EcoMat Conference 2025

Materials & Technologies for

Sustainable Future

28 JULY – 01 AUGUST

İTÜ Macka Campus, İstanbul

İTÜ

The Hong Kong Polytechnic University
香港理工大學

Welcome to EcoMat 2025!

We are excited to welcome you to EcoMat 2025 – Materials & Technologies for a Sustainable Future, which will take place from July 28 to August 1, 2025, at İstanbul Technical University, Maçka Campus.

EcoMat 2025 is a global platform that brings together scientists, industry professionals, entrepreneurs, non-governmental organizations, and policymakers to exchange ideas and solutions for a more sustainable world. Focusing on eco-friendly materials, energy efficiency, recycling, green production technologies, and advanced biomaterials, the conference aims to address some of the most pressing challenges of our time.

Throughout the event, attendees can network with academic and industry authorities while engaging in motivational keynote discusses, scientific lectures, and panels.

With five dedicated symposiums covering Catalysis, Energy Storage, Circular Economy, Optoelectronic Applications, and Biomedical Engineering, EcoMat 2025 promises a rich and dynamic experience for all participants.

We look forward to connecting with you in İstanbul to share knowledge, foster collaboration, and contribute to building a cleaner, greener, and more sustainable future.

Let’s shape the future together at EcoMat 2025!

Prof. Dr. Özgül Keleş Assoc. Prof. Dr. B. Deniz Karahan Prof. Dr. Zijian Zheng

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Prof. Dr. Özgül Keleş
(İstanbul Technical University, Türkiye)

Prof. Dr. Zijian Zheng
(Hong Kong PolyU, Chair of EcoMat conference series, HK)

Assoc. Prof. Dr. B.Deniz Karahan
(İstanbul Technical University, Türkiye)

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OUTLINE

Materials&Technologies for a Sustainable Future" is the theme of EcoMat 2025.

From July 29 to August 1, 2025, Istanbul Technical University's Maçka Campus's Mustafa Kemal Amphitheatre will host the EcoMat 2025 "Materials for a sustainable future" Conference.

With an emphasis on the development of sustainable solutions and eco-friendly materials for industrial applications, EcoMat 2025 brings together scientists, businesspeople, non-governmental organizations entrepreneurs, and policy makers from around the world. This event combines materials science, sustainability, and technology to address the issues of the future.

The EcoMat 2025 Conference's Focusses on World's main Challenges;
Development of Sustainable Materials: Creation and application of materials that have a low impact on the environment, recyclable, and biodegradable.
Energy Efficiency: The development and industrial use of technology to improve the energy efficiency of the production and consumption of materials
Waste Management and Recycling: Developing creative ways to reduce waste, generate material cycles, and turn waste into value.
Environmentally Friendly Production Processes: Creation of strategies and techniques to reduce the negative effects of material production on the environment,
Biomaterials and biotechnology: Innovating materials and technologies to improve living conditions of all species in the world.

The EcoMat 2025 Conference will explore solutions influenced by research, talk about how new technologies affect the environment, and promote a dialogue between academia and industry. The event seeks to increase awareness of global environmental challenges while offering participants chances for knowledge exchange, teamwork, and creativity. More than just a conference, EcoMat gives attendees opportunity to expand their perspectives on the world's future through keynote speakers, interactive workshops, and innovative projects that highlight the value of teamwork for a sustainable future.

Our objective for this event is to propose solutions for these challenges via creating professional networks worldwide with industry, academia and non- governmental organizations by sharing findings on;

Symposium A: Catalysts and Catalysis
Symposium B: Energy Storage
Symposium C: Gas/Water Management and Circular economy
Symposium D: Emerging Materials and Devices for Optoelectronic Applications
Symposium E: Materials for Energy and Biomedical Engineering

About EcoMat

Aim and Scope

EcoMat is an interdisciplinary journal uniting research on functional materials for green energy and environments. *EcoMat* aims to publish on a wide variety of topics from different disciplines that share the focus on cutting-edge advanced materials for green energy and environment. The scope of *EcoMat* is intentionally broad and encompasses relevant fields for developing ecofriendly and sustainable energy, including topics such as wind, water and solar energy harvesting & conversion, batteries and supercapacitors, energy system and networks, thermoelectrics, fuel cells, carbon capture and storage, piezo and triboelectrics, water and air pollution control & cleaning, artificial photosynthesis, hydrogen generation & storage. This journal recognizes the complexity of issues, and therefore particularly welcomes innovative interdisciplinary research with wide impact. It will aim to make a mark in the materials science and adjacent fields with ambitions of a high academic impact.

Impact

2024 Journal Impact Factor: **12.6**

Five-year Journal Impact Factor: **12.3**

2024 CiteScore: **20.5**

For more details, visit *EcoMat* website

http://www.wileyonlinelibrary.com/journal/ecomat

İstanbul Technical University: Beyond a Technical University, a Global Vision for the Future.

İstanbul Technical University (İTÜ), founded in 1773, is one of the oldest and most prestigious technical universities in the world. With a proud history of over 250 years, İTÜ has been a pioneer in engineering, architecture, and natural sciences, playing a key role in Türkiye's modernization and technological advancement.

Offering a broad range of programs in engineering, architecture, business, arts, and natural sciences, by fusing its distinguished academic culture with state-of-the-art research, İTÜ is regarded as one of the essential origins of innovative engineering applications for Türkiye.

With its five campuses located in the heart of İstanbul — Maslak, Maçka, Taşkışla, Gümüşsuyu, and Tuzla — İTÜ provides a dynamic and inspiring environment for learning and research. The educational experience is enhanced by cutting-edge labs, research facilities, and a lively campus community, while innovation hubs encourage technology transfer and entrepreneurship.

İTÜ stands out with internationally accredited programs, a distinguished academic staff, and a vast global alumni network, empowering students with a strong international perspective. Consistently ranked among the top universities in the world, İTÜ is committed to shaping future leaders in science, technology, and society.

The EcoMat Editorial Office is pleased to welcome you to the EcoMat Conference 2025.

This year's gathering brings together cutting-edge research and visionary ideas in an era when sustainable materials science has never been more vital. EcoMat, an open-access journal published jointly by The Hong Kong Polytechnic University and John Wiley & Sons, is dedicated to advancing functional materials for green energy and environmental applications. We are happy to see so many innovative abstracts reflecting the interdisciplinary spirit that defines our journal.

Set against the historic backdrop of Istanbul – where Europe and Asia converge – EcoMat Conference 2025 will be hosted from July 29 to August 1, 2025 at Istanbul Technical University's Maçka Campus. Here, in a city long celebrated for bridging worlds, you will explore topics spanning sustainable material synthesis, energy harvesting and storage, circular-economy processes, biomaterials, and beyond.

As you leaf through these pages, you will find the seeds of tomorrow's breakthroughs. Each abstract and lecture represent rigorous scholarship, creative problem-solving, and a commitment to shaping a more sustainable future. We extend our deepest thanks to every presenter for submitting your abstracts, to our symposium chairpersons for their insightful guidance, and to the conference organizers for crafting an inspiring programme.

We encourage you to engage fully with your peers, with the city's rich history, and with the promise of new collaborations. After the conference, we invite you to consider extending your findings into manuscripts for submission to EcoMat. Together, let us accelerate the transition toward eco-friendly materials and technologies that will define the next generation of sustainable solutions.

Welcome to EcoMat Conference 2025, where ideas meet impact. We look forward to the conversations, connections, and discoveries that lie ahead.

Sincerely,
EcoMat

Innovation Driven Electrochemical Applications: IDEA Research Group at İTÜ

The goal of engineering should be to allow life to flourish and survive in a peaceful, habitable planet. The experience of 'living a life' is not exclusive to a single species, and coexistence in harmony serves to strengthen and sustain the ecosystem. Therefore, rather of taking a biased, profit-driven approach, engineering processes should be carried out with the aim of creating a sustainable system and the machinery to operate within it.

The IDEA group's mission is to use science to develop engineering concepts for creating a sustainable life for all species. At Istanbul Technical University's ENERGY STORAGE TECHNOLOGIES MATERIALS RESEARCH and DEVELOPMENT LABORATORY, we are carrying out more research on this subject...

IDEA Research group's infrastructure incorporates numerous instruments that have been custom-designed, leveraging extensive expertise in materials science and process engineering. The ongoing projects are related to the fabrication and characterization of separators and current collectors, as well as electrode-active materials' synthesis for secondary batteries and biosensor. Within this scope, the reactors used for the co-precipitation process are also custom designed and fabricated domestically. This fact enables to run experiment both in laboratory- and prototype-scale. Additionally, IDEA group advances in material synthesis through solid-state techniques, including mechanical alloying and heat treatments using furnaces with diverse properties. Morever, IDEA group's research extend to corrosion behavior analysis of existing systems and the development of eco-friendly anti-corrosion coatings through the strategic selection of materials and process design.

At IDEA, each study accounts for the carbon footprint of synthesized materials, emphasizing low-energy consuming synthetic processes design for sustainable practices. In addition, research efforts include material recovery from waste, recycling, and reusing. The laboratory also undertakes projects on capacitors, biosensors, and advanced energy storage technologies beyond lithium-ion batteries.

Assoc. Prof. Dr. B. Deniz Karahan

Prof. Dr. Özgül Keleş

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Getting to ITU Maçka Campus

ITU Maçka Campus is housed in a historic building located in one of Istanbul's most vibrant and central districts. It is nestled between the upscale shopping area of Nişantaşı and the lively Beşiktaş neighborhood, with the beautiful Maçka Democracy Park right next to it. The campus is within walking distance of many hotels, cafes, and cultural attractions.

Campus Address: Maçka Caddesi, 34357 Şişli/İstanbul, Türkiye

From Istanbul Airport (IST)

- **1.1 By Airport Shuttle (HAVAIST):** This is the recommended option for convenience and cost. Take the **HVIST-16** bus line to **Taksim Square**. From Taksim, the campus is a short taxi ride or a 15-20 minute walk away.
    - **Fee:** Approx. TRY 250 ~€5.5
    - **Transit time:** ~90-110 minutes (depending on traffic)
- **1.2 By Metro:** This option avoids road traffic. Take the **M11** metro line from the airport to **Gayrettepe** station. Transfer to the **M2 (Yenikapı direction)** line and get off at **Osmanbey** station. The campus is a 10-15 minute walk from the station.
    - **Fee:** Less than TRY 100 ~€2
    - **Transit time:** ~60 minutes
- **1.3 By Taxi:** This is the most direct but also the most expensive option.
    - **Fee:** Approx. TRY 1500-2000 ~€40-45 (subject to change based on traffic and route)
    - **Transit time:** ~45-75 minutes (highly dependent on traffic)

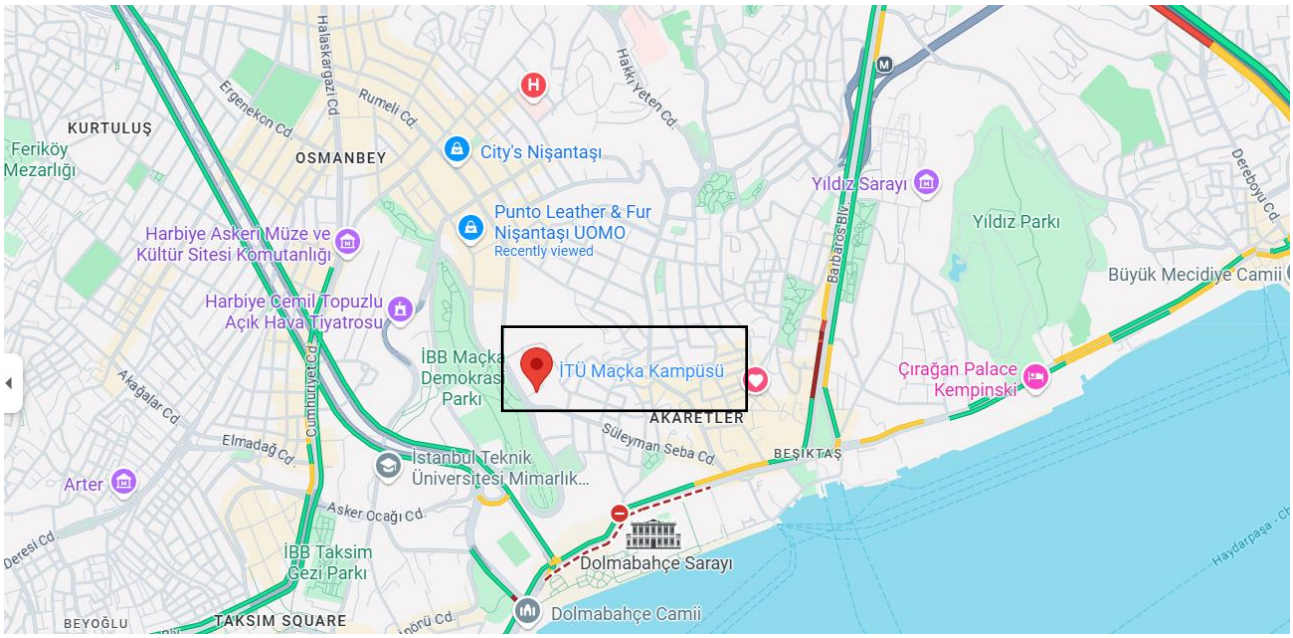
From Sabiha Gökçen Airport (SAW)

- **2.1 By Airport Shuttle (HAVABUS):** Take the shuttle bus to **Taksim Square**. From Taksim, the campus is a short taxi ride or a 15-20 minute walk away.
    - **Fee:** Approx. TRY 250 ~€5.5
    - **Transit time:** ~110-140 minutes (highly dependent on traffic)
- **2.2 By Metro:** This route involves multiple transfers. Take the **M4** metro from the airport to **Ayrılık Çeşmesi** station. Transfer to the **Marmaray** line (towards Halkalı) and go to **Yenikapı** station. At Yenikapı, transfer to the **M2** line (towards Hacıosman) and get off at **Osmanbey** station. The campus is a 10-15 minute walk from the station.
    - **Fee:** Less than TRY 150 ~€3
    - **Transit time:** ~90-100 minutes
- **2.3 By Taxi:** This is a direct but costly option due to the distance and potential bridge traffic.
    - **Fee:** Approx. TRY 2000-2200 ~€45-50 (subject to change based on traffic and route)
    - **Transit time:** ~60-90 minutes (highly dependent on traffic)

From Taksim Square (Central Hub)

- **3.1 By Walking:** A pleasant 15-20 minute downhill walk through Gezi Park or along the main road (Cumhuriyet Caddesi).
    - **Transit time:** ~15-20 minutes
- **3.2 By Taxi:** A very short ride.
    - **Fee:** Approx. TRY 135 ~€2.5-3 (minimum taxi fare)
    - **Transit time:** ~5 minutes
- **3.3 By Cable Car (Teleferik):** A scenic and unique option. Walk to the **TF1 Taşkışla-Maçka** cable car station near the Grand Hyatt hotel. The ride takes you directly down to Maçka Park, right next to the campus.
    - **Fee:** Less than TRY 20 ~€0.5
    - **Transit time:** ~15 minutes (including walk to the station)

Disclaimer: All fees and transit times are estimates and may vary depending on the time of day, traffic conditions, and fare changes.



28 July 2025 (Monday)

14.00 - 17.00	**Early Registration (ITU Mustafa Kemal Amphitheatre Foyer)**

29 July 2025 (Tuesday)

09.20 - 09.50	**Opening Ceremony-Mustafa Kemal Amphitheatre** **Prof. Dr. Zijian Zheng** - EcoMat 2025 Conference Chair **Prof. Dr. Lütfiye Durak Ata** - İTÜ Vice Rector **Prof. Dr. Özgül Keleş** - EcoMat 2025 Conference Chair **Assoc. Prof. Dr. B. Deniz Karahan** - EcoMat 2025 Conference Chair
09.50 - 10.35	**PLENARY SPEAKER 1-Mustafa Kemal Amphitheatre** Session Chair: **Prof. Dr. Zijian Zheng** **Prof. Dr. Metin Sitti** Title: "Small-scale mobile robots down to cell size for biomedical and environmental applications"
10.35 - 11.00	Coffee Break (Mustafa Kemal Amphitheatre Foyer)
11.00 - 11.45	**PLENARY SPEAKER 2-Mustafa Kemal Amphitheatre** Session Chair: **Prof. Dr. Zijian Zheng** **Prof. Dr. Yunqi Liu** Title: "Intrinsic flexibility: Materials and devices"
11.45 - 12.30	**PLENARY SPEAKER 3-Mustafa Kemal Amphitheatre** Session Chair: **Prof. Dr. Zijian Zheng** **Prof. Dr. Hua Zhang** Title: "Phase Engineering of Nanomaterials"
12.30 - 13.30	Lunch Break (İTÜ Cafeteria)

29 July 2025 (Tuesday)

13.30 - 15.00	**Symposium C** | Session 1 **HALL A** KEYNOTE SPEAKERS: **Emin İlkmen** **Prof. Dr. Birgül Tantekin Ersolmaz** **Dr. Hüseyin Güler** **Başak Dik** **Dr. Pınar Afşin** ORAL PRESENTATION: **Burak Onur**	**Symposium D** | Session 1 **HALL B** KEYNOTE SPEAKERS: **Prof. Dr. Lang Jiang** **Prof. Dr. Junliang Yang** INVITED SPEAKERS: **Assoc. Prof. Dr. Bo Qu** ORAL PRESENTATION: **Pelin Oral** **Hanchao Zhang**	**Symposium E** | Session 1 **HALL C** KEYNOTE SPEAKERS: **Prof.Dr. Pooi See Lee** **Asst. Prof. Dr. Mustafa Ordu** INVITED SPEAKERS: **Assoc. Prof. Dr. Xiaochuan Dai** ORAL PRESENTATION: **Syed Zubair Hussain**
15.00 - 16.00	Poster Session 1 & Coffee Break (Mustafa Kemal Amphitheatre Foyer)		
16.00 - 17.45	**Symposium A** | Session 1 **HALL A** KEYNOTE SPEAKERS: **Prof. Dr. Mustafa Ersöz** **Prof. Dr. Pengfei Wang** **Prof. Dr. Liping Zhang** INVITED SPEAKERS: **Asst. Prof. Dr. Jian Wang**	**Symposium B** | Session 1 **HALL B** KEYNOTE SPEAKERS: **Prof.Dr. Wenjun Zhang** **Assoc. Prof. Dr. Jongwoo Lim** INVITED SPEAKERS: **Prof. Dr. Ruiping Liu** ORAL PRESENTATION: **Burcu Ünal** **Cansu Çamlık** **Yiyuan Ma**	**Symposium E** | Session 2 HALL C KEYNOTE SPEAKERS: **Prof.Dr.Qiyao Huang** **Assoc. Prof. Dr. Yavuz Nuri Ertaş** **Prof.Dr. Hüsnü Emrah Ünalan** ORAL PRESENTATION: **Ugur Ergin** **Hasan Celik** **Yaokang Zhang**

30 July 2025 (Wednesday)

09.00 - 09.45	**PLENARY SPEAKER 4 – HALL A** Session Chair: **Prof. Dr. Özgül Keleş** **Prof.Dr.Yasemin Yüksel Durmaz** Title: "Nanoparticle-Mediated Histotripsy for Non-invasive Cancer Ablation"	
09.45 - 10.30	**PLENARY SPEAKER 5 – HALL A** Session Chair: **Prof. Dr. Özgül Keleş** **Prof. Dr. Sang Il Seok** Title: "Integrated Engineering for High-Performance Perovskite Solar Cells"	
10.30 - 11.00	Coffee Break (Mustafa Kemal Amphitheatre Foyer)	
11.00 - 12.45	**Symposium C | Session 2** **HALL A** KEYNOTE SPEAKERS: **Prof.Dr. Feng Wang** **Burcu Akyüz Kırgız** INVITED SPEAKERS: **Prof. Dr. Mustafa Bakkal** ORAL PRESENTATION: **Burçin Coşkun** **Eylem Cağrıcan Gök** **Derviş Eren Ünsal**	**Symposium E | Session 3** **HALL B** KEYNOTE SPEAKERS: **Prof. Dr. Ali Çırpan** **Prof. Dr. Yakup Aykut** **Asst. Prof. Dr. Tural Khudiyev** INVITED SPEAKERS: **Assoc. Prof. Pınar Çakır Hatır**
12.45 - 14.00	Lunch Break (İTÜ Cafeteria)	

30 July 2025 (Wednesday)

14.00 - 15.45	**Symposium D** | Session 2 **HALL A** KEYNOTE SPEAKERS: **Dr. Jian Zhang** **Dr. Erkan Aydın** INVITED SPEAKERS: **Prof. Dr. Anyi Mei** ORAL PRESENTATION: **Elif Demir Arabacı** **Mustafa Yaşa**	**Symposium E** | Session 4 **HALL B** KEYNOTE SPEAKERS: **Dr. Erkan Şenses** **Assoc. Prof. Dr. Bilge Baytekin** **Asst. Prof. Dr. Elif Hocaoğlu** INVITED SPEAKERS: **Dr.Koray Bahadır Dönmez** ORAL PRESENTATION: **Orhan Sözer | S. Onur Göyünç**
15.45 - 16.45	Poster Session 2 & Coffee Break (Mustafa Kemal Amphitheatre Foyer)	
16.45 - 18.30	**Symposium D** | Session 3 **HALL A** KEYNOTE SPEAKERS: **Prof.Dr.Saim Özkar** **Prof. Dr. Ebru Menşur** INVITED SPEAKERS: **Dr.Zheling Zhang** ORAL PRESENTATION: **Zhiyong Fan** **Gökçen Gökçeli**	**Symposium B** | Session 2 **HALL B** KEYNOTE SPEAKERS: **Prof. Dr. Sang Bok Lee** **Prof. Dr. Yaxiang Lu** ORAL PRESENTATION: **Selin Sarıyer** **Elif Güloğlu** **Nahid A. Keshtiban**
19.30 - 22.30	**Conference Banquet and Awards Ceremony**	

31 July 2025 (Thursday)

09.00 - 09.45	**PLENARY SPEAKER 6 - HALL A** Session Chair: **Assoc. Prof. Dr. B. Deniz Karahan** **Hakan Doğu** Title: "The Emergence of Electromobility in Different Geographies and Foresight Future Scenarios"	
09.45 - 10.15	Coffee Break (Mustafa Kemal Amphitheatre Foyer)	
10.15 - 12.00	**Symposium C** | Session 3 **HALL A** KEYNOTE SPEAKERS: **Nihan Cin** **Oğuzhan Akınç** **Kutsal Anıl** INVITED SPEAKERS: **Dr. Vildan Bayram Karakuşlu** ORAL PRESENTATION: **Esra Dönmez** **Shanqing Zhang**	**Symposium A** | Session 2 **HALL B** KEYNOTE SPEAKERS: **Prof. Dr. Bolong Huang** **Prof. Dr. Min-Rui Gao**
12.00 - 13.00	Lunch Break (İTÜ Cafeteria)	
13.00 - 14.30	**Symposium B** | Session 3 **HALL A** KEYNOTE SPEAKERS: **Prof.Dr. Yunlong Guo** **Dr. Tim-Patrick Fellinger** **Assoc. Prof. Dr. Zhenxing Feng** ORAL PRESENTATION: **Hava Çavuşoğlu Vatansever**	**Symposium A** | Session 3 **HALL B** KEYNOTE SPEAKERS: **Assoc. Prof. Dr. Sarp Kaya** **Dr.Can Akyıl** ORAL PRESENTATION: **Govardhana Babu Bodedla**
14.30 - 15.00	Coffee Break (Mustafa Kemal Amphitheatre Foyer)	
15.00 - 17.00	Wiley Editor Forum & EcoMat Researcher Awards Lectures **HALL A**	

1 August 2025 (Friday)

09.00 – 10.45	**Symposium C** | Session 4 **HALL A** INVITED SPEAKERS: **Assoc. Prof. Dr. Yihao Chen** ORAL PRESENTATION: **Baidaa Alkhateab** **Elif Emil Kaya** **Esra Dönmez | Yiğit Bartu Ilgaz** **Elif Bengi Güneş Yerlikaya** **Esra Dönmez | İsmail Kırang** **Buket Erdoğan**	**Symposium A** | Session 4 **HALL B** KEYNOTE SPEAKERS: **Prof.Dr.Chang-An Wang** **Assoc. Prof. Dr. Cem Örnek** **Prof. Dr. Chuan Zhao** ORAL PRESENTATION: **Aylin Saltuk**
10.45 – 12.30	**Symposium B** | Session 4 **HALL A** KEYNOTE SPEAKERS: **Dr. Alexandre Ponrouch** ORAL PRESENTATION: **Qi Qi** **Serra Ersoy** **Tutku MUTLU ÇETİNKAYA** **Emre Çetin** **Mehmet Yılmaz** **Mehbare Doğrusöz**	
12.30 – 13.00	**Closing Remarks -HALL A** Prof. Dr. Özgül Keleş - EcoMat 2025 Conference Chair Prof. Dr. Zijian Zheng - EcoMat 2025 Conference Chair Assoc. Prof. Dr. B. Deniz Karahan - EcoMat 2025 Conference Chair	

Plenary Speakers

Hakan Doğu
(Alagan Partners, Turkiye)

Prof. Dr. Yunqi Liu
(The Institute of Chemistry, CAS, China)

Prof. Dr. Sang Il Seok
(UNIST, Korea)

Prof. Dr. Metin Sitti
(Koç University, Türkiye)

Prof. Dr. Yasemin Yuksel Durmaz
(İstanbul Medipol University)

Prof. Dr. Hua Zhang
(City University of Hong Kong, China)

Prof. Dr. Metin Sitti - *(Koç University, Türkiye)*

Prof. Dr. Metin Sitti is the President and Professor of Koç University in Istanbul, Turkey since fall 2023. Formerly, he was a Director of the Physical Intelligence Department at Max Planck Institute for Intelligent Systems, Germany (2014-2023), Professor at ETH Zurich, Switzerland (2020-2024), Professor at Carnegie Mellon University, USA (2002-2014), and Research Scientist at UC Berkeley, USA (1999-2002). He received his BSc (1992) and MSc (1994) degrees from Boğaziçi University, Turkey, and PhD degree from University of Tokyo, Japan (1999). His research interests include wireless medical devices, small-scale mobile robots, bioinspiration, and physical intelligence. He is a member of National Academy of Engineering in USA, Academy Europea, and Max Planck Society (2014-2023). He received the Highly Cited Researcher recognition (2021-2024), Frontiers of Science Award (2025), Materials Science Leader Award (2023-2025), Breakthrough of the Year Award in the Falling Walls World Science Summit (2020), ERC Advanced Grant (2019), Rahmi Koç Science Medal (2018), SPIE Nanoengineering Pioneer Award (2011), and NSF CAREER Award (2005). He has supervised and mentored over 70 (18 current) PhD students and 80 (10 current) postdocs, where over 65 of his group alumni are professors around the world. He has published 2 books and over 420 journal articles and has over 30 patents. He founded Setex Technologies Inc. to commercialize his lab's gecko-inspired microfiber adhesive technology. He is the editor-in-chief of Journal of Micro-Bio Robotics journal and associate editor in Science Advances journal.

Small-scale Medical Robots down to Cell Size inside Our Body

Prof. Dr. Metin Sitti
Koç University

Wireless small-scale medical robots have the unique capability of navigating, operating and staying inside hard-to-reach, tight, risky and deep sites inside our body. This talk reports our recent milli- and microscale wireless miniature medical robots down to cell size that could achieve various minimally invasive medical functions, such as targeted active drug delivery, neural stimulation, clot opening, liquid biopsy, biofluid pumping, cauterization, and hyperthermia. Due to miniaturization limitations on on-board actuation, powering, sensing, computing and communication, new materials and methods need to be introduced in creating and controlling such robots. Moreover, they need to be tracked under medical imaging modalities, such as ultrasound, fluoroscopy, photoacoustic imaging, and MRI, for their precise and safe operation. 3D microprinting and assembly-based fabrication methods and biocompatible and multifunctional soft composites with embedded micro/nanomaterials are proposed to create novel medical milli/microrobots. Soft-bodied medical miniature robot designs enable active shape programming-based adaptive, multimodal and multifunctional navigation and functions, and safe operation. External physical forces, such as magnetic fields, acoustic waves and light, and physical or chemical (e.g., catalytic) interactions with the operation medium are used to actuate and steer such miniature robots wirelessly as a single robot or robot collectives. These robots are aimed to save lives of more patients by curing diseases not possible or hard to cure and decrease the side effects and invasiveness of disease treatments drastically.

