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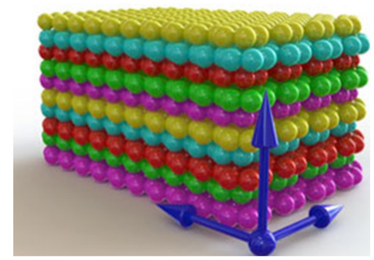
EFFECT OF GRAPHITE PLATELETS ON THERMAL AND GAS BARRIER PROPERTIES OF POLYMERS



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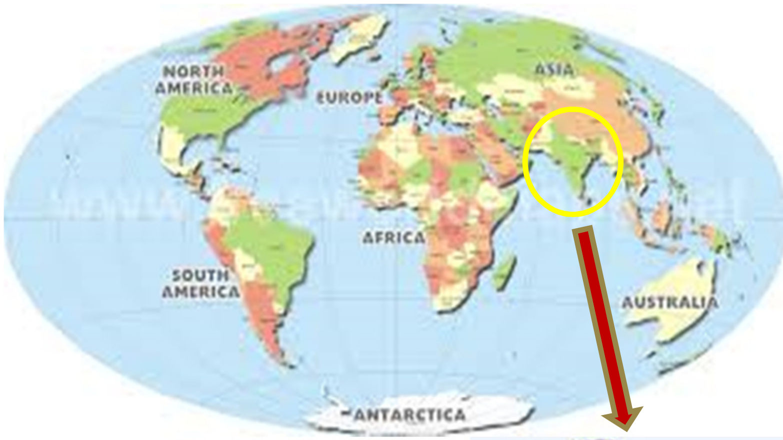
3rd International Conference and Exhibition on Materials Science & Engineering
October 06-08, 2014 San Antonio, USA

My Location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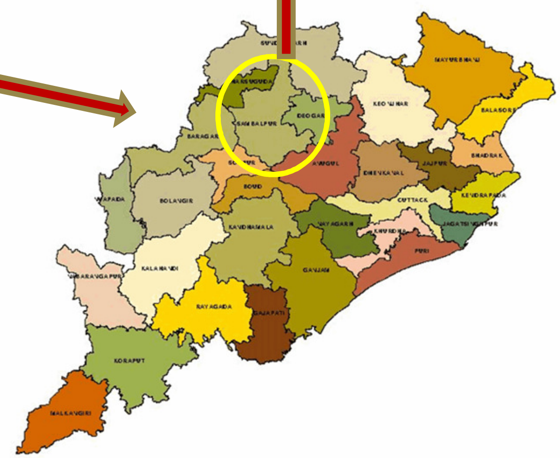


INTRODUCTION

COMPOSITE

Dispersion of a discontinuous phase within a continuous phase in a controlled manner to achieve superior properties than the individual components.

NANOCOMPOSITE

If at least one of the phases has one dimension of the order of nanometers, then the composite is termed as 'nanocomposite

Polymer Nanocomposites Containing Conducting fillers

The nanocomposite, in which a polymer makes the continuous phase, while conducting fillers is dispersed as the discontinuous or reinforcing phase.

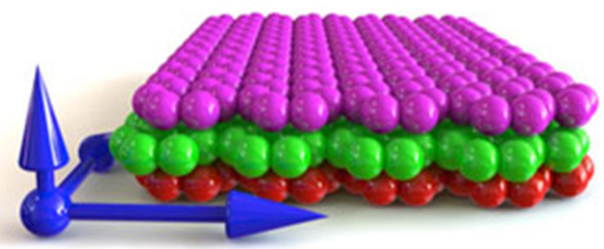
CHALLENGES

Neat polymers

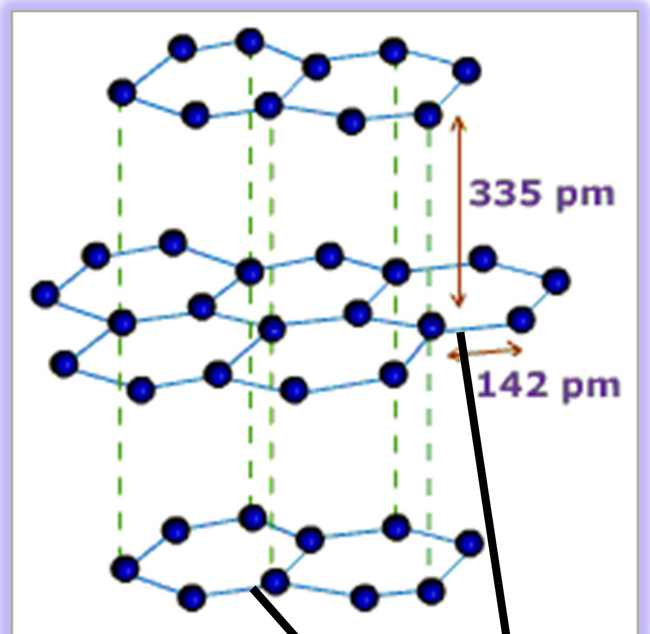
Non conductive of electricity
Less resistance to air penetration
Weak mechanical strength
Less thermal stability

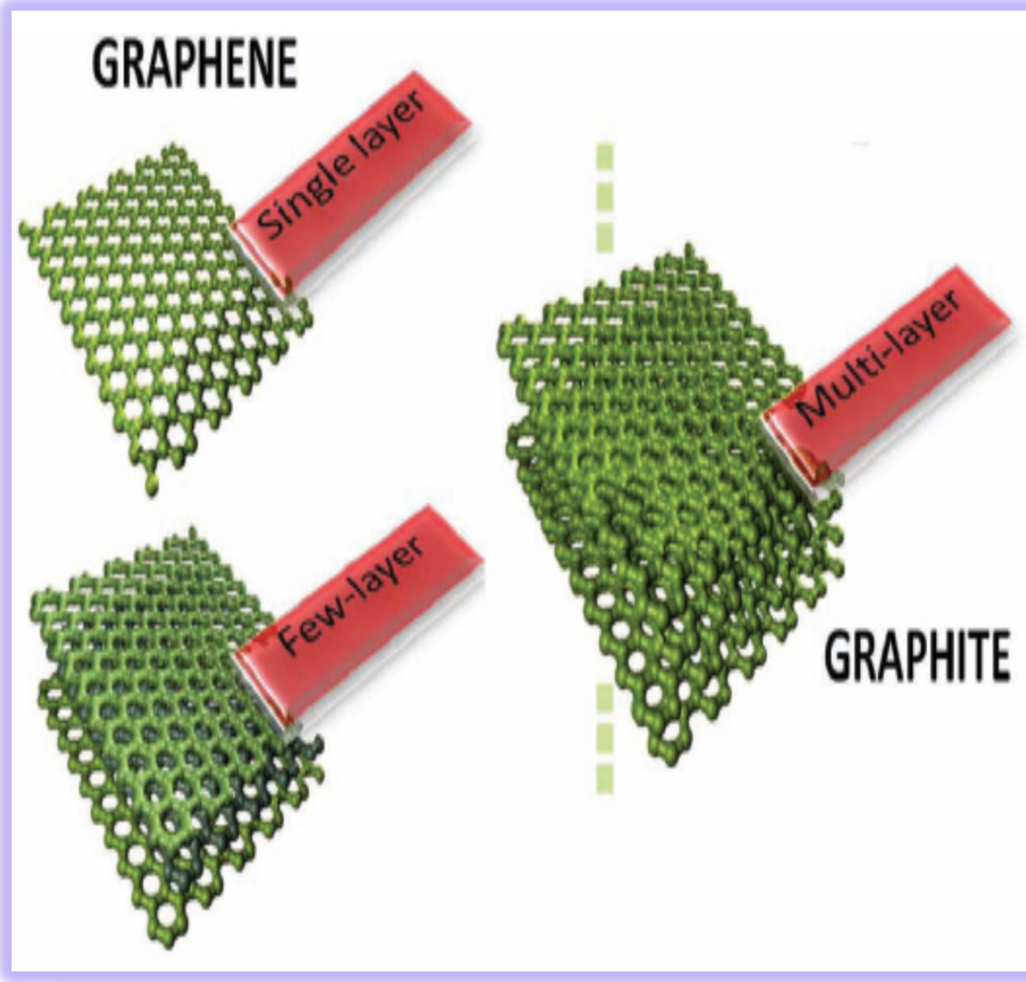
Advantages of Conducting fillers based Polymer nanocomposites

Electrical conductive
High resistance to air penetration
Strong mechanical strength
Greater thermal stability
Increase in gas barrier properties



