



GRAPHENE OXIDE BASED POLYMER NANO COMPOSITES

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Abstract

The objective of this paper is to identify the potentiality of Graphene Oxide(GO) based polymer nanocomposites for load critical applications. Polymer composites have very excellent mechanical properties and it is used from decades for several applications. Because of the rapid industrialization the need and demand for new and innovative materials is increasing day by day, Polymer nanocomposites also have several merits and these are full filling the required material properties because of tailored properties according to industrial and human needs. GO is hydrophobic in nature and having some properties which are compatible with polymer resin. Because of the interaction between these two materials we will get the better mechanical properties just by adding little amount of GO. In the present paper we have conducted experiments at different weight percentages of GO and found that the mechanical properties are increasing as increasing the percentage of GO.

Key words: Resin, Polymer, Graphene Oxide(GO), Nano fillers, Fiber.

I INTRODUCTION

Nano composites plays very crucial role in many fields of engineering now a days because of rapid industrilization and need for new and innovative materials in several fields. polymer composites have several important and commercial applications that include elastomers used for damping, electrical insulations, and good strength to weight ratio for structures in composites are needed for use in aircraft. materials with high performace are chosen to prepare composites with the tailored properties i.e ,when low modulus material polymer are

added to high modulus fibers (glass or carbon) will create stiff and very light weight composites are possible and these composites are also toughness upto some extent . this concept is also reached to an end because of its limitations. the properties were also compromised in some cases. it is very difficult to invent a new materials. in such cases it is better to have modify the existing materials and its properties just by incorporating the nanofillers in the materials.in which the fillers are less than 100nm in at least one dimension. this new materials is called nanocomposites. if the nano fillers are added to polymer then this materials is called polymer nanocomposite. if more athan two materials are added then that is called hybrid polymer nancocompoistes. Nano fillers are available in different shapes and sizes, generally these are available in three firoms that is tube or fiber which ihave a diameter less than 100nm, plate like fillers which are layered materials whose thickness is less than 100nm and particles whose diameter is less than 100nm. processing techniques used and properties depends on the geometry of fillers.

Research on graphene oxide is increasing day by day and it is the fastest growing area. Lot of research is also going on in this area irrespective of branch. Interdisciplinary research is also going on i.e physics, chemistry, materials science and nanocomposites. It is due to unique properties of GO and its compatibility with other materials. it has several application. The graphene era started from 2004. Graphite is a three dimensional carbon based material. It is made of several million layers of graphene. in oxidation process by using strong oxidizing agents the layers will expand and separate and also makes the materials to be hydrophilic.

Hydrophilic means it can dispersed in water. Because of this property GO is exfoliated in water using sonication. The main difference between Graphite oxide and graphene oxide is that the number of layers. Although, the pristine graphene has the highest theoretical strength, it has shown poor dispersion in polymer matrices due to restacking as well as its low wettability, resulting in decreased mechanical properties of reinforced Nano composites. GO is commonly used to improve the mechanical properties of graphene/polymer composites, for the reasons of excellent mechanical properties (e.g. Young's modulus of monolayer of GO is 207.6 ± 23.4 GPa [63]), abundant functional groups, which facilitate strong interfacial interactions and load transfer from the host polymers to the GO and ability to significantly alter the Vander Waals interactions between the GO sheets, making them easier to disperse in polymer matrices [24]. El Achaby et al. [25] have fabricated graphene oxide Nano sheets (GOn)/PVDF Nano-composite films by solution casting method with various GOn contents in dimethylformamide (DMF). Due to the strong and specific interaction between carbonyl group (C = O) in GOn surface and fluorine group (CF₂) in PVDF, the GOn were homogeneously dispersed and distributed within the matrix. The Young's modulus and tensile strength of PVDF were increased by 192% and 92%, respectively with the addition of 2 wt% GOn. The morphology of Nano composites where the majority of GOn has been exfoliated and uniformly dispersed throughout the polymer matrix with almost no large agglomeration is in excellent agreement with observation of improved mechanical properties. The property enhancements can be related to the strong and specific interfacial interaction that results in the adsorption of macromolecular chains of PVDF on to the GOn surface. Strong interfacial adhesion between the graphene platelets and polymer matrix is crucial for effective reinforcement. Incompatibility between phases may lower stress transfer due to poor interfacial adhesion, resulting in a lower composite strength properties. Covalent or non-covalent functionalization of graphene based materials can be used to tailor the interface to promote stronger non-covalent interaction between the matrix and graphene platelets. Hydrogen bond

