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■ 大会报告

Plenary Report Abstracts



Dr. Jiujuun Zhang (张久俊) is a Professor and Dean of the Institute for Sustainable Energy and Dean of the College of Science at Shanghai University, and former Principal Research Officer at the National Research Council of Canada (NRC), a Member (Fellow) of The Academy of Science of the Royal Society of Canada (RSC-CA), Member (Fellow) of The Engineering Institute of Canada (EIC), Member (Fellow) of The Canadian Academy of Engineering (CAE), Fellow of the International Society of Electrochemistry (ISE), and a Fellow of the Royal Society of Chemistry (RSC). Dr. Zhang is the chairman/president of the International Academy of Electrochemical Energy Science (IAOEES). The technical expertise areas of Dr. Zhang are Electrochemistry, Photoelectrochemistry, Spectroelectrochemistry, Electrocatalysis, Fuel cells (PEMFC, SOFC, and DMFC), Batteries, and Supercapacitors. Dr. Zhang received his B.S. and M.Sc. in Electrochemistry from Peking University in 1982 and 1985, respectively, and his Ph.D. in Electrochemistry from Wuhan University in 1988. Starting in 1990, he carried out three terms of postdoctoral research at the California Institute of Technology, York University, and the University of British Columbia. Dr. Zhang holds more than 14 adjunct professorships, including one at the University of Waterloo, one at the University of British Columbia and one at Peking University. Up to now, Dr. Zhang has more than 500 publications with approximately 40000 citations, including 350 refereed journal papers, 25 edited /co-authored books, 43 book chapters, 190 conference plenary/keynotes/invited presentations, as well as over 16 US/EU/WO/JP/CA patents, and produced in excess of 90 industrial technical reports. Dr. Zhang serves as the editor-in-Chief for Springer Nature Journal of “Electrochemical Energy Reviews”, the associate editor for “Green Energy and Environment”, the editor for CRC book series “Electrochemical Energy Storage and Conversion”, and editorial board member for several international journals. Dr. Zhang is Chairman/President of the International Academy of Electrochemical Energy Science (IAOEES), an active member of The Electrochemical Society ECS), the International Society of Electrochemistry (ISE), and the American Chemical Society (ACS, as well as the Canadian Institute of Chemistry (CIC).

+ Abstract

Catalysis of Low-Temperature Electrochemical CO₂ Reduction to Produce Low-Carbon Fuels: Challenges and Perspectives

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CO₂ conversion to useful low-carbon chemicals/fuels is one of the important approaches in emission reduction. Electrochemical catalytic reduction of CO₂ to produce methanol, formic acid, CO, methane, ethanol, etc. has been proven to be feasible. However, the insufficient

durability of electrocatalysts is the major challenge in CO₂ electroreduction at low temperatures. To overcome this challenge, various catalysts have been explored including metals, metal alloys, metal complexes, etc. in the last several decades. In this presentation, several major types of electrocatalysts for CO₂ reduction are reviewed in terms of their activity, stability and product selectivity. The work of this speaker in developing novel catalysts is also summarized. Some research directions in this area are also suggested in facilitating the research and development of CO₂ electroreduction catalysts towards technology commercialization.

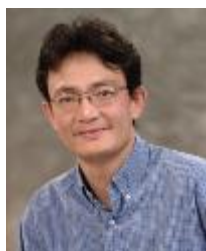


Dr. Shizhang Qiao (乔世璋), is currently a professor (Chair of Nanotechnology) at School of Chemical Engineering and Advanced Materials of the University of Adelaide. His research expertise is in nanostructured materials for new energy technologies including electrocatalysis, photocatalysis, fuel cell, supercapacitor and batteries. He has co-authored more than 398 papers in refereed journals (over 55,600 citations with h-index 121). He has filed several patents and has attracted more than 12.0 million dollars in research grants from industrial partners and Australian Research Council (ARC). Prof. Qiao was honoured with a prestigious ARC Australian Laureate Fellow (2017), ExxonMobil Award (2016), ARC Discovery Outstanding Researcher Award (DORA, 2013) and an Emerging Researcher Award (2013, ENFL Division of the American Chemical Society). He has also been awarded an ARC ARF Fellowship and an ARC APD Fellowship. Prof. Qiao is a Fellow of Institution of Chemical Engineers (FIChemE), a Fellow of Royal Society of Chemistry (FRSC) and a Fellow of Royal Australian Chemical Institute (FRACI). He is currently an Associate Editor of Journal of Materials Chemistry A, and is a Thomson Reuters/Clarivate Analytics Highly Cited Researcher (Chemistry, Materials Science).

+ Abstract

Nanostructured Electrocatalysts for Energy-relevant Conversion Processes

Replacement of precious metal catalysts by commercially available alternatives is of great importance among both fundamental and practical catalysis research. Nanostructured carbon-based and transition metal materials have demonstrated promising catalytic properties in a wide range of energy generation/storage applications. Specifically engineering carbon with guest metals/metal-free atoms can improve its catalytic activity for electrochemical oxygen evolution reaction (OER) and hydrogen evolution reaction (HER), thus can be considered as potential substitutes for the expensive Pt/C or IrO₂ catalysts in metal-air batteries and water splitting process. In this presentation, I will talk about the synthesis of nonprecious metal and metal free elements-doped graphene, and their application on electrocatalysis. The excellent OER and HER performance (high catalytic activity and efficiency) and reliable stability indicate that new materials are promising highly efficient electrocatalysts for clean energy conversion. I will also present some new research results of CO₂ and N₂ electrocatalytic reduction conducted in my research group.



Yunfeng Lu received his B.S. in chemistry from Jilin University, M.S. in polymer from the Changchun Institute of Applied Chemistry, and PhD in Chemical Engineering from the University of New Mexico. Currently, he is a professor at UCLA. His research has been focusing on the design and synthesis of materials for energy storage and conversion, as well as nanomedicines.

Chemical and Biomolecular Engineering, the University of California, 420 Westwood plaza, Los Angeles, CA 90059

+ Abstract

Material Design Towards Better Electrochemical Devices

Chemical and Biomolecular Engineering Department, the University of California Los Angeles

There are increasing demands for high-performance electrochemical-energy-storage devices, such as lithium ion batteries and fuel cells, for microelectronics, electrical vehicles, and other applications. Generally, such devices are operated through charge separation in one electrode, during which electrons and ions are transported respectively through the external circuit and the electrolyte and recombined in the other electrode, accomplished through the redox reactions occurred in the electrodes. Material design that lead to better charge separation, transport, and recombination, in this context, holds great promise towards better electrochemical-energy-storage devices. In this presentation, the design of electrode materials and electrolytes, which lead to better performance lithium-ion batteries and fuel cells will be discussed.



潘锋教授（博导）是北京大学深圳研究生院新材料学院创院院长，美国劳伦斯伯克利国家实验室高级访问科学家。1985年获北大化学系学士，1988年获中科院福建物构所硕士（师从梁敬魁先生），1994年获英国 Strathclyde 大学博士(获最佳博士论文奖)，1994-1996 年瑞士 ETH 博士后。

目前聚焦“新材料基因科学与工程（材料的“基因”探索，材料高通量的计算、合成与检测及数据库等系统工程）”的研发及用于“清洁能源及关键材料研发”，包括新型太阳能电池、热电发电、储能和动力电池及关键材料的跨学科的基础研究和应用，具有十多年在国际大公司从原创基础研究到创新产品产业化的经历。

+ Abstract

Research of “Material Genes” and Structure Chemistry for Li-ion Battery 锂电池材料基因与结构化学探索

The Green Energy R&D Center in Peking University Shenzhen Graduate School is devoted to exploring the science and engineering of “Material Genes”, which includes building material big data based on artificial intelligence as well as new chemistry paradigm based on graph theory. Aiming to reveal the structural evolution, this work is featured by considering atoms or structure motifs as dots so that the isomorphism can be identified based on how the dots are connected. In addition, the local organization, placement and dynamic evolution of structures can be measured by large-scale scientific equipment with high intensity and time-spatial resolutions (e.g. synchrotron and neutron diffraction spectrometer). By applying this new paradigm to study structural motifs and electron structures of transition metal layered oxides, it is found that the interactions between spinning electrons on d-orbitals of transition metals leads to triangle magnetic frustration and super-exchange phenomenon. It is also found that via electron sharing, 6 adjacent transition metal atoms could form an “inorganic aromatic ring” and further constitute a 2D plane. Based on this structure unit, a novel battery cathode material with excellent electrochemical performance is designed and prepared. Moreover, by establishing nano-particle electrochemical theories/methods as well as atomic-scale in-situ measurements, it is found that the truncated symmetry at the 2D interface could lead to interfacial reconstruction during electrochemical tests or material synthesis, which can be utilized in the field of lithium-ion batteries and catalysis (e.g. water splitting, nitrogen and CO₂ fixation).

北京大学深圳研究生院新材料学院材料基因与新能源材料团队一直在开展材料基因的科学和工程的探索，包括构建了基于人工智能的材料大数据系统和发展了基于图论的结构化学新范式。其特征是将原子或结构基元作为点并用点的连接方式来识别结构同构性和异构度，便于发现结构演化过程。并利用同步辐射 X 射线和中子大科学装置的高强度、高空间和时间分辨率测量结构局域排序和连接方式及其动态演化过程。运用新范式研究层状氧化物的结构基元和电子结构时发现过渡金属 d 轨道的自旋电子相互作用会形成三角磁阻挫结构及超交换相互作用。此外还发现由 6 个过渡金属原子通过电子共享形成“无机芳香环”及其单独作为结构单元或连接成二维平面，并以此作为电池正极材料

的结构单元，成功设计和制备出新型高性能电池电极材料。通过创建单纳米颗粒电化理论和实验技术及原子尺度形貌变化和组分等原位联动研究技术，发现了晶体三维结构在界面降低到二维时引起对称性破缺及在材料制备和应用的化学及电化学环境下会产生特定界面重构的规律，应用锂电池和水分解/固氮/ CO_2 等催化等领域研发。



Professor Aibing Yu specialized in process metallurgy, obtaining BEng in 1982 and MEng in 1985 from Northeastern University, PhD in 1990 from University of Wollongong, and DSc in 2007 from the University of New South Wales (UNSW). He is currently Pro Vice-Chancellor and President (Suzhou), Monash University. He has been Inaugural Director of UNSW Centre for Simulation and Modelling of Particulate Systems, Deputy Director of ARC Centre of Excellence for Functional Nanomaterials, Founding Director of Australia-China Joint Research Centre for Minerals, Metallurgy and Materials, ARC Research Hub for Computational Particle Technology, and JITRI Research Institute for

Process Modelling and Optimisation. He is a world-leading scientist in particle/powder technology and process engineering. He has made many significant contributions and is recognised as an authority in particle packing and flow, particulate and multiphase processing, and simulation and modelling. He has authored/co-authored >1,000 publications (including >700 collected in the ISI Web of Science), delivered many invited plenary/keynote presentations at various international conferences, and graduated >40 postdoc fellows and >100 PhD students. He is Editor of Powder Technology, Regional Editor of Granular Matter, and on the editorial board of ~20 learned journals. He is a recipient of numerous prestigious awards and fellowships. He was elected to Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) in 2004, and Australian Academy of Science (AAS) in 2011, and Foreign Member (Academician) of Chinese Academy of Engineering (CAE) in 2017.

+ Abstract

Powder processing in advanced material manufacturing



Dr. Hua Zhang (张华) obtained his B.S. and M.S. degrees at Nanjing University in China in 1992 and 1995, respectively, and completed his Ph.D. with Prof. Zhongfan Liu at Peking University in China in July 1998. He joined Prof. Frans C. De Schryver's group at Katholieke Universiteit Leuven (KU Leuven) in Belgium as a Research Associate in January 1999. Then he moved to Prof. Chad A. Mirkin's group at Northwestern University as a Postdoctoral Fellow in July 2001. He started to work at NanoInk Inc. (USA) as a Research Scientist/Chemist in August 2003. After that, he worked as a Senior Research Scientist at Institute of Bioengineering and Nanotechnology in Singapore from November 2005 to July 2006. Then he joined the School of Materials Science and Engineering in Nanyang Technological University (NTU) as an Assistant Professor. He was promoted to a tenured Associate Professor on March 1, 2011, and Full Professor on Sept. 1, 2013. In 2019, he joined the Department of Chemistry in City University of Hong Kong as a Chair Professor (Herman Hu Chair Professor of Nanomaterials).

+ Abstract

Phase Engineering of Nanomaterials (PEN)

In this talk, I will summarize the recent research on the phase engineering of nanomaterials (PENs) in my group. It includes the first-time synthesis of hexagonal-close packed (*hcp*) Au nanosheets (AuSSs) on graphene oxide, the first-time synthesis of 4H hexagonal phase Au nanoribbons (NRBs), the synthesis of crystal-phase heterostructured 4H/*fcc* Au nanorods, the epitaxial growth of metals with novel phases on the aforementioned Au nanostructures, and the synthesis of amorphous/crystalline hetero-phase Pd nanosheets. In addition, the first-time synthesis of 1T'-MoS₂ and 1T'-MoSe₂ crystals have been achieved. Moreover, the phase transformation of transition metal dichalcogenide nanomaterials during our developed electrochemical Li-intercalation method will also be introduced. Interestingly, the lithiation-induced amorphization of Pd₃P₂S₈ is also achieved. Currently, my group focuses on the (crystal) phase-based properties and applications in catalysis, surface enhanced Raman scattering, waveguide, photothermal therapy, chemical and biosensing, clean energy etc., which we believe are quite unique and very important not only in fundamental studies, but also in practical applications. Importantly, the concepts of phase engineering of nanomaterials (PEN), crystal-phase heterostructures, and hetero-phase nanomaterials are proposed.

■ Session I

Lithium and Sodium Batteries



Professor Chen received his BEng in Chemical Engineering from Dalian University of Technology, China, MEng and PhD degrees from McGill University in Canada. He joined the Department of Chemical and Biomolecular Engineering of The Hong Kong University of Science and Technology (HKUST) in 1994 and worked there until 2017. He has been the Head of the Department from 2012 to the end of 2016. He is now the Chair Professor of Energy Conversion and Storage at Department of Mechanical Engineering, an Associate Vice President (Research Support) concurrently at The Hong Kong Polytechnic University. Professor Chen was the 17th President of the Asian Pacific Confederation of Chemical Engineering, is the Vice President, World Chemical Engineering Council, Editor of Separation and Purification Technology. Professor Chen's recent research interests include electrochemical technologies for energy and environmental applications. Professor Chen received the Certificate of Excellence from the World Forum of Crystallization, Filtration and Drying in 2007 and the inaugural Research Excellence Award from the School of Engineering of HKUST in 2011. He was elected as a Fellow of Hong Kong Institute of Engineers, and Fellow of American Institute of Chemical Engineers.

+ Abstract

Building ultraconformal protective layers on both secondary and primary particles of layered lithium transition metal oxide cathodes

With the ever increasing demand of the high capacity batteries for power supplies, the layered lithium transition metal oxides are being explored as the cathode material to replace the conventional lithium ferrous phosphate. Despite their relatively high capacity, layered lithium transition metal oxides suffer from crystal and interfacial structural instability under aggressive electrochemical and thermal driving forces, leading to rapid performance degradation and severe safety concerns.

The transformative approach using the oxidative chemical vapor deposition technique can build a protective conductive polymer (PEDOT) skin on layered oxide cathode materials. The ultraconformal PEDOT skin facilitates the transport of lithium ions and electrons, significantly suppresses the undesired layered to spinel/rock-salt phase transformation and the associated oxygen loss, mitigates intergranular and intragranular mechanical cracking, and effectively stabilizes the cathode–electrolyte interface. This approach remarkably enhances the capacity and thermal stability of layered oxides cathodes under high-voltage operation. Building a protective skin at both secondary and primary particle levels of layered oxides offers a promising design strategy for Ni-rich cathodes towards high-energy, long-life and safe lithium-ion batteries.



Dr. Yuping Wu, a distinguished professor at Nanjing Tech University since 2015. He obtained Ph. D. from Institute of Chemistry, CAS, China in 1997. In 2003 he moved from Chemnitz University of Technology (Germany, Humboldt Fellow) to Fudan University as full professor. So far he published over 300 papers in journals such as *Energy Environ. Sci.*, *Angew. Chem. Int. Ed.*, *Adv. Mater.*, *Adv. Energy Mater.*, *Nano Lett.*, *Chem. Soc. Rev.* and *Prog. Mater. Sci.* with H-index of 73, 7 books with sales above 40000 copies, and issued 24 patents with 7 ones pending in US, EP and JP. He was awarded “National Distinguished Youth Scientists” by Natural Science Foundation of China in 2014, selected as the World's Most Influential Minds by Thomson Reuters from the Highly Cited Researchers in 2015, and won the Albert Nelson Marquis Lifetime Achievement Award in 2019.

+ Abstract

How to Improve the Crucial Safety for Lithium Batteries

Lithium batteries are increasing in energy densities. Consequently, the corresponding safety should be improved, which is mainly related to the separator. Here we will introduce the research and development of separators with high safety, and mainly about our work on the new generations of separators leading to better safety and reliability. For example, our 3G gel separator shows dominant advantages over the ceramic-coated separators in terms of safety such as weight shock, short-circuit at elevated temperature, and needle puncture. In the meanwhile, we for the first time proposed the concept of fourth generation (4G) pore-free separator, which can avoid dendrite of lithium metal and lead to charge-discharge at high current densities up to 10 mA/cm^2 for lithium metal, which can markedly solve the micro short-circuit problems, which are difficult to test even in the case of Tesla. In addition, further development will also be pointed out.



余彦，中国科学技术大学材料科学与工程系教授，博士生导师。中组部首批青年千人；国家优秀青年基金获得者，英国皇家化学会会士。Journal of Power Sources 副主编。2006 年获得中国科学技术大学博士学位，随后在美国（Florida International University）和德国马普固体研究所（Max Planck Institute for Solid State Research）从事科学研究工作。2012 年加入中科大，任教授，博导。主要研究方向为高性能锂离子电池、钠离子电池、锂硫电池等关键电极材料的设计、合成及储能机制。目前在 Science, Nature Energy, J. Am. Chem. Soc., Angew. Chem. Int. Ed., Adv. Mater., Nano Lett., Energy Environ. Sci., 等国际著名期刊上发表论文 200 余篇，以第一/通讯作者发表 SCI 论文中 IF>10 的总共 60 余篇，其中包括 Adv. Mater. 23 篇，Angew. Chem. Int. Ed. 6 篇，Nano Lett. 8 篇，ACS Nano 8 篇，Adv. Funct. Mater. 7 篇，Adv. Energy Mater. 8 篇。其中 27 篇入选 ESI 高被引论文；SCI 他引 10000 余次，H 因子 58。入选“科睿唯安”以及“爱思唯尔”材料类高被引学者榜单。获德国洪堡基金会“索菲亚奖”、中国硅酸盐学会青年科技奖、中国化工学会侯德榜科技青年奖，德国 Wiley 杂志社“Outstanding Young Researcher”，德国 Wiley 杂志社“Small Young Innovators”等奖项。

+ Abstract

合金机理储钠(钾)负极材料

近年来钠、钾离子电池成为电化学储能技术研究的热点，有望成为新一代高能量密度和低成本电化学能储能系统。然而，较大的离子半径、较慢的反应动力学等特性，其应用仍然面临着极大的挑战。目前，关于高性能钠（钾）离子电池负极材料的报道主要集中在碳基材料上，而这些基于脱嵌反应机理的碳基负极的比容量普遍低于 300 mAh/g，很难满足实际需求。开发高比容量，长循环寿命和高倍率性能的合金类负极材料具有广阔的应用前景。因此，为解决合金类负极材料在脱、嵌 Na⁺、K⁺过程中较大的体积变化效应和导电性差等问题，我们课题组近期在合金类负极材料（锡、红磷、锑、铋）开展了相关研究。首先，针对 Sb 这一合金类负极材，我们发展了纳米限域电偶置换法，成功制备出一种空心蛋黄-壳结构的 Sb@C 材料，测试表明碳壳可有效缓解 Sb 在充放电过程体积变化，促进 SEI 的稳定性，进而保持电极结构的完整性和电化学性能的稳定性。近期研究中，申请人发展了简单的液相法，合成了具有核/壳结构的 Bi@C 复合材料，表现出优异的储钠和储钾性能，同时原位透射电镜揭示核/壳结构在充放电过程中可有效地缓解体积膨胀，保证了电极结构的稳定性。接下来，对于红磷这一高比容量合金类负极材料，我们设计了一种红磷镶嵌氮掺杂中空多孔碳纳米纤维自支撑负极材料，有效的抑制了红磷的体积膨胀，获得了长循环寿命和高比容量的储钠（钾）性能，同时，原位 Raman 和非原位 XRD 分析并证实了红磷的储钾机理。



张其春博士 1970 年出生, 江苏高邮人。1988 年江苏省扬州中学毕业, 1992 年南京大学本科分析专业毕业, 1998 年中科院北京化学所物理化学硕士毕业, 2003 年美国加州大学洛杉矶分校 (University of California, Los Angeles) 有机化学硕士毕业, 2007 年在美国加州大学河滨分校 (University of California, Riverside) 无机化学博士毕业, 2007-2008 年美国西北大学 (Northwestern University) 做博士后, 2009 年受聘于新加坡南洋理工大学材料科学与工程学院助理教授。2014 年 3 月, 晋升为 新加坡南洋理工大学材料科学与工程学院副教授 (终身职位)。2014 年 12 月受聘于新加坡南洋理工大学数理学院副教授。2015 年成为固态化学副主编。2017 年当选为英国化学会会士。2016 年成为材料化学前沿, 无机化学前沿, 亚洲化学, 和材料化学(C, JMCC)顾问委员会成员。研究兴趣包括有机半导体材料的合成和自组装和它们在有机半导体器件上的应用, 以及无机半导体晶体材料的合成和应用。2018 和 2019 年, 全球高倍引作者之一。目前已在 Nature Chemistry, Nature. Commun, J. Am. Chem. Sci, Angew. Chem. Int. Ed., Chem. Sci, Advanced Energy Materials, ACS Nano, Chem Comm, Advanced Functional Materials, Org. Lett, J. Org. Chem. 等期刊上发表近 340 篇论文, 被引超 16000 次, H-index: 69。

+ Abstract

Nanostructured Conjugated Polymers as Promising Electrodes for Li-ion Batteries

Electrode materials play a critical role in approaching high energy density and long cycle life lithium-ion batteries (LIBs). The increasing concern about the traditional inorganic electrode materials on resources and environmental issues has strongly inspired scientists to switch on searching green energy electrodes. Organic compounds are potentially sustainable and renewable materials as many of them can be obtained from natural products and biomass. Additionally, the properties of organic compounds can be tuned through the modification of the structures as well as the introduction of functional groups. In this talk, I will present our recent progress on the preparation of novel conjugated polymers and their application in Li-ion batteries.



蔚海军，2003 年东北大学材料与冶金学院获学士学位；2007 年东北大学材料与冶金学院获得工学博士学位；之后在北京有色金属研究总院（2007-2010）和日本国立产业技术综合研究所（2010-2015）从事电池材料、动力电池、电池系统及电动车应用等相关科研工作，2015 年起在北京工业大学工作，组织并协调完成了北京奥运会和北京市为期一年的 2 辆燃料电池新能源客车运营项目。近年来在先进电池材料领域从事研究，在电极材料微区畴结构设计及解析、电化学过程畴结构演化与反应机制、以及畴结构比例调控与电化学性能的构效关系方面开展了系统的探索，并于 2018 年率先提出了“晶畴电池材料”概念，2019 年对“晶畴电池材料”进行了定义和三级结构分类，实现了锂/钠离子电池材料晶畴设计、晶畴解析、晶畴调控、晶畴演化到晶畴反应机制方面的系统创新研究成果，获中国材料研究学会科学技术二等奖 1 项和北京青年五四奖章，在 *J. Am. Chem. Soc.*、*Angew. Chem. Int. Ed.*、*Adv. Mater.*、*Energy & Environ. Sci.* 和 *Acc. Chem. Res.* 等国际知名能源化学期刊上发表学术论文 100 余篇，申请专利 40 项，已授权 6 项。2016 年获国家自然科学基金委优秀青年基金资助；2016 年获国家千人计划青年千人项目资助；2015 年获北京市海聚工程青年人才称号。2016 年受邀兼任国际电化学能源科学院(IAOEEs)理事，中国金属学会功能材料分会委员和中国化学学会电化学委员会委员。担任 *Journal of Material Science and Technology*(JMST)、*Rare Metals* 和 *Chinese Chemical Letters* (CCL) 期刊编委和编辑等职。

+ Abstract

晶畴电池材料

二次电池的研究重点是如何进一步提升其能量密度，尤其是对正极材料的高能量化设计方面需求迫切。电极材料的晶体/电子结构与其电化学性能密切相关，在电池材料的研究历史中，新开发电极材料的电化学性能都有其特殊的晶体结构和电子结构。目前，已开发了多种锂/钠/钾离子电池正极材料，有层状结构、尖晶石结构、橄榄石结构等。如何进一步提升锂/钠/钾离子电池正极材料的能量密度，一方面可以通过提高充电截止电压并结合掺杂元素稳定结构的方法来实现，另一方面也可以引入微区畴结构通过“晶畴调控”改变其电化学性能。针对锂/钠离子电池正极材料，我们前期对于晶畴设计、晶畴解析、晶畴调控、晶畴与电化学性能的构效关系、以及晶畴反应机制方面开展了长达 10 年的持续性实验与理论计算工作，取得了一些研究成果，对于开发新型先进电池材料具有一定的理论和实际应用指导意义。本报告将介绍晶畴电池材料在锂离子电池方面的最新工作。



Dr. Xiong (熊胜林) is the professor and doctoral supervisor of school of chemistry and chemical engineering in Shandong University and selected as the Taishan Scholar of Shandong province. He obtained the doctor's and bachelor's degrees in University of Science and Technology of China and Anhui Polytechnic University in 2007 and 2001, respectively. Then, he engaged in postdoctoral research work in University of Science and Technology of China and National University of Singapore. Since Jul. in 2011, he has worked in

Shandong University and focused on the research of fundamentals and application exploration of inorganic energy materials. In the past five years, he has published nearly 50 SCI papers as the corresponding author in the journals of *Angew. Chem. Int. Ed.*, *Energy Environ. Sci.*, *Adv. Mater.*, *Adv. Energy Mater.*, *Adv. Funct. Mater.*, *Nano Energy*, *J. Mater. Chem. A* etc. At present, the total citation is more than 8200 times, 18 papers were selected as highly cited ESI papers and the H index is 52. In Jan. 2017, he served as the young editorial board member of *Chinese Chemical Letters*. In 2018, he won the second prize of natural science of Shandong Province as the first adult and was selected as China's highly cited scholar of Elsevier. In 2019, he was selected as the highly cited researcher of Clarivate Analytics.

+ Abstract

Mesoscopic energy material chemistry

Dr. Xiong has mainly engaged in the fundamental research of inorganic energy material chemistry. Particularly, by direction of functionalization of energy storage, he has achieved the important progress in inorganic mesoscopic-scale materials. He has design and synthesized a series of carbon-based mesoscale material system based on the synthesis strategy of new structure-oriented template. 3) By optimizing the surface structure and electronic structure of their active sites, the electrochemical performance including LIBs, SIBs, PIBs, and lithium-sulfur batteries is greatly improved. These results greatly contribute to the development of functionalization and energy storage applications of inorganic mesoscopic-scale materials.



周亮，武汉理工大学教授。2006 年获复旦大学化学系理学学士学位，2011 年获复旦大学化学系理学博士学位，师从赵东元院士和余承忠教授。2011 年加入南洋理工大学楼雄文教授课题组从事博士后研究；2012 年加入昆士兰大学余承忠教授课题组从事博士后研究；2015 年 3 月加入武汉理工大学材料复合新技术国家重点实验室。主要从事功能化纳米材料电化学储能研究，在 *Nat. Commun.*, *Chem. Soc. Rev.*, *Angew. Chem. Int. Ed.*, *Adv. Mater.*, *Nano Lett.*, *Adv. Energy Mater.*, *Adv. Funct. Mater.*, *ACS Energy Lett.*, *Energy Storage Mater.*, *Nano Energy* 等国际期刊发表 SCI 论文 120 余篇，论文引用 7000 余次，H 因子为 45。

+ Abstract

氧化硅基高容量锂离子电池负极材料

氧化硅具有容量高、成本低等优点，是一种有前景的锂离子电池负极材料。然而，氧化硅导电性差、嵌锂过程中体积膨胀大，限制了其规模化应用。为了解决上述问题，我们设计了一系列氧化硅基复合材料，包括 Ni/SiO₂ 复合空心球、SiO_x/无定型碳微球、SiO_x/石墨化碳微球、SiO_x/C 蛋黄@蛋壳结构、SiO_x/C 石榴状微球。理性的结构设计提高了材料的导电性，缓解了其体积膨胀，大幅提高了储锂性能。以 SiO_x/石墨化碳微球为例，在 1 A/g 电流下循环 2000 圈后，其容量仍高达 780 mAh/g。

+ Abstract

2D MXene Based Composites for Sodium Storage

The manifold consumption of lithium has resulted in an exponential price rise in the past decade, and it also brings fears of a potential lithium shortage in the future. Hence, sodium-ion batteries (SIBs), as a promising alternative to Li-ion batteries, would become more competitive in the coming half century because of the low cost and abundance of sodium sources.[1] Sodium-ion batteries with high power density present tremendous potential for large-scale energy storage applications. However, it remains a big challenge to develop suitable anode materials for ultrafast and highly reversible sodium ion storage. MXenes, a new family of 2D materials, are considered a rising star for energy storage due to their unprecedented combinations of properties: excellent electronic conductivity, hydrophilicity, mechanical flexibility and compositional adaptability.[2] Many works have verified that MXenes could play an extraordinary synergistic role when combining with metal oxide materials. In addition, compared with graphene, MXene with a lateral size from a few hundred nanometres to micrometres is expected to be a better choice that can individually constrain oxides nanomaterials because of the smaller difference between the lateral size of the MXene and active materials.[3-4]



Weihua Chen is a professor at Zhengzhou University, China. She received her Ph.D. in physical chemistry in 2009 from Wuhan University, China. She received her B.S. degree in chemistry in 2004 from Zhengzhou University, China. She specializes in the research and development of electrochemistry and energy storage materials, including sodium/lithium-ion batteries, supercapacitors and other new energy storage systems. During her research career, she has published more than 90 scientific papers on international journals, including *Adv. Mater.*, *Nature communications*, *Chem.*, *Chem. Mater.*, *Chem. Sci.*, *Small*, *J. Mater. Chem. A*, *ACS Appl. Mater. Interfaces*, *J. Power Sources*, *J. Phys. Chem. C*, and so on. She holds the post of Independent reviewer for *Adv. Energy Mater.*, *Adv. Funct. Mater.*, *Chem. Mater.*, *ACS Appl. Mater. Interfaces*, *J. Mater. Chem. A*, *J. Power Sources* and other renowned journals. She has applied 23 Chinese national invention patents and 14 of these patents have been authorized. She has directed 4 national science foundations of China.

+ Abstract

High-Performance Sodium-ion Batteries and Key Materials

Sodium-ion batteries (SIBs) have attracted extensive attention owing to the advantages of natural abundance, low cost as well as similar energy storage mechanism with lithium-ion batteries. As the main parts of device of SIBs, electrode materials, electrolytes and separators determine their comprehensive properties including energy density, power density, long cycle life and safety. Therefore, to realize the practical applications, the collaborative promotion of them is needed. Due to the advantages of high-safety and high-theoretical-specific-capacity metal sulfides are considered to be one of the potential anode materials for sodium ion batteries. However, they suffer from bad cycling life. We have investigated the shuttle effect of iron sulfide with extremely abundant resources as an example in sodium ion batteries, which can cause capacity decay. Considering another reported reason of particle expansion, effective unique structure was design and synthesized to solve the up-mentioned issues so that high-performance sodium ion batteries could be obtained. In addition, other metal sulfide (Tin Sulfide) was tried as anode. As well as we known, in sodium ion batteries, the usually used separator is glass fiber membrane, which is far from the flexibility. Therefore, flexible cellulose acetate based separators for sodium-ion batteries with ultralong cycle stability and excellent wettability was fabricated by electrospinning and interface chemical groups transforming. In addition, we also designed and synthesized flame-retardant phosphate gel electrolyte with high ion conductivity and thermal stability for high safety and high-performance SIBs.



Dr. Feixiang Wu (吴飞翔), 中南大学特聘教授, 博士生导师, 国家青年千人, 德国洪堡学者。本、硕、博毕业于中南大学冶金与环境学院, 美国佐治亚理工学院联合培养博士研究生, 佐治亚理工学院 Yushin 教授课题组博士后研究员, 德国马普固体研究所 Maier 教授课题组研究员。主要从事材料冶金、高比能电池材料及其电解液的应用基础研究, 主持中组部青年千人计划、国家自然科学基金、中南大学创新驱动等项目。已在 *Advanced Materials*, *Energy & Environmental Science*, *Advanced Energy Materials*, *Advanced Functional Materials*, *ACS Nano*, *Nature Communications*, *Joule*, *Materials Today*, *Nano Energy*, *Journal of Materials Chemistry A* 等国际知名期刊上发表学术论文五十多篇, 授权中国发明专利 4 项和美国发明专利 1 项, 申请德国发明专利 1 项。目前担任国际顶尖期刊 *Materials Today* (IF: 24.4) 的亚欧区主管编辑 (Managing Editor)。

+ Abstract

Conversion Cathodes for Lithium and Lithium-ion Batteries

Commercial lithium-ion (Li-ion) batteries built with Ni- and Co-based intercalation-type cathodes suffer from low specific energy, high toxicity and high cost. Further increase in the energy storage characteristics of such cells is challenging because capacities of such intercalation compounds approach their theoretical values and further increase in their maximum voltage induces serious safety concerns. The growing market for portable energy storage is undergoing a rapid expansion as new applications demand lighter, smaller, safer and lower cost batteries to enable broader use of plug-in hybrid and pure-electric vehicles (PHEV and EV), drones and renewable energy sources, such as solar and wind. Conversion-type cathode materials are some of the key candidates for the next-generation of rechargeable Li and Li-ion batteries. Continuous rapid progress in performance improvements of such cathodes is essential to utilize them in future applications. In this talk we will consider price, abundance and safety of elements in the periodic table for their use in conversion cathodes. We further compare specific and volumetric capacities of a broad range of conversion materials. By offering a model for practically achievable volumetric energy density and specific energy of Li cells with graphite, silicon (Si) and lithium (Li) anodes, we observe the impact of cathode chemistry directly. This allows us to estimate potentials of different conversion cathodes for exceeding the energy characteristics of cells built with state of the art intercalation compounds. We additionally discuss the key challenges faced when using conversion-type active materials in cells and general strategies to overcome them. Finally, we discuss our recent results on conversion cathode materials.

