Highly loaded PbS/CdS quantum dots for application in solar cells and photoelectrochemical water splitting

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For the last decade, quantum dots (QDs) have attracted a great amount of attention as the next-generation solar energy conversion materials owing to their high absorption coefficient, band gap tunability, and potential multiple exciton generation. In this study, we developed nanocomposite PbS/Mn-doped CdS QDs coated on mesoporous TiO_2 electrodes with greatly improved QD loadings. The conventional successive ionic layer adsorption and reaction process used for QD coating was modified to control the surface charge of the mesoporous TiO2 electrodes, resulting in the increase of the PbS and CdS QD loadings by 44 and 18%, respectively. These photoanodes, which exhibited superior light-harvesting capability, were applied not only in QD-sensitized solar cells (QDSCs) but also for hydrogen production via photoelectrochemical water splitting. As a result of the improved QD loadings, the conversion efficiency of the QDSCs was enhanced by ~33%. Furthermore, an unprecedented photocurrent of 22.1 mA/cm2 (at 0.6 V vs. RHE) was obtained for the hydrogen production via PEC water splitting, which is the highest value ever reported in QD studies.