Fabrication and characterization of graphene oxide and reduced graphene oxide on MoS_2 film for IR detectors

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ABSTRACT

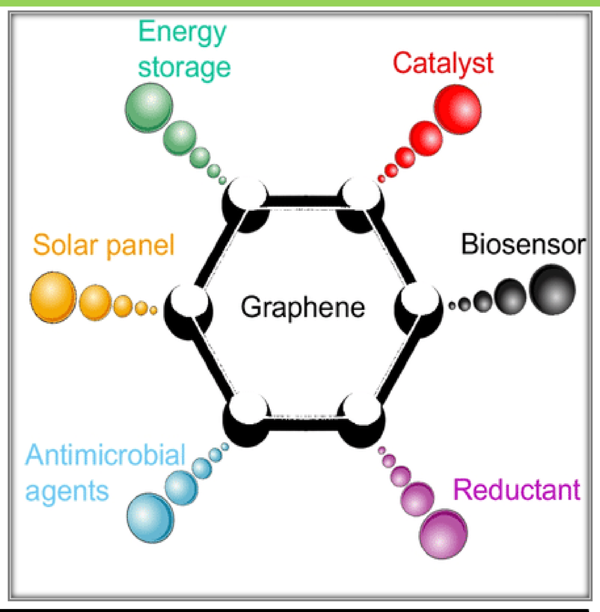
In recent years, infrared detectors have been widely used in surveillance, medical diagnosis, remote sensing devices, defence, industrial automation, communication, astronomy, where the advance materials are required to enhance the device performance. Graphene has gained tremendous attention in the field of photonics and electronics because of its numerous outstanding properties like zero bandgap, exceptionally high crystal and electronic quality, high mechanical strength, and electrical conductivity. In the cutting edge of technology, the graphene oxide - molybdenum disulphide hybrid structures have drawn tremendous attention for the development of high efficiency IR detectors, where MoS_2 film is used for generation of photoelectrons, and graphene oxide is used to enhance the carrier mobility. In this work, modified Hummer's method is used for the fabrication of graphene oxide (GO), where reduced graphene oxide (rGO) is obtained by the thermal reduction of GO at 350 °C for 1 hour. The appearance of XRD peak, corresponding to (001) and (002) peaks for GO and rGO, respectively confirms the crystalline nature of the materials. The characteristic Raman peaks of GO and rGO are observed at 1358 cm^{-1} and 1597 cm^{-1}, which correspond to the D bands and G bands, respectively. The layered structure of rGO is observed by Scanning electron microscope (SEM) technique. On the other hand, MoS_2 film was grown by the sulphonation of sputtered Mo film on silicon substrate (p-type, 1-10 Ω.cm, 525 ± 20 µm). The characteristics XRD peak of MoS_2, corresponding to (002) plane, is observed around 2θ = 14.1° whereas Raman characteristic bands are observed at 386 cm^{-1} (E^1_{2g}) and 408 cm^{-1} (A_{1g}). Afterwards, rGO layer was deposited on MoS_2 thin film. The Post-deposition morphological and electrical properties of reduced graphene oxide and MoS_2 thin film is carried out and co-related for next generation optoelectronic devices.

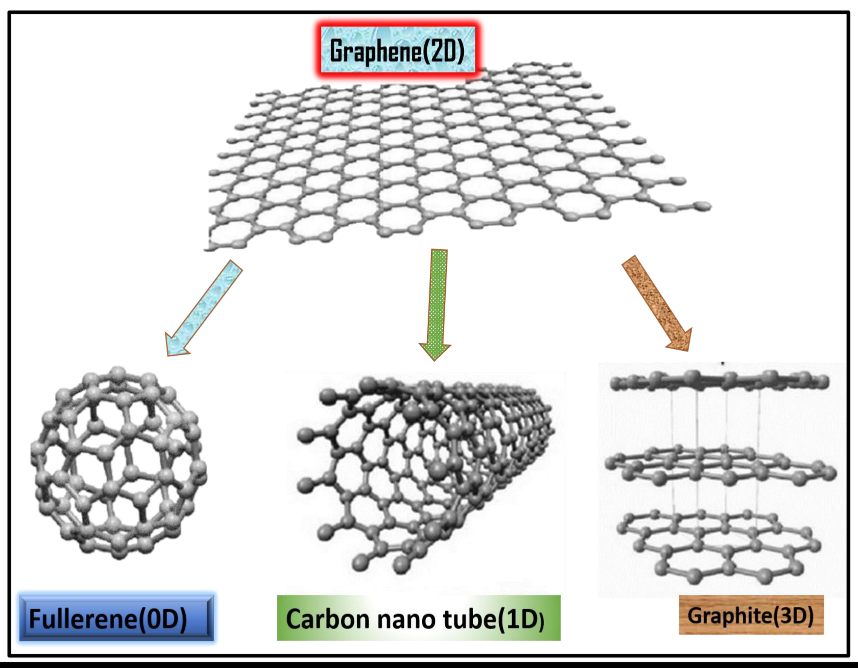
Keywords: rGO, Hummer's method, MoS_2, XRD, Raman