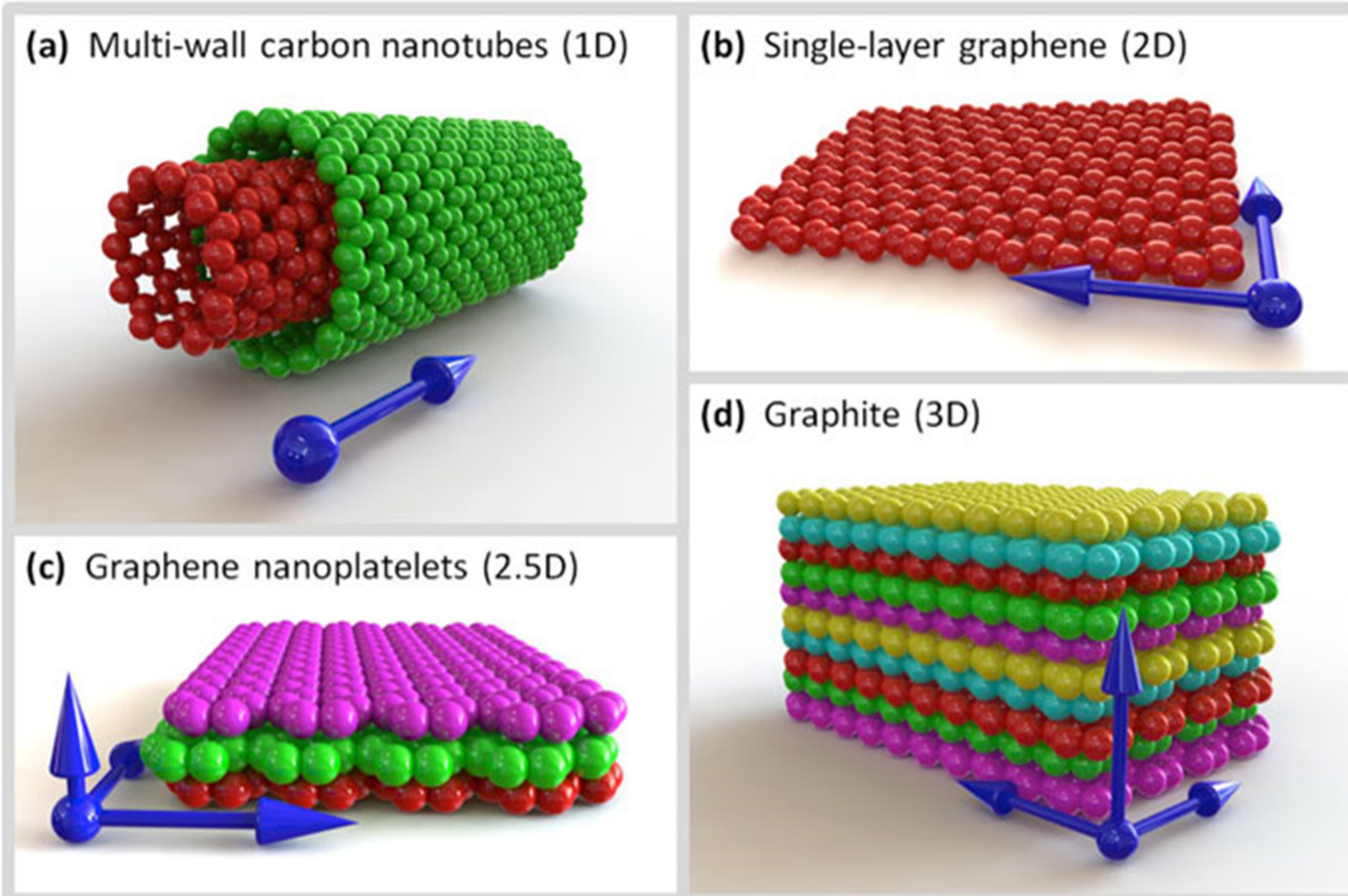
Graphite as Filler





Graphite Nanosheets

It is an ideal filler for the preparation of conductive nanocomposite



(a) Multi-wall carbon nanotubes (1D)
(b) Single-layer graphene (2D)
(c) Graphene nanoplatelets (2.5D)
(d) Graphite (3D)

Objectives

- ❖ **Synthesis of polymers and copolymers based conducting nanocomposites by non conventional low cost green technique.**

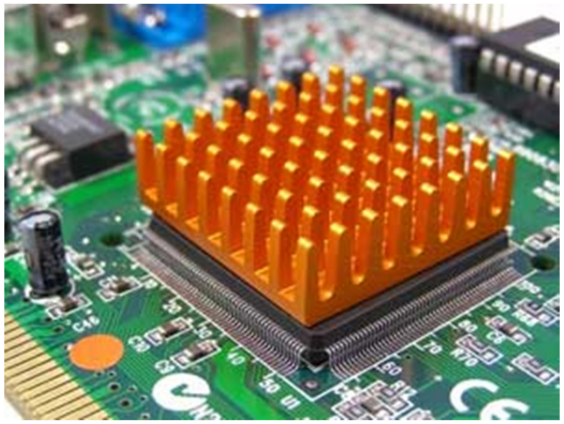
- ❖ **Study of intermolecular interactions of polymers and copolymers matrices with conducting nano fillers (Graphite).**

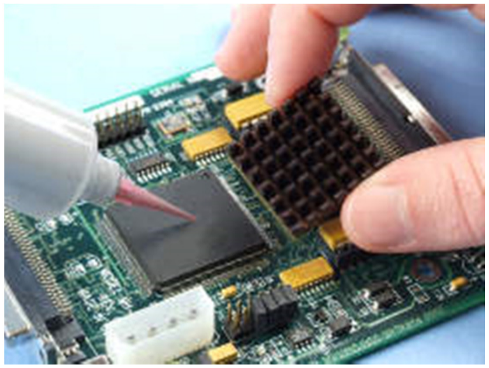
- ❖ **Measurement of electrical conductivity of synthesized nanocomposites in comparison with non conducting polymers and copolymers.**

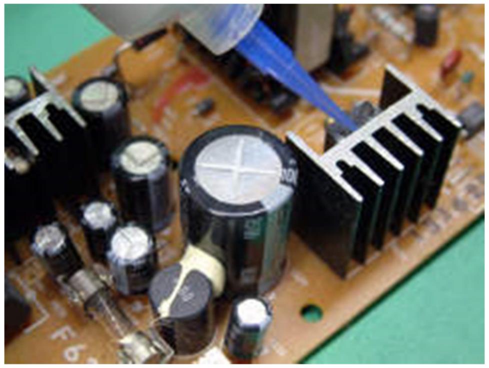
- ❖ **Study of mechanical, thermal, chemical resistance and oxygen barrier properties of nanocomposites.**

- ❖ **Preparation of thermal resistant with substantial reduction in oxygen barrier properties may enable the synthesized materials suitable for future packaging applications.**

APPLICATIONS





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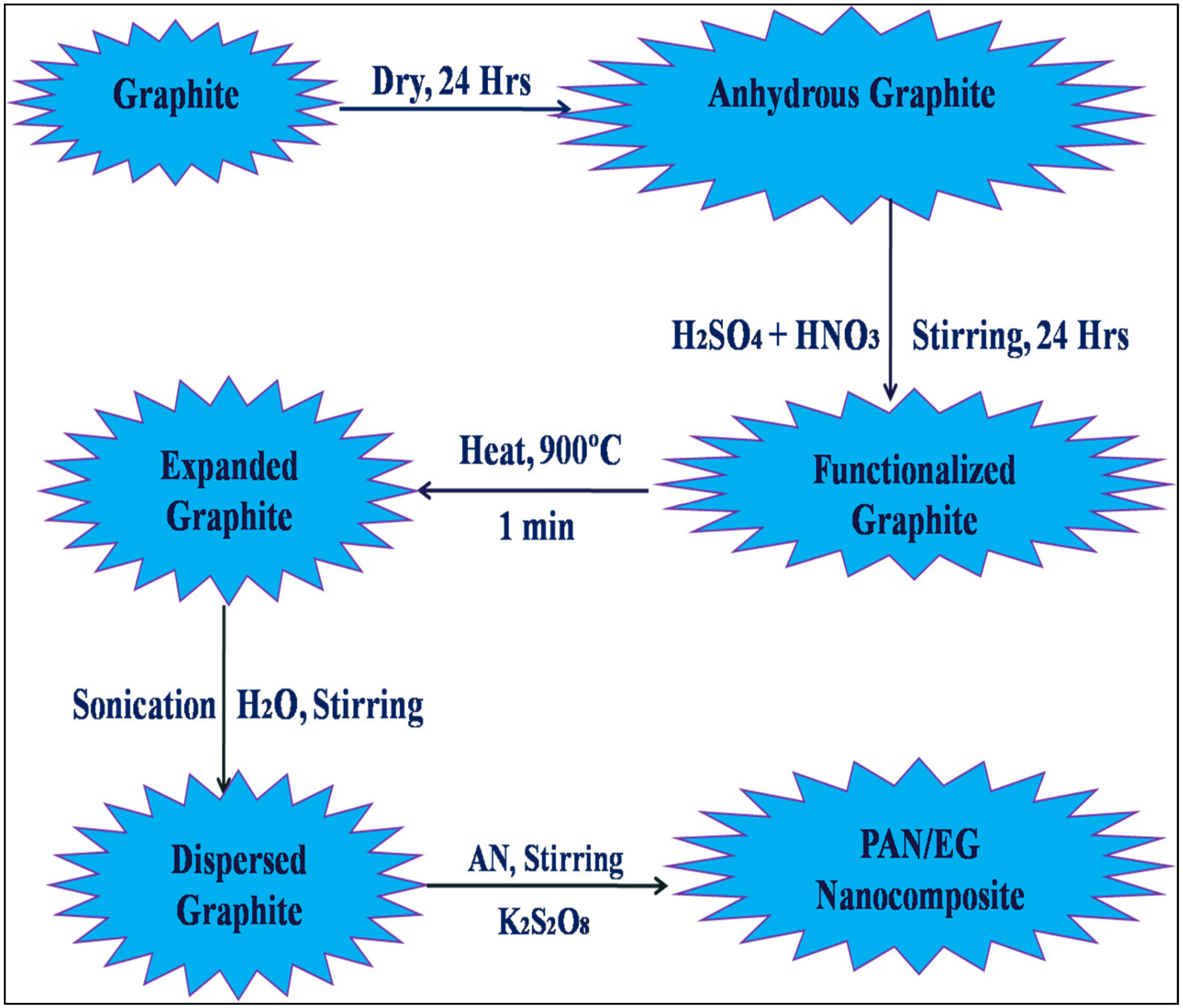
Polyacrylonitrile (PAN)/Graphite Nanocomposites



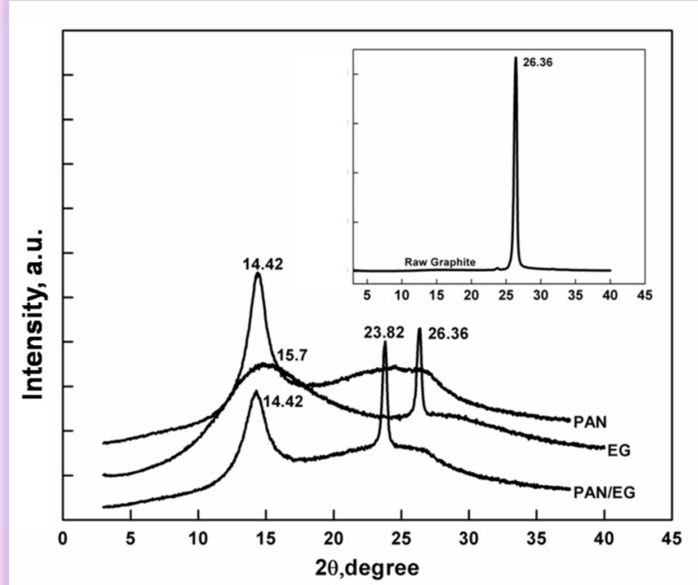
Swain et. al, Polym. Compos., 32:1336–1342, (2011)

Characterization

❖The raw graphite exhibits a sharp diffraction peak at 2θ value of 26.36°.