+ Abstract

高暴露{010}面单晶富锂锰基层状氧化物正极材料合成及电化学性能研究

富锂锰基层状氧化物 $x\text{Li}_2\text{MnO}_3 (1-x)\text{LiMO}_2$ ($\text{M}=\text{Mn}, \text{Ni}, \text{Co}$)，由于高的放电容量，在电压范围 2.0-4.8V，放电容量超过 250 mAh g^{-1} 和高达 900 Wh kg^{-1} 的功率密度以及低的镍和钴含量，成为下一代商业化锂离子电池正极材料的最可能替代者^[1]。不幸的是，在商业化使用过程中，富锂锰基层状氧化物正极材料遭到一些障碍，包括差的倍率性能、大的首次循环不可逆容量和长循环中电压和容量的衰减^[2]。为了优化富锂锰基层状氧化物电极材料的电化学性能，提高锂离子的脱嵌速率，表面结构和形貌控制是决定锂离子脱嵌速度的两个关键因素^[3]。

在这项工作中，我们使用了一种简单且易控制的方法来制备高暴露{010}面单晶 $\text{Li}_{1.2}\text{Mn}_{0.56}\text{Ni}_{0.16}\text{Co}_{0.08}\text{O}_2$ 正极材料。该工作创新之处在于：首先合成过程中，对前驱体 $\text{Mn}_{0.7}\text{Ni}_{0.2}\text{Co}_{0.1}(\text{OH})_2$ 分别在 100, 300 和 500 °C 下进行预氧化处理研究（分别记作 MNC-100, MNC-300 和 MNC-500 样品）。研究发现，随着预氧化温度的升高，前驱体形貌逐渐由纳米板变为纳米单晶颗粒，最后变为团聚体。使用 300 °C 下预氧化前驱体为原料可以合成具有高暴露{010}活性面的单晶富锂锰基正极材料（记作 LMNC-300 样品）。图 1(a)和(b)为高暴露{010}面单晶富锂锰基正极材料颗粒的合成示意图，首先对镍钴锰前驱体进行中温预氧化处理，使纳米板状颗粒分解成纳米单晶颗粒，然后通过高温固相合成，不同的预氧化温度制备出富锂锰基正极材料的{010}面的暴露面积和形貌有明显的不同。如图 1(c)和(d)分别为以 100 °C 和 300 °C 下进行预氧化样品为前驱体合成的富锂锰基正极材料的形貌，从图中可见，LMNC-300 样品，纳米板沿着厚度方向完全分化为微纳米单晶颗粒，电化学活性{010}平面的厚度大约为 900nm。通过此方法合成的单晶 LMNC-300 样品具高的首次库伦效率和倍率性能，如图 1(e)和(f)所示。



杨全红博士，天津大学化工学院讲席教授、博士生导师。国家杰出青年科学基金获得者、“长江学者”特聘教授、“万人计划”领军人才、天津市有突出贡献专家，科睿唯安和爱思唯尔“高被引学者”。从事碳功能材料和先进电池研究，获国家技术发明二等奖和天津市自然科学一等奖等 6 项。担任 *Energy Storage Materials* 副主编，*Carbon* 和 *Science China Materials* 等 10 余份国际和国内刊物编辑和编委。发表 SCI 论文 200 余篇，他人引用 15000 余次，H 因子 69。拥有中国和国际授权发明专利 40 余项。

+ Abstract

“自内而外”——面向实用化锂金属电池的锂枝晶抑制策略

金属锂负极的不稳定性和枝晶生长引发的严重副反应是制约其实用化的关键。通过提高集流体的亲锂性可以实现锂离子的均匀沉积，同时通过集流体和凝胶电解质的三维化结构设计，可以抑制枝晶生长，显著提高金属锂负极的循环稳定性。借鉴电子封装工艺，在金属锂表面构建了新型的表面防水涂层，也可以有效提高锂金属负极在真实工作环境中的稳定性。本报告归纳了我们团队近期在三维集流体和凝胶电解质结构设计与表面亲锂改性、环境稳定的锂负极界面构建等方面的研究进展。



张强，清华大学长聘教授，从事能源材料研究，尤其是金属锂、锂硫电池和电催化的研究。曾获得国家自然科学基金杰出青年基金、中组部万人计划青年拔尖人才、英国皇家学会 Newton Advanced Fellowship、2017-2018 年科睿唯安全球高被引科学家。

担任国际期刊 *J Energy Chem* 编辑、*Adv Mater Interfaces*、*Sci China Mater*、*Sci China Chem*、*Philos Trans A* 编委，*Energy Storage Mater*、*Adv Funct Mater* 客座编辑。主持国家重点研发计划课题、自然科学基金、教育部博士点基金、北京市科委重点项目等。担任 *Nature Energy*、*Nature Nanotech*、*Nature Catal*、*Sci. Adv.*、*JACS*、*Adv. Mater.*、*Angew. Chem.* 等期刊特约审稿人或仲裁人。以第一作者/通讯作者在 *Adv. Mater.*、*J. Am. Chem. Soc.*、*Angew. Chem. Int. Ed.*、*Nature Commun.*、*Sci. Adv.*、*Chem* 等发表 SCI 收录论文 100 余篇；所发论文引用 25000 余次，h 因子为 86，74 篇为 ESI 高引用学术论文。

+ Abstract

Emerging Energy Chemistry of Li Metal Anode in Safe Batteries

Li metal is considered as the “Holy Grail” of energy storage systems. The bright prospects give rise to worldwide interests in the metallic Li for the next generation energy storage systems, including highly considered rechargeable metallic Li batteries such as Li-O₂ and Li-sulfur (Li-S) batteries. However, the formation of Li dendrites induced by inhomogeneous distribution of current density on the Li metal anode and the concentration gradient of Li ions at the electrolyte/electrode interface is a crucial issue that hinders the practical demonstration of high-energy-density metallic Li batteries.

In this talk, we review energy chemistry of lithium metal anode in safe batteries. Firstly, the importance and dilemma of Li metal anode issues in lithium-sulfur batteries are underscored, aiming to arouse the attentions to Li metal anode protection. Specific attentions are paid to the surface chemistry of Li metal anode. Next, the proposed strategies to stabilize solid electrolyte interface and protect Li metal anode are included. Finally, a general conclusion and a perspective on the current limitations, as well as recommended future research directions of Li metal anode in rechargeable batteries are presented.

+ Abstract

Design Strategies for Structural and Chemical Synergistic Encapsulation of Polysulfides for Lithium–Sulfur Batteries

The fast depletion of fossil fuels and deterioration of the environment have led to an increasing demand for renewable energies and efficient energy storage technologies. Rechargeable lithium–sulfur (Li–S) batteries have been regarded as highly promising as they deliver an extremely high theoretical energy of 2600 W h kg^{−1} with low cost and toxicity by utilizing naturally abundant sulfur as the cathode material. The major challenge in the practical implementation of Li–S batteries resides in the dramatic capacity decay originated from the dissolution of intermediate lithium polysulfides into liquid electrolytes, and the loss of electrical contact and the structural instability due to the volume variation of sulfur during cycling. To address these issues, we design nanostructured materials from the molecular level to efficiently entrap lithium polysulfides based on both structural and chemical considerations. We report a strategy of utilizing anthraquinone, a natural abundant organic molecule, to suppress dissolution and diffusion of polysulfides species through redox reactions during cycling. The keto groups of anthraquinone play a critical role in forming strong Lewis acid-based chemical bonding. This mechanism leads to a long cycling stability of sulfur-based electrodes. With a high sulfur content of ~73%, a low capacity decay of 0.019% per cycle for 300 cycles and retention of 81.7% over 500 cycles at 0.5 C rate can be achieved. This finding and understanding paves an alternative avenue for the future design of sulfur–based cathodes toward the practical application of lithium–sulfur batteries. We also report here for the first time a novel design strategy to efficiently entrap lithium polysulfides from the synergistic effect of structural restriction and chemical encapsulation using metal oxide-decorated hollow sulfur spheres. The hollow spheres with inner void space not only alleviate the volume expansion of S upon lithiation but also structurally restrict soluble lithium polysulfides within the spherical structure while the decorated metal oxide nanosheets with a large surface area chemically minimize polysulfide dissolution by forming strong bonds. Such a unique composite architecture enables the achievement of an S cathode with ultralong cyclability and high capacity for high-performance Li–S batteries.

Dr. Dawei Su is **Senior Lecturer** for School of Mathematical and Physical Sciences in Faculty of Science. He is also the winner of the **Discovery Early Career Researcher Award (DECRA) Fellowship**. His original research related to advanced energy storage and conversion, including rechargeable lithium-ion, sodium-ion, potassium-ion, lithium-sulfur, and lithium-Air (O₂) batteries. Especially, He is a pioneer in the study of sodium-ion batteries. His research activities involve the design, investigation and development of novel nanostructured materials for batteries applications.

+ Abstract

Novel Electrode Materials Design for Rechargeable Batteries (Na-ion, K-ion and Li-S batteries)

Li-ion batteries have dominated the global market for electronic devices, and are considered to be the most promising power system for electric vehicles (EVs), and hybrid electric vehicles (HEVs). However, current Li-ion battery systems are still far from reaching the demands of the high energy density on EVs and HEVs due to limitations on the capacity of the electrodes. In addition, to overcome the controversial debates regarding the size of reserves and higher cost of obtaining Li, the counterpart to Li-ion batteries, Na-ion batteries, K-ion batteries, Li-S batteries have been researched due to the low cost, abundant supply and widespread terrestrial reserves of sodium mineral salts. However, the analogue intercalation compounds for Li-ion batteries are not applicable for Na-ion batteries due to the higher ionization potential and larger ionic diameter of the Na and K. Consequently, suitable electrode materials for Na-ion and K-ion batteries were also developed and optimised. Appropriate active materials having sufficiently large interstitial space within their crystallographic structure to host Na ions and achieve a satisfactory electrochemical performance were created.¹⁻³ The high energy density and capacity of Li-S batteries could match the high charge/discharge current requirements of the next generation of batteries. However, the lithium polysulphides shuttle effects make the Li-S batteries suffer from the low cycability. Designing nanotechnology and nanomaterials as the host matrix can address these problems. Herein, a series of nanostructured materials with designed morphology: nanoparticles, nanowires, 2-dimension nanoplate and mesoporous structure were developed.



朱昌宝, 中山大学材料科学与工程学院, 教授, 博导, 国家青年千人。主要研究方向为高性能锂(钠)离子电池等关键电极材料的理性设计、可控制备与离子电子输运研究。特别关注储能体系中的缺陷化学, 纳米离子学, 以及离子输运与存储过程中的尺寸效应。其中对于高性能聚阴离子钠离子电池材料开发, 离子-电子输运和尺寸效应研究, 静电纺丝与静电喷雾技术制备高性能电池材料等方向取得一系列重要成果。迄今为止, 在《Science》, 《Adv. Mater.》, 《Angew. Chem. Int. Ed.》, 《J. Am. Chem. Soc.》, 《Nano Lett.》等材料化学领域著名国际期刊上发表论文 32 篇, 其中 ESI 高被引论文 (top 1%) 6 篇, ESI 热点论文 (top 0.1%) 1 篇。第一作者论文中影响因子大于 10 的 16 篇, 包括: 《Science》(1 篇), 《Angew. Chem. Int. Ed.》(2 篇), 《Adv. Mater.》(2 篇), 《Nano Lett.》(2 篇), 《Adv. Funct. Mater.》(3 篇), 《Adv. Energy Mater.》(1 篇), 《Adv. Sci.》(1 篇), 《Small.》(2 篇), 《Chem. Mater.》(1 篇), 《J. Mater. Chem. A》(1 篇)。多篇论文被选为封面文章和卷首插图文章。SCI 论文引用次数超过 2800 余次, 单篇最高引用 600 余次。研究工作被《Nature》《Materials Views China》等作为亮点报道, 已授权欧洲专利和中国专利各一项。担任《Adv. Mater.》《Adv. Funct. Mater.》, 《Nano Energy》等 18 种国际期刊的特邀审稿人。被第九届亚洲电化学能源会议 (The 9th Asian Conference on Electrochemical Power Sources 2017)、第十九次全国电化学会议等国际、国内会议邀请并做邀请报告。

+ Abstract

高功率-高能量聚阴离子型钠离子电池正极材料

由于钠具有资源丰富和成本低廉的优势, 钠离子电池受到科学界和工业界的广泛关注。因此开发高能量密度与高功率密度的钠离子电池电极材料是提升钠离子电池竞争力以及成功产业化的关键。

根据材料的传输特性, 有针对性地构筑高效离子混合导电网络, 可以有效提高材料的倍率性能。^[1] 从高功率密度钠电正极的研发来说, 我们选定 $\text{Na}_3\text{V}_2(\text{PO}_4)_3$ 为研究对象, 通过构筑高效离子-电子导电网络^[2-4], 极大提高了该材料的倍率性能。作为钠电池正极, 其高倍率性能甚至超过锂电主流材料 LiFePO_4 。

为了进一步提高能量密度, 我们对以 $\text{Na}_3\text{V}_2(\text{PO}_4)_2\text{F}_3$ - $\text{Na}_3(\text{VO})_2(\text{PO}_4)_2\text{F}$ 为代表的高电压氟化磷酸盐进行了系统的研究。明确了该材料为离子电导占主导的混合离子导体, 其中离子电导率比电子电导率高 3-4 个数量级。^[5] 本研究通过两步法 (溶剂热-静电喷雾) 制备出双连续的有序 $\text{Na}_3(\text{VO})_2(\text{PO}_4)_2\text{F}/\text{rGO}$ (NVOPF/rGO) 复合电极^[6], 该方法拓展了静电喷雾方法的适用范围, 实现了静电喷雾方法对于氟化物体系的制备。该复合材料中 NVOPF 的颗粒尺寸只有 15nm, 含碳量为 3.5%, 且该复合电极直接生长于集流体上而不需要额外的导电剂和粘结剂的辅助。与 NVP 相比, 该复合电极能量密度提升 25% 以上, 同时功率密度可以和 NVP 媲美。



杨成浩，教授，博导。国家优青、广东省杰青获得者。主要从事原位拉曼/XRD 表征，固体氧化物燃料电池、锂（钠、钾）离子电池和锂硫电池关键材料与器件的开发与产业化研究。先后在 *Adv. Mater.*、*Angew. Chem. Int. Ed.*、*Energy Environ. Sci.* 和 *ACS Nano* 等刊物上发表 SCI 论文 100 余篇。

+ Abstract

过渡金属硫族化合物在钠离子电池中的应用研究

在众多负极材料中，层状 TMCs (MX_2) 因其合适的层间距便于 Na^+ 脱嵌，具有容量高和稳定性好等优势，已成为最受重视的负极材料体系之一。我们通过湿化学剥离法 V_5S_8 与石墨复合纳米片制备出一种 $\text{ce-V}_5\text{S}_8\text{-C}$ 复合钠离子电池负极材料。这种材料具有高的可逆比容量 (682 mAh g^{-1} at 0.1 A g^{-1}) 和优异的充放电循环稳定性 (496 mAh g^{-1} at 1.0 A g^{-1} after 500 cycles)。这主要是由于 V_5S_8 具有一种理想的三维结构，可以看做是 VS_2 层状材料之间插入一层 VS_6 八面体制备而成。原位 XRD 测试显示 $\text{ce-V}_5\text{S}_8\text{-C}$ 钠离子电池负极材料高的比容量主要是由于其在充放电过程中出现插嵌和转化反应。这些前期研究结果表明 V_5S_8 材料是一种非常有应用前景的钠离子电池负极材料。



Dr. Yongming Sun (孙永明) received his PhD degree from Huazhong University of Science and Technology in 2012. He was a postdoctoral member at Stanford University during 2013-2017. He is currently a full professor in Wuhan National Laboratory for Optoelectronics at Huazhong University of Science and Technology. His research focuses on energy storage materials and technologies, including prelithiation of lithium-ion batteries, flexible/stretchable electrode and devices, lithium metal anodes and solid electrolytes for lithium-based rechargeable batteries, and lithium-sulfur batteries. He published more than 50 papers, including two first-author Nature Energy papers. His papers have been cited over 8200 and his H index is 42 according to Google Scholar. He was a winner of “Materials Research Society (MRS) Postdoctoral Awards” in 2016 and he was also a winner of “MIT Technology Review 35 Innovators Under 35 (MIT TR35 China)” in 2018.

+ Abstract

High-areal-capacity red phosphorus electrode with safe lithiation potential for fast-charging lithium-ion batteries

Rechargeable lithium-ion batteries (LIBs) that combine fast-charging capability with high energy density have raised substantial interest to satisfy the increasing requirements of mobile devices and electric vehicles. We propose that red phosphorus (P) is an ideal anode material for fast-charging LIBs due to the combined advantages of high capacity ($6,075 \text{ mAh cm}^{-3}$) and relatively low yet safe lithiation potential ($\sim 0.7 \text{ V vs. Li/Li}^+$). Its high capacity significantly reduces the thickness of electrodes and the charge carrier transport distance, and its reasonable lithiation potential allows red P to deliver a high capacity even with large overpotentials at high current densities without the growth of lithium metal dendrites. A red P/C nanocomposite has been fabricated, featuring amorphous red P nanodomains embedded in the nanopores of micrometer-scale porous conductive carbon with interior nanoscale void spaces, a conductive P-free carbon nanoshell and a high tap density of 1.0 g cm^{-3} . The P/C electrode maintains a substantial 70% of its 1 C lithiation capacity at 8 C (0.7 mAh cm^{-2} at 8.8 mA cm^{-2}). At an industrial-level areal capacity loading (3.5 mAh cm^{-2}), a P/C electrode shows considerably better fast-charging capability than commercial graphite and $\text{Li}_4\text{Ti}_5\text{O}_{12}$ electrodes, as well as much higher volumetric capacity and specific capacity based on the whole electrode. Meanwhile, at a high areal capacity loading of $\sim 3.0 \text{ mAh cm}^{-2}$ at 0.86 mA cm^{-2} , our P/C electrode shows excellent long-term cycling stability with Coulombic efficiency of 100.0 (± 0.1)% from the 5th to 500th cycle and delivers an areal capacity of 2.7 mAh cm^{-2} at the 500th cycle.



Dr. Zhe Peng is currently an associate research fellow at Ningbo Institute of Materials Technology and Engineering (NIMTE), Chinese Academy of Science. He received his Ph.D. degree from Superior National School of Chemistry of Montpellier, France in 2012. He worked as an Alternate Sponsored Fellow (ASF) of the Pacific Northwest National Laboratory (PNNL) in 2018–2019. His research interests are focused on Electrochemistry and Materials in Lithium secondary batteries. Dr. Zhe Peng has coordinated several provincial and national projects including the Ningbo Natural Science Foundation, Zhejiang Provincial Natural Science Foundation of China, China Postdoctoral Science Foundation funded project, and National Natural Science Foundation of China (NSFC) for the research fund for International Young Scientists. During his research career, Dr. Zhe Peng has published more than 30 papers in SCI journals including *Advanced Energy Materials*, *Advanced Functional Materials*, *Nano Energy*, etc., and holds 1 PCT patent granted with another 10 patents pending.

+ Abstract

Fluorinated interfacial structures for stable Li metal anode

Li metal is an ideal anode material for high-energy secondary batteries owing to its ultrahigh capacity (3860 mAh g^{-1}) and the lowest reduction potential (-3.040 V vs the standard hydrogen electrode). Nevertheless, the application of Li-metal anode in secondary batteries is seriously hindered by the formation of mossy/dendritic lithium deposits, leading to tremendous side reactions and fast battery failures. Replacing the native solid electrolyte interphase (SEI) layers by artificial interfaces is an effective strategy to improve the cycling stability of Li metal anodes. Our works focused on the fluorinated interfacial structures to accommodate uniform Li deposition and efficacious protection of Li surface, including a fluorinated layered carbon layer (figure a) and a Ag-LiF imbedded surface (figure b).[1, 2] For both of these structures, the presence of fluorine has played critical role to enable modified Li^+ ion transfer mode with altered surface chemistry. These structures endow much improved cycling performances of Li metal anodes with dendrite-free features, revealing the importance of interfacial engineering for achieving stable high-energy-density Li metal batteries.



表数篇论文。

张文超于 2012 年和 2015 年分别获得中南大学获得学士和硕士学位, 并于 2019 年在澳大利亚伍伦贡大学获得博士学位。博士期间从事的课题研究主要集中于合金基化合物电极材料与优化的电解液用于二次可充电电池, 博士导师为郭再萍教授。前往美国凯斯西储大学学术访问, 合作导师为戴黎明教授。交流期间的主要研究方向是无金属碳材料用于碱土金属二氧化碳电池。目前在伍伦贡大学为博士后研究员, 以一作身份在国际顶级期刊诸如 *Sci. Adv.*, *Joule*, *Angew. Chem.*, *J. Am. Chem. Soc.*, *Adv. Funct. Mater.*, *Nano Energy* 发表数篇论文。

+ Abstract

Materials And Interfacial Design For Advanced Potassium Ion Storage

Developing new renewable energy storage devices is vital for regulating the energy output of intermittent solar and wind energy, which have been expected to occupy increasing proportions of energy sources in light of the environmental issues caused by fossil fuel energy. Amid staggering advances on grid-scale devices and electric vehicles, there has been great interest in exploring potassium ion batteries (PIBs). The motivations triggering the study of PIBs relate to the benefits of their relatively high energy density resulting from the low standard redox potential of potassium ($-2.93\text{ V vs. }E^0$), which is close to that of lithium ($-3.04\text{ V vs. }E^0$), their low cost, which is ascribed to the abundance of potassium (1.5 wt. %) in the Earth's crust), and also their fast ion transport kinetics in electrolyte [1]. In terms of electrode materials, alloy-based materials have been considered as good candidates for high-energy-density devices due to their relatively high theoretical capacity. However, the huge volume variations and sluggish ionic diffusion hinder their cycle life and fast charge/discharge capability. Through the optimization of materials processing, the introduction of carbon matrix and the selection of electrolytes, the high-energy-density and long cycle life alloy-based anodes have been obtained [2-3]. In addition, to further increase the energy density, we successfully fabricate the K-CO₂ batteries by employing three-dimensional carbon-based metal-free electrocatalysts [4]. We hope the relevant work will promote the developments of K ion chemistry in energy storage fields.

■ Session Session II

Li-S, Li/Zn-Air, Solid-State Batteries



廖世军, 华南理工大学教授, 广东省燃料电池技术重点实验室主任, 国家重点研发计划项目首席科学家, 中国储能与动力电池专业委员会副主任委员, 中国化学会催化专业委员会等多个专业委员会委员, *Scientific Reports* 等六种国际刊物的编委。曾先后在南非西开普大学、加拿大卡尔加里大学、美国布鲁克海文国家实验室从事燃料电池相关研究工作, 先后主持及完成省级以上的科研项目 50 多项, 包括国家重点研发计划项目 2 项 (主持和参加各 1 项), 国家 863 项目 2 项, 广东省重大科技项目 1 项。共在国内外刊物上发表论文 300 余篇 (影响因子大于 10 的 50 余篇), 2014-2018 连续五年入选 Elsevier “中国高引用学者”。申请发明专利 50 余件, 其中国际专利 PCT 4 件, 美国发明专利 2 项, 已获授权 25 件; 获省部级科技奖励 5 项, 其中排名第一的获教育部高等学校科技进步二等奖、教育部高等学校自然科学二等奖各一项。

+ Abstract

Rational designed three-dimensional N doped graphene architecture mounted with Ru single atoms/clusters as high efficient air cathode for Lithium-Oxygen Batteries

In terms of the high theoretical capacity of 3861 mA h g^{-1} (based on Li-anode) and theoretical specific energy of 3505 Wh kg^{-1} , the rechargeable lithium-oxygen (Li-O_2) battery has attracted worldwide attention, it is becoming one of the most promising candidates for next generation of energy storage and conversion devices instead of state-of-the-art commercial lithium-ion battery[1]. However, its practical application has still been hindered by a series of challenges, such as low rate performance, poor energy efficiency and short cycle life etc.[2] Thus, the materials with good electronic conductivity, high surface area, porous structure and sufficient active sites should be mainly considered in the design of high effective air cathode for Li-O_2 battery[3]. In this paper, we attempted to design and synthesize a high performance RGO and Ru based catalyst, three-dimensional integrated graphene with interconnected porous structure and high content of doped nitrogen, further decorated with high dispersed multiscale Ru components. The high specific surface area and 3D porous structure of the catalyst are expected to provide adequate space to accommodate discharge products, the high content of nitrogen doping and the high dispersed Ru species mounting are expected to endow the catalyst with high ORR/OER activity, leading to the low charge overpotential. As expected, the catalyst exhibits high discharge capacity of up to 23922 mAh g^{-1} with low charge overpotential (0.89V) at a current density of 100 mA g^{-1} , high rate capability, and a long-term charge/discharge stability of 200 cycles (1200 h), making the catalyst as a promising cathode for Li-O_2 battery applications.



Professor Zaiping Guo received a PhD in Materials Engineering from the University of Wollongong in December 2003. She was an APD Fellow at University of Wollongong, where she continued as a group leader from 2007. She is a Distinguished Professor in the school of Mechanical, Materials, Mechatronic, and Biomedical Engineering, University of Wollongong. Her research focuses on the design and application of electrode materials for energy storage, including rechargeable batteries, supercapacitor and hydrogen storage.

She published more than 350 papers in peer-reviewed Journals, more than 150 papers were published in journals with IF > 10, and these publications have been cited >21600 times with a h-index of 79. Her research achievements have been recognised through numerous awards, including an ARC Queen Elizabeth II Fellowship in 2010, an ARC Future Fellowship (FT3) in 2015, and the Clarivate Analytics Highly Cited Researcher Award in 2018 and 2019.

+ Abstract

Advanced Electrode Materials for Metal-ion Batteries

Energy storage is an important problem to realize low carbon society and there have been many challenges. Metal-ion batteries have attracted remarkable attention recently due to the high energy storage demands. The requirement of feasible electrode materials with high capacity and good cycling stability has promoted the exploration of various electrode materials for metal ion batteries. Materials engineering plays a key role in the field of battery research. In particular, engineering materials at the nanoscale offers unique properties resulting in high performance electrodes in various energy storage devices. Consequently, considerable efforts have been made in recent years to fulfil the future requirements of electrochemical energy storage devices. Various multi-functional hybrid nanostructured materials are currently being studied to improve energy and power densities of next generation batteries. In this talk, I will present some of our recent progress in the synthesis of different types of hybrid nanostructures to enhance the electrochemical energy storage properties of metal-ion battery.



支春义，中科院物理所取得博士学位，随后到日本物质材料研究机构工作，历任博士后研究员，研究员 (faculty) 以及主任研究员 (永久职位)。目前在香港城市大学材料科学与工程系任副教授及松山湖材料实验室兼职研究员。研究方向为可穿戴柔性电存储器件，包括多水系电解质，功能型超级电容器，高安全电池和金属空气电池等，为各种柔性器件和可穿戴器件系统提供柔性电源解决方案。到目前为止，已发表有关 SCI 论文超过 270 篇，他引超过 16000 次 (ISI)，H 因子为 70，专利授权 70 项。编辑著作两本。支春义博士获得城大校长奖，青年杰出研究奖，Elsevier NML 研究者奖，北京市自然科学一等奖。

+ Abstract

Flexile Zinc Ion Battery

Our research focuses on development of flexible energy storage/conversion devices, including supercapacitors, batteries and metal air batteries. Here we introduce an extremely safe and wearable solid-state zinc ion battery (ZIB) comprising a novel gelatin and PAM based hierarchical polymer electrolyte (HPE) and an α -MnO₂ nanorod/carbon nanotube (CNT) cathode. Benefiting from the well-designed electrolyte and electrodes, the flexible solid-state ZIB delivers a high areal energy density and power density (6.18 mWh cm⁻² and 148.2 mW cm⁻², respectively), high specific capacity (306 mAh g⁻¹) and excellent cycling stability (97% capacity retention after 1000 cycles at 2772 mA g⁻¹). More importantly, the solid-state ZIB offers high wearability and extreme safety performance over conventional flexible LIBs, and performs very well under various severe conditions, such as being greatly cut, bent, hammered, punctured, sewed, washed in water or even put on fire. In addition, flexible ZIBs were integrated in series to power a commercial smart watch, a wearable pulse sensor, and a smart insole, which is the first time that has been achieved to the best of our knowledge.



Dr. Jia Xie, Professor in School of Electrical and Electronic Engineering at Huazhong University of Science and Technology (HUST). He got his B.S. from Peking University and PhD from Stanford University. Before joined academia, he spent 8 years in industry including working in Dow Chemical and Hefei Guoxuan on battery & materials development, commercialization and applications in electric vehicles and grid-scale energy storage. He currently works on new energy storage materials and devices such as lithium-sulfur and solid-state batteries. He has published over 50 peer-review papers in prestigious journals including JACS, Angew, Adv. Energy Mater.. He has been granted 45 patents including 20 invention patents.

+ Abstract

Chemical manipulation towards high performance Li-S Batteries

Lithium-sulfur batteries have been regarded as one of the most promising new battery technologies due to their high theoretical energy density (2600 Wh kg⁻¹) and the abundant resource as well as the low cost of sulfur. However, current sulfur cathodes and lithium metal anodes can't meet the design requirements for high specific energy batteries. In this talk we will introduce several chemical manipulation methods for high performance Li-S batteries. On the sulfur cathode side, a new reaction pathway is proposed and Se or Te as eutectic accelerator is introduced to boost reaction kinetics. It is possible to eliminate polysulfide dissolution while under the dissolution deposition mechanism and obtain high performance sulfur cathodes compatible with both ether and carbonate electrolytes. For lithium metal anodes, we have developed a couple of multifunctional artificial layers through simple and facile chemical methods. The multifunctional layers are beneficial not only for uniform deposition of lithium, but also for prolonged cycling performance. With the newly developed anode and cathode materials, a high energy lithium-sulfur battery with significantly improved performance is obtained. The energy density and cycle life are expected to show breakthrough in large Li-S batteries.



王舜，博士，二级教授，博士生导师，国家有突出贡献中青年专家，“百千万人才工程”国家级人选，英国皇家化学会会士，Carbon Energy 主编，中国电化学学会委员，国际电化学能源科学院理事会理事。现任温州大学化学与材料工程学院院长，温州大学新材料与产业技术研究院院长，浙江省化学一流学科（A类）带头人，浙江省微纳结构碳材料技术国际科技合作基地负责人。长期从事新能源材料的设计、合成与应用研究，发表学术论文 100 余篇，其中影响因子 >20 的 12 篇，>10 的 31 篇，6 篇入选全球高被引论文。获省部级奖 3 项，国际发明专利 2 项，国家发明专利 42 项，出版教材 2 部。

+ Abstract

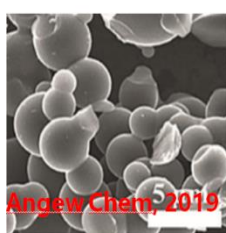
高密度多孔碳的设计合成、形成机理及应用

金辉乐，杨超，李俊，王舜*

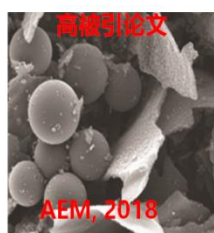
温州大学化学与材料工程学院，温州，中国，325035

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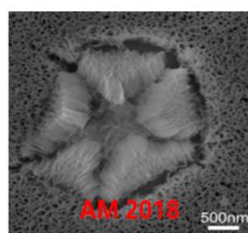
随着便携式电子产品和电动汽车向着轻量化、小型化的快速发展，开发与之相匹配的兼具高体积能量密度和高功率密度的致密储能器件已成为我国与我省新能源汽车、柔性电子以及新材料等产业发展的迫切需求。多孔碳材料具有结构多样、来源丰富、导电性好、比表面积大、化学稳定性高、功率密度大、循环性长以及充放电快速等优点，被认为最有希望成为替代或补充二次电池电极材料。然而，低体积能量密度正严重制约碳基致密储能器件的实际应用。为此，本课题组在国际上率先提出了一类基于“卤代烃原位脱卤聚合-碳化制备超高密度杂原子掺杂多级孔碳储能材料”新方法，大幅提升了碳基致密储能器件的体积容量、体积能量密度以及倍率性能^[1-3]。



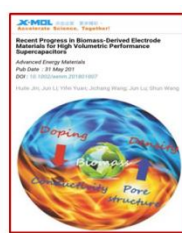
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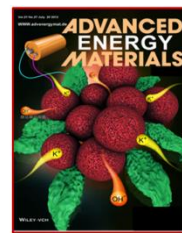
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三维多孔石墨烯



AEM, 2018, 综述论文



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+ Abstract

锂硫电池中的能源界面调控策略

面向未来社会的能源需求，发展下一代高比能电池系统是实现电能高效存储和利用的重要环节。在诸多电池系统中，锂硫电池具有理论能量密度高、电池成本较低等优势。但锂硫电池同时面临活性材料导电性低，反应中间产物存在溶解扩散带来副反应等一系列复杂的耦合反应过程。

本研究从锂硫电池中的隔膜功能化及界面强化策略出发，探索了功能化隔膜在正极侧的界面强化作用，以及对金属锂负极界面的稳定化策略。具体地，针对金属锂负极不均匀沉积易形成枝晶的问题，提出稳定空间离子浓度场，实现锂离子的均匀沉积。通过在金属锂表面形成稳定的、可转移的固体电解质界面，也有利于强化金属锂界面的稳定性，实现其高效循环。在锂硫电池正极一侧，针对锂硫电池中间产物穿梭扩散导致效率低的问题，提出选择性隔膜提高电池库伦效率的原理和方法。通过隔膜正极侧的导电、极性修饰，有效强化正极侧硫正极反应动力学，提升了电池整体倍率性能。相关功能化隔膜修饰策略和界面强化方法可批量化应用，为金属锂电池的未来应用提供了新的思路。

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童叶翔，中山大学化学学院教授；先后担任中国化学会理事，教育部大学化学课程教学指导委员会委员，中国化学会电化学分会委员，广东省化学会秘书长。主要从事纳米材料的物理与化学研究领域的研究工作，主持国家和省级科研项目 10 余项；2015 年获广东省自然科学一等奖和中国高校自然科学二等奖（排名第一）；发表论文 400 余篇，其中 $IF > 10$ 的论文 50 余篇，SCI 他引次数超过 26,600 次， $H-index = 88$ ；50 余篇论文入选 ESI Highly Cited Papers。2017–2019 年连续三次入选科睿唯安“全球高被引科学家”。

+ Abstract

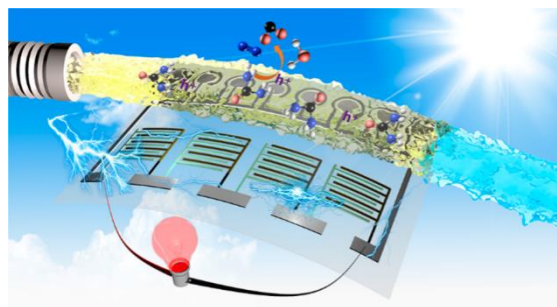
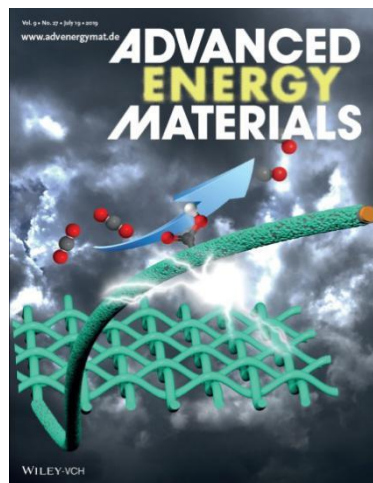
纳米能源材料的制备与器件研究**

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简介中山大学化学学院电化学团队在纳米能源材料的制备与器件研究方面的研究概况和今后的在能源、环境领域应用的设想。



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唐永炳博士于 2007 年在中科院金属所获得材料学博士学位；2007 年至 2013 年于香港城市大学从事访问研究，2013 年 8 月加入中科院深圳先进技术研究院，任功能薄膜材料研究中心主任，研究员，博士生导师。主要从事新型储能器件及关键材料、功能薄膜材料制备及产业化应用研究。已发表学术论文 130 余篇，2014 年独立科研工作后以通信作者发表论文 80 余篇，部分成果发表于 *Nat. Chem.*, *Angew. Chem.*, *Nat. Comm.*, *Adv. Mater.*, *Adv. Energy Mater.*, *ACS Nano*, *Adv. Funct. Mater.* 等刊物, 12 篇被选为封面论文。已申请专利 382 项，发明专利 243 项，PCT 专利 45 项，美欧日韩专利 12 项，授权专利 101 项。基于新型电池的 23 项相关专利依托单位已实现了转移转化，研发的柔性超快充放电池被第十九届高交会专家委员会从 1000 个推荐产品中评为十大人气产品奖和优秀产品奖。

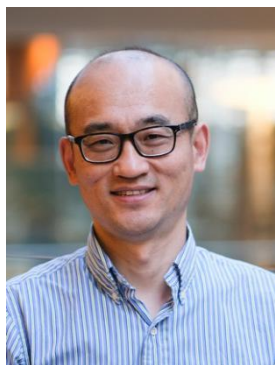
+ Abstract

基于多离子反应机理的新型储能器件及材料

由于锂资源储量有限且地域分布不均匀，锂离子电池在规模化储能领域的应用受到了制约。Na、K、Ca 等碱（土）金属元素不仅资源丰富，而且具有与锂相似的电化学性质，基于此类元素的储能器件在储能等领域具有良好的应用前景。然而，由于 Na^+ 、 K^+ 、 Ca^{2+} 等具有较大的离子半径及多价态特性，此类新型电池仍面临动力学过程缓慢、可逆性差、尤其是缺乏合适的正负极材料等一系列挑战。我们前期研究工作发现，多离子反应策略在提升新型电池电化学性能方面展现出较好的可行性。实验结果证实：通过双离子、三离子等多离子反应策略，可有效提高钠离子电池、钾离子电池、钙离子电池等新型储能器件的电化学性能，这种策略可以将不同离子的特点有效结合起来，不仅可显著改善离子扩散动力学及电池循环稳定性，而且提供了更广泛的电极材料选择范围。因此，这种多离子策略可能是发展新一代高效低成本储能器件的有效途径之一。

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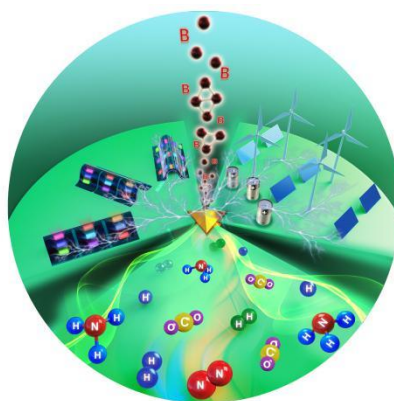
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Dr. Zhenguo Huang (黄振国) is currently working at the University of Technology Sydney. He was awarded a Discovery Early Career Research Award and Future Fellowships by the Australian Research Council. He is a Research Advisor appointed by the National Institute for Materials Science, Japan, a recipient of the Humboldt Research Fellowship for Experienced Researchers, the Chair of the International Hydrogen Carriers Alliance, and a graduate of Australian Institute of Company Directors. His research is centered on boron chemistry for energy conversion and storage. Research interests are in the fields of hydrogen storage materials, electrolytes, and two-dimensional boron-containing nanosheets.

+ Abstract

Boron for Energy Storage and Transfer (BEST) Materials



Boron, hydrogen, and nitrogen form many compounds together (denoted as BHN) that have high hydrogen capacity (weight percent). These compounds typically feature extensive intra- and/or intermolecular $\text{N-H}^{\delta+} \cdots \text{H}^{\delta-}-\text{B}$ dihydrogen interactions, which enable facile dehydrogenation (Huang et al. 2012, 2019). We have been developing novel synthesis methods and exploring new BHN compounds for hydrogen storage, which has been one of the bottlenecks for wide deployment of hydrogen fuel cell cars. Boron is also a key element of the electrolyte salt for the emerging Na-ion and Mg batteries. Its ability to form large and electrochemically stable ions enables good tuning of the interactions between anions and cations, and the conductivity and electrochemical windows of the corresponding electrolytes. For example, sodium-difluoro(oxalato)borate (NaDFOB) outperforms the most widely used commercial salts for Na-ion batteries in terms of rate capability and cycling performance (Chen et al. 2015). This breakthrough in hydrogen storage and Na-ion batteries has been successfully commercialized in partnership with Boron Molecular, a specialist chemical manufacturer. Boron and nitrogen together form a layered compound, hexagonal boron nitride (h-BN), which is isostructural to graphene. By guiding the dehydrogenation, BHN compounds can be made to form few-atomic-layered h-BN. We have been able to grow large

few-atomic-layer h-BN nanosheets on Cu substrates. h-BN nanosheets could be an excellent atomically thin protective layer over Cu substrate if it is made with high quality (Khan et al. 2017). Our recent findings have seen boron nitride nanosheets dramatically improve the thermal response of temperature-sensitive hydrogels (Xiao et al. 2015). h-BN nanosheets have recently been found to show interesting catalytic properties such as selective oxidative dehydrogenation of alkane to alkene and photocatalytic H₂ and O₂ generation from water.

