Johns Hopkins University
Department of Chemical and Biomolecular Engineering
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Atomically Precise Nanocrystal Surfaces and Interfaces for Electrocatalysis

Presented by Professor Sen Zhang

ABSTRACT

Crucial to sustainable energy future is the ability to manipulate important chemical reactions for the production and conversion of clean hydrogen (H2) fuel and renewable carbon-based chemicals through the development of advanced catalysts. Well-defined nanocrystals with atomically precise surfaces and interfaces allow us to bridge the knowledge gap between conventional single-crystal bulk materials and powder catalysts to achieve a new and in-depth understanding of structure-catalytic property relationships. In this talk, I will highlight how nanocrystal catalyst surfaces and interfaces can be synthetically tuned with atomic precision for the improved performance in the oxygen-mediated energy conversion reactions: the oxygen reduction reaction (ORR) for fuel cells and the oxygen evolution reaction (OER) for water electrolyzer. The first nanocrystal system I will discuss is the M-Pt (M=non-precious metals) core-shell nanocrystals within which desirable/undesirable interfaces between non-precious metal M core and precious metal Pt shell were identified by theoretical calculations and were experimentally balanced through wet-chemical synthesis. The optimized core-shell nanocrystals exhibited favorable interfacial interaction through properly coupled electronic and strain effects, leading to an enhanced electrocatalytic efficiency towards the ORR. In the second system, we elucidated and modulated the interaction of single-site Co, Fe, Ni catalytic centers and inorganic coordination environments in the surface of doped metal oxide nanocrystals for the OER. The seamless integration of controlled synthesis of nanocrystals, operando structural/catalytic characterization, and advanced theoretical calculation for oxygen electrocatalyst development will be discussed, which will also be extended to other electrocatalytic (e.g., CO2 reduction and biomass-derived molecule upgrading) and thermocatalytic processes (e.g., CO2 hydrogenation).

BIO

Dr. Sen Zhang received his B.Sc. in Polymer Chemistry at the University of Science and Technology of China in 2008. From there he went on to receive his Ph.D. in inorganic chemistry in 2013 at Brown University under advisor Prof. Shouheng Sun. He worked as a NatureNet postdoctoral fellow under Prof. Christopher Murray at the University of Pennsylvania from 2013 to 2016. He joined the University of Virginia as an assistant professor of chemistry in August 2016. His research interests are in nanomaterials controlled synthesis, assembly, and heterogeneous catalysis for reactions involved in energy and environmental applications, such as fuel cells reactions, water splitting, CO2-to-fuel conversion and biomass conversion. He was selected for awards and honors, including NSF CAREER award (2022), Scialog Collaborative Innovation Award by the Alfred P. Sloan Foundation and Research Corporation for Science Advancement (2021), NatureNet Science Fellow by the Nature Conservancy (2013), Potter Prize by Brown University (2014), “2020 Rising star in Chemistry” by the Frontiers in Chemistry, and “Emerging Investigator” by the Journal of Materials Chemistry (2019) and Nanoscale (2020).

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