methods using liquid organic hydrogen carrier molecules (LOHC). Among them, formic acid (FA) stands out for its favorable properties and high hydrogen content, but its dehydrogenation reaction to produce hydrogen requires selective catalysts. Pd-based catalysts supported on carbon materials have shown superior activity for this reaction. In this work, biomass-based activated carbons were used as catalytic supports (AS_HTC). In addition, the activated carbons were functionalized with nitrogen groups (NAS_HTC). XPS analysis of NAS_HTC support confirmed the presence of pyridine groups (34%), pyrroles/pyridones (19%), and amides/amines (47%). Nitrogen incorporation significantly boosted catalytic efficiency, achieving a total gas production of 35 and 98 mL for the non-functionalized Pd/AS_HTC and Pd/NAS_HTC, respectively, under the same conditions. Pd/NAS_HTC catalyst maintained its catalytic activity during six consecutive runs.

The catalytic improvement due to the N groups can be related to a higher proportion of surface Pd^{2+}/Pd^0 and a smaller average particle size. Additionally, DFT calculations were performed to understand how nitrogen groups affect the reaction mechanism of FA dehydrogenation. DFT calculations confirmed that nitrogen functionalities decrease the energy barrier for H_2 desorption (the rate-limiting step) with pyridinic groups providing the most significant promotional effect compared to the N-free system.

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Poster Presentation P4 (Id.22)

Biomass-derived nitrogen-doped Pd/C catalysts: tuning nitrogen groups for hydrogen storage and production

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Hydrogen storage, Carbon materials, formic acid, Palladium

Hydrogen is a promising alternative to fossil fuels, although its storage is a critical technological challenge[1]. In this field, formic acid (HCOOH) stands out as a highly attractive Liquid Organic Hydrogen Carrier (LOHC) due to its low toxicity, ease of handling, and integration into a carbon-neutral cycle through CO_2 hydrogenation[2]. Pd catalysts supported on carbon materials are considered highly interesting for the two reactions included in that cycle. Numerous studies indicate the beneficial effect of incorporating nitrogen groups into the support on the final behavior of these catalysts[3].

This study evaluates the development of palladium (Pd) catalysts supported on activated carbon derived from biomass waste (almond shells), synthesized by hydrothermal carbonization (HTC) with an acid additive and heat treatment at 900 °C. To improve catalytic efficiency, three nitrogen-doped supports were synthesized: i) incorporation of dicyandiamide during the HTC process to simplify synthesis; ii) through a subsequent organic reaction at low temperature; and iii) by incorporating carbon nitride (C_3N_4) from dicyandiamide. The catalysts, prepared by wet impregnation, were tested in both formic acid dehydrogenation and CO_2 hydrogenation. The results show the positive effect of incorporating nitrogen into the support and how surface chemistry affects catalytic activity in both reactions. This study identifies the key functional groups that enhance catalytic performance, establishing a strategic basis for the rational design of future high-efficiency catalysts.

Acknowledgements

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M. Bernal-Vela thanks PRE2022-104824 grant funded by MICIU/AEI/10.13039/501100011033 and by “ESF+”. M. Navlani-García acknowledges the Ramón y Cajal contract (RYC2021-034199-I) funded by MCIN/AEI/10.13039/501100011033 and the
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Poster Presentation P5 (Id.32)

Methodology for MEA characterization

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords: Fuell Cells, Hydrogen, PEM Fuel Cell, Platinum electrocatalyst, Cyclic voltametry, Electrochemical impedance spectroscopy

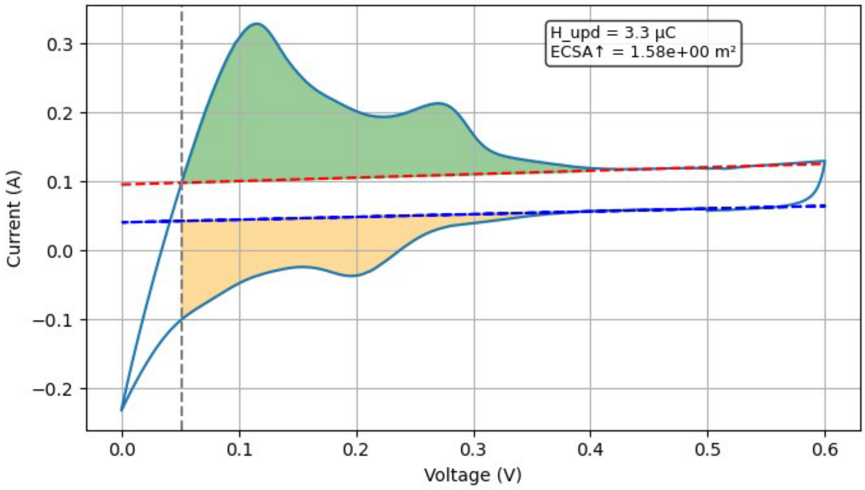
MEAs are one of the most important components in PEM fuel cells, and characterizing their performance is essential for the subsequent design of the complete PEM stack. Although there is extensive literature on characterization techniques in threeelectrode cells, the application of some of these techniques to in-situ MEAs is not as widespread, whereas these characterization methodologies can provide significant added value for the study and monitoring of degradation processes in these electrochemical systems.

Three commercial PEM membrane electrode assemblies (MEAs) from different suppliers were benchmarked under an identical activation and testing protocol to establish quantitative correlations between cell performance, impedance response and electrochemically active surface area (ECSA).

Following a controlled conditioning procedure, polarization curves were recorded with air and O_2 at the cathode to differentiate kinetic and mass transport contributions. Electrochemical impedance spectroscopy (EIS) was performed under the same operating conditions to extract ohmic and charge transfer resistances. Cyclic voltammetry (CV) was conducted in two potential windows: 0.05–0.60 V for ECSA determination via hydrogen underpotential depostion (Hupd), and 0.05–1.30 V to evaluate oxide formation and surface electrochemical features.

A consistent performance ranking (N1 > N2 > N3) was observed across all techniques. Higher current densities were directly associated with lower charge transfer resistance and larger cathodic ECSA values. The integrated Hupd charge revealed significantly higher electrochemically active surface area at the cathode than at the anode in all MEAs, in agreement with manufacturer catalyst loadings.

The results demonstrate that a combined IV–EIS–CV methodology enables robust discrimination of commercial MEAs and provides a consistent link between intrinsic catalytic surface area and full-cell performance.



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Poster Presentation P6 (Id.47)

Highly porous carbons from hydrochar by means of a controlled physical activation process and their hydrogen storage performance

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Type of abstract Poster Presenters
Subject area: Hydrogen
Keywords:porous carbon, biomass, hydrogen storage, physical activation

Nanoporous carbon materials are used in a myriad of applications by virtue of properties such as high surface area, easy-totune textural and chemical properties, non-toxicity, high chemical/thermal stability, and potential cost-effectiveness and sustainability. In particular, they are one of the most promising candidates for H2 storage. Under cryogenic and high pressure conditions, the H2 storage capacity has been shown to be governed by the surface area and pore volume, with micropores playing the leading role [1, 2]. Consequently, research on H2 stores is targeting the development of highly microporous carbons with surface area greater than 2500 m2/g. The most widely used approaches to produce such materials continue to be based on activation. Within this line, herein, we propose a step-wise approximation for the production of highly microporous carbons (BET surface area of up to ~3300 m2/g) from two biomass residues (eucalyptus sawdust and pistachio shells) by using an environmentally and user-friendly physical activation process with CO2. The key step in the successful synthesis of the porous carbons lies in the implementation of a hydrothermal carbonization process, which increases the overall yield of the synthesis and decreases the reactivity toward CO_2. In this way, a uniform generation of porosity inside the carbon particles takes place, leading to materials with relatively narrow pore size distributions in the micro- to small mesopore region (<3.5 nm), with microporosity accounting for >60% of the total pore volume. These materials store significant amounts of H2 at -196 ºC/100 bar, up to 9.8 wt%. Based on theoretical calculations, a combined temperature and pressure swing adsorption system (-196 ºC/100 bar to -116 ºC/5 bar) is shown to be the most energyefficient way of storing H2, allowing to substantially enhanced the working capacities up to 9.7 wt%.

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Poster Presentation P7 (Id.51)

Aqueous-phase catalytic ammonia decomposition for hydrogen production at moderate temperature

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Type of abstract Poster Presenters
Subject area: Hydrogen

NH3 is a promising hydrogen carrier for H_2 storage, transport and on-site generation due to its high volumetric hydrogen density and carbon-free nature [1]. However, conventional NH_3 decomposition is typically performed in the gas phase at high temperatures, increasing energy demand and limiting decentralized applications [2]. In this work, an alternative route is assessed: aqueous-phase catalytic NH3 decomposition at moderate temperature, inspired by aqueous-phase reforming concepts [1].
Ru-based monometallic (5–10 wt%) and Pt–Ru bimetallic catalysts (5 wt%) were prepared by wet impregnation on Al_2O_3, activated carbon and SiO_2 supports. Batch and continuous NH_3 decomposition tests were performed at 220 °C and 30 bar with aqueous NH_3 solutions of 500, 1000 and 1500 mg·L-1. The gas products were analyzed by GC-TCD (H_2), liquid samples by ion chromatography (NH_4^+), and catalysts were characterized by N_2 physisorption, XPS, TEM and XRF/TXRF.
Figure 1 shows stable H_2 production in continuous tests with Ru/Al_2O_3 (5 wt%) catalyst. The production increased with NH_3 concentration (0.05, 0.11 and 0.15 µmol·min^{-1} for 500, 1000 and 1500 mg·L-1, respectively). Increasing Ru loading up to 10 wt% improved H_2 production to 0.15 µmol·min^{-1} and raised NH_3 conversion to 20 % at 1000 mg·L-1. Overall, Al_2O_3 provided the best combination of activity and stability. Post-reaction characterization revealed nanoparticle growth, some surface chemical changes and partial loss of specific surface, supporting aqueous-phase NH3 decomposition over Ru-based catalysts as a viable moderate-temperature route to H_2.