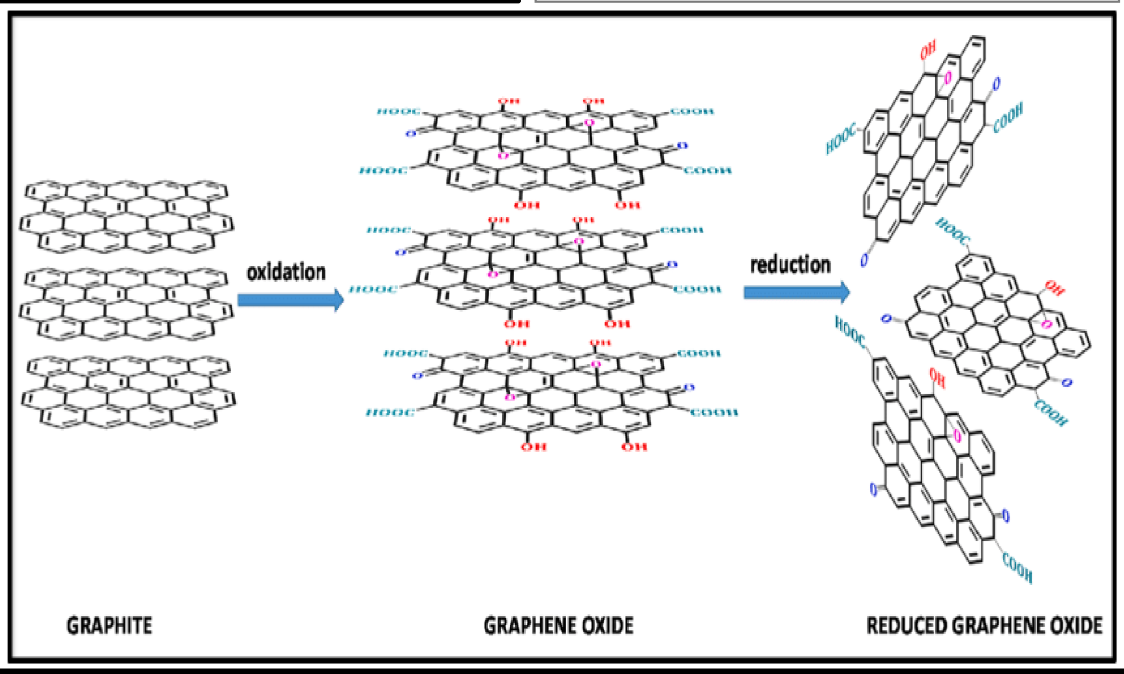
INTRODUCTION

Carbon

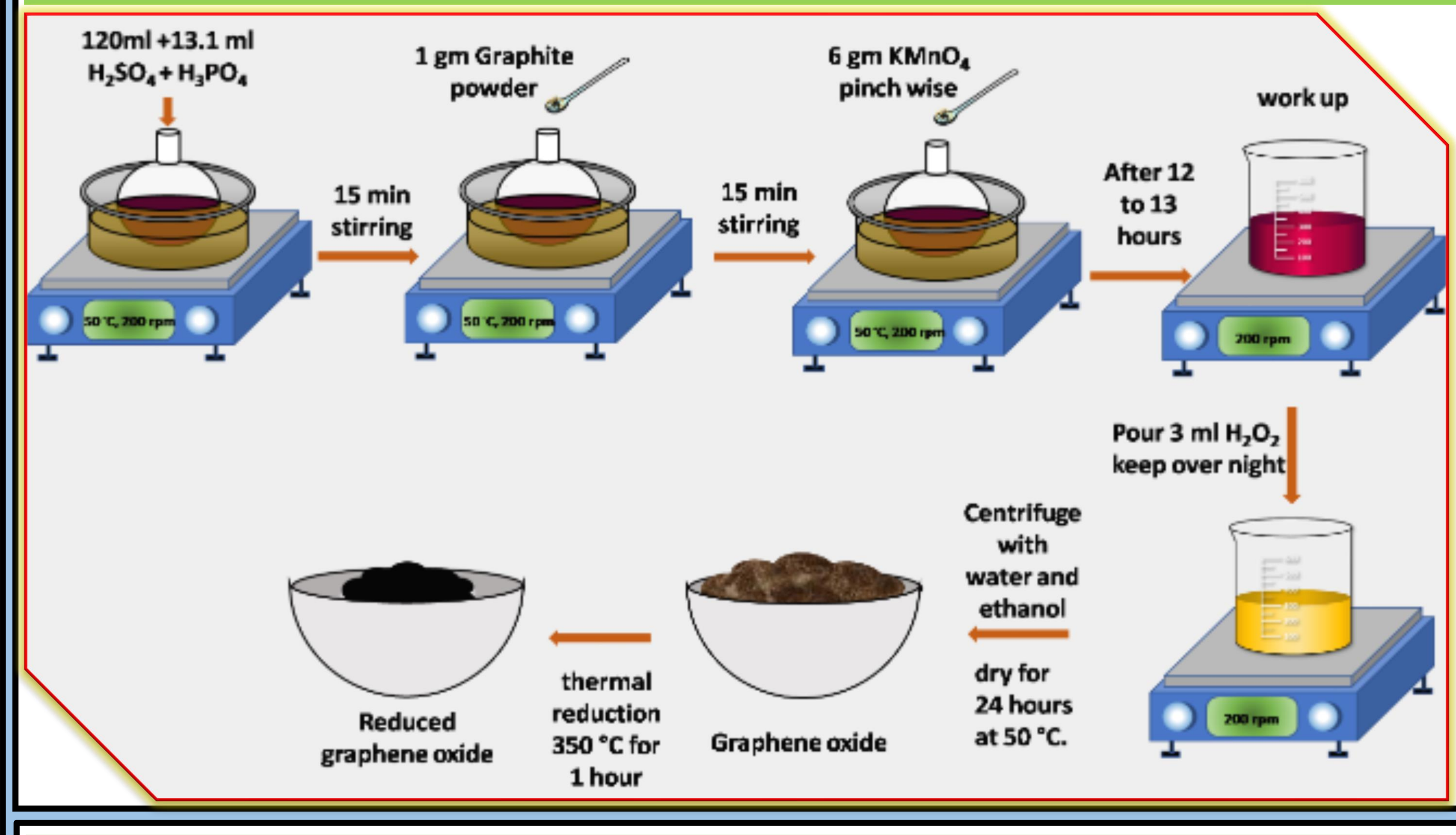
Non-graphitic Carbon	Graphitic Carbon
✓Hard	✓Soft
✓Porous	✓Non-porous
✓Low density	✓High density
✓Very disorder microstructure	✓Very order microstructure







