Materials Chem Seminar

By UW-Madison Chemistry Professor

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Electrochemical Approach for the Development of Highly Efficient Photoelectrode and Catalyst Materials for Use in Solar Fuel Production

Among the various approaches of utilizing semiconductor materials for solar fuel production, the use of photoelectrochemical cells (PECs) for direct water photolysis or reduction of CO_2 is one of the most viable options for low cost solar fuels since both the generation of electron-hole pairs and their use to drive desired chemical reactions are achieved by the same semiconductor electrode (photoelectrode) in a single device. While the construction of highly efficient PECs has already been demonstrated based on single crystal or monolithic electrodes, commercially viable PECs will be most likely designed based on polycrystalline photoelectrodes considering the high manufacturing cost of single crystal electrodes. The overall objective of our research for solar fuel production is to bring about a marked improvement in the construction, understanding, and available variety of high performance polycrystalline photoelectrodes by exploiting the unique advantages of electrochemical synthesis, allowing for an exceptional level of freedom in controlling the compositions and morphologies of polycrystalline photoelectrodes.

In this presentation, we report our new efforts on the electrochemical preparation of photoelectrodes based on ternary oxides (both n-type oxides that can serve as photoanodes and p-type oxides that can serve as photocathodes). To date, most studies on the development and understanding of electrodes for use in a water-splitting photoelectrochemical cell have been performed using simple binary systems. However, there are a far greater number of ternary systems that have not been studied extensively although they are predicted to be potentially excellent photoelectrodes. Ternary systems can also offer more possibilities for band gap and band position tuning. We will also discuss how to enhance the selectivity and stability of the photoelectrodes by pairing them with a proper water oxidation or reduction catalyst. The systems we will discuss include a $BiVO_4$-based photoanode that achieves a current density of 1.0 mA/cm^2 for water oxidation to O_2 under AM 1.5G, 100 mW/cm^2 illumination using a record low applied bias of 0.5 V vs. RHE, while operating in neutral media (pH 7).

Thursday, Sept. 13, 2012

12:15 pm, Seminar Hall (1315 Chemistry)