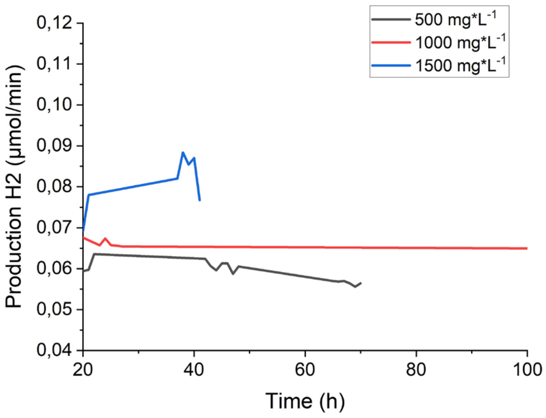

Figure 1. H_2 production using Ru/Al_2O_3 (5 wt%) at different feeding NH_3 concentrations

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Poster Presentation P8 (Id.52)

Techno-economic analysis of the integration of biomass-based processes and water electrolysis for hydrogen and renewable fuels production

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Hydrogen production, biomass gasification, biomass oxy-combustion, water electrolysis, renewable energy

Biofuels and hydrogen will play an essential role in clean energy transition. They complement direct electrification and energy efficiency measures to reduce emissions in hard-to-abate sector, while providing security and development opportunities. Renewable hydrogen can be produced from biomass conversion, but it is also a key asset to improve biomass processes when supplied from other sources, such as water electrolysis using renewable electricity. Smart integration of hydrogen and biomass-based processes offers opportunities to optimize resources, reduce costs and improve overall system flexibility. In this context, the AIHRE project (Analysis and Promotion of Renewable Hydrogen in the Spain-Portugal CrossBorder Region) addresses the hybridization of these technologies, from a technical and economic point of view, to optimize the generation of different products.

The present work assesses the technical and economic feasibility of integrating biomass conversion processes and water electrolysis, in hybrid plants to produce e-biomethanol and pure hydrogen for other uses (e.g. mobility). The work compares different configurations, scales and level of integration, considering biomass commercially available in Spain, Portugal, Costa Rica and Colombia, as well as different sources of supply of renewable electricity for hydrogen production in these countries (solar local generation, renewable power purchase agreement and direct connection to grids with high renewable energy penetration), in order to increase the utilization factor, optimize the size of all the elements of the integrated plant, optimize overall energy efficiency, reduce energy operating costs and minimize the levelized cost of the final products.

Poster Presentation P9 (Id.55)

Electrooxidation of glycerol catalyzed by low-temperature heattreated NiO-based catalysts in alkaline media

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Electrochemical reforming, Glycerol, Nickel oxide, Carbon, Zero-gap

Glycerol (GLY) is a by-product of biodiesel production, typically ~10 wt % of total output[1,2]. As the OECD-FAO Agricultural Outlook for 2025-2034 predicts global biomass-based diesel demand to reach 80.9 billion liters by 2034, the resulting surge presents a significant opportunity for valorization via electrochemical reforming. This strategy is a powerful tool for synthesizing value-added chemicals at the anode under mild conditions[3], while green hydrogen is being produced at the cathode more safely and cost-effectively than traditional water electrolysis1. To replace expensive noble metals, Ni-based catalysts are commonly employed for glycerol electrochemical oxidation[3,4]. This study examines two different synthesis methods for NiO-Vulcan (XC72-R) electrocatalysts. The first approach involved ball milling (BM) mixing of nickel oxide, obtained via chemical precipitation and low-temperature calcination (250 ºC), with Vulcan. The second method, named as in situ (IS), consists in the addition of Vulcan during the chemical precipitation stage of nickel oxide, followed by lowtemperature calcination. Comprehensive physicochemical and electrochemical characterization revealed that the NiO-Vulcan synthesized via the IS method exhibited superior performance. This catalyst achieved remarkable current densities up to 3500 A/gNi and 30 mA/cm^{-2} in a three-electrode cell, despite having a Ni content below 5 wt %. To further validate these results, the best electrocatalyst was tested in an H-type cell to assess selectivity and hydrogen production, and in a zero-gap cell with a 5 cm^2 electrode area to probe its performance at a larger scale.

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Poster Presentation P10 (Id.57)

Low-coated Pt/graphene electrocatalysts for HER: synthesis, optimization and characterization in acidic and alkaline media

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Graphene Hydrogen Nanoparticles HER

The growing demand for sustainable hydrogen production, particularly for aerospace applications, requires efficient and cost-effective electrocatalysts for the hydrogen evolution reaction (HER). This work presents the development of low-loaded platinum nanoparticles supported on graphene-based materials obtained via electrochemical cathodic exfoliation, a scalable and environmentally friendly method.

The graphene support exhibits high conductivity, low oxidation degree, and suitable morphology for catalytic applications. The influence of synthesis parameters, including stirring time and Pt loading (5–20 wt.%), was studied to optimize nanoparticle dispersion and electrochemical performance. Physicochemical characterization (TEM, XPS, ICP) confirmed the successful incorporation of Pt nanoparticles and their dependence on synthesis conditions.

Electrochemical analysis revealed that 10 wt.% Pt and shorter stirring times provide the best balance between dispersion and activity, achieving high current densities and Tafel slopes close to theoretical values. Temperature studies showed improved HER performance up to 50 °C with stable behavior.

Additionally, the catalysts will be characterized in both acidic and alkaline media to evaluate their performance under different electrochemical environments.

These results demonstrate the potential of graphene-supported Pt nanoparticles as efficient, low-Pt electrocatalysts for HER in advanced water electrolysis systems.

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Poster Presentation P11 (Id.59)

Lactic acid photoreforming over CdS: influence of crystallinity on activity under UV and solar irradiation

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Type of abstract: Poster Presenters
Subject area: Hydrogen

This work investigates H_2 production by photoreforming an aqueous lactic acid (LA) solution using CdS, aiming to correlate crystalline properties with photocatalytic activity.

Commercial CdS (named CdS (0)) was evaluated, as well as the same material after heat treatment in N_2 at 400, 500, 600, or 700 °C (CdS (0)-T). In addition, 3 CdS samples were synthesized hydrothermally (CdS (1)-(3)) under different conditions.

Characterization showed that CdS (0) had moderate crystallinity and similar amounts of the cubic (C) and hexagonal (H) phases. In CdS (0)-T series, both crystallinity and H fraction increased with treatment temperature. Samples CdS (1)-(3) were highly crystalline with predominant H phase. CdS (0) had larger surface area than CdS (1)-(3), but it decreased after thermal treatment. The Eg values ranged from 2.01 to 2.34 eV, with the highest values for CdS (1) and CdS (2).

Photocatalytic tests under simulated solar, UV and natural sunlight, with gas analysis by mass spectrometry, confirmed that all the photocatalysts were active. In general, simulated solar light gave higher H_2 production rates than UV (0.2-2.8 vs

0.1-1.6 mmol $H_2 \cdot g_{cat}^{-1} \cdot h^{-1}$). The relative activity order remained the same in the three set-ups: CdS (0) showed moderate activity, improving after treatment at 500 °C and worsening at 600-700 °C; CdS (1) was the most active, CdS (2) intermediate, and CdS (3) the least active, highlighting the importance of the H phase and porous texture. Under natural sunlight, H_2 production rates were generally lower than under simulated solar light but higher than under UV, confirming the potential of sulfides under solar irradiation. In addition, CO_2 formation was minimal under solar irradiation but very high under UV. This could be related to different concentration of organic compounds in the liquid media, with larger values under solar light, linked to partial oxidation of the substrate, and lower under UV, linked with complete oxidation of the substrate.

Poster Presentation P12 (Id.60)

Boosting hydrogen production via photoreforming of the aqueous phase from hydrothermal carbonization of olive stones: effect of reaction conditions

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Carbon nitride, hydrogen, visible light, photoreforming.