Prof. Dr. Yunqi Liu – *(The Institute of Chemistry, CAS, China)*

Curriculum Vitae Yunqi Liu was graduated from Nanjing University in 1975, received a doctorate from Tokyo Institute of Technology, Japan in 1991. Presently, he is a Professor at the Institute of Chemistry, Chinese Academy of Sciences (CAS), an Academician of CAS, and a Fellow of The World Academy of Sciences (TWAS). His current research interests include design and synthesis of molecular materials, including π-conjugated small molecules, polymers, and graphene, fabrication of related devices, including field-effect transistors and molecular electronics, and investigation of their electronic properties. He has published more than 800 papers in SCI journals, and cited by other researchers for more than 60,000 times with an h-index greater than 120. In addition, he has obtained 80 of granted patents, published three books and 17 book chapters. He received the National Natural Science Award (2nd grade) in 2007, 2016 and 2019, and Beijing Science and Technology Award in 2017 and 2022 (1st grade). He serves on the Editorial Board Member or Advisory Board Members for Nanoscale, ACS Mater. Lett., SmartMat., Wearable Electronics, FlexMat, Chin. J. Struct. Chem., etc.

Intrinsic flexibility: Materials and devices

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Intrinsic flexibility originates from molecular-level deformation, such as chemical bond rotation, conformational interconversion, molecular chain extension/slip and dynamic bond formation, it is an elastic deformability providing small radius of curvature (less than 0.5 mm), high stretchability (more than 25%), and cross-scale modulus adaptability (1 kPa ~10 GPa). The ultimate goal is to achieve free-form deformation.

Technically, there are different routes for the realization of flexibility. (i) Physical flexibility: any rigid material that is extremely thin or has a very small diameter can be flexible. (ii) Structural flexibility: for example, the wire-connecting fractal and spring configuration can provide macroscopic flexibility for the rigid chip. (iii) Intrinsic flexibility: the materials (such as polymers and carbon materials) in a device have a flexible and stretchable nature. The combination of physical and structural flexibility has facilitated the development of hinge technology in folding-screen phones. However, the long-term mechanical stability of such phones is still a considerable challenge. Usually, the flexibility is quantified by the bending radius (R). A decreased R means improved flexibility of devices.

In this presentation, I will introduce a few design strategies for the realization of semiconducting molecular materials. Solution processed method is used to fabricate highperformance OFETs. Their various potential applications are also involved.

Prof. Dr. Hua Zhang - *(City University of Hong Kong, China)*

In 2020, he was elected as a Foreign Fellow of the European Academy of Sciences (EurASc). In 2015, he was elected as an Academician of the Asia Pacific Academy of Materials (APAM). In 2014, he was elected as a Fellow of the Royal Society of Chemistry (FRSC). He was listed in the "Highly Cited Researchers" in Materials Science (Clarivate Analytics/Thomson Reuters, 2014-2023 (10 consecutive years)), in Chemistry (Clarivate Analytics/Thomson Reuters, 2015-2023 (9 consecutive years)), and in Environment and Ecology (Clarivate Analytics, 2022). In 2015, he was listed as one of 19 “Hottest Researchers of Today” in the world in the World’s Most Influential Scientific Minds 2015 (Thomson Reuters, 2015). In 2014, he was listed as one of 17 “Hottest Researchers of Today” and No. 1 in Materials and More in the world in the World’s Most Influential Scientific Minds 2014 (Thomson Reuters, 2014). Moreover, he also received the Croucher Senior Research Fellowship (2025, Croucher Foundation, Hong Kong), BOCHK Science and Technology Innovation Prize (2024, Hong Kong Alliance of Technology and Innovation), IUMRS-Frontier Materials Scientists Award (2023, IUMRS-ICFM), EcoMat Mid-Career Research Award (2023, Wiley-VCH), Outstanding Research Award (2022, City University of Hong Kong), President’s Award (2021, City University of Hong Kong), Young Investigator Award (Young Giants of Nanoscience 2016, Hong Kong), Vice-Chancellor’s International Scholar Award (University of Wollongong, Australia, 2016), ACS Nano Lectureship Award (2015), World Cultural Council (WCC) Special Recognition Award (2013), the ONASSIS Foundation Lectureship (Greece, 2013), Asian Rising Stars (15th Asian Chemical Congress, 2013), SMALL Young Innovator Award (Wiley-VCH, 2012) and Nanyang Award for Research Excellence (2011).

Dr. Zhang’s research is highly interdisciplinary. His current research interests focus on phase engineering of nanomaterials (PEN) and controlled epitaxial growth of heterostructures, including the synthesis of ultrathin two-dimensional nanomaterials (e.g., metal nanosheets, graphene, metal dichalcogenides, metalorganic frameworks, covalent organic frameworks, etc.), novel metallic and semiconducting nanomaterials, novel amorphous nanomaterials, and their hybrid composites for various applications, such as catalysis, clean energy, (opto-)electronic devices, chemical and biosensors, and water remediation.

Phase Engineering of Nanomaterials (PEN)

Hua Zhang
Department of Chemistry, Hong Kong Institute for Clean Energy (HKICE), Hong Kong Branch of National Precious Metals Material Engineering Research Center (NPMM), City University of Hong Kong, Hong Kong, China
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Google Scholar: https://scholar.google.com/citations?user=Cgo45S8AAAAJ&hl=en

In this talk, I will summarize the recent research on phase engineering of nanomaterials (PEN) in my group, particularly focusing on the rational design and synthesis of novel nanomaterials with unconventional phases for various promising applications. For example, by using wet-chemical methods, for the first time, we have successfully prepared novel Au nanostructures (e.g., the hexagonal-close packed (hcp) 2H-Au nanosheets, 4H-Au nanoribbons, and 4H/fcc and fcc/2H/fcc heterophase Au nanorods), epitaxially grown metal nanostructures on the aforementioned unconventional Au nanostructures and 2H-Pd nanoparticles, and amorphous/crystalline heterophase Pd, PdCu, Rh and Rh alloy nanosheets. By using gas-solid reactions, metastable 1T'-phase group VI transition metal dichalcogenides (TMDs), e.g., WS2, WSe2, MoS2, MoSe2, WS2xSe2(1-x) and MoS2xSe2(1-x), have been prepared. Impressively, the 1T'-MoS2-supported single-atomically dispersed Pt (s-Pt) atoms with Pt loading up to 10 wt% exhibit superior performance in hydrogen evolution reaction. Importantly, 1T'-TMD monolayers can be stabilized on 4H-Au nanowires, which have been used for ultrasensitive SERS detection. Moreover, the salt-assisted 2H-to-1T' phase transformation of TMDs have been achieved, and the phase transformation of TMDs during our developed electrochemical Liintercalation process has been observed. Impressively, the lithiation-induced amorphization of Pd3P2S8 has been achieved. Currently, my group focuses on the investigation of (crystal) phase-dependent physicochemical properties, functions and applications in catalysis, (opto-)electronic devices, clean energy, chemical and biosensors, surface enhanced Raman scattering, photothermal therapy, etc., which we believe are quite unique and very important not only in fundamental studies, but also in future practical applications. Importantly, the concepts of phase engineering of nanomaterials (PEN), crystal-phase heterostructures, and heterophase materials are proposed.

Keywords: Phase engineering of nanomaterials (PEN); Noble metal nanomaterials; Transition metal dichalcogenides; Crystal phases; Unconventional phases; Amorphous phase; Crystal-phase heterostructures; Heterophase nanomaterials
Reference: (1) Nature, 2023, 621, 300. (2) Nat. Mater., 2024, 23, 1355. (3) Nat. Mater., 2021, 20, 1113. (4) Nat. Rev. Chem., 2020, 4, 243. (5) J. Am. Chem. Soc., 2020, 142, 18971. (6) Nat. Chem., 2018, 10, 638. (7) Nat. Chem., 2018, 10, 456. (8) Nat. Catal., 2018, 1, 460. (9) Adv. Mater., 2018, 30, 1803234. (10) Chem. Sci., 2017, 8, 795. (11) ACS Nano, 2015, 9, 9451. (12) Nat. Commun., 2015, 6, 7684. (13) Nat. Commun., 2013, 4, 1444. (14) ACS Nano, 2012, 6, 74. (15) Nat. Commun., 2011, 2, 292. (16) Angew. Chem. Int. Ed., 2011, 50, 11093.

Prof. Dr. Yasemin Yuksel Durmaz – *(İstanbul Medipol University)*

Prof. Dr. Yasemin Yuksel Durmaz received her bachelor's degree from Yıldız Technical University, Department of Chemistry in 2003. She completed her master's and doctoral studies at Istanbul Technical University, Department of Polymer Science and Technology, between 2003 and 2009. Between 2010 and 2014, she conducted her postdoctoral research at the University of Michigan, Department of Biomedical Engineering. Yuksel Durmaz, who was supported by a Postdoctoral Research Scholarship from the Susan G. Komen Foundation during her postdoctoral research. She has been a faculty member at Istanbul Medipol University, Department of Biomedical Engineering since 2015. Her research focuses on polymeric nanotherapeutics for various application especially for nanoparticles mediated histotripsy. She received the FABED Eser Tümen Research Award in 2016, the scientist woman of the year award under the Unesco-L'Oreal "for women in science" program and the TÜBA-GEBİP Outstanding Young Scientist award in 2018.

Nanoparticle-Mediated Histotripsy for Non-invasive Cancer Ablation

Waleed Mustafa[1], Sarah Hall[2], Mohamad Abu Chakra1, Ibtisam Naser[1], Semih Macit[1], Özge Şensoy[1,3], Eli Vlaisavljevich[2], Yasemin Yüksel Durmaz[1,3],

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Histotripsy is a non-invasive and non-thermal mechanical tissue ablation technique that relies on acoustic cavitation generated with high-pressure, short-duration focused ultrasound pulses.[1] Histotripsy uses already existing gas pockets in the tissue as cavitation nuclei to form bubble clouds when the peak negative pressure is raised beyond the cavitation threshold of the tissue. These gas bubbles are transformed into highly energetic microbubbles that can rapidly expand (>50 μm) and violently collapse, resulting in the complete ablation of the tissue into a liquefied homogenate with no remaining viable cells.[2] Although histotripsy has approved by FDA and have promising potential for many clinical applications, high negative pressure values often >25-30 MPa to produce the desired cavitation in the tissue is a major limitation that requires the additional imaging technique for precise ablation without damaging the surrounding healthy tissue. Nanoparticle mediated histotripsy (NMH) addresses this concern using ultrasound active nanoparticles as cavitation nuclei that can significantly lower the cavitation threshold pressure (10-15 MPa).[3-4] Perfluorocarbon containing nanoparticles can undergo acoustic droplet vaporization and form gas bubbles. Their ability to selectively accumulate on the tumor through EPR effect helps the selective ablation of the tumor at lower cavitation threshold without damaging the healthy neighboring tissue. The first-generation nanoparticles used for NMH were nanodroplets consisting of triblock copolymers with a hydrophobic core comprising acoustically excitable perfluoropentane (PFP) or perfluorohexane (PFH), lowering the overall cavitation threshold. More recently, nanocone cluster (NCC) have been developed as next-generation histotripsy agents overcome limitations such as relatively larger size (>200 nm), dose indeterminacy, and complex synthetic routes.[5-6] These structures are also engineered to accommodate combinational treatment to eliminate any tumor remnant in the treated area. This study outlines the rational design of nanoparticles for NMH and their in vitro and in vivo feasibility for a safe and more effective therapeutic ablation.

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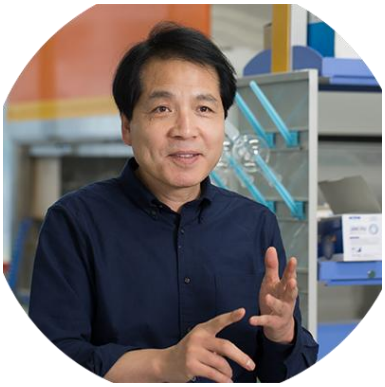
Prof. Dr. Sang Il Seok - *(UNIST, Korea)*



Sang Il Seok is a Distinguished Professor in the Department of Energy and Chemical Engineering at the Ulsan National Institute of Science and Technology (UNIST), Korea. He earned his Ph.D. in Inorganic Materials Engineering from Seoul National University, Korea. Following his doctoral studies, he conducted postdoctoral research in Materials Science and Engineering at Cornell University, USA, focusing on defects and transport phenomena in the Fe-Ti-O spinel structure. He further broadened his academic experience as a visiting scholar at the University of Surrey, UK, in 2003, and École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, in 2006.

Before joining UNIST in 2015, Professor Seok served as a principal investigator at the Korea Research Institute of Chemical Technology (KRICT) and held a joint appointment as a professor in the Department of Energy Science at Sungkyunkwan University. He has been recognized as a Highly Cited Researcher by Clarivate Analytics every year since 2018, a testament to the global impact of his work. He has authored numerous high-impact peer-reviewed papers, including over 10 articles published in Nature and Science as a corresponding author, underscoring his pioneering contributions to perovskite solar cell research.

Throughout his distinguished career, Professor Seok has received numerous prestigious awards. In 2017, he was honored with the "Korean Scientist Award" by the Korean government. He received the KyungAhm Prize in 2019 and, most notably, the Rank Prize in 2022 for his groundbreaking achievements in perovskite solar cell development.

His research focuses on functional inorganic-organic hybrid materials and their applications in advanced devices, particularly perovskite solar cells. With his expertise and unwavering commitment to innovation, Professor Seok has firmly established himself as a global leader in energy materials and chemical engineering.

Integrated Engineering for High-Performance Perovskite Solar Cells

Sang Il Seok

Department of Energy and Chemical Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan, Korea, E-mail: seoksi@unist.ac.kr

Perovskite solar cells (PSCs) have progressed from laboratory curiosities to record-breaking photovoltaic devices, with certified power-conversion efficiencies skyrocketing from 3.8 % in 2009 to beyond 26 % in just over a decade. This extraordinary rise is rooted in a nuanced interplay of crystal chemistry, defect physics, and interfacial energetics. Our group has pioneered solvent-engineering protocols—coupling anti-solvent droplet deposition with tailored alkyl-ammonium chloride additives—to produce dense, pinhole-free formamidinium lead tri-iodide (FAPbI3) films while stabilizing the optically active α-phase. We further developed SnO2-based electron-transporting layers and low-temperature hybrid TiO2/SnO2 colloids that simultaneously suppress electronic defects, accelerate electron extraction, and preserve substrate flexibility. Precise energy-level alignment at the buried junction quenches nonradiative recombination, extends photovoltage, and yields long-term operational lifetimes under continuous one-sun illumination. Most recently, we revealed how side-reaction by-products such as methylformamidinium (MFA^+) modulate phase stability and defect distributions, offering an additional lever for fine-tuning device performance. This presentation will highlight these advances and provide an integrated perspective on how materials synthesis, interface engineering, and device design continue to push the efficiency and stability frontiers of PSCs.

Hakan Doğu - *(Alagan Partners, Türkiye)*

Born in Bursa, Turkey, Hakan Doğu holds dual Turkish and French nationality. He earned his degree in Materials and Metallurgical Engineering from Istanbul Technical University and began his career at Valeo Group, where he held a range of key positions in Purchasing, Sales, and Business Development. He eventually served as Managing Director of Valeo's Transmission Business Unit. He later joined the Renault-Nissan-Mitsubishi Alliance, taking on critical global leadership roles, including Head of Powertrain Purchasing, Global Managing Director of After Sales for the Alliance, and Global Senior Vice President of After Sales for Renault Group. He was also a member of the Renault Group Management Committee and served as CEO of Renault in Turkey — the brand's second-largest market — leading strategic transformation initiatives and market expansion.

With deep expertise in general management, mobility services (MaaS, CaaS), electric vehicles, supply chain optimization, the automotive supplier industry, after-sales operations, and marketing, Hakan Doğu is widely recognized as the highest-ranking Turkish-born executive within a global automotive manufacturer.

He has lived and worked extensively in France and has completed long-term international assignments in Japan, China, and India, giving him a truly global leadership perspective.

Currently, Hakan Doğu continues to contribute to the future of mobility through various strategic roles:

• Founding Partner at Alagan.tech Solutions, a company developing holistic solutions for next-generation mobility challenges

• Angel Investor in clean-tech startups

• Senior Expert at Roland Berger, providing high-level consulting in the automotive and mobility sectors

• Founder and Chairman of the Sustainable Mobility Initiative (smi.social), advocating for environmentally conscious transportation strategies

• Advisor and Board Member to multiple companies and organizations

He currently resides between Istanbul and Paris and is an active thought leader and influencer on platforms like LinkedIn and X (Twitter), where he shares insights on the future of the automotive and mobility industries.

EcoMat Researcher Award Winners

EcoMat Mid-career Researcher Award

Feng Gao is a full professor and head of the Optoelectronics Unit at Linköping University in Sweden since 2020. He has been appointed as a Wallenberg Scholar since 2024. His group focuses on emerging semiconductors for next-generation optoelectronic devices. He obtained his Ph.D. degree (2011) from the University of Cambridge, M.S. (2007) and B.S. (2004) degrees from Nanjing University. He received from the European Research Council (ERC) an ERC Consolidator Grant (2021) and an ERC Starting Grant (2016). He became a Swedish Foundation for Strategic Research (SSF) Future Research Leader in 2019 and a Wallenberg Academy Fellow in 2017. He received the Tage Erlander Prize in Physics (2020) and the Göran Gustafsson Prize in Physics (2025), both awarded by the Royal Swedish Academy of Sciences.

This award lecturer will be scheduled at 15:00 – 15:45, July 31st.

Towards Sustainable Perovskite Photovoltaics

Feng Gao
Department of Physics, Chemistry, and Biology, Linköping University
*feng.gao@liu.se

Perovskite solar cells have reached high power conversion efficiencies over 26%, with the stability also significantly improved during the past few years. As such, the industry is now actively considering the commercialization of this emerging photovoltaic technology. Learning from commercial silicon photovoltaics, we understand that circular photovoltaics with efficient recycling is mandatory for commercialized photovoltaics to manage accumulated solar module waste. We have developed a low-cost, green solvent-based holistic recycling strategy to recover all valuable components from perovskite photovoltaic waste. After repeated degradation-recycling processes, the recycled devices exhibit similar efficiency and stability compared to fresh devices. With recycling, the levelized cost of electricity also decreases for both utility-scale and residential systems. We highlight the unique opportunities of perovskite photovoltaics for holistic recycling which paves the way for a sustainable perovskite solar economy.

EcoMat Young Researcher Award

Yifei Yuan is currently a professor at Wenzhou University (China), prior to which he was a research assistant professor at the University of Illinois (Chicago), jointly with Argonne National Laboratory (USA). He obtained his Ph.D. from Michigan Technological University (USA). Yuan conducts research on fundamental studies of electrochemical energy storage materials. He investigates local atomic and nanometric structure-property correlations to elucidate design principles for advanced energy materials by rational syntheses, advanced characterization, and integration of material engineering strategies. He has led publications appearing in journals like Nat. Energy, Nat. Sustain. and Nat. Commun., etc., with an *H*-index 78. He was one of the Innovators Under 35 (Asia Pacific, 2021) selected by《MIT Technology Review》, and one of the Rising Stars (2024) selected by the journal《Small》.

This award lecturer will be scheduled at 15:45 – 16:30, July 31st.

Sustainable Energy Storage Within Octahedral Molecule Sieves

Yifei Yuan[1],
1. Wenzhou University

Tunnel-structured manganese dioxides (MnO2), also known as octahedral molecule sieves (OMS), are widely studied in geochemistry, deionization, energy storage and (electro)catalysis. These functionalities originate from their characteristic sub-nanoscale tunnel framework, which, with a high degree of structural polymorphism and rich surface chemistry, can reversibly absorb and transport various ions.An intensive understanding of their structure–property relationship is prerequisite for functionality optimization, which has been recently approached by implementation of advanced (in situ) characterizations providing significant atomistic sciences.

This presentation will thus timely cover recent advancements related to OMS and their energy storage applications [1-3], with a focus on the atomistic insights pioneered by researchers including our team: the origins of structural polymorphism and heterogeneity, the evolution of faceted OMS crystals and its effect on electrocatalysis, the ion transport/storage properties and their implication for processing OMS.

These studies represent a clear rational behind recent endeavors investigating the historically applied OMS materials.

The summary is expected to deepen the scientific understandings and guide material engineering for functionality control.

Keywords: manganese dioxides; energy storage; microstructure

EcoMat Editorial Board

Editor-in-Chief

Zijian Zheng

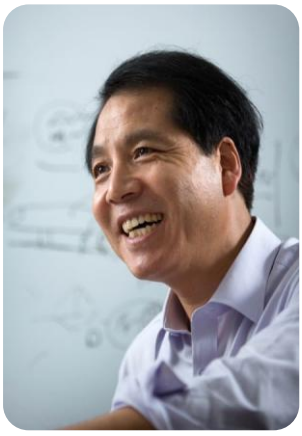
The Hong Kong Polytechnic University, Hong Kong, China

Zijian Zheng is currently Chair Professor of Soft Materials and Devices at the Department of Applied Biology and Chemical Technology at The Hong Kong Polytechnic University. He received his B. Eng. in Chemical Engineering at Tsinghua University in 2003, and PhD in Chemistry at University of Cambridge in 2007 (Supervisor: Prof. Wilhelm T. S. Huck). In 2008, he worked as postdoctoral researcher with Prof. Chad A. Mirkin at Northwestern University. He joined ITC as Assistant Professor in 2009 and was promoted to tenured Associate Professor in 2013 and then Professor in 2017. He serves as Guest Editor for Advanced Materials and Small. He is Founding Member of The Young Academy of Sciences of Hong Kong. His research interests are surface and polymer science, nanolithography, flexible and wearable materials and devices.

Associate Editors

Sang Il Seok

Ulsan National Institute of Science and Technology, Ulsan, South Korea



Sang Il Seok is currently a Distinguished Professor at the School of Energy and Chemical Engineering, Ulsan National Institute of Science and Technology (UNIST), Korea. Before he joined UNIST in 2015, he served on the principle investigator of Korea Research Institute of Chemical Technology, and Professor at Department of Energy Science, Sungkyunkwan University. In 2017, he was appointed as guest professor of Nankai University in China. He obtained his Ph.D. degree at Department of Inorganic Materials Engineering of Seoul National University, Korea. He experienced a post-doc to investigate defects and transport in Fe-Ti-O Spinel structure in Cornell University, USA, and visiting scholar in University of Surrey, UK, in 2003, and École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, in 2006 respectively. He published around 200 peer-reviewed papers including Nature, Science etc. with several awards for his Excellency. He is the recipient of "Korean Scientist Award" from the Korean government in 2017. His research focus is based on inorganic-organic hybrid solar cells, in particular perovskite solar cells.

Ben Xu
Northumbria University, United Kingdom

Dr. Ben B Xu is a full professor in materials and mechanics with a multi-disciplinary research interest covering soft matter, smart surface, functional materials, energy materials, applied mechanics, micro-engineering, flexible/wearable electronics, sustainable engineering and technologies. Ben obtained his PhD in *Mechanical* Engineering at Heriot-watt University (Scotland) in 2011 and subsequently worked as a postdoc researcher at University of Massachusetts Amherst (2011-2013).

Ben is a vice chair for division of 'composites' in AICHE (US) and chairing the Materials Characterisation&Properties Group in the Institute of Materials, Mining and Minerals (IoM^3). He has published 7 patents, 7 book(incl. chapters) and over 190 peer-reviewed articles in the leading journals (*h*-index 39). Ben is also an associate editor for *Advanced Composites and Hybrid Materials* (*SpringerNature*) and Advanced Devices and Instrument (AAAS). He is a named expert in **COVID-19 action database** acknowledged by UK Parliament, with his work of 'Masks for COVID-19' archived in the **WHO Covid-19 literature database**. Ben is an elected Fellow of the Royal Society of Chemistry (FRSC), Fellow of the Indian Chemical Society (FISC), Fellow of the Institute of Materials, Mining and Minerals (FIMMM), Fellow of the Royal Society for the Encouragement of Arts, Manufactures and Commerce (FRSA), a chartered scientist and a chartered engineer.

Guihua Yu

The University of Texas at Austin, USA

Dr. Guihua Yu is a Temple Foundation Professor of Materials Science and Mechanical Engineering at The University of Texas at Austin. His research has broadly centered on nanomaterials innovation for advanced energy, environment, and sustainability technologies. Yu is a Fellow of MRS, RSC, IOP, and IAAM, and has been consistently ranked among one of the Top Highly Cited Researchers in both Materials Science and Chemistry fields by Web of Science. He has received many prestigious international/national awards and honors for research and education, including Blavatnik National Awards Honoree, RSC Horizon Prize, Norman Hackerman Award in Chemical Research by The Welch Foundation, Edith and Peter O'Donnell Award by Texas Academy of Medicine, Engineering and Science (TAMEST), TMS Brimacombe Medalist Award, Polymer International-IUPAC Award for Creativity in Applied Polymer Science, Camille Dreyfus Teacher-Scholar Award, Sloan Research Fellow, MIT Technology Review 'Top Innovators Under 35' global list.

Qiang Zhang

Tsinghua University, Beijing, China

Qiang Zhang is a full professor at Tsinghua University. He obtained his Ph.D. in chemical engineering (2009) from Tsinghua University, China, and subsequently held Research Associate/Postdoc Research Fellow positions in the Case Western Reserve University, USA, and Fritz Haber Institute of the Max Planck Society, Germany. He held the Newton Advanced Fellowship from Royal Society, UK and the National Science Fund for Distinguished Young Scholars. He is selected as highly cited researchers at 2017, 2018, and 2019 by Clarivate Analytics. His current research interests are advanced energy materials, including dendrite-free lithium metal anode, lithium sulfur batteries, and electrocatalysis, especially the structure design and full demonstration of advanced energy materials in working devices. The very recent progress on the Li metal protection is quite effective and have potentials for next-generation high-energy-density batteries.

Huijun Zhao

Griffith University, Southport, Australia

Huijun Zhao is the founding Director of the Centre for Clean Environment and Energy, Griffith University, Australia. He obtained his Ph.D. in Chemistry (1994) from the University of Wollongong, Australia, and subsequently held Research Fellow/Senior Research Fellow positions in the University of Wollongong and University of Western Sydney (1994-1997). He took a Lecturer position at Griffith University in late 1997 and was promoted to Senior Lecturer (2001), A/Professor (2003), Chair Professor of Chemistry (2005) and Chair of Griffith Commercialization Laboratory (2005). He is the Fellow of the Royal Society of Chemistry (FRSC) and the Fellow of the Royal Australian Chemical Institute (FRACI), and the recipient of The R.H. Stokes Medal for electrochemistry. He has expertise in energy and environmental nanomaterials, water source control and management system, field-based sensing technologies and aquatic environmental quality assessment. One of his current pursuits is to explore new means to unlock the catalytic powers of nonprecious materials as high performance catalysts for important catalysis reactions. He has published over 430 refereed journal papers and gained 68 international patents within 8 world-wide patent families in functional nanomaterials and photoelectrocatalysis for which all have been successfully commercialized.

EcoMat Conference 2025

Materials & Technologies for Sustainable Future

KEYNOTE SPEAKERS

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THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Designing Functional Membranes for Integrated Boron Removal and Desalination

Ş. Birgül Tantekin-Ersolmaz

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Polyamide-based thin film composite (TFC) membranes remain the gold standard in the desalination industry, while intensive research efforts are currently devoted to exceeding their inherent limitations. One such limitation is their inadequacy to remove trace solutes, including boron species. Boron levels are particularly high in the Mediterranean Sea, making irrigation a challenge for growing vital crops such as citrus fruits and nuts. This picture recently motivated us to explore the possibility of designing membranes for simultaneous boron removal and desalination. While most existing efforts aiming efficient boron removal rely on surface modification of conventional TFC membranes, my research group evaluated different thin film nanocomposite (TFN) membrane designs considering their potential for achieving improved water flux and fouling resistance. However, this requires carefully selecting the type, functional group profile, and loading ratio of the nanomaterials alongside optimizing interfacial polymerization and post-treatment protocols. This presentation introduces our progress in embedding functionalized carbon nanotubes (CNTs) into polyamide-based reverse osmosis membranes for improving boron and salt rejections and water flux. In our parameter space, the dispersion homogeneity and geometrical alignment of CNTs inside the polymeric matrix stood out, in addition to more common parameters such as the thickness and crosslinking ratio of the selective layer. And full-atomistic molecular dynamics simulations helped us understand the impact of tip-functionalized CNTs on boron rejection further.

Sustainable Materials: Discovering the New Face of Innovation

Hüseyin Güler
Kastamonu Entegre

In a world grappling with ecological and societal challenges, true innovation transcends novelty—it carries purpose. Circular and bio-based approaches in material science are reshaping how sustainability and innovation are understood and practiced.
Key case studies from Kastamonu Entegre illustrate this transformative journey:

- **CoffeeBoard**: Transforms office coffee waste into a high-value material. More than just upcycling, CoffeeBoard exemplifies a collaborative startup model that fosters social value within the circular economy.
- **HempBoard**: Utilizes industrial hemp's woody residues—typically considered waste—to create a renewable board material, sustainably harvested multiple times per year.
- **PureBoard**: Employs bio-based adhesives instead of fossil-derived chemicals while achieving fully recyclable product. PureBoard's design philosophy minimizes carbon footprint while promoting healthier living spaces.

These innovations demonstrate how sustainable materials can do more than reduce environmental impact—they can spark new forms of collaboration, enable regenerative thinking, and help redefine industrial value creation through eco-design principles.

