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Fabrication of graphite/tin oxide/polyaniline composite counter electrode for application in dye-sensitized solar cells

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Dye-sensitized solar cells (DSSCs) have attracted significant attention as an alternative to fossil energy due to its low cost and simple fabrication process and environmental friendliness. Generally, the counter electrodes (CE) of DSSCs are fabricated from platinum (Pt). However, the usage of Pt leads to high production cost of DSSCs. Therefore, many research studies are being conducted to replacing the Pt based CEs by using other low-cost materials. Carbon-based materials and conducting polymers have attracted more recent attention by researchers due to their relatively low-cost, high chemical stability and high catalytic behaviour. The use of a carbon-based material or a conducting polymer alone has always associated with some drawbacks such as low adhesion to the conducting glass substrate, poor redox performance, and low electrical conductivity of the material. However, by using a composite of these materials, electrical conductivity and electro catalytic activity of the resulting material can be significantly enhanced. In this study, a composite CE consisting of Sri Lankan natural graphite, tin oxide nanoparticles (SnO_2) and polyaniline (PANI) conducting polymer, is prepared by spray technique. Sri Lankan natural graphite has a good demand due to its high purity and high crystallinity required for many hi-tech applications. To improve the adhesion of graphite on conducting glass substrate, SnO_2 nanoparticles were mixed with graphite and to improve the electro-catalytic activity of the CE, different amounts of PANI conducting polymer is introduced to the graphite/SnO_2 composite. To fabricate the DSSC, titanium (IV) chloride treated titanium dioxide (TiO_2) based photoanode and an iodide based liquid electrolyte was used. Prepared CEs are characterized by X-ray diffraction, Raman spectra and scanning electron microscope (SEM) and the excellent catalytic activity of the composite CE is obtained from cyclic voltammetry (CV) analysis. The photovoltaic performance of DSSCs based on this novel CE is found to be significantly influenced by the added SnO_2 and PANI. The power conversion efficiency of DSSCs improved from 4.38 % for the pristine graphite-based CE to 5.58 % by introducing SnO_2 nanoparticles. At the optimum compistion of the graphite/SnO_2/PANI composite CE, the power conversion efficiency of 6.97 % is achieved. This composite counter electrode based DSSCs showed good stability and a satisfactory performance compared to Pt CE based DSSC of efficiency 9.02 % under similar conditions.