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Photocurrent improvement in grape dye sensitized solar cells by in cooperation of electrodeposited Cu particles in TiO_2 photoanode

M. D. P. A. Shakya[1*], K. M. D. C. Jayathilaka[1], W. T. M. P. K. Wanninayake[1], R. Kumara[2], W. P. Siripala[1] and R. P. Wijesundera[1]

[1]Department of Physics and Electronics, University of Kelaniya, Kelaniya, Sri Lanka
[2]Japan Synchrotron Radiation Research Institute (JASRI), Kouto 1-1-1, Hyogo 679-5198, Japan
paramiamashakya1996@gmail.com*

A worldwide effort is currently underway to address the world's energy crisis by finding sustainable energy alternatives. The Dye-Sensitized Solar Cell (DSSC) is a type of solar cell device that functions based on electrochemical principles and uses light sensitive dyes within its TiO_2 photoelectrode layer to absorb light. The DSSC, one of the potential solutions, appears to be the most viable option for a future renewable energy source due to its sustainability and environmental friendliness. In cooperation of metal particles like Au or Ag in nano scale to the photoanode is one of the promising methods to improve the efficiencies of these DSSCs. Among these metal particles Cu has some distinct properties such as abundance, low toxicity, low cost and it undergoes Localized Surface Plasmonic Resonance (LSPR) effect like Au nanoparticles. Therefore, to improve the DSSC performances, in this study, Cu particle incorporation to the TiO_2 electrode was carried out by electrochemical deposition method. Homogeneous TiO_2 paste prepared by mixing appropriate amount of TiO_2 powder (Titanium (IV) dioxide), ethanol, and acetic acid was deposited on a transparent Indium-doped Tin Oxide (ITO) conductive glass substrate by doctor blading method. Electrodeposition of Cu particles were potentiaostatically grown in the TiO_2 electrode at -700 mV vs Ag/AgCl reference electrode using a three-electrode electrochemical cell configuration with Pt as the counter electrode and 0.1 M sodium acetate and 0.01 M cupric acetate electrolyte at room temperature. Natural dye grapes have been used as sensitizer in the study. DSSCs were fabricated by sandwiching above TiO_2 films with a C coated counted electrode using KI/I_2 based electrolyte. The devices were characterized by analysing the UV – vis absorbance spectra and current density-voltage (*J-V*) curves and controlled potential coulometry measurements. The UV – vis absorbance spectrum revealed that the light absorption of DSSCs enhanced due to the incorporation Cu. The power conversion efficiency of 0.10%, photocurrent density (J_{SC}) of 501 μA/cm^2, open circuit voltage (V_{OC}) of 0.47 V, and fill factor (FF) of 42% were achieved after the Cu incorporation in the photoanode. It is found that due to the incorporation of Cu particles, a slight voltage drop was visible, but there was a significant increase in the photocurrent density (J_{SC}) from 308 μA/cm^2 to 501 μA/cm^2. The efficiency also increased from 0.07 to 0.10%. DSSC with the incorporated Cu particles showed 62% enhancement in the photocurrent compared to the DSSC without Cu particles.

Keywords: Copper, DSSC, Electrodeposition, Photocurrent