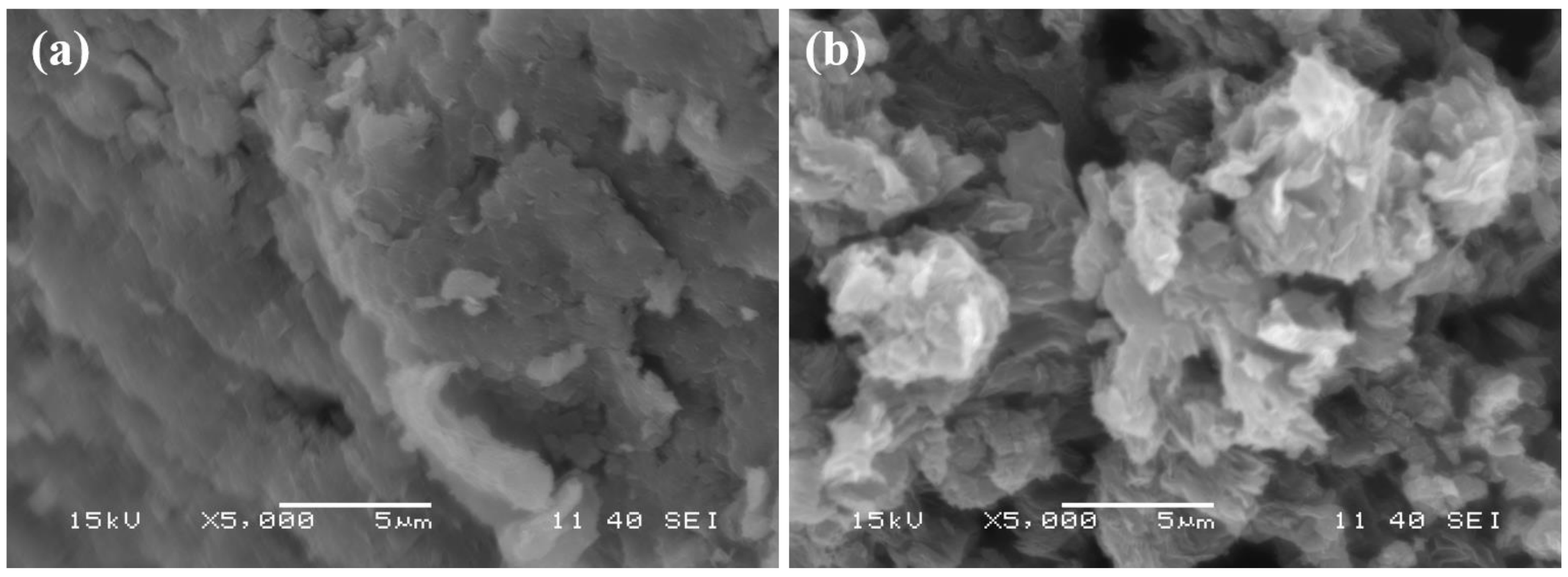
EXPERIMENTAL DETAILS



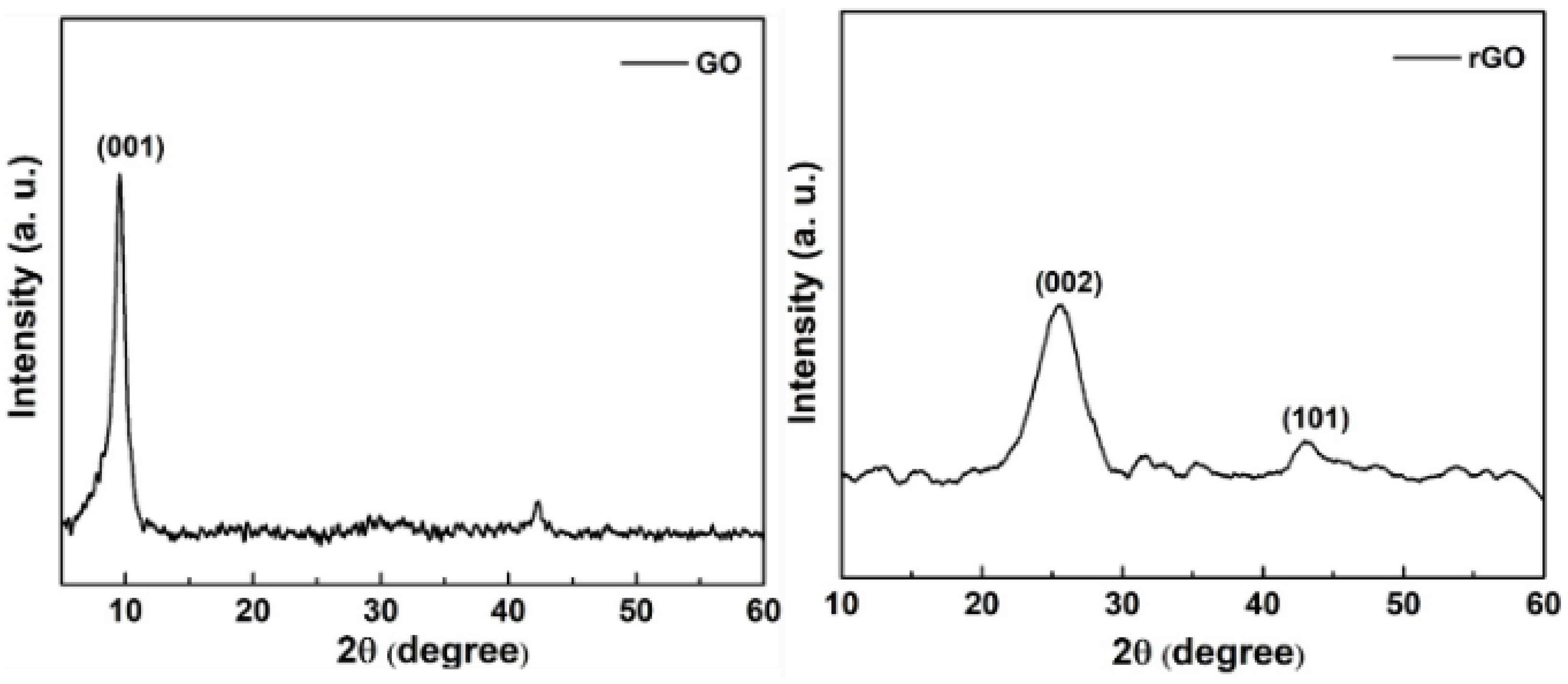
PROPERTIES OF GRAPHENE, GO AND rGO

Graphene	GO	rGO
Strong electrical conductivity (10^6 S cm^{-1})	Electrical conductivity ~1900 S cm^{-1}	Electric conductivity 6300 S cm^{-1}
Strong thermal conductivity (5000 W m^{-1} k^{-1})	Thermal conductivity ~4000 Wm^{-1} K^{-1}	High mobility of 320 cm^2 V^{-1} s^{-1}
High mechanical strength (~40 N m^{-1})		
Optical transmittance (~97.7%)	Optical transmittance (~60%)	Optical transmittance (92.63%)
Large specific surface areas (~2600 m^2 g^{-1})	Specific surface area of GO sheets is around 890 m^2g^{-1}	
Young's module of 1 TPa	Young's modulus of 207.6 ±23.4 GPa	Young's modulus of ~1.0 TPa