❖ The corresponding d-spacing was calculated to be 0.32nm.

❖From the XRD of EG, the broad peak at 2θ value of 15.7° in addition the peak at 2θ value of 26.36° of raw graphite may be attributed to the change in interlayer spacing of EG which had been expanded to different degrees.



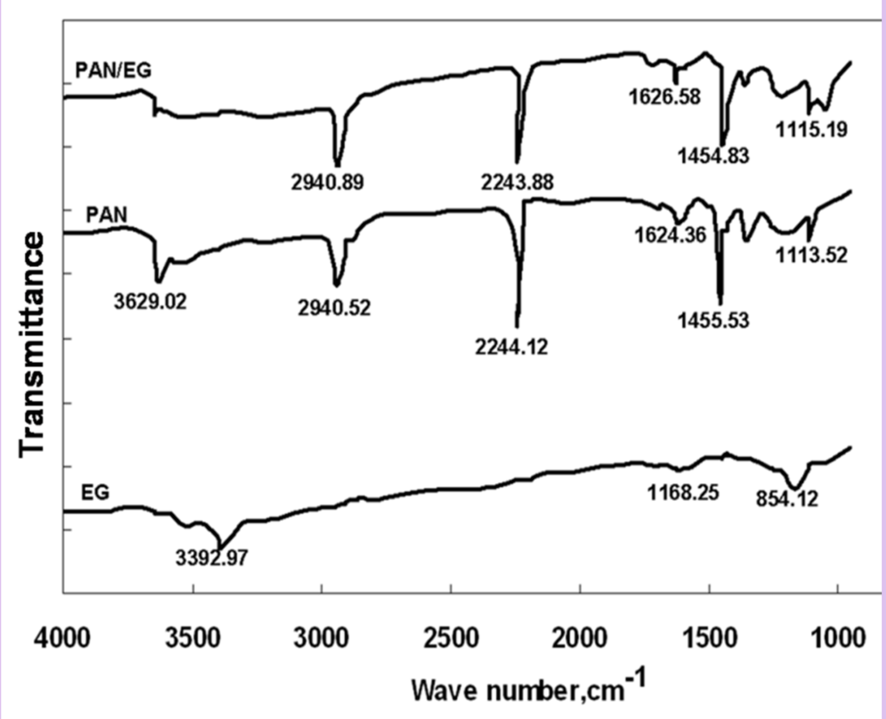
X-ray diffraction patterns of raw graphite (RG), expanded graphite (EG), PAN and PAN/EG nanocomposite.

Swain et. al, Polym. Compos., 32:1336–1342, (2011)

❖ FTIR spectrum of PAN revealed the absorption frequency at 3629 cm^{-1} is due to –OH stretching of persulphate end group in the polymer, 2940 cm^{-1} is due to –CH stretching, 2244 cm^{-1} corresponds to –CN stretching and 1455 cm^{-1} for $–CH_2$ bending.

❖The absorption peak at 3392 cm^{-1} for expanded graphite may be due to the remaining hydroxyl group after functionalization. The absorption peak at 1168 cm^{-1} and 854 cm^{-1} corresponds to C-C stretching and –CH bending frequency respectively.

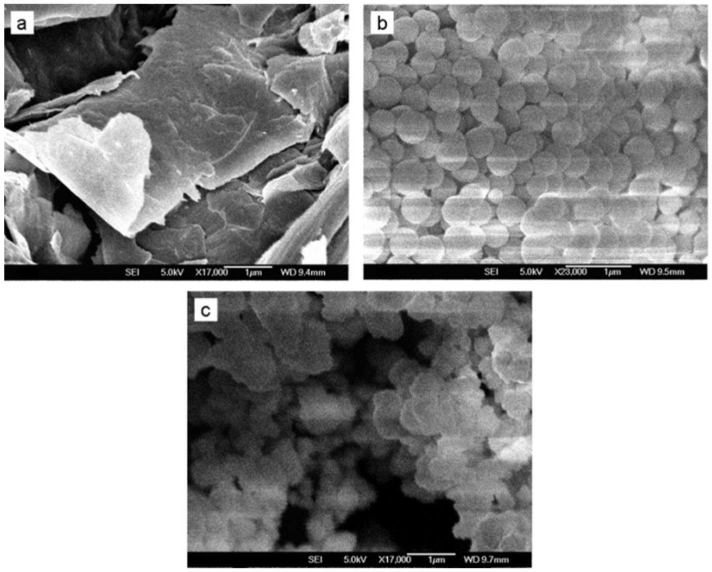
❖The disappearance of absorption peak of EG at 3392 cm^{-1} in the FTIR spectrum of PAN/EG nanocomposite due to chemical interaction of hydroxyl group on the surface of EG with the –OH of persulphate end group of PAN macromolecular chain.



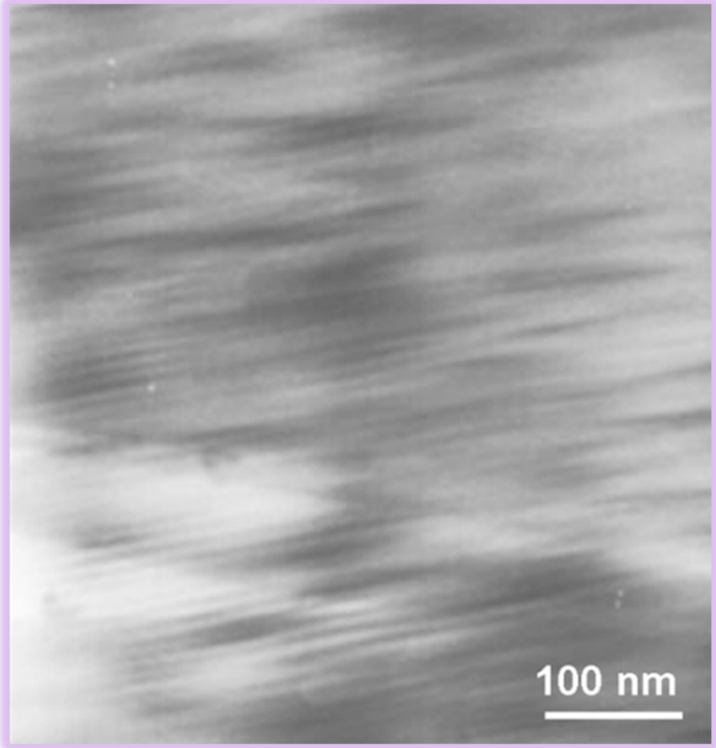
FTIR spectra of (a) PAN/EG nanocomposite(b) PAN and (c) Expanded graphite.

Swain et. al, Polym. Compos., 32:1336–1342, (2011)

Morphological analysis



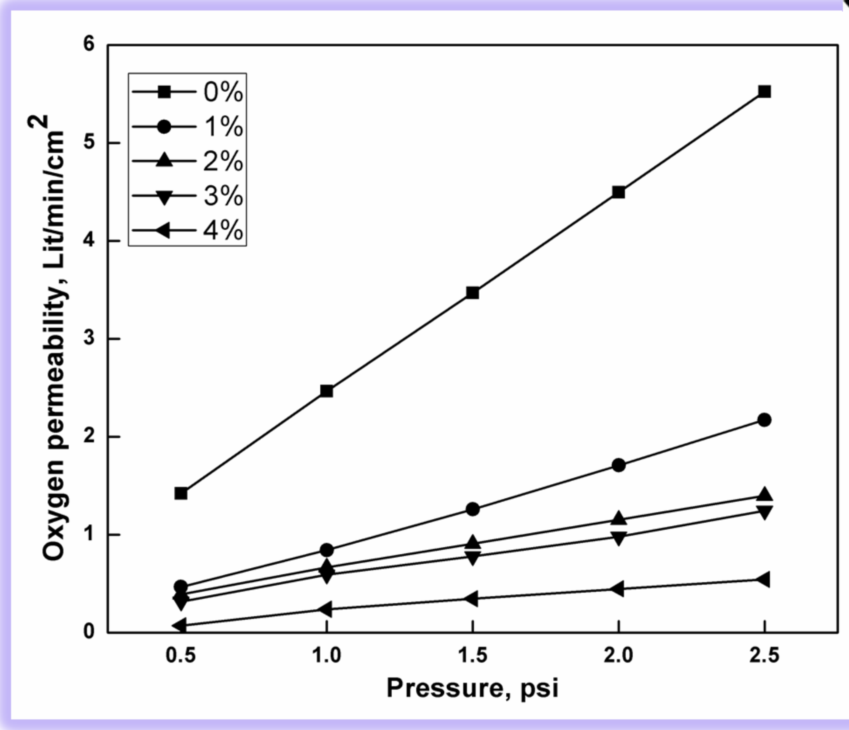
SEM images of (a) Expanded graphite (b) Virgin PAN (c) PAN/EG nanocomposite at 4% EG concentration.