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The application offered a strategy to controllable synthesis of various nanostructures for new energy storage and conversion through the special structure in renewable natural marine polymers. This could address the issues in conventional synthesis of nanomaterials including serious aggregation of nanoparticles and uncontrollable morphology and porous structure. His major contributions include: controllable synthesis of transition metal oxygen (sulfur) compounds and hierarchical porous carbonaceous material using “double-helix” structure of carrageenan and the “egg-box” structure in sodium alginate, which provides a new way for the green synthesis of negative electrode for lithium/sodium ion batteries; finding the mechanism of oriented synthesis of high-performance non-noble metal nano-aerogel electrocatalysts based on the “egg-box” structure in sodium alginate; revealing the mechanism of suppressing cation mixing in cathode materials of lithium ion batteries. In last 5 years, he was granted 5 research projects, including “Taishan Scholars” distinguish professor talents project, Outstanding Youth of Natural Science in Shandong Province, National Natural Science Foundation of China (General Program; Youth Fund). He has published 91 peer-reviewed papers in highly ranked journals on materials and chemistry science since 2013, such as *Angew. Chem. Int. Ed.*, *ACS Nano*, *Adv. Energy Mater.*, *ACS Cent. Sci.* These papers have been cited more than 2000 times.

+ Abstract

Functional biomass for Energy storage and conversion

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The preparation of traditional electrochemical energy storage and conversion materials depends on non-renewable resources (e.g. petroleum and coal) and precious metals, which seriously limits the establishment and development of renewable energy systems. Recently, the synthesis of porous carbon electrode materials from terrestrial plants (e.g. bamboo and wood) has been extensively studied. However, there are still some problems during the process of synthesizing various nanostructures by natural macromolecules, such as uneven distribution of nanoparticles, uncontrollable morphology and pore structure. In this work, abundant and renewable marine bio-polysaccharide resources have been used as precursors to realize controllable preparation of electrochemical energy storage and conversion materials. The novel structures of “egg-box” and “double-helix” help to realize the controllable synthesis of metal oxygen/nitrogen/sulfur compounds and carbonous nanostructures, such as

various metal oxide/carbon composite fibers, ion nitride/graphene composite aerogels, metal sulfides/carbon aerogels and mesoporous carbon nanofibers, etc. Meanwhile, their mechanism for energy storage in lithium/sodium ion batteries, supercapacitors, metal-air batteries and fuel cells has been revealed.[1-8] This work provides a green and effective strategy for preparing energy storage and conversion materials.

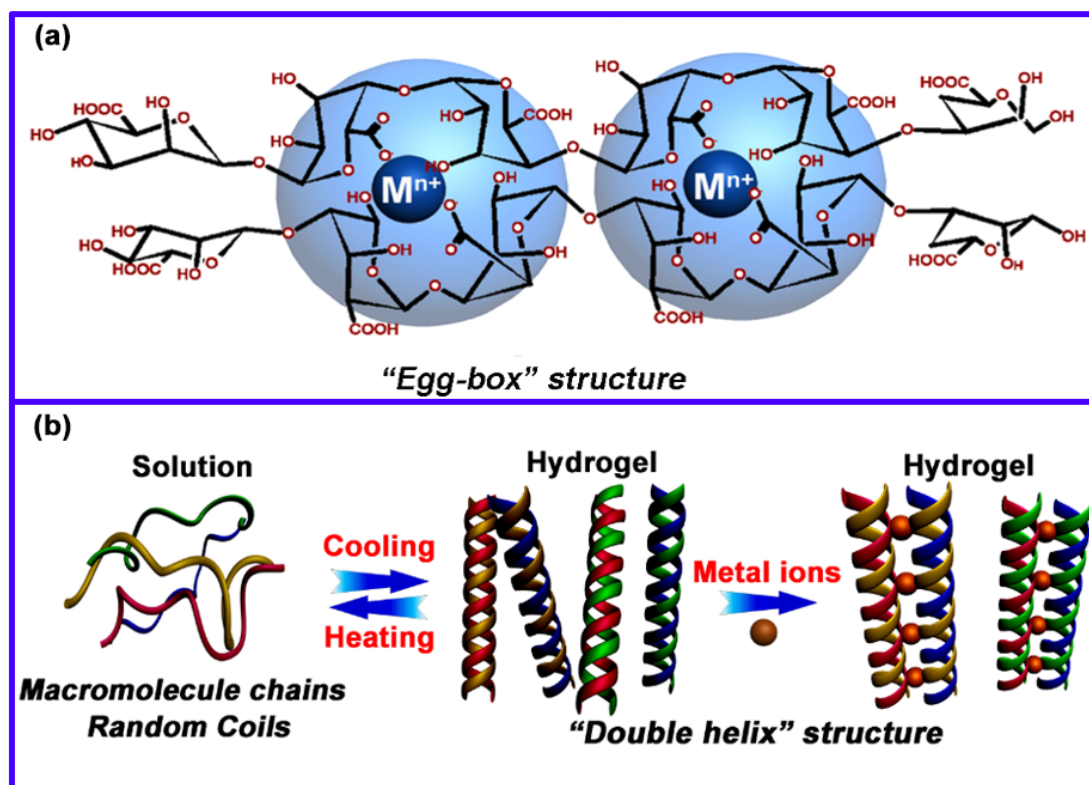


Figure 1. Scheme of "egg-box" structure in alginate (a) and "double helix" structure in carrageenan (b).

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Fei-Fei Cao received her B.S. degree from Wuhan University in 2006. In 2011, she received her Ph.D. degree from the Institute of Chemistry, Chinese Academy of Sciences under the supervision of Prof. Li-Jun Wan and Prof. Yu-Guo Guo. After that, she worked in the College of Science, Huazhong Agricultural University. From 2014 to 2015, she worked at the group of Prof. Hua Zhang, Nanyang Technological University as a research fellow. Her research interests focus on nanostructured energy materials. As a first or corresponding author, she has published more than 30 papers, including 1 J. Am. Chem. Soc., 1 Angew. Chem. Int. Ed., 2 Adv. Mater., 1 Energy Environ.. She has 6 ESI highly cited papers and 1 hot paper, and authorized 4 invention patents.

+ Abstract

Nano-electrode materials prepared from agricultural waste

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In China, the amount of agricultural wastes is enormous, but it has not been effectively reused. We make use of agricultural wastes (rice husks, edible fungus slag, silkworm excrement, etc.) to prepare nano electrode materials. We develop a fungi-enabled method for the preparation of porous carbons with ultrahigh specific surface area, and elucidate the mechanism underlying the direct growth of mushroom toward the lignocellulosic substrate. This study reveals a novel pore formation mechanism in root-colonizing fungi and anticipates a valuable function for fungi in developing the useful porous carbons with a high specific surface area. Such porous carbons could have potential applications in energy storage, environment treatment and electrocatalysis [1-2]. At the same time, the nano particles of red phosphorus are loaded into the porous carbon to obtain the red phosphorus/porous carbon composite material, which was used as the negative electrode material of the sodium ion battery to effectively alleviate the volume effect.

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+ Abstract

Nanostructured energy storage materials produced by ball milling

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Ball milling is an exciting field in nanoscience and nanotechnology. Recently, mechanochemical synthesis has been increasingly popular as an advanced technique for the manufacture of various nanostructured energy storage materials, including nanoparticles, nanowires, nanorods, nanotubes, nanosheets and nanocomposites. The mechanochemical process is a relatively novel, simple, clean and green process. Driven by mechanical energy, a complex series of phase transformations and even chemical reactions take place during mechanical grinding. Because the whole process is cold and maintains a temperature close to ambient temperature, nanostructured energy storage materials can be produced. Mechanochemical synthesis represents a unique way to obtain new nanostructured energy storage materials in large quantities and improves their properties, which have been used in energy storage fields.



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His current research interests focus on new nanomaterials for electrochemical energy storage and micro/nano energy devices. He pioneered development and innovative application of single nanowire electrochemical device and in situ techniques, leading to understanding structural evolution, charge transport and electrocatalysis. He has published over 330 papers in peer-reviewed journals such as Nature, Nat. Nanotechnol., Nat. Commun., Adv. Mater., J. Am. Chem. Soc., Chem. Rev., etc. He has conducted more than 30 research projects as project principal such as National Basic Research Program of China, the National Science Fund for Distinguished Young Scholars, the Key Program of National Natural Science Foundation, etc. He is the winner of China Youth Science and Technology Award, and Guanghua Engineering Science and Technology Prize, the EEST2018 Research Excellence Award, the First Prize of Natural Science Award by the Ministry of Education, etc. He is the guest editor of Adv. Mater., and serves on the Editorial and Advisory Boards of Joule (Cell press), Acc. Chem. Res., ACS Energy Lett., Adv. Electron. Mater., Nano Res. and Sci. China Mater.

+ Abstract

One Dimensional Nanomaterials for Emerging Energy Storage

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One-dimensional nanomaterials can offer large surface area, facile strain relaxation upon cycling and efficient electron transport pathway to achieve high electrochemical performance. Hence, nanowires have attracted increasing interest in energy related fields. We designed the single nanowire electrochemical device for in situ probing the direct relationship between electrical transport, structure, and electrochemical properties of the single nanowire electrode to understand intrinsic reason of capacity fading. The results show that during the electrochemical reaction, conductivity of the nanowire electrode decreased, which limits the

cycle life of the devices. We have developed a facile and high-yield strategy for the oriented formation of CNTs from metal–organic frameworks (MOFs). The appropriate graphitic N doping and the confined metal nanoparticles in CNTs both increase the densities of states near the Fermi level and reduce the work function, hence efficiently enhancing its oxygen reduction activity. In addition, we demonstrated the critical role of structural H₂O. The results suggest that the H₂O-solvated Zn²⁺ possesses largely reduced effective charge and thus reduced electrostatic interactions with the V₂O₅ framework, effectively promoting its diffusion. We also identified the exciting electrochemical properties (including high electric conductivity, small volume change and self-preserving effect) and superior sodium storage performance of alkaline earth metal vanadates through preparing CaV₄O₉ nanowires. Furthermore, a novel assembled nanoarchitecture was also presented, which consists of V₂O₃ nanoparticles embedded in amorphous carbon nanotubes that are then coassembled within a reduced graphene oxide network. The naturally integrated advantages of each subunit exhibit highly stable and ultrafast sodium-ion storage. Our work presented here can inspire new thought in constructing novel one-dimensional structures and accelerate the development of energy storage applications.

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He is the recipient of various awards, such as the member of Global Young Academy (2017), ECS-Toyota Young Investigator Fellow (2017), UPAC Novel Materials Youth Prize (2017), Canada Governor General's Academic Gold Medal, NSERC Alexander Graham Bell Canada fellowship, the 1st Prize of Natural Science Award of Anhui Province, ISE award for young electrochemist, etc. He is the Vice President of the International Academy of Electrochemical Energy Science (IAOEES). He serves as the Executive Editor-in-Chief of *Electrochemical Energy Reviews* (EER), editor of *Nano Advances*, editor of *Catalysts*, and the editorial board member for another 3 journals related to nanomaterials and energy.

+ Abstract

Novel Nanostructured Electrocatalysts for H₂ Fuel Cells and Zn-Air Batteries

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As clean and sustainable energy conversion devices, proton-exchange membrane fuel cells (PEMFCs) are expected to play dominant role in future clean energy solutions for various applications, particularly for electric vehicles (EVs). However, the high cost of Pt catalyst is one of the main obstacles for the wide-spread commercialization of PEMFCs. Therefore, developing highly efficient low-Pt and non-Pt group metal (Non-PGM) catalysts are one of the key solutions to solve the above-mentioned challenges.

Here, I will present our recent progress in developing advanced electrocatalysts mainly for oxygen reduction reaction (ORR) in PEMFCs. Among the Non-PGM catalysts, Fe/N/C catalysts are considered one of the most promising ORR catalysts. One major breakthrough has been made by Dodelet et al, with activity and performance of Fe/N/C catalyst

approaching to that of Pt (*Science* 2009, *Nature Communications* 2011). However, the durability of Fe/N/C catalysts is still insufficient for practical applications and its performance decay mechanism is still unclear. Very recently, we made a systematic study to verify whether iron is at the origin of the first rapid decay (stability problem) of the Fe/N/C catalyst for ORR in PEMFCs, which is important to find better ways to improve the durability of Fe/N/C catalysts. Moreover, other types of novel nanostructured NPM catalysts will also be discussed. At the same time, a series of low-Pt nanostructured electrocatalysts, synthesized by green chemistry and atomic layer deposition (ALD), including nanowires, nanotubes and single atoms, for fuel cells will also be presented. In the end, I will also briefly introduce our work beyond fuel cells, including Li-ion/Na-ion/Zn-ion batteries, solar water splitting for H₂ production, and metal-air batteries.

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Dr. Meng Ni received his PhD in Mechanical Engineering from University of Hong Kong (HKU) in 2007. Afterwards, Dr. Meng Ni worked at HKU as a post-doctoral fellow for 2 years before he took up the Assistant Professor position at The Hong Kong Polytechnic University in July 2009. Dr. Ni was promoted to an Associate Professor in July 2012 and a Full Professor and an Associate Head in July 2016. Dr. Meng Ni conducted collaborative research at Forschungszentrum Jülich (Germany) as a Humboldt Fellow from January 2017 to July 2017. Dr. Meng Ni's research covers fuel cells, hydrogen energy and metal-air batteries. His current H-index is 37. Dr. Ni served as an Associate Editor for *Science Bulletin* between 2015 and 2017 and received the Best Associate Editor Award in consecutively 2 years. Presently, Dr. Ni is serving as an Associate Editor for *Sustainable Energy Technologies and Assessments (Elsevier)* and an Editorial Board Member for several journals including *International Journal of Energy Research*. Dr. Ni is also an active reviewer for over 60 journals, including *Science*, *Nature Communications*, *Journal of Materials Chemistry A*, *Advanced Energy Materials*, *Journal of Power Sources*, *Applied Energy*, *International Journal of Heat and Mass Transfer* etc.

+ Abstract

Hybrid Zn-metal/air batteries for high energy density and efficiency

Rechargeable zinc-air batteries are promising power sources due to their high theoretical energy density, safe operation, and relatively low cost. However, the discharge voltage of Zn-air batteries is usually below 1.2V while the charge voltage is higher than 2.0V. For comparison, Zn-M batteries such as Zn-Ni and Zn-Ag batteries exhibit higher discharge voltage. In this presentation, a series of Zn-Metal/air hybrid batteries are introduced to achieve both high energy density and high efficiency, including Zn-Ni/air, Zn-Co/air, and Zn-Ag/air batteries. Moreover, perspectives on the electrode material optimization, reaction interface design, and operation management are provided for the further development of novel electrochemical energy storage systems.



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Dr. He focused on studying and constructing the high safety, low resistance and high stability electrode/liquid and solid state electrolyte interface, systems and relevant materials to solve the safety problem of current and future lithium battery. Dr. He has published more than 150 SCI papers in journals such as *Nature Commun.*, *Adv. Mater.*, *Energy Environ. Sci.*, *Angew. Chem. Int. Ed.*, *Adv. Energy Mater.*, *Adv. Funct. Mater.*, *Nano. Lett.*, *Nano Energy*, *Chem. Mater.* His papers have been cited more than 5500 times by SCI journals such as *Nature*, *Nature Nanotech.*, *Nature Energy*, and *Chem. Rev.*, with an H factor of 43. 12 of his papers are ESI papers. Dr. He has been authorized 30 invention patents. He's research work has won many awards such as the Second Prize of the National Technology Invention (Ranked 5th, 2017), Hou Debang Chemical Science and Technology Youth Award (2018), Second Prize of Guangdong Science and Technology (Ranked 1st, 2015), Second Prize of Shenzhen Natural Science (Ranked 1st, 2016). Dr. He is selected as Young Scholars of Changjiang Scholars Program of China (2018) and Young Talent of Science and Technology Innovation in Guangdong Province (2015). He was invited to give a Keynote and invited presentation more than 60 times in academic conferences and industrial forum, who also served as reviewers and arbitrators of more than 50 journals including *Nature*, *Nature Commun.*, *Adv. Mater.*, *Angew. Chem. Int. Ed.* etc. Dr. He is also a member of youth editorial committee of *Chinese Chemical Letters*.

+ Abstract

Solid-state electrolyte and interface construction for solid state batteries

The high electrochemical and thermal side reactions at the electrode/liquid electrolyte interface are the root causes of the poor electrochemical and safety performance of the lithium ion battery. The high-impedance electrode/solid-state electrolyte interface and poor interface stability restrict the improvement of the performance of the solid-state battery. An ultra-thin, hierarchical nitrile all-solid polymer electrolyte was designed and in-situ prepared on the electrode surface. In this solid polymer electrolyte, the cyanoethyl polyvinyl alcohol (PVA-CN) polymer was uniformly dispersed in succinonitrile and was cross-linked with the polyacrylonitrile electrospinning fiber network, which greatly improved the mechanical strength and flexibility of the composite solid electrolyte. A $\text{LiFePO}_4/\text{SEN}/\text{Li}$ solid battery with good electrochemical performance was obtained. Lithium metal anodes are prone to grow lithium dendrites during the cycling process. The use of a high-safety solid electrolyte is an effective method for suppressing the growth of lithium dendrites. Based on diglycidyl ether of bisphenol-A (DEBA), poly(ethylene glycol) diglycidyl ether (PEGDE) and diamino-poly(propylene oxide) (DPPO), an initiator-free ring-opening polymerization reaction was developed to synthesize a three-dimensional crosslinked network gel polymer electrolyte with a dense structure (3D-GPE). The electrolyte has excellent mechanical strength, thermal stability, and high ionic conductivity ($2.36 \times 10^{-3} \text{ S/cm}$). At the same time, it promotes the formation of a uniform and stable SEI film on the surface of the lithium electrode, which can significantly inhibit the growth of the lithium dendrite and enhance the performance of the lithium metal battery. In addition, a low-impedance integrated all-solid-state lithium battery was designed by using PEO-LiTFSI (PL) all-solid electrolyte with $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$ nanowires and PL-based cathode binder, which effectively reduces the ion transportation impedance at the cathode/electrolyte interface and in the cathode. An ultra-thin ZnO layer was also constructed on the surface of $\text{Li}_{1.4}\text{Al}_{0.4}\text{Ti}_{1.6}(\text{PO}_4)_3$ by magnetron sputtering, which effectively solve the problems of high interface impedance, interface instability and

lithium dendrite growth. For the problem of high reactivity of sodium metal and electrolyte, the combination of dense-structure gel electrolyte and inorganic ionic conductor can significantly reduce the interfacial side reaction of sodium metal/liquid electrolyte and increase the cycle life of sodium battery.

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Dr. Junjie Guo (郭俊杰) is a professor of Taiyuan University of Technology. He received ph D. in materials science from Tohoku University, Japan in 2010. He was engaged in postdoctoral research at Oak Ridge National Laboratory, United States from 2011-2014. His current research focuses on the atomic-scale structure tuning of two dimensional (2D) materials for improved properties. So far, he has published more than 50 papers, including Nature communications, Nano Energy, Acta Mater., Small, Carbon, Electrochimica Acta, and Appl. Phys. Lett.

+ Abstract

Atom-by-atom defect control of 2D materials for improved electrochemical properties

High-performing electrocatalysts for hydrogen evolution reaction (HER), oxygen reduction reaction (ORR), oxygen evolution reaction (OER), and CO₂ reduction reaction (CO₂RR) etc. are of the most importance for critical renewable energy technologies like fuel cells, batteries, and electrochemical water splitting. Two-dimension (2D) nanosheets such as graphene and MoS₂ have been attracting increasing interests of researchers for their excellent performances in energy storage and conversion due to their high specific surface areas, rich active sites and tunable properties etc. Particularly, the electrocatalytic reactivities of these 2D materials are highly dependent on their surface electronic structures, which can be well tuned by controlling their microstructures and compositions.

In this study, the atomic configurations of graphene, graphene nanomesh, BN, and atomically-thin 2D metal oxides were analyzed by using the gentle aberration-corrected scanning transmission electron microscopy operated to study the atomic origin of their improved electrochemical properties. It is found that the atomic defects in these 2D materials, such as vacancy, nanopore, heteroatom dopant and grain boundary, etc., play the key role to modulate the defect structure and thus their properties.

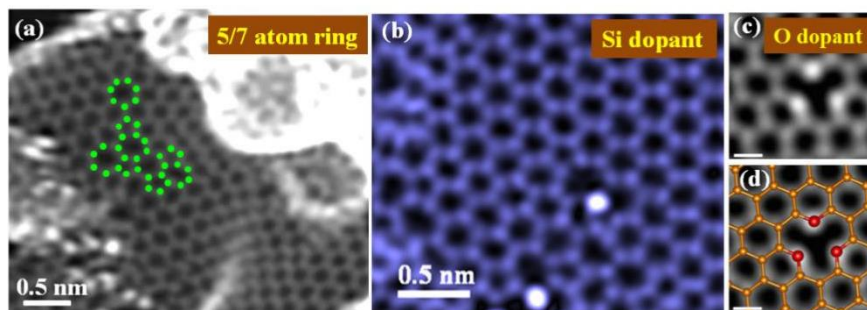


FIG. 1. ADF-STEM images of defects in graphene

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Dr. Jian Liu is a Professor at Dalian Institute of Chemical Physics, Chinese Academy of Science, China, he also held an adjunct reader position in Department of Chemical and Process Engineering, University of Surrey, UK. Dr. Liu has been PI/CIs in sponsored research (including three ARC DP grants, one ARC LP grant, one Chinese Government 1000 young talent plan, two international linkage grants from the Australian Academy of Sciences, and four UQ major grants) in the last eight years, and as of November 2019, has published more than 170 peer reviewed journal articles including top ranking journals such as Nature Mater., Nature Commun., Angew. Chem. Int. Ed., Adv. Mater., JACS, Chem. Sci., Chem. Soc. Rev., et al. 1 book, 8 book chapters. A recent search (November 2019) of ISI Web of Science shows his entire publications have been cited for over 13000 times. He has an H-index of 55 and his research has been featured on 21 Cover pages of scientific journals. He was listed as 2018, 2019 Highly Cited Researchers from Clarivate Analytics in Cross-Field. He is the Editor-in-Chief of Materials Today Sustainability (Elsevier). As recognition of his achievements in research, he was honoured with a prestigious UQ Foundation Research Excellence Award, Australian Postdoctoral Fellowship (APD), JSPS Invitation Fellowships, UQ Postdoctoral Research Fellowship, President Award (Chinese Academy of Sciences) and a Young Scientists Award of the 14th International Congress on Catalysis.

+ Abstract

Nanoengineering hollow structured carbon spheres as nanoreactors for sustainable energy applications

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Colloidal carbon sphere nanoreactors have been explored extensively as a class of versatile materials for various applications in energy storage, electrochemical conversion, and catalysis, due to their unique properties such as excellent electrical conductivity, high specific surface area, controlled porosity and permeability, and surface functionality. This talk aims to summarize the latest updated research on colloidal carbon sphere nanoreactor, in terms of both their synthesis and applications. Various synthetic strategies are first discussed, including the hard template method, the soft template method, hydrothermal carbonization, the microemulsion polymerization method and extension of the Stöber method. In the following section, the functionalization of hollow structured carbon sphere nanoreactors, including the nanoengineering of compositions and the surface features is then discussed. Afterward, I will present the recent progress in the major applications of hollow structured carbon sphere nanoreactors, in the areas of energy storage, electrochemical conversion and catalysis. Finally, the perspectives and challenges are discussed for future developments in terms of controlled synthesis and functionalization of the hollow structured carbon sphere nanoreactors with

tuneable structure, and the composition and properties that are desirable for practical applications.¹⁻⁷

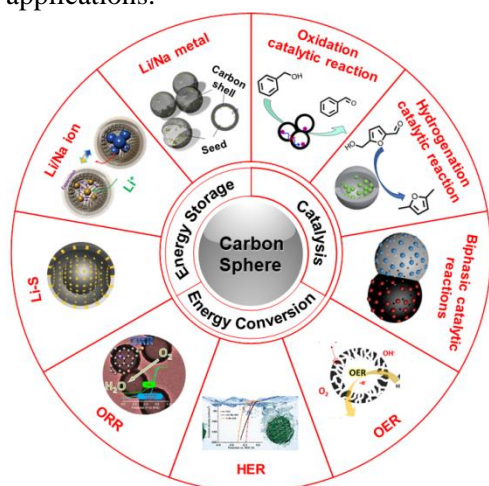


Fig. 1 | Design of colloidal carbon spheres as nanoreactors towards catalysis, energy storage and conversion.⁷

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Dr. Ting Liao is a tenured Associate Professor at the School of Chemistry, Physics and Mechanical Engineering, Queensland University of Technology, Australia. She received her PhD in 2009 from Institute of Metal Research, Chinese Academy of Sciences. Since then, she is awarded four Research Fellows and work at National Institute for Materials Science (NIMS), Japan, the University of Queensland, Australia, and University of Wollongong (UOW), Australia. In 2017, she joined Queensland University of Technology (QUT), Australia, as Senior Lecturer and ARC Future Fellow, and in the second year she was promoted to Associate Professor. Dr. Liao also received some honorary positions, such as the Editorial Board Member of Scientific Reports (Nature Publishing Group) and Honorary Fellow in University of Wollongong. Her current research interests is theoretical design of nanomaterials in targeted energy applications including photovoltaic, nanocatalytic, and energy conversion and storage, etc.

+ Abstract

Two-dimensional materials and their hybrids in Energy Applications

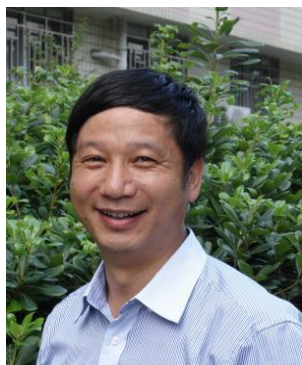
Recently two-dimensional (2D) nanomaterials have attracted an increasing attention for their unique properties which cannot be obtained from the corresponding bulk forms, such as super-high chemically reactive surfaces, rapid “in-plane” charge transport, significant quantum-confinement effect, etc. In this presentation, hybrid nanomaterials formed from 2D nanomaterials as platform and other lower dimensional semiconducting nanomaterials as adsorbent has been studied by DFT calculations, with the aim of understanding the nature and mechanisms of their interfacial electronic coupling, charge transfer, and resultant optical response and catalytic activity in hydrogen evolution reactions (HER), oxygen evolution reactions (OER), and dissociative adsorption reaction of hazardous gases, like H_2S . 2D nanomaterials and their hybrids, which promote interfacial coupling and efficient charge separation arise from the effects of adsorbent nature, quantum size engineering, and defect assistance, are therefore promising photovoltaic and photocatalytic nanomaterials.

**Dr. Wei XING (邢伟)**

Dr. Wei Xing got his B.Eng., M.Eng., Ph.D. degrees from China University of Petroleum. Currently, he is a young scientist at the Institute of New Energy, China University of Petroleum. His research expertise is in nanoporous materials for adsorption and new energy technologies. He has co-authored more than 100 papers in refereed journals, including *Energy and Environmental Science*, *Advanced Functional Materials*, *Chemistry of Materials* and *Carbon* (more than 5000 citations in Web of Science). He has filed 10 patents on novel functional nanomaterials. These materials are very promising for energy storage and gas adsorption, etc. He has attracted more than 10 million RMB in research grants from National Natural Science Foundation of China, Shandong Province and industrial partners. In recognition of his achievements in research, he was honored with a Distinguished Young Scientist and First-Level award in Natural Science (twice) by Shandong Province.

+ Abstract**Robust polyaniline/graphene oxide composites for high-performance aluminum-ion batteries**

Aluminum-ion batteries (AIBs) have attracted rising attention owing to its low cost, high safety, and three-electron-redox properties, which can potentially lead to high capacity.^[1,2] The investigations on cathode materials for RAIBs have mainly focused on graphene-based materials and metal dichalcogenide materials. In the case of graphene-based cathode materials, their discharge capacity (usually below 130 mAh g⁻¹) is difficult to further improve, since the interlayer space of graphene materials can only store a limited amount of large-sized [AlCl₄]⁻ anions. On the other hand, metal dichalcogenide cathode materials show significantly higher initial discharge capacities (300-500 mAh g⁻¹ at 100 mA g⁻¹), but they suffer from poor cycle performance, and this is the main obstacle for its further application in AIBs. So, there is an urgent need to develop cathode materials with both high capacity and good cycle performance.



李庆余, 男, 广西师范大学教授, 博士研究生导师。深圳清华大学研究院客座研究员; 广西低碳能源材料重点实验室主任。The Board Committee Member of the International Academy of Electrochemical Energy Science; 中国化学会电化学委员会委员; 中国硅酸盐学会固态离子学分会理事; 中国化工学会储能工程专业委员会委员; 中国化学与物理电源行业协会专家委员会委员。

李庆余教授长期从事新能源材料、新能源技术、应用电化学和有色冶金等领域的研究与开发, 承担国家高技术(863)课题、国家重大基础规划项目(973)子课题、国家自然科学基金、国家自然科学基金广东省联合基金、广西科学研究与技术开发计划项目、广西科学基金和横向课题等科研项目 30 多项; 成功研发“动力锂离子电池正极材料-LiFePO₄ 生产技术”、“铝塑膜软包装锂离子电池生产技术”、“超级电容器生产技术”、“涂层锰酸锂正极材料生产技术”、“船用锂离子电池动力模块生产技术”、“铝电解用常温固化 TiB₂ 阴极涂层技术”和“铝电解碳素阳极用抗氧化涂层技术”等高新技术; 在 Journal of Materials Chemistry、Electrochimica Acta、Journal of Power Sources、Chemical Engineering Journal 等国内外知名刊物上公开发表学术论文 160 多篇; 获得授权国家发明专利 30 项; 获得中国有色金属工业科学技术二等奖 1 项, 广西技术发明奖二等奖 1 项。广西高等学校高水平创新团队带头人, 卓越学者。

+ Abstract

Fe, Co, Ni-based bimetallic sulfides as the catalyst for polysulfides conversion in Li-S batteries

Dingjiao Lv, Zhijie Zhang, Zhaoling Ma,* Qingyu Li*

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The commercial applications of Li-S batteries are still hindered by the fatal problem of short cycle life in spite of its exceptionally high theoretical specific capacity (1675 mAh g⁻¹) and energy density (2600 Wh Kg⁻¹). The shuttle effect resulted from the slow kinetics is considered as the root cause. Fe, Co, Ni-based pyrite structure were found to effectively catalyze the reduction the polysulfide anions in Solar sensitized battery field.¹ In attempt to boost the kinetics of polysulfides conversion, Fe, Co, Ni-based bimetallic sulfides grown on carbon paper were applied to serve as the catalysts in Li-S batteries. The designed interlayer holds two advantages of physical obstruction as fish-net as well as the strong chemical binding and rapid electron transfer of bimetallic sulfides (Figure 1a).² CNS-2 and CFS-2 respectively synthesized under Co-Ni and Co-Fe ratio of 2:1 possess single phase and even more robust chemical adsorption towards polysulfides than monometallic sulfides (Figure 1b-e), which verifies that the incorporation of Co atoms endow the distinguished catalytic

property of CFS-2. CFS-2/CP even exhibits more prolonged cycle life in contrast to CNS-2/CP although it has lower initial special capacity. This work demonstrated that bimetallic compounds with remarkable and stable catalytic effect would be considered as the promising material for high energy density Li-S batteries.

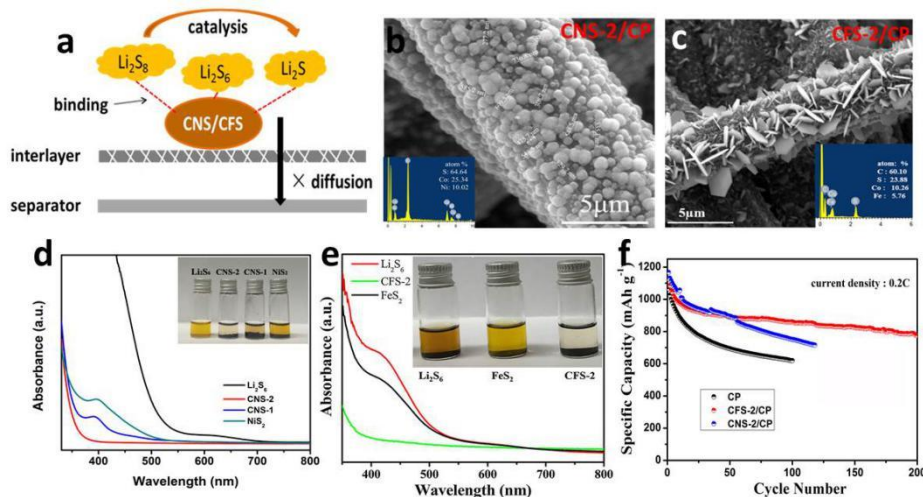


Figure 1. Schematic diagram and structure characterization of CNS-2/CP and CFS-2/CP interlayers, and their chemical adsorption and electrochemical performances in Li-S batteries

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2. W.-G. Lim, S. Kim, C. Jo and J. Lee, *Angewandte Chemie International Edition*, 2019, 131, 58, 2-14.

■ Session III

Capacitors, Battery Characterization



Dr. Cheng Yan is a professor in the School of Chemistry, Physics and Mechanical Engineering, and the domain leader of Metals, Rocks and Inorganic Materials of the Institute for Future Environment, Queensland University of Technology, Australia. His main research interest is synthesis and characterization of nanocomposites, energy and biomedical materials. He has generated 220 international journal papers and received A\$8 million research funds, including 16 Australian Research Council (ARC) grants. He was awarded several competitive fellowships from ARC (Australian Postdoctoral Fellow and Australian Research Fellow), University of Sydney (Sesqui Fellow) and Queensland Government (Inaugural International Fellowship and Nanotechnology Category Winner). He is the associate editor or board member of five international journals.

+ Abstract

Characterization and modeling of nano carbon for applications in batteries

Nano carbon such as carbon nanotube and graphene have attracted major interest due to their exceptional physical properties. We have investigated the mechanical, thermal and electrical properties at nano carbon/polymer interfaces for applications in composites and batteries. Our simulations show that oxygen-functionalized graphene leads to increased interface adhesion between graphene and polymer. Grafting polymer chains on top of graphene layers can improve the interface thermal conductivity. The electrical conductivity of nano carbon polymer composites have been studied using experimental and numerical approaches. For energy storage applications, graphene oxide wrapped Fe₂O₃ has been used as anode materials in Li-ion, Na-ion and zinc-air batteries with improved mass transfer and mechanical integrity. Si/carbon composites have been adopted to improve the electrical conductivity and volume expansion of Si batteries. The effects of different dopants on graphene on the performance of Li-S and Na-ion batteries have been investigated using density functional theory (DFT) simulations.



Professor Yong Lei worked as an Alexander von Humboldt Fellow at Karlsruhe Institute of Technology (Germany) in 2003–2006. Later he worked at University of Muenster (Germany) as a group leader (2006–2009) and a Junior professor (2009–2011). In 2011, he joined the Technical University of Ilmenau (Germany) as Professor (Full Professor, permanent) and Head of the Group of Applied Nano-Physics (Fachgebiet Angewante Nanophysik). His research interests focuses on template-based multiple and surface nanostructuring, energy-related devices (sodium-ion and potassium-ion batteries) and optoelectronic applications of functional nanostructures and surface nano-patterns. So far he has authored 189 papers in SCI-indexed journals and 2 patents, many of them are published in first-class journals, including 16 papers published in journals with impact factor higher than 20, and 59 papers published in journals with impact factor of 10–20. Prof. Lei received a few prestigious large projects in Europe and Germany, including European Research Council, BMBF (Federal Ministry of Education and Research of Germany), DFG (German Research Foundation), and VW-Stiftung (Volkswagen Foundation). Now he is an Editorial Advisory Board Member of the journal *Advanced Energy Materials*, Advisory Board Member of the journals *Carbon Energy* and *InfoMat*, and Associate Editor of the journal *Energy & Environmental Materials*.

+ Abstract

Template-based Large-scale Arrays and Regular Nanostructures for Energy Storage Devices

Template-based technique provides a perfect approach to realize large-scale arrayed nanostructures with high regularity. We have developed nanostructuring techniques using anodic aluminum oxide templates with scalable, parallel and fast processes,^[1] for fabricating different three-dimensional and surface nanostructures. The obtained functional nanostructures possess large-scale arrayed configuration, high structural density, perfect regularity and cost-effectiveness, and are highly desirable for constructing energy storage devices, including rechargeable sodium-ion and potassium-ion batteries,^[2–5] and supercapacitors^[7–9]. The device performances demonstrated that the obtained nanostructures benefit these applications through the precise control over the structural features enabled by the geometrical characteristics of the templates. These achievements indicate the high potential and importance of template-based nanostructuring techniques for both basic research and device applications.

