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NOVEL PEG6000 DOPED GRAPHENE NANO POWDER COMPOSITE WITH IMPROVED STRUCTURAL AND MECHANICAL PROPERTIES

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Abstract

This study investigates the synthesis, characterization and properties of polyethylene Glycol/graphene nano powder binary composites (PEG/GNPs). These nanocomposites were prepared by co-precipitation method. Structural, morphological, and mechanical properties of these samples were investigated by X-ray powder diffraction (XRD), Fourier transformation infrared (FTIR), Field Emission Scanning Electron Microscopy (FE-SEM) and Universal testing machine (UTM). XRD confirms the phase analysis and crystallinity of the composite. SEM, FTIR and EDS spectroscopy confirms the microstructure of graphene nano powder, identification of functional group and quantitative analysis for elements, respectively and counter confirms the formation of the composites. SEM gives detailed information about the morphology and part distribution. It shows that with the increasing ratio of GNPs (2wt% to 3wt%), the average thickness becomes reduced from 18.43nm to 14.69nm respectively. Mechanical properties were characterized by universal testing machine (UTM). From a mechanical point of view, there was an excellent balance between a remarkable increase in young's modulus of 3.99N/mm^2 for 2wt% and 24 N/mm^2 for 3wt% with a slight reduction in the elongation break i.e., 61.11(%) and 33.84(%) respectively.

Keywords: Novel PEG/GNP Composites, Structural Study, Mechanical Study.

1. INTRODUCTION

Immense research has devout to multiple composites like binary and ternary graphene-based composites in current years. This is due to the fact that graphene, with its anomalous properties, stimulated researcher of different disciplines and fabricate numerous graphene composites or hybrid for application in various field [1]. A variety of top-down and bottom-up techniques have been victoriously employed to prepare graphene and its derivatives [2]. Recently, carbon family are the most attractive nanofiller. It is a promising operative nanofiller to increase the polymer's properties. However, effectual interfacial interaction and uniform distribution between the nanofiller and matrix are needed for obtaining ideal material properties [3-4].

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meanwhile, Graphene is stronger and strength a two-dimension sheet of a single atomic thick layer of a hexagonally lay out carbon atom with a range of remarkable distinctive physical properties. These make graphene flawless supreme candidate for a broad range of applications [5].

2. EXPERIMENTAL METHOD

Analytical grade chemicals including, Graphene nano powder, PEG (Polyethylene Glycol), Ammonium hydroxide, NMP (N-Methyl pyrrolidone) were used for the production of Novel PEG/GNP Composites.

Co-precipitation method was used in order to uniformly disperse 01 g GNPs in deionize water via sonication for 30 mins. The temperature of hot plate was maintained at 80°C with magnetic stirring for 1 hour. Then given amount of PEG was added in deionized water to obtain PEG solution by stirring and adding in GNP thick solution. NH_4OH solution was then added dropwise in above solution at 150°C temperature and 400 rpm. Wash the solution with deionize water. Collect all the precipitate. Dried the solution in oven. Grind the dry sample and make fine powder with the help of electronic griding. Samples with low contents of GNPs (2wt% and 3wt%) were prepared.

Crystallographic study of sintered sample was carried out using PANalytical diffractometer Bruker D-8 X-ray using a Copper K-alpha source (λ~1.54 Å), the samples were scanned within the range of 20°~120° with a step size of 0.03°. Scanning Electron Microscopy (SEM) analysis was carried out in order to explore the microstructure of the sample, Fourier Transform Infrared Spectroscopy (FTIR) was carried out to recognize types of chemical bonds, i.e., functional groups (Model no: Perkin Elmer precisely FT-IR spectrometer) over the wave number range of 4500-500 cm^{-1}, and Tensile properties of the samples were explored by Universal testing machine SHIMADZU (screwed AG-X 100 KN).

3. RESULTS AND DISCUSSION

3.1 Structural Analysis

3.1.1 X ray Diffraction Analysis

The PEG_{6000}/GNP composite were prepared by the co-precipitation method and the crystal plane of PEG_{6000} are indicated at 13.8° (110), 14.8° (020), 19.3° (120), 23.2° (032), 27.0° (024), 27.4° (131), 31.0° (220), 36.4° (111) and 43.1° (200) as shown in Fig 1(a). These peaks are observed in composites, especially when the wt% of GNPs increases to 3wt% [6]. Whereas, the scattering angle (2θ) of GNPs were at 38°, 44.5°, and 65°and 78° as mentioned in Fig1 (b). The diffraction peaks of GNPs at angle 44.5° allocate the graphite-like structure [7].

