Sustainable 3D Network Counter Electrodes Based on Peanut Shell–Derived rGO/NiS for Dye-Sensitized Solar Cells

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Peanut shells, an abundant byproduct of peanut processing, generate a substantial amount of agricultural waste annually. In this study, peanut shells were utilized as a sustainable carbon source for the synthesis of reduced graphene oxide (rGO-PS) via a modified Hummers method. A nickel sulfide–reduced graphene oxide (rGO-PS/NiS) composite with a three-dimensional network structure was subsequently prepared through a hydrothermal process. The rGO-PS/NiS composite was blended with PEDOT:PSS and deposited onto fluorine-doped tin oxide (FTO) glass substrates using the doctor-blade technique for application as a counter electrode (CE) in dye-sensitized solar cells (DSSCs). Structural and compositional properties were analyzed by X-ray diffraction (XRD) and Raman spectroscopy, while surface morphology was examined using scanning electron microscopy (SEM). Electrochemical characterization using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and Tafel polarization revealed reduced charge-transfer resistance and enhanced catalytic activity toward the I^-/I_3^- redox couple. The DSSC fabricated with the rGO-PS/NiS CE achieved a power conversion efficiency (PCE) of 4.67%, which is comparable to that of the conventional platinum-based counter electrode (4.95%). These results demonstrate the potential of biomass-derived rGO-based composites as cost-effective and sustainable alternatives to noble-metal counter electrodes.

Keywords: Counter electrode, Dye sensitized solar cells, Reduced graphene oxide, Nickel sulphide ,Peanut shells