INCOOPERATION OF TRIPLE LAYERED STRUCTURE OF TIN OXIDE PHOTOANODE TOWARDS THE EFFICIENCY ENHANCEMENT IN DYE SENSITIZED SOLAR CELLS.

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ABSTRACT

Dye sensitized solar cells (DSSCs) are considered as most promising alternatives for the conventional solar cells. DSSCs are relatively low cost and easy to fabricate compared to the silicon solar cells. These devices are composed of a nano crystalline semiconducting layer, a dye which act as the photosensitizer, a redox electrolyte and a counter electrode. When it exposes to sunlight, initially photo excitation occurs on the dye molecules attached to the semiconductor like TiO_2 and it injects electrons into the conduction band of the semiconducting layer. These electrons travel through the photo anode and go around the external circuit and reach the counter electrode of the device. Redox electrolyte in the device capture these incoming electrons from the external circuits and then transfer them to the oxidized dye molecules to regenerate the dye cations. Therefore, the roll of the photo anode is one of the crucial factors which determine the efficiency of these devices.

Typically, DSSCs with high efficiencies consist of TiO_2 as the phot anode. However, materials like SnO_2, ZnO can also be used as the photo anode due to their various promising properties such as higher electron mobility, large band gap (3.6 eV), high electron mobility ($100 - 200\ cm^2\ V^{-1}\ S^{-1}$), and low conduction band effective mass. However, efficiencies of DSSCs based on SnO_2 are very poor and not sufficient work has been carried out compared to the case of TiO_2 to employ it as the photo anode in DSSCs. Therefore, in this study we have explored the possibility of incorporation of triple structured SnO_2 layers in photo anode of DSSCs towards the efficiency enhancement. Instead of a conventional nanoparticle single layer of SnO_2, here we have introduced a nano fibre layer of SnO_2 in between two conventional nanoparticle SnO_2 layers. nano fibre layer of SnO_2 was prepared by electrospinnig techniques and adjacent layers were fabricated by spray techniques. In order to see the effect of incorporation of triple layer structure, the anionic dye, Rose Bengal was used as the sensitizer and potassium iodide (KI) in acetonitrile was used as the electrolytic medium. According to the preliminary studies, DSSCs prepared with the conventional type of SnO_2 electrodes showed 0.79% efficiency under the irradiance of 1000 W m^{-2}. The short circuit current density (J_{sc}), open circuit voltage (V_{OC}) and the Filling Factor (FF) are 5.13 mA cm^{-2}, 319 mV and 48% respectively. The DSSC with nano fibre layer of SnO_2 having the same thickness as in the conventional type photo anode, showed 1.10% efficiency under the same illumination conditions. Corresponding values for J_{sc}, V_{OC} and the FFS were 5.94 mA cm^{-2}, 359 mV and 52% respectively. Therefore, more than 55% enhancement in the overall efficiency can be achieved by incorporating this tri layered structure of SnO_2 as the photo anode. One of the reasons is the improved light scattering within the device due to the incorporation of nano fibre layer in the photo anode as evident from the UV-visible absorption spectroscopy.

Keywords: Dye sensitized solar cells, SnO_2, Rose Bengal.

STUDY OF DYE-SENSITIZED SOLAR CELLS WITH TIO_2 NANOPARTICLES/NANOFIBERS COMPOSITE ELECTRODE USING PHOTOVOLTIC AND EIS MEASUREMENTS

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ABSTRACT

Increment of the efficiency of dye-sensitized solar cells (DSSC) by an innovative type of photoanode consisting of a composite mixture of conventional P-25 titanium dioxide (P25-TiO_2) nanoparticles and electrospun TiO_2 nanofibers (EL TiO2 NF) with optimized weight ratio is obtained. This novel composite photoanode harvests sunlight more strongly compared to a DSSC made with conventional photoanode which consists only P25-TiO_2. Thus the efficiency of DSSCs made with this novel composite photoanode is significantly higher than the DSSC made with conventional P25-TiO_2 photo anode. The TiO_2 nanofibers were prepared by the electrospinning technique and the composite photoanode was prepared by using 0%,1%,2%,5%,10%,15%,20% and 25% weight ratios of TiO_2 nanofibers in the TiO_2 nanofiber: nanoparticle mixture. These cells were characterized by UV-Vis spectroscopy, J-V characteristics, EIS analysis and dark I-V measurements.

While the overall efficiency of the DSSC comprising with novel photoanode with nanofibres showed 7.01% under the illumination of 1000 W m^{-2}, the DSSCs with conventional P-25-TiO_2 photoanodes showed 5.11% under the same conditions. Therefore , 37.18% enhancement in the overall efficiency is achieved by employing this novel photoanode in the DSSCs. The high efficiency of the solar cell appears to be due to the increased short-circuit photocurrent density by enhanced light harvesting caused by the increased light absorption due to scattering within the composite TiO_2 Nano-structure with nanofibres.

Keywords : Dye-sensitized solar cells, performance, nanoparticles, nanofibers, electrospinning, UV-VIS spectroscopy, photocurrent, light harvesting, electrolyte.

1. INTRODUCTION

The solar cell which converts sunlight into directly into electricity is a rapidly growing energy technology which is gaining great popularity because of the low cost in fabrication and minimized transition losses by fixing them near the end user. In terms of higher efficiency and easy fabrication, the dye-sensitized solar cell (DSSC) is one of the most promising replacement to the currently available high cost silicon solar cells. The third generation, low manufacturing cost and simple structure Dye-sensitized solar cells have been widely investigated by B. O'Regan and M. Gratzel in 1991 [1-10]. This simple structure and low cost technology have further stimulated great research interest to improve the efficiency of dye-sensitized solar cells [11].

Typical lab scale DSSC consists of a transparent mesoporous semiconducting photoanode usually TiO_2, made up on a glass substrate coated with a thin film of Fluorine doped SnO_2 layer, a charge transfer dye covalently bonded to the surface of the oxide layer to enhance light harvesting, an electrolyte containing redox mediator (I^-/I_3^-) in a solvent effecting dye-regenerating and a cathode made of a plate coated with a catalyst (typically, platinum) to enable electron circulation