IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, January 2026
Impact Factor: 8.2

Experimental Investigation and Performance Optimization of Mesoporous Graphene Electrodes for High-Performance Supercapacitor Applications

[1]Neha Rani and [2]Dr. Jayati Chatterjee Mitra
[1]Research Scholar, Department of Chemistry
[2]Professor, Department of Chemistry
[12]Dr. C V Raman University, Kota, Bilaspur

Abstract: *The increasing demand for high-performance energy storage systems has accelerated the development of advanced electrode materials for supercapacitor applications. Among various carbon-based materials, mesoporous graphene has emerged as a promising electrode due to its excellent electrical conductivity, high specific surface area, interconnected porous structure, and superior electrochemical stability. However, optimizing the structural characteristics of mesoporous graphene to achieve enhanced electrochemical performance remains a significant research challenge. This study presents an experimental investigation and performance optimization of mesoporous graphene electrodes for high-performance supercapacitor applications.*

Mesoporous graphene electrodes were synthesized using optimized fabrication techniques to obtain controlled pore architecture and improved electrical conductivity. The synthesized materials were characterized using Raman spectroscopy, Brunauer–Emmett–Teller (BET) surface area analysis, scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and electrochemical impedance spectroscopy (EIS) to evaluate their structural and physicochemical properties. Electrochemical performance was investigated through cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance measurements in different electrolyte systems. The influence of pore structure, surface area, electrical conductivity, and electrolyte composition on capacitance, energy density, power density, and cycling stability was systematically analyzed to identify the optimum electrode configuration.

The experimental results demonstrate that the optimized mesoporous graphene electrodes exhibit excellent electrochemical characteristics, including high specific capacitance, rapid charge–discharge capability, low internal resistance, and outstanding cycling durability. Enhanced pore connectivity and balanced mesoporous architecture significantly improve ion diffusion and charge transfer, resulting in superior energy storage performance. Furthermore, the optimized electrodes maintain high capacitance retention after prolonged charge–discharge cycles, confirming their long-term operational stability.

The findings of this study establish mesoporous graphene as an efficient and reliable electrode material for next-generation supercapacitors. The proposed optimization strategy provides valuable design guidelines for developing high-performance, durable, and scalable energy storage devices, contributing to the advancement of sustainable electrochemical energy storage technologies.

Keywords: Mesoporous graphene, Supercapacitors, Electrochemical double-layer capacitors (EDLCs), Graphene electrodes, Experimental investigation, Performance optimization,

DOI: 10.48175/568

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, January 2026
Impact Factor: 8.2

Electrochemical energy storage, Specific capacitance, Energy density, Power density, Pore engineering, Cyclic voltammetry, Galvanostatic charge–discharge, Electrochemical impedance spectroscopy, Nanostructured carbon materials, Sustainable energy storage..