A Future Shaped by Glass

Başak Dik

Gürok Group

GCA approaches sustainability not merely as an environmental responsibility but as a fundamental part of its business conduct, aiming to generate comprehensive value for the environment, society, and the economy by leveraging the infinite recyclability of glass.

The company's sustainability strategy spans multiple dimensions, including energy management, circular economy practices, resource efficiency, equal opportunity, and social impact. With the commissioning of a regenerative furnace in 2021 and the ongoing construction of a 50 MW solar power plant launched in 2024, GCA has significantly reduced both energy consumption and carbon emissions. The company is committed to becoming carbon neutral by 2050 and aims to increase the share of recycled glass in its production to 35% by the end of 2030.

As part of its commitment to the circular economy, GCA launched the EKOMAT Project, which enabled the recovery of 2.3 million units of glass packaging waste within a period of one and a half years. This success was recognized with the 2024 ÇEVKO Green Dot Incentive Award. As a member of the European Container Glass Federation (FEVE), GCA actively contributes to the sector-wide goal of reaching a 90% glass recycling rate across Europe, while also supporting the development of recycling infrastructure in Türkiye. Through lightweight packaging design and dedicated R&D efforts, the company continues to enhance resource efficiency without compromising product durability. Environmental compliance and regulatory alignment remain top priorities across all operations.

GCA also places strong emphasis on social sustainability. With women now comprising 30.56% of leadership positions, the company fosters an inclusive corporate culture. Social impact projects include environmental education programs for children and nature-based solutions that support both biodiversity and women's employment.

In 2024, GCA solidified its leadership with notable national and international achievements, including design and quality awards. Centered on the transformative potential of glass, GCA's holistic approach highlights its ongoing contribution to environmental, social, and economic progress

Bulk and Interface Regulation of Triple-Cation Perovskite Solar Cells

Junliang Yang

Central South University

Perovskite solar cells (PSCs), as a new generation of thin-film solar cells, possess many advantages, including high efficiency, low cost, tunable bandgap, and the capability for flexible and tandem fabrication, which becomes one of the most promising photovoltaic technologies for future applications.

In our group, a strategy of introducing N-chlorosuccinimide (NCS) into the SnO2 precursor solution is proposed to achieve multifunctional interface regulation. The devices with NCS modification improves the efficiency from 22.42% to 24.74%[1]. Then, the strategy uses a molecular additive, N-acetyl-L-phenylalanine to improve perovskite film quality by delaying crystallization and suppressing impurities, which leads to high-efficiency PSCs with an efficiency of 25.05%[2]. Furthermore, a post-treatment strategy of surface micro-etching and reconstruction of perovskite is developed to employ a precise stoichiometric mixture of L-lactic acid (LA) and isopropanol (IPA) (LA/IPA) to dissolve the perovskite surface, which reacts with octyl iodide amine (OAI) to form 2D perovskite and construct a quasi-three dimensional (3D) structural interface to regulate the residual stress on the perovskite film surface (Fig. 1a). Based on this strategy, the device achieved an efficiency of 25.54%, which is one of the highest efficiency for triple-cation (FAMACs) PSCs (Fig.1b), and the mini-module (10.4 cm2) exhibits an efficiency of 21.02% (Fig.1c).References1. Ding Y, Feng X, Chang J, Li H, Long C, Gao Y, Lu Y, Yang J. Small, 2024, 20(26): 2308836.2. Ding Y, Lu S, Chang J, Feng E, Li H, Long C, Yang Y, Yi C, Zheng Z, Ding L, Yang J. Small, 2024, 21(3): 2410601.3. Ding Y, Feng E, Lu S, Chang J, Long C, Tong S, Li H, Yang J. Energy & Environmental Science, 2024, 17(23):9268-92

Keywords: Perovskite solar cells; bulk; interface.

Functional Composites with Actuation Functionalities

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Functional nanocomposites play a critical role in the development of high-performance soft actuators and sensors which are attractive for soft electronics, soft robotics and wearables. This talk focuses on our design strategies, synthetic approaches and device mechanism in realizing functional electronic and ionic composites inspired by natural organisms.
These soft and flexible materials and devices can be triggered by different stimuli such as light and electricity and deliver responsive and active functionalities. Interlayer spaces of 2D MXenes are ideal nanoreactors for introducing functionalization and facilitate nanofiller interactions.
These interlayer galleries also allow spaces for co-insertion/desertion of ions during applied potential, leading to high in-plane sliding of MXene sheets for bending actuator. In addition, incorporation of conductive fillers like liquid metal into elastomer forms nanocomposite suitable for dielectric elastomer actuators.Furthermore, we explore electrochemically triggered actuation in nanocomposite electrodes based on ions intercalation and volumetric changes.
The effect will be illustrated with ionic liquid based ternary electrodes for high performance ionic actuation with high stability and low-voltage operation, promising for applications in smart grippers, bioinspired robotics, and human-machine interface.

Keywords: Actuator, mechanical energy conversion, electrochemical

Advancing Wearable Technologies with Fiber-Based Nanogenerators

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Bilkent University

The rapid growth of wearable technologies drives demand for real-time, self-sustained tracking of human activity and physiological signals. Flexible piezoelectric and triboelectric nanogenerators offer a compelling solution by serving as self-powered sensors that function without external power supplies. These devices also enable energy harvesting from everyday human motion, presenting a viable alternative energy source for low-power electronics. Among them, fiber-shaped nanogenerators stand out due to their inherent flexibility, stretchability, and compatibility with textile manufacturing, allowing direct integration into wearable fabrics. In this talk, I will introduce the development of fiber-based triboelectric and piezoelectric nanogenerators from our research activities, highlighting their dual role as both self-powered sensors and energy harvesters. By integrating low-dimensional nanomaterials into thermally drawn fibers, the sensing and energy conversion performances of nanogenerators are significantly enhanced. These smart fibers demonstrate promising capabilities for tracking physical human activities and vital signs such as heart rate, respiration, and blood pressure. Furthermore, their ability to convert mechanical energy into electricity opens pathways for powering small-scale electronics, such as digital watches or calculators, without the need for traditional batteries.

Keywords: Nanogenerators, Fibers, Triboelectricity, Piezoelectricity

Photocatalytic Hydrogen Evolution: From Natural Scaffolds to Hybrid Materials

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1. Selcuk University

Photocatalytic hydrogen evolution has emerged as a promising route toward clean and sustainable energy generation by converting solar energy into hydrogen fuel through semiconductor-driven water splitting. To overcome the key limitations of traditional photocatalysts—such as poor visible light absorption, rapid charge recombination, and the use of rare or toxic materials—extensive research has focused on designing innovative and efficient material systems. These include natural clay-based scaffolds, heterostructure engineering, interfacial catalysis, and the integration of earth-abundant elements. Natural materials like sepiolite and Laponite D clays have served as effective supports for active species such as molybdenum disulfide, enabling improved surface reactivity and solar-to-hydrogen conversion efficiencies. Likewise, hybrid systems combining graphitic carbon nitride, black phosphorus, and MoS_2—further enhanced with transition metal co-catalysts like Ni and Co—have demonstrated superior light utilization and charge separation properties.Complementary strategies have explored shape-controlled multinary sulfide nanostructures, thermally exfoliated graphene-based composites, and kesterite-type chalcogenide nanofibers, all designed to optimize catalytic performance while maintaining scalability and sustainability. Furthermore, soft interface systems—particularly those operating at liquid-liquid boundaries—have proven effective for facilitating charge transport and enhancing reaction kinetics, utilizing materials such as Cu, NiO, Co_3O_4, and WS_2. The inclusion of NIR-responsive black phosphorus composites has expanded photocatalytic activity into the infrared region, allowing for more complete solar spectrum harvesting. Collectively, these studies present a holistic and evolving approach to photocatalyst development, integrating structural innovation, material functionality, and interfacial design to advance the field toward practical solar hydrogen production.

Keywords: Photocatalytic hydrogen evolution Sustainable energy Heterostructure photocatalysts

Application of Plant-derived Photosensitizers in Photobiology

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Photosensitizers are versatile molecules that absorb light and convert it to a different form of energy, which made them indispensable in numerousscientific fields including photochemistry,dye-sensitized solar cells,andbiomedicine.For examples, photodynamic therapy (PDT) has been explored for use in treating cancer and pathogenic microorganisms using photosensitizers.Underlight irradiation, the photosensitizer absorbs photons and is excited to the excitedsinglet state, and then reaches the excitedtriplet state by an intersystem crossing.Thetriplet state photosensitizers interact with oxygen to form reactive oxygen species (ROS) through either electron transfer (Type I) or energy transfer (Type II). ROS are highly oxidized and can interact with nucleic acids and proteins in cells to induce apoptosis.

Plant-derived photosensitizers have been receiving considerable attention in PDT due to their good biocompatibility and high ROS generation. However, plant-derived photosensitizers still have some shortcomings including poor water solubility and week absorption in the PDT window (600–900 nm). Recently, we have developed a series of photosensitizers based on curcumin/hypocrellin through chemical modification or supramolecular assembly for photodynamic/photothermal synergistic treatment of tumors, photodynamic antibacterial therapy, etc.

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These studies will provide effective strategies for the rational design of efficient photosensitizers for clinical use.

Keywords: photosensitizers, photodynamic therapy, curcumin, hypocrellin

The Development of Chinese Society for Imaging Science and Technology (CSIST) in the Field of Photocatalysis

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The Chinese Society for Imaging Science and Technology (CSIST) is an academic organization formed by professionals in photochemistry and imaging technology. As a component of the China Association for Science and Technology, CSIST is an important force in promoting the development of photochemistry and imaging science in China. CSIST not only promotes the popularization and application of photochemistry and imaging science, but also facilitates the growth and improvement of photochemistry and imaging technology professionals.The Professional Committee on Photocatalysis of CSIST was established on September 24, 2012. The Photocatalysis Committee has organized and established various high-level, specialized, and international industry platforms and activities within the field. For example, the committee's International Forum of 100 Scholars in Photocatalysis and the biennial Photocatalysis Forum for Mid-Career Scholars have become highly influential academic conferences in the field. In addition, the committee has prioritized the development of a comprehensive photocatalysis standard system as a key focus. From its inception, it has led the drafting of numerous national, industry, and group standards, and has successfully organized the completion of China's first ISO international standard in photocatalysis, making significant contributions to the development of China's photocatalysis standard system.

Keywords: photocatalysis, imaging technology, imaging science

Electrode and Electrolyte Engineering Towards Efficient Energy Storage

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Aqueous zinc-ion batteries have gained significant attention as promising candidates for next-generation large-scale energy storage due to their high safety, environmental friendliness, and cost-effectiveness. However, the performance of Zn anodes is hindered by several challenges, including uncontrolled dendrite growth, slow deposition kinetics, and chemical corrosion associated with hydrogen evolution reactions, which severely limit their cycling stability. This presentation will highlight our recent efforts to enhance the efficiency and stability of energy storage and conversion through electrode-electrolyte interface engineering. Key strategies include the fabrication of cetyltrimethylammonium functionalized carbon nanotube hosts, electrolyte engineering via anion regulation, the introduction of aprotic solvents, and the development of artificial solid electrode interphases using materials such as nano-diamond, amorphous zinc pyrophosphate, natural cellulose, and boehmite.

Keywords: Aqueous zinc-ion batteries

Dynamic Lithium Transport within İndividual Lithium Battery Particles

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Seoul National University

Understanding lithium transport within battery particles is critical for advancing secondary battery performance. Under applied external voltage, lithium ions from the electrolyte undergo a charge transfer process at the particle-electrolyte interface, where they pair with electrons from the current collector and insert together into electrode particles. Once charge-neutral lithium enters the particle, it fills vacancies through solid-state diffusion. Utilizing real-time X-ray microscopy techniques, we visualized lithium insertion and diffusion within individual particles. This study provides two key insights: first, it elucidates how liquid electrolytes influence charge transfer kinetics and alter lithium insertion pathways; second, it successfully captures lithium diffusion within the solid phase. Notably, lithium diffusion is modulated by factors beyond concentration gradients, including strain/stress, mixing enthalpy, and interfacial energy. Our findings reveal how these factors, particularly chemical potential gradients, govern lithium transport dynamics within NMC and LFP particles.

Keywords: Batteries, Energy Storage

Electronic-integrated Textiles Towards Wearable Applications

Qiyao Huang

The Hong Kong Polytechnic University

The integration of functional electronics into wearable systems has unlocked transformative applications in healthcare monitoring, therapy, and human-machine interactions. While thin-film-based flexible electronics have achieved remarkable progress in performance and integration, critical challenges remain in achieving biocompatibility, permeability, and long-term wearability, which are highly essential for practical adoption in wearable and on-skin electronic applications. Textile-based electronics, leveraging fibers, yarns, and fabrics as fundamental building blocks, offer a promising solution by combining intrinsic softness, breathability, and diverse structural designs with advanced electronic functionalities. This presentation will highlight our multidisciplinary efforts to bridge textile engineering and flexible electronics, focusing on the fabrication of electrical and ionic conductive fibers, as well as their application as building blocks in various types of textile devices.

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Nanoparticle and Implantable 3D-Printed Scaffold-Based Approaches for Enhanced Cancer Treatment via Radiotherapy

Yavuz Nuri Ertaş

Erciyes University

Radiotherapy is a common cancer treatment in medical practice that utilizes high-energy X-rays to administer radiation doses to cancerous tissues. However, the therapeutic use of radiotherapy is constrained by its low radiosensitivity, inaccurate tumor localization and poor differentiation between lesions, and the adverse effects of irradiation in healthy tissues. Hence, it is crucial to develop methods to enhance the radiosensitivity of malignancies while reducing their systemic side effects. Combining nanotechnology with radiation improves therapeutic results. Using high-atomic-number (high-Z) nanoparticles as radiosensitizers can greatly enhance the effectiveness of breast cancer treatment when exposed to X-ray radiation, as evidenced by studies evaluating cell viability, proliferation, reactive oxygen species production, and in vivo antitumor effects. Implementation of chemotherapy along with radiotherapy, known as synchronous chemoradiotherapy, can further augment the treatment efficacy. Tumor-targeted and anticancer drug-loaded nanoparticles will be discussed within this concept. Finally, this talk will focus on improving local cancer therapy via surgical implantation of 3D-printed nanoparticle-containing scaffolds to address the chronic problem of metastasis after surgical removal of tumors. Biocompatible and biodegradable scaffolds may potentially lower the recurrence and metastasis rates in breast cancer patients by inhibiting residual tumor cells following post-surgery, as well as exhibit anticancer properties in other solid tumors.

Scalable and Sustainable Triboelectric Nanogenerators for Wearable and Environmental Energy Harvesting

Husnu Emrah Unalan
Middle East Technical University

Triboelectric nanogenerators (TENGs) have gained significant attention as sustainable power sources for wearable electronics, human–machine interfaces, and ambient energy harvesting. Our recent work has focused on scalable and practical TENG architectures tailored for real-world applications. We demonstrated fabric-based TENGs using silver nanowire-modified cotton laminated with thermoplastic polyurethane (TPU), combining washability, Joule heating, and energy harvesting for human–machine interfacing [1]. We also developed coaxially wet-spun core–shell fibers incorporating carbon black, Ag nanowires, and TPU, offering stretchability and integration into IoT-enabled textiles [2]. In another effort, we optimized Ag nanowire networks as transparent electrodes for droplet-driven TENG sensors, enabling self-powered pH and chemical concentration sensing with integrated heater functions [3]. Moreover, we introduced buoy-based TENGs for blue energy harvesting, achieving stable performance under simulated ocean waves with a power output up to 1.1 W/m² [4].Building upon these advances, we now present a compact, modular TENG operating in free-standing mode, designed to convert linear mechanical motion into electrical energy. The system features oscillating PTFE marbles in narrow 3D-printed PLA channels interacting with aluminium electrodes. Among seven thermoplastic candidates, PLA—a biodegradable polymer—demonstrated the highest output, aligning with our materials sustainability goals. Parametric studies on electrode separation, marble count, and substrate thickness revealed key design-performance trade-offs. The system achieved 110 V open-circuit voltage and 100 μW peak power with 32 vertically stacked units. A Scotch Yoke mechanism simulated bio-relevant frequencies (0.7–2.5 Hz), confirming linear performance scaling.Altogether, this work bridges material sustainability, device modularity, and real-world performance—extending TENG applications across wearables, autonomous sensing, and marine systems.

Keywords: nanogenerators; flexible electronics, wearables

Light Generation by Mechanical Excitation

Feng Wang

City University of Hong Kong

Mechanical energy that is ubiquitously available in nature can provide sustainable solutions to challenging problems in the fields of biology and optoelectronics as well as energy and environmental sciences. In this talk, I focus on our recent efforts to incorporate lanthanide and transition ions into nano/microstructure crystals for achieving tunable emissions under different types of excitations, such as X-ray, ultraviolet/near-infrared photons, and especially mechanical action. We demonstrate rational control over luminescence processes and properties by leveraging characteristics of the host materials and their complex yet manageable interactions with various dopant ions. We show that these doped mechanoluminescent materials hold promise in many exciting applications in sensing, information security, and biomedical sciences.

Keywords: Luminescence; Lanthanide; Energy

From Process to Product: The Green credentials of Galvanized Steel

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General Galvanizers Association

Galvanized steel stands at the intersection of performance and sustainability, offering robust corrosion protection while aligning with global environmental goals. This paper explores the green credentials of galvanized steel across its entire lifecycle — from production processes to end-use applications and recyclability. Through comparative environmental impact analyses and case studies, the paper highlights how galvanized steel supports carbon footprint reduction, enhances the durability of structure, and minimizes maintenance needs. As industries strive for greener solutions, galvanized steel emerges not only as a durable choice but as a sustainable one.

Innovative Materials and Current Approaches in Energy Applications

Ali Çırpan

Middle East Technical University

In this study, a series of novel donor–acceptor type organic materials were rationally designed and synthesized by incorporating heavy atoms, such as selenium, into the donor units to enhance spin–orbit coupling (HSO) and improve reverse intersystem crossing (RISC) efficiency in thermally activated delayed fluorescence (TADF) systems. Among these, a pure blue emitter (SeDF-B) demonstrated exceptional performance with external quantum efficiencies (EQE) approaching 26% in OLED devices. Furthermore, for the first time, flexible graphene-based anodes were successfully integrated into TADF-OLEDs, achieving performance comparable to or surpassing that of conventional ITO-based devices.Beyond OLEDs, these newly developed organic materials were also explored as polymeric donor components in organic photovoltaic (OPV) devices. Their structural and optoelectronic properties were tuned to facilitate efficient charge generation and transport. Initial device results revealed promising power conversion efficiencies (PCEs), highlighting the dual functionality of these materials in both light-emitting and energy-harvesting applications. This work presents a comprehensive approach that combines molecular engineering, heavy-atom substitution, and flexible electrode integration to enable next-generation organic electronic devices.

Keywords: Organic solar cells, TADF-OLEDs

Advanced Electrospun-Nanofibrous Structures: From Polymers, Ceramics and Carbon to Biomedical, Energy, Sensory, Environmental, etc. Applications

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Nanofibers are used in many functional applications due to their extremely high surface area, and new application areas are emerging day by day, depending on the properties of the material used. Polymers, ceramics, carbon, and composite structures of these materials can be produced and used in nanofiber form. Electrospinning is one of the most common methods used for the production of nanofibers with desired functional properties. When publications related to nanofibers produced by electrospinning in recent years are examined, it is clearly seen that the studies are carried out by people who are experts in many branches. This reveals that nanofibers produced by electrospinning can be applied in many fields such as biomedical, energy, sensory, environmental, etc. [1-3]. In summary, if we want to obtain nanofibers from a polymer or polymer mixture by electrospinning, the polymer (and the components to be mixed) is first dissolved in a suitable solvent at a certain rate or melted to bring it into a fluid form. Then, this liquid form is continuously flowed through a conductive nozzle, high voltage is applied to this nozzle, and the fluid is extended and ejected to the grounded plate positioned on the opposite side. Finally, the nanofibers are collected on the grounded plate. On ceramic and carbon nanofibers, the polymer nanofibers are transformed into carbon nanofibers by thermal treatment applied after the production of precursor nanofibers or the transformation of ceramic precursor nanofibers into ceramic nanofibers by calcination. In this presentation, the data obtained from the studies that have completed the production of polymer, ceramic and carbon nanofibers by electrospinning will be introduced.

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Scalable fiber-based energy storage for wearable electronics and 3D printing

Tural Khudiyev

National University of Singapore

The rapid advancement of mobile computing, robotics, and wearable electronics has intensified the demand for compact, portable, and adaptable energy storage solutions—particularly those compatible with non-flat, customized form factors. Fibers, as foundational elements in textiles and additive manufacturing, offer unique opportunities for the development of flexible, multidimensional power systems. Their small diameters and high aspect ratios support seamless integration into 1D, 2D, and 3D electronic architectures, but also demand innovative fabrication approaches to achieve the required energy density and scalable lengths for practical use.We introduce a novel energy storage fiber produced via a thermal drawing technique that enables the simultaneous integration of multiple electroactive materials within a protective, flexible cladding. This top-down manufacturing process supports the continuous production of functional battery fibers with arbitrary lengths and tunable material compositions.The resulting fibers exhibit excellent mechanical flexibility, safety, and environmental robustness—including resistance to water, fire, and mechanical stress. These characteristics make them well-suited for integration into wearable fabrics, 3D-printed structures, and other non-planar electronic systems. We demonstrate their application in powering a range of next-generation devices, such as wearable electronics, underwater systems, and wireless communication platforms. This work represents a significant step toward realizing scalable, fiber-based energy storage for pervasive electronics.

Keywords: energy storage fiber

Fully printed carbon-based mesoscopic perovskite solar cells

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Carbon-based mesoporous perovskite solar cells (C-MPSCs) prepared based on a prefabricated three-layer mesoporous films (mesoporous TiO2/mesoporous ZrO2/porous Carbon) by fully printed technology have shown promising application prospects due to their excellent stability and convenient large-area preparation process. However, the power conversion efficiency (PCE) of C-MPSCs isrestricted by the imbalance of carrier transport at the interface between the perovskite film and charge transport layer, as well as the difficulty in controlling the crystal quality of the perovskite film in the three-layer mesoporous films. In response to the key scientific issues mentioned above, we applied organic amine molecules to post-treat the perovskite films/Carbon interface. By in-situ room temperature reaction between organic amine molecules and FA+ at the interface, large-sized organic cations were formed, and an embedded 2D/3D perovskite heterojunction was constructed, thereby optimizing the interface energy level arrangement, improving the interface hole extraction. Finally, C-MPSCs with PCE exceeding 23% were prepared, and the devices exhibited good stability.

Interfaces at Work: Enhancing Perovskite Solar Cells for Both Terrestrial and Space Environments

Erkan Aydin
LMU Munich

Over the past decade, perovskite-based solar cells have seen remarkable advancements in efficiency, with single-junction devices surpassing 27%, all-perovskite tandems exceeding 30%, and perovskite–silicon tandems nearing 35%. Despite these milestones, further gains in both efficiency and stability are essential for real-world applications, including extreme environments such as outer space. Our research aims to systematically enhance the performance of perovskite–silicon tandem solar cells and assess their viability under demanding thermo-mechanical conditions, particularly relevant for space deployment.

Our approach is based on a comprehensive set of material and interface engineering strategies. These include the introduction of dielectric interlayers between perovskite and fullerene to reduce interfacial defect states, optimization of the recombination junction using ultrathin indium zinc oxide electrodes, and the deployment of alternative hole-selective contacts such as conductive polymers, nickel oxide, and self-assembled monolayers. To further address device stability, especially under encapsulated conditions, we investigated the effects of thermomechanical stress and interfacial strength.

Through these targeted strategies, we achieved three certified power conversion efficiency (PCE) records of 32.5%, 33.2%, and 33.7% for perovskite–silicon tandem devices. Our optical and electrical simulations suggest that efficiencies up to 37.8% are realistically attainable. Interface quality was found to play a crucial role not only in achieving high efficiency but also in long-term stability, especially under thermal cycling and encapsulation stress. For space applications, preliminary studies revealed that device degradation is strongly governed by interfacial resilience during rapid thermal fluctuations, highlighting the importance of interface engineering.

Our findings demonstrate that advanced interface and contact engineering are central to achieving high-efficiency, stable perovskite–silicon tandem solar cells. Moreover, the same principles are proving essential in extending these technologies to space applications. By systematically addressing the mechanical and thermal challenges at material interfaces, we open pathways for deploying perovskite-based photovoltaics not only on Earth but also in space environments.

Keywords: perovskite, tandem, stability, interfaces

Smart Composite Hydrogels Based on Nature-made Nanocrystals

Erkan Şenses
Koç University

Cellulose-based nanocrystals (CNCs) have emerged as natural and biorenewable alternatives to ceramic-based nanoparticles due to their ability to conjugate various drug molecules, abundance, biocompatibility, and superior rheological behavior in aqueous media. The electrostatically stabilized CNCs form isotropic and biphasic suspensions in dilute and semi dilute regimes (typically below 5 wt.%); yet the liquid suspensions can transition to aqueous soft gel state upon addition of various salts, surfactants, and polymers. The resulting composite hydrogels are usually 'passive' in the sense that they do not strongly respond to environmental stimuli, such as pH, temperature, and light, limiting their applications as smart materials often demanded for targeted drug delivery. In our work, we incorporated stimuli-responsive moieties for the purpose of developing active composite hydrogels that can display the outstanding features of CNCs while dynamically and reversibly changing their mechanical properties.

We use poly(ethylene oxide)–poly(propylene oxide)–poly(ethylene oxide) (PEO-PPO-PEO) triblock copolymers, specifically Pluronic F127 and Pluronic L121, which exhibit unimer-to-micelle and unimer-to-polymersome transitions, respectively.1,2 I will explain the phase behavior, morphology, and rheological properties of the resulting complex fluids as the block-copolymers self-assemble upon heating.

The results showed that the close-packed micelle network is disturbed by CNC addition at moderate concentrations (up to 3%), making the stiff and fragile F127 gels much softer and more flexible. Higher CNC concentration allows recovery of the linear elastic moduli without sacrificing flexibility. The composite gels also show exceptional fluidization at high shear rates and immediate recovery after shear near the body temperature.

These injectable composite hydrogels are promising for developing novel responsive materials based on nature-made nanocrystals.

Keywords: smart hydrogels, nanocellulose, rheology

Mitigation of Static Electricity on Polymer Materials

Bilge Baytekin
Bilkent University

One of the few scientific problems that has persisted for millennia is the mechanism by which static electricity is generated upon the rubbing or contact of insulator surfaces. In addition to being a scientific conundrum, static charging (tribocharging) of insulators is a significant issue that is particularly important for several industries, including polymers, pharmaceuticals, electronics, and space. There are several feasible tribocharge mitigation techniques, but none of them can match the effectiveness of those employing light.

In this presentation, I will discuss how to mitigate triboelectric charges on common polymers using light. In the presence of an organic dye mediator, the tribocharged polymers are discharged when exposed to light of the proper wavelength.

Through a mechanism involving the photoexcitation of organic dyes, our approach offers temporal and spatial control over the mitigation of static charges on typical polymer surfaces, providing an extra "wavelength" control.

This method can be developed to prevent energy and economic losses in the production of polymer and plastic materials.

Keywords: tribocharging, static electricity, polymers, plastics

Robotic Human Augmentation: Personalized Assistive and Rehabilitative Technologies

Elif Hocaoğlu

Living Robotics Laboratory, Istanbul Medipol University, Research Institute for Health Sciences and Technologies

Robots are transforming medicine, not only by replicating lost human functions, but also by enabling individuals to accomplish tasks once deemed difficult or impossible. Among the most impactful applications is the development of advanced prosthetic systems that enhance the quality of life for individuals with limb loss. Central to this progress is the creation of intuitive, natural control interfaces that mimic the biomechanical and sensory capabilities of the human hand. The challenge lies in translating these complex characteristics into responsive, electromechanical systems that feel both capable and human-like.

In parallel, robotic rehabilitation technologies are redefining recovery pathways for patients with neuromuscular and neurological conditions, such as stroke, Parkinson's disease, and multiple sclerosis. Intelligent, task-specific robots provide adaptive therapy that not only increases repetition and precision but also tracks recovery metrics. Recent advancements have extended these systems into the home, enabling independent, self-guided therapy, particularly critical for aging populations with limited access to regular clinical care.

This keynote explores the current frontiers in human augmentation and the design of robotic systems that bridge gaps between engineering and human recovery. A particular emphasis will be placed on human-machine interface enhancement, where sensory feedback plays a transformative role. Multimodal feedback, especially visual and haptic channels, enriches user interaction. Among these, innocuous painful stimulation emerges as a novel modality, offering a powerful means to restore tactile awareness between amputees and their prosthetic limbs.

By investigating how best to reflect physical interactions back to the user, we aim to close the sensory loop and foster a more natural, embodied experience. Through case studies of system design, implementation, and experimental validation, this talk outlines both the challenges and breakthroughs shaping the next generation of assistive and rehabilitative robotics.

