BOOK OF ABSTRACTS

ACSSI 2026

19th Asian Conference on Solid State Ionics

Incorporating ICSMEI 2026

September 13-16, 2026

Montien Hotel Surawong
Bangkok, Thailand

HOSTED BY

Chulalongkorn University

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Acknowledgments

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INTERNATIONAL CONFERENCE ON SUSTAINABLE MATERIALS AND ENVIRONMENTAL INNOVATION

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Message from the Conference Chair

Dear Colleagues and Friends,

It is my great pleasure to welcome you to the **19th Asian Conference on Solid State Ionics (ACSSI 2026)**, incorporating the International Conference on Sustainable Materials and Environmental Innovation (ICSMEI 2026), in Bangkok. On behalf of the Organizing Committee, I am honored to present this Book of Abstracts as a record of the ideas, discoveries, and collaborations that bring our scientific community together.

Solid state ionics continues to play a vital role in addressing some of the defining challenges of our time. Advances in ionic materials and interfaces are opening new paths for safer energy storage, cleaner energy conversion, smarter devices, and more sustainable technologies. The work represented in these pages reflects both the depth of our field and its growing connections with materials science, chemistry, physics, engineering, computation, and environmental innovation.

Bringing ACSSI 2026 and ICSMEI 2026 together creates a valuable opportunity for ideas to move across disciplines and national borders. I encourage every participant to look beyond the formal program: ask thoughtful questions, exchange perspectives, meet new colleagues, and begin collaborations that may continue long after we leave Bangkok. A conference succeeds when presentations become conversations and conversations become shared work.

I extend my sincere appreciation to our invited speakers, authors, session chairs, reviewers, delegates, and exhibitors. I am deeply grateful to every member of the Organizing Committee and the many colleagues working behind the scenes. My thanks also go to Chulalongkorn University, the Asian Society for Solid State Ionics, our ICSMEI 2026 partners, the Electrochemical Society Thailand Section, our supporting organizations, and all sponsors whose contributions have made this conference possible.

May this Book of Abstracts serve as a useful scientific reference and as a reminder of the community gathered here. I hope ACSSI 2026 brings you stimulating discussions, new insights, productive partnerships, and warm memories of your time in Thailand. Welcome to ACSSI 2026, and welcome to Bangkok.

Assoc. Prof. Soorathep Kheawhom, PhD, FRSC

Conference Chair, ACSSI 2026

Department of Chemical Engineering, Faculty of Engineering

Chulalongkorn University

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19th Asian Conference on Solid State Ionics

ACSSI-2026

incorporating ICSMEI 2026

13 – 16 September 2026

Montien Hotel Surawong, Bangkok, Thailand

Hosted by Chulalongkorn University

A board meeting of the Asian Society for Solid State Ionics (ASSSI)
will be held in conjunction with this event

SCIENTIFIC TRACKS

Track 1 — Energy Conversion Materials and Devices

Track 2 — Energy Storage Materials and Devices

Track 3 — Iontronics

Track 4 — Computational Science

Track 5 — ICSMEI 2026

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19th Asian Conference on Solid State Ionics

ACSSI-2026

CONFERENCE PROGRAM

📅 13–16 September 2026

📌 Montien Hotel Surawong, Bangkok, Thailand

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Scientific Tracks

Track 1: Energy Conversion Materials and Devices
Track 2: Energy Storage Materials and Devices
Track 3: Iontronics
Track 4: Computational Science

Day 1 — Monday, 14 September 2026

Plenary & Common Sessions

Time	Session	Presenter	Affiliation	Abstract ID	Title
08.00-09.00	*Registration (Early Morning Break)*				
Location: **Rajamontien 4** MC: **Ravisara Wattana** and **Chanon Pornrungroj**					
09.00-09.40	*1. Opening Remarks (Soorathep Kheawhom, Vice President of Chulalongkorn University, Deans of Faculty of Science & Faculty of Engineering)* *2. Welcome Remarks (Zhaoyin Wen, B.V.R. Chowdari, Sam Sung Ting)* *3. Photo Session*				
Session Chair: **Zhaoyin Wen**					
09.40 - 10.20	Special Lecture	**B.V.R. Chowdari**	National University of Singapore & Nanyang Technological University, Singapore	—	ASSSI & ACSSI – Past, Present and Future Perspectives
Session Chair: **Rojana Pornprasertsuk** and Session Co-Chair: **Sukwon Cha**					
10.20 - 11.00	Plenary 1	**Turgut M. Gür**	Stanford University, Stanford, United States. Chulalongkorn University, Bangkok, Thailand	157	Tera-Watt and Giga-Ton Challenges for Solid State Ionic Devices
11.00 - 11.40	Plenary 2	**Soorathep Kheawhom**	Chulalongkorn University, Bangkok, Thailand	186	Beyond Ionic Conductivity: Coordination-Transport-Interface Design Rules for Durable Sodium Batteries
11.40 - 13.00	*Lunch (Regular Participants: **Montientip Room**, Halal Participants: **Piman Room**)*				
16.00 - 18.00	*ASSSI Board meeting (**An An1 Room**) – Hybrid meeting*				
16.40 - 18.00	*Poster session (**Exhibition Hall**)*				
*Location: **Rajamontien 1-4*** *MC: **Jitti Kasemchainan** and **Manaswee Suttipong***					
17.30 - 21.00	*Banquet (All Oral and Poster Presenters are invited.)* - *Thai performance* - *Sponsor Session* - *Karaoke*				

Track 1 — Energy Conversion Materials and Devices (Location: Rajamontien 1)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Pei-Chen Su** and Session Co-Chair: **Sangwook Park**					
13.00 - 13.20	Keynote	**Tatsumi Ishihara**	Kyushu University, Fukuoka, Japan	30	Double Decker Cell Design for High Performance Solid Oxide Reversible Cells
13.20 - 13.40	Keynote	**Suk-Won Cha**	Seoul National University, Seoul, Korea, Republic of	1	Beyond Performance: Structural Strategies for Robust SOFC Systems
13.40 - 14.00	Keynote	**Minfang Han**	Tsinghua University, Beijing, China	91	Relation of Performance and Reduction Process of NiO-YSZ Anode in Commercial Solid Oxide Fuel Cell
14.00 - 14.20	Keynote	**Chia-Yu Lin**	National Cheng Kung University, Tainan City, Taiwan	12	Ampere-Level Single-Pass CO_2 Electroreduction to CO Using Molecularly Dispersed Phthalocyanine Gas-Diffusion Electrodes
14.20 - 14.40	Oral	**Hyuntak Sohn**	Seoul National University, Seoul, Republic of Korea	43	Compositional Optimization of Ni–YSZ Nanostructured Anode Functional Layers for Thin-Film Anode-Supported SOFCs
14.40 - 15.00	*Afternoon Break*				
Session Chair: **Tatsumi Ishihara** and Session Co-Chair: **Sukwon Cha**					
15.00 - 15.20	Keynote	**Yuji Okuyama**	University of Miyazaki, Miyazaki, Japan	15	Power Generation and Impedance Properties of Protonic Ceramic Fuel Cells Using Barium Zirconate Doped with Ytterbium
15.20 - 15.40	Keynote	**Zhipeng Li**	Northwestern Polytechnical University, Xi'an, Shanxi, China	75	Solid Oxide Fuel Cells: from Materials Research to Industrial Fabrication
15.40 - 16.00	Oral	**Maoqing Liu**	Tsinghua University, Beijing, China	94	A Thermodynamic-Defect-Wagner Unified Model for Oxygen Permeation in MIEC Membranes

Track 2 — Energy Storage Materials and Devices (Location: Rajamontien 4)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Stefan Adams** and Session Co-Chair: **Soorathep Kheawhom**					
13.00 - 13.20	Keynote	**Yogesh Sharma**	Indian Institute of Technology, Roorkee, India	164	Modulating the Na^+ Conductivity to Na Metal Compatibility by Synergistic Doping in Nasicon-Structured $Na_3Zr_2Si_2PO_{12}$ (NZSP)
13.20 - 13.40	Keynote	**Amartya Mukhopadhyay**	Indian Institute of Technology Bombay, Mumbai, India	22	Development of Sustainable and High Energy Density Na-Ion Batteries: Water-Stable 'Layered' Transition Metal Oxide Based Cathodes and 'Alloying Reaction' Based Anode

Time	Session	Presenter	Affiliation	Abstract ID	Title
13.40 - 14.00	Keynote	**Ranjith Thangavel**	Indian Institute of Technology Tirupati, Tirupati, India	173	Hybrid Artificial Solid Electrolyte Interphase (SEI) Layer for Dendrite Free Sodium Metal Anodes
14.00 - 14.20	Oral	**Zerong Deng**	China Three Gorges University, Yichang, China	108	Countering Fluorine Loss in $Na_3V_2(PO_4)_2F_3$ Cathodes: Three Complementary Strategies
14.20 - 14.40	Oral	**Sruthy E S**	Kerala University of Digital Sciences,Thiruvananthapuram, India	170	Biomass Precursor Guided Engineering of Hard Carbon Anodes for Sodium-Ion Batteries
14.40 - 15.00	*Afternoon Break*				
Session Chair: **Jitti Kasemchainan** and Session Co-Chair: **Amartya Mukhopadhyay**					
15.00 - 15.20	Keynote	**Stefan Adams**	National University of Singapore, Singapore, Singapore	153	Durable High Energy Solid-State Batteries by Compressible Light Solid Electrolytes
15.20 - 15.40	Keynote	**Sang-Young Lee**	Yonsei University, Seoul, Korea, Republic of	9	Low-Pressure, Low-Cost All-Solid-State Batteries Enabled by Monomer-In-Salt Polymer Electrolytes
15.40 - 16.00	Invited	**Neelam Srivastava**	Banaras Hindu University, Varanasi, India	37	The Search for Ideal Hosts for Polymer-In-Salt Electrolytes Synthesis:From Fundamentals to Design Rules

Track 3 — Iontronics (Location: Rajamontien 2)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Natthaphon Raengthon** and Session Co-Chair: **Hanxing Liu**					
13.00 - 13.20	Keynote	**Pongsakorn Kanjanaboos**	Mahidol University, Nakhon Pathom, Thailand	25	Perovskite Solar Cells and Radiative Cooling Films as Energy Materials for the Era of Energy Crisis
13.20 - 13.40	Keynote	**Jongin Hong**	Chung-Ang University, Seoul, Republic of Korea; Chulalongkorn University, Bangkok, Thailand	147	Advanced Scanning Probe Microscopy for Ferroelectric and Multiferroic Materials
13.40 - 14.00	Keynote	**Hyung Gyu Park**	Postech, Pohang, Republic of Korea	119	Synaptic Response of 2D Lamellar Architecture via Regulable Ion Release
14.20 - 14.40	Keynote	**Xin Guo**	Huazhong University of Science And Technology, Wuhan, China	106	Solid State Ionics for Information, Energy and Environmental Applications

Time	Session	Presenter	Affiliation	Abstract ID	Title
14.40 - 15.00	*Afternoon Break*				
Session Chair: **Ravisara Wattana** and **Jongin Hong**					
15.00 - 15.20	Keynote	**Daisuke Mori**	Mie University, Tsu, Japan	44	Synthesis, First-Principles Calculations, and Fluorine Ionic Conductivity of Double Perovskite-Type Cs_2RbBiF_6-Based Fluoride
15.20 - 15.40	Keynote	**Wijendra Bandara**	University of Peradeniya, Peradeniya, Sri Lanka	142	Fluorine-Free, Ceramic and Organic Binders for High-Performance Electrochemical Double-Layer Supercapacitors
15.40 - 16.00	Keynote	**Duangmanee Wongratanaphisan**	Materials Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand	197	Passivation Strategies for Sustainable Carbon Electrode-Based Perovskite Solar Cells

Track 4 — Computational Science (Location: Rajamontien 3)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Kota Suzuki** and Session Co-Chair: **Manaswee Suttipong**					
13.00 - 13.20	Keynote	**Manfred Martin**	RWTH Aachen University, Aachen, Germany	7	The Crucial Role of Defect Interactions for Thermodynamics and Kinetics in Solid State Ionics
13.20 - 13.40	Keynote	**Siriporn Jungsuttiwong**	Ubon Ratchathani University, Ubon Ratchathani. Thailand	191	Bridging Experiment and Theory for Next-Generation Energy Storage Materials: Insights from DFT
13.40 - 14.00	Keynote	**Suwit Suthirakun**	Suranaree University of Technology, Nakhon Ratchasima, Thailand	192	Single-Atom Engineering of Mo_2 B_2 O_2 MBene Cathodes for High-Performance Li-S Batteries
14.00 - 14.20	Oral	**Makino Keisuke**	Nagoya Institute of Technology, Nagoya, Japan	2	Thermodynamic Stability Screening Using Anomaly Detection Based Only on Composition Descriptors
14.20 - 14.40	Oral	**Manussada Ratanasak**	University of Tsukuba, Tsukuba, Japan	21	Computational Elucidation of Hydrogen-Bonded Superexchange Pathways in a Humidity-Responsive Tristate Magnetic Spin-Cluster Material
14.40 - 15.00	*Afternoon Break*				
Session Chair: **Manfred Martin** and Session Co-Chair: **Siriporn Jungsuttiwong**					
15.00 - 15.20	Keynote	**Sayato Terashima**	Nagoya Institute of Technology, Nagoya, Japan	10	Analysis of Li-Ion Exchange Reactions at $Li_7La_3Zr_2O_{12}$/$LiCoO_2$ Interfaces Using Machine-Learning Potential
15.20 - 15.40	Keynote	**Kota Suzuki**	Institute of Science Tokyo,	107	Prediction and Experimental Verification: ML-Guided Exploration of Lithium-Ion-

Time	Session	Presenter	Affiliation	Abstract ID	Title
			Yokohama, Japan		Conducting Sulfides

Track 5 — ICSMEI 2026 (Location: An An2 Room)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Sirithan Jiemsirilers**					
13.00 - 13.30	Keynote	**Huirong Le**	Tsinghua University, China	215	Waste Derived Geopolymers - Processing Technologies and Applications
13.30 - 14.00	Keynote	**Alexandra Chirescu**	INCDPM Bucharest, Romania		Evaluating soil amendment strategies for enhancing climate resilience in triticale agroecosystems using the DNDC model
14.00 - 14.20	Invited	**Yeong Yin Fong**	Universiti Teknologi PETRONAS	205	Comparison of Silane-Modified and Unmodified SAPO-34/Polyimide Mixed Matrix Membranes for CO_2 and CH4
14.20 - 14.40	Invited	**Gina Ghita**	INCDPM Bucharest, Romania	206	Assessment of Acetaminophen Contamination in Lakes of the Bucharest Metropolitan Area, Romania, and its Efficient Removal using Chitosan-Based Hybrid
14.40 - 15.00	*Afternoon Break*				
Session Chair: Norazian Mohamed Noor					
15.00 - 15.20	Invited	**Siti Hasnah Kamarudin**	Universiti Teknologi MARA, Malaysia	207	Towards Sustainable Polymer Composites: Tensile Performance, Interfacial Morphology, and Biodegradation Behaviour of Bamboo Fiber- Reinforced Recycled Polypropylene
15.20 - 15.35	Oral	**Florina-Diana Gheorghe**	INCDPM Bucharest, Romania	208	Wastewater Treatment using Hybrid Materials. A Review
15.35 - 15.50	Oral	**Wan Nor Raihan Wan Jaafar**	Universiti Teknologi MARA, Malaysia	209	Surface Modification of Spent Coffee Ground for Composite Production
15.50 - 16.05	Oral	**Monica Matei**	INCDPM Bucharest, Romania	210	Absolute Quantification of Antibiotic-Resistance Genes in Municipal Wastewater using Digital PCR
16.05 – 16.20	Oral	**Georgeta Tudor**	INCDPM Bucharest, Romania	211	Assessing sediment transport in a complex terrain area with sturgeon migration disruption risk using numerical modelling
16.20 – 16.35	Oral	**Dora Ioniță**	INCDPM Bucharest, Romania	212	Urban recreational lakes in Bucharest as reservoirs of fecal and opportunistic microbial contamination
16.35 – 16.50	Oral	**Andra-Gabriela Zorcă**	INCDPM Bucharest, Romania	213	Heavy metals removal from the aquatic system using alginate–agar composite with onion peel additives
16.50 – 17.05	Oral	**Nurul Izzati Natasya Hussin**	Universiti Teknologi MARA, Malaysia	214	Thermal Stability and Antibacterial Activity of Bioplastic Films Incorporating Lemongrass Essential Oil

Day 2 — Tuesday, 15 September 2026

Plenary & Common Sessions

Time	Session	Presenter	Affiliation	Abstract ID	Title
Location: **Rajamontien 4** Session Chair: **Zhaoyin Wen**					
08.00 - 08.30	Special Session	**Zhaoyin Wen and ACSSI Board Members**	Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China	—	*New ACSSI Board Announcement*
08.30 - 08.50	Memorial Talk in **Memory of Prof. Selvasekhara Pandian** (Hybrid Event)				
Session Chair: **Yogesh Sharma** and Session Co-Chair: **Orapa Tamwattana**					
08.50 - 09.30	Plenary 3	**Zhaoyin Wen**	Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China	56	Solid Electrolytes and Application in Energy Storage Batteries
09.30 - 10.10	Plenary 4	**Kisuk Kang**	Seoul National University, Seoul, Republic of Korea	195	Solid State Ionics of Halide Superionic Conductor for Lithium Batteries
10.10 - 10.30	*Morning break*				
11.50 – 13.00	*Lunch (Regular Participants: **Montientip Room**, Halal Participants: **Piman Room**)*				
15.40 - 17.00	*Poster Session + the 2nd Annual ECS Meeting*				

Track 1 — Energy Conversion Materials and Devices (Location: Rajamontien 1)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Yuji Okuyama** and Session Co-Chair: **Junjuda Unruangsri**					
10.30 - 10.50	Keynote	**Jia Guo**	Fudan University, Shanghai, China	134	Emerging Covalent Organic Framework Photocatalysts with Molecular Precision for Sustainable Hydrogen Generation
10.50 - 11.10	Keynote	**Lakshman Dissanayake**	National Institute of Fundamental Studies, Kandy, Sri Lanka	136	Iodide Ionics: Effect of Iodide Ion Conductivity in Efficiency Enhancement in Dye Sensitized Solar Cells
11.10 - 11.30	Invited	**Yan Chen**	South China University of Technology, Guangzhou, China	82	Recovery of Doped-Electrocatalysts from Solid Waste for Catalytic Valorization of Waste-Derived Molecules
11.30 - 11.50	Oral	**Chaowaphat Seriwattanachai**	Mahidol University, Nakhon	50	High-Efficiency and Stable HTL-Free Carbon-Based Perovskite Solar Cells for Indoor

Time	Session	Presenter	Affiliation	Abstract ID	Title
			Pathom, Thailand		Photovoltaics via Facet Control
Session Chair: **Junjuda Unruangsri** and Session Co-Chair: **Shafeer Kalathil**					
13.00 - 13.20	Keynote	**Ashish Garg**	Indian Institute of Technology Kanpur, Kanpur, India	121	Improving Performance and Stability of Perovskite Solar Cells Through Materials Engineering
13.20 - 13.40	Oral	**Sangwook Park**	Seoul National University, Seoul, Republic of Korea	152	Ultrafast Flame Synthesized CuRu and NiFe Catalysts for Alkaline and AEM Water Electrolysis
13.40 - 14.00	Oral	**Akihiro Ishii**	Tohoku University, Sendai, Japan	41	Anion Redox Activity and Stability of One-Dimensional π-Conjugated Li_3BN_2 Polymorphs
14.00 - 14.20	Oral	**Rei Sato**	Tohoku University, Sendai, Japan	42	Fluence Window Determination for Scalable and Reproducible Laser Sintering
14.20 - 14.40	*Afternoon Break*				
Session Chair: **Patchanita Thamyongkit** and Session Co-Chair: **Ashish Garg**					
14.40 - 15.00	Keynote	**Xianwen Mao**	National University of Singapore, Singapore, Singapore	187	Quantitative functional imaging of complex interfaces
15.00 - 15.20	Oral	**Ci Lin**	Hainan University, Haikou, China	23	Regulating the Oxygen Evolution Mechanism Through in Situ Reconstruction of Ru-Modified Manganese Oxybromide
15.40 - 17.00	*Poster Session + the 2nd Annual ECS Meeting*				

Track 2 — Energy Storage Materials and Devices (Location: Rajamontien 4)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Manunya Okawilai** and Session Co-Chair: **Won-Hee Ryu**					
10.30 - 10.50	Keynote	**Jongsoon Kim**	Sungkyunkwan University, Suwon, Republic of Korea	17	Development of High Performance Cathode Materials for Na-Ion Battereis
10.50 - 11.10	Keynote	**Aravindan Vanchiappan**	Indian Institute of Science Education And Research (IISER) Tirupati, Tirupati, India	31	Na-Ion Batteries from Spent Li-Ion Batteries
11.10 - 11.30	Invited	**Kai Zhu**	Harbin Engineering University, Harbin, China	113	Electrode-Electrolyte Interfacial Reconstruction towards Capable Zn Metal Batteries

Time	Session	Presenter	Affiliation	Abstract ID	Title
11.30 - 11.50	Invited	**Jeng-Yu Lin**	Tunghai University, Taichung City, Taiwan	34	Modification of MOF-5 Thin Film on MnO_2 Cathodes for Ultra-Stable Aqueous Zinc-Ion Batteries
Session Chair: **Soorathep Kheawhom** and Session Co-Chair: **Jongsoon Kim**					
13.00 - 13.20	Keynote	**Seokwoo Jeon**	Korea University, Seoul, Republic of Korea	125	Connecting Electrochemical Property with Structural Factor of 3D Nanostructure
13.20 - 13.40	Keynote	**Jae Hyun Kim**	DGIST, Daegu, Republic of Korea	27	Functional Materials Design of Polymer Electrolytes for Next-Generation Energy Storage
13.40 - 14.00	Keynote	**Hans-Jürgen Meyer**	University of Tübingen, Tübingen, Germany	13	A Complete Cathode Recovery Cycle of an Exhausted and Dismantled Lithium Battery Material
14.00 - 14.20	Keynote	**Won-Hee Ryu**	Yonsei University, Seoul, Republic of Korea	61	Lithium Metal–Air Batteries: from Fundamental Gas-Phase Electrochemistry to Atmospheric Open-Cell Energy Storage
14.20 - 14.40	*Afternoon Break*				
Session Chair: **Jiaqian Qin** and Session Co-Chair: **Aravindan Vanchiappan**					
14.40 - 15.00	Keynote	**Raju Kumar Gupta**	Indian Institute of Technology Kanpur, Kanpur, India	156	Material-To-Cell Integration for High-Performance Sodium-Ion Batteries
15.00 - 15.20	Keynote	**Yanbing He**	Tsinghua University, Shenzhen, China	76	Advanced Solid Electrolyte Interphase for Solid-State Lithium Batteries
15.20 - 15.40	Keynote	**Quan-Hong Yang**	Tianjin University, Tianjin, China	131	Sieving is believing: what is right carbon for sodium batteries?
15.40 – 16.00	Invited	**Abhik Banerjee**	TCG Crest, Kolkata, India	188	Engineering Fluorine Chemistry in Chloride Solid Electrolytes for Next-Generation Li-Metal Batteries

Track 3 — Iontronics & Track 2 — Energy Storage (Afternoon) (Location: Rajamontien 2)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Seokwoo Jeon** and Session Co-Chair: **Numpon Insin**					
10.30 - 10.50	Keynote	**Rajendra K. Singh**	Banaras Hindu University, India	201	Next-generation sodium-ion battery cathode materials for battery energy storage: performance optimization, recent advances, and future perspectives
10.50 - 11.10	Keynote	**Kandalam V. Ramanujachary**	Rowan University, USA	200	Nephelauxetic Study of Photoluminescence in Structurally and Anionically Modified Materials

Time	Session	Presenter	Affiliation	Abstract ID	Title
11.10 - 11.30	Oral	**Dipti Yadav**	Jaypee Institute of Information Technology, Noida, India	46	Flexible Polysaccharide-Based Polymer-In-Salt-Electrolytes (PISEs) Doped with Magnesium Salt for All-Solid-State Ultra-Capacitor: Anion Effect
11.30 – 11.50	Oral	**Zhenshen Li**	Tianjin University, Tianjin, China	123	Low-Ion-Electron Transport Strategy Minimizes Electrolyte Oxidation for Stable All-Solid-State Batteries without Cathode Modification
Session Chair: **Raju Kumar Gupta** and Session Co-Chair: **Prasit Pattananuwat**					
13.00 - 13.20	Keynote	**Takeshi Yajima**	Nagoya University, Nagoya, Japan	16	Single-Crystal Studies on Conduction Mechanisms in Lithium Superionic Conductors
13.20 - 13.40	Keynote	**Feng LI**	Chinese Academy of Sciences, Shenyang, China	140	Ion Mobility in Polymer-Based Solid-State Batteries
13.40 - 14.00	Invited	**Jiayun Wen**	University of Shanghai For Science And Technology, Shanghai, China	141	Interface Engineering and Wetting Behavior Study of Solid-State Lithium Metal Batteries
14.00 - 14.20	Oral	**Junjie Wang**	Tianjin University, Tianjin, China	126	Size-Dependent Trade-Off between Sulfur Catalysis and Sulfide Electrolyte Decomposition for Room-Temperature Ultrahigh-Rate All-Solid-State Li-S Batteries
14.20 - 14.40	*Afternoon Break*				
Session Chair: **Seokwoo Jeon** and Session Co-Chair: **Jae Hyun Kim**					
14.40 - 15.00	Invited	**Ming Liu**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	66	A Direct View on Li Ions Transport in Solid State Batteries
15.00 - 15.20	Invited	**Pulkit Garg**	Indian Institute of Technology Jammu, Jammu, India	165	Tailoring $ZnMn_2O_4$ Through Metal Doping for Enhanced Zinc-Ion Hybrid Supercapacitor Performance
15.20 - 15.40	Invited	**Brindha Moorthy**	Indian Institute of Technology Tirupati, Tirupati, India	179	Design and Optimization of High-Performance Cathode Materials for Sodium-Ion Batteries

Track 4 — Computational Science (Morning) & Track 2 — Energy Storage Materials and Devices (Afternoon) (Location: Rajamontien 3)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Manaswee Suttipong** and Session Co-Chair: **Wanwisa Limphirat**					
10.30 - 10.50	Keynote	**Gregory Offer**	Imperial College London, London, United Kingdom	146	Predicting the Lifetime of Lithium-Ion and Next Generation Batteries via Physics Based Modelling
10.50 - 11.10	Invited	**Hui Xia**	Nanjing University of Science and Technology, Nanjing, China	64	Manganese-Based Cathode Design and Interface Modulation for High-Performance Sodium-Ion Batteries
11.10 - 11.30	Oral	**Yoshiya Matsuoka**	Nagoya Institute of Technology, Nagoya, Japan	8	Atomistic Insights into Ion Transport at Ceramics–Polymer Composite Electrolyte Interfaces via Neural Network Potential Molecular Dynamics
11.30 - 11.50	Oral	**Ali Hassan**	Chulalongkorn University, Bangkok, Thailand	143	Molecular Dynamics Investigation of PEO-Modified Sodium-Ion Liquid Electrolytes
Session Chair: **Anongnat Somwangthanaroj** and Session Co-Chair: **Manfred Martin**					
13.00 - 13.20	Invited	**Chunpeng Yang**	Tianjin University, Tianjin, China	67	AI-Assisted Study on Solid-State Electrolytes for Lithium Batteries
13.20 - 13.40	Invited	**Chunxi Hai**	Chengdu University of Technology, Chengdu, China	24	Configuring Highly Ultra-Stable $Na_3V_2(PO_4)_3$ Cathodes for Long-Cycle-Life Sodium-Ions Batteries
13.40 - 14.00	Oral	**Yichun Zhao**	Wuhan University of Technology, Wuhan, China	114	3D MOF-Derived Novel CuF_2 Nanocubes as Cathode: Porous Structure Design and Application in High Energy Density Primary Batteries
14.00 – 14.20	Invited	**Ahmad Azmin Mohamad**	Universiti Sains Malaysia, Malaysia	230	Mn Doping on the Structural, Surface, and Electrochemical Properties of $SrTiO_3$ for Hybrid Supercapacitors
14.20 - 14.40	*Afternoon Break*				
Session Chair: **Rojana Pornprasertsuk** and Session Co-Chair: **Hans-Jürgen Meyer**					
14.40 - 15.00	Oral	**Jeet Sharma**	The University of New South Wales (UNSW), Sydney, Australia	159	Liquid Crystal Display-Printed Programmable Nanochannels via Photo-PIMS for Lithium Metal Batteries
15.00 - 15.20	Oral	**Maya Das**	Tribhuvan University, Kathmandu, Nepal	184	Zinc Functionalized Reduced Graphene Oxide Hydrogel: a Potential Paradigm for Advanced Energy Storage Applications
15.20 - 15.40	Oral	**Daya Rani**	INST Mohali, Mohali, India	154	Nitrogen-Doped Carbon Interfaces to Regulate Lithium Transport in Entropy-Stabilized Oxides for Lithium Storage
15.40 - 16.00	Oral	**Qidi Zhang**	Harbin Engineering University, Harbin, China	158	Interfacial Engineering of Lithium Metal Anodes for Next-Generation High-Energy-Density Batteries

Track 5 — ICSMEI 2026 (Location: An An 2 Room)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Orathai Boondamnoen**					
10.30 – 11.00	Keynote	**Lai Chin Wei**	Universiti Malaya, Malaysia	204	Advancing Environmental Remediation with Titanium Dioxide-Based Nanoparticles: From Innovation to Real-World Applications
11.00 - 11.30	Keynote	**Pei-Chen Su**	Nanyang Technological University, Singapore	193	Hydrogen-Free Exsolution of Socketed Ir-Fe Nanoalloys for Stable SOC Air Electrodes
11.30- 11.50	Invited	**Thiam Leng Chew**	Universiti Teknologi PETRONAS, Malaysia	216	Mixed Matrix Membranes Incorporated with Mesoporous Silica MSU-2 for Enhancement in CO_2/CH_4 Permeation
11.50 - 13.00	*Lunch*				
Session Chair: **Irnis Azura Zakarya**					
13.00 – 13.15	Oral	**Mohamad Azim Faris Bin Roslee**	Universiti Tun Hussein Onn, Malaysia	217	Design of Experiments (DOE) for the Parametric Study of a Multi-Axis Air Injection Banana Fiber Opener
13.15 – 13.30	Oral	**Raynabelle Emilia Raymond**	Universiti Tun Hussein Onn, Malaysia	218	Development and Finite Element Analysis of a Pneumatic Needle-Punching Machine for Laboratory-Scale Nonwoven Production
13.30 - 13.45	Oral	**Wei Sing Yong**	Swinburne University of Technology Sarawak Campus, Malaysia	219	Cellulose nanocrystals reinforced paint: rheological evaluation and performance study
13.45 – 14.00	Oral	**Chanon Manee**	Chulalongkorn University, Thailand	220	Exploration of Shelf-Life Extension and Antimicrobial PVA Biocomposite Films Incorporating Eggshell Membrane-Derived Collagen and Rhinacanthin-C Extract from
14.00 - 14.15	Oral	**M. Amirulhusni M.Fadzir**	Universiti Tun Hussein Onn, Malaysia	221	Stability of biopolymer from renewable resources
14.15 - 14.40	*Afternoon Break*				
Session Chair: **Irnis Azura Zakarya**					
14.40 – 14.55	Oral	**Sovankongkea Som**	Chulalongkorn University, Thailand	222	Influence of TPS/ENR Ratio and MCC Incorporation on Blend Morphology and Mechanical Performance
14.55 – 15.10	Oral	**Amin Suffian bin Suleiman**	Universiti Tun Hussein Onn, Malaysia	223	Physical Characterization of Waste oil Polymer Composite After Prolonged Storage
15.10 - 15.25	Oral	**Ahmad Shawqee Hasan**	Universiti Tun Hussein Onn, Malaysia	224	Theoretical Framework for BIM Personnel Competencies: A Review of Technical and Non-Technical Competencies in the Construction Industry
15.25- 15.40	Oral	**Theara Yann**	Chulalongkorn University, Thailand	225	Natural Rubber Fibrous Mats via Solution Blow Spinning: Effect of Processing Parameters on Fiber Formation
15.40-15.55	Oral	**Alvin Guo Jian Lee**	Swinburne University of Technology Sarawak Campus, Malaysia	226	Operating pH influencing nickel and zinc carbonation using bicarbonate-carbonate from CO2 capture with NaOH-CaCO3

Time	Session	Presenter	Affiliation	Abstract ID	Title
15.55-16.10	Oral	**Daniel Nyuin Alfred Damu**	Swinburne University of Technology Sarawak Campus, Malaysia	227	Utilisation of captured CO2 as calcium bicarbonate with silicomanganese slag for sustainable pressed brick production
1610-16.25	Oral	**Sk Md Kamal Uddin**	Khulna University of Engineering & Technology (KUET), Bangladesh	228	Investigating the potential of jute hurd for sustainable bio-composite construction materials

Day 3 — Wednesday, 16 September 2026

Plenary & Common Sessions

Time	Session	Presenter	Affiliation	Abstract ID	Title
Location: **Rajamontien 4** Session Chair: **Nipapan Ruecha** and Session Co-Chair: **Pawin Iamprasertkun**					
08.30 - 09.10	Plenary 5	**Charles S Henry**	Colorado State University, Fort Collins, United States	103	Electrochemical Detection in Microfluidics: Innovations for Affordable and Portable Analytical Sensing
09.10 - 09.50	Plenary 6	**Ming-Kang Tsai**	National Taiwan Normal University, Taipei, Taiwan	14	Quantitative Predictions for the Molecular Properties of Metal-Ligand Coordination Compounds Using Chemical Text-Based Information
09.50 - 10.10	*Morning break*				
Location: **Rajamontien 4** Session Chair: **Yogesh Sharma**					
11.50 - 12.20	*Award Announcement and Appreciation Remarks (by ASSSI New Board Committee)*				
12.20 - 13.30	*Lunch (Regular Participants: **Montientip Room**, Halal Participants: **Piman Room**)*				

Track 1 — Energy Conversion Materials and Devices (Location: Rajamontien 1)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Pinit Kidkhunthod** and Session Co-Chair: **Sangwook Park**					
10.10 - 10.30	Keynote	**Wanwisa Limphirat**	Synchrotron Light Research Institute	199	X-ray Absorption Spectroscopy at SLRI for Advanced Energy Conversion and Storage Materials
10.30 - 10.50	Keynote	**Chinmoy Ranjan**	Indian Institute of Science, Bengaluru, India	172	High Temperature CO_2 Electrolysis: Operando Studies
10.50 - 11.10	Invited	**Ping He**	Nanjing University, Nanjing, China	169	Electrocatalytic Energy Storage
11.10 - 11.30	Invited	**Yihan Ling**	China University of Mining And Technology, Xuzhou, China	65	The Anode Support of Microporous Channels Can Safely and Efficiently Convert and Utilize Low Concentration Coal Mine Methane in High-Temperature Fuel Cells
11.30 - 11.50	Oral	**Abdul Basit**	Harbin Institute of Technology, Harbin, China	110	Effects of RF Plasma Treatment on the Electrolyte for Intermediate Temperature Solid Oxide Fuel Cells

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Chanon Pornrungroj** and Session Co-Chair: **Ravisara Wattana**					
13.30 - 13.50	Invited	**Jianghua Chen**	Hainan University, Haikou, China	26	Quantitative and 3D Imaging in Electron Microscopy for Materials Science
13.50 - 14.10	Oral	**Sanni Lawal Enesi**	Federal University Dutse, Jigawa, Nigeria	98	Development of Cobalt Doped Activated Carbon Nanomaterial Derived from Biowaste as an Efficient Electrocatalyst for Hydrogen Generation
14.10 - 14.30	Oral	**Manasi Murmu**	Chonnam National University, Republic of Korea	151	ALD Enabled Interface Engineering of WO_3/MXene/FeOOH Photoanodes for Efficient Photoelectrochemical Water Oxidation
14.30 - 14.50	Oral	**Nathawuth Wongwutcharanukoun**	Tohoku University, Sendai, Japan	32	Understanding the Role of Cobalt Substitution in Low-Temperature Oxygen Surface Exchange of $SrTi_{1-x}FexO_{3-\delta}$
14.50 - 15.10	Invited	**Huiyu Zhang**	Xi'an Jiaotong University, Xi'an, China	105	Mechanism of Synergistic Regulation between Electrochemical Performance and Thermal Uniformity for Segmented Series Tubular Solid Oxide Fuel Cells with Direct Internal Methane Reforming

Track 2 — Energy Storage Materials and Devices (Location: Rajamontien 4)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Prasit Pattananuwat** and Session Co-Chair: **Panawan Vanaphuti**					
10.10 - 10.30	Keynote	**Wei-Ren Liu**	Chung Yuan Christian University, Taoyuan, Taiwan	190	Oxygen Vacancies Engineering to Boost Li-Ion Transport and Cycling Stability in $TiNb_2O_7$ Anodes
10.30 - 10.50	Keynote	**Derrick Fam Wen Hui**	Institute of Materials Research and Engineering (IMRE), A*STAR	202	Polymer-Based, Mechanically-Robust, All-Solid-State Batteries
10.50 - 11.10	Keynote	**Hong Li**	Institute of Physics, CAS, Beijing, China	196	R&D on In Situ Solidification
11.10 - 11.30	Invited	**Mani Pujitha Illa**	National Institute of Technology Tiruchirappalli, Tiruchirappalli, India	175	Upcycling Spent Graphite for Multivalent Aqueous Zinc-Ion and Aluminum-Ion Batteries
11.30 – 11.50	Invited	**Shu-Hao Chang**	Chung Yuan Christian University, Taoyuan City, Taiwan	160	Designing Current Collectors and Interfaces for Stable Lithium and Zinc Metal Batteries

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Derrick Fam Wen Hui** and Session Co-Chair: **Orapa Thamwattana**					
13.30 - 13.50	Invited	**Hongqiang Wang**	Guangxi Normal University, Guilin, China	99	Research on Electrode Materials for High-Energy-Density Lithium-Ion Batteries
13.50 - 14.10	Oral	**Sudarshan Narayanan**	Indian Institute of Technology Kanpur, Kanpur, India	189	Ion-Transport Enhancement Strategies for High-Performance NASICON-Type Na-Ion Solid-State Battery Electrolytes
14.10 - 14.30	Oral	**Yuki Nagao**	Japan Advanced Institute of Science and Technology, Nomi, Japan	11	Decoupling Interfacial Proton Transport in Thin Polymer Electrolytes
14.30 - 14.50	Invited	**Ya You (Online)**	Wuhan University of Technology, Wuhan, China	62	Construction of Electrolyte for Batteries toward Extreme Temperature Application
14.50 – 15.10	Invited	**Ya Chen (Online)**	Shanghai Jiao Tong University, Shanghai, China	58	Multi-Scale Interfacial Design for Inorganic All-Solid-State Lithium Metal Batteries

Track 2 — Energy Storage Materials and Devices (Location: Rajamontien 2)

Time	Session	Presenter	Affiliation	Abstract ID	Title
Session Chair: **Pawin Iamprasertkun** and Session Co-Chair: **Orapa Thamwattana**					
10.10 - 10.30	Invited	**Insik In**	Korea National University of Transportation, Chungju, Korea, Republic of	231	Surface-functionalized MXene (f-MXene) towards energy storage
10.30 - 10.50	Invited	**Chen-Zi Zhao**	Tsinghua University, Beijing, China	39	Designing Electrolytes for 600 Wh kg−1 Lithium Batteries
10.50 - 11.10	Invited	**Chilin Li**	Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China	84	Recent Progresses of Fluoride Batteries
11.10 – 11.30	Oral	**Debin Kong**	China University of Petroleum (East China), Qingdao, China	194	Lithium-Chlorine Batteries and Associated Critical Materials
Session Chair: **Panawan Vanaphuti** and Session Co-Chair: **Pawin Iamprasertkun**					
13.30 - 13.50	Invited	**Xin Ao**	Nanchang University, Nanchang, China	93	Strategies for Enhancing PEO-Based Polymer Solid-State Electrolytes

Time	Session	Presenter	Affiliation	Abstract ID	Title
13.50 - 14.10	Oral	**Yimeng Huang**	Tongji University, Shanghai, China	78	Integrated Rocksalt-Polyanion Cathodes for High-Energy and Stable Lithium-Ion Batteries
14.10 - 14.30	Oral	**Guang Sun**	Tongji University, Shanghai, China	73	Dynamic Structural Adaptation in Halide Cathodes for All-Solid-State Lithium Batteries

Special Session: Thai-UK Workshop (Morning) + Track 2 — Energy Storage Materials and Devices (Afternoon) (Location: Rajamontien 3)

Note: Track 3 and Track 4 ran out of scheduled speakers by 15 September noon. From this point onward, this meeting room also hosts Track 2 — Energy Storage Materials and Devices presentations. The room/track assignment itself is unchanged.

Time	Session	Presenter	Affiliation	Abstract ID	Title
09.00 - 09.30	Keynote	**Jiaqian Qin**	Chulalongkorn University, Bangkok, Thailand	—	Surface Modification of Copper Current Collectors and Solid-State Electrolytes for Advancing Lithium Metal Batteries
09.30 - 09.45	Invited	**Jingwen Weng**	Imperial College London, London, United Kingdom	150	Battery Thermal Safety and Phase-Change-Materials-Based Thermal Management Strategy
09.45 – 10.00	Invited	**Mohammed Asheruddin Nazeeruddin**	Imperial College London, London, United Kingdom	149	Physics-Based Modelling of LFP Cell and Pack Performance under Thai Climatic and Driving Conditions
10.00 – 12.00	**Panel Discussion and Battery Modelling Workshop**				

Special Session: Green Hydrogen and Advanced Characterization Workshop and Seminar

Time	Session	Presenter	Affiliation	Abstract ID	Title
13.30 – 13.40	Invited	**Chanon Pornrungroj**	Chulalongkorn University, Thailand		
13.40 – 13.50	Invited	**Pawin Iamprasertkun**	Sirindhorn International Institute of Technology, Thailand		
13.50 – 14.00	Invited	**Manunya Okhawilai**	Chulalongkorn University, Thailand		
14.00 – 14.10	Invited	**Wanwisa Limphirat**	Synchrotron Light Research Institute, Thailand		

Time	Session	Presenter	Affiliation	Abstract ID	Title
14.10 – 14.20	Invited	**Wisit Hirunpinyopas**	Kasetsart University, Thailand		
14.20 – 15.00	**Panel Discussion**				

Poster Presentations (Location: Exhibition Hall)

Poster presenters are split evenly across the two poster sessions and grouped by track below.

Poster Session — Day 1 (Monday, 14 September 2026, 16.40 – 18.00)

Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
Track 1 — Energy Conversion Materials and Devices					
P-01	Track 1	**Suhyuk Ko**	Seoul National University, Seoul, Republic of Korea	36	Highly Textured BZY Thin Films with Enhanced Proton Conductivity for Proton-Conducting Solid Oxide Cells
P-02	Track 1	**Daniel Gil**	Seoul National University, Seoul, Republic of Korea	40	Effect of Anode Nanostructures on the Electrochemical Performance of Thin-Film SOFCs Fabricated on Nanoporous AAO Substrates
P-03	Track 1	**Inyoung Jeong**	Seoul National University, Seoul, Republic of Korea	45	Redox-State Engineering of Ni/GDC Thin-Film Anodes for Carbon-Tolerant Syngas-Fueled SOFCs
P-04	Track 1	**Feungsiri Jankrajangjaeng**	Chulalongkorn University, Bangkok, Thailand	48	Micro-Honeycomb Monolith Fabricated by Ice-Templating for Enhanced Photocatalytic Hydrogen Production Couple with Alcohol Oxidation
P-05	Track 1	**Yuan Gao**	China University of Mining And Technology, Xuzhou, China	60	In-Situ Formed High-Entropy Composite Air Electrode with Brilliant Tri-Phase Conductivity for Proton-Conducting Tubular Solid Oxide Cell
P-06	Track 1	**Jiahong Hu**	University of Science And Technology of China, Hefei, China	69	Anode Supported Solid Oxide Fuel Cells with Enhanced Mechanical Strength and Thermal Cycle Stability
P-07	Track 1	**Thanakorn Khumtong**	Ubon Ratchathani University, Ubon Ratchathani, Thailand	54	Annealing-Temperature-Driven Structural Evolution and Photoelectrochemical Performance of Well-Defined Iron Oxide Nanorod Arrays
P-08	Track 1	**Darinee Phromyothin**	King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand	53	Electrochemical Detection of Salbutamol Using the Molecular Imprinted Polymer Technique with Nano Copper Oxide
P-09	Track 1	**Narathon Khemasiri**	King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand	55	Unveiling the Crucial Role of Post-Annealing in Crystal Structure Evolution and Photoelectrochemical Performance of $BiVO_4$ Films for Self-Powered H_2O_2 Detection
P-10	Track 1	**Jiawen Jian**	Ningbo University, Ningbo, China	83	Study and Application of High-Temperature Solid Electrolyte Gas Sensors
Track 2 — Energy Storage Materials and Devices					
P-11	Track 2	**Sunglun Kwon**	The Catholic University of Korea, Bucheon-Si, Republic of Korea	4	Electrochemical Formate and CO Reduction Utilizing LDH(Layered Double Hyroxide) Nanosheet

Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
P-12	Track 2	**Hyeryun Jeong**	GIST, Gwangju, Korea, Republic of	5	Multidimensional Chemical–Biological Evaluation of Encapsulation Materials for Implantable Micro-LED Bioelectronic Interfaces
P-13	Track 2	**Riku Imanishi**	Mie University, Tsu, Japan	29	Lithium Metal Electrode Coated with Inorganic Thin Film by Pulsed Laser Deposition
P-14	Track 2	**Wasinee Sirifongnukul**	Chulalongkorn University, Bangkok, Thailand	47	Development of Semi-Transparent 3D Structured Conductive Electrode
P-15	Track 2	**Yudai Huang**	College of Chemistry, Xinjiang University,, Urumqi, China	57	Design and Stabilization Mechanism of the Negative Electrode Interface for Aqueous Zinc-Ion Batteries
P-16	Track 2	**Jun Jin**	Chinese Academy of Sciences, Shanghai, China	68	Single-Atomic Triggered Fast Redox Conversion in Li-S Batteries
P-17	Track 2	**Xiangwei Wu**	Chinese Academy of Sciences, Shanghai, China	88	Structure Design of the Cathode Enables Na-$NiCl_2$ Batteries with High Rate and Long Cycling Performance
P-18	Track 2	**Huijian Wang**	Hunan University, Changsha, China	102	Solid-To-Solid Zn Anode and Interhalogen Iodine Cathodes for High-Voltage Fluoride-Ion Batteries
P-19	Track 2	**Yuan Zhou**	Chengdu University of Technology, Chengdu, China	28	Preparing High-Performance Resin-Based Hard Carbon for Sodium-Ion Batteries
P-20	Track 2	**Gia-Linh Huynh**	Chulalongkorn University, Bangkok, Thailand	90	All-Solid-State Electrode for Potentiometric Chloride Detection in Biological Fluids
P-21	Track 2	**Xiao Liang**	Hunan University, Changsha, China	100	Earth-Abundant Elements for High-Energy Rechargeable Batteries
P-22	Track 2	**Parame Janson**	Chulalongkorn University, Bangkok, Thailand	49	Direct Regeneration of Spent $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532) Cathodes via Carbon Flotation and LiI-LiOH Eutectic Molten Salt
P-23	Track 2	**Bumjoon Kim**	KAIST, Daejeon, Korea, Republic of	33	Elastomeric Electrolytes and Protective Layers for Stable Operation of Lithium Metal Batteries
Track 3 — Iontronics					
P-24	Track 3	**Mingdeng Wei**	Fuzhou University, Fuzhou, China	63	Amorphization of Zirconium-Based Halide Electrolytes for All-Solid-State Batteries
P-25	Track 3	**Sisi Liu**	Tianjin University, Tianjin, China	71	A Dense Fluorinated Composite Polymer Electrolyte Featuring Fluoride- Rich Interface for Long-Life Lithium Batteries
P-26	Track 3	**Zichang You**	China; University of Chinese Academy of Sciences, Beijing, China	77	In Situ Grain Boundary Engineering Enabling Ultra-Long Stable Cycling Garnet-Based Solid-State Electrolytes
P-27	Track 3	**Weijie Liu**	Tsinghua Shenzhen International Graduate	118	Coupling Coordination Structures and Superionic LithiumConduction in Amorphous Oxyhalide Solid-State Electrolytes

Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
			School, Shenzhen, China		
P-28	Track 3	**Chien-Pan Liu**	Tunghai University., Taichung City, Taiwan	35	UV-Cured Fluorinated All-Component Crosslinked Solid Polymer Electrolytes via Diazide Nitrene Insertion for High-Voltage Solid-State Lithium Metal Batteries
P-29	Track 3	**Xiaorong Dong**	Chinese Academy of Sciences, Shanghai, China	104	Tailoring Solvation Structure via Soft-Hard Segment Synergy in Gel Polymer Electrolytes Enables Dendrite-Free Sodium Batteries with Ultra-Long Cycling
Track 4 — Computational Science					
P-30	Track 4	**Kittiyaporn Siaosuk**	Chulalongkorn University, Bangkok, Thailand	148	Molecular Dynamics Insights into Anion-Dependent Solvation and Ion Transport in DME-Based Sodium-Ion Battery Electrolytes
P-31	Track 4	**Yujin Oh**	Sejong University, Seoul, Korea, Republic of	177	Compositional Engineering of High-Conductivity Amorphous Sulfide Electrolytes via Data-Driven Optimization

Poster Session — Day 2 (Tuesday, 15 September 2026, 15.40 – 17.00)

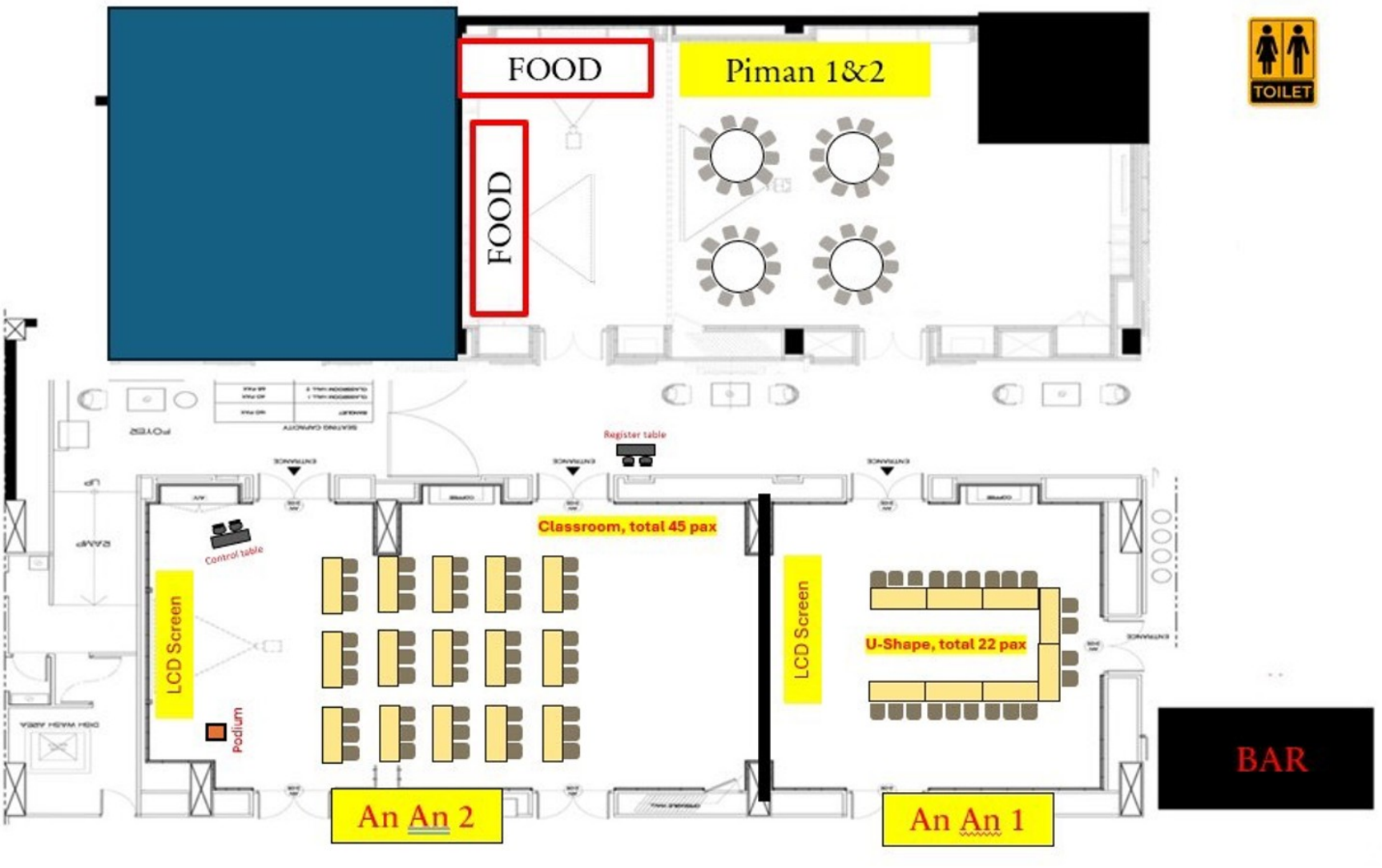
Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
Track 1 — Energy Conversion Materials and Devices					
P-01	Track 1	**Bo Wei**	Harbin Institute of Technology, Harbin, China	79	Turning Detrimental Segregation into Beneficial Surface Reconstruction in Double Perovskites for SOFCs
P-02	Track 1	**Hongru Hao**	Harbin Institute of Technology, Harbin, China	80	F-Doped $GdBaCo_2O_{5+\delta}$ Layered Perovskite Cathodes for Enhanced Oxygen Reduction Activity and CO_2 Tolerance
P-03	Track 1	**Jian Zhou**	Harbin Institute of Technology, Harbin, China	81	Etching Promoted Surface Reconstruction of $PrNi_{0.3}Co_{0.7}O_3$ for Enhanced Oxygen Electrocatalysis
P-04	Track 1	**Hailu Dai**	Yancheng Institute of Technology, Yancheng, China	89	$La_{0.5-x}ScxSr_{0.5}MnO_{3-\delta}$ Cathodes for Proton-Conducting Solid Oxide Fuel Cells: Taking Advantage of the Secondary Phase
P-05	Track 1	**Chalinee Auanphui**	Chulalongkorn University, Bangkok, Thailand	138	A Laser-Induced Graphene-Based Potentiometric Aptasensor for Escherichia Coli Detection: Comparative Performance of Cationic and Anionic Marker Ions
P-06	Track 1	**In Won Choi**	Seoul National University, Seoul, Korea, Republic of	166	Enhanced Activity and Durability of a Layered Double Perovskite Oxygen Electrode via Niobium Doping for Intermediate-Temperature Reversible Solid Oxide Cells
P-07	Track 1	**Pravesh Negi**	Indian Institute of Technology Roorkee, Roorkee, India	180	Engineering Silicon Nanostructures for Efficient Solar-Driven Hydrogen Evolution
P-08	Track 1	**Napol Chuanchart**	Chulalongkorn University,	185	A Net-Structured Graphene–Chitosan Electrochemical Immunosensor for Sensitive