interactions and Van der Waals interactions were reported as the responsible interactions for improved mechanical properties [23]. We have reviewed the recent advances in fabrication and properties of graphene-polymer Nano composites. We have also discussed the recent studies and progress of synergistic property improvement in hybrid graphene- CNT polymer Nano composites. Based on the review, it is clear that the reinforcement of graphene and its derivatives in polymer matrices has shown very promising results in improving mechanical strength and elastic modulus, enhancing electrical conductivity at a low percolation threshold, increasing thermal conductivity, stability and flame resistance, and reducing gases and water vapour permeation. All of these enhancements have a great potential for applications in many fields either as structural or functional materials. For example, high strength and light weight structural polymer composites can be used in aerospace and automobile industries. Mechanically reinforced thin film composites find their applications in petrochemical and biomedical industries. Thermally conductive and stabilized composites can be used in the structures requiring thermal management. Electrically conductive composites have been widely used for making various sensors, conductive electrode for solar cells, antistatic coatings, electromagnetic interference shielding, etc.

II EXPERIMENTAL

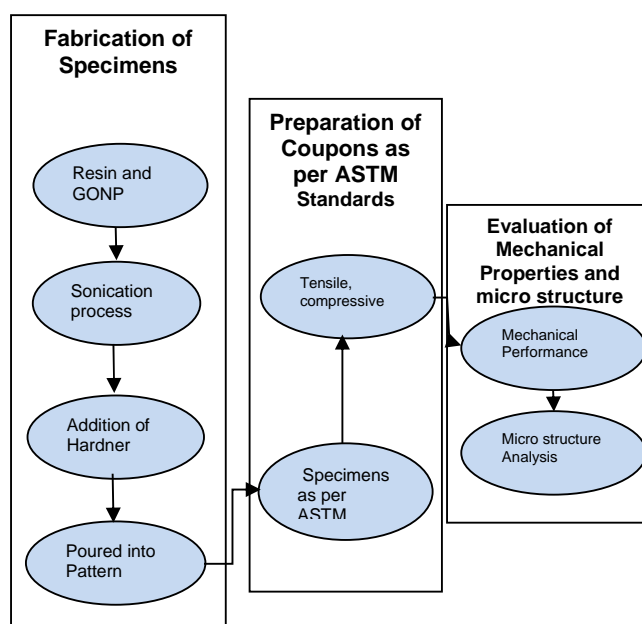


Fig.1.

To fabricate the composites materials we have followed a sequence of operations as shown in the above figure. We have divided the entire experimentation into three segments as fabrication, preparation of specimens as per ASTM standard and Evaluation of Mechanical properties. In the first stage the resin is modified by adding the GO nanoparticles. For proper dispersion of nanoparticles in the resin we have used the sonicator. After proper dispersion cool the mixture to room temperature. Then add the hardener to the mix and pour it into the patterns. Apply some pressure over the patterns after pouring the mix and keep it for 6-7 Hours and then cut the specimens as per ASTM standards and conduct the tests for mechanical properties.

- Then take the required amount of Resin and mix it with the Hardener. The required proportions to mix the Resin and Hardener should be 10:1.
- At first we have to make the specimens without the nanoparticles. The specimens should be done with the help of Pattern which are made up of wood.
- Fiber and resin volume ratios are 60 : 40 percentages.
- We have used the Teflon sheet sprayed with silicon release spray for easy removal of specimen from the pattern.
- The pattern are given some tolerances to get exact dimensions to the specimens after cutting.
- The specimens are cured for 12 to 15 hours
- After removing the specimen from the pattern. We will cut the raw pattern in to required dimensions. In one pattern we can make three specimens i.e., Tensile, Compressive, Hardness.
- After this we carry the tests like Tensile test, Compressive test on Universal Testing Machine and Hardness test on Brinell or Rockwell hardness testing machine.

