

DIFFERENT SURFACE TREATMENTS OF HYDROTHERMALLY SYNTHESIZED TITANIA NANOTUBES FOR THE IMPROVEMENT OF THE DYE-SENSITIZED SOLAR CELLS

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Dye-sensitized Solar Cells (DSCs) are considered as a promising alternative system for conventional silicon based solar cells with economically viable cost. One of the major factors limiting the power conversion efficiency (η) of the DSC is the charge carrier recombination which is mainly due to the random orientation of the nanocrystalline TiO_2 particles. Therefore, the main objective of this study is to introduce one-dimensional TiO_2 nanotubes as the electron transport medium in the fabrication of DSCs to reduce the charge carrier recombination. For this purpose, TiO_2 nanotubes with diameter of ~ 10 nm and length of ~ 250 nm were successfully synthesized *via* hydrothermal treatment of TiO_2 nanoparticles and different surface treatment methods were investigated for the improvement of the DSCs.

DSCs fabricated using hydrothermally synthesized TiO_2 nanotubes treated with 0.5 M TiCl_4 and sensitized with N719 dye showed the η of 7.6 % at AM 1.5 G illumination with iodide/tri-iodide electrolyte. In this work, the effect of different TiCl_4 concentration treatment on both TiO_2 nanotubes and TiO_2 nanoparticles were investigated. The effect of TiCl_4 treatment is more significant for TiO_2 nanotubes than TiO_2 nanoparticles and the TiCl_4 surface treatment step is crucial for the enhancement of the solar cell performance. The electron transport resistance, electron life-time and charge recombination properties of bare and TiCl_4 treated TiO_2 nanotubes were investigated by electrochemical impedance method (EIS).

Further surface treatment of the TiO_2 nanotubes was done with the MgO coating. The DSCs fabricated using TiO_2 nanotube electrode treated with 0.02 M Mg^{2+} solution showed the highest η of 8.9 % while the bare electrode showed the η of 5.4 %. Drop and Immerse treatment methods were investigated to optimise the MgO coating on TiO_2 nanotubes. Drop method showed the better passivation on TiO_2 -nanotubes to suppress the charge carrier recombination than the immerse method.

Finally, a composite electrode consists of both TiO_2 nanotubes and nanoparticle films were fabricated on a conductive glass substrate using electrophoretic deposition and doctor-blade methods respectively. DSC fabricated using the composite photoelectrode showed the η of 9.2 %. The efficiency enhancement was mainly due to the enhancement of charge collection efficiency and better light scattering effects which were confirmed by charge transport parameters measured by EIS and the diffuse reflectance spectra. EIS analyses also revealed that the composite incur smaller charge transport resistances when compared with those in the TiO_2 nanotubes and TiO_2 nanoparticle films.