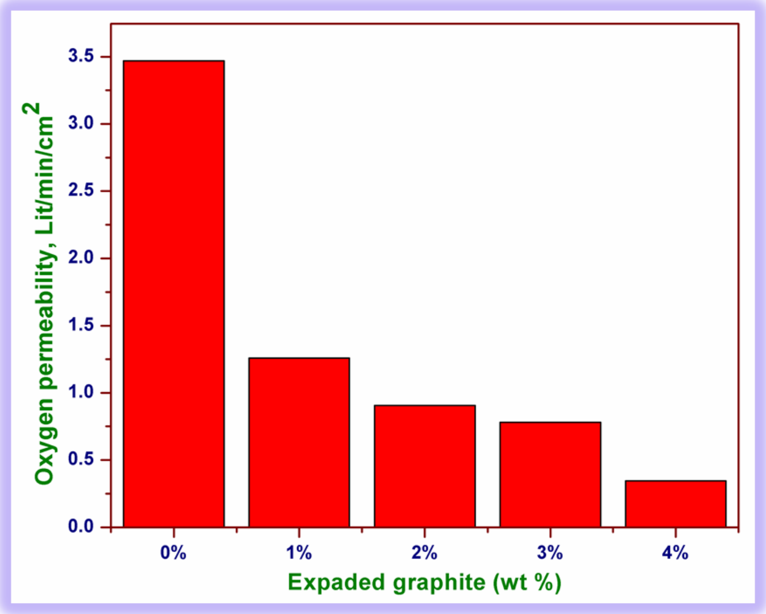
TEM image of PAN/EG nanocomposite at 4% EG concentration

Swain et. al, Polym. Compos., 32:1336–1342, (2011)

The oxygen flow rate through all the nanocomposites was observed to be less in comparison to the virgin PAN up to 2.5 psi.



Oxygen permeabilities of the PAN/EG nanocomposites as a function of EG content at different pressures.

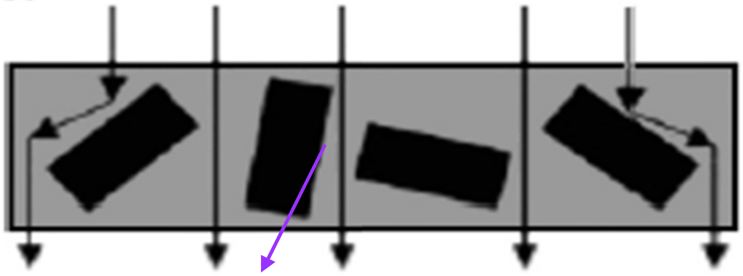


Oxygen permeabilities of the PAN/EG nanocomposites as function of EG content at constant pressure of 1.5 psi.

The permeability of PAN/EG nanocomposites substantially reduced to approximately 13 times with increase in EG content.

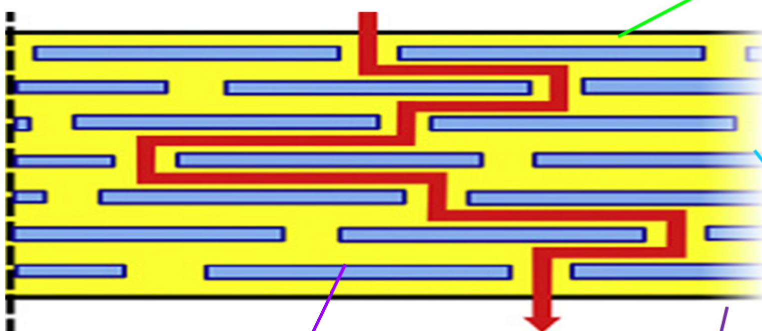
Swain et. al, Polym. Compos., 32:1336–1342, (2011)

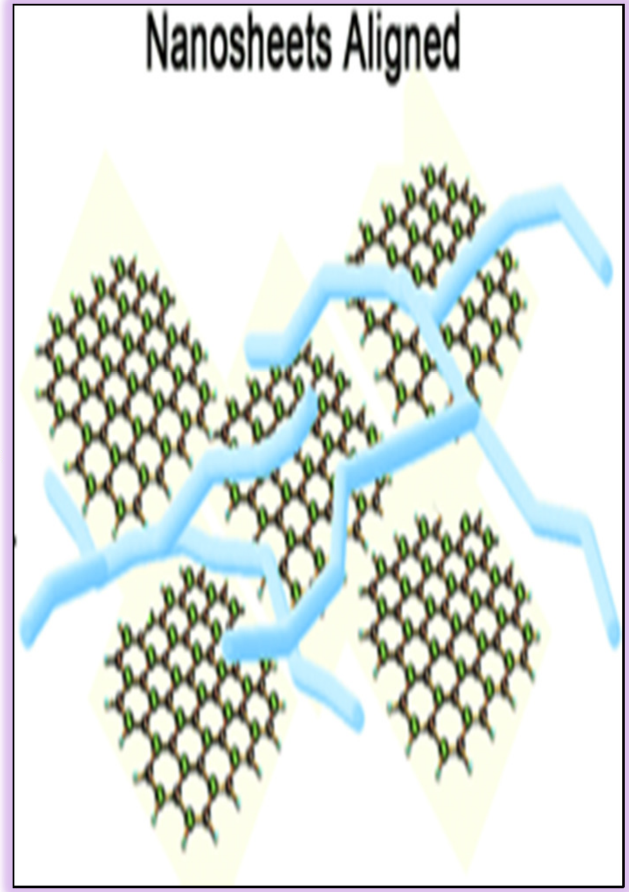
Gas Barrier Properties



Conventional composites have a less restrictive path for oxygen permeation

Tortuous Path





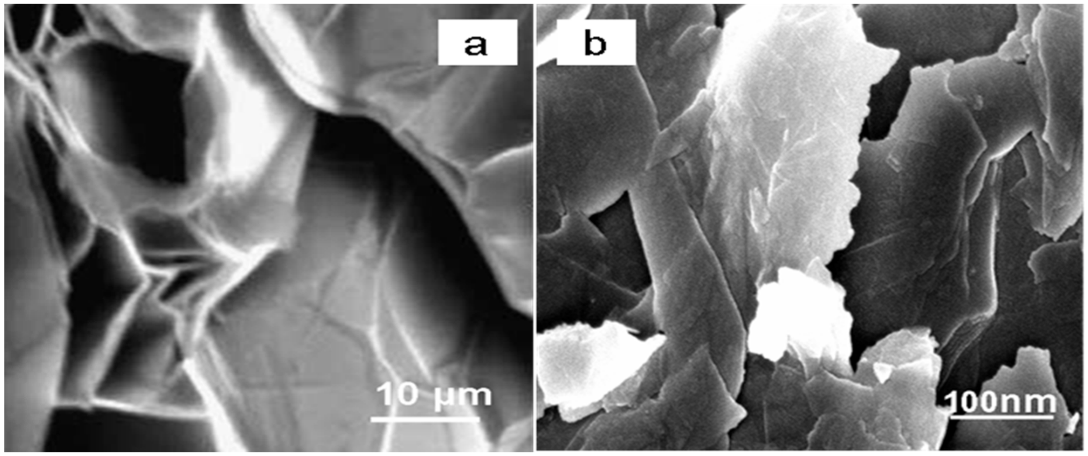
Exfoliated graphite nanosheets

Polymer matrix

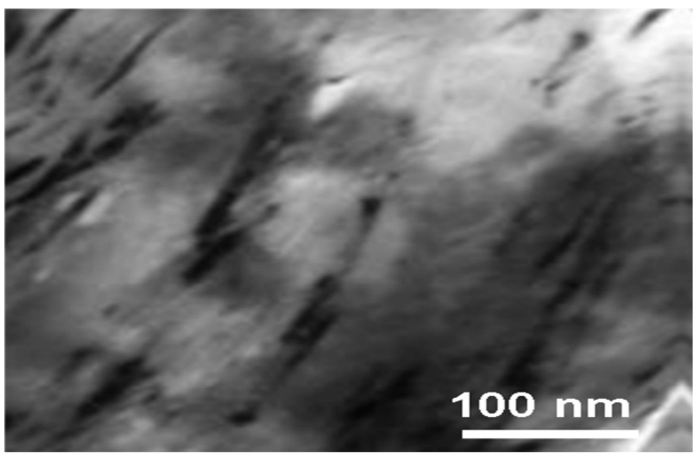
Polymer/EG nanocomposites have highly-ordered nanolayered structure which creates a tortuous zigzag path for oxygen penetration

Swain et. al, Polym.er, 48, 481-489 (2007)

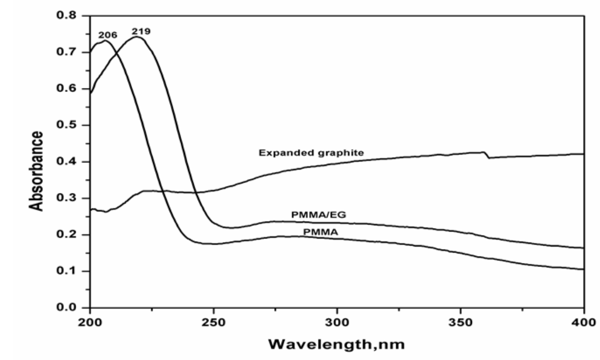
Polymethyl methacrylate (PMMA)/Graphite Nanocomposites



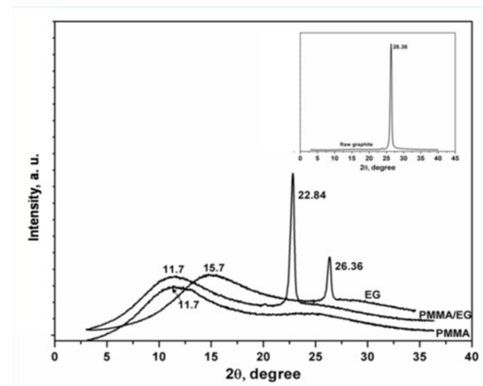
SEM images of EG at different magnifications (a) 10 μm (b) 100 nm.



