



UNIVERSITY OF DELAWARE
DELAWARE ENERGY
INSTITUTE

DEI SEMINAR

FRIDAY

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10:00 AM

366 COLBURN LAB



RACHEL DAVIDSON

UNIVERSITY OF DELAWARE

Rachel Davidson started as an Assistant Professor in the Department of Chemistry and Biochemistry at the University of Delaware in Fall 2023. Her lab focuses on developing and understanding materials using local electrochemical systems. Prior to getting started at UD, she was an Intelligence Community Postdoctoral Fellow supported by the Office of the Director of National Intelligence and the National Reconnaissance Office and was a 2020 Cottrell Postdoctoral Fellow. She completed undergraduate studies with honors at the University of Alabama at Birmingham and earned her PhD in Chemistry from Texas A&M University under the advisement of Prof. Sarbjit Banerjee. During her PhD, she was a National Science Foundation Research Traineeship (NRT) Fellow and a Manual P. Soriaga Graduate Fellow. Her prior work focused on understanding electrodeposition of light metals to gain insight on dendrite formation and design of metal anodes for magnesium-based batteries as well as on design of nanocomposite coatings for corrosion protection of light metal alloys.

ELECTROACTIVE MATERIALS ACROSS DECADES OF LENGTH SCALES: OPTIMAL PATHWAYS THROUGH DATA-DRIVEN DESIGN

Electrochemical reactions are governed by local electric fields due to the inherently heterogeneous nature of electrode surfaces. This fundamental idea underpins many of the challenges in design of active materials in electrochemical systems and in design of materials using electrochemistry. This talk will discuss the interplay of this idea in three distinctive areas of interest: in the design of anodes for rechargeable batteries, coatings for corrosion inhibitions, and in the study and design of materials using local electrochemical probes.

Area 1: For rechargeable batteries, there is great interest in moving beyond lithium-ion towards magnesium-based electrochemical energy systems, driven in large measure by the alleged imperviousness of metallic magnesium to dendrite formation. Mitigating dendrite formation would allow for the use of metal anodes affording much higher capacities than graphite, but this would require plating and stripping processes at the anode to occur consistently over the course of hundreds of cycles. Our efforts have focused on exploration of electrocrystallization mechanism of magnesium through in situ video microscopy coupled with detailed structural characterization and mesoscale modeling, considering the influence of electrolyte concentrations, applied electric field, and the effects of growth-directing ligands. The studies reveal a diverse range of dendritic, aggregated, and even single-crystal products. Our

work opens the door for development of anode designs that mitigate dendrite growth, which will be essential for continued progression of Mg-based battery technology.

Area 2: Mitigating distinctive degradation phenomena is critical to the effective utilization of light metals in structural applications. We have developed a modular design approach to nanocomposite coatings that imbue multiple modes of corrosion protection. I will focus on our efforts in the design of magnesium-nanoparticle- and exfoliated-graphite-based nanocomposites that activate sacrificial cathodic protection and path tortuosity mechanisms, respectively.

Area 3: At UD the Davidson group aims to precisely design and analyze materials across length scales in order to obtain systems which allow for precise control of the flow of mass, charge, and energy across time. Our specific efforts focus on blending concepts in crystal growth and nanoparticle synthesis with the idea of electrochemical additive manufacturing using scanning electrochemical probes to spatially confine electrodeposition to design functional materials such as battery electrodes with precisely defined diffusional pathways, surfaces with gradients in wettability to passively control flow of fluids, and nanoplasmonic arrays. We are also investigating the stability and evolution of local catalytic sites for CO₂ electrocatalytic reduction by measuring local site activity using scanning electrochemical cell microscopy and deconvoluting the relative catalytic site contributions of various crystallographic features and electronic structure signatures through correlative transmission electron microscopy mapping of crystallographic structure and scanning transmission X-ray microscopy maps of electronic structure. In each these efforts, the group leverages data-enabled approaches to strategically navigate synthesis designs spaces.

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