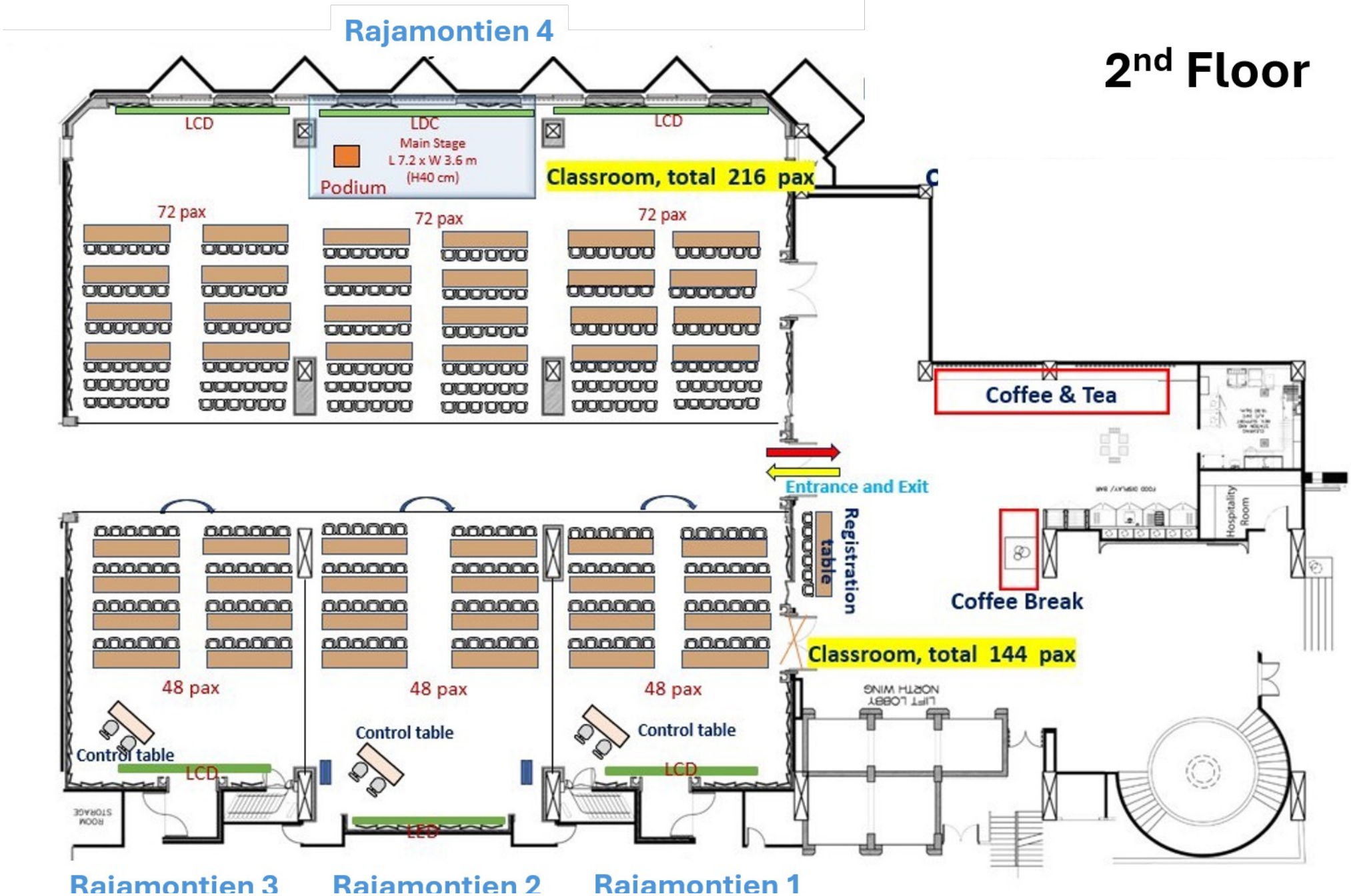
Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
			Bangkok, Thailand		Detection of Mpox Virus
P-09	Track 1	**Nichapat Parvilairut**	Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, Thailand	229	CoII-Phthalocyanine-based Photoanodes for Photoelectrochemical Water Oxidation
Track 2 — Energy Storage Materials and Devices					
P-10	Track 2	**Junwei Liang**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	109	Longitudinal Spatial Charge Transfer Optimization in Composite Cathodes Enables Ultra-Stable All-Solid-State Batteries
P-11	Track 2	**Guanyou Xiao**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	116	In-Situ Polymerized Composite Electrolytes for High-Voltage Solid-State Lithium Metal Batteries
P-12	Track 2	**Nan Fang**	Tsinghua University, Shenzhen, China	117	Efficient Ion Percolating Network and Interfacial Engineering for PVDF-Based Solid-State Battery with High Loading Cathode and Long-Cycling-Life
P-13	Track 2	**Zhenshen Li**	Tianjin University, Tianjin, China	123	Low-Ion-Electron Transport Strategy Minimizes Electrolyte Oxidation for Stable All-Solid-State Batteries without Cathode Modification
P-14	Track 2	**Zhenhan Xie**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	132	Activating Interfacial Ion Exchange in Composite Electrolytes for High-Rate and Long-Cycling Solid-State Lithium Batteries
P-15	Track 2	**Hui Dou**	Nanjing University of Aeronautics and Astronautics, Nanjing, China	133	Fast Deposition Kinetics Enabled by $Na_{15}Sn_4$/NaBr Interphase Engineering for Superior Sodium Metal Batteries at Room and Low Temperatures
P-16	Track 2	**Aamir Khan**	Chulalongkorn University, Bangkok, Thailand	176	Green Synthesis of AuNPs and GO-AuNPs Nanocomposite Using Withania Cogulans Seed Extract.
P-17	Track 2	**Asha Chaudhary**	IIT Roorkee, Roorkee, India	182	Calcination Temperature Effect on the Morphology of NVP/Carbon Nanofibers and the Performance of the Optimized Cathode
P-18	Track 2	**Rahul Patel**	India Institute of Technology Roorkee, Roorkee, India	183	Improved PEMFC Performance via Sulfamic Acid-Doped SPEEK/MIL-101 Membranes
P-19	Track 2	**Chatmongkhon Konwitthayasin**	Chulalongkorn University, Bangkok, Thailand	178	Effects of Mn_2O_3 Content on the Phase Formation and Sintering Behavior of $Na_3Zr_2Si_2PO_{12}$ Prepared by Reactive Sintering from the $Na_2ZrSi_2O_7$-ZrO_2-$NaPO_3$ System
P-20	Track 2	**Tham Le Mai Hong**	Chulalongkorn University, Bangkok, Thailand	181	Mn-Doped $NiCo_2S_4$ Composite with Bifunctional ORR/OER Activities in Rechargeable Zinc-Air Batteries
P-21	Track 2	**Chonnamas Piadsoongnern**	Chulalongkorn University, Bangkok, Thailand	144	Preparation of Manganese Dioxide/Graphitic Carbon Nitride Photocatalyst Composites for Dye Degradation under Visible Light Irradiation

Poster No.	Track	Presenter	Affiliation	Abstract ID	Title
Track 3 — Iontronics					
P-22	Track 3	**Zheng Zhang**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	120	A Ductile Solid Electrolyte Interphase for Solid-State Batteries
P-23	Track 3	**Junjie Wang**	Tianjin University, Tianjin, China	126	Size-Dependent Trade-Off between Sulfur Catalysis and Sulfide Electrolyte Decomposition for Room-Temperature Ultrahigh-Rate All-Solid-State Li-S Batteries
P-24	Track 3	**Kang-Rui Ren**	Tsinghua Shenzhen International Graduate School, Shenzhen, China	128	Supramolecular Ligands Enable Efficient Ion Transport in Solid-State Lithium Batteries
P-25	Track 3	**Zhiyuan Zhu**		130	Oxygen-Rich Crosslinker Modulated Weakly-Solvating Gel Polymer Electrolyte for Stable High-Voltage Lithium Metal Batteries
P-26	Track 3	**Ke Yue (Cancelled)**	Zhejiang University of Technology, Hang Zhou, China	171	Low-LUMO Orotic Acid Enables Li_3N-Embeded Solid Electrolyte Interphase for Stable All-Solid-State Lithium Metal Batteries
P-27	Track 3	**Jiajie Wen**	Shanghai Institute of Ceramics, Shanghai, China	122	Nano-Inorganic Cluster Chains Construct Internal Interfaces in Polymer Solid Electrolytes to Enhance Sodium-Ion Transport

Meeting Room in Montien Surawong Hotel

B Floor




Rajamontien 4
2nd Floor
LCD
LDC
Main Stage
L 7.2 x W 3.6 m
(H40 cm)
Podium
LCD
Classroom, total 216 pax
72 pax
72 pax
72 pax
Coffee & Tea
Entrance and Exit
Registration table
Hospitality Room
Coffee Break
Classroom, total 144 pax
48 pax
48 pax
48 pax
Control table
Control table
Control table
LCD
LCD
LCD
NORTH WING
Rajamontien 3
Rajamontien 2
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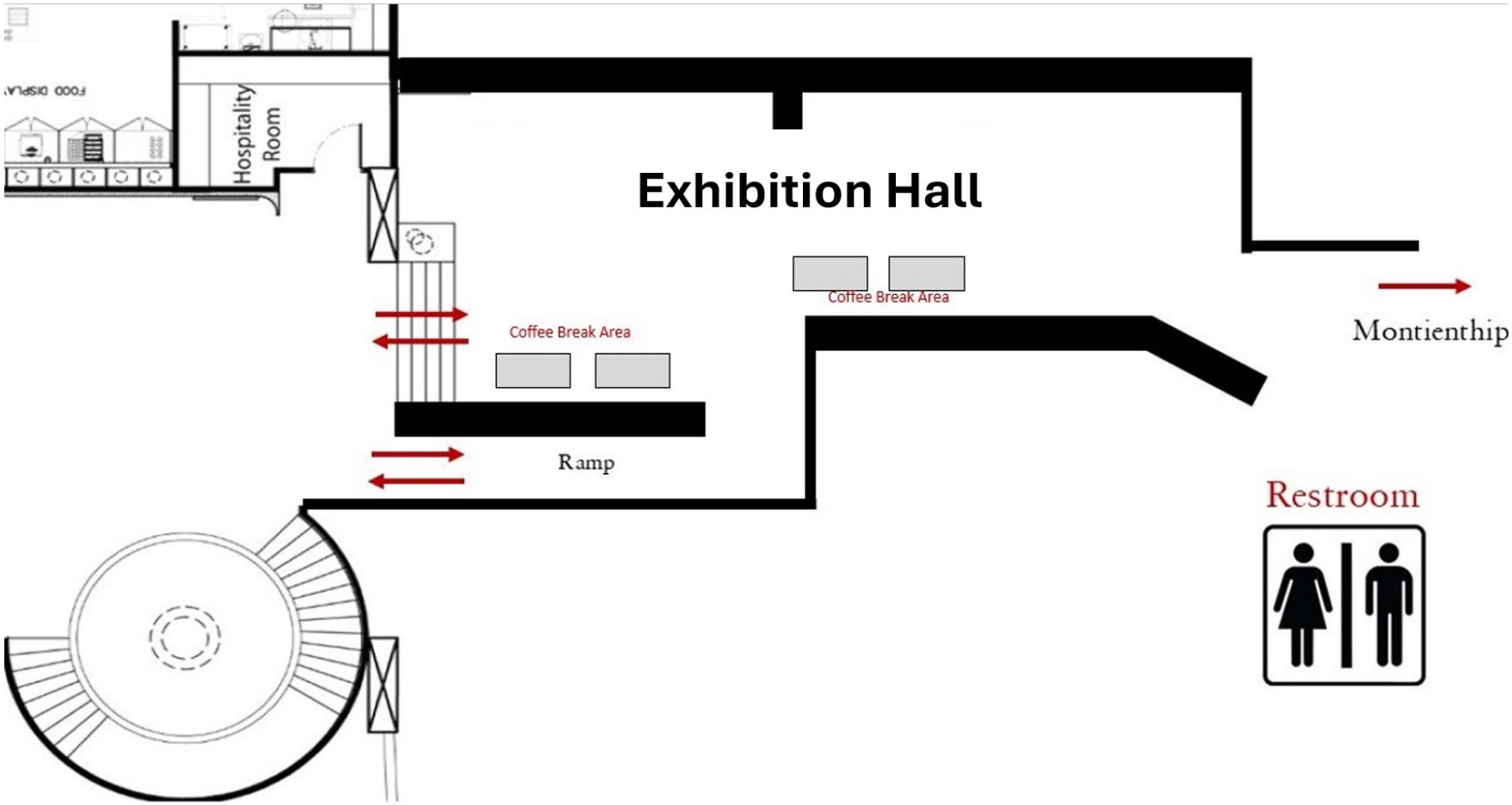
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1

Beyond Performance: Structural Strategies for Robust SOFC Systems

Suk-won Cha, Daniel Gil
Seoul National University, Seoul, Korea, Republic of

Abstract

The structural design of Solid Oxide Fuel Cells (SOFCs) is a critical factor in determining operational reliability and long-term efficiency. Since SOFCs consist entirely of solid-state ceramic components, engineering the physical architecture is essential to managing the inherent thermal-mechanical stresses and thermal expansion mismatches that occur during high-temperature operation. This lecture provides a comprehensive overview of the diverse support configurations that characterize modern SOFC development, ranging from foundational geometries to advanced integration strategies.

The discussion begins with the fundamental design rationale behind self-supporting configurations, such as Electrolyte-Supported (ESC), Anode-Supported (ASC), and Cathode-Supported Cells (CSC). It analyzes how these traditional architectures prioritize specific objectives, whether focusing on the chemical stability of thick electrolytes or the high power density achieved through thin-film integration on porous electrodes. Also addressed is the strategic role of inert support materials, which provide a mechanical backbone for electrochemically active layers and allow for the independent optimization of individual cell components and their respective microstructures. Building on these concepts, the lecture introduces emerging structural pathways designed to overcome the intrinsic brittleness of ceramic-based systems. This involves the integration of Metal-Supported Cells (MSC) for improved thermal cycling and the application of AAO (Anodic Aluminium Oxide)-based templates for precision nanostructural control. By comparing these diverse configurations, this session establishes a technical framework for selecting the optimal cell architecture based on specific application requirements, ranging from large-scale stationary power plants to dynamic mobile systems.

2

Thermodynamic Stability Screening Using Anomaly Detection Based Only on Composition Descriptors

Makino Keisuke
Nagoya Institute of Technology, Nagoya, Japan

Abstract

Materials informatics (MI) often relies on existing materials databases, which can exclude unexplored compositions. Although recent studies have used experimentally reported compounds as positive examples to predict synthesizability, conventional supervised MI generally requires labeled negative examples, such as “unsynthesizable” compositions, which are rarely available. Here, we developed a positive-only anomaly-detection framework based on a deep autoencoder that scores synthesizability of arbitrary compositions using composition-derived descriptors alone. We extracted 58,235 stable phases with energy above hull (E_{hull}) < 0.01 eV atom^{-1} from the Materials Project as training data. The input consisted of 1994-dimensional composition descriptors, including histograms of elemental properties such as atomic number, group, period, Mendeleev number, atomic mass, electronegativity, atomic radii, and s/p/d/f electron counts, together with descriptors representing binary elemental co-occurrence. A fully connected autoencoder with a 16-dimensional latent space was trained, and reconstruction RMSE was defined as an anomaly score corresponding to synthetic difficulty. The trained model accurately reconstructed descriptors of stable phases, and RMSE increased with E_{hull}, indicating that reduced thermodynamic stability was captured as higher anomaly. Notably, experimentally reported ICSD-linked compounds with E_{hull} > 0.01 eV atom^{-1} were enriched in the low-RMSE region, suggesting that the model can identify synthesizable candidates overlooked by stability-based screening alone. For 50,000 charge-unconstrained dummy oxides, larger deviations from charge neutrality led to higher RMSE distributions, even without explicit oxidation-state labels. Kernel SHAP analysis revealed that spdf-, group/period-, and binary-pair descriptors strongly contributed to the judgment. These results demonstrate rapid, interpretable composition-only screening of unexplored inorganic materials.

3

Dihydrophenazine-based porous composite organic cathode for lithium-ion battery

Gulraiz Tanvir
Nationanl Center for Nanoscience & Technology, Beijing, China

Abstract

Conjugated microporous polymers (CMPs) have emerged as promising materials for energy storage devices, including lithium-ion batteries (LIBs), owing to their high surface area, chemical tunability, eco-friendliness, and fast redox kinetics. However, their practical applications are limited by poor conductivity, low active material utilization, lower redox potential, and cycling degradation, which hampers their utilization for LIBs. Herein, we report the synthesis of dihydrophenazine-based CMP (TPA-DPZ) with multi-redox centers and its composite with acid-functionalized CNTs equal to only 5% of CNTs by total wt.% of monomers using in situ polymerization technique (TPA-DPZ@CNT 5%). The fabricated cathode with high active material loading of 80% with an average discharge potential of 3.39 V achieved a maximum specific capacity of 128 mAh g^{-1} . Remarkably, at a higher current density of 20 A g^{-1}, it retains a capacity of 68.34 mAh g^{-1} with a discharge time of only 13 s. The electrode exhibits excellent long-term stability, retaining 89% of its initial capacity after 10 000 cycles. It possessed a high energy density of 445 Wh kg^{-1} (at 0.1 A g^{-1}) combined with a high power density of 67 kW kg^{-1} at 20 A g^{-1}. This work highlights the synergistic effect of multi-redox CMP and conductive CNTs in overcoming the limitations of organic electrodes.

4

Electrochemical Formate and CO Reduction utilizing LDH(Layered Double Hyroxide) nanosheet

Sunglun Kwon
The Catholic University of Korea, Bucheon-si, Korea, Republic of

Abstract

This study presents a high-performance electrochemical $CO_{(2)}$ reduction system utilizing LDH (Layered Double Hyroxide) nanosheet 'house-of-cards' scaffolds. By leveraging the high porosity and exfoliation of LDH to disperse Cu catalysts, we achieved a remarkable C_{2+} partial current density of -1251 mA cm^{-2} at -0.7 V_{RHE}, a 14-fold increase compared to unsupported catalysts. In sub-reactions such as formate reduction, the system's versatility was extended to selective formate reduction through boron (B) doping and hydrophobic surface modification. The incorporation of boron significantly increased the specific surface area by approximately 4.7 times, maximizing the exposure of active catalytic sites. Quantitative analysis using 600 MHz NMR confirmed that this optimized catalytic environment, achieving an outstanding methanol selectivity of approximately 30%. These findings provide a critical technical foundation for industrial-scale carbon utilization, enabling the selective production of high-value liquid fuels and multi-carbon chemicals.

5

Multidimensional Chemical–Biological Evaluation of Encapsulation Materials for Implantable Micro-LED Bioelectronic Interfaces

Hyeryun Jeong
GIST, Gwangju, Korea, Republic of

Abstract

The successful clinical translation of implantable micro-light-emitting diode (μLED) bioelectronic devices requires encapsulation materials with high chemical stability and biocompatibility at the tissue–device interface. In this study, we conducted a multidimensional evaluation of three representative encapsulation polymers—polydimethylsiloxane (PDMS), Ecoflex, and Kapton—integrated with μLED systems. Material–cell interactions were assessed using mitochondrial metabolic activity assays, Annexin V/propidium iodide flow cytometric apoptosis analysis, and morphological characterization in L-929 fibroblasts under both direct-contact and extract exposure conditions. All materials maintained cell viability above 90% with minimal apoptotic responses, indicating high cytocompatibility and limited cellular stress.

To evaluate chemical stability and potential contaminant release, inductively coupled plasma–mass spectrometry (ICP–MS) was used to quantify arsenic leaching under physiologically relevant conditions. All encapsulation materials exhibited arsenic levels well below toxicological safety thresholds, demonstrating robust barrier performance and minimal risk of inorganic contaminant migration. Ecoflex and Kapton showed negligible detectable leachate levels, whereas PDMS exhibited trace release within acceptable safety margins.

In vivo subcutaneous implantation in Sprague–Dawley rats further demonstrated stable tissue compatibility without necrosis or severe foreign body reactions. Histological analysis revealed only mild differences in extracellular matrix remodeling among materials.

Collectively, these findings establish a comprehensive framework linking chemical durability, cellular stress responses, and tissue remodeling at implantable bioelectronic interfaces, supporting the development of reliable and safe implantable optoelectronic device platforms.

6

Development of Cobalt Doped Activated Carbon Nanomaterial Derived from Biowaste as an Efficient Electrocatalyst for Hydrogen Generation

Sanni Lawal Enesi[1], Abdu Muhammad Bello[2], Sani Nazifi Dalhatu[2], Mustapha Balarabe Idris[3]
[1]MESCO Lab, Federal University, Dutse, Jigawa, Nigeria. [2]Aliko Dangote University of Science and Technology,, Wudil, Kano State, Nigeria. [3]MESCo Lab, Federal University, Dutse, Jigawa, Nigeria

Sanni Lawal Enesi

Abstract

Although developing efficient, inexpensive, and stable electrocatalysts for electrocatalytic water splitting to generate hydrogen is highly desirable, it's quite challenging. Herein, we report the electrocatalytic performance of cobalt-doped activated carbon nanomaterial (Co-ACN-MH) derived from biowaste, namely millet husk. While the pristine activated carbon nanomaterial (CAN-MH) was prepared by pre-activation, followed by activation and carbonisation at 550 °C, Co-ACN-MH was prepared via a hydrothermal route using $CoSO_4$ as the cobalt source. The influence of hydrothermal dwelling time on the electrocatalytic activity of Co-ACN-MH is investigated systematically. The electrochemical performance of the Co-ACN-MH electrocatalyst, studied in a three-electrode system in 1 M KOH using linear sweep voltammetry at 10mAcm^{-2}, yielding and overpotential of 0.52 (V) vs RHE with a current density of 1.50 mA cm^{-2}. The result obtained indicated that 18 hours is the optimal hydrothermal dwelling time to achieve the lowest overpotential at 10 mA cm^{-2} and the smallest Tafel slope. The electrochemical impedance spectroscopy studies revealed that Co-ACN-MH synthesised at 18 hours (Co-ACN-MH_18), exhibits the lowest charge-transfer resistance, indicating that adsorption and subsequent hydrogen generation at the interface are facile. This study highlights a cost-effective and sustainable strategy for developing efficient electrocatalysts from biowaste for hydrogen production.

7

The crucial Role of Defect Interactions for Thermodynamics and Kinetics in Solid State Ionics

Steffen Neitzel-Grieshammer[1], Manfred Martin[2,3,4]
[1]FH Münster University of Applied Science, Münster, Germany. [2]RWTH Aachen University, Aachen, Germany. [3]Seoul National University, Seoul, Korea, Republic of. [4]Chulalongkorn University, Bangkok, Thailand

Manfred Martin

Abstract

Defect interactions play a crucial role for thermodynamics and kinetics in Solid State Ionics. They strongly affect both the thermodynamics of defect formation in a solid and the mobility of defects and ions. This applies in particular to oxides with relatively high defect concentrations, which are nowadays used in many technical applications such as sensors, electrolysers, solid oxide fuel cells etc. As examples for this class of oxides, we consider ceria as prototype mixed ionic-electronic conductor, doped ceria as prototype oxygen ion conductor, and doped barium zirconate as prototype proton conductor. Here we summarize our years of computational work in which we applied density functional theory (DFT) in combination with Metropolis Monte Carlo simulations (MMC) and kinetic Monte Carlo simulations (KMC) to investigate the defect chemistry and ion transport in these prototype oxides.

8

Atomistic Insights into Ion Transport at Ceramics–Polymer Composite Electrolyte Interfaces via Neural Network Potential Molecular Dynamics

Yoshiya Matsuoka[1], Naoto Tanibata[1], Hayami Takeda[1], Masanobu Nakayama[1], Ru-Shi Liu[2]
[1]Nagoya Institute of Technology, Nagoya, Japan. [2]National Taiwan Univeristy, Taipei, Taiwan

Abstract

Ceramic–polymer composite solid electrolytes exhibit enhanced ionic conductivity compared to pure polymer electrolytes, yet atomistic understanding of ion transport at their heterogeneous interfaces remains limited. Here, we investigate Li-ion transport at the interface between a garnet-type oxide electrolyte (LLZT) and a polyethylene oxide (PEO)-based electrolyte using large-scale molecular dynamics simulations driven by a neural network potential. An interfacial model containing approximately 2500 atoms with dissolved LiTFSI salt was constructed and systematically compared with bulk PEO electrolyte systems. The simulations reveal that Li-ion diffusivity is slightly reduced at the ceramic–polymer interface, whereas the mobility of TFSI anions is significantly suppressed. As a consequence, the Li-ion transference number is increased near the interface. Structural analyses further demonstrate enhanced salt dissociation and preferential accumulation of PEO chains and TFSI anions in the interfacial region, accompanied by local Li depletion. These results indicate that the interface strongly modifies both local coordination environments and ion transport behavior. To further clarify the transport mechanism, metadynamics simulations were performed to evaluate the free-energy landscape for Li-ion migration near the interface. The calculations reveal an energy barrier of approximately 1 eV, suggesting that the interfacial region is energetically unfavorable for long-range Li transport. This behavior is attributed to reduced polymer-chain mobility caused by interfacial trapping effects and strong local structural constraints. These findings provide atomistic insights into ion transport at ceramic–polymer interfaces and highlight the critical role of interfacial structure in governing ion selectivity, ion dynamics, and transport properties in composite solid electrolytes.

9

Low-Pressure, Low-Cost All-Solid-State Batteries Enabled by Monomer-in-Salt Polymer Electrolytes

Sang-Young Lee
Yonsei University, Seoul, Korea, Republic of

Sang-Young Lee

Abstract

Practical all-solid-state batteries are limited not only by ionic conductivity, but by the pressure and cost penalties required to translate solid electrolytes into working cells. High stack pressure is commonly needed to maintain solid–solid contact, close interparticle voids, and ensure cathode utilization, but this adds inactive mass and volume at the cell and module levels. At the same time, expensive inorganic solid electrolytes and complicated cathode fabrication processes challenge the economic feasibility of ASSBs. Here, I present monomer-in-salt polymer electrolytes as a design platform for low-pressure and low-cost solid-state batteries.

For low-pressure ASSBs, zwitterionic dry polymer electrolytes are designed through a conflicting entropy strategy. High mixing entropy in the monomer–salt precursor promotes salt dissociation and compositional homogeneity, while reduced conformational entropy after polymerization produces aligned, decoupled Li^+ transport channels. This ion-transport architecture enables high Li^+ transference, oxidative stability above 5 V, nonflammability, and stable high-areal-capacity pouch-cell operation at 25 °C under 0.5 MPa stack pressure.

For low-cost ASSBs, an acrylic-acid-based monomer-in-salt polymer catholyte is introduced as a dry-processable alternative to sulfide catholytes. The liquid precursor uniformly infiltrates and disperses cathode components before in situ polymerization, forming AGG/AGG^+-rich percolated ion channels and suppressing through-thickness redox heterogeneity. Its low material cost, solvent-free cathode processing, reduced fabrication burden, and compatibility with high-loading cathodes enable Ah-class pouch cells with projected costs below 100 USD kWh_{cell}^{-1}. These findings establish monomer-in-salt polymer ionics as a practical route to ASSBs that are not only high-energy, but also pressure-lean, manufacturable, and cost-competitive.

10

Analysis of Li-Ion Exchange Reactions at $Li_7La_3Zr_2O_{12}/LiCoO_2$ Interfaces Using Machine-Learning Potential

Sayato Terashima[1], Naoto Tanibata[1], Hayami Takeda[1], Masanobu Nakayama[1], Roger De Souza[2]
[1]Nagoya Institute of Technology, Nagoya, Japan. [2]RWTH Aachen University, Aachen, Germany

Abstract

Extensive research has been conducted worldwide toward the practical application of all-solid-state batteries because of their safety and energy density. Among various solid electrolytes, garnet-type materials represented by $Li_7La_3Zr_2O_{12}$ (LLZO) have attracted considerable attention as next-generation solid electrolytes owing to their high ionic conductivity and excellent safety. However, the increase in interfacial resistance caused by poor contact between electrodes and solid electrolytes remains a issue for practical applications. Although such interfacial resistance has been reported to degrade battery performance, the underlying atomic-scale mechanism has not yet been fully clarified. In this study, large-scale molecular dynamics simulations involving approximately 40,000 atoms were performed using machine-learning potentials to investigate the Li-ion transport mechanism at the interface between LLZO and $LiCoO_2$ (LCO). The simulation results revealed the formation of a Li-deficient region approximately 10 Å near the interface. This Li-deficient region was found to act as a barrier to Li-ion transport and may contribute to the increase in interfacial resistance. Furthermore, analysis of the time evolution of the number of exchanged Li ions demonstrated different transport behaviors between the LLZO/interfacial layer and the LCO/interfacial layer. In addition, the activation energies for Li-ion exchange reactions at each interface exhibited different values, indicating the presence of interface-position-dependent transport mechanisms. These results suggest that Li-ion transport at the LLZO/LCO interface exhibits spatially and temporally heterogeneous transport dynamics. This study contributes to understanding the mechanisms underlying interfacial resistance in all-solid-state batteries and provides guidelines for improving battery performance through interface design.

11

Decoupling Interfacial Proton Transport in Thin Polymer Electrolytes

Yuki Nagao[1,2], Yusuke Abe[1], Kentaro Aoki[1], Athchaya Suwansoontorn[1], Kunal Karan[3], Isao Shitanda[4]
[1]Japan Advanced Institute of Science and Technology, Nomi, Japan. [2]Chulalongkorn University, Bangkok, Thailand. [3]University of Calgary, Calgary, Canada. [4]Tokyo University of Science, Noda, Japan

Yuki Nagao

Abstract

Proton transport at electrode/electrolyte interfaces plays a critical role in electrochemical energy devices such as fuel cells and electrolyzers. In practical systems, ionomers form thin interfacial layers on electrode surfaces, where transport behavior can differ significantly from that in bulk membranes. However, interface-specific transport properties remain difficult to evaluate because contributions from multiple interfaces often overlap in conventional impedance measurements.

In this work, interfacial proton transport in thin polymer electrolytes was decoupled using an impedance-based approach combining extended low-frequency measurements and systematic variation of electrode pad length. Thin Nafion films (~50 nm) were deposited on model interfaces consisting of Pt, carbon, and SiO2 regions integrated into interdigitated electrode structures. By shifting the characteristic response of each interface, previously overlapping impedance contributions were experimentally separated.

The results revealed distinct proton transport behavior at different interfaces within the same thin-film system. Geometry-normalized analysis confirmed that the extracted proton conductivity was independent of electrode dimensions, demonstrating the validity of the interface-separation method. This approach provides a new route for quantifying proton transport at buried interfaces and offers insight into ion transport processes in confined polymer electrolyte systems for future energy applications.

12

Ampere-Level Single-Pass CO_2 Electroreduction to CO Using Molecularly Dispersed Phthalocyanine Gas-Diffusion Electrodes

Chia-Yu Lin
Department of Chemical Engineering, National Cheng Kung University, Tainan City, Taiwan. Center for Resilience and Intelligence on Sustainable Energy Research (RiSER), National Cheng Kung University, Tainan City, Taiwan. Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

Abstract

Electrocatalytic CO_2 reduction (e-CO_2RR) powered by renewable electricity offers a compelling pathway for upgrading CO_2 into high-value chemicals and fuels. Herein, we report multi-walled carbon nanotube (MWCNT) supported CuPc-CoPc modified gas-diffusion electrodes (GDEs), featuring a molecular-level dispersion of cobalt phthalocyanine (CoPc) and copper phthalocyanine (CuPc). The introduction of CuPc effectively suppresses CoPc aggregation, enabling tunable mass loading, enhanced fractional accessibility of electrochemically active CoPc sites, and improved CO_2 adsorption capacity. Furthermore, density functional theory (DFT) calculations reveal that in situ demetallization of CuPc during electrolysis forms H_2Pc, inducing synergistic electronic interactions among CoPc, MWCNTs, CuPc, and H_2Pc that optimize CO_2 binding affinity. Benefiting from these structural advantages, the optimized MWCNT|CuPc-CoPc GDE exhibits exceptional e-CO_2RR performance across a broad CO_2 concentration range (20%–98%). Remarkably, using a dilute 20%CO_2 feed at an ampere-level current (0.625 A), the system achieves efficient single-pass conversion to CO, yielding a CO production efficiency ~66 % and an energy efficiency of ~55%. Moreover, the electrode demonstrates robust durability, maintaining a FE_{CO} above 80.4% during a 72-hour stability test under a simulated biogas atmosphere. These findings underscore the potential of molecularly engineered catalyst architectures for efficient and selective CO production from low-concentration CO2 emission sources.

13

A complete cathode recovery cycle of an exhausted and dismantled lithium battery material

H.-Jürgen Meyer, Fabian Grahlow, Patrick Schmid
University of Tübingen, Tübingen, Germany

H.-Jürgen Meyer

Abstract

One of the most important Li-ion cathode materials developed to date is lithium nickel manganese cobalt oxide ($Li(Ni,Mn,Co)O_2$), abbreviated as Li-NMC battery. Cathode materials of this type can refer to a variety of blends, where cobalt contents such as NMC 6:2:2 ($LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$) or NMC 5:3:2 are preferred to reduce material costs and environmental impacts. A simple and cost-effective recycling process for spent graphitic NMC Li-ion battery materials is reported for a material obtained from a commercial thermomechanical battery segmentation process.

Thermo-analytical studies carried out on genuine Li-NMC/graphite material show the successive loss of electrolyte and graphite with increasing temperature. Subsequent laboratory-scale heating experiments of genuine Li-NMC/graphite materials in air confirm these findings. Impurities are removed by pH-controlled precipitation followed by electrolysis to remove and recover copper. An aqueous sol-gel process was chosen to synthesize fresh NMC cathode material. Depending on the processing conditions, the products obtained relate to an average NMC composition of 6:2:2 and 5:3:2, as shown by powder XRD measurements, structure refinement and chemical analyses.

14

Quantitative Predictions for the Molecular Properties of Metal-Ligand Coordination Compounds Using Chemical Text-Based Information

Ming-Kang Tsai
National Taiwan Normal University, Taipei, Taiwan. National Tsing Hua University, Hsinchu, Taiwan

Ming-Kang Tsai

Abstract

We report a SchNet-based Ligand-Embedding Extended Transformer (SLEET) model, developed within a feature-driven neural network framework for predicting molecular electronic structure properties of transition-metal complexes (TMCs). SLEET integrates the SchNet architecture with a bond-step representation weighted by reduced atomic numbers. In this approach, ligands are generated by segmenting purely two-dimensional SMILES representations, while metal–ligand interactions are modeled using a Transformer-like architecture. This design enables the construction of a property prediction framework that is closely aligned with chemical intuition and effectively captures ligand-field characteristics in TMCs. As a result, SLEET achieves accurate HOMO–LUMO gap predictions comparable to those obtained from models incorporating three-dimensional structural information. Moreover, it demonstrates strong predictive performance for molecular-weight-independent electronic properties, highlighting its potential as an efficient and chemically interpretable framework for transition-metal complex property prediction. We further benchmark the quantitative prediction of ligand binding energies using SLEET, and discuss its application to the quantitative analysis of ligand-field strength.

15

Power generation and impedance properties of protonic ceramic fuel cells using barium zirconate doped with ytterbium

Yuji Okuyama
University of Miyazaki, Miyazaki, Japan

Yuji Okuyama

Abstract

Yttrium-doped zirconium barium exhibits high proton conductivity at 600°C, making it a promising material for protonic ceramic fuel cells (PCFCs). In this study, we constructed a Ni anode-supported fuel cell using $BaZr_{0.8}Yb_{0.2}O_{3-\delta}$ (BZYb) as the electrolyte and investigated its power generation and impedance characteristics.

To elucidate the power generation characteristics of PCFCs, we investigated the relationship between current and voltage. Furthermore, by measuring changes in the water vapor concentration on the cathode side during power generation, the proton and hole currents were evaluated to determine the amount of electron leakage and the energy efficiency. The electron leakage in PCFCs is found to be negligible at temperatures below 500°C, and the effect of electron leakage decreases as the current increases.

Electrode impedance was measured to clarify the electrode characteristics of PCFCs. By investigating the isotope effect on impedance during proton/deuterium exchange, the impedance components of the cathode and anode were separated. It was found that the component observed at the highest frequency corresponds to the anode impedance. The cathode components were further separated using DRT analysis. By comparing the impedance characteristics of SOFCs, we identified the impedance components associated with oxygen dissociation and adsorption, which are common electrode reactions in both SOFCs and PCFCs. Furthermore, we identified through isotope effects that the lowest-frequency impedance component is attributable to the steam formation reaction.

Acknowledgment

This work was partially supported by NEDO project (JPNP20003) and GteX program (JPMJGX23H).

16

Single-Crystal Studies on Conduction Mechanisms in Lithium Superionic Conductors

Takeshi Yajima
Nagoya University, Nagoya, Japan

Abstract

Understanding conduction mechanisms in solid electrolytes is essential for the development of high-performance all-solid-state lithium-ion batteries and related electrochemical devices. In solid ionic conductors, macroscopic ionic conductivity is governed by multiple microscopic factors, including carrier concentration, the arrangement of mobile-ion sites, migration pathways, local coordination environments, and interactions among mobile ions. However, the roles of these factors are often obscured in polycrystalline samples by grain boundaries, secondary phases, microstructural heterogeneity, and orientation averaging.

Single-crystal studies provide a direct approach to these issues. They allow intrinsic ionic conductivity to be evaluated using well-defined crystals, including the orientation dependence of conduction properties. They also enable precise structural analysis of mobile-ion distributions and potential landscapes within the same crystallographic framework. By combining these two aspects, single-crystal studies can connect macroscopic conduction properties with microscopic crystallographic features, providing a basis for discussing conduction mechanisms beyond simplified hopping models.

In this presentation, I will discuss our recent single-crystal studies on lithium superionic conductors. The combined evaluation of intrinsic conduction properties and precise crystal structures reveals how lithium-ion conduction is governed by microscopic structural features, thereby offering a crystallographic basis for understanding and designing advanced solid electrolytes.

17

Development of High Performance Cathode Materials for Na-Ion Battereis

Jongsoon Kim
Sungkyunkwan University, Suwon, Korea, Republic of

Jongsoon Kim

Abstract

Renewable energies play a crucial role in addressing recent environmental challenges associated with global climate change. Currently, lithium-ion batteries (LIBs) are the primary power sources for portable electronics and are widely used in electric vehicles and for storing electricity generated by power plants and renewable energy sources. However, the limited and geographically concentrated lithium resources on Earth pose significant challenges to maintaining stable production levels and price stability. These factors are expected to drive up the production costs of LIBs in the near future. As a result, extensive research efforts have been dedicated to developing low-cost and efficient energy storage systems (ESSs) using earth-abundant materials. Our innovative approach combines synthesis, first-principles calculations, and advanced structural analysis techniques to efficiently discover high-performance cathode materials for low-cost rechargeable batteries. This approach enables precise confirmation of detailed reaction mechanisms and rapid optimization of electrochemical properties. We believe our findings will pave the way for the development of effective cathode materials, offering high energy density, high power output, and reduced production costs, thereby opening new opportunities for advancing battery technology.

18

Novel Quasi-solid-state electrolyte membranes for Zn2+ ion energy storage devices.

Arpita Mishra, Anshuman Dalvi
Birla Institute of Technology and Science, Pilani, Pilani, India

Arpita Mishra

Abstract

In the present work, a hydrogel electrolyte based on a cellulose/polyvinyl alcohol (PVA) composite dual-crosslinked with good mechanical robustness and electrochemical performance was successfully designed via an integrated method of freeze–thaw physical crosslinking and chemical crosslinking. The resulting prepared hydrogel displayed a porous, interpenetrating network structure with an average pore size in the micrometer-to-nanometer range. The hydrogel electrolyte with CPC-dcZ-optimization exhibited favorable mechanical strength due to synergistic interactions among hydrogen bonding, crystallite formation, and covalent linkages. The ionic conductivity of the electrolyte thus formed is ~19 × 10^{-2} Ω^{-1} cm^{-1} at 30 °C, activated with 2 M $ZnSO_4$. The hydrogel displayed excellent thermal stability and electrolyte retention (85–90% at 72 h). The prepared hydrogel electrolyte is then used to fabricate symmetric EDLC (electric double-layer capacitor) devices using high-surface-area (~1800 m^2 g^{-1}) porous Activated Carbon electrodes. The device delivers an arial capacitance of 361±3 mF cm^{-2} at 1 V/1 mA (0.64 mA cm^{-2}), 312±3 mF cm^{-2} at 1 V/5 mA (3.24 mA cm^{-2}), and 277±3 mF cm^{-2} at 1 V/15 mA (9.74 mA cm^{-2}). The device delivers an energy and power density of 60 μWh cm^{-2} and 2355 μW cm^{-2}, respectively. In addition, the supercapacitor demonstrated excellent cycling stability up to 15000 GCD cycles, with capacitance retention of ~82% and ESR variation from 2.7 Ω cm^2 (1^{st} cycle) to ~7.6 Ω cm^2 ($15{,}000^{th}$ cycle). Along with low-temperature operation, the device exhibits an Areal capacitance of ~188±3 mF cm^{-2} at −20 °C.

19

Porous Spinel Powering Solid-State Supercapacitors

BHARGAB SHARMA, Anshuman Dalvi
Birla Institute of Technology and Science, Pilani, Pilani, India

BHARGAB SHARMA

Abstract

A hierarchically porous $NiCuFe_2O_4$ electrode was synthesized using a NaCl hard-templating route and integrated with a $Li_{6.75}La_3Zr_{1.75}Nb_{0.25}O_{12}$ (LLZNO) garnet-type solid electrolyte infused with ~6 wt.% 1-ethyl-3-methylimidazolium tetrafluoroborate (EMIM BF_4) to construct a pseudo-solid-state Li-ion supercapacitor. The salt-templated ferrite retained a cubic spinel framework with a high surface area (~140 $m^2\ g^{-1}$), abundant Ni, Cu, and Fe redox centers, and diffusion-controlled pseudocapacitive storage. In symmetric configuration operated at 40 °C, the device delivered a high specific capacitance of ~974 $F\ g^{-1}$ (330 $mF\ cm^{-2}$) at 2.0 V and 1 mA, corresponding to a specific energy of ~115 $Wh\ kg^{-1}$ (174 $\mu Wh\ cm^{-2}$) at 1 $mg\ cm^{-2}$ active mass, along with a specific power ≥3000 $W\ kg^{-1}$ at 2.0 V/8 mA. Multivalent redox processes involving Ni^{2+}/Ni^{3+}, Cu^{2+}/Cu^{3+}, and Fe^{2+}/Fe^{3+} were confirmed by cyclic voltammetry and XPS. The device showed good cycling stability, retaining 63% of its initial capacitance after 3000 cycles at 2.0 V and 2 mA, and 56% after 10,000 cycles at 1.5 V and 3 mA. These results demonstrate NaCl-templated $NiCuFe_2O_4$ as a promising electrode for next-generation solid-state energy storage.

20

Crystal Structural Frameworks as a Design Principle for Lithium Super-Ionic Conductors: From Topological Analysis to AI-Driven Molecular Dynamics

Qiang Bai
Taiyuan University of Technology, Taiyuan, China

Abstract

Lithium super-ionic conductors are key solid electrolytes for all-solid-state lithium batteries, yet the structural origin of fast Li-ion transport remains a central question. Here, we present a crystal-structural-framework perspective for understanding and discovering Li super-ionic conductors. By combining topological analysis with ab initio molecular dynamics simulations, we systematically examine Li-conducting oxide and sulfide frameworks and quantify the structural features governing Li sites, diffusion channels, and the migration energy landscape. A key descriptor is the enlarged Li site, which originates from large local spaces in the immobile anion framework and promotes positional disordering of Li ions. Together with an appropriate percolation radius and a well-connected three-dimensional Li diffusion network, such enlarged Li sites enable a flat and highly connected transport landscape for fast Li-ion conduction. Based on these descriptors, high-throughput screening successfully recovers known Li super-ionic conductors and identifies new candidate frameworks, several of which are validated by ab initio molecular dynamics to exhibit promising room-temperature conductivities. We further discuss how this framework-based design principle can be extended beyond conventional oxides and sulfides to emerging mixed-anion lithium nitrides. As a recent example, coupled vacancy-anion tuning in $Li_{8-x}Ch_{1+x}N_{2-x}$ (Ch = Se, Te) reshapes the Li diffusion network, softens the lattice, and activates long-range three-dimensional Li transport. Large-scale molecular dynamics enabled by machine-learned interatomic potentials further reveals stable Li metal|nitride interfaces and rapid interfacial Li migration. These results highlight crystal structural frameworks, augmented by artificial-intelligence-driven atomic simulations, as a powerful strategy for discovering and optimizing next-generation solid electrolytes.

21

Computational Elucidation of Hydrogen-Bonded Superexchange Pathways in a Humidity-Responsive Tristate Magnetic Spin-Cluster Material

Manussada Ratanasak[1], Shintaro Akagi[1], Junhao Wang[1], Eiji Nishibori[1], Shin-ichi Ohkoshi[2], Hiroko Tokoro[1], Yasuteru Shigeta[1]

[1]University of Tsukuba, Tsukuba, Japan. [2]The University of Tokyo, Tokyo, Japan

Abstract

Advanced multistate magnetic materials require precise control of magnetic coupling, yet the microscopic mechanisms governing their switching behavior remain unclear. In this study, broken-symmetry density functional theory (BS-DFT) calculations were performed using the unrestricted M06 (UM06) functional to elucidate the superexchange pathways responsible for the reversible, humidity-induced tristate magnetic switching in the cyanide-bridged spin-cluster assembly Ni_9W_6 reported in our work [1]. Experimental measurements revealed distinct transitions across three relative humidity (RH) levels: a paramagnetic state at 75% RH, a ferromagnetic state below the Curie temperature (TC = 11 K) at 11% RH, and an interacting superparamagnetic state below the blocking temperature (TB = 13 K) at 0% RH. Using a fragment-based approach, magnetic exchange coupling constants (J) were evaluated via the Yamaguchi approach [2] by defining a high-spin ferromagnetic quartet state and a broken-symmetry antiferromagnetic doublet state. Calculations utilized the LANL2DZ basis set for Ni and W atoms and 6-31G(d) for lighter elements. Spin density difference maps revealed that while the cluster framework stays structurally rigid, the removal of in-layer crystallization water molecules at lower humidities disrupts intercluster pathways, effectively switching the magnetic state. These findings provide critical microscopic insights into hydrogen-bond-mediated magnetic coupling for designing high-precision, stimuli-responsive molecular magnets.

22

Development of sustainable and high energy density Na-ion batteries: Water-stable ‘layered’ transition metal oxide based cathodes and ‘alloying reaction’ based anode

Amartya Mukhopadhyay
Indian Institute of Technology Bombay, Mumbai, India

Amartya Mukhopadhyay

Abstract

For moving up the energy density ladder, Na-ion batteries need the development of high capacity, high voltage and stable cathode materials, *viz*., ‘layered’ Na- transition metal (T_M) oxides exhibiting anion-redox, as well as ‘alloying reaction’ based anodes. Furthermore, from the sustainability point-of-view, developing ‘layered’ Na-T_M-oxide cathode materials that are stable upon exposure to air and water are also important. The latter can also facilitate ‘aqueous’ electrode processing, using water, instead of highly toxic/hazardous NMP [*J. Power Sources* **610** (2024) 234716]. Against this backdrop, the talk will discuss about the development of air/ water-stable ‘layered’ Na-T_M-oxides by way of either shrinking the ‘inter-slab’ spacing or precise positioning of dopant cation at the tetrahedral site of the Na-layer to suppress spontaneous Na-removal (or Na^+/H^+ exchange) upon exposure to moisture, as well as water [*J. Mater. Chem. A* **8** (2020) 18064, *Chem. Mater.* **34** (2022) 10470, *Adv. Energy Mater.* **13**[19] (2023) 2204407, *J. Mater. Chem. A* **13** (2025) 5807]. This will be followed by a discussion on stable and low hysteretic oxygen redox behaviour, as exhibited by high Na-containing P2-structured ‘layered’ Na-T_M-oxides. On the anode side, considering the disadvantages of hard carbon due to low tap density and high irreversible capacity loss, the latter half will reveal the development of highly stable carbon-free Sn-based anode materials, which exhibit excellent cyclic stability and rate-capability, primarily due to the enhancement of intrinsic strength via precipitation strengthening. Challenges w.r.t. ‘full’ Na-ion cell development with anion-redox-based cathodes and Sn-based anodes will also be discussed.

23

Regulating the Oxygen Evolution Mechanism through In Situ Reconstruction of Ru-Modified Manganese Oxybromide

Ci Lin
Hainan University, Haikou, China

Abstract

Regulating the oxygen evolution reaction (OER) mechanism presents a promising yet challenging approach to address the performance-stability trade-off of acidic water oxidation catalysts. Here we demonstrate the regulation of the OER mechanism through in situ surface reconstruction of manganese oxybromides (MOB) catalysts modified with single-atom ruthenium (Ru-MOB). In situ Raman spectroscopy reveals that Ru incorporation intensifies the inherent, reversible surface reconstruction of MOB, resulting in the formation of a γ-MnO_2 layer with an onset potential approximately 100 mV lower. Various operando/in situ characterizations and theoretical calculations show that the reconstructed Ru-MOB significantly suppresses the lattice oxygen mechanism while simultaneously enhancing the adsorbate evolution mechanism. In an electrochemical cell, the reconstructed Ru-MOB drives acidic OER with an overpotential about 90 mV lower at 10 mA cm^{-2} compared to pure MOB, and it shows negligible performance degradation for over 1400 h. Our work offers a design strategy for the future development of acidic OER catalysts.

24

Configuring highly Ultra-stable Na3V2(PO4)3 cathodes for long-cycle-life Sodium-Ions batteries

Chunxi Hai, Ziyi Wan, Yuan Zhou
Chengdu University of Technology, Chengdu, China

Chunxi Hai

Abstract

Due to its unique three-dimensional Na^+ diffusion channels and relatively excellent physico-chemical stability, $Na_3V_2(PO_4)_3$, a typical NASICON-type materials, has attracted a surge of interests for successfully configuring long-term ultra-stable Sodium-ion Batteries, which is regarded as one of the most effective candidates for large-scale energy storage in the future. However, the practical implementation of $Na_3V_2(PO_4)_3$ cathodes is severely impeded by its intrinsically low electronic conductivity, resulting in poor discharging/charging capabilities, and significant structural degradation upon prolonged (de)sodiation cycling. Therefore, it is aimed at configuring a porous-structured $Na_3V_2(PO_4)_3$ cathodes with perfect electrical and ionic conductivity and structure stability, which is validated by optimizing the synthesis method, synthesis condition, and doping technology. Based on different advanced characterizations, for example XPS, HR-TEM, XAFS, and theoretical calculation and so on, it is no suspicious to conclude that the in-situ doping technology grants the $Na_3V_2(PO_4)_3$ cathodes largely improved electrochemical properties. Based on the detailed theoretical calculations, experimental and analytical results, the corresponding formantion and working mechanisms of $Na_3V_2(PO_4)_3$ cathodes for long-term cycling sodium ions batteries is initially concluded, which is significantly important for promoting practical application valid.

