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Seminar: Wednesday, Feb 11th—10:30 A.M.—BS 3018 - INDY

<https://purdue-edu.zoom.us/j/92496707373?pwd=RGghRQDL7yFZOdUXGaHbabnbbsVoM.1>

Understand and Control Charge Transfer Reactions in Electrochemical Energy and Manufacturing Systems

Abstract:

Electrochemical systems find wide applications in energy and manufacturing applications (e.g., batteries, water electrolyzers, metal production, etc.). A physical understanding of thermodynamics and kinetics of the interfacial charge (ion and electron) transfer reaction, especially in emerging electrolyte systems (such as concentrated electrolytes, water-in-salt electrolytes, etc.), is essential for rational electrolyte design to enhance performance, reduce cost, and improve scalability.

In the first part of this talk, I will discuss the electro-deposition of transition metals in aqueous environment, the core reaction in low-cost energy storage (iron and zinc batteries) and emission-free metal production (electrowinning). We demonstrated that concentrated electrolytes can enhance the efficiency of these reactions. In addition to the long-held understanding that attributes the improved efficiency to better deposit morphology and suppressed water reactivity, our study reveals an overlooked mechanism related to the metal redox (M^{2+}/M) and metal-anion complex. I will present our experimental findings and discuss the fundamental understanding based on electrode reaction and complex formation equilibria.

In the second part of the talk, I will turn to ion insertion reaction, an important family of charge transfer reactions that underpin batteries, smart windows, and critical material extraction. I will present our understanding of Li insertion kinetics and how we can leverage this understanding to design better electrolytes with extreme performance for defense and space applications, and to design a new platform technology for the separation and production of critical metals.

Biography:

Dr. Gao obtained his BS/MS from Tsinghua University, PhD from University of Maryland, College Park, and postdoc training from Massachusetts Institute of Technology. He is currently an assistant professor at the Department of Chemical Engineering, University of Utah. His lab studies electrochemical technologies for energy and manufacturing applications, including batteries, metal production, critical material extraction, etc. He has published 70+ papers in journals including Science, Nature Communication, Joule, etc. He has an H-index of 60, with a total citation of more than 23, 000. He is the recipient of NSF CAREER Award (2025), Investigator on the Rise Award at University of Utah (2025), Highly Cited Researcher Recognition by Clarivate (2022-2024), the Emerging investigator Award by Royal Society of Chemistry (RSC) Journal of Material Chemistry (2023), Early Career Investigator Award by the American Chemical Society (ACS) Energy and Fuel Division (2022), Dean's Dissertation Fellowship at University of Maryland (2016) and Outstanding Graduate Assistant Award at University of Maryland (2016).

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