Kyushu University World Premier International Researcher Invitation Program: "Progress 100"

Special Short Seminar Series

Electrochemical Energy Conversion Research at Illinois

9th January, 10:00~

I2CNER-1, 2nd Floor Conference Room

Part 1: Recent Development of Electrocatalysts for Hydrogen-Powered Fuel Cell Technology

Part 2: Dynamics of Nanostructures and Their Effects on the Non-PGM Catalysts for Purifications of Carbon Dioxide from Simulated Flue Gas

Part 3: Understanding the Growth and Assembly for the Formation of Nanostructures

Hong Yang, Richard C. Alkire Endowed Chair Professor
University of Illinois at Urbana Champaign
Department of Chemical & Biomolecular Engineering

Bio-sketch: Prof. Hong Yang is the Richard C. Alkire Chair Professor of Chemical Engineering at the University of Illinois at Urbana-Champaign (UIUC). He received his B.Sc. degree from Tsinghua University (1989), and Ph.D. degree from University of Toronto (1998). He did his postdoctoral research at Harvard University as an NSERC Canada Postdoctoral Fellow. Among his awards and honors, Dr. Yang is an elected Fellow of American Association for the Advancement of Science (AAAS), one of the two NSERC Canada Doctoral Prize recipients in Science, and a US National Science Foundation CAREER Award winner. He is a Section Editor on Nanotechnology for *Current Opinion in Chemical Engineering*, and the Subject Editor on electrochemical energy conversion for *Frontiers in Energy*. He serves on several Editorial Boards, such as *Nano Today* and *ChemNanoMat.* He has given close to 200 invited talks. His research interests include formation of nanocrystals, catalysis, and electrocatalysis, and nanomaterials for energy and sustainability applications.

Chair: Stephen M. Lyth

Talk 1 (10:00 – 11:00): Recent Development of Electrocatalysts for Hydrogen-Powered Fuel Cell Technology

Electrocatalyst plays an essential role in the development of hydrogen-powered fuel cell technology because of the sluggish kinetics of the oxygen half reactions. Platinum group metals and less-than-optimized reaction conditions are used to improve In this presentation, I will present our recent efforts in addressing this techno-economic challenge from the following areas related to the electrocatalyst developments. Specially, I will present our efforts in the low- and non-platinum group metal (PGM) oxygen reduction reaction (ORR) electrocatalysts and ternary metal oxide electrocatalysts, such as pyrochlores for oxygen evolution reaction. On the low-PGM ORR catalysts, we have developed new processing methods for making highly dispersed PtCo intermetallic nanoparticles showing outstanding ORR durability. New processing approach was also developed for making iron-based non-PGM ORR catalysts based on the creation and control of single atoms. On the hydrogen production, I will present our latest work on the preparation of nanoparticles of pyrochlore-type ceramic electrocatalysts for improving the oxygen evolution reaction under acidic conditions.

Talk 2 (11:00 – 12:00): Dynamics of Nanostructures and Their Effects on the Non-PGM Catalysts for Purifications of Carbon Dioxide from Simulated Flue Gas

Catalyst is alive and its surface structures changes during the reactive processes. It is thus important to understand the dynamics of atoms at near surface. While many approaches have been developed for making nanostructures with predetermined overall compositions, the control of surface structures with a high degree of accuracy is still a challenge. In this presentation, I will discuss the dynamic structures under variable temperatures and reactive atmospheres of metallic nanostructures and provide an overview of factors governing the dynamic processes of metallic restructuring, such as the surface energetics of shaped metallic nanoparticles under gaseous environments and diffusion-controlled restructuring process. Such knowledge leads to the design of non-precious metal group datalysts in my group. As one example, we developed copper-based catalysts for studying the sequestration of carbon dioxide (CO_2) due to the power generation. Our approach is targeted especially for the oxy-combustion process for the catalytic removal of oxygen gas from the flue gas streams. We demonstrated the catalytic conversion of oxygen from a simulated flue gas stream using methane as the reductant and supported copper as catalysts to achieve high purity CO_2 in the final gas product. Our results show our catalyst could change the surface structures dynamically under the reactive conditions and achieve both 100% conversion of oxygen and 100% selectivity to CO_2, outperforming the precious group metal (PGM) catalyst tested (palladium) in reaching the desired targets of gas purity. This study suggests non-noble metal catalysts could be great candidates for various important oxygenic reactions because of their dynamic nature.

Talk 3 (13:00 – 14:00): Understanding Growth and Assembly for the Formation of Nanostructures

Formation of nanoparticles is a topic of great interest to research community across disciplines for years because of their unique properties. The ability to precisely synthesize nanoparticles with the desired shape and size relies heavily on our understanding on the factors influencing the formation mechanisms. Fundamental study of nucleation and growth and assembly of nanoparticles was brought to the forefront of such research once again with recent developments of new techniques and understandings. Formations of various nanostructured materials can now be revealed by the new methods in liquid media in a spatiotemporal fashion. In this presentation, I will focus on our latest studies on using both in situ and ex situ techniques to quantifying the formation of nanostructures by considering diffusion, surface reaction, attachment, coalescence and self-assembly. Both single and ensembles of nanoparticles were studied to understand the whole formation processes.