The existence of all these peaks (PEG6000 and GNPs) are clearly observable in the composites, when the concentration of GNPs is maximum (at 2wt% and 3wt%). The small peaks observed at an angle of between 10° and 20°, indicates that graphene is not fully

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interlocked with oxygen atoms at smaller content of GNPs, but by increasing the number of GNPs to 3wt%, reasonable high intensity peak is 0observed at 27º. According to the reported literature, both GNPs and PEG have few common peaks at the same angles, which can be due the superposition of the PEG and GNPs [8-9]. As the concentration of Graphene nano powder increases, the peaks become sharper and show more crystallinity in composites [10].

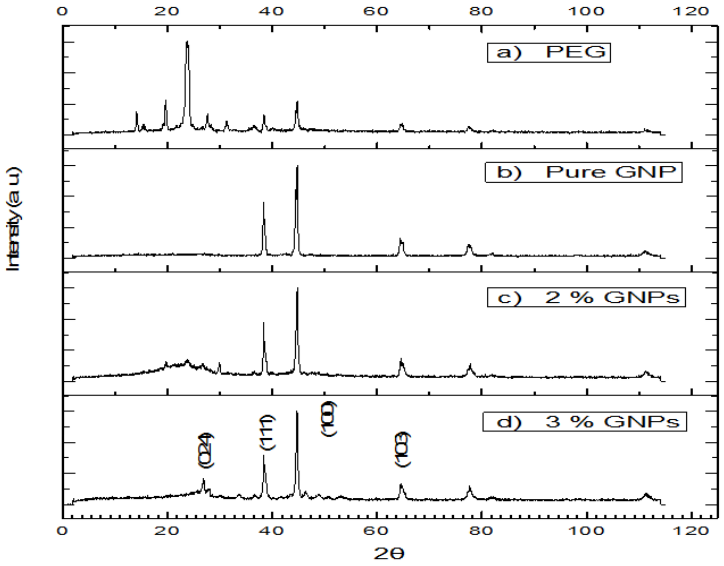

Fig 1: a) PEG b) Pure GNP c) 2%GNPs d) 3%GNPs

3.1.2 Fourier Transform Infrared Spectroscopy Analysis

The FTIR spectra of PEGs as shown in Fig. 2 with two different molecular weights indicate different functional groups such as, the peaks located at 1098 cm^{-1} and 958 cm^{-1} represent the –C–O–C– symmetrical and asymmetrical stretching, respectively. These peaks of PEGs indicated adequate agreement with the behavior proclaimed by another author [11]. Whereas, the peak detected at 1575 cm^{-1} attributed to carbon-carbon double bond for aromatic C=C bond confirm the defined structure of graphene. Peaks at 1060 (C–O), 1720 (C=O), 2878 (C–H), 3409 (O–H) stretching vibrations, indicates formation of graphene nanosheet which is further confirmed by SEM results. Next, the peak at 3409 cm^{-1} is allocate to O–H bonds vibration, whereas the peak allocated at 2878 cm^{-1} is associated to C–H bonds incorporated in GNPs/PEG composites [12-13].

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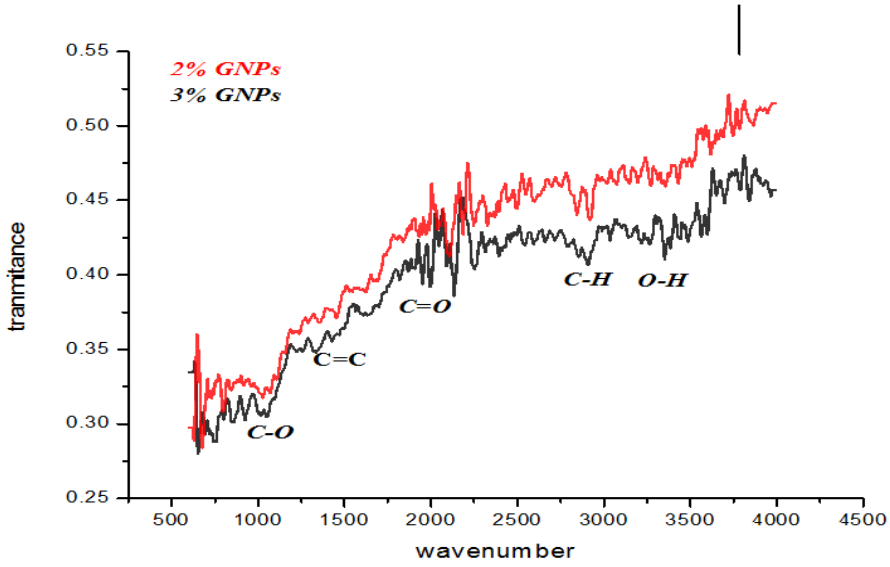