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Dr. Wei Kong Pang is an Australian Research Council (ARC) Future Fellow and is currently a senior research fellow of Institute for Superconducting and Electronic Materials (ISEM), University of Wollongong. He received his Ph.D. in Applied Physics from the Curtin University, Western Australia in 2011. After the PhD completion, he was first pursuing a postdoctoral research in large-format lithium-ion battery research in Taiwan (2011 – 2013) and then a joint research fellow position at the University of Wollongong (UOW) and Australian Nuclear Science and Technology Organisation (ANSTO) (2013 – 2016). Notably, his research work focuses on the mechanistic studies of energy materials for rechargeable metal-ion batteries, especially the high-voltage electrode materials for lithium-ion batteries, using in operando neutron and synchrotron technique as tools.

+ Abstract

Understanding Energy Storage Materials Function Using In Operando Neutron Powder Diffraction

The performance of energy storage materials such as rechargeable battery electrodes is influenced by the crystal structure and phase changes of components during device operation. Understanding the structure–function relation of such materials is therefore crucial to both improving existing energy storage materials as well as directing the development of future technologies. Neutrons have unique properties that make them essential in determining the phase and crystal structure of many energy storage materials and their high penetration through materials means that neutron powder diffraction can be used to study the changes to materials phase and crystal structure during operation of a whole device. The ability to study in detail the structural mechanism of materials function in an unmodified commercial device guarantees that the determined phase and crystal structure changes accurately represent the material function within the real-life applied device. The mechanistic understanding of the reaction pathways, i.e. the atomistic and molecular-scale origin of battery performance, will enable the rational improvement of electrode materials and pave the way for entirely new battery systems. In this presentation, I will showcase some examples of crystallographic analysis of electrode materials and in operando studies of electrode materials in whole devices in real time.

References:

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2010 Masterpiece Award of Excellent Graduate Paper Award, The Physical Society of Republic of China

2008 Second Prize Award of Student Oral Presentation, National Synchrotron Radiation Research Center

2006 First Prize Award of Student Poster Presentation, National Synchrotron Radiation Research Center

2005 Second Prize Award of Student Oral Presentation, National Synchrotron Radiation Research Center

+ Abstract

The Role of the Copper Oxidation State in the Electrocatalytic Reduction of CO₂ into Valuable Hydrocarbons

Redox-active copper catalysts with accurately prepared oxidation states (Cu^0 , Cu^+ , and Cu^{2+}) and high selectivity to C₂ hydrocarbon formation, from electrocatalytic cathodic reduction of CO₂, were fabricated and characterized. The electrochemically prepared copper-redox electro-cathodes yield higher activity for the production of hydrocarbons at lower oxidation state. By combining advanced X-ray spectroscopy and in situ micro-reactors, it was possible

to unambiguously reveal the variation in the complex electronic structure that the catalysts undergo at different stages (i.e., during fabrication and electrocatalytic reactions). It was found that the surface, subsurface, and bulk properties of the electrochemically prepared catalysts are dominated by the formation of copper carbonates on the surface of cupric-like oxides, which prompts catalyst deactivation by restraining effective charge transport. Furthermore, the formation of reduced or partially reduced copper catalysts yields the key dissociative proton-consuming reactive adsorption of CO_2 to produce CO, allowing the subsequent hydrogenation into C2 and C1 products by dimerization and protonation. These results yield valuable information on the variations in the electronic structure that redoxactive copper catalysts undergo in the course of the electrochemical reaction, which, under extreme conditions, are mediated by thermodynamics, but critically, kinetics dominate near the oxide/metal phase transitions.

Dr. Jun Zhong is a professor at Institute of Functional Nano & Soft Materials (FUNSOM) at Soochow University and the assistant director of Soochow University-Western University Centre for Synchrotron Radiation Research. He received his B.Sc. degree in 2002 from Tsinghua University and received his Ph.D. degree in 2008 from Institute of High Energy Physics, Chinese Academy of Sciences. He joined Soochow University since 2010. His research interests focus on the development of synchrotron radiation techniques and their applications in energy related materials. More than 130 articles were published based on his research. Currently he is also in charge of the construction of a new beamline for the soft X-ray in-situ XAS experiments at Hefei light source.

+ Abstract

X-ray Absorption Spectroscopy Study of Carbon Based Nanomaterials For Energy Related Applications

Synchrotron radiation based X-ray absorption spectroscopy (XAS) is a powerful tool to probe the electronic structure of various materials. Here we will describe our recent efforts in the XAS study of carbon based nanomaterials for energy related applications by using typical XAS, scanning transmission X-ray microscope (STXM), and in-situ XAS techniques at both soft and hard X-ray ranges. Data will show the advantages of XAS to probe the electronic structure of complicated systems at the interface and at a working state, which can help to understand the reaction mechanism in energy related applications. A new beamline built by us at Hefei light source will also be introduced, which focuses on the in-situ XAS study at the soft X-ray range for energy related applications.



Dr Yu Lin Zhong completed his PhD in Chemistry at the National University of Singapore (NUS) and did his post-doctoral training at Princeton University (2009) and Massachusetts Institute of Technology (2011). After spending three years in the USA, he worked as a Research Scientist at the Institute of Bioengineering and Nanotechnology, A*STAR Singapore, (2012) and thereafter, as an ARC DECRA Fellow at Monash University (2013). He is currently an Associate Professor at the School of Environment and Science, Griffith University (Gold Coast campus) and a full research member of the Centre for Clean Environment and Energy (CCEE).

+ Abstract

Advancing Electrochemical Engineering of Functional Nanomaterials for Wearable Smart Devices

Although graphene oxide (GO) has shown enduring popularity in the research community, its synthesis remains cost prohibitive for many of its demonstrated applications. While significant progress has been made on developing an electrochemical route to GO, existing methods have key limitations regarding their cost and scalability. To overcome these challenges, we employ a combination of highly robust boron-doped diamond (BDD) with a wide electrochemical potential window and commercially available fused deposition modelling (FDM) 3D printing to fabricate a scalable packed-bed electrochemical reactor (PBER) for GO production. The scalability of the reactor along the vertical and lateral dimensions was systematically demonstrated to facilitate its eventual industrial application. Our current reactor is cost-effective and capable of producing electrochemically derived graphene oxide (EGO) on a multiple-gram scale. The as-produced EGO is dispersible in water and other polar organic solvents (e.g. ethanol and DMF) and can be exfoliated down to predominantly single-layer graphene oxide. The simplicity, cost-effectiveness and unique EGO properties make our current method a viable contender for large-scale synthesis of graphene oxide. Subsequently, we have demonstrated a new efficient technique for 3D printing of conductive PDMS/graphene ink by using an emulsion method to form a uniform dispersion of PDMS nanobeads, EGO and PDMS precursor binder. The formulated nanocomposite ink exhibits high storage moduli and yield stress that can be employed for Direct Ink Writing (DIW) 3D printing. Due to the unique hybrid structure of PDMS and EGO sheet, the 3D printed EGO/PDMS nanocomposite possesses high, linear and reproducible sensitivity that is suitable for application as skin-attachable wearable health monitoring device.



Dr. Kwun Nam Hui received his B.Sc. degree in physics from the Hong Kong University of Science and Technology in 2003. He obtained his M.Phil. (2006) and Ph. D. degree (2009) in Electrical and Electronic Engineering from the University of Hong Kong. He is currently an Associate Professor at the Institute of Applied Physics and Materials Engineering of the University of Macau. His current research focuses on the design and synthesis of nanostructured materials for electrochemical energy storage and conversion, including batteries, supercapacitors, and fuel cells.

+ Abstract

Defect engineering of nanomaterials for high-performance supercapacitors

As an emerging candidate for electrochemical energy technologies, supercapacitors have been extensively investigated due to their high-power output, long cycle lifetime, and light weight. However, the main bottleneck in using supercapacitors is the enhancement of their energy density to compete with rechargeable batteries without sacrificing the power density. Generally, pseudocapacitors with battery-type materials have high specific capacity but still suffer from inferior rate performance and poor cyclic stability due to the slow ionic diffusion and sluggish electron transfer kinetics of the electrode materials upon cycling. Accordingly, reduction of their particle size, increase of their electroactive surface area, combination with conductive carbon and/or development of surface defect engineering have been well-recognized to potentially transform battery-type materials into “extrinsic” pseudocapacitive materials. In this talk, defect engineering strategy will be discussed to improve the electron transports, electrolyte ions diffusion kinetics, and electrical conductivity of metal oxide-based electrodes. Experimental analyses and theoretical calculations reveal that the electronic structure of metal oxides can be efficiently modulated by incorporating heteroatoms and oxygen vacancies, thereby simultaneously reducing the energy band gap and increasing electrical conductivity. In particular, the heteroatoms doping approach is demonstrated to lower the diffusion barrier of electrolyte ions in intercalated supercapacitors.

+ Abstract

Origin of functionality for functional materials

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Structure is an arbitrary partition of a space. From Euclid to Hilbert space, from numerical to topological space, the design for optimized structures in complex systems remains nontrivial. After algebra gradually replaced calculus, the use of inner and outer product of vectors became an instrument to describe physical processes, which oppositely however, also limited the imagination of utilizing other forms of products. In one electron processes, the origin of functionality is highly determined by the local symmetry, which is governed by the inner product of matrices. The demand for accurate characterization of local symmetry at picometer scale has greatly promoted the development of spherical aberration corrected electron microscopy. In addition, modern microscopy seems to be able to address Prof. Feynman's assignment to solve the three fundamental postulates in band theory, periodic potential, one electron, and adiabatic approximations. This talk will focus on the picometer scale fine structure and novel physical properties of functional materials under symmetry breaking within the realm of inner product functionality.

王大伟博士现为澳大利亚新南威尔士大学副教授，澳大利亚研究理事会 Future Fellow，新南威尔士大学 Scientia Fellow。他的研究领域为二维能源材料的合成化学和界面机理，及新型能源技术（主要为超级电容器，金属/硫电池和高通量生物电解技术等）。他已发表 100 余篇论文，获得 19000 余次引用，为 2018 及 2019 年科睿唯安高被引作者。

+ Abstract

Capacitor Materials from Porous Solid to Fluid-in-Solid Heterostructure

The use of porous electrode has been the most popular option for capacitive storage, simply because of the linear proportion between the capacitance and the electrode surface area. But is this true when the surface area is more often measured via non-electrochemical means? In recent years, it has been more widely recognized about the inconsistency between the gas adsorption method and the electrochemical processes in detecting the truly effective electrode areas.

Rather than struggling heavily to maximize the gas adsorption surface area, one should really look at what is demanded by the electrode processes, that is the ion accessibility. In this work, instead of creating ‘dry’ porous network for ion to access, we created ‘wet’ network with prescribed fluid as the ion conduction channels for ion to access.

Such a structure mimics the natural clays in terms of the fluid-in-solid nature. Given the non-porous nature, the ion access behavior is more suitable described as an intercalation mechanism. Though the philosophy of getting ions into ‘wet’ instead of ‘dry’ network seems straightforward, the artificial synthesis of such clay-like structure bearing both good ionic and electronic conductivity has been extremely challenging. In this talk, I’d like to share the discovery of a new layered material with intercalative fluid-in-solid heterostructure and their related capacitive behaviors. Their great potential in device applications will be highlighted as well.

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+ Abstract

Wood Carbon and Their Electrochemical Properties

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Porous carbon electrodes have emerged as important cathode materials for metal-air battery systems. Considering the natural abundance, environmental friendliness and low cost, biomass has been regarded as one of the most promising candidates for developing green carbon-based energy materials. Herein, the recent process of advanced biomass-based materials in our groups will be introduced. (1) With the design concept of “Rotten wood can be carved”, a “bottom-up” and “template-free” strategy was proposed to fabricate a wood-based nitrogen-doped porous carbon plates. Owing to the high surface area and rich hierarchical pores resulting from enzyme-catalyzed hydrolysis treatment and novel wood conduit structure, the resultant catalyst revealed excellent ORR and OER catalytic properties, and also had great potential for use as a low-cost, highly efficient air cathode for rechargeable zinc-air batteries and fuel cells. When used as metal-free cathodes in zinc-air batteries, the batteries demonstrated a specific capacity of 801 mA h g^{-1} and an energy density of 955 W h kg^{-1} with a long-term stability as high as 110 h. (2) To convert natural wood with compact structure into porous carbon plates, pores-creating methods (e.g. hydrothermal treatment and Lewis acid hydrolysis pretreatment) were proposed. The as-prepared single atom wood-based catalysts with Fe-N-C active sites shown a high specific capacity of 790 mA h g^{-1} and an energy density of $1003.3 \text{ W h kg}^{-1}$, when used as air cathodes for rechargeable zinc-air batteries. (3) Using the three components of lignocellulose as carbon precursor (i.e., lignin, cellulose and hemicellulose), a series of flexible all-biomass based carbon aerogels with 2D lamellar structure were fabricated via a directional freeze-casting method. The excellent mechanical flexibility, good electrocatalytic properties and high sensing performances make the as-prepared carbon aerogels highly attractive for wearable sensors/devices, zinc-air batteries, lithium-ion batteries, and flexible supercapacitors. This work paves the way for the readily conversion of abundant biomass into high-value engineering products for energy-related applications.

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张桥保，厦门大学材料学院副教授，中国科学院深圳先进技术研究院客座研究员。近年来主要围绕二次电池，超级电容器及其关键电极材料开展了系统的研究工作，以开发高性能电极材料为目标，通过原位透射电镜等先进表征方法，重点研究了电极材料结构形貌与其电化学性能之间的构效关系，取得了系列研究成果，在Chem. Soc. Rev (1)、Prog. Mater. Sci (1)、Energy Environ. Sci (1)、Nature Commun.(1)、Adv. Energy. Mater (1)、Adv. Funct. Mater. (1)、ACS Nano (3)、Nano Lett. (1)、Nano Energy (6)、Energy Storage Materials (1)、ACS Catalysis (1)、J. Mater. Chem. A (4)、Small (1)等国际刊物发表论文40余篇。其中九篇论文入选 ESI 高被引论文，三篇入选ESI热点论文。

+ Abstract

转化/合金机理负极材料和原位电镜表征

随着新能源材料与技术的快速发展，特别是面向新型便携式通讯、新能源汽车、大规模储能、航空航天、国防军事等领域的巨大技术和市场需求，高能量密度锂离子电池关键电极材料的研究开发具有重要的科学意义和实用价值。如何设计先进电极材料并对其电化学性能进行调控是获得高性能锂离子电池负极材料的关键。本报告将主要讨论合金化反应机理硅以及转化/合金反应机理硫化钛复合负极材料的合理电极结构设计和电化学性能提高的策略，重点从原位电镜的角度来详细研究复合负极在嵌脱锂过程中的电化学行为为更深入地理解电极反应机理和揭示电化学性能提高提供直观可靠的实验证据。



Dr. Jianlin Huang is a professor in the School of Environment and Energy at South China University of Technology (SCUT). He worked as a postdoctoral fellow at McGill University, Canada. His current research interests include design and fabrication of emerging nanomaterials for energy, environment, and flexible electronics.

+ Abstract

Ultra-Thick Electrodes Based on Activated Wood-Carbon toward High-Performance All-Solid-State Supercapacitors

The ever-growing smart electronics and electric vehicles (EVs) urgently require advanced energy storage technologies (e.g., supercapacitors and rechargeable batteries) toward higher energy/power densities, longer cycling life and better safety[1,2]. Herein, a facile, low-cost, and efficient strategy by surface engineering to synthetic ultrathick electrodes of all-solid-state symmetric supercapacitor (SSC) based on activated wood-carbon (AWC) monoliths is presented (Fig.1). The AWC as a freestanding ultrathick electrode shows an impressive areal capacitance of 6.85 F cm^{-2} at 1 mA cm^{-2} and 4.55 F cm^{-2} at 20 mA cm^{-2} . Furthermore, an all-solid-state SSC assembled by the two identical AWC monoliths delivers an encouraging energy density of 0.23 mWh cm^{-2} (4.59 Wh Kg^{-1} and 0.77 Wh L^{-1}) at a power density of 500 mW cm^{-2} (9.9 mW Kg^{-1} and 2500 W L^{-1}) while keeping a capacitance retention of 86% after 10 000 continuous charge-discharge cycles. The remarkable electrochemical performance is attributed mainly to the preservation of structural integrity from natural wood, the introduction of oxygen-containing functional groups and ultrathick electrode design, which significantly improves electroactive material loading and device integration.

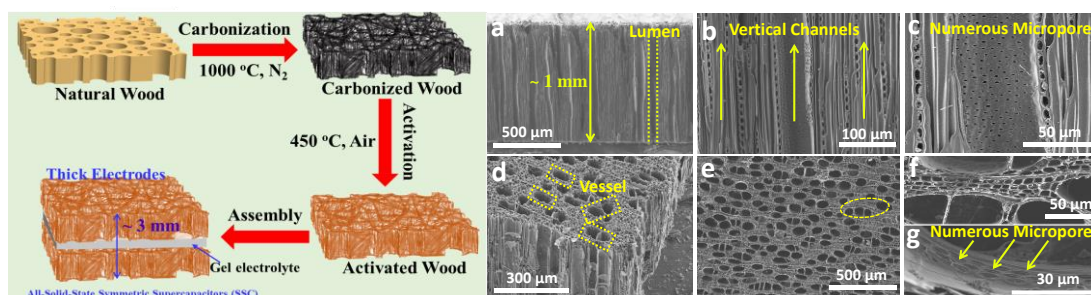


Fig. 1 Construction of an all-solid-state symmetric supercapacitor (SSC) based on activated wood carbon (AWC) monoliths as freestanding thick electrodes. (a-g) SEM images of AWC.

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Prof. Dr Xuchuan Jiang, 1000-Talent Program Fellowship of China, currently works at Monash University (Australia) and Fasten Group Company (Jiangyin, China), has fully devoted to the synthesis, self-assembly and functional applications of nanoparticles since PhD graduated in 2001 at University of Sci. & Tech. of China. Dr. Jiang has been working in various academic research environments in the past years, including University of Washington (USA), University of Paris (France), and University of New South Wales (Australia). He has published over 130 papers in *Nano Lett*, *J. Am. Chem. Soc.*, *Adv. Mater. Progress in Mater. Sci.* ACS Nano, and others, with SCI citations over 7000 times, and *H*-index 42. He has been awarded Australia Research Council (ARC) Future Fellow and ARC Queen Elizabeth II Fellow in 2009. Currently, he is the Editor/Editor Board of four international journals, and referee over 20 international journals.

+ Abstract

Engineering Vanadium Dioxide Nanoparticles for Smart Coatings: From Lab to Industry

Xuchuan Jiang

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Vanadium dioxide (VO₂) as a very prominent representative of nanomaterials is known for several decades because of its low-temperature thermochromic phase transition, and it has been intensively studied in scientific and technical aspects recently, especially achieved enormous attention and attraction for potential applications in smart window coatings. However, the technology transfer from lab to industrial scale production of VO₂ is still challengeable. The problems in large-scale production such as complicated preparation procedures, instability and agglomeration of nanosized particles limit currently industrial applications in smart coatings for energy-saving windows. In addition, the currently faced limitations in the glass coatings with low visible transmittance and weak solar modulating capability also delay the commercialisation and market penetration of VO₂ nanomaterials/film coatings. This presentation will talk about the possible solutions to the problems how to transfer lab results to industrial scale production for large-scale applications in smart windows for energy and environment, based on our recent research findings in this field.



邵宗平，男，1973 年生，南京工业大学材料化学工程国家重点实验室特聘教授，享受政府特殊津贴。同时也是澳大利亚 Curtin University John Curtin Distinguished Professor。曾获得国家自然科学基金委杰出青年基金（2010）、教育部长江学者特聘教授（2011）、国家万人计划（2019）、国家百千万人才工程、科技部中青年科技领军人才、霍英东青年基金和教育部分新世纪优秀人才等人才项目或称号。从事能源储存和环境催化领域的研究，包括：燃料电池、储能电池、低温催化、水处理、太阳能电池和混合导体透氧膜等。目前在 *Nature*（2），*Nature Energy*（1），*Nature Commun.*（5），*Science Adv.*（1）等期刊上发表论文 640 余篇，其中影响因子大于 10 的 130 多篇。论文引用超 28000 次（google scholar），H-index 为 78，获授权专利 32 项，美国专利 2 项，出版英文专著 1 本以及 3 本章节。是 2014、2017 和 2018, 2019 年全球高被引科学家，及 2015-2018 年能源领域中国高被引学者。曾荣获教育部自然科学奖二等奖（1/5），江苏省科学技术奖二等奖（1/5），和湖北省科学技术奖二等奖（2/3）。是 *Materials Reports: Energy* 期刊副主编，*Scientific Report*、*Energy Science & Engineering*、*Journal of Ceramics*、*The Open Fuels & Energy Science Journal* 及材料导报、热科学与技术等学术期刊编委。

+ Abstract

双功能催化剂的开发及在 Zn-Air 电池中的应用



Qinghong Yuan received her Doctoral Degree in Theoretical Chemistry from the Chinese University of Hong Kong in 2010. After working in Hong Kong Polytechnic University as a postdoctoral researcher, she was appointed as an associate professor in 2012 and was promoted to a full professor in 2015 in the department of physics, East China Normal University. Qinghong Yuan got a DECRA fellowship from the ARC in 2016. Her research interest focuses on theoretical study of low-dimensional nanomaterials, including the mechanism of

chemical vapour deposition growth of graphene and carbon nanotubes, theoretical design of new carbon nanomaterials, and catalysis. Her research, sponsored by the National Science Foundation, Shanghai Science and Technology Commission, ARC etc, resulted in over 40 peer-reviewed papers in high impact journals, including *Nat. Mater.*, *Nat. Commun.*, *J. Am. Chem. Soc.*, *Phys. Rev. Lett.*, *Adv. Mater.*, *Adv. Funct. Mater.*, *Angew. Chem. Int. Edit.*, *ACS Nano*, and *Adv. Sci.* etc.

+ Abstract

Understand the controllable synthesis of nitrogen-doped graphene from a theoretical perspective

Nitrogen-doped graphene (NG) has been demonstrated as an excellent catalyst for electrochemical reactions¹⁻² due to their unique electronic properties derived from the conjugation between the nitrogen lone-pair electrons and the graphene π system. However, the NGs that can currently be fabricated experimentally always have a mixture of graphitic, pyridinic and pyrrolic nitrogen dopants, which limits the desirable physical and chemical properties. In this work, by combining theoretical calculations with experimental results, we proposed possible ways to synthesize NGs with controllable doping of graphitic or pyridinic nitrogen.³⁻⁵ Theoretical predictions have been confirmed by experimental characterizations.

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Dr. Tang Yuxin is an Assistant Professor in the Institute of Applied Physics and Materials Engineering at University of Macau. He graduated from Nanyang Technological University (NTU, Singapore) with a PhD in Materials science (2013), developing functional materials for environmental protection. After that, he did a postdoc at NTU, and worked on advanced functional materials for energy conversion and storage application. He received the prestigious awards and honors including Emerging Investigators for Journal of Materials Chemistry (2017), World Future Foundation Ph.D. Prize Award for best PhD thesis (2013), and Chinese Government Award for Outstanding Self-financed Students Studying Abroad (2013). So far, He has published over 80 scientific articles including, Chem. Soc. Rev., JACS, Adv. Mater., Angew. Chem., Adv. Energy Mater., Adv. Funct. Mater., Small, etc.

+ Abstract

Fast charging Lithium-ion Batteries: Electrode Material Design and In-situ Electrochemical Reaction Monitoring

Fundamental insight into the surface charging mechanism of batteries materials is limited due to the limitations of available characterization tools that can directly probe surface charging process. Here, we report an in-situ approach to monitor the dynamic valence state of a prototype TiO₂-based electrodes, which utilizes in-situ X-ray absorption spectroscopy (XAS) to identify the origin and contribution of surface storage. A real-time correlation is elucidated between the rate-dependent electrode performance and dynamic Ti valence-state change. A continuous Ti valence state change was directly observed through the whole charging/discharging process regardless of charging rates, which proved that along with the well-known non-faradaic reaction, the surface charging process also originated from a faradaic reaction. The quantification of these two surface storage contributions at different charging rates is further realized through in-situ dynamic valence state monitoring combined with traditional cyclic voltammetry measurement. The methodology reported here can also be applied to other electrode materials for the real-time probing of valence state change during electrochemical reactions, the quantification of the faradaic and non-faradaic reactions, and the eventual elucidation of electrochemical surface charging mechanisms.



Dr. Mai is full professor in Jinan University. He is also the department head of Physics Department. His research interests include Li/Na/K/Zn ion batteries, supercapacitors, solar cells, photodetectors, and water splitting. He has published ~100 papers in peer-reviewed journals such as Science and PNAS with citations above 5500 times. He has received 3 national funding projects and 7 provincial funding projects. He has been awarded many honors such as Guangdong Provincial Outstanding Young Scholars.

+ Abstract

Development of high-performance flexible supercapacitors and in-situ optical detection of their energy storage status

The pursuit of harmonic combination of technology and fashion intrinsically points to the development of smart garments. Herein, we present an all-solid tailorable energy textile possessing integrated function of simultaneous solar energy harvesting and storage, and we call it tailorable textile device. Our technique makes it possible to tailor the multifunctional textile into any designed shape without impairing its performance and produce stylish smart energy garments for wearable self- powering system with enhanced user experience and more room for fashion design. Further, we investigate the possibility of using in-situ technology to monitor the energy status of the supercapacitors and obtain very interesting results.



Ping He was born in Nanjing, China, in 1981. He obtained his Ph. D. in Physical Chemistry from Fudan University in 2009, and later worked as a postdoctoral fellow at National Institute of Advanced Industrial Science and Technology (AIST), Japan. He currently is a Full Professor of College of Engineering and Applied Sciences at Nanjing University. Prof. He obtained National Science Fund for Excellent Young Scholars and Jiangsu Natural Science Fund for Distinguished Scholars. His research interests focus on electrochemical functional materials and energy storage system such as lithium-ion batteries and lithium-air batteries. Prof. He published more than 110 peer-reviewed papers which were cited more than 5000 times. H-Index is 42.

+ Abstract

Research on Mechanism of electrochemical reaction at Interface of Li-O₂ battery in Complex Systems

The comprehensive performance of Li-air batteries is still far from practical application at present, including the cycle life, rate capability, energy conversion efficiency and so on. The Li-air battery is a half-open system. During the battery operation, the process of material exchange proceeds between the open cathode and atmosphere. In this report, other air components such as CO₂ and H₂O are introduced into the electrode/electrolyte interface system. The processes of CO₂ discharge and charge at electrode will be described in detail. Besides, the effect of H₂O in electrolyte and air on the discharge and charge performance of cell will also be present. And the new reaction mechanism caused by H₂O will be detailed.

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Research on Mechanism of electrochemical reaction at Interface of Li-O₂ battery in Complex Systems

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The comprehensive performance of Li-air batteries is still far from practical application at present, including the cycle life, rate capability, energy conversion efficiency and so on. Further investigations on fundamental theories concerning Li-air batteries are required to promote these properties. The Li-air battery is a half-open system. During the battery operation, the process of material exchange proceeds between the open cathode and atmosphere. Since dry oxygen is incorporated into the research system, it is set as “battery-oxygen” system. During the process of discharge, the Li anode loses electrons forming Li^+ and oxygen acquires electrons and reacts with Li^+ to form Li_2O_2 at cathode. In the subsequent process of charge, it happens inversely to above reactions that Li_2O_2 decomposes at high voltage, producing O_2 and Li at cathode and anode, respectively.

The “dry oxygen” system has been studied thoroughly, of which the reaction mechanism at the three-phase interface between “electrode/electrolyte/oxygen” has been basically probed and the performance of electrode has been optimized progressively. Nonetheless, the dry oxygen system is only a simplified ideal research object to make the original complex open system accessible. Through the study of this simplified system, it is beneficial to clarify the electrode reaction mechanism of energy conversion and storage, design high performance catalysts and establish suitable research methods for air cells. However, limitations still exist in this system. Firstly, the electrochemical reactions at the solid-liquid-gas three-phase interface of other components in the air are not considered. Secondly, the “dry oxygen” simplified system contains the processes of oxygen reduction and evolution at the catalyst/electrolyte interface, ignoring a series of parasitic reactions resulting from the instability of electrode components. For example, the carbon materials and trace amounts of water in the electrode have been proved to participant in the electrode reactions. The study on the simple “dry oxygen” system has also achieved great achievements currently. And it should be further extended--introducing other constituents like CO_2 , H_2O and N_2 from the atmosphere into the research system.

In this report, other air components such as CO_2 and H_2O are introduced into the electrode/electrolyte interface system. The processes of CO_2 discharge and charge at electrode will be described in detail and the control of CO_2 reversible and irreversible processes has been realized by Ru catalysts. Besides, the effect of H_2O in electrolyte and air on the discharge and charge performance of cell will also be present. And the new reaction mechanism caused by H_2O will be detailed. The great efforts have been made to focus on a series of parasitic reactions at the electrode/electrolyte interface and understand the complex electrode reactions at air electrode/electrolyte interface extensively. In the near future, the research system will be extended to the real atmosphere, and Li-air batteries will be put into practical applications gradually.

+ Abstract

Novel Hierarchical Structures based on Two-Dimensional Materials: Preparation and Energy-related ApplicationsXiehong Cao^{1*}¹Zhejiang University of Technology, Hangzhou, China

The hierarchical structure is a structure that is common in living organisms. By assembling the basic units of different characteristics into a whole in an ordered hierarchical structure, the synergistic effect of the components is utilized to achieve functions that are not possessed by a single component. Multi-level structural materials constructed of nano-materials can not only inherit the excellent physicochemical properties of their building units, but also avoid their agglomeration or stacking, thereby effectively increasing the surface area of the material and fully exposing the active sites. Therefore, nanomaterials with hierarchical structures have attractive applications in many fields, such as energy, environment and catalysis. The unique structure and excellent performance of two-dimensional nanomaterials have made it an excellent basic unit for constructing hierarchical structures.^[1,2] Recently, we have introduced metal-organic frameworks (MOFs) into the construction of two-dimensional composites with hierarchical structure. From the three aspects of synthesis strategy, macro/micro structure design and performance control, we have developed a series of different hierarchical structures based on two-dimensional materials, including graphene, MoS₂, metal oxide/hydroxide nanosheet, 2D MOFs (Figure 1).^[3-5] The applications of these materials in the field of energy storage and conversion, such as lithium-ion batteries, supercapacitors, Zn-air batteries, and oxygen evolution reaction, were also explored.

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Dr. Han Hu is a professor from State Key Lab of Heavy Oil Processing, China University of Petroleum (East China). He obtained his Ph.D. degree from Dalian University of Technology, China in 2014. Then, he conducted post-doc researches at Nanyang Technological University, Singapore, Leibniz Institute for Solid-state and Materials Research, Germany, and The University of Queensland, Australia for 4 years. His research interest includes new energy materials and value-added utilization of heavy oil by-products.

+ Abstract

Petroleum Asphalt-derived Carbon Materials for Energy Storage

Advanced energy storage technologies are of paramount importance for the deployment of sustainable and renewable energy. As the key components of energy storage systems, energy storage materials, especially carbon materials have aroused wide attention in the past decades. Herein, we demonstrated that the low-cost and heavy by-products from the petroleum industry, namely asphalt, is the promising precursor to prepare nanostructured carbon materials in a desired manner. By constructing electrodes using these materials, excellent performances have been realized in a wealth of energy storage devices, including lithium-ion capacitors, sodium-ion batteries, lithium-sulfur batteries, and so on. The strategies suggested maybe a viable solution to value-added utilization of petroleum industry by-products and bridge the gap between the traditional and emerging industries.

Dr. Ji Liang obtain his B.S. and M.S. degree at Tianjin University in China, and received his Ph.D. from the University of Adelaide in 2014. After a two-year T. S. Ke Fellowship in the Institute of Metal Research of the Chinese Academy of Sciences, he was appointed an ARC-DECRA research fellow in the Institute for Superconducting and Electronic Materials of the University of Wollongong, Australia. Then, he joined the School of Materials Science and Engineering in Tianjin University. His research interests lie in the design of functional carbon-based materials for electrochemical catalysis and energy storage applications.

+ Abstract

Silica-Mediated Formation of Transition Metal Compounds on CNT Films for Versatile Energy Storage

Pengyi Lu, Wenlei Guo, Zhiyuan Sang, Lei Wang, Feng Hou*, Ji Liang*

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With the rapid development of portable and wearable electronics, the corresponding flexible energy storage (FES) devices (i.e., batteries or capacitors) to power them have become increasingly important.^[1-3] Nevertheless, the design and fabrication for suitable electrodes with both high mechanical flexibility and excellent electrochemical performance remains challenging. Various carbon nanomaterials, especially carbon nanotubes (CNTs), have been regarded as a feasible candidate for the requirements of mechanical properties due to their low weight, high conductivity and various bulky forms. To further enhance their electrochemical performance, we report an effective and universal silica-mediated strategy to uniformly decorate various metal compounds on CNT film. In this hybrid film, transition metal composites provide sufficient active sites for redox reactions, and CNTs network acts as an efficient electron highway, maintaining the structural integrity of the composite as well. These merits thus enable this composite film to meet the requirements of versatile energy storage applications. Significantly, the FES device based on this film possessed high energy/power density, outstanding cycling stability and excellent mechanical flexibility. Moreover, this strategy opens new avenues for the facile design and manipulation of functional flexible materials for future energy storage.

■ Session IV

Catalysis Related & Applications



Prof. Dr. Yongfa Zhu received his BA degree in 1985 from Nanjing University and obtained his master degree in 1988 from Peking University. He had studied and worked at Tsinghua University since 1992 to now and received a PhD degree at 1995. He is currently a full professor of Tsinghua University and associate editor for Applied Catalysis B.

His current research is focused on photocatalysis and application on environmental, energy conversion and anti-tumor. He is the author and co-author of 377 original research papers published in SCI journals. The total cited numbers reached about 25900 and the H-index arrived at 88. About 34 papers was selected as High-Cited Papers by Essential Science Indicators. Besides, he has written about 5 books and applied about 24 patents.

+ Abstract

Supramolecular Photocatalysts for Pollutant Degradation and Tumor Removal

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A new class of organic supramolecular photocatalysts with full visible spectrum response has been successfully developed. The texture structure, crystal structure, photoelectric physicochemical properties, organic electron energy band structure, photocatalytic oxidation and anticancer properties can be adjusted via molecular structure and stacking structure. The degradation ability, water splitting ability and anticancer came from the HOMO and LUMO level. The photocatalytic activity came from molecular dipole, ordered stacking and nanostructure.

Self-assembled PDINH supramolecular is an effective visible-light photocatalyst for the photodegradation of pollutants and even split water for oxygen evolution. Compared with monomeric PDINH, self-assembled PDINH supramolecular have band-like electronic energy level structure similar to inorganic semiconductor due to orbital overlaps between PDINH-molecular units. Strong π - π stacking between PDINH molecules enables effective long-range electrons delocalization and accordingly promotes photo-generated charge migration and separation, leading to its remarkable photocatalytic activity.

Supramolecular organic nanofibers, self-assembled by a carboxy-substituent PDI molecule via H-type π - π stacking and hydrogen bonding, can act as an effective photocatalyst for both organic pollutants degradation and water oxidation under full visible light. The high activity came from the molecular dipole and the nanocrystallization. Higher π - π supramolecular packing leads to a smaller bandgap, a deeper valence band position, enhanced light absorption and photo-oxidation capability. The inter-electronic field raised from ordered dipole can effectively promote the migration and separation of photo-generated carriers. H/J-type aggregated PDI supramolecular nanostructures were constructed via length of linear

carboxy-substituent side-chains. H-aggregates have higher π -electron conjugation and show more semiconductor characteristics, which results in higher carrier separation and migration efficiency. Whereas, J-aggregates exhibit more molecular properties due to low π -electron conjugation caused by head-to-tail stacking mode. H-aggregated PDI mainly forms superoxide radicals ($\cdot\text{O}_2^-$) and holes (h^+) through electron-transfer (ET). In contrast, J-aggregated PDI mainly generates singlet oxygen species ($^1\text{O}_2$) via energy-transfer (EnT). Benefit from the stronger oxidization ability of $\cdot\text{O}_2^-$ and h^+ , H-aggregated PDI shows higher photocatalytic activity for degradation and oxygen evolution under visible light. Whereas, J-aggregated PDI exhibits good photocatalytic anti-cancer activity owing to short length of nanofiber.

The full spectrum responsive supramolecular photocatalyst, SA-TCPP has been synthesized via an easy-conducted π - π stacking. The SA-TCPP can powerfully split water to hydrogen and oxygen at 40.8 and 36.1 $\mu\text{mol}\cdot\text{g}^{-1}\cdot\text{h}^{-1}$ without co-catalyst. The organic pollutants can be efficiently mineralized by the SA-TCPP under visible light irradiation. The degradation performances of SA-TCPP were over 10 times better than the inorganic photocatalysts. The single crystalline structure of π - π stacking promoted the transportation and separation of photogenerated carriers. Supramolecular photocatalyst SA-TCCP of bio-safe amount, targeted injection into the solid tumor inside, completely kill the tumor within 10 min under the deep penetration of red light (600-700 nm) irradiation. Photogenerated holes work as the most significant radical in the photocatalytic therapy process, which is abundant on the surface of photocatalyst in cytoplasm. The solid tumors was completely removed via photocatalysts injection and red-light irradiation.