25

Perovskite Solar Cells and Radiative Cooling Films as Energy Materials for The Era of Energy Crisis

Pongsakorn Kanjanaboos
Mahidol University, Nakhon Pathom, Thailand

Pongsakorn Kanjanaboos

Abstract

Growing energy demand, high solar irradiation, and hotter climate present both challenges and opportunities for sustainable energy technologies. This talk highlights two emerging energy materials, perovskite solar cells and radiative cooling films, which have strong potential to support the energy transition toward a low-carbon and energy-efficient future. Perovskite thin films have gained tremendous attention for solar cell application due to their charge/photon conversion capability and low-cost fabrication via scalable solution processes i.e., spray coating, dipping coating, and roll-to-roll printing. As precursor inks are in liquid form, doping and compositional tuning are facile. Precursor inks later solidify into perovskite thin films via selected fabrication processes, which affect perovskite nucleation and crystallization processes. Different cost reduction strategies can be applied to achieve real world usage. In parallel, radiative cooling films offer a passive cooling strategy by reflecting incoming solar radiation while emitting thermal energy through the atmospheric window to outer space. These materials can reduce temperature without external energy input, addressing increasing cooling demand. The radiative cooling films can be fabricated via low-cost processes like spray coating and polymer extrusion, which allow facile compositional and morphological tuning to maximize heat release for reduction in carbon generation and electricity consumption in agriculture and real estate sectors.

26

Quantitative and 3D imaging in electron microscopy for materials science

Jianghua Chen[1], Cuilan Wu[2], Shiyong Li[1]

[1]Pico Electron Microscopy Center, College of Materials Science and Engineering, Hainan University, Haikou, China.

[2]Center for High-Resolution Electron Microscopy, College of Materials Science and Engineering, Hunan University, Changsha, China

Abstract

Atomic-resolution imaging in aberration-corrected scanning TEM can provide straightforward structure models at the atomic-scale, whereas atomic-resolution imaging in aberration-corrected high-resolution TEM (HRTEM) with rapid quantitative image simulation analysis can provide the refined structures with high precision beyond the resolution limitation of the microscope. The combination of the two techniques can be more powerful in solving difficult structure problems in materials science. Furthermore, 3D electron tomography (3D-ET) in STEM is a rapidly developing area, and it faces challenges in the so-called missing-wedge (MW) problems when applied to practical bulk materials. Solving MW problems in 3D-ET seems being material-related. We have developed a few practical 3D-ET methods which are applicable to different materials.

Developments of high-strength aluminum alloys have always faced a difficult problem: owing to their small size, the early-stage strengthening precipitates are difficult to characterize in terms of composition, structure and evolution. Here we employ atomic-resolution transmission electron microscopy (TEM) imaging and first-principles energy calculations to address these problems. Recent years, we have investigated tens of typical high strength aluminum alloys, such as 2xxx, 6xxx and 7xxx alloys, with different compositions and with varying thermal processes for understanding their property-structure-process correlations. Using aberration-corrected HRTEM and aberration-corrected STEM, much of our attention has been paid to revisit the strengthening precipitates in these important alloys and to clarify the controversies left in the past about their precipitation behaviors. The fine precipitation scenarios revealed in our studies are rather different from previous understandings in the textbooks and literatures published thus far.

27

Functional Materials Design of Polymer Electrolytes for Next-Generation Energy Storage

JAE HYUN KIM
DGIST, Daegu, Korea, Republic of

JAE HYUN KIM

Abstract

Solid-state lithium metal batteries (SSLMBs) have emerged as promising next-generation energy storage systems owing to their high energy density and improved safety. However, the development of practical polymer electrolytes remains challenging because of limited ionic conductivity, interfacial instability, and restricted operating temperatures. This presentation reviews recent progress in advanced polymer electrolyte systems developed to address these challenges. First, composite polymer electrolytes incorporating porous zeolite fillers are introduced. The unique porous structures and Lewis acid sites of zeolites facilitate lithium salt dissociation, suppress polymer crystallization, and promote efficient lithium-ion transport, resulting in enhanced electrochemical performance and stable lithium metal compatibility. Second, a fluorinated ether-anchored polymer electrolyte based on a semi-interpenetrating polymer network is presented as a molecular engineering approach for wide-temperature battery operation. By regulating local solvation environments and interfacial chemistry, this electrolyte enables improved ionic transport and stable electrochemical performance from ambient to sub-zero temperatures. Through these representative examples, the presentation highlights how both structural engineering and molecular design can provide effective solutions for improving the safety, durability, and practical applicability of solid-state lithium metal batteries.

28

Preparing high-performance resin-based hard carbon for sodium-ion batteries

Yuan Zhou, Juncheng Liu, Chunxi Hai
Chengdu University of Technology, Chengdu, China

Yuan Zhou

Abstract

Due to its disordered structure and relatively large interlayer spacing, hard carbon is widely believed as one of the most promising carbon candidates for sodium ion batteries. However, the sodium storage mechanism of hard carbon remains controversial. The intrinsic structural uncertainty hinders precise structural regulation and leads to low initial Coulombic efficiency and limited rate performance, thereby restricting further improvement in sodium storage performance. In this work, a formaldehyde-free green phenolic resin precursor was developed, and a multiscale structural regulation strategy was employed to achieve controllable construction of hard carbon microstructures and enhance sodium storage performance. Based on detailed discussion o the relationship between structure-performance of the as-configured carbon for batteries, not only the preparing condition is optimized, but also the corresponding formation and working mechanism are systematically concluded. This study provides a new strategy for the controllable construction of green phenolic resin-derived hard carbon and the optimization of its sodium storage performance, offering valuable insights for the sustainable development of anode materials for sodium-ion batteries.

29

Lithium Metal Electrode Coated with Inorganic Thin Film by Pulsed Laser Deposition

Riku Imanishi, Sou Taminato, Daisuke Mori, Nobuyuki Imanishi
Mie university, Tsu, Japan

Abstract

Due to their extremely high theoretical capacity and low standard electrode potential, lithium metal anodes are regarded as promising materials capable of significantly improving the energy density of next-generation batteries. However, continuous side reactions with organic electrolytes and the heterogeneous growth of lithium dendrites during charge-discharge cycles lead to internal short circuits and the formation of dead lithium, posing major barriers to practical application. While the formation of an artificial solid electrolyte interphase (SEI) has garnered attention as an approach to suppress these issues, few attempts have utilized inorganic materials as the main phase, and the influence of their morphology on the electrochemical properties has not been fully elucidated. Therefore, in this study, we used pulsed laser deposition to form dense and smooth Al2O3 and SiO2 thin films with a thickness of tens of nanometers on a lithium metal electrode, thereby fabricating a lithium metal electrode coated with a dense inorganic material. The thin-film coating prevented direct contact between the electrolyte and the lithium metal electrode, effectively suppressing the increase in SEI resistance caused by side reactions. Furthermore, observation of the electrode surface after 100 cycles confirmed that the thin-film coating effectively suppressed heterogeneous dendrite growth and maintained an electrochemically active and stable electrode surface. In constant-current charge-discharge tests, the coated electrode exhibited a cycle life twice as long as that of the uncoated electrode. These results indicate that this thin film suppresses side reactions and heterogeneous dendrite growth, and is effective in stabilizing the electrode and extending battery life.

30

Double Decker Cell Design for High Performance Solid Oxide Reversible Cells

Tatsumi Ishihara, Khan Sovann
Kyushu University, Fukuoka, Japan

Abstract

Solid oxide reversible cells are one of the key energy conversion devices for achieving carbon neutral society. A single solid-ion conductor such as oxide ion or proton is generally used for the electrolyte sandwiched between positive and negative electrodes. However, because of the low long term stability of Ni fuel electrode, a high operating temperature is required resulting in low stability and high operational cost. In contrast, a cell using proton-conducting oxide electrolyte can operate at intermediate temperatures around 773 K, however, the Faradaic efficiency becomes low because of the partial hole conduction. Double decker reversible design consisting of oxide and proton conducting solid oxide films onto an intermediate porous electrode will be reported. A proton-conducting electrolyte, $BaZr_{0.44}Ce_{0.36}Y_{0.1}O_{3-\delta}$ (BZCY) film was deposited on a porous NiO-$Sr_{0.5}Ce_{0.4}Y_{0.1}O_{3-\delta}$ substrate by the tape-casting and co-sintering method. Onto this half-cell, a porous interlayer electrode of $LaFeO_3$-BZCY was deposited, and the upper electrolyte film of $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ was further deposited by the pulsed laser deposition method. Finally, an air electrode was deposited to assemble a single cell with two electrolyte layers. By using oxide, proton and electron triple conductor for the interlayer electrode, the newly designed cell generated good performance (0.44W/cm^2 in SOFC and 0.6A/cm^2 at 1.5V in SOEC mode at 773K) for both fuel cell and steam electrolysis modes. More importantly, this cell shows a high and stable Faradaic efficiency despite the BZCY proton conductor cell, which makes it more promising for green H_2 production from steam electrolysis.

31

Na-ion Batteries from Spent Li-ion Batteries

Aravindan Vanchiappan
Indian Institute of Science Education and Research (IISER) Tirupati, Tirupati, India

Aravindan Vanchiappan

Abstract

Sodium-ion batteries (NIBs) are gaining significant attention as a promising next-generation energy storage technology and a sustainable alternative to conventional Li-ion batteries (LIBs). However, unlike Li, Na-ions cannot readily intercalate into graphite to form stable binary graphite intercalation compounds (NaC_6 or NaC_8) due to thermodynamic limitations, particularly in ester-based electrolytes. In this work, we present a sustainable strategy for recovering graphite anodes and polypropylene (PP) separators from end-of-life LIBs and repurposing them for NIB applications. By employing ether-based electrolytes, reversible sodium-ion intercalation into the recovered graphite is enabled through a solvent co-intercalation mechanism, leading to the formation and stabilization of a ternary graphite intercalation compound that supports highly reversible sodium storage. Full NIBs were fabricated using carbon-coated $Na_3V_2(PO_4)_3$ as the cathode, recovered graphite as the anode, tetraethylene glycol dimethyl ether (TEGDME) as the electrolyte solvent, and the recovered PP separator under balanced mass-loading conditions. Detailed structural, morphological, and electrochemical characterization of all recycled components was performed. The resulting graphite/PP/$Na_3V_2(PO_4)_3$ full cell delivered a maximum energy density of 78 Wh kg^{-1} at room temperature, calculated based on the total mass of active materials. To further improve cycling stability, graphite-decorated electrospun carbon nanofibers were developed, exhibiting outstanding electrochemical durability with stable operation over 10,000 cycles and minimal capacity fading. Additionally, the electrochemical conversion of $LiFePO_4$ to $NaFePO_4$ was demonstrated, followed by the successful assembly of a $NaFePO_4$/graphite full cell, providing an additional route for the recycling and valorization of spent LIB materials in NIB technologies.

32

Understanding the Role of Cobalt Substitution in Low-Temperature Oxygen Surface Exchange of $SrTi_{1-x}Fe_xO_{3-\delta}$

Nathawuth Wongwutcharanukoun, Akihiro Ishii, Hitoshi Takamura
Tohoku University, Sendai, Japan

Abstract

Improving oxygen surface exchange at low temperatures is essential for developing durable solid-oxide cells with shorter start-up times. However, sluggish oxygen surface exchange at the oxygen electrode remains a major kinetic bottleneck[1]. Co substitution has been reported to enhance oxygen exchange in several perovskite oxides[2], but its specific improvement of oxygen surface exchange in the low-temperature region remains unclear.

In this study, $SrTi_{0.5}Fe_{0.5}O_{3-\delta}$ was investigated to clarify how Co substitution improves the oxygen surface exchange at low temperatures. The oxygen surface exchange rates were evaluated using pulse isotopic exchange, and the oxygen nonstoichiometry was measured using coulometric titration. From the Arrhenius analysis of the surface exchange rates, activation energies were obtained for each Co content. The Co-content dependence of these activation energies showed a strong correlation with the oxygen vacancy concentration derived from coulometric titration. This correlation suggests that oxygen vacancies play a key role in the low-temperature oxygen surface exchange, possibly through a defect-assisted mechanism.

The observed Co-content dependence also revealed that low Co substitution initially decreased the oxygen vacancy concentration compared with undoped $SrTi_{0.5}Fe_{0.5}O_{3-\delta}$, whereas higher Co substitution promoted the vacancy formation. This non-monotonic behavior may indicate a change in charge compensation, where low Co substitution favors electronic compensation involving Co/Fe redox rather than oxygen-vacancy formation. The Co and Fe valence states will be examined to further evaluate the proposed charge-compensation mechanism.

Reference

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[2] H. Chen *et al.,* Adv. Sci. **8**, 2102713 (2021).

33

Elastomeric Electrolytes and Protective Layers for Stable Operation of Lithium Metal Batteries

Bumjoon Kim, Doh Chang Lee
KAIST, Daejeon, Korea, Republic of

Abstract

Lithium-metal batteries (LMBs) are garnering attention as a next-generation battery technology that can surpass conventional Li-ion batteries in terms of energy density, but suffers from the safety issue and unstable cycling. Herein, we report a class of elastomeric electrolytes with a three-dimensional interconnected plastic crystal phase. The elastomeric electrolytes show a combination of mechanical robustness, high ionic conductivity, low interfacial resistance and high lithium-ion transference number. Moreover, the elastomer electrolytes enable stable operation of the full cells under constrained conditions delivering a high specific energy. Next, I will present the structure-property-electrochemical performance relationship of the elastomeric electrolytes in the LMBs. In the last part, I will introduce our recent work on polymer protective layers for enhancing the cyclability of lithium metal batteries.

34

Modification of MOF-5 thin film on MnO2 Cathodes for Ultra-Stable Aqueous Zinc-Ion Batteries

Jeng-Yu Lin
Department of Chemical and Materials Engineering, Tunghai University, Taichung City, Taiwan. Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

Abstract

To tackle the growing energy crisis and frequent extreme climate events, it is essential to develop energy systems that are dependable, cost-effective, and environmentally sustainable. Aqueous zinc-ion batteries (AZIBs) have attracted considerable attention as promising next-generation energy storage options, mainly because of zinc's plentiful resources, their safety, and affordability. A key focus in AZIB development is improving electrochemical stability through interfacial engineering. This study introduces a novel interfacial phase reconstruction method that leverages the confined induction capabilities of MOF-5.

In this method, Mn^{2+} ions preloaded in an electrolyte composed of 2M $ZnSO_4$ and 0.2M $MnSO_4$ mainly interact with Zn^{2+} ions on the MOF-5 surface. This interaction forms a dynamic, reversible in situ $ZnMn_2O_4$ interphase that greatly enhances the performance and stability of AZIBs. The $ZnMn_2O_4$ interphase acts as a self-expanding, reversible host crucial for energy management and maintaining structural integrity. By incorporating MOF-5, confined nucleation sites are provided, promoting the selective deposition of $ZnMn_2O_4$ and protecting the underlying MnO_2 from collapse and dissolution. In this dynamic interfacial engineering, the CC/MO@MOF-5 electrode attains a reversible capacity of 173.7 mAh g^{-1} at 0.1 A g^{-1}, which gradually decreases to 79 mAh g^{-1} after 5000 cycles at 1 A g^{-1}. The electrochemical reversibility of $ZnMn_2O_4$ and its phase evolution as a function of voltage are thoroughly studied. This research repositions $ZnMn_2O_4$ as a customizable, electrochemically active primary storage phase and introduces a co-design strategy for the electrolyte and interphase in aqueous multivalent-ion batteries operating under extreme conditions.

35

UV-Cured Fluorinated All-Component Crosslinked Solid Polymer Electrolytes via Diazide Nitrene Insertion for High-Voltage Solid-State Lithium Metal Batteries

Chien-Pan Liu
Department of Chemical and Materials Engineering, Tunghai University., Taichung City, Taiwan

Chien-Pan Liu

Abstract

The surging energy density demands of electric vehicles and wearable electronics have pushed conventional liquid lithium-ion batteries toward their physicochemical limits, where uncontrolled interfacial side reactions yield unstable solid electrolyte interphases (SEI), dendritic lithium growth, and irreversible lithium loss, posing critical safety and cycling stability concerns. Replacing liquid electrolytes with solid-state alternatives—particularly solid polymer electrolytes (SPEs)—offers a compelling pathway toward safer solid-state lithium metal batteries (SSLMBs); however, the fundamental trade-off between room-temperature ionic conductivity and high-voltage oxidative stability remains a persistent bottleneck. This research work presents a diazide-based all-component crosslinked SPE (Diazide all-component crosslinked SPE) fabricated via rapid UV photocuring, wherein photogenerated nitrene intermediates undergo non-selective C–H insertion reactions to simultaneously lock fluorinated elastomers (PVDF-HFP), ionic liquids (EMIM-TFSI), plastic crystals (succinonitrile), and LiTFSI into a unified covalent network. The high fluorine content of the custom-synthesized crosslinkers—ethane-1,2-diylbis(4-azido-2,3,5,6-tetrafluorobenzoate) (2Bx) and its ethylene oxide-extended analogue (2Bx-4EO)—lowers the electrolyte's HOMO energy level through strong electron-withdrawing effects, intrinsically enhancing anodic stability. By systematically varying crosslinker chain length, tunable lithium-ion transport channels are engineered across the network. A minor FEC additive further suppresses parasitic reactions at the lithium metal anode. The precursor solution is directly blade-coatable onto both electrodes, enabling scalable fabrication. This strategy simultaneously addresses the triple challenges of high-voltage stability, mechanical flexibility, and interfacial reliability in next-generation SSLMBs.

36

Highly Textured BZY Thin Films with Enhanced Proton Conductivity for Proton-Conducting Solid Oxide Cells

Suhyuk Ko, Suk-won Cha
Seoul National University, Seoul, Korea, Republic of

Abstract

Proton-conducting solid oxide cells (P-SOCs) have attracted considerable attention owing to their favorable characteristics, including low activation energy for ion transport at intermediate-to-low operating temperatures and water formation at the air electrode, which mitigates fuel dilution. Among various proton-conducting ceramic materials, yttrium-doped barium zirconate (BZY) has demonstrated excellent chemical stability under H_2O- and CO_2-containing atmospheres. However, BZY electrolytes fabricated by conventional processes generally exhibit relatively low ionic conductivity compared with other proton conductors, such as yttrium-doped barium cerate (BCY). This limitation is mainly attributed to the poor sinterability of zirconate-based materials, which leads to a high density of grain boundaries and the formation of secondary phases.

Sputtering offers a promising route to enhance the ionic conductivity of BZY by enabling the formation of highly textured thin films. In this study, thin-film BZY was synthesized using a co-sputtering process based on the in-situ solid-state reaction of deposited nanoparticles. To obtain a highly textured film, key sputtering parameters, including radio-frequency power and pressure, were systematically controlled. The crystallinity, chemical composition, and surface/cross-sectional morphology of the deposited films were characterized using XRD, DP-XPS, and SEM, respectively. In addition, the epitaxial structure of the deposited film was investigated by STEM-HAADF. The in-plane ionic conductivity of the deposited films was evaluated using AC impedance spectroscopy. These results demonstrate the successful fabrication of highly textured BZY thin films with enhanced ionic conductivity for proton-conducting solid oxide cell applications.

37

The Search for Ideal Hosts for Polymer-In-Salt Electrolytes Synthesis:From Fundamentals to Design Rules

Prof. Neelam Srivastava
Banaras Hindu University, Varanasi, India

Prof. Neelam Srivastava

Abstract

Starch, a renewable polymer, has been explored for PISE synthesis and it was observed many fundamental properties which decides guidelines for PISE synthesis. Since the salt breaks the starch in smaller molecules which enhances the number of available -OH and -H and hence with increasing salt concentration starch itself enhances its ability to accommodate enhanced number of ions from salt. Since in starch-salt complexes ions act more like a guest coordinated by the polymer host rather than reacting chemically with the starch and both starch and high amount of salt make the system highly hygroscopic and hence when such PISEs are left in ambient they start flowing after some time, because absorption of water disturbs the starch-salt coordination and due to decreased starch-salt interaction strength, it changes the morphology from membrane to viscous liquid. Hence crosslinking is required. Crosslinkers like glutaraldehyde, malonic acid, succinic acid, malic acid etc., can be successfully used to get flexible membranes. The amount and type of crosslinkers also depends on the type of salt, i.e. monovalent/divalent/trivalent cations, because divalent/trivalent cation itself behaves as crosslinker. Electrochemical and mechanical properties of the PISEs also depends upon the anion. Specially the structure and electronegativity of anion has significant effect because it controls the space distribution and hydrogen bonding. All PISEs synthesized with these guidelines resulted in flexible PISEs which successfully used in supercapacitor (SC) fabrications with power density~kWh/kg, i.e. thoughtfully selected polymer hosts can lead to PISEs suitable for commercial energy device fabrication.

38

Nucleation and growth of quasicrystal-related precipitates within the Al-matrix of AlEr(Fe) alloys

S. Zhan[1], Y.X. Lai[2], J.H. Chen[2]
[1]Hunan University, Changsha, China. [2]Hainan University, Haikou, China

Abstract

Since the discovery of quasicrystals, their applications to industry have been interesting issues, among which attempts of introducing quasicrystal-related precipitates into the Al-matrix to enhance properties of Al alloys have been made without adequate understandings. Here, we report a formation pathway of quasicrystal-related precipitates in the Al-matrix of an AlEr(Fe) alloy. It is shown that upon thermal aging of the alloy, Al3Er precipitates form firstly in the Al-matrix, then quasicrystal-related (AlFe)-precipitates may nucleate heterogeneously within the Al3Er precipitates and grow large. As the quasicrystal-related precipitate grows large, the Al3Erprecipitate reform as the thin “skin” of the formed composite precipitate, keeping the quasicrystal-related portion well separated from the matrix. Atomic-resolution electron microscopy and spectroscopy reveal that these composite precipitates are the mixtures of the Al13Fe4 quasicrystal approximant structure and/or quasicrystalrelated aperiodic structures, as well as their surrounding skin with Al3Er-structure. As such, Fe atoms as vexing impurity in Al alloys can be absorbed continuously into such composite precipitates. Our findings provide insights into the feasibility to form quasicrystal-related precipitates in the Al-matrix.

39

Designing electrolytes for 600 Wh kg^{-1} lithium batteries

Chen-Zi Zhao
Tsinghua University, Beijing, China

Chen-Zi Zhao

Abstract

The combination of lithium metal anodes and lithium-rich manganese-based cathodes is widely regarded as one of the most promising routes toward next-generation high-energy-density batteries. However, their practical implementation remains hindered by interfacial side reactions associated with oxygen activity at high voltages and the instability of lithium metal anodes. Herein, I will discuss our recent efforts in electrolyte and interfacial design for high-energy lithium metal batteries. By constructing anion-rich solvation structures and developing electrolyte systems with enhanced oxidative stability, we regulate electrode–electrolyte interfacial chemistry to improve oxygen redox reversibility, mitigate parasitic reactions, and promote more stable lithium plating/stripping behavior. These strategies enable lithium metal batteries with cell-level energy densities exceeding 600 Wh kg^{-1} while maintaining favorable safety. In addition, fluorine-free high-voltage electrolyte designs are explored in response to growing PFAS-related concerns, offering potential insights for the development of next-generation high-energy-density solid-state lithium batteries.

Key References

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40

Effect of Anode Nanostructures on the Electrochemical Performance of Thin-Film SOFCs Fabricated on Nanoporous AAO Substrates

Daniel Gil, Jaewon Hwang, Suk Won Cha
Seoul National University, Seoul, Korea, Republic of

Abstract

Thin-film solid oxide fuel cells (TF-SOFCs) represent a highly promising technology for clean and efficient power generation at reduced operating temperatures. While lowering the temperature is advantageous, it often leads to sluggish reaction kinetics at the electrodes. Overcoming this limitation requires precise morphological control. In particular, engineering the nanoscale architecture of the anode is widely recognized as a pivotal strategy for enhancing overall electrochemical performance. In this study, we introduce architecturally tailored TF-SOFCs built upon nanoporous anodic aluminum oxide (AAO) templates. Using co-sputtering and glancing angle deposition (GLAD), four unique anode geometries—vertical, slanted, zigzag, and spiral—were sculpted on the AAO supports. The cells comprised a composite yttria-doped ceria (YDC) and nickel (Ni) anode, a dense yttria-stabilized zirconia (YSZ) electrolyte, a lanthanum strontium cobalt ferrite (LSCF)-gadolinium cerium oxide (GdCe) cathode, and a platinum (Pt) current collector. Testing at 500°C in pure hydrogen via current-voltage (i-V) profiling and electrochemical impedance spectroscopy (EIS) revealed distinct morphological dependencies. Modifying deposition angles effectively tuned the active triple phase boundary (TPB) sites within the anode, significantly impacting catalytic activity. Additionally, FE-SEM, XPS, and XRD validated the structural stability and elemental purity of the films. Ultimately, engineering the anode's architecture on nanoporous AAO platforms maximizes TPB density, elevating electrochemical kinetics and offering a robust blueprint for next-generation TF-SOFCs.

41

Anion Redox Activity and Stability of One-Dimensional π-Conjugated Li_3BN_2 Polymorphs

Akihiro Ishii, Hitoshi Takamura
Tohoku University, Sendai, Japan

Abstract

Utilizing anion redox reactions is one strategy for achieving high-energy-density cathode active materials beyond conventional cation-centered redox chemistries. This study focuses on the anion-redox activity and stability of Li_3BN_2. Generally, transition-metal nitrides exhibit relatively low redox voltages because their redox reactions involve electron transfer in d orbitals. In contrast, nitrides composed of typical metal elements may undergo redox reactions involving N 2p orbitals, which could enable higher redox voltages suitable for cathode applications. In particular, the nitride anions in Li_3BN_2 have the potential to be redox active owing to the unique one-dimensional π-conjugated framework of the $[\text{-Li-N-B-N-}]^{2-}$ anionic chains in its crystal structure. Previous studies have suggested two-electron redox activity accompanied by rapid electrochemical deactivation in rutile-type Li_3BN_2, one of the three known polymorphs (rutile, anatase, and monoclinic). This study experimentally revealed that the electrochemical deactivation is due to the formation of electrochemically inert BN phases on delithiated $Li_{3-d}BN_2$ particles. The slight enhancement in the redox stability of monoclinic Li_3BN_2 was supported by both DFT-GGA calculations and experimental analyses. The polymorph dependence of redox stability provides insights into the design of stable anion-redox materials.

42

Fluence Window Determination for Scalable and Reproducible Laser Sintering

Rei Sato, Akihiro Ishii, Hitoshi Takamura
Graduate School of Engineering, Tohoku University, Sendai, Japan

Abstract

The laser sintering technique has been studied for time- and energy-efficient production of solid-state devices comprising refractory oxides. Recent studies have achieved laser sintering of solid-oxide fuel cells [1]. However, laser sintering generally suffers from low reproducibility due to the narrow processing window among multiple parameters, such as sample dimensions and laser-scanning conditions [2]. This poor reproducibility restricts the processable sample width to the millimeter scale to avoid cracking and inhomogeneous densification caused by subtle parameter deviations.

To enhance reproducibility, this study proposes a new strategy focusing on laser fluence. Given that fluence determines the local heating intensity, we considered an acceptable fluence range, called the fluence window, for successful laser sintering. The fluence window is determined in three steps: 1) determining the upper fluence limit to sinter specimens while avoiding unintended reactions by repeating laser-sintering experiments under relatively high fluence conditions; 2) identifying the crack-free threshold by narrowing the sample width under this upper limit; and 3) mapping the received fluence range by quantitatively measuring the fluence distribution of the laser beam. Once determined, the fluence window allows the generation of laser-sintering diagrams that show the maximum sinterable width at given laser-fluence-distribution, scanning-speed, and laser-power sets.

In this presentation, the effectiveness of this strategy is demonstrated using 8 mol%Y_2O_3-doped ZrO_2 free-standing membranes as a case study, and its usefulness for laser sintering of wide and substrate-supported films is discussed.

Reference

[1] H. Huang *et al.*, *Device* **3** (2025).

[2] A. Ishii *et al.*, *Materials Research Bulletin* **143** (2021) 111446.

43

Compositional Optimization of Ni–YSZ Nanostructured Anode Functional Layers for Thin-Film Anode-Supported SOFCs

Hyuntak Sohn, Suk-won Cha
Seoul National University, Seoul, Korea, Republic of

Abstract

Efficient operation of solid oxide fuel cells at reduced temperatures requires electrode/electrolyte interfaces that support rapid reactions while minimizing resistive losses. Anode-supported SOFCs are well suited for this purpose because their mechanically strong anode substrate allows the use of a thin electrolyte, thereby reducing ohmic resistance. In thin-film cells, the anode functional layer plays a key role in determining performance by providing triple-phase boundary regions and charge-transport pathways. Nanostructured anode functional layers can further enhance interfacial reaction activity, but their electrochemical behavior is strongly affected by the relative composition of Ni and YSZ, which influences catalytic activity, ionic conduction, and microstructural connectivity.

In this study, thin-film anode-supported SOFCs were fabricated to investigate the effect of Ni–YSZ composition in the nanostructured anode functional layer. NiO–YSZ anode supports were used as substrates, and Ni–YSZ nAFLs with various composition ratios were deposited. A YSZ electrolyte was then formed by magnetron sputtering, followed by the fabrication of a Pt cathode. The cells were characterized using SEM, XRD, electrochemical impedance spectroscopy, and current–voltage–power density measurements at 510°C. The relationship between Ni–YSZ composition and electrochemical resistance was analyzed to identify a suitable composition that balances catalytic activity and charge transport. These findings provide useful guidance for designing nanostructured anodes in high-performance thin-film AS-SOFCs.

44

Synthesis, First-principles calculations, and fluorine ionic conductivity of double perovskite-type Cs2RbBiF6-based fluoride

Daisuke Mori[1], Ko Sakakibara[1], Satoru Okamoto[1], Eiki Niwa[1], Sou Taminato[1], Nobuyuki Imanishi[1], Ayako Taguchi[2], Hiroki Moriwake[2]
[1]Mie University, Tsu, Japan. [2]Japan Fine Ceramics Center, Nagoya, Japan

Daisuke Mori

Abstract

All-solid-state fluorine batteries have received much attention due to their potential for high safety and high energy density. However, their high operating temperature due to low ionic conductivity is a practical issue for the batteries. This study focused on the double-perovskite-type fluoride Cs_2RbBiF_6 with high lattice stability. Trivalent Bi in Cs_2RbBiF_6 was substituted for monovalent Rb and divalent Mg to enhance ionic conductivity by introducing fluorine deficiency. First-principles calculations were performed to understand the ionic conduction mechanism.

The lattice parameter of $Cs_2Rb_{1+x}Bi_{1-x}F_{6-2x}$ (x = 0.025, 0.05, 0.075) increased with Rb substitution. The ionic conductivity of the sample with x = 0.025 (F = 0.595) was 3.5×10^{-6} S cm^{-1}, an improvement of about one order of magnitude compared with that of the parent Cs_2RbBiF_6. A decrease in ionic conductivity was observed as the substitution content of Rb increased. The first-principles calculation indicated that the F^-deficiencies were associated with doped Rb, which increased the barrier to F^- anion migration. Therefore, Mg^{2+} substitution, which is expected to have a smaller difference in electrostatic energy from Bi^{3+}, was examined. The activation energy of Mg-substituted Cs_2RbBiF_6 was estimated to be 0.52 eV from the difference in formation energy of F^- deficiency at each site, which is in good agreement with the experimentally obtained value.

This work was supported by the RISING3 (JPNP21006) commissioned by NEDO.

45

Redox-State Engineering of Ni/GDC Thin-Film Anodes for Carbon-Tolerant Syngas-Fueled SOFCs

Inyoung Jeong, Suk Won Cha
Seoul National University, Seoul, Korea, Republic of

Abstract

Syngas-fueled solid oxide fuel cells (SOFCs) offer a promising route for efficient conversion of carbon-rich feedstocks, but carbon deposition on Ni-based anodes remains a critical barrier to stable operation. In this study, co-sputtered Ni/GDC thin-film anodes were employed as a model platform to control the initial surface ceria redox state by varying the GDC content. Under syngas operation at 650 °C, the anode with an intermediate GDC composition exhibited the most stable early/intermediate performance, showing lower power-density degradation and a smaller increase in polarization resistance than both pure Ni and high-GDC anodes. Raman and post-test SEM analyses confirmed that the optimized Ni/GDC anode suppressed carbon accumulation while maintaining microstructural stability, whereas excessive GDC promoted Ni agglomeration and local structural degradation. XPS results demonstrated that GDC content systematically modulates the initial Ce^{3+}/Ce^{4+} ratio, and DFT calculations further revealed that partially reduced ceria provides the most favorable energetic and electronic environment for the reverse Boudouard reaction and CO intermediate stabilization. These results suggest that tuning the ceria redox state at the Ni–ceria interface is an effective strategy for designing coke-resistant SOFC anodes for carbon-containing fuels.

46

Flexible Polysaccharide-Based Polymer-In-Salt-Electrolytes (PISEs) Doped with Magnesium Salt for All-Solid-State Ultra-capacitor: Anion effect

Dipti Yadav[1], Neelam Srivastava[2]
[1]Jaypee Institute of Information Technology, Sector 62 Noida, India. [2]Banaras Hindu University, Varanasi, India

Dipti Yadav

Neelam Srivastava

Abstract

Modern commercial energy devices demand the development of flexible, cost-effective, and environmentally sustainable electrolytes that possess robust electrochemical characteristics. While Polymer-In-Salt-Electrolytes (PISEs) show significant electrochemical promise, their practical application is often hindered by laboratory-level challenges such as host polymer brittleness and the recrystallization of ion sources. Addressing these issues typically necessitates complex, expensive, and strictly controlled formulation environments. In this study, PISEs were synthesized using glutaraldehyde (GA) crosslinked corn starch—a renewable polysaccharide—combined with various magnesium salts, specifically MgCl2, Mg(ClO4)2, and Mg(NO3)2, separately. This synthesis protocol is notable for its simplicity, as it eliminates the need for controlled conditions, making the resulting electrolytes both economical and eco-friendly. At ambient temperatures, these flexible electrolytes demonstrated exceptional performance, including a high ionic conductivity of approximately 0.05 Scm-1, an expansive electrochemical stability window exceeding 2.5 V, and a rapid relaxation time in the microsecond range. The formulated PISEs were evaluated in supercapacitor applications using activated carbon electrodes. The system utilizing Mg(NO3)2 achieved a peak specific capacitance of 750 F/g and a power density reaching the kW/kg scale. These results categorize the devices as ultracapacitors, highlighting the potential of these polysaccharide-based PISEs for advanced energy storage.

47

Development of Semi-transparent 3D Structured Conductive Electrode

Wasinee Sirifongnukul[1], Anongnat Somwangthanaroj[1], Hirotaka Nakatsuji[2], Hirotomo Nishihara[2,3], Chanon Pornrungroj[1]
[1]Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand. [2]Institute of Multidisciplinary Research for Advance Materials, Tohoku University, Sendai, Japan. [3]Advanced Institute for Materials Research (WPI-AIMR), Tohoku University, Sendai, Japan

Wasinee Sirifongnukul

Anongnat Somwangthanaroj

Hirotaka Nakatsuji

Hirotomo Nishihara

Chanon Pornrungroj

Abstract

Fluorine doped Tin Oxide (FTO) and Indium Tin Oxide (ITO) function as semi-transparent conductive support materials utilized in (photo)electrochemical devices/electrodes systems. Their conventional flat-film structures limit available surface area, which limits their electrochemical performance. A 3D structured FTO or ITO electrode would increase the surface area and would be beneficial for (photo)electrochemical, but the fabrication remained challenging. In this work, cellulose nanofibers (CNFs) are proposed as structure-directing agents for the fabrication of 3D microhoneycomb monoliths containing FTO or ITO particles via unidirectional freeze-drying. The CNFs network is expected to guide the formation of aligned porous channels during the freezing process, while the incorporated FTO or ITO particles will provide electrical conductivity to the resulting monoliths. The 3D porous structure is anticipated to provide a much greater accessible surface area compared to conventional flat or planar FTO or ITO structures. The successful incorporation of FTO and ITO nanoparticles into CNF-derived microhoneycomb monoliths was achieved over a range of particle loadings. The influence of nanoparticle concentration on pore morphology and electrical conductivity was investigated. The resulting conductive microhoneycomb monoliths show promise as high-surface- area electrode materials for (photo)electrochemical applications. The research will contribute to achieving sustainable means by providing a method to fabricate large surface area conductive porous material suitable for use as electrodes.

48

Micro-honeycomb Monolith Fabricated by Ice-templating for Enhanced Photocatalytic Hydrogen Production Couple with Alcohol Oxidation

Feungsiri Jankrajangjaeng[1], Anongnat Somwangthanaroj[1], Hirotaka Nakatsuji[2], Hirotomo Nishihara[2,3], Chanon Pornrungroj[1]

[1]Departmentof Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand. [2]Institute of Multidisciplinary Research for Advance Materials, Tohoku University, Sendai, Japan. [3]Advanced Institute for Materials Research (WPI-AIMR), Tohoku University, Sendai, Japan

Feungsiri Jankrajangjaeng

Anongnat Somwangthanaroj

Hirotaka Nakatsuji

Hirotomo Nishihara

Chanon Pornrungroj

Abstract

Hydrogen has attracted significant attention as a clean energy source due to its high energy density and environmentally friendly properties. However, conventional hydrogen production methods, particularly water electrolysis, still require high energy consumption and operational costs. Therefore, photocatalytic hydrogen production has emerged as a promising alternative because it can utilize abundant natural solar energy. In addition, replacing the oxygen evolution reaction with alcohol oxidation reaction (AOR) can reduce the reaction energy barrier while simultaneously producing hydrogen and value-added chemicals. In this work, a floating photocatalytic system is developed using aligned macroporous monoliths (AMMs) as porous supporting materials for the CN_x/Ni_2P photocatalyst. The micro-honeycomb AMM structure is fabricated through a unidirectional ice-templating process using cellulose nanofiber and phenolic resin to obtain a mechanically robust porous structure capable of floating on water and supporting photocatalytic materials. Different photocatalyst loadings of 20, 30, 40, and 50 wt% are investigated to evaluate their effects on hydrogen production and value-added chemical generation from the AOR process. The porous structure is expected to enhance light absorption and promotes efficient liquid-solid-gas interactions under 365 nm light irradiation. In addition, integrating CN_x/Ni_2P onto the porous AMM structure could improve catalyst stability, suppresses particle aggregation, and minimizes catalyst leakage into water compared with conventional powder photocatalyst systems. This work demonstrates the potential of AMM-base floating photocatalytic systems for sustainable hydrogen and clean energy production.

49

DIRECT REGENERATION OF SPENT $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532) CATHODES VIA CARBON FLOTATION AND LiI-LiOH EUTECTIC MOLTEN SALT

Parame Janson[1], Pakinee Thongrit[1,2], Panawan Vanaphuti[3], Jiaqian Qin[1,4,5], Rojana Pornprasertsuk[1,4,5,6]
[1]Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. [2]Synchrotron Light Research Institute (Public Organization), Nakhon-Ratchasima, Thailand. [3]Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. [4]Center of Excellence in Petrochemical and Materials Technology, Chulalongkorn University, Bangkok, Thailand. [5]Center of Excellence on Advanced Materials for Energy Storage, Chulalongkorn University, Bangkok, Thailand. [6]Department of Materials Science and Bioengineering, Nagaoka University of Technology, Nagaoka, Japan


Parame Janson


Pakinee Thongrit


Panawan Vanaphuti


Jiaqian Qin


Rojana Pornprasertsuk

Abstract

The rapid expansion of lithium-ion batteries (LIBs) in electric vehicles has intensified demand for sustainable cathode recycling. Spent $Li_xNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532) cathodes contain valuable critical minerals, yet conventional pyrometallurgical and hydrometallurgical methods are energy-intensive and destroy the pristine crystal structure, preventing direct material reuse. This study integrates the froth flotation for carbon removal and the direct recycling route using LiI–LiOH eutectic molten salt for spent NMC532 relithiation. Froth flotation selectively removed residual carbon black using oleic acid (0.04 wt%) as a collector and pine oil as a frother. Optimizing the frother dosage revealed that 0.10 vol% pine oil achieved the highest carbon separation efficiency of 76.46%, whereas higher concentrations (0.14 and 0.18 vol%) reduced selectivity to 67.22% and 69.45% due to excess froth entraining NMC532 particles. The carbon-depleted powder was was then relithiated using a eutectic molten salt (1:3 molar ratio) with varying total lithium content (2.5, 5, and 7.5 wt%) via a two-stage thermal process (200–250 °C for 4 h, followed by 800–850 °C for 5 h). Regenerated materials were assembled into CR2032 coin cells for electrochemical evaluation. This work demonstrates a practical and scalable pathway for direct NMC532 cathode recycling.

50

High-Efficiency and Stable HTL-Free Carbon-Based Perovskite Solar Cells for Indoor Photovoltaics via Facet Control

Chaowaphat Seriwattanachai[1], Somboon Sahasithiwat[2], Varakorn Phiriyasas[1], Kanokwan Choodam[1], Thanawat Kanlayapattamapong[3], Sirawit Kamnoedmanee[4], Nattawut Kamjam[1], Noppawit Sukpan[1], Worawut Rueangsawang[1], KO KO Shin Thant[1], Apicha Pontavatchai[1], Tanakorn Kittikool[1], Ladda Srathongsian[1], Ratchadaporn Supruangnet[5], Hideki Nakajima[5], Pipat Ruenkam[3], Yue Hu[4], Pongsakorn Kanjanaboos[1,6]

[1]Advanced Technologies for Energy and Sustainability Lab, School of Materials Science and Innovation, Faculty of Science, Mahidol University, 73170, NAKHON PATHOM, Thailand. [2]National Metal and Materials Technology Center (MTEC), National Science and Technology Development Agency (NSTDA), 114 Thailand Science Park, Phahonyothin Road, Khlong Luang, 12120, Pathum Thani, Thailand. [3]Department of Physics and Materials Science, Faculty of Science, Chiang Mai University, 50200, Chiang Mai, Thailand. [4]School of Chemistry, University of Edinburgh, Edinburgh, United Kingdom. [5]Synchrotron Light Research Institute, 111 University Avenue, Muang District, 30000, Nakhon Ratchasima, Thailand. [6]Center of Excellence for Innovation in Chemistry (PERCH-CIC), Ministry of Higher Education, Science, Research and Innovation, 10400, Bangkok, Thailand

Chaowaphat Seriwattanachai

Abstract

Carbon-based perovskite solar cells (C-PSCs) offer an exceptionally short energy payback period. The hole transport layer-free (HTL-free) architecture can further accelerate the energy saving. Although various strategies were demonstrated for HTL-free C-PSCs, the perovskite layer has rarely been tailored to solve electronic band energy mismatches between perovskite/carbon and imbalanced charge transport at perovskite/ETL. In this study, we modulated the (111) and (100) perovskite facets at the buried interface to achieve enhanced in-plane crystal orientation via molecular structures of chosen antisolvents, significantly improving the electronic band alignment at the ETL junction. Furthermore, residual PbI_2 formed on the perovskite surface effectively facilitates 2D/3D defect passivation. As a result, the optimized devices achieved an outstanding indoor light power conversion efficiency (PCE) of up to 32.31%. The cells also exhibited excellent long-term operational stability, retaining over 98% of their initial PCE after more than a year of continuous testing under the standard ISOS-D-1 protocol. This simplified strategy aligns with environmentally friendly manufacturing practices by achieving high performance with minimal procedure.

51

Atomic-Resolution Imaging of Organic Halide Perovskites via Ultra-low-dose Ptychography

Biao Yuan
Hainan University, Haikou, China

Biao Yuan

Abstract

Organic–inorganic halide perovskites are promising photovoltaic materials owing to their outstanding optoelectronic properties. However, their extreme structural instability under electron irradiation has long prevented direct atomic-resolution characterization by transmission electron microscopy. Here, we demonstrate, for the first time, direct imaging of the intrinsic surface atomic structure of an organic halide perovskite solar-cell material at ultra-low doses. By employing an exceptionally weak probe current and a fast scanning strategy, we acquired 4D-STEM datasets showing atomic resolution at tens of e^{-} $Å^{-2}$. Our data are the lowest dose atomic-resolution ptychography reported to date. Dose fractionation allows us to both image the intrinsic atomic structure of the material, using signal up until the point at which damage occurs, and observe the dynamic evolution of its edges and defects, facilitating the correlation of damage rates with different structures.

52

High-performance solid-state supercapacitor using Li+-garnet polymer composites

KAMALDEEP BISHT
Birla Institute of Technology and Science Pilani, Pilani, India

Abstract

This work delves into novel Li^{+}-ion garnet polymer composites and their applications in solid-state supercapacitors (SSCs). For this, Niobium (Nb) doped cubic garnet LLZNO ($Li_{6.75}La_3Zr_{1.75}Nb_{0.25}O_{12}$) is synthesized and incorporated into the PEO matrix to get an optimized composite that exhibits conductivity ~10^{-4} Ω^{-1} cm^{-1} at RT. The cubic phase formation of LLZNO is confirmed by XRD spectra and Rietveld analysis. The polymer composite membrane was then used as the electrolyte, along with a high-surface-area activated carbon electrode, to fabricate SSC. The interface was subsequently improved by creating a microgel layer using a small amount of organic solvent between the electrode and the electrolyte membrane. The SSC with a modified interface exhibit much superior performance C_S ~145 F g^{-1} at 2 V/1 mA, P ~1323 W kg^{-1}, E ~25 Wh kg^{-1}, and shows ~60% cycle stability after 15,000 GCD cycles. The temperature tolerance of the SSCs is tested over a wide range of temperatures (-10 ^{o}C to 50 ^{o}C). The SSC show stability up to 100,000 GCD cycles, with >50% C_S retention. Finally, the real-life application of fabricated SSCs is demonstrated by powering two LEDs connected in parallel for more than 30 minutes, using two 2 V devices connected in series.

53

Electrochemical detection of salbutamol using the molecular imprinted polymer technique with nano copper oxide

Darinee Phromyothin, Teeranuch Khummung, Supakorn Puengvigrai
King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

Abstract

Salbutamol (SAL) is a synthetic β2-adrenergic receptor agonist widely prescribed as a bronchodilator for the treatment of respiratory diseases such as bronchial asthma and chronic obstructive pulmonary disease. This study developed a highly sensitive and selective electrochemical detection method for salbutamol by modifying a screen-printed carbon electrode (SPCE) with copper oxide nanosheets and a molecularly imprinted polymer (CuO/MIP/SPCE). The CuO nanosheets were intended to increase the electroactive surface area and enhance electron transfer kinetics, while the rationally designed MIP layer was electropolymerized to provide selective sites for SAL molecules. The structural, morphological, and electrochemical properties of the step-wise modified electrodes were systematically characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), atomic force microscopy (AFM), Brunauer-Emmett-Teller (BET), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS). The mesoporous MIP network offers specific recognition cavities for SAL binding. Under optimal conditions, the SPE/CuO/MIP electrode exhibited a linear dynamic range from 0.1 to 250 ppm, with a limit of detection (LOD) of 0.4406 ppm and a limit of quantification (LOQ) of 1.3351 ppm. The modified electrode demonstrated outstanding selectivity toward structural analogs and common interferents, along with excellent reusability.

54

Annealing-Temperature-Driven Structural Evolution and Photoelectrochemical Performance of Well-defined Iron Oxide Nanorod Arrays

THANAKORN KHUMTONG[1], Narathon Khemasiri[2], Waritsara Thajitr[1], Khodchaphak Angkanawichint[2], Navaphun Kayunkid[2], Sakon Rahong[2], Annop Klamchuen[3], Worasak Sukkabot[1], Jiti Nukeaw[4]

[1]Department of Physics, Faculty of Science, Ubon Ratchathani University, Ubon Ratchathani, Thailand. [2]School of Integrated Innovative Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. [3]National Nanotechnology Center (NANOTEC), NSTDA, Bangkok, Thailand. [4]School of Integrated Innovative Technology, King Mongkut's Institute of Technology Ladkrabang, bangkok, Thailand

THANAKORN KHUMTONG

Abstract

The direct conversion of solar energy into chemical energy via photoelectrochemical (PEC) systems has attracted considerable attention for addressing the global energy crisis. Therefore, the development of photocatalytic materials with high PEC performance and long-term stability has become a major research focus. Here, we investigate the impact of post-annealing temperature on the crystal structure and PEC activity of iron oxide nanorods (α-Fe_2O_3-NRs) synthesized via hydrothermal route. X-ray diffractograms revealed that the complete phase transformation of iron oxyhydroxide nanorods (β-FeOOH) into α-Fe_2O_3-NRs occurred at an annealing temperature (T_a) of 300^{o}C. As T_a increased from 300^{o}C to 500^{o}C, the crystalline size of the (110) plane increased from 7.89 nm to 20.24 nm, indicating enhanced crystallinity. However, structural deterioration was observed above 500^{o}C, resulting in a reduced crystalline size of 19.75 nm and an increased average diameter accompanied by a lower nanorod density. All α-Fe_2O_3 samples exhibited rapid photoresponse under solar illumination. The photocurrent density increased dramatically from 0.34 to 310.69 μA/cm^2 as T_a increased from 300 to 500^{o}C owing to reduced charge trapping at crystalline grain boundaries. Further increasing T_a to 600^{o}C decreased the photocurrent density to 264.28 μA/cm^2 because of the reduced semiconductor–electrolyte interface. These findings highlight the critical role of annealing temperature in optimizing hematite-based photoelectrodes.

55

Unveiling the Crucial Role of Post-Annealing in Crystal Structure Evolution and Photoelectrochemical Performance of $BiVO_4$ Films for Self-Powered H_2O_2 Detection

Narathon Khemasiri[1], Prapakorn Rattanawarinchai[1], Khodchaphak Angkanawichitn[1], Navaphun Kayunkid[1], Adirek Rangkasikorn[1], Annop Klamchuen[2], Chaiyuth Sae-kung[3], Sirirat Khemasiri[4], Sakon Rahong[1], Jiti Nukeaw[1]
[1]Department of Nanoscience and Nanotechnology, School of Integrated Innovative Technology (SIITec), King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. [2]National Nanotechnology Center (NANOTEC), NSTDA, Pathum Thani, Thailand. [3]National Energy and Technology Center (ENTEC), NSTDA, Pathum Thani, Thailand. [4]Department of Chemical Engineering and Biotechnological Engineering, Université de Sherbrooke, Sherbrooke, Canada

Narathon Khemasiri

Abstract

Highly sensitive photoelectrochemical detection of biomolecules has gained tremendous attention in recent years owing to its broad applications in food and beverage quality control, clinical diagnostics, and environmental analysis. Consequently, considerable efforts have been devoted to the exploration and development of materials with superior photocatalytic and photoelectrochemical properties. Herein, we investigated the post-annealing-induced crystal structure evolution of bismuth vanadate ($BiVO_4$) film at temperatures ranging from 200^{o}C to 600^{o}C. A critical annealing temperature of 400^{o}C was identified for the formation of single monoclinic phase (m-$BiVO_4$) with a preferred-(121) orientation. In contrast, tetragonal (t-$BiVO_4$) and V_2O_5-$BiVO_4$ phases were obtained below and above 400^{o}C, respectively. The m-$BiVO_4$ exhibited a rapid photoresponse under solar irradiation, delivering a photocurrent density of 93.54 uA/cm^2, approximately 4 and 1.7 times higher than those of the t-$BiVO_4$ and V_2O_5-$BiVO_4$ phases, respectively. Furthermore, the photocurrent response of m-$BiVO_4$ film increased markedly in the presence of H_2O_2, even under zero bias conditions, revealing a signal-on self-powered photoelectrochemical sensing behavior. This finding is attributed to the hole-scavenging characteristic of H_2O_2, which promotes charge separation and facilitates electron transfer. The m-$BiVO_4$ sensor exhibited a linear response over the H_2O_2 concentration range of 0.01-4 mM with sensitivities of 6.87 and 2.10 nA/cm^2.mM in the concentration ranges of 0.01-1 mM and 1-4 mM, respectively. These findings highlight the crucial role of post-annealing in tailoring crystal evolution and photoelectrochemical properties of $BiVO_4$ films and demonstrate their potential as self-powered photoelectrochemical sensing platforms for H_2O_2 and related biomolecule detection.

56

Solid electrolytes and application in energy storage batteries

Zhaoyin Wen
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Zhaoyin Wen

Abstract

To date, a wide range of solid electrolytes have been discovered and extensively investigated, many of which have been deployed in diverse electrochemical devices. Among all electrolyte systems, lithium-ion, sodium-ion, proton, and oxide-ion conductors represent the most extensively studied and practically valuable categories. This report summarizes research on various ionic conductors conducted in the authors' laboratory, together with their applications in solid-state lithium batteries, sodium batteries, reversible fuel cells, and sensors.

