Green Synthesis of MnO_2 Via Plant Extract Composite with rGO for High Performance Towards Supercapacitor Applications

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Abstract:

Manganese dioxide (MnO_2) nanoparticles are attractive electrode materials for supercapacitor applications because of their high pseudocapacitance, low cost, and environmental friendliness. In this study, MnO_2 nanoparticles were synthesized using a green and sustainable approach with *Amaranthus blitum* plant extract as a natural reducing and stabilizing agent, while potassium permanganate ($KMnO_4$) served as the precursor. This eco-friendly method avoids toxic chemicals and enables cost-effective nanoparticle synthesis. To improve electrical conductivity and electrochemical performance, MnO_2/reduced graphene oxide (rGO) composites were prepared by physical mixing and calcined at different temperatures (300–600 °C). The influence of temperature on structural and electrochemical properties was systematically investigated. X-ray diffraction (XRD) confirmed the formation of crystalline MnO_2, and scanning electron microscopy (SEM) revealed uniform dispersion of MnO_2 nanoparticles on rGO sheets, promoting efficient charge transport. Brunauer–Emmett–Teller (BET) and Barrett–Joyner–Halenda (BJH) analyses demonstrated a mesoporous structure with enhanced surface area, providing abundant electroactive sites for charge storage. The electrochemical performance was evaluated using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge–discharge (GCD) measurements. Among all samples, the MnO_2/rGO composite calcined at 500 °C exhibited the best performance, delivering a specific capacitance of 0.943 F g^{-1} at 0.1 A g^{-1} along with excellent cyclic stability and low charge-transfer resistance. The improved capacitive behavior arises from the synergistic interaction between pseudocapacitive MnO_2 and the highly conductive rGO network. Overall, the green-synthesized MnO_2/rGO composite shows strong potential as a sustainable electrode material for advanced supercapacitor applications.

References

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Figure

Figure 1: Insert caption to place caption below figure (Century Gothic 10)