Recent Advances in Hydrogen Generation from the Catalytic Hydrolysis of Ammonia Borane

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Because of depletion of fossil energy reserves and global warming there is an urgent demand for replacing the fossil fuels with renewable energy sources on the way towards a sustainable energy future. As a green energy carrier hydrogen is anticipated to play a vital role in such a transition. However, there exist impediments in using H_2 as energy carrier arising from the difficulty of its safe and efficient storage. Solid hydrogen storage materials have been vigorously developed for safe and compact storage of hydrogen. Ammonia borane is one of the most promising solid hydrogen storage materials which can release hydrogen through hydrolysis in the presence of suitable catalysts at ambient conditions. Noble metals are much more active catalysts than the non-noble metals in releasing H_2 from the hydrolysis of ammonia borane. However, the high price of precious noble metals hampers their large-scale applications in this catalysis. Therefore, an immense challenge is the further enhancement of the overall utilization efficiency of precious metals with the goal of lowering the cost of noble metal catalyst as much as possible. The following issues need to be considered for achieving a perceivable improvement in total efficiency of noble metal nanocatalysts in hydrolytic dehydrogenation of ammonia borane: (i) obtaining the highest catalytic activity by using the smallest amount of metal relative to substrate, (ii) generating the largest fraction of metal atoms as active sites in the nanocatalyst, and (iii) creating noble metal nanocatalysts which are highly stable, yet catalytically active and long-lived. Herein, the available methods for increasing the utilization efficacy of noble metal catalysts in hydrogen evolution from the hydrolysis of ammonia borane will be discussed. The noble metals which will be covered are ruthenium, rhodium, palladium, and platinum. Each method will be assessed for its ability to escalate the catalytic activity, durability, stability, lifetime, and reusability of the noble metal nanocatalysts in the light of existing literature. The progresses in developing highly efficient noble metal nanocatalysts for the evolution of H_2 through hydrolysis of ammonia borane will be discussed briefly. The existing approaches for the development of noble metal nanocatalysts will be presented in the order of using (a) water soluble metal complexes as homogenous catalysts in aqueous solution, (b) colloidal metal(0) nanoparticles, (c) carbonaceous materials as support for the metal nanoparticles, (d) oxide materials as support for the metal nanoparticles, (e) porous materials to confine metal nanoparticles, (f) multimetallic nanoparticles by mixing the precious metals with the cheap non-noble metals, (g) increasing the lifetime and reusability of noble metal nanocatalysts by supporting them on magnetic powder. In each set, the narrated results will be assessed in terms of enhancement obtained in catalytic activity, durability, stability, lifetime, and reusability. The results demonstrate that the catalytic efficiency of noble metal nanocatalysts in hydrolytic dehydrogenation of ammonia borane can also be increased by a suitable combination of all the available methods.

Electrocaloric Effects in Ferroelectric Materials: Innovations for Sustainable Cooling Technologies

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Ferroelectric materials, both lead-based and lead-free, have emerged as promising candidates for electrocaloric cooling, offering energy-efficient and environmentally sustainable alternatives to conventional refrigeration. Our research on textured ferroelectric ceramics, composites, and bulk materials has demonstrated significant enhancements in electrocaloric performance, achieving large adiabatic temperature changes and high isothermal entropy shifts under moderate electric fields. For instance, lead-based systems like PMN-PT exhibit robust electrocaloric effects due to their high polarization, while lead-free alternatives such as PVDF/BCZT composites offer comparable performance with reduced environmental impact. Textured ceramics optimize phase transitions for enhanced electrocaloric efficiency, and our novel composite designs integrate ferroelectric fillers to improve thermal conductivity and scalability. Also, we have conducted a predictive study with machine learning for future step. These advancements enable compact, solid-state cooling systems with minimal carbon footprints, directly addressing the global demand for sustainable thermal management. By bridging material innovation with practical application, our findings pave the way for next-generation, eco-friendly cooling technologies that align with the sustainability goals of Ecomat 2025.

Nanostructures and Thin Film Science and Processes: Fast Electrochemistry

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Nanostructures and thin film structures have great potentials in revolutionizing electrochemistry such as in the research areas of electrochromics and energy storages in the aspects of fast ion transports and cycling stability. Effective transport of electrons and ions is critical for utilizing given electrode materials for such electrochemical devices. While we have systematically investigated ion insertion/extraction and electron transport mechanisms on the single nanostructure level and other ordered nanostructures, mesoscale architecture opportunities and challenges lie in the electrochemical behaviour of assembled nanostructures that not only benefit from the excellent performance on individual building block level, but also address the potential problems of these electrodes. In this aspect of the study, the following scientific questions rise: (1) What are the rationally assembled nanostructures and the assemble techniques? (2) What are the transport behaviour of ion and electrons in the mesoscale electrodes, especially its relationship with the microscopic structures such as porosity and tortuosity of the electrodes; (3) how is the understanding of ion transport and distribution at interfaces between electrodes and electrolyte layers? Here we utilize a combination of well-defined porous 1D, 2D and 3D structures and materials deposition techniques to fabricate a variety of systematically variable electrode architectures. The structural control and electrode design are described in detail. Then, analysis of the rate performance, with a focus on distinguishing between diffusion and charge transfer limited reaction mechanisms, is carried out for two distinct electrode systems, focusing on different issues which face advanced electrode architectures. This opens up opportunities for rationally designed advanced electrode architectures and interfaces to optimize the performance of electrochemical energy storage devices in the future.

Keywords: Nanostructure, thin film

Interfaces and interphases in Mg and Ca Metal Anode Batteries

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ICMAB-CSIC

Various metals have been used as battery anodes in electrochemical cells ever since the birth of the batteries with Volta's pile and in the first commercialized primary (Zn/MnO2, Leclanché 1866) and secondary (Pb/acid, Planté 1859) batteries. Li-MoS2 cells, employing Li metal anodes, with specific energies two to three times higher than both Ni/Cd and Pb/acid cells, were withdrawn from the market due to safety issues related to dendrites growth. Instead, electrodeposition of Mg and Ca appears to be less prone to dendrite formation. Pioneering work by Aurbach et al. in the early 1990's showed a surface-film controlled electrochemical behavior of Ca and Mg metal anodes in electrolytes with conventional organic solvents. The lack of metal plating was attributed to the poor divalent cation migration through the passivation layer.Nevertheless, demonstration of Ca plating and stripping in the presence of a passivation layer has paved the way for assessment of new electrolyte formulations with high resilience towards oxidation. However, several challenges remain to be tackled for the development of Ca and Mg based batteries. Among these, the need for reliable electrochemical test protocols, mass transport limitations and high desolvation energies (due to strong cation-solvent and cation–anion interactions) are implied.Here, the reliability of electrochemical set-ups involving multivalent chemistries is discussed, and a systematic investigation on the impact of the electrolyte formulation on the cation solvation structure and transport is presented. A systematic characterization of the SEI formed on the Ca and Mg metal anode in various electrolyte formulations using complementary techniques allowed for the identification of the most suitable SEI compounds in terms of divalent cation mobility. Finally, recent development on cathode materials will be discussed including promising organic cathode materials.

Keywords: multivalent battery, interphase

Advanced Atomic Catalysts Design for Energy Systems

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Currently, atomic catalysts (ACs) as the frontier research topics have attracted tremendous attention due to their ultra-high electroactivity and broad applications. However, a large number of possible combinations between metals and support materials, the complexity of catalytic materials, as well as the complicated reaction mechanisms, are still the main difficulties for designing novel ACs.

To supply theoretical guidance for designing novel electrocatalysts, we have carried out comprehensive theoretical studies of ACs supported on graphdiyne (GDY) through density functional theory (DFT) calculations and machine learning (ML) techniques.

First, we have proposed the "Redox Barrier Model" to quantify the capability of electron exchange and transfer. For the hydrogen evolution (HER) process, we have extended the conventional indicator of proton binding energy to more diverse criteria, where the screened electrocatalysts for HER are also verified by ML. To design dual atomic catalysts (DACs), the formation stability and electronic modulations for all the combinations between transition metals (TMs) and lanthanide (Ln) metals are compared. Due to the electronic self-balance effects by f-d orbital coupling, the combinations of the Ln metals and TMs achieve optimized stability and electroactivity of GDY-DACs. For the applications of GDY-ACs in the CO2 reduction reaction, a comprehensive reaction pathway mapping of C1 and C2 products is achieved for the first time, where the integrated large-small cycle mechanism and double-dependence correlations are identified. Moreover, the first principles machine learning (FPML) approach is proposed to predict the reaction trends for different products and C-C couplings for novel C3 products. Recently, we also further realized the explorations of the challenging C2+ product formation (e.g. C_2H_6, CH_3OCH_3, C2H2, and CH_2CO) on GDY-ACs.

Therefore, these theoretical explorations have supplied important insights and effective approaches for the design of novel ACs, opening a new avenue to enable broad applications of ACs toward different energy systems.

Keywords: Atomic Catalyst, Machine Learning, Electrocatalysis

Nickel-Based Anode Catalysts for Hydroxide Exchange Membrane Fuel Cells

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In recent years, the Anion Exchange Membrane Fuel Cell (AEMFC) has garnered attention as an economical and efficient fuel cell technology due to its mild alkaline working environment, which permits the use of platinum group metal-free catalysts. However, the hydrogen oxidation reaction activity of platinum catalysts in alkaline electrolytes is approximately two to three orders of magnitude slower compared to their performance in acidic electrolytes. Consequently, to achieve a similar power density as a Proton Exchange Membrane Fuel Cell, the AEMFC anode necessitates the utilization of approximately ten times more precious metal platinum. This report presents the design and creation of a highly efficient and stable non-noble metal alloy electrocatalyst, leveraging the compositional and alloy effects between metals. It also explores the application of this electrocatalyst in membrane electrode assembly.

Keywords: Metal-free catalysts; Fuel cells

Stretchable organic-inorganic perovskite photodetectors

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Transistor is the key device of the existing microelectronics industry, promoting significant progress in the human modern society. In recent years, organic optoelectronic devices with organic semiconductors have received significant attention from scientists due to their tunable molecular functions, low-temperature preparation, and good compatibility with organisms. Especially, intrinsically stretchable polymeric materials and devices are attracted many eyes. It can have stable performance and detection functions under large deformation conditions, which gives people great space for application imagination.[1-2] Recently, we fabricated stretchable organic-inorganic perovskite photodetectors, which showed high sensitivity to high energy photons, such as UV light or X-ray.[3-4] Further, we tuned the morphology of perovskite in SEBS and achieved ultra-low power synapse devices.[5]

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Commercial State-of-the-Art Sodium-Ion Batteries and Perspectives for the Negative Electrode (Anode)

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The current strong interest in electromotive mobility and the need to transition to an energy grid with sustainable storage devices has led to a renewed interest in sodium ion batteries (SIBs). Chinese battery manufacturers marketed the first cells, which are commercially available now. We have purchased and investigated two of these early cells to understand their composition and be able to compare to the state-of-the-art in the scientific community. According to our results and the current literature, all commercial cells utilize carbon-based anodes, with the characteristic sloping charge-discharge profile. In the presentation the results will be discussed in context with safety aspect and space for improvement. The latter aspect will be focused on hard carbon anodes. Amorphous disordered carbons such as hard carbons (HCs) are promising candidates for high-capacity negative electrode materials in SIBs. Their high capacities, however, are often accompanied with high irreversible capacity losses during the initial cycles,[1] while low initial losses are accompanied with moderate capacities.[2] In our research we are aiming at morphologically improved carbons to reduce irreversible losses using a core-shell concept.[3, 4] We investigated different methods to obtain core-shell structures with improved interfaces to restrict SEI formation to the external particle surface, while leveraging the Na storage potential of porous carbon core materials. With a simple and scalable chemical vapour deposition we obtained a 190-fold decrease in surface roughness, resulting in drastically reduced first cycle losses. Interestingly, the sodiation capacity at the same time increased to 400 mAh/g revealing the interference of excessive SEI formation with the storage process within the particles.

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Durable, Fast Charging Electrodes for Aqueous Metal-Ion Batteries

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Aqueous metal-ion batteries are attractive battery alternatives for stationary energy storage due to their inherently low cost and high safety. The development of advanced electrode materials with excellent performance and low cost is crucial for the success of aqueous batteries.

We recently have studied sodium phosphate oxides and Prussian-blue analogous based electrodes as promising anodes and cathodes, respectively, for aqueous sodium-ion and magnesium-ion batteries.

We found that such electrodes not only exhibited fast ionic diffusion that enables the fast-charging rate (> 100C), super long cycle life (> 17,000 cycles), high-capacity retention and rate capability, but also could hosted monovalent and multivalent cations. In particular, ball-milling of these electrodes can further improve the efficiency of the cation intercalation, resulting in much improved capacity and better utilization of the wider stability window of the water-in-salt electrolyte.In combination of electrochemical characterization and multimodal synchrotron X-ray scattering and spectroscopy methods, we attributed the superior performance to the cation deficiency or vacancy and new phase induced through the ball-milling processes.

Our work also underlines the importance of fabricating aqueous batteries on the basis of the Earth-abundant, cost-effective, and non-toxic elements.

Keywords: aqueous battery fast charging

The Role of Charge Carriers in Oxide Photoelectrode Performance for Photoelectrochemical Water Splitting

Sarp Kaya
Koç University

Photoelectrochemical water splitting is a promising method for converting solar energy into chemical energy stored in molecular hydrogen and oxygen. However, the efficiency of this process is heavily dependent on the properties of the photoelectrode materials used. Metal oxide semiconductors are commonly used as photoelectrode materials, but they have poor charge transport properties and surface catalytic activity, which can limit their efficiency.In this talk, interfacial charge trapping and transfer processes taking place in BiVO4 and photoanodes and CuBi2O4 photocathodes and their time evolution will be presented. In these photoelectrodes, charges trapped in surface defect sites hamper the reaction kinetics in a millisecond time scale and could be eliminated by covalently coordinated catalyst layers and surface doping. Surprisingly, bulk charge carriers with lifetimes in picosecond–nanosecond time scale are not entirely decoupled from the surface processes.

Keywords: PEC, pump-probe spectroscopy, photoelectrodes

Construction and performance of highly stable supported noble metal catalysts

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Tsinghua University

Supported noble metal catalysts have a wide range of applications in the chemical, energy conversion and environmental protection fields due to their excellent catalytic activity and selectivity, as an important component of non-homogeneous catalysts. However, the highly dispersed noble metal nanoparticles have high surface energy, which allows migration growth easily during high temperature operation, thus degrading the activity and selectivity of the catalyst.

To address this problem, in our group, a lot of strategies have been developed to prepare high stable supported noble metal catalysts. In this report, we will give a brief introduction of the research progress, including enhancing interactions between metal and support, constructing strong metal-support interactions (SMSI), applying oxide coatings, confining them within porous material matrices, and alloying nanoparticles. Lastly, the current challenges and future trends for developing supported noble metal catalysts with excellent morphological stability against sintering shall be discussed.

Keywords: supported noble metal catalysts/preparation/catalytic performance/stability

Advancing Hydrogen Permeation Testing: In Situ XRD Microscopy for Real-Time Diffusivity Mapping in Complex Microstructures

Cem Örnek[1], Ammar Aksoy[2],
1,2. Istanbul Technical Universirty

To develop and validate an in situ, non-destructive method for quantifying hydrogen diffusivity and concentration within complex microstructures, overcoming the limitations of conventional permeation testing and ex-situ hydrogen analysis.
- Employed in situ synchrotron X-ray diffraction (XRD) microscopy to measure lattice strain with micrometre-scale spatial resolution and 10^{-5} strain sensitivity.- Combined electrochemical hydrogen charging with applied tensile strain to simulate service conditions.- Correlated experimentally measured lattice strains to local hydrogen concentrations using density functional theory (DFT) calculations.- Used this correlation to generate spatial maps of hydrogen concentration and to infer hydrogen diffusivity.
- Demonstrated that in situ XRD microscopy can detect and map hydrogen-affected regions in real time.- Validated that lattice strain evolution during charging correlates with local hydrogen concentration.- Identified spatial heterogeneities in hydrogen distribution linked to microstructural features, including grain boundaries.- Provided improved input for transport models by capturing dynamic hydrogen-material interactions under simultaneous mechanical and electrochemical loading.
In situ synchrotron XRD microscopy, combined with DFT-informed strain–concentration correlation, offers a novel, operando pathway to visualise and quantify hydrogen transport in complex materials. This method bridges a critical gap in hydrogen embrittlement research by enabling real-time, non-destructive insight into diffusion behaviour and microstructure-dependent hydrogen interactions.

Keywords: Hydrogen diffusivity mapping

Materials Exploration For High-Performance Na-Ion Batteries

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Na-ion batteries (NIBs) stand out as promising candidates for large-scale energy storage due to their resource abundance and lower costs compared to lithium-ion batteries, sharing similar working principles. It is well-acknowledged that the properties of key materials are decisive factors influencing NIB performance, where layered oxide cathodes and disordered carbon anodes represent foundational advancements. Inspired by high-entropy alloy materials, we propose the concept of high-entropy layered oxide cathodes in an effort to further enhance the stability of cathode materials. We delve deeply into the effects of the high-entropy configuration strategy on retarding phase transitions to improve cycling performance, facilitating sodium-ion transport pathways to boost rate capability, and regulating electronic structures to elevate charge compensation capacity, thereby steering the advancement in this field. In parallel, we explore various strategies to maximize sodium storage in disordered carbon anodes, shedding light on the phenomenon of fast charging of Ah-level NIBs, which have demonstrated the remarkable capability to sustain 3,000 charge-discharge cycles within a mere 9-minute period without exhibiting any noticeable sodium plating. Looking towards the solid-state future of NIBs, our recent breakthrough involves a new category of viscoelastic inorganic glass (VIGLAS) electrolytes, characterized by unique attributes that bridge the gap between traditional inorganic ceramics and organic polymers. These VIGLAS electrolytes play a pivotal role in maintaining chemomechanically stable interfaces between solid electrolytes and high-voltage electrode materials, thereby advancing the frontier of NIB technology.

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Perovskite Solar Cells

Bo Qu
Peking University

This submission is for Oral presentation (Invited Speaker)The targeted symposiumis DPerovskite Solar CellsBo QuState Key Laboratory for Artificial Microstructures and Mesoscopic Physics,Department of Physics, Peking University, Beijing, 100871, ChinaEmail: bqu@pku.edu.cnPerovskite solar cells (PSCs) have attracted broad attention. The certified efficiency has exceeded 27%, which is comparable to silicon-based counterparts. However, the environmental problems caused by the lead in perovskite restrict their large-scale applications.
In order to resolve toxicity of lead-based perovskites, Bo Qu group prepared PSCs based on lead-free double perovskite Cs2AgBiBr6 in 2017 (Adv. Science 2018, 5, 1700759), and then fabricated semi-transparent solar cells with an average visible light transmittance of 73% (Solar RRL 2020, 4, 2000056).However, the relatively large bandgap (~2.0 eV) of Cs2AgBiBr6 hinders its optoelectronic applications in longer wavelength bands of visible and near-infrared regions. We replaced some of Bi elements in Cs2AgBiBr6 with trace doping (~1%) of iron (Adv. Function. Mater. 2021, 322109891) and ruthenium (Mater. Adv. 2022, 3, 4932) to broaden its absorption range to near-infrared region (1200-1350 nm).
The bottleneck in the application of lead-free perovskite photovoltaics can be overcome by regulating the structural or electronic dimensions, and we were invited to publish a cover article in Chemical Society Reviews (2024, 531769-1788, Top 1% highly cited paper).
On the other hand,black-phase formamidinium lead iodide (α-FAPbI3) perovskites are the desired phase for photovoltaic applications, but water can trigger formation of photoinactive impurity phases. Recently, we introduced chlorine-containing organic molecules to form a capping layer that blocked moisture penetration while preserving DMSO-based complexes to regulate crystal growth. We report PCE of >24.5% for perovskite solar cells fabricated across an RH range of 20 to 60%, and 23.4% at 80% RH. The unencapsulated device retained 96% of its initial performance in air (with 40 to 60% RH) after 500-hour maximum power point operation.(Science2024, 385, 161-167)

Keywords: perovskite; Solar cell; Stability

Probing and Modulating Electrocatalyst Reconstruction for Sustainable Energy Applications

Jian Wang
City University of Hong Kong

Electrocatalysis stands as a cornerstone of many carbon-neutral technologies. However, the harsh operational conditions inherent to electrocatalysis induce rapid alterations in the physicochemical properties of catalytic electrodes. These changes occur in situ, affecting the surface and/or bulk compositions, structures, and valences, deviating from their initial states. Critically, this reconstruction process reshapes the electrode-electrolyte interface, a defining factor in catalytic performance and long-term durability. Achieving rational advancements in electrolysis thus hinges on precise control over this complex reconstruction phenomenon, a challenge that remains formidable. Our studies aim to understand and precisely modulate electrocatalyst reconstruction to superior energy applications.

In this talk, I will present our systematic efforts to unravel and engineer in situ reconstruction to reconstruct catalytic electrodes for superior electricity-hydrogen conversion. Central to our work is the concept of "reconstruction activity"—a quantitative metric we developed to evaluate the reconstruction propensity of catalysts. By integrating operando synchrotron characterizations with thermodynamic/kinetic modeling, we mapped the reconstruction pathways of model catalytic electrodes.

Our analysis revealed a volcano relationship between reconstruction activity and their catalytic performance, demonstrating that moderate reconstruction activity optimizes both catalytic efficiency and stability. Furthermore, we have identified that electrochemical reconstruction-accelerated leaching is the primary obstacle preventing the use of typical Mn/Co oxides in acidic water electrolysis environments. To mitigate this, we have proposed a novel hetero-interface engineering approach that effectively suppresses in-situ reconstruction, leading to a significant enhancement in catalytic performance. We also pioneered a redox modulation strategy to direct surface reconstruction toward favorable pathways, which method engineered the catalyst leaching potential, manipulated the cation leaching amount, and redirected the dynamic catalyst reconstruction.

These advances have yielded high-performance catalytic electrodes for membrane-based electrolyzers. By understanding and modulating electrocatalyst reconstruction, we aim to accelerate the translation of durable, high-efficiency electrolysis systems.

Keywords: electrocatalyst, reconstruction, operando characterization, modulation

Interfacial Engineering towards long-term cycling for Sulfide-based All-solid-state Li-metal Batteries

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Sulfide solid electrolytes are considered as a viable strategy for developing all-solid-state lithium metal batteries. However, the parasitic interfacial reactions between electrolyte and lithium anode, and lithium dendrite growth inside the electrolyte have not been completely resolved. Herein, we will report some interfacial engineering strategies to facilitate the long-term cycling of the all-solid-state lithium metal batteries.

We select argyrodite-type sulfide solid electrolytes (LPSCl) with relatively low raw material costs as the research subject, conducting studies from both material and interface perspectives to enhance their compatibility with lithium metal.

The Li5.5PS4.5Cl1.5 electrolyte exhibits the highest ionic conductivity (σ=11.6 mS cm-1) and the best lithium stability (CCD=0.86 mA cm-2). Furthermore, a targeted multi-step constant current charge-discharge protocol can significantly enhance the cycle life of all-solid-state batteries. Second, the Li3N-LPSCl significantly improves the wettability of the Li/SSE interface and reduces the interface resistance, and the high ionic conductivity (σ=1.72 mS cm-1) ensures the rapid transport of lithium-ions. Third, the ionic-conductor LiC6 ensures ionic transport across the interface at high currents, while the LiZn alloy provides moderate electronic conductivity to prevent void accumulation. Last, a Li/Li-Al/LiCl/LPSCl multilayer lithiophilic-lithophobic structure was prepared. Specifically, the LiCl with high interfacial energy and electronic insulation properties can effectively inhibit the growth of lithium dendrites, and the lithiophilic Li-Al alloy layer can improve the wettability of the interface and regulate lithium deposition.

We reveal the influence of chlorine doping levels in LPSCl on the (electro)chemical performance of all-solid-state batteries, elucidate the stabilization mechanisms of intermediate layer materials with different characteristics at the Li/LPSCl interface, and explore the practical application potential of interface protection strategies, optimizing and improving the electrochemical performance of all-solid-state batteries.

Keywords: All-solid-state Batteries;

Developing Sustainable Composites: Microwave-Cured Elium/PMMA for Structural Automotive Components

Mustafa Bakkal
Istanbul Technical University

Thegrowing needfor sustainable materials demands green composite solutions. This study investigates acrylic-based thermoplastic Elium (PMMA) as a viable alternative to epoxy for structural composites, with a focus on automotive applications. Elium's key advantage lies in itsinherent recyclability, offering a crucial path towards moresustainable material life cycleswhile also deliveringcomparable mechanical performance. An important processing benefit explored is microwave-assisted curing. This method enables rapid cure times (minutes) and significantly lower energy consumption compared to conventional techniques,adding to the sustainability profile.

Composite specimens were manufactured using Resin Transfer Molding (RTM).Mechanical testing provided a complete mechanical characterization of the Elium-based system.The performance of this novel, recyclable composite was thenthoroughlyevaluated for a representative automotive structural component. This assessmentusedan integrated approach, combining detailed Finite Element Analysis (FEA) simulations with physical experimental validation under relevant loading conditions. The results confirm the material's structural suitability for use in the automotive industry.

The results confirm the material's structural suitability for use in the automotive industry.

This work demonstrates the potential of recyclable Elium composites, enhanced by efficient microwave processing, as sustainable, high-performance alternatives for demanding automotive structures.

Keywords: Sustainable composites Elium Microwave curing

Bioinspired Smart Polymers from Renewable Resources for Biomedical Applications

Pınar Çakır Hatır ,
Istinye University

Bioinspired smart polymers derived from renewable resources represent a new generation of sustainable materials for advanced biomedical applications. Mimicking the natural systems, these polymers exhibit intelligent responses to external stimuli such as pH, temperature, light, or enzymes, enabling controlled changes in their structure and function. By utilizing bio-based monomers and green synthesis approaches, these materials combine environmental sustainability with high biocompatibility and functional versatility. Their tunable responsiveness makes them particularly attractive for applications such as targeted drug delivery, wound healing, tissue engineering, and biosensing. This abstract explores the design principles, functional mechanisms, and biomedical applications of renewable-resource-based bioinspired smart polymers, while addressing the current challenges and prospects for their translation into clinical settings.

Hole-conductor-free, fully printable mesoscopic perovskite solar cells

Anyi Mei

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Halide perovskites offer exceptional promise for developing high-performance solution-processable photovoltaics. However, conventional perovskite solar cells (PSCs) with the planar structure suffer from three critical limitations to be solved: (1) efficiency losses during area scaling due to pinholes in perovskite films, (2) manufacturing costs associated with vacuum deposition and costly materials, and (3) stability challenges induced by component exchange through the interface.

To address these issues, our group developed hole-conductor-free, fully printable mesoscopic perovskite solar cells (p-MPSCs). These devices employ a cost-effective, wet-processed triple-mesoporous scaffold (TiO2/ZrO2/carbon) fabricated entirely by printing, while perovskite is filled inside the pores rather than in the form of an individual film.

By strengthening perovskite-related interfaces and grain boundaries within this chemically and physically stable porous structure, p-MPSCs achieved operational stability exceeding 9000 hours. Through growth-dominated crystallization control, we achieved uniform, high-quality perovskite formation within the mesopores, significantly enhancing light absorption and charge transport. Meanwhile, the mesoporous TiO2 electron transport layer ensures efficient charge separation at the nanoscale, enabling the realization of high-performance p-MPSCs without the hole conductor.

Through systematic optimization of charge transport and interfacial passivation, we realized carbon-based hole-conductor-free p-MPSCs with PCE surpassing 22%. These advancements have been successfully scaled to fabricate large-area perovskite solar modules with an area surpassing 1.5 m2.

Keywords: printable mesoscopic perovskite solar cells

Multifunctional Strategies in Supercapacitors: Tailored Electrodes and Solid-State Electrolytes for Asymmetric and Symmetric Systems

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Asymmetric and symmetric supercapacitors continue to attract significant attention due to their complementary advantages in energy storage performance. While asymmetric devices are primarily developed to enhance energy density through optimized electrode material combinations [1], symmetric devices benefit greatly from advances in flexible carbon-based electrodes and novel solid-state electrolytes, which improve stability and mechanical adaptability [2].Recent efforts in electrode synthesis techniques have yielded high-capacity materials suitable for asymmetric configurations, paired effectively with biomass-derived carbons to maximize performance. Simultaneously, the integration of liquid crystal-based gel electrolytes with flexible carbon nanomaterials in symmetric systems has demonstrated improved energy storage capabilities, outperforming traditional KOH–PVA electrolytes and offering enhanced thermal stability, particularly in microscale device formats.This overview will highlight these dual approaches, emphasizing how innovations in both electrode materials and electrolyte design are critical for pushing the boundaries of supercapacitor performance and enabling versatile, flexible energy storage solutions.