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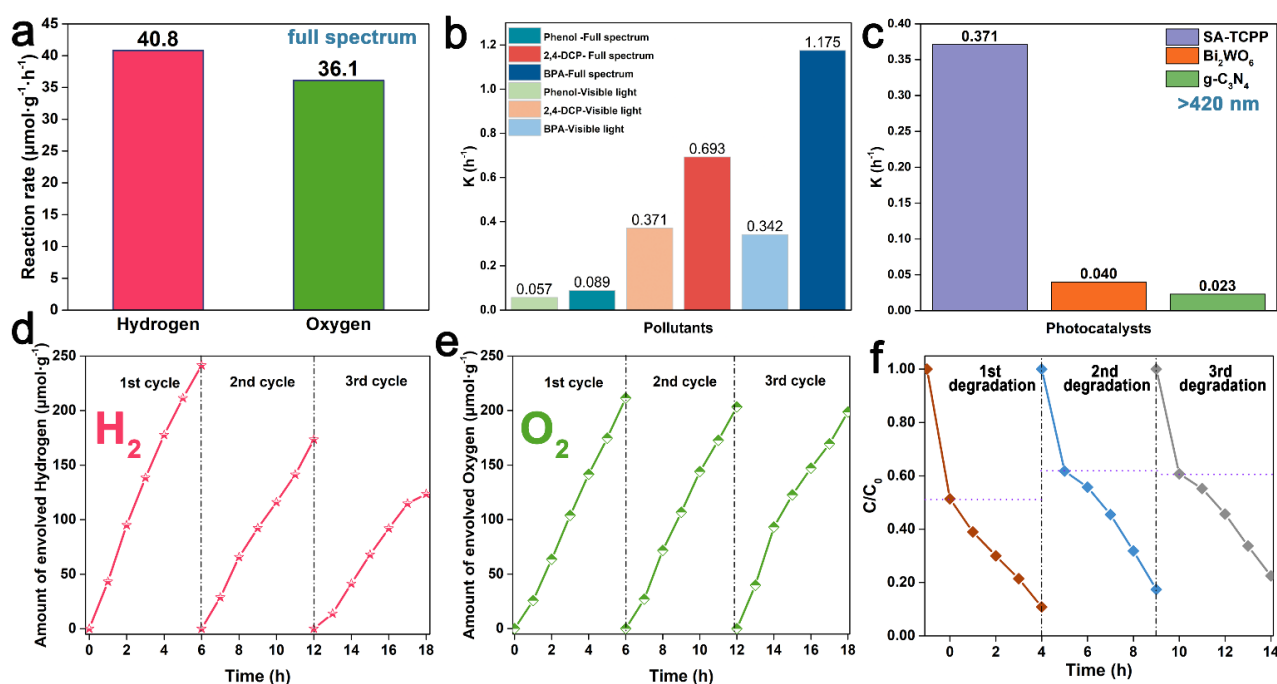
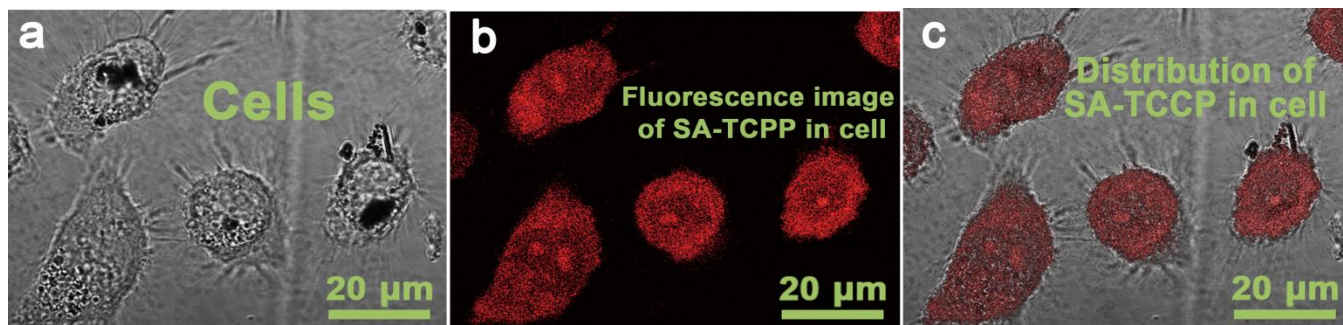
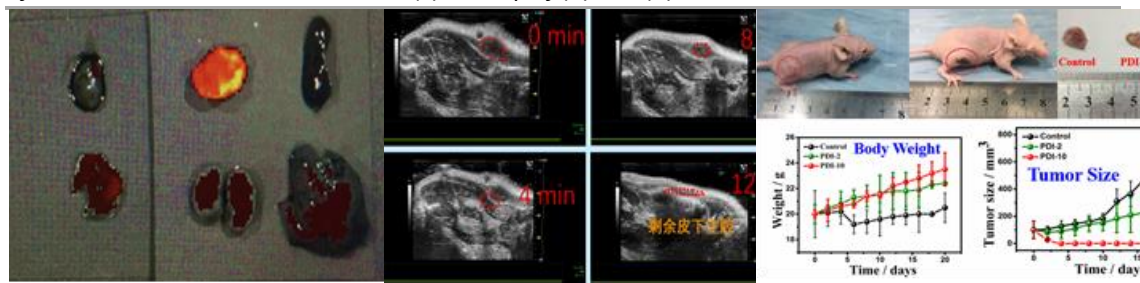


Fig. 1. Photocatalytic water splitting and degradation of pollutants. (a) Photocatalytic water splitting reaction rate of SA-TCPP under full spectrum; (b) Apparent rate constants k of degradation reactions for different pollutants under visible light and full spectrum; (c) Comparison of apparent rate constants



k of different photocatalysts for 5.00 ppm 2,4-DCP degradation; (d) Cyclic reactions of hydrogen evolution with trolamine as hole scavenger; (e) Cyclic reactions of oxygen evolution with AgNO_3 as electrons scavenger; (f) Cyclic degradations of 5.00 ppm 2,4-DCP.

Figure 2. The distribution of SA-TCPP in cancer cells. (a) Bright-field image and (b) Fluorescence image of Hela cells incubated with SA-TCPP, (c) overlap of (a) and (b).



SA-TCPP self-targeted into tumor

Rapid removal of tumor vis photocatalysis about 12 min

Tumor remoavel on mice by photocatalkysis

Figure 3 The performances for anti-tumor SA-TCPP superamolecular photocatalysts under visible light of 650nm

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+ Abstract

Nanostructured Layered Double Hydroxide Based Photocatalysts for Solar Fuels and Value-added Chemicals

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Photocatalysis is considered as a very promising technology to solve the energy crisis. Low-cost and high efficient photocatalysts are very critical for the practical application of photocatalysis technology. Some very recent research progress in my group will be reported in this talk on rational design of nanostructured Layered Double Hydroxide (LDH) based photocatalysts for highly efficient photoreduction of CO₂ or CO into hydrocarbons and N₂ fixation into ammonia. Ultrathin LDH nanosheets with abundant surface defect structures serving as active sites were prepared to promote adsorption and activation of reactant molecules such as CO₂ for enhanced activity. We also developed LDH-based 2D metal/oxide heterostructures of which the optimized interfacial structures played critical roles in the direct synthesis of high value-added products through the regulation of intermediates reaction pathway.[1-8]

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彭峰, 1968 年出生, 教授, 博士生导师。1996. 07–2018. 01 在华南理工大学从事教学、科研工作, 2018. 01–至今任广州大学化工学科带头人, 中国颗粒学会第七届理事会副理事长, 常务理事, 教育部新世纪优秀人才。共主持包括科技部 863 计划, 国家自然科学基金, 广东省科技攻关计划等科技项目 20 余项, 在 *Angew Chem Ed Int*, *J Catal*, *ACS Catal*, *ChemSusChem* 等国内外有影响刊物上发表 SCI 源刊物论文 300 多篇; SCI 他引 8000 余次, H 因子 48; 主编 “工业催化剂设计与开发” 专著一部; 获得发明专利授权 28 件; 获得教育部自然科学二等奖一项; 2014–2018 年连续 5 次入选爱思唯尔公布的中国高被引学者榜单(化学工程领域)。一直致力于能源与环境中的纳米材料与催化研究, 目前主要研究内容为光催化制氢, 燃料电池中的催化与电催化化学转化。

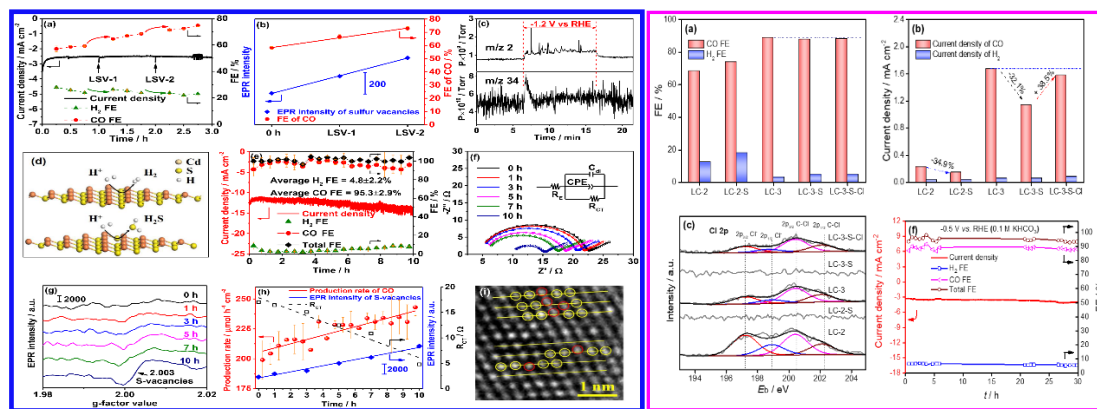
± Abstract

调控 CO₂ 电催化还原转化 CO 的方法

随着现代工业的快速发展和化石燃料的广泛使用, 大气中 CO₂ 的浓度不断上升导致温室效应, 进而导致一系列的气候问题。将 CO₂ 循环利用到多种具有经济价值的化学品和燃料中, 是有效缓解能源短缺问题的途径。其中, 电催化还原 CO₂ 被证明是一种可控、高效的方法, 将太阳能电池和电解池结合起来电化学还原二氧化碳, 可以有效地将太阳能转化为燃料和化学品^[1,2]。

(1) 采用简单的溶剂热法制备了一种新型电催化剂 CdS-CNTs, 该催化剂在 CO₂ 电化学还原为 CO 的过程中, FE 超过 95%。随着反应时间的增加, CdS-CNTs 表面的硫空位增多, 同时 CO₂ 还原的催化活性也增加。利用原位红外方法、结合 DFT 的计算发现, 硫空位的形成改变催化剂表面的电子密度, 减少反应中间体转换的能量势垒, 促进 CO₂ 电化学还原为 CO。在自然光照条件下进行了光-电化学转化, 晴天时, CE_{solar-CO} 为 1.65%, CO 和 H₂ 的产率分别为 274.7 和 20.3 μmol h⁻¹ cm⁻²; 阴天时, CE_{solar-CO} 为 5.64%, CO 和 H₂ 的产率分别为 73.5 和 8.7 μmol h⁻¹ cm⁻²。太阳能电池板在自然光条件下与 CO₂ 电化学还原相结合, 预示了一个有希望的应用前景。

(2) 从生物质木质素衍生制备了一种含有硫、氮、氯杂原子的多孔生物碳催化剂, 在 490 mV 的低过电位下, CO₂ 电化学还原为 CO 的选择性高达 95.9%, 平均电流密度为 -1.98 mA cm⁻², CO 的产率为 8.8 L m⁻² h⁻¹, 在长达 30 小时的稳定性测试中, 催化剂活性以及产物 CO 和 H₂ 的选择性都没有明显变化。研究表明, 氮的掺杂有利于 CO₂ 电化学还原为 CO 的选择性; 碳材料表面的氯来源于盐酸的洗涤处理, 该表面吸附的氯大大提升了电化学 CO₂ 还原反应的活性, 进而增加 CO 的产率。



图左 (a-i) 硫空穴助力CO₂电化学还原结构分析与电催化性能；右(a-e) N,S掺杂碳材料表面吸附的氯提升CO₂电化学还原CO的性能。

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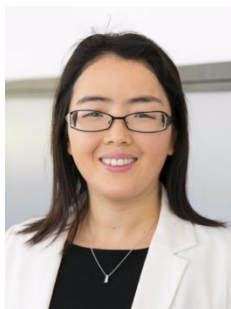
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余丁山, 2008 年于中山大学获得工学博士学位。2008 至 2015 年先后在美国 University of Dayton 和 Case Western Reserve University 以及新加坡 Nanyang Technological University 从事博士后研究。2015 年 2 月入选中组部“青千”, 同年 5 月加入中山大学任化学学院教授, 博士生导师。迄今为止共发表学术论文近 100 篇(含已接受), 其中以第一作者和通讯作者在 Nature Nanotechnology, Chem. Soc. Rev, J. Am. Chem. Soc., Angew. Chem. Int. Ed, Adv. Mater, Energy Environ. Sci, 等国际学术期刊上发表论文近 50 篇, 在 Chem. Soc. Rev 等期刊上发表综述论文 8 篇。论文已被引用 8700 余次, H 因子为 35。目前承担国家重点研发计划课题, 国家自然科学基金面上项目等多个项目。

+ Abstract

聚合物基能源催化剂

为了解决日益严峻的能源枯竭和环境污染问题, 发展新型、高效的清洁能源器件成为了当今社会研究的焦点。燃料电池和可充电金属-空气电池能够实现高效且洁净的能量转换, 被认为是最可行且有效的几类绿色能源器件。在上述能源器件中, 电催化氧化和氧析出分别扮演了至关重要的角色, 决定了能量转换效率。然而, 这几个反应本征缓慢的动力学成为这一领域亟需解决的瓶颈问题。传统商用的电催化剂主要是贵金属铂或钌基材料, 但贵金属价格昂贵、资源稀缺、稳定性差。因此, 人们为了加速这类能源器件的商业化进程, 开发高效而低成本的非贵金属催化剂, 解决催化反应过程中缓慢的动力学问题成为当前迫在眉睫的任务。目前, 广泛研究的非贵金属基电催化剂主要集中在纳米碳材料和过渡金属及衍生物。相比广泛研究的无机材料, 有机聚合物材料由于具有结构的可设计性, 更好的修饰空间及加工应用前景。这些独特的优势使得有机聚合物及其复合材料有望成为下一代高效的绿色能源催化剂。从长远看来, 聚合物基能源催化将会是一个非常具有潜力的研究方向。在此, 我将介绍本课题组在聚合物基能源催化剂的研发方面取得的一些进展。



Dr Yijiao Jiang is a Senior Lecturer at the School of Engineering at Macquarie University, Sydney and the Chair of Macquarie University Women in Engineering. After completing her PhD at University of Stuttgart, she worked as postdoc at ETH Zürich from 2008 to 2010. Yijiao was awarded UNSW Vice-Chancellor's Research Fellowship in 2011 and ARC Discovery Early Career Researcher Award (DECRA) in 2012, which was jointly hosted by Lawrence Berkeley National Lab. Since joining at MQ in August 2014, she has secured over AUD\$4.3m in research grants from the ARC Industrial Transformation Research Hub with Rio Tinto and JITRI, ARC Discovery Projects, the EU H2020 etc. Currently Yijiao is leading a dynamic research group with 1 ARC DECRA Fellow, 1 postdoc, 7 PhD students, and 5 UG thesis students under her principal supervision. Her research interests mainly focus on the development of better thermal-, photo-, and electro-catalytic systems for green chemical processes, renewable energy production and environmental protection. She has developed various in situ and operando spectroscopic techniques including NMR, EPR, IR, UV-Vis and Raman for achieving breakthroughs in catalysis research.

+ Abstract

Heterogeneous molecular electrocatalysts for carbon dioxide reduction in water

Electroreduction of carbon dioxide (CO_2) to carbon monoxide (CO) in aqueous electrolyte is a promising approach to utilize this abundant and virtually free single-carbon feedstock. Heterogeneous molecular catalysts based on first row transition metal complexes drive this process with remarkable activity and selectivity, however their low stability under negative potentials calls for development of novel stabilization strategies. This work presents a mechanistic study of Co tetraphenylporphyrin degradation pathway during CO_2 reduction in aqueous electrolyte. Our work reveals that the complex decay does not yield chlorins or phlorins but instead leads to uptake of oxygen from CO_2 by the porphyrin core in a minor concurrent reaction. This finding enabled systematic work on stabilization of catalytically active $[\text{Co}^{\text{I}}]$ species using thermodynamic and kinetic approaches. For the first time, we have proved that kinetic inhibition of catalyst deactivation is a promising approach while thermodynamic stabilisation of $[\text{Co}^{\text{I}}]$ active form of the catalyst is hardly a viable strategy.



Chuanxin He received his Ph.D. in polymer chemistry and physics from University of Science and Technology of China in 2010. He is currently Professor of Chemistry at Shenzhen University. His current research interest is to prepare novel nanostructure materials and their application in fuel cells, water splitting, or electrochemical reduction of carbon dioxide. He has published more than 80 peer-review papers, including JACS, Advanced Materials, Advanced Energy Materials, Angewandte Chemie International Edition, Nano Energy, Small, Chemsuschem, Chemical Communications, Journal of Materials Chemistry A, Carbon, Journal of Power Sources.

+ Abstract

Design and performance regulation of interface-enhanced composite electrocatalysts

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Electrochemical reduction of CO_2 (CO_2RR) in aqueous solution has been widely recognized as a promising strategy for alleviating the concerns on the increasing level of atmospheric CO_2 concentration. CO_2RR catalysts are mostly powder-based, hence polymer binders such as Nafion, are always used to make these catalysts into working electrodes. Since CO_2RR occurs at the three-phase boundaries, and exposing the active sites is highly important for the reactant transfer around the interface. Unfortunately, the accessibility of those reaction interface could be significantly covered or blocked by these binders.

In our recent work, we constructed a series of flexible, hetero-doped porous carbon nanofiber films via electrospinning method, which can be directly used as cathode for CO_2RR without any additional binder. The network porous structure of these nanofibers can fabricate massive interfaces for the catalytic reaction, thereby greatly improving the catalytic performance. For example, we reported a robust and scalable strategy for synthesis of

nitrogen and sulfur co-doped, hierarchically porous carbon nanofiber (NSHCF) membranes, which carry good productivity and can be easily tailored to specific shapes and then directly used as cathode for CO₂RR. The outstanding CO Faradaic efficiency can be attributed to the doping of N and S atoms, which effectively decrease the Gibbs free energy of key *COOH intermediate. Furthermore, the hierarchically porous structure impart a much higher density of accessible active sites for CO₂RR. With the synergistic effect of N & S co-doping and structure tuning, NSHCF membranes generated CO with 94% Faradaic efficiency and -103 mA cm^{-2} current density with only $\sim 1.2 \text{ mg}$ catalyst loading, which are among the best results ever obtained by metal-free CO₂RR catalysts. In addition, we also implanted platinum nanoparticles (Pt-NPs) into nitrogen-doped carbon nanofibers (NCNFs) on flexible carbon cloth and copper foil substrates, thereby preparing Pt-NPs@NCNFs@CC and Pt-NPs@NCNFs@Cu-foil. Both of them can be used as highly efficient and stable catalysts for electrochemical fixation of CO₂.

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Dr. Yanguang Li (李彦光) is currently a Professor in the Institute of Functional Nano & Soft Materials (FUNSOM) at Soochow University, China. He received his BS in Chemistry from Fudan University, China in 2005; and obtained his PhD in Chemistry from Ohio State University in 2010 under the supervision of Prof. Yiying Wu. He then moved to the Stanford University and completed the post-doctoral training under the supervision of Prof. Hongjie Dai before taking the current faculty position in 2013. Dr. Li's research focuses on nanostructured functional materials for energy applications, particularly in the realm of electrocatalysis. At present, Dr. Li has coauthored more than 100 peer-reviewed papers, and received a total citations of >25000 times. He has been selected as the "Highly Cited Researcher" in the category of Chemistry by Clarivate Analytics in 2017-2019, and is the recipient of "Materials Today" Rising Star Award, "Nano Research" Young Innovator Award and a few other awards.

+ Abstract

Bismuth-based nanostructures for electrocatalytic and solar conversion of CO₂ to formate

High-performance electrocatalysts for CO₂ reduction to valueable chemical fuels are a key component in the design of efficient artificial photosynthetic systems. Formate is a common CO₂ reduction product, and its selective electrochemical production is desirable but challenging. Most current attention focuses on Sn-based materials, which unfortunately exhibit moderate-to-high formate selectivity only within a very narrow and highly cathodic potential region. Bi has a great potential for formate production but remains under-explored. In this presentation, we report several different strategies to prepare unique Bi-based nanostructures with large surface areas. The final product exhibits large cathodic current density, excellent Faradaic efficiency (>90%) over a broad potential window and great stability for CO₂ reduction to formate. Furthermore, we integrate Bi with a p-type Si photocathode and achieve photoelectrochemical CO₂ reduction to formate with high selectivity and stability. We also couple Bi with an oxygen evolution reaction electrocatalyst in full cells, and achieve battery-driven or solar-driven splitting of CO₂/H₂O into formate and oxygen at high energy conversion efficiency.



Dr. Xuebin Ke studies at the Dalian University of Technology (Bachelor) and the Nanjing Tech University (PhD). After that he has been working at the Queensland University of Technology (Australia) for 10 years. In 2016 he moved to University of Hull (United Kingdom) to hold a lectureship. He is one of the pioneers to introduce the surface plasmon resonance effect into organic synthesis. His current research is focused on materials chemistry, membrane separation and photocatalysis.

+ Abstract

Photocatalytic production of solar fuels

Xuebin Ke^{a,b*} and Jun Wang^a

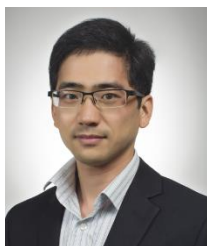
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High-performance electrocatalysts for CO₂ reduction to valueable chemical fuels are a key component in the design of efficient artificial photosynthetic systems. Formate is a common CO₂ reduction product, and its selective electrochemical production is desirable but challenging. Most current attention focuses on Sn-based materials, which unfortunately exhibit moderate-to-high formate selectivity only within a very narrow and highly cathodic potential region. Bi has a great potential for formate production but remains under-explored. In this presentation, we report several different strategies to prepare unique Bi-based nanostructures with large surface areas. The final product exhibits large cathodic current density, excellent Faradaic efficiency (>90%) over a broad potential window and great stability for CO₂ reduction to formate. Furthermore, we integrate Bi with a p-type Si photocathode and achieve photoelectrochemical CO₂ reduction to formate with high selectivity and stability. We also couple Bi with an oxygen evolution reaction electrocatalyst in full cells, and achieve battery-driven or solar-driven splitting of CO₂/H₂O into formate and oxygen at high energy conversion efficiency.



Linxin Zhong is an associate professor in South China University of Technology. He received his Ph.D. from South China University of Technology, China, in 2011. He was a visiting scholar at National University of Singapore (Department of Chemistry) in 2017-2018. His accomplishments were honored with *the* Distinguished Young Scholar and Young Talent of Guangdong province. His current research interests focus on designing and manufacturing aerogels and porous carbons for flexible energy storage and pressure sensing applications, with current research projects supported by National Natural Science Foundation of China, Guangdong natural Science Foundation, National Natural Science Foundation of China, Guangdong Natural Science Funds for Distinguished Young Scholar, and Guangdong Special Support Program. He has published more than 60 SCI papers.

+ Abstract

Lightweight carbon aerogels for flexible pressure sensing

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Compressible and elastic carbon aerogels are extremely important for the applications in wearable pressure- or strain-sensing electronics and electronic skins. Although some compressible carbon materials have been successfully fabricated for piezoresistive sensors, these materials face the following major challenges due to the brittleness of carbon and structural limitation of carbon materials. Herein, we fabricated lightweight carbon aerogels that exhibited strong mechanical strength and ultrahigh sensitivity, by using nanocelluloses such as CNC and CNF as nanodispersant, nanobinder, or nanosupport. To further improve mechanical and sensing performances, lamellas structures were created to ensure large elastic deformation and interspace to output stable responding signals from tiny pressure or strain. This strategy led to lightweight carbon aerogels with not only super compressibility (can repeatedly undergo extreme compression) and elasticity, but also excellent bendability. As compared with the present carbon-based pressure piezoresistive materials, our aerogel shows unexpected performances: (1) super stable structure that can undergo an extreme high compression and has high structural stability after long-term cycle, (2) ultrahigh linear sensitivity, and (3) very broad linear range. Due to these advantages, the aerogel shows its application in wearable devices for detecting biosignals.

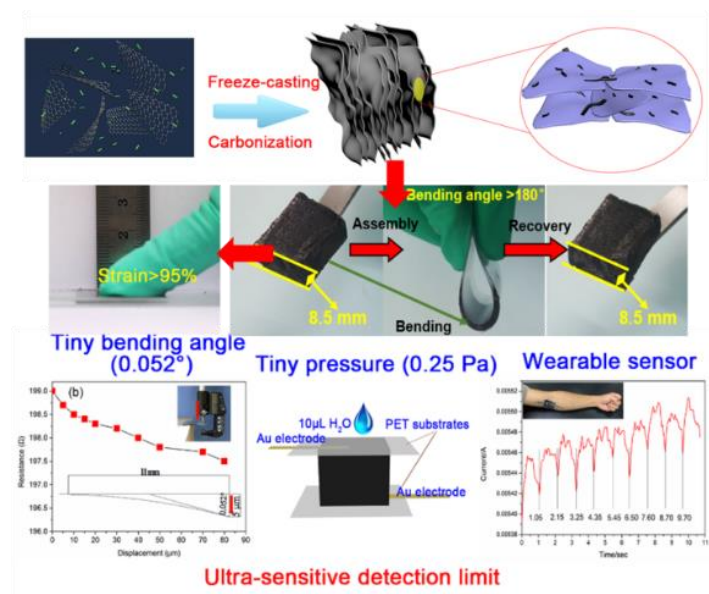


Fig. 1 Super-compressible, elastic and bendable carbon aerogel with ultra-sensitive detection limits for compression strain, pressure and bending angle.

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Prof. Zhi-Gang Chen is a Professor of Energy Materials at the University of Southern Queensland (USQ). He received his PhD degree in 2008. Before joining USQ, he had worked at the University of Queensland with various prestigious fellowships, including UQ Postdoctoral Fellowship, ARC Postdoctoral Fellowship, and QLD Smart Future Fellowship. Since joining USQ, he has worked/working as Associate Professor (2016), and Professor (2018-) and concentrating in smart thermoelectrics from synthesizing materials to understanding their underlying physics and chemistry. Prof. Chen has published more than 220 high impact publication with Scopus citation of 11,700 and H-index of 55.

+ Abstract

High-Performance Thermoelectric Materials and Devices for power generation

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Thermoelectrics, enabling the interconversion between heat and electricity, become a typical component in the drive for eco-friendly energy technology. The mass-market application demands a high energy conversion efficiency, evaluated by the figure-of-merit (zT), which is proportional to power factor and reciprocal of lattice thermal conductivity. Besides, thermoelectric materials are supposed to be environmentally benign. GeTe is the competent choice to replace the highly toxic Pb-based alloys that are commonly used as mid-temperature thermoelectric materials. Recently, super-high zT over 2.0 for GeTe-based materials has been reported by several research groups. Particularly, our innovative contributions have significantly promoted the advance of high-performance GeTe (Adv. Mater. 2018, 30, 1705942 and Adv. Energy Mater. 2018, 8, 1702333).

Herein, we review the most recent research outcomes in GeTe-based thermoelectric materials. First, we summarize the features of GeTe (i.e., crystal structures, phase transition, multiple sub valence bands, and phonon dispersions), which endow diverse degrees of freedom to manipulate the thermoelectric properties for GeTe. Accordingly, the strategies for enhancing power factor are settled, including alignment of multiple valence bands, resonant distortion of density-of-states, and an increase of band degeneracy induced by slight symmetry reduction. To decrease thermal conductivity, we highlight the methods of strengthening intrinsic phonon-phonon interactions and introducing various lattice imperfections as scattering centers. Then, we overview the current GeTe-based thermoelectric devices, including the technical challenges and the solutions. In the end, we propose possible future directions for developing GeTe.

The significance of this presentation can be summarized as

- (i) The delivered information will bridge the communications among physicists, chemists, and engineers to further enhance the performance of GeTe and to facilitate the establishment of large-scale thermoelectric devices with high conversion efficiency.

- (ii) The achieved high thermoelectric performance in GeTe-based thermoelectric materials with the rationally developed strategies could serve as references for broader materials to pursue high performance.

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Dr. Zhengyu Bai is a professor at School of Chemistry and Chemical Engineering at Henan Normal University. She received her Ph.D. in 2010 from Henan Normal University. She received the Distinguished Young Investigator Awards at the 4th International Conference on Electrochemical Energy Science and Technology 2018 (EEST 2018). Her research is focused on new green energy nanomaterials, such as nanostructured electrocatalysts for fuel cell and metal-air batteries. Dr. Bai has published over 80 peer-reviewed journal articles. She is also listed as an inventor on 25 national patents, with 8 patents licensed in China.

+ Abstract

Biomimetic Design and Synergistic Catalytic Mechanism of Nano-Assembled Structures with Multi-Active Sites

The broad applications of implantable biofuel cells (BFCs) have become very attractive in biomedical sciences. The key challenge towards the success of this field is achieving inorganic-organic composite biocompatibility, while at the same time improving activity and selectivity of the catalysts. Herein, nano-engineered red blood cells (NERBCs) are fabricated through an environmentally friendly method by employing red blood cells as the raw material and hemoglobin (Hb) embedded with ultra-small hydroxylapatite (HAP, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$) as the functional material, showing greatly enhanced cell performance with superior electrocatalytic activity, high stability and selectivity. The NERBCs maintain the original bio-properties of the natural cell, while promoting catalytic (oxygen reduction reaction, ORR) ability through the interaction between the -OH group in HAP and the Hb in RBCs. They also allow for direct electron transportation, eliminating the need for an electron transfer mediate, and moreover their extraordinary selectivity showed catalytic inactivity for glucose oxidation, enabling development of potential separator-free BFCs. This BFC design exhibited extraordinary performance with an open-circuit voltage of 0.636 V and a maximum energy density of $21.11 \mu\text{W cm}^{-2}$. This research provides an effective strategy for exploring novel electrocatalysis and serves as an avenue for controlling cell functionality for power generation.



Dr. Hai-Long Jiang (江海龙) completed PhD in 2008 from Fujian Institute of Research on the Structure of Matter, CAS. He subsequently worked at National Institute of Advanced Industrial Science and Technology (Japan, 2008–2011). After a postdoctoral stint at Texas A&M University, he became a full professor at USTC in 2013. He is a Fellow of the Royal Society of Chemistry (FRSC) and was recognized as a highly cited researcher (2017 & 2018 & 2019) in chemistry by Clarivate Analytics. He has published over 140 papers with a citation of >16800 times (H index 65). His research interest currently lies in crystalline porous and nanostructured materials for energy/environment-related catalysis.

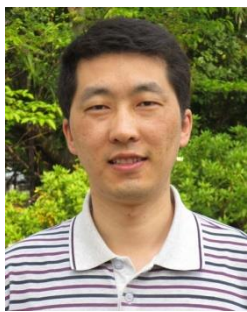
+ Abstract

Interplay of Metal-Organic Frameworks and Metal Nanoparticles for Photocatalysis

Metal-organic frameworks (MOFs) have witnessed their great potential in wide fields, particularly in catalysis, in recent years. Unfortunately, the types of active sites in pristine MOFs are limited, resulting in their applicability in limited catalytic reactions.

The pore character MOFs endows great opportunity to incorporate active species for improved catalysis -- pore space functionalization. The stabilization of guest active centers (particularly, metal nanoparticles) in the pore space of MOFs not only greatly expand the scope of catalytic reactions but also improve the catalytic performance, based on the synergetic properties of the host MOF and guest species.

These pore space functionalization studies greatly contribute to the development of MOF catalysis.



Dr. Ya-Qian Lan (兰亚乾) 南京师范大学化学与材料学院教授，博士生导师。主要从事配位化学研究，致力于晶态材料在能源领域的应用探索。2009 年获得东北师范大学物理化学博士学位，2010–2012 年日本学术振兴会 (JSPS) 博士后，日本产业技术综合研究所 (AIST) 关西中心外国人特别研究员，2012 年底加入南京师范大学。独立工作后获第四批国家“万人计划”科技创新领军人才、科技部中青年科技创新领军人才、教育部青年长江学者奖励计划、国家优秀青年科学基金、江苏省“双创团队”领军人才、江苏省杰出青年基金等人才称号。现任南京师范大学校学术委员会委员，化学与材料科学学院教授委员会主任。近五年来以通讯作者在 *Nat. Commun.* (3)、*J. Am. Chem. Soc.* (5)、*Angew. Chem. Int. Ed.* (7)、*Adv. Mater.* (1)、*Matter* (1)、*Chem. Soc. Rev.* (1) 等期刊上发表通讯作者论文 100 余篇。论文被他引 11000 多次，ESI 高引论文 19 篇，个人 H-index 56。

+ Abstract

晶态材料人工光合作用催化剂

金属团簇是单原子和金属纳米颗粒之间的一个重要桥梁。与单原子催化剂相比金属团簇催化剂可以提供多电子转移和协同催化活性，有利于完成复杂反应，并且可以从原子层面阐明活性位点和催化机制，为实现精准催化提供理论和实验依据。以 CO₂ 还原转化为例，目前大量研究者希望通过电催化或者光催化将 CO₂ 还原利用。金属簇催化剂可以提供多电子转移和促进 C–C 键偶联，有利于生成高附加值产物。但金属团簇作为催化剂仍然存在很多问题：如稳定性差、比表面积低、催化性能单一等。设计合成多孔的金属簇基功能配合物有望解决上述问题。近五年来我们课题组设计合成了一系列具有催化功能的金属簇，进一步引入多功能光电基元构筑了多孔的金属簇基配合物。通过精确调控金属簇和功能配体实现了对人工光合作用的模拟，将 CO₂ 直接转化为乙酸，并通过这些晶体模型来研究催化的位点和机理。



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于中国科学技术大学获学士、博士学位，法国 IRCELYON 研究所和希腊 Univ. Patras 大学博士后。2007 年至今在天津大学工作。入选教育部新世纪人才、天津市中青年科技创新领军人才、天津市 131 人才第一层次、荣获国际催化理事会青年科学家奖。担任 J. Chem. Technol. Biotechnol. (Wiley) 副主编、Catal. Today (Elsevier) 客座编辑、中国化学会分子筛专业委员会委员、中国稀土学会催化专业委员会委员等。

+ Abstract

钴基催化剂的费托合成产物调控新策略

我国化石资源呈现“富煤、贫油、少气”的特点，在金属催化剂上将煤基合成气(CO 和 H_2)转化为合成油燃料，是实现煤炭清洁高效利用的有效途径。(1) 构建了金属催化剂镶嵌在介孔载体中的“西瓜籽”结构纳米反应器，不但可以抑制金属钴催化剂烧结，还可以通过精确控制金属的晶粒尺寸改变其电子结构，未经二次反应即可突破 ASF 分布限制，实现煤基合成气高选择性制取合成柴油和汽油。该成果颠覆了学术界“大晶粒钴催化剂易得到高碳数费托合成产品”的传统认知。(2) 通过改变炭化温度来调节碳基载体上掺杂氮元素(包括吡咯氮、吡啶氮和石墨氮)的种类和含量，发现钴与吡咯氮相互作用力最强、与石墨氮相互作用力最弱。钴与吡咯氮之间较强的相互作用可以改变催化剂的电子结构，增大金属钴表面电子密度，有利于提高钴催化剂的费托合成活性和长链烃产品选择性，同时提高了催化剂的抗烧结能力和催化稳定性。(3) 采用物理溅射、胶囊化等方法构筑了“金属中心-酸中心”集成的双功能催化剂，将费托合成(金属中心)与催化裂化和异构化反应(酸中心)串联式耦合，并通过强化金属中心与酸中心之间的传质、消除内扩散等策略提高合成汽油产品的辛烷值和选择性。

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Dr. Minhua Shao (邵敏华) is a Professor in the Department of Chemical and Biological Engineering and Associate Director of the Energy Institute at HKUST. He earned BS and MS degrees in chemistry from Xiamen University, and a PhD degree in materials science and engineering from the SUNY-Stony Brook in 2006. Before he joined HKUST in 2014, he worked at UTC Power and Ford Motor Company. He is an Associate Editor of Journal of The Electrochemical Society (2018), a founding member of the Hong Kong Young Academy of Sciences. He has published over 130 peer-reviewed articles and filed over 30 PCT patent applications (15 issued). He has also received a number of awards, including the Supramaniam Srinivasan Young Investigator Award from the ECS Energy Technology Division (2014).

+ Abstract

Electrocatalysts for carbon dioxide Electrochemical reduction reaction

Electrochemical reduction of carbon dioxide is a promising technology converting CO₂ into value-added chemicals and fuels. However, several bottlenecks have hindered its wide adoption, especially the unsatisfying performance of catalysts, which have led to the great effort on searching and developing high-performance catalytic materials. In this study, several nanocatalysts are developed that show significantly improved CO selectivities. A maximum CO faradaic efficiency of 95% (at -0.6 V), and an extremely low overpotential of 90 mV for CO formation with a faradaic efficiency of 8.5% can be achieved. Combined in situ infrared spectroscopic studies and density function theory calculations reveal the importance of surface defects and compositions on regulating the selectivity and activity.



Associate Professor Jun Huang (黄骏) received his PhD from University of Stuttgart, Germany in 2008 and worked as a postdoctoral fellow at Georgia Institute of Technology, USA and ETH Zürich, Switzerland, respectively. He was appointed as a Lecturer at the University of Sydney in 2010 and Senior Lecturer in 2013 and Associate Professor in 2016. He has made significant contributions to develop emerging catalytic technologies for more attractive, practical, and cleaner processes using in situ spectroscopic techniques, coupled with new catalyst design and innovative reaction engineering. Jun has published over 120 journal publications in high-rank Catalysis Journals as well as in Chem/Science Journals. He has been awarded over AU\$ 6m research grants and many prestigious awards including Grand Challenge Champion (2019), Sydney Accelerator Fellowship Awards (2018), USYD-UC Davis Partnership Collaboration Award (2018), The Vice-Chancellor's Awards for Excellence Outstanding Research (2017), Australia-China Low-Emissions Coal Partnership Future leader (2013), France-Australia Science Innovation Collaboration program Early Career Fellowships (2012). Jun is the Editor-in-Chief of Materials Today Sustainability and the ECR Board member of ACS Sustainable Chemistry & Engineering as well as the guest editor of ChemCatChem for the yearly special issue of Advanced Spectroscopy and Microscopy for Catalysis.