The EU's Clean Industrial Deal promotes industrial processes based on renewable sources, including hydrogen (H2) produced through low-impact technologies. Photocatalytic water splitting, particularly under solar or visible radiation, stands out as an innovative and sustainable approach. Its efficiency can be enhanced by adding electron-donor organic compounds, which promote water photo-oxidation and reduce charges recombination, enabling photocatalytic reforming to generate H2 [1]. Hydrothermal carbonization (HTC) has been used to produce high-performance, carbon-based photocatalysts, and it offers an effective route for the valorization of residual biomass such as olive stones (OS), an important byproduct from the olive oil industry. A liquid phase is also obtained during HTC, often considered as a waste stream and containing a wide range of oxygenated low-molecular-weight compounds, which may serve as a promising feedstock for photocatalytic reforming, thereby enhancing sustainable H2 production.

This work examines the preparation and performance of photocatalysts based on Pt-doped carbon nitride (PCN) in the production of H2 from the aqueous phase obtained after the HTC of OS. The best CN precursor (dicyandiamide over urea) was determined according to the photocatalytic performance in the production of H2 using model compounds, such as glucose, methanol and furfural, selected as representative molecules formed during the HTC-OS process [2,3]. Key operational parameters were optimized using furfural as target compound, including substrate concentration, photocatalyst dose and Pt-co-catalyst content. Finally, the generation of H2 through the photoreforming of real HTC-OS aqueous phases was investigated, exploring the effect of the HTC conditions (temperature, residence time and water-to-solid ratio). The results demonstrate the potential of these photocatalysts for boosting the H2 production using the liquid streams resulting from HTC-OS as sustainable feedstocks.

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Poster Presentation P13 (Id.61)

H_2 production by glycerol photoreforming under UV and solar light using TiO_2-Cu photocatalyst

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Type of abstract Poster Presenters
Subject area: Hydrogen
Keywords: Titanium dioxide, glycerol, photoreforming, copper

In recent decades, the increased combustion of fossil fuels has led to a significant rise in greenhouse gas emissions. In order to partially decarbonize the energy system, alternative approaches for energy generation based on green hydrogen have emerged. In this context, photocatalytic processes are particularly attractive for hydrogen production, especially when designed to take advantage of solar radiation. In the present work, TiO_2-based materials were employed as photocatalysts for the glycerol photoreforming reaction to produce hydrogen. TiO_2 was synthesized via a hydrothermal method using titanium tetraisopropoxide as precursor. In addition to bare TiO_2, Cu-modified materials were prepared. Thus, a Cu precursor was incorporated during the synthesis (for Cu loadings ranging from 1 to 4 wt%) in order to enhance visible-light response and reduce electron-hole pair recombination. These samples were denoted as TiO_2-xCu-HT, where x represents the nominal Cu content expressed in wt.%. The photocatalysts were characterized by ICP-OES, X-ray diffraction (XRD), N_2 physisorption at -196 °C, XPS, and UV-Vis absorption spectroscopy.

The UV–Vis spectra showed a variation in the Eg values in the Cu-containing samples, which decrease as the copper content increases. It has also been observed that the surface area increases with the addition of copper. Photocatalytic tests were performed using a 10 vol.% glycerol solution in water, under both UV irradiation (150 W Hg lamp, λmax = 365 nm) and simulated solar light (65 W Xe lamp, λmax = 470 nm). An increase in H_2 production was observed for the Cu-modified materials compared to bare TiO_2, reaching values above 7 and 2 mmol*h^(-1)*g^(-1) under UV and simulated solar irradiation, respectively. Furthermore, a high H_2/CO_2 ratio was detected for the studied catalysts, which prompted further analysis of the reaction medium to identify possible high-value-added compounds derived from glycerol.

Poster Presentation P14 (Id.65)

Hydrogen production via steam gasification of char obtained from slow pyrolysis of lignocelullosic biomass

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords:lignocellulosic biomass, steam gasification, reactivity, gases prediction.

Most of hydrogen still comes from natural gas reforming, which has a high carbon footprint. In this sense, steam gasification of lignocellulosic biomass is considered as a renewable and more sustainable alternative. The aim of this work is to carry out steam gasification of biomass chars derived from slow pyrolysis to maximize hydrogen production.

Chars derived from different lignocellulosic biomass (olive stone, almond shell and hemp) were obtained by pyrolysis at 800 °C for 1 h. These chars, designated as OS, AS and H, were subsequently gasified with 30 % (v/v) steam in a downdraft fixed bed reactor within a temperature range of 800 – 900 °C.

The influence of gasification temperature, the nature of the char and steam concentration on the composition of the syngas was evaluated. The gas obtained consisted mainly of H_2, CO_2 and CO, while CH_4 production was negligible in all cases, regardless of the char used. Among the materials evaluated, hemp char proved to be the most reactive, achieving the highest H_2/CO ratio (close to 9) at 800 °C with a steam concentration of 30 % (v/v). Reactivity followed the same order as the inorganic matter content present in the chars (H > AS > OS), which in the case of H is characterized by higher levels of potassium. Furthermore, the effect of steam concentration (20 – 50 % v/v) at 800 °C was studied for hemp char, and it was observed that an increase of the steam in the reaction medium favors the formation of H_2 and CO_2, to the detriment of CO generation, due to the reaction of the latter with water vapor. As a result, the H_2/CO ratio increased from 7.4 to 10.2, demonstrating that higher steam concentrations, combined with the catalytic effect of the inorganic matter, clearly enhance hydrogen production.

The authors thank Junta de Andalucia/CUII and ESF+ (DGP_PRED_2024_01095), MCIN (TED2021-131324B-C21; PID2022-140844OB-I00) and European Union "NextGenerationEU"/PRTR (MCIN/AEI/10.13039/501100011033).

Poster Presentation P15 (Id.66)

Hydrogen production through the water – gas shift reaction using sustainable Cu and Cu/ZnO – based catalysts

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: activated carbon, copper, hydrogen, water gas shift.

The water gas shift (WGS) reaction is key to producing high – purity H_2, but its efficiency depends on the catalyst stability. Commercial $Cu/ZnO/Al_2O_3$ – based catalysts have high activity, but they also exhibit low thermal resistance and susceptibility to sintering. In this sense, activated carbons (AC) derived from lignocellulosic biomass waste can be considered as a more renewable and sustainable alternative. Therefore, the aim of this work is to evaluate Cu and Cu/Zn catalysts supported on AC derived from lignocellulosic biomass waste, such as olive stone, in the WGS reaction.

The support (A_{BET} = 1200 m^2/g) was prepared by physical activation of olive stone char at 800 °C and steam gasification at 850 °C. The catalysts were prepared by wet impregnation of the AC with a theoretical Cu mass loading of 12 wt.% and different ZnO contents (0 – 15 wt.%). In each experiment, 500 mg of catalyst was loaded into a fixed bed reactor and reduced in situ with H_2 at 300 °C. The feed stream composition was 16 % CO and 32 % H_2O in N_2, and the reactions took place between 150 and 300 °C.

The Cu catalyst yielded CO conversion (X_{CO}) of 80 % and a hydrogen productivity of 120 µmol H2·$(g_{Cu\text{-}ICP}\cdot s)^{-1}$, approximately double that of the commercial T-2130 catalyst (Süd-Chemie). The incorporation of ZnO did not improve X_{CO}. TEM-EDX images reveal that there is not a clear interaction between Cu and ZnO, which avoided the promoting effect of ZnO, probably due to the wider porosity of the support. The Cu catalyst also showed excellent stability at 300 °C for 24 h. These results demonstrate that AC derived from lignocellulosic waste can be used to obtain sustainable Cu – based catalysts with CO conversions comparable to those of commercial catalyst, but with higher hydrogen productivity.

The authors thank Junta de Andalucia/CUII and ESF+ (DGP_PRED_2024_01095), MCIN (TED2021-131324B-C21; PID2022-140844OB-I00) and European Union "NextGenerationEU"/PRTR (MCIN/AEI/10.13039/501100011033).

Poster Presentation P16 (Id.69)

Hybrid Battery–Hydrogen Energy Storage for Data Center Power Supply and Long-Duration Backup: Architecture and Hierarchical EMS

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Data centers; long-duration energy storage; hydrogen; fuel cell; electrolyzer; energy management system (EMS)

Data centers require ultra-high availability and increasingly face grid constraints, volatile electricity prices and pressure to decarbonize long-duration backup. We propose a hybrid battery–hydrogen energy storage architecture that combines fast electrochemical storage (UPS/batteries) with a hydrogen chain (electrolyzer, H_2 storage and fuel cell) to provide both transient ride-through and extended autonomy without diesel. A hierarchical Energy Management System (EMS) prioritizes (i) continuity of critical loads, (ii) operational cost and (iii) emissions, across four modes: grid-connected, grid-support/peak shaving, backup during outages and islanded operation. The EMS enforces reserve margins (battery SOC and H_2 inventory), converter ramp limits and start-up constraints, and can schedule electrolysis to exploit low-price/low-carbon periods while keeping sufficient contingency headroom. Practical deployment aspects are discussed, including sizing trade-offs, safety/space constraints for H_2 equipment and the coordination of power converters to avoid excessive switching and battery cycling.

The contribution is architectural and methodological: it defines functional requirements, interfaces and operating constraints, and outlines a reproducible evaluation plan based on scenarios and KPIs (unserved energy, autonomy, cost and CO_2). The concept also enables limited grid-support services when reserve margins allow, with quantitative validation addressed in forthcoming work.