57

Design and stabilization mechanism of the negative electrode interface for aqueous zinc-ion batteries

Yudai Huang
College of Chemistry, Xinjiang University,, Urumqi, China

Yudai Huang

Abstract

The dendrites and side reactions of the metallic zinc (Zn) anode in aqueous zinc-ion secondary batteries (AZIBs) have always been the obstacles hindering their development. The mechanism of dendrite growth and interfacial side reactions is complex and can be driven by ion concentration gradients, temperature gradients, local catalytic surfaces, local stress effects, or a combination of these factors. The electrode/electrolyte interface engineering strategy has achieved a good effect on enhancing the reversibility of the Zn anode and plays a key role in improving the interface physicochemical properties and electrochemical performance of AZIBs. This work aims to enhance the reversibility, current density, cumulative deposition capacity, coulombic efficiency (CE) and lifespan of Zn anodes. A "three-in-one" research framework of "solid electrolyte interface function design-performance research-mechanism exploration" is constructed, and three functional solid electrolyte interface films with given functions at the experimental level are designed. Combined with in-situ/non-in-situ characterization methods, deeply explores the structure-activity relationship between the physicochemical properties, functional characteristics, etc. of the solid electrolyte interface film and the durability of the Zn anode, reveals the corresponding rules, and proposes effective engineering strategies for the metal Zn anode/electrolyte interface.

58

Multi-scale Interfacial Design for Inorganic All-Solid-State Lithium Metal Batteries

Ya Chen[1], Xin Gao[1], Zhen Huang[1], Zhaoyin Wen[2]
[1]Shanghai Jiao Tong University, Shanghai, China. [2]Shanghai Institute of Ceramics of Chinese Academy of Sciences, Shanghai, China

Ya Chen

Xin Gao

Zhen Huang

Zhaoyin Wen

Abstract

Inorganic all▲solid▲state lithium metal batteries using Li_6PS_5Cl (LPSC) face multi▲scale interfacial transport limitations. We propose systematic designs at three scales. At the anodic side, a composite interlayer of LPSC and nano-$Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ blocks grain-boundary electronic conduction and dynamically heals cracks via reaction with Li dendrites, achieving symmetric-cell critical current density >5 mA cm^{-2} and stable cycling for 1600 h at 10 mA cm^{-2}; $LiCoO_2$ full cells retain 85.6% after 1200 cycles at 1 C. At the cathodic side, gradient modification of Li-rich Mn-based oxide (LRMO) via S/Zr co-doping and amorphous $Zr(SO_4)_2$ coating stabilizes lattice oxygen and ensures intimate contact with LPSC, delivering 292 mAh g^{-1} at 0.1 C and 81.8% retention after 2000 cycles at 1 C, with pouch cell areal capacity of 8.5 mAh cm^{-2}. For the composite cathode, biomass-derived carbon pollen@MoO_2 additive with few oxygen groups and porous defects adsorbs and electrocatalytically converts reactive oxygen species to molecular oxygen (DFT confirmed). This additive enables 99.9% retention after 500 cycles at 0.2 C and >87% retention after 3000 cycles at 5 C with high voltage LRMO. These synergistic strategies provide a comprehensive interfacial engineering roadmap toward practical inorganic all-solid-state batteries.

59

Iron-Based Polyanionic Solid-Solution Phases for Sodium-Ion Batteries

Xiangjun Pu
Wuhan Universtiy, Wuhan, China

Xiangjun Pu

Abstract

Anions generally constitute the structural framework of crystalline solids, making their extensive substitution, particularly for the formation of anionic solid solutions in polyanionic compounds, highly challenging. Herein, we propose that a new series of Fe-based polyanionic intercalation compounds, $Fe_2[(MoO_4)_{1-x}(SO_4)_x]_3$ ($0 \le x \le 1$), for potential low-temperature and high-power sodium-ion batteries. In this series, two new anionic-type solid-solution regions are identified: monoclinic phase ($0 \le x \le 0.3$) and rhombohedral phase ($0.8 \le x \le 1$). The optimized monoclinic phase (FMSO) delivers superior Na storage capability (1.99 Na^+ per formula) compared with the end-members (1.77 Na^+ for $Fe_2(MoO_4)_3$ and 0.46 Na^+ for $Fe_2(SO_4)_3$), while maintaining outstanding power capability even at low temperature (-40 °C). Structural evolution, electrochemical properties, and reaction mechanisms have been comparatively elucidated for this series of solid solutions. Furthermore, the concept is extended to rhombohedral $Fe_2[(WO_4)_\xi(SO_4)_{1-\xi}]_3$ ($0 \le \xi \le 0.2$) phases, suggesting a general rule for anionic solid-solution formation. These results broaden the chemical diversity of Fe-based redox, which typically needs to be framed in polyanionic crystalline for high-voltage operations, and open new directions for designing high-power and cost-effective cathodes for sodium-ion batteries.

60

In-situ Formed High-entropy Composite Air Electrode with Brilliant Tri-phase Conductivity for Proton-conducting Tubular Solid Oxide Cell

Yuan Gao, Yanan Liu, Yihan Ling
China University of Mining and Technology, Xuzhou, China

Abstract

Proton-conducting tubular solid oxide cells (T-SOCs) have attracted widespread attention from researchers as advanced energy conversion devices. The efficiency and service life are related to the intrinsic activity of the air-electrode materials and the in-situ evolution of the surfaces under long-term operating conditions. To improve the poor tri-phase conductivity of the $La_{0.6}Sr_{0.4}Co_{0.2}Mn_{0.2}Ni_{0.2}Cu_{0.2}Fe_{0.2}O_{3-\delta}$ (HE-LSF) air electrode in proton-conducting T-SOCs, this study combines $BaCoO_3$ with HE-LSF to form an in-situ heterostructure, thereby improving the water adsorption capacity and enhancing the air electrode performance and stability under reversible operating conditions. At 700 °C, the T-SOC with the composite air electrode reaches 1253.75 $mW \cdot cm^{-2}$ in fuel cell mode and 3319.74 $mA \cdot cm^{-2}$ at 1.3 V in electrolysis cell mode, which is attributed to the excellent proton adsorption capacity brought by $BaCoO_3$. More importantly, the proton-conducting T-SOCs operates stably for 120 h under reversible cycling conditions at 600 °C, with no noticeable changes in electrode morphology or cell performance degradation observed. With these advantages, the composite high-entropy electrode materials are considered promising alternative materials for the commercial application of proton-conducting T-SOCs.

61

Lithium Metal–Air Batteries: From Fundamental Gas-Phase Electrochemistry to Atmospheric Open-Cell Energy Storage

Won-Hee Ryu
Yonsei University, Seoul, Korea, Republic of

Won-Hee Ryu

Abstract

Conventional electrochemical energy storage technologies have predominantly relied on solid-state electrodes and liquid electrolytes. Among emerging next-generation battery systems, lithium metal–air batteries have attracted significant attention owing to their exceptionally high theoretical energy density, enabled by the direct utilization of lightweight and abundant gaseous reactants such as oxygen and carbon dioxide from the atmosphere. By replacing heavy transition-metal-based cathodes with gas-phase reactants, lithium metal–air batteries offer a promising pathway toward ultra-high-energy-density storage systems for future electrification and sustainable energy applications.

Despite their tremendous potential, the practical implementation of lithium metal–air batteries remains challenging due to sluggish gas-electrode reaction kinetics, parasitic side reactions, electrolyte instability, and the accumulation of insulating discharge products. Addressing these challenges requires a fundamental understanding of gas-phase electrochemical reactions and the development of advanced catalysts, redox mediators, electrode architectures, and electrolyte systems.

This presentation will highlight recent advances in lithium metal–O_2 and lithium metal–CO_2 batteries, focusing on reaction mechanisms, catalytic materials, and electrolyte engineering strategies that enable enhanced reversibility and long-term cycling stability. Furthermore, emerging concepts such as atmospheric open-cell battery architectures and aeroelectrolyte systems will be introduced as novel approaches that directly exploit gaseous reactants and environments. These developments demonstrate how gas-phase electrochemical systems can redefine the design paradigm of energy storage technologies and pave the way toward sustainable, high-energy-density batteries for future energy and mobility applications.

62

Construction of Electrolyte for Batteries Toward Extreme Temperature Application

Ya You
Wuhan University of Technology, Wuhan, China

Abstract

The performance degradation and safety issue of secondary battery under low temperature (<0 °C) and high temperature (>50 °C) operation are considered as one of challenges. Achieving stable operation across a broad temperature window is a challenging task, as it requires the simultaneous resolution of issues arising from both low and high temperatures, yet these two scenarios impose fundamentally conflicting demands.At subzero temperatures, the primary concern is to suppress electrolyte salt precipitation and freezing, which lead to low capacity and sluggish charge/discharge kinetics. At elevated temperatures, conversely, capacity and rate capability are improved, but such benefits are offset by accelerated aging and increased safety risks.Our work focuses on two key scientific issues: low-temperature electrode reaction kinetics and high-temperature thermodynamic stability. To address these issues, we design a series of "temperature-adaptive" materials. The properties of these materials undergo adaptive changes in response to temperature variations, thereby fulfilling the requirements of both extreme conditions.Electrolytes endowed with such temperature-adaptive characteristics enable sodium-ion batteries to operate stably between -50 °C and 60 °C. Furthermore, they significantly enhance the overall safety of the batteries.

63

Amorphization of Zirconium-Based Halide Electrolytes for All-Solid-State Batteries

Mingdeng Wei, Zongnan Li
Fuzhou University, Fuzhou, China

Mingdeng Wei

Abstract

Zr-based halide solid electrolytes are attractive for all-solid-state lithium batteries because of their oxidative stability, cost-effectiveness and mechanical deformability, but their room-temperature ionic conductivity remains insufficient. Herein, an amorphous oxychloride Zr-based halide electrolyte, $Li_{2.1}Zr_{0.95}Cu_{0.05}Cl_{4.4}O_{0.8}$ ($LZCCO_{0.8}$), was developed by a cation-anion sublattice engineering strategy using ball milling. The coupled incorporation of Cu^{2+} and O^{2-} increases the amorphous content to 88.2% while preserving the Zr-based coordination framework. Cu^{2+} weakens Li^{+}-Zr^{4+} Coulombic trapping, and O^{2-} promotes an oxychloride local structure containing bridging and non-bridging oxygen, which broadens Li^{+} migration pathways and lowers the transport barrier. Consequently, $LZCCO_{0.8}$ delivers an ionic conductivity of 2.05 mS cm^{-1} at 25 °C, low activation energy, good deformability and improved oxidative tolerance. When coupled with a $LiNi_{0.83}Co_{0.11}Mn_{0.06}O_2$ cathode, $LZCCO_{0.8}$-based all-solid-state lithium batteries exhibit stable interfacial kinetics, excellent rate capability, and 90.3% capacity retention after 1000 cycles at 2 C at room temperature. This work provides a feasible amorphization strategy for designing low-cost, high-performance Zr-based halide electrolytes for durable all-solid-state batteries.

64

Manganese-based Cathode Design and Interface Modulation for High-Performance Sodium-ion Batteries

Hui Xia
Nanjing University of Science and Technology, Nanjing, China

Abstract

Manganese-based cathode materials are attractive for sodium-ion batteries (SIBs) due to their natural abundance and low cost, but they often suffer from poor cycling stability and rate capability. In this work, we present strategies for enhancing the electrochemical performance of SIB cathodes through both bulk structural design and targeted interface modulation. We focus on the development of sodium-rich birnessite-type cathodes, investigating the influence of their unique layered structure—specifically the Mn-O coordination and interlayer chemistry—on sodium-ion storage mechanisms. By controlling Mn defects and interlayer water content, we optimize the Na^+ diffusion kinetics and structural stability. Additionally, we address the critical challenges at the electrode/electrolyte interface. We explore the use of advanced electrolyte additives to construct a stable and robust cathode-electrolyte interphase (CEI). This interfacial engineering effectively suppresses undesirable side reactions and transition metal dissolution, thereby expanding the electrochemical stability window and significantly improving long-term cycling durability. Our findings underscore the importance of a holistic approach that integrates rational material design with interface engineering to unlock the full potential of manganese-based cathodes for high-performance and practical SIBs.

65

The anode support of microporous channels can safely and efficiently convert and utilize low concentration coal mine methane in high-temperature fuel cells

Yihan Ling, Xinxin Wang
China University of Mining and Technology, Xuzhou, China

Abstract

This report describes the safe and efficient utilization of low concentration-coal mine methane through the integration of micro-pressure vacuum pressure swing adsorption (PSA) technology with solid oxide fuel cells (SOFCs). Using micro-pressure vacuum pressure swing adsorption for deoxygenation and concentration enhancement, we safely and efficiently reduce the O_2 concentration in low concentration-coal mine methane while elevating methane concentration to levels suitable for direct utilization. SOFCs represent a green, high-efficiency energy conversion device featuring an all-solid-state ceramic structure, no precious metals, and broad fuel adaptability. This eliminates the multi-stage energy conversion losses inherent in traditional gas power generation technologies. SOFCs significantly reduce pollutant emissions, and their electrochemical reactions operate unrestricted by flammability limits. By optimizing SOFC cell configurations and developing anti-coking catalysts, we have enhanced electrochemical performance and extended operational lifespan under hydrocarbon fuels. This enables direct conversion of chemical energy from deoxygenated low concentration -coal mine methane into electricity, achieving resource utilization of low concentration -coal mine methane.

66

A Direct View on Li ions Transport in Solid State Batteries

ming liu
Institute of Materials Research (IMR). Tsinghua Shenzhen International Graduate School,, shenzhen, China

Abstract

The scope of this Talk is the investigation and improvement of solid electrolytes, with the emphasis on the possibilities offered by solid-state NMR and neutron depth profiling as direct probes for the study of critical processes that involve Li ions and Li metal. Solid-state NMR allows us to unravel the complex interface chemical environment and the diffusion processes both in the bulk solid electrolyte and in the interface environment. These studies shed light on the role of interface composition, wetting and space-charge layers, on the macroscopic battery performance. Another technique that enables probing Li directly is operando neutron depth profiling, which allows us to determine the Li density as a function of depth. It provides a noninvasive and effectively nondestructive tool to examine delamination, irreversible reactions and dendrite formation during plating/stripping. Results demonstrate that it is very challenging to maintain the contact between Li metal and the SE during cycling, especially for the “anode-less” or “anode-free” configuration under low-pressure conditions. A perspective is provided on the potential improvement of the Li-ion transport, dendrite suppression, and preventing Li-metal-solid-electrolyte delamination as well as on the potential role of solid-state NMR and NDP techniques to guide these developments.

67

AI-Assisted Study on Solid-State Electrolytes for Lithium Batteries

Chunpeng Yang
Tianjin University, Tianjin, China

Chunpeng Yang

Abstract

Solid-state lithium batteries are expected to become the next-generation energy storage technology in the post-lithium-ion battery era due to their high safety and high theoretical energy density. However, developing high-performance solid-state electrolytes (SSEs) with both excellent ionic conductivity and electrochemical stability remains the core challenge at present. Meanwhile, the rapid development of artificial intelligence (AI) technologies, including machine learning and large language models (LLMs), has emerged as a powerful tool for accelerating material discovery and optimization, creating new opportunities for the advancement of solid-state lithium batteries.

Our study integrates domain-specific chemistry with AI to explore novel SSEs, focusing on three interconnected research aspects. First, a chemistry-informed ML framework is developed to design multi-anion-doped lithium halide SSEs. By embedding experimental information into feature engineering and machine learning, the model identifies SSE compositions that balance high ionic conductivity and stability against lithium metal, which has been a long-standing difficulty for halide SSEs. Second, an intelligent mining platform integrating large language models and representation learning is developed to excavate novel MOF-based SSE materials from metal–organic framework (MOF) databases. Third, a solid-state electrolyte agent based on large language models is designed for the exploration of lithium oxyhalide solid-state electrolytes, which intelligently realizes literature text mining, data analysis, candidate screening, and machine learning performance prediction. Ultimately, a family of oxyhalide solid-state electrolytes is discovered, exhibiting outstanding ionic conductivity and comprehensive battery performance. Our study demonstrates the synergistic potential of AI and materials science in addressing complex challenges in SSLBs.

68

Single-Atomic Triggered Fast Redox Conversion in Li-S Batteries

jun Jin, Zhaoyin Wen
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Abstract

Lithium-sulfur (Li-S) batteries are widely recognized as one of the most promising next-generation energy storage technologies owing to their high theoretical energy density (~2600 Wh kg^{-1}), cost-effectiveness, and environmental friendliness. However, their practical application is severely hindered by slow electrochemical reaction kinetics and the detrimental shuttle effect of lithium polysulfides. Single-atom catalysts (SACs), characterized by nearly 100% atomic utilization and high catalytic activity, have been extensively investigated in sulfur cathodes to accelerate sulfur redox reactions. Nevertheless, individual single-atom sites usually exhibit limited catalytic efficacy for multi-step sulfur conversion processes, leading to suboptimal practical performance. Herein, we construct a structure comprising atomically dispersed Fe single atoms anchored on MoS_2 nanosheets (FeSA-MoS_2@NC), with Fe atoms stabilized at Mo-top sites via Fe-S3 coordination. This Fe-S3-Mo interfacial coupling induces electronic redistribution and enhances host-guest interactions, thereby significantly boosting both catalytic and adsorption capabilities compared to single-component systems. As a result, the S/FeSA-MoS2@NC cathode exhibits superior electrochemical performance, enabling lean-electrolyte pouch cells. This work provides a novel strategy for engineering single-atom catalysts and offers valuable insights into the advancement of high-performance Li-S batteries.

69

Anode supported solid oxide fuel cells with enhanced mechanical strength and thermal cycle stability

Jiahong Hu, Jianhua Huang, Congcong Huang, Chusheng Chen
University of Science and Technology of China, Hefei, China

Abstract

Ensuring long-term stable and continuous operation is a major challenge for the commercialization of solid oxide fuel cells (SOFCs). In this study, we report a method that effectively improves the mechanical strength and durability of NiO-YSZ anode-supported SOFCs without compromising their electrochemical performance. Finger-like porous NiO-YSZ anode green tapes were prepared by phase-inversion tape casting. To enhance mechanical strength, the green tapes were infiltrated with paraffin wax, subjected to warm isostatic pressing (3000 psi, 80 °C), and then sintered at 1400 °C for 5 hours. The resulting support exhibited a mechanical strength of 29.17 MPa, compared to only 17.80 MPa for the as-prepared support without infiltration and pressing. A cell incorporating the strengthened anode delivered a current density of 0.776 A cm^{-2} at 0.7 V and 700 °C in humidified hydrogen (3 vol.% H_2O). After 10 thermal cycles between 700 and 400 °C at 10 °C min^{-1}, its current density decreased slightly to 0.753 A cm^{-2} (a 3% reduction). In contrast, a cell with the low-strength anode showed a significant drop from 0.833 to 0.628 A cm^{-2} (a 25% reduction). This method provides an effective approach to enhance the mechanical integrity and thermal cycling durability of SOFCs.

70

Enhancing Ionic Transport in PEO-based Composite Electrolytes Using a 3D Sulfonate-functionalized MOF for All-solid-state Supercapacitors

PRIYANKA BHARDWAJ
Birla Institute of Technology and Science, Pilani, India

Abstract

The growing demand for safe, high-power, and long-cycle energy storage devices has accelerated the development of all-solid-state supercapacitors. Despite their safety and flexibility advantages, the practical performance of these devices is often limited by the low ionic conductivity of polymer electrolytes. A sulfonate-functionalized three-dimensional metal-organic framework (MOF), **BITSP**, was incorporated as an active additive in poly(ethylene oxide) (PEO)-based composite polymer electrolytes (CPEs). Among the prepared electrolytes, PEO-10% **BITSP**-$LiClO_4$ exhibited the best electrochemical performance, achieving ionic conductivities of 6.8×10^{-4} S cm^{-1} at room temperature and 1.4×10^{-3} S cm^{-1} at 50 °C. It also showed a near-unity lithium-ion transference number of 0.996 and an electrochemical stability window of 2.02 V. The optimized CPE was employed in an all-solid-state supercapacitor with the configuration Cu|AC|PEO-10% **BITSP**-$LiClO_4$|AC|Cu. The device delivered a specific capacitance of 185 F g^{-1} at 2 V, a coulombic efficiency of 99% at 1 V, and retained 75% capacitance after 10,000 galvanostatic charge-discharge cycles. DSC, XPS, and DFT analyses indicate that the free sulfonate oxygen and imine nitrogen sites of **BITSP** provide favourable coordination sites for Li^+ transport. Meanwhile, the Cd(II) centres interact with counter anions and PEO chains, suppressing PEO crystallinity and generating amorphous ion-conduction pathways. Comparison with PEO-10% **BITSP**-LiTFSI electrolytes further confirms the cooperative role of **BITSP** and $LiClO_4$ in improving ionic transport and electrochemical performance of all-solid-state supercapacitor.

71

A Dense Fluorinated Composite Polymer Electrolyte Featuring Fluoride-Rich Interface for Long-Life Lithium Batteries

Sisi Liu, Chunpeng Yang
Tianjin University, Tianjin, China

Abstract

Solid polymer electrolytes (SPEs) are promising for solid-state lithium (Li) metal batteries due to their enhanced safety and high energy density. However, the inherent trade-off between ionic conductivity and mechanical strength severely limits their practical application. Herein, we report a dense fluorinated composite polymer electrolyte (d-FCPE) that simultaneously addresses the challenges of mechanical robustness, ionic conductivity, and interfacial stability in Li metal batteries. The dense architecture endows the d-FCPE with favorable mechanical strength, elongation, and adhesion, ensuring superior processability and intimate interfacial contact. Concurrently, the fluorinated composite polymer suppresses electrolyte crystallinity and regulates the ion solvation structure, thereby achieving a high ionic conductivity of 8.6×10^{-4} S cm^{-1} at room temperature. Crucially, the integrated dense structure promotes the in-situ formation of a robust, LiF-enriched solid electrolyte interphase, which effectively suppresses lithium dendrite growth and enhances electrochemical cycling stability. Consequently, the Li|d-FCPE|Li symmetric cell exhibits stable cycling for over 4500 h at 0.5 mA cm^{-2}. The batteries using $LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$ cathode and d-FCPE deliver a long cycle life, maintaining capacity retention of 83.2% (0.5C) and 84.5% (2C) after 1000 cycles. This work highlights the pivotal role of fluorination-assisted densification in developing high-performance SPEs for advanced solid-state energy storage.

72

Study on the construction of high safety and rapid ion conduction gel polymer lithium battery

Lianqi Zhang
Tianjin University of Technology, Tianjin, China

Abstract

Solid-state electrolytes offer a promising alternative to address the safety issues of liquid electrolytes in lithium batteries. Among them, polymer-based systems show superior scalability due to mechanical robustness and favorable interfacial compatibility with electrodes. However, intrinsic Li^+ transport limitations and safety risks under extreme conditions remain critical bottlenecks for practical application. To overcome the weak Li^+ dissociation and discontinuous matrix structure of polyvinylidene fluoride hexafluoropropylene, two strategies are proposed: constructing a semi-interpenetrating polymer network and regulating crystal facet/phase structures via solvent processing. These approaches establish additional Li^+ transport pathways, improving ion transport. Meanwhile, cycling stability of ether-based sulfidized polyacrylonitrile batteries is enhanced by designing an oversized cross-linked polymer electrolyte network. For safety, flame-retardant fluoro-, cyano-, and phosphorus-containing moieties are in situ introduced into the matrix, while solid content is progressively increased to mitigate combustion risks. The resulting electrolyte exhibits exceptional fire resistance, withstanding an open flame for 190 s without ignition. Furthermore, gel polymer electrolytes prepared using FEC as the sole solvent enable pouch cells to remain below 50°C during nail penetration and show no thermal runaway in ARC tests. These works offer insights for constructing polymer lithium batteries with high safety and rapid ion conduction.

73

Dynamic structural adaptation in halide cathodes for all-solid-state lithium batteries

guang sun
Tongji University, Shanghai, China

Abstract

All-solid-state lithium batteries require cathodes that can undergo reversibly lithiation and delithiation while preserving contact with solid electrolytes during cycling. Most cathode design has therefore focused on rigid, extended inorganic frameworks, where structural change is usually treated as a cause of degradation. Here, we show that halide cathodes can follow a different route: dynamic structural adaptation can support both lithium storage and interfacial contact. Using $MoCl_5$ as a molecular-crystal model, operando synchrotron X-ray absorption spectroscopy and diffraction reveal that discrete Mo_2Cl_{10} dimers reversibly rearrange into a corner-sharing $MoCl_6$ framework during lithiation, enabling 172 mAh g^{-1} and 85.6% capacity retention after 500 cycles. This adaptive behavior also appears at the composite-electrode scale. In mixed nanocrystalline–amorphous halide cathodes, in situ synchrotron X-ray computed tomography shows that lithiation reduces porosity and restores internal contact with the solid electrolyte. This contact restoration is linked to partial crystallization from the amorphous phase and strain generation, leading to an early capacity increase and 98.8% retention after 300 cycles. These findings identify dynamic structural adaptation as a useful design principle for halide cathodes in all-solid-state lithium batteries.

74

Sulfide-Based Solid-State Batteries and Materials Interface Engineering

Jun Lu
zhejiang university, Hang zhou, China

Abstract

The rapid development of new energy vehicles, the low-altitude economy, and emerging energy storage technologies has placed higher demands on battery endurance, safety, and energy density. Sulfide-based solid-state batteries, when paired with high-energy cathode and anode materials, offer both enhanced safety and high specific energy, making them a promising direction for next-generation battery technologies. However, their practical development still faces several key challenges, including poor solid-solid interfacial contact, insufficient high-voltage stability of electrolytes, and severe side reactions at both cathode and anode interfaces. To address these issues, this work focuses on ion-electron coupled transport design strategies in high-energy composite cathodes, as well as structural optimization and interfacial regulation of core sulfide solid electrolytes. These approaches aim to improve the intrinsic stability of materials while optimizing interfacial stability and ionic transport, thereby enhancing the performance of solid-state battery systems based on high-energy-density ternary/sulfur cathodes and lithium-metal/silicon-based anodes. This research provides theoretical guidance for the development of solid-state batteries with high safety and high specific energy.

75

Solid Oxide Fuel Cells: From Materials Research to Industrial Fabrication

Zhipeng Li
Northwestern Polytechnical University, Xi'an,Shanxi, China

Zhipeng Li

Abstract

Solid oxide fuel cells (SOFCs) can directly convert the chemical energy stored in fuels into electrical energy, achieving power generation efficiencies of 50-60% (LHV). Combined cycle systems can attain efficiencies as high as 60-70%. SOFCs can utilise a diverse range of fuels including low-purity hydrogen, natural gas, coal gas, biogas, propane, methanol, ethanol, and diesel for power generation, effectively addressing fuel purity and transportation challenges at the supply end. In the United States and Japan, SOFCs have seen widespread application in unmanned aerial vehicles, autonomous vehicles, submarines, portable power sources, domestic combined heat and power systems, and data centre power supply. China possesses years of accumulated research in SOFC materials and components, yet lags significantly in practical application and industrialisation. There is an urgent need to increase investment in the large-scale production of SOFC single cells and in the R&D of stack and system technologies. This will enable the development of proprietary SOFC products and advance the practical implementation of SOFC technology within China. This lecture provides an overview of fuel cell materials, fabrication processes, and industrial development. It analyses critical technical challenges in transitioning from laboratory-scale production to industrial manufacturing, explores the application of advanced industrial manufacturing techniques within the SOFC sector, and offers technical support for SOFC industrialisation.

76

Advanced Solid Electrolyte Interphase for Solid-State Lithium Batteries

Yanbing He, Guanyou xiao, Kangrui Ren
Tsinghua Shenzhen International Graduate School, Tsinghua University, Shenzhen, China

Yanbing He

Abstract

We focused on solving the ion transport issues of the cross-interface, cross-phase, and cross-gap in solid-state batteries. First, we proposed and illustrated an in-situ interface reaction solid-state mechanism for solid-state battery. A single-crystal oriented lithium anode was constructed by lattice adaptation of interface materials, which realized the interfacial atomic level coupling and cross-interface compatibility. Second, we invented a new coupling method of dielectric and electrolyte ceramic materials, which achieved the efficient dissociation of lithium salt and the spontaneous across-phase transport of ions. A solid-state electrolyte composite material with high ionic conductivity was developed. Third, we developed a in-situ reaction strategy of a robust cathode interface layer and a ductile solid electrolyte interphase on lithium metal anode, which greatly improve the long cycle performance of all-solid-state battery at room temperature. Based on above innovative research achievements, we propose a quantizable concept of ion transport throughput, which provides a significant criterion for investigation of all-solid-state battery. In this meeting, we will introduce how to construct advanced solid electrolyte interphase for solid-state lithium batteries.

77

In Situ Grain Boundary Engineering Enabling Ultra-long Stable Cycling Garnet-Based Solid-State Electrolytes

Zichang You[1,2], Chujun Zheng[1,2], Jiaxin Wu[1,2], Huayan Huang[1,2], Chengshuai Bao[1,2], Yan Lu[1,2], Zhaoyin Wen[1,2]
[1]The State Key Lab High Performance Ceram & Superfine, Shanghai, China. [2]University of Chinese Academy of Sciences, Beijing, China

Abstract

Solid-state lithium metal batteries (SSLMBs) have garnered significant attention as a next-generation battery technology owing to their high safety and energy density. However, the growth and penetration of lithium dendrites in solid electrolytes remain obstacles to their application. Herein, we propose an in-situ grain boundary modification strategy utilizing the reaction of $LiTaO_3$ with Ta-doped garnet-type electrolyte. This approach facilitates the formation of a pseudo-crystal Li_3TaO_4/Zr_3O (LZT) phase at grain boundaries (GBs). The LZT phase not only reduces the electronic conductivity at GBs and within grains, but also amalgamates the beneficial properties of both crystalline and amorphous materials. This modification strategy inhibits abnormal grain growth, strengthens GBs bonding, and enhances the fracture toughness of the ceramics, thereby mitigating dendrite formation and propagation. The modified electrolyte 2LTaO exhibits a notably low electronic conductivity of 8.58×10^{-9} S cm^{-1}. The results demonstrate that the symmetrical Li | 2LTaO | Li cell achieves a high critical current density of 2.2 mA cm^{-2} and exhibits prolonged cycling stability up to 12,000 hours at 0.3 mA cm^{-2}. Furthermore, the full cell configuration showcases excellent cycling stability and rate performance. This novel grain boundary modification strategy offers a promising pathway for the development of high-performance SSLMBs.

78

Integrated rocksalt-polyanion cathodes for high-energy and stable lithium-ion batteries

Yimeng Huang
Tongji University, Shanghai, China

Yimeng Huang

Abstract

Co- and Ni-free disordered rocksalt (DRX) cathodes for lithium-ion batteries offer high capacity through combined cationic and anionic redox, but oxygen loss and structural degradation limit cycling stability at high voltages. We report integrated rocksalt–polyanion cathodes (DRXPS), in which strongly bonded XO_4 (X = P, B, Si) units are incorporated into a Li-excess, cation-deficient rocksalt framework to stabilize lattice oxygen without sacrificing energy density (*Nature Energy* 2024, 9, 1497-1505). Mn-rich DRXPS materials were synthesized by one-step room-temperature mechanochemistry. The prototype $Li_{1.67}Mn_{1.5}P_{0.17}O_4$ shows bulk phosphate incorporation and spinel-type cation ordering. When cycled to 4.8 V versus Li/Li^+, it delivers capacities above 350 mAh g^{-1} and gravimetric energy densities above 1100 Wh kg^{-1}, with more than 70% energy density retention after 100 cycles. The concept also extends to multiple transition-metal and polyanion chemistries. Subsequent work shows that AI-assisted method enables efficient exploration and optimization in the broad compositional space of DRXPS (*manuscript in revision*). By combining the high capacity of Li-excess rocksalt oxides with the strong covalent bonding of polyanion units, DRXPS integrates key advantages of rocksalt-type and polyanion-olivine cathodes, providing a versatile platform for high-energy, earth-abundant lithium-ion batteries.

79

Turning Detrimental Segregation into Beneficial Surface Reconstruction in Double Perovskites for SOFCs

Bo Wei, Hongru Hao, Zhe Lv
Harbin Institute of Technology, Harbin, China

Abstract

Solid oxide fuel cells (SOFCs) are highly efficient energy converters, but their cathode durability is critically limited by detrimental cation segregation (e.g., BaO) and subsequent poisoning from Cr vapors and CO_2, which form insulating phases like $BaCrO_4$ and $BaCO_3$. Double perovskite $LnBaCo_2O_{5+\delta}$ cathodes exhibit excellent activity yet suffer from severe surface degradation. Here, we apply configurational entropy engineering to $GdBaCo_2O_{5+\delta}$ by introducing multiple cations at the B-site (Co, Mn, Fe, Ni, Cu) and A-site (La, Pr, Nd, Sm, Gd), yielding medium-entropy (ME-GBCO) and high-entropy (HEO) cathodes. The ME-GBCO shows markedly enhanced Cr tolerance: after 20 h at 700 °C in Cr-containing air, its polarization resistance increases modestly from 0.16 to 0.24 Ω cm^2, whereas pristine GBCO degrades from 0.44 to 0.70 Ω cm^2. The HEO achieves an ultralow R_p of 0.05 Ω cm^2 at 700 °C and excellent CO_2 stability. Structural and spectroscopic analyses reveal that, unlike GBCO which forms $BaCrO_4$, $BaCO_3$, and Co_3O_4, the entropy-stabilized surfaces spontaneously generate $BaCoO_{3-\delta}$ nanoparticles that are inert to contaminants and enhance surface oxygen exchange. Mechanistically, increased entropy induces lattice distortion that suppresses Ba segregation and promotes beneficial BCO formation, thereby improving both activity and durability. This work establishes entropy engineering as a powerful strategy for rational surface reconstruction, turning detrimental segregation into a beneficial pathway for robust SOFC cathodes.

80

F-Doped GdBaCo2O5+δ Layered Perovskite Cathodes for Enhanced Oxygen Reduction Activity and CO2 Tolerance

Hongru Hao, Bo Wei, Zhe Lv
Harbin Institute of Technology, Harbin, China

Abstract

The development of high-performance cathode materials with enhanced oxygen reduction reaction (ORR) activity and long-term stability is critical for intermediate-temperature solid oxide fuel cells (IT-SOFCs). In this work, a series of F-doped $GdBaCo_2O_{5+\delta}F_x$ (x = 0, 0.1, 0.2, 0.3) layered double perovskites are synthesized, and the effects of F-substitution on crystal structure, electrochemical performance, and poisoning resistance are systematically investigated. Additionally, the influence of Ba/Co stoichiometry is examined. Electrochemical impedance spectroscopy and Arrhenius analysis reveal that the polarization resistance (R_p) decreases with increasing temperature and first decreases then increases with rising Ba/Co ratio. The optimal composition, GBCO02, exhibits an exceptionally low R_p of 0.067 Ω cm^2 at 700 °C and an activation energy of 107.7 $kJ \cdot mol^{-1}$, demonstrating superior ORR catalytic activity. Moreover, CO_2 stability tests show that GBCO02 exhibits significantly enhanced resistance to CO_2 poisoning compared to pristine GBCO. In 10% CO_2, the R_p of GBCO02 increases by only 0.62 times and recovers fully upon returning to air, whereas GBCO suffers severe irreversible degradation. The improved performance and stability are attributed to the synergistic effects of F-doping and optimized Ba/Co stoichiometry, which suppress inert phase formation and preserve the electrode microstructure. This work provides a promising strategy for developing robust IT-SOFC cathodes with high activity and durability.

81

Etching promoted Surface Reconstruction of PrNi0.3Co0.7O3 for Enhanced Oxygen Electrocatalysis

Jian Zhou, Hongru Hao, Bo Wei, Zhe Lv
Harbin Institute of Technology, Harbin, China

Abstract

Cobalt-based perovskites are regarded as promising non-precious metal alternatives for oxygen reduction/evolution reaction (ORR/OER), but their performance still need to be further enhanced due to insufficient surface reconstruction. Here, a $PrNi_{0.3}Co_{0.7}O_3$ perovskite (denoted PNC-Fe) modified with a NiCoFeOOH active diffusion layer was synthesized via a simple cation pre-etching strategy. In situ Raman spectra show that during the OER process, the initial $NiCo(OH)_2$/FeOOH transforms into highly active NiCoFeOOH as the potential increases, and reverts to $NiCoFe(OH)_2$ when the potential drops. This reversible transition remains stable over 500 cycles. Differential electrochemical mass spectrometry combined with theoretical calculations reveals that the reconstructed PNC-Fe catalyst increases its metal-oxygen bond covalency, triggering the LOM mechanism and leads to excellent OER performance. The catalyst requires an overpotential of only 320 mV at 10 mA cm^{-2}, outperforming pristine PNC and benchmark RuO_2. A PNC-Fe based zinc-air battery delivers a peak power density of 148.6 mW cm^{-2} and remains stable for 600 hours of cycling. This work provides a simple route to constructing transition metal active diffusion layers through cation etching for activating perovskite reconstruction, which is highly relevant for the practical use of metal-air batteries.

82

Recovery of Doped-Electrocatalysts from Solid Waste for Catalytic Valorization of Waste-Derived Molecules

Yan Chen
South China University of Technology, Guangzhou, China

Yan Chen

Abstract

The electrocatalytic conversion of waste-derived molecules, including CO_2, CH_4, N_2O, NOx, and biomass, into valuable chemicals or fuels is critical for advancing carbon neutrality and establishing sustainable nitrogen cycles. However, this approach still faces challenges such as low efficiency, poor selectivity, and high energy consumption.

Meanwhile, solid waste contains significant quantities of valuable metals like Cu, Ni, Co, Mn, and Pt. Yet recycling these metals is hindered by the complex mixture of impurities in waste streams, which complicates separation and utilization processes.

In this talk, we will present our recent progress on a defect-impurity co-regulation strategy for material reconstruction. This method enables the construction of highly active catalysts for efficient conversion of waste-derived molecules, addressing both catalytic and recycling challenges. Our findings demonstrate the potential of a waste-to-resource paradigm that aligns with circular economy objectives, offering a dual solution for sustainable chemical synthesis and metal recovery.

83

Study and Application of High-Temperature Solid Electrolyte Gas Sensors

Jiawen Jian
Ningbo university, Ningbo, China

Abstract

Yttria-stabilized zirconia (YSZ) solid electrolytes boast outstanding mechanical strength and high-temperature resistance. Leveraging their unique oxygen ion conduction properties, researchers have developed a series of high-temperature gas sensors, which are deployed in various harsh environments featuring high temperatures and intense vibrations, and have cultivated a vast commercial market. Centered on the applications of solid electrolyte high-temperature gas sensors in automobiles and instrumentation, this report takes domestic and international research progress as the main thread. Drawing on years of research achievements from our research group, it elaborates in detail the research advances of solid electrolyte gas sensors—including concentration-cell oxygen sensors, wide-range air-fuel ratio oxygen sensors, NO_x sensors and more—covering their sensing mechanisms, structural design, and detectable gas species. It also presents practical product application cases in the automotive and instrumentation sectors. Notably, emerging novel sensing principles and multi-chamber structural designs in recent years have accelerated the integrated application and advancement of solid electrolyte gas sensors for measuring humidity, carbon dioxide, combustible gases, flow velocity and other physical and chemical parameters.

84

Recent progresses of fluoride batteries

Chilin Li
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Abstract

The team led by Prof. Chilin Li has long been dedicated to the research and development of novel fluoride conversion battery, fluoride-ion battery, and fluoride solid-state battery systems and materials, proposing the new directions for fluoride batteries with framework-type materials, acceptor-modified electrolytes, and solid-state architectures. Through the dual strategy of electrode microstructure design and electrolyte formulation regulation, the group have developed the carbon fluoride, iron fluoride, and copper fluoride batteries with high specific energy, high rate capability, long cycle life, and low polarization. The group proposed the ceramic-based and polymer-reinforced lithium-fluoride conversion solid-state battery configurations, constructed the large-capacity, large-size pouch-type all-solid-state Li/FeF_3 batteries, and developed the air-stable fluoride-based solid electrolytes for lithium and sodium ion transports with the highest recorded ionic conductivity and the widest stable voltage window, along with their fluoride-based solid-state batteries. The group proposed the near-room-temperature solid-state fluoride-ion batteries based on layered solid electrolytes and polymer-type fluoride-ion conductors, designed a series of room-temperature fluoride-ion batteries based on novel anion acceptors and solvents, with the highest level of electrolyte ionic conductivity. This group firstly achieved the theoretical capacity of fluoride-ion batteries, broke through the difficulty of their reversible operation at high voltages, and developed the large-size, large-capacity, long-life pouch-type fluoride-ion batteries based on green electrolytes.

85

Electrolyte Design and Interphase Regulation for Sodium-Ion Batteries

Weihua Chen
Zhengzhou University, Zhengzhou, China

Weihua Chen

Abstract

Sodium-ion batteries (SIBs) are considered one of the most promising candidates for next-generation large-scale energy storage systems due to the abundance of sodium resources and their potential low-cost advantages. As a core component of the battery, constructing a stable electrolyte/electrode interphase is crucial for enhancing SIBs performance. However, traditional solvent-dominated solvation structures fail to form a robust interphase film, leading to excessive electrolyte consumption and continuously increasing interfacial impedance, which represents a critical bottleneck for the commercialization of SIBs. This presentation focuses on electrolyte design and interphase engineering for SIBs. By constructing a compact, ultra-thin, inorganic-rich, and fast ion-conductive solid electrolyte interphase (SEI), sodium dendrite deposition is effectively prevented. Concurrently, attention is paid to the cathode side to promote the formation of a highly stable cathode electrolyte interphase (CEI), which strengthens solid-solid interfacial contact and suppresses both cathode material structural degradation and electrolyte side reactions. Consequently, the electrochemical performance of the full cell is significantly enhanced. This work provides new insights into the precise regulation of interphases through tailored electrolyte design.

86

Light-Field-Induced Composite Electrode Design and Interphase Regulation for High-Efficiency Photo-Rechargeable Sodium Batteries

Mingrui Yang, Weihua Chen
Zhengzhou University, Zhengzhou, China

Mingrui Yang

Abstract

Photo-rechargeable sodium batteries (PRSBs) offer a promising path for sustainable energy by integrating solar conversion with energy storage. However, severe carrier recombination and unstable light-driven electrode/electrolyte interphases severely hinder their efficiency. Herein, we report a novel TiO2/CdSe/Na3Fe2(PO4)P2O7 (NFPP) composite cathode to address these issues via tailored electrode design and interphase regulation. The constructed type-II heterojunction promotes the directional migration of photo-generated holes, accelerating transition-metal valence transitions and lowering the Na^+ transport barrier. Concurrently, these holes regulate surface charge distribution to induce an ultra-thin, NaF-rich cathode electrolyte interphase (CEI), effectively suppressing electrolyte side reactions. As a result, the full cell exhibits significantly enhanced capacity and rate capability under illumination. This work provides new insights into light-field-induced interphase engineering for high-efficiency PRSBs.

87

Fluoride-based batteries and materials

Keyi Chen, Chilin Li
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Abstract

Conversion-type iron fluorides are regarded as promising cathode candidates for next-generation rechargeable batteries, mainly because of their considerable energy density as well as low-cost and eco-friendly advantages. We focus on developing advanced strategies to enhance reaction kinetics and suppress parasitic side reactions for fluoride electrode materials, including synthesis method development, electrode microstructure engineering, electrolyte composition design, and interfacial chemistry regulation. We developed mild and safe fluorination routes, including deep eutectic solvent fluorination and MOF-etching fluorination, to successfully fabricate heterostructured and lattice-oxygen-doped fluorides. Furthermore, we elucidated the regulation mechanisms of phase transformation pathways in fluorides and revealed the crucial role of anion receptor chemistry in promoting reversible fluoride conversion. Ultimately, high-performance fluoride-based conversion battery systems were realized.

88

Structure design of the cathode enables Na-NiCl2 batteries with high rate and long cycling performance

Xiangwei Wu
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Abstract

Na-$NiCl_2$ batteries exhibit intrinsic safety, high specific energy density and long cycle life, making them one of the ideal choices for large-scale stationary energy storage applications. However, the non-conductive $NiCl_2$ formed during charging disrupts the conductive network of the cathode, and the significant volume effect during charging and discharging compromises the structural stability of the cathode, leading to performance degradation of the battery. Herein, Ni_3S_2-coated Ni nanowires are prepared via hydrothermal sulfidation method and used as the active material to substitute the conventional Ni powders in the cathode. The interweaving of Ni nanowires facilitates the formation of a three-dimensional conductive network, which helps to counteract the blocking effect of $NiCl_2$. The Ni_3S_2 layer mitigates the expansion and fracture of Ni nanowires during cycling and helps to maintain the structural stability of the electrode. Electrochemical analysis demonstrates that Ni_3S_2 can also deliver additional capacity. Moreover, the Ni_3S_2 layer boosts the conversion reaction between Ni and NaCl, while suppressing the polarization at deep discharge states. At 100% SOC, the Ni_3S_2-coated Ni electrode demonstrates the low interfacial impedance, which is 1/5 that of the bare Ni nanowires, improving the cycling stability, capacity retention and rate performance of Na-$NiCl_2$ batteries.

89

La0.5-xScxSr0.5MnO3-δ cathodes for proton-conducting solid oxide fuel cells: taking advantage of the secondary phase

Hailu Dai
Yancheng Institute Of Technology, Yancheng, China

Hailu Dai

Abstract

Designing high-performance cathodes is crucial for proton-conducting solid oxide fuel cells (H-SOFCs), as the cathode heavily influences cell performance. Although manganate cathodes exhibit superior stability and thermal compatibility, their poor cathode performance at intermediate temperatures renders them unsuitable for H-SOFC applications. To address this issue, the Sc element is utilized as a dopant to modify the traditional $La_{0.5}Sr_{0.5}MnO_3$ cathode at the La site. Although the solubility of Sc at the La site is restricted to 2.5%, this modest quantity of Sc-doping can improve the material's oxygen and proton transport capabilities, hence improving cathode and fuel cell performance. Furthermore, when the doping concentration exceeds 2.5%, the secondary phase $ScMnO_3$ forms in situ, resulting in $La_{0.475}Sc_{0.025}Sr_{0.5}MnO_3$ (LScSM)+$ScMnO_3$ nanocomposites. Although the secondary phase is often considered undesirable, $ScMnO_3$'s high protonation capacity can compensate for LScSM's low proton diffusion ability. These two phases complement each other to provide high-performance cathodes. The nominal $La_{0.4}Sc_{0.1}Sr_{0.5}MnO_3$ is the optimal composition, which takes advantage of LScSM's excellent electronic conduction and fast oxygen diffusion rates, as well as $ScMnO_3$'s good proton diffusion capacity, to produce a high fuel cell output of 1529 mW cm^{-2} at 700 ºC. Furthermore, the fuel cell exhibits good operational stability under working conditions, indicating that $La_{0.4}Sc_{0.1}Sr_{0.5}MnO_3$ is a viable cathode choice for H-SOFCs.

90

All-solid-state electrode for potentiometric chloride detection in biological fluids

Gia-Linh Huynh[1], Kanyapat Teekayupak[2], Nipapan Ruecha[2]
[1]College of Interdisciplinary and Integrative Studies, Chulalongkorn University, Bangkok, Thailand. [2]Metallurgy and Materials Science Research Institute, Chulalongkorn University, Bangkok, Thailand

Abstract

Chloride ions (Cl^-) are critical electrolytes in human physiology, with concentrations in biological fluids such as sweat (10-100 mM) and urine serving as clinically relevant biomarkers for cystic fibrosis diagnosis, dehydration monitoring, and renal function assessment. There is a growing need for flexible, miniaturized electrochemical sensors capable of real-time Cl^- monitoring in wearable or portable devices. This work presents a flexible, all-solid-state potentiometric chloride ion-selective electrode (ISE) fabricated on a polyimide/poly(vinyl chloride) (PI/PVC) substrate, using laser-induced graphene (LIG) as the solid-contact transducer layer and a PVC-based ion-selective membrane (ISM) incorporating Chloride Ionophore II (ETH 9009). LIG electrodes were produced by direct CO_2 laser scribing of PI tape laminated onto flexible PVC substrates (160 mm/s, 9 mm focal distance), yielding a porous, highly hydrophobic 3D graphitic network that suppresses the interfacial water layer and mitigates potential drift. The ISM was formulated by dissolving Chloride Ionophore II (2.00 wt%), ETH500 (0.03 wt%), DOS (64.97 wt%), and PVC (33.00 wt%) in cyclohexanone (10-25 wt%), deposited by sequential drop-casting of five layers, with 0.3 µL per layer. OCP measurements were performed against a commercial Ag/AgCl reference electrode using a PalmSens4 potentiostat over NaCl concentrations from 10^{-7} M to 1 M. The LIG-based ISE exhibits a well-defined Nernstian response toward Cl^-, with enhanced potential stability and selectivity compared to screen-printed Ag/AgCl electrodes. With its high sensitivity, repeatability, and cost-effective flexibility, the developed device is perfectly suited for clinical point-of-care diagnostics and wearable patch integration.

91

Relation of Performance and Reduction Process of NiO-YSZ Anode in Commercial Solid Oxide Fuel Cell

Minfang Han, Xiaoyu Wang, Peiyuan Liu, Zewei Lyu
Tsinghua University, Beijing, China

Abstract

The reduction and initial operation of the anode are critical processes prior to the stable operation of a solid oxide fuel cell (SOFC). However, the various phenomena occurring during two processes and their underlying mechanisms have not been sufficiently summarized. In the study of the reduction process, the effects of hydrogen concentration, water vapor concentration of the reduction gas, Y_2O_3 content in the YSZ anode, and temperature were investigated; while in the study of initial operation, the effect of temperature and current were specifically examined. The results showed that the addition of water vapor to the reduction gas caused a temporary stasis in the open-circuit voltage, and the duration of this stasis was nearly independent of the water vapor concentration. The classical shrinking core model can be used to explain this phenomenon. During the initial operation, the SOFC sequentially undergoes an activation stage and a rapid-degradation stage before reaching steady-degradation stage operation; these stages are mainly associated with the microstructural evolution of the Ni in the anode, and temperature exerts a significant influence on them. Based on the above-mentioned experimental phenomena, optimization attempts and verification of the reduction and initial operating conditions were conducted.

92

Wiring Life: From CO_2 and Sunlight to Fuels and Chemicals

Shafeer Kalathil
Northumbria University, Newcastle, United Kingdom

Shafeer Kalathil

Abstract

Connecting renewable electricity and sunlight to the chemistry of life offers a route to sustainable chemical synthesis that neither biology nor materials science can achieve alone. This talk presents a research programme built on biological interfaces with both electrodes and photocatalysts that route electrical energy and light directly into living enzymatic systems, controlling chemical reactivity at the biological–material boundary with a precision that synthetic catalysts have not achieved.

Central to this programme is the development of material architectures that support intact microbial and enzymatic systems under simultaneous energy input and real-time interrogation, enabling mechanistic understanding of electron transfer in living systems at a resolution not previously accessible.

Building on this foundation, we have demonstrated Power-to-X conversions spanning the chemical landscape. Solar-driven CO_2 fixation through semi-artificial photosynthesis couples living organisms directly to semiconductor photocatalysts and photoelectrodes, achieving efficiencies beyond natural photosynthesis. Renewable electricity drives microbial metabolism to produce acetate and medium-chain fatty acids from CO_2 through biohybrid consortia. Plastic waste is valorised to electricity and chemicals through syntrophic co-cultures. Most recently, biological nitrogen fixation to ammonia has been achieved through direct interspecies electron transfer between cooperative microbial specialists, under ambient conditions and powered entirely by renewable energy.

The design principles emerging from this body of work point toward a general manufacturing platform in which living catalysts, powered by renewable electricity and light, produce the molecules the world needs.

93

Strategies for Enhancing PEO-Based Polymer Solid-State Electrolytes

Xin Ao
Nanchang University, Nanchang, China

Abstract

This report will systematically discuss the modification strategies of poly(ethylene oxide) (PEO)-based polymer solid electrolytes, aiming to address the inherent limitations of pristine PEO and improve its electrochemical performance. The key modification strategies to be elaborated include: strategies for reducing the crystallinity of PEO electrolytes, approaches for promoting the dissociation of lithium salts in the electrolyte, methods for constructing fast lithium-ion transport networks, as well as the hybrid application of the above strategies. Finally, the current development status, existing challenges, and future development prospects of PEO-based solid electrolytes will be further explored and prospected, providing valuable insights for the practical application of PEO-based solid electrolytes in all-solid-state lithium batteries.

94

A Thermodynamic-Defect-Wagner Unified Model for Oxygen Permeation in MIEC Membranes

Maoqing Liu, Peng Zhang, Minfang Han
Tsinghua university, Beijing, China

Abstract

The selection of oxygen permeation models for mixed ionic-electronic conducting membranes is strongly governed by the pressure dependence of mobile oxygen vacancies and by the relative contribution of bulk transport to the overall resistance. Classical Zhu-type resistance models are effective when the mobile oxygen-vacancy concentration varies weakly with oxygen partial pressure, whereas Xu-Thomson-type models are more appropriate when vacancy concentration gradients provide the dominant bulk transport variable. However, materials with intermediate defect responses cannot be rigorously described by either limiting formulation. Here, we develop a defect-chemistry-resolved Wagner framework that retains oxygen chemical potential as the thermodynamic driving force while allowing the ambipolar conductivity to vary with oxygen partial pressure through a generalized vacancy response. Analytical integration gives a generalized bulk potential function, which can be coupled with surface chemical-potential drops to describe surface-bulk mixed control. The framework recovers the classical Wagner equation, the Xu-Thomson vacancy-diffusion model, and the Zhu/Yang three-resistance model under explicit limiting assumptions. Systematic oxygen permeation data with varied P_{O2}, temperature, and membrane thickness will be used to evaluate model applicability and distinguish weak-vacancy-response, strong-vacancy-response, and intermediate transport regimes.

