Department of Chemical Engineering Seminar Series

Advanced Catalysts for Electrochemical Energy Conversion and Storage Systems

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Electrochemistry is central to many applications such as water purification, membrane separation, sensors, energy storage and conversion systems. Among different electrochemical systems, energy storage (e.g., batteries) and conversion (hydrogen generation) systems that could harvest energy from renewable sources, e.g., solar and wind in the form of chemical bonds have received much attention due to having tremendous potential as an alternative to fossil fuels. Despite its importance, these systems have advanced far more slowly over the last two decades than many companion fields due to the lack of suitable and affordable catalysts. To date, numerous catalysts, such as carbon derived materials, metal-carbon hybrid structures, and noble metal catalysts are extensively used for electrocatalytic reactions, despite the low reaction rates or high overpotentials. While many physical and chemical approaches have been employed to enhance the catalytic performance of these materials, there appears to be a fundamental limit, connected to the electronic structure of these catalysts.

My research aim is to design, synthesize and characterize advanced catalysts with unique electronic properties suitable for electrocatalytic reactions. I will present recent findings where we showed that the edge states of transition metal dichalcogenides (TMDCs) in ionic liquid (IL) electrolytes offer a new paradigm for electrocatalytic reactions. We have tested the performance of this class of catalysts for the carbon dioxide (CO_2) reduction reaction, oxygen reduction reaction and oxygen evolution reactions and lithium-air batteries, a potential alternative to lithium-ion batteries. Our results include 1000 times higher catalytic activity for the CO_2 reduction reaction, far exceeding the performance of state-of-the-art catalysts, highly efficient bi-functional catalysts for oxygen reduction and evolution reactions exceeding that of expensive noble metal catalysts such as platinum and gold. In this talk, I will discuss these and other results including the potential of our recent discovery to open a new route towards energy efficient, highly active and cost effective electrocatalysis energy storage and conversion systems to replace fossil fuel

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