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Poster Presentation P17 (Id.77)

New water treatment for green hydrogen production

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Ultrapure water, Green Hydrogen, Electrodialysis, Brine valorisation, EDEN

Over the past two decades, the impacts of climate change have become evident. A range of promising technologies has emerged, including those related to hydrogen generated through electrolysis.

However, the water used for electrolysis must meet very high purity standards. Reaching this quality necessitates a demineralization process that yields ultrapure water for the electrolyzer while simultaneously producing a concentrated brine stream. This saline by-product is typically discharged back into the source: lake, river, sea, or underground. As hydrogen production scales up, the disposal of brines could lead to the salinization of freshwater environments, posing a significant environmental challenge. Therefore, the goal of this project is to develop a process capable of supplying pure water without affecting to the water resources increasing the H2 to water ratio.

The most important objectives of this project:

-Developing a softening unit to ensure the elimination of ions that produce precipitation.

-Optimize an electrodialysis system that allows to produce a pure water stream while minimizing brine generation

-Implement an electrodeionization unit to produce ultrapure water for the optimal performance of commercial electrolyzers.

-Evaluate the performance of the generated ultrapure water in a commercial electrolyzer and compare it to industrial pure water.

-Implement the EDEN electrolyzers [1,2] to produce hydrogen, sodium hydroxide, and chlorine species.

- Integration of all the previously mentioned operations.

Some preliminary results have been obtained that validates the concept of each individual operational unit, but further development is needed for the optimization and integration of the process.

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Poster Presentation P18 (Id.84)

Advanced Energy Management Strategies for Hybrid Fuel Cell and Multi-Chemistry Battery Systems in Renewable Desalination Applications

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords: Hybrid Energy Storage Systems; Model Predictive Control; Hydrogen Fuel Cell; Vanadium Redox Flow Battery; Renewable-Powered Desalination

Among the numerous applications of hybrid energy storage systems (HESSs), their use in desalination technologies represents a promising solution, as the large-scale deployment of desalination plants is mainly limited by their high energy consumption and associated operational costs. In this context, the integration of renewable energy sources into desalination systems constitutes a viable approach for sustainable water production. However, the intermittent nature of renewable generation introduces operational challenges that require advanced energy management strategies.

This work presents a predictive energy management approach for a renewable-powered desalination system developed within the framework of the European AQUASOL project [1]. The proposed architecture integrates photovoltaic and wind generation with a HESS composed of a hydrogen-based fuel cell and electrochemical storage technologies, including a lithium-ion battery based on LFP chemistry and a vanadium redox flow battery (VRFB).

Dynamic models of the main system components, including the fuel cell and the different battery technologies, are developed and validated with experimental data. These models are used to design an energy management strategy based on Model Predictive Control (MPC), which predicts system behaviour and determines the optimal power allocation among renewable sources, storage devices, and the desalination load [2].

Finally, the results obtained with a classical self-consumption maximization strategy, an ideal predictive controller assuming perfect forecasts, and the proposed MPC under realistic conditions are presented and discussed. The analysis highlights the complementary roles of the different storage technologies under various operating scenarios and system constraints. Thus, the proposed MPC strategy improves power allocation between storage technologies, enhances system stability, and increases renewable energy utilization in desalination infrastructures.

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Poster Presentation P19 (Id.91)

Design of ionic liquid-based ionogel membranes as alternatives to PFSA-based membranes in PEM fuel cells

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords: Ionic liquids; Ionogel membranes; PEM fuel cells

Ionic liquid-based ionogels are emerging as promising alternatives to conventional Nafion® membranes for proton exchange membrane fuel cells (PEMFCs), combining high ionic conductivity with improved thermal and mechanical stability [1–3]. In this work, ionogel-type membranes are being developed using uncharged polymer matrices, including poly(vinylidene fluoride), poly(vinyl chloride), and poly(ethyl methacrylate), as hosts for selected ionic liquids. Protic ionic liquids such as diethylmethylammonium trifluoromethanesulfonate ([Hdema][TfO]) are considered due to their dual proton transport mechanisms and high thermal stability [4].

Functionalized imidazolium-based systems such as [HSO_3BuMIm][TfO], which present a labile proton and have shown promising behaviour in related materials, are also investigated [5]. An aprotic ionic liquid, [EMIm][TfO], is included as a reference system.

The prepared membranes will be systematically evaluated to establish structure–property relationships governing ionic conductivity, liquid retention, and mechanical performance. Characterisation includes spectroscopic techniques (NMR, FT-IR, Raman), electrochemical impedance spectroscopy for ionic conductivity, and thermomechanical analysis (DMA, TGA, DSC). Ionic liquid retention and stability are assessed through gravimetric and leaching studies. This ongoing work aims to identify key parameters controlling ionogel performance and to assess their potential as next-generation electrolytes for PEMFC applications.

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Poster Presentation P20 (Id.93)

Role of pore structure in the stability of Fe–N–C catalysts based on carbon xerogels for fuel cells

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords:carbon xerogel, Fe-N-C catalyst, gas diffusion electrode (GDE), oxygen reduction reaction (ORR), PEM fuel cells.

Fe-N-C catalysts are widely known as promising alternatives to Pt/C catalysts for fuel cells. In recent years, many studies have investigated single-atom Fe-based catalysts for the oxygen reduction reaction, with activities comparable to those of noble metals. However, the durability of these catalysts remains insufficient for practical applications [1-3].

In this work, Fe-N-C based on carbon xerogels with different porosities are investigated towards the OR]. Catalysts are subjected to accelerated stress tests to evaluate the effect of porosity on the degradation of the Fe-N-C catalyst [2]. This work aims to conduct an in-depth analysis of key durability aspects of Fe-N-C catalysts using a gas diffusion electrode (GDE) system in acid (0.5 M H_2SO_4) and/or alkaline (1 M KOH) media. The use of the GDE allows the study of electrode behaviour in an intermediate system between the ideal rotating electrode system (RDE, thin-film, aqueous electrolyte) and the full fuel cell, thereby revealing several critical aspects of the catalytic system scale-up. The results obtained with the synthesised catalysts are compared with benchmark Pt/C catalysts. Post-mortem analyses with Mossbauer spectroscopy were carried out to identify the loss of active sites.

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Poster Presentation P21 (Id.96)

Direct Electron Transfer of HRP entrapped in Silica Thin Films: Potential for peroxide-based biofuel cell

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Type of abstract: Poster Presenters
Subject area: Fuel cells

Biofuel cells have been the subject of research as an alternative technology for self-sustaining biodevice applications [1]. Enzymatic biofuel cells (EBFCs) utilize redox enzymes to convert renewable fuels into energy via anodic biofuel oxidation and cathodic reduction of electron-accepting species [1, 2 3]. A noteworthy improvement in EBFC design is the transition from mediated to direct electron transfer (DET) [2]. Horseradish peroxidase (HRP) serves as a model enzyme; its heme active site has been shown to allow the bioelectrocatalytic reduction of H_2O_2, offering significant potential for peroxide-based cells technology [3–4]. This work explores strategies to facilitate the DET of HRP immobilized on indium tin oxide (ITO) electrodes. To enhance the stability and performance of the system for biocathode applications, the HRP was entrapped within silica matrix prepared by a sol-gel method. The redox behavior of the heme site was monitored using in situ UV-Vis spectroelectrochemistry, allowing real-time observation of the Soret band transition to confirm the enzyme's DET within the matrix. The electrocatalytic performance of the modified electrodes towards H_2O_2 reduction was evaluated through cyclic voltammetry. Comparative studies reveal that the use of a methyl-modified silica matrix (Me-silica) improves the catalytic response compared to standard silica (Figure 1). This enhancement is attributed to the optimized microenvironment provided by the methyl groups, which facilitates substrate diffusion and maintains a favorable enzyme orientation. Further improvements of this system comprise the optimizing these HRP@silica biocathodes by incorporating thiophene-derived conducting polymers. This approach creates a hybrid interpenetrating material designed to act as an electrical bridge between the enzyme's heme active site and the electrode surface.

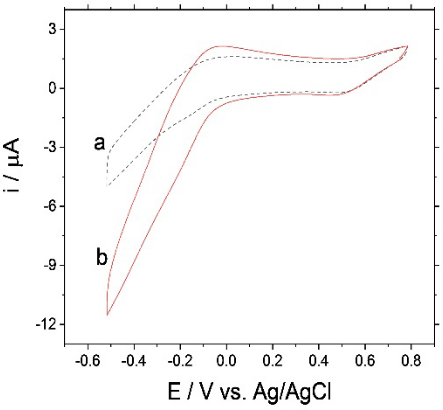

Figure 1. Cyclic voltammograms of (a) HRP@silica and (b) HRP@Me-silica in the presence of 5.0×10-3 M H2O2. Scan rate: 10 mV s-1.