+ Abstract

Nanoscale characterization of catalysts for the sustainable catalysis

Silica-alumina materials, particularly crystalline zeolites and amorphous silica-alumina (ASA), are among the most popular solid acids that have been widely commercialized as efficient and environmentally friendly catalysts in petrochemical industry. The formation of BAS in silica-alumina is based on aluminum centers distributed in the silica framework or network. The location and synergy of Al species in the silica network has been studied using solid-state NMR spectroscopy and atom probe tomography (APT). The ^{27}Al double-quantum single-quantum (DQ-SQ) through-space homonuclear correlation (*D-HOMCOR*) NMR experiments allowed us to probe ^{27}Al - ^{27}Al proximities by applying recoupling sequences that restore the dipolar interaction between neighboring ^{27}Al spins. Atom probe tomography can provide quantitative three-dimensional (3D) information on elemental distributions in catalyst nanoparticles at the atomic scale. The combined APT investigations and ^{27}Al and ^1H DQ-SQ NMR experiments revealed, for the first time, the existence of a synergy between Al species in the ASA network. This synergy can significantly enhance the acid strength of ASA.

Understanding the cooperative action of metal and acid sites of bifunctional catalysts is essential for developing more efficient catalysts for greener chemical processes. We used in situ attenuated total reflection infrared (ATR-IR) spectroscopy in combination with modulation excitation spectroscopy (MES) and phase sensitive detection (PSD) to examine the functioning of Pd/silica-alumina (Pd/SA) catalysts with different acidity of the support in the liquid phase hydrogenation of acetophenone (AP). The spectroscopic studies revealed that AP was adsorbed on the Pd surface in $\eta^1(\text{O})$ configuration and initially hydrogenated to 1-phenylethanol (PE) on the metallic Pd sites.

Supported metal nanoparticles play key roles in nanoelectronics, sensors, energy storage/conversion, and catalysts for the sustainable production of fuels and chemicals. Direct observation of the dynamic processes of nanocatalysts at high temperatures and the confinement of supports is of great significance to investigate nanoparticle structure and functions for practical utilization. Here we present *in situ* high-resolution transmission electron microscopy (HRTEM) photos and videos with correlating dynamics simulations to reveal the real time dynamic behaviour of Pt nanocatalyst at operation temperatures. Amorphous Pt surface on moving and deforming particles is the working structure during the high operation temperature rather than a static crystal surface and immobilization on supports as proposed before. The free rearrangement of the shape of Pt nanoparticles allowed them to pass through narrow windows, which was generally considered to immobilize the particles. The porous confinement blocks the sintering of the particles under the confinement size of pores.

Dr. Ziqi Sun (孙子其) is currently an Associate Professor and ARC Future Fellow at the Queensland University of Technology (QUT), Australia. His research interest includes developing bio-inspired smart nanomaterials and 2D metal oxide nanomaterials for sustainable energy and environmental applications, such as rechargeable batteries, oil-water separations, and catalysis. Ziqi received his PhD degree on Materials Science and Engineering from Institute of Metal Research, Chinese Academy of Sciences, followed with research experience in Japan and Australia. Ziqi also serves as the Editors-in-Chief of Sustainable Materials and Technologies (CiteScore = 8.31, Elsevier), Editor of Physics Open (Elsevier), Principal Editor of Journal of Materials Research (MRS), Associate Editor of Surface Innovations (ICE), Editorial Board Member of Scientific Reports, Journal of Materials Science and Technology, and Nano Materials Science.

+ Abstract

Molecular self-assembly of metal oxide nanomaterials for sustainable energy applications

Silica-alumina materials, particularly crystalline zeolites and amorphous silica-alumina (ASA), are among the most popular solid acids that have been widely commercialized as efficient and environmentally friendly catalysts in petrochemical industry. The formation of BAS in silica-alumina is based on aluminum centers distributed in the silica framework or network. The location and synergy of Al species in the silica network has been studied using solid-state NMR spectroscopy and atom probe tomography (APT). The ^{27}Al double-quantum single-quantum (DQ-SQ) through-space homonuclear correlation (*D-HOMCOR*) NMR.



李光琴，教授，中山大学化学学院，千人计划青年项目，广东省“珠江人才计划”引进创新团队带头人，主要从事多孔配位聚合物纳米复合材料在储氢、热催化、电催化和电化学能源转换与存储等方面的研究。曾先后获国际金属储氢会议最佳海报奖、第 63 届日本配位化学会青年奖、第 4 届国际金属有机骨架会议最佳海报奖、日本学术振兴会 JSPS 育志奖、京都府知事奖、中山大学芙兰奖教金科研奖等。以第一/通讯作者在 Nature Materials、Nature Communications、J. Am. Chem. Soc.、Adv. Mater.、Adv. Energy Mater. 等国际期刊发表论文多篇，申请发明专利 4 件，授权 1 件。

+ Abstract

Tuning electronic structure of MOFs based nanomaterials for electrocatalysis

电解水过程包含析氢反应（HER）和析氧反应（OER）两个半反应，其中由于 OER 过程在动力学上的困难性成为了电解水制氢的瓶颈。目前商用的 OER 催化剂主要为 RuO_2 、 IrO_2 等贵金属，其高昂的价格和稀有的储量严重制约了 OER 的发展，寻找价格低廉和储量丰富的非贵金属基 OER 催化剂成为近年来研究的热点^[1]。金属有机框架（Metal-organic frameworks, MOFs），是近年来发展起来的一类具有周期性网络结构和多孔特征的晶态材料，被广泛应用于催化、吸附、环境、能源、光电材料等领域。以 MOFs 为前端材料开发应用于新型能源小分子氧气、氢气等的储存与转换的新材料，对促进新能源材料的发展具有重要意义^[2-3]。

我们课题组^[4]在 MOFs 电子结构调控电催化方面开展了一系列工作，首次设计了一系列 Co、Fe 双金属的 BDC 及 NH_2 -BDC 的双金属双配体 MOFs，通过不同金属和不同配体的电子结构调控作用，可以得到电催化性能不同的 OER 电催化剂（如图 1a 所示）。图 1b 和 1c 显示制备的 $\text{A}_{2.7}\text{B-MOF-FeCo}_{1.6}$ 为长度约 500 nm 棒状结构，得到的最优催化剂 $\text{A}_{2.7}\text{B-MOF-FeCo}_{1.6}$ 在 10 mA/cm^2 电流密度下的过电位仅为 288 mV。该体系中双金属双配体有效的优化了 MOFs 的电催化活性，基于态密度以及 Co 的 3d 轨道电子计算验证了双金属双配体的电子结构调控作用。以及通过设计配体缺陷调控 MOFs 电子结构^[5]，该系列工作对如何优化纯 MOFs 的电催化活性以及如何调节 MOFs 的电子结构具有重要的意义。通过对 MOFs 衍生物的电子结构调控，还可以用于氧还原（ORR）和 OER 双功能催化剂^[6-7]。

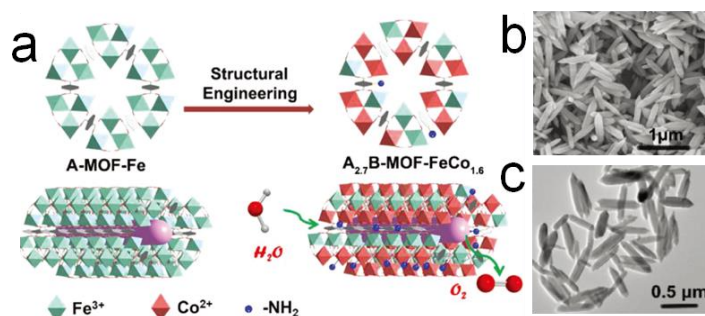


图 1 (a) 双金属双配体 MOFs 用于电催化 OER; (b-c) SEM 和 TEM 图

Fig. 1 (a-c) The preparation of heterogeneity MOFs for electrocatalytic oxygen evolution.

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石墨烯基金属单原子的制备、结构与电催化应用

费慧龙*

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单原子催化剂是近几年来催化研究领域的热点和前沿, 其兼具了均相催化剂和传统异相催化剂的优势, 包括最大原子利用率、高活性、高选择性、易与产物/溶剂分离等。作为一类特殊的单原子催化剂, 石墨烯基金属单原子因其具有高比表面积、高导电性、高(电)化学稳定性而被广泛应用于电催化领域, 而行之有效的合成方法以及原子结构的确立是探索 and 实现石墨烯基单原子材料电催化性能的前提条件。

我们以氧化石墨烯为前驱体, 利用其热解过程中产生的缺陷来锚定金属单原子(包括铁、钴、镍等)(图1a), 并发现氮元素的引入有利于形成强M-N键而稳定金属单原子[1]。针对传统热解法耗时、耗能且易造成单原子高温团聚等问题, 我们开发了瞬时微波加热(2秒)来快速制备多种石墨烯基金属单原子材料的新方法(图1b), 具有高效性、普适性、简易性、可量化等优点[2]。结构解析发现, 在制备所得金属单原子材料中, 金属与周边的四个氮原子相键合, 镶嵌在石墨烯的双空位缺陷(图1c), 构成了MN₄C₄型单原子结构[3,4]。以此具有明确原子结构的石墨烯基单原子材料为模型催化剂, 我们结合实验和理论研究, 探讨了金属原子种类对催化性能的影响, 发现CoN₄C₄和NiN₄C₄分别可用于电催化析氢和析氧反应。

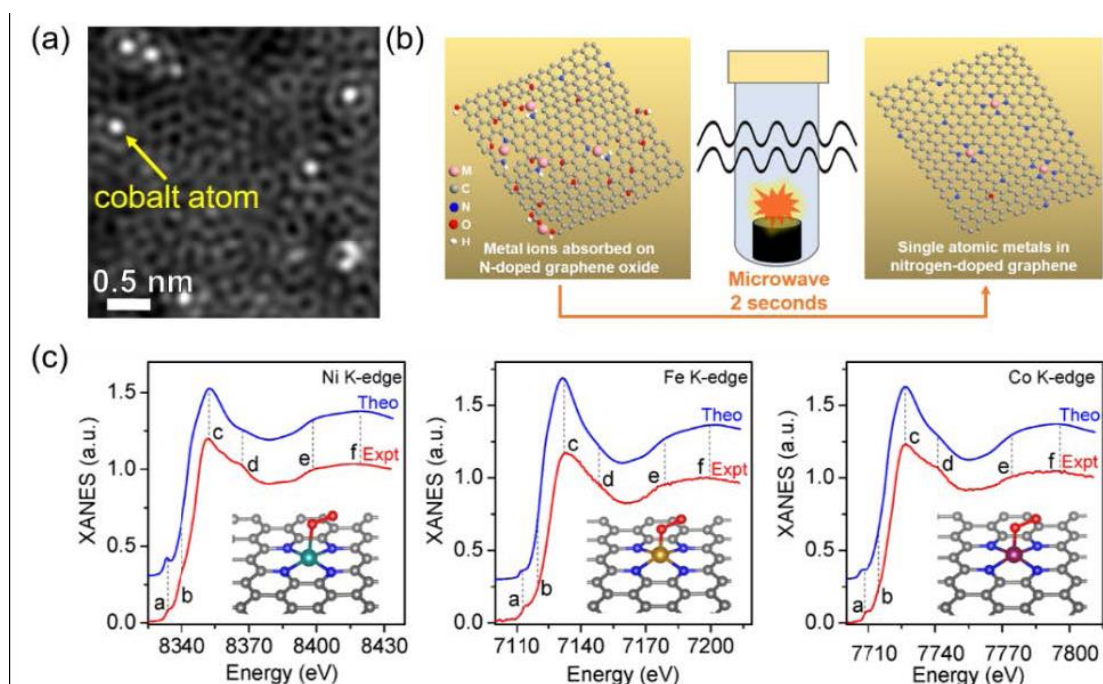


图1 (a) 石墨烯负载钴原子球差电镜图; (b) 微波法合成石墨烯负载金属单原子示意图; (c) 同步辐射解析获得石墨烯负载金属原子配位构型。

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- [2] H. Fei, et al. *Adv. Mater.*, **2018**, *30*, 1802146.

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Graphene-supported single atomic metals: synthesis, structure and electrocatalytic applications

Huiling Fei*

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余林 教授, 广东工业大学轻工化工学院教授, 博士生导师。主要研究方向为催化新材料的可控制备及其在环境催化、电催化中的应用。迄今为止, 在国内外重要学术刊物上发表学术论文 400 余篇, 其中 SCI 收录论文 134 篇, 被引频次超过 1500 次; 获授权发明专利 57 件, 转让 12 件。先后主持省部及以上项目 30 余项, 包括国家自然科学基金、教育部优秀青年教师资助计划项目、广东省自然科学基金(团队项目、重点项目等)等。曾获得第十五届广东省丁颖科技奖(2019 年)、广东省技术发明奖一等奖(2018 年)、广东省科技进步三等奖(2008 年)和二等奖(2007 年)各 1 项、汕头市科技进步一等奖 2 项(2007 和 2006 年)、2015 年“南粤优秀教育工作者”和 2000 年“南粤优秀教师(教坛新秀)”称号、广东省“千百十工程”省级第三批培养对象。

+ Abstract

Hydrogen production from water/glucose electrolysis process

Increasing environmental issues and depletion of fossil fuels have motivated intense research on alternative clean and sustainable energy carriers. Hydrogen has been regarded as a promising energy carrier by virtue of its high energy density and zero-emission when burned with oxygen. In this presentation, two kinds of approaches for producing hydrogen are introduced. One is electrochemical water splitting, and the other one is an integrated device consisting of a liquid-catalyst fuel cell (LCFC) stack and a polymer exchange membrane electrolytic cell (PEMEC). For the electrochemical water splitting, the hollow CoP material with a homogeneous nanocage structure was adopted as a high-efficiency electro-catalyst, which exhibited outstanding HER and OER electroactivities. For the electrolysis cell, polyoxometalate (POM) was used to replace exoelectrogenic microbe as the catalyst, which could rapidly oxidize glucose and be completely self-regenerated during the process.



Dr. Yueping Fang (方岳平), Yueping Fang received his BS and MS degrees in chemistry from Wuhan University in 1987 and 1990, respectively. Then, he joined the faculty of Guangxi Normal University. He obtained his PhD degree in Chemistry from Sun Yat-sen University in 2004. He was a post-doctor at the Hong Kong University of Science and Technology from 2004 to 2005. Since 2009 he is a professor at College of Materials and Energy in South China Agricultural University. During 2008–2009 and 2013–2014, he worked as a visiting professor at Kansas State University. His research interests include the synthesis and applications of quasi one-dimensional nanomaterials and hybrid organic–inorganic nanocomposite materials.

+ Abstract

助催化剂和异质结策略增强光催化水的完全分解与产氢

对于高效光催化剂的开发而言，不同的工程策略，尤其是助催化剂负载量与其他策略组合的协同效应似乎更有希望。报告重点介绍影响太阳能分解水的异质半导体效率的一些关键因素（即改进的电荷分离和转移，促进的光吸收，优化的带隙位置以及增强的稳定性和水分解动力学），并探讨不同的工程策略，例如能带结构工程，助催化剂工程，异质半导体的表面/界面工程，对光催化水的完全分解效率影响，阐明关键的效率限制步骤和设计高效的太阳能燃料转换系统。

■ 青年论坛报告

Youth Scholars Forum Abstracts



Zhenzhen Wu is a Ph.D. candidate under the supervision of Prof. Shanqing Zhang in Griffith University (Australia) and the external supervisor Prof. Qichun Zhang in Nanyang Technological University (Singapore). She received her B.Eng. and M.S. degree at Jiangsu Normal University and Nankai University (China) in 2014 and 2017, respectively. Her current research mainly focuses on organic electrode materials for rechargeable lithium/sodium batteries.

Title:

Rational design of organic electrode materials for advanced energy storage devices



李泽珩,

教育背景

2017.9-至今

浙江大学 化学工程与生物工程学院 化工所 工学博士 导师梁成都教授

研究方向：功能高分子材料在储能器件中的应用，包括锂离子电池硅基负极粘结剂，锂硫电池粘结剂和用于金属锂负极的高分子材料。

2014.9-2017.1

毕业于哈尔滨工业大学，获工学硕士学位（材料学）

2010.9-2014.7

毕业于哈尔滨工业大学，获工学学士学位（材料科学与工程）

发表工作

[1] Li Z, Ji J, Wu Q, et al. A new battery process technology inspired by partially carbonized polymer binders[J]. Nano Energy, 2019: 104234.

[2] Li Z, Fang C, Qian C, et al. Polyisoprene Captured Sulfur Nanocomposite Materials for High Areal Capacity Lithium Sulfur Battery[J]. ACS Applied Polymer Materials, 2019.

[3] Ma X, Li Z, Chen D, et al. Nitrogen-doped porous carbon sponge-confined ZnO quantum dots for metal collector-free lithium ion battery[J]. Journal of Electroanalytical Chemistry, 2019, 848: 113275.

[4] Li S, Li Z, Cao G, et al. Sulfur - /Nitrogen - Rich Albumen Derived “Self - Doping” Graphene for Sodium - Ion Storage[J]. Chemistry - A European Journal, 2019.

[5] Li Z, Bai L, Zhou C, et al. Highly Acid - Resistant, Magnetically Steerable Acoustic Micromotors Prepared by Coating Gold Microrods with Fe₃O₄ Nanoparticles via pH Adjustment[J]. Particle & Particle Systems Characterization, 2017, 34(2): 1600277.

Title:

用于锂离子电池中高性能硅基负极的粘结剂



吉加鹏

教育背景

2016.9-2021.6

浙江大学 化学工程与生物工程学院 化工所 工学博士 导师梁成都教授

研究方向：金属亚纳米团簇在电化学储能的研究与应用

电催化析氢 HER，燃料电池阴极还原 ORR，锂硫电池多硫化物催化转化等。

2012.9-2016.6

大连理工大学 化学工程与工艺（创新实验班） 工学学士

主修课程：无机化学、有机化学、物理化学、分析化学、化工原理、生物化学、高等数学、计算机应用等。

发表工作

- [1] J. Ji, Y. Zhang, L. Tang, C. Liu, X. Gao, M. Sun, J. Zheng, M. Ling, C. Liang, Z. Lin, Platinum single-atom and cluster anchored on functionalized MWCNTs with ultrahigh mass efficiency for electrocatalytic hydrogen evolution. *Nano Energy* **2019**, 63, 103849.
- [2] M. Sun, J. Ji, M. Hu, M. Weng, Y. Zhang, H. Yu, J. Tang, J. Zheng, Z. Jiang, F. Pan, C. Liang, Z. Lin, Overwhelming the Performance of Single Atoms with Atomic Clusters for Platinum-Catalyzed Hydrogen Evolution. *ACS Catal.* **2019**, 9, 8213-8223.
- [3] Z. Li, J. Ji, Q. Wu, D. Wei, S. Li, T. Liu, Y. He, Z. Lin, M. Ling, C. Liang, A new battery process technology inspired by partially carbonized polymer binders. *Nano Energy* **2019**, 104234.
- [4] D. Chen, J. Ji, Z. Jiang, M. Ling, Z. Jiang, X. Peng, Molecular-confinement Synthesis of Sub-nano Fe/N/C Catalysts with High ORR Activity and Excellent Durability for Rechargeable Zn-Air Batteries. *J. Power Source* **2019**.

Title:

Nickel atomic clusters accelerating polysulfide conversion in lithium-sulfur batteries



Shengshen Gu completed his bachelor and master's degree of Chemical Engineering at East China University of Science and Technology in 2016. During Master's degree, he helped complete the 863 Program- Study on Particles Flow Pattern and Reaction Kinetics in Gas-Solid Fluidized Beds. After graduation, he was awarded scholarship from MQ-CSC. Now he is a 3rd year PhD student in the School of Engineering at Macquarie University. He is currently working on electrocatalysis of CO₂ reduction in aqueous

solution. His research is aimed at developing an advanced catalyst-electrode hybrid system to achieve efficient CO₂ reduction. In particular, he focuses on engineering the chemical environment around catalyst immobilized on electrode to improve the selectivity and efficiency of CO₂ reduction.

顾晟荣在华东理工大学完成了化学工程专业学士和硕士学位。硕士期间参与完成国家863项目-气固流化床颗粒运动规律及反应、动力学研究。毕业后，他获得了麦考瑞-国家留学基金委联合奖学金。如今他是麦考瑞大学工程学院三年级博士研究生。他致力于水相体系中电催化还原二氧化碳的研究。他的研究目的是开发先进的催化剂-电极复合体系来实现高效的二氧化碳还原。其中，他特别关注改良电极表面催化剂的化学环境来提高二氧化碳的还原效率。

Title:

Cobalt porphyrin immobilised on the TiO₂ nanotube electrode for CO₂ electroreduction in aqueous solution



XIAOLING TENG PH.D CANDIDATE.

State Key Laboratory of Heavy Oil Processing,
College of Chemical Engineering
Qingdao Campus, University of Petroleum (East China)

Since 2016, all of the research works I have done are based on self-supported anode materials for batteries and supercapacitors:

- Preparation of nanocrystalline anode materials by pulsed laser deposition (PLD) technique.
- Combination of physics (PLD and magnetron sputtering) and chemical method to design Flexible LIBs, including tin dioxide and excess metal oxides with different nanostructures.
- Research on magnetic variation of Co-MOF in lithium-ion battery.
- Fabrication of laser induced graphene (LIG) for micro-supercapacitors.

Publications (*IF: Impact factor*)

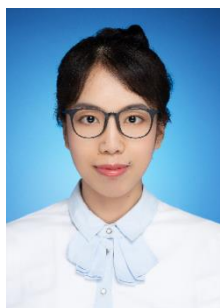
1. X. Teng, J. Zhang, Q. Li, X. Wang, W. Ye, H. Li, J. Xu, D. Cao, S. Li, and H. Hu, Self-Supported SnO₂ Nanorod Arrays with an Amorphous Buffer Layer as Anodes for Flexible Lithium-Ion Batteries, (in publish)
2. X. Teng, Y. Qin, X. Wang, H. Li, X. Shang, S. Fan, Q. Li, J. Xu, D. Cao and S. Li, A Nanocrystalline Fe₂O₃ Film Anode Prepared by Pulsed Laser Deposition for Lithium-Ion Batteries, Nanoscale Research letters, 2018, 13(1): 60. (*IF:3.125*)
3. S. Fan, J. Zhang, X. Teng, X. Wang, H. Li, Q. Li, J. Xu, D. Cao, S. Li and H. Hu, Self-Supported Amorphous SnO₂/TiO₂ Nanocomposite Films with Improved Electrochemical Performance for Lithium-Ion Batteries, J. Electrochem. Soc., 2019, 166, A3072-A3078. (*IF:3.405*)

Patents

1. Tin dioxide - titanium dioxide composite film material, lithium battery and preparation method, CN201710319311.8, China; 37, 2017, X. Teng (6).
2. Tin dioxide - cobalt oxide composite film material, lithium battery and preparation method, (CN201710319284.4), CN201710319284.4, China; 37, 2017, X. Teng (6).
3. Tin dioxide thin film material, lithium battery and preparation method CN201810428323.9, China; 37, 2018, X. Teng (2).

Title:

Self-supporting amorphous film anodes prepared by pulsed laser deposition for lithium-ion batteries



王 迪 南京大学博士

教育背景

南京大学 材料科学与工程 工学博士 2017/09-至今

研究方向:

锂电池正极材料制备, 金属空气电池电极材料设计及其机理研究, 二次电池电解质体系的调控, 二次空气电池体系原位表征技术。

主要学术成果:

现主持南京大学研究生科研创新基金项目 1 项(20 万)。近五年在 *Angewandte Chemie International Edition*, *Materials Today*, *Journal of Power Source* 等期刊发表 SCI 论文 20 余篇。其中以第一作者身份发表论文 7 篇, 包括顶级期刊及一区文章 4 篇, 总影响因子 60.6。个人 H-index: 11。

Title:

Studies on electrolytes of post lithium-ion batteries



田新龙, 2016 年于华南理工大学获得工学博士学位; 2016 年 11 月--2019 年 2 月在华中科技大学化学与化工学院从事博士后研究工作; 2019 年 3 月加入海南大学南海海洋资源利用国家重点实验室, 主要研究方向为贵金属合金纳米材料和 MOF 基单原子材料的可控合成, 应用于可燃冰存储、催化和定向转化, 燃料电池及电催化。当前, 在 *Science*, *J. Am. Chem. Soc.*, *Joule*, *ACS Energy Lett.*, *ACS Catal.* 等学术期刊上发表 SCI 论文 40 余篇, 主持国家级基金 2 项, 省部级 2 项。

Title:

Engineering bunched Pt-Ni alloy nanocages for efficient oxygen reduction in practical fuel cells



袁洪，中共党员，特别研究员，博士生导师。2011年-2017年在北京理工大学化学工程与技术专业学习并获得工学博士学位。2017年-2019年在清华大学化工系从事博士后研究。现任北京理工大学前沿交叉科学研究院特别研究员，博士生导师。

作为课题负责人承担国家自然科学基金青年基金、中国博士后科学基金面上项目（一等）和中国博士后科学基金特别资助等项目。参与国家自然科学基金面上项目、企业横向课题等项目。

主要从事能源存储与转化过程中的能源材料制备、能源化学机制以及产业应用等方面的研究。主要研究领域包括太阳能电池、锂离子电池、锂硫电池、锂金属电池以及其它新型可充电电池。具体包括：

- 1) 锂硫电池硫转化过程动力学机制与反应界面调控；
- 2) 金属锂负极保护策略以及锂沉积行为规律；
- 3) 固态电池电解质结构设计、离子输运机制以及界面演变规律。

代表性研究成果：

相关研究成果在 *Angewandte-Chemie International Edition*, *Advanced Energy Materials*, *Small Methods*, *Journal of Materials Chemistry A*, *Journal of Power Sources*, *Carbon*, *Advanced Materials Interfaces* 等学术期刊发表 SCI 论文 20 余篇，其中 ESI 高被引论文 2 篇。

Title:

Interface regulation of improving reaction kinetics in (all-solid-state) lithium sulfur batteries



佴建威博士，2014年1月博士毕业于北京航空航天大学。2014年至2018年间分别在美国芝加哥大学与新加坡南洋理工大学从事博士后研究工作。2018年9月加入浙江工业大学材料学院。近年来，围绕铁系微纳组装材料及其催化特性进行了研究，共发表 SCI 收录论文近 30 篇，包括 *Sci. Adv.*、*Adv. Mater.*、*J. Am. Chem. Soc.*、*Angew. Chem. Int. Ed* 等国际期刊；论文共被引用 >1000 次，多篇论文为 ESI 高被引论文或热点论文；2018 年入选浙江省“千人计划”特聘专家。

Title:

铁系微纳有序组装材料的精准构筑与催化性质研究



张耕，副教授，华中农业大学理学院化学系。2008年毕业于山东大学，获学士学位。2013年毕业于中国科学院大连化学物理研究所，获博士学位。主要从事燃料电池与水电解相关催化剂的研究工作。主持国家自然科学基金青年基金项目以及中央高校基本科研业务费项目。已在 *ACS Catal.*, *ACS Appl. Mater. Interfaces*, *Appl. Catal., B* 及 *J. Power Sources* 等期刊上发表了多篇研究论文，其中有 2 篇入选 ESI 高被引论文。

发表论文：

- 1) W. Lu*, X. Li, F. Wei, K. Cheng, W. Li, Y. Zhou, W. Zheng, L. Pan, **Geng Zhang***, In-Situ Transformed Ni, S-Codoped CoO from Amorphous Co-Ni Sulfide as an Efficient Electrocatalyst for Hydrogen Evolution in Alkaline Media, *ACS Sustainable Chemistry & Engineering*, 2019, 7: 12501-12509.
- 2) W. Lu*, X. Li, F. Wei, K. Cheng, W. Li, Y. Zhou, W. Zheng, L. Pan, **Geng Zhang***, Fast sulfurization of nickel foam-supported nickel-cobalt carbonate hydroxide nanowire array at room temperature for hydrogen evolution electrocatalysis, *Electrochimica Acta*, 2019, 318: 252-261.
- 3) **Geng Zhang**, Yu-Shuo Feng, Wang-Ting Lu, Dan He, Cao-Yu Wang, Yong-Ke Li, Xun-Ying Wang and Fei-Fei Cao*. Enhanced Catalysis of Electrochemical Overall Water Splitting in Alkaline Media by Fe Doping in Ni₃S₂ Nanosheet Arrays. *ACS Catalysis*, 2018, 8: 5431-5441. (ESI 高被引)
- 4) **Geng Zhang**, Ping Wang, Wangting Lu, Caoyu Wang, Yongke Li, Cong Ding, Jiangjiang Gu, Xinsheng Zheng and Fei-Fei Cao*, Co Nanoparticles/Co, N, S Tri-doped Graphene Templated from In-Situ-Formed Co, S Co-doped g-C₃N₄ as an Active Bifunctional Electrocatalyst for Overall Water Splitting. *ACS Applied Materials & Interfaces*, 2017, 9: 28566-28576.
- 5) Wangting Lu, **Geng Zhang***, Feng Wei, Wenhui Li, Kun Cheng, Fei Ding, Jiying Zhang, Wanquan Zheng. Shape-controlled synthesis of Pd nanocrystals in an aqueous solution by using amphiphilic triblock copolymers as both the stabilizer and the reductant. *Colloid and Polymer Science*, 2017, 295: 703-707.
- 6) **Geng Zhang**, Wangting Lu, Longsheng Cao, Xiaoping Qin, Fei Ding, Shun Tang, Zhi-Gang Shao*, Baolian Yi, Large faceted Pd nanocrystals supported small Pt nanoparticles as highly durable electrocatalysts for oxygen reduction, *Journal of Power Sources*, 2016, 326: 23-34.
- 7) **Geng Zhang***, Wangting Lu, Feifei Cao, Zhidong Xiao, Xinsheng Zheng, N-doped graphene coupled with Co nanoparticles as an efficient electrocatalyst for oxygen reduction in alkaline media, *Journal of Power Sources*, 2016, 302: 114-125. (ESI 高被引)

Title:

Amorphous Ni-Fe-Mo Suboxides Coupled with Ni Network as Porous Nanoplate Array on Nickel Foam: A Highly Efficient and Durable Bifunctional Electrode for Overall Water Splitting



李涯皓，男，1988 年出生，化学工程博士，2018 年毕业于挪威科技大学（NTNU）化工系催化组。随后在同组任职研究员（researcher），为期半年。19 年上半年加入浙江大学材料学院从事博士后研究工作，合作导师为夏新辉研究员。主要研究领域是电化学催化，包括氧还原电催化（ORR）和氮气还原电催化（NRR）的催化剂材料制备及催化机理研究。目前已发表 SCI/EI 论文 11 篇，其中第一作者 6 篇，h 指数为 8；获英国专利 1 项。

Title:

Carbon-based transition metal single-atom catalysts: preparation and ORR applications



李运勇，男，广东工业大学材料与能源学院 副教授，博士生导师，广东省青年珠江学者，广东省杰出青年科学基金和广州市珠江科技新星获得者。

当前主要围绕热门的新型电化学储能领域开展项目研究工作，立足于从材料、化学、物理多学科角度，围绕新型石墨烯和 MXene 等二维储能与转换材料的结构设计、合成机理、器件制造及应用等方面开展成体系的基础和应用研究工作，现已在 *Adv. Mater.*, *Nano Energy* 等国际权威杂志上发表 SCI 论文 40 余篇，其中 IF>10 十余篇，3 篇 ESI 高被引论文，1 篇被《Nature》作专题报道，单篇最高他引 480 余次，已被 Science, Nature 等国际期刊累计引用 1600 余次。申请发明专利 22 件，其中授权 6 件，目前主持国家自然科学基金面上和青年项目、广东省杰出青年科学基金等项目近 10 项。

Title:

High-density graphene-based hybrids for high-volumetric electrochemical energy storage



王松灿，博士，教授，2011 年本科毕业于中南大学，2014 获中南大学硕士学位，2018 年获澳大利亚昆士兰大学博士学位（导师：王连洲教授），随后继续在澳大利亚昆士兰大学从事近两年的博士后研究，2019 年入职西北工业大学。主要从事新能源半导体纳米材料与器件的研究，主要包括光催化、电催化和柔性储能器件等。目前，他在 *Chemical Reviews*、*Advanced materials*、*Angewandte Chemie*、*Advanced Functional Materials* 和 *Nano Energy* 等重要国际期刊发表论文 40 余篇，专著章节 2 部，论文他引 1100 余次（Web of Science），1 篇入选 ESI 热点论文，5 篇入选 ESI 高被引论文。获西北工业大学翱翔海外青年学者、国家优秀自费留学生奖学金、澳大利亚政府国际研究生奖学金（IPRS）和昆士兰大学功能纳米材料优秀研究奖等

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Title:

Development of Efficient Photoanodes for Photoelectrochemical Water Splitting



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2016 年博士毕业于华南理工大学化学与化工学院，导师彭峰教授。同年，就职于华南农业大学材料与能源学院，加入方岳平教授“绿色能源材料”研究团队，主要从事适用于光催化、光电催化分解水制氢无机半导体材料的开发与应用。目前分别主持国家自然科学基金-青年基金、广东省自然科学基金、华南农业大学校级科研项目各一项，于 2016 年参与获得广东省科学技术奖二等奖一项。报告人已在 *Applied Catalysis B: Environmental*; *Journal of Materials Chemistry A*; *Journal of Power Sources* 等期刊上共发表 SCI 论文 30 余篇。

本次报告主要内容：泡沫金属（Ni）基底负载 CdS@Ni₃S₂ 光电极的设计、制备与光/光电催化分解水产氢研究。

Title:

Ni foam supported CdS@Ni₃S₂ core-shell nanorod arrays for multifunctional H₂

**production**

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研究方向: 功能粘结剂, 硅基负极, 锂硫电池, 锂离子电池

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2. **Jie Liu**, Qian Zhang and Yang Kook Sun*, Recent progress of advanced binders for Li-S batteries, *J. Power Sources*, 2018, 396, 19-32.
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Title:

功能聚合物在高载量电池中的应用



刘铁峰，2017 年 1 月博士毕业于哈尔滨工业大学，随后在浙大-广工进行联合博士后研究 2 年，2019 年 1 月以校聘教师加入浙江工业大学材料学院，长期从事锂离子电池和钠离子电池的材料研发以及高性能粘结剂和电池回收设计的研究工作，目前共发表 SCI 论文 31 篇，总引用 700 余次，以第一作者/共同一作在 Nat. Commun. (2 个)、Energy Environ. Sci. (1 个)、Adv. Energy Mater. (2 个)、Nano Energy (1 个) 等领域内的高水平期刊发表论文 11 篇，其中 IF > 10 的论文 7 篇。

Title:

高比能量二次电池结构与材料的绿色设计

■ 墙报摘要

Poster Abstracts

Biomass-Based Porous N-Self-Doped Carbon Framework/Polyaniline Composite with Outstanding Supercapacitance

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Composites combining electrostatic charge accumulation and faradic reaction mechanisms are especially attractive high-performance supercapacitor electrodes for electrochemical energy storage. Up to now, it is difficult to prepare low-cost carbon composites from renewable resources. In this work, an outstanding and low-cost composite was fabricated by using sustainable N-self-doped carbon framework as a hierarchical porous carbon substrate from renewable resource. The N-self-doped carbon framework was fabricated from chitosan via a facile yet unique self-assembly and ice template method without any physical or chemical activation, and exhibited hierarchical porous structure. This texture not only allowed the efficient infiltration and uniform coating of polyaniline (PANI) in the inner network but also permitted a rapid penetration and desorption of electrolytes. Due to short diffusion pathway, uniformly coating of PANI, and high accessibility of PANI to electrolytes, the composite electrode had a very high supercapacitance of 373 F g^{-1} (1.0 A g^{-1}) and excellent rate capability (275 F g^{-1} , 10 A g^{-1}) in a three-electrode system. The symmetric supercapacitor also showed a supercapacitance of high up to 285 F g^{-1} (0.5 A g^{-1}), and a very high energy density of 22.2 Wh kg^{-1} . Furthermore, the composite also presented a good cycling stability.^[1]

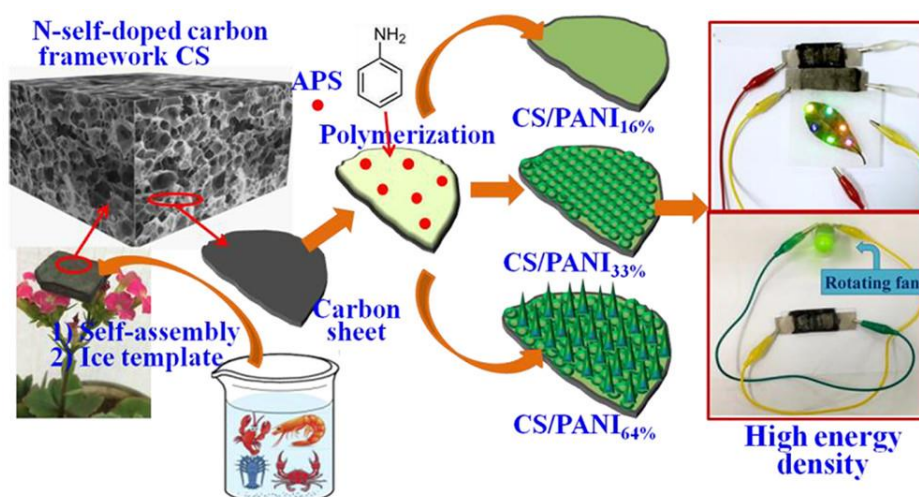


Fig. 1 Illustration of fabricating a N-self-doped carbon framework/PANI composite and its applications.