95

Enhancing performances of perovskite electrocatalysts for solid oxide fuel cells/solid oxide electrolysis cells

Jingli Luo
Shenzhen UniVersity, Shenzhen, China

Abstract

Perovskite oxides are the very attractive electrode materials for solid oxide fuel cells/solid oxide electrolysis cells (SOFCs/SOECs) due to their excellent ionic and electronic conductivities, and good redox properties. Nonrtheless, in comparison with metal-based catalysts, their generally poor catalytic activity needs to be tackled prior to their large scale applications. To address this challenge, we herein present several promising strategies: In-situ construction of hetero-structured perovskite composites with exsolved metallic nanoparticles; Regulation of the lattice oxygen *p*-band center of the perovskite electrocatalysts; the in-situ co-exsolution of alloy catalysts and PrO_x nanoparticles; double-exchange effect coupling spin modulation; the coupling of crystal-structure regulation and electronic tuning; strategy of codoping with high-order orbital elements; B-site supplement of Perovskite oxides. This presentation primarily focuses on the above strategies in regards to their developmental progress and applications to achieve the ultimate goal of enhancing the performance of perovskite electrocatalysts for SOFC/SOEC.

96

Electrocatalysts and devices for co-generation of value-added chemicals and hydrogen/electrical energy without CO2 emissions

Xianzhu Fu
Shenzhen University, Shenzhen, China

Abstract

Carbon-based fuels such as fossil fuels and biomass are both energy and important chemical raw materials. When using carbon-based fuel for power generation or hydrogen production by reforming, CO_2 greenhouse gas emissions usually cannot be avoided. In addition, it is also challenging to cleanly and efficiently synthesize value-added chemicals using carbon-based raw materials derived from fossil fuels and biomass. In order to utilize carbon-based fuels more cleanly and efficiently, we developed a series of electrocatalysts for highly selective anodic dehydrogenation of carbon-based fuels, and constructed electrochemical reactor for co-generation of electrical energy/hydrogen and value-added chemicals. For example, when the partial oxidative methanol or formaldehyde or ethane dehydrogenation anode is selected to be coupled with the oxygen reduction cathode, the constructed fuel cells can CO_2-emission free co-produce electrical energy and high selective formate or ethylene value-added chemicals simultaneously. When the partial oxidative dehydrogenation of methanol or formaldehyde or ethane is selected for the electrolytic cell coupling with HER cathode, the energy consumption can be reduced to produce pure hydrogen gas and obtain value-added chemicals at the same time while without CO_2 emission.

97

Correlation between anionic redox and voltage hysteresis in Li/Na layered compounds

Biao Li
Peking University, Beijing, China

Biao Li

Abstract

Anionic redox (AR) enables ultrahigh energy density for Li/Na-ion cathode materials but is severely plagued by unresolved issues like voltage hysteresis, ambiguous activation mechanisms, and performance decay, hindering practical deployment. Herein, we systematically unravel the critical correlations between cationic redox, ligand-to-metal charge transfer (LMCT), cation migration, and voltage hysteresis in rock-salt and layered oxide cathodes. Using model Li-rich disordered rock-salt materials, we identified non-equilibrium redox pathways and sluggish O(2p)-Fe(3d) charge transfer as the origin of voltage hysteresis, and experimentally validated long-lived $Ni^{3+/4+}$ intermediates in AR-triggering LMCT processes. For lithium-rich NMCs, $Ni^{3+/4+}$ and Co^{4+} act as AR triggers via LMCT, with cobalt inducing faster LMCT kinetics but worse cycling stability. In P2-type Na-ion cathodes, we decoupled cation migration from AR, confirming electrochemically inactive cation size directly drives voltage hysteresis via reversible interlayer migration. This work clarifies fundamental AR mechanisms, establishes cationic species-migration-hysteresis relationships, and provides targeted guidelines for designing high-capacity, low-hysteresis Li/Na-ion cathode materials.

98

Development of Cobalt Doped Activated Carbon Nanomaterial Derived from Biowaste as an Efficient Electrocatalyst for Hydrogen Generation

Sanni Lawal Enesi[1,2], Abdu Muhammad Bello[3], Sani Nazifi Dalhatu[3]

[1]Federal University Dutse, Jigawa, Nigeria. [2]Materials For Electrochemical Energy Storage and Conversion (MESCo) Laboratory, Department of Chemistry, Federal University Dutse, Dutse, Nigeria. [3]Aliko Dangote University of Science and Technology Wudil, Wudil, Kano, Nigeria

Sanni Lawal Enesi

Abstract

Although developing efficient, inexpensive, and stable electrocatalysts for electrocatalytic water splitting to generate hydrogen is highly desirable, it's quite challenging. Herein, we report the electrocatalytic performance of cobalt-doped activated carbon nanomaterial (Co-ACN-MH) derived from biowaste, namely millet husk. While the pristine activated carbon nanomaterial (CAN-MH) was prepared by pre-activation, followed by activation and carbonisation at 550 °C, Co-ACN-MH was prepared via a hydrothermal route using $CoSO_4$ as the cobalt source. The influence of hydrothermal dwelling time on the electrocatalytic activity of Co-ACN-MH is investigated systematically. The electrochemical performance of the Co-ACN-MH electrocatalyst was studied in a three-electrode system in 1 M KOH using linear sweep voltammetry at 10 mV s^{-1}. The result obtained indicated that 18 hours is the optimal hydrothermal dwelling time to achieve the lowest onset potential of 0.52 (V) vs RHE with a current density of 1.50 mA cm^{-2} and the smallest Tafel slope. The electrochemical impedance spectroscopy studies revealed that Co-ACN-MH synthesised at 18 hours (Co-ACN-MH_18), exhibits the lowest charge-transfer resistance, indicating that adsorption and subsequent hydrogen generation at the interface are facile. This study highlights a cost-effective and sustainable strategy for developing efficient electrocatalysts from biowaste for hydrogen production

99

Research on Electrode Materials for High-Energy-Density Lithium-Ion Batteries

Hongqiang Wang
Guangxi Normal University, Guilin, China

Abstract

Improving lithium-ion battery energy density is critical for clean energy transition and technological innovation. Higher energy density allows electric vehicles to exceed a 1,000-kilometer driving range, alleviating range anxiety, speeding up gasoline vehicle replacement and facilitating global carbon neutrality. In consumer electronics, it supports battery downsizing or longer device operation, promoting wearables, drones and portable devices. For energy storage, high-energy-density batteries better accommodate wind and solar power, stabilize grid volatility and raise renewable energy utilization. They also reduce material usage and production costs per capacity, cutting lifecycle carbon emissions.From a material perspective, energy density can be enhanced by increasing either material specific capacity or discharge voltage. This report presents research by the Materials Electrochemistry Group of Guangxi Normal University on high-capacity and high-voltage electrode materials. To address inherent deficiencies in nickel-rich ternary, lithium-rich manganese-based, lithium nickel manganese oxide and alloy anode materials, the team develops modification approaches tuning microstructures, macrostructures and interfacial characteristics, together with relevant performance enhancement results.

100

Earth-abundant elements for high-energy rechargeable batteries

Xiao Liang
Hunan University, Changsha, China

Abstract

Intrinsically safe and high-energy-density battery systems are critical energy technologies for supporting the global transition to clean energy, advancing electric transportation, and achieving sustainable development. To overcome the performance limitations and resource constraints associated with conventional battery materials, the development of multielectron electrode reaction chemistries based on earth-abundant elements, beyond the single-electron intercalation mechanism of lithium-ion batteries, has emerged as a promising direction for next-generation high-performance energy storage systems.

Halogen and chalcogen elements, owing to their unique electronic structures and multiple accessible oxidation states, offer inherent advantages for constructing high-voltage redox couples capable of multielectron transfer. However, under high-voltage and multielectron reaction conditions, the corresponding active species are prone to side reactions and interfacial instability, resulting in efficiency loss and material degradation. Achieving precise regulation of their redox behavior remains a significant challenge, particularly due to the limited understanding of rate-determining reaction steps, interfacial formation and evolution mechanisms, and coupled multiphysics processes across electrode length scales.

Focusing on halogen- and chalcogen-based earth-abundant elements, we have systematically investigated the fundamental principles and regulation mechanisms of electrode reactions, developed multiple novel electrochemical redox systems featuring high reaction potentials and multielectron-transfer characteristics, and constructed high-energy-density battery devices through interfacial engineering and ion-transport regulation.

101

Aluminum – A New Power System for Ships

Qingyu Li
Guangxi Normal University, Guilin, China

Abstract

To tackle the environmental pollution and resource scarcity issues associated with fossil fuel-driven marine power, the short cruising range of lithium-ion battery-powered ships, and the hydrogen storage and transportation limitations of hydrogen fuel cell marine systems, this paper proposes a novel aluminum-based green energy flow system for ship propulsion and expounds its key core technologies. It comprehensively reviews conventional industrial aluminum electrolysis techniques and the latest research progress of carbon-free aluminum electrolysis. This paper also summarizes the application status of aluminum-based alloy hydrogen-generating materials, analyzes the practical application of lithium-ion battery power systems in new energy ships, and presents the recent research advances in marine hybrid propulsion systems combining lithium-ion batteries and hydrogen fuel cells.

102

Solid-to-Solid Zn Anode and Interhalogen Iodine Cathodes for High-Voltage Fluoride-Ion Batteries

Huijian Wang, Xiao Liang
Hunan University, Changsha, China

Abstract

Fluoride ion batteries (FIBs) operated at room temperature typically suffer from low output voltages (< 0.5 V) due to the lack of reversible, suitable electrode chemistries in liquid electrolytes. Here, we report a high-voltage aqueous FIB system delivering an output voltage of ~1.3 V by coupling a zinc/zinc hydroxyfluoride (Zn↔ZnOHF) anode with an iodine cathode undergoing reversible $I^- \leftrightarrow I_2F^-$ interhalogen conversion in an NH_4F-based methanol/water hybrid electrolyte. At the anode, strong complexation between NH_4^+ and Zn^{2+} activates a reversible solid-to-solid Zn↔ZnOHF conversion. Meanwhile, methanol effectively suppresses HER and accelerates fluoride-ion desolvation, leading to fast kinetics and high reversibility. As a result, the ZnOHF/Zn anode exhibits remarkable durability for over 1100 h at 1 mA cm^{-2} and 2 mAh cm^{-2}. At the cathode, tetrahexylammonium iodide (THAI) induces the formation of insoluble $THAI_2F$ during the fluorination of I_2 cathode, effectively immobilizing iodine species and suppressing shuttle effects. The proposed fluoride-ion-shuttled Zn/I_2 cells deliver a high specific capacity of 168 mAh g^{-1} at 2 A g^{-1} and retain 81% capacity after 2500 cycles. This work establishes interhalogen chemistry and electrolyte-regulated solid-state fluorination as viable strategies for designing high-voltage, long-life FIBs.

103

Electrochemical Detection in Microfluidics: Innovations for Affordable and Portable Analytical Sensing

Charles Henry
Colorado State University, Fort Collins, United States

Abstract

Electrochemical detection has emerged as a transformative approach for developing low-cost, portable analytical devices, particularly through the integration with microfluidic platforms, which enable precise control of small sample volumes, enhance sensitivity through miniaturization, and allow for rapid, multiplexed analyses in a compact format. This talk will discuss advances from our laboratory in the design, development, and application of integrated electrochemical and microfluidic technologies for environmental and clinical diagnostics. Carbon electrodes are widely utilized in electrochemistry due to their advantageous properties, including low cost, biocompatibility, and a wide potential window. Additionally, carbon electrodes can be easily and rapidly manufactured using techniques such as stencil/screen printing and laser-induced graphene formation, enabling the high-throughput fabrication of large numbers of electrodes in a short period of time. Next, methods to better control electrode surface chemistry and applications to a variety of sensing applications will be presented. Finally, we will discuss the use of these combined microfluidic and electrochemical methods for sensing applications using low-cost disposable microfluidic devices and inexpensive potentiostats to address real-world sensing needs. In conclusion, we will demonstrate how these platforms can be tailored to address real-world analytical challenges, offering new opportunities for decentralized testing and improved accessibility to multiple applications.

104

Tailoring Solvation Structure via Soft-Hard Segment Synergy in Gel Polymer Electrolytes Enables Dendrite-Free Sodium Batteries with Ultra-Long Cycling

Xiaorong Dong, Xiangwei Wu, Zhaoyin Wen
Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China

Abstract

The development of polymer electrolytes with high ionic conductivity, robust mechanical strength, and excellent interfacial stability remains a critical challenge for high-performance sodium batteries. Herein, a “chemical-structural dual regulation” strategy introduces complementary soft and hard segments into a gel polymer electrolyte (GPE), enabling concurrent optimization of solvation structure and mechanical properties. Soft segments with strong electron-withdrawing -CF_3 groups form solvent-rich domains that weaken Na^+-solvent interactions, while amide N–H groups create polymer-rich domains that enhance mechanical strength and anchor anions via hydrogen bonding, promoting sodium salt dissociation. Benefiting from this rational molecular design, GPE-9 delivers an outstanding ionic conductivity of 1.11 mS cm^{-1} and a high Na^+ transference number of 0.74 at room temperature, and supports long-term cycling of Na||Na symmetric cell at 0.2 mA cm^{-2} for 7000 h. The Na|GPE-9|$Na_3V_2(PO_4)_3$ (NVP) cell demonstrates excellent rate durability, sustaining 12 000 and 20 000 cycles at 5C and 10C, respectively, with nearly 100% Coulombic efficiency. Furthermore, a 29-layer pouch cell with NVP cathode and hard carbon (HC) anode delivers a high capacity approaching 1.0 Ah. This study demonstrates that designing polymer segments capable of regulating solvation structure and directing interfacial fluorination offers a promising strategy for high-performance GPEs for Na batteries.

105

Mechanism of Synergistic Regulation Between Electrochemical Performance and Thermal Uniformity for Segmented Series Tubular Solid Oxide Fuel Cells with Direct Internal Methane Reforming

Huiyu Zhang, Chengxin Li
State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, Xi'an, China

Abstract

A two-dimensional axisymmetric multi-physics coupling numerical model is established for segmented series tubular solid oxide fuel cells with direct internal methane reforming (DIR-T-SIS-SOFC). With fixed total tube length, the number of series segments n adjusts species distribution by varying the effective length of single cell L_{eff}, thereby determining cell performance. The thermal equilibrium point is defined by simultaneous balance of endothermic/exothermic reactions and minimized axial temperature difference, featuring constant fuel utilization and total hydrogen consumption rate independent of geometric configurations. Increasing segment numbers shortens L_{eff} and hydrogen mass transfer distance, flattens concentration gradients, homogenizes species distribution and improves power output. Nevertheless, geometric optimization reaches a saturation limit: when $L_{eff} \leq 4$ mm, species distribution approaches ideal uniformity, and local current density as well as power cease to grow. At 75% fuel utilization, the configuration of $n = 14$ delivers comparable power to $n = 22$ under high fuel flow, with superior thermal uniformity. Pre-reforming elevates inlet hydrogen concentration and Nernst potential to boost power, yet enlarges axial temperature gradient, revealing a trade-off between power enhancement and thermal homogeneity. This work clarifies the performance-promoting mechanism via segment number modulation for uniform species distribution, balances geometric performance and thermal uniformity under high fuel utilization, and elaborates the synergistic optimization between pre-reforming and internal reforming, providing theoretical guidance for multi-objective design of series tubular SOFCs.

Keywords: Segmented series tubular SOFC; Direct internal methane reforming; Multi-physics coupling simulation; Geometric configuration optimization.

106

Solid State Ionics for Information, Energy and Environmental Applications

Xin Guo
Huazhong University of Science and Technology, Wuhan, China

Xin Guo

Abstract

Crystals inherently possess defects of varying dimensions, the ubiquitous presence of these defects causes material properties to deviate from those of ideal crystals. However, through multi-scale defect engineering, these imperfections can be harnessed to manipulate and optimize material properties. Building upon this foundation, our current research focuses on the following areas:

(1) Neuromorphic Systems: Mimicking the brain's ionic information processing, we develop memristors utilizing ionic defect migration in oxides. Multiple resistance states with distinct time constants enable these devices to serve as artificial synapses and neurons, forming networks for brain-inspired AI.

(2) Intelligent Olfactory Systems: Inspired by the human nose, we develop artificial systems integrating sensor arrays, signal acquisition, and pattern recognition. By extracting spatiotemporal features via artificial neural networks, we effectively identify multi-component gases in complex environments.

(3) Solid-State Batteries: Our polymer-based solid-state lithium batteries achieve up to 520 Wh kg^{-1} energy density, 4C fast charging (95.52% capacity retention), and over 3,500 cycles (77.2% retention). Crucially, they exhibit unparalleled safety, withstanding nail penetration, 200°C thermal abuse, and 5.8 mm ballistic impacts without thermal runaway—a safety milestone unattainable by conventional liquid electrolytes.

107

Prediction and Experimental Verification: ML-Guided Exploration of Lithium-Ion-Conducting Sulfides

Kota SUZUKI
Institute of Science Tokyo, Yokohama, Japan

Kota SUZUKI

Abstract

The discovery of high-performance solid-state electrolytes is essential for realizing practical all-solid-state batteries. This study presents Elements-To-Ionics (E2I), a composition-based machine learning framework that predicts ionic conductivity from elemental compositions alone. To demonstrate its capability, the framework was applied to the exploration and optimization of argyrodite-type sulfide electrolytes. Guided by the model predictions, a wide range of compositionally modified argyrodites was designed, synthesized, and experimentally evaluated. The machine learning model identified promising compositional regions with enhanced ionic conductivity while reducing the experimental search space. Experimental verification revealed multiple optimized compositions exhibiting lithium-ion conductivities exceeding 10^{-2} S cm^{-1} after processing optimization. The E2I framework effectively distinguished high- and low-conductivity compositions and enabled efficient exploration of complex compositional spaces without relying on structural descriptors. These results demonstrate that composition-based machine learning, combined with experimental validation, provides a powerful strategy for accelerating the discovery and optimization of solid-state electrolytes.

108

Countering Fluorine Loss in Na3V2(PO4)2F3 Cathodes: Three Complementary Strategies

Zerong Deng, Biaoyang Li, Lulu Zhang, Xuelin Yang
China Three Gorges University, Yichang, China

Abstract

$Na_3V_2(PO_4)_2F_3$ (NVPF) is a highly promising cathode material for sodium-ion batteries owing to its high operating voltage, excellent structural stability, and high theoretical capacity. However, fluorine loss inevitably occurs during high-temperature synthesis, leading to the formation of $Na_3V_2(PO_4)_3$ (NVP) impurity with low capacity and voltage. To address this critical issue, we systematically develop three complementary strategies: (i) fluorine compensation via polytetrafluoroethylene (PTFE) addition, which simultaneously serves as a carbon source, to suppress impurity formation and yield phase-pure NVPF with improved specific capacity (126.6 mAh g^{-1} at 0.5C) and long-term cyclability (85.3% retention after 500 cycles at 10C); (ii) fluorine stabilization through Ga^{3+} doping, which strengthens V–F bonding interaction, mitigates thermal fluorine volatilization, and concurrently enhances both Na^+ ion diffusivity and electronic conductivity, thus delivering 125.5 mAh g^{-1} at 0.2C and 90.1% retention after 200 cycles at 1C); and (iii) post-purification via water treatment, which chemically decomposes the NVP impurity while simultaneously inducing O-for-F substitution that stabilizes the lattice framework, achieving 129.6 mAh g^{-1} at 0.2C and 92.3% retention after 500 cycles at 1C. Collectively, these three strategies, fluorine supplement, fluorine stabilization, and post-purification, provide a multi-stage framework for effectively mitigating fluorine loss and advancing high-performance NVPF cathodes for sodium-ion batteries.

109

Longitudinal spatial charge transfer optimization in composite cathodes enables ultra-stable all-solid-state batteries

Junwei Liang
Tsinghua Shenzhen International Graduate School, Shenzhen, China

Abstract

All-solid-state batteries (ASSBs) promise high energy density and inherent safety but face critical challenges in complex charge transfer process across the longitudinal cathode. Here, through multiphysics simulation, it is firstly revealed that charge transfer critically governs electrochemical reaction heterogeneity, dictating where reactions initiate preferentially along the lengthways of cathode. Building on this insight, a charge-transfer-optimized cathode (CTOC) is proposed to conceptually validate the effectiveness of charge-transfer regulation in homogenizing the longitudinal Li concentration. The CTOC features a double-layer architecture: a carbon-free layer with large-sized catholytes near separator to enhance Li-ion transfer while reduce electron conduction and a carbon-containing layer near current collector to ensure efficient electronic conductivity, thus tandem modulating the spatial ion and electron transfer dynamics longitudinally. Through graded ionic and electronic conduction to achieve decoupled but synchronized ion and electron transport pathways, the CTOC enables longitudinally homogeneous Li distribution throughout the cathode. As a result, CTOC exhibits excellent cycling performance, retaining 82.7% capacity after 2000 cycles at 2C, a 27.4% durability improvement over conventional single-layer designs. This work establishes electrode-level charge transfer optimization as a design principle for heterogeneous reaction control, offering fundamental insights and practical strategies for high-performance ASSBs.

110

Effects of RF Plasma Treatment on the Electrolyte for Intermediate Temperature Solid Oxide Fuel Cells

Abdul Basit, Xu Han, Yu Peng, Bo Wei, Zhe Lü*
Harbin Institute of Technology, Harbin, China

Abstract

Intermediate-temperature solid oxide fuel cells (IT-SOFCs) require electrolyte and electrode materials with enhanced performance and long-term structural and electrochemical stability. Radio-frequency (RF) plasma treatment has emerged as a surface engineering technique capable of tailoring surface properties without the high thermal budget associated with conventional modification methods. However, prior to investigating plasma-induced enhancements in cathode materials, it is essential to establish plasma processing conditions that preserve the structural integrity of ceramic SOFC components. In this work, we applied Ar plasma to treat dense GDC ($Ce_{0.8}Gd_{0.2}O_2$) and LSGM ($La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_3$) pellets by different time (0, 15, 30, 45 min). X-ray diffraction (XRD) and Raman spectroscopy were employed to characterize the treated samples. XRD patterns of GDC samples showed only fluorite peaksunder all treatments and no secondary phase was detected. LSGM XRD patterns similarly showed single-phase with perovskite structure. Raman of GDC revealed the F_2g band at 458.98 cm^{-1} (untreated) shifting only to 459.67, 459.46 and 458.68 cm^{-1} (15–45 min) while its FWHM narrowed from 29.74 to 26.43 cm^{-1}. This ~11% sharpening suggests reduced near-surface disorder (enhanced local ordering) rather than bulk damage. No new defect-related bands (e.g. ~550–600 cm^{-1}) appeared. The F_2g position aligns with literature (pure CeO_2 ~460 cm^{-1}). Identical fitting protocols ensured consistency. In summary, Ar plasma (≤45 min) affects only the surface: the fluorite/perovskite bulk lattices are preserved while only minor local lattice changes occur.

111

CO_2-Activated Freeze-Dried Carbon Aerogel Electrodes for High-Performance Sodium-Ion Solid-State Supercapacitors

HARDEEP HARDEEP, Anshuman Dalvi
Birla Institute of Technology and Science, Pilani, Pilani, India

HARDEEP HARDEEP

Abstract

Porous carbon aerogels with tailored pore architecture were developed as electrode materials for high-performance sodium-ion solid-state supercapacitors. Freeze-dried organic gels were carbonized at 800 °C for 2 h under an inert atmosphere to obtain freeze-dried carbon aerogel (FDCA-S1). To further enhance the textural properties, the carbon aerogels were activated in a CO_2 atmosphere at 900 °C for 2.5 h (FDCA-S2) and 4.5 h (FDCA-S3). CO_2 activation progressively increased the specific surface area from **942.5** to **1508.3** and **1828.9 m^2 g^{-1}**, leading to improved electrolyte accessibility and charge storage.

The electrochemical performance evaluated in a three-electrode configuration showed a significant increase in specific capacitance with increasing surface area. The optimized FDCA-S3 electrode delivered **403.2 F g^{-1}** from CV (20 mV s^{-1}) and **436.8 F g^{-1}** from GCD (1 mA), compared to **232.6** and **228.4 F g^{-1}**, respectively, for FDCA-S1. A symmetric solid-state supercapacitor employing FDCA-S3 electrodes and a NASICON-based ionic liquid electrolyte exhibited a specific capacitance of **132.9 F g^{-1}** (CV, 50 mV s^{-1}) and **187.3 F g^{-1}** (GCD, 1 mA) over a **2.0 V** operating window, delivering a maximum energy density of **23.9 Wh kg^{-1}** and a power density of **2856.7 W kg^{-1}**.

These results demonstrate that controlled CO_2 activation effectively tailors the pore structure of freeze-dried carbon aerogels, making them promising electrode materials for high-energy-density sodium-ion solid-state supercapacitors.

Keywords: Carbon aerogel, CO_2 activation, Solid-state supercapacitor, NASICON electrolyte, Sodium-ion energy storage.

112

Unveiling interfacial electron-ion coupled dynamics in organic-inorganiccomposite materials for fast air self-charging zinc-ion batteries

Chao Ma
Taiyuan University of Technology, Taiyuan, China

Abstract

Air self-charging aqueous zinc-ion batteries (AZIBs) have garnered significant attention for their integrated energy-harvesting and storage capabilities. However, their performance is often hindered by sluggish electrode reaction kinetics and restricted cation transport channels. Herein, an organic-inorganic composite cathode, 1,4,5,8-naphthalenetetracarboxylic dianhydride (NTCDA)@VO_2, is constructed via a synergistic design strategy, in which NTCDA molecules uniformly coat and partially intercalate into the VO_2 layers, thereby optimizing electron transport and ion diffusion pathways. Compared with reported organic-inorganic composite cathodes that mainly rely on inorganic additives to improve conductivity or structural stability, NTCDA@VO_2 constructs an active organic-inorganic interface, in which VO_2 acts as an electron donor to regulate the electronic structure of NTCDA, while its layered framework enables the ordered distribution of NTCDA molecules. Benefiting from this structural synergy, the Zn//NTCDA@VO_2 battery exhibits an open-circuit voltage recovery to 1.21 V after 1 h of air exposure and delivers a high discharge capacity of 170.1 mAh g^{-1} at 0.2 A g^{-1}. Experimental andtheoretical analyses reveal that the carbonyl (C=O) groups serve as the main redox-active sites, participating inthe cooperative insertion/extraction of $Zn^{2+}$and H^+. Meanwhile, VO_2 acts as an electron donor when combinedwith NTCDA, promoting oxygen activation and reducing the oxygen reduction reaction (ORR) energy barrierfrom 0.91 to 0.39 eV, thereby accelerating charge transfer and ion migration. This work elucidates the electron-ion coupling mechanism at the organic-inorganic interface regulated by the inorganic framework, providing new insights for designing efficient air self-charging energy storage systems.

113

Electrode-Electrolyte Interfacial Reconstruction towards Capable Zn Metal Batteries

Kai Zhu
Harbin Engineering University, Harbin, China

Abstract

Rechargeable aqueous zinc-ion batteries (ZIBs) are expected to be the next generation of low-cost, safe, and high-energy-density energy storage systems. However, undesirable electrode/electrolyte interfacial (EEI) side reactions of anode and dissolution of cathode materials during cycling of ZIBs have led to drastic degradation of battery performance. Here, we develop a phosphated electrolyte to facilitate the simultaneous formation of a $Zn_3(PO_4)_2$-rich solid electrolyte interphase (SEI) and the cathode/electrolyte interface (CEI) as well as improved solvent chemistry. The in-situ generated robust EEI induce uniform deposition of zinc and inhibit solvation of the cathode material to achieve a high performance ZIBs. The improved solvent chemistry promises stable cycling at low temperatures with an ultra-long life of 600 hours at -10°C. Moreover, the pouch cell with phosphated electrolyte exhibits excellent cycling performance with no significant capacity degradation after 150 cycles. In addition, the phosphated electrolyte in anode-free ZIBs performances a long lifetime of 200 cycles. This study provides a simple and effective strategy for interface construction in ZIBs.

114

3D MOF-derived novel CuF_2 nanocubes as cathode: Porous structure design and application in high energy density primary batteries

Yichun Zhao[1], Zhiyong Yu[1], Hanxing Liu[2]

[1]Wuhan University of Technology, Wuhan, China. [2]bState Key Laboratory of Advanced Technology for Materials Synthesis and Processing, School of Material Science and Engineering, International School of Material Science and Engineering, Wuhan University of Technology, Wuhan, China

Abstract

High-energy-density primary lithium-ion batteries have significant application value in deep space exploration, special equipment, and other fields[1]. Developing high-capacity cathodes is the core direction to improve their energy storage density. Copper fluoride(CuF_2) relies on the dual electron conversion reaction to store lithium ($CuF_2+2Li^++2e^- \rightarrow Cu+2LiF$), with a theoretical specific capacity of over 500 mAh g^{-1} and a working potential of approximately 3.55 V (vs. Li^+/Li), showing significant potential[2]. However, the controllable synthesis of its morphology is a long-term technical challenge. Traditional preparation methods are difficult to accurately control its microstructure, and the resulting products are mostly nanoparticles or amorphous, which not only delays the electrochemical reaction kinetics but also cannot buffer the volume effect of deep discharge, resulting in a much lower utilization rate of active substances than the theoretical value[3,4].

In response to the above bottlenecks, this article used 3D Cu-based MOFs as precursors to prepare graded porous CuF_2 nanocube cathodes through a controllable fluorination strategy, with a BET specific surface area exceeding 30 m^2 g^{-1}. This structure could effectively alleviate discharge volume expansion and significantly improve reaction kinetics, achieving a discharge capacity of 516.32 mAh g^{-1} at a rate of 0.01 C. Reasonable morphology design is the core path to break through dynamic limitations and unleash high energy storage potential, based on the characteristics of a single deep discharge of a battery. This study provides feasible references for the development of high-performance primary lithium battery cathodes and transformation type metal fluoride morphology engineering.

115

MXene-Based Functional Materials: Rational Design, Computational Prediction, and Recent Advances in Energy Applications

Hanxing Liu[1], Zhiyong Yu[2], Tianli Li[2], Jingsai Cheng[2]

[1]State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, International School of Material Science and Engineering, School of Material Science and Engineering, Wuhan, China. [2]School of Materials Science and Engineering, Wuhan University of Technology, Wuhan, China

Abstract

MXenes, a family of two-dimensional transition metal carbides/nitrides, have emerged as promising candidates for advanced energy applications due to their high conductivity, tunable surface chemistry, and unique layered structure. In this talk, I will summarize the recent progress made in our group on the rational design, structural engineering, and functionalization of MXene-based materials. Our research focuses on establishing fundamental structure–property relationships, with particular emphasis on both experimental and computational approaches.

We have systematically explored the modulation of MXene composition, structural features, and surface functional groups to address key challenges in energy systems. By combining high-throughput calculations and data-driven strategies, we have developed predictive models to screen and identify promising MXene candidates, accelerating the discovery of high-performance materials. Guided by these theoretical predictions, we carried out experimental validation of the identified MXene candidates. The underlying design principles, key structure-performance correlations, and the potential of MXenes to enable next-generation energy technologies will be discussed.

116

In-situ Polymerized Composite Electrolytes for High-Voltage Solid-State Lithium Metal Batteries

Guanyou Xiao, Hao Xu, Yan-Bing He
Tsinghua Shenzhen International Graduate School, Shenzhen, China

Abstract

High-voltage solid-state lithium metal batteries require electrolytes that combine rapid Li^+ transport with stable electrode/electrolyte interfaces. Here, we present two functional-filler-assisted in-situ polymerization strategies for composite solid polymer electrolytes. In the first, Mg^{2+}-containing montmorillonite initiates the polymerization of 1,3-dioxolane, yielding uniform poly(1,3-dioxolane) chains and MgF_2-rich interphases on both electrodes. Strong Mg^{2+}-anion coordination improves Li^+ transport and extends oxidative stability to 5.3 V, enabling Li/NMC811 cells to operate stably for more than 500 cycles. In the second, $BaTiO_3$ is introduced as a dielectric regulator to tailor Li^+ coordination and suppress space-charge effects at the cathode interface. The resulting composite electrolyte exhibits an oxidative limit above 5.2 V and supports Li/NMC811 cycling for 1800 cycles at a 4.6 V cut-off voltage and 1300 cycles at 4.7 V. These results demonstrate that combining in-situ polymerization with filler-mediated coordination and interfacial regulation can simultaneously accelerate ion transport, stabilize high-voltage interfaces, and extend cycling life, offering a practical route toward durable, high-energy-density solid-state lithium metal batteries.

117

Efficient Ion Percolating Network and Interfacial Engineering for PVDF-based Solid-State Battery with High Loading Cathode and Long-cycling-life

NAN FANG, AN XUFEI, Liu Yang, LIU MING, HE YANBING, KANG FEIYU
Tsinghua University, Shenzhen, China

Abstract

Solid-state polymer electrolytes (SPEs) based on PVDF are highly promising for solid-state lithium metal batteries due to their flexibility, mechanical strength, thermal stability, and room-temperature performance. However, pairing them with high-mass-loading cathodes remains challenging, limited by ion transport in the cathode and Li dendrite growth at interfaces. We find that $[Li(DMF)x]^+$ can diffuse into the cathode to aid Li^+ transport, but only for low-loading electrodes. To extend this, carbon-coated $Li_{1.4}Al_{0.4}Ti_{1.6}(PO_4)_3$ nanowires are used to build a stable conduction network in high-loading cathodes. Furthermore, dielectric $NaNbO_3$ filler undergoes Li^+/Na^+ exchange during cycling; the substituted Na^+ helps form a fluorinated Li/Na hybrid solid electrolyte interphase with high Young's modulus, which accelerates Li^+ transfer at high areal capacity and suppresses dendrites. Our work provides fundamental insights into cathode Li^+ pathways and anode interface engineering, enabling stable PVDF-based SSLMBs with high cathode loading.

118

Coupling Coordination Structures and Superionic LithiumConduction in Amorphous Oxyhalide Solid-State Electrolytes

zhihao Lei, likun Chen, Weijie Liu, Ming Liu
Tsinghua Shenzhen International Graduate School, Shenzhen, China

Abstract

Amorphous oxyhalide solid-state electrolytes (SSEs) hold great promise for achieving all-solid-state batteries (ASSBs) due to their superionic conductivity and high-voltage stability. However, their fundamental understanding of atomic-scale structures and ion conduction mechanisms remains unclear. Herein, we reveal the general “volcano-type” relationship between ionic conductivity and inorganic lithium salt concentration in tantalum-based amorphous oxyhalide SSEs ($TaCl_5$-xLi_2O). Lithium salt concentration modulates the lithium-ion concentration, dualanion (O/Cl) framework structure, and precipitation of LiCl impurities, collectively determining the ionic conductivity. Based on this finding, the optimized amorphous $TaCl_5$-0.5Li_2O achieves a high ionic conductivity of 7.27×10^{-3} S cm^{-1} at 25 °C. Structural analysis further reveals that the existence of multiple Ta-O-Cl polyhedra and oligomers contributes to disordered lithium coordination environments. The weak interactions between lithium ions and the dual-anion framework contribute to low migration energy barriers, establishing an energetically flat three-dimensional lithium-ion migration network. Furthermore, the $TaCl_5$-0.5Li_2O-based ASSBs achieve good rate performance and cycling stability over 600 cycles. These findings provide fundamental insights into the mechanistic correlation between the coordination structures and the ionic conduction in amorphous oxyhalide SSEs.

119

Synaptic Response of 2D Lamellar Architecture via Regulable Ion Release

Hyung Gyu Park
POSTECH, Pohang, Korea, Republic of

Hyung Gyu Park

Abstract

Ions, fundamental to biological computation, are attracting attention as physical carriers for artificial neuromorphic devices, serving as essential active components. Although research is advancing toward harnessing anomalous ion transport and artificial synapses thereupon, replicating and implementing complex brain functions remains a critical technical challenge. Here, we report non-volatile synaptic responses driven by stable ion storage and release in a two-dimensional (2D) multichannel of ascorbic acid-reduced graphene oxide (ArGO). Regulation of ion release reveals features of synaptic plasticity, including long-term potentiation and depression as well as prolonged memory retention. Arguably, our ionic device parallels biological neural networks, as its behavior aligns with the Ebbinghaus forgetting curve and the temporal dynamics of synaptic weight modulation in response to stimulus frequency. Additionally, ArGO 2D multichannels successfully display heterosynaptic plasticity, in which signal transmission at one synapse can alter the synaptic weight of an adjacent synapse. Beyond the synaptic behavior, the ion storage-release dynamics leads to emulating the action potential generation observed in neurons, implying adaptability of our device to various neuromorphic functions in a controlled manner. We believe our 2D manifold architecture, featuring unique ion storage and release properties, proposes a new avenue to designing artificial synapses.

120

A Ductile Solid Electrolyte Interphase for Solid-State Batteries

Jinshuo Mi[1], Zheng Zhang[1], Tingzheng Hou[1], Wei Lv[1], Yan-Bing He[1], Quan-Hong Yang[2], Feiyu Kang[1,3]
[1]Tsinghua Shenzhen International Graduate School, Shenzhen, China. [2]Nanoyang Group, Tianjin Key Laboratory of Advanced Carbon and Electrochemical Energy Storage, Tianjin, China. [3]School of Materials Science and Engineering, Tsinghua University, Beijing, China

Abstract

Solid-state lithium metal batteries promise high energy density, but operation at high current density and areal capacity is limited by brittle solid-electrolyte interphase (SEI), sluggish Li-ion transport and dendrite-driven side reactions. Here we present a mechanics-guided strategy to construct a ductile inorganic-rich SEI for high-rate solid-state batteries. First, Pugh's criterion and density-functional calculations identify Ag_2S and AgF as ductile SEI components with low deformation and Li-ion diffusion barriers. Second, a PVDF-based dielectric composite solid polymer electrolyte (PALA), containing Ag/LLZTO fillers and $AgNO_3$, drives in situ substitution of Li_2S/LiF by Ag_2S/AgF, forming an asymmetric SEI with Ag_2S/AgF near the electrolyte and Ag/Li-Ag near lithium. Third, this coupled electrolyte-SEI design improves ion transport and stress accommodation, giving 9.65×10^{-4} S cm^{-1} conductivity at 25 °C and a Li^+ transference number of 0.57. Li||Li cells operate for 4,500 h at 15 mA cm^{-2}/15 mAh cm^{-2} and for 7,000 h at −30 °C under 5 mA cm^{-2}/5 mAh cm^{-2}, while NCM811||Li cells retain 88.0% capacity after 300 cycles at 5 C. This work establishes SEI ductility as a design principle for fast-cycling solid-state lithium metal batteries.

121

Improving performance and stability of perovskite solar cells through materials engineering

Ashish Garg, Yugesh Kumar, Saurabh Srivastava, Sudhir Ranjan
Indian Institute of Technology Kanpur, Kanpur, India

Abstract

Since their emergence in 2009, perovskite solar cells have come a long way with top efficiencies approaching 27%. Despite all the high-efficiency claims, its commercial implementation has not been possible, primarily because of poor atmospheric stability, driven by multiple factors. There are multiple degradation pathways, each requiring different strategies to improve device stability. This talk will focus on strategies that we have adopted in our group to improve the stability of perovskite solar cells and on detailed investigations of the underlying physical mechanisms. Our work involves testing the atmospheric stability of perovskite solar cells in various conditions and stressors to assess their impact on the device performance. The approaches this presentation will show are additive engineering, composition engineering, interface engineering and the use of lab-made optical filters.

122

Nano-inorganic cluster chains construct internal interfaces in polymer solid electrolytes to enhance sodium-ion transport

Jiajie Wen, Xiangwei Wu, Zhaoyin Wen
Shanghai Institute of Ceramics, Shanghai, China

Abstract

Composite polymer electrolytes generally suffer from low ionic conductivity and inferior interfacial stability. Here, we propose to use the hydrothermal method to prepare nano-inorganic cluster chains in order to obtain the optimal ionic conductivity and mechanical strength of the composite polymer electrolyte. The nano-structured inorganic fillers with oil-containing surface groups prepared can be uniformly dispersed in the non-polar precursor solvent, enabling the ions to rapidly and uniformly transmit through the created continuous organic-inorganic network interface, facilitating the dissociation of sodium salts and releasing more free sodium ions, raising the sodium-ion transference number of the electrolyte to 0.63. The assembled Na//NVP solid-state batteries achieve high specific capacity (105 mAh/g @0.1C) and stable cycling performance of over 1000 cycles @0.5C. Additionally, the interconnected 3D structure can significantly reduce the crystallinity of PEO, providing a continuous interface for anion adsorption, effectively improving the interfacial stability of fillers/electrolyte and electrolyte/electrode. The symmetrical Na//Na battery exhibits extremely long and stable cycling life at a current density of 0.1 mA cm^{-2}, with a cycling duration of over 1000 hours.

123

Low-Ion-Electron Transport Strategy Minimizes Electrolyte Oxidation for Stable All-Solid-State Batteries Without Cathode Modification

Zhenshen Li, Jing Shen, Yanyan Wang, Shichao Wu, Quan-Hong Yang
Nanoyang Group, State Key Laboratory of Chemical Engineering, School of Chemical Engineering and Technology, Tianjin University, Tianjin, China

Abstract

The severe oxidative decomposition of argyrodite sulfide solid electrolytes (SSEs, e.g., Li_6PS_5Cl) at high operating voltages presents a formidable challenge for all-solid-state lithium batteries (ASSLBs). Although conventional mitigation strategies primarily focus on bulk or surface modification of cathode active materials (CAMs), they frequently overlook the parasitic electrochemical oxidation localized at the electrochemically active carbon additive interface. Herein, we demonstrate that the oxidative degradation of Li_6PS_5Cl is fundamentally governed by an Ion-Electron Coupling Transport (IECT) mechanism. This coupled extraction of lithium ions and electrons proceeds via a concerted pathway, bypassing the high thermodynamic energy barriers associated with sequential, stepwise charge transfer. Consequently, blocking only a singular charge carrier is insufficient, as compensatory pathways sustained by the unrestricted carrier continue to drive electrolyte degradation.

To address this challenge, we propose a carbon-targeted “Low-Ion-Electron Transport” (LIET) strategy, realized by synthesizing a conformal, 2-nm-thick N-heterocyclic conjugated polymer (NCP) layer directly on the conductive carbon surface. The resulting modified carbon (LIETC) simultaneously suppresses electronic tunneling through its conjugated backbone and immobilizes interfacial Li^+ via coordination with abundant pyridine-nitrogen sites, forming highly localized Li-N bonds. Consequently, without requiring modification of the cathode active material, the engineered battery delivers robust high-rate cycling, maintaining a 99.4% capacity retention over 2,000 cycles at a 5C rate. Demonstrating broad universality across diverse solid electrolytes and carbon morphologies, this LIET principle establishes a mechanism-driven paradigm for stabilizing composite cathodes.

125

Connecting electrochemical property with structural factor of 3D nanostructure

Seokwoo Jeon
Korea University, Seoul, Korea, Republic of

Seokwoo Jeon

Abstract

Three-dimensional (3D) nanostructuring of electrodes provides a powerful route to enhance electrochemical performance, yet a clear linkage between measurable electrochemical properties and governing structural factors is still needed for rational design and scale-up. In this talk, I introduce Proximity field nanoPatterning (PnP), a unique 3D nanopatterning method that utilizes optical interference from conformal phase masks in direct contact with photosensitive materials. This contact-based approach offers exceptional stability in patterning area, resolution, and reproducibility, enabling large-area architectures with extended thickness and structural degrees of freedom.

Building on recent progress toward macroporous, inch-scale nanostructures with submicron lattice parameters, I will discuss how key geometric descriptors—such as porosity, pore-size distribution, interconnectivity, tortuosity, surface area, and conductive pathway continuity—govern electrochemical metrics including areal capacity, rate capability, polarization/impedance evolution, and cycling stability. Emphasis will be placed on identifying structure–property correlations that explain why mechanically robust, well-connected porous frameworks can simultaneously facilitate fast ionic transport and efficient electronic conduction while mitigating local stress and degradation.

Finally, I will highlight representative energy-electrode demonstrations, with particular focus on Li-ion battery configurations, and outline design principles for translating 3D nanostructured concepts into practical, scalable electrodes. Ongoing efforts on larger-area, low-cost fabrication will be discussed in the context of high-end, lightweight power sources for drones, mobile devices, and wearable systems.

126

Size-Dependent Trade-off between Sulfur Catalysis and Sulfide Electrolyte Decomposition for Room-Temperature Ultrahigh-Rate All-Solid-State Li-S Batteries

Junjie Wang[1,2,3], Chuannan Geng[3], Wei Lv[2], Quan-Hong Yang[1]

[1]Nanoyang Group, State Key Laboratory of Chemical Engineering, School of Chemical Engineering and Technology, Tianjin University, Tianjin, China. [2]Shenzhen Geim Graphene Center, Engineering Laboratory for Functionalized Carbon Materials, Tsinghua Shenzhen International Graduate School, Tsinghua University, Shenzhen, China. [3]Centre of Energy Storage for Extreme Environments, Frontier Energy Technologies Institute, Shenzhen University of Advanced Technology, Shenzhen, China

Abstract

All-solid-state lithium-sulfur batteries (ASSLSBs) are promising candidates for next-generation high-energy and high-safety energy storage, yet their power capability is fundamentally limited by sluggish solid-phase sulfur conversion especially at high current densities. Although catalytic strategies can accelerate sulfur redox kinetics, their adverse impact on sulfide solid-state electrolytes (SSEs) has been largely overlooked. Here, we reveal for the first time that catalytic acceleration under overlapping electrochemical potential conditions inevitably induces parasitic decomposition of sulfide SSEs, disrupting continuous Li^+ transport and constraining high-rate performance. To overcome this intrinsic trade-off, we report a rational catalyst-structure design by confining precisely sized cobalt clusters within an ultra-microporous carbon host. This design enables intimate sulfur-catalyst contact to accelerate sulfur conversion while physically isolating catalytic surfaces from the bulk SSE, thereby suppressing electrolyte decomposition and preserving continuous Li^+ transport pathways. Benefiting from this decoupled catalytic configuration, ASSLSBs exhibit the highest reported room-temperature rate performance, achieving stable cycling at an ultrahigh rate of 15 C (25.0 mA cm^{-2}) for more than 15000 cycles, demonstrating a viable strategy for high-power all-solid-state sulfur batteries. This work establishes a general catalyst design principle for simultaneously achieving fast sulfur conversion and stable electrolyte interfaces in high-power all-solid-state batteries.

128

Supramolecular Ligands Enable Efficient Ion Transport in Solid-State Lithium Batteries

Qian-Nan Zhu, Kang-Rui Ren, Jun-Yao You, Zhen-Han Xie, Hai Su, Yan-Bing He
Tsinghua Shenzhen International Graduate School, Shenzhen, China

Abstract

Poly(vinylidene fluoride) (PVDF)-based composite solid electrolytes are promising for solid-state lithium metal batteries but suffer from sluggish Li+ transport and unstable interfacial chemistry. Here we report a supramolecular ligand strategy using 18-crown-6 to regulate the Li+ coordination environment in a PVDF/LLZTO/LiFSI composite electrolyte. The electron-rich cavity of 18-crown-6 weakens Li+-FSI− interactions and promotes salt dissociation, increasing the population of mobile Li+ and improving both ionic conductivity and Li+ transference. The ligand also homogenizes Li+ flux at the lithium metal interface and facilitates the formation of a dense LiF/Li3N-rich solid-electrolyte interphase, which suppresses side reactions and dendrite growth. As a result, Li||Li symmetric cells using the modified electrolyte cycled stably for over 800 h with low polarization. Li||NCM811 solid-state cells delivered excellent rate capability and long-term cycling, retaining 84.2% capacity over 2500 cycles at 10 C. Even under a high cutoff voltage of 4.5 V, the cells maintained 72.5% capacity after 780 cycles at 5 C. This work demonstrates that supramolecular ligand regulation is an effective approach to coupling fast ion transport with stable interfacial chemistry in PVDF-based solid-state lithium batteries.

129

Temperature Dependence of Saddle-Shaped Dielectric Relaxation in High-Entropy Layered Double Hydroxides

Tosapol Maluangnont
KMITL, Bangkok, Thailand

Tosapol Maluangnont

Abstract

High-entropy layered double hydroxides (HE-LDHs) exhibit conductivity-assisted dielectric relaxation arising from the migration of hydroxide ions and hydrated species. However, the influence of temperature on this process remains poorly understood. Here, temperature-dependent impedance spectroscopy was employed to investigate the evolution of an unusual saddle-shaped dielectric relaxation from 20 Hz to 1 MHz. This response evolves systematically with temperature and is it reasonably followed the Ryabov-Gutina-Arkhipov-Feldman (RGAF) formalism. These findings provide new insight into ionic transport in HE-LDHs and establish a framework for understanding dielectric relaxation in hydroxide-ion conducting layered materials.

130

Oxygen-Rich Crosslinker Modulated Weakly-Solvating Gel Polymer Electrolyte for Stable High-Voltage Lithium Metal Batteries

Zhiyuan Zhu

Abstract

The practical application of lithium metal batteries (LMBs) paired with high-voltage Ni-rich cathodes is severely hindered by uncontrolled Li dendrite growth, unstable electrode/electrolyte interfaces, and limited ionic conductivity of gel polymer electrolytes (GPEs). Herein, we report a novel in-situ polymerized weakly-solvating gel polymer electrolyte (WS-GPE) incorporating an oxygen-rich crosslinker, ethoxylated trimethylolpropane triacrylate (ETPTA), to address these challenges simultaneously. Unlike conventional crosslinkers that serve solely as mechanical scaffolds, ETPTA exhibits a dual functionality: (i) its abundant C-O-C segments act as additional Li^+-hopping sites, compensating the reduced ionic conductivity inherent to weakly-solvating environments; and (ii) it modulates the Li^+ solvation sheath by promoting anion-rich coordination (CIP/AGG formation), which lowers the Li^+ desolvation energy barrier and facilitates the formation of a LiF-rich, thin, and uniform inorganic solid electrolyte interphase (SEI). Comprehensive characterizations including Raman spectroscopy, $^{19}F/^{7}Li$ NMR, XPS, and TOF-SIMS confirm the anion-derived SEI chemistry and the homogeneous Li deposition morphology enabled by this design. As a result, the optimized WS-GPE delivers exceptional rate performance (93.7% capacity retention from 0.5C to 2C) and stable long-term cycling in Li||NCM811 cells, maintaining a reversible capacity of 220 mAh g^{-1} at 1C under a high cutoff voltage of 4.5 V with significantly improved capacity retention. This work provides a new paradigm for designing high-performance gel electrolytes by harnessing the synergistic effect of weak solvation and oxygen-rich polymer networks for next-generation high-energy-density LMBs.

131

Sieving is believing: what is right carbon for sodium batteries?

Quan-Hong Yang
Tianjin Key Laboratory of Advanced Carbon and Electrochemical Energy Storage, School of Chemical Engineering and Technology, Tianjin University, Tianjin, China

Quan-Hong Yang

Abstract

Lithium-sulfur batteries are widely regarded as a promising technological route for overcoming the energy-density limitations of rechargeable batteries. However, their practical application is severely hindered by the high solubility of lithium polysulfides, the key cathode intermediates, in the electrolyte and their sluggish conversion kinetics. The resulting accumulation of polysulfides during cycling gives rise to the well-known shuttle effect, leading to increased cell polarization and rapid capacity fading. This report focuses on the electrochemical conversion behavior of sulfur species in both liquid and solid-state systems, and systematically discusses the catalytic mechanisms and the corresponding material design strategies for promoting sulfur conversion. In liquid-state lithium-sulfur systems, particular attention is given to catalytic approaches that accelerate the conversion of dissolved lithium polysulfides and shorten their residence time in the electrolyte, thereby effectively suppressing the shuttle effect. For all-solid-state lithium-sulfur systems, the kinetic bottlenecks of solid-phase sulfur conversion and the associated interfacial failure modes are discussed, together with strategies for constructing solid-phase catalytic interfaces. Representative examples from our group on catalyst design are presented to highlight the important role of catalytic strategies in advancing the practical application of both liquid and solid-state lithium-sulfur batteries.

132

Activating Interfacial Ion Exchange in Composite Electrolytes for High-Rate and Long-Cycling Solid-State Lithium Batteries

Zhenhan Xie
Tsinghua Shenzhen International Graduate School, Shenzhen, China

Abstract

Composite solid electrolytes (CSEs) are promising for solid-state lithium metal batteries, yet inefficient cross-phase Li^+ transport commonly limits rate capability and cycling durability. Here, we reveal that in poly(vinylidene fluoride) (PVDF)-based CSEs containing $Li_{6.4}La_3Zr_{1.4}Ta_{0.6}O_{12}$ filler, the de-coordination barrier of Li^+ clusters governs interfacial Li^+ exchange and thus controls the formation of fast percolation pathways. To overcome this bottleneck, N-methyl-2,2,2-trifluoroacetamide (NMTFA) was introduced as a weakly coordinated ligand to lower the Li^+ de-coordination energy and activate interfacial ion exchange. The optimized electrolyte delivers an ionic conductivity of 7.30×10^{-4} S cm^{-1} and increases the interfacial Li^+ transport contribution from 11% to 26%, as quantified by $^6Li/^7Li$ solid-state NMR. The NMTFA-regulated solvation structure also promotes inorganic-rich interphases on both Li metal and NCM811 electrodes. Consequently, Li||NCM811 solid-state batteries exhibit long cycling lifetimes of 2400, 3000, and 10,000 cycles at 2, 5, and 10C, respectively, and stable operation at 50 °C and −30 °C. This work highlights interfacial Li^+ exchange as a key design principle for high-rate, long-life composite solid electrolytes.