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Poster Presentation P22 (Id.98)

Highly active Ni-Cu catalysts for the ammonia oxidation reaction

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords: Ammonia oxidation reaction; Nickel; Copper; Hollow nanocages

Carbon-based energy sources such as coal, oil, and natural gas have led to a substantial increase in CO_2 emissions, contributing significantly to climate change and environmental pollution. To mitigate the environmental impact associated with fossil fuels, the transition to sustainable energy carriers, like hydrogen, is essential. However, hydrogen storage typically requires high-pressure conditions, which create logistical challenges and increase operational costs. Ammonia has emerged as a promising alternative hydrogen carrier due to its well-established infrastructure for storage and transport. Additionally, ammonia can be directly utilized in fuel cells, where energy is generated through the ammonia oxidation (AOR) couples with the oxygen reduction reactions (ORR). Nevertheless, the AOR involves complex reaction kinetics, and currently available catalysts often suffer from limited stability and durability. [1]

To address these challenges, Cu_2O nanocubes were employed as templates to synthesize $Ni(OH)_2@Cu_2O$ hollow nanocages (Figure 1a). The physicochemical characterization of the nanoparticles was carried out using X-ray diffraction (XRD), scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDX), and X-ray photoelectron spectroscopy (XPS).

The synthesized nanocages exhibited high catalytic activity toward the AOR (Figure 1c), along with good stability during long-term electrochemical measurements. Notably, the nanocubes preserved their morphology throughout the electrochemical experiments (Figure 1b). The combination of structural integrity and enhanced catalytic performance highlights the potential of these nanocages as durable and efficient electrode materials for direct ammonia fuel cells.

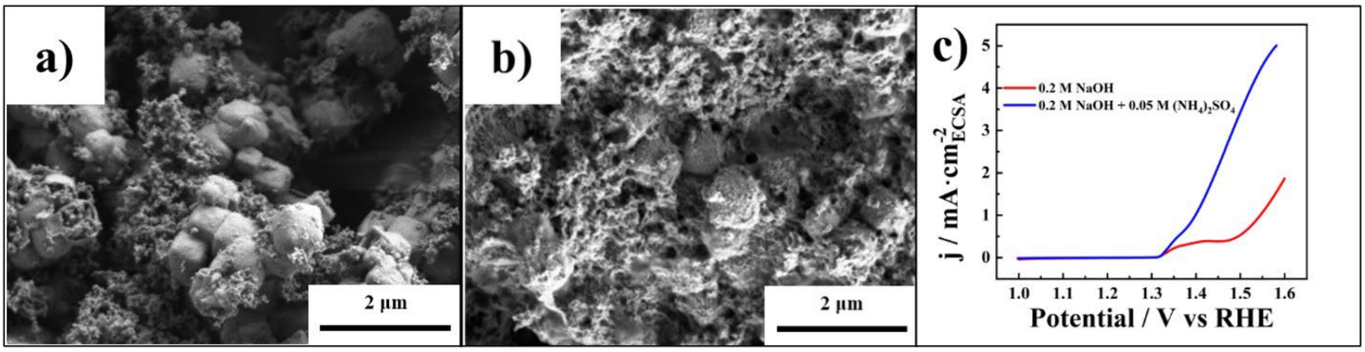

Figure 1. a) SEM image of $Ni(OH)_2@Cu_2O$ hollow nanocages powder; b) SEM image of $Ni(OH)_2@Cu_2O$ hollow nanocages after 24 h at 1.55 V vs RHE; c) LSV curve of $Ni(OH)_2@Cu_2O$ hollow nanocages in absence and presence of NH_3.

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Poster Presentation P23 (Id.107)

Optimization of a Temperature Swing Adsorption dryer for green hydrogen.

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Type of abstract: Poster Presenters
Subject area: Hydrogen

Transitioning from fossil-based fuels to sustainable alternatives is a necessary endeavor for worldwide economies that requires careful but hasteful action. Currently, an accepted route for the decarbonization of the energy sector is via harvesting electrical power from clean sources and storing it in hydrogen via electrolytic water splitting. The produced hydrogen may be used directly or as feedstock for other value-added fuels and specialty chemicals. Electrolytically-produced hydrogen that is not consumed in-situ requires purification for transport at high pressure (>700 bar) in order to prevent the occurrence of explosive mixtures with oxygen and water condensation inside the pressure vessels that compromises their functional integrity, where neither may be above a concentration of 5 ppm or -65.5 °C of dew point temperature [1].

Temperature Swing Adsorption (TSA) driers are effective solutions for removing humidity from gaseous mixtures, especially when hot and cold utilities are available for regeneration. TSAs have intrinsically high recoveries due to constant-pressure operation throughout the production and regeneration stages, with the added benefit of potentially lower CAPEX costs, since most systems require only two columns.

A TSA dryer, shown in Figure 1, was assembled in the laboratory for hydrogen drying experiments. They will be tailored to enable comparative insight into the results obtained in a VPSA setting, currently under external review. Firstly, the jacketed columns will be evaluated for their effectiveness in heating and cooling the adsorbent bed. Secondly, screening experiments will set the boundaries for optimization via response surface methodology in a central composite design, followed by the optimization experiments. Finally, optimal conditions will be tested to validate the quadratic model.

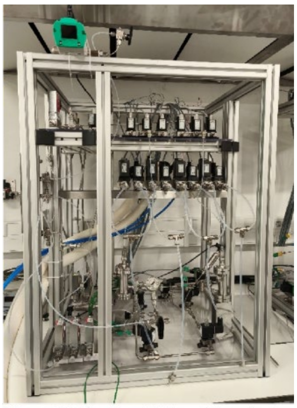

Figure 1-Laboratory TSA work bench.

Acknowledgements
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Poster Presentation P24 (Id.112)

Carbon-containing $LaMn_{1-x}Cu_xO_3$ Perovskites for Selective CO_2 Electrochemical Reduction

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Type of abstract: Poster Presenters
Subject area: Fuel cells
Keywords: Perovskite, carbon material, CO2RR, mass spectrometry, HPLC, TOC

In recent years, noble-metal-free perovskite-type metal oxides have emerged as promising electrocatalysts due to their high chemical and thermal stability, tunable electronic structure, and adjustable B-site composition and they can be suitable for CO2RR [1]. In this study we have analysed $LaMn_{1-x}Cu_xO_3$ perovskite as electrocatalyst for CO2RR with the incorporation of a carbon material. The partial substitution of Mn by Cu allows fine-tuning of the B-site oxidation state and oxygen vacancy concentration, which can critically govern CO_2 adsorption, activation, and the stabilization of key reaction intermediates [2]. Coupling CO2RR with in situ mass spectrometry enables to stablish a correlation between catalyst electronic structure and the evolution of gaseous products (i.e., CO, H_2, CH_4, C_2H_4,…). The analysis of the liquid electrolyte and the gas products enables to close the carbon balance, allowing rigorous determination of faradaic efficiency and catalyst stability.

The incorporation of a carbon phase, in this study carbon black, enhances electrode conductivity and charge transfer, while also influencing active-site dispersion and selectivity [3,4]. Although definitive conclusions require further experimental validation, preliminary observations suggest that carbon-modified $LaMn_{1-x}Cu_xO_3$ perovskite promotes improved current densities and modified product distributions, potentially favoring specific CO2RR pathways. Systematic studies are therefore underway to elucidate structure–activity–selectivity relationships in these composite systems.

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Poster Presentation P25 (Id.116)

Optimizing Nanoparticle Positioning in Nanotubes: A Chemometric and Finite Element Approach

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Type of abstract: Poster Presenters
Subject area: Hydrogen
Keywords: Finite Element Method Secondary Current Distribution Factorial Design

Porous materials coated with catalyst nanoparticles are essential for hydrogen and oxygen evolution reactions. This work proposes a Secondary Current Distribution model, combining Laplace and Butler-Volmer equations, to describe the positional effect of an iridium nanoparticle on a titanium nanotube's inner wall. The model considers conductivities of $2.05\ 10^{6}$ S cm^{-1} for Ti, $2.13\ 10^{5}$ S cm^{-1} for Ir and 0.2 S cm^{-1} for the electrolyte (0.5 mol L^{-1}). Exchange current densities (j_0) were $1.54\ 10^{-5}$ mA cm^{-2} (Ti) and 0.20 mA cm^{-2} (Ir).

A 100 µm long nanotube was subjected to -100 mA cm^{-2}. Four variables were investigated at five levels: nanoparticle radius (r_{NP}), nanotube radius (r_{NT}), nanoparticle position (z'_{NP}), and nanotube density (ρ_{NT}). The Juliana's rule was applied to incorporate random error, enabling the statistical significance analysis of factorial design parameters and response surfaces.

The results show that nanotube density (ρ_{NT}) is the most significant effect, as higher density increases the active catalytic surface, thereby reducing overpotential. Nanoparticle position (z'_{NP}) is the third most relevant effect; shifting from -5 µm

(surface) to -95 µm (bottom) increases cathodic overpotential by 11%, indicating lower activity at the tube's base. This indicates that nanoparticles located closer to the bottom of the nanotube are less active and require additional applied potential to achieve the same current density. The response surface (Fig 1A) shows that the optimal condition occurs when both ρ_{NT} and z'_{NP} are at their highest levels.

Analysis of three-nanoparticle arrangements shows the surface-proximal is most active, though influenced by those below (Fig 1B). The model successfully quantified the individual contribution of each nanoparticle, providing strategic guidelines for optimizing catalytic efficiency and energy savings.