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Self-Biotemplate Preparation of Hierarchical Porous Carbon for an Ultrahigh Energy-Density Supercapacitor

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Although hierarchical porous carbons (HPCs) have attracted great interest in electrochemical energy storage, it is still a challenge to develop a facile and cost-effective method for fabricating HPCs. Herein, we proposed a combination strategy (i.e. self-biotemplating and chemical activation) to synthesize biomass (rice straw) derived N-self-doped HPC according to the following two key considerations: 1) intrinsic silica in rice straw acts as an built-in biotemplate to form large numbers of mesopores, and 2) chemical activation generates numerous micropores and thus results in a high specific surface area. The as-prepared N-self doped HPC has a hierarchical porous structure with reasonable mesopore ratio and high contents of O functionalities, which allows the fast transport of ions, highly accessible surface area, and also provides additional pseudocapacitive behavior. The as-prepared HPC exhibits ultrahigh specific capacitance (357 F g^{-1} at 0.5 A g^{-1} in a three-electrode system and 260 F g^{-1} at 1 A g^{-1} in a two-electrode system), excellent capacitance retention and cycling stability, superior to those of most biomass-derived carbons. Furthermore, the HPC also has an ultrahigh energy density of 29.3 W h kg^{-1} at a power density of 900 W kg^{-1} . In addition, the HPC exhibits high CO_2 capture capacities of 6.57 mmol g^{-1} at 0°C and 4.13 mmol g^{-1} at 25°C . This work provides an effective and low-cost way to synthesize HPC for high-performance supercapacitors and CO_2 capture.

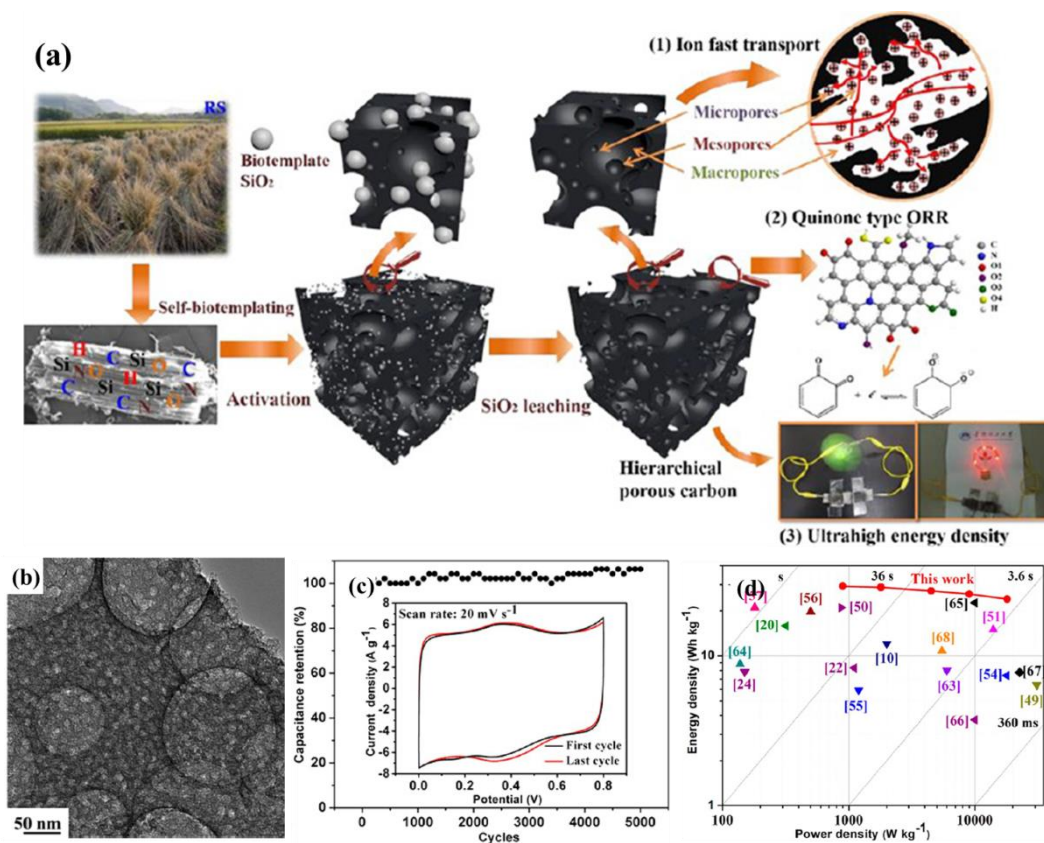


Fig. 1 Illustration of fabricating N-self-doped HPC from rice straw via the self-biotemplating method (a). TEM image indicating the hierarchical porous structure of the HPC (b). Cycling stability of the HPC (c). Ragone plots compared with those of other carbon materials in aqueous electrolyte (d).

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Cellulose Carbon Aerogel/PPy Composites for High-performance Supercapacitor

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Energy storage and conversion systems have recently attracted great interest in application of various electronic devices. Conductive polymers are promising pseudocapacitive materials for supercapacitors due to their low cost, low environmental impact, high pseudo capacitance, and ease of fabrication. However, the poor cycling stability limits their application. Here, we use cellulose as a carbon precursor to prepare a hierarchical porous carbon aerogel as a support for conductive polymer polypyrrole (PPy). The hierarchical porous architecture not only enables the efficient penetration and uniform loading of PPy throughout the carbon network, but also ensures a rapid transfer of electrolytes and the high accessibility of PPy. The as-prepared hybrid (Cell@PPy) shows a high specific capacitance of 387.6 F g^{-1} (0.5 A g^{-1} in $1.0 \text{ M H}_2\text{SO}_4$) and excellent cycling stability (92.6 % capacitance retention after 10000 cycles). This work provides an effective method to sustainably fabricate porous composite electrodes from renewable cellulose for supercapacitor.

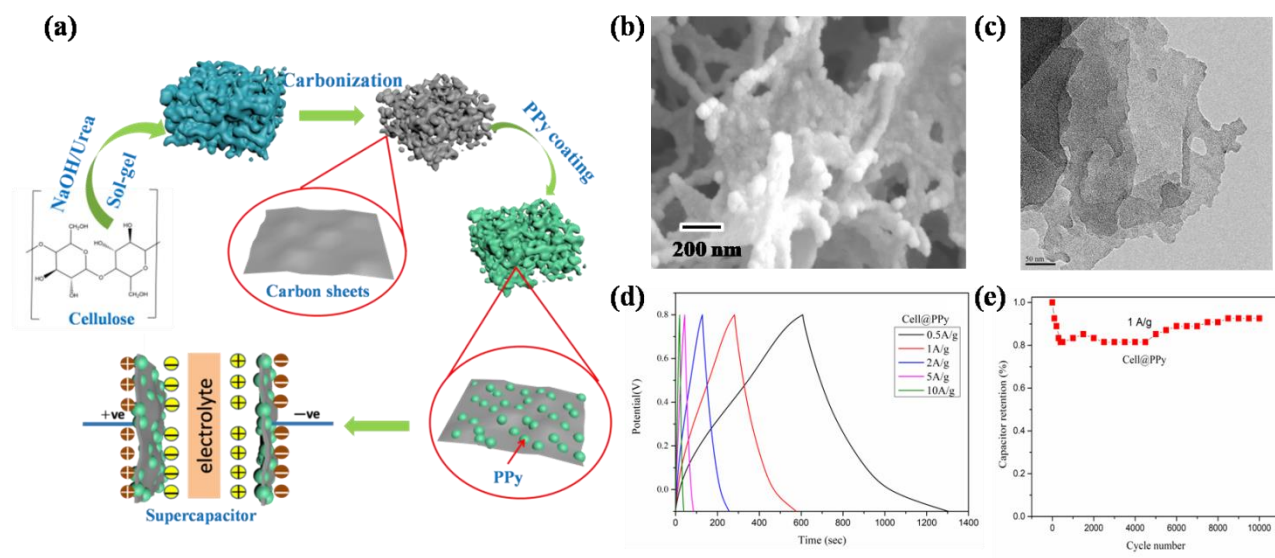


Fig. 1 The fabrication of 3D hierarchical porous carbon aerogel/PPy composite for supercapacitor (a). SEM image of Cell@PPy composite (b). TEM image of Cell@PPy (c). Charge/discharge curves of Cell@PPy at different currents (d). The capacitance retention of Cell@PPy at a constant current density of 1 A g^{-1} for 10000 cycles (e).

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Formation of Yolk-Shell Structure Spinel CuCo_2O_4 Microsphere with High Performance for Ammonia Borane Hydrolysis for Efficient Hydrogen Evolution

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Hydrogen has been regarded as one of the most promising candidates to replace the traditional fossil fuels due to its high calorific value, zero-emissions, and renewable natures. Hydrolysis of ammonia borane to produce hydrogen has attracted worldwide attention from researchers, due to the AB has a high hydrogen content (19.6 wt%), excellent stability in solid and aqueous solution at room temperature and no toxicity.[1] However, a suitable catalyst is necessary for hydrogen fast release from AB hydrolysis.[2] Thus, rational design of a catalyst with high catalytic performance, low-cost, high stability in harsh reaction condition is of significance. Recently, fabrication of a non-noble metal-based catalyst with yolk-shell structure has been proposed, due to this kind of catalyst has some advantages of low-cost, low density, high surface area, enhanced structural accommodation under harsh reaction condition and shortening diffusion distance of charges, which is regarded as the most promising candidate. However, to prepare a monodisperse non-noble metal-based catalyst with yolk-shell structure is still a challenge. In this study, we propose a facile strategy to fabricate monodisperse yolk-shell structure CuCo_2O_4 microsphere, and the catalytic performance of as-synthesized catalyst toward AB hydrolysis has been tested. The result demonstrates the yolk-shell structure CuCo_2O_4 microsphere exhibits robust catalytic performance with a high turnover frequency of 129.2 min^{-1} . The formation mechanism of yolk-shell structure has also been preliminarily discussed. This work is expected to be a guideline to produce a catalyst with yolk-shell structure.

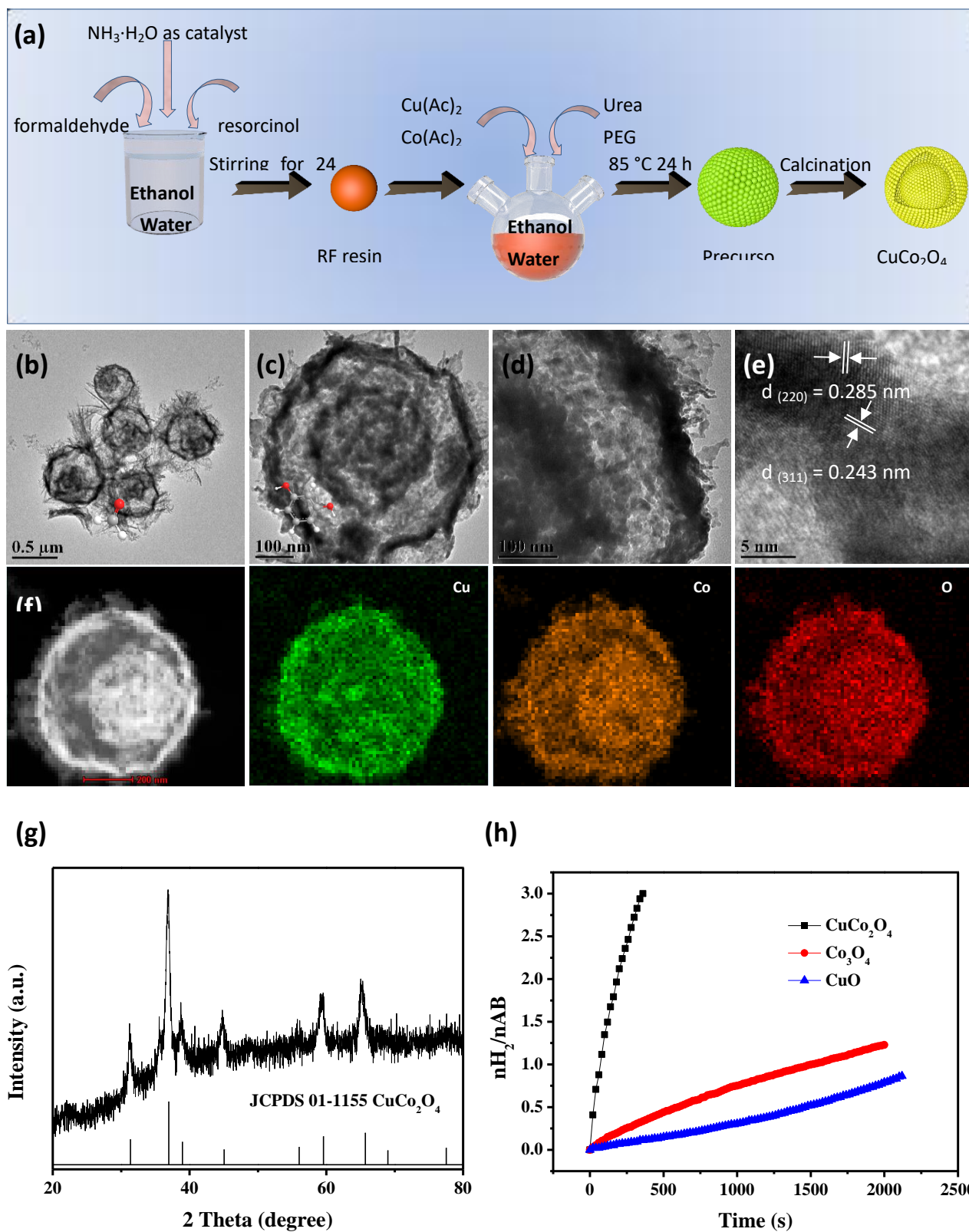


Fig. 1 Schematic diagram and structure characterizations as well as activity testing toward AB hydrolysis of yolk-shell structure CuCo_2O_4 microsphere.

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Strain Discrepancy-Assisted Liquid Exfoliation for Large-Scale Production of Few-Layered Transition Metal Dichalcogenides

Qian Zhou

Highly active, durable, and inexpensive nanostructured catalysts are crucial for achieving efficient and economical electrochemical water splitting. However, developing efficient approaches to further improve the catalytic ability of the well-defined nanostructured catalysts is still a big challenge. Herein, we report a facile and universal cation-exchange process for synthesizing Fe-doped Ni(OH)₂ and Co(OH)₂ nanosheets with enriched active sites toward enhanced oxygen evolution reaction (OER). In comparison with typical NiFe layered double hydroxide (LDH) nanosheets prepared by the conventional one-pot method, Fe-doped Ni(OH)₂ nanosheets evolving from Ni(OH)₂ via an Fe³⁺/Ni²⁺ cation-exchange process possess nanoporous surfaces with abundant defects. Accordingly, Fe-doped Ni(OH)₂ nanosheets exhibit higher electrochemical active surface area (ECSA) and improved surface wettability in comparison to NiFe LDH nanosheets and deliver significantly enhanced catalytic activity over NiFe LDH. Specifically, a low overpotential of only 245 mV is required to reach a current density of 10 mA cm⁻² for Ni_{0.83}Fe_{0.17}(OH)₂ nanosheets with a low Tafel slope of 61 mV dec⁻¹, which is greatly decreased in comparison with those of NiFe LDH (310 mV and 78 mV dec⁻¹). Additionally, this cationexchange process is successfully extended to prepare Fe-doped Co(OH)₂ nanosheets with improved catalytic activity for oxygen evolution. The results suggest that this cation-exchange process should have great potential in the rational design of defectenriched catalysts toward high-performance electrocatalysis.

Zn-vacancy promoted electron-hole separation in CdS/ZnS core/shell heterojunction for efficient visible light driven hydrogen productionYuan Lin^{a, b}, Qiao Zhang^a, Yunpeng Liu^{a, b}, Feng Peng^{a, *}^a School of Chemistry and Chemical Engineering, Guangzhou University, Guangzhou 510006, China^b School of Chemistry and Chemical Engineering, South China University of Technology, Guangzhou 510640, China

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Hydrogen is widely recognized as a clean energy carrier. Hydrogen evolution from photocatalytic water splitting is regarded as a promising method, since it only uses the abundant water sources and solar energy on earth.[1] Cadmium sulfide (CdS) possesses narrower band gap (2.4 eV) and more negative flat band potential (−0.9 V vs. NHE), therefore the utilization of solar energy can be extended to visible light region.[2] An incompletely covered CdS/ZnS core/shell is synthesized via a simple hydrothermal method.[3] Due to the defect energy levels introduced by zinc vacancies, the typical type-I heterojunction of CdS/ZnS evolves to a type-II heterojunction and Z-scheme hybrid structure, so that the ZnS shell is able to timely transfer and capture the photogenerated holes from CdS core. The surface photovoltage (SPV) distribution caused by photogenerated charges on the surface of catalyst is visually presented by Kelvin probe force microscope (KPFM) with synchronous illumination (microscope SPV). It intuitively proves the effective spatial separation of photogenerated holes from CdS core to ZnS shell, for the first time. Under optimal conditions, the highest hydrogen production rate of CdS/ZnS reached 24.1 mmol g^{−1} h^{−1} under visible light illumination. It exhibits highly efficient photocatalytic H₂ evolution with well stability.

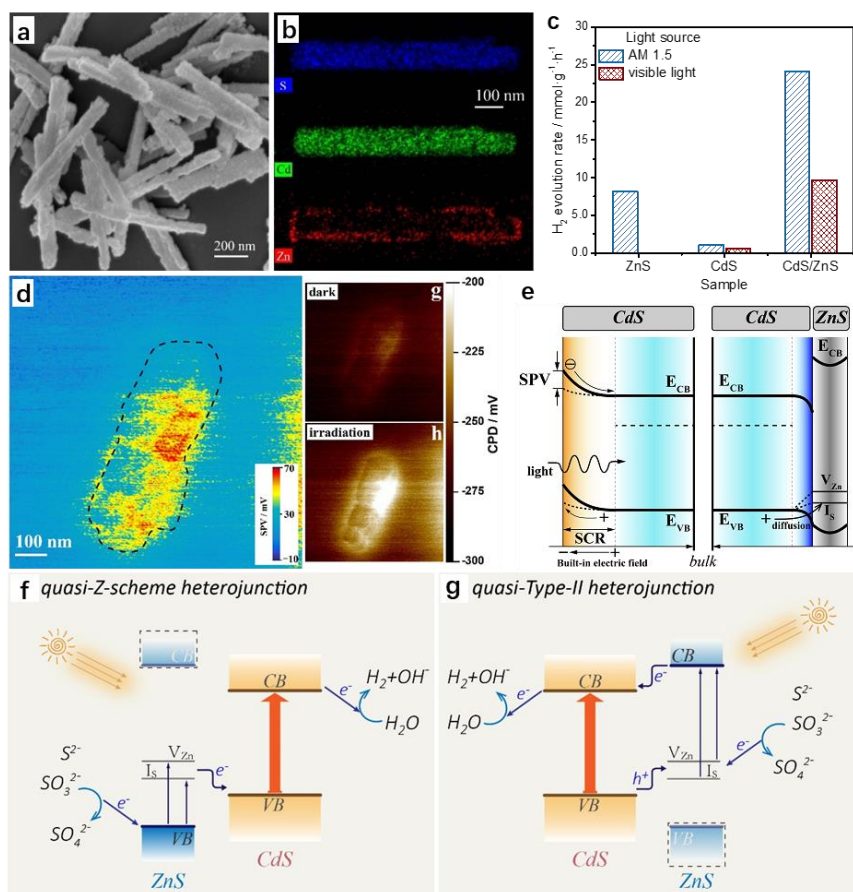


Fig. 1 (a, b) Morphology, (c) photocatalytic H₂ evolution performance and (d) surficial SPV distribution of the as prepare CdS/ZnS core/shell composite. (e-g) schematic diagrams of photo-introduced charges transfer.

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The real status of graphite electrode investigated by three electrodes system

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Abstract:

Ascribing to the low operating potential and slow kinetics of Li^+ intercalation, lithium can easily plate on the surface of graphite and subsequently deteriorates the performance of LIBs. Hence, graphite anode is widely regarded as one of the main culprits impeding the application of commercial LIBs at high rates.¹ However, the real behaviour of the graphite electrode is hardly to be distinguished in conventional two electrodes cell.²

Herein, we compare the charge-discharge curves tested by the conventional two electrodes cell and the innovative three electrodes cell. It reveals that the capacity tested by three electrodes cell is closer to theoretical value, and the real polarization of the graphite electrode is a fraction in the whole half cell especially at high rates. Consequently, precisely characterizing the status of graphite electrode is essential to guide the direction of improving the electrochemical performance of graphite for fast-charging application.

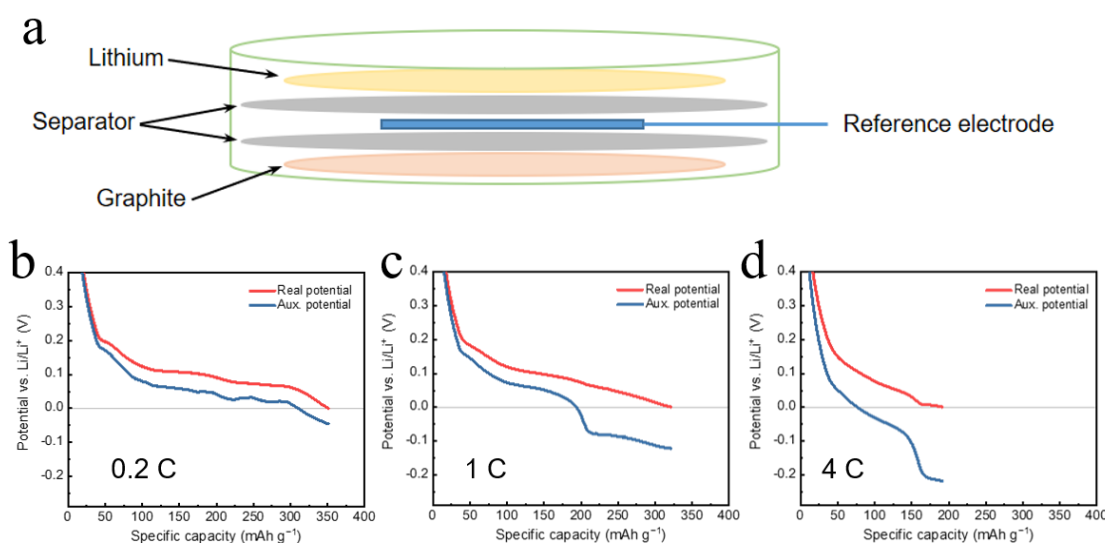


Fig. 1 (a) Schematic illustration of the three electrodes system, the comparison of discharge

curves of two electrodes (Aux potential) and three electrodes (Real potential) at the rate of (b) 0.2 C, (c) 1 C and (d) 4 C.

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2. C. Yan, R. Xu, J. L. Qin, H. Yuan, Y. Xiao, L. Xu and J. Q. Huang, *Angew. Chem. Int. Ed.*, 2019.

The failure behavior for solid-state lithium-sulfur pouch cells

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Abstract: Solid-state lithium-sulfur batteries are recognized as a research hotspot of a new generation of electrochemical energy storage systems, depending on high energy density and high safety. However, The electrochemistry behavior of solid-state lithium-sulfur pouch cells under the actual situation is poorly understood. Therefore, it is necessary to prepare solid-state lithium-sulfur pouch cells to analyze the failure behavior. In this work, we have adopted a commercial sulfide-based solid electrolytes to the solid-state lithium-sulfur pouch cells. The pouch cell consists of a S/C/Li₁₀GeP₂S₁₂ cathode, a Li metal anode and a sulfide based electrolyte. The pouch cells exhibited a charge capacity of about 1050 mAh g⁻¹ at 0.01mA cm⁻² and 60 °C. On the basis of the successful preparation of pouch cells, the failure analysis of pouch cells was carried out. The test results show that micro-short circuit is the main cause of the failure. This will provide a research basis for the development of solid state batteries with long lifespan, high energy density and high safety.

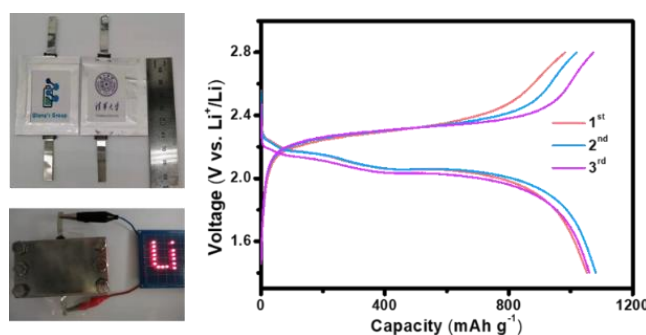


Figure 1. Solid-state lithium-sulfur pouch cells and the charge-discharge voltage profiles for

the solid-state lithium-sulfur pouch cells at 0.01mA cm^{-2} and $60\text{ }^{\circ}\text{C}$.

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Unraveling the dynamic processes of lithium plating in indium electrode for all solid state batteries

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(Department of Chemical Engineering, Tsinghua University, Beijing, P.R. China;

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Abstract:

The solid state battery is the ultimate solution towards the undesirable safety concerns^[1]. Due to the high ionic conductivity at room temperature, sulfide solid state electrolytes are perfect candidates to realize the solidification of electrolyte. However, their instability against Li metal hinders their further development^[2]. The Li-indium alloy enables to suppress the anodic parasitic reactions after contacting with the sulfide electrolytes, which has drawn great attention. Although Li-In alloy has been applied in the all-solid-state batteries, till now, their low content of lithium and high relative voltage will restrain the possibility to accomplish high energy density. Comprehensive understanding on the dynamic processes of Li-In alloy with different lithium contents can provide references to break the anodic bottlenecks.

Herein, we evaluate the lithium intercalation of pure indium electrode in solid state system. The lithium distribution at the interface is detected by a TOF-SIMS system. The results can directly display the lithium diffusion processes in Li-In alloy anode, which provide fundamental understanding on anodic mechanism for solid state battery.

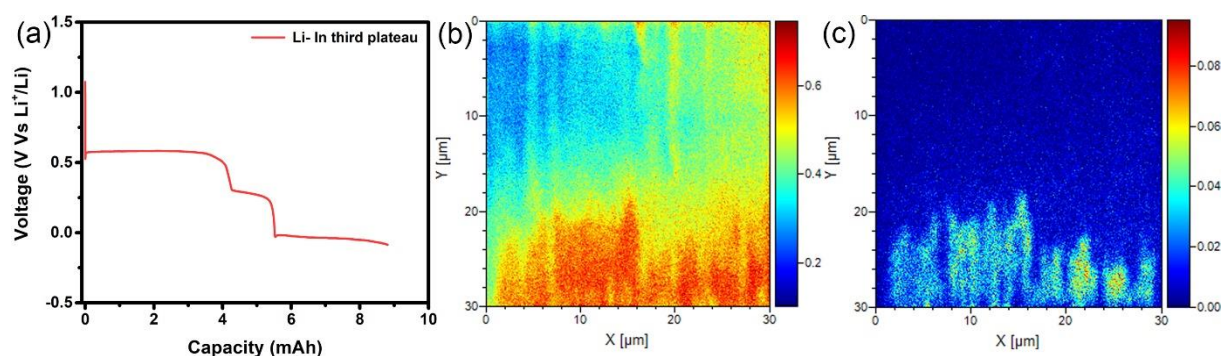


Fig. 1 (a) The typical lithium storage profile of In electrode. The TOF-SIMS mapping exhibiting the element distribution of (b) Li and (c) In at the interfaces.

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借助三合一表面修饰技术制备超长寿命 $\text{Li}_{1.2}\text{Mn}_{0.6}\text{Ni}_{0.2}\text{O}_2$ 正极材料

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电压和容量衰减是高能富锂锰基层状氧化物正极材料商业化面临的最主要挑战。^[1-5] 目前的研究认为这种衰减是由于高电压下氧的释放以及电解液的腐蚀引起的。基于此机理, 我们结合表层结构裁剪与表面氮掺杂碳包覆双重修饰的策略提高 $\text{Li}_{1.2}\text{Mn}_{0.6}\text{Ni}_{0.2}\text{O}_2$ (LMNO) 的电压和容量稳定性。通过表层结构裁剪释放出 LMNO 颗粒表层的低共价活性氧, 产生氧空位; 同时诱导表层过渡金属离子迁移, 形成尖晶石相主导的尖晶石-层状兼容共存区。表层结构裁剪有利于降低高电压下氧的释放, 并提高氧阴离子氧化还原的可逆性, 从而可以减缓 LMNO 正极材料的电压和容量衰减速度。在表面包覆氮掺杂的碳既可以提高材料的电导率, 又可以避免活性材料直接与电解液接触, 从而再次减缓 LMNO 正极材料的电压和容量衰减速度。如此双重修饰处理后, LMNO 的电化学性能得到了明显改善。0.5 C 倍率下首次放电比容量达 245.5 mAh g^{-1} , 循环 100 次后也未有明显衰减迹象; 并且 1 C 倍率下 500 次循环后的容量保持率仍高达 89.9 %。

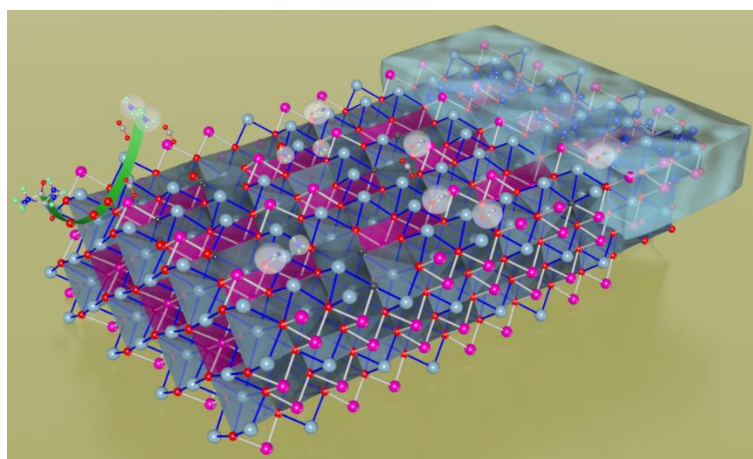


图 1 富锂锰基材料表层与尿素的反应机理图。

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Nickel-substituted $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{Co}_{0.8}\text{Fe}_{0.2}\text{O}_{3-\delta}$: a highly active perovskite oxygen electrode for reduced-temperature solid oxide fuel cells

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A key need for the advancement of high-performance solid oxide fuel cells (SOFCs) is to develop viable cathode materials with high electrocatalytic activity for the oxygen reduction reaction (ORR) at reduced operating temperatures below 700 °C. This study reports a Ni-substituted perovskite composition $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{Co}_{0.7}\text{Fe}_{0.2}\text{Ni}_{0.1}\text{O}_{3-\delta}$ (BSCFN) as a potential cathode material focusing on enhancing the electrochemical performance. Considerable attention is paid to the research of physicochemical properties primarily by crystal structure and oxygen transport measurements, with the aim to build up the correlation with the ORR activity. With the BSCFN cathode, a symmetrical cell achieves a very low area-specific polarization resistance of only $0.018 \Omega \text{ cm}^2$ and a single cell delivers a maximum power density as high as $\sim 1.8 \text{ W cm}^{-2}$ at 650 °C. Such a large electrode performance improvement is attributed to the sustained cubic-symmetry perovskite structure and fast oxygen kinetics promoted by Ni substitution. The desirable ORR activity and durability highlight the potential of BSCFN as a highly promising oxygen electrode for reduced-temperature SOFCs.

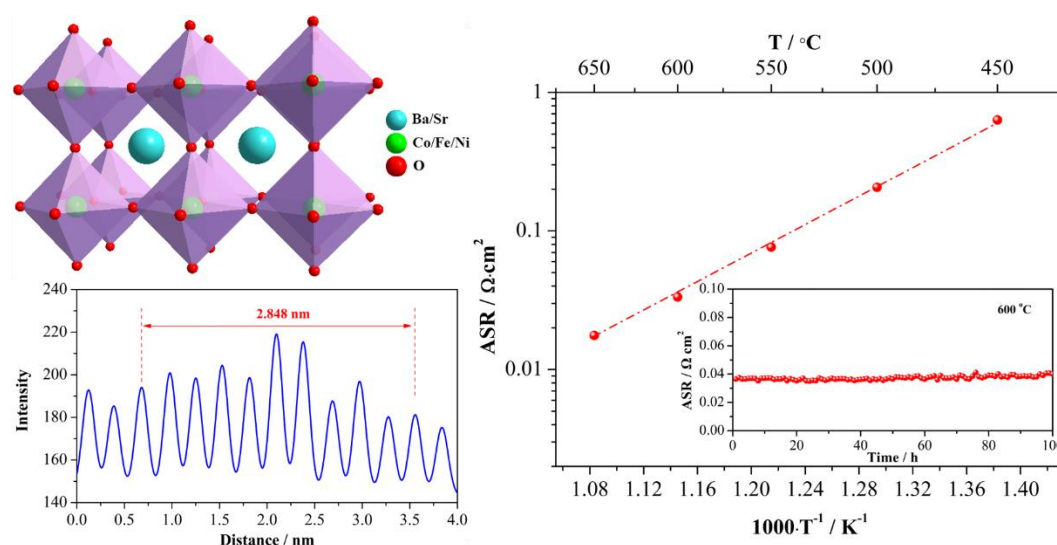


Fig. 1 Schematics of the crystal structure and intensity profile of crystalline fringes of BSCFN,

Arrhenius-type plots of the BSCFN-based symmetrical cell as a function of temperature and durability characterization of the BSCFN sample at 600 °C in air under OCV conditions.

An innovation: Dendrite free quinone paired with ZnMn_2O_4 for zinc ion storage

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Graphite was reported by J.O. Besenhard as the reservoir for alkali ions in 1974. The booming period of lithium-ion batteries arrived after the graphite patent issued by Sony Co. in 1991. The flourish development is due to the address of lithium dendrite issue through the substitution from lithium metal to graphite. Currently, the zinc dendrite formation in zinc-ion batteries is one of the major issues. Herein, we fabricate a zinc-ion full battery by replacing zinc metal with organic quinone, which is a zinc dendrite free material [1]. This novel zinc-ion full battery exhibits excellent cycling stability with capacity retention of 94.4% and high specific capacity of 189.5 mA h g⁻¹ after 500 cycles. Ascribed to the low cost of quinone and long cycle performance, this work could inaugurate a new era for rechargeable aqueous zinc-ion batteries.

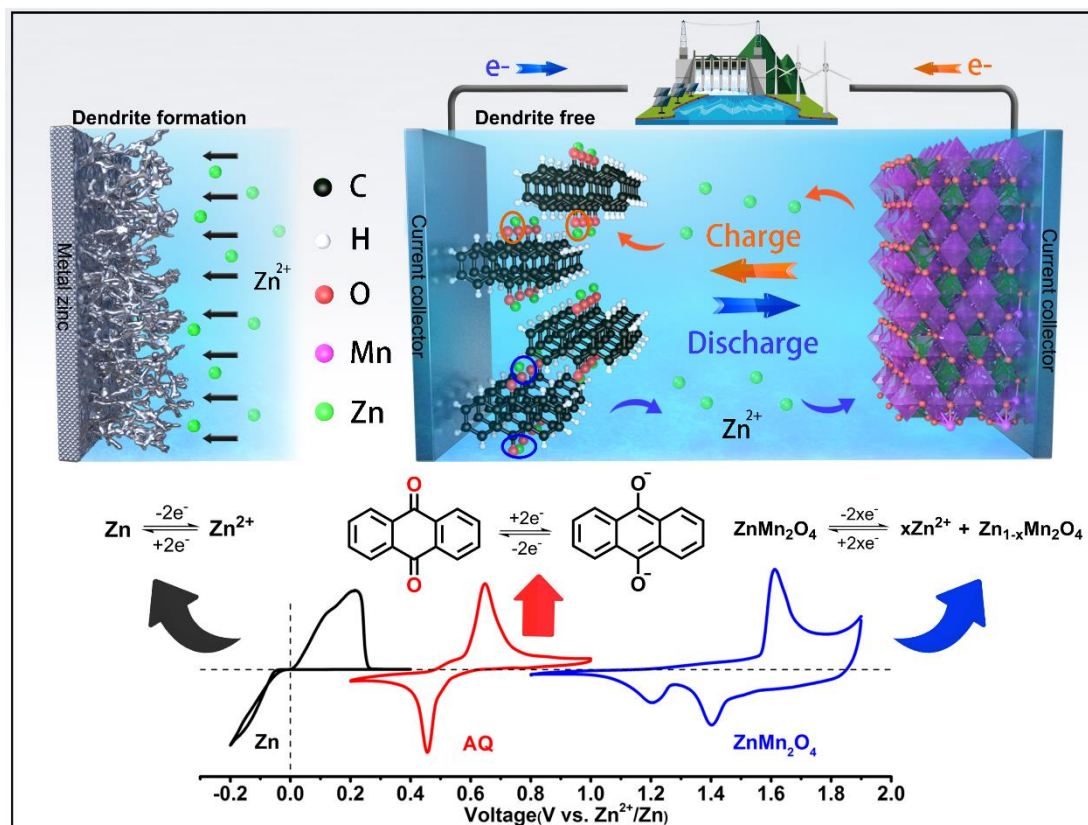


Fig. 1 Schematic drawing of the reversible work mechanism in the novel aqueous ZIBs

[1] Yan, L.; Zeng, X.; Li, Z.; Meng, X.; Wei, D.; Liu, T.; Ling, M.; Lin, Z.; Liang, C., An innovation: Dendrite free quinone paired with ZnMn_2O_4 for zinc ion storage. *Materials Today Energy* 2019, 13, 323-330.

