



Contents lists available at ScienceDirect

Chemical Physics Impact

journal homepage: www.sciencedirect.com/journal/chemical-physics-impact

Full Length Article

Enhanced solar energy harvest in dye-sensitized solar cells using silver-doped TiO₂ Photoelectrodes via Spray Pyrolysis

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ARTICLE INFO

Keywords:

DSSC

Spray pyrolysis

Ag-doped tio2

Hydrothermal synthesis

TTIP

PCE

ABSTRACT

This study focuses on doping TiO₂ with trace amounts of Ag⁺ ions, employing spray pyrolysis to prepare the Ag-doped TiO₂ photoelectrode for application in Dye-Sensitized Solar Cells (DSSCs). In this regard, Ag-doped TiO₂ nanomaterials were initially synthesized from Titanium(IV) isopropoxide (TTIP) with varying concentrations of Silver nitrate (AgNO₃). The structural and optical characterizations of the synthesized nanomaterials confirmed the presence of TiO₂ in pure anatase phase and enhanced light absorption, respectively. The morphological characterization of Ag-doped TiO₂ nanomaterials revealed spherical shaped particles. Subsequently, the DSSCs were fabricated using Ruthenium-based N719 dye and imidazolium iodide/ triiodide redox couple as the sensitizer and electrolyte, respectively. Photovoltaic performances were evaluated under simulated solar irradiation (100 mW cm⁻², 1 sun, AM 1.5). The optimized device with 3 mmol % Ag-doped TiO₂ photoelectrode exhibited PCE (η) of 8.32 %, which was about 13 % greater than the device with un-doped TiO₂ (η = 7.35 %). The observed upsurge in PCE is due to the 10 % increase in short-circuit current density (*J*_{SC}) value resulting from enhancement in visible light absorption which was confirmed by UV-Visible spectroscopic analysis. Moreover, an improved electron transport in the Ag-doped TiO₂ based device was confirmed by electrochemical impedance spectroscopic study which is ascribed to the significant reduction in charge recombination. These findings demonstrate the potential of Ag-doped TiO₂ for enhanced DSSC performance, offering a viable pathway for improving solar energy conversion efficiency.