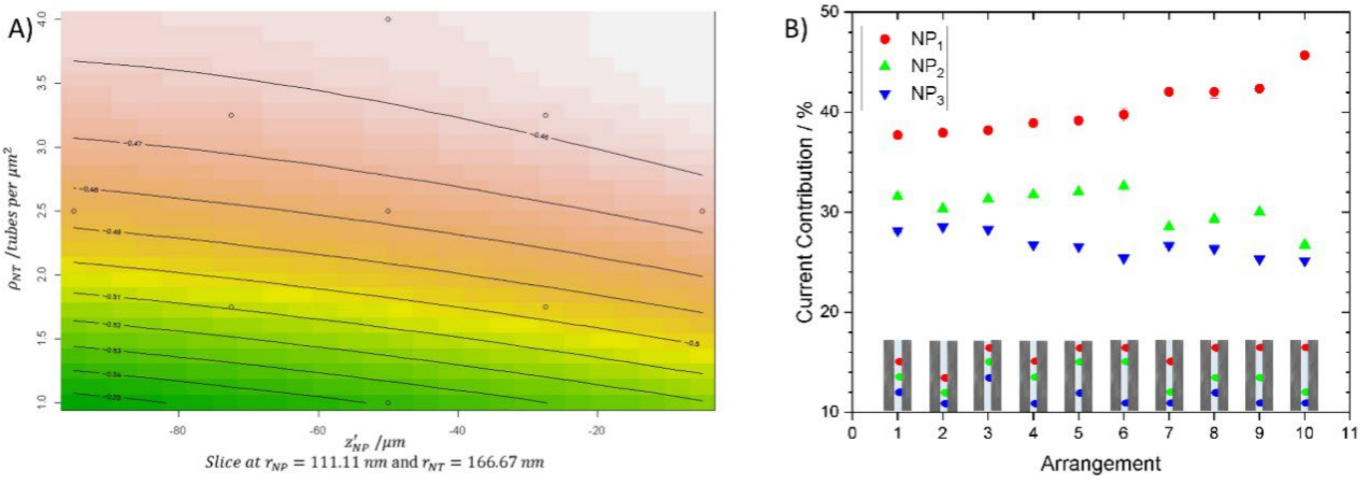

Fig 1. A) a response surface for the overpotential as a function of ρ_{NT} and z'_{NP} and B) the percentage contribution of each nanoparticle

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Poster Presentation P26 (Id.129)

Valorization of corn cob waste into biochar-based electrodes for sustainable energy generation in microbial fuel cells

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Type of abstract: Poster Presenters
Subject area: Fuel cells

Agro-industrial waste management, particularly corn cob (Zea mays) residues, poses a significant environmental challenge due to limited reuse1. Finding ways to use corn cob waste through low-impact technologies such as microbial fuel cells (MFCs) can support both energy generation and wastewater treatment in self-sustaining homes. This approach converts the chemical energy of organic residues in water directly into electricity via the metabolic activity of electrogenic bacteria. These bacteria colonize the anode surface, forming a biofilm capable of extracellular electron transfer (EET) from metabolism to the electrode2. Recent studies highlight the impact of electrode properties on EET and current generation. Although electroactive biochar is a promising candidate for large-scale environmental applications of microbial electrochemistry, further optimization is needed to improve its performance in MFCs. Additionally, the valorization of abundant agro-industrial wastes, such as corn cobs, into biochar electrodes should be explored.

This study investigates the use of corn cob wastes to produce biochar-based electrodes for MFCs. Various biochars were obtained via pyrolysis at different temperatures. The effect of temperature (600-900°C) and its hybridization with Ni and Cu ferrites (electroactive metal oxides based on abundant metals) was examined. The ferrites were synthesized using the coprecipitation method3. Textural characterization showed that the sample treated at 700 ºC had a BET surface area of 370 m2 g-1, ideal for microbial adhesion, while even at 900 °C it retained a high surface area of 322 m2 g-1. Bioelectrochemical performance was evaluated by monitoring current and power density in a MFC. The optimized anodes showed significant bioelectrochemical activity, including electricity generation and organic matter biodegradation, supporting the valorization of corn cob into biochar as an eco-friendly alternative to fossil-derived bioanodes for MFCs.

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Poster Presentation P27 (Id.27)

Sustainable functionalization of carbon materials with nitrogen via mechanochemistry for energy storage applications

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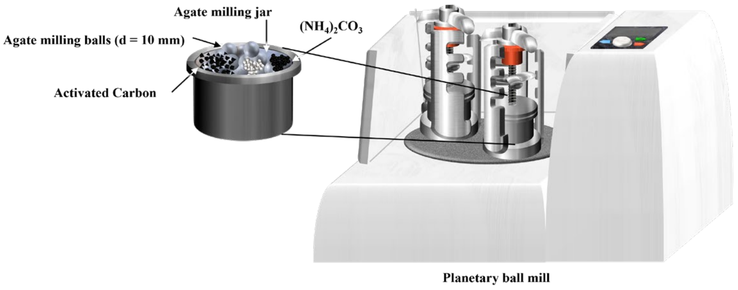
Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Supercapacitors Nitrogen functionalization Activated carbon Life cycle assessment

The enhancement of the electrochemical performance and stability of electric double-layer capacitors (EDLCs) strongly depends on the surface chemistry of the activated carbons used as electrodes. Hence, it is necessary to implement simple, low-cost, and more sustainable methodologies to optimize the surface chemistry of activated carbons. In this context, the incorporation of nitrogen functional groups into activated carbons employed as electrodes has become an effective strategy to improve their electrochemical performance. In a previous work, we applied the Life Cycle Assessment (LCA) methodology to determine the environmental impacts associated with a process for producing nitrogen-functionalized activated carbons. This study revealed that the main source of environmental impacts was associated with the functionalization stage, mainly due to the use of hazardous organic compounds. In this work, a more sustainable methodology for nitrogen functionalization of activated carbons has been developed through mechanochemistry, avoiding the use of solvents. The resulting activated carbons were physicochemically characterized by N_2 physisorption at −196 °C, XPS, and TPD. These activated carbons achieved a nitrogen content above 4 %, while preserving the textural properties of the original activated carbon. Furthermore, symmetric capacitors were assembled in an organic electrolyte (1M $TEMABF_4$/PC) to evaluate their electrochemical performance. The devices exhibited higher energy density at high power densities compared to the original activated carbon, with promising capacitance retention. In summary, the proposed functionalization strategy represents an environmentally advantageous approach for the preparation of high-performance electrochemical electrodes, with strong potential for industrial-scale implementation.



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Poster Presentation P28 (Id.28)

Activated carbons with different porous texture for zinc-ion hybrid capacitors

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Type of abstract Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords:activated carbon, biomass waste, hybrid supercapacitor, energy storage.

The increasing demand for sustainable energy storage systems has promoted the development of electrochemical energy storage technologies capable of complementing intermittent renewable energy sources[1]. Among these, hybrid capacitors combine the advantages of batteries and electrochemical double-layer capacitors, offering high energy density with long cycling stability[2]. In these systems, carbon-based materials are widely used as positive electrodes due to their high surface area, well-developed porosity, and tunable surface chemistry[3].

In this study, activated carbons were synthesized from biomass waste (almond shells and pomegranate peel) through physical activation with carbon dioxide and chemical activation with H_3PO_4. In addition, the chemically activated carbon underwent a subsequent heat treatment to improve the electrical conductivity. Their electrochemical performance was evaluated in aqueous $ZnSO_4$ electrolyte through cyclic voltammetry, galvanostatic charge-discharge, and impedance spectroscopy.

The results showed that the hybrid supercapacitor based on chemically activated carbon exhibited a superior electrochemical performance due to its excellent textural properties, such as high surface area, a balanced combination of microporosity and mesoporosity, and the presence of functional groups, which enhanced ion accessibility. In contrast, the physically activated carbon-based hybrid supercapacitor displayed poor performance, which was associated with its predominantly microporous texture that limits ion transport and reduces the overall electrochemical efficiency. The results demonstrate that chemical activation represents a simple synthesis route for the development of electrochemical devices for energy storage.

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Poster Presentation P29 (Id.30)

Can sodium carbonate be a sustainable electrolyte for activated carbon–based supercapacitors?

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Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Supercapacitor, Aqueous electrolyte, Activated carbon, Energy storage.

Development of sustainable energy storage systems is essential to mitigate the intermittency of renewable energy sources. Supercapacitors are promising due to their high power density, fast charge-discharge response and long cycle life. The selection of a safe, low-cost, and environmentally friendly electrolyte is crucial. While organic electrolytes enable wider operating voltage, they are often flammable, toxic, and costly. In contrast, aqueous electrolytes offer higher ionic conductivity and improved safety, though they are typically limited by a narrower electrochemical stability window. This work explores the use of an aqueous sodium carbonate (Na_2CO_3) electrolyte as a sustainable alternative for supercapacitor applications.

