

# Development of Low-Cost Substrate-Free Electrodes for Hybrid Supercapacitor Device Fabrication Employing Metal Oxides-Doped r-GO Films

## 1. Introduction

With increasing global energy demands, energy storage technologies like supercapacitors are gaining significant attention due to their high power density, fast charge/discharge rates, and long cycle life. However, traditional supercapacitor electrodes are often fabricated on expensive or rigid substrates, which increase cost and limit flexibility. Developing substrate-free electrodes using metal oxides-doped reduced graphene oxide (r-GO) presents a promising low-cost and flexible solution for hybrid supercapacitors.

## 2. Objectives

- ✓ To synthesize metal oxide-doped r-GO films using cost-effective methods.
- ✓ To fabricate substrate-free electrodes for hybrid supercapacitor devices.
- ✓ To evaluate the electrochemical performance (e.g., specific capacitance, energy/power density, and cycle stability).
- ✓ To demonstrate scalability and cost-effectiveness for practical applications.

## 3. Methodology

### a. Synthesis of r-GO

- Prepare GO using the modified Hummers' method.
- Reduce GO using chemical or thermal reduction.

### b. Doping with Metal Oxides

- Incorporate metal oxides (e.g.,  $\text{MnO}_2$ ,  $\text{NiO}$ ,  $\text{Co}_3\text{O}_4$ ) into the r-GO matrix via sol-gel, hydrothermal, or electrodeposition techniques.

### c. Fabrication of Substrate-Free Electrodes

- Form freestanding r-GO/metal oxide films using vacuum filtration or casting techniques.
- Peel off the films to obtain flexible, conductive, substrate-free electrodes.

### d. Device Assembly and Characterization

- Assemble a hybrid supercapacitor device (asymmetric or symmetric).

### Characterize via:

- ✚ Cyclic voltammetry (CV)
- ✚ Galvanostatic charge–discharge (GCD)
- ✚ Electrochemical impedance spectroscopy (EIS)

## 4. Expected Outcomes

- Successfully developed flexible, substrate-free electrodes using doped r-GO.
- Enhanced electrochemical performance due to synergistic effects of r-GO conductivity and metal oxide pseudocapacitance.
- Reduced cost and environmental impact compared to conventional electrodes.

## 5. Significance

- This work supports the development of next-generation, low-cost, high-performance energy storage systems, potentially useful in flexible electronics, wearable devices, and grid storage applications.