2.1 Materials:

Resin: Araldite LY556 is an epoxy resin based on Bisphenol-A suitable for high performance composite FRP applications, it has good fiber impregnation properties excellent mechanical, dynamic and thermal properties.

E-Glass fiber: E-Glass Fiber bidirectional mat with 450 GSM. E-Glass is also called electrical grade It has excellent fibre forming capabilities. Now a days it is used in almost all the reinforcing phase in the materials. it is commonly well known as fibreglass. Melt spinning is one of the technique to produce glass fibres. it involves melting the glass into a platinum crown which has small holes for the molten glass to flow. Continuous fibres can be drawn out through the holes and wound onto spindles, while short fibres may be produced by spinning the crown, which forces molten glass out through the holes centrifugally. Fibres are cut to length using mechanical means or air jets. Fibre dimension and to some extent properties can be controlled by the process variables such as melt temperature (hence viscosity) and drawing/spinning rate. The temperature window that can be used to produce a melt of suitable viscosity is quite large, making this composition suitable for fibre forming. As fibres are being produced, they are normally treated with sizing and coupling agents. These reduce the effects of fibre-fibre abrasion which can significantly degrade the mechanical strength of the individual fibres.

Nanoparticles: Nanoparticles have one dimension that measures less than 100nm. The properties of many conventional materials change when formed as nanoparticles. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to some other molecules. In our experimentation we have used the nanoparticles which are supplied from nanowings, khammam. They have supplied the nanoplatelets with thickness 10 to 15nm and Area 100micron meters.

Preparation of GO/epoxy resin

The original GO powder was cleaned using ethanol. take on vessel and add the GO nano filler to the resin. Mix this resin for some time by using hand or magnetic stirring. Place the mixtures under the sonicator. Stir it at high speeds and temperature so that the air bubbles in the resin and resin Go mixture will be released and allow them to escaped.

Composite Manufacturing:

The composite specimens must be prepared in a required dimensions. The dimensions

should be taken according to the ASTM standards as shown in table No.1

Tests Conducted	ASTM TEST STANDARD
Tensile test	ASTM D3039 (250*25*3)
Compression test	ASTM D3410 (155*25*3)
Hardness test	Any size of the specimen

Fig No.2




	
E- Glass Fiber	GO Nano particles
	
Wooden Mould	Modified Epoxy applied to E-Glass fiber
	
Neat Epoxy composite for tensile test	Neat Epoxy composite hardness test
	
Modified epoxy composite	Modified epoxy composite

Fig No,3

Modal Calculations for preparation of Specimens:

Density of E-Glass fiber=0.00254 g/mm³

Density of Araldite LY556 resin

=0.00117 g/mm³

Volume of the total specimen to be prepared = 260*80*3 = 62400 mm³

The fiber and resin are taken in the ratio of 60:40

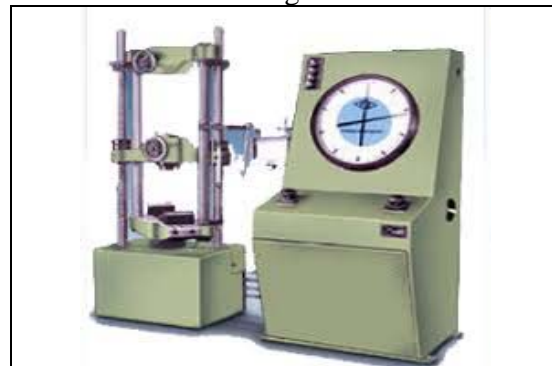
Mass of the resin to be taken

=density * 40% of volume

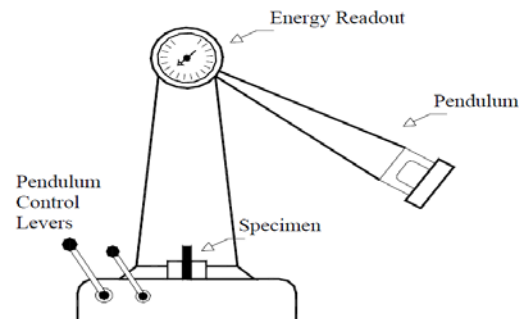
=0.00117*(0.4*62400)

=29.2032 g

Fig No.4



Universal Testing Machine with 60 Ton Capacity



Impact Testing Machine.

