Plenary Talk
Can the FFC Cambridge Process Enable Green Steelmaking?

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Abstract: Iron and steels have been made and used for various purposes in human history since more than 3000 years ago [1] and form one of the strongest cornerstones supporting human civilization. The fundamental chemistry of iron- and steelmaking is known as carbothermic reduction in which the refined iron ore (> 90 wt% Fe_2O_3) is reduced to iron by carbon (coke) at elevated temperatures (up to 1700 ºC). The energy consumption in modern industry is about 5 kWh/kg-Fe or lower. As a result, iron- and steelmaking together have reached possibly the highest production volume and the lowest market prices amongst most, if not all, manmade materials. Nevertheless, the use of carbon as the reductant means emission of CO_2. In theory, the emission as the mass ratio of CO_2/Fe is 3:5, but the industrial ratio is 8:5, accounting for ca. 10% of global CO_2 emission. To reduce or avoid CO_2 emission, it is possible to use a non-carbon and affordable reductant, such as the H_2 gas that can be produced by renewable energy driven electrolysis of water, which is currently a hot topic in both academia and industry [2,3]. Alternatively, electrochemical reduction of Fe_2O_3 in solid, or dissolved in molten oxides or aqueous alkaline (to avoid H_2 evolution) electrolytes is theoretically more efficient because of its one step nature. This presentation reviews selected laboratory efforts in direct electro-reduction of solid Fe_2O_3 to Fe powder in molten salts [4,5] and the commercial prospects of this process which is known as the FFC Cambridge process and was co-invented by Fray, Farthin and Chen in the University of Cambridge more than two decades ago [6,7]. It has been studied in laboratories around the world for both fundamental and applied purposes and commercially exploited for making expensive metals and alloys such as titanium and tantalum and their alloys. Its potential for large cale and green iron- and steelmaking is only recently promoted in literature [8,9].

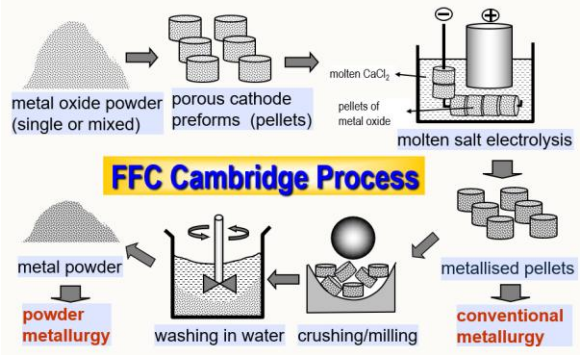


Fig. 1. Flow diagram of the FFC Cambridge

Keywords: FFC Cambridge process, ironmaking, steelmaking, electrolysis, molten salts.

Acknowledgement: I thank the EPSRC, Innovate UK, Royal Society, industrial sponsors, and families of students for financial support, and also past and present co-workers whose names appear in the references cited below and in the presentation for their hard work and valuable contributions.

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Keynote talk

Clean interfaces based on 2D semiconductors

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Two-dimensional (2D) semiconductors, specifically monolayer transition metal dichalcogenides (TMDs), have attracted tremendous interest due to their fundamental merits in transistor scaling. However, the main challenge for realizing high-performance field effect transistors (FETs) on monolayer TMDs is that the atomically thin TMDs are very sensitive to any perturbation at the metal/semiconductor and semiconductor/dielectric interfaces. In this talk, I will introduce our work on realizing clean van der Waals contacts for FETs on atomically thin TMDs [1, 2]. Further, I will discuss our recent work on investigating how the interface interactions between monolayer TMDs and dielectrics influence the device performance [3].

[1] Nature, 568, 70–74 (2019)

[2] Nature 610, 61–66 (2022)

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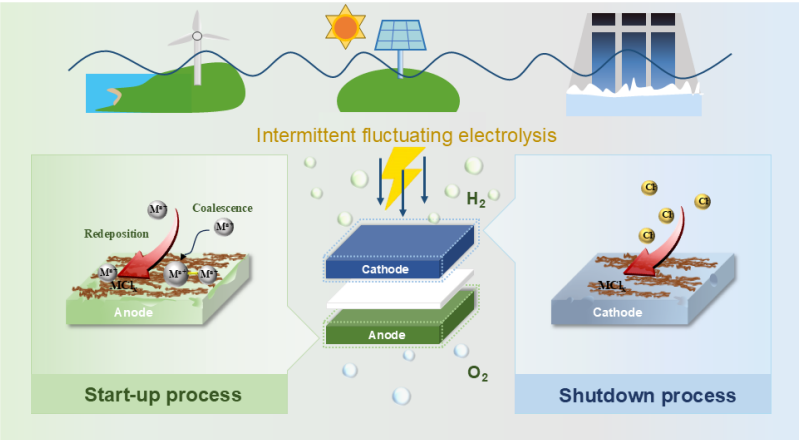
Invited talk 1
Combating Corrosion in Dynamic Water Electrolysis: The Key to Scaling Up Green Hydrogen

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Abstract
As a clean and renewable energy source, hydrogen is gradually becoming a cornerstone in developing future energy systems. Green hydrogen, generated by electrolysis driven by renewable energy, has gained significant attention. Due to the inherent intermittency of renewable energy, electrodes face serious corrosion challenges during the electrolysis process. Specifically, voltage fluctuations can lead to the dissolution, migration, deposition, and coalescence of anode and cathode, thereby reducing catalysis activity and stability. When the current suddenly increases, a large number of bubbles form on the electrode surface. These bubbles cover the catalytically active sites, increasing the resistance of the catalytic reaction. More seriously, due to the uneven distribution of reactions across the electrode surface, localized hot spots are generated, which accelerate the localized degradation of catalysts. Additionally, the unstable power and the corrosive electrolytes will make components of the affiliated pipeline and container corroded, too. The detailed analysis in this presentation covers the corrosion mechanisms and failure cases of the cathode and anode in the electrolyzer, as well as the corrosion factors and failure cases of the main components of the affiliated pipeline and container. It also introduces newly developed anti-corrosion methods targeting increase the lifetime and stability of water electrolyzer.

Keywords: Green hydrogen, Corrosion, Water electrolysis

Graphic / Image (Optional)



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Y.Zh. Li, L.D. Li, B. Lin, J.Ch. Qiao, H.L. Zhang, T.G. Zhou, Y.Y. Wang, J.L Tang*, T. Wada, H. Kato, Degradation mechanism of self-supported high-entropy metallic glass cathode in fluctuating renewable energy-powered acid water electrolysis, Corrosion Science, 236, 2024, 112223.

Biography of Professor Junlei Tang



Dr. Junlei Tang is a National Distinguished Professor (Young Changjiang Scholar), professor at Southwest Petroleum University, Director for Sustainable Energy, China-Iraq Belt and Road Joint Laboratory on Oil and Gas Energy.