A high porosity activated carbon was used as the electrode material for the supercapacitors, using both symmetric and asymmetric configurations. Different operating voltages (1.8, 2.0, and 2.1 V) were investigated. The electrochemical performance of the devices was evaluated through cyclic voltammetry and galvanostatic charge-discharge measurements. In addition, long-term stability was assessed by extended cycling at high operating voltages.

The preliminary results suggest a stable capacitive behaviour across the tested voltages. Specific capacitance values for the capacitor were measured in the range of 20 F/g, with the 1.8 V configuration showing a tendency toward higher energy efficiency and stability. Initial cycling tests indicate a promising capacitance retention of approximately 98% for the lowest voltage after 10,000 cycles, highlighting the possible viability of Na_2CO_3 aqueous electrolytes for energy storage.

Acknowledgements: The authors thank BioEnH2 project PLEC2023-010216 funded by MICIU/AEI/10.13039/501100011033. DST thanks Plan GenT (CIDEXG/2023/2), funded by GV.

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Poster Presentation P30 (Id.33)

Influence of Oxygen Functional Groups on Iron Phthalocyanine–Graphene Interactions for Enhanced ORR Electrocatalysis

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Type of abstract Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Graphene Electrochemical synthesis of graphene Iron phthalocyanine Oxygen reduction reaction (ORR)

Carbon-based nanomaterials are one of the most investigated classes of materials in the twenty-first century. Among them, graphene exhibits outstanding physicochemical properties, which have stimulated interest in both technological applications and fundamental scientific research [1]. In parallel, metal phthalocyanines (MPcs), particularly iron phthalocyanine (FePc), have been widely employed as electrocatalysts for the oxygen reduction reaction (ORR), demonstrating remarkable catalytic performance [2,3]. The electrocatalytic activity of FePc is primarily attributed to its porphyrin-like molecular structure [4], which consists of an iron cation coordinated to a nitrogen-containing macrocyclic MN_4 ring.

In this work, two graphene-based materials with different oxygen contents were synthesized via an electrochemical method developed in our group. This method allows us to produce graphene-based materials with a controlled degree of oxidation, without the need for strong oxidizing agents or elevated temperatures [5]. The materials were subsequently decorated with iron phthalocyanine and subjected to microwave treatment to partially reduce the support. The materials were extensively washed with DMF and HCl. Electrochemical characterization was carried out using cyclic voltammetry, and the electrocatalytic activity for the ORR was evaluated by linear sweep voltammetry before and after five hours of stability tests. Stability was further assessed through cyclic voltammetry and chronoamperometry. Physicochemical characterization was performed using ICP and XPS, and DFT calculations were carried out to study the interaction between iron phthalocyanine and the graphene-based supports, considering the effect of different oxygen functional groups.

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MCIN/AEI/10.13039/501100011033 and ERDF/EU. Samuel Calabuig-Mompó thanks to Ministerio de Universidades for the FPU21/01230.

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Poster Presentation P31 (Id.43)

Synthesis of two-dimensional materials through controlled chemical and electrochemical exfoliation

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Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Exfoliation. MXene/graphene hybrids.

Two-dimensional materials have attracted significant interest due to their outstanding electronic and electrochemical properties. Graphene and MXenes are particularly promising for electrocatalysis and energy storage because of their high conductivity and large surface area. Few-layer graphene can be produced by electrochemical exfoliation of graphite with low oxidation and controlled defects. MXenes are synthesized by selective etching of MAX phases such as Ti_3AlC_2, traditionally using HF. Alternatively, HCl and LiF generate HF in situ, enabling improved process control [1].

In this study, MXene ($Ti_3C_2T_x$) and few-layer graphene were synthesized. MXene was obtained by selective etching of Ti_3AlC_2 in 6 M HCl with LiF (HF generated in situ) for 45 h, followed by washing, sonication, and centrifugation for delamination. Fewlayer graphene was prepared by electrochemical exfoliation of graphite in 0.5 M K_2SO_4 (10–15 V) [2]. Platinum was incorporated from H_2PtCl_6 to obtain 10 wt% Pt materials supported on MXene/graphene hybrids. Characterization was performed by SEM, TEM, and Raman. HER electrocatalytic activity of the Pt-containing material was evaluated in H_2SO_4 using a rotating ring-disk electrode. The MXene/graphene hybrids were also evaluated as electrodes for supercapacitors.

The synthesized materials showed excellent electrochemical performance in both the hydrogen evolution reaction (HER) and energy storage. Pt-containing MXene (MX6D) and graphene exhibited catalytic activity comparable to commercial Pt/C (20 wt% Pt) but using lower platinum loadings, indicating a more efficient noble metal utilization. Additionally, the MXene/graphene hybrid delivered a specific capacitance of 378 F g^{-1}, attributed to improved charge transfer kinetics and enhanced ionic accessibility within the electrode structure.

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Poster Presentation P32 (Id.81)

Dual-Phase High-Entropy Oxide $(CrMnCoNiCu)_xO_y$ as a High Performance Anode for Lithium-Ion Batteries

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Subject area: Advanced batteries and capacitors
Keywords: lithium-ion batteries, high-entropy oxide, high-entropy materials, anode

High-entropy materials (HEMs) have emerged as a transformative class of energy storage materials, where high configurational entropy stabilizes the crystal lattice [1]. This stabilization offsets the enthalpy of formation in the Gibbs free energy equation, $\Delta G = \Delta H - T^*\Delta S$, allowing for exceptional structural integrity during the mechanical strain of lithiation/delithiation [2]. While most high-entropy oxide (HEO) studies focus on single-phase rocksalt [3] or spinel structures [4-5], this work explores the potential of a dual-phase system.

A dual-phase HEO, (CrMnCoNiCu)xOy, was synthesized via controlled oxidation of a parent high-entropy alloy precursor, resulting in a quasi-equimolar distribution of spinel and rocksalt phases. Cyclic voltammetry (CV) reveals a multi-step reduction process and a broad oxidation region, highlighting the complex electrochemical contributions of the diverse transition metal cations. The CV profiles exhibit high reversibility and alignment in subsequent cycles, indicating excellent structural stability.

Rate capability tests demonstrate superior performance at high current densities, with a characteristic capacity increase observed during extended cycling. Post-mortem analysis suggests that this "regeneration" effect originates from in-situ particle size reduction during the conversion reaction, leading to increased electroactive surface area and enhanced pseudocapacitive contributions.

These results demonstrate that dual-phase HEOs offer a promising pathway toward high-capacity and long-life anode materials for next-generation lithium-ion batteries.

Acknowledgments

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Poster Presentation P33 (Id.83)

High-Entropy Oxide $(CrMnFeCoNi)_3O_4$ as an Electrocatalyst for High-Performance Lithium-Sulfur Batteries

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Keywords: lithium-sulfur batteries, high-entropy oxide, anode

Lithium-sulfur (Li-S) batteries are premier candidates for next-generation energy storage due to their high theoretical specific capacity (1675 mAh g^{-1}) and energy density (2600 Wh kg^{-1}) [1, 2]. Despite these advantages, the practical application of Li-S technology is limited by the insulating nature of sulfur and the "shuttle effect," where soluble lithium polysulfides (LiPSs) migrate to the anode, causing active material loss and poor cycling stability [2].

To address these challenges, this study explores the catalytic potential of High Entropy Oxides (HEOs). HEOs are single phase, multicomponent systems that leverage synergistic effects from multiple metal cations to accelerate electrochemical kinetics and anchor LiPSs [3-5]. We utilized a spinel-structured HEO, specifically $(CrMnFeCoNi)_3O_4$, as a catalyst within a sulfur-carbon composite cathode. The electrodes were prepared using high-energy ball milling and planetary centrifugal mixing.

Electrochemical analysis demonstrated that the HEO-modified cathodes significantly enhance redox kinetics and suppress the shuttle effect compared to standard sulfur electrodes. The HEO-integrated cells exhibited moderate rate capability and high-capacity retention over 200 cycles. This improved performance is attributed to the chemical adsorption of LiPSs on the HEO surface through metal-sulfur and lithium-oxygen bonding [3-5]. These results highlight the potential of entropystabilized oxides in developing sustainable, long-life energy storage systems.

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Poster Presentation P34 (Id.100)

Activated Carbon from Peach Pits with Chicken Feather Keratin for Supercapacitor Electrodes.

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Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Peach pits, chicken feathers, keratin, activated carbons, supercapacitors.

According to the United Nations Global Compact and the Sustainable Development Goals (SDGs), transition to renewable energy (RE) sources and the sustainable use of resources is a global priority. However, due to the intermittency of RE, there is a need for efficient energy storage systems such as supercapacitors (SCs), whose performance strongly depends on electrode materials. In this context, low-cost activated carbons derived from biomass waste and modified with heteroatom-rich dopants emerge as a promising strategy to enhance electrochemical performance while promoting circular economy

principles[1–3]. In this work, pulverized peach pits (PD) were used as a biomass precursor and impregnated with keratin (H) extracted from white chicken feathers. Chemical activation was carried out using 25 % H_3PO_4 with a biomass:activating agent ratio of 1:4. A precursor mixture containing 90 wt% PD and 10 wt% H (PDH) was prepared, and activated carbons were synthesized by direct impregnation. The materials were then pyrolyzed at 700, 800, and 900 °C under N_2 atmosphere.

