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ENHANCED PERFORMANCE IN HYBRID TITANIUM DIOXIDE / POLY (3-HEXYLTHIOPHENE) POLYMER SOLAR CELLS: A COMPARATIVE STUDY WITH NOVEL RU BASED DYE AS INTERFACE MODIFIER

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ABSTRACT

Nanoporous Titanium dioxide (TiO₂) combined with poly (3-hexylthiophene) polymer is a promising nanocomposite for cost efficient photovoltaic devices. However, the poor power conversion efficiency found in such devices is mainly attributed to the lower chemical compatibility between the metal oxide and polymer. As such, it causes poor polymer penetration in to highly-structured nanoporous TiO₂. More recently, we have shown that polymer penetration can be improved by coating the nanoporous TiO₂. We further showed that hole-mobility of the polymer can also be improved by modifying the nanoporous TiO₂ with dye over layer.

In this work, monolayer of commercially available and widely used ruthenium (Ru) based dye, N719, and a newly synthesized [Ru(bpy)₂(dcbpy)][PF₆]₂ (bpy = 2,2'-bipyridine; dcbpy = 4,4'-dicarboxy-2,2'-bipyridine) dye (RuC2) were introduced at the TiO₂ / P3HT interface, and their effect in photovoltaic parameters were examined.

RuC2 dye adsorption on nanoporous TiO₂ electrode is higher than other Ru based dyes studied. This is probably due to its chemical structures; the N719 dye consist NCSisothiocyanate functional group along with carboxylic acid (COOH) substituted two biphenyl rings, whereas the newly synthesized dye contains three biphenyl rings with two COOH groups, which can bind easily to TiO₂ due to less steric hindrance. Nanoporous TiO₂ films treated with these dyes showed a very weak optical absorption in the visible region in comparison with the absorption of the polymer used in this study. Quantum efficiency spectra of both control and dye coated devices show that dyes has no contribution in creating of carriers for device current, but the dye serves as interface modifier. RuC2 dye treated devices showed a 75 % of enhancement in the power conversion efficiency compared to the devices treated with the commercial (N719) dye, mainly due to increase in short circuit current density. This is attributed due to better interaction between RuC2 and TiO₂ as well as lower lying LUMO of synthesized RuC2 dye which enables an easy electron transfer cascade from P3HT to the RuC2 interface layer to TiO₂ and, thereby, potentially enhancing charge separation at the TiO₂ interface. Additionally, on account of the deep HOMO level of RuC2 relative to P3HT, the RuC2 layer is expected to obstruct hole-transfer between P3HT and TiO₂, and thus to localize hole-polarons in the P3HT away from the TiO₂ surface.

Keywords: hybrid solar cell, P3HT, Titanium dioxide, interface modifier, Ru dye