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9.4% EFFICIENCY OF A QUASI-SOLID-STATE DYE-SENSITIZED SOLAR CELL UNDER LOW LIGHT IRRADIANCE

S.M.S. Gunathilake[1*], T.M.W.J. Bandara[1, 2] and B.M.K. Pemasiri[1, 2]

[1]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka
[2]Department of Physics, University of Peradeniya, Peradeniya, Sri Lanka
[*]shiwanthakc@gmail.com

To convert highly abundant solar energy to electricity, low-cost dye-sensitized solar cells (DSCs) have attracted researchers' attention. Solar cells do not receive constant irradiance throughout the day when used in real outdoor applications. The efficiency of Si solar cells decreases with decreasing irradiance. However, very few studies have focused on studying the performance of DSCs as a function of light intensity. The present research is focused on improving gel polymer electrolyte-based DSCs and studying their performances under variable irradiance. The cells were fabricated with photoelectrodes having six spin-coated TiO_2 layers photo-sensitized by N719 dye. The counter electrode was a piece of Pt-coated glass, and the gel polymer electrolyte contained binary salts tetrahexylammonium iodide and lithium iodide. Performance enhancers, 4-tert-butyl pyridine and 1-methyl-3-propylimidazolium iodide, were added to maximize the efficiency of the cell. In addition, the cell's performance was enhanced by the infusion of graphene into the fourth layer. The fabricated DSC was irradiated using Peccell PEC-LO1 solar simulator, and the irradiation level varied from 1,000 W m^{-2} to 67 W m^{-2}, changing the distance from the solar simulator to the cell. To the best of our knowledge, this is the first study of the light intensity dependence of efficiency in graphene-incorporated DSCs. The fabricated quasi-solid-state DSC performed at an overall maximum efficiency of 6.8%, an open-circuit voltage of 770 mA, a short circuit current density of 13.4 mA cm^{-2}, and a 66.3% fill factor under 1,000 W m^{-2} irradiation. The efficiency and fill factor of the DSC increased gradually with the decreasing solar irradiance. The DSC achieved maximum efficiency and fill factor of 9.4 and 83.3%, respectively, at 67 W m^{-2} of input solar irradiance. The present study concludes that the efficiency and fill factor of graphene-added DSC increase with the decrease of solar irradiance. Lower efficiencies at higher irradiance relate to the transport limitation of the redox mediator in such cells.

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Keywords: Dye-sensitized solar cells, Gel polymer electrolyte, Graphene, Light intensity, Low light irradiation