Keywords: supercapacitor, electrode, electrolyte, gel electrolyte

Directional Modulation of the Chemical Environment of Printable Mesoscopic Perovskite Solar Cells

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To enhance the power conversion efficiency (PCE) of printable mesoporous perovskite solar cells (p-MPSCs) without post-thermal-annealing processes, two approaches were explored: gradient volatilization of multi-component solvents and the influence of solvent properties on precursor solution stability. A binary solvent system consisting of 2-methoxyethanol (2-ME) and N-methylpyrrolidone (NMP), with acetonitrile (ACN) as a co-solvent, was introduced. The high volatility and excellent wettability of ACN were utilized to optimize the quality of $MAPbI_3$ perovskite films and improve their crystallization rate. Enabling the formation of high-quality perovskite films within mesopores at room temperature, this approach achieved a PCE of 18.30%. Secondly, the influence of solvent properties on precursor solution stability was investigated using a multi-solvent system in the perovskite precursor solution. Tetrahydrofuran (THF) served as a volatile co-solvent, while N-hexyl-2-pyrrolidone (CHP) acted as a coordinating solvent. This optimized multi-solvent system enhanced the PCE of p-MPSCs from 16.39% to 18.29%. Furthermore, when applied to formamidine (FA)-based printable mesoporous perovskite solar cells, this approach successfully boosted their efficiency to 21.12%. These findings demonstrate that carefully designed solvent systems can significantly improve the performance of p-MPSCs without requiring post-thermal-annealing processes.

Integration of Healed Graphite into Lithium-Ion Pouch Cells

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The rising demand for lithium-ion batteries (LIBs) in electric vehicles and stationary energy storage highlights the urgent need for sustainable material sourcing. Graphite, the dominant anode material in LIBs, contributes significantly to the carbon footprint of LIBs. Recovering and reusing graphite from end-of-life batteries offers a viable pathway toward circularity and reduced environmental impact. This study investigates the application of **healed graphite**—graphite recovered and rejuvenated through a direct recycling method—in lithium-ion pouch cells. The recycled material was characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), dynamic light scattering (DLS), and Brunauer-Emmett-Teller (BET) surface area analysis to evaluate particle morphology, crystallinity, particle size and surface area. Pilot-scale anode electrodes were fabricated with the healed graphite and first tested in half-cell configurations to assess electrochemical behavior. Full 1 Ah pouch cells were then assembled using the recycled graphite anodes paired with commercial cathodes. The cells underwent charge-discharge cycling to evaluate capacity retention, rate performance, and long-term stability. The healed graphite exhibited excellent structural integrity and comparable electrochemical performance including high specific capacity and stable cycling behavior. Notably, its performance approached that of conventional synthetic graphite, validating its potential for reintegration into commercial LIBs. These results demonstrate that direct recycling can yield high-performance anode materials while significantly lowering environmental impact and economic costs. This work supports the adoption of recycled graphite in industrial cell production, aligning with global sustainability targets and forthcoming regulatory requirements for recycled content in battery manufacturing.

Keywords:
Recycled graphite, lithium-ion batteries, anode

Effect of Controlled Moisture Content In Electrolyte on the Electrochemical Performance of 18650 Lithium-Ion Cells

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Sustainable energy storage solutions are vital for the transition to green energy, supporting technologies such as solar and wind power to combat climate change. In this context, lithium-ion batteries have emerged as key components, playing a crucial role in energy storage systems, electric vehicles, and portable electronics. Among various chemistries and cell formats, high-nickel cathode and graphite anode-based cylindrical 18650 cells offer advantages in volumetric energy density, reliability, and cost-effectiveness. However, environmental factors—particularly humidity levels during production—significantly affect cell performance. Elevated humidity in non-aqueous electrolytes can lead to hydrolysis of LiPF6 salt, releasing hydrofluoric acid (HF), which accelerates material degradation.[1,2]

This study systematically investigates the impact of controlled humidity levels in non-aqueous LiPF6-based electrolytes on the electrochemical performance of commercial 18650 cells. Cells were subjected to charge–discharge cycling, high-rate tests, electrochemical impedance spectroscopy, internal resistance measurements, cycle life evaluation, capacity retention analysis, safety testing, and post-mortem characterization to identify degradation induced by moisture exposure.

Results show that elevated humidity in the electrolyte triggers parasitic side reactions, increases gas generation, and consumes active materials, leading to reduced cell performance and accelerated capacity fade. These findings highlight the critical need for strict humidity control during electrolyte handling and cell manufacturing to improve the longevity and reliability of 18650 lithium-ion batteries for sustainable energy applications.

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Miniatured Designs of Implantable and Wireless Hemodynamic Pressure Monitoring Capsules

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Hemodynamic pressure (HP) monitoring is critical for managing cardiovascular diseases. Clinical Doppler echocardiography and invasive catheter monitoring cannot realize remote continuous monitoring in daily life. Current implantable wireless equipment depends on custom chips or indirect sensing, presenting challenges in cost-effective and precise applications.

Here, we present systematic design strategies for implantable, wireless, and battery-free capsule-like HP monitoring under near and middle-distance circumstances. Methods: The systems were composed of completely non-customized devices, with extremely compact volumes (< 0.4 cm³). Near-distance monitoring utilized Near Field Communication with a piezoresistive sensor and foldable circuit designs. Middle-distance monitoring employed dual-winding antennas based on magnetic resonance (~600 kHz) and Bluetooth. The power feedback circuit was optimized through human model electromagnetic simulations. Validation involved in vitro and in vivo experiments.

Results: Near-distance system achieved 0.35 mmHg omnidirectional pressure accuracy under 5 mm tissue shielding. Middle-distance system attained the longest wireless power transfer distance (7.5 cm) via electromagnetic fields, supporting a capacitive sensor with 0.4 mmHg accuracy. In vitro tests in artificial tissue demonstrated for stable data/energy transfer, accommodating axial misalignments up to ±45°. In vivo experiments on the beagle demonstrated real-time, wireless monitoring of left-atrial pressure, whose rhythm synchronized with electrocardiograph recordings. The interatrial septum interventional installation was also validated.

Conclusion: The wireless and implantable capsules enables near and middle-distance hemodynamic pressure monitoring, even in dynamic swinging intracardiac situations. and has been validated in animal experiments. Significance: The designs provide a universal method for in vivo fully-implantable pressure monitor development.

Keywords: HP monitoring, battery-free

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ORAL PRESENTATIONS

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THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Efficiency and Economic Assessment of Single-Speed Versus Multi-Speed Transmissions in Electric Buses

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Growing environmental concerns, fossil fuel depletion, and demand for energy efficiency have accelerated transition to electric vehicles and intensified related R&D efforts in transportation sector. In addition to range extension cost reduction has emerged as a crucial area of focus. Within this scope, concrete efforts toward cost reduction include optimization of thermal management systems, vehicle weight reduction strategies, improvements in manufacturing processes, development of new batteries and improving alternative transmission systems.
In this study, efficiency and cost aspects of single-speed and multi-speed transmission systems in electric buses are analysed. A mathematical model of an electric bus developed, incorporating motor efficiency maps instead of fixed efficiency values, thereby enabling evaluation of dynamic operating conditions. For multi-speed transmission system, three gear ratios and corresponding gear change RPM values were defined. For both models, vehicle parameters; total weight (14,700 kg), wheel radius (0.483 m), frontal area (7.5 m²), drag coefficient (0.62), and differential ratio (5.7) were kept constant. Vehicle performance compared based on energy consumption values (kWh/km) across different speed ranges.
As a result of simulation conducted under a single SORT-1 driving cycle, energy consumption of vehicle equipped with a single-speed transmission was determined to be 0.8927 kWh/km. In contrast, vehicle equipped with a multi-speed transmission exhibited energy consumption values of 0.8776 kWh/km at 2700 rpm, 0.8845 kWh/km at 3200 rpm, 0.8836 kWh/km at 3500 rpm, 0.8952 kWh/km at 4000 rpm, and 0.9285 kWh/km at 4500 rpm, based on analyses conducted at different gear change RPM values. Gear shifting behaviour tends to keep motor operating within high-efficiency “green zone” of efficiency map.
Ultimately, both transmission systems yielded similar energy consumption results, with a percentage difference of only ±0.13%. However, motor and transmission components used in multi-speed systems are generally less costly and multi-speed configuration offers overall cost advantage despite comparable energy consumption performance.

Keywords: Electric Buses, Transmission,Efficiency

Ternary Organic Solar Cell Applications of Benzoditiophene Based Polymers

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Organic solar cells are emerging as a promising technology in the photovoltaic field due to their potential for producing lightweight, flexible devices and low-cost fabrication. The ternary strategy, involving the incorporation of a third component into the active layer, has been widely utilized to significantly enhance photovoltaic performance through improved light absorption, additional energy and charge transfer pathways, and optimized active layer morphology. In this work, ternary solar cells are fabricated by using benzodithiophene based donor polymer BDTOX-Cl within commercial donor material D18 and Y6 acceptor material in the active layer.

Ternary organic solar cell devices were fabricated with a device structure ofITO/PEDOT:PSS/BDTOX-Cl:D18:Y6/PDINN/Ag in inert glovebox systems. I-V measurements were carried out under solar simulator for characterization of the organic solar cell devices.

The highest-performing device exhibits power conversion efficiency (PCE) of 12.82 %, short circuit current density (Jsc) of 22.37 mA/cm2, open circuit voltage (Voc) of 0.85 V and fill factor of 67.43%. The use of D18 as a third component significantly enhanced the photovoltaic performance of the device leading a notable increase in power conversion efficiency and fill factor.

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Keywords: Ternary Organic Solar Cells

Bilayer Solar Crystallizer by a Directional liquid Transport fabric for Stable Brine Treatment and Ion Recycling

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Directional and asymmetric liquid transport (DALT) materials have great potential for human moisture management and atmospheric water harvesting, but it is less known for its benefits in brine transportation and salt crystallization. In this work, we discovered a unique salt crystallization behavior of the DALT fabric that the salt with porous structure preferred to crystallize on the surface rather than in the inner space of the DALT fabric. Based on that, we engineered a bilayer solar crystallizer by integrating this DALT fabric as an external crystalline interface with an inner adsorbent-loaded wicking layer for simultaneous brine treatment and resource recovery. This bilayer structure separated the brine-wicking channel from the crystallization interface, thereby reducing the efficiency losses by salt scaling to maintain the stable evaporation rate (>1.6 L/m2/h) during the brine treatment. Furthermore, the adsorbent in inner layer can recover Li+ during the brine evaporation, and the adsorption efficiency is significantly enhanced compared to bulk solution adsorption because the increase of ion concentration with the water evaporation and the heat from photothermal conversion. This work fills up the understanding of brine transportation and salt crystallization in DALT materials, demonstrating thegreat potential for its application in wastewater treatment and resource recovery

Keywords: Solar evaporation, Li recovery

Nanomaterial integrated fiber-based piezoelectric–triboelectric hybrid nanogenerator via thermal drawing as energy harvester

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To develop a self-encapsulated, fiber-based piezoelectric–triboelectric hybrid nanogenerator (PT-HNG) using a scalable, low-cost thermal drawing technique.To enhance the β-phase content and improve the overall electrical output of the fiber by incorporating graphene nanoplatelets into the PVDF matrix.To enable the flexible fiber to function as a self-powered sensor for seamless integration into clothing, supporting advanced smart textile applications.To utilize the nanocomposite hybrid fiber for harvesting energy and sensing biomechanical motion by detecting pressure changes on the skin caused by physiological activities such as heartbeat and respiration.

Graphene nanoplatelets (GNPs) with varying weight percentages ultrasonicated in DMF, while PVDF is simultaneously dissolved via magnetic stirring in DMF. Later, the GNP and PVDF solutions are combined and stirred magnetically for 4 hours, then cast onto a glass plate for solvent evaporation.All functional layers, including electrodes , are assembled and hot-pressed in a mold. A PTFE layer is placed between the functional PC and PVDF nanocomposite layers during pressing to form an air gap, which is created by removing the PTFE afterward.The resulting preform is thermally drawn using a draw tower, yielding 15 meters of continuous hybrid fiber.

For 5% GNP-PVDF, OCV increased up to 114% compared to pristine PVDF PT-HNG (15.2V to 32.6V), and SSC increased up to 164.9% compared to pristine PVDF PT-HNG (15.1 μA to 40 μA)Peak power output of 21 μW for 5 wt% GNP - PVDF fiber, at 5 MΩ resistance.Power density 266.27 mWm-2 for (contact length 7.1 cm)

Successfully fabricated a 15-meter-long thermally drawn piezoelectric–triboelectric hybrid fiber.Incorporating graphene nanoplatelets (GNPs) into the PVDF matrix enhanced overall electrical output.The hybrid fiber demonstrated superior performance in energy harvesting.The fiber exhibited high-pressure sensitivity and effectively sensed pulse waveforms when attached to various body locations.

Keywords: Hybrid nanogenerator, Energy harvesting

Unveiling the Current Collector Effect: Performance and Corrosion Dynamics in Aqueous Al-Ion Batteries with TiO_2 Anode

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Aqueous electrolyte aluminum-ion batteries (AAIBs) represent a promising direction for safe and cost-effective energy storage as an alternative to Li-ion batteries1,2. However, the corrosion of current collectors in chloride-based electrolytes severely limits battery performance and durability3,4.

In this study, we systematically investigate the corrosion behaviour and electrochemical impact of four different current collectors: stainless steel (SS), nickel (Ni), titanium (Ti) and graphite plate (GP) in 1.0 M AlCl3 aqueous electrolyte 5. Using cyclic voltammetry, linear polarization resistance (Tafel extrapolation), and galvanostatic charge-discharge measurements, we demonstrate that graphite plates exhibit the highest corrosion resistance and electrochemical stability.

When used with a sol-gel synthesized anatase TiO2 electrode, the GP current collector enabled an initial discharge capacity of 249 mAh/g at a current density of 3 A/g, retaining 105 mAh/g after 50 cycles with a Coulombic efficiency of 73.9%. In contrast, Ti presented the lower performance due to voltage limitations, and both SS and Ni exhibited rapid degradation and hydrogen evolution reaction.

The findings underscore the importance of selecting appropriate current collectors to reduce parasitic side reactions, such as corrosion and hydrogen evolution, which commonly occur in aqueous Al-ion systems. The results further confirm that the current collector selection significantly affects both the electrochemical stability and performance of the system.

Keywords: Aqueous electrolyte, Al-ion battery

Unlocking Dynamic Charge Acceptance for Next Generation Lead Acid Batteries

Çanşu Çamlık
İnci GS Yuasa Battery

Lead-acid batteries (LABs) continue to be a viable option for energy storage in automotive and renewable applications, particularly where cost, recyclability, and safety are prioritized. However, their limited performance under high-rate partial state-of-charge (HRPSoC) conditions restricts their broader utilization. This study investigates the influence of different carbon additives with varying external surface areas on the dynamic charge acceptance (DCA) and overall performance of LABs.

A total of five commercially available carbon additives including carbon black and graphite were incorporated at 1 wt.% into the negative active material (NAM), and 2V cells with 6N7P configuration were tested.Using a combination of N2 sorption measurements, SEM analysis, mercury porosimeter, and electrochemical testing (capacity, charge acceptance, water loss and cycle life) on the cells, we demonstrate at complete cell level that the external surface area of carbon additives is the dominant factor influencing DCA performance but insufficient of explaining the variations.

Graphitic carbons, with their high sp^2 hybridization, exhibited superior integration with lead and enhanced both charge acceptance and capacity, while maintaining lower water loss and better cold-temperature performance compared to high surface area carbon blacks. Among the investigated carbons, low surface area graphite had the lowest water loss despite increasing DCA by 20% without further optimization studies. This outcome contrasts with the commonly reported trend in the literature where improved DCA performance is typically accompanied by extreme water consumption.

These findings emphasize the importance of tuning carbon texture, chemistry, and morphology to develop advanced NAM formulations. In a broader context, optimizing carbon-enhanced LABs not only enables more efficient use of materials and longer battery life, but also aligns with sustainability goals by supporting circular economy principles through reducing the need for frequent battery replacements in automotive and energy storage systems.

Keywords: LAB, DCA, PSoC,carbon.

High-performance Small Molecular Organic Cathodes for Calcium Metal Batteries

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To achieve high-performance organic cathodes for sustainable Ca metal batteries.

in situ-XRD；in situ-Raman；FTIR；XPS；NMR

Safety concerns and potential cost issues are shifting interest from lithium-ion batteries to calcium-ion batteries, which provide advantages in cost, safety, and resource availability as a viable alternative. However, the development of high-performance calcium batteries has been constrained by the lack of high-capacity cathodes. Here, we employed a 9,10-phenanthrenequinone (PQ) as a small molecular organic cathode to achieve high-performance and stable CMBs, exploiting rapid enolization of multi-redox centers (C=O) and flexible intermolecular structures. The PQ cathode achieves a specific capacity of 250 mAh g-1 at 0.2 C over 200 cycles, with excellent rate capabilities. This performance is attributed to reduced dissolution in weakly solvating ether electrolytes and improved inter- and intralayer Ca ion diffusion pathways. Paired with a calcium metal anode, the full cell delivers 214 mAh g-1 at 0.2 C and an average voltage of 2.5 V vs. Ca/Ca2+, representing the highest performance for calcium metal batteries to date.

This work is expected to expedite the development of high-capacity organic cathodes for sustainable Ca metal batteries.

Keywords: organic cathode， calcium ion batteries

Simulating hydrogen storage by integrating solar photovoltaic-PEM electrolyzer model

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The awareness of global warming and climate change, associated with the highest rate of greenhouse gas emissions from fossil fuels, increases the interest in alternative energy sources. As an energy carrier, hydrogen is a promising alternative fuel to replace fossil fuels, particularly when produced from renewable resources. Integrating excess renewable energy, such as solar, into the electrolysis system during peak production enables the reliable storage of green hydrogen. This approach not only addresses peak energy demands in the automotive and transportation sectors but also serves as a sustainable source of heat and raw material for various industrial applications. The purpose of this study is to model the PEM electrolysis system, which is one of the most common electrolyzer technologies, in terms of efficiency and performance under realistic operational conditions.

In this study, the performance of a PEM electrolyzer system fed by photovoltaic energy was evaluated under varying operation conditions such as temperature, pressure, and membrane thickness. In this context, the PEM electrolyzer model provided by MathWorks was adapted to simulate a hydrogen production system powered by a photovoltaic system. Furthermore, the production capacity of photovoltaic is up to 50 kW.

Preliminary findings show that the hourly hydrogen production rate varies depending on time in the electrolysis system operating with power obtained from the photovoltaic system throughout the day, as shown in Figure 1a. The total hydrogen production capacity of this system is approximately 6.73 kg at the end of the day as presented in Figure 1b.

These findings provide important inputs for the optimization of the investment costs of future electrolyzer components (i.e. electrode, membrane) and other balance of plant components for the green hydrogen production and storage.

Keywords: PEMWE, hydrogen, energy storage

CFD analysis of a PEM fuel cell system for renewable energy transmission

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Hydrogen promises a significant contribution to the global renewable and clean energy transition. As an effective energy carrier, hydrogen provides the highest energy density per the lowest volume. By using a proton-exchange membrane fuel cell (PEMFC), hydrogen can be effectively converted into useful electric energy. This study aims to investigate the effects of different flow configurations to enhance the PEMFC performance.

To achieve this objective, 3D model simulations of PEMFC were conducted by employing computational fluid dynamics (CFD) in ANSYS/Fluent. The proposed model describes how different serpentine flow channel configurations affect PEMFC performance with an active cell area of 4 cm2, channel width and height of 1 mm. The model consists of a membrane electrode assembly (MEA) including catalyst layers at both sides of membrane, gas diffusion layers (GDL), flow channels, and bipolar plates. In the generated model, complex mechanisms of gas transport in the anode and cathode channels, diffusion in the catalyst layers, and the movement of hydrogen ions in the MEA are included.

Preliminary findings show that the channel design remarkably influences local pressure drops, species distribution, and velocity profile. Moreover, results from this study were validated with the previous studies, and findings guide the improvement of robust and high-performance PEMFCs.

Further studies will be performed for deep analysis of channel design optimization to further improve fuel performance.

Keywords: PEMFC, CFD simulation, channel configuration

Assessing the Carbon Footprint and Sustainability of Dormitory Living: A Case Study Approach

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This study assesses the carbon footprint of a student dormitory in Turkey's Trakya region using the GHG Protocol. It analyzes electricity use, heating, transportation, and fuel types. The findings highlight the dormitory's environmental impact and support sustainability improvements in student housing.

This study focuses on the carbon footprint assessment of a student dormitory located in the Trakya region of Turkey. The analysis was conducted within the framework of sustainability and employed open-source data from the Greenhouse Gas (GHG) Protocol. Key parameters considered in the assessment include electricity consumption, heating data, daily transportation activities of students and staff, and the types of fuels used by staff vehicles. The results provide valuable insights into the environmental impact of dormitory operations and offer a foundation for improving sustainability practices in student housing facilities.

Figure 1 shows that electricity consumption is the largest source of carbon emissions in the student dormitory. It significantly contributes to both Scope 1 and Scope 2 emissions. Literature confirms its major role in carbon footprints. Globally, efforts are underway to reduce emissions, highlighting the need to minimize fossil fuel use, especially electricity, and waste in all living spaces.

This study used the GHG Protocol framework, with boundaries and calculations based on its open-source Excel tools. Emission analysis was conducted using collected data. Similarly, Zayit et al. (2021) illustrated campus emission sources and classification for scope determination.Environmental awareness is of great importance in enabling individuals to recognize the opportunities provided by their surroundings, understand the long-term impacts of their actions on both themselves and future generations, and take responsibility for those actions. Minimizing individual carbon footprints and considering the recommendations outlined below within communal living spaces are essential steps toward this goal.

Keywords: GHG protocol, emmisions, dormitory.

Energy Efficient Synthesis of Green Antibacterial Composite Scaffold

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In this study, an antibacterial wound dressing prototype was developed without lyophilization by incorporating silver nanoparticles (AgNPs), propolis, and curcumin into a rigid scaffold based on cellulose isolated from Phaseolus vulgaris (red kidney bean) pods—an underutilized agricultural waste—and embedded within a chitosan–gelatin matrix. The cellulose contributes structural integrity and sustainability, while the phytochemical agents enhance antibacterial and anti-inflammatory functions. AgNPs provide broad-spectrum bactericidal effects, which act synergistically with curcumin and propolis to reduce infection risk.

The production process involves cellulose extraction from dried bean pods, formulation of biopolymer solutions, incorporation of antimicrobial agents, and solidification. This method eliminates the need for expensive lyophilizers, offering a more accessible and cost-efficient alternative using standard laboratory equipment. The final material forms into a rigid, porous disk with enhanced mechanical durability, suitable for biomedical handling and wound coverage.

Material characterization was performed via FTIR and SEM to evaluate chemical structure and surface morphology. Compression tests confirmed that the scaffold exhibits high mechanical strength, placing it within the ideal performance range for wound dressing applications requiring structural support. The AgNP + curcumin combination demonstrated enhanced antibacterial activity through reactive oxygen species (ROS) generation. Meanwhile, propolis extract not only contributed to antibacterial action but also aided in AgNP stabilization, as evidenced by homogenous nanoparticle dispersion in SEM images.

Applications for this biocomposite scaffold in the treatment of both acute and chronic wounds are highly promising, especially in situations where mechanical robustness is necessary. Furthermore, because plant waste is upcycled and lyophilization is avoided, the process is advantageous from an economic and environmental standpoint, allowing for greater scalability in environments with limited resources.

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Keywords: waste valorization, biocomposite, antibacterial, wound.

Impact of Silicon Substitution in Donor Moieties on the Optoelectronic Properties of D–π–A Polymers for Photovoltaic Applications

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Organic solar cells (OSCs) have attracted significant attention as promising alternatives to silicon-based photovoltaics due to their lightweight, flexibility, and potential for low-cost production1,2. The development of new conjugated polymers with finely tuned optoelectronic properties is key to improving device efficiency3.

In this study, we report the design, synthesis, and characterization of two novel donor–acceptor (D–A) type conjugated polymers incorporating selenophene π-bridges for OSC applications. The polymers, P1 and P2, feature4,4-dioctyl-4H-silolo[3,2-b:4,5-b']dithiopheneand2,2'-bithiophene as donor units, respectively, while 2,1,3-benzooxadiazole (BOz) serves as the electron-accepting unit.The impact of the silicon atom and fused ring structure in the donor group on the polymer backbone was thoroughly investigated in terms of optical, electrochemical, and photovoltaic properties. The incorporation of the silole unit led to a decrease in the optical bandgap (from 1.64 eV to 1.56 eV) and a downshift in HOMO energy levels (from −5.42 to −5.62 eV). A red-shift in maximum absorption wavelengths was also observed (from 587/633 nm to 606/650 nm), indicating enhanced π-conjugation and light-harvesting ability.P1 exhibited superior device efficiency, achieving a power conversion efficiency (PCE) of 3.64%, with a short-circuit current density (JSC) of 8.60 mA/cm², an open-circuit voltage (VOC) of 0.66 V, and a fill factor (FF) of 64.04%.This performance improvement is attributed to enhanced backbone planarity, stronger π–π stacking interactions, and better charge carrier mobility induced by the silicon-based donor structure.Additionally, the use of selenophene as a π-bridge contributed to improved intermolecular interactions and broader light absorption. These findings highlight the critical role of silicon integration in tuning the optoelectronic properties of D–A conjugated polymers and demonstrate its potential for the development of high-efficiency OSC materials.

Acknowledgement: We are thankful for financial support from METU Scientific Research Projects under Grant number TEZ-D-103-2022-11044.

Keywords: conjugated polymers, donor, silole, solar-cell.

Functionalized Phenyl Methanaminium Salts Provide Highly Stable Perovskite Solar Cells

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Perovskite solar cells (PSCs) offer excellent optoelectronic properties, low-cost materials, and simple fabrication, yet stability remains a major challenge. Internal defects, especially interfacial iodine vacancies, lead to charge trapping, nonradiative recombination, and reduced open-circuit voltage (VOC). This study aimed to develop effective passivating agents to mitigate ion migration and recombination losses at the absorber/HTL interface. Furan-, thiophene-, and selenophene-functionalized phenyl methanaminium iodide salts—FPMAI, TPMAI, and SPMAI—were synthesized and tested for this purpose in CsFAMA-based n-i-p PSCs.

The salts were synthesized via mild coupling reactions and spin-coated on the perovskite layer. Characterization included XRD, SEM, UV-vis, PL, TRPL, UPS, and EQE. Device performance (VOC, JSC, FF, PCE) and hysteresis indices were measured. Long-term illumination (1250 h) and thermal stability (225 h at 65 °C) were tested. Contact angle tests evaluated hydrophobicity, while DFT simulations modeled iodine vacancy passivation and adsorption mechanisms.

TPMAI-passivated devices achieved a champion PCE of 23.15% (vs. 20.91% for reference) and retained 98% of initial efficiency after 1250 h illumination, compared to 54% for controls. Thermal stability was also improved (87% vs. 54%). DFT showed TPMAI had the lowest iodine vacancy formation energy and promoted iodine migration to maintain interface stoichiometry. Unique S–S interactions between TPMAI molecules enhanced monolayer stability, a feature absent in other salts.

TPMAI significantly improved PSC performance and durability through synergistic mechanisms: effective iodine vacancy passivation, enhanced interfacial integrity, S–S molecular interactions, and increased moisture resistance. These results highlight TPMAI's promise as a powerful passivating agent for stable and efficient perovskite photovoltaics.

Keywords: photovoltaics, perovskites, passivation, recombination states.

Hydrogen-Based Dual Pathways for Carbon-Neutral Powertrains

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Hydrogen is emerging as a critical enabler in the global transition to carbon-neutral energy systems. As a versatile energy carrier, it can be utilized both in fuel cell systems and internal combustion engines (ICE), offering complementary pathways for decarbonization across key sectors such as transportation, power generation and heavy industry. The choice between these technologies depends largely on application-specific requirements, infrastructure maturity and system complexity.

Fuel cell electric vehicles (FCEVs) deliver high efficiency and zero tailpipe emissions, making them suitable for urban environments and long-range transport where hydrogen infrastructure is already established. On the other hand, hydrogen-powered ICE systems offer a pragmatic transition route by leveraging existing engine platforms and manufacturing capabilities. This makes them particularly attractive for heavy-duty, off-highway and retrofit applications.

One of the key engineering challenges in H_2-ICE lies in injector design. Due to hydrogen's low viscosity and high diffusivity, the injectors must ensure precise metering, leak tightness, and thermal resilience. At Bosch Sanayi ve Ticaret A.Ş., the industrialization of H_2-ICE injectors and sub-components is being advanced through dedicated project work and close collaboration with Bosch's development centers in Germany.Other key challenges include material selection, advanced measurement techniques, injector durability and cross-domain engineering.

This study highlights how tailored hydrogen injector designs can improve combustion control, thermal efficiency and regulatory compliance. The outcomes support the broader integration of hydrogen into ICE platforms, especially where fuel cell adoption remains technically constrained. Ongoing work focuses on integration into existing engine systems, pre-series development activities and validation of injector functions under varying operating conditions.

