Sensitization of Single Crystal Semiconductors with Dyes and Quantum Dots

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Even though investigations of dye-sensitized nanocrystalline semiconductors in solar cells has dominated research on dye sensitized solar energy conversion over the past two decades, single crystal electrodes represent far simpler model systems for studying the sensitization process. Single crystal surfaces prove to be more controlled experimental models for the study of dye-sensitized semiconductors than the nanocrystalline substrates. The preparation of surfaces of single crystal WSe_2 SnS_2 and TiO_2 electrodes, to serve as reproducible model systems for charge separation at dye sensitized solar cells, will be described.

In experiments with ruthenium complexes at TiO_2 and with carboxylated cyanine dyes, we demonstrate the promise of this simple model for understanding dye-sensitized solar cells. In each of these systems, we can observe and analyze the complex photochemistry in a quantitative manner. Molecules of the well-known N3 ruthenium complex attach to four different crystallographic faces of anatase and rutile TiO_2 at different rates and to a different extent. With carboxylated cyanine dye sensitizers on these surfaces, molecular aggregation on the surface is a function of molecular structure and crystallographic face. Finally quantum dot (QD) sensitization of TiO_2 crystals, which could eventually lead to sensitizers with higher stability and absorption coefficients, will be discussed as well as our recent demonstration of multiple exciton generation and collection with PbS QDs.