Charpy -Izod Impact Testing Machine



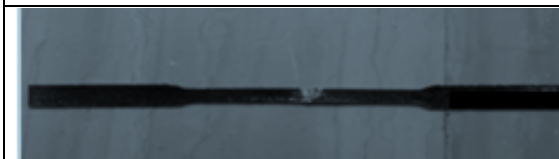
Rockwell Cum Brinell Hardness tester

III RESULTS AND DISCUSSION

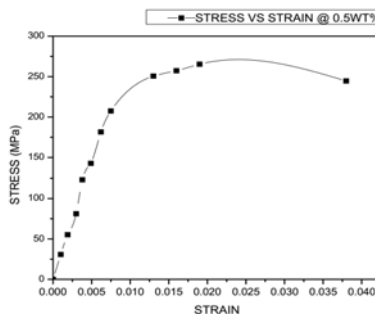
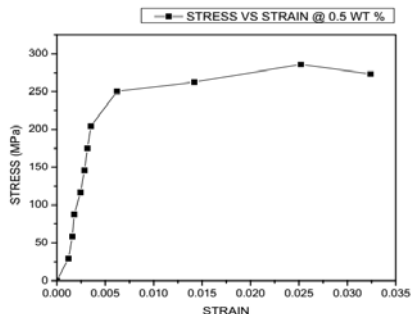
TENSION TEST:



Bidirectional Neat Epoxy Polymer Composite



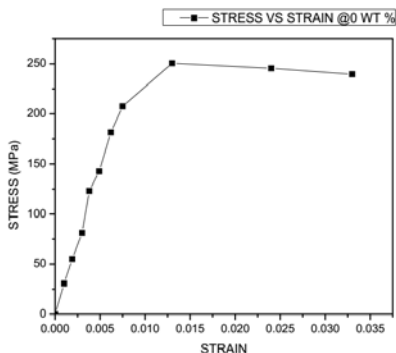
Bidirectional GO based polymer nanocomposite



Specimen	Machine	Test conducted	Ultimate tensile strength (Mpa)
Without of GONP in the specimen	UTE-60	Tension	250.443
Without of GONP in the specimen	UTE-60	Tension	265.345
With 1% addition of GONP	UTE-60	Tension	285.449

COMPRESSION TEST:

Specimen	Machine	Test conducted	Ultimate tensile strength (Mpa)
With of GONP in the specimen	UTE-60T,MCS	Compression	7.09
With of GONP in the specimen	UTE-60T,MCS	Compression	7.10
With 1% addition of GONP	UTE-60T,MCS	Compression	7.23



Hardness Test:

Specimen	Equipment used	Test conducted	Hardness Values
With of GONP in the specimen	Shore Hardness Tester	Shore "D" Hardness	53
With of GONP in the specimen	Shore Hardness Tester	Shore "D" Hardness	55
With 1% addition of GONP	Shore Hardness Tester	Shore "D" Hardness	57

CONCLUSIONS

Under Tensile test loading when compared with neat polymer composites materials, the GO based polymer nanocomposite exhibit better mechanical properties. Neat epoxy composites have 250 MPa of stress, 0.5 weight percentage GO based composites have 265 MPa of maximum stress and 1 Weight percentage of GO based composites have 285 MPa stress. Under compression the specimens were not able to withstand for longer loads. It fails at very less load compared with tensile loading. Neat epoxy failed at 7.09 MPa, 0.5 weight percent specimen fails at 7.10 and 1 weight percent specimen fails at 7.23 MPa. In Hardness test near polymer composites gives hardness number as 53, 55 and 57 respectively for neat, 0.5 weight percentage of GO and 1 weight percentage of GO. If we still increase the concentration of GO the mechanical properties will also improve. Still this is under investigation. GO nano fillers can disperse in resin under sonication. The bonding between GO nanofiller and resin have good interaction. To determine this interaction we need to conduct the SEM analysis.

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