Role of Ruthenium and Quarterthiophene based dyes in enhancing the performance of Hybrid Titanium dioxide / Polymer Solar Cells

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Abstract

Conjugated polymers and metal oxides are promising material combination for cost efficient solar cells. However, power conversion efficiency of these hybrid solar cells are limited due to several factors such as poor chemical compatibility of inorganic Titanium dioxide (TiO_2) with polymer, interfacial carrier recombination at the interface, limited spectral response and charge transport of polymer. Our research group has implemented several strategies to modify the metal oxide surface in order to improve electronic properties of metal oxide / polymer hybrid materials, such as use of self-assembled monolayers, carbon nanotubes, CdS quantum dots (QDs) as interface modifiers. We have also shown that a thin overlayer of alumina retards recombination kinetics in hybrid TiO_2 / Poly(3-hexylthiophene) (P3HT) solar cells and improves the overall cell performance.

This work focuses on the role of Ruthenium and Quarterthiophene based dyes in enhancing the performance of hybrid TiO_2 / P3HT solar cells. Standard [cis-Bis(isothiocyanato)(2,2'-bipyridyl-4,4'-dicarboxylato) (4,4'-di-nonyl-2'-bipyridyl)ruthenium(II)] (Z907), synthesized $Ru(bpy)_2(dcbpy)(ClO_4)_2$[(bpy)2,2'-bipyridine;dcbpy=4,4'-dicarboxy-2,2'-bipyridine] (RuC) and synthesized ((E)-2-cyano-3-(3',3'',3'''-trihexyl-[2,2':5',2'':5'',2'''- quaterthiophene]-5-yl) acrylic acid) (4T) dyes were employed as the interface modifiers at the TiO_2 / P3HT interface. Ruthenium based Z907 and RuC dyes have absorption peaks in visible and near UV regions, respectively, whereas thiophene based 4T dye has its absorption peak in the visible region with higher molar extinction coefficient compared to that of Z907 and RuC dyes. External Quantum Efficiency spectra, and J-V of solar cells made with Z907, RuC and 4T as modifier showed current densities of 3.70, 6.44 and 7.30 mA/cm^2, respectively. However, RuC based solar cells showed efficiency of 2.35 %, whereas 4T and Z907 based solar cells had efficiencies of 2.04 and 1.01 %, respectively. This is due to the fact that RuC dye plays multiple roles in the TiO_2 / P3HT solar cells, through extension of the spectral response in near UV region and reduction of interfacial recombination that was evidenced by photoluminescence quenching and low dark current.

Keywords: Hybrid solar cells, Interface modifiers, External Quantum Efficiency.

Table 1. Current density *vs.* voltage (J-V) measurement of interface modified Hybrid solar cells.

Interface modifier	J_{SC} ($mAcm^{-2}$)	V_{OC} (V)	Fill factor %	Efficiency %
Z907	3.70	0.71	38	1.01
RuC	6.44	0.65	56	2.35
4T	7.30	0.57	49	2.04

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