His research interests include advanced materials and renewable energy, specifically hydrogen energy technologies such as advanced electrolyzers for seawater hydrogen production, hydrogen storage, and corrosion within oil and hydrogen energy systems. He is the Chief Scientist for the National Key R&D Project of China “Research on Key Technology and Equipment Integration and Application of Megawatt-Class Fluctuation-Resistant Direct Electrolysis of Seawater”. In recent years, Dr. Tang has led 6 national projects, 17 provincial and ministerial projects, and over 20 corporate-funded projects. He holds more than 20 national patents, has authored 3 monographs, published over 130 peer-reviewed papers, and contributed to 1 National Standard. His contributions have been recognized with 6 Scientific Research Achievement Awards at the national and provincial levels.

Invited talk 2
Interfacial Chemistry and Stress-Driven Nanotopography Evolution of Metallic Implants

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Abstract

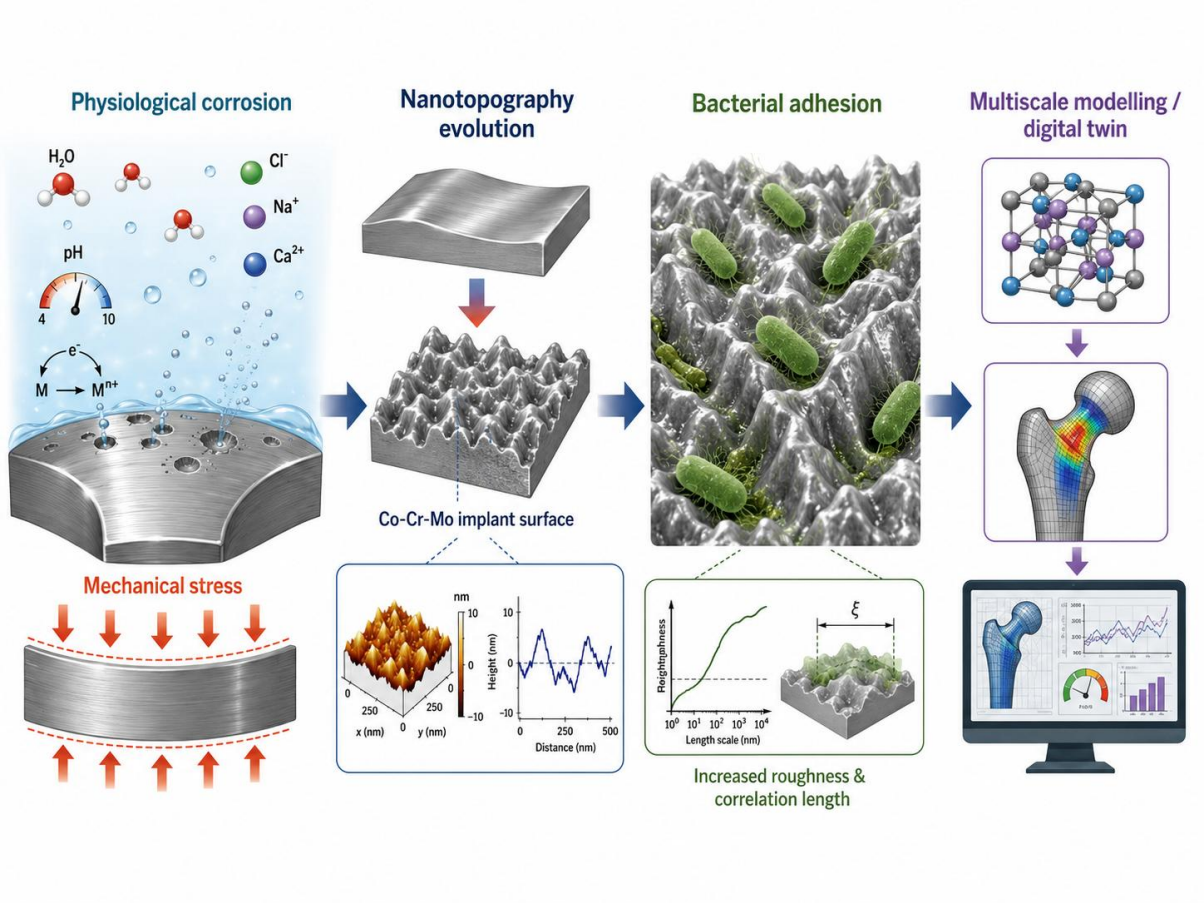
The surface of a metallic implant is a dynamic interface where chemical, mechanical and biological processes interact across multiple length scales. Implant-associated infection is strongly influenced by bacterial adhesion, for which surface nanotopography is an important controlling factor. This work examines the evolution of metallic implant surfaces under the coupled effects of physiological corrosion and mechanical stress. A continuum model based on interfacial energy, electrochemical driving potential and elastic strain energy predicts the time-dependent evolution of nanoscale surface roughness. For Co–Cr–Mo implants, the analysis identifies competing regimes of surface smoothing and stress-driven roughening; sustained high stresses can increase both RMS roughness and surface correlation length, creating conditions more favourable for bacterial retention.

The work is placed within a broader multiscale framework for interfacial science. Earlier atomistic–continuum studies demonstrated how interatomic bonding, local interface structure and continuum loading can be coupled across nanoscopic and macroscopic scales. More recent molecular-dynamics simulations of rough solid interfaces further show that nanotopography is not merely an outcome of surface evolution, but can itself alter local stress concentration, friction, temperature and atomic structural change. Together, these results suggest a feedback between interfacial chemistry, mechanics and evolving surface morphology.

Looking forward, recent physics-informed digital-twin methodologies provide a route for integrating mechanistic models with measurements and data assimilation. Such approaches may enable predictive, multiscale digital representations of implant interfaces for monitoring surface evolution and assessing conditions associated with bacterial adhesion.

Keywords: Interfacial chemistry; Metallic implants; Surface nanotopography; Stress-assisted corrosion; Multiscale modelling

Graphic / Image



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Invited talk 4

Zirconia–Halloysite Nanotube Composites for the Removal of Arsenic Species from Water: Adsorption Performance and Mechanism

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Abstract

Arsenic contamination in water is a major environmental concern, while the practical use of nanoscale adsorbents is often restricted by particle agglomeration and difficulties in their separation and recovery. In this study, halloysite nanotubes (HNTs) were employed as a natural support for zirconia nanoparticles to develop a ZrO_2/HNTs composite for the removal of inorganic arsenic species from water. The structure and morphology of the composite were characterised, and the adsorption behaviour of both As(III) and As(V) was systematically investigated through kinetic, equilibrium, thermodynamic and solution-chemistry studies. Hydrothermal synthesis enabled monoclinic ZrO_2 nanoparticles to be uniformly distributed on the external surface of HNTs. The resulting composite showed rapid adsorption of both arsenic species. As(III) adsorption reached equilibrium within 100 min, with a maximum Langmuir adsorption capacity of 36.08 mg g^{-1} at 25 °C, while As(V) adsorption reached equilibrium within 30 min with a maximum capacity of 27.46 mg g^{-1}. The adsorption kinetics of both species were well described by the pseudo-second-order model. As(III) adsorption was only weakly affected by solution pH, whereas As(V) adsorption decreased markedly with increasing pH. Common ions present in natural water had little effect on arsenic adsorption, except phosphate, which significantly inhibited arsenic uptake. Spectroscopic analyses and adsorption modelling indicated that surface Zr–OH groups acted as the principal active sites. Arsenic removal occurred predominantly through ligand exchange and formation of inner-sphere surface complexes. These findings demonstrate that supporting ZrO_2 on halloysite nanotubes is an effective strategy for improving nanoparticle dispersion while maintaining strong arsenic adsorption performance, providing a promising material platform for water treatment applications.

