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Influence of Atmospheric Plasma Jet Pre-Treatments of TiO₂ Electrodes on Dye Adhesion and DSSC Cell performance

Stephen Sheehan¹, Mahfujur Rahman², Denis Dowling²

¹University College Dublin, Dublin 4, Ireland ²University College Dublin, Dublin, Ireland

sheehan.ucd@gmail.com

There is increasing interest in dye-sensitized solar cells (DSSCs) due to their relatively low cost and ease of manufacture. Enhancing the solar to electrical energy conversion efficiency of DSSC's depends on a number of factors, one of which is the level of dye adsorption. The dye absorbs light where it can excite electrons that then flow into the nano-porous metal oxide electrode layer. The focus of this study is to evaluate if atmospheric plasma pre-treatment of the titanium dioxide (TiO₂) electrode surface can enhance the level of dye adsorption. The investigation was carried out using an air plasma jet system called PlasmaTreat™. This was used to activate a TiO₂ layer deposited onto a conducting (FTO) glass substrate. This layer was deposited by applying nanoparticles of the oxide which had been sintered onto FTO coated glass in a furnace at 500°C. This study investigate a number of treatment parameters such as jet orifice to substrate distance (5-20 mm), speed of the CNC onto which the jet is mounted (50 to 250 mm/sec) and plasma power (20-100%). The morphological and crystallographic properties of the sintered TiO₂ layer both before and after plasma treatment were investigated using SEM, optical profilometry and X-ray diffraction techniques. The dye adsorption was carried out using a ruthenium based dye (N719) dissolved in ethanol. The level of dye adsorption on the treated and non-treated TiO₂ coatings was assessed using UV-Vis spectroscopy. This analysis was performed by desorbing the dye from a fixed area of TiO₂ coated glass in a buffer alkaline solution. Based on the intensity of the UV-Vis absorption spectra measurements it was concluded that the pre-treatment of the TiO₂ using the air plasma resulted in an increase in the level of dye adsorption. This was reflected in the power density obtained by I-V measurement. This study demonstrated an increase of 10% in power density obtained by the plasma pre-treated samples compared to the non-pretreated samples. A possible explanation for the enhanced level of dye adsorption after plasma activation is the removal of aqueous and organic contaminants from the TiO₂ surface.

Keywords

Atmospheric Plasma

Dye-sensitized solar cells