MORPHOLOGICAL AND STRUCTURAL CHARACTERISTICS

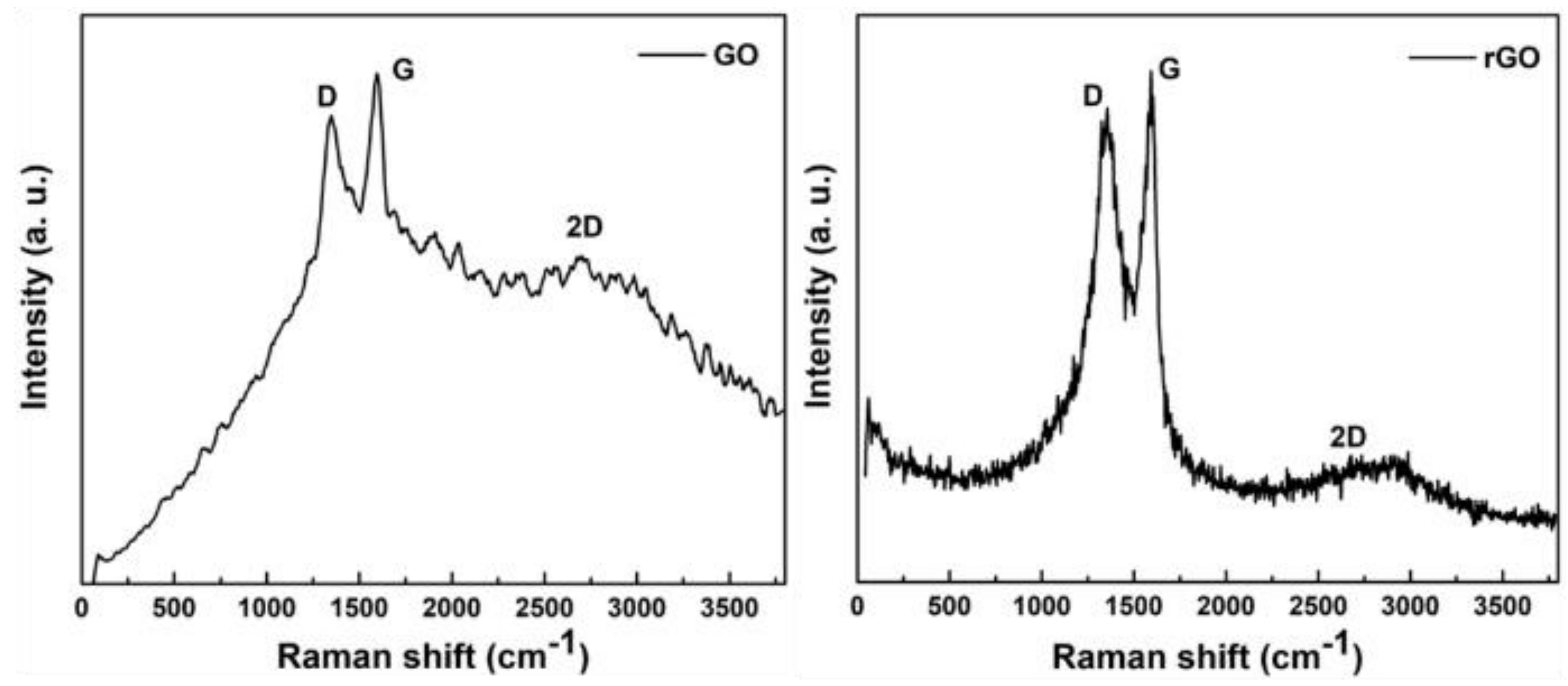


SEM micrograph that GO and rGO are forming layred structures, which affords ultrathin and homogeneous graphene films.



XRD pattern of (a) GO and (b) rGO powder

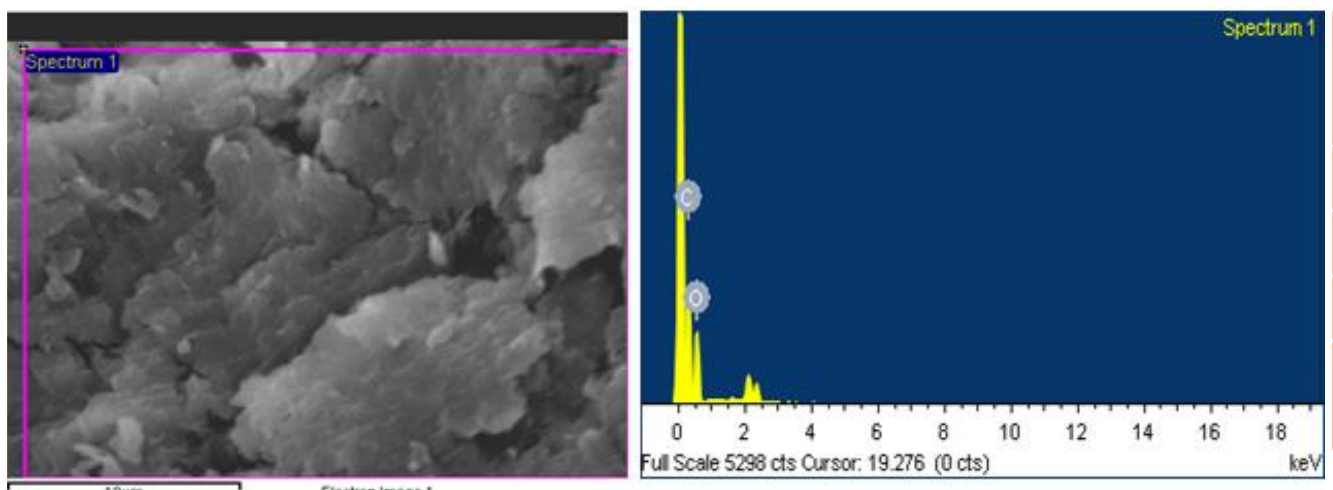
- A dominant diffraction peak (0 0 1) of GO is positioned at 2θ = 9.96°.
- In case of rGO powder, broad peaks centered at around 25.25° for (0 0 2) plane and around 43° for (1 0 1) plane are obtained.