Fig 2: (a) 2%GNPs (b) 3%GNP

3.2 Morphology and Microstructural Analysis

The SEM micrograph of GNPs/PEG composite as shown in Fig. 3 showed a laminated sheet like structure, well- homogenously distributed with no agglomerates. Meanwhile, the extremely thin and flexible nature of graphene sheets can be distinctly observed in the high magnification SEM images. **The SEM of composites is different from SEM of pure PEG and GNPs** and the differences in morphology are clearly evident of its reaction.

The graphene nanosheets are resemble with sheet of paper. It is stretchable and easily deformed, mainly when the maximum shear force is applied GNS are interface by plane to plane so the contact area among layers is large [14]. With these preferentially oriented nano-sheets, it is use in the setup of multilayer parallel plate capacitor [8]. Then, EDS analysis was carried out to observe the chemical characterization and quantitative analysis for the occurrence of oxygen containing groups on the sheets. It shows a good distribution of carbon and oxygen on the surface as well as the edges of the graphene nanosheets. Existence of oxygen in samples show the functionalization of graphene nanosheets [15]. At the low concentration of GNPs, the thickness of GNPs/PEG composites sheets were thinner.

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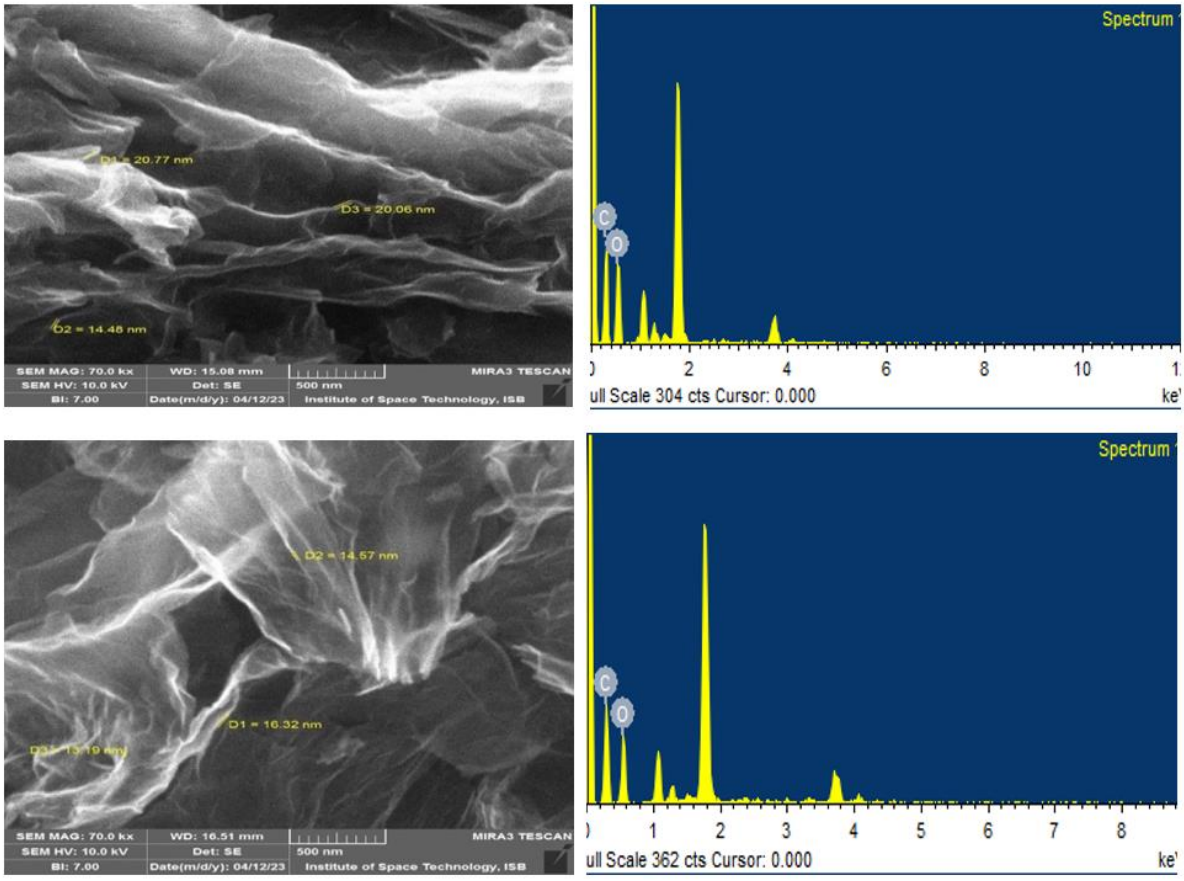