133

Fast Deposition Kinetics Enabled by Na15Sn4/NaBr Interphase Engineering for Superior Sodium Metal Batteries at Room and Low Temperatures

Hui Dou, Jia Guo
Nanjing University of Aeronautics and Astronautics, Nanjing, China

Abstract

Sodium metal batteries (SMBs) are promising for high-energy storage but hindered by unstable solid electrolyte interphase (SEI) and sluggish Na^+ kinetics, especially at low temperatures. Herein, an in situ integrated multifunctional interface ($Na_{15}Sn_4$/NaBr@Na) is constructed to promote Na^+ desolvation and regulate sodium deposition. The sodiophilic $Na_{15}Sn_4$ alloy lowers the desolvation energy barrier and provides abundant nucleation sites, while NaBr accelerates Na^+ transport and suppresses electron tunneling. Their synergistic effect enables uniform sodium deposition, suppresses dendrite growth, and stabilizes the interface under both room- and low-temperature conditions. Consequently, symmetric cells exhibit ultralong cycling for 2100 h at 25 ℃ and 2165 h at −20 ℃. Full cells paired with $Na_3V_2(PO_4)_3$ achieve 8000 cycles at 5 C and 1600 cycles at −20 ℃. This simple and effective interface engineering strategy offers new insights into the development of practical sodium metal batteries.

134

Emerging Covalent Organic Framework Photocatalysts with Molecular Precision for Sustainable Hydrogen Generation

Jia Guo
Fudan University, Shanghai, China

Abstract

Photocatalytic hydrogen evolution (PHE) is a sustainable and eco-friendly pathway for solar energy conversion to alleviate the permanent challenges of the energy crisis. Utilizing covalent organic frameworks (COFs) as photocatalysts is promising for PHE, as they offer a designable crystalline platform, enabling the periodic arrangement of donor-acceptor or the spatial isolation of single-atom metal sites for enhanced photophysical properties. In addition to molecular engineering, the hierarchical structures of 2D COFs, including layered stacking, microcrystal assembly, and surface morphology, also play a pivotal role in the photocatalytic process. In recent work, we have pursued a distinct strategy that exploits the chiral nature of 2D COFs to enhance PHE activity. We developed the chirality-induced approach to constructing conformationally chiral two-dimensional COFs using achiral building blocks and investigated the structure-to-activity relationship in PHE applications. Our findings represent the potential of 2D chiral COFs in terms of photocatalysis, which not only provides interesting insights for optimizing PHE but also offers great promise for exploring optoelectrical applications of chiral materials.

135

An Aqueous Proton Battery under Alkaline Electrolyte

Xiaogang Zhang, Hang Ren, Shengyang Dong
Nanjing University of Aeronautics and Astronautics, Nanjing, China

Abstract

Aqueous proton batteries (APBs) have attracted much attention owing to their fast kinetics, low cost and sustainability. However, the employment of strong acidic electrolytes in most commonly reported APBs will inevitably lead to severe hydrogen evolution reaction and corrosion issues. Here, a small molecule organic compound, azobenzene (AB) containing an azo group (N=N), is explored as an anode material for APBs under alkaline electrolytes with a low redox potential of around −0.6 V (vs. Hg/HgO). The AB anode achieves high-rate capacity of 151 mAh g^{-1} at a high current density of 10 A g^{-1} and excellent cycling stability over 12,500 cycles. The experimental results and theoretical calculations confirm that AB undergoes a two-electron redox reaction involving a central N=N group interacting with two protons from H_2O molecules. The key revelation that the protonation occurs in azo-materials with electroneutral H_2O molecules under slightly acidic aqueous environments allowed the expansion of new insights into proton storage, such as interfacial properties, pH dependence, electrolyte tuning, and molecular structure design, for the development and engineering of high-performance small organic molecules exhibiting multi-electron redox behavior for advanced electrochemical energy storage devices.

136

Iodide Ionics: Effect of iodide ion conductivity in efficiency enhancement in dye sensitized solar cells

M.A.K.Lakshman Dissanayake[1], G.K.R. Senadeera[2], T.M.W.J. Bandara[3], J.M.K.W. Kumari[1]
[1]National Institute of Fundamental Studies, Kandy, Sri Lanka. [2]Open University of Sri Lanka, Colombo, Sri Lanka.
[3]University of Peradeniya, Peradeniya, Sri Lanka

M.A.K.Lakshman Dissanayake

Abstract

Recent research on quasi-solid-state dye-sensitized solar cells (DSSCs) shows that the ionic conductivity of the iodide/triiodide redox electrolyte strongly influences photo-current generation and photovoltaic efficiency, making electrolyte engineering essential for improving DSSC performance. Iodide ion conductivity depends not only on the polymer host but also on the accompanying cation. Cation–polymer interactions determine salt dissociation, ion mobility, and iodide/triiodide charge transport. These studies demonstrate that optimizing iodide conductivity requires balancing bulk ion transport with favorable interfacial charge-transfer processes rather than simply maximizing electrolyte conductivity.

A major research finding is the identification and systematic investigation of the “mixed cation effect”. Polymer gel electrolytes containing binary mixtures of two iodide salts have consistently exhibited superior photovoltaic performance compared with single-cation electrolytes. This effect was observed in several polymer electrolyte systems, indicating that the mixed cation effect is a general characteristic of iodide-based quasi-solid-state electrolytes.

Several host polymers, including polyacrylonitrile (PAN), polymethylmethacrylate (PMMA), poly(vinylidene fluoride) (PVdF), and polyethylene oxide (PEO), have been investigated. DSSCs employing binary iodide mixtures of an alkali metal iodide (small cation) and a quaternary ammonium iodide such as tetrapropylammonium iodide (Pr_4NI) (large cation) exhibited efficiency enhancements exceeding 25% owing to the mixed cation effect.

Mixed-cation iodide electrolytes synergistically combine the advantages of small and bulky cations: small cations adsorb on TiO_2, shifting the conduction band and enhancing electron injection (higher J_{sc}), while bulky cations improve iodide dissociation, ionic conductivity, suppress charge recombination, and prolong electron lifetime, collectively increasing V_{oc}, fill factor, and overall efficiency.

137

Functional Solid Electrolytes Design for High-Performance All-Solid-State Lithium Batteries

Chuang Yu[1], Ziyu Lu[2], Miao Deng[2], Lin Li[2], Wenqian Tian[2]
[1]Xidian Univerisity, Xidian, China. [2]Huazhong University of Science and Technology, Wuhan, China

Abstract

- The rapid growth of transportation electrification and distributed energy storage makes conventional liquid-electrolyte lithium-ion batteries inadequate for high safety, energy density, cost-effectiveness, and long cycle life. Liquid electrolytes pose leakage, corrosion, and fire hazards, which are aggravated by high-energy-density requirements, rendering intrinsic safety improvement critical. All-solid-state batteries using non-flammable solid electrolytes offer superior safety, energy/power density, longevity, low cost, environmental adaptability, and recyclability, emerging as the ultimate solution. Among them, argyrodite Li_6PS_5X (X = Cl, Br) shows high room-temperature ionic conductivity (10^{-3}–10^{-2} S cm^{-1}) and great industrial potential. However, practical sulfide-based ASSBs still face challenges including chemical/electrochemical instability, poor compatibility with electrodes and Li metal, thermal stability, and cost. In this work, we first employ anion modulation to enhance ionic conductivity. Then, guided by the short-board principle, we adopt multiple synergistic strategies to comprehensively improve electrolyte overall performance, albeit at the partial expense of ionic conductivity, thereby accelerating their practical application in ASSBs.

138

A Laser-Induced Graphene-Based Potentiometric Aptasensor for *Escherichia coli* Detection: Comparative Performance of Cationic and Anionic Marker Ions

Chalinee Auanphui[1], Pattarachaya Preechakasedkit[2], Nanthika Khongchareonporn[3], Nipapan Ruecha[2,4]
[1]Graduate Program in Nanoscience and Technology College of Interdisciplinary and Integrative Studies, Chulalongkorn University, Bangkok, Thailand. [2]Metallurgy and Materials Science Research Institute, Chulalongkorn University, Bangkok, Thailand. [3]Institute of Biotechnology and Genetic Engineering, Chulalongkorn University, Bangkok, Thailand. [4]Center of Excellence for Food and Water Risk Analysis (FAWRA), Department of Veterinary Public Health, Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand

Abstract

Foodborne illnesses caused by pathogenic microorganisms remain a major global public health concern, with *Escherichia coli* (*E. coli*) being one of the most common contaminants in food and water. Therefore, rapid, sensitive, and reliable detection methods are essential for food safety monitoring. In this study, a label-free laser-induced graphene (LIG)-based potentiometric ion-flux aptasensor was developed for the selective detection of *E. coli* and the performance of cationic and anionic marker-ion systems was compared. The LIG electrode was fabricated by CO_2 laser engraving of polyimide tape and modified with marker ions, a five-layer carboxylated poly(vinyl chloride) (PVC-COOH) membrane, and an *E. coli*-specific aptamer. Tetrabutylammonium chloride (TBACl) and sodium tetraphenylborate (NaTPB) were employed as cationic and anionic marker ions, respectively. The aptasensor detected *E. coli* over a range of 1–10^4 CFU mL^{-1}, with a detection limit of 1 CFU mL^{-1} and a response time of less than 10 min. The TBACl-based sensor showed higher sensitivity (11.883 mV $decade^{-1}$, R^2 = 0.9808) and better interface stability than the NaTPB-based sensor (11.079 mV $decade^{-1}$, R^2 = 0.9482). The proposed aptasensor also exhibited good reproducibility, excellent selectivity, and satisfactory recoveries of 85–107% in drinking water samples, with results comparable to the APHA 9221:2017 standard method. These results demonstrate the potential of the proposed LIG-based potentiometric aptasensor as a rapid, portable, low-cost, and highly sensitive platform for on-site *E. coli* detection.

139

Iron-Based Polyanionic Solid-Solution Phases for Sodium-Ion Batteries

Xiangjun Pu
Wuhan University, Wuhan, China

Xiangjun Pu

Abstract

Anions generally constitute the structural framework of crystalline solids, making their extensive substitution, particularly for the formation of anionic solid solutions in polyanionic compounds, highly challenging. Herein, we propose that a new series of Fe-based polyanionic intercalation compounds, $Fe_2[(MoO_4)_{1-x}(SO_4)_x]_3$ ($0 \le x \le 1$), for potential low-temperature and high-power sodium-ion batteries. In this series, two new anionic-type solid-solution regions are identified: monoclinic phase ($0 \le x \le 0.3$) and rhombohedral phase ($0.8 \le x \le 1$). The optimized monoclinic phase (FMSO) delivers superior Na storage capability (1.99 Na^+ per formula) compared with the end-members (1.77 Na^+ for $Fe_2(MoO_4)_3$ and 0.46 Na^+ for $Fe_2(SO_4)_3$), while maintaining outstanding power capability even at low temperature (-40 °C). Structural evolution, electrochemical properties, and reaction mechanisms have been comparatively elucidated for this series of solid solutions. Furthermore, the concept is extended to rhombohedral $Fe_2[(WO_4)_\xi(SO_4)_{1-\xi}]_3$ ($0 \le \xi \le 0.2$) phases, suggesting a general rule for anionic solid-solution formation. These results broaden the chemical diversity of Fe-based redox, which typically needs to be framed in polyanionic crystalline for high-voltage operations, and open new directions for designing high-power and cost-effective cathodes for sodium-ion batteries.

140

Ion Mobility in Polymer-Based Solid-State Batteries

Feng LI
Institute of Metal Research, Chinese Academy of Sciences, shenyang, China

Abstract

Abstract: Polymer-based solid-state batteries feature high lithium utilization efficiency, which is also intimately associated with lithium ion mobility and reversibility. In a battery system where the total lithium content remains constant, a comprehensive design of the polymer electrolyte is required to improve reaction kinetics and reversibility. In this presentation, we will begin by introducing lithium utilization efficiency, analyzes non-cyclable and irreversible lithium, and optimizes the ionic coordination environment. By constructing fast interfaces, lithium ion mobility is enhanced, with the aim of controlling lithium ion transport and exploring the applications of polymer-based batteries. Finally, the presentation outlines perspectives on polymers across different length scales, as well as future development paradigms and directions.

141

Interface Engineering and Wetting Behavior Study of Solid-State Lithium Metal Batteries

Jiayun Wen
University of Shanghai for Science and Technology, Shanghai, China

Jiayun Wen

Abstract

Solid-state lithium-metal batteries, combining high safety and high energy density, are considered one of the most promising next-generation energy storage devices. The stability of the interface between the solid electrolyte and the lithium metal anode is crucial for achieving high-performance solid-state lithium-metal batteries. Focusing on lithium lanthanum zirconium tantalum oxide (LLZTO) solid electrolytes, this study addresses issues such as insufficient contact between LLZTO and lithium metal by designing the composition of lithium metal to regulate the viscosity of the lithium-based anode, thereby improving interfacial wettability with LLZTO. Additionally, through careful selection of additives, an interfacial layer is introduced at the lithium composite anode/LLZTO interface to protect lithium metal or suppress lithium dendrite growth. Building upon this, a layered design approach systematically resolves challenges at the LLZTO/current collector interface, constructing a composite interfacial protective layer that maintains interface stability, enables uniform lithium deposition, and ensures even lithium-ion flux, thereby enabling stable, efficient, and high-performance anode-free solid-state batteries. By optimizing the structure of each component and investigating their effects on electrochemical performance, this work provides valuable guidance toward developing solid-state batteries with high energy density and long cycle life.

142

Fluorine-Free, Ceramic and Organic Binders for High-Performance Electrochemical Double-Layer Supercapacitors

Thennakoon Mudiyanselage Wijendra Bandara
University of Peradeniya, Peradeniya, Sri Lanka

Abstract

Conventional fluorinated binders, such as polyvinylidene fluoride and polytetrafluoroethylene, provide excellent thermal and chemical stability for supercapacitor electrodes. However, they are non-biodegradable and require toxic organic solvents. Non-fluorine binders, including titanium dioxide (TiO_2) and D-glucose, etc., are investigated to enhance performance utilize greener fabrication of supercapacitors. To make supercapacitor electrodes, Mahogany wood-derived AC with a PVDF binder was tested using titanium and nickel current collectors. Specific capacitance was evaluated via cyclic voltammetry (CV), while energy and power densities were determined through galvanostatic charge-discharge (GCD) using 1 M Na_2SO_4 electrolyte. Optimal performance occurred at 2 mV s^{-1}, yielding specific capacitances of 116.14 Fg^{-1} (Ti) and 172 Fg^{-1} (Ni). Maximum energy densities were 27.31 Wh kg^{-1} (Ti) and 62.54 Wh kg^{-1} (Ni) at 0.5 mA cm^{-2}, at power densities of 1971.21 W kg^{-1} (Ti) and 4916.13 W $kg^{-}1$ (Ni).

TiO_2-based binders were investigated for supercapacitor electrodes with graphene oxide (GO) and reduced graphene oxide (rGO) using HNO_3 or DMF solvents. The rGO–DMF system achieved the highest specific capacitance (146 F g^{-1} at 2 mV s^{-1}), while GO–DMF and rGO–DMF delivered the highest energy density (21.58 Wh kg^{-1}) and power density (81.55 W kg^{-1}), respectively. TiO_2 binders were also evaluated with AC from jack wood and coconut shells, yielding specific capacitances of 147 and 223 F g^{-1}, respectively, with the latter also exhibiting high power density. Furthermore, a D-glucose binder with mahogany wood-derived AC achieved the highest specific capacitance (298.46 F g^{-1}) and excellent energy and power performance.

143

Molecular Dynamics Investigation of PEO-Modified Sodium-Ion Liquid Electrolytes

Ali Hassan, Manaswee Suttipong
Chulalongkorn University, Bangkok, Thailand

Ali Hassan

Abstract

Understanding ion solvation and transport is essential for the rational design of high-performance sodium-ion battery electrolytes. In this study, all-atom molecular dynamics (MD) simulations were performed to investigate the influence of poly(ethylene oxide) (PEO) as a coordinating additive in $NaClO_4$-based carbonate electrolytes consisting of propylene carbonate (PC) and diethyl carbonate (DEC). Unlike conventional polymer electrolytes, where PEO serves as the polymer host, this work examines its effect in a hybrid liquid-polymer electrolyte. The MD simulations reveal that PEO significantly modifies the Na^+ solvation environment by replacing solvent molecules in the primary solvation shell through coordination with its ether oxygen atoms. This structural reorganization weakens Na^+-ClO_4^- interactions, suppresses ion pairing, and increases ion dissociation. However, stronger Na^+-PEO coordination also restricts cation mobility, resulting in lower Na^+ diffusivity despite the greater population of dissociated ions. Consequently, the ionic conductivity decreases systematically with increasing PEO concentration, from 1.21 mS cm^{-1} in the PEO-free electrolyte to 0.35 mS cm^{-1} at 20 wt% PEO. These results demonstrate that PEO governs electrolyte performance through the competing effects of enhanced ion dissociation and reduced cation mobility. The molecular-level insights obtained in this study provide useful design principles for optimizing hybrid liquid-polymer electrolytes for next-generation sodium-ion batteries.

144

PREPARATION OF MANGANESE DIOXIDE/GRAPHITIC CARBON NITRIDE PHOTOCATALYST COMPOSITES FOR DYE DEGRADATION UNDER VISIBLE LIGHT IRRADIATION

Chonnamas Piadsoongnern, Rojana Pornprasertsuk, Wuttichai Reainthippayasakul
chulalongkorn university, bangkok, Thailand

Chonnamas Piadsoongnern

Rojana Pornprasertsuk

Wuttichai Reainthippayasakul

Abstract

The discharge of dye-contaminated wastewater from textile industries and manufacturing plants into natural water bodies has severely escalated water and environmental pollution, presenting a critical global crisis. This study presents the synthesis of a high-performance multifunctional manganese dioxide/graphitic carbon nitride (MnO_2/g-C_3N_4) composite as a photocatalyst for the efficient degradation of dye pollutants under visible-light irradiation. The fabrication process initially involved the preparation of g-C_3N_4 via a pyrolysis method using urea as a precursor, while MnO_2 nanoparticles were synthesized through a hydrothermal process. Subsequently, the MnO_2/g-C_3N_4 composites were formed by blending MnO_2 and g-C_3N_4 at specific MnO_2 mass ratios of 1.00, 3.00, and 5.00 wt%. The as-prepared composites were systematically characterized using X-ray diffraction (XRD) to elucidate their crystalline structure and phase composition, scanning electron microscopy (SEM) to examine surface morphology and the dispersion of MnO_2 nanoparticles on the g-C_3N_4 matrix, and Brunauer–Emmett–Teller (BET) analysis to determine specific surface area and porosity characteristics. The resulting composites were then evaluated for their degradation efficiency against the contaminant Rhodamine B (RhB) to determine the optimal ratio that yields the highest photocatalytic performance.

145

Formation of NiMo nano-alloys via ALD to accelerate electron transport and achieve sustainable solar hydrogen production in silicon photocathodes.

Selvaraj Seenivasan[1], Do-Heyoung Kim[2]
[1]Indian Institute of Technology Goa, Goa, India. [2]Chonnam National University, Gwangju, Korea, Republic of

Abstract

Silicon (Si) photocathodes are promising candidates for green hydrogen production using solar energy, thanks to their favorable light absorption and suitable band energetics; however, the slow kinetics of the hydrogen evolution reaction (HER) and inefficient electron transport at the interface remain fundamental challenges. In this work, we demonstrate an atomic-layer engineering strategy for forming a NiMo nano-alloy surface catalyst on an n^+-p-Si photocathode. A 10 nm Ni electron-transport layer was deposited, followed by a single atomic layer deposition (ALD) cycle of MoO_x as a co-catalyst. The resulting Ni/MoO_x interface introduced an additional barrier to electron transport. Subsequent thermal treatment in a hydrogen atmosphere promoted the reduction of MoO_x and the formation of a NiMo nano-alloy surface, leading to improved interfacial electron transport and hydrogen evolution reaction (HER) kinetics. Under sunlight, the optimized and modified NiMo photocathode exhibited a photocurrent density of 27.5 mA cm^{-2} at 0.0 V vs. the reversible hydrogen electrode (RHE) and maintained stable operation for 100 hours. Electrochemical impedance spectroscopy revealed potential-dependent interfacial charge-transfer behavior and demonstrated that the formation of the NiMo nano-alloy facilitates electron transport from the Si photocathode to the catalytically active surface. These results highlight the effectiveness of single-cycle atomic layer deposition (ALD) as a precise precursor engineering strategy to transform an initially resistive Ni/MoO_x interface into an efficient, alloy-mediated interface for electron transfer and catalysis. This work offers a material-efficient approach to incorporating extremely low Mo loadings into Si photocathodes, aiming to achieve sustainable and efficient solar-driven hydrogen production.

146

Predicting the lifetime of lithium-ion and next generation batteries via physics based modelling

Gregory Offer, Monica Marinescu, Mohammed Asheruddin Nazeeruddin, Jingwen Weng
Imperial College London, London, United Kingdom

Gregory Offer

Abstract

Predicting the lifetime of lithium-ion batteries is a challenging problem to solve. Degradation is complex and path dependent involving multiple mechanisms which interact with each other. Typically, it is not possible to isolate a single degradation mechanism and study it experimentally in commercial cells, therefore models that only include a limited number of degradation mechanisms have a significant risk of over-fitting. Greg will present the latest work from the Electrochemical Science and Engineering Group at Imperial and also partners in the Faraday Institution Multi-Scale Modelling project, who have been working to solve this problem. Predominantly done in PyBaMM, an open-source battery modelling framework, progress on modelling and coupling multiple degradation mechanisms will be presented. The models are already versatile enough to explore the latest developments in battery chemistry, such as lithium iron oxide for lithium iron phosphate, explaining how releasing extra lithium during cycling can either mitigate or accelerate degradation depending on cell design and operating strategies. The models can also be used to optimise cell design for end-of-life, i.e. lifetime, not just beginning-of-life performance, expanding on the idea of finite reservoirs, such as lithium inventory and active material, to include porosity, electrolyte volume, and others. The challenges and progress in developing modelling frameworks for lithium-sulfur and lithium-metal, both anode-free, liquid and solid electrolyte configurations will also be discussed.

Additional co-authors will be acknowledged where their work is included in the presentation.

147

Advanced Scanning Probe Microscopy for Ferroelectric and Multiferroic Materials

JONGIN HONG
Chung-Ang University, Seoul, Korea, Republic of. Chulalongkorn University, Bangkok, Thailand

JONGIN HONG

Abstract

Advanced scanning probe microscopy (SPM) has become an indispensable platform for probing and engineering electric dipoles at the nanoscale. In ferroelectric and multiferroic materials, recent advances have moved beyond conventional domain imaging toward quantitative, artifact-aware measurements that resolve local polarization switching, domain-wall conduction, and magnetoelectric coupling. In this talk, I will provide an overview of these developments and highlight emerging directions in the field. First, I will discuss how rigorous signal interpretation is essential for reliable piezoresponse force microscopy (PFM), focusing on decoupling intrinsic electromechanical responses from electrostatic and topographical artifacts. Second, I will introduce multimodal SPM approaches that correlate piezoresponse, local conductance, electrochemical strain, surface potential, and magnetic force measurements on the same region. This integration enables direct visualization of magnetoelectric coupling and the disentanglement of intrinsic ferroelectric responses from ionic and electrochemical contributions. Third, I will address how big-data and machine-learning-driven analysis of hyperspectral SPM datasets, together with autonomous experimentation, is transforming SPM from an imaging tool into a discovery platform. Together, these advances demonstrate that advanced SPM enables us not only to observe but also to design ferroelectric and multiferroic functionalities for next-generation neuromorphic electronics, nanoelectronics and iontronics.

148

Molecular Dynamics Insights into Anion-Dependent Solvation and Ion Transport in DME-Based Sodium-Ion Battery Electrolytes

Kittiyaporn Siaosuk, Asst. Prof. Dr. Manaswee Suttipong
Department of Chemical Technology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Abstract

The choice of salt anion strongly influences the solvation structure and transport properties of sodium-ion battery electrolytes. In this study, all-atom molecular dynamics (MD) simulations were performed to investigate five 1 M sodium salt electrolytes ($NaBF_4$, $NaPF_6$, NaOTf, NaFSI, and NaTFSI) in 1,2-dimethoxyethane (DME). Solvation structure and transport properties were characterized using radial distribution function, coordination number, diffusion coefficient, ionic conductivity, sodium-ion transference numbers, and ion-pair speciation. The results reveal that the salt anion regulates the balance between solvent coordination and cation-anion association, giving rise to distinct Na^+ solvation environments. Although DME remains the primary coordinating solvent in all electrolytes, stronger Na^+-anion interactions promote contact ion-pair formation, whereas weaker interactions favor solvent-separated ion pairs. Among the systems studied, $NaPF_6$/DME exhibits the highest proportion of solvent-separated ion pairs, while NaOTf/DME shows the strongest tendency toward contact ion-pair formation. These structural differences are reflected in the transport properties: $NaBF_4$/DME exhibits the highest Na^+ diffusivity and ionic conductivity, whereas NaOTf/DME achieves the highest sodium-ion transference number despite its lower ionic conductivity. Overall, NaFSI/DME provides the best balance between favorable solvation structure and ion transport, highlighting its potential as a promising electrolyte for sodium-ion batteries.

149

Physics-Based Modelling of LFP Cell and Pack Performance under Thai Climatic and Driving Conditions

Mohammed Asheruddin Nazeeruddin, Jingwen Weng, Monica Marinescu, Gregory Offer
Imperial College London, London, United Kingdom

Mohammed Asheruddin Nazeeruddin

Abstract

Lithium iron phosphate (LFP) batteries are increasingly attractive for electric vehicles because of their safety, cost and cycle-life advantages. However, their performance and degradation under the high ambient temperatures and demanding operating conditions prevalent in Thailand must be understood at both cell and pack levels. This work develops a physics-based modelling framework in PyBaMM for a 15 Ah Gotion LFP–graphite cells.

The cells are characterised at temperatures from 10 to 45 °C, C-rates from C/40 to 1C, and across different state-of-charge windows. Ageing experiments are conducted at 25 and 45 °C using both standard cycling profiles and Thai-representative driving cycles, with periodic C/20 reference performance tests used to quantify changes in capacity and voltage response.

A central contribution is the representation of voltage hysteresis in LFP electrodes. Unlike the relatively small or approximately state-defined hysteresis of many intercalation chemistries, LFP hysteresis arises from phase transformation and depends strongly on the cell's preceding operating history. Consequently, a single-valued open-circuit-potential relationship cannot adequately reproduce its dynamic voltage response. A history-dependent hysteresis formulation is therefore incorporated into a PyBaMM-based electrochemical model and coupled with thermal and degradation submodels to investigate alternative end-of-life pathways.

Cell-level simulations are subsequently integrated into a pack-scale thermal simulation wrapper. This multiscale framework enables evaluation of how pack configuration, cooling strategy, ambient temperature and Thai driving conditions influence temperature distributions, performance and ageing. The resulting experimentally informed framework supports the design of durable LFP battery systems and effective thermal-management strategies for electric vehicles operating in hot climates.

150

Battery thermal safety and phase-change-materials-based thermal management strategy

Jingwen Weng
Imperial College London, LONDON, United Kingdom

Jingwen Weng

Abstract

The rapid deployment of lithium-ion batteries in electric vehicles and stationary energy-storage systems has increased the demand for effective thermal-safety management, particularly under high-power operation, elevated ambient temperatures and abusive conditions. Excessive heat generation and non-uniform temperature distribution can accelerate electrochemical degradation, promote side reactions and, under extreme conditions, trigger thermal runaway and its propagation within battery modules and packs.

This presentation provides an overview of battery thermal safety, covering heat generation during normal and abnormal operation, the initiation and evolution of thermal runaway, and the mechanisms governing heat transfer and failure propagation between neighbouring cells. Particular attention is given to phase-change-material-based thermal management as a passive and thermally adaptive strategy for controlling transient temperature rise and improving cell-to-cell temperature uniformity. By absorbing heat through latent heat storage, phase-change materials can reduce local hot spots, delay the attainment of critical temperatures and provide additional response time for active safety systems.

The presentation will also discuss the major limitations of conventional phase-change materials, including low thermal conductivity, leakage, flammability and limited heat-release capability after complete melting. Advanced design strategies, such as thermally conductive networks, shape-stabilised composites, flame-retardant modification and hybrid passive–active cooling configurations, will be introduced. Finally, key material and system-level design criteria will be discussed, including phase-transition temperature, latent heat, thermal conductivity, cycling stability, structural integrity and module integration. These strategies provide a promising route towards safer and more temperature-uniform battery systems, particularly for high-rate applications and operation in hot climates.

151

ALD Enabled Interface Engineering of WO_3/MXene/FeOOH Photoanodes for Efficient Photoelectrochemical Water Oxidation

Manasi Murmu, Bhavna Sunil Hedau, Do-Heyoung Kim
School of Chemical Engineering, Chonnam National University, 77 Yongbong-ro, Buk-gu, Gwangju, Korea, Republic of

Manasi Murmu

Bhavna Sunil Hedau

Do-Heyoung Kim

Abstract

The development of efficient and stable photoanodes for Photoelectrochemical (PEC) water splitting is crucial for sustainable hydrogen production. WO_3 has attracted considerable attention owing to its favorable valence band position, low cost and chemical stability. However, its practical application is hindered by sluggish charge-transfer kinetics and rapid recombination of photogenerated charge carriers. To address these limitations, a WO_3/MXene/FeOOH heterostructured photoanode was fabricated through hydrothermal synthesis, drop casting and chemical bath deposition, followed by atomic layer deposition (ALD) based interface engineering. MXene, a two-dimensional transition metal carbide with high electrical conductivity and large surface area, was incorporated to facilitate charge transport and suppress electron-hole recombination. FeOOH was further introduced as an oxygen evolution recation (OER) co-coatalyst to accelerate surface reaction kinetics and provide additional active sites. The synergistic interaction among WO_3, MXene, and FeOOH promoted efficient charge separation and enhanced interfacial charge transfer, resulting in significantly improved photoelectrochemical performance. Compared with pristine WO_3 (0.69 mA/cm^{-2}) the optimized WO_3/MXene/FeOOH photoanode exhibited an enhancement of approximately 1.13 mA/cm^{-2}, corresponding to a nearly 164% increase in photocurrent response under simulated solar illumination. Electrochemical analyses revealed reduced charge transfer resistance and improved carrier utilization, highlighting the crucial role of MXene in facilitating rapid electron transport across the heterointerface. These findings demonstrate that integrating conductive MXene with catalytic FeOOH, together with ALD enabled interface engineering provides an effective strategy for developing high performance, earth abundant photoanodes for sustainable energy conversion.

152

Ultrafast Flame Synthesized CuRu and NiFe Catalysts for Alkaline and AEM Water Electrolysis

Donggeun Eom, Sangwook Park
Seoul National University, Seoul, Korea, Republic of

Abstract

Anion exchange membrane water electrolysis (AEMWE) is a promising route to carbon neutrality, yet practical applications are hindered by sluggish alkaline hydrogen evolution reaction (HER) kinetics and complex electrode fabrication. To address these challenges, we report an ultrafast, 1-second flat-flame synthesis strategy that directly transforms spray-coated Cu and Ru precursors into a high-performance Ru@aCu cathode (Ru nanoparticles anchored on amorphous Cu domains). Characterization reveals that this method achieves an ultra-low Ru loading of 36.4 um/cm2 while delivering an exceptional overpotential of just 134 mV at 1 A/cm2. Both in situ Raman spectroscopy and density functional theory (DFT) calculations confirm that the amorphous Cu support optimizes the catalytic environment by lowering the water dissociation energy barrier and reducing inactive dangling O–H species. When integrated into an AEMWE full cell with a flame-synthesized NiFe anode, the system demonstrates outstanding efficiency and economic viability, achieving 1.671 V at 1 A/cm2, 320 hours of stable operation, and a low levelized cost of hydrogen (LCOH) of 3.32 $/kgH2. This work establishes ultrafast flame synthesis as a highly energy-efficient and scalable pathway for manufacturing practical, low-precious-metal AEMWE electrodes.

153

Durable High Energy Solid-State Batteries by Compressible Light Solid Electrolytes

Stefan Adams
National University of Singapore, Singapore, Singapore

Stefan Adams

Abstract

High-energy high-power solid-state batteries require anolytes and catholytes that combine fast-ion conductivity with minimal impact on cell mass. Two strategies will be discussed focusing on how to facilitate lasting contact with breathing cathodes [1-3]. In ceramic-in-polymer composite electrolytes surface-active nanoceramics boost ionic conductivity of polymer electrolytes with wide electrochemical windows. Percolating networks of fast-conductive interphases enables conductivities of 1.8 mS/cm at densities close to those of liquid electrolytes. In combination with LFP cathodes they achieve discharge capacities of 165mAh/g, and robust (dis)charging at up to 10C with over 80% capacity retention after 200 cycles.

An alternative all-inorganic approach exploits the relationship between ionic conductivity and glass forming ability, e.g. in glass-ceramic oxyhalides $Li_xNbO_xCl_{5-x}$ [4,5] with conductivities up to 11 mS/cm for $0.9<x<1$. Large-angle rotations of $NbCl_4$ groups around the axis of the $(NbCl_4O_{2/2})_n$ polyanion chains facilitate Li^+ transport. Pressure-dependent measurements revealing exceptionally low activation volumes. In NCM811|LNOC|Argyrodite|Li–In dual electrolyte cells, LNOC facilitates robust performance with cycle-life up to 7,000 cycles. At room temperature, cells maintain >93.9% of their initial capacity over 3,000 cycles at 2C. Nearly the same capacity retention is achieved even under high loading at a current density of 7.6 mA/cm^2.[6]

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154

Nitrogen-doped Carbon Interfaces to Regulate Lithium Transport in Entropy-Stabilized Oxides for Lithium Storage

Daya Rani
INST Mohali, Mohali, India

Abstract

The concept of entropy stabilization in multicomponent oxide systems has attracted increasing attention for advanced electrochemical energy storage applications owing to its ability to enhance structural robustness and electrochemical reversibility. Here, we report on the reversible lithium storage properties of a nitrogen-doped carbon-coated high-entropy oxide (NC@HEO), the underlying mechanisms governing its superior electrochemical behaviour, and the critical role of interfacial engineering in regulating Li^+ transport kinetics. It is found that the synergistic coupling between the entropy-stabilized multicationic oxide framework and the conductive N-doped carbon shell significantly improves charge-transfer kinetics, structural stability, and long-term cycling durability. When assembled into a full cell, it delivers a high specific capacity of 440.92 mAh g^{-1} at 0.1 A g^{-1} together with an energy density of 122.48 Wh kg^{-1} without compromising power density of 835 W kg^{-1} and stable up to 35k cycles. Additionally, atomistic simulations reveal that nitrogen doping lowers the Li migration barrier and promotes rapid ion redistribution across the interface along with a localized strained-induced HEO matrix, thereby enhancing fast-charging behaviour. These findings demonstrate that entropy stabilization combined with defect-engineered carbon interfaces provides an effective strategy to tailor the electrochemical properties and kinetics of high-performance hybrid energy storage systems applicable to the next generation hybrid automobile sector.

155

Strength in Unity: Designing of hybrid heterostructure (NiSe2/rGO/PANI) electrode towards high Performance, Flexible, asymmetric supercapacitor device for renewable energy storage

Harini E.M
Institute of Nano Science and Technology, Mohali, India

Abstract

Heterostructure creation has been an effective strategy to synthesise hybrid supercapacitor electrodes by combining materials of various charge storage mechanisms, leveraging the advantages, and minimising the drawbacks of individual materials as separate entities. Herein, a hybrid supercapacitor electrode has been fabricated producing ternary $NiSe_2$/rGO/PANI heterostructure, through simple hydrothermal followed by in-situ polymerisation techniques. Owing to the synergy between the materials, the electrode decorated on a flexible carbonaceous template exhibits a remarkable capacity of 657.36C g^{-1}@1 A g^{-1} offering excellent stability over 12,000 cycles. Subsequently, a hybrid asymmetric supercapacitor (HASC) constructed using $NiSe_2$/rGO/PANI as a positive electrode and AC as a negative electrode possesses a high energy density of 98.82 Wh kg^{-1} at a power density of 750.05 W kg^{-1} with a capacitive retention of 95.04 %. Encasing the complete device with Polydimethylsiloxane (PDMS) mould acting as an energy storage band demonstrates an unaltered device performance at various bending angles of 0° to 135°, which refers to its compatibility in flexible electronics. Further, the practical usefulness of the as-designed prototype has been exhibited by powering several devices such as; Light Emitting Diodes (LEDs) of various colours, homemade windmill, Arduino board, and LCD monitor via charging through a commercial silicon solar panel paving the way to bloom renewable energy conversion and storage.

156

Material-to-Cell Integration for High-Performance Sodium-Ion Batteries

Nagmani Nagmani, Priyanka Pal, Pradeep Kumar Bagri, Shreya Umrao, Kumar Brajesh, Gurpreet Singh, Raju Kumar Gupta
Indian Institute of Technology Kanpur, Kanpur, India

Raju Kumar Gupta

Abstract

Sodium-ion batteries (SIBs) are promising alternatives to lithium-ion batteries for large-scale energy storage owing to the abundance, low cost, safety, and sustainability of sodium resources. However, their practical deployment requires the development of high-performance anode and cathode materials with improved capacity, cycling stability, and rate capability. Herein, we report an integrated electrode engineering strategy comprising biomass-derived hard carbon anode and doped layered oxide cathode for high-performance SIBs. The anode material was synthesized from sugarcane bagasse *via* an in-situ amino-aldehyde condensation approach followed by controlled carbonization. This process generated a nitrogen-rich hard carbon framework with abundant closed pores, facilitating enhanced sodium storage and stable solid electrolyte interphase formation. The optimized hard carbon delivered a reversible specific capacity exceeding 372 mAh g^{-1} at 0.1C with excellent cycling stability. For the cathode, O3-type $NaMn_{0.5}Ni_{0.5}O_2$ (NMNO) was optimized through metal doping. The doped NMNO retained the hexagonal O3 layered structure while exhibiting improved crystallographic ordering and favourable micro/nanostructural features for Na^+ transport resulting in excellent capacity retention. Further, a full sodium-ion pouch cell was fabricated using the optimized hard carbon anode and doped NMNO cathode. In-house development of both cathode and anode materials highlights a scalable and sustainable pathway toward high-energy, long-life sodium-ion batteries for large-scale energy storage applications.

157

Tera-watt and Giga-ton Challenges for Solid State Ionic Devices

Turgut Gür
Stanford University, Stanford, United States. Chulalongkorn University, Bangkok, Thailand

Turgut Gür

Abstract

Realizing rapid transition to a sustainable energy future pose serious challenges and difficult choices in meeting > 40% growth in electricity demand from the current 30,000 TWh to > 42,000 TWh by 2050, while cutting CO_2 emissions by nearly 50% in the same period. The core problem is world's heavy reliance on fossil fuels that continue to provide > 80% of the global energy and > 57% of world's electricity generation. Fossil fuels also emit > 38 Gt of CO_2 annually, which presents an imminent and existential threat to our carbon constrained world. The solution lies in transforming the global energy economy primarily to renewable sources which are essential for rapid decarbonization. However, this presents major challenges also because intermittent renewables such as solar, wind, geo and marine are intermittent sources with variable outputs, not suitable for grid integration and require building massive storage capacities. Solid state ionic devices and systems such as batteries and fuel cells are key to achieving clean, distributed and efficient electric power storage and generation with minimum emissions. Understanding and engineering of point defects in electrochemically functional materials has led to important advances in sustainable energy conversion and storage systems such rechargeable batteries, solid oxide fuel cells and electrolyzers.

In this talk, I will frame the global energy and electricity landscape in the context of CO_2 emissions, highlight the immense magnitudes of global challenges for sustainable solutions, and discuss technological opportunities for solid state ionic systems for clean and efficient electrochemical power storage and conversion.

158

Interfacial Engineering of Lithium Metal Anodes for Next-Generation High-Energy-Density Batteries

Qidi Zhang, Kai Zhu
Harbin Engineering University, Harbin, China

Qidi Zhang

Abstract

The complex reaction at the electrode-electrolyte interface in Lithium metal batteries (LMBs) leads to difficulties in precisely modulating the electrolyte interphase (SEI) composition. However, the composition and chemical coordination of compounds in the inner Helmholtz layer (IHP) play a crucial role in the evolution of SEI components. Therefore, we engineer an interface for cation-anion co-enrichment in IHP by fabricating a Lewis amphoteric V_2CT_x-Cu (T_x: -O/-OH/-F) substrate. V_2CT_x-Cu is elaborately designed to coordinate with solutes in the electrolyte via Lewis acid-base interactions (Cu^{2+}-$TFSI^-$ and T_x^--Li^+), and increases the anion concentration in the IHP and guides two-dimensional Li deposition behavior along T_x, which promotes the formation of an elastic LiF-dominated SEI and achieves uniform deposition of Li. Under the synergistic effect of the dual mechanism, dendrite-free Li deposition/ stripping was achieved even at 8 mA cm^{-2} and 24 mAh cm^{-2}, facilitating high capacity retention of LMBs with low N/P ratios. The $LiFePO_4$ based anode-free Li metal batteries with a commercial level aeral capacity (4.1 mAh cm^{-2}) enable stable operation. This work highlights the critical role of interfacial composition and provides valuable insights into the optimization of the IHP through electrode interfacial charge engineering.

159

Liquid Crystal Display-Printed Programmable Nanochannels via Photo-PIMS for Lithium Metal Batteries

JEET SHARMA, Qian Huang, Cyrille Boyer
The University of New South Wales (UNSW), SYDNEY, Australia

Abstract

This work investigates how bottlebrush side-chain architecture affects the ionic conductivity and electrochemical properties of solid polymer electrolytes (SPEs). Using reversible addition fragmentation chain transfer (RAFT)-mediated photo-polymerization-induced microphase separation (photo-PIMS) strategy compatible with 3D printing, POEGMA-x macro-chain transfer agents (x=5,10,20) were chain-extended with hydrophobic monomers. This approach generated bicontinuous ion-conducting nanochannels within a crosslinked matrix. Varying the ethylene oxide side-chain length yielded locally ordered, globally disordered nanodomains (16-22 nm). The optimized membranes achieved high room-temperature Li^+ conductivities (1.2-3.28 mS cm^{-1}), lithium transference numbers up to 0.6, and high shear storage moduli ($G'>10^8$ Pa). The SPEs exhibited an electrochemical window up to 4.3 V vs Li/Li^+, stable Li stripping/plating for > 600, and delivered discharge capacities up to 150 mAh g^{-1} with 82% capacity retention over 135 cycles in quasi-solid-state Li|| $Li_4Ti_5O_{12}$ batteries. Ultimately, this work demonstrates that side-chain-engineered bottlebrush blocks provide a precise handle for programming nanostructures to simultaneously optimize the transport, mechanical, and electrochemical performances of 3D-printed SPEs.

160

Designing Current Collectors and Interfaces for Stable Lithium and Zinc Metal Batteries

Shu-Hao Chang
Chung Yuan Christian University, Taoyuan City, Taiwan

Shu-Hao Chang

Abstract

High-energy metal batteries are often limited by nonuniform metal deposition, unstable electrode–electrolyte interfaces, and the continuous loss of electrochemically active metal. In this study, functional current collectors and interfacial engineering strategies were developed to regulate metal nucleation and deposition in both anode-free lithium metal batteries and aqueous zinc metal batteries. For the lithium system, copper current collectors modified with $Cu_{1.94}S$-based interfacial layers provided abundant lithiophilic nucleation sites and reduced the lithium nucleation overpotential from approximately 243 to 121 mV. The engineered interfaces promoted uniform lithium deposition, decreased polarization, and enhanced interfacial stability during repeated plating and stripping. When paired with an NCM811 cathode, the modified current collectors achieved improved capacity retention compared with bare copper. For the zinc system, CuS/PVP-based interfacial layers were introduced to regulate Zn^{2+} transport and homogenize zinc deposition. The protective interfaces suppressed localized deposition and parasitic interfacial reactions, leading to more stable zinc plating/stripping behavior and prolonged cycling stability. These results demonstrate that rational control of surface chemistry, ion transport, and metal nucleation provides a versatile strategy for improving metal utilization and extending the lifetime of next-generation lithium and zinc metal batteries.

161

Design and Optimization of Xanthan Gum-Based Gel Electrolyte Using Mixed Magnesium Salts for Mg-Ion Batteries

Shasmini Peiris, Uvindu Kalhara, Priyanthika Sanganayaka, Osuri Egodawaththa, Kaveenga Koswatthage, Manel Sarangika
Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka

Abstract

Magnesium ion batteries have gained major attention as a promising alternative to lithium ion batteries due to the high natural abundance, improved safety, high volumetric capacity and low cost of magnesium. The development of efficient electrolyte with wide electrochemical stability, high ionic conductivity and good mechanical properties remains a major challenge. This study focuses on design and optimizing of natural polymer-based gel electrolyte using magnesium salts. Xanthan gum was used as a natural polymer material due to its biodegradable, non-toxic, low cost, eco-friendly and excellent film forming ability. Gel electrolyte was developed using ethylene glycol (EG), magnesium borohydride ($Mg(BH_4)_2$), magnesium acetate ($Mg(CH_3COO)_2$) and xanthan gum. A series of gel electrolyte with different mass ratios of magnesium borohydride and magnesium acetate were prepared to optimize the electrolyte. The optimized composition of 1 ml of EG, 1:3 mass ratio of $Mg(BH_4)_2$, $Mg(CH_3COO)_2$ and xanthan gum showed highest ionic conductivity of 1.01×10^{-3} Scm^{-1} while maintaining excellent mechanical flexibility. Liner Sweep Voltammetry (LSV) measurements demonstrate electrochemical stability window of 2.79 V indicating the suitability of the electrolyte in Mg ion batteries. DC polarization measurements revealed that the optimized electrolyte sample exhibited a magnesium-ion transference number (t_{Mg}^{2+}) of 0.80 and a total ionic transference number (t_{Ion}) of 0.98. Charge-discharge (GCD) measurements were evaluated the electrochemical compatibility of the optimized electrolyte using C/TiO2 composite cathode. The electrolyte showed favorable charge storage capability and improved discharge performance.

Keywords: Magnesium salt, Ionic conductivity, Natural polymer, Transference number

162

Micro-scale study on sensitive lithium metal battery materials

Yujing Liu, Ke Yue
Zhejiang University of Technology, Hang Zhou, China

Abstract

The development of energy storage systems with high specific energy density is an important way to solve the problem of depleting fossil energy sources and climate deterioration. Lithium (Li) metal is considered as the"holy grail" anode for next generation Li-ion batteries due to its high theoretical specific capacity (3,860 mAh g^{-1}) and lowest redox potential (–3.04 V vs Standard hydrogen electrode). However, safety issues caused by Li dendrites growth have hindered its large-scale application. How to understand the growth behavior of Li dendrites, and to conduct a detailed and non-destructive analysis of the composition and distribution of the solid-state electrolyte interphase (SEI) that is crucial for the cycle stability of Li metal batteries. By virtue of the development of cryo-genic transmission electron microscope (Cryo-TEM), Nano-Fourier Transform Infrared Spectroscope (Nano-FTIR) and low-dose TEM technologies, our group has carried out a series of studies on the SEI compositions and failure mechanisms of Li metal anodes, and is committed to promoting the commercial application of Li metal batteries.

163

Influence of Glycerol Plasticizer on Ionic Conductivity and Dielectric Properties of Biodegradable Sodium Alginate Gel Electrolytes

Kalhara H.P.U[1], Sarangika H.N.M[2], Koswattage K.R.[1]

[1]Center for Nanodevice Fabrication and Characterization, Faculty of Technology, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka. [2]Department of Physical Sciences and Technology, Faculty of Applied Sciences , Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka

Abstract

Biodegradable gel polymer electrolytes were synthesized using varying masses of glycerol with constant masses of sodium alginate (0.15 g) and magnesium acetate tetrahydrate (0.25 g), and their dielectric properties, including dielectric constant, loss tangent (tan δ), log ionic conductivity, and the real part of the electric modulus, were investigated as a function of glycerol content. All samples exhibited high dielectric constant values at lower frequencies, on the order of 10^7–10^8, attributed to polarization and charge accumulation at the electrode-electrolyte interface. The log ionic conductivity spectra stabilized at lower frequencies, indicating dominant dc conductivity behavior in this region, and the sample containing 0.05 g of glycerol showed the highest ionic conductivity, approximately 6.3×10^{-4} S cm^{-1}, suggesting suitability for practical applications. Electric modulus analysis offered further insight into the bulk relaxation processes within the gel structure, with minimal contribution from electrode polarization effects; the real part of the modulus (M′) decreased with increasing glycerol content, consistent with the corresponding rise in dielectric constant, with M′ values around 10^{-7}. The loss tangent increased steadily with frequency and showed no distinct relaxation peaks, indicating relatively free ion motion through the gel structure across the studied frequency range, along with significant polarization-related energy loss at higher frequencies. Together, these results highlight the influence of glycerol content on the dielectric and conduction behaviour of the electrolyte system.

Keywords: Sodium alginate, glycerol, Gel polymer electrolyte, Magnesium acetate tetrahydrate

164

Modulating the Na^+ conductivity to Na metal compatibility by Synergistic doping in NASICON-structured $Na_3Zr_2Si_2PO_{12}$ (NZSP)

Yogesh Sharma
Indian Institute of Technology, Roorkee, India

Yogesh Sharma

Abstract

The performance of solid-state sodium metal batteries is critically influenced by the ionic conductivity and interfacial stability of the solid electrolyte. NASICON-structured $Na_3Zr_2Si_2PO_{12}$ (NZSP) solid-state electrolytes yield sufficiently high Na-ion conductivity; however, their overall electrochemical performance is severely hindered by the occurrence of undesirable secondary phases and an unstable Na||NZSP interface. This study presents a novel dual-element doping strategy designed to address both challenges simultaneously. The concurrent incorporation of Mg^{2+} and Nb^{5+} in the NZSP lattice not only enhances the overall conductivity of the system but also facilitates lower temperature sintering of the NZSP phase, alters the proportion of the mixed monoclinic-rhombohedral NZSP phases, and modifies the characteristics of the interface and grain boundaries. The co-doped composition Mg, Nb (0.2,0.05) demonstrates sufficiently high ionic conductivity (~1.7 $mS.cm^{-1}$), densified microstructure and lower activation energy (~0.27 eV). Notably, the optimized co-doped Mg, Nb (0.2,0.05)-NZSP shows enhanced interfacial contact with sodium metal by significantly suppressing the ZrO_2 formation at the interface, which results in a reduced interfacial resistance of 28.47 $\Omega.cm^2$ and an enhanced critical current density of 1.3 $mA.cm^{-2}$, facilitating stable galvanostatic sodium stripping-plating over 500 h. An 85 wt% ceramic composite membrane further demonstrates robust full-cell compatibility, sustaining Na3V2(PO4)3||NZSP-CM||Na cycling for more than 1000 cycles at 6 C without mechanical or electrochemical degradation. This work establishes co-doping as an effective route to concurrently engineer bulk transport and interfacial kinetics in NASICON electrolytes, advancing the rational design of stable solid-state sodium batteries.

165

Tailoring $ZnMn_2O_4$ through Metal Doping for Enhanced Zinc-Ion Hybrid Supercapacitor Performance

Pulkit Garg, Ankit Tyagi
Indian Institute of Technology Jammu, Jammu, India

Abstract

The increasing demand for sustainable and high-performance energy storage devices has led to considerable interest in aqueous zinc-ion hybrid supercapacitors (ZHSCs) for their intrinsic safety, environmental sustainability, and cost-effectiveness. Nonetheless, there is a lack of cathode materials capable of delivering high specific capacitance, high rate capability, and long-term cycling stability. In this work, we have synthesised a novel metal-doped $ZnMn_2O_4$ through a hydrothermal route followed by calcination. Incorporation of metal ions into the $ZnMn_2O_4$ spinel structure tunes the electronic structure, enhancing electrical conductivity and diffusion kinetics by introducing additional oxygen vacancies and redox-active sites.

XRD, FE-SEM, TEM, and XPS analyses were carried out for structural, morphological, and chemical characterisations of the synthesised material. The results confirm the successful incorporation of metal without disrupting the spinel phase, with a uniform distribution of metal-doped $ZnMn_2O_4$ nanoparticles. Electrochemical measurements were carried out using a coin-cell device configuration with metal-doped ZnMn2O4 as the cathode, AC as the anode, and a 2 M ZnSO4 + 0.1 M MnSO4 electrolyte. The device achieved a specific capacitance of 112.78 F g-1 at a current density of 1 A g-1, an energy density of 69 Wh kg-1, and a power density of 5.25 kW kg^{-1}. Furthermore, the device retained 87% of its initial capacity after 10000 cycles, suggesting excellent cycle stability. The metal doping facilitated quicker Faradaic reactions by reducing charge-transfer resistance, as witnessed by EIS.