Keywords:

Zirconia; Halloysite nanotubes; Arsenic; Adsorption; Water treatment

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Invited talk 5

Analysis and Identification of Intracellular and Extracellular Enzymes of Thiobacillus Denitrificans and Their Effect on the Corrosion of EH36 Steel by Sulphate-Reducing Bacteria

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Abstract

The phenomenon that microorganisms accelerate the corrosion process of materials is collectively referred as microbiological corrosion. The primary microorganisms responsible for this corrosion are sulphate-reducing bacteria (SRB), and identifying effective methods for their control is key to addressing metal protection issues. This study demonstrates that Thiobacillus Denitrificans (TDN) has an inhibitory effect on the corrosion of metals caused by SRB.

In this work, various analytical techniques including scanning electron microscopy (SEM) analysis, the weight loss method, liquid chromatography–mass spectrometry (LC-MS) and electrochemical testing are conducted to investigate the composition of intracellular and extracellular enzymes in TDN, as well as their effect on SRB-induced corrosion of EH36 steel. The results indicate that SRB cells are rod-shaped, approximately 1 μm in length and 0.4 μm in diameter; TDN cells are smaller and rod-shaped, measuring 400–600 nm in length and 200–400 nm in diameter. In the analysis of the intracellular and extracellular enzyme composition of TDN, LC-MS detected a total of 11 extracellular enzymes, of which phosphate-binding proteins and glyceraldehyde-3-phosphate dehydrogenase are found to inhibit the expression of SRB protein (enzyme) activity; 51 intracellular enzymes are identified in TDN, of which 41 are enzymes that regulate normal bacterial life processes and metabolism, whilst 10 have not been previously reported. Based on mass loss experiments and electrochemical impedance results, it can be concluded that these 10 previously unreported intracellular enzymes of TDN exert a certain inhibitory effect on the corrosion of EH36 steel by SRB.

Keywords: Thiobacillus Denitrificans; Sulphate-reducing bacteria; Intracellular and extracellular enzymes; Liquid chromatography–mass spectrometry

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Invited talk 6

Aqueous Battery Electrolytes Beyond the Solvation Default: From Solvation Structures to Interfacial Ion Accessibility

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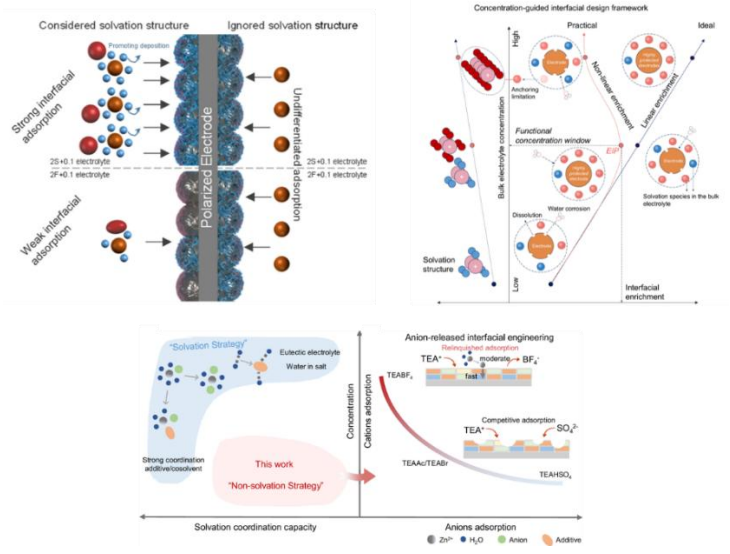
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Abstract

Electrolyte engineering is central to aqueous battery design, and performance improvements are often attributed to bulk solvation restructuring. Yet electrochemical reactions ultimately occur at the electrode interface, so the key question is how species defined in the bulk become functional interfacial species. This contribution synthesizes three studies that reveal distinct solvation-to-interface pathways. First, in Zn-Mn sulfate/sulfonate electrolytes, the nominal Mn^{2+} faradaic reaction is unchanged, but the kinetics differ strongly. Treating the complete solvation structure as the interfacial reactant resolves this discrepancy: stronger specific adsorption of sulfate-associated solvated species enhances Mn redox and Zn deposition kinetics. Second, in aqueous Al-I batteries, increasing chloride does not monotonically strengthen protection. Chloride-rich Al solvation motifs sequester choline in the bulk, so excessive additive content reduces interfacial accessibility and weakens polyiodide confinement, defining a functional concentration window. Third, for 10 mM tetraethylammonium-based additives in 2 M $ZnSO_4$, the bulk Zn^{2+} solvation shell remains nearly unchanged, yet counter-anions strongly regulate performance by competing with TEA^+ for Stern-layer access and thereby altering interfacial population and SEI kinetics. Together, these results show that solvation structure and interfacial behavior are related but not equivalent. Electrolyte formulations may regulate bulk coordination, interfacial accessibility, or both. We therefore suggest evaluating bulk solvation deviation and interfacial restructuring as complementary dimensions to clarify how bulk solvation motifs evolve into functional interfacial species.

Keywords: Aqueous batteries; Solvation structure; Interfacial ion accessibility; Electric double layer; Electrolyte additives



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Invited talk 7
Spatially confine cobalt species within mesopores of iron-nitrogen doped carbon catalyst to boost the dual activities to oxygen reduction and evolution reactions

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Abstract

Rechargeable zinc-air batteries (RZABs) usually use precious-metal-based Pt/C and RuO_2 or IrO_2 to catalyse the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER), respectively, occurring on the air electrode during the discharge and charge processes. The high cost and low reservation of the precious metals restrict the wide utilization of the technology. In recent decades, the transition metal and nitrogen co-doped carbon materials (M-N-C) have gained intensive attentions as the catalysts toward ORR. Beside the superior ORR performance, the OER activity of M-N-C has also been demonstrated in recent investigations. However, the OER activity of M-N-C is usually accepted as a subsidiary property of ORR and the intentional regulation on the OER performance is rarely considered.

