RESCON 2025 PS 49

AGAR-BASED BIOPOLYMER GEL ELECTROLYTES FOR POSSIBLE APPLICATIONS IN CdS QUANTUM DOT SENSITISED SOLAR CELLS

N.T. Widanage[1]*, T.M.W.J. Bandara[1], K.B. Wijayaratne[1] and G.R.A. Kumara[2]

[1]*Department of Physics, University of Peradeniya, Peradeniya, Sri Lanka.*
[2]*National Institute of Fundamental Studies, Kandy, Sri Lanka.*
*tharudya23@gmail.com

Quantum dot-sensitised solar cells (QDSCs) with liquid electrolytes suffer from poor long-term stability and leakage issues. This study focused on developing a sustainable, agar-based biopolymer gel electrolyte (GPE) optimized for CdS QDSCs. Agar is a biodegradable polymer derived from red algae, as an eco-friendly alternative to synthetic polymer electrolytes. To synthesise the photoanode, TiO_2 nanocrystalline films were deposited on transparent fluorine-doped tin oxide (FTO) conductive substrates using a combination of spray pyrolysis and spin coating methods, followed by CdS quantum dot deposition through the successive ionic layer adsorption and reaction (SILAR) approach. Agar-based GPEs with concentrations of 0.5 mol L^{-1} and 1.0 mol L^{-1} were synthesised, and QDSCs were fabricated in glass/FTO/TiO_2/CdS/electrolyte/Pt/glass configuration. The samples were characterised using electrochemical impedance spectroscopy to measure the ionic conductivity of the GPE, and the photovoltaic performance of the solar cells were tested under standard illumination conditions, using simulated sunlight at an intensity of 1000 W m^{-2}. The ionic conductivity of the gel electrolytes was evaluated over a temperature range from 24 °C to 70 °C. The study reveals that conductivity increased with temperature following the Vogel-Tammann-Fulcher behavior. In comparison of the performance in 0.5 mol L^{-1} and 1.0 mol L^{-1} electrolytes, the 1.0 mol L^{-1} agar-based GPE recorded the highest room-temperature conductivity of 29.16 mS cm^{-1} at 24 °C Additionally, it exhibited the lowest activation energy of 0.018 eV, indicating enhanced ion mobility. However, the highest efficiency of 0.11%, a fill factor of 27%, an open-circuit voltage of 369 mV and short-circuit current of 1.12 mA cm^{-2} were exhibited for the solar cell fabricated using a 0.5 mol L^{-1} agar-based polysulfide gel polymer electrolyte with two TiO_2 layers in the photoanode. The study reveals that the number of TiO_2 layers has a significant impact on device performance, suggesting the need for future studies and highlighting the suitability of biopolymer gel electrolytes for developing sustainable QDSCs.

Keywords: Agar, Cadmium sulfide, Gel polymer electrolytes, Quantum dot, Quantum dot sensitised solar cells