Keywords: Bosch, H2-ICE, FCEVs, Process Development

From Sunflower Seed Shells to Sun-Harvesting Perovskite Solar Cells

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Sunflower seeds have a significant market share in Türkiye, both as a snack food and as a raw material in oil production. The sunflower seed shells (SS) resulting from this consumption are typically subjected to direct incineration as waste. In this context, the present study aims to evaluate this biowaste for sustainable activated carbon (AC) synthesis and introduce it into carbon-based perovskite solar cells (C-PSCs) to improve optoelectronic performance.

Chemical activation method has been used in the production of AC. For this purpose, H_3PO_4, a relatively-environmentally-friendly activating agent was preferred. SS-derived AC (SS-AC) has been characterized by thermogravimetry, scanning electron microscopy (SEM), Raman analysis, X-ray diffraction, and N_2 adsorption-desorption measurements. All layers of C-PSC have been fabricated under ambient conditions by solution-based methods consisting of spin and blade-coating. The device architecture has been configured as ITO/SnO_2/Perovskite/Carbon and SS-AC has been integrated into this configuration as a functional carbon interlayer between the active layer and the counter electrode, while reference devices with and without Poly(3-hexylthiophene-2,5-diyl) (P3HT) hole-transport layer (HTL) were used for comparison. Photovoltaic parameters including open-circuit voltage (V_{oc}), short-circuit current density (J_{sc}), fill factor (FF), and power conversion efficiency (PCE) were monitored for 35 days to investigate the chemical-stability.

The HTL-free reference cell exhibited a maximum PCE of 9.96%, with the incorporation of P3HT, the efficiency raised to 10.83%. On the other hand, the introduction of the SS-AC interlayer resulted in the highest PCE of 12.13% with the retention of 82% of the initial efficiency. The overall improvement has found to be a consequence of simultaneous improvements in V_{oc}, J_{sc}, and FF which can be attributed to the optimized interfacial charge transport and band alignment. These findings indicate that functional carbon dispersions may offer a sustainable alternative to traditional HTLs and play a strategic role as an interface engineering tool.

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Keywords: solar cell, activated carbon.

MnO_2-based Cathode Materials for Aqueous Zinc-Ion Batteries

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Zinc has historically played an important role in energy storage technologies and has made significant contributions to the commercialization of energy storage systems, especially non-rechargeable alkaline-based primary batteries. Rechargeable aqueous zinc ion batteries (AZIBs) have become a promising alternative for grid-scale energy storage applications due to their low cost, environmental friendliness, safety, high theoretical capacity of zinc metal (820 mAh/g), and stability in an aqueous environment.

Therefore, studies on the development of cathode materials that can reversibly intercalate Zn2+ ions have gained attention. Among cathode materials, MnO2 is a remarkable cathode material AZIBs owing to its easy synthesis, non-toxicity, low cost, and various polymorphs (α, β, γ, δ and λ) offering different electrochemical properties.2In this study, a MnO2-based cathode material, β-MnO2, is synthesized via a hydrothermal method, and the effect of Mn2+ dissolution was deeply investigated by varying the type of binders.

Thus, besides conventional PVdF binder, cross-linked binder composed of xanthan gum and citric acid, denoted as c-XG-CA, was used as a choice binder.This binder has also been tested in a commercial Zn–MnO2 battery. It was observed that the electrode utilizing the c-XG-CA binder exhibited superior electrochemical performance compared to the PVdF-based electrode.

Double-helix structure of c-XG-CA facilitated strong interactions among electrode components, resulting in a uniform slurry distribution and improved adhesion strength. In conclusion, the c-XG-CA binder effectively adsorbed Mn^{2+} ions due to its abundant functional groups, contributing to enhanced cycling stability, high discharge capacity, and excellent capacity retention.

Keywords: battery, cathode, binder.

Efficient Leaching of Lithium-Ion Battery Cathodes Using Malonic Acid-Based Deep Eutectic Solvent Systems

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With the intensifying global transition toward electrification and renewable energy integration, lithium-ion batteries (LIBs) have become indispensable components in a wide range of applications, from consumer electronics to electric mobility and grid-scale storage systems1. This widespread adoption has led to a sharp rise in battery waste, underscoring the urgent need for innovative recycling approaches that are both sustainable and resource-efficient. LIBs are composed of critical raw materials such as lithium, cobalt, nickel, and manganese2. In addition, the presence of hazardous compounds within these batteries presents considerable environmental and human health risks if end-of-life management is neglected. Addressing these challenges requires the development of advanced recycling solutions that minimize ecological impact while maximizing material recovery3.In the pursuit of more environmentally responsible and efficient recycling methods, deep eutectic solvents (DESs) have emerged as a promising alternative to conventional leaching agents. These innovative solvents are synthesized by combining specific molecular components: typically a hydrogen bond donor and acceptor4. This allows DESs to remain in the liquid phase under mild thermal conditions. Owing to their favorable characteristics, including low vapor pressure, biodegradability, and customizable solvation behavior, DESs offer a highly effective medium for the selective dissolution and recovery of critical metals from end-of-life LIBs5.

In this study, malonic acid-based DESs were employed to recover critical metals from cathode materials extracted from real-world, end-of-life LIBs. A series of experimental parameters, including temperature, leaching duration, solid-to-liquid ratio, and the application of ultrasonic assistance, were systematically investigated to optimize the metal recovery process.

The results demonstrated that under specific conditions, the DES system facilitated the efficient dissolution of valuable metals into solution, achieving high leaching efficiencies and confirming its potential as a green and effective alternative.

As a result of the high leaching efficiency, metal-rich solutions were successfully obtained.

Keywords: LIBs, Recovery, Deep Eutectic Solvents.

Spray Coated Electrode–Electrolyte for Supercapacitors Based on Pectin Ionogels

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Pectin, a plant-derived, biodegradable, and non-toxic polysaccharide, offers a safe and environmentally friendly platform for developing next-generation soft bioelectronic materials. Owing to its natural origin and excellent biocompatibility, pectin is particularly suitable for diverse applications such as energy storage devices, medical technologies, and skin-contact systems[1-2]. In this work, we report the fabrication and optimization of a pectin-based ionogel intended for dual use as both a solid-state electrolyte and an electrode in supercapactiors for biomedical applications.[3-4]

The system was engineered using calcium chloride ($CaCl_2$) as a crosslinker and ionic dopants such as ammonium chloride (NH_4Cl), resulting in enhanced ionic conductivity, structural flexibility, and electrochemical stability. Spray-coating was employed to deposit thin films (30–150 μm) with precise control over thickness and geometry. This fabrication approach enables integration into wearable or implantable medical devices where conformability and uniformity are essential.Electrochemical characterization, including cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS), demonstrated reliable ion transport, acceptable conductivity values, and promising areal capacitances. The unique potential of pectin to function as both an electrolyte and an active electrode material paves the way for fully biopolymer-based, safe, and transient energy systems.

The schematic illustrates the stepwise fabrication of a pectin-based gel electrolyte on an electrode surface using a spray-coating technique and their initial electrochemical results. Initially, a homogeneous solution of pectin and ammonium chloride (NH_4Cl) is uniformly sprayed onto the electrode, forming a thin precursor film. Subsequently, a calcium chloride ($CaCl_2$) solution is sprayed to initiate ionic crosslinking between Ca^{2+} ions and the deprotonated carboxyl groups of pectin. This dual-spray approach enables precise control over film thickness, composition, and uniformity. The final panel shows the crosslinked gel layer adhered to the electrode, demonstrating clear structural stability key properties for flexible and biocompatible energy storage devices.

Keywords: energy storage devices, biomaterials.

High-Performance 30% Glass Fiber Reinforced Polyamide 6 with 65 % Post-Industrial Recycled Content for Sustainable Automotive Applications

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In response to the EU Green Deal and the draft End-of-Life Vehicles Directive (ELV-D), which impose stringent circularity, waste-reduction and material-recovery targets for industries, especially for automotive OEMs. Plastics account for a large proportion of modern vehicles' mass and are indispensable for meeting lightweighting, safety, and durability requirements in the automotive industry Among plastic materials, glass-fibre-reinforced polyamide 6 (PA6) compounds are particularly valued for their mechanical strength, thermal stability, and chemical resistance, finding widespread application in structural and exterior components. Present study investigates the substitution of a conventional petroleum-based primary sources with a sustainable plastic compound alternative.

The scope of the study developing 30% glass-fibre reinforced PA6 compound which contains 65% post-industrial waste (PIR) plastic waste to reduce embedded carbon footprint and extending application areas of recycled PA materials for automotive industry by revealing technical performance and environmental impact advantages of recycled PA alternatives for automotive applications. In this respect, the present study was conducted by considering integration of sustainable PA6 material into automotive plastic part production. Mechanical strength, thermal stability, and surface quality were evaluated all relevant national and international automotive performance standards while offering significant environmental and economic advantages which revealed by conducted life-cycle assessment (LCA) studies.

The combined technical and environmental benefits underscore the viability of high content recycled plastics in vehicle components

By validating the functional equivalence and strategic value of high-recycled-content PA composites, this work provides a tangible model for integrating sustainable feedstocks, reducing reliance on virgin polymers, mitigating greenhouse-gas emissions and supporting supply-chain resilience across the automotive industry.

Keywords: PA6 PIR Plastics Automotive LCA

The functionalization of biomass for electrochemical storage devices

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Organic materials (OMs) derived from abundant and renewable biomass offer a promising pathway for sustainable energy storage in modern electrochemical devices. Biomass-based materials can be utilized in various components of metal-ion batteries (MIBs), including organic electrode materials, binders (e.g., alginate, Arabic gum, polyfurfural, chitosan), and polymer electrolytes (e.g., cellulose).

The functionalization of biomass endows these materials with exceptional battery performance due to their molecular versatility, structural flexibility, and sustainability.

Their inherent properties—such as high flexibility, diverse structural motifs, and renewable sourcing—make them ideal candidates for replacing traditional materials in energy storage applications. Moreover, biomass-based materials offer a low environmental cost and a sustainable alternative to conventional synthetic polymers and metals. This talk will explore the potential of functionalized biomass in MIBs, discussing the advantages of these materials, including enhanced electrochemical performance and reduced environmental impact.

We will also highlight key challenges and future research directions in optimizing biomass-based materials for next-generation energy storage devices, paving the way for more sustainable and efficient energy storage solutions.

Keywords: Functionalization, biomass, lithium ion batteries

Three-Layer “Cell-to-Pack” Blade Battery Box for Cost-Effective EV Bus Retrofitting

Esra Dönmez

Temsa Skoda Sabancı Ulaşım Araçları San. Ve Tic. A.Ş.

In modern urban public transportation systems, the increasing electric buses necessitates the optimization of energy storage systems in terms of performance, safety, and cost. In this context, battery pack design must simultaneously provide several critical parameters such as energy density, modularity, maintainability, and cost-effectiveness.Traditional battery packaging often fails to provide enough energy capacity in limited spaces, requiring innovative designs with new cell architectures.In this study, a modular and compact battery pack has been designed using three-layered, cell-to-pack with blade cells, in response to the increased height requirements depending on the battery location in the electric buses. The blade cells are positioned side by side through end-plate structures which also provide mechanical connections between layers.

This mechanical design allows for the addition of more layers without transferring the weight of the upper layers onto the cells in the lower layer. As a result, the battery height can be increased by adding layers when needed. Furthermore, the end-plate structures compress the cells to mitigate safety risks such as abnormal heating and swelling.

The battery enclosure, vehicle mounting structure, and energy density remained unchanged in the existing vehicle model. This strategy guarantees that batteries with expired warranties in field vehicles can be seamlessly replaced with the newly designed batteries.

As a result, each battery pack replacement provides 35% less cost. A patent application for this innovative design was filed in 2024.

Keywords: Three-Layer, Blade Battery Box

PAN-lignin based carbon nanofiber anodes for lithium-ion batteries

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Electrospun carbon nanofibers (CNFs) have attracted attention in the field of energy storage as an alternative to graphite electrode due to having high surface area, flexibility, versatile use both as host and active material for the fabrication of free-standing electrodes. In this study, PAN/lignin based CNFs were fabricated by electrospinning method for li-ion battery anode.

Polyacrylonitrile (PAN) is widely used synthetic polymer for this method offering high carbon yield, good mechanical strength and spinnability. However, the high cost has led researchers to seek low-cost and natural polymer sources [2, 3]. Among them lignin is a remarkable biorenewable polymer with high carbon yield [4]. Nevertheless, electrospinning of lignin alone is quite difficult because of its low molecular weight and non-linear molecular structure [4, 5]. PAN/lignin based CNFs were fabricated by electrospinning method followed by thermal stabilization and carbonization. Firstly, PAN/lignin based CNFs were produced with different PAN/lignin weight ratios as 3/1, 2/1, and 1/1 which were coded as PL31-CNFs, PL21-CNFs, and PL11-CNFs, respectively. The electrospun nanofibers were stabilized at 280°C and then carbonized at 650°C. The thermal decomposition behaviour of polymers was investigated bythermogravimetric analysis (TGA). The prepared electrodes were characterized by scanning electron microscopy (SEM),Fourier-transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and Raman analyses. Electrochemical properties of the self-standing CNF electrodes were tested with Li-ion coin half-cells. Cyclic voltammetry (CV) test was used to investigate Li storage mechanism of the prepared electrodes and CV curves were obtained between 0.01 and 3 V at a scan rate of 0.2 mV/s.

Galvanostatic charge/discharge analysis showed that PL11-CNFs had the highest specific capacity with a specific discharge capacity of 464 mAh g^{-1} after 100 cycles at at 50 mA g^{-1} and maintaining good cycling stability.

This anode exhibited good rate capability up to 2 A g^{-1} delivering a discharge capacity of 178 mAh g^{-1}.

Keywords: Carbon nanofiber, Li-ion battery

Molecular Engineering of Porphyrin-Based Photocatalysts for Photocatalytic Hydrogen Evolution

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Among clean and sustainable energy sources, the conversion of solar energy into hydrogen (H_2) is one of the most promising strategies, as H_2 is an excellent energy carrier with high energy capacity. The photocatalytic system (PS) used to produce H_2 from water splitting under light-driven conditions consists of a photocatalyst, a cocatalyst, and sacrificial donors. Among these components, the photocatalyst plays a pivotal role in improving photocatalytic H_2 evolution (PHE). In this context, porphyrin-based photocatalysts have attracted considerable attention for PHE due to their strong light-harvesting properties in the UV-visible region and their tunable optoelectronic properties, which can be adjusted by modifying the peripheral substituents on the porphyrin macrocycle or by inner metal complexation.Our group has mainly focused on improving the PHE of porphyrin PSs through structural modification of the porphyrin photocatalysts. The following strategies have been employed to enhance the PHE of porphyrin photocatalysts: (i) introduction of suitable chromophores at peripheral positions on the porphyrin macrocycle and insertion of various metals into the porphyrin ring; (ii) study of self-assembled porphyrin small molecules with well-defined morphology through facile molecular design; (iii) molecular design of porphyrin small molecules for cocatalyst-free PHE; and (iv) design of visible-to-near-infrared light-harvesting A-π-D-π-A porphyrins.

Keywords: Porphyrin, Photocatalysts, Photocatalytic Hydrogen Evolution

Gel Electrolyte for Flexible Lithium-ion Batteries

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Lithium-ion batteries (LIBs) are extensively used in portable electronic devices due to their high energy density and theoretical specific capacity. However, conventional LIBs employing liquid electrolytes pose safety risks – particularly leakage and flammability – limiting their suitability for wearable and flexible devices. Gel polymer electrolytes (GPEs) offer a promising alternative, providing enhanced electrochemical stability and safety.While efforts focused on improving ionic conductivity of GPEs, achieving sufficient flexibility remains a challenge, especially for stretchable or wearable energy storage systems.In this study, we present a UV-curable GPE system that achieves both high conductivity and mechanical compliance. By blending acrylate monomers with diverse side chains and carefully tuning their stoichiometry, we tailor the polymer microstructure to enhance Li^+ mobility and mechanical elasticity.

The GPEs were synthesized via UV curing of acrylate monomer blends mixed with $LiPF_6$ or LiTFSI. Key parameters, such as the Li+: monomer ratio, curing time, and UV exposure distance, were systematically optimized.

FTIR and Raman spectroscopy confirmed successful polymerization. The resulting gels exhibit excellent mechanical performance, with up to 30% strain at maximum load in tensile compression tests. Electrochemical impedance spectroscopy (EIS) revealed an impressive ionic conductivity of 4 $mS{\cdot}cm^{-1}$.

This work demonstrates a fast, scalable, and cost-effective approach to fabricating UV-curable GPEs with the dual advantage of high ionic conductivity and mechanical flexibility, paving the way for safer and more adaptable lithium-ion batteries in flexible electronics.This study is financially supported by the Scientific and Technological Research Council of Turkey (TUBITAK) (Project No.123M050)

Keywords: Lithium-ion Batteries. Gel Electrolyte

Sustainable Production of Al–Si Alloys from Waste Silicon Solar Wafers and End-of-Life Aluminum Cables

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Aluminum–Silicon (Al–Si) alloys are promising lightweight structural materials widely used in the aerospace, automotive, and consumer electronics industries due to their excellent castability, high specific strength, and high electrical and thermal conductivity (1-3). In this study, Al–Si alloys were produced using waste silicon solar wafers and end-of-life (EoL) aluminum (Al) cables in an induction furnace.Waste Al cables are an important source of raw material as they are very pure. In Germany alone, about 150.000 tons of Al waste cable is generated annually (4). Meanwhile, the global surge in solar panel installations has been remarkable. By 2050, an estimated 9.57 million tons of EoL solar panels are expected to accumulate (5). Without a comprehensive recycling strategy of waste Al cable and solar wafers, this presents a growing environmental and resource management challenge.

To address this, a hydrometallurgical process was first developed to recover silver from the waste silicon solar wafers. After purification, the cleaned wafers were used as a sustainable silicon source for Al–Si alloy production. The dissolution behavior of silicon wafers in molten waste Al cable was investigated. Furthermore, microstructural characterization of Al-Si alloys was conducted using Scanning Electron Microscopy (SEM) and Electron Probe Microanalysis (EPMA).

Al–Si alloys were successfully produced in an induction furnace. Microstructural and chemical composition analyses revealed the presence of intermetallic phases and confirmed the alloy's chemical composition.

The results demonstrate the technical feasibility of producing Al–Si alloys from secondary resources, specifically waste Al cables and purified silicon solar wafers. The successful integration of these end-of-life materials into alloy production not only contributes to circular economy practices but also highlights a sustainable pathway for reducing raw material dependency and environmental impact. The developed process presents a promising approach for high-value recovery and reuse of critical materials from growing waste streams.

Keywords: Al-Si, recycling, EoL product, circulareconomy.

Optimization of Laser Welding Parameters for Efficient and Safe Li-Ion Cell to Aluminum Busbar Connections

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1. Temsa Skoda Sabancı Ulaşım Araçları San. Ve Tic. A.Ş.

Nowadays, with the rapid advancement of electric vehicle technologies, safety and the efficiency of battery systems has become increasingly critical. One of the most important points within a battery pack is minimizing the total internal resistance which directly affects the system safety and performance. In this context, the quality of the cell connections in the Li-Ion battery modules affects system performance. Aluminum busbars are commonly used for cell connections, for this reason laser welding technology stands out due to its high precision, low thermal impact, and suitability for automation.This study aims to determine the most suitable laser welding configuration between Li-Ion cells and aluminum busbars via optimizing the laser welding parameters in accordance with system safety.

During the experimental process, key parameters such as laser power, scanning speed, and frequency were systematically changed and busbars are welded. For each parameter combination, welding quality was evaluated through tensile test in accordance with ISO 6892-1 and macrostructural analysis based on ISO 17639. The welding parameter studies were also inspected for compliance with the aluminum laser welding standard ISO 13919-2. According to this standard, welding joints with high mechanical strength and sufficient penetration are achieved.

With regards to the optimal parameter combination, a tensile strength of 170 kgf and a penetration depth of 1.2 mm on a 3 mm-thick cell terminal were obtained.

These findings demonstrate that laser welding technology is an effective method for safe, durable, and long-life connections in battery modules. Furthermore, the correct selection of laser welding parameters is shown to be critically important for safety and efficiency of the battery module connections.

Keywords: Laser Welding, Aluminum Busbar, Li-Ion

Unleashing the Socio-Economic Drivers of Off-grid Energy Systems on Rural Development: A Meta-Analytical Perspective

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Access to reliable, affordable, and sustainable energy is a critical enabler of rural development, economic diversification, and poverty reduction. In many rural areas, off-grid energy solutions—such as solar home systems (SHS), community-based mini-grids, and pay-as-you-go solar models—have emerged as viable alternatives to centralized grid extension. This study aims to systematically evaluate the socio-economic impacts of such decentralized energy interventions on rural livelihoods. A systematic literature review was conducted following the PRISMA protocol, ensuring transparency and reproducibility through clearly defined inclusion and exclusion criteria. Ten peer-reviewed empirical studies that quantitatively assessed the impacts of off-grid energy systems were selected for meta-analysis. Using a structured coding framework, effect sizes were extracted and synthesized across key outcome domains: household income, employment generation, energy expenditure and affordability, energy access levels, and social outcomes such as education, gender equity, and perceived well-being.

The meta-analytic results reveal consistently positive effects of off-grid energy adoption, particularly in enhancing household income and reducing reliance on expensive or polluting energy sources. Evidence also suggests improvements in job creation, time savings—especially for women and children—and access to lighting and digital technologies. However, the magnitude of impacts varies significantly depending on local context, financing models, and institutional support structures. This study contributes to the growing body of evidence supporting decentralized energy planning by emphasizing the importance of location-specific strategies, participatory implementation, and the use of measurable impact indicators. The findings provide actionable insights for policymakers, development practitioners, and energy planners aiming to design inclusive and scalable energy access programs tailored to rural needs.

Keywords: Energy poverty, off-grid energy systems, rural energy access, rural development, meta-analysis.

Limitation of Thermal Propagation in Li-Ion Batteries: A Comparative Study of Thermal Pad Performance

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1. Temsa Skoda Sabancı Ulaşım Araçları San. Ve Tic. A.Ş.

In modern electric vehicles, safety is one of the most critical design parameters in the Li-Ion battery system. Flame-retardant thermal pads are applied in battery packs to provide thermal insulation between cells and limit thermal propagation during thermal runaway. In this study, flame retardant performance of the thermal pads have been tested and evaluated between current pad and developed pad.

The test setup consisted of three battery cells, thermal pads placed between them, and three temperature sensors. One sensor measured ambient temperature, while the other two were positioned on the thermal pads to monitor the surface temperatures between the cells. During the test, thermal runaway was initiated with puncturing the first cell, and temperatures were recorded throughout the process.

In the test with the current thermal pad, initial temperatures were measured as 40 °C in the ambient, 33.9 °C between cells 1-2 and 35.7 °C between cells 2-3. Maximum temperatures recorded during the test were 493.3 °C in the ambient, 750.3 °C between cells 1-2, and 514 °C between cells 2-3. As a result, all three cells were burned out.On the other hand, the test with the improved thermal pad began with initial temperatures of 41 °C in the ambient, 29.5 °C between cells 1-2, and 28 °C between cells 2-3. Maximum temperatures reached were 104 °C in the ambient, 788.7 °C between cells 1-2, and 665 °C between cells 2-3. In this case, only the punctured cell burned, the second cell showed signs of swelling, and the third cell remained non-damaged. In this study, thermal pads were improved using press-formed composite laminates reinforced with E-glass fibers.

This study demonstrates that the performance of the thermal pad material has a direct impact on battery safety. The improved pad contributed to battery protection via limiting thermal propagation during thermal runaway,thereby highlighting the importance of passive safety measures in the battery system.

Keywords: Thermal Pad, Thermal Propagation, Battery.

Life Cycle Assessment (LCA) of a Waste-derived Thermal Insulation Coating Applied in Energy Intensive Industries

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In this study, geopolymer-based composites made from hollow glass microspheres, waste fly ash, and metakaolin were applied to hot metal surfaces using a basic spray deposition technique. Moreover, a Life Cycle Assessment (LCA) study was conducted for insulation material product.

Life Cycle Assessment (LCA) study was conducted by cradle to grave methodology to evaluate environmental impacts and identify areas for improvement through all stages including raw material supply, transportation, manufacturing, and end-of-life disposal.

After one year of demonstration, the coating showed no damage, and surface temperatures dropped to approximately 60°C, yielding an estimated $5700 in natural gas savings and approximately 30 tons of CO_2 reduction annually.

The results indicated that this newly developed material holds high potential for use as a thermal insulation solution for equipment with complex geometry in energy-intensive industries. LCA results of this material are presented including various impact categories (i.e., global warming potential (kg CO2-Eq/kg, acidification (kg Sox-eq/kg), abiotic depletion (MJ-Eq/kg)), and revealed that the use of secondary raw materials and a sustainable production route provides to eliminate environmental emissions caused during the production of the material.

Keywords: Life Cycle Assesment (LCA)

TWC (Three Way Catalyst) In Catalytic Convertors

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Catalytic conversion of toxic NO and CO gases produced by fossil-fuel combustion in vehicles, power plants, and chemical industries into harmless N_2 and CO_2 is a significant topic due to their negative impact on human health and the environment. Automobile three-way catalysts (TWCs) have been used to remove CO, NO_x, and hydrocarbons from exhaust gases since the 1970s, marking an important development in the field. Rh is the most effective noble metal for converting NO_x into N_2, however, Rh is very uncommon and costly. Designing catalysts requires a thorough understanding of the catalytic action of metal clusters and particles. Experimenting with heterogeneous catalytic reactions by metal clusters/particles remains challenging due to limited experimental equipment and analysis approaches. Theoretical research into the reactivity and catalysis of metal clusters and particles is essential.

In this study, NO reduction by CO of Rh complexes (atomically dispersed Rh sites or Rh clusters) bonded to γ-Al_2O_3 support in three-way catalysts will be investigated with the aim of understanding the catalytic activity and selectivity observed in the experimental work of Asokan et al.[1] Thus, the reaction pathways (Figure 1) will be modeled to monitor which pathway is energetically more favorable by comparing the reaction mechanisms and activation barriers corresponding to them. In addition, the modification of the metal oxide support will beexamined to indicate the effect of the electronic environment and electron-donor/acceptor properties. Density functional theory (DFT) techniques will be performed. In this study, the PBE exchange correlation functional will be used. 6-31G(d,p) basis set for H, C, O, Al as well as LANL2DZ basis set of Hay and Wadt will be carried out Rh.

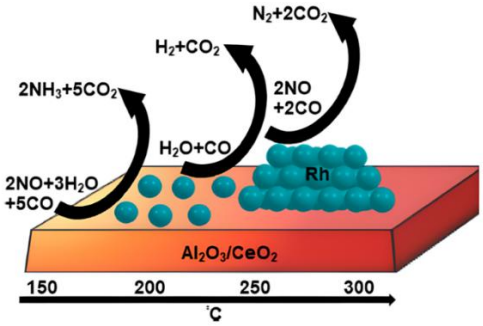

Figure 1. Depiction of product formation during NO reduction over different Rh structures on oxide supports at increasing temperature between 150 to 300 °C.[1]

Keywords: Catalyst, catalysis, SAC, Rh, DFT

References Asokan C, Yang Y., Dang A., Getsoian A. B., and Christopher P. Low-Temperature Ammonia Production during NO Reduction by CO Is Due to Atomically Dispersed Rhodium Active Sites. *ACS Catalysis*, 2020:10(9), 5217-5222.

Utilizing Zinc Oxide Nanoparticles Made with Various Chromoplast Pigments from Plants and Using Symmetric Supercapacitor Devices

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Compared to traditional approaches, green synthesis has gained popularity in the manufacture of nanoparticles since it is inexpensive, sustainable, and non-toxic. However, the electrical properties of nanoparticles prepared by green synthesis have never been mentioned before, unlike biological studies. In this study, research has been conducted on the use of nanoparticles produced from different plant extracts via green synthesis of zinc oxide as symmetric supercapacitor devices in energy storage applications.

Zinc oxide nanoparticles were produced by the bio-reduction method using plant extracts as stabilizing and reducing agents. In the current experiments, zinc oxide nanoparticles were synthesized via zinc acetate dihydrate with the help of plant extracts obtained from tangerine, spinach, and hot pepper peels with varying pH values at 60°C for 1 hour in a magnetic stirrer. The prepared ZnO solution was dried at 100°C for 24 hours and then calcined at 500°C for 1 hour.

Particle characterization of ZnO nanoparticles was performed, and physicochemical analyses were also performed to understand the chemicals contained in plant extracts and how they contribute to nanoparticles. Moreover, after electrochemical analyses, the specific capacitance of ZnO nanoparticles prepared with tangerine, spinach, and hot pepper extracts was calculated as 30.82 F/g, 32.78 F/g, and 80.26 F/g, respectively, for a 100 mV/s scan rate with a 6 M KOH electrolyte solution. Furthermore, energy density values were calculated as 1.07, 1.14, and 2.8 Wh/kg, respectively. Also, it was seen that the best specific capacitance value was given by the ZnO nanoparticle prepared with hot pepper extract because it has the smallest 50 nm-sized particles and leads to a high surface area with its rod-like structure.

