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Engineering Interfaces for Photovoltaic Energy Conversion

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Dye-sensitized solar cells (DSSCs) and the related quantum dot-sensitized solar cells (QDSSCs) show promise as inexpensive, efficient next-generation photovoltaic technologies. A typical cell design consists of a sensitizer chemisorbed to a nanoporous TiO_2 substrate; the sensitizer absorbs a photon and an excited electron is injected into the TiO_2 where it diffuses to the anode. However, many devices suffer from a high rate of electron-hole recombination at the interface between TiO_2 and the hole conductive material, leading to reduced conversion efficiency. In this work we explore whether a passivating layer at the interface can improve efficiency by acting as a barrier against electron recombination. We have studied both organic and inorganic approaches to modifying the interfacial properties in DSSC and QDSSC devices. In studies of CdS-based QDSSCs, a series of organic self-assembled monolayers were formed at the interface, and their effect on CdS uptake and resulting optoelectronic and device properties was investigated. In DSSCs, nanoscale inorganic dielectric films of different thicknesses were applied to the interface using atomic layer deposition prior to dye absorption. The effect on device performance was measured experimentally and compared with predictions from kinetic models. The results of these investigations will be discussed in the context of the ability of interface engineering to improve photovoltaic energy conversion.