In this work, a secondary modification strategy is used to control cobalt species within porous lignin-derived iron-nitrogen-doped carbon (Fe-N-C) to develop a highly active bifunctional oxygen electrocatalyst. First, porous Fe-N-C with a nest-like iron and nitrogen co-doped carbon framework (G-FeLgN) showing predominant ORR activity is prepared by carbonizing lignin with carbon nitride and iron chloride. Then, cobalt species are introduced within the mesopores of the G-FeLgN matrix, and through confined reduction by a second pyrolysis step to introduce highly dispersed active sites that contribute effectively to OER. The super activity and stability of the formed bifunctional oxygen electrocatalyst (G-FeLgN900Co) are recorded by both RDE measurement in liquid electrolyte and zinc-air battery test. The catalyst demonstrates an ORR half-wave potential of 0.918 V and an OER overpotential of 1.631 V at 10 mA cm^{-2}, as well as a higher discharge voltage (1.28 V) and a lower charge voltage (2.12 V) compared to the benchmark Pt/C+RuO_2 (1.21 V, 2.36 V), demonstrating the significantly improved rechargeability under practical operating conditions.

Keywords: Oxygen reduction reaction; oxygen evolution reaction; bifunctional catalyst; nitrogen-doped carbon; cobalt confinement

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Talk 1
Platinum Nanowire-Coated Porous Transport Layers with Improved Interfacial Contact for Enhanced Performance of Proton Exchange Membrane Water Electrolyser

Liqiu Liu[a], Xiaoqiang Zhang[b], Yichang Yan[a*], Meng Cao[c], Geng Qiao[b], Shaoliang Guan[d], Yu-Lung Chiu[e], Shangfeng Du[a*]

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Abstract

Proton exchange membrane water electrolysis (PEMWEs) has emerged as a promising technology for sustainable hydrogen production.[1] The porous transport layer (PTL), located between the catalyst layer and the bipolar plate, plays a crucial role in electrolysers and has multiple functions. Platinum coatings are widely used for anodic titanium PTLs to suppress titanium passivation and mitigate performance degradation.[2] However, the influence of Pt coating architecture on the PTL/catalyst layer interface and electrolyser performance remains poorly understood. In this work, a platinum nanowire (PtNW) array coating is grown on Ti felt PTLs via a facile chemical reduction strategy and systematically compared with Pt thin films prepared by physical vapour deposition (PVD) and Pt nanoparticle coatings prepared by electrodeposition. Comprehensive structural and electrochemical characterisations are conducted to elucidate the structure-performance relationship of the coated PTLs.

The PtNW coating forms a highly interconnected and rough nanowire network, enabling excellent surface coverage and hydrophilicity at ultra-low Pt loading (0.212 mg_{Pt}/cm^2) compared to conventional >2 mg_{Pt}/cm^2 for commercial PTLs. The Pt nanowire-coated PTL exhibits a superior performance in the PEMWE single cell test, recording an improvement of 50 mV at 2 A/cm^2 and a comparable degradation rate compared to the commercial Pt-coated Ti felt, which is attributed to the improved interfacial contact with the catalyst layer and corrosion resistance. Post-mortem analysis further revealed that the PtNW architecture better preserved the PTL/CL interfacial morphology after long-term operation. This Pt nanowire strategy provides a promising pathway towards low-Pt-loading, durable, and high-performance PTLs for next-generation PEMWE systems.

Keywords: Porous transport layer, platinum coating, water electrolysis, corrosion.

Graphic / Image (Optional)

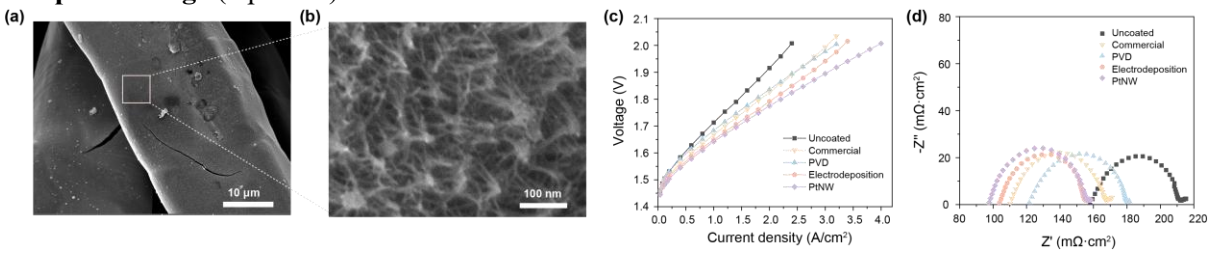


Figure 1*(a)(b) SEM images of a PtNW-coated PTL, (c) polarisation curves of PEMWE single cells with different PTLs, and (d) Nyquist plots at 0.5 A/cm².*

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Talk 2
Decoupling Iodine Conversion from Hidden Chloroaluminate Intercalation Enables Ultrafast and Ultralong-Life Aluminium–Iodine Batteries

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Abstract

Fast-charging batteries require electrochemical reactions that combine high-capacity redox couples with rapid charge transfer and ion transport. In chloroaluminate ionic liquid electrolytes, $AlCl_4^-$ intercalation into carbon cathodes supports minute-level charging but stores limited specific capacity, whereas confined iodine conversion is fast, being limited by neither solid-state ion diffusion nor reconstructive phase transitions and can store the charge through multiple electrons per iodine.[1]-[6] Aluminium–iodine (Al-I_2) batteries should therefore unite the two attributes. We show that the key limitation arises from electrode architecture rather than iodine chemistry alone. Carbon paper current collectors store $AlCl_4^-$ within the same potential window as iodine redox and produce a stable plateau capacity that can be mistaken entirely for the halogen redox chemistry. Operando Raman spectroscopy and relaxation time analysis trace this apparent iodine capacity to the collector itself. Free-standing I_2@carbon films remove the carbon paper current collector and reveal a fast, multi-electron iodine conversion spanning I^-, I_2 and I–Cl interhalogen species, which retains 86.7% of its capacity over 250,000 cycles at 30 A g^{-1}. Based on the mass of iodine active materials, the film delivers 385 Wh kg^{-1} at 3.5 kW kg^{-1} and retains 88 Wh kg^{-1} at 26.4 kW kg^{-1}, highlighting a material combination of high-rate output and high redox capacity. Beyond demonstrating a fast-charging Al-I_2 battery, these results make the case that bare-collector controls, full-mass normalization, and operando speciation analysis belong in the standard evaluation of conversion cathodes on carbon scaffolds.