Thanks to the study, it has been proven that green synthesis can be used not only in biological studies but also in the field of energy storage.

Keywords: biological synthesis, electrochemical, plant extracts

Facilitating Selenium Conversion Kinetics in Li-Se Batteries via MOF-Integrated Electrodes

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Lithium-Selenium (Li-Se) batteries have attracted attention for next-generation energy storage technologies due to the electrical conductivity of selenium and its improved compatibility with carbonate-based electrolytes.1,2 However, a major limitation of Li-Se batteries is the sluggish redox kinetics associated with solid-solid conversion reactions between Se and the least discharge product, Li2Se, in carbonate-based electrolytes, as well as the irreversible formation and accumulation of Li2Se with poor electrical conductivity. These drawbacks ultimately lead to rapid capacity fading and low Coulombic efficiency.3

In this study, MIL-91(Al) as an electrocatalyst/electroadsorbent has been employed in Li-Se batteries to facilitate the controlled precipitation of Li2Se during discharge and the oxidation of Se during charge in carbonate-based electrolyte.4

Electrochemical test results revealed that the composite containing MIL-91(Al) exhibits higher discharge capacity, cycle stability and lower polarization compared to the composite withoutelectrocatalyst/electroadsorbent (Figure 1). Moreover,the incorporation of MIL-91(Al) is confirmed by staircase potentiostatic electrochemical impedance spectroscopy (SPEIS) and galvanostatic intermittent titration technique (GITT) to significantly enhance Li-ion transfer rate and reduce internal resistance. Ab initio calculations and molecular dynamics simulations demonstrate that Li2Se binds to nearby dangling oxygen atoms belonging to the phosphonate groups of the organic linker in the MIL-91(Al) structure. This interaction leads to a relaxation of the Li-Se-Li bond angle, enhancing the overall stability of the structure. Consequently, the cell with MIL-91(Al) delivers a high specific capacity of 320 mAh/g even at a high current density of 20C (1C=675 mA/g) after 200 cycles, demonstrating excellent cycling stability and Coulombic efficiency.

The utilization of MIL-91(Al) enables the uniform nucleation and deposition of Li2Se, improving the overall electrochemical performance of the Li-Se batteries.

Keywords: Lithium-Selenium Batteries, Electrocatalyst, MOF

Deciphering the Liquid Sulfur Formation Dynamics for Room Temperature Lithium-Sulfur Electrochemistry

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Lithium-sulfur batteries (LSBs) present significant potential as next-generation rechargeable batteries, primarily due to the high energy density and cost-effectiveness of sulfur cathodes. However, the insulation of sulfur particles poses challenges for capacity utilization, particularly at low temperatures and lean-electrolyte condition, which are essential for achieving the practical application of LSBs. Based on our previous mechanism studies of the electrochemical generation of liquid sulfur droplets within the LSB system and the discovery of their rapid reaction kinetics, we further investigated the kinetics of the polysulfide oxidation reaction (SOR) under different electrolyte/sulfur (E/S) ratios and low-temperature conditions. Real-time observations using in-situ optical and Raman microscopy demonstrate the formation of liquid sulfur during SOR is E/S ratio-independent and can be maintained over a wide range of operating temperatures. Quantitative analysis of polysulfide reactant concentrations and the resultant liquid sulfur under different charging conditions reveals pseudo-zero-order kinetics and E/S ratio-dependent reaction constants during the SOR process. Furthermore, even under extreme conditions of -20 °C and with a low E/S ratio of 5 μL mg^{-1}, liquid sulfur can be preserved due to the rapid SOR kinetics. These findings offer new insights into the dynamics of liquid sulfur generation in LSB chemistry, enhancing the understanding of how the E/S ratio and operating temperature affect oxidation kinetics in LSBs.

Keywords: Liquid sulfur, in-situ observations, Liquid Sulfur Formation Dynamics, In-situ optical and Raman microscopy to achieve real-time observations, Quantitative analysis of polysulfide reaction mechanisms.

Preliminary Study on BTO Additives in Sb/C Composite Anodes for Sodium-Ion Batteries

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The production of Lithium-ion batteries (LIBs) has drastically increased with the rise of electric vehicles in the recent years. However, the paucity of Lithium (Li) resources is insufficient to meet the increasing demand in the long run. Thus, the excessive use of LIBs forces producers to find alternatives. Sodium ion batteries (SIBs) are seen as one of the most feasible alternatives owing to their similar electrochemical reaction, natural abundance and lower cost. While research on SIBs continues to progress rapidly, energy density and lifespan for SIBs become researchers' focal point. In this work, antimony (Sb) and hard carbon (HC), commonly used as SIBs anode material, are optimized through different material ratios. Addition of $BaTiO_3$ (BTO) as a piezoelectric material was studied to observe the piezoelectric effect of $BaTiO_3$ on the performance of Sb/C composite anodes in SIBs. It is expected that the addition of piezoelectric material may help improve Na-ion diffusion efficiency due to the local electrical field induced by the piezoelectrical property. Results showed that %10 addition of BTO in the anode material can increase the specific capacity and the capacity retention of Sb/C anode materials. At the 175th cycle, the BTO-added Sb/C anode achieved a specific capacity of 230 mAh/g, which was higher than the 160 mAh/g observed for the pristine Sb/C anode. Further analysis was done to ascertain whether this improvement is due to synergic, catalytic or piezoelectric effects.

Acknowledgement

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Insight into low cost aqueous binder for NMA cathodes: dual component Polyvinyl alcohol (PVA)- citric acid cross-linking

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Polyvinyl alcohol (PVA) is a cost-effective, water-soluble polymer commonly preferred in environmentally conscious binder systems. In this study, an aqueous binder system made of dual component was developed for lithium-ion battery applications by cross-linking PVA with citric acid (CA) in varying ratios. The structural, thermal, and rheological properties of the resulting binders were investigated using FTIR spectroscopy, thermogravimetric analysis (TGA), and rheometry. Slurries were prepared with $LiNiMnAlO_2$ (NMA), a cobalt-free and eco-friendly cathode active material that has recently gained increasing interest in lithium-ion battery research. The rheological behavior of these slurries was analyzed to assess processability, and optical microscopy was used to examine the surface of electrodes produced with different binder formulations. Electrochemical performance of the resulting half-cells was evaluated through galvanostatic charge/discharge tests. The results highlight how binder composition and cross-linking degree influence electrode structure and performance, offering insights for future aqueous binder design in sustainable battery technologies.

Acknowledgement

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Preparation and investigation of the electrocatalytic performance of carbon spheres supported ZIF-derived non-noble metal catalyst

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Currently, the rational design and facile synthesis of high-performance and cost-effective non-precious metal electrocatalysts remain a significant challenge. In this study, carbon spheres were synthesized via a hydrothermal method and subsequently acid-functionalized. As a template, the carbon spheres not only increase electrical conductivity for target composites but also prevent the aggregation of active components. The Zn doping level in the bimetallic zeolite-imidazole framework precursor was systematically adjusted on acid-functionalized carbon spheres (CoZn-ZIF/CSs). Upon pyrolysis at 1000℃, Co nanoparticles were uniformly anchored on N-doped carbon spheres (CoZn-ZIF/CSs-1000), and their oxygen evolution reaction (OER) properties were comprehensively investigated. Acid-functionalized carbon spheres were loaded with MOF precursors (CoZn-ZIF, Co-ZIF, Zn-ZIF), among which CoZn-ZIF/CSs-1000 demonstrated superior OER activity in alkaline media. Specifically, CoZn-ZIF/CSs-1000 exhibited an overpotential of only 167 mV at a current density of 10 mA cm^{-2}. In comparison, Co-ZIF/CSs-1000 showed an overpotential of 216 mV under the same conditions, while Zn-ZIF/CSs-1000 presented an overpotential of 270 mV, comparable to that of RuO_2. All catalysts displayed remarkable OER catalytic activity. These findings suggest that modulating the Zn doping level in MOF precursors can effectively enhance the OER catalytic performance, offering a novel strategy for optimizing the catalytic behavior of carbon material templates and MOF derivatives.

Keywords: Electrocatalytic, Metal catalyst, Hydrothermal method

Biodegradable, Permeable and Stretchable Liquid Metal Microelectrodes for Electrotherapy

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Biodegradable electronics present transformative potential for intelligent biomedicine by avoiding secondary removal and reducing electronic waste. Biodegradable microelectrodes have been demonstrated to delivery the electrotherapy for enhancing the tissue regeneration. However, conventional encapsulation of biodegradable microelectrodes is impermeable to maintain electrical stability in dynamic biological environments, which hinder the long-term biocompatibility and effective tissue regeneration. Here, we reported biodegradable, permeable and stretchable liquid metal microelectrodes for electrotherapy.
The microelectrodes combined biodegradable and stretchable fibrous encapsulation with liquid metal patterns to balance permeability and operation durability.
The liquid metal microelectrodes exhibited biodegradability, permeability, mechanical compliance (300% strain tolerance), robust cycling stability (>1,000 stretching cycles) and stable electrical function during 7-day operation. Biodegradable, permeable and stretchable microelectrodes with short-term stable electrotherapy could more effectively reduce the chronic inflammation and accelerate the muscle regeneration compared with conventional biodegradable microelectrodes.
This work establishes a paradigm for biodegradable and permeable microelectrodes for electrotherapy in dynamic biological environments.

Keywords: biodegradable, permeable, liquid metal

The Growth of Diamond Crystals and The Application in Thermal Management of Gan-Based Light-Emitting Diode

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Wide bandgap gallium nitride (GaN)-based semiconductors have advantages over traditional silicon-based semiconductors, such as high operating temperature, large breakdown electric field, and strong radiation resistance[1]. Especially, high-power lighting devices represented by GaN-based LEDs are widely used in the automotive field[2]. However, when a current flows through the transistor channels during operation, the self-heating effect deriving from joule heat generation causes a significant increase in the temperature[3]. As shown in Fig. 1 (a), traditional GaN-based LEDs directly transfer heat to the heat dissipation substrate during use. Therefore, high-power GaN-based LEDs are limited by the thermal conductivity of the material, accumulating a large amount of heat during use, thereby reducing the lighting effect and service life of the devices.It is well known that diamond has an extremely high thermal conductivity and can transfer heat rapidly[4, 5]. Applying diamond films in gan-based LED devices can effectively reduce their operating temperature(shown in Fig. 1 (b)). In this work high-quality diamond crystal films were synthesized by using MPCVD and showed excellent thermal management performance in GaN-based LEDs. As shown in Fig. 1 (c) and 1 (d), the operating temperatures of the AlNGaN-based LED and the DIAGaN-based LED are 80.6℃ and 168.3℃ respectively, with a decrease of 87.7℃.The device temperatures under different operating currents are shown in Fig. 1 (e). It can be seen that the temperatures of the DIA GaN-based LED are significantly reduced. And the temperature reduction rate are shown in Fig. 1 (f), and its temperature reduction efficiency reaches 52%. This indicates that the prepared high-quality diamond crystal films can effectively reduce the temperature of GaN-based LEDs. This work has laid a research foundation for the thermal management application of diamond films in high-power devices.

Keywords: Diamond crystals, Thermal management

The Hydrolysis of Dimethylamine Borane over Graphitic Carbon Nitride Supported Ruthenium Based Bimetallic Catalysts

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To supply the increasing global demand for clean energy, the use of hydrogen depends heavily on safe and efficient hydrogen storage methods. Among solid hydrogen storage materials, dimethylamine borane (DMAB) is a remarkable amine borane for hydrogen production due to its high hydrogen content, stability, good water solubility and economic potential. However, efficient catalysts are needed to increase the dehydrogenation rate of DMAB. In this context, the design of catalysts with multiple active sites and high catalytic activity is of great importance [6,7].
In this study, catalytic hydrolysis of dimethylamine borane was investigated on ruthenium-based bimetallic nanocatalysts (Ru-M) supported by graphitic carbon nitride (g-C3N4). Bimetallic nanocatalysts were synthesized by using borohydride precipitation method with different metals (M = Cr, Mn, Fe, Co, Ni, Cu) to increase the activity and stability of ruthenium catalyst. SEM, EDX, XRD, XPS, TEM characterization techniques were used to investigate the structural and chemical properties of the synthesized catalysts in detail.
Among the tested secondary metals, Fe demonstrated a significant synergistic effect when incorporated into the Ru/g-C_3N_4 catalyst. It was determined that Ru0.70-Fe0.30/g-C3N4 nano catalyst showed the highest activity in dimethylamine borane hydrolysis reactions. After that the hydrolysis reaction parameters were optimized. Under optimized conditions, specific catalytic activity (TOF) value was found as 13074 h^{-1} and activation energy was found as 57.56 kJ/mol. In durability tests of the catalyst and the activity was maintained by 62% after the fifth cycle.
In conclusion, this study introduces the one of the most active bimetallic transition metal-containing catalyst reported in the literature for the hydrolysis of DMAB. The findings offer the potential for integration into practical hydrogen storage and production systems with provide a novel nanocatalyst with high activity and stability, cost-effective, easy to synthesise, reproducible, reusable and high efficiency.

Keywords: Hydrogen Storage, DMAB, Hydrolysis, Nanocatalyst,

Optimization of Pyrolysis Conditions for Biomass-Derived Carbon Anodes in Sodium-Ion Batteries

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Sodium-ion batteries (SIBs) have emerged as promising alternatives to lithium-ion batteries (LIBs) due to their sustainability, low cost, and abundant raw material availability. However, the large ionic radius of sodium (Na^+) limits its intercalation into graphite, which is the conventional anode material in LIBs, with conventional carbonate based electrolytes.1 Therefore, the development and optimization of anode materials are essential for practical high-energy SIBs. As an alternative to graphite, disordered carbon materials are commonly preferred as anodes in SIBs. Biomass-derived sources, which are generally low-cost and sustainable, serve as typical carbon precursors and are widely used to obtain disordered carbon structures via pyrolysis.2

In this study, a biomass-derived carbon precursor was pyrolyzed at different temperatures (1000, 1250, and 1500 °C) under a nitrogen atmosphere. The electrochemical performances of the synthesized anode materials were tested in 1 M NaPF6 electrolyte solutions prepared with ether and carbonate-based solvents.

Preliminary results indicate that the anode material synthesized at 1250 °C demonstrates superior electrochemical performance compared to anodes synthesized at other temperatures, exhibiting a discharge capacity of 264 mAh/g with about 81% capacity retention after 68 cycles at a current density of C/10 (1C = 300 mA/g).Moreover, the ether-based electrolyte exhibited enhanced electrochemical performance compared to the carbonate-based system.

The optimized pyrolysis condition and electrolyte selection led to improved electrochemical performance, highlighting the potential of biomass-derived carbons as effective and sustainable anode materials for SIBs.

Keywords: Sodium-ion battery, Carbon anode

Enhanced Ammonia Synthesis via Alkali-Promoted Ru/MgO-Cr2O3 Catalysts for Energy Efficient Production

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Ammonia is a crucial component in fertilizer production; however, its conventional synthesis via the Haber-Bosch process requires harshreactionconditions [1–3]. This study aims to develop a more efficient and cost-effective catalyst for ammonia synthesis, addressing the high energy demands of the Haber-Bosch process. By enhancing ruthenium-based catalysts with a novel MgO-Cr2O3 support and alkali metal promoters (Cs and Ba), the goal is to achieve higher catalytic activity under milder reaction conditions and to mitigate catalyst poisoning from hydrogen impurities.

Ru based catalysts and MgO-Cr2O3 support were synthesized via borohydride reduction and coprecipitation techniques, respectively. Alkali promoters (Cs, Ba) were then impregnated onto Ru/MgO or Ru/MgO-Cr2O3catalyst. Catalyst characterization was performed using XRD, SEM and EDX to analyze crystalline phases, morphology, and elemental composition. Ammonia synthesis activity was evaluated in a fixed-bed reactor at 350–500 °C and 1-10 bar using a N2:H2 feed ratio of 1:3. Ammonia production was quantified via conductometry determination method.

According to the experimental study, it was found that the alkali promoted catalysts showed higher catalytic activity than that of unpromoted ones due to improved resistance to hydrogen poisoning. Alkali doping, especially with Cs, significantly enhanced activity due to increased surface basicity and electron donation to Ru [4,5]. The Ru/MgO-Cr2O3 catalyst exhibited superior ammonia formation rates compared to Ru/MgO, attributed to improved electron transfer and suppression of Ru nanoparticle agglomeration by Cr2O3. The Cs-Ru/MgO-Cr2O3 catalyst achieved the highest ammonia production rate of 40,245 mmol NH3/(gcat·h) at 10 bar.

The results of this study demonstrate that MgO-Cr2O3 supported Ru catalysts, particularly with Cs promotion, enable higher ammonia yields under milder conditions. These findings highlight the potential of the developed catalyst system to contribute to more energy-efficient and economically sustainable ammonia production technologies suitable for industrial implementation.

Keywords: Ammonia synthesis, Ruthenium catalysts, Alkali-promoter

Hard and Soft Carbon Precursors for the Development of Low-Cost Anodes in Sodium-Ion Batteries

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Sodium-ion batteries, with their low cost and abundant resources, are a viable alternative to lithium-ion systems1,2. However, the development of suitable anode materials remains a significant challenge, as carbon-based anodes often suffer from limited capacity and poor cycling stability3,4. Petroleum waste sources provide a cost-effective precursor for soft carbon anodes.

In this study, soft carbon derived from petroleum waste source (MP) and hard carbon obtained from biomass source, were synthesized as individual and composite anode materials (MIX) for sodium-ion batteries. The influence of different pyrolysis temperatures (1000°C, 1250°C, 1500°C) on the structural and electrochemical properties was systematically investigated.

Among the soft carbon anodes, MP-1000 (PVdF + DEGDME) demonstrated the best performance, delivering an initial discharge capacity of 186 mAh/g and retaining 93 mAh/g after 50 cycles at a current density of C/10. Notably, the MIX-1250 (PVdF + DEGDME) anode outperformed all other samples, achieving an initial capacity of 235 mAh/g and maintaining 139 mAh/g after 50 cycles. MIX-1250 (PVdF) exhibited an initial capacity of 140 mAh/g and maintained 85 mAh/g after 100 cycles at a current density of 1C rate (1C=372 mA g-1), demonstrating good performance even at high current densities.

These results highlight that combining low-cost soft and hard carbon materials offers a promising strategy for developing high-performance and sustainable anodes for sodium-ion batteries. This study provides valuable insights for optimizing carbon-based anodes for next-generation energy storage systems.

Keywords: Hard and Soft Carbon Anodes

Enhancing Sodium-Ion Battery Performance with Hydrothermally Treated Biomass-Derived Hard Carbon

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Today, the effective utilization of renewable energy depends significantly on the development of high-performance energy storage systems. In this context, lithium-ion batteries, which are currently the most widely used technology, face challenges due to limited lithium resources and high production costs, prompting the search for alternative energy storage solutions. This study investigates sodium-ion batteries (SIBs) as a promising alternative, using hard carbon as the anode material.

The hard carbon material was synthesized from biomass under various processing methods and conditions. Its synergy with different binders and electrolytes was systematically examined. The effect of a hydrothermal pre-treatment and subsequent high-temperature carbonization (pyrolysis) at varying temperatures was studied in detail. The pore structure of the resulting hard carbon was evaluated using X-ray diffraction (XRD), and its morphology was examined through scanning electron microscopy (SEM). Two different binders were used to fabricate anode electrodes from the synthesized hard carbons, and these electrodes were tested in combination with three different electrolytes.

The results showed that the highest capacity was achieved with the carbon material synthesized to hydrothermal carbonization followed by pyrolysis at 1000 °C, in combination with the PVdF binder and 1M NaPF6 electrolyte in EC:PC solvent.

The primary objective of these half-cell tests, involving various parameters, was to assess the commercial viability of sodium-ion batteries and to optimize the components used in the battery.

Keywords: Sodium Ion Battery, Hard Carbon

Development of Separator-electrode Assembly for Flexible Li-ion Batteries

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The rise in wearable electronics has led to an increase demand for flexible batteries1. Currently, the fabrication processes of these flexible cells are still mostly manual, and a limited amount of automation is applied as opposed to manufacturing processes of other types of cells2. Electrospinning is a widely used method to develop advanced novel separators from various polymers such as Polyvinylidene fluoride (PVDF) and Polyimide (PI) due to its ability to manipulate fiber sizes and structures3. In this work, the separator-electrode assembly is developed by directly electrospinning the separators onto electrodes to reduce complexity of flexible battery cell assembling processes.

Lithium iron phosphate (LFP) and graphite electrodes (GE) are electrospun with Poly (vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) microfibers. The structure of the fibers and crystal structures of electrodes are analyzed after prolonged exposure to high voltage during the electrospinning process. The rate performances of pristine LFP and LFP which has been subjected to electrospinning process are also compared. The separator-electrode assembly is developed with GE and electrospun PVDF-HFP separator (Direct PVDF-HFP). The rate performance and long-term cycling performance of cells assembled with Direct PVDF-HFP is compared to cells assembled with Separately electrospun PVDF-HFP separator (Separate PVDF-HFP) and commercially available separator, Celgard 2325. The separator-electrode assembly concept is then further explored in pouch cells with double-sided GE.

The result shows how cells with Direct PVDF-HFP perform compared to cells with Separate PVDF-HFP and Celgard 2325 in electrolyte-lean setting.

This work demonstrates the possibility to directly fabricate separators directly onto electrodes, which can greatly reduce the complexity in assembly process of flexible Li-ion batteries

Keywords: Flexible batteries, Electrospinning, Manufacturing process

Self Assembled Monolayer Based Organic Solar Cells

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About 85% of our energy comes from non-renewable sources like fossil fuels, which can not be replaced while renewable energy helps coping with this problem and reduces greenhouse gas emissions. Solar cells are photovoltaic devices (PVs) that convert sunlight into electricity. Organic solar cells (OSCs) offer unique advantages such as lightweight structure, flexibility and low-cost fabrication. This study focuses on semitransparent organicsolar cells(ST-OSCs) which has applications inagricultural PV (AgroPV) and building integrated PV (BIPV).
The fabrication was carried out in an inert atmosphere (N2 gas) using a glove box system. Metal layers were deposited with thermal evaporation, while solution-based layers were coated using a spin coater.
In this study,different self-assembled monolayers (SAMs) such as 2PACz, Br-2PACz and MeO-2PACz were used as hole transport material. Semitransparent organic solar cells with the device architecture of ITO/SAM /PTQ:Y6/PDINN/Au/Ag Were fabricated. A power conversion efficiency (PCE) exceeding 9% was achieved using a 2PACz as the SAM layer.
The best performance semitransparent OSC exhibits power conversion efficiency (PCE) of 9.63%, short circuit current density (Jsc) of 19.92 mA/cm2, open circuit voltage (Voc) of 0.83 V, fill factor of 58.26%

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Keywords: Organic photovoltaics, Semi-Transparent OSC, SAM

Development of Efficient Mo-Based Electrocatalysts for Alkaline Hydrogen Production

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The aim of this study is to develop a highly efficient and low-cost hydrogen evolution reaction (HER) catalyst by doping metals onto a porous 304 stainless steel surface for application in alkaline water electrolysis. The focus is on achieving high conductivity and catalytic activity using environmentally friendly materials.

Molybdenum (Mo) was electrochemically deposited on NiP-doped 304 stainless steel electrodes, following procedures reported in previous literature. The coating time was optimized to 200 seconds. Structural and surface characterizations were carried out using X-ray diffraction (XRD) and scanning electron microscopy (SEM). The electrocatalytic performance was evaluated by electrochemical impedance spectroscopy (EIS) and linear sweep voltammetry (LSV).

The Mo-coated electrode showed the best HER performance, with a low charge transfer resistance of 1.86 $\Omega \cdot cm^2$ at -1.3 V and a high current density of -94.56 mA cm^{-2} at the same potential. Electrolysis conducted in 1 M KOH at 2.1 V for 60 minutes resulted in 180 mL of hydrogen gas evolution using a Zirfon membrane.

The results demonstrate that electrochemically Mo-coated NiP/SS304 electrodes are promising HER catalysts for alkaline water electrolysis. The developed electrode exhibits excellent catalytic activity, low resistance, and efficient hydrogen production, making it suitable for practical electrolysis applications.

Keywords: Hydrogen Evolution Reaction, Molybdenum, electrocatalyst

Desıgn And Synthesıs Thienothıophene Π-Bridge Modıfıed Quinoxaline Based Conjugated Polymers For Organic Solar Cells

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Production of energy directly from sunlight using photovoltaic technology is considered one of the most important ways to meet increasing global energy needs using a renewable resource. Organic solar cell research has evolved over the past 30 years, but has attracted scientific and economic attention, especially in the last decade, triggered by the rapid increase in power conversion efficiency.

In the organic solar cell device, there are five layers which are cathode, electron transporting layer, hole transport layer, anode, and active layer which includes the energy conversion process by thienothiophene π-bridged quinoxaline-based molecule. Also, the properties such as their potential benefits of being produced in large areas, flexibility, easy integration, and cheap cost of solution processing are among the advantages of organic solar cells (OSCs).

Halogen substitution on the main chain of organic photovoltaic materials is a robust strategy for modifying the aggregation morphology, electronic energy levels, and intermolecular interaction those which are vital for developing the power conversion efficiency (PCE) of the organic solar cells. Herein, donor conjugated polymers were synthesized using Stille cross-coupling reaction between the thienothiophene π-bridged acceptor molecule based on quinoxaline and the benzodithiophene-based donor molecule. Moreover, fluorination and chlorination effect on the main chain of the quinoxaline-based acceptor molecule were investigated.

After the photovoltaic applications of these polymers, the properties which are the open circuit voltage (VOC), short circuit current density (JSC), power conversion energy (PCE), and fill factor (FF) of organic solar cell devices are enhanced.

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Keywords: Organic Solar Cell, Thienothiophene, Quinoxaline

Organic Solar Cells Based on Thienopyrrolydione and Benzooxadiazole Donor Polymers with Non-fullerene Acceptors

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Organic solar cells (OSCs) have attracted significant attention due to their lightweight, flexibility, and potential for low-cost fabrication via solution-based processing techniques. Among these, devices incorporating materials derived from the Y6 molecular framework are becoming quite popular. In this study,thienopyrrolydione and benzooxadiazole based polymer , PO, is used as donor in organic solar cells.

The synthesized donor PO polymer has light absorption range from 400 to 700 nm, and PO exhibits a highest occupied molecular orbital (HOMO) energy level of −5.65 eV and a lowest unoccupied molecular orbital (LUMO) energy level of −3.61 eV, as determined by cyclic voltammetry. OSCs with the device architecture of ITO / PEDOT:PSS / PO:Y6 / PDINN / Ag were fabricated in N2 filled glove box system.

I-V characterizations were tested under a solar simulator (AM 1.5G). In the preliminary studies, OSCs based on PO and the non-fullerene acceptor Y6 exhibited a power conversion efficiency (PCE) of 4.79%, with a fill factor (FF) of 44.51% as a result of I-V measurement, and improvements in short-circuit current density.

These results highlight the importance of molecular design in developing high-performance donor materials for use with Y6-based OSCs and provide valuable insights into donor–acceptor interactions and device optimization.

Keywords: Organic Solar Cell Applications

Asymmetric Hybrid Supercapacitor Devices Based on π-Bridge-Engineered Conjugated Polymers and V_2O_5 Nanowire Electrodes

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In pursuing sustainable and eco-friendly solutions for future technologies, the development of multifunctional materials plays a crucial role, especially in renewable energy storage. Supercapacitors have emerged as promising candidates due to their long cycle life, fast charge–discharge characteristics, and environmental compatibility.These features make them promising candidates. The performance of supercapacitors largely depends on the nature of the electrode materials, which motivates the search for novel, tunable, and sustainable alternatives with enhanced electrochemical and optical properties.

In this study, an asymmetric hybrid supercapacitor device (ITO/V_2O_5 nanowire/gel electrolyte/novel conjugated polymer/ITO) was constructed using two newly designed donor–π–acceptor (D-π-A) type monomers. Vanadium pentoxide (V_2O_5) nanowires were employed as the cathode due to their structural stability and complementary charge storage mechanism with polymer-based anodes. In the molecular design, 3,4-ethylenedioxythiophene (EDOT) served as the electron-donating donor unit, while triphenylamine (TPA) was selected as the electron-accepting unit and thiophene (Th) and 3-cyano-thiophene (CNTh) were used as π-bridges. While thiophene ensures effective π-conjugation and backbone stability, the electron-withdrawing cyano group in 3-cyano-thiophene is expected to lower the redox potential and enhance charge storage capabilities.Monomers were electropolymerized (three-electrode system) to obtain conjugated polymers (PTh and CNTh).