TEM image of PMMA/EG nanocomposite at 5% EG concentration.



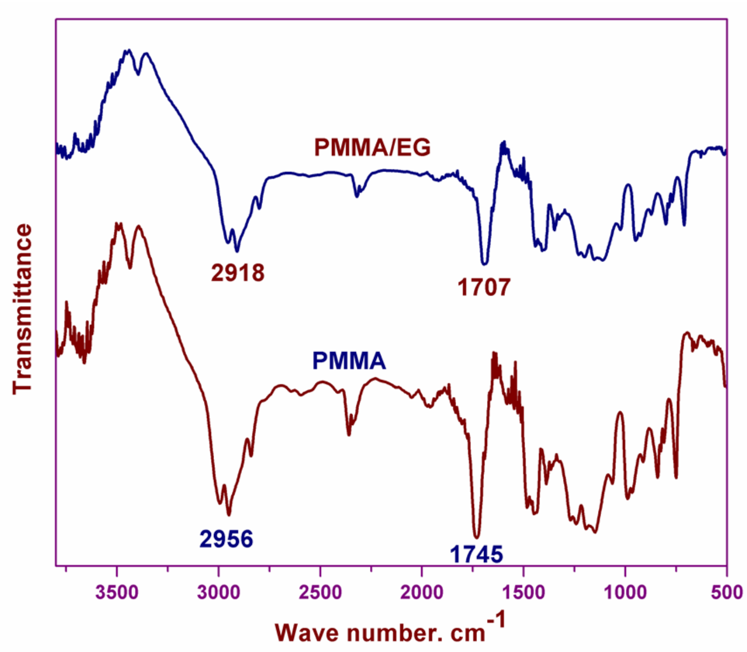
UV-Vis spectra of EG, PMMA and PMMA/EG (5 wt %) nanocomposite.



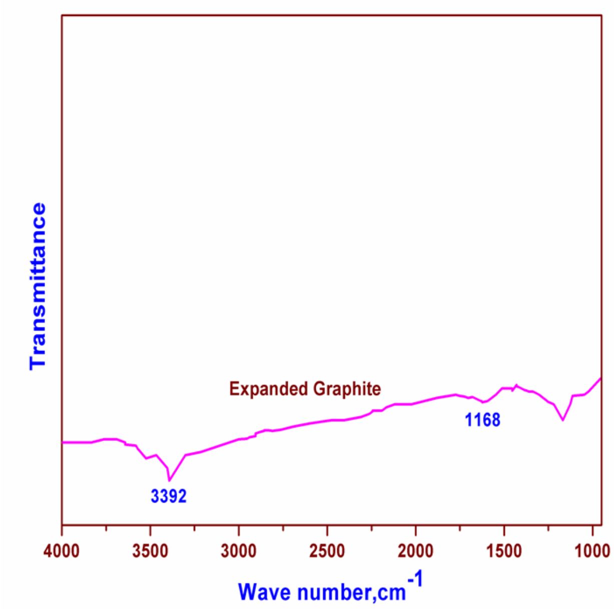
X-ray diffraction patterns of raw graphite (RG), expanded graphite (EG), PMMA and PMMA/EG nanocomposite.

Swain et. al J. of Expt. Nanosci, 9 (3), 240-248 (2014)

FTIR Study



FTIR spectra of PMMA and PMMA/EG (5 wt %) nanocomposite

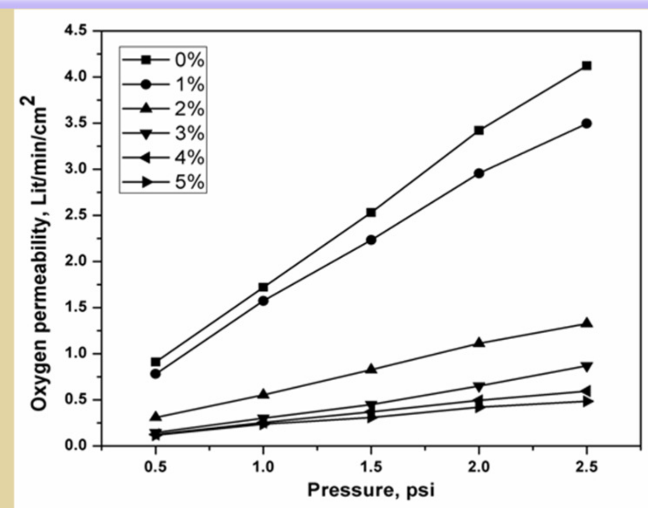


FTIR spectra of expanded graphite.

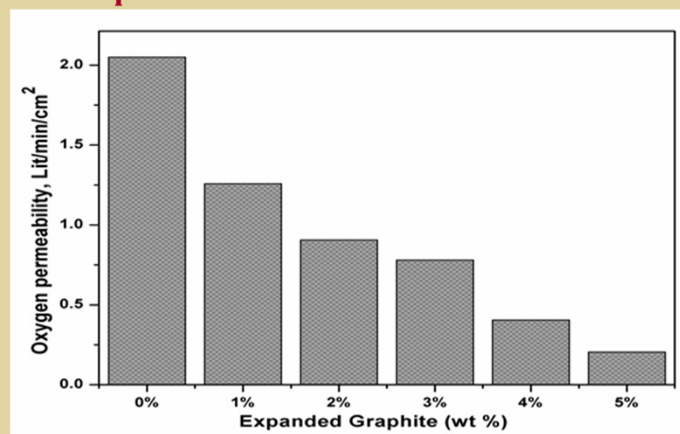
Swain et. al J. of Expt. Nanosci, 9 (3), 240-248 (2014)

Gas Barrier property

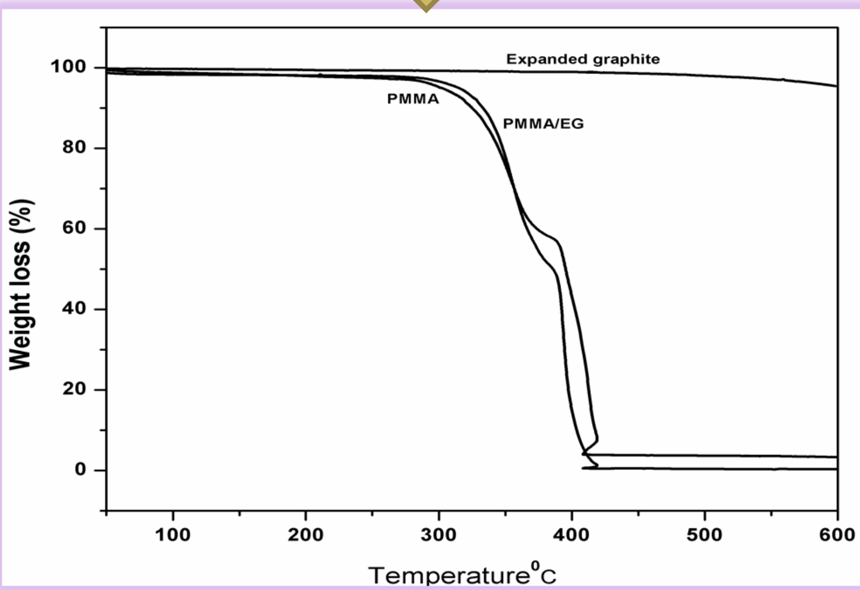
TGA Analysis



Oxygen permeabilities of the PMMA/EG nanocomposites as function of EG content at different pressures.



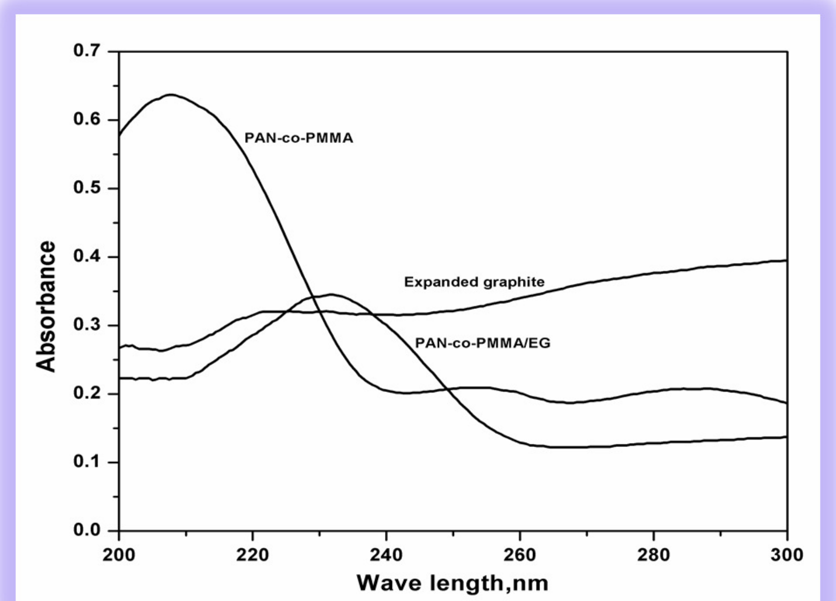
Oxygen permeabilities of the PMMA/EG nanocomposites as a function of EG content at constant pressure of 2 psi.