Keywords: fast-charging Al-I_2 battery

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Talk 3
Mechanistic Insights and Process Optimization of Ni-Fe Catalyzed Pyrolysis of Waste Plastics into Carbon Nanotubes and Hydrogen

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Abstract

The substantial accumulation of waste plastics creates an urgent need for efficient technologies to convert plastic waste into value-added products. Catalytic pyrolysis over low-cost transition-metal catalysts provides a promising route for the simultaneous production of hydrogen (H_2) and carbon nanotubes (CNTs). However, their catalytic activity and stability under diverse conditions over Ni-Fe catalysts system remain insufficiently understood. In this study, Ni-Fe bimetallic catalysts were employed to convert waste plastics into CNTs and H_2 in a two-stage fixed-bed reactor. The effects of Ni-Fe ratio, catalytic temperature, gas flow rate, catalyst-to-feedstock ratio, and plastic type were systematically investigated. Compared with monometallic Ni- and Fe-based catalysts, Ni-Fe bimetallic catalysts exhibited a pronounced synergistic effect. Fe-rich catalysts promoted carbon deposition and H_2 production, while an appropriate Ni content enhanced graphitic carbon formation and CNTs structural quality. Fe-rich catalysts enhanced total carbon deposition and H_2 generation, while an optimized Ni content increased the proportion of graphitic carbon in total carbon production. The highest H_2 production of 28.49 mmol $g^{-1}_{plastics\ PP}$ with yield of multi-walled CNTs of 25.10 wt.% was achieved under optimized conditions (Ni:Fe mass ratio of 1:3, catalytic temperature of 700 °C, flow of 50 mL min^{-1} and catalyst-to-feedstock ratio of 1:2). Further comparison among polyolefin, polystyrene, and polyester plastics revealed distinct feedstock-dependent carbon formation behaviours, while comprehensive Raman analysis clarified differences in graphitization degree and interlayer stacking. This work correlates catalysts performance with carbon structure evolution and advances the understanding of plastic feedstock-dependent CNTs formation over Ni-Fe catalysts, providing insights for the rational optimization of plastic upcycling toward H_2 and high-value carbon materials.

Keywords: Carbon nanotubes; plastics pyrolysis; waste plastics; hydrogen; Ni-Fe catalysts

Talk 4

Water serves as a charge-transfer medium for ultrafast aqueous batteries

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Abstract

Charge storage in aqueous batteries is commonly understood through an ion-centric picture, in which metal ions or pre-existing protons transport and compensate charge. However, conventional metal-ion diffusion and proton insertion do not fully account for seconds-level kinetics, strong cation–electrode specificity, and experimentally detectable proton signatures observed at the low equilibrium proton concentrations in aqueous metal-ion batteries. In this Perspective, we propose that interfacial water can serve as a charge-transfer medium under certain conditions, with ultrafast kinetics arising from the cleavage and reorganization of water at electrode–electrolyte interfaces. In this framework, water-derived protons provide charge compensation through insertion processes and the formation and relaxation of short-lived water-derived intermediates reportreflect the activation of water cleavage. We outline the working principles of ultrafast charging behaviour mediated by interfacial water and its positioning among known fast charging pathways in aqueous batteries; the physical origin and tunability of interfacial water cleavage; and transient spectroscopic tools capable of resolving the evolution of short-lived water-derived intermediates. Finally, we discuss the implications of this interfacial-water-centred view for electrode and device design and for high-power aqueous energy-storage applications.

Keywords: aqueous batteries, water splitting

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Jie Chen, Guanjie He*. Nature Reviews Materials, accepted (in press)

Talk 5

Electrified Carbon-Neutral Methanol Production Pathways: A Multiscale Techno-Economic-Environmental Assessment Based on the UK Energy System

Yuanjing Zhao[a], Shiyu Wang[b], Grazia Leonzio[c], Jin Xuan[a], Huajie Yin[d,*], Lei Xing[a,*]

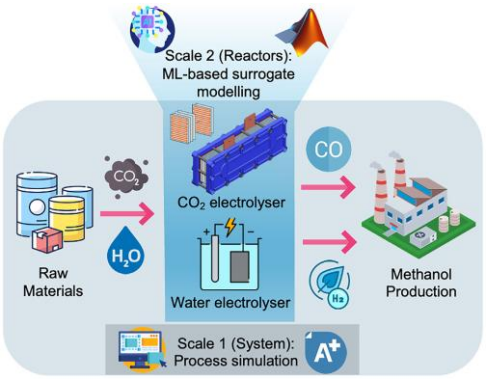
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Abstract

Electrified methanol could couple captured CO_2 with renewable electricity, but its viability depends on interactions across electrolysis, process integration, economics and life-cycle impacts[1]. We develop a multiscale framework that embeds symbolic-regression surrogates for CO_2-to-CO and alkaline water electrolysers into Aspen Plus flowsheets. Three UK pathways are compared: two-step CO_2 hydrogenation using green H_2, three-step CO_2 electrolysis plus green H_2 and methanol synthesis, and conventional steam methane reforming. The framework predicts operating-condition-dependent Faradaic efficiency, conversion, current density, stack voltage and hydrogen crossover, then evaluates mass and energy balances, costs, investment performance and environmental impacts. Under current conditions, the conventional route has the lowest production cost (US$0.44 kg^{-1}), whereas the two- and three-step routes cost US$0.71 and US$0.68 kg^{-1}. Electrolysers contribute 35–43% of CAPEX and electricity 64–67% of OPEX in the electrified routes. The two-step route delivers the highest energy efficiency (49.34%) and a 2024 global warming potential of 0.71 kg CO_2-eq kg^{-1}. The three-step route achieves the highest system conversion (85.85%) and methanol output (144,186 t y^{-1}), with a comparable 2024 climate impact (0.76 kg CO_2-eq kg^{-1}). Under projected UK grid decarbonisation and the adopted CO_2-uptake accounting, its apparent cradle-to-gate global warming potential reaches −1.20 kg CO_2-eq kg^{-1} by 2050. Electricity price, electrolyser cost and system conversion therefore govern the transition to commercially viable low-carbon methanol.

Keywords: Green methanol; electrochemical CO_2 reduction; symbolic regression; techno-economic analysis; life-cycle assessment

Graphic / Image



Hierarchical multiscale modelling framework for electrified methanol production [2].

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Talk 6

Synergistic interaction of quaternary ammonium cations and inorganic anion clusters enabling long-cycling static aqueous zinc-bromine batteries

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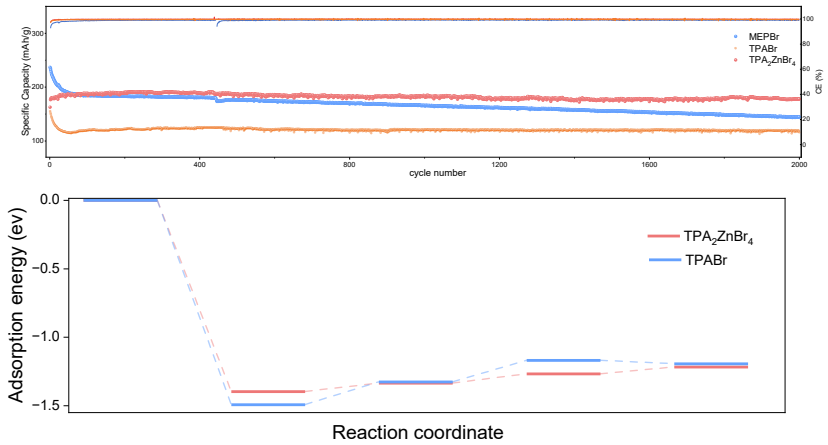
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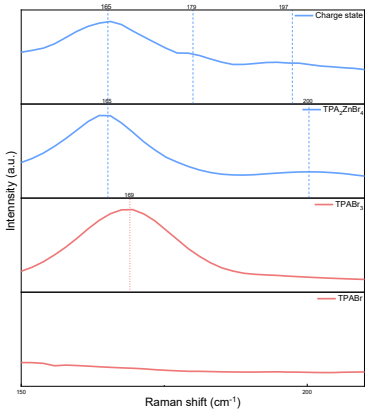
Abstract

