Enhancing the Performance of Dye Sensitized Solar Cells Using Ru-Doped TiO_2 Electrode

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Abstract

During the past few decades, the dye sensitized solar cells (DSSCs) have intensively been focused as an alternative energy source due to their low cost, easy fabrication and environment friendly operation. However, relaxation and recombination processes connected to the charge carriers hinder the performance of DSSCs. One of the alternatives extensively studied to improve the mobility of charge carriers in DSSCs is the use of doped TiO_2 electrode. In this study, Ruthenium (Ru) was selected as the dopant as Ru-based dyes have been reported to give better photovoltaic performance. TiO_2 was doped with $RuCl_3$ and the performance of the DSSC using Ru- doped TiO_2 electrode was investigated systematically varying the Ru content (0.002 to 0.04 wt%). The synthesised Ru-doped TiO_2 nanomaterials were characterised by X-ray diffraction (XRD), UV–Visible spectroscopy (UV–Vis), Fourier-transform infrared spectroscopy (FTIR) and Scanning electron microscopy (SEM) techniques. The XRD pattern confirms the presence of mixed anatase and rutile phases of TiO_2; the optical absorption spectra of undoped and Ru doped TiO_2 revealed red shift in the absorption peak with Ru doping. The undoped and Ru-doped TiO_2 thin films were separately deposited on dense TiO_2 coated FTO using doctor-blading method and subsequently liquid state DSSCs were fabricated with commercially available N719 dye, I^-/I_3^- electrolyte and FTO/Pt electrodes and photovoltaic performance of the devices were studied using Keithley-2420 source meter under simulated irradiation of intensity 100 $mWcm^{-2}$ with AM 1.5 filter. The 0.004 wt% Ru-doped TiO_2 electrode showed the best power conversion efficiency (PCE) of 7.34% with a 25% enhancement in the PCE relative to undoped TiO_2 based DSSC (PCE= 5.88%) mainly due to the increment of short circuit current density.