

ENHANCING ELECTRON EXTRACTION IN DYE-SENSITISED SOLAR CELLS VIA REDUCED GRAPHENE OXIDE INTERFACIAL LAYER INTRODUCED TO SEMICONDUCTOR PHOTOELECTRODE

**T.M.P.N. Thennakoon^{1*}, R.T. Sooriyagoda¹, D.R. Jayasundara¹,
V.P.S. Perera², G.C. Wickramasinghe¹ and S. Davisan²**

¹*Department of Physics, University of Colombo, Colombo, Sri Lanka.*

²*Department of Physics, The Open University of Sri Lanka, Nugegoda, Sri Lanka.*

*pamudithanaween2020@gmail.com

Dye-sensitised solar cells (DSCs) have emerged as a promising low-cost and efficient photovoltaic device for solar energy conversion. However, the high electron recombination occurs in the semiconductor photoelectrode remains one of the major problems limiting the performance of DSCs. The objective of this study was to effectively extract electrons from the conduction band of the semiconductor to minimise recombination losses and enhance the current generation of the cell. This was achieved by introducing a reduced graphene oxide (RGO) interfacial layer between two titanium dioxide (TiO₂) layers as a sandwich-type structure (TiO₂/RGO/TiO₂) for the photoelectrode. The first TiO₂ layer was deposited by spin coating to get a uniform layer, followed by the graphene oxide (GO) layer using the same method. The final TiO₂ layer was applied via spray coating. The reduction of GO was carried out in an N₂ atmosphere. Subsequently, the concentration of RGO in the intermediate layer was optimised, identifying 5 mg mL⁻¹ as the optimal value. The optimal cell exhibited a significant increase in short-circuit current density (J_{sc}) 14.01 mA cm⁻², compared to 9.73 mA cm⁻² obtained from the conventional photoelectrode without the RGO layer. However, the open-circuit voltage (V_{oc}) decreases from 770 mV with the conventional photoelectrode (TiO₂) to 650 mV with the 5 mg mL⁻¹ concentrated photoelectrode, attributing to a down shift in the TiO₂ quasi-Fermi level due to efficient electron extraction. The equivalent circuit of electrochemical impedance spectroscopy reveals an increase in charge transfer resistance at the TiO₂/electrolyte interface from 25.3 Ω to 118.7 Ω , indicating suppressed recombination. The electron lifetime obtained from the Bode-phase plot increases, confirming improved charge carrier dynamics. The series resistance (R_s) decreases from 35.5 Ω to 24.1 Ω (electrode surface area 0.49 cm²), indicating improved electrical contact through the RGO layer. The development of the layer-by-layer structured photoelectrode has proved that the RGO conductive interfacial layer effectively balances electron extraction and recombination suppression, offering a promising strategy to overcome recombination losses and improve the performance of DSC.

Keywords: Dye-sensitised solar cells, Electrochemical impedance spectroscopy, Electron recombination, Reduced graphene oxide