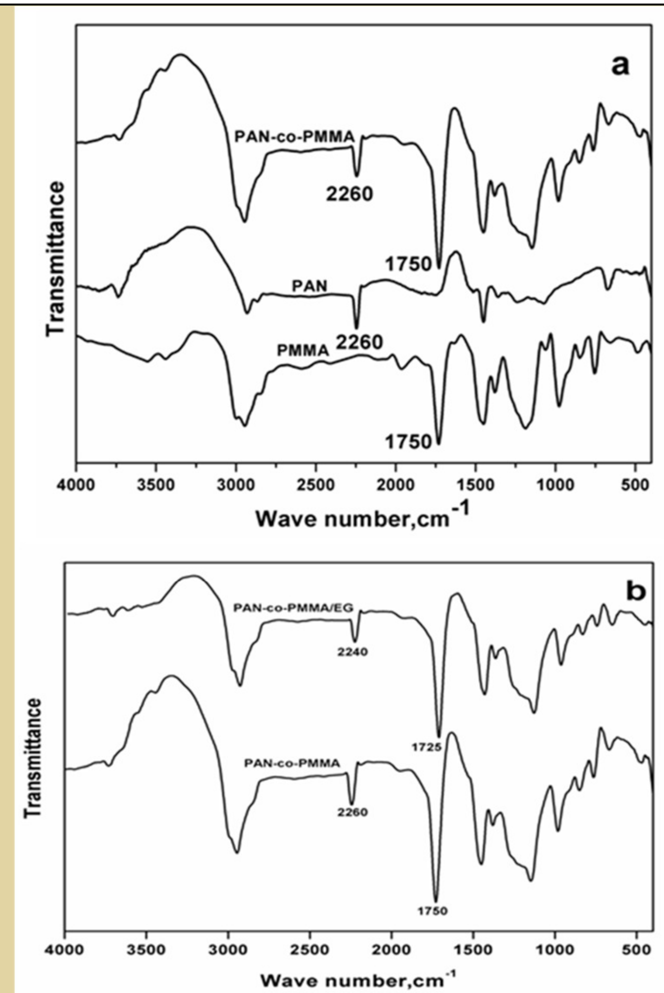
Thermogravimetric analysis (TGA) curves of EG, PMMA and PMMA/EG nanocomposite.

Swain et. al J. of Expt. Nanosci, 9 (3), 240-248 (2014)

\PAN-co- PMMA/Graphite Nanocomposites



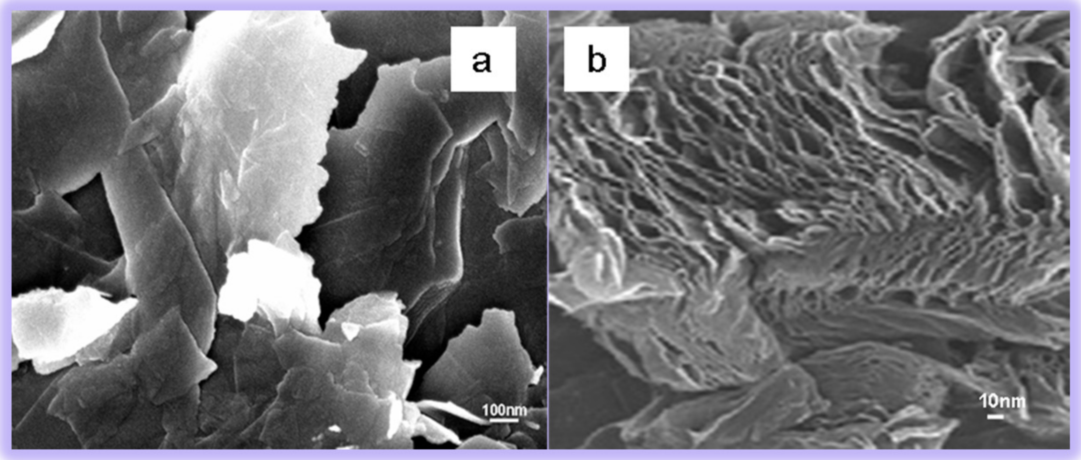
UV-Vis spectra of expanded graphite, PAN-co-PMMA and PAN-co-PMMA/EG nanocomposite.



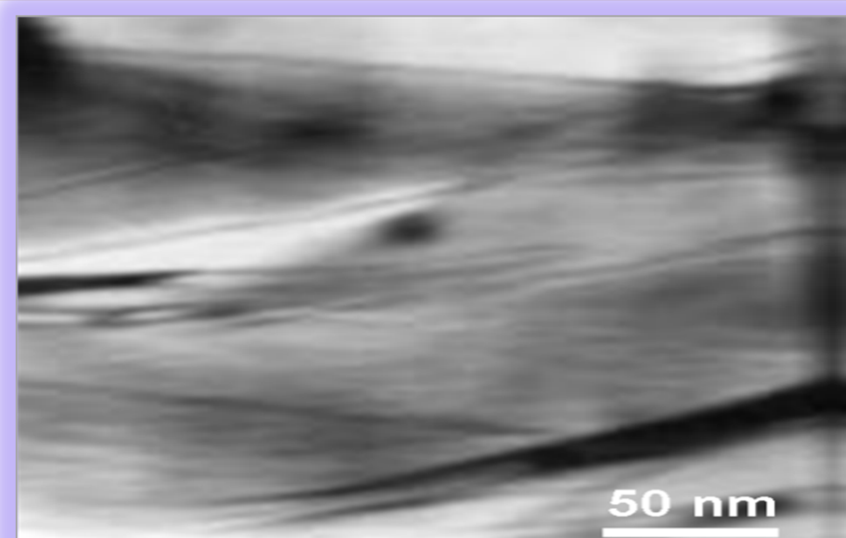
F T I R spectra of (a) PMMA, PAN and PAN-co-PMMA.(b) PAN-co-PMMA and PAN-co-PMMA/EG nanocomposite.

Swain et. al.New Carbon Materials,, 27(4): 271–277 (2012)

Morphological analysis

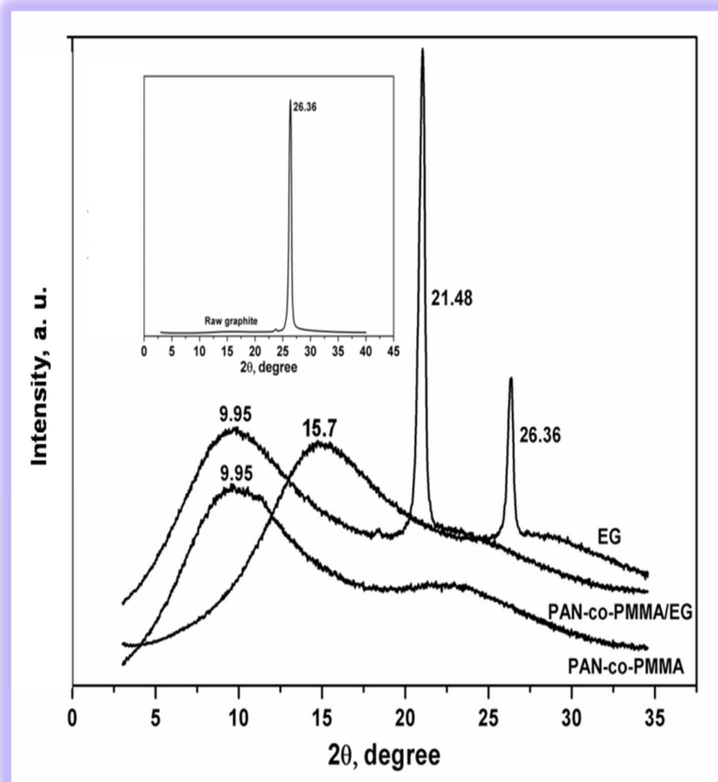


SEM images of (a) Expanded graphite (b) HRSEM image of PAN-co-PMMA/EG nanocomposite at 4% graphite.



TEM image of PAN-co-PMMA/EG nanocomposite at 4% graphite.

XRD Study

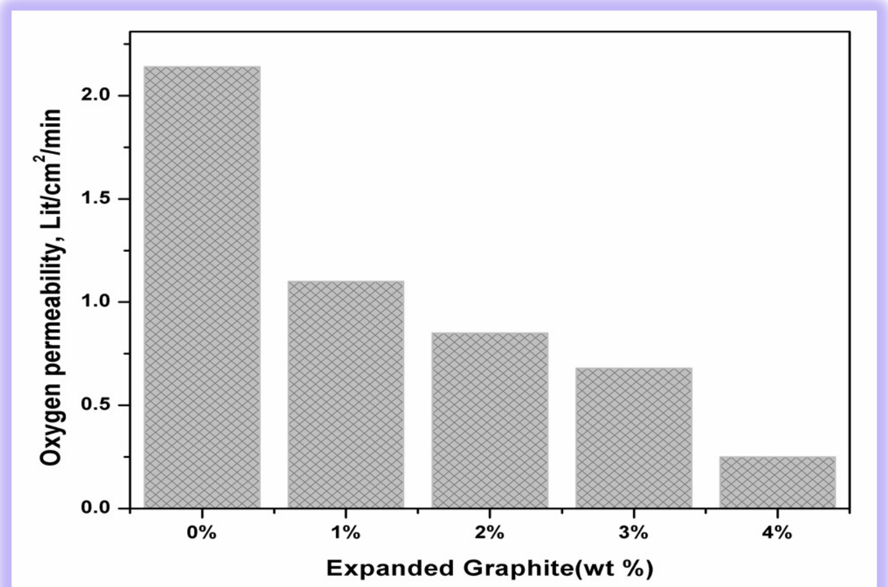


X-ray diffraction patterns of raw graphite, PAN-co-PMMA and PAN-co-PMMA/EG nanocomposite.