Fig. 3: (a) 2%GNPs (b)3% GNPs composites

Table 1 Thickness of Graphene sheets

Samples	Sheets Thickness (nm)	Average Thickness (nm)
3%GNPs	13.19, 14.57, 16.32	14.69
2%GNPs	14.48, 20.77, 20.06	18.43

3.3 Mechanical Properties

Mechanical properties of PEG/GNPs composites have been determined using Universal testing machine. The content of GNPs layers and produced composition have been directly correlated to mechanical properties as depicted in Fig 4. From a mechanical perspective, there was an extraordinary balance between a significant increase in young's modulus of 3.99 N/mm^2 and 24.4 N/mm^2 for 2wt% and 3wt% doping of GNPs respectively, and a slight depletion in the elongation at break as shown in Table 2 [16].

Table 2: Mechanical Properties

Samples	Load Break m(N)	Load yield (N)	Strain break (%)	Stress yield (N/mm^2)	Youngs modulus (N/mm^2)
2%GNPs	116.00	25.00	61.25	0.3183	3.9956
3%GNPs	151.00	151.00	33.843	1.9226	24.464

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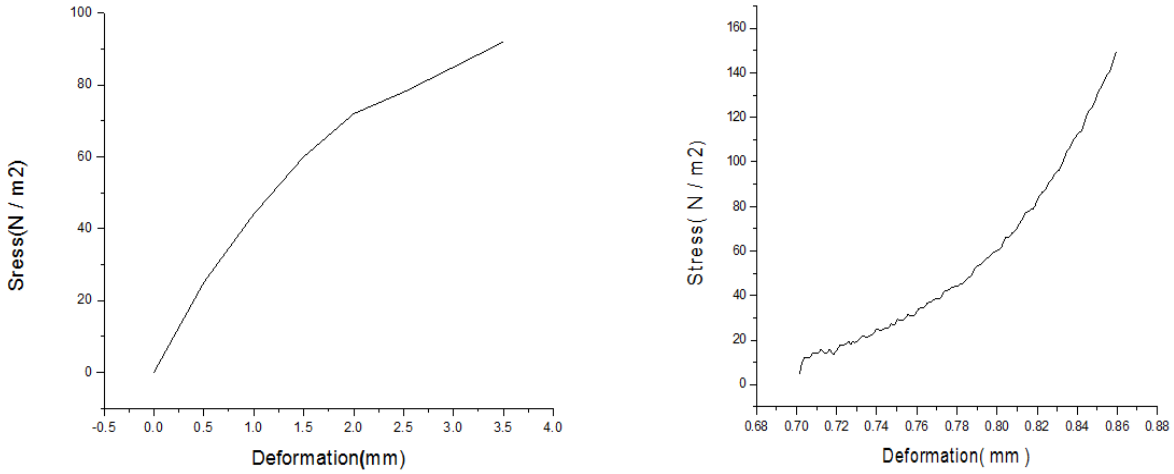

Fig. 4: (a). 2%GNPs (b). 3%GNPs composites

4. CONCLUSIONS

The characteristic behavior was observed by using different techniques. FTIR results showed corresponding functional groups and bond formation of stretching. XRD confirms the crystal structure of GNPs/PEG composites. It shows more crystallinity by increasing low content of GNPs in Composite. SEM analysis of composites show its unique sheets like structure. The composites achieve the sheets like morphology which provide the more contact area and increase strength. The nature of GNPs content scattering in polymer lattice corresponds to its mechanical properties which show an increase in young modulus by increasing GNPs content in PEG from 3% to 2% GNPs.

This study concludes that the Graphene based PEG nano-composites is paying attention day by day due to their prospective application including mechanical, structural and electrical.

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Statements & Declarations

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript, and reported work is in compliance with ethical standards.

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