Y-doped $\text{Li}_4\text{Ti}_5\text{-xY}_x\text{O}_{12}$ anode materials: Superior rate capability and ultra long cyclability for half/full lithium-ion batteries

Wenyan Chen

$\text{Li}_4\text{Ti}_5\text{O}_{12}$ (LTO) anode materials has been attracting attention owing to its structural stability and tiny volume change. However, its application is still restricted due to the low conductivity and Li^+ diffusion coefficient. To address these disadvantages, here, Y^{3+} doped $\text{Li}_4\text{Ti}_{5-x}\text{Y}_x\text{O}_{12}$ (LYTO) anode materials have been synthesized by an easy solid state calcination methods combination with ball milling activation using $\text{Y}(\text{NO}_3)_3$ as the dopant. The structural analysis shows that Y^{3+} doped LTO materials do not change the crystal structure and exhibit uniform particle size distribution. When applied to the anodes of lithium ion batteries, $\text{Li}_4\text{Ti}_{4.8}\text{Y}_{0.2}\text{O}_{12}$ possess outstanding long-cycle stability and excellent rate performance. The discharge specific capacity achieves 213 mAh g^{-1} and 117 mAh g^{-1} after 1000 cycles at the current density of 1 A g^{-1} and 7 A g^{-1} (10 C) respectively. In addition, full coin cells and pouch cells are assembled using $\text{Li}_4\text{Ti}_{4.8}\text{Y}_{0.2}\text{O}_{12}$ as anodes and LiCoO_2 as cathodes. The specific capacity of coin full cell remains 150 mAh g^{-1} after 100 cycles at 0.2 C, while the pouch full cell exhibits 149 mAh g^{-1} under the same conditions. Therefore, obtained results clearly confirm that LYTO is one of the best and novel electrode materials for high performed lithium-ion batteries which exhibits excellent electrochemical properties.

In-situ Construction of Hierarchical Porous SiO_x/C Composites Derived from Bamboo Charcoal for Highly Reversible and Superior Lithium Storage

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Ongoing pursuit of high performance functional materials from natural and inexpensive resources receive continuous attention. In light of the silicon-reservoir feature of natural bamboo, 3D porous SiO_x/C composites are constructed from bamboo charcoal only via an in situ top-down synthetic route involving activated carbonization and mild aluminothermic reduction. Particularly, the obtained composites possess a well-reserved porous and hierarchical structure where SiO_x nanoparticles are embedded in the entire 3D carbon framework. As the active material for lithium-ion battery anode, the optimal sample achieves impressive specific capacity (1100 mA h g⁻¹) at 200 mA g⁻¹ after 300 cycles as well as prominent cyclic stability under 1 A g⁻¹ (700 mA h g⁻¹ after 200 cycles). Besides, the composite anode demonstrates perfect capacity retentions and superior cyclic stability in full cells. This low cost bamboo-derived composite can further broaden the vision of advancing new-generation anode materials for rechargeable batteries and related hierarchical composites.

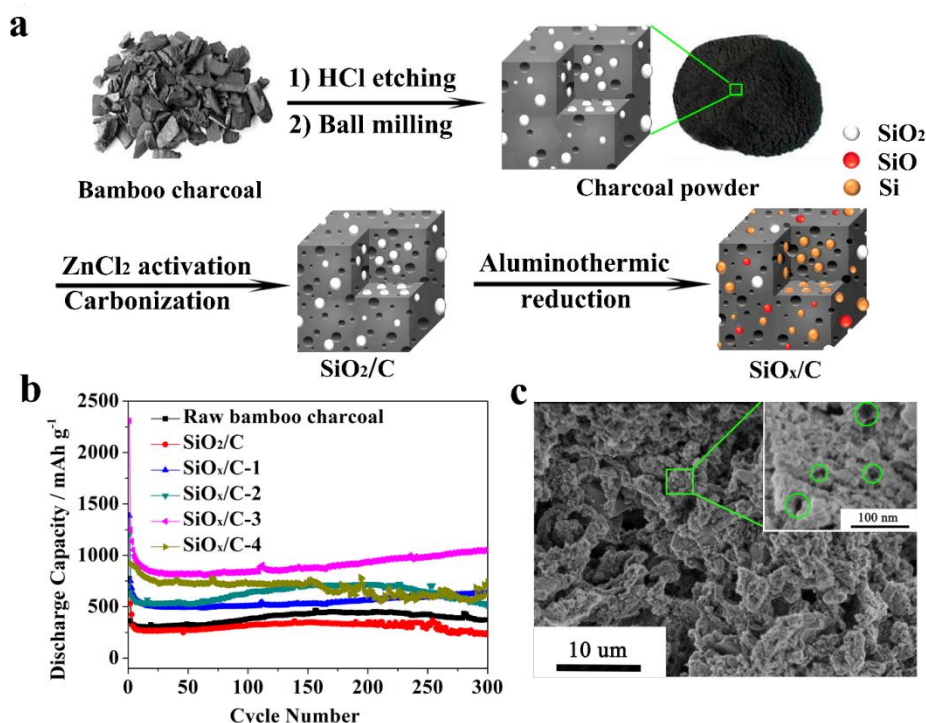


Fig. 1 (a) Scheme of the synthetic process of the SiO_x/C (SC) composite from bamboo charcoal; XRD patterns (b) and Raman (c) spectra of the samples.

Cathode Materials for Lithium-ion Batteries

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With the popularity of lithium-ion batteries and their high demand for energy density, lithium-rich manganese-based materials have attracted the focus of researcher 's attention. In this section, $\text{La}_2\text{O}_3/\text{LiLaO}_2$ is used to in situ coat $\text{Li}_{1.2}\text{Ni}_{0.13}\text{Co}_{0.13}\text{Mn}_{0.54}\text{O}_2$. The interface characteristics and electrochemical properties of the material before and after modification are analyzed. The $\text{La}_2\text{O}_3/\text{LiLaO}_2$ coating layer is used to stabilize the material structure and improve electrical properties. $\text{La}_2\text{O}_3/\text{LiLaO}_2$ build a solid crystalline structure layer with a thickness of about 5 nm on the surface of the material to stabilize the reversible deintercalation channel of Li^+ . The coated-cathode is cycled 200 times at 1C rate, and the discharge specific capacity is 177.9 mAh g^{-1} with capacity retention rate is 80.9%. The structure of the material's bulk phase is stabilized after coating $\text{La}_2\text{O}_3/\text{LiLaO}_2$, which suppresses the expansion of the material cell and reduces defects in the lattice after cycling. Meanwhile, coating with $\text{La}_2\text{O}_3/\text{LiLaO}_2$ improves the dynamic properties of the material enhance the reversibility and stability of the electrode.

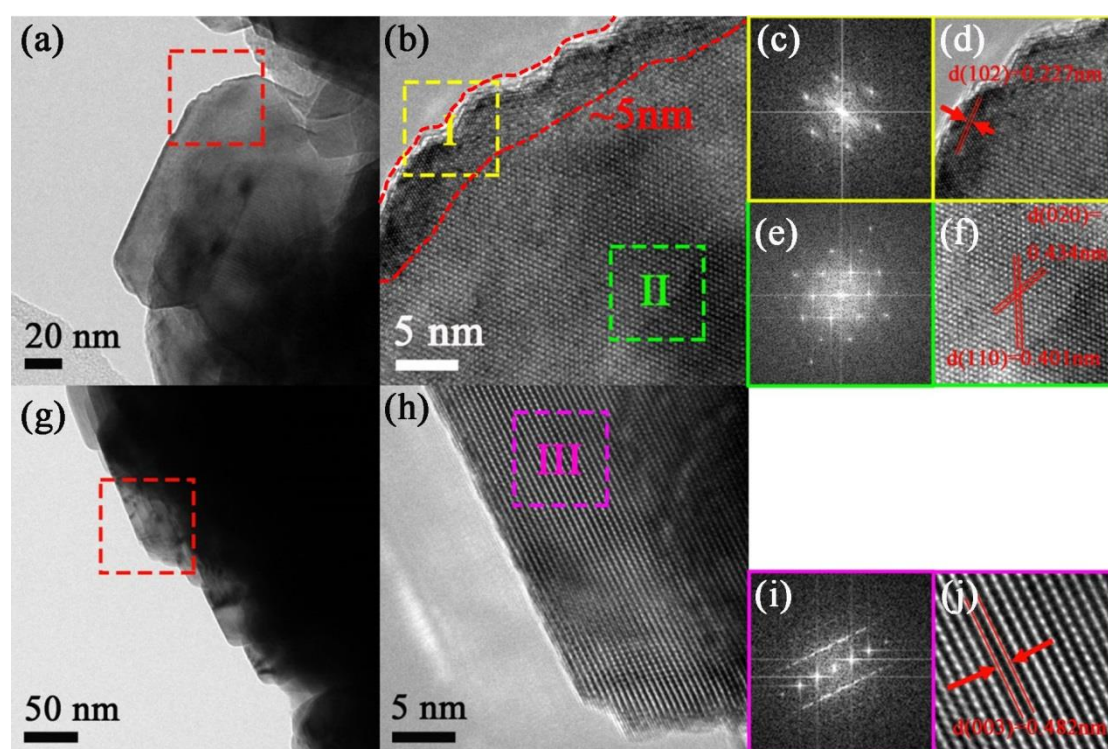


Figure 1. The TEM, HRTEM FFT images of (a-f) La3 electrode and (g-j) bare

Direct Z-scheme AgI/Zn₃(VO₄)₂ hybrid photocatalysts for enhanced photocatalytic degradation of tetracycline

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Water contamination with heavy metal ions and organic compounds is a serious problem in the natural environment. [1] Fortunately, photocatalysis has been considered as one of the most promising alternatives for biorefractory contaminants degradation, owing to the continuous generation of highly reactive oxidative radicals capable of degrading recalcitrant organics effectively. [2] Nevertheless, it is significantly limited by the challenging charge separation process. The construction of Z-scheme photocatalysts has been proved to be highly effective for improving the photocatalytic efficiency. [3] This work reports an all solid Z-scheme AgI/Zn₃(VO₄)₂ photocatalyst *via* an *in-situ* method, and the resulted AgI/Zn₃(VO₄)₂ photocatalyst shows extremely high photocatalytic activity in photocatalytic removal of tetracycline compared to single sample under visible light irradiation, which is attributable to the formation of Z-scheme heterojunction between Zn₃(VO₄)₂ and AgI, effectively facilitating the spatial charge separation. This work provides an effective strategy for rationally constructing charge separation and transfer pathway in semiconductor-based photocatalysts for water purification.

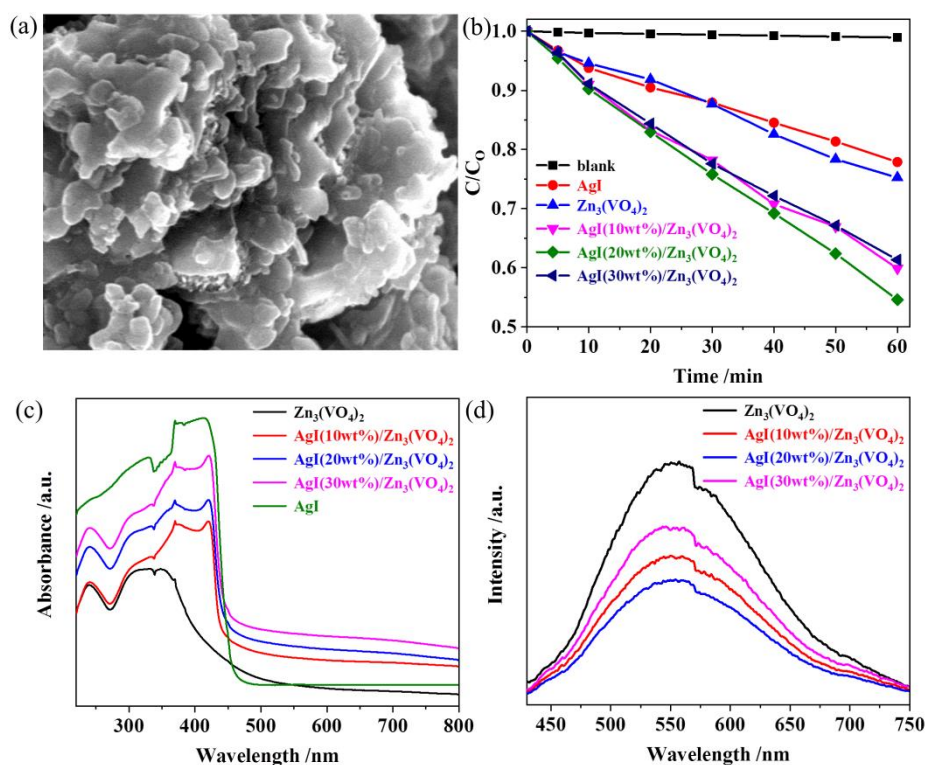


Fig. 1 SEM image (a) of AgI(20wt%)/Zn₃(VO₄)₂, photocatalytic activity towards the degradation of TC over the as-prepared samples (b) , UV-Vis DRS (c) and PL (d) spectra of the as-resulted samples.

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Optimizing Performance through Anion Exchange in Bulk Alkaline Electrolytes

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Nickel hydroxide as the key alkaline cathode is widely used for Ni-Zn, Ni-Cd, Ni-H battery. Nevertheless, lack of stability seriously limiting its practical application. Nickel hydroxide formula can be expressed as $\text{Ni}(\text{OH})_{2-x}(\text{A}^{n-})_{x/n} \cdot y\text{H}_2\text{O}$, where A represent anions located at the interlayer space of hydroxide, where x range from 0.2 to 0.4, y range from 0.6 to 1.[1] Meanwhile, according to previous reports, tunability of anions in layers of hydroxide were widely applied to enhance performance in various application.[2] However, anion adjusting in layers still remained the two main methods: (1) intercalation anion of hydroxide layers controlled by selected relevant anion salt in precursor solution during materials synthetic process or (2) anion exchange of materials through immersing relevant anion solution before application. Problems arise, anion could also be replaced by hydroxyl when transfer electrodes into bulk KOH electrolyte during electrochemical measurement. Herein, this study describes concentrated mixed electrolytes to address this issue. In this mixed electrolyte, the electrochemical behaviors become significantly tunable, such as redox potential and cycling stability, which provide a new strategy to optimizing electrochemical performance of alkaline battery system.

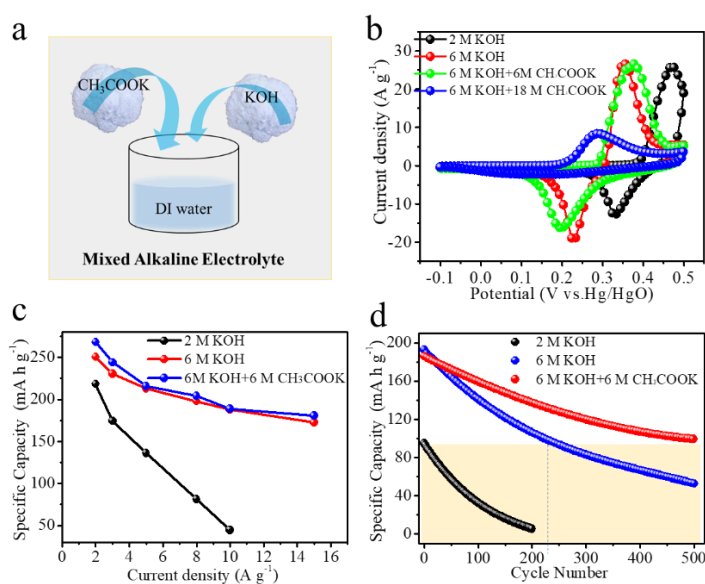


Fig. 1 Schematic diagrams of electrolytes optimization and corresponding electrochemical behaviors of $\text{Ni}(\text{OH})_2$ in different electrolytes

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Trimetallic Hydroxides Sheath Enable NiCo_2O_4 Nanoarrays as Efficient Bifunctional Air

Cathode for Flexible Zinc-air Batteries

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Flexible energy storage devices with the merits of low weight, miniaturization, adaptability to mechanical deformation, and compatibility with common fabrics, which are indispensable for the rapid expanse of wearable electronics. To fully satisfy the demands of growing wearable electronics market, high energy density and cycle durability are highly desired for the flexible energy storage system.[1] Zn-air batteries are considered to be suitable candidates to power flexible electronics for their unique advantages including relatively high specific energy (1370 W h kg^{-1}) and safety. [2] However, poor chargeability and low energy efficiency limit their practical application. The main obstacles are the large overpotential generated by the sluggish reaction kinetics of air cathodes, including oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) during the discharging and recharging process[3]. Therefore, the development of efficient bifunctional oxygen electrocatalysts is the key technology to solve these problems and achieve high performance zinc air batteries. In this study, we first report trimetallic hydroxides sheath enable NiCo_2O_4 nanoarrays as efficient bifunctional air cathode (the potential difference (ΔE) between the half-wave potential of ORR and overpotential at 10 mA cm^{-2} of OER is 695 mV) for flexible zinc-air batteries. Benefiting from the excellent electrocatalytic activity and cycle stability, the rechargeable zinc air batteries for both liquid and all solid state perform well under ambient conditions.

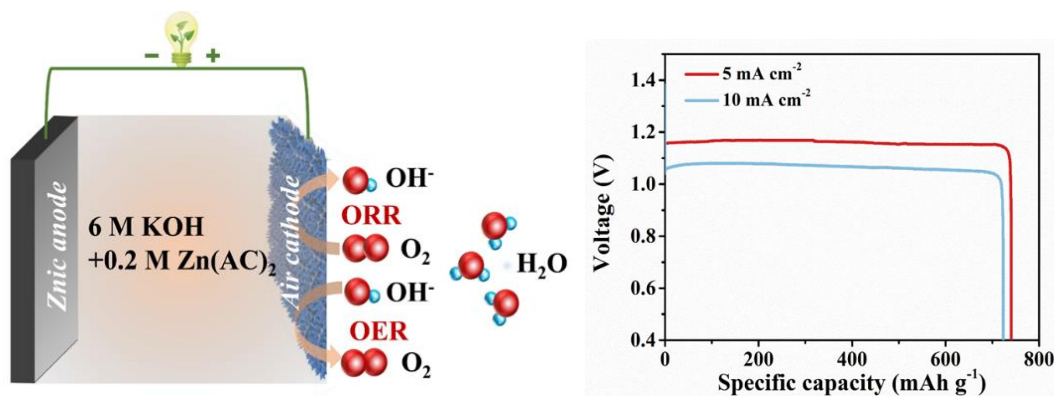


Fig. (a) Schematic illustration of the assembled aqueous ZAB.

Fig. (b) Specific capacities (based on the mass of the consumed zinc) of the aqueous ZAB.

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Graphene-like Co@NC nanosheets for high energy density Li-S batteries

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With the merits of non-poisonous, natural abundance and environmental amenity, lithium sulfur (Li-S) battery is considered to be the next-generation energy system which can substitute to Lithium-ion batteries. However, although the performance of Li-S batteries has been ameliorated meaningfully towards its theoretical capacity (1675 mAh g^{-1}), it still encounters several significant challenges. The key bottleneck problem troubling the application of Li-S batteries is the limited utilization of active S species, due to the slow kinetics process.[1, 2] In this work, we successfully address these challenges by using a novel graphene-like Co@NC nanosheets (N-doped graphene-like nanosheets coated cobalt nanoparticles). After reasonable combination with elemental S, the composite electrode exhibits ultralow resistance, outstanding rate performance and preminent cycling stability, which reinforced the overall electrochemical performance of the assembled Li-S batteries. We anticipate that this design mode of multifunctional metallic carbon-based composites could stimulate more investigations for advantaged high energy density Li-S batteries.

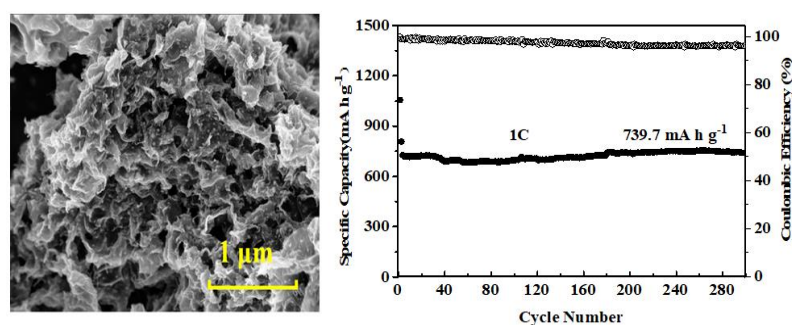


Fig. 1 SEM image and cycling stability at 1C

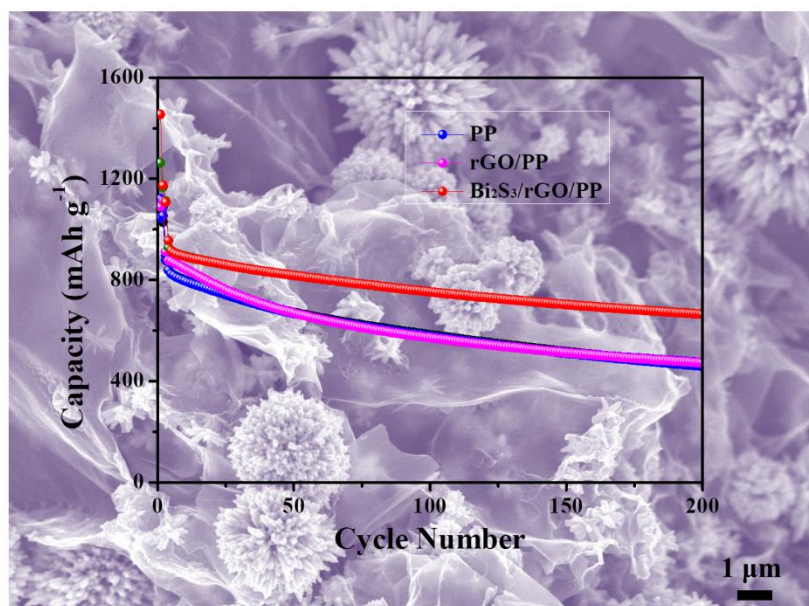
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Bi₂S₃/rGO modified separator for high performance Lithium-sulfur Batteries

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Lithium-sulfur (Li-S) battery has been one of the most promising candidates for next generation energy storage batteries due to its high theoretical specific energy density. However, the “shuttle effect” of intermediate polysulfides easily leads to poor cycle life, hindering the practical application of Li-S batteries. To solve this obstacle, introducing polar transition metal compounds to anchor polysulfides is considered as an effective strategy^[1]. Herein, we have designed a thin Bi₂S₃/rGO cover layer modifying commercial polypropylene (PP) separator with a simple hydrothermal and filtration method. The mass loading of Bi₂S₃/rGO on PP separator is about 0.26 mg cm⁻³. The flower-like VN can offer sufficient adsorption sites, and rGO can afford good conductivity. Hence, the Bi₂S₃/rGO interlayer provides robust chemical adsorption of polysulfides and reutilization of the trapped polysulfides. Benefitting by effective reduction of the “shuttle effect”, the cell assembled with Bi₂S₃/rGO interlayer delivers high reversible capacities and good cycle stability, exhibiting an initial discharge capacity of 1454 mAh g⁻¹, and a reversible capacity of 660 mAh g⁻¹ after 200 cycles at 0.5 C.

Fig. 1 SEM image and cycle performance of the Bi₂S₃/rGO composite.

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A free-standing Antimonene/CNT/PANI electrode aiming at the supercapacitor with enhanced capacity and cyclability

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Antimonene emerges as an important family member of 2D materials, because of its strong spin-orbit coupling and furious evolution of properties from bulk to the few-layer system. [1] Preliminary research suggests that antimonene can improve the performance of a carbon electrode for supercapacitor in both cyclic voltammetry and galvanostatic charging, as well as the environmental stability. [2] However, the advantages of antimonene (e.g. flexibility and conductivity) are not maximized. As a proof of concept, a free-standing antimonene/carbon nanotube (CNT)/polyaniline (PANI) electrode with enhanced pseudo-capacitive performance was fabricated by taking advantage of the intrinsic flexibility and conductivity of antimonene. The free-standing antimonene/CNT/PANI electrode exhibits an ultrahigh specific capacitance of 505.3 F g⁻¹ in 1M H₂SO₄. The further assembled flexible supercapacitor device demonstrates a remarkable specific capacitance of 442.9 F g⁻¹ and an outstanding cyclability of 91.9% retention over 10000 cycles. The facile strategy reported herein sheds new light on the effective utilization of antimonene for designing high-performance flexible energy device, catering the needs of portable and wearable electronics.

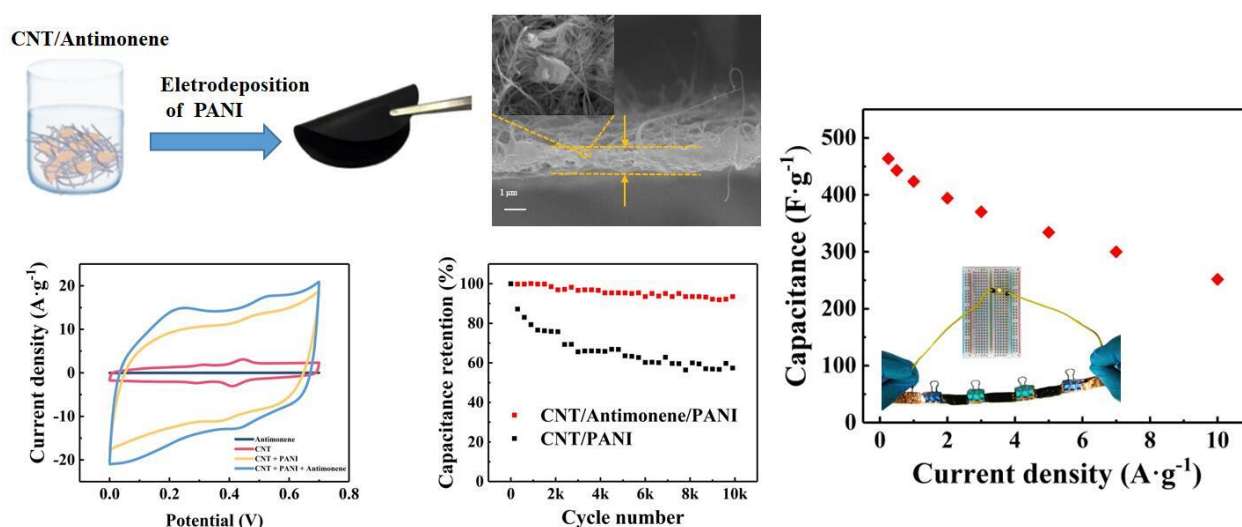


Fig. 1 The manufacturing process of free-standing Sb/SWCNT/PANI flexible supercapacitor and its electrochemical performance.

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3D Lithiophobic-lithiophilic composite architecture for high performance lithium metal batteries

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Metallic lithium (Li) has been acclaimed as the most promising anode materials for lithium batteries due to its ultrahigh theoretical capacity of 3860 mA h g^{-1} . Its practical application is impeded, however, due to the notorious problems related to dendrite growth caused by its uneven current density distribution and high Li nucleation overpotential.^{1,2} In this work, we report a three-dimensional (3D) lithiophobic phase (Cu) and lithiophilic phase (Zn or Sn) composite architecture realized through a facile electrochemical co-deposition technology and its use as a scaffold for dendrite-free Li metal anode. The simultaneous formation of this lithiophobic-lithiophilic composite on Cu foam leads to ultrafine lithiophilic phase (20nm) and reduced Li nucleation overpotential, as well as enhanced homogeneity. In the meanwhile, the lithiophobic component in the composite acts as a strong backbone, helping to maintain structural stability during lithium storage.³ The $\text{LiFePO}_4/\text{SPAN}$ -based full cells with the composite architecture/Li as anode presented excellent capacity retention and safety. This work broadens the horizon of lithiophilic hosts for next-generation high-performance Li metal batteries.

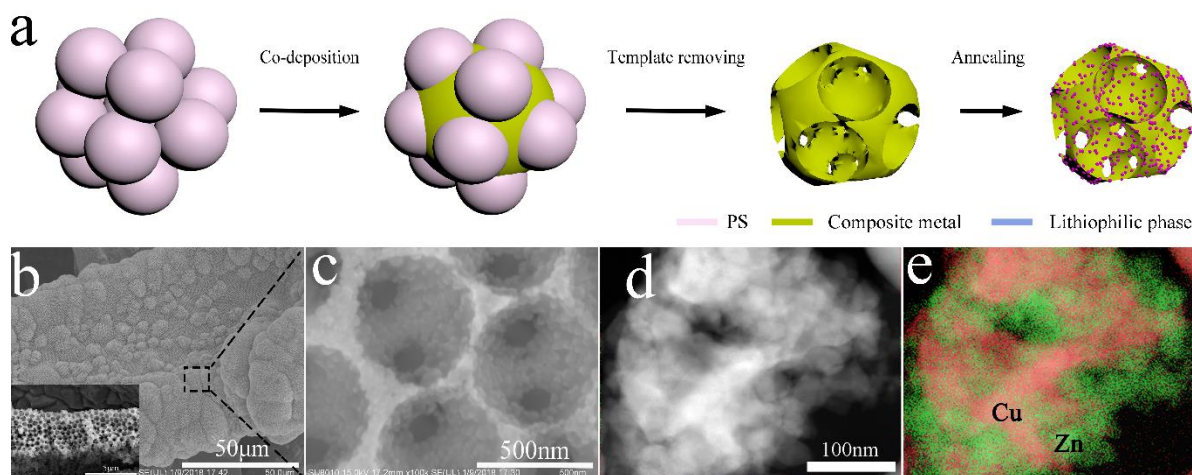


Fig. 1 Schematic diagrams of the fabrication procedure for the 3D lithiophobic/lithiophilic composite architecture and its structure characterizations.

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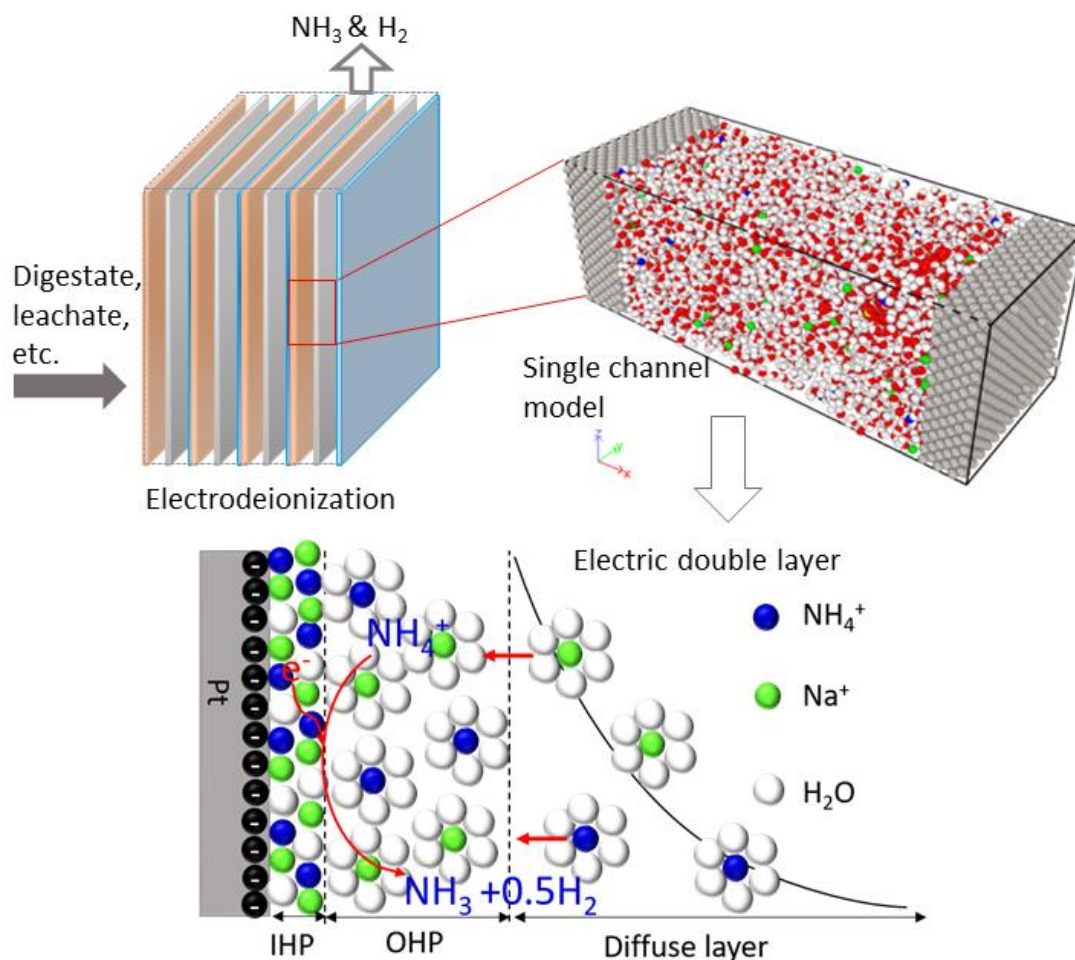
Increasing ammonia recovery from high-level ammonium wastewater via adding sodium sulfate to prevent nitrogen generation in the cathode

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The high-level ammonium-nitrogen ($\text{NH}_4^+\text{-N}$) is a contaminant for aqueous environment but a potential hydrogen fuel as it is extracted from wastewater through electrodeionization. Herein, this study investigated how to increase ammonia recovery via adding sodium sulfate of 0-1.5 M preventing from nitrogen generation. The results of experiment test, electrochemical analysis and MD simulation demonstrated that added Na_2SO_4 assisted ammonium transport on dilution and inhibited nitrogen gas generation on concentration. The change of Na_2SO_4 increased the migration rates of NH_4^+ and Na^+ increased on dilution (0-0.25 M) but decreased on concentration (>0.5 M) in electric double layer (EDL). The fierce competitive adsorption of Na^+ forming a thick layer blocked NH_4^+ migration and electron transportation and water molecules led to a potential drop. Therefore, 0.25 M Na_2SO_4 was the optimal concentration. The results obtained in this study can allow the manipulation of EDI capacity optimization.



Iron metal-organic frameworks with controllable crystal facets for enhanced electrocatalytic oxygen evolution

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Metal-organic frameworks (MOFs) has caused extensive concern in the field of electrocatalytic, due to its unique structure, large surface area and more exposed contactable active sites^[1]. The controllable of structure and crystal facets are considered to be effective routes to enhance catalytic performance^[2]. However, the orientated growth and facet control of MOFs is challenging because of the variety of MOFs structures and unavoidable deformation of the orientated growth processes of MOFs.

In this study, Fe-MOFs with controllable crystal facets were synthesized by adjusting the ratio of iron ion to ligand and proposed as enhanced OER electrocatalyst. As shown in Fig.1a-f, Fe-MOFs (defined as Fe-MOF-L, L represents the geometric length of the (100) crystal facet) present different orientated crystal facets. From Fig. 1g, XRD patterns of Fe-MOFs-L are consistent with that of Single-crystal X-ray diffraction. It should be pointed out that the peak at 7.8° can be attributed to (100) facet while 10.2° belongs to the (101) facet of hexagonal Fe-MOF. Moreover, the (101) facet occupied proportion was 82% (Fe-MOF-3.3), 84% (Fe-MOF-2.1), and 86% (Fe-MOF-0.7). In order to evaluate the electrocatalytic activities of Fe-MOFs-L, the LSV were performed in 1 M KOH. As presented in Fig.1h-i, Fe-MOF-0.7 exhibits lower overpotentials and smaller Tafel slope than Fe-MOF-2.1 and Fe-MOF-3.3. The results indicate the (101) crystal facet may be active surface and improve the electrocatalytic performance of OER.

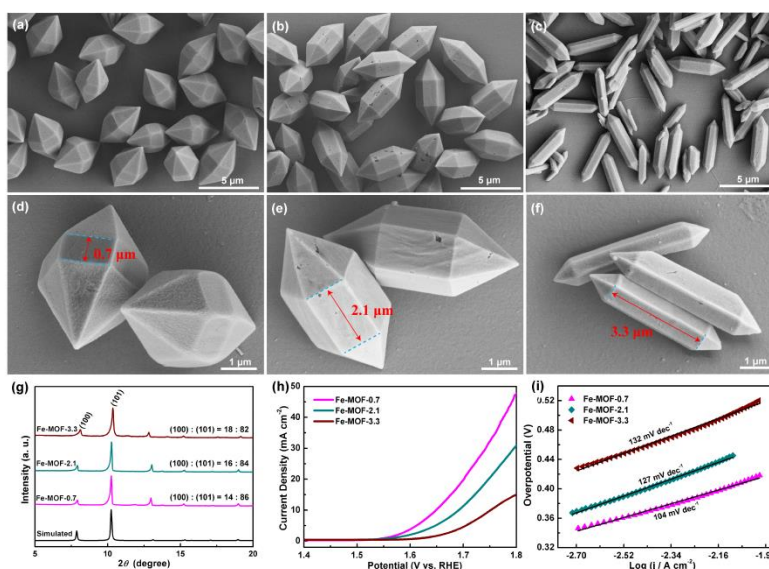


Fig. 1 (a-f) The FE-SEM image, (g) XRD patterns, (h) LSV curves in 1 M KOH and (i) the corresponding Tafel plots of Fe-MOF-L.

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