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Development of Pt free counter electrode for dye sensitized solar cells using composite of graphite, graphene quantum dots and MnO_2

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Dye-sensitized solar cells (DSSCs) represent a low-cost, flexible, and environmentally friendly alternative to conventional silicon-based solar cells. In light of the growing global energy demand and the depletion of fossil fuel resources, DSSCs have emerged as a promising technology for sustainable and renewable energy generation. Platinum-coated counter electrodes (CEs) are typically used in DSSCs due to their excellent catalytic activity, which contributes to high power conversion efficiencies. However, the high cost of platinum substantially increases the overall cost of the device, highlighting the need for affordable alternative materials to enable large-scale commercialization. This study focuses on optimizing CEs using composites based on carbonaceous materials to enhance the performance of DSSCs. The counter electrodes were fabricated using a combination of Sri Lankan vein graphite, manganese dioxide (MnO_2), and graphene quantum dots (GQDs). A series of DSSCs were constructed and tested with CEs containing different weight ratios of graphite to GQDs. The CE incorporating graphite and 0.1 mM GQD showed the best performance. Based on this optimized condition, MnO_2 was introduced into the composite, and the graphite-to-MnO_2 weight ratio was systematically varied. Among the fabricated devices, the DSSC employing a CE with an 8:2 graphite-to-MnO_2 weight ratio demonstrated the highest power conversion efficiency of 2.78% under standard illumination conditions (100 mW cm^{-2}, AM 1.5). This enhancement is attributed to the optimal synergy between the high electrical conductivity of the graphite/GQD matrix and the strong electrocatalytic activity of MnO_2. This combination facilitates efficient electron transport and effective reduction of triiodide (I_3^-) at the counter electrode, thereby significantly improving the overall device performance**.** Future studies will investigate the durability and large-scale fabrication potential of the graphite/ GQD/ MnO_2 electrode for practical solar energy applications

Keywords: *Carbonaceous materials, composites, electrocatalytic activity, power conversion efficiency, sustainable energy*