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Development of Activated carbon/Graphite/Pt nanoparticle composite counter electrodes for Dye-Sensitized Solar Cells: A cost-effective alternative to Platinum

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The counter electrode (CE) is a crucial component of dye-sensitized solar cells (DSSCs), essential for enabling efficient electron transfer and ensuring the electrical continuity of the external circuit. Composite CEs have gained a significant attention in DSSC research due to their potential to replace platinum (Pt), which is costly and scarce. The development of cost-effective composite CEs with comparable or superior performance to Pt is essential for enhancing the affordability and sustainability of DSSCs. In this study, a composite CE was fabricated by incorporating activated carbon (AC), graphite (GR), and a minimal amount of Pt nanoparticles. The objective was to minimize the Pt content while maintaining the essential electrochemical properties required for efficient DSSC performances. Additionally, Sri Lankan natural vein graphite was employed to lower the material costs while simultaneously improving the electrical conductivity and enhancing the stability of the CE. The results demonstrated that the DSSCs with composite CEs composed of AC:GR:Pt and AC:GR exhibited efficiencies of 5.07% and 4.26%, respectively, under simulated sunlight at 100 mW/cm² (AM 1.5). In comparison, DSSCs employing the traditional Pt electrode achieved an efficiency of 6.41% under the same illumination conditions. The performance of the composite CE was assessed using various characterization techniques. Cyclic voltammetry and Tafel analysis confirmed favorable electrocatalytic ability, while Raman spectroscopy, scanning electron microscopy(SEM) and X-ray diffraction(XRD) provided insights into the morphology and structural composition of the composite material. Electrical Impedance Spectroscopy (EIS) results indicated efficient charge transport, thereby confirming the viability of the composite CE to be used in DSSCs. Furthermore, incident photon to current conversion efficiency (IPCE) and current-voltage (*I-V*) measurements confirmed the satisfactory performance of the composite CE.

Keywords: Composite counter electrode, Dye-sensitized solar cells, Sri Lankan vein graphite