Monomers were electropolymerized (three-electrode system) to obtain conjugated polymers (PTh and CNTh). Comprehensive analysis of PTh, employing kinetic, spectroelectrochemical, and EIS measurements, SEM analysis was performed. The polymer demonstrated outstanding energy storage capabilities with specific capacitances of 38.2 mF/cm² (CV) and 35.2 mF/cm² (GCD), coupled with an energy density of 21.3 μWh/cm2 and power density of 98.3 μW/cm2. Optically, exhibited 44% transmittance at 1000 nm, rapid switching (0.92 s), and high coloration efficiency (178.30 cm²/C).

The primary objective of this work is to elucidate the role of the cyano substituent in the π-bridge on modulating the band gap, influencing charge storage kinetics, and enhancing device-level performance.

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Keywords: Conjugated Polymers, Energy Storage,Supercapacitors

Asymmetric Supercapacitor Based on V_2O_5 Nanowire and CN-Modified EDOT–Thienothiophene–TPA Conjugated Polymer Electrodes

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The majority of renewable energy sources heavily rely on regional weather conditions, making it essential to develop efficient energy storage systems to harness these resources effectively. Among energy storage devices, supercapacitors stand out as one of the most crucial electrochemical energy storage devices due to their high power density, long life cycle, and fast charge-discharge rates1.

Triphenylamine (TPA) based compounds are known to have high redox stability, and fast electron transfer rate.3,4-ethylenedioxythiophene (EDOT) based conjugated molecules are known to have a good electrochromic property2,3. In this study, a donor-π-acceptor-π-donor (D-π-A-π-D) type monomer, synthesized via Stille coupling, was used, consisting of EDOT as the donor, thienothiophene as the π-bridge, and TPA as the acceptor.Electron-withdrawing cyano (CN) group was also incorporated into para position of TPA to enhance both electrochromic properties and energy storage performance by reducing the energy gap and LUMO energy levels3.The monomer was polymerized electrochemicallyby CV.

Δ%T values were 29.5% in the visible region and 52.3% in the NIR region, indicating strong optical modulation, with fast switching times of 1,84 1160 nm. The maximum area-specific capacitance values of the polymer film, obtained from GCD and CV, were calculated as 19.5 mF/cm² and 22.2 mF/cm², respectively. The energy and power densities were calculated as 11.8 μWh/cm² and 138.6 μW/cm², respectively. The morphological property of the synthesized polymer film was examined using scanning electron microscopy, which revealed a porous surface structure.

In this study, the asymmetric hybrid supercapacitor device is designed. One of the electrodes is the conjugated polymer the other one is V2O5 nanowire.Characterizations will be done to get high specific capacitance value. This study aims to combine electrochromic and supercapacitor functionalities in a single device, with a specific focus on examining the effect of the CN group on energy storage performance.

Acknowledgement: This study was supported by Scientific and Technological Research Council of Turkey (TUBITAK) under the Grant Number 124Z087. The authors thank to TUBITAK for their supports."

Keywords: Conjugated Polymers, Supercapacitor, Triphenylamine

Impact of Carbon Anode Porosity on Cycling Performance and Initial Coulombic Efficiency in Sodium-Ion Batteries

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Porous carbon materials have attracted considerable interest as promising anode candidates for sodium-ion batteries (SIBs) due to their high surface area and advanced electrochemical properties. The porous structure plays a crucial role in facilitating ion diffusion, enhancing electrolyte accessibility, and promoting the formation of a stable solid electrolyte interphase (SEI). In this study, we synthesised micro- and mesoporous hard carbons and investigated the effect of porosity on electrochemical performance. To overcome the limitations of traditional hard templating techniques, which require harsh chemical conditions that can damage the carbon structure, we used an environmentally friendly salt templating method1. Nitrogen-doped porous carbon (denoted as GA-ST-800) was prepared from glucosamine using a LiCl/ZnCl2 salt mixture as a template. This approach effectively improved sodium ion storage by facilitating the formation of a well-defined porous structure. Additionally, the nitrogen doping increased electronic conductivity and created additional active sites for sodium ion adsorption.For comparison, the reference hard carbon material (GA-P-800) was synthesised by direct pyrolysis of glucosamine at 800 °C without salt templating. The GA-ST-800 electrode demonstrated superior cycling stability, improved sodium ion diffusion coefficients and excellent rate capability.In contrast, the GA-P-800 exhibited significantly lower performance. Despite its advantages, the GA-ST-800 also experienced relatively low initial irreversible capacity loss due to its high surface area and associated SEI formation. These results highlight the importance of optimizing pore architecture. A balanced combination of micro, meso, and macro pores is necessary to achieve high capacity, improved cycle performance, and enhanced initial Coulombic efficiency in sodium-ion batteries.

Keywords: sodium-ion batteries, porosity, nitrogen-doped

Organic Solar Cells Based on Benzodithiophene–Quinoxaline Donors for Enhanced Efficiency

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Solar cells are devices that convert sunlight directly into electrical energy. As one of the most promising renewable energy technologies, photovoltaics are expected to play a vital role in the future energy landscape. Their advantages—such as low weight, mechanical flexibility, ease of fabrication, and notably high power conversion efficiency (PCE) relative to cost—make them highly suitable for a wide range of applications.

In this study, we developed and optimized bulk heterojunction organic solar cells utilizing a novel donor material blended with Y6 as the acceptor in the active layer. The donor materials consist of benzodithiophene and quinoxaline derivatives featuring a thiophene π-bridge structure.

The photovoltaic performance of non-fullerene based binary systems was investigated by determining key device performance metrics including fill factor (FF), power conversion efficiency (PCE), open circuit voltage (Voc), and short circuit current density (Jsc).

The best-performing device exhibited a PCE of 8.16 %, FF of 50.33 %, Voc of 0.87 V, and Jsc of 18.60 mA/cm².

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Keywords: Organic solar cells, organic photovoltaics

Silicon-carbon Anode Lithium-ion Battery Performance Prediction Through Machine Learning for Experimental Approaches

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In this study, we aimed to integrate machine learning (ML) methods with experimental results to identify and validate reaction conditions that can predict the electrochemical performance of Si/C composite anodes in advance, thereby avoiding inefficient synthesis routes.For the ML-based analysis, we reviewed 100 scientific publications and extracted 270 data points. The key input features included the silicon-to-carbon ratio, binder type, conductive additive, electrolyte type, and cycling rate, while the target outputs were Initial Coulombic Efficiency (ICE), first discharge capacity, and capacity retention. Six different machine learning models were employed for each target, with three to four distinct classification strategies per target variable. Among these models, Gradient Boosting achieved the highest Receiver Operating Characteristic (ROC) score for predicting the first discharge capacity (0.798) and Random Forest yielded the best performance for both capacity retention (0.811) and ICE (0.876). Feature importance analysis highlighted the significant impact of silicon and carbon content on battery performance.To experimentally validate the findings, we used Si/C composite anode synthesized earlier by coating silicon with hard carbon derived from microwave-assisted hydrothermal carbonization of glucosamine (GA), followed by pyrolysis at 750 °C1. The resulting nitrogen-doped carbon structure (Si-GA-C-750) was characterized using X-ray Photoelectron Spectroscopy (XPS), while Thermogravimetric Analysis (TGA) confirmed a silicon content of 45%. The electrochemical performance of this composite anode was evaluated via cyclic voltammetry (CV), galvanostatic charge/discharge profiling, cycling and rate capability tests, and electrochemical impedance spectroscopy (EIS). After 100 cycles at a C/5 rate, the anode delivered a specific discharge capacity of 905 mAh/g. Overall, the output values predicted by the model for similar samples (e.g., high initial capacity, medium ICE) were compared with experimentally obtained values, and the obtained initial discharge capacity of 970 mAh/g, 76% ICE, and 29% capacity retention rate were consistent with the model's predictions.

Keywords: Machine Learning, Silicon, Carbon, Anode

Photovoltaic Properties of Thienothiophene Π-Bridge Modified Quinoxaline Based Conjugated Polymers

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Organic solar cells (OSCs) have gained significant interest due to their lightweight, flexibility, and compatibility with cost-effective, solution-based fabrication methods.Thienothiophene π-bridge modified quinoxaline-based conjugated polymers have emerged as promising donor materials for organic solar cells (OSCs) due to their favorable optoelectronic properties, tunable energy levels, and strong absorption in the visible region. In this study, novel conjugated polymers that involves thienothiophene π-bridges were synthesized and utilized in bulk heterojunction OSCs to investigate their photovoltaic performance. The introduction of the thienothiophene unit aimed to enhance intramolecular charge transfer and improve molecular planarity, leading to more efficient charge transport and exciton dissociation.
Device fabrication and characterization were carried out in a N2-filled glovebox system. Current–voltage (I–V) characteristics were measured under solar simulator (AM1.5G).
The best-performing device exhibited a PCE of 4.3 %, FF of 44 %, Voc of 0.75 V, and Jsc of 13 mA/cm². The results demonstrate that thienothiophene π-bridge incorporation can be an effective strategy to optimize quinoxaline-based donor materials for high-performance organic photovoltaics.
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Keywords: organic photovoltaics, quinoxaline

Quinoxaline Based Polymers for Organic Solar Cell Applications

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In the last few years, organic solar cells have attracted attention both in academia and industry as a promising renewable energy technology. OSCs are flexible, lightweight, semitransparent and eco-friendly.

In this work, bulk heterojunction organic solar cells were fabricated using a novel polymer containing benzodithiophene (BDT) and quinoxaline (Qx) as the donor material. OSCs were fabricated and characterized in N2 filled glove box system. Device optimizations were carried out using the nonfullerene acceptors ITIC-Th, ITIC-4F, and Y6 with varying donor:acceptor ratios. Furthermore, PDINO and PDINN were employed as cathode interlayer materials, and their effect on device performance was systematically investigated.

Finally, current-voltage (I-V) characterizations of OSCs were performed under solar simulator AM1.5G (100mW/cm2). Key parameters affecting device performance such as fill factor (FF), power conversion efficiency (PCE), open-circuit voltage (Voc), and short-circuit current density (Jsc)were obtained from I-V characterization measurements.

The best performance OSC has the architecture of ITO / PEDOT:PSS / P5:Y6 / PDINO / Ag and exhibited PCE of 9.70% , FF of 62.77% , Voc of 0.77Vand Jsc of 20.07 mA/cm2.

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Keywords: Organic Solar Cell, Photovoltaic

Design and Synthesis of Carbazole-Phenothiazine Donor Polymers with Pendent Benzophenone for TADF-Based OLEDs

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The growing demand for next-generation display technologies has spurred interest in organic light-emitting materials due to their potential for flexibility, lightweight design, and low power consumption[2]. Among these, thermally activated delayed fluorescence (TADF) materials have gained significant attention due to their ability to utilize both singlet and triplet excitons through reverse intersystem crossing (RISC), offering high external quantum efficiency (EQE) with low production costs. Despite these advantages, conventional TADF emitters often suffer from low solubility, which limits their compatibility with solution-based traditional coating methods commonly used in device fabrication[1].It is essential to design materials with excellent performance and processability in order to produce next-generation display technology.

To overcome this limitation, this study introduces a novel approach based on donor-backbone–pendent-acceptor (DBPA) polymer design. A random copolymer incorporating alkyl chains was developed to improve solubility while maintaining high optoelectronic performance. The polymer features carbazole and phenothiazine as donor units and benzophenone as a pendant acceptor, aiming to achieve both a low singlet-triplet energy gap and high photoluminescence quatum yield for OLED applications.

The synthesized monomers were characterized using nuclear magnetic resonance (NMR) spectroscopy and high-resolution mass spectrometry (HRMS). The resulting polymer was analyzed using photoluminescence (PL) and UV-visible spectroscopy, gel permeation chromatography (GPC), and cyclic voltammetry (CV) to evaluate its optical, structural, and electrochemical properties.

This research demonstrates the potential of DBPA-based TADF polymers as efficient, solution-processable materials for next-generation OLED displays, addressing current limitations in solubility and processability while advancing the performance of organic emitters in display technologies.

Keywords: TADF OLED , solution-processed OLEDs

An Innovative Azobenzene-Based Photothermal Fabric with Excellent Heat Release Performance for Wearable Thermal Management Device

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Azobenzene (azo)-based photothermal energy storage systems have garnered great interest for their potential in solar energy conversion and storage but suffer from limitations including rely on solvents and specific wavelengths for charging process, short storage lifetime, low heat release temperature during discharging, strong rigidity and poor wearability. To address these issues, an azo-based fabric composed oftetra-ortho-fluorinated photo-liquefiable azobenzene monomer and polyacrylonitrile fabric template is fabricated using electrospinning. This fabric excels in efficient photo-charging (green light) and discharging (blue light) under visible light range, solvent-free operation, long-term energy storage (706 days), and good capacity of releasing high-temperature heat (80–95 °C) at room temperature and cold environments. In addition, the fabric maintains high flexibility without evident loss of energy-storage performance upon 1500 bending cycles, 18-h washing or 6-h soaking. The generated heat from charged fabric is facilitated by theZ-to-Eisomerization energy, phase transition latent heat, and the photothermal effect of 420nm light irradiation. Meanwhile, the temperature of heat release can be personalized for thermal management by adjusting the light intensity. It is applicable for room-temperature thermal therapy and can provide heat to the body in cold environments, that presenting a promising candidate for wearable personal thermal management.

Keywords: solar energy,photo-liquefiable azobenzene, PTM

Dendrite-Free and High-Rate Potassium Metal Batteries Featuring an Inorganic-Rich SEI Sustained by Graphene-Skinned Materials

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Potassium metal battery is an appealing candidate for future energy storage. However, its application is plagued by the notorious dendrite proliferation at the anode side, which entails the formation of vulnerable solid electrolyte interphase (SEI) and non-uniform potassium deposition on the current collector.

Here, this work reports a dual-modification design of aluminium current collector and separator to render dendrite-free potassium anodes with favourable reversibility. The modulated electronic structure of the designed current collector and regulated electric double layer (EDL) by the tailored separator achieve an SEI architecture with robust inorganic-rich constituents, which is evidenced by detailed cryo-TEM inspection and X-ray depth profiling.

The thus-produced SEI manages to expedite ionic conductivity and guide homogeneous potassium deposition.

Compared to the potassium metal cells assembled using typical aluminium current collector and glass fiber separator, cells based on the designed current collector and separator realize improved rate capability (50 mA cm-2), low-temperature durability (-50 ℃) and elongated lifespan (6000 h), respectively. Moreover, scalable production of the current collector and separator allows for the sustainable construction of high-safety potassium metal batteries, with the potential for reducing the manufacturing cost.

Keywords: Metal batteries, SEI, graphene, collector

Popularizing Holistic High-Index Crystal Plane via Nonepitaxial Electrodeposition Toward Hydrogen-Embrittlement-Relieved Zn Anode

Yuhan Zou
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Electrodeposition is promising to fabricate Zn electrodes affording non-epitaxial single-crystal textures. Achieving epitaxial electrodeposition of Zn(002) typically requests substrates affording a minimal lattice mismatch to the Zn(002) plane. However, this tactic might be hindered by material costs and scalability concerns. Note that there still remains a deficiency in the comprehensive investigation and assessment of the interface morphology and quality of deposition layer at "under-limiting/over-limiting" conditions.

We propose to promote high-index Zn(112) plane formation targeting durable Zn anodes by employing a constant-potential electrodeposition mode. The morphology and texture of the non-epitaxial deposited Zn layers could be precisely controlled by varying the deposition voltage.

By precisely identifying the "limiting" conditions for electrodeposition, we find a striking balance among improved deposition quality, tailored deposition kinetics and suppressed hydrogen evolution. We show that (002) faceted Zn electrode could be indeed produced, yet the rampant hydrodynamic convection and hydrogen embrittlement issue under such "over-limiting" preparation condition pose challenges in the electrode lifespan. In contrast, an optimized deposition minimizes hydrodynamic disturbances and mitigates hydrogen embrittlement effect, where the thus-generated holistic high-index (112)-textured Zn electrode manifests impressive deposition quality and demonstrates deep cycling stability.

The electrode with a Zn(112) texture demonstrates an impressive cycle life of ~3000 h at 1.0 mA cm^{-2}/0.5 mAh cm^{-2}.The punch cell by pairing a ZnVO cathode manages reversible specific capacity of ~130 mAh and a capacity retention of 98.42%. This study offers guidance for the development of dendrite-free and hydrogen-embrittlement-relieved Zn electrodes, emphasizing the potential of leveraging high-index plane textures for advanced Zn batteries.

Keywords: Hydrogen embrittlement, constant-potential electrodeposition

Investigation of Radiation Effects in Perovskite Materials via GEANT4 Monte-Carlo Simulations

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Hybrid halide perovskitesstand out due to their exceptional optoelectronic properties. In these materials, A is typically CH3NH3+ (MA+), CH(NH2)2+ (FA+), or Cs+; B is Pb2+ or Sn2+; and X is a halide ion like I^-, Br^-. These compounds offer strong light absorption, tunable bandgaps, high photoluminescence quantum yields, simple solution-based synthesis, and structural flexibility. As a result, they have been widely explored for solar cells, light-emitting diodes, and other optoelectronic devices[1, 2]. Notably, perovskite solar cells have reached power conversion efficiencies exceeding 26% [3].Perovskites are emerging as promising candidates for space-based technologies, where low weight, high efficiency, and low-cost fabrication are essential, attractive for powering satellites, spacecraft, and space stations due to their high power-to-weight ratio [4]. However, space environments pose several challenges, such as thermal cycling, exposure to the AM0 solar spectrum, and irradiation by high-energy particles, causing vacancies, displaced atoms, leading to performance degradation and other issues [5].This study quantitatively evaluates the effects of particle irradiation on MAPbI3 perovskite using GEANT4 simulations.

To assess these effects quantitatively, we performed a simulation study using the GEANT4 toolkit [6. 7], modeling the interaction of MAPbI3 with gamma-rays, electrons, protons, and neutrons across an energy range of 0.1 to 90 MeV.

The simulation results show the energy per particle and events per particle for MAPbI3 under irradiation. The differences in energy deposition and event distribution across the type of exposure are highlighted.

The study focused on electromagnetic and hadronic processes, secondary radiation generation, and the resulting structural damage within the material. it presents how different types of ionizing radiation interact with perovskite, revealing variations in energy deposition and event patterns that shed light on the material's reaction to radiation damage.This work was supported by Ministry of Science and Higher Education of Russian Federation (Project N◦075-15-2024-532).

Keywords: Hybrid perovskites, radiation effects, GEANT4

Molecular Modifier as a Way To Enhance The Radiation Stability of Lead Halide Perovskites

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Hybrid halide perovskite solar cells have recently achieved over 27% efficiency . They offer low-cost materials, simple manufacturing, strong light absorption and a tunable band gap. Their low weight and flexibility also make them suitable for space applications. This is especially important for satellites, where lighter solar panels reduce launch costs and increase payload capacity. However, long-term stability remains a major challenge in space due to exposure to radiation, vacuum, and extreme temperatures.

While moisture and oxygen – primary causes of perovskite degradation on Earth – are absent in space, exposure to ionizing radiation still induce defects and ion migration in the perovskite structure, negatively impacting device performance.To address this, the use of molecular modifiers is a promising strategy. These organic additives can enhance the radiation resistance of perovskites by improving their chemical stability and structural robustness. To analyze changes in the structure and properties of perovskite before and after irradiation with electrons with an energy of 8 MeV and fluence corresponding to 10 years of solar panels in orbit, X-ray photoelectron spectroscopy was used.

The results show that there are two main ways of degradation of the obtained structures under the influence of ionizing radiation. The first is associated with instability in the cationic B-sublattice, the second is associated with the rearrangement of the organic A-cation. For example, the presence of the amino group NH2 in the composition of an organic additive leads to crosslinking of the A-cation and the modifier along the grain boundaries, and the presence of OH group leads to the formation of uncoordinated Pb2+ ions.

The results are of significant value for obtaining the most stable PSC composition in the future under operating conditions in outer space, where ion migration and defect formation represent key durability constraints.

Keywords: Perovskites, modifier, stability.

Preparation of Phosphazene-Based Anthraquinone Polymer/SWCNT Composite Materials and Investigation of Their Usability Potential in Aqueous Zinc Batteries

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In the rechargeable batteries that organic structures used as cathode materials have been desired in recent years due to the fact that obtained from renewable resources, having a flexible structure, easy modifiable, being designed to give multiple electron reactions, having high specific capacity, being able to give redox reactions with transition metals such as magnesium and zinc etc. as well as alkali metals, are of interest. 9,10-anthraquinone (AQ) structures, which have more than one redox active site, provide the opportunity for functionalization/polymerization at different positions and are in the sustainable material category, stand out in this field. The most significant issue with organic cathodes is the decline in battery performance, particularly due to the dissolution of small molecular structures in the electrolyte solution.1Polyphosphazenes, which are an important member of the inorganic polymer class, also allow the preparation of polymers whose physical and chemical properties can be adjusted according to the different substituted groups by simple nucleophilic substitution reactions of many reactants with P-Cl bonds on the main chain, and these polymers can be used in various applications.
Within the scope of this study, the preparation of polymer/CNT composites using phosphazene-based anthraquinone polymers, their structural analysis, thermal, surface and electrochemical properties were investigated. .
The composites used as cathode materials, cyclic voltammetry measurements, and charge-discharge capacity, voltage-capacity, and cycle number tests were performed. In addition, the structural changes of their structures during battery cycles were investigated using (ex-situ) FT-IR and XPS methods

Keywords: Polyphosphazene,cathode materials, Zinc Batteries

Effect of Diamond Particle Addition on Na-Ion Conductivity of PEO Polymer Solid Electrolytes

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Solid electrolytes allow ions to move freely within a solid material, enabling electrical conduction much like saline solutions or molten salts. Polymer solid electrolytes (SPEs), in particular, offer remarkable advantages due to their flexibility, light weight, and adaptability in shape. These properties make them highly promising for applications ranging from power sources for electronic paper to advanced systems like fuel cells, high-power secondary batteries, and even gas separation and production.One common SPE, polyethylene oxide (PEO), is a high-molecular-weight polymer. While flexible and strong, PEO faces a critical limitation: its ionic conductivity drops sharply below its melting point (65-67°C), from approximately 10-3S/cm to 10-7 S/cm. This drastic reduction is due to its crystalline structure at lower temperatures.

Our research aimed to overcome this challenge by incorporating diamond particles into PEO-based solid electrolytes. We prepared these composites using sodium perchlorate (NaClO4) and sodium thiocyanate (NaSCN) as the sodium salts. Our method involved dispersing diamond particles in acetonitrile solvent, then adding PEO (average molecular weight: 600,000–1,000,000) and the chosen sodium salts. After 14 hours of stirring, the mixture was dried in stages: 24 hours in an oven at 60°C, followed by another 24 hours in a vacuum desiccator at 60°C on a hot plate.

We found that adding diamond particles significantly enhanced the Na ion conductivity of the PEO solid electrolytes. Specifically, conductivity increased by477% with NaClO4 and a remarkable1971% with NaSCN. This improvement occurred regardless of the sodium salt type. We attribute this boost in conductivity to the Lewis acid-base interactions promoted by the functional groups on the diamond particle surfaces.

(1) Regardless of the Na salt, the addition of diamond to the PEO polymer electrolyte membrane improves the ionic conductivity.(2) Acidic functional groups on the diamond surface promote Lewis acid-base interactions, resulting in higher ionic conductivity.

Keywords: Solid Electrolytes Polyethylene Oxide (PEO) Diamond Particles

Green and Integrated Production of Nanocellulose from Microcrystalline Cellulose Using Deep Eutectic Solvents and Low-Energy Treatments

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Developing sustainable materials from renewable resources is essential for reducing the environmental footprint of material production. In this study, we present a green and integrated approach for producing nanocellulose from microcrystalline cellulose (MCC), using acidic deep eutectic solvents (DES) and energy-efficient treatments.
Biodegradable acidic deep eutectic solvents (DES) were prepared and used as pretreatment agents to enhance cellulose breakdown and dispersion.Following DES pretreatment, MCC was processed through homogenization (10,000 rpm), ultrasonication (30% amplitude), and a low-temperature, short-duration heating step using microwave irradiation. For comparison, conventional treatment methods were performed under the same physical conditions. Visual observations and suspension behaviour, along with XRD and FTIR analysis, confirmed that DES-assisted samples exhibited greater fibrillation, improved dispersibility, and more refined nanostructures than their conventional counterparts
Visual observations and suspension behaviour, along with XRD and FTIR analysis, confirmed that DES-assisted samples exhibited greater fibrillation, improved dispersibility, and more refined nanostructures than their conventional counterparts.This integrated process eliminates the need for harsh chemicals and reduces energy consumption, offering an eco-friendly route to nanocellulose production. The combination of biodegradable solvent systems and mild processing conditions aligns with the principles of green chemistry and sustainable materials development. As part of future work, we aim to explore the fabrication of flexible nanocellulose-based membranes from the materials produced for different applications (environment, energy etc)
This study demonstrates a practical and sustainable pathway for converting cellulose into high-quality nanomaterials through recyclable solvent systems and low-impact mechanical processing. The approach contributes to ongoing efforts in the circular bioeconomy, biomass valorization, and environmentally responsible materials development. By requiring less time, less energy, and less water, and employing eco-friendly, reusable solvents, this method offers an encouraging and scalable strategy for future green production of advanced bio-based materials.

Keywords: Nanocellulose, DES, green processing, sustainability,Eco-materials

Plant Derived Exosomes as Biomaterials for Industrial Use

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Exosomes, nano-sized extracellular vesicles found in both animal and plant sources that are secreted by cells that facilitate intercellular communication by transportation of certain metabolites such as proteins, lipids, RNAs etc. are gaining recognition as natural and sustainable biomaterials with wide-ranging applications in cosmetics, food technology, medicine. Their biocompatibility, low immunogenicity, and capacity to carry bioactive molecules make them a promising eco-conscious innovation.

In cosmetics, exosomes are used in skin regeneration and hair growth products due to their ability to promote collagen synthesis and hydration. In the food industry, they serve as natural carriers of antioxidant and nutrients, improving bioavailability while reducing reliance on synthetic additives. Pharmaceutical research highlights their role as natural delivery systems for drugs or RNA molecules, especially in cancer therapy. These examples underscore the promise of exosomes as sustainable, multifunctional materials that align with green technology goals.

We conduct a wide range of studies to explore the potential industrial applications of exosomes derived from plant sources and agricultural wasted materials, focusing on their functional properties. Accordingly, in this study, we isolated exosomes from Citrus nobilis (mandarin) peel extract through differential centrifugation and characterized them using zeta potential analysis, nanoparticle tracking analysis (NTA), and electron microscopy. To assess their therapeutic potential, we investigated the cytotoxic effects of these exosomes against human glioblastoma (GBM), one of the most aggressive and lethal brain tumors. In vitro treatments of LN229 GBM cells with mandarin-derived exosomes at concentrations ranging from 10 to 100×10^8 particles resulted in a marked decrease in cancer cell viability. These findings highlight the potential use of mandarin peel-derived exosomes as a novel therapeutic approach for glioblastoma. Further studies are warranted to elucidate their molecular mechanisms and optimize their therapeutic efficacy. Overall, our results underscore the promise of utilizing exosomes from agricultural byproducts as sustainable, targeted, and environmentally friendly nanocarriers in cancer therapy.

Keywords: Green technology, biomaterials, plant derived exosomes, cancer, glioblastoma.

Carbonate-Based Materials from Non-Ferrous Die Cast Scraps Used in Energy Storage: Mutual Gains for Industry

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Electrochemical energy storage devices, particularly lithium-ion batteries (LIBs), play a pivotal role in advancing power-efficient, environmentally friendly, and sustainable energy systems to support global development. A critical factor influencing the performance of such energy storage systems lies in the morphological architecture, chemistry and structure of the material used in electrode fabrication, which would affect the electrochemical performance eventually. In recent years, metal carbonates have emerged as a prominent research focus due to their exceptional theoretical capacity, cost-effectiveness, and straightforward synthesis processes. Concurrently, there has been growing emphasis on the repurposing of metallurgical waste to mitigate environmental hazards and address challenges associated with waste management.

In this study, first time in the literature, the utilization of non-ferrous industrial die cast (Zn-%4Al alloy, known as 'zamak') scrap is used to synthesize zinc carbonate based composite anode active materials for LIBs. In this scope, unlike to the conventional method, where the feeding and allimentation components are recuperated and utilized again to feed into the casting laddle with new raw material at a precise ratio, or put aside in casting facilities to be sold as scrap, herein, an inventive method is put forth and an original flow chart is designed for the transformation of these feeding and allimentation components into a micron-sized composite material incorporating aluminum and zinc carbonate. The derived powder was subjected to comprehensive chemical, morphological, and structural characterization. Furthermore, the electrochemical performance of the synthesized material is evaluated through both potentiostatic and galvanostatic analyses to assess its viability as an anode material in lithium-ion batteries.

This production approach, which is less harmful to the environment than synthesis from synthetic chemicals, has provided a low-cost and environmentally friendly solution to produce a high-value-added product. It also fosters mutual benefit between the casting and energy sectors, supporting the diversification of the circular economy into industrial applications.

Keywords: Zamak, energy storage, lithium ion, scrap.