Swain et.al. New Carbon Materials,, 27(4): 271–277 (2012)

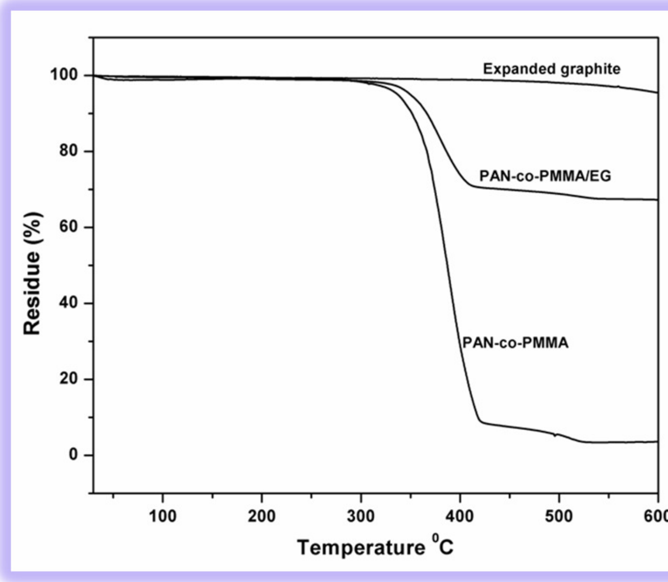
Study of Properties

Gas barrier property



Oxygen permeability of PAN-co-PMMA/Expanded graphite nanocomposite as function graphite content at constant pressure.

TGA Analysis

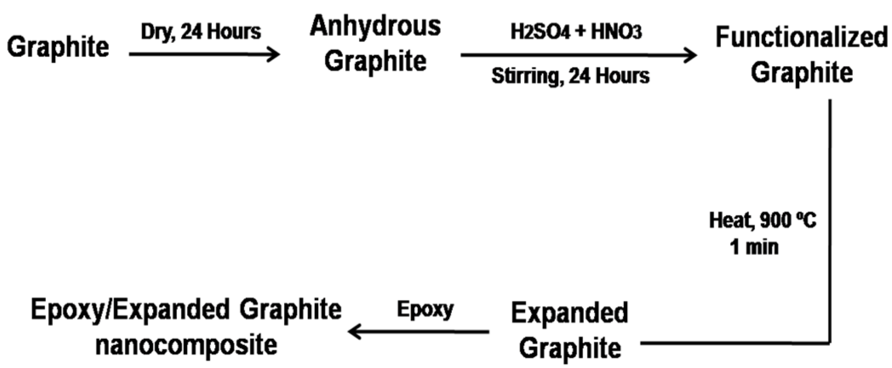


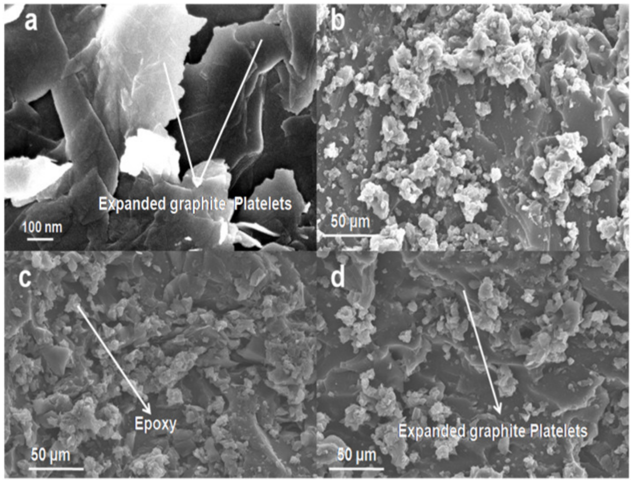
Thermogravimetric analysis (TGA) curves of Expanded Graphite, PAN-co-PMMA and PAN-co-PMMA/EG nanocomposite.

The permeability of PAN-co-PMMA/EG nanocomposites substantially reduced to about 8 times with increase in graphite content.

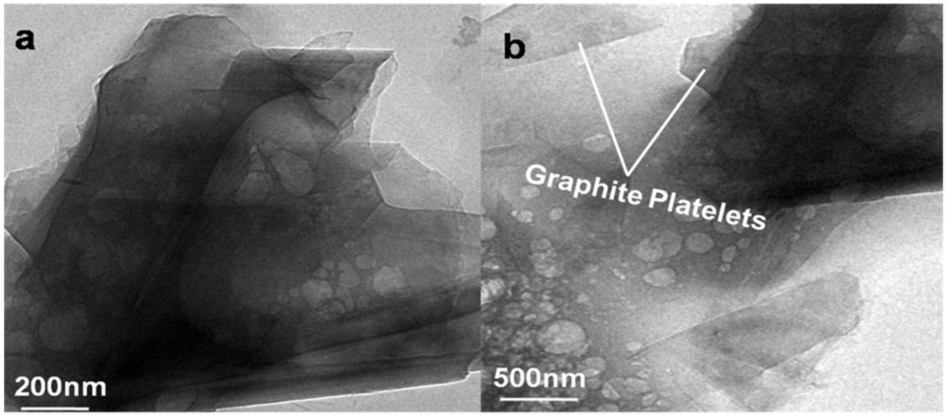
New Carbon Materials,, 27(4): 271–277 (2012)

Epoxy/graphite





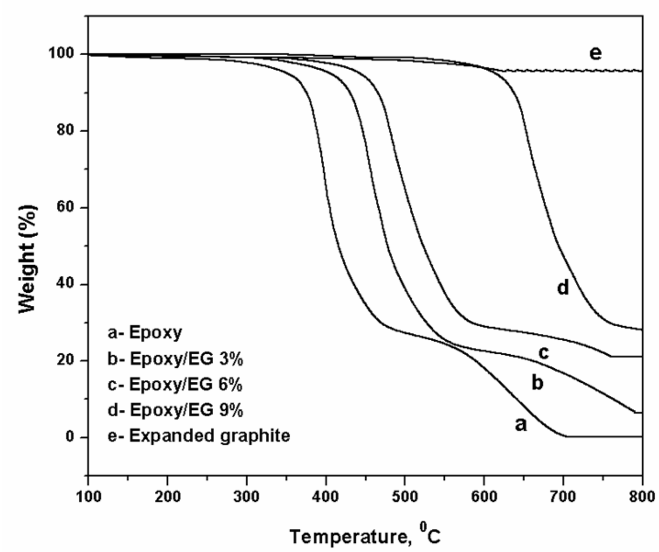
FESEM images of (a) Expanded graphite and epoxy /EG composite at graphite concentration of (b) 3 wt% (c) 6 wt% (d) 9 wt% .



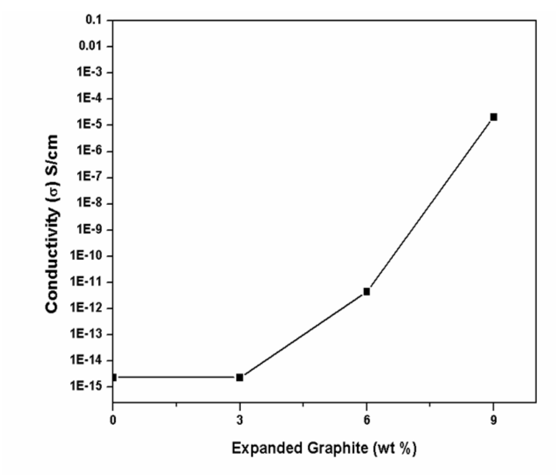
HRTEM images of (a) Expanded graphite (b) epoxy/EG composite at 9 wt% of graphite concentration.

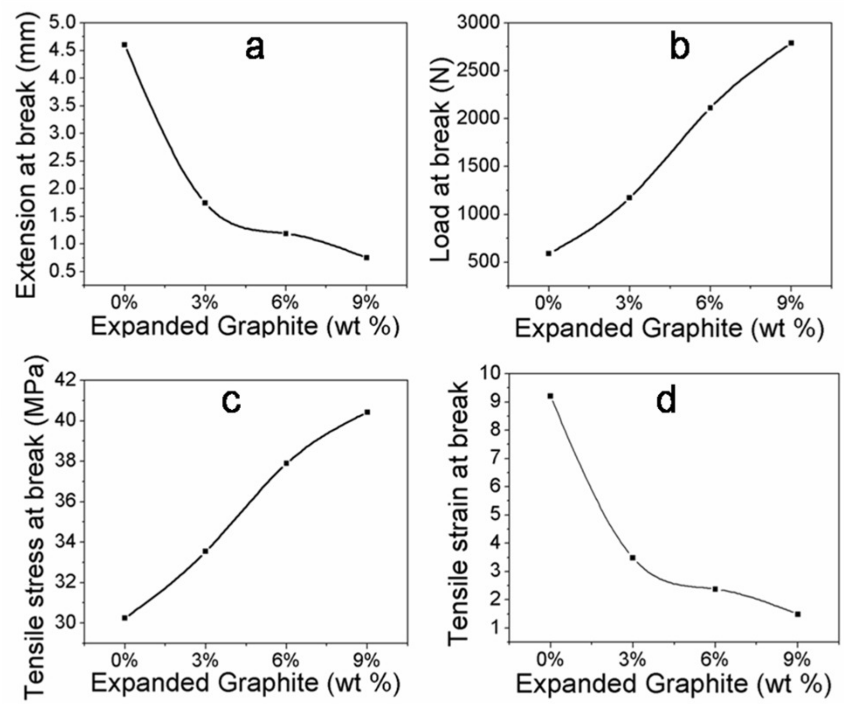
Swain et.al New Carbon Materials,, (2014) Accepted

Epoxy/graphite



TGA of (a) Epoxy (b) Epoxy /EG, 3 wt% (c) Epoxy/EG, 6 wt% (d) Epoxy/EG, 9 wt% (e) Expanded graphite



