

Convenient method to seal dye-sensitized solar cells

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Solar energy, the most promising source of renewable energy that is readily available can be used to produce electricity with many different photovoltaic technologies. Dye-sensitized Solar Cell (DSC) is one such technology that facilitates the fabrication of cost-effective and environmentally friendly devices. DSC consists of a working electrode comprising of an interconnected nanoparticulate mesoporous semiconductor material (typically TiO₂) on to which a sensitizer has been adsorbed, a platinum-based counter electrode and an electrolyte containing a redox couple. DSCs can be classified based on the physical state of the electrolyte, depending on which the liquid state, solid state, quasi-solid state, gel-polymer DSCs are termed. Even though the liquid state DSCs have reached a certified maximum energy conversion efficiency of 11.9%, long term stability of these devices is limited, mainly due to the volatility and the leachability of the liquid electrolyte. In order to overcome these problems, solid states DSCs have been developed as an alternative. However, the maximum efficiency of the solid state DSCs is limited to 5% due to the poor contacts at the interfaces of the different layers.

The objective of this study is to develop DSCs with a minimum volume of the liquid electrolyte just enough to fill the pores of the mesoporous semiconductor particle matrix, and to seal the liquid using a graphene film that is deposited on the top surfaces of the particles. In order to achieve this, the working electrode is fabricated by following the usual procedure and then, a few microliters of I⁻/I₃⁻ based electrolyte are added to the working electrode. It is then allowed to penetrate through the mesoporous TiO₂ layer. The excess electrolyte is then wiped off and graphene is deposited on top of the working electrode to cover the liquid electrolyte and thereby to minimize the solvent evaporation. This also helps the sealing of the cell which otherwise challenging with liquid electrolytes. The fabrication of the device is then completed by the addition of a platinized fluorine doped tin oxide (FTO-Pt) counter electrode. These devices are then characterized by obtaining current-voltage (*J-V*) curves. Parameters such as the thickness of the dense TiO₂ layer, thickness of the mesoporous TiO₂ layer and the time allowed for I⁻/I₃⁻ based electrolyte to penetrate through the anode were completely optimized.

Finally, a maximum photoelectric conversion efficiency of 5.20% was achieved with an open circuit voltage of 700 mV, a short circuit current density of 10.1 mA cm⁻², and a fill factor of 0.74 under simulated one sun irradiation (AM 1.5 irradiation with 100 mWcm⁻² intensity).