Quaternary ammonium salts have been widely employed as electrolyte additives and electrode materials in zinc–bromine batteries, where they can complex with bromine species and thereby mitigate bromine crossover. However, symmetric alkyl-chain quaternary ammonium salts, such as tetrapropylammonium bromide (TPABr), exhibit limited applicability due to their low co-solubility with zinc bromide in aqueous electrolytes, resulting in the formation of precipitates. In this work, we demonstrate that the precipitate formed from TPABr and zinc bromide is electrochemically redox-active and exhibits distinct performance advantages. Notably, the resulting system achieves stable capacity retention over prolonged cycling. Furthermore, theoretical calculations and comprehensive characterization were conducted to elucidate the underlying reaction mechanism and understand the origin of its electrochemical activity.

Keywords: zinc aqueous battery， zinc-bromine battery ， Quaternary ammonium salts

Graphic / Image (Optional)





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Talk 7

Relay Catalysis Enabled by Spatially Differentiated Pair-atom Sites for Industrial Nitrate-to-Ammonia Electrosynthesis

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Abstract

Electrocatalytic nitrate reduction reaction (eNO_3RR) provides a promising route for sustainable ammonia production while mitigating nitrate-contaminated wastewater. However, the efficient conversion of nitrate to ammonia remains challenging because conventional single-site catalysts generally exhibit limited capability to independently regulate oxygenated and hydrogenated intermediates throughout the multistep proton-coupled electron transfer process. Herein, we propose a spatially differentiated pair-atom relay catalysis strategy consisting of the neighboring Ni and Co centres embedded within an N-doped carbon framework on the Cu foam (DA NiCo-NC@Cu). The electronic coupling between adjacent Ni and Co atoms induces asymmetric charge polarization and site-dependent orbital interactions, enabling sequential regulation of NO_x activation and NH_x hydrogenation during eNO_3RR. In particular, the Co-associated region preferentially promotes the adsorption and activation of oxygenated intermediates, while the Ni-associated region facilitates subsequent hydrogenation and NH_3 desorption. Combined in-situ FTIR and DFT investigations reveal that such asymmetric electronic coupling accelerates intermediate migration and suppresses nitrite accumulation through a relay catalytic pathway. Benefiting from this mechanism, the DA NiCo-NC@Cu foam achieves a high NH_3 Faradaic efficiency, an NH_3 yield rate, and industrial-level current density with an excellent long-term durability. These findings demonstrate how asymmetric dual-atom electronic structures can be exploited to decouple elementary reaction steps and improve the efficiency of complex electrochemical reduction reactions.

Keywords: NO_3RR, single-atom, wastewater treatment

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Talk 8

Sustainable production and optimization of high value compounds through biomass staged pyrolysis

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Abstract

At present, biomass pyrolysis is widely recognized as a sustainable and environmentally attractive route for converting renewable feedstock into value-added products. Biomass pyrolysis typically produces three major product fractions: char, syngas and bio-oil. Bio-oil is a highly complex mixture containing hundreds of organic compounds, making the selective production and separation of individual high-value chemicals particularly challenging. Most existing studies investigate pyrolysis as a single-stage process and generally target one specific platform chemical within the resulting bio-oil. Consequently, the development of strategies capable of selectively producing multiple high-value compounds within an integrated pyrolysis process remains an important research opportunity.

This study investigates a staged pyrolysis strategy based on temperature-dependent reaction control, with the aim of maximising the recovery of multiple high-value products from a single integrated thermal conversion process. Biomass consists primarily of cellulose, hemicellulose and lignin, which exhibit distinct thermal decomposition behaviours across different temperatures[1]. Based on this, catalysts and pretreatment approaches were selected for different pyrolysis stages to promote the selective formation of target products. Corncob was selected as the representative biomass feedstock. It was pretreated using Lewis-acid-containing solutions, including zinc chloride and ferric sulfate[2], as well as dilute sulfuric acid and nitric acid solutions[3]. Sodium carbonate and titanium dioxide were subsequently employed as heterogeneous catalysts[4]. The effects of these pretreatment and catalytic conditions on bio-oil composition were evaluated at pyrolysis temperatures of 300, 400 and 500 °C.

The results demonstrate that the staged approach can significantly enhance the selective production of several valuable compounds. At 300 °C, sulfuric-acid pretreatment of corncob resulted in a furfural selectivity of 48.6 wt%. At 400 °C, dilute-acid pretreatment increased levoglucosan selectivity to more than 15 wt%. At 500 °C, sodium-carbonate-catalysed pyrolysis promoted the formation of guaiacol, achieving a selectivity of 12.5 wt%. By integrating these three temperature stages sequentially, the staged pyrolysis process offers the potential to selectively recover three high-value compounds during a single overall thermal conversion process. Overall, these findings demonstrate the potential of staged pyrolysis as a strategy for improving the selective valorisation of biomass.

Keywords: Biomass, Pyrolysis, Catalysis

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Talk 9
Heterointerface-Enabled Photoelectrochemical Coupling in $BiI_3/BiOIO_3$ for Photo-Assisted Aqueous Zinc-Ion Batteries

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Abstract
The growing global energy demand and increasing penetration of intermittent renewable energy sources have intensified the need for efficient and sustainable energy conversion and storage technologies. The integration of photoactive materials into aqueous zinc-ion batteries (AZIBs) provides a promising strategy to directly couple solar-energy harvesting with electrochemical energy storage. However, the effective utilization of photoexcited energy is often restricted by inefficient separation and rapid recombination of photogenerated charge carriers in conventional photoelectrodes, limiting their participation in subsequent electrochemical reactions. Heterojunction engineering offers an effective approach to regulate interfacial charge migration and improve photogenerated-carrier utilization. Herein, a $BiI_3/BiOIO_3$ heterostructure is constructed as a photoactive cathode for photo-assisted AZIBs. The heterointerface between BiI_3 and $BiOIO_3$ is designed to promote the separation and migration of photogenerated charge carriers, thereby increasing their availability for interfacial electrochemical reactions. Structural and spectroscopic characterizations, including X-ray diffraction, Raman spectroscopy, X-ray photoelectron spectroscopy and transmission electron microscopy, reveal the phase composition, interfacial structure and electronic interactions within the heterostructure. Optical characterization further provides insights into the photoresponse and electronic structure of the coupled system. Under illumination, the $BiI_3/BiOIO_3$ heterostructure exhibits distinct electrochemical behaviour compared with dark conditions, indicating the participation of photogenerated carriers in interfacial redox processes. These results demonstrate that heterointerface engineering provides a promising strategy for improving photogenerated-carrier utilization and coupling light harvesting with electrochemical energy storage, offering new opportunities for the development of photo-assisted aqueous zinc-ion batteries.