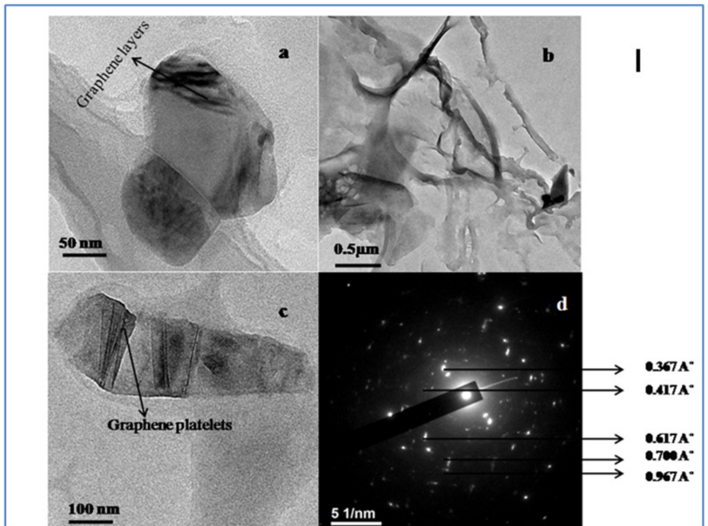


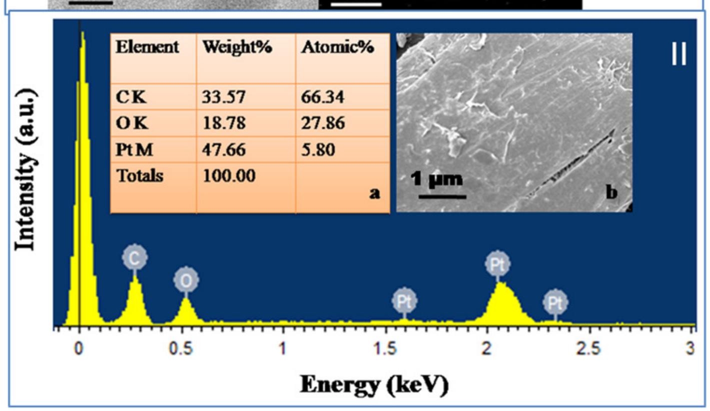
Mechanical properties of epoxy/EG composite as a function of EG concentration for study of (a) extension at break (b) load at break (c) tensile stress at break (d) tensile strain at break.

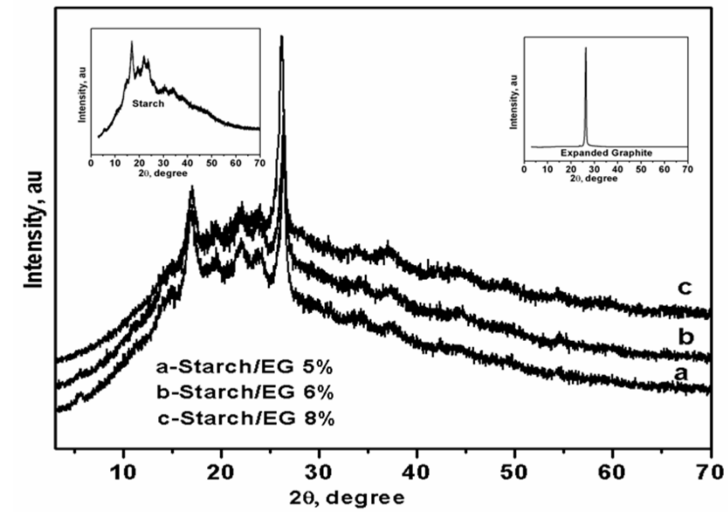
Swain et.al New Carbon Materials,, (2014) Accepted

Starch/EG Bionanocomposites

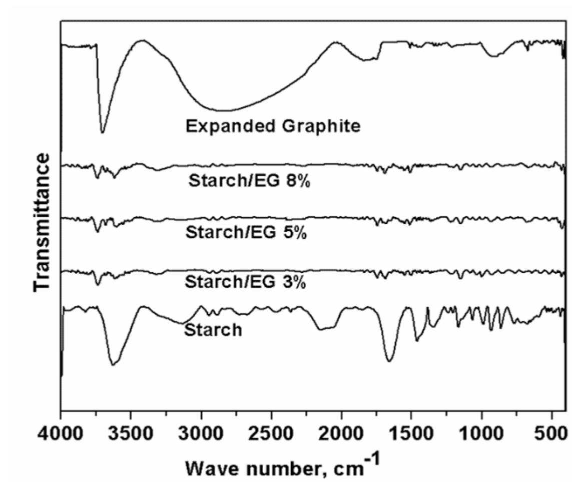
Morphological analysis







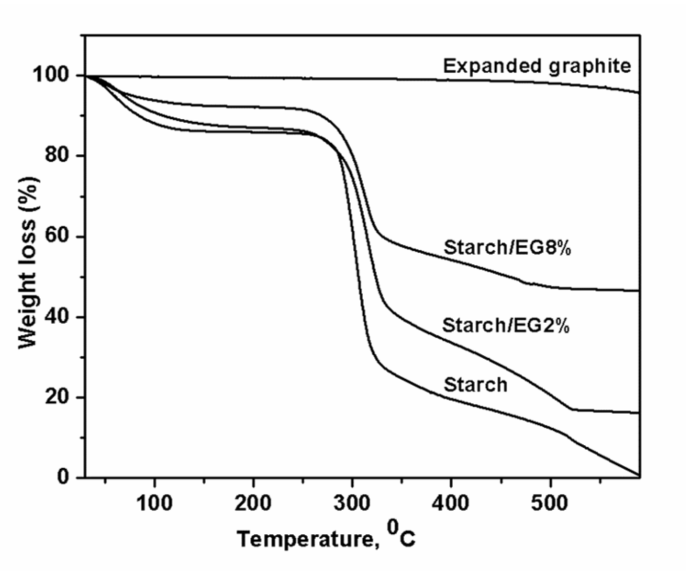
XRD pattern of starch, EG (in set) and starch/EG bionanocomposites as function of EG concentration



FTIR spectra of starch, EG and starch/EG bionanocomposite.

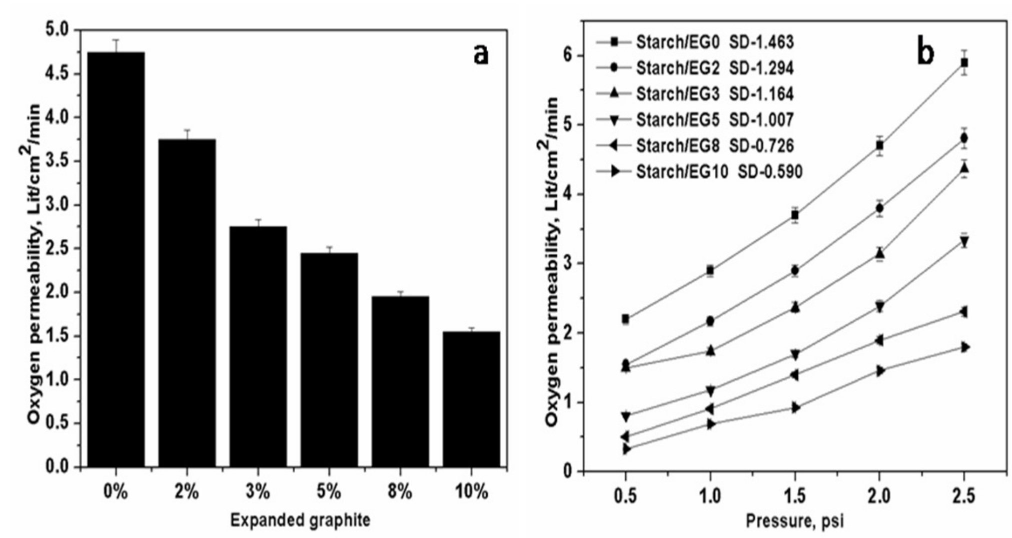
Swain et. al, Carbohydrates Polym (2014)

TGA Analysis



TGA curves of starch, EG and starch/EG bionanocomposites of 2 and 8 wt % of EG.

Gas barrier property



Oxygen permeability of starch and starch/EG bionanocomposites at constant pressure (a) and different pressure (b). (SD-Standard deviation)

Swain et. al, Carbohydrates Polym (2014)

CONCLUSION

- Polymer based bionanocomposites are prepared by green technique with reinforcement of graphite
- Uniform dispersion of graphite platelets is achieved due to strong interfacial adhesion of graphite with surface of the polymers
- Synthesized nanocomposites are characterized by FTIR, XRD, FESEM, HRTEM
- Gas barrier properties of biopolymers is enhanced by increasing percentage of graphite
- Graphite reinforced composites have enhanced thermal properties
- Chemical resistant and biodegradable properties of nanocomposites are studied

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DAE-BRNS, Government of India

Department of Biotechnology, Govt. of Odisha

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- Dr. S. Dash
- Dr. SK Basiruddin
- G.C. Pradhan
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- N. Sarkar
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- F. Mohanty
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Recent Publications

2014

1. ***Carbohydrate Polymers*** (Elsevier) 99, 306-310 (2014).
2. ***Composites Part B: Engineering*** (Elsevier), 62, 236-241(2014)
3. ***Chinese Journal of Polymer Science (****Springer),* (2014)
4. ***Polymer-Plastics Technology and Engineering*** (Taylor Francis) (2014)
5. ***Polymer Composites***, ***(****Wiley)* (2013) . DOI 10.1002/pc.22897
6. ***Materials Science in Semiconductor Processing***, (Elsevier) (2014). 23, 115-121 (2014)
7. ***Fibers and Polymers,*** (Springer) In press (2014).
8. ***J. Mater Sci. Techn (Elsevier)***. (**2014**) Early View DIO: 10.1016/j.jmst.2013.12.017
9. ***Polymer Composites***, ***(****Wiley)* 00, 00-00 (2014) DOI 10.1002/pc.22773.
10. **J Exp. Nano Sci**,, 09 (03), 240-248 (**2014)**
11. ***Ind. J. Pure Appl. Phys*** *52, 30-34* (2014).
12. SPE, ***Pastics Research Online***, (**2014)** DOI: 10.2417/spepro.005285
13. **New Carbon Materials (Elsevier) In press 2014**
14. **Polymer Composites (Wiley) 2014 Early view**


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