This study introduces a different view on metal-doped materials for hybrid supercapacitors through increasing electrical conductivity and promoting the formation of oxygen vacancies.

166

Enhanced activity and durability of a layered double perovskite oxygen electrode via niobium doping for intermediate-temperature reversible solid oxide cells

In Won Choi, Seung Jae Lee, Jae Woong Choi, Daniel Gil, Yang Jae Kim, Su Hyuk Ko, Suk Won Cha
Seoul National University, Seoul, Korea, Republic of

Abstract

Reversible solid oxide cells (RSOCs), which reversibly convert chemical energy into electrical energy and vice versa, possess high potential for sustainable energy conversion and storage. However, more efficient and durable oxygen electrode materials are still required for their practical application. Here, we report a niobium-doped layered double perovskite oxide, $PrBa_{0.8}Ca_{0.2}Co_{1.47}Fe_{0.49}Nb_{0.04}O_{5+\delta}$, as a reversible oxygen electrode material for both the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER). Nb doping increases the oxygen vacancy concentration through changes in the oxidation states of the B-site cations. The increased oxygen vacancy concentration facilitates ionic conduction during the ORR and OER, thereby reducing the electrode polarization resistance. Furthermore, the high local oxidation state of Nb ions at the B sites suppresses cation segregation, resulting in significantly enhanced stability during RSOC operation.

167

Synergistic Coupling of Co-doped V_2O_5 nanobelts with Reduced Graphene Oxide for Enhanced Oxygen Evolution Electrocatalysis

Dnyaneshwari Lokhande, Sakshi Khatavkar, Dr. Amol Vedpathak
Symbiosis International University, PUNE, India

Dnyaneshwari Lokhande

Sakshi Khatavkar

Dr. Amol Vedpathak

Abstract

For sustainable hydrogen production through water electrolysis, efficient, low-cost, and earth-abundant electrocatalysts are needed for the oxygen evolution reaction (OER). Co-doped vanadium pentoxide ($Co_{0.25}V_2O_5$) nanobelts and reduced graphene oxide (rGO) composite were synthesized by a simple hydrothermal method in this work. The incorporation of Co into the V_2O_5 lattice and the integration of conductive rGO were designed to increase the number of active catalytic sites, enhance charge transfer and improve the electrical conductivity. To study the crystal structure, morphology, elemental composition and surface chemical state of the synthesized materials, were systematically characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), high-resolution TEM (HRTEM), selected area electron diffraction (SAED) and energy-dispersive X-ray spectroscopy (EDS) and X-ray photoelectron spectroscopy (XPS). The analysis results verified that Co-doped V_2O_5 nanobelts were successfully grown on the conductive rGO sheets with uniform distribution, thus constructing a well-connected hybrid structure. The OER activity of $Co_{0.25}V_2O_5$rGO composite was found to be higher than that of pristine $Co_{0.25}V_2O_5$ by the electrochemical studies, which could be attributed to the synergic interaction between nanobelts and the conductive graphene network. The improvement in performance is attributed to accelerated fast electron transport, improved charge transfer kinetics, larger electrochemically active surface area and effective suppression of nanobelt aggregation. This study showcases a straightforward and cost-effective approach to fabricate high-performance transition-metal oxide/carbon hybrid electrocatalysts for sustainable hydrogen production.

168

Interlayer-Stabilized Layered $Co_{0.25}V_2O_5$ Nanobelts for High-Energy and Durable Supercapacitor Applications

Sakshi Khatavkar, Dnyaneshwari Lokhande, Amol Vedpathak
a. Symbiosis Centre for Nanoscience and Nanotechnology, Symbiosis International (Deemed University), Lavale, Pune – 412 115, INDIA, Pune, India

Sakshi Khatavkar

Dnyaneshwari Lokhande

Amol Vedpathak

Abstract

Pre-insertion of multivalent metal ions into layered electrode structure is an effective strategy to control interlayer chemistry, to maintain the structural stability of the host structure and to enhance the electrochemical charge-storage characteristics. One-dimensional Co pre-inserted vanadium oxide ($Co_{0.25}V_2O_5$) nanobelts were successfully prepared via a simple hydrothermal method and used as a pseudo-capacitive electrode material in supercapacitors. Structural and morphological analyses showed that the nanobelts are indeed ultrathin, having a monoclinic layered framework. The concurrent entrapment of Co ions and interlayer water not only stretched and stabilized the V-O layers but also created pathways for the transport of electrolyte ions. In the interlayer galleries, Co species serve as the coordination pillars to maintain the structural integrity and prevent the collapse of the layers when the ions are repeatedly inserted and extracted. Moreover, the one dimensional nanobelts morphology allows continuous electron-transport pathways, high electrochemically available surface area and scaled down ion diffusion pathway. Complementary structural features facilitate fast and reversible redox processes, improved charge-storage capacity and stable electrochemical cycling. A quasi-solid-state coin-cell supercapacitor with activated carbon (AC) and $Co_{0.25}V_2O_5$ electrodes also showed the applicability of the engineered material in energy-storage devices. The results reveal a useful lattice engineering method for the synthesis of structurally stable layered vanadium oxides and for the development of longer lasting, high energy pseudocapacitive materials multivalent ion pre-insertion.

169

Electrocatalytic Energy Storage

Ping He
College of Engineering and Applied Science, Nanjing University, Nanjing, China

Abstract

To break through the specific energy bottleneck of traditional intercalation-based energy storage systems, moving toward "conversion-reaction" batteries based on non-metallic multi-electron redox chemistry has become a frontier trend in the field of energy storage. However, such systems universally face common bottlenecks, including strong covalent bond cleavage and sluggish multiphase mass transfer kinetics. This report systematically explores the application of the unique theoretical framework of "electrocatalytic energy storage" in ultimate specific-energy batteries.First, addressing the sluggish kinetics of gas electrodes, a multi-level modulation system for bond-forming/cleaving energy barriers was constructed, achieving precise tailoring of the intrinsic activation enthalpy. Second, a non-chemical-bond-induced polarization mechanism was proposed, leveraging weak interactions to solve the configurational entropy loss dilemma during the conversion of insulating solid-phase products (entropy increase). Based on the synergistic modulation strategy of electrocatalysis and mass transfer, a practical lithium–air battery with a specific energy of up to 860 Wh/kg was developed, and the relevant modulation logic was successfully extended to ambient-temperature CO_2 resource utilization and direct lithium extraction devices from seawater.Finally, targeting the mechanical stress mismatch and interfacial contact failure induced by severe phase transitions in all-solid-state lithium–air batteries, an overall regulation strategy of "enthalpy reduction, entropy increase, and pathway preservation" is proposed. Through interfacial structural optimization and multi-scale stress field modulation, this strategy aims to ensure the physical continuity of ion/electron transport pathways throughout the entire lifecycle, providing theoretical support and technical pathways for breaking through the kinetic limits of all-solid-state systems and developing high-specific-energy prototype batteries.

170

Biomass Precursor Guided Engineering of Hard Carbon Anodes for Sodium-Ion Batteries

Sruthy E S[1], Christie Thomas Cherian[1], Bipin P[2], Shaijumon M M[2]
[1]Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala), Thiruvananthapuram, India.
[2]Indian Institute of Science Education & Research (IISER), Thiruvananthapuram, India

Sruthy E S

Abstract

Biomass-derived hard carbons stand out as a promising anode material for sodium-ion batteries owing to their abundance and low cost. Nevertheless, a fundamental understanding of how biomass composition governs the microstructure and electrochemical performance of hard carbon anodes is still lacking, restricting the rational utilisation of biomass resources for practical sodium-ion battery applications. In this work, lignin and cellulose, the two principal constituents of lignocellulosic biomass, were selected as model precursors to establish the role of precursor-derived microstructure on the electrochemical performance of hard carbon anodes.

The sodium storage performance of pristine hard carbons derived from cellulose and lignin was found to differ significantly, with cellulose-derived hard carbons showing a higher reversible capacity (250 mAh g^{-1}) and better cycling stability over 200 cycles at 0.1 A g^{-1} than their lignin-derived counterpart (140 mAh g^{-1}). These results demonstrate how the intrinsic microstructure inherited from the biomass precursor significantly affects sodium storage behaviour. Further, boron and nitrogen doping were employed to enhance the electrochemical performance. Boron doping was found to increase the rate capability and cycling stability, whereas nitrogen doping primarily improved the reversible capacity. These insights provide the foundation for further optimisation through surface engineering and composite design.

This study establishes a framework linking biomass composition, hard carbon microstructure and sodium storage performance, enabling the rational selection of biomass feedstocks with favourable cellulose-to-lignin composition for high-performance sodium-ion battery anodes.

171

Low-LUMO Orotic Acid Enables Li3N-Embeded Solid Electrolyte Interphase for Stable All-Solid-State Lithium Metal Batteries

Ke Yue
Zhejiang University of Technology, Hang Zhou, China

Abstract

Biomacromolecules hold promise as sustainable fillers to address the challenges of low ionic conductivity and interfacial instability in polymer electrolytes, yet their structural complexity obscures in-depth mechanistic understanding. Herein, small biomolecules are strategically incorporated, which retain the key functional groups of biomacromolecules, as highly effective fillers for polymer electrolytes. Orotic acid (OA), a small-molecule building block of ribonucleic acid, enhances lithium (Li) ion conductivity by facilitating the dissociation of lithium bis(trifluoromethanesulfonyl)imide without compromising the crystallinity of the polyethylene oxide (PEO) matrix. The amide-rich conjugated structure endows OA with a low lowest unoccupied molecular orbital energy level, promoting its preferential decomposition to form a lithium nitride (Li3N) embedded solid electrolyte interphase. This dual-function mechanism enables the OA-optimized PEO electrolyte to achieve 95.2% capacity retention after 350 cycles (0.5 C, initial capacity: 148 mAh g−1) and >80% retention after 600 cycles (1.0 C, initial capacity: 128.6 mAh g−1) in Li||LiFePO4 cells.

172

High Temperature CO2 Electrolysis: Operando Studies

Chinmoy Ranjan
Indian Institute of Science, Bengaluru, India

Chinmoy Ranjan

Abstract

CO_2 electro-reduction using solid oxide electrodes is one of the most promising technologies for converting CO_2 to fuels (Power to X). CO_2 reducing cathodes such as Ni-YSZ and $MCeO_{2-\delta}$ -YSZ have shown promise in converting CO_2 to CO. In the presence of H_2, these systems are prone to reverse water gas shift reactions and at 800 degrees both electrochemical and thermochemical reactions compete. Our operando studies will report on Ni-YSZ and Ceria -YSZ based electrodes. $CeO_{2-\delta}$ electrodes perform well in both CO_2 and CO_2 ($+H_2$) environments. The CO yield increases with increasing negative bias concomitant with increase in the number of Ce^{3+} sites. Our studies will uncouple production of CO by both thermochemical and electrochemical means and how they are correlated through similar active sites. The studies will highlight mechanistic aspects of both CO production and coking. Nature of the active site will be discussed. Unlike purely thermochemical systems, electrochemical systems present an opportunity to control CO and H2 ratios in syngas using simply bias.

173

Hybrid Artificial Solid Electrolyte Interphase (SEI) Layer for Dendrite Free Sodium Metal Anodes

Ranjith Thangavel
IIT Tirupati, Tirupati, India

Ranjith Thangavel

Abstract

Attempts to develop high-performance energy storage system with high energy – high power – high cycle life combination has been the focus of increasing attention in recent years. Owing to the natural abundance of sodium resources and the similar working mechanism with lithium-ion batteries (LIBs), sodium-ion batteries (SIBs) are an appealing and low-cost candidate for large-scale applications. However, the capacity limitations in anode and cathode have severely limited the energy output of the SIBs. Increasing the energy density of the SIBs equivalent to LIBs is a key to achieve its commercialization in EVs and grid storage. Sodium metal (Na) anodes are considered the most promising anode for high-energy-density sodium-ion batteries, sulfur/solid state batteries because of their high capacity (~1166 mAh g-1) and low electrochemical potential (-2.71 vs SHE). Na metal has several limitations such as stability, reversibility, and safety due to their thermodynamic instability with organic electrolytes that lead to severe dendrite formation. The current talk with cover the engineering contributions in achieving a dendrite free and stable Na metal anode using artificial solid electrolyte interphase (SEI) layer for next generation sodium-based energy storage systems. The multifunctional approach adapted to realize a dendrite free, long life and safer Na anode will also be presented. The progress achieved in Na metal battery and solid-state Na metal battery will also be presented.

174

High-temperature solid-state lithium batteries defined by multi-scenario application

jiaju Wang
Harbin Institute of Technology, Harbin, China

Abstract

The rapid advancement of reusable commercial spaceflight has created an urgent demand for high-temperature solid-state batteries capable of operating up to 150 °C, addressing extreme thermal challenges in reusable rockets and aerospace systems. These batteries greatly relax thermal design constraints and enable lighter, lower-cost detectors. However, critical challenges persist: lithium-metal anodes suffer from high-temperature creep that degrades safety and cycling stability, while silicon anodes exhibit non-conformal solid-solid contact with electrolytes, increasing tortuosity and hindering fast ion-electron transport.

In this talk, we present a heat-resistant anode design featuring a Zintl-phase-like core and an ion-electron dual-conducting conformal coating. Our report demonstrates that this structure effectively relieves local strain and suppresses high-temperature interfacial deactivation, offering a promising pathway for robust high-temperature lithium-metal batteries. In addition, we will also discuss the application progress of high-temperature batteries in fields such as oil and gas field drilling.

175

Upcycling Spent Graphite for Multivalent Aqueous Zinc-ion and Aluminum-ion Batteries

Mani Pujitha Illa, Subhesh Selvam
National Institute of Technology Tiruchirappalli, Tiruchirappalli, India

Mani Pujitha Illa

Subhesh Selvam

Abstract

With the ever-increasing demand for lithium-ion batteries, the estimated number of End-Of-Life batteries will reach 1.4 Metric tons by 2030. The spent batteries are a valuable resource for many critical raw materials, particularly graphite, which accounts for 22% of a battery's total weight. Efficient recovery and reuse of graphite from spent batteries not only reduces the environmental burden associated with battery disposal but also decreases the dependency on graphite mining, thereby supporting the circular economy. In this work, we investigated the effects of different recycling approaches on the physiochemical properties of spent graphite and evaluated its potential as a functional component in MnO_2/recycled composite cathodes for aqueous Zinc-ion and Aluminum-ion batteries. The incorporation of recycled graphite overcomes the intrinsic shortcomings of the pristine MnO_2 cathode by providing a continuous conductive framework for electron and ion transport, serving as a structural buffer for volume expansion during cycling, and suppressing manganese dissolution by providing confinement sites. As a result, the MnO_2/recycled composite graphite cathode delivered a high reversible capacity of 460 mAh/g at 0.2 A/g with excellent capacity retention over 1500 cycles and remarkable rate capability in a zinc-ion battery. Furthermore, the same composite delivered a stable capacity of 180 mAh/g at 1 A/g after 1500 cycles in Aluminum-ion batteries, demonstrating its versatility across multivalent battery systems. These findings highlight the potential of recycled graphite as a sustainable, value-added, high-performance energy storage material, advancing safe and resource-efficient next-generation battery technologies.

176

Green synthesis of AuNPs and GO-AuNPs nanocomposite using Withania cogulans seed extract.

Aamir khan[1], Dr. Manunya Okhawilai2[2], Dr. Nipapan Ruecha[3]

[1]International Graduate Program of Nanoscience & Technology, Chulalongkorn University, Bangkok, Thailand.

[2]Department of Chemical Engineering, Faculty of Engineering Chulalongkorn University, Bangkok, Thailand. [3]Metallurgy and Materials Science Research Institute, Chulalongkorn University, Bangkok, Thailand

Aamir khan

Abstract

The synthesis of gold nanostructures by aqueous plant-extract mediation provides an eco-friendly alternative to traditional chemical reducing and capping agents. Here, we present an aqueous and phytochemical-mediated method for gold nanoparticles (AuNPs) and graphene oxide-gold nanoparticles (GO-AuNPs) nanocomposites employing Withania coagulans seed extract as a reducing and stabilizing agent. AuNP synthesis was optimized by varying the extract-to-$HAuCl_4$ ratio (1:5, 1:6, and 1:7) at 60 °C under continuous stirring for 24 h. The optimized colloidal particles demonstrated a typical light-yellow-to-dark-red transition and narrow localized surface plasmon resonance (LSPR) bands at 537, 538, and 539 nm, indicating stable, quasi-spherical, minimally polydisperse AuNPs. GO-AuNPs (GO: 0.005, 0.010, and 0.015 wt%) enable in situ Au deposition on oxygenated graphene sheets without surfactants. The optimized 0.010 wt% GO composite displayed a red-shifted absorption maximum at 548 nm, indicating alteration of the AuNP dielectric environment and interfacial electronic interaction with GO. FESEM verified evenly dispersed, spherical AuNPs on GO sheets without evident aggregation. EDX proved the coexistence of C, N, O, and Au and indicated GO-dependent Au loadings of 53.48, 32.85, and 31.29 wt% for 0.005, 0.010, and 0.015 wt% of GO, respectively. These results reveal that GO concentration controls metal-support interactions, nanoparticle surface coverage, and plasmonic activity. The resultant nanocomposites offer a durable, high-area conductive platform suited for signal-amplified electrochemical and optical biosensing.

177

Compositional Engineering of High-Conductivity Amorphous Sulfide Electrolytes via Data-Driven Optimization

Yujin Oh, Young Hoon Seo, Jin Seok Hong, Minsung Lee, Geunhyeong Kim, Huiwon Kim, Kee-Sun Sohn
Sejong University, Seoul, Korea, Republic of

Abstract

Sulfide glasses are attractive for all-solid-state batteries owing to their conductivity, deformability, and synthetic flexibility. Here, we use a two-stage particle swarm optimization (PSO) scheme to explore a quaternary sulfide composition space spanning eight compositional variables and identify highly conductive amorphous solid electrolytes. Every candidate is prepared by the same hybrid melt-quenching and mechanical alloying route, which promotes amorphization and keeps composition the only variable. The first stage comprises five generations of global exploration with twenty-four particles per generation, screening both the constituent elements and their ratios. The element set is then fixed to the best-performing selection, and five further generations of twenty particles each refine the remaining compositional variables. Across the ten generations, more than 200 compositions are synthesized and their room-temperature conductivities measured, giving a compositionally dense dataset over the search space. PSO identifies a champion composition exhibiting 2.5 mS cm^{-1} at room temperature. With the composition converged, the process variables are then tuned at fixed stoichiometry, yielding an electrolyte with no detectable crystalline reflections by X-ray diffraction and a room-temperature conductivity above 3.0 mS cm^{-1}. These results indicate that staged PSO combined with a hybrid melt-quenching and mechanical alloying route provides an effective means of navigating broad sulfide composition spaces experimentally, and that the identified composition supports high conductivity in a fully amorphous state.

178

Effects of Mn_2O_3 Content on the Phase Formation and Sintering Behavior of $Na_3Zr_2Si_2PO_{12}$ Prepared by Reactive Sintering from the $Na_2ZrSi_2O_7$-ZrO_2-$NaPO_3$ System

Chatmongkhon Konwitthayasin[1,2], Apirat Theerapapvisetpong[1,2], Tsuyoshi Honma[3]
[1]Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. [2]Center of Excellence on Advanced Materials for Energy Storage, Faculty of Science, Chulalongkorn University, Bangkok, Thailand.
[3]Department of Materials Science and Bioengineering, Nagaoka University of Technology, Nagaoka, Japan

Chatmongkhon Konwitthayasin

Apirat Theerapapvisetpong

Tsuyoshi Honma

Abstract

Liquid electrolytes pose safety concerns, driving the development of solid-state electrolytes for next-generation sodium-ion batteries. $Na_3Zr_2Si_2PO_{12}$ (NZSP) is a promising NASICON-type solid electrolyte because of its three-dimensional Na^+ conduction pathways. However, its electrochemical performance is strongly influenced by phase formation, microstructure, and densification during sintering. In this study, the effects of Mn_2O_3 addition on the phase formation and sintering behavior of NZSP prepared by reactive sintering from the $Na_2ZrSi_2O_7$-ZrO_2-$NaPO_3$ system were investigated. Mn^{3+} was introduced to partially substitute Zr^{4+} in the NZSP structure, while $NaPO_3$ glass was used as a reactive sintering component to promote phase formation and densification. Compositions of $Na_{3+x}Zr_{2-x}Mn_xSi_2PO_{12}$ with x = 0, 0.05, 0.10, 0.15, 0.20, and 0.25 were characterized by X-ray diffraction, differential thermal analysis, heating microscopy, scanning electron microscopy, and density measurements. XRD results showed that NZSP was the major crystalline phase in all compositions, consisting of monoclinic and rhombohedral phases, with residual ZrO_2 detected as a secondary phase. The undoped sample began to shrink near 1150 °C, while increasing Mn content shifted the shrinkage onset to lower temperatures. An endothermic peak at approximately 1000 °C appears to be associated with liquid-assisted reactions and NZSP phase formation during reactive sintering. After sintering at 1150 °C for 12 h, the sample with x = 0.15 achieved the highest relative density of 90% with a liquid absorption of 0.66%, while relative density decreased at $x \geq 0.20$, indicating that further Mn addition did not enhance densification at 1150 °C.

179

Design and Optimization of High-Performance Cathode Materials for Sodium-Ion Batteries

Brindha Moorthy
IIT Tirupati, Tirupati, India

Abstract

The growing demand for cost-effective and sustainable energy storage systems has accelerated research into sodium-ion batteries (SIBs) as a promising alternative to lithium-ion technology. Owing to the natural abundance, low cost, and wide geographical distribution of sodium resources, SIBs are particularly attractive for large-scale applications such as grid storage and low-cost electric mobility. However, their commercialization is hindered by the lack of high-performance cathode materials that can deliver superior electrochemical stability, high energy density, and long cycle life. This research focuses on the design and optimization of advanced cathode materials based on polyanionic frameworks, particularly NASICON-type structures such as $Na_3V_2(PO_4)_3$, $Na_3V_2O_2(PO_4)_3F$ and its derivatives. These materials exhibit excellent structural stability and fast sodium-ion diffusion pathways but suffer from intrinsic limitations including low electronic conductivity, limited sodium extraction, and relatively high molar mass, which reduce their practical capacity. To address these challenges, the proposed work explores multi-element doping strategies, including transition metal substitution to enhance electronic conductivity and tune the redox potential. Additionally, ex-situ carbon coating and nano structuring approaches are employed to improve charge transfer kinetics and reduce particle size, thereby enhancing electrochemical performance. The synergistic effects of co-doping and surface engineering are systematically investigated to understand their impact on ionic mobility, structural integrity, and cycling stability.

180

Engineering Silicon Nanostructures for Efficient Solar-driven Hydrogen Evolution

Pravesh Negi, Deepika Singh, Arup Samanta
Indian Institute of Technology Roorkee, Roorkee, India

Abstract

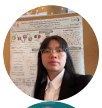
The realization of practical solar-to-hydrogen conversion systems depends on the availability of photocatalysts that are not only highly efficient but also economically viable. Among semiconductor materials, silicon has emerged as a promising platform because of its high optical absorption, natural abundance, and well-established manufacturing technology. Nevertheless, the photocatalytic performance of conventional silicon nanostructures is often compromised by insufficient photon utilization and rapid recombination of photogenerated charge carriers. In this work, a hierarchical silicon architecture consisting of vertically aligned silicon nanowires (SiNWs) grown on silicon inverted pyramids (SiNWs–IPs) is constructed through sequential copper- and silver-assisted chemical etching. Morphological characterization verifies the uniform formation of dense SiNWs across the surfaces of the inverted pyramids, producing a well-defined micro/nanostructure. Owing to this hierarchical design, the SiNWs–IPs exhibit outstanding antireflection characteristics, with an average reflectance of only 1.92% across the visible region, significantly lower than that of conventional SiNWs (3.5%). The improved optical properties turn directly into enhanced photocatalytic hydrogen production under light irradiation. The SiNWs–IPs generate hydrogen at a rate of 2.32 μmol h^{-1}, which is approximately three times greater than the 0.75 μmol h^{-1} achieved by SiNWs. This remarkable enhancement is attributed to the synergistic influence of the hierarchical micro/nanostructure, which promotes broadband light confinement through multiple reflections inside the inverted pyramids, increases the available catalytic surface area, and facilitates efficient separation and transport of photogenerated charge carriers.

181

Mn-doped $NiCo_2S_4$ composite with bifunctional ORR/OER activities in rechargeable zinc-air batteries

Tham Le Mai Hong[1], Nisit Tantavichet[1,2]

[1]Department of Chemical Technology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. [2]Centre of Excellence for Energy Storage Technology, CEST, Faculty of Science, Chulalongkorn University, Bangkok, Thailand



Tham Le Mai Hong

Nisit Tantavichet

Abstract

Nowadays, zinc-air batteries have become an alternative material for energy storage applications because of abundance source, high energy density, safety and inexpensive. Therefore, this research explores the potential of Mn-doped $NiCo_2S_4$ (NCS) structure over carbon-based structures such as graphene oxide (GO) and carbon black (CB) for comparison. This present study demonstrated significant improvement of effective oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) performance of Mn-doped on NCS compared NCS which played a crucial role in replacing the platinum group in the future. The catalysts Mn-doped NCS were synthesized by a two-step hydrothermal method which prepared the intermediate precursor at the first step and then additional of carbon source and thiourea for second step, then samples were washed and dried in vacuum oven. The bare of NCS was made in similar method to Mn-doped NCS but without using Mn source. The electrochemical performance was evaluated through ORR/OER, polarization curve, specific capacity, and charge-discharge test. Furthermore, the catalysts will be characterized to confirm structure, morphology, composition, element dispersion, and oxidation state through XRD, SEM-EDS, XRF, TGA, and XPS analysis. The sample NCS@rGO showed bifunctional electrocatalytic activity with an OER overpotential of (η_{10} = 1.68V vs. RHE) at a current density of 10 mA cm^{-2} and achieved ORR onset potential (0.80 V) and half-wave potential (0.60 V). Therefore, this sample exhibits a bifunctional electrocatalytic reactivity with a high ΔE of 1.08 V. Meanwhile, when a rechargeable zinc-air battery assembled from Mn-doped NSC@rGO at 0.88 V and (η_{10} = 1.44V vs. RHE) in term of onset and overpotential, respectively, resulting in a low bifunctional voltage gap (ΔE) of 0.65 V. The influence of Mn-doped increases electronic conductivity by enhancing electron density and promoting effective redistribution, which reduced internal resistance and improved electrochemical kinetics. These findings highlight the promising potential of Mn-doped on NCS structure in promotion bifunctional electrocatalysts, and future studies are warranted to further explore its potential applications in zinc-air batteries.

182

Calcination Temperature Effect on the Morphology of NVP/Carbon Nanofibers and the Performance of the Optimized Cathode

Asha Chaudhary, Yogesh Sharma
IIT ROORKEE, Roorkee, India

Abstract

Owing to its robust NASICON framework and high operating voltage, $Na_3V_2(PO_4)_3$ (NVP) is regarded as one of the most reliable cathode materials for Na-ion batteries. Herein, one-dimensional NVP/carbon composite nanofibers were successfully prepared via electrospinning and subsequently calcined in an argon atmosphere. Calcination temperature was varied, and its impact on the morphology of the fibers was evaluated. Citric acid served as a chelating and reducing agent, and also as a carbon source. Strongly binding to vanadium ions in solution, it helps in adjusting the vanadium valence toward the V^{4+}/V^{3+} state imperative to NVP formation. Afterwards, during calcination, it decomposes to form a thin carbon coating that improves electronic conductivity. SEM characterization showed that the calcination temperature has a strong impact on fiber integrity and particle connectivity. Along with that, the optimized sample retained fibrous architecture and uniformly distributed nanoparticles. CHNS analysis had confirmed the amount of carbon present in the sample after calcination. Galvanostatic charge-discharge measurements showed stable voltage plateaus characteristic of the NVP redox reaction. Cyclic voltammetry revealed highly reversible Na^+ insertion/extraction kinetics with minimal polarization. These observations present a systematic optimization of calcination temperature, quantification of residual carbon content, exploring the microstructure as well as electrochemical behaviour of electrospun NVP/carbon nanofibers. Detailed results will be presented at the conference.

183

Improved PEMFC Performance via Sulfamic Acid-Doped SPEEK/MIL-101 Membranes

Rahul Patel, Yogesh Sharma
India Institute of Technology Roorkee, Roorkee, India

Abstract

Maintaining physical strength and excellent conductivity is often a tradeoff in hydrocarbon-based proton exchange membranes. In this study, we developed a sulfamic acid (SA)-doped mixed-matrix proton exchange membrane using sulfonated poly(ether ether ketone) (SPEEK) and chromium(III) terephthalate (MIL-101). The incorporation of MIL-101 significantly improved the membrane's thermo-mechanical properties and water uptake capacity, while SA loading increased monotonically with MIL-101 content. The optimized 5 wt% MIL-101/SPEEK/SA membrane demonstrated the highest proton conductivity of 2.92 mS cm^{-1}, with an activation energy of only 4.9 kJ mol^{-1}, among the lowest values reported to date for a mixed-matrix membrane. Under identical operating conditions, this membrane achieved a peak power density of 400 mW cm^{-2}, twice that of the pristine SPEEK/SA and Nafion membranes, highlighting the substantial performance gains enabled by the incorporation of MIL-101. Furthermore, the composite membrane exhibited excellent open-circuit voltage (OCV) retention over 50 hours of continuous operation, indicating superior chemical resistance to oxyradical attack and enhanced durability. Accelerated stress testing further confirmed the membrane's robustness and long-term stability under fuel cell operating conditions.

184

Zinc Functionalized Reduced Graphene Oxide Hydrogel: A Potential Paradigm for Advanced Energy Storage Applications

Maya Das
Tribhuvan University, Kathmandu, Nepal

Maya Das

Abstract

The aim of this work was to synthesize zinc-functionalized reduced graphene oxide hydrogel (Zn-rGO-Hy) from graphene oxide (GO) and to evaluate its suitability as an electrode material for supercapacitors. Zn-rGO-Hy was synthesized through self-assembly reduction of GO in the presence of nano zinc precursors. Structural and morphological features were characterized using UV–Vis spectroscopy, X-ray diffraction (XRD), Fourier-transform infrared (FTIR) spectroscopy, FT-Raman spectroscopy, scanning electron microscopy (SEM), energy-dispersive X-ray (EDX), X-ray Photoelectron Spectroscopy (XPS), Brunner–Emmett–Teller (BET), Thermogravimetric Analysis – Differential Scanning Calorimetry. (TG-DSC) analysis and Electrochemical properties were studied in 6 M KOH electrolyte by cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS), cyclic stability. Electrochemical measurements showed a specific capacitance of 478 F/g at 1 A/g, with 92.61% retention at 3 A/g. Thus, Zinc-functionalized (Zn-rGO-Hy) hydrogel significantly enhances electrochemical performance, indicating its promise as an efficient electrode material for advanced supercapacitors.

185

A Net-structured graphene–chitosan electrochemical immunosensor for sensitive detection of mpox virus

Napol Chuanchart[1], Thosaporn Khajornyothin[1], Kurt Kalcher[2], Astrid Ortner[2], Sudkate Chaiyo[1]
[1]Chulalongkorn University, Bangkok, Thailand. [2]University of Graz, Graz, Austria

Abstract

Mpox virus (MPXV) infection remains a public health concern, highlighting the need for rapid, sensitive, and adaptable diagnostic platforms. In this study, a net-structured electrochemical immunosensor was developed for the detection of MPXV A29 protein. The sensing electrode was fabricated using a graphene–chitosan composite, in which graphene enhanced electrical conductivity while chitosan provided abundant amino groups for antibody immobilization. The net electrode architecture was designed to provide an open sensing interface, facilitate sample penetration, and improve the utilization of the electroactive surface. Electrochemical characterization using the ferricyanide/ferrocyanide redox couple demonstrated that, although the net electrode produced a lower absolute current than the whole electrode because of its smaller electroactive area, it exhibited a higher area-normalized current response. An anti-A29 antibody was subsequently immobilized onto the graphene–chitosan surface to construct the electrochemical immunoassay. Under optimized conditions, the developed sensor achieved a limit of detection of 0.24 ng mL^{-1} and a limit of quantification of 0.79 ng mL^{-1} for MPXV A29 protein. The applicability of the platform was evaluated using spiked artificial urine and artificial saliva samples, providing recoveries ranging from 92.26% to 112.49%. These results demonstrate that the net-structured graphene–chitosan electrode is a promising platform for sensitive MPXV protein detection and may support the future development of compact electrochemical devices for point-of-care infectious disease screening.

186

Beyond Ionic Conductivity: Coordination-Transport-Interface Design Rules for Durable Sodium Batteries

Soorathep Kheawhom
Chulalongkorn University, Bangkok, Thailand

Soorathep Kheawhom

Abstract

Sodium batteries are emerging as attractive energy-storage technologies because of their potential cost, resource, and supply-chain advantages. However, the practical durability of these systems is often poorly predicted by the metric most commonly used to rank electrolytes: bulk ionic conductivity. Electrolytes with high conductivity can still exhibit rapid polarization, interfacial resistance growth, unstable sodium plating, or premature cell failure. This discrepancy indicates that electrolyte performance must be understood beyond bulk ion transport alone.

This lecture introduces a Coordination-Transport-Interface (CTI) framework for connecting electrolyte chemistry with cell-level durability across liquid and solid sodium electrolytes. Coordination establishes the local chemical environment of Na^+ and biases electrolyte decomposition and interphase formation. Transport determines whether the electrolyte can sustain ion flux under the required current density, areal capacity, and temperature. The interface integrates these effects into an evolving resistance trajectory that ultimately governs cell lifetime.

Using ionic liquids, high-concentration and localized high-concentration electrolytes, polymers, oxides, sulfides, halides, hydroborates, and hybrid architectures as representative systems, the lecture will show why each electrolyte class should be assessed according to its dominant bottleneck rather than its nominal conductivity. Particular attention will be given to grain-boundary resistance, electrode wetting, interphase reactivity, contact loss, stack-pressure dependence, and chemo-mechanical degradation.

Six practical design rules and a failure-mode-based decision framework will be presented. The central message is that durable sodium batteries require not simply fast ion conductors, but coordination environments, transport pathways, and interfaces that remain mutually compatible under realistic operating conditions.

187

Quantitative functional imaging of complex interfaces

Xianwen Mao
National University of Singapore, Singapore, Singapore

Abstract

AI-driven materials discovery is creating new opportunities to accelerate the development of low-carbon energy materials, but its success depends critically on the availability of experimentally grounded descriptors that capture real functional behavior under operating conditions. To date, local experimental data related to complex interfaces are much less documented than bulk systems. In this talk, I will present our strategy for extracting such descriptors at complex interfaces using advanced operando optical imaging, with an emphasis on bridging theoretical prediction, data-driven screening, and experimentally measurable performance metrics in complex energy materials.

Rather than relying solely on bulk observables, our approach resolves functional heterogeneity across individual particles, interfaces, and reactive domains, enabling quantitative readouts of charge-transfer activity, reaction cooperativity, interfacial coupling, and dynamic structural evolution. I will highlight how single-particle and subparticle-resolved imaging can produce experimentally accessible descriptors that are more physically interpretable and closer to true operating functionality than many conventional averaged metrics. Representative examples include spatiotemporal imaging of electrochemical transformation and imaging of interfacial electron-transfer processes in semiconductor-based systems, both of which reveal descriptor-level information that can inform data-centric materials design.

188

Engineering Fluorine Chemistry in Chloride Solid Electrolytes for Next-Generation Li-Metal Batteries

Abhik Banerjee
TCG Crest, Kolkata, India

Abhik Banerjee

Abstract

Lithium fluoride (LiF) is widely recognized as one of the most important inorganic components of the solid electrolyte interphase (SEI) for achieving stable and efficient Li-metal deposition. Its high band gap (~6 eV), high mechanical modulus (>100 GPa), favorable interfacial properties with Li metal, and moderate Li-ion diffusivity have motivated the development of fluorine-rich electrolytes capable of promoting rapid and effective interphase formation, enabling Coulombic efficiencies approaching 99.9%. However, the use of liquid electrolytes with Li-metal anodes continues to raise significant safety and stability concerns, motivating the development of solid-state batteries.

Despite their promise, solid-state batteries face a fundamental challenge: achieving simultaneous high ionic conductivity and effective interfacial passivation at the Li-metal/solid-electrolyte interface. In particular, many fluorine-containing Li-ion conducting inorganic materials exhibit extremely low room-temperature ionic conductivity (typically ~10^{-10} S cm^{-1}), making them unsuitable as practical solid electrolytes.

In this talk, I will present a fluorine-engineering strategy for chloride-based solid electrolytes that introduces fluorine into the electrolyte framework without severely compromising Li-ion conductivity. I will discuss how controlled fluorine incorporation modifies the chemical and structural characteristics of the electrolyte and promotes the formation of a stable, passivating interphase at the Li-metal interface. The resulting changes in **interfacial stability, air/moisture tolerance, Li-metal compatibility, and electrochemical stability** will be discussed in detail. Furthermore, I will highlight the role of fluorine in stabilizing chloride solid electrolytes and their interfaces with high-voltage cathodes, addressing one of the key challenges limiting long-term cycling of high-energy-density solid-state batteries.

189

Ion-transport Enhancement Strategies for High-Performance NASICON-type Na-ion Solid-State Battery Electrolytes

Vishal Ranawade[1], Lingzi Sang[2], Raju Kumar Gupta[1], Sudarshan Narayanan[1]
[1]Indian Institute of Technology Kanpur, Kanpur, India. [2]University of Alberta, Edmonton, Canada

Sudarshan Narayanan

Abstract

Conventional lithium-ion batteries face two major issues: the scarcity and high cost of key elements like lithium and cobalt, and the flammability of organic liquid electrolytes. Sodium solid-state batteries (SSSBs) are a promising alternative because sodium is more abundant and cheaper. They can utilize low-cost aluminium current collectors instead of copper, reducing overall costs. Solid electrolytes such as NASICON and polymers provide non-flammability, broad electrochemical stability, good air stability, and compatibility with metallic sodium anodes. Properly engineered SSSBs can achieve energy densities around 355 Wh/kg, comparable to lithium-ion batteries (250-300 Wh/kg). Challenges include improving ionic conductivity, stabilizing electrode-electrolyte interfaces, and developing flexible, ultrathin electrolytes.

To optimize ion transport in NASICON-type $Na_3Zr_2Si_2PO_{12}$ (NZSP), substituting Zr^{4+} with super-valent dopants like Ta^{5+} enhances Na vacancy formation, ion migration pathways, and decreases activation energy. Ta-doped NZSP exhibits an ionic conductivity of 4.3 $mS.cm^{-1}$ – nearly 20 times higher than undoped NZSP – and is stable over 1000 cycles with low overpotential. Fully sodium-based cells with Ta-NZSP maintain 89.5% capacity after 100 cycles. Other dopants, like Ruthenium and Vanadium, improve ion migration and reduce grain-boundary resistance, aiding dendrite suppression. Overall, cation substitution in NASICON-type electrolytes offers a versatile route to overcome transport limitations, enhancing ionic conductivity, stability, and safety for practical sodium solid-state batteries.

190

Oxygen vacancies engineering to boost Li-ion transport and cycling stability in TiNb2O7 anodes

Wei-Ren Liu
Chung Yuan Christian University, Taoyuan, Taiwan

Wei-Ren Liu

Abstract

With the rapid growth of portable electronics and electric vehicles, lithium-ion batteries (LIBs) have become a core technology for modern energy storage systems. However, the increasing demand for lithium resources, coupled with rising extraction costs, poses significant challenges to the sustainable development of LIBs. $TiNb_2O_7$ (TNO) has attracted attention due to its intercalation-type mechanism, moderate operating voltage and a theoretical capacity of ~387 mAh g^{-1}. This study investigates the effects of Sc^{3+} doping on enhancing the structural and electrochemical properties of TNO. A combination of analytical techniques, including DFT calculations and pseudocapacitive analysis, is employed to elucidate lithium-ion storage behavior. 3 mol.% Sc^{3+} doping achieved the highest reversible capacity of 363.9 mAh g^{-1} at 0.1C, with a capacity retention of 86.6% after 500 cycles at 5 C. CV, GITT, and EIS tests all showed improved lithium-ion diffusion kinetics and charge transfer properties at this doping level. This study demonstrates that targeted compositional modifications can significantly optimize the structural features and electrochemical behavior of TNO, providing a promising pathway for developing high-rate, long-cycle lithium-ion battery anode materials.

191

Bridging Experiment and Theory for Next-Generation Energy Storage Materials: Insights from DFT

Siriporn Jungsuttiwong

Ubon Ratchathani University, Ubon Ratchathani, Thailand

Siriporn Jungsuttiwong

Abstract

The transition toward sustainable and carbon-neutral energy systems requires advanced materials that enable efficient energy storage, rapid ion transport, and long-term electrochemical stability. First-principles density functional theory (DFT) calculations have become a powerful tool for uncovering the atomistic origins of these properties and for guiding the rational design of next-generation energy materials. In this talk, recent advances in integrating DFT calculations with experimental observations will be presented, with particular emphasis on battery and solid-state ionic materials. Atomistic insights into electronic structure, ion adsorption and migration, defect chemistry, and interfacial interactions will be discussed to elucidate key factors governing electrochemical performance. Selected case studies will demonstrate how theoretical calculations can explain experimentally observed trends, identify structure-property relationships, and predict promising materials and interfacial configurations prior to experimental validation. Particular attention will be given to the synergy between computation and experiment in understanding electrode and electrolyte behavior at the atomic scale. Finally, emerging opportunities for integrating DFT with advanced characterization and data-driven approaches will be highlighted as a pathway toward accelerated discovery and optimization of safer, higher-performance, and more sustainable energy-storage materials.

192

Single-Atom Engineering of $Mo_2B_2O_2$ MBene Cathodes for High-Performance Li-S Batteries

Wongsathorn Kaewraung[1], Sirisak Singsen[1], Lappawat Ngamwongwan[1], Anchalee Junkaew[2], Suwit Suthirakun[1]
[1]Suranaree University of Technology, Nakhon Ratchasima, Thailand. [2]National Nanotechnology Center, Pathum Thani, Thailand

Suwit Suthirakun

Abstract

Li-S batteries promise high energy density at low cost, but the shuttle effect, sluggish sulfur reduction kinetics, and slow Li_2S decomposition remain major barriers to practical use. In this talk, I will present a first-principles screening study of 19 single-atom (SA) decorated Mo_2B2O_2 MBene cathodes spanning the 3d and 4d transition metal series. SA decoration strengthens lithium polysulfide adsorption through SA-S bonding, and I will show how electronic factors (charge transfer, d-p orbital occupancy) control this behavior in 3d systems, while structural factors dominate in 4d systems. Most SA-$Mo_2B_2O_2$ surfaces eliminate the sulfur reduction overpotential entirely — a stark contrast to pristine Mo2B2O2 (2.16 V) — and enable barrier-free Li_2S decomposition during charging. V- and Nb-$Mo_2B_2O_2$ emerge as top candidates, combining strong polysulfide anchoring with fast redox kinetics. I will conclude with the design principles this work offers for engineering MBene-based cathodes with improved cycling stability and energy efficiency.

193

Hydrogen-Free Exsolution of Socketed Ir-Fe Nanoalloys for Stable SOC Air Electrodes

Pei-Chen Su
Nanyang Technological University, Singapore, Singapore

Pei-Chen Su

Abstract

Surface modification is essential for enhancing the catalytic activity of solid oxide cell (SOC) air electrodes. While metal nanoparticle decoration is effective, deposited nanoparticles rapidly coarsen or detach at high temperatures. Conventional exsolution offers a solution by producing socketed nanoparticles anchored to the perovskite surface, yet this process fundamentally requires hydrogen reduction, making it incompatible with the oxidizing environment of air electrodes. This incompatibility has long excluded exsolution from air-electrode engineering.

Here, we report a fundamentally different pathway that achieves hydrogen-free exsolution directly in air. By exploiting the intrinsic chemical affinity and broad miscibility between iridium and iron, we demonstrate that atomic-layer-deposited Ir nanoparticles act as thermodynamic sinks, selectively redistributing Fe from the $Sr_2Fe_{1.5}Mo_{0.5}O_{6-\delta}$ (SFMO) perovskite lattice during annealing at 800°C in air. This process directly yields socketed Ir-Fe nanoalloys without any reducing gas.

The resulting architecture delivers multiple synergistic benefits: the socketed geometry resists coarsening, Fe incorporation relaxes interfacial strain and suppresses Sr segregation, and the alloy surface enhances oxygen exchange kinetics. Electrochemical impedance spectroscopy shows that Ir-Fe decorated SFMO maintains stable polarization resistance at 800°C, whereas bare SFMO degrades severely. This work establishes alloy affinity, rather than hydrogen, as a viable driving force for exsolution-like surface reconstruction in air, opening a new design route for durable SOC air electrodes.

194

Lithium-chlorine batteries and associated critical materials.

Debin Kong
China University of Petroleum (East China), Qingdao, China

Debin Kong

Abstract

Addressing the critical challenges of poor cycling stability, sluggish reaction kinetics, and limited adaptability across a wide temperature range in lithium-chlorine batteries, this report presents our research progress in catalytic mechanism elucidation, key material design, and device performance optimization. First, we reveal the failure mechanism at the cycling interface and establish a reversible electrochemical reaction pathway based on iodine co-deposition, which suppresses the formation of highly crystalline metal chlorides. Second, we develop single-atom catalysts with tunable local micro environments, which significantly reduce the decomposition barrier of metal chlorides with high binding energy and enable rapid and reversible solid-gas chlorine conversion at temperatures as low as -40^{o}C. Third, we clarify the synergistic mechanism of mechanical and kinetic enhancement at the interface between the chlorine-containing electrolyte and the lithium-silicon alloy anode. This approach effectively mitigates self-discharge caused by parasitic reactions between the electrolyte and the anode, thereby achieving long-life lithium-chlorine batteries with broad operational temperature windows. Our findings provide fundamental insights into interfacial chemistry and catalytic design, offering a pathway toward high-energy-density battery systems under extreme conditions.

195

Solid State Ionics of Halide Superionic Conductor for Lithium Batteries

Kisuk Kang
Department of Materials Science and Engineering, Institute for Recharbeable Batttery Innovation, Seoul National University, Seoul, Korea, Democratic People's Republic of

Kisuk Kang

Abstract

Halides have emerged as a new class of solid electrolytes that can deliver a superionic conductivity comparable to that of state-of-the-art sulfide electrolytes and the electrochemical stability suitable for high-voltage (> 4V) operations. While these merits have led to an extensive exploration of various halide-based materials in recent years, the understandings of the superionic conduction mechanism and its structure dependency remain in their infancy, impeding a rational design of new halide electrolytes. In this presentation, I will discuss the fundamental lithium transport mechanisms in halide superionic conductors, focusing on two representative structural types: the trigonal hexagonal-close-packed (hcp) and monoclinic cubic-close-packed (ccp) phases of LixMyClz (M = Y, Sc, Er, Zr, etc.). Our findings reveal unique structure–property relationships in each framework, providing general design principles for next-generation halide superionic conductors for all-solid-state lithium batteries.

196

R&D on *in situ* solidification

Hong Li
Institute of Physics, CAS, Beijing, China

Hong Li

Abstract

Developing advanced lithium ion batteries with high energy density, high power density, high safety, long cycle life, wide operation temperature, low cost and large production ability is an important target for various emerging applications. All solid state batteries (ASSB) is regarding as the most promising direction. There are several possible technological solutions. The commercialization time of ASSB have been claimed from 2027-2030 by various manufacturers. We purposed to develop Hybrid-solid/liquid electrolyte lithium ion batteries (HELB) and ASSB by an *in-situ* solidification technology (ISST) since 2016. Currently, HSLB for 3C, drone , EV and energy storage have been developed and commercialized. New efforts are paid to develop key materials, cell and manufacturing for ISST-ASSB. In this report, we will report our related fundamental progresses on HSLB and ASSB with the help of AI.

197

Passivation Strategies for Sustainable Carbon Electrode-based Perovskite Solar Cells

Woraprom Passatorntaschakorn, Warunee Khampa, Wongsathon Musikpan, Chukwuebuka Emmanuel Usulor, Isaac Chinaza Ogbuagu, Sukhanidhan Singh, Athipong Ngamjarurojana, Anusit Kaewprajak, Pisist Kumnorkaew, Pongsakorn Kanjanaboos, Pipat Ruankham, Duangmanee Wongratanaphisan

Chiang Mai University, Chiang Mai, Thailand. National Nanotechnology Center (NANOTEC), Pathum Thani, Thailand. Mahidol University, Nakhon Pathom, Thailand. Thailand Center of Excellence in Physics (ThEP Center), Bangkok, Thailand

Abstract

Carbon-electrode based perovskite solar cells (C-PSCs) have emerged as promising next-generation photovoltaics owing to their low cost, excellent stability, and compatibility with low-temperature fabrication. Replacing vacuum-deposited noble metal electrodes with carbon electrodes enables energy-efficient manufacturing while enhancing long-term device durability. In addition, perovskites integrated with carbon electrodes offer a sustainable platform for scalable photovoltaic technologies. This work summarizes recent progress in sustainable C-PSCs, focusing on the transition from laboratory-scale devices to scalable mini-modules through entirely low-temperature processes. Emphasis is placed on passivation strategies, including defect passivation, grain boundary modification, and interface engineering at the electron transport layer (ETL)/perovskite, perovskite/hole transport layer (HTL), and HTL/carbon interfaces. These approaches effectively suppress non-radiative recombination, mitigate ion migration, improve charge extraction, and enhance long-term operational stability under both one-sun and indoor illumination. Recent advances in free-standing carbon electrodes and scalable module fabrication further demonstrate practical pathways toward cost-effective manufacturing and commercialization. Collectively, these developments support sustainable photovoltaic technologies that contribute to Affordable and Clean Energy (SDG 7), Industry, Innovation and Infrastructure (SDG 9), and Climate Action (SDG 13).

198

Effect of Mn Compounds on Synthesis of Na_xMnO_2 Electrode Material for Sodium-Ion Batteries

Pramote Palasak, Weeraporn Treerittiwittaya, Jitti Kasemchainan
Department of Chemical Technology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Abstract

Sodium-ion batteries (SIBs) are promising alternative energy storage systems under intensive research and development to replace lithium-ion batteries. This interest is driven by their electrochemical performance comparable to lithium-based systems and the global abundance of sodium resources. Cathode materials are indispensable components for utilizing SIBs, with tunnel-type Mn-based oxides attracting significant attention due to their low cost, non-toxicity, and unique, rigid tunnel structure that facilitates Na-ion extraction/insertion. In this study, Na_xMnO_2 (NMO) was synthesized via a flux growth method using three distinct manganese sources MnO, Mn_2O_3, and Mn_3O_4 whereby the respective Mn oxidation states were +2, +3, as well as mixed +2 & +3. The synthesis was conducted at 850 °C for 24 h to obtain high-quality mono-crystals of NMO. Preliminary X-ray diffraction (XRD) analysis confirmed that the synthesis method successfully transformed all three structurally distinct Mn precursors into an identical tunnel-typed structure. Each of the resulting Mn-based materials were then cast into a composite positive electrode and assembled into CR2032 coin-cell batteries with a Na metal electrode using 1 M $NaClO_4$ in PC:EC (1:1 v/v) electrolyte. The cells delivered comparable capacities of 115.03, 99.53, 97.37, 94.14, and 89.15 mAh g^{-1} at current densities of 10, 20, 50, 100, and 200 mA g^{-1}, respectively, regardless of NMO prepared from which sources. Long-term cyclability testing at a constant current density of 10 mA g^{-1} demonstrated excellent stability with a capacity retention of 100%, where the initial capacity evolved from 124.15 mAh g^{-1} to 133.62 mAh g^{-1} after 100 cycles.

199

X-ray Absorption Spectroscopy at SLRI for Advanced Energy Conversion and Storage Materials

Wanwisa Limphirat
Synchrotron Light Research Institute, Nakhon Ratchasima, Thailand

Abstract

The development of advanced energy conversion and storage materials requires a detailed understanding of their electronic structure, local atomic coordination, and structural evolution under realistic operating conditions. The Synchrotron Light Research Institute (SLRI) operates five X-ray Absorption Spectroscopy (XAS) beamlines covering a broad photon-energy range of 1–30 keV, providing element-specific characterization capabilities for a wide range of energy-related materials. X-ray Absorption Near Edge Structure (XANES) enables investigation of oxidation states and electronic configurations, while Extended X-ray Absorption Fine Structure (EXAFS) provides quantitative information on local coordination environments and bond distances. Micro-focused XAS offers spatially resolved chemical characterization, and time-resolved XAS enables monitoring of dynamic physicochemical transformations.

For energy conversion and storage research, these capabilities are complemented by integrated sample environments, including controlled gas-flow and temperature systems, electrochemical cells, and operando battery-testing configurations. These facilities enable in-situ and operando investigations of catalysts, energy-storage materials, and electrochemical systems under realistic working conditions. By correlating changes in electronic structure and local atomic coordination with material performance, XAS provides critical insights into reaction mechanisms, active-site evolution, degradation processes, and structure–function relationships. The SLRI XAS facilities therefore provide an advanced synchrotron platform for accelerating the development and optimization of next-generation materials and devices for energy conversion and storage, while strengthening regional research capabilities in synchrotron-based materials science.

