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Quantum Dot Solar Cells. Understanding Charge Transfer at Nanostructure Interface¹

PRASHANT KAMAT, University of Notre Dame

Quantum dot solar cells are designed using a chemical approach. Different size CdSe quantum dots are assembled on mesoscopic TiO₂ films either by direct adsorption or with the aid of molecular linkers. Upon bandgap excitation, CdSe quantum dots inject electrons into TiO₂ nanoparticles and nanotubes, thus enabling the generation of photocurrent in a photoelectrochemical solar cell. The interfacial processes that dictate the photoelectrochemical performance of these solar cells have now been evaluated by comparing photoelectrochemical behavior with charge transfer dynamics between different size CdSe quantum dots and various oxide substrates. The primary photochemical event in these solar cells is the charge injection from excited CdSe quantum dots into nanostructured metal oxide films. This process can be modulated by varying the particle size of CdSe quantum dots or the conduction band of the acceptor oxide. The difference in the conduction band energy of two semiconductors serves as a driving force for the interparticle electron transfer. According to Marcus theory, for a non-adiabatic reaction in the activation limit, the rate of electron transfer depends on the electronic coupling between the donor and acceptor states, the density of states (DOS) per unit volume and the driving force. Because of the quasi continuum of states in the metal oxide conduction band, the total electron transfer rate depends on the sum of all possible electronic transitions. The dependence of electron transfer rate constant on the energy gap and its implication in photoconversion efficiency of quantum dot solar cells will be presented.

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