The Expanding Toolkit for Quantifying Electrochemical Reactivity: Addressing Challenges from Energy Storage to Biomimetics

Recently, there has been a dramatic increase in the application and development of electrochemical approaches to address global challenges, ranging from grid-scale energy storage and desalination to commercial production of commodity chemicals and pharmaceutical synthesis. The success of many such promising technologies depends on an ability to control electron flow near the interface between a liquid solution and electrode surface. This is accomplished by utilizing small electrochemically active molecules that can act as either “electron shuttles” for electrocatalysis, or as “energy reservoirs” for energy storage applications depending on their reactivity in the charged state. Despite their ubiquity in emerging green energy technologies, the structure-reactivity relationships of electrochemically charged small molecules remains poorly understood due to the rapid timescale at which electrochemically charged species tend to react. Consequently, discovery/implementation of new redox molecules is slowed by a reliance on the “guess and check” approach. The Hickey research group integrates computational modelling with cutting-edge analytical methods to tune and identify electroactive small molecules and polymer materials for a variety of applications related to energy storage, catalysis, and biosensing. I will describe our collaborative efforts to design redox active molecules for two disparate areas of research: grid-scale energy storage and electrochemically recyclable biomimetic coenzymes. By studying electrochemical mechanisms and understanding molecular interactions at electrode interfaces, we aim to elucidate universal molecular design principles that can be applied across a wide range of cross-cutting research topics.

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