200

Nephelauxetic Study of Photoluminescence in Structurally and Anioically Modified Materials

KANDALAM RAMANUJACHARY
Rowan University, Glassboro,, United States

Abstract

Development of cost-effective phosphors is gaining increasing importance because of the potential to design highly efficient and environmentally friendly hosts. Recently, we have been focusing on developing materials that can serve as photo- luminescent hosts for transition metal and rare earth ions. In this presentation, we show how anionic modification and structural variations can effectively alter both the excitation and emission wavelengths. In particular, we have studied the luminescence of trivalent europium in rock-salt and perovskite-related Mg3NF3 and Ca2NF compositions respectively. We compare these changes to that observed in the Eu3+ doped pure oxides. We will also show the changes in the emission wavelengths of the rare earth ions in several anionically modified materials. These variations in the emission spectra seem to be related to the Nephelauxetic phenomenon often attributed to the coordination effects of the ligands around transition and rare earth ions. Keywords: Keyword 1; Nephelauxetic 2; phosphors 3: Pervoskite

201

Next-generation sodium-ion battery cathode materials for battery energy storage: performance optimization, recent advances, and future perspectives

Rajendra Kumar Singh
Department of Physics, Banaras Hindu University, Varanasi, India

Rajendra Kumar Singh

Abstract

Abstract

The growing demand for sustainable, cost-effective, and high-performance energy storage systems has accelerated the development of next-generation rechargeable batteries for electric vehicles and large-scale energy storage applications. Among emerging technologies, sodium-ion batteries (SIBs) have attracted considerable attention as a promising alternative to lithium-ion batteries because of the natural abundance, low cost, and wide geographical availability of sodium resources. However, achieving competitive energy density, rate capability, long-term cycling stability, and operational safety remains a major challenge for the practical deployment of SIBs.

Among the various components of a sodium-ion battery, the cathode plays a decisive role in determining its energy density, electrochemical performance, structural stability, and cycle life. This talk will focus on recent advances in the development of high-performance sodium-ion cathode materials, with particular emphasis on transition-metal-based oxide systems, including Ni–Mn–Co/Fe compositions. The effects of composition, structural modification, and surface engineering on the electrochemical properties of these materials will be discussed. Particular attention will be given to surface modification and protective coating strategies aimed at suppressing undesirable interfacial reactions, improving structural stability, enhancing sodium-ion transport, and mitigating capacity degradation during prolonged cycling.

The talk will further highlight recent developments and performance optimization strategies for cathode materials investigated for sodium-ion batteries, including approaches for improving reversible capacity, rate capability, and long-term cyclability. Finally, emerging challenges and future research directions in cathode engineering will be discussed, with emphasis on developing high-energy, durable, safe, and economically viable sodium-ion batteries for next-generation automotive and stationary energy-storage applications.

202

Polymer-Based, Mechanically-Robust, All-Solid-State Batteries

Derrick Fam[1,2,3], Shermin Goh[1], Dorsasadat Safanama[1], Sirin Binti Kamarulzaman Binti Kamarulzaman[2]
[1]Institute of Materials Research and Engineering, A*STAR, Singapore, Singapore. [2]School of Materials Science and Engineering, Nanyang Technological University, Singapore, Singapore. [3]Battery Consortium Singapore, Singapore, Singapore

Derrick Fam

Abstract

Solid-state electrolytes improve battery safety by reducing or eliminating flammable liquid electrolytes. However, scaling and commercialisation remains constrained by the high manufacturing costs, the need for high external stack pressures and their limited electrochemical windows which is especially true for inorganic solid electrolytes. In contrast, solid polymer electrolytes (SPEs) have attracted significant interest due to their manufacturability and ability to operate with very little or no external pressures. Polyethylene oxide (PEO)-based SPEs have been successfully commercialised but challenges such as low ionic conductivity (10^{-5}-10^{-6} S cm^{-1}) below their melting point and poor electrochemical stability (<4.0 V vs Li) still remain.

Here, a dynamic crosslinking strategy that enables a mechanically robust SPE while maintaining sufficient ion transport for practical cell cycling is being demonstrated. An elastomeric poly(triazolium) (PT-Li) SPE combining poly(ionic liquid) and covalent adaptable network characteristics exhibits a wide electrochemical stability window of up to 5.2 V. Dynamic triazolium crosslinking maintains mechanical integrity and with a shear loss factor ≤0.2 at cell cycling temperatures, demonstrating its solid state operation. Meanwhile, cationic triazolium moieties facilitate Li^+ transport, achieving an ionic conductivity of 2×10^{-4} S cm^{-1} in solid state and a high Li^+ transference number of close to 0.8. These properties enable stable cycling of all-solid-state Li|$LiFePO_4$ cells, with uniform Li^+ deposition at the lithium interface and enhanced rate capability. We envision that this concept can also extend to Na-solid-state chemistries and beyond.

203

Development of PTFE dry-process binder for high-loading graphite anodes of lithium-ion batteries: From Mechanism Understanding to Practical Solutions

Ruiqin ZHANG
City University of Hong Kong, Kowloon, Hong Kong

Ruiqin ZHANG

Abstract

Polytetrafluoroethylene (PTFE) is an excellent solvent-free dry-process binder for high-loading lithium-ion battery electrodes, but its practical use in graphite anodes has been blocked since 1996 by severe irreversible capacity loss of unknown origin. Combining density functional theory (DFT) and multi-technique characterization (XPS, FTIR, SEM, TEM), we reveal that PTFE undergoes reductive decomposition at ~1.2 V vs. Li/Li^+—far above the graphite lithiation potential (~0.02 V)—via C–F bond cleavage that generates LiF and converts the continuous $–[CF_2]_n–$ structure into PVDF-like disrupted segments, destroying binder integrity and causing irreversible capacity loss. To overcome this, we developed two complementary strategies: (i) a 1.25 wt% polyethylene oxide (PEO) coating on graphite blocks electron transfer to PTFE while conducting Li^+, raising the initial Coulombic efficiency (ICE) from 69.5% to 90.9% (half-cell) and from 47.1% to 83.7% in NM75/graphite pouch cells (4.8/5.2 mAh/cm²), achieving 258.7 Wh/kg with 87.3% capacity retention after 1,700 cycles at 1/3C; (ii) 3 wt% N-phenyl-bis(trifluoromethanesulfonimide) (PTFSI) as an electrolyte additive, whose LUMO lies below that of long-chain PTFE, enabling preferential reduction to form a protective solid-electrolyte interphase (SEI) on both graphite and PTFE surfaces before PTFE decomposes, yielding 86.5% ICE (half-cell) and 78.2% in pouch cells with 80.5% retention over 400 cycles and 80% SOC in 20 min at 3C. Both approaches eliminate toxic NMP solvent, reduce manufacturing costs by 10–20% and energy consumption by 46%, and establish PTFE as a viable green binder for next-generation high-energy-density LIBs.

204

Advancing Environmental Remediation with Titanium Dioxide-Based Nanoparticles: From Innovation to Real-World Applications

Lai Chin Wei
Nanotechnology and Catalysis Research Centre (NANOCAT), National Higher Institution Centre of Excellence (HiCoE), Universiti Malaya, Kuala Lumpur, Malaysia

Lai Chin Wei

Abstract

Titanium dioxide (TiO_2) is one of the most extensively studied transition-metal oxides due to its excellent physical and chemical properties, including high chemical stability, strong oxidizing ability, non-toxicity, and cost-effectiveness. These characteristics have made TiO_2 an important functional material in environmental remediation technologies. In recent years, TiO_2-based nanomaterials have gained increasing attention for a wide range of practical applications, particularly in antibacterial and antiviral coatings, formaldehyde degradation, self-cleaning surfaces for solar panels, and innovative cooling roof coatings for energy-efficient buildings. The performance of nanosized TiO_2 in these applications is strongly influenced by its structural, electronic, optical, and morphological characteristics, as well as its surface properties, including the exposure of specific crystal facets and surface active sites. By manipulating these properties at the nanoscale, the photocatalytic activity and surface reactivity of TiO_2 can be significantly enhanced. Consequently, considerable research efforts have been devoted to tailoring TiO_2 nanostructures through controlled synthesis strategies, enabling the development of materials with diverse dimensional architectures and improved functional performance. Such structural engineering not only enhances photocatalytic efficiency and pollutant degradation capability but also improves environmental stability and long-term durability under real operational conditions. These advances open new opportunities for translating laboratory-scale nanomaterials into practical environmental technologies. This presentation will highlight recent progress in the synthesis, structural design, and functional optimization of TiO_2-based nanomaterials. Particular emphasis will be placed on their emerging real-world applications in environmental remediation, including pollution control, antimicrobial surface technologies, and the development of advanced functional protective coatings for sustainable infrastructure.

205

Comparison of Silane-Modified and Unmodified SAPO-34/Polyimide Mixed Matrix Membranes for CO_2 and CH_4 Permeation

Yin Fong Yeong and Norwahyu Binti Jusoh
Department of Chemical Engineering, Universiti Teknologi PETRONAS, Perak, Malaysia.
Centre for Sustainable Energy, Environment and Social Innovation (SEnSI), Universiti Teknologi PETRONAS, Perak, Malaysia.

Abstract

Membrane-based gas separation has emerged as a promising alternative for gas permeation and separation applications due to its energy efficiency and operational simplicity. In this study, a series of silane-modified and unmodified SAPO-34/6FDA-durene mixed matrix membranes (MMMs) were fabricated and evaluated for CO_2 and CH_4 gas permeation. The MMMs were prepared by incorporating 5 and 10wt% loadings of silane-modified and unmodified SAPO-34 particles into 6FDA-durene polyimide, respectively. The synthesized SAPO-34 and silane-modified SAPO-34 particles were characterized using Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM) to verify their chemical functionality and morphology. The resulting MMMs were further characterized by SEM to investigate membrane morphology and particles dispersion. Based on the gas permeation results, the MMMs incorporated with silane-modified SAPO-34 particles showed lower CO_2 and CH4 gas permeation compared with MMMs incorporated with unmodified SAPO-34 particles. However, the CO_2/CH_4 ideal selectivity was found to be slightly higher in silane-modified SAPO-34/6FDA-durene MMMs. The obtained results could be attributed to the partial pore blockage of MMMs by the silane groups in SAPO-34 particles. These findings highlight the critical influence of particle characteristics and interfacial engineering on the separation performance of SAPO-34-based mixed matrix membranes for gas permeation and separation applications.

206

Assessment of Acetaminophen Contamination in Lakes of the Bucharest Metropolitan Area, Romania, and its Efficient Removal using Chitosan-Based Hybrid Composite Adsorbents

Gina Ghita, Mihaela Ilie, Diana Gheorghe, Cristina Dumitrescu, Camelia Zamfir, Adrian Moraru, Alexandra Chirescu, Daniela Stelescu, Alexandra Popa
National Institute for Research and Development in Environmental Protection, Bucharest, Romania

Abstract

The present study investigates the occurrence and concentration levels of acetaminophen (paracetamol), a widely used pharmaceutical compound, in multiple lakes in the Bucharest metropolitan area, Romania. Surface water samples were collected from eighteen lakes across different seasons and analysed using online solid-phase extraction coupled with ultra-high-performance liquid chromatography-tandem mass spectrometry (SPEonline-UHPLC-MS/MS). The results revealed the presence of acetaminophen in all sampled lakes, with concentrations ranging from 1.5 to 2605 ng/L. These findings indicate widespread contamination, most likely originating from municipal wastewater discharges and urban runoff. To address this emerging pollution issue, novel chitosan-based composite adsorbents were synthesised and evaluated for their efficiency in removing acetaminophen from aqueous solutions. The composites, incorporating chitosan with silica gel and mesoporous silica, exhibited significantly enhanced adsorption capacity compared to unmodified chitosan. Batch adsorption capacities experiments demonstrated maximum removal of up to 125 mg/g. This research highlights the presence of acetaminophen as a pharmaceutical contaminant in urban lakes around Bucharest. It demonstrates the promising potential of chitosan-based hybrid composite materials as efficient, low-cost, and environmentally friendly adsorbents for the remediation of pharmaceutical pollutants in surface waters.

207

Towards Sustainable Polymer Composites: Tensile Performance, Interfacial Morphology, and Biodegradation Behaviour of Bamboo Fiber-Reinforced Recycled Polypropylene Modified with Palm Stearin

Siti Hasnah Kamarudin, Mohd Rozi Ahmad
School of Industrial Technology, Faculty of Applied Sciences, Universiti Teknologi MARA, Selangor, Malaysia
Nanocomposite Materials and Processing Research Group, Universiti Teknologi MARA, Selangor, Malaysia
Social and Cultural Innovation Group, Universiti Teknologi MARA, Selangor, Malaysia

Abstract

The growing accumulation of plastic waste and agricultural residues has intensified the need for sustainable composite materials that support circular economyinitiatives. This study investigates the tensile performance, interfacial morphology, and biodegradation behaviour of recycled polypropylene (rPP) composites reinforced with bamboo fiber (BF) and modified using palm stearin (PS) biohybrid resin. Bamboo fibers were treated with 6 wt.% sodium hydroxide (NaOH) to improve fiber–matrix compatibility. Composite formulations were prepared through melt blending followed by compression moulding. Tensile properties were evaluated according to ASTM D638, while morphological characteristics were examined using scanning electron microscopy (SEM). Environmental degradability was assessed through soil burial testing over four weeks. Results showed that untreated bamboo fiber reduced tensile strength from 6.10 MPa to 4.37 MPa due to poor interfacial adhesion. However, alkaline treatment significantly improved tensile performance, with rPP/BF treated reaching 6.068MPa. The highest tensile strength of 6.452 MPa was obtained for the rPP/BF/PS treated composite, representing a 47.6% improvement compared with untreated bamboo fiber composites. SEM observations revealed a more homogeneous morphology with reduced void formation and enhanced fiber–matrix adhesion after treatment. Soil burial analysis demonstrated substantially higher degradation behaviour for bamboo fiber composites compared with neat rPP, with weight loss values exceeding 20% after four weeks. The findings confirm that treated bamboo fiber and palm stearin can effectively enhance both the mechanical performance and sustainability profile of recycled polypropylene composites, making them promising candidates for green composite applications.

208

Wastewater Treatment using Hybrid Materials. A Review

Florina-Diana Gheorghe, Iulia Istrate, Cristina Rodica Dumitrescu, Adrian Moraru, Teodor Diaconu, Elena Holban, Alexandra Diana Chirescu, Cristina Raluca Popescu
National Institute for Research and Development in Environmental Protection, Bucharest, Romania
Doctoral School of Biotechnical Systems Engineering, National University of Science and Technology POLITEHNICA of Bucharest, Bucharest, Romania
Faculty of Chemical Engineering and Biotechnologies, National University of Science and Technology POLITEHNICA of Bucharest, Bucharest, Romania
University of Bucharest, Bucharest, Romania

Abstract

Water pollution has become a critical global environmental issue, exacerbated by population growth. Traditional treatment methods are proving ineffective against both persistent and emerging pollutants, including heavy metals, pharmaceutical residues, and microplastics. This review investigates hybrid materials developed from organic and inorganic components that can be applied to water treatment. Within the paper, several synthesis strategies are presented, including the sol-gel process, self-assembly techniques, solvent-free mechanochemistry, and green synthesis approaches. Also, various multistage remediation mechanisms, such as adsorption, photocatalytic degradation, and membrane filtration, were taken into account to support the effective removal of different classes of pollutants.
Moreover, challenges related to cost and ecotoxicological safety were tackled, and their perspectives when combined with artificial intelligence / machine learning was highlighted. This paper intends to provide a starting point for developing selective and sustainable hybrid materials that can be used in innovative technologies to reduce the global water crisis.

209

Surface Modification of Spent Coffee Ground for Composite Production

Wan Nor Raihan Wan Jaafar, Siti Norasmah Surip
Faculty of Applied Sciences, Universiti Teknologi MARA, Selangor, Malaysia

Abstract

Spent coffee grounds (SCG) represent an abundant, carbon-rich agro-industrial waste with significant potential as sustainable bio-fillers in polymer composites. However, their native state is limited by surface impurities, lipids, and a high fraction of amorphous components that restrict interfacial bonding and thermal stability. This study evaluates the chemical, crystalline, and thermal structural shifts of SCG subjected to hydrothermal (boiling water) and alkaline (1.0M NaOH) pretreatments. Characterization was executed using Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), and Thermogravimetric Analysis with its derivative curve (TGA/DTG). FTIR analysis verified that alkaline modification with 1.0M NaOH has effectively extracted surface waxes, fats, and amorphous hemicellulose, maximizing the exposure of structural hydroxyl (-OH) and aliphatic (-C-H) groups. XRD profiles confirmed a substantial increase in the relative percentage of crystallinity from 207 counts (untreated) to over 385 counts (hydrothermal) post-treatment due to the targeted dissolution of disordered amorphous phases. TGA/DTG data demonstrated that all treated substrates maintain full thermal stability below 200°C, aligning perfectly with industrial thermoplastic processing windows. The treated samples manifested advanced thermal order, evidenced by a distinct crystalline cellulose decomposition peak emerging at 350°C and a notable increase in char residue at 600°C. Ultimately, the 1.0M NaOH treatment proved superior, successfully engineering raw SCG into a high-stiffness, thermally stable, and chemically reactive bio-filler optimized for green bio-composite manufacturing.

210

Absolute Quantification of Antibiotic-Resistance Genes in Municipal Wastewater using Digital PCR

Monica Matei, Raluca Prangate, Elena Holban, Mădălina Boboc, Lavinia-Ingrid Petrișor, Laura Lupu, Dana Mierlă
National Institute for Research and Development in Environmental Protection, Bucharest, Romania
Doctoral School of Biotechnical Systems Engineering, National University of Science and Technology POLITEHNICA of Bucharest, Bucharest, Romania

Abstract

Antimicrobial resistance (AMR) is a growing global health problem driven by the rapid dissemination of antibiotic resistance genes (ARGs). Antibiotics released in aquatic environments have been shown to exert selective pressure on bacterial communities, contributing to the emergence of ARGs. Moreover, urban wastewater systems and wastewater treatment plants (WWTPs) are recognised hotspots for the spread of ARGs and antibiotic-resistant bacteria (ARB), which can then be further released into the environment. Consequently, this study directly analysed wastewater samples from the entrance of Glina Wastewater Treatment Plant (WWTP) near Bucharest. The analysis investigated the presence and dynamics of 11 ARGs in the influent water using digital PCR (dPCR) over 8 weeks from August to September 2023. The targeted panel comprised eight β-lactamase genes (blaTEM, blaSHV, blaAmpC, blaCTX-M, blaNDM, blaKPC, blaVIM, blaOXA-48), two plasmid-mediated quinolone resistance genes (PMQR) (qnrB, qnrS), and a gene associated with efflux pumps (oqxA). Total ARG levels ranged from 3.558 $\log_{10}$ copies/L for blaNDM to 6.461 $\log_{10}$ copies/L for blaTEM. Ten genes were consistently detected across all samples, while only one was found sporadically. These results indicate the presence of the WWTP resistome and highlight the importance of effective monitoring and treatment of ARGs in wastewater.

211

Assessing sediment transport in a complex terrain area with sturgeon migration disruption risk using numerical modelling

Georgeta TUDOR, Mirela FĂTU, György DEÁK, Maria CARACHICIU, Elena HOLBAN, Monica MATEI , Mădălina BOBOC
National Institute for Research and Development in Environmental Protection, Bucharest, Romania
Doctoral School of Biotechnical Systems Engineering, National University of Science and Technology POLITEHNICA of Bucharest, Bucharest, Romania
Academy of Romanian Scientists, Bucharest, Romania

Abstract

The conservation of anadromous sturgeon populations in the Lower Danube is a major ecological priority, closely linked to maintaining the integrity of their critical habitats. To achieve this, numerical modeling is a key tool for identifying solutions to reduce impacts on sturgeon species' migration pathways and spawning habitats in the area of interest. Thus, a three-dimensional numerical and geometric model of the Bala Branch was developed using the advanced hydrodynamic module MIKE 3 HD. The calibration and validation of the model were based on data obtained from in situ measurements and granulometric analyses. Numerical simulations run under transient conditions enabled the precise determination of sediment transport processes and the prediction of the morphological evolution of the riverbed. The results highlight structural changes in the riverbed and provide essential technical and predictive support to justify complementary conservation measures, directly contributing to the expansion of strict protection zones for sturgeons in accordance with the EU Biodiversity Strategy for 2030.

212

Urban recreational lakes in Bucharest as reservoirs of fecal and opportunistic microbial contamination

Dora Ioniță, Andra Zorcă, Monica Matei, Mădălina Boboc, Elena Holban, Alexandra Popa
National Institute for Research and Development in Environmental Protection, Bucharest, Romania
Doctoral School of Faculty of Chemical Engineering and Biotechnology, National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

Abstract

Urban recreational lakes can be significant sources of microbial contamination and constitute health risks to the general public. The current study evaluated the microbiological quality of 18 lake samples by examining general bacterial indicators and specific fecal and opportunistic microorganisms, including thermotolerant coliforms, Escherichia coli, Pseudomonas aeruginosa, Clostridium perfringens, and enterococci. The findings demonstrated that P. aeruginosa was present in every sample and reached the highest concentrations among the microorganisms investigated, suggesting extensive contamination and beneficial environmental conditions for its continuation. Fecal bacteria, including enterococci and E. coli, were found in the majority of samples and showed significant variation among lakes, indicating unequal fecal pollution across the study area. The occurrence of persistent or episodic contaminated inputs is supported by the occasional detection of C. perfringens. Overall, the data show that these urban lakes have microbiological effects and could pose a health risk to recreational users. It is advised that opportunistic infections and fecal indicators be continuously monitored to boost water quality management and protect public health.

213

Heavy metals removal from the aquatic system using alginate–agar composite with onion peel additives

Andra-Gabriela Zorcă, György Deák, Dora Ioniță, Diana Gheorghe, Gina Ghiță, Mihaela Ilie, Alexandra Popa
National Institute for Research and Development in Environmental Protection, Bucharest, Romania
Doctoral School of Biotechnical Systems Engineering, National University of Science and Technology POLITEHNICA of Bucharest, Bucharest, Romania
Academy of Romanian Scientists, Bucharest, Romania
Doctoral School of Faculty of Chemical Engineering and Biotechnology, National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

Abstract

The present study describes the fabrication and characterisation of alginate-agar composite materials containing vegetal powder for the removal of heavy metals from aqueous solutions. FTIR studies demonstrated that the matrix is mostly composed of a polysaccharide structure, while SEM measurements disclosed that increasing the vegetal powder concentration increased material porosity. Nevertheless, excessive addition encouraged particle agglomeration. This structural change was reflected in the swelling degree, which ranged from 370% to 1000%, with the highest value observed for the AAO1 sample after 4 hours of immersion in water. These compositional differences also affected the heavy metal removal tests: AAO1 exhibited higher adsorption efficiency for cadmium, whereas zinc, lead, and copper were more effectively removed during the filtration process. AAO5 showed better adsorption performance than filtration. The findings emphasise the need to optimise the composition of obtained materials to balance porosity, swelling behavior, adsorption capacity, and metal retention.

214

Thermal Stability and Antibacterial Activity of PLA Bioplastic Films Incorporating Lemongrass Essential Oil

Nurul Izzati Natasya Hussin, Siti Norasmah Surip
Faculty of Applied Sciences, Universiti Teknologi MARA, Selangor, Malaysia

Abstract

This study aimed to develop green bioplastic films based on polylactic acid (PLA) incorporated with lemongrass essential oil (LEO) using simple method which is the solvent casting. The percentage of LEO used was varied from 0%, 0.5%, 1.0%, 1.5% and 2.0%. The thermal behaviour of the films was evaluated by Differential Scanning Calorimetry (DSC), revealing that LEO incorporation significantly influenced the thermal properties of the PLA matrix. At lower LEO concentrations, the glass transition temperature (Tg) increased slightly, whereas higher concentrations (1.5–2.0 wt%) resulted in a decrease in Tg, indicating a plasticizing effect. Furthermore, the melting temperature (Tm) and crystallization temperature (Tc) gradually decreased with increasing LEO content, suggesting reduced crystallinity and thermal stability of the bioplastic films.The antibacterial activity of the PLA/LEO films was assessed against Staphylococcus aureus and Escherichia coli. Among the formulations tested, only the film containing 2.0 wt% LEO exhibited a measurable inhibition zone which is about 1.0 mm against both bacterial strains, while films with lower LEO concentrations showed no detectable antibacterial activity. Overall, the incorporation of LEO enhanced the flexibility of the PLA films through its plasticizing effect and imparted antibacterial functionality at higher concentrations. These findings demonstrate the potential of LEO-incorporated PLA bioplastic films, particularly those containing 2.0 wt% LEO, as sustainable packaging materials for food industry.

215

Waste Derived Geopolymers - Processing Technologies and Applications

Kaibao Wang, Muhammad Rauf, Huirong Le
The Future Lab, Tsinghua University, Beijing, P. R. China
Department of Mechanical Engineering, Tsinghua University, Beijing, P. R. China
School of Material Science and Engineering, Tsinghua University, Beijing, P. R. China

Abstract

Faced with the urgent need to manage large volumes of industrial solid waste and reduce carbon emissions, green and low-carbon building materials have become a key strategy for advancing circular economy and achieving carbon neutrality goals. This study uses industrial by-products such as fly ash and slag as precursors to produce geopolymer tiles via an alkaline activation process, which are then systematically compared with conventional cement tiles and sintered ceramic tiles in terms of mechanical load-bearing capacity and thermal performance. Results indicate that this material holds significant potential to replace traditional masonry products. Additionally, by leveraging metakaolin and industrial waste acid in a synergistic reaction, non-sintered geopolymer were developed. This system not only effectively stabilizes heavy metal ions but also demonstrates excellent thermal stability, offering a promising approach for integrated treatment of difficult-to-manage waste acids and heavy metal contamination. Furthermore, due to the tunable three-dimensional network structure of geopolymers, this material system can be extended to wastewater treatment filtration membranes, where its porous structure and surface activity enable physical retention and chemical degradation of pollutants in water, positioning it as a novel environmental functional material. Life cycle assessment reveals that these processes significantly reduce fossil energy consumption and greenhouse gas emissions, aligning well with strategic directions for green manufacturing and resource recycling. This research provides feasible solutions for the integrated management of industrial solid waste and waste acid, and shows broad application prospects in low-carbon ceramic tiles, advanced wastewater treatment, and remediation of heavy metal-contaminated sites.

216

Mixed Matrix Membranes Incorporated with Mesoporous Silica MSU-2 for Enhancement in CO_2/CH_4 Permeation

Thiam Leng Chew, Nur Nasrina Abdan Naser, Qi Hwa Ng, Chii-Dong Ho, Zeinab Abbas Jawad
Department of Chemical Engineering, Universiti Teknologi PETRONAS, Perak, Malaysia.
Centre for Sustainable Energy, Environment and Social Innovation (SEnSI), Universiti Teknologi PETRONAS, Perak, Malaysia.
Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia.
Centre of Excellence for Frontier Materials Research (CFMR), Universiti Malaysia Perlis (UniMAP), , Perlis, Malaysia.
Department of Chemical and Materials Engineering, Tamkang University, New Taipei City, Taiwan.
Department of Chemical Engineering, College of Engineering, Qatar University, Doha, Qatar.

Abstract

Mixed matrix membranes (MMMs) is potential for effective gas permeation and separation, for example carbon dioxide (CO_2)/methane (CH_4) gas permeation and separation. The choice of filler to be incorporated into the MMMs plays an important role in affecting the properties of the formed MMMs as well as gas permeation performance of the MMMs. In this study, the polysulfone (PSF) polymer matrix was incorporated with unfunctionalized or functionalized mesoporous silica, Michigan State University No. 2 (MSU-2) filler to form MMMs with the aim to enhance the CO_2/CH_4 gas permeation. The fabricated MMMs were then analyzed by using several characterization techniques and were studied for the CO_2/CH_4 gas permeation. SEM analysis indicated that the interfacial void in the MMMs were avoided by incorporating Tetraethylenepentamine(TEPA)-functionalized MSU-2 into the MMMs. Meanwhile, the incorporation of TEPA-functionalized MSU-2 into the MMMs almost maintained the thermal stability of the membrane, as indicated by TGA analysis. Incorporating 3wt % TEPA-functionalized MSU-2 into the MMMS enhanced CO_2 gas permeability and ideal CO_2/CH_4 selectivity of the MMMs by 36.6% and 91.3% respectively, compared to the pristine PSF membrane.

217

Design of Experiments (DOE) for the Parameter Study of a Multi-Axis Air Injection Banana Fiber Opener

Mohamad Azim Faris Roslee, Muhammad Farid Shaari, Norhaidah Mohd Asrah, Nur Suhailah Khamis, Radin Khairul Faizi Radin Kamarudin
Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia
Faculty of Applied Science and Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia
TDK Electronics (Malaysia) Sdn. Bhd., Johor, Malaysia
Bambusoideae Technology Sdn Bhd, Cyberjaya, Malaysia

Abstract

Banana fiber is a natural fiber which is sustainable, biodegradable and light weight with mechanical properties comparable to glass fiber, making it a good alternative to the textile industry. Despite its advantages, industrial application of banana fiber is still limited compared to cotton or jute due to the problems in the fiber opening stage. Conventional mechanical beater machines and manual methods often apply excessive force which can damage the fiber, break its structure and reduce its tensile strength. The primary objectives of this research are to investigate the effects of beater speed, processing time and fiber load on the opening efficiency of banana fibers using a Multi-Axis Air Injection with Rotary Arm Fiber Opener Machine (MAIRA-FOM) and to find the best combination of parameters for maximizing efficiency and minimizing damage. The study made use of 33 full factorial Design of Experiments consisting of 27 runs to investigate three controllable parameters which include fiber quantity (50g, 100g, 150g), rotational speed (150 rpm, 200 rpm, 250 rpm) and processing time (5, 10, 15 minutes). Performance was evaluated based on opening efficiency and mass loss, with the data analyzed using Analysis of Variance (ANOVA) at a 0.05 significance level. Principal results indicated that processing time was the most significant factor affecting overall opening performance, followed by fiber quantity and speed. Opening efficiency improved as duration and speed increased, and higher fiber loads (150g) facilitated better separation through increased internal friction. The maximum opening efficiency achieved was approximately 54%. In conclusion, the MAIRA-FOM serves as a feasible and sustainable alternative for processing banana fibers. The optimal operating conditions were determined to be 15 min at 250 rpm rotational speed with 150g fiber load. These results will provide a basis for upscaling air-assisted fiber opening technologies.

218

Development and Finite Element Analysis of a Pneumatic Needle-Punching Machine for Laboratory-Scale Nonwoven Production

Raynabelle Emilia Raymond, Muhammad Farid Shaari, Radin Khairul Faizi Radin Kamarudin, Mohd Nazrul Roslan
Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
Bambusoideae Technology Sdn. Bhd, Cyberjaya, Malaysia

Abstract

The increasing need for adaptable and economical non-woven production systems points out the inadequacy of standard industrial needle-punching machines for laboratory use. This study reports on design, development and FEA of small-scale pneumatic needle punching machine for sustainable natural fibre nonwoven production using bamboo and banana fibres. The main aim of the study was to design a compact and structurally sound needle-punching system that could generate a stable reciprocating motion with less mechanical complexity compared with the traditional crank-slider mechanisms. The research involved conceptual design selection, 3D modelling, electro-pneumatic system integration, structural FEA evaluation and operational performance assessment at different punching frequencies. A pneumatic cylinder-based mechanism was selected to provide the direct linear rotary motion for the needling assembly. SolidWorks simulation was used to analyse the stress distribution, displacement behaviour and strain concentration under simulated operational loading. The maximum von mises obtained were stress , displacement and strain . This indicated that the machine operated within the elastic deformation region without the structural instability. Experimental evaluation also confirmed stable operation at frequencies up to 120 strokes/min with low vibration and acceptable needle alignment deviation. The obtained results are in line with the design objectives and confirm the previous findings that simplified linear actuation systems can reduce vibration and improve the operational controllability for compact needle-punching applications. Thus, the developed machine has a high potential as a laboratory-scale platform for sustainable natural fibre nonwoven research and small-batch production.

219

Cellulose nanocrystals reinforced paint: rheological evaluation and performance study

Wei Sing Yong, Lachlan Thompson, Ping Ping Chung, Yeu Yee Lee, Elammaran Jayamani, Ai Bao Chai, Mostafa Nikzad
Faculty of Engineering, Computing and Science, Swinburne University of Technology Sarawak Campus, Kuching, Malaysia
Department of Mechanical and Product Design Engineering, Swinburne University of Technology, Hawthorn, Australia
Department of Mechanical, Materials and Manufacturing Engineering, Faculty of Science and Engineering, University of Nottingham Malaysia, Selangor, Malaysia

Abstract

Cellulose nanocrystals (CNCs) are nanoscale biopolymers derived from cellulose sources. In this study, CNC was extracted from sago waste via mixed acid hydrolysis using sulfuric acid and oxalic acid, aiming to combine high hydrolysis efficiency with the sustainability advantages of oxalic acid. Characterization results confirmed the successful production of CNC. Both scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyses revealed irregular nanoscale particles with particle sizes ranging from 28.76 to 65.06 nm. Fourier-transform infrared (FTIR) spectroscopy spectra demonstrated the removal of lignin and hemicellulose, as well as the presence of cellulose. Brunauer–Emmett–Teller (BET) analysis indicated that extracted CNC has a high surface area of 36.11 m2/g. The extracted CNC was incorporated into water-based paint at a concentration of 0.1 wt.%, and cyclic salt spray tests showed that steel painted with CNC addition exhibited better corrosion resistance. Finally, rheological tests revealed that paints containing CNC exhibited higher viscosity, indicating good storage stability and reduced likelihood of sagging after application.

220

Exploration of Shelf-Life Extension and Antimicrobial PVA Biocomposite Films Incorporating Eggshell Membrane-Derived Collagen and Rhinacanthin-C Extract from *Rhinacanthus nasutus*

Chanon Manee, Charasphat Preuksarattanawut, Arsa Thammahong
Department of Metallurgical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand
Department of Microbiology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Chanon Manee

Abstract

Polyvinyl Alcohol (PVA) is a biodegradable and environmentally friendly packaging. However, PVA has several limitations for food packaging applications such as low mechanical properties, poor water resistance and a lack of antimicrobial activity. To address these limitations, a novel PVA/collagen/Rhincanthin-C extract biocomposite film was developed. The collagen used in this study was obtained from eggshell membranes separated from eggshell waste, while Rhinacanthin-C extract from Rhinacanthus nasutus was incorporated into the PVA matrix. In addition, the morphology, chemical interactions, mechanical properties, water resistance and antimicrobial activity of the novel biocomposite film were investigated using a variety of analytical techniques. The results showed that the incorporation of Rhinacanthin-C extract into the PVA matrix enhanced antimicrobial activity of the film. Furthermore, the addition of collagen improved the mechanical properties and reduced the hydrophilicity of the biocomposite film, thereby improving its potential to extend the shelf life. The above findings indicate that this biocomposite film represents another promising approach to produce biodegradable and antimicrobial food packaging in the future. Moreover, this research aligns with the Sustainable Development Goals (SDGs), particularly those that promote “the creation of social innovation”, thereby contributing to the achievement of the SDGs by 2030. This approach supports SDG goals 3, 9, 12 and 13.

221

Stability of biopolymer from renewable resources

M. Amirulhusni M.Fadzir, Anika Zafiah M. Rus, Noraini Marsi, Amin s suleiman, Nurulsaidatulsyida
Sustainable Polymer Engineering, Advance Material and Manufacturing Centre (AMMC), Faculty of Mechanical Engineering and Manufacturing, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
Fakulti Kejuteraan Mekanikal, Universiti Teknologi MARA (UiTM) Cawangan Johor, Johor, Malaysia

Abstract

Despite increasing interest in renewable polymers, the influence of virgin and waste vegetable oils on the thermal stability and biodegradation behaviour of bio-based polyurethane remains insufficiently understood. This study compares polyurethane synthesized from virgin palm oil (VOP) and waste cooking oil (WOP) to establish the relationship between chemical structure, thermo-oxidative stability, and biodegradation performance. Bio-based polyols were prepared via epoxidation followed by acid-catalysed ring-opening reactions before polyurethane synthesis. Thermal stability was evaluated using Fourier transform infrared spectroscopy (FTIR) and thermogravimetric analysis (TGA), while biodegradation was investigated through natural soil burial in accordance with EN ISO 846:1997. FTIR and carbonyl index analyses showed that VOP contained more reactive functional groups, resulting in lower thermo-oxidative stability than WOP. TGA further confirmed the improved thermal resistance of WOP, with a decomposition onset temperature of 325°C compared with 280°C for VOP. After 80 days of compost soil burial, VOP exhibited 51.15% weight loss, whereas WOP showed only 30.53%, indicating greater structural stability. Optical microscopy revealed more extensive microbial-induced surface erosion and fragmentation in VOP. These findings demonstrate that waste cooking oil is an effective renewable feedstock for producing thermally stable bio-based polyurethane, whereas virgin palm oil offers greater biodegradability for environmentally degradable polymer applications.

222

Influence of TPS/ENR Ratio and MCC Incorporation on Blend Morphology and Mechanical Performance

Sovankongkea Som, Chuanchom Aumnate, Yukikazu Takeoka, Orathai Boondamnoen
International Collaborative Program in Sustainable Materials and Technology for Industries between Nagoya University and Chulalongkorn University, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand
International Collaborative Program in Sustainable Materials and Technology for Industries between Nagoya University and Chulalongkorn University, Graduate School of Engineering, Nagoya University, Nagoya 464-8601, Japan
The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand
Department of Molecular and Macromolecular Chemistry, Nagoya University, Nagoya, Japan
Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand
Center of Excellence in Upcycled Materials from Industrial and Agricultural Wastes, Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Sovankongkea Som

Abstract

In this study, thermoplastic starch/epoxidized natural rubber (TPS/ENR) blends were prepared at the ratios of 80/20 and 60/40 TPS/ENR by melt blending in an internal mixer, followed by compression molding. Microcrystalline cellulose (MCC) and the silane coupling agent (KH550) were incorporated to investigate the effects on the morphology, storage modulus, tan d and mechanical properties of obtained blends. SEM results revealed a uniform fracture surface with fine tear lines. For the blends without MCC and KH550, increasing the ENR content from 20 to 40 wt% reduced the tensile strength but increased the elongation at break, reflecting the greater contribution of the flexible rubber phase. The addition of MCC in combination with KH550 slightly increased in tensile strength of 80/20 blend. In contrast, the modified 60/40 blend (with MCC and KH550) exhibited lower tensile strength and storage modulus, accompanied by a marked increase in elongation at break to 207%. DMA results revealed two tan relaxation regions, suggesting that the TPS and ENR phase retained partially distinct relaxation behavior. Fracture-surface observations supported the mechanical results, revealing different deformation behavior varied with TPS/ENR ratio after adding MCC and KH550.These findings suggest that strength of TPS/ENR blends can be tailored by adjusting the blend ratio and MCC/KH550 incorporation to obtain different levels of stiffness and flexibility.

223

Physical Characterization of Waste oil Polymer Composite After Prolonged Storage

Amin S Suleiman, Anika Zafiah M. Rus, Noraini Marsi, M. Amirulhusni M.Fadzir, Nurulsaidatulsyida
Sustainable Polymer Engineering, Advance Material and Manufacturing Centre (AMMC), Faculty of Mechanical Engineering and Manufacturing, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
Fakulti Kejuteraan Mekanikal, Universiti Teknologi MARA (UiTM) Cawangan Johor, Johor, Malaysia

Abstract

This study focuses on the mechanical and physical properties of waste oil polymer (BP) and waste oil polymer composite (WOP) after Ultra-Violet (UV) irradiation exposure at extended period of time. BP and WOP exist in the form of thin film was kept in closed container estimated for 6000 hours. WOP was from BP that was doped with Titanium Dioxide (TiO2) as UV stabilizer. Universal Testing Machine was used to measure the tensile strength and the elongation at break. UV-Vis spectrophotometer was used to analyze the light absorbance spectra. The data obtained was then compared with previous study. The mechanical properties show decreases in strength except for WOP2.5 and WOP5. The UV-Vis indicate the graph peak shift from wavelength 400-500 nm range to 500-600 nm with broader range. The colours also change from yellowish to light brownish colour.

224

Theoretical Framework for BIM Personnel Competencies: A Review of Technical and Non-Technical Competencies in the Construction Industry

Ahmad Shawqee Hasan, Norliana Sarpin
Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia

Abstract

Building Information Modelling (BIM) is widely promoted as a digital transformation platform capable of improving cost, time, quality, and collaboration outcomes in construction. Yet across both advanced and developing markets, the anticipated benefits of BIM remain inconsistently realised, and a growing body of literature attributes this shortfall not to technological limitations but to deficiencies in the competency of BIM personnel. This review critically synthesises the literature on BIM personnel competency to develop an integrated theoretical account of how technical and non-technical competencies jointlydetermine BIM implementation effectiveness and benefits realisation. Drawing on Resource-Based View (RBV) and Human Capital Theory, and criticallycomparing established competency frameworks (including Succar's BIM competency taxonomy, the Technology-Organisation-Environment framework, BIM maturity models, and the BIM Benefits Realisation Framework), the review argues that BIM competency should be conceptualised as an integrated,multidimensional capability rather than mere software proficiency. The analysis identifies persistent overemphasis on technical skills, fragmented and largelydescriptive competency models, limited empirical linkage between role-specific competency and project performance, and an almost complete absence ofcontext-sensitive frameworks for developing-country and small-and-medium-enterprise (SME) settings. Building on these gaps, the review proposes a theoretically grounded conceptual framework in which technical skills and non-technical skills function as complementary organisational resources that, mediated by improvement strategies, generate BIM benefits. The review contributes a coherent theoretical narrative linking individual competencydevelopment to organisational capability and competitive advantage, and offers practical implications for construction organisations, universities and TVET institutions, and BIM certification bodies, while identifying the need for empirical validation of the proposed framework.

225

Natural Rubber Fibrous Mats via Solution Blow Spinning: Effect of Processing Parameters on Fiber Formation

Theara Yann, Yew Hoong Wong, Phanny Yos, Orathai Boondamnoen
Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand
Department of Mechanical Engineering, Faculty of Engineering, Universiti Malaya, Kuala Lumpur, Malaysia
Research Innovation Center, Materials Science and Structure, Institute of Technology of Cambodia, Phnom Penh, Cambodia
Center of Excellence in Upcycled Materials from Industrial and Agricultural Wastes, Department of Materials Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Theara Yann

Abstract

Natural rubber (NR) is an excellent flexibility, biocompatibility, biodegradability, and renewable, making it a promising material for applications in filtrationsystems, medical device, and flexible electronics. Nevertheless, the fabrication of NR micro/nanofibrous mats via Solution Blow Spinning (SBS) remainschallenging because of the high molecular weight and inherent elastic recovery of natural rubber, which adversely affect jet stability and fiber formation. In this study, the effects of NR solution concentration and key SBS processing parameters, including solution flow rate, working distance (needle-to-collector distance), and air pressure, on fiber formation and morphology were systematically investigated. At a low NR concentration of 2% w/v, the solution produced film-like deposits on the collector owing to its low viscosity and insufficient polymer chain entanglement. In contrast, increasing the concentration to 4% w/vresulted in the formation of coarse fibers with diameters of approximately 3-4 μm due to the elevated solution viscosity. Extending the working distance to 30 cm facilitated complete solvent evaporation, thereby eliminating fused fibers and improving fiber uniformity. Furthermore, increasing the air pressure to 30 psi enhanced jet stability and produced uniform, bead-free micro/nanofibers with an average fiber diameter of 1.11 ± 0.02 μm. The optimum condition of SBSwas identified as a 3% w/v NR, 10 mL/h flow rate, 30 cm working distance, and 30 psi air pressure.

226

Operating pH influencing nickel and zinc carbonation using bicarbonate-carbonate from CO_2 capture with NaOH-$CaCO_3$

Alvin Guo Jian Lee, Jaka Sunarso, Ngie Hing Wong, Lock Hei Ngu
Research Centre for Sustainable Technologies, Faculty of Engineering, Computing and Science, Swinburne University of Technology Sarawak Campus, Kuching, Malaysia

Abstract

Mitigating both global carbon dioxide (CO_2) emissions and toxic heavy-metal wastewater simultaneously poses a critical environmental challenge. This study proposes a novel, dual-function mineral carbonation approach utilizing CO_2 absorption effluent (sodium hydroxide and calcium carbonate absorbents) as a direct precipitant to remove nickel (Ni) and zinc (Zn) from simulated industrial wastewater. By replacing conventional chemical precipitants with carbonate-rich effluent, this method aims to sequester captured carbon while achieving environmental remediation. The effects of operating pH (6–12) on precipitation dynamics, heavy metal removal efficiency, and carbon mineralization (CM) efficiency were systematically investigated. Results demonstrated that operating pH is a critical parameter governing overall system performance. Nickel removal reached nearly 100 % at a neutral pH of 7 and remained highly stable, indicating an optimal thermodynamic driving force for solid-phase nucleation. In contrast, zinc removal peaked at 98.9% at pH 10 but declined under extreme alkaline conditions (pH > 10) due to amphoteric resolubilization into soluble zincate complexes. Furthermore, CM efficiency was highly effective for Ni (91.09 %) and Zn (96.53 %) between pH 6 and 9, achieving the up to highest CO_2 uptake for Ni and Zn with 0.27 and 0.58 g CO_2 uptake per g Ni and Zn precipitate, respectively; however, extreme alkalinity (pH > 10) significantly suppressed carbonation because competitive precipitation dynamics favored the formation of pure metal hydroxides over stable metal carbonates. Morphological characterizations revealed that nickel precipitated as dense, highly ordered primary crystallites, whereas zinc formed a highly amorphous, porous, and sponge-like matrix indicative of rapid precipitation kinetics. Spectral analysis confirmed a successful phase transition to stable mineral carbonates, without intermediate bicarbonate states. Ultimately, this integrated closed-loop strategy offers an economically viable and sustainable pathway for simultaneously utilizing carbon and achieving highly efficient wastewater treatment.

227

Utilisation of captured CO_2 as calcium bicarbonate with silicomanganese slag for sustainable pressed brick production

Daniel Nyuin Alfred Damu, Chung Siung Choo, Yat Choy Wong, Lock Hei Ngu
Faculty of Engineering, Computing and Science, Swinburne University of Technology, Sarawak, Malaysia
Research Centre for Sustainable Technologies, Swinburne University of Technology, Sarawak, Malaysia
Research Centre for Innovative Society, Swinburne University of Technology, Sarawak, Malaysia
Department of Mechanical and Product Design Engineering, School of Engineering, Hawthorn, Australia

Abstract

This study investigates the use of silicomanganese slag (SiMnS) as a replacement for natural sand in pressed bricks prepared with aqueous calcium bicarbonate, $Ca(HCO_3)_2$, derived from a CO_2 capture process. Five replacement levels (0 %, 25 %, 50 %, 75 %, and 100 % by mass) were tested at a fixed binder-to-aggregate ratio of 1:8. Specimens were pressed at 20 MPa and cured under ambient conditions for 28 days. Physical and mechanical properties, including gross dry density, compressive strength, water absorption, and drying shrinkage, were evaluated against BS EN 771-2:2011. X-ray diffraction (XRD) was used to identify reaction products. Compressive strength increased from 6.05 MPa at 0 % replacement to 19.02 MPa at 100 %, exceeding 15 MPa of CS15 strength class. Water absorption remained below 16 % for all mixes, well within the limits specified in BS EN 771-2:2011. Carbon storage from the $Ca(HCO_3)_2$ mixing liquid was estimated at approximately 46.58 g CO_2 per tonne of brick. XRD confirmed progressive consumption of portlandite with increasing SiMnS content, consistent with pozzolanic reaction and C-S-H formation. The results demonstrate that SiMnS combined with captured CO_2 in bicarbonate form can produce a masonry unit meeting established standards, offering a viable carbon capture and utilisation (CCU) pathway that valorises ferroalloy waste.

228

Investigating the potential of jute hurd for sustainable bio-composite construction materials

Sk Md Kamal Uddin, Israk Bin Samim, M. Harunur Rashid
Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh

Abstract

The construction sector contributes heavily to embodied carbon and greenhouse gas emissions, and that has pushed interest toward bio-based composite materials as alternatives to conventional cement and masonry. Hemp hurd is the most researched bio-aggregate, and it is what gives hempcrete its name. But hemp cultivation is still legally restricted across much of South Asia, which limits its production in this area. This study considered jute hurd instead, an abundant, currently underused by-product of Bangladesh's, as a regionally viable alternative. Reported physical and chemical properties of hemp hurd and jute hurd were reviewed and compared to work out what a bio-aggregate needs to perform well in a cementitious composite. That review shows jute hurd's cellulose, hemicellulose, and lignin content sits close to hemp hurd's, supporting the idea that it is a structurally similar aggregate. To back this up with some actual data, five cement-sand-bound "Jutecrete" mixes with varying jute hurd content were made and tested for density, compressive strength, tensile strength, and flexural strength after 28 days of curing. Density and mechanical performance both rose consistently with binder content (density ranged 965 to 1566 kg/m^3), and compressive strength ran from 0.777 to 3.843 MPa, tensile strength from 0.187 to 0.987 MPa, and flexural strength from 0.517 to 3.380 MPa, values that meet or exceed the benchmarks reported for lime-based hempcrete. These results make jute hurd look like a promising, regionally appropriate bio-aggregate to consider for more research, as its thermal performance, durability, and dimensional stability still need testing before it can be judged fully.

229

Co^{II}-Phthalocyanine-based Photoanodes for Photoelectrochemical Water Oxidation

Nichapat Parvilairut, Permsak Chairat, Patchanita Thamyongkit
Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Abstract

Herein, we present a comparative investigation of monomeric and polymeric Co^{II}-phthalocyanine (CoPc) as interfacial modifiers on a $BiVO_4$ photoanode for photoelectrochemical water oxidation. Through a photoelectropolymerization approach, the monomeric CoPc species was converted into an extended, π-conjugated polymeric framework directly on the semiconductor surface. The photoelectrochemical performance of the resulting photoanodes was evaluated and compared between the monomeric and polymeric forms, with particular attention to differences in photocurrent response and charge transport behaviour. The polymeric CoPc-modified photoanode was found to outperform its monomeric counterpart, suggesting that the extended conjugated architecture favors more efficient charge transfer at the molecular/semiconductor interface. These findings illustrate how a simple change in molecular connectivity, from discrete monomer to conjugated polymer, can meaningfully influence the behaviour of catalyst-modified photoanodes, offering a broader design consideration for future interfacial engineering of metal-phthalocyanine-based photoelectrochemical systems.

230

Mn Doping on the Structural, Surface, and Electrochemical Properties of SrTiO3 for Hybrid Supercapacitors

AHMAD AZMIN MOHAMAD, Uzair Naeem
Universiti Sains Malaysia, Nibong Tebal, Malaysia

Abstract

Strontium titanate (SrTiO3) is a promising electrode material for hybrid supercapacitors, although its practical performance is still limited by low electrical conductivity and a small number of active sites. In this work, Mn doping serves as a defect-engineering approach for tailoring the structural, surface, and electrochemical properties of SrTiO3. Powders with 0 to 3.0 mol. % Mn were synthesized hydrothermally and evaluated through structural, surface, and electrochemical characterization in three- and two-electrode configurations. All compositions preserved the cubic perovskite phase with no detectable secondary phases, and the 0.75 mol. % Mn sample showed the highest crystallinity and lattice ordering. This composition also formed a uniform nanocubic morphology with the finest particles and the largest specific surface area, 22.33 m2 g-1. Surface chemical analysis verified Mn incorporation and a higher oxygen vacancy concentration, which enhanced charge transfer and created extra electrochemically active sites. The optimized sample achieved 165.23 F g-1 at 5 mV s-1 and 113.05 F g-1 at 0.5 A g-1, and the assembled hybrid device (MS 0.75//AC) attained 13.64 Wh kg-1 at 345 W kg-1 with stable cycling across 10,000 cycles.

231

Surface-functionalized MXene (f-MXene) towards energy storage

Insik In
Korea National University of Transportation, Chungju, Korea, Republic of

Insik In

Abstract

MXenes, particularly $Ti_3C_2T_x$, have attracted considerable attention for energy-storage applications because of their high electrical conductivity, hydrophilic surfaces, and tunable interlayer structures.

However, oxidation, restacking of nanosheets, limited dispersion stability, and insufficient interfacial compatibility with other electrode components remain major challenges for their practical utilization. In this work, we explore surface functionalization as a versatile strategy to overcome these limitations while preserving the intrinsic electrical properties of MXenes. Catechol-based small molecules and polymeric ligands are employed as surface modifiers through strong noncovalent interactions with $Ti_3C_2T_x$ surfaces.

By tailoring the chemical functionality of the ligands, the oxidation stability, solvent dispersibility, interfacial adhesion, and interlayer environment of MXene can be systematically controlled. Such surface-functionalized MXenes provide improved integration with active materials and polymeric binders while maintaining continuous conductive pathways. In addition, functional groups introduced into the interlayer galleries can regulate ion transport and surface redox processes, offering further opportunities for electrochemical energy storage.

Representative applications in battery electrodes and related energy-storage systems demonstrate that surface chemistry is a powerful tool for tuning MXene performance beyond its pristine state. These results highlight surface-functionalized MXenes as a promising platform for designing stable, processable, and multifunctional electrode materials for next-generation energy-storage technologies.

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