Efficient Hybrid Titanium Dioxide / Poly-3-Hexylthiophene Solar Cells Using an Oligothiophene Dye as an Interface Modifier

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Abstract

Hybrid metal oxide-polymer nanocomposites are promising material combination for cost efficient solar cells. However, the power conversion efficiency (PCE) of these hybrid solar cells are limited due to several reasons, including poor chemical compatibility of inorganic acceptor and organic donor. Our group recently reported that hole mobility of the polymer can be increased up to two order of magnitude when an oligothiophene dye is introduced at TiO_2 / P3HT interface modifier. This work focuses on studying the influence of dyes, including a 3-hexylthiophene derivative dye with a cyanoacrylic acid group ((E)-2-cyano-3-(3′,3′′,3′′′-trihexyl-[2,2′:5′,2′′:5′′,2′′′-quaterthiophene]-5-yl) acrylicacid) (4T), on the photovoltaic (PV) performance of TiO_2 / P3HT solar cells. The insertion of dye at the interface improves the efficiency regardless of the dye used. However, 4T dye significantly improved the efficiency by a factor of three when compared to the corresponding TiO_2/P3HT solar cells. This improvement is mainly due to increase in short circuit current density, which is consistent with higher hole mobility value of the polymer reported in TiO_2/P3HT nanocomposite with 4T dye. Optical absorption data further reveals that 4T extends spectral response of TiO_2/P3HT nanocomposite which could also enhance the short circuit current density. The reduced dark currents upon dye insertion ensure that the carrier recombination is controlled at the interface and this in turn increased the open circuit voltage. Optimised TiO_2/P3HT device with 4T dye showed average efficiency of about 2.0 % under simulated irradiation of 100 $mWcm^{-2}$ (1 sun) with AM 1.5 filter.

Keywords: Hybrid solar cells, Titanium dioxide, Poly (3-heylthiophene), oligothiophene dye, interface modifier, photovoltaic, absorption, quantum efficiency, polymers, efficiency.