Raman spectrum of (a) GO and (b) rGO powder

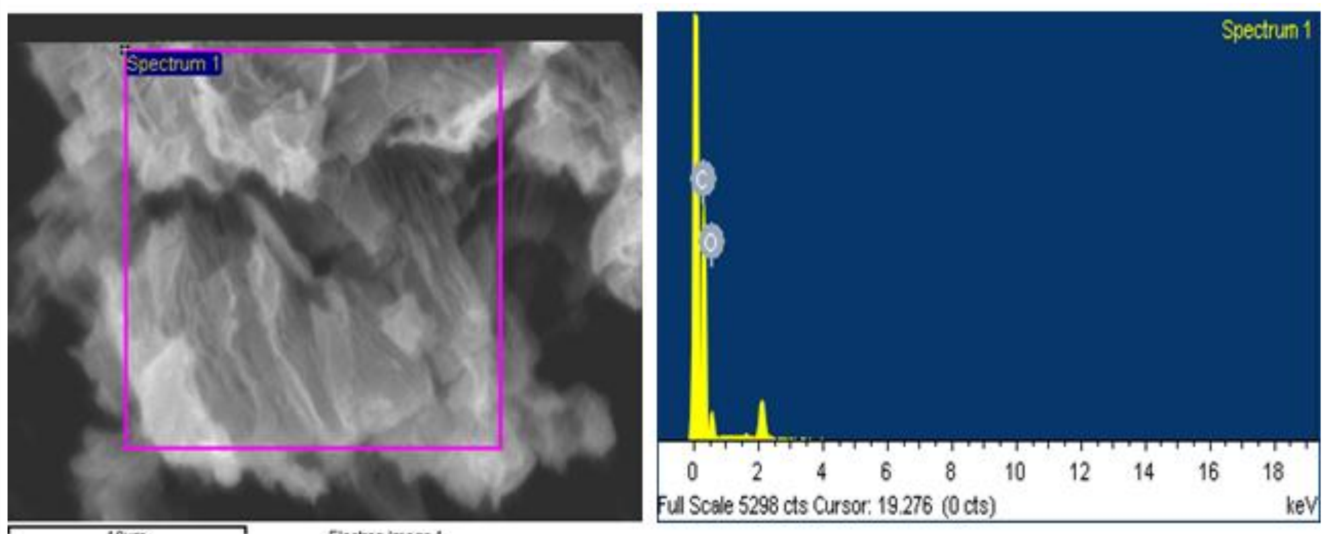
- Raman spectra of both GO and rGO powder show prominent Raman peaks at 1358 cm^{-1} corresponding to the D bands and 1597 cm^{-1} corresponding to the G bands, respectively.

ELEMENTAL ANALYSIS



Element	Weight %	Atomic%
C K	48.26	55.41
O K	51.74	44.59
Totals	100.00	

EDX analysis of GO powder



Element	Weight %	Atomic %
C K	74.46	79.53
O K	25.54	20.47
Totals	100.00	

EDX analysis of GO powder

CONCLUSION

- ✓ Graphene oxide and reduced graphene oxide are prepared by modified Hummer's method.
- ✓ A dominant diffraction peak (0 0 1) of GO is positioned at 2θ = 9.96°. In case of rGO powder, broad peaks centered at around 25.25° for (0 0 2) plane and around 43° for (1 0 1) plane are obtained.
- ✓ Raman spectra of both GO and rGO powder show prominent Raman peaks at 1358 cm^{-1} corresponding to the D bands and 1597 cm^{-1} corresponding to the G bands, respectively.
- ✓ EDX spectra of GO powder confirms the atomic percentage of carbon and oxygen 55.41% and 44.59% respectively.
- ✓ EDX spectra of rGO powder confirms the atomic percentage of carbon and oxygen 79.53% and 20.47% respectively, which confirms the reduction of oxygen and increase of carbon to oxygen ratio.

PUBLICATIONS

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