Joint Workshop

EI-CBE Joint Workshop

Chemical Process and Conversion

Date: 21 Feb 2023 (Tuesday)
Time: 2 – 5:40 pm
Venue: Room 6581 (Lifts 27-28)
The Hong Kong University of Science and Technology
Clear Water bay, Kowloon, Hong Kong

Program:

Time	
1:45 pm	Registration
2:00 – 3:00	Process Integration and Intensification — Developing New Industrial Applications from Traditional Chemical Engineering Processes **Prof. Jesse Zhu** Distinguished University Professor and Canada Research Chair Director, Particle Technology Research Centre Department of Chemical and Biochemical Engineering The University of Western Ontario, Canada
3:00 – 3:30	Research Career Planning for Yong Academics **Prof. Jesse Zhu,** The University of Western Ontario, Canada **Prof. Huijun Zhao,** Griffith University, Queensland, Australia **Prof. Shi-Zhang Qiao,** The University of Adelaide, Australia
3:30 – 3:40	Break
3:40 – 4:40	Catalytic Conversion of Earth-Abundant Biomass and Simple Molecules into Valuable Chemicals and Fuels **Prof. Huijun Zhao** Director of Centre for Catalysis and Clean Environment and Energy (CCEE) Griffith University, Queensland, Australia
4:40 – 5:40	Nanostructured Materials for Electrocatalytic Refinery **Prof. Shi-Zhang Qiao** Chair professor of Nanotechnology Founding Director of Centre for Materials in Energy and Catalysis (CMEC) School of Chemical Engineering and Advanced Materials The University of Adelaide, Australia

Prof. Jesse Zhu
Distinguished University Professor and Canada Research Chair,
Director, Particle Technology Research Centre,
Department of Chemical and Biochemical Engineering,
The University of Western Ontario, Canada

Prof. Jesse Zhu is a Distinguished University Professor and Canada Research Chair in the Department of Chemical and Biochemical Engineering, Western University. He received his Bachelor Degree from Tsinghua University in 1982 and his PhD from the University of British Columbia in 1988. After working several years at Shell Central Laboratory in Amsterdam, he decided to return to academics. At Western University, he established the Particle Technology Research Centre in 1999 and developed a very successful Research Chair Program in Particle Technology Applications, through which he has trained over 250 graduate students and postdoctoral fellows, including 30+ professors world-wide and 3 Fellows of Canadian Academy of Engineering. With 500^{+} journal publications and 50^{+} patents, he has worked on a very wide range of R&D projects, many from the industry. In addition to fundamental research, he is particularly active in technology development and transfer, with several inventions commercialized or being commercialized.

Dr. Zhu is a Fellow of Royal Society of Canada and Canadian Academy of Engineering. He has also received many awards including the highest career (R.S.Jane) award from the Canadian Society for Chemical Engineering, the highest Particle Technology (Elsevier) Award from the American Institute of Chemical Engineers, the highest research award (Hellmuth) from Western University, and two major medals from Engineering Institute of Canada and Professional Engineers of Ontario.

Process Integration and Intensification —
Developing New Industrial Applications from Traditional Chemical Engineering Processes

Abstract

Chemical Engineering processes can be made more intensive through Process Intensification and more efficient through Process Integration. While both concepts are not new, a combination of the two have not been paid enough attention, although Process Integration and Process Intensification (PIPI) can often leads to excellent process designs. Fluidization (either gas-solid or liquid-solid) provides very efficient heat and mass transfers, given the intimate contact between the fluid phase and the particulate solid phase, and thus intensification. And the combination of multiple fluidized beds allows more processes to be completed in one system, given the easy transportation of fluid and particles among the multiple units, and thus integration. The concept of PIPI is first introduced using the well established Fluid Catalytic Cracking process and the benefits of PIPI is then demonstrated following the development history of the new liquid-solid circulating fluidized bed for applications in biological processes. In the circulating fluidized bed system, process integration lies in the combination of two columns (the riser and the downer units), which operate separately and simultaneously; while process intensification is embodied in the improved mass and heat transfer efficiency in each unit because particles are rigorously in contact among and collide with each other when fluidized. The unique PIPI feature contributes to successful developments of several bio-processes.

Prof. Huijun Zhao
Director of the Centre for Catalysis and Clean Energy,
Griffith University, Queensland, Australia

Prof. Huijun Zhao is the Director of the Centre for Catalysis and Clean Energy at Griffith University, the elected Fellow of Australian Academy of Science (FAA) and Australian Academy of Technological Sciences & Engineering (ATSE), the Fellow of Royal Society of Chemistry (FRSC) and the Fellow of the Royal Australian Chemical Institute (FRACI). He has extensive expertise in functional materials, energy conversion and storage, catalysis and sensing technologies. He has published over 550 refereed journal papers and gained 68 international patents within 8 world-wide patent families. One of his current pursuits is to explore new ways to unlock the catalytic capabilities of nonprecious materials as high performance catalysts for important catalysis reactions.

