The effect of a blocking layer on the photovoltaic performance in CdS quantum-dot-sensitized solar cells

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Abstract
In order to reduce the surface recombination at the interface between the fluorine-doped tin oxide (FTO) substrate and the polysulfide electrolyte in CdS quantum-dot-sensitized solar cells (QDSCs), compact TiO₂ is deposited on the FTO electrode by sputtering. The TiO₂-coated CdS-sensitized solar cell exhibits enhanced power-conversion efficiency (0.52%) compared with a bare CdS-sensitized solar cell (0.23%). Charge-transfer kinetics are analyzed by impedance spectroscopy, open-circuit decay, and cyclic voltammetry. The TiO₂ layer deposited on the FTO substrate acts as a blocking layer, which plays a significant role in reducing the electron back transfer from the FTO to the polysulfide electrolyte. Interestingly, with respect to the incident photon-to-current conversion efficiency (IPCE) data, asymmetric enhancement is observed from the sample with a thicker blocking layer. This is because CdS quantum dots absorb ultraviolet light completely with the TiO₂ layer because of the high extinction coefficient of the CdS quantum dots compared with dye molecules.

Highlights
• The electron-recombination mechanisms within FTO/electrolyte interface are analyzed.
• The TiO₂-coated solar cell exhibits enhanced efficiency by more than a factor of two.
• The electron-carrier lifetime is one order of magnitude higher than bare sample.
• IPCE shows asymmetric behavior due to high extinction coefficients of quantum dots.