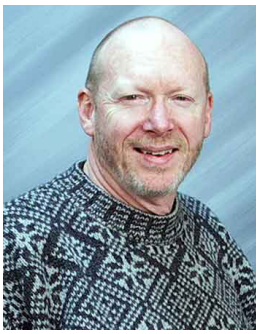
Materials Chemistry McElvain Seminar



Dr. John Turner

National Renewable Energy Laboratory

Thursday, October 27th, 12:15 pm
1315 Chemistry- Seminar Hall

Semiconductor Systems and Catalysis for Photoelectrochemical Water Splitting

Forty years after the first reported photoelectrochemical (PEC) water splitting experiment, commercial hydrogen production from PEC is still a dream. Literally 100's of millions of dollars and thousands of papers later and still no semiconductor system has been identified that has the potential for economical hydrogen production via PEC water splitting.

Recent technoeconomic analysis studies indicate that a >15% solar-to-hydrogen PEC conversion efficiency is necessary for a commercially viable system. Additional requirements of lifetime (years), and cells costs (<$400/m^2) make a working device extremely challenging. To achieve such high efficiencies, semiconductors with superior electronic properties are required as well as highly active catalysts. Clearly then one must decide whether to use an existing PV-based semiconductor or search for a new semiconductor with the necessary electronic properties. The majority of the research has been directed at metal oxides due to their expected low costs, ease of synthesis and stability, but so far their poor electronic properties has prevented them from reaching the high efficiencies necessary for a working device. The III-V-based solar cells show the highest solar PV efficiency and thus are excellent candidates for a PEC system, but cell costs are high and lifetime is limited.

Incorporation of proper electrocatalysts onto the illuminated semiconductor surface is necessary to both stabilize the PEC interface and increase catalysis, thus enhancing the overall device performance. The branching ratio between catalysis and corrosion must be extremely high (>10^6) in order for the system to have the necessary lifetime, thus the catalysts must have a very high turnover frequency)and turnover number. Noble metals, particularly platinum, are commonly applied as they are the most active for the water redox reactions. Nobel metals are neither earth abundant nor low-cost, so identifying catalytic systems that can match the activity and stability of platinum but are based on earth abundant materials are clearly a high-priority area of research. Such materials for semiconductor surface modification are particularly beneficial if they are potentially low-cost and scalable, transparent and conductive while also highly catalytically active and stable. Work on hydrogen evolution catalysts has been a very active area of research where numerous molecular, nanomaterial, and bulk catalysts have been developed.

This presentation will discuss some of the challenges and opportunities facing PEC community in our search for a workable PEC solar water-splitting system that could lead to a commercial device. The discussion will include tandem cells for PEC water splitting and the importance of surface treatments for band edge control and the advantage of a visible-light transparent hydrogen evolution catalysts.

Graduate students may contact mlumley@wisc.edu to meet with the speaker

DEPARTMENT OF
Chemistry
UNIVERSITY OF WISCONSIN–MADISON