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Enhancement of the Photocurrent in Dye-Sensitized Solar Cells by the Incorporation of MWCNT

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Abstract – The effect of the incorporation of acid-treated multi-wall carbon nanotubes (MWCNT) in TiO_2 films on photocurrent-voltage characteristics of dye-sensitized solar cells (DSSC) was studied. Compared with the pristine electrode, the modified cell containing TiO_2/MWCNT films showed an 85 % increase in short-circuit photocurrent (J_{sc}). The enhanced in J_{sc} is attributed to the improvement in the electronic transport due to the presence of a MWCNT network.

Dye-sensitized solar cells (DSSC), known also as Graetzel´s cell, have been developed over the past decade as one of the candidate towards cheap solar energy conversion [1]. Photo-generated charge recombination must be prevented in order to increase device's efficiency. Strategies include fast electron transfer through film electrodes and the blockage of interface states lying below the edge of conduction band. Interface states may facilitate recombination of the injected electrons with I_3^- ions [2]. In this work, the effect of incorporating multi wall carbon nanotubes (MWCNT) in TiO_2 (Degussa) films on the photocurrent-voltage (*J-V*) behavior is reported. The carbon derivative was intentionally added to improve the electronic transport.

The mesoporous layer of TiO_2 was prepared by grinding TiO_2 powder (P25 Degusa), polyethylene glycol (PEG 20000) and different amount of previously acid-treated MWCNT in distilled H_2O and acetylacetone. Several drops of this suspension were spread onto the electrode (FTO, $R_s \leq 10\ \Omega$) surface using a glass rod. The electrode was dried in air and heated at 430 °C for 30 min. The TiO_2/MWCNT films were characterized by SEM, XRD, Raman and AFM. The counter-electrodes were prepared by sputtering thin Pt films (400 Å) onto an ITO substrate. The gel electrolyte used was prepared as describe in a previous work [3]. The working electrodes, at ~70 °C were immersed in 1.5×10^{-3} mol L^{-1} ethanolic solution of the sensitizer Ruthenium N719 (Solaronix), for 18 h at room temperature. The gel polymer electrolyte was deposited onto the porous nanostructured electrodes by casting at ~ 60 °C. The DSSC were finally assembled by pressing the Pt counter-electrode against the sensitized porous electrode coated with the gel polymer electrolyte. A thin PVC (polyvinyl chloride) film was used as the spacer. The *J-V* curves were measured using the Eco Chimie-Autolab PGSTAT 10 potentiostat. The *J-V* data were measured under standard AM 1.5 conditions (1 sun, 100 mW cm^{-2}).

Figure 1 shows the *J-V* characteristics of the DSSC assembled with pristine TiO_2 and TiO_2-MWCNT films and Table 1 displays the electrical parameters. The short circuit photocurrent density (J_{sc}) is found to increase from 10.9 to 20.2 mA/cm^2 after addition of 0.05 wt% of MWCNT. The open circuit potential (V_{oc}) values remained constant.

The enhancement observed in the J_{sc} values is an indicative that the electronic transport through the TiO_2 film was affected positively by the MWCNT network. We believe that these carbon materials act as bridges or shortcuts, allowing the electrons to reach the contact faster than if no nanotubes were presented.

Table 1: Photocurrent J-V parameters for MWCNT incorporated TiO_2 electrodes in DSSCs.

Composition of TiO_2-MWCNT	V_{oc} / V	J_{sc} / mA/cm^2	*FF*	% Efficiency
0 wt.%	0,73	10,9	0,55	4,43
0.02 wt.%	0,70	18,2	0,45	5,74
0.03 wt.%	0,71	18,3	0,46	6,07
0.05 wt.%	0,74	20,2	0,49	7,31
0.07 wt.%	0,62	17,8	0,35	3,82

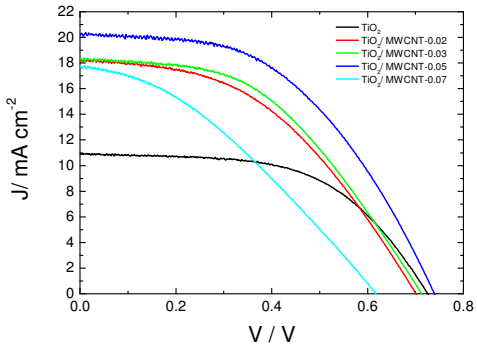

Figure 1: J-V characteristics of solar cells using TiO_2 and TiO_2-MWCNT.

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