Catalytic Conversion of Earth-Abundant Biomass and Simple Molecules into Valuable Chemicals and Fuels

Abstract

Catalysts play an essential role for over 90% of current chemicals/fuels manufacturing processes and hold a central key for clean energy and green manufacturing future. For industrial production of chemicals and fuels, the majority of high performance catalysts currently in use are made of precious metals-based materials, however, unsustainable due to their expensive and scarcity nature. The development of cheap and plentiful materials-based catalysts is therefore vital for the economically viable future of chemicals manufacturing industry. Unfortunately, the most of nonprecious materials in their pristine forms possess poor catalytic activity. As such, exploring effective means to endow nonprecious materials with superior catalytic power is a must, but highly challenging. In addition, the petroleum-based feedstocks are almost exclusively used for production of chemicals and fuels at industry-scales, emitting CO_2 that is environmentally damaging and unsustainable due to the rapid depletion of petroleum resources. Therefore, an ability to use cheap and earth-abundant biomass and simple molecules (e.g., N_2, CO_2, O_2, H_2O and NaCl) as feedstocks for production of chemicals and fuels would reduce not only CO_2 emission, but also our reliance on petroleum resources.

This presentation intends to illustrate the pressing issues for developing applicable industrial catalysts and effective approaches to activate nonprecious materials as high performance catalysts for catalytic conversion of biomass and simple molecules into valuable chemicals and fuels. A number of findings resulting from our recent investigations will be used to exemplify the effectiveness and applicability of new synthetic approaches and activation principles to empower the nonprecious materials with superior catalytic capabilities toward a spectrum of important thermo- and electro-catalysis reactions for green production of fine and commodity chemicals.

Prof. Shi-Zhang Qiao
Chair professor of Nanotechnology,
founding Director of Centre for Materials in Energy and Catalysis (CMEC),
The University of Adelaide, Australia

Prof. Shi-Zhang Qiao joined the School of Chemical Engineering of the University of Adelaide (UoA) in March 2012 as the inaugural Chair professor of Nanotechnology. He is the founding Director of Centre for Materials in Energy and Catalysis (CMEC). His research expertise is in nanostructured materials for new energy technologies (electrocatalysis, photocatalysis, batteries, fuel cell). He has co-authored more than 496 papers in refereed journals, including Nature, Nature Energy, Nature Materials, Nature Catalysis, Nature Communications, Science Advances, Angew Chem Int Ed, J. Am. Chem. Soc, Advanced Materials (over 91,020/105,215 citations, h-index: 154/165, Web of Sci./Google Scholar). In recognition of his achievements in research, he was honoured with the South Australian Scientist of the Year (2021), inaugural UoA Vice-Chancellor's Award for Excellence in Research (2019), prestigious ARC Australian Laureate Fellow (2017), ExxonMobil Award (2016), ARC Discovery Outstanding Researcher Award (DORA, 2013), Emerging Researcher Award (2013, ENFL Division of the American Chemical Society) and UQ Foundation Research Excellence Award (2008). He has also been awarded an ARC ARF Fellowship, an ARC APD Fellowship and an inaugural UQ Mid-Career Research Fellowship.

Dr Qiao is currently an Editor-in-Chief of *EES Catalysis* (RSC), Associate Editor of *Journal of Materials Chemistry A*; a Fellow of Institution of Chemical Engineers (FIChemE), Royal Society of Chemistry (FRSC) and Royal Australian Chemical Institute (FRACI). Dr Qiao is a Clarivate Analytics Highly Cited Researcher (with 123 highly cited papers) in three categories of Chemistry, Materials Science, Environment and Ecology.

Nanostructured Materials for Electrocatalytic Refinery

Abstract

Compared to modern fossil fuel-based industrial refineries, the emerging electrocatalytic refinery (e-refinery) is a more sustainable and environmentally benign strategy to convert renewable feedstocks and energy sources to transportable fuels and value-added chemicals. E-refinery promisingly leads to defossilization, decarbonization, and decentralization of chemical industry. Specifically, powered by renewable electricity (e.g., solar, wind and hydro power), oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) can efficiently split water into green hydrogen, CO_2 reduction reaction (CRR) can convert CO_2 emissions to transportable fuels and commodity chemicals, and N_2 reduction reaction (NRR) can potentially manufacture fertilizers at ambient conditions.

A crucial step in realizing this prospect is the knowledge-guided design of appropriate reactions and optimal electrocatalysts with high activity and selectivity for anticipated reaction pathways, which dominantly involve cleavage and formation of chemical bonds between H, O, C, and N. In this presentation, I will talk about our recent progress in mechanism understanding and material innovation for a series of crucial electrocatalytic reactions (OER, HER, CRR, NRR, etc.), which are achieved by combining atomic-level material engineering, electrochemical evaluation, theoretical computations, and advanced *in situ* characterizations. A special emphasis is placed on the rational exploration of novel single-atom catalysts. I will also demonstrate the framework and methodologies of e-refinery with greater complexity by electrocatalytic coupling *in situ* generated intermediates (integrated reactions) or products (tandem reactions). It will inspire and accelerate further investigations of e-refinery to complement or displace some important industrial processes, and ultimately make the energy and chemical sectors sustainable.