Keywords: Aqueous zinc-ion batteries; Photo-assisted batteries; Energy storage; Heterostructures; Photoelectrochemistry

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Talk 10
Dynamic CO2 Absorption Modeling in KOH Solution: Single-Pass Gas Flow and Closed-Loop Gas Recirculation

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Abstract
Carbon capture and utilisation require absorber models capable of describing the transient coupling between gas–liquid CO_2 transfer and aqueous carbonate chemistry. Although solvent-based CO_2 capture is well established, strongly alkaline systems such as KOH involve rapid reaction with OH^-, dynamic pH changes, and redistribution of dissolved carbon among CO_2(aq), HCO_3^- and CO_3^{2-} species [1–5]. This work develops a compartment-based dynamic model for CO_2 absorption in circulating aqueous KOH solution. The bubble-column absorber is discretised into 50 axial compartments, allowing spatial and temporal variations in the gas and liquid phases to be resolved. The model combines gas-phase convective transport, CO_2 dissolution, liquid-side mass transfer with chemical enhancement, electrolyte-corrected Henry-law equilibrium, and fast carbonate speciation recovered from charge balance. The main liquid-phase dynamic variables are dissolved CO_2 and TCL, defined as the sum of bicarbonate and carbonate, while pH, total inorganic carbon and total alkalinity are calculated as outputs. Two operating cases are considered. In Case 1, fresh CO_2/N_2 gas is continuously supplied and passes once through the absorber, while the liquid is recirculated. In Case 2, both the liquid and a finite gas inventory are recirculated through the absorber and a variable-volume gas reservoir, so the inlet CO_2 fraction decreases with time. The model predicts outlet CO_2 behaviour, cumulative CO_2 uptake, absorption-rate evolution, pH and carbonate-species distributions. These outputs provide a basis for experimental validation using outlet CO_2, pH, total alkalinity and total inorganic carbon measurements, and for future integration with absorbent-regeneration and CO_2-utilisation studies.

Keywords: CO_2 absorption; KOH solution; Dynamic modelling; Gas–liquid mass transfer; Carbonate speciation

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Talk 11
Accelerating electro-thermochemical energy storage via additive manufacturing

Qiqiu Huang[a], Yongliang Li [a,*]

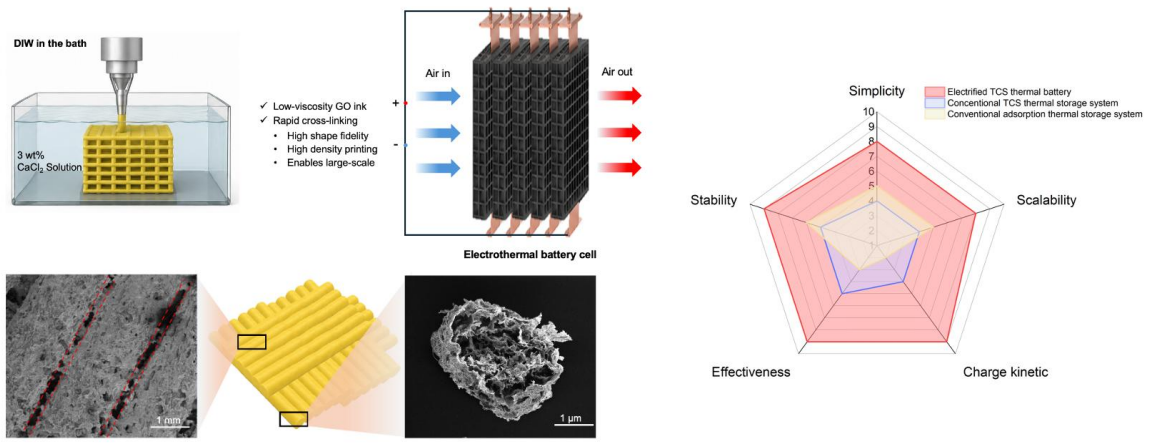
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Abstract

Thermochemical energy storage offers high theoretical energy density and low standby loss, but complexity severely limits practical density and adoption. Here we report a modular electrothermal battery that, for the first time, adopts a battery-inspired cell–module–pack architecture for electrified thermochemical energy storage. The electrothermal battery combines electrically conductive thermochemical sorbents, direct volumetric Ohmic heating, and gas-mediated heat delivery within a monolithic additively manufactured structure, eliminating external heaters and heat-transfer loops. A direct ink writing-in-bath strategy produces densely packed yet highly porous composites that enable rapid heat and mass transfer. The electrothermal battery achieves system-level volumetric energy density of 542 Wh L^{-1}, further increasing to 667 Wh L^{-1} with flash Ohmic heating, rivalling state-of-the-art electric batteries. This architecture provides a scalable route to compact, low-cost electrified thermochemical energy storage for grid-responsive and mobile heating applications.

Keywords: Electrified thermal energy storage, Thermochemical energy storage, Flash Ohmic heating, Additive manufacturing, Modular design



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Talk 12

Stabilizing Zn Anodes under Lean-Electrolyte Conditions via a Reconstructed Glass-Fibre/Cellulose Nanofibre Separator

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Abstract

Practical aqueous zinc-ion batteries require minimizing electrolyte demand and separator thickness without compromising Zn reversibility. However, conventional glass-fibre (GF) separators are typically thick and highly porous, resulting in substantial electrolyte consumption and inefficient utilization under lean-electrolyte conditions. Here, we reconstruct discarded GF offcut with 2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO)-oxidized cellulose nanofibres (TCNF) through a simple vacuum-filtration process to develop a thin and functional GF-TCNF composite separator. The composite integrates a porous GF scaffold with a hydrophilic, carboxylate-rich TCNF network, enabling efficient electrolyte distribution and regulated Zn^{2+} transport, thereby promoting uniform Zn deposition under limited electrolyte supply. With only 20 μL electrolyte, Zn||Zn symmetric cells employing the GF-TCNF separator achieve stable cycling for 1037 h at 1 mA cm^{-2}/0.5 mAh cm^{-2}, while Zn||I_2 full cells with GF-TCNF separator deliver a better capacity retention of 94.1% at 1 A g^{-1}, markedly outperforming conventional GF separators. Moreover, a GF-TCNF-based Zn||I_2 pouch cell operates stably for 350 cycles at a low electrolyte-to-capacity ratio of 8.4 μL mAh^{-1}, further demonstrating its practical feasibility under lean-electrolyte conditions. Together, these results establish an effective separator design that simultaneously reduces separator thickness and electrolyte demand while maintaining stable Zn electrochemistry under lean-electrolyte conditions.

