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A simple solvothermal approach to synthesize Zn-doped TiO_2 nanomaterials for dye sensitized solar cells

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Dye sensitized solar cells (DSSC) are considered one of the most promising organic solar cells. It is found as an alternative to traditional silicon based solar cells due to low-cost, ease of fabrication, ability to work under low light conditions and environmentally friendly nature. In DSSCs, titanium dioxide (TiO_2) is commonly used as a promising wide bandgap semiconductor photoanode and the light harvesting properties of the photoanode is a crucial factor that determines the overall efficiency of DSSCs. Doping could be used to improve the light harvesting properties of the photoanode by tuning the bandgap of the semiconductor. TiO_2 photoanodes doped with elements such as alkali-earth metals, transition metals, rare-earth elements and non-metals are found to improve the power conversion efficiency (PCE) of DSSCs. Among these elements, transition metal doped TiO_2 photoanodes perform efficiently by suppressing the relaxation and recombination of charge carriers and improving the absorption of light in the visible region. This work reports the possibility of enhancing the PCE of DSSCs by employing Zn-doped TiO_2 photoanodes since Zn is one of the promising n-type transition metals and Zn-doped TiO_2 improves the photocurrent in DSSCs. Zn-doped TiO_2 nanomaterials were synthesized, using varied amounts of Zn precursors, by a facile solvothermal method using a reaction bottle instead of an autoclave and characterized by X-ray diffraction and UV-Visible spectroscopy. The X-ray diffraction studies confirmed the presence of anatase phase of TiO_2 in the synthesized nanomaterials is unaffected by Zn-doping. The UV-Visible spectra of Zn-doped TiO_2 showed a red shift which could be attributed to the reduced bandgap resulted by Zn doping. Subsequently, the DSSCs were fabricated by doctor-blade method with an effective area of 0.25 cm^2 utilizing N719 dye, I^-/ I_3^- redox couple and Pt electrode as the sensitizer, electrolyte and counter electrode respectively. Then, performances of the fabricated devices were investigated. Significant enhancement in PCE was observed with 1.0 mol% Zn-doped TiO_2 based DSSC tested under simulated irradiation of intensity 100 mW/cm^2 with AM 1.5 filter, which was 35 % greater than that of the control device fabricated with un-doped TiO_2 photoanode. These improvements are attributed to the reduced band gap energy and the enhanced photocurrent due to Zn doping on TiO_2.

Keywords: DSSCs, Doped TiO_2, Solvothermal method, Zinc, PCE

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