



Engineering Electron Flow: Molecular Electrochemistry for Biosynthesis, Sensing, and Energy Storage

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Abstract: Electrochemical control of enzyme-catalyzed reactions offers a powerful route to sustainable synthesis, biosensing, and energy conversion by replacing stoichiometric chemical reagents with electricity. A central challenge for this approach is the design of efficient bioelectrochemical interfaces that enable rapid, selective, and stable electron transfer between electrodes, redox cofactors, and enzymes. In this seminar, I will focus on molecular design strategies for addressing this challenge, with an emphasis on electrochemically recyclable NADH biomimetics. Our work combines physical organic electrochemistry, impedance spectroscopy, and molecular modeling to identify how steric shielding, solvation, and ion pairing govern electron-transfer kinetics and radical stability in nicotinamide-inspired cofactors. These insights enable the rational design of biomimetic redox molecules that are compatible with enzymatic turnover while remaining efficiently regenerable at electrodes. I will also highlight how the same molecular design principles extend to pyridinium-based redox materials for nonaqueous energy-storage applications, where intermolecular interactions dictate solubility, viscosity, and electron-transfer rates. Together, these studies establish unifying structure–property relationships for controlling electron flow across bioelectrochemical interfaces.

Bio: David P. Hickey is an Assistant Professor in the Department of Chemical Engineering & Materials Science at Michigan State University (MSU), where he leads pioneering research at the intersection of electrochemistry, catalysis, and molecular engineering. Specifically, his research aims to elucidate electrochemical mechanisms and understand molecular interactions at electrode interfaces relevant to bioelectrocatalysis and energy storage. Dr. Hickey holds a Ph.D. in Chemistry from the University of Oklahoma working with Daniel Glatzhofer and completed his postdoctoral research with Shelley Minter and Matthew Sigman at the University of Utah. Dr. Hickey was awarded ACS PRF Doctoral New Investigator and NSF CAREER grants, and he has authored or coauthored more than 80 publications, 5 book chapters, and holds 2 patents. His research has been featured on the covers of the Journal of the American Chemical Society, ChemElectroChem, the Journal of Physical Chemistry B and the AIChE Journal, and has been highlighted in the Chronicle of Higher Education, Yahoo! Finance, Chemical Engineering Progress (CEP), and Chemical & Engineering News (C&EN).

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