Keywords: Aqueous zinc-ion batteries; Lean electrolyte; Separator; Cellulose nanofibres

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Talk 13

Chemical Structural Evolution of Bituminous Coal under Supercritical CO_2–H_2O Conditions: Implications for CO_2 Geological Storage

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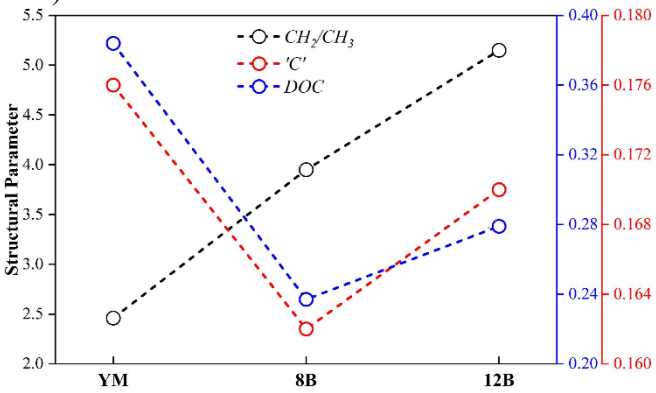
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Abstract

Supercritical CO_2 ($ScCO_2$) injection into water-bearing coal triggers physicochemical interactions that can alter coal surface chemistry and thereby influence CO_2 adsorption and transport. This study investigates the pressure-dependent chemical restructuring of low-rank bituminous coal after $ScCO_2$–H_2O exposure at 308 K and 8 or 12 MPa for 20 days. Fourier-transform infrared spectroscopy combined with peak deconvolution was used to quantify hydroxyl, aliphatic, oxygen-containing and aromatic functional groups, together with the CH_2/CH_3, 'C' and DOC structural parameters. $ScCO_2$–H_2O treatment reduced the overall abundance of functional groups without changing their main types. At 8 MPa, OH–π and O–H groups decreased by 20% and 19%, respectively, while aliphatic hydrocarbons decreased by up to 21%. The oxygen-containing groups C=O, C–O–C and C–O decreased by 12%, 22% and 21%, respectively, and declined further at higher $ScCO_2$ pressure. Aromatic substituent groups also decreased, indicating bond dissociation and extraction of organic compounds under $ScCO_2$–H_2O conditions. Meanwhile, the CH_2/CH_3 ratio increased by 61.2% at 8 MPa and increased further at 12 MPa, whereas the 'C' and DOC parameters decreased after treatment, indicating longer aliphatic chains and reduced aromatic ordering. These chemical changes weaken CO_2–surface interactions and may facilitate CO_2 desorption and diffusion, while acting together with pore-structure evolution during storage. The results reveal a pressure-dependent chemical pathway by which $ScCO_2$–H_2O exposure modifies coal sorption and transport behaviour, providing insight into the long-term performance of CO_2 geological storage in coal seams.

Keywords: Supercritical CO_2; CO_2 geological storage; Bituminous coal; Functional groups; FTIR

Graphic / Image (Optional)



References

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Talk 14

Dual-Anion Hofmeister Regulation of a Gelatin Interphase for Stable and Reversible Zn Metal Anodes

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Abstract

Aqueous Zn metal anodes fail through uneven Zn^{2+} flux, dendritic growth and hydrogen evolution.[1] Polymer interphases can suppress these failures but face an intrinsic trade-off: a dense, rigid layer mechanically confines Zn protrusions yet impedes Zn^{2+} transport, whereas a soft, highly hydrated layer conducts Zn^{2+} readily but loses mechanical confinement. Here we use the Hofmeister effect to program this trade-off, treating electrolyte anions as a structural handle on a thin gelatin interphase pre-coated onto Zn.

Kosmotropic SO_4^{2-} and OAc^- dehydrates the gelatin chains and promotes interchain association, giving a contracted, stiffer network; chaotropic OTf^- and ClO_4^- preserves chain hydration, giving a softer, water-rich and more open one. Because neither limit is optimal, we combine them: co-existing SO_4^{2-} and OTf^- yield an interphase that is robust without being over-densified and hydrated without being over-swollen. The mixed-anion coating outperforms both single-anion counterparts in Zn‖Cu reversibility and Zn‖Zn cycling stability, and shifts Zn from rough deposits to compact, uniform growth — establishing an anion → polymer network → ion transport → Zn nucleation design chain for programming biopolymer interphases in aqueous metal batteries.

Keywords: aqueous zinc batteries; Hofmeister effect; gelatin interphase

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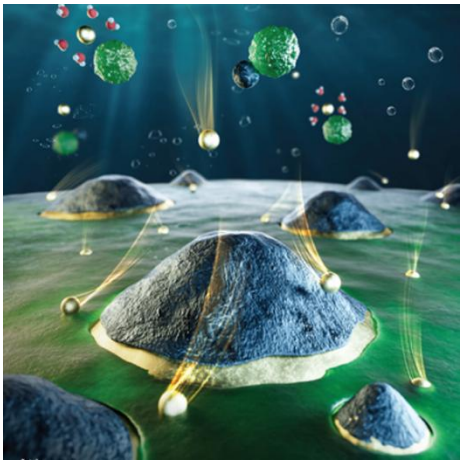
Talk 15

Unveiling Cation–Anion Synergy at the Zn/Electrolyte Interface for Ultrastable Aqueous Zinc Batteries

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Abstract
Aqueous zinc batteries are promising for next-generation energy storage owing to their intrinsic safety, abundant resources, and high theoretical capacity. However, the practical reversibility of Zn metal anodes is hindered by parasitic hydrogen evolution, interfacial by-product formation, and non-uniform Zn deposition. Previous electrolyte engineering approaches have predominantly relied on the isolated regulation of either cationic or anionic chemistry, overlooking the fundamental coupling between ionic species that governs the dynamic interplay among Zn^{2+} solvation, interfacial electric fields, and parasitic reactions at the Zn/electrolyte interface. Here, we develop potassium hydrogen phthalate (KHP) as a multifunctional electrolyte additive by integrating cationic shielding with anionic chemistry. K^+ provides electrostatic shielding to homogenize the interfacial electric field and promote uniform Zn deposition, while HP^- regulates the Zn^{2+} solvation structure by reducing the activity of coordinated H_2O and contributes to the formation of a stable interfacial layer. Meanwhile, the synergistic action of K^+ and HP^- effectively regulates the interfacial pH and suppresses parasitic reactions and by-product formation. Consequently, Zn symmetric cells achieve stable Zn plating/stripping for over 4500 and 2600 h at 1 and 5 mA cm^{-2}, respectively. Zn||I_2 full cells further maintain 78.5% of their capacity after over 1400 cycles. This work highlights the importance of synergistic cation–anion interactions in electrolyte design and provides an effective strategy for comprehensive regulation of Zn deposition and interfacial chemistry toward ultrastable aqueous zinc batteries.

Keywords: Aqueous Zn batteries, Electrolyte engineering, Solvation structure
Graphic:



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