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ENHANCEMENT OF PHOTOVOLTAIC PERFORMANCE OF DYE-SENSITIZED SOLAR CELLS USING COOH FUNCTIONALIZED SINGLE-WALLED CARBON NANOTUBES IN TiO_2

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Titanium dioxide (TiO_2) is a promising wide bandgap semiconductor for dye-sensitized solar cells (DSSCs). The light-harvesting properties of the photoanode are a crucial factor that determines the overall efficiency of DSSCs. Dip-coating could be used to improve the light-harvesting properties of the photoanode by tuning the bandgap of the semiconductor. Further, carbon nanotubes (CNTs) have a high potential for finding unique applications in wide areas. This work reports the possibility of enhancing the power conversion efficiency (PCE) of DSSCs by employing COOH functionalized single-walled carbon nanotube (SWCNTs-COOH) dip-coated TiO_2 photoanodes. P25- TiO_2 films were dip-coated in SWCNTs-COOH (diameter 0.8-1.4 nm, length $\geq$ 5 μm) solution by systematically varying the SWCNTs-COOH concentration from 50 to 500 μg/ml in steps of 100 μg/ml. The SWCNTs-COOH dip-coated TiO_2 nanomaterials were characterized by X-ray diffraction (XRD) and UV-visible (UV–Vis) spectroscopy. The presence of mixed anatase and rutile phases of TiO_2 was observed with the XRD patterns of pure and SWCNTs-COOH dip-coated TiO_2 nanomaterials. The estimated bandgap values obtained from Tauc-plot using UV-Vis spectroscopy were found to be 3.20, 2.79, 2.66, 2.43, 2.35, 2.31, and 2.22 eV for the pure TiO_2, 50, 100, 200, 300, 400, and 500 μg/ml SWCNTs-COOH dip-coated TiO_2 nanomaterials, respectively. This narrowing down of bandgap can be due to the formation of a mid-band gap between valence and conduction bands of TiO_2 as a result of the introduction of SWCNTs-COOH. It was also observed that incorporating SWCNT-COOH increases the absorption of light by the TiO_2/dye electrode and, thus, enhances the short circuit current density (J_{SC}). Optimized cells with 200 μg/ml SWCNTs-COOH dip-coated TiO_2 electrodes showed efficiency (η = 6.31%), which is more than 23% of the efficiency of the control cell (η = 5.14%) due to the effect of SWCNTs-COOH under-stimulated illumination (100 mW cm-2, 1 sun) with AM 1.5 filter. These improvements were attributed to the reduced bandgap energy and the reduced charge recombination by dip-coating of SWCNTs-COOH on TiO_2.

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Keywords: Dye-sensitized solar cells, Dip-coated, Enhancement, P25-TiO_2, SWCNTs-COOH