Textural properties analyzed by N_2 and CO_2 adsorption show surface areas up to ~ 1453 $m^2\ g^{-1}$ (BET) and high microporosity (~ 792 $m^2\ g^{-1}$) for samples at 900 °C. Electrochemical evaluation by CV in 1 mol L^{-1} H_2SO_4 (Figure 1a) shows that peach pits activated carbons (CAD_{700}, CAD_{800}, CAD_{700}) and their keratin-modified 10 wt % Q (CAH_{700}, CAH_{800}, CAH_{900}) exhibit a quasirectangular profile and enhanced capacitance upon keratin modification, reaching ~125 F g^{-1} at 10 mV s^{-1} in three electrodes and 36 F g^{-1} at 5 mV s^{-1} in two electrodes for CAH_{800}. These results highlight keratin as an effective dopant to enhance the electrochemical performance of biomass-derived activated carbons for supercapacitor electrodes.

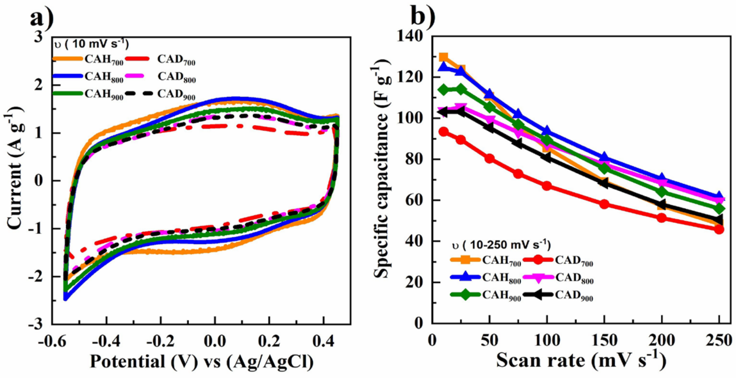

Figure 1. a) CV at 10 mV s^{-1} and b) Cs at 700, 800 900 °C for AC.

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Poster Presentation P35 (Id.102)

TEMPO immobilized on magnetic silica nanoparticles as electrocatalyst for energy storage applications

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Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords:TEMPO, Redox mediator, Immobilized catalyst, Magnetic nanoparticles, ORMOSIL silica, Pseudocapacitance, Electrochemical characterization

2,2,6,6-Tetramethylpiperidin-1-oxyl (TEMPO) is a redox mediator widely used in the selective oxidation of primary alcohols, both in homogeneous systems and in heterogenized form on electrodes of different nature[1,2]. Its interest lies not only in its well-established catalytic activity, but also in its electrochemical behaviour associated with its characteristic redox couple, which has motivated numerous studies aimed at evaluating its potential application in energy storage and conversion devices[3,4]. In this work, magnetically recoverable iron oxide nanoparticles were encapsulated in an amino-functionalized ORMOSIL silica matrix prepared via a sol–gel route. TEMPO was subsequently immobilized through a sustainable aqueous process using glutaraldehyde as a covalent linker, thereby avoiding the use of hazardous reducing agents and organic solvents.

The resulting material was electrochemically characterized to compare the response of immobilized TEMPO with its behaviour in the homogeneous phase. More specifically, its pseudocapacitive response, charge-storage capability, and electrochemical stability over successive charge–discharge cycles were investigated. Finally, the suitability of electrochemical techniques as simple and reliable analytical tools for the identification and quantification of accessible TEMPO radical species immobilized on nanoparticulate catalysts was evaluated.

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Poster Presentation P36 (Id.113)

Valorization of grape pomace residues into N-doped activated carbons as electrochemical capacitor electrodes

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Type of abstract: Poster Presenters
Subject area: Advanced batteries and capacitors
Keywords: Electrochemical capacitor, grape pomace waste, CO2 activation, N-doping

The growing demand for efficient electrical energy storage systems driven by the expansion of renewable energy technologies has intensified interest in electric double-layer capacitors (EDLCs), which offer high power density and fast charge-discharge capability. Activated carbons are widely used as EDLC electrode materials due to their high surface area, electrical conductivity, and chemical stability. Their production from biomass precursors further enhances sustainability while reducing material cost [1].

In this work, grape pomace (GP) residues were valorized into N-doped activated carbons through a hydrothermal treatment followed by carbonization at 900 °C in the presence of the nitrogen source and subsequent CO2 activation for different times (20-40 min) [2]. The electrochemical behaviour of the resulting materials (CN-GP-X, with X denoting activation time) was assessed in 1 M H_2SO_4 using both three- and two-electrode configurations. The undoped counterparts were also evaluated for comparison purposes.

All samples exhibited nearly rectangular cyclic voltammetry profiles, confirming ideal EDLC behaviour. Nitrogen-doped materials consistently delivered higher specific capacitance than undoped analogues, reflecting the beneficial role of N-functionalities in enhancing charge distribution. Galvanostatic charge–discharge curves revealed quasi-triangular and highly-reversible profiles, indicative of efficient capacitive storage. Ragone analysis identified CN-GP-40 as the bestperforming material, achieving 36 Wh kg-1 at 697 W kg-1 with excellent energy retention at higher power densities. These findings underscore the potential of grape-processing residues as sustainable precursors for efficient EDLC carbon electrodes.

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Poster Presentation P37 (Id.117)

Protocols for evaluating advanced bio-sourced gel polymer electrolytes (GPEs) for sustainable zinc-air battery (ZAB) applications

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Keywords:zinc-air battery, gel polymer electrolyte, biopolymer, crosslinking

Given lithium scarcity, safety concerns, and environmental impact, interest in alternative energy storage technologies is growing. Zinc-air batteries (ZABs) offer high theoretical capacity, inherent safety and nontoxicity, while using abundant and inexpensive material [1].

One of the key challenges for ZAB advancement is the development of electrolyte. C. The state of the art is largely based on synthetic gel polymer electrolytes (GPEs), which are often non-biodegradable or derived from unsustainable sources. Biobased polymers offer a more sustainable alternative but are typically unstable under the strongly alkaline conditions required for ZAB operation [2].

Crosslinking is a viable strategy to improve the chemical and mechanical stability of these materials and mitigate degradation over time. However, comparing GPE performance across literature is hindered by absence of a comprehensive, standardized evaluation workflow, particularly under technology-specific conditions.

In this work, we develop a protocol tailored to ZAB requirements, based on practical experimental constraints. The standardized mechanical testing used addresses issues common in alkaline hydrogels, such as corrosion and sample slippage. Systematic and reproducible analysis of load-displacement curves, supported by material-specific knowledge, supports iterative improvement of GPE formulations. Next, we perform a systematic aging study of modified GPE, to evaluate its resistance to the cell operational conditions. The analysis is complemented with thermal analysis of the biopolymer GPE.

The workflow is applied to in-house developed agarose-based GPE, selected for its biodegradability and non-toxicity [3]. A crosslinking strategy is implemented to improve mechanical properties and stability under alkaline conditions. The work establishes a structured approach for electrolyte evaluation and supports the development of bio-based GPEs for ZAB applications.

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Poster Presentation P38 (Id.130)

Binder-free and self-standing porous carbon fabric for flexible supercapacitors

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Keywords: Activated carbon fabrics, flexible supercapacitors, K_2CO_3 activation, porous carbon materials, gel electrolyte.

The development of high-performance flexible supercapacitors requires the balanced design of porous carbons combining high surface area, optimized pore architecture and structural integrity. At the same time, the growing demand for sustainable energy storage technologies calls for environmentally friendly and scalable synthesis strategies. However, integrating high surface area and well-developed porosity with sufficient mechanical robustness in flexible electrodes remains challenging.

In this work, highly porous carbon fabrics were synthesized through a sustainable approach using a woven cotton fabric precursor and a mild activating agent such as K_2CO_3. The process consists of two steps in which the pre-carbonization temperature was tuned to control the reactivity with K_2CO_3 and the resulting pore development. Reducing the precarbonization temperature from 800 to 300 °C increased the oxygen content up to 31.8%, enhancing alkali-mediated and gasification pathways during activation. By optimizing the pre-carbonization temperature and the K2CO3 amount, the structural integrity of the fabric was preserved while achieving a BET surface area of ~2300 m^2 g^{-1} and a total pore volume of ~1.1 cm3 g-1, with ~85% of the pore volume corresponding to micropores (1–2 nm) and the remainder to small mesopores, values comparable to the state-of-the-art for carbon fabrics.

When evaluated in a symmetric supercapacitor using 6 M KOH, the electrode delivers a specific capacitance of 226 F g-1 and an areal capacitance of 1174 mF cm-2 at 0.2 A g-1. The device reaches ~8 Wh kg-1 while maintaining >3 Wh kg-1 even at ~24 kW kg-1, outperforming commercial YP-80F activated carbon. In addition, it shows excellent stability with 96% capacitance retention after 10,000 cycles. When integrated into a flexible quasi-solid-state device using a PVA/KOH (1 M KOH) gel electrolyte, the fabric still delivers ~180 F g-1 at 0.2 A g-1, demonstrating its potential for flexible and wearable energy-storage systems.

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