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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF EPOXY POLYMER REINFORCED WITH GRAPHENEOXIDE

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ABSTRACT: In this study, the effects of graphene oxide (GO) on composites based on epoxy resin were analyzed. Different ratios of GO from 0 to 1% were added to epoxy resin. The GO and epoxy composite materials was prepared using the casting method and performed under room temperature .To perform the Mechanical tests' results such as tensile test,and Flexural test show enhancements of the mechanical properties of the GO/epoxy composite. The experimental results show the filler material in the epoxy/resin increase the tensile strength and hardness. The Flexural strength was seen to decrease, pointing to brittleness increase of the GO/epoxy composite.So to increase the strength of flexual strength an healing agent used to improve the properties. A microstructure analysis Scanning Electron Microscopy (SEM) is done for GO composite to understand the structure,bond and crack of GO/Epoxy composite material From this research the GO/epoxy composites that if filler material ratio increased the strength of the material decreases.

KEYWORDS: Epoxy,Graphene,Nanocomposites

INTRODUCTION

Graphene oxide (GO) composites are carbon-based materials with excellent performance and low cost. [1]They possess high Young's modulus and tensile strength . They are applied in a variety of civil, mechanical and aerospace applications. Carbon fiber composites also have found widespread use since their creation in the 1950s. They also have highly advantageous mechanical properties, and at the same time they are light and easy to manufacture .[3] GO materials are used in polymer composite systems as fillers to improve the mechanical properties of the parent polymer materials. [5]Epoxy – GO systems have the ability to produce light and strong materials with many useful features. However, the method they proposed for preparation and mixing of the solution did not sufficiently distribute GO in the epoxy matrix. [8]A microscopic examination showed agglomerates several tens of micrometers large after maxing.

According to , the modulus of epoxy-based composites increases when fluorinated GO is present managed to significantly improve the adhesion .[7] The additions of GO to the epoxy yielded better Young's modulus and strength.Research that uses GO to reinforce epoxy-based composites shows that the matrix generally contains only a limited content of GO and a homogeneous dispersion is achieved. However, the processing time is long due to the use of solvent. In this paper, the intention is to eliminate the use of solvent while raising the GO content and the homogeneity of dispersion. The proportion of GO is increased in the epoxy matrix and it is shown that the mechanical properties are enhanced as a result. There is an improvement in hardness and tensile strength. The GO/epoxy composites are more brittle, which is why there is a reduction in impact strength.

3.EQUIPMENT

3.1 MATERIALS

3.1.1 SILICONE RUBBER RTV 1613-A&1613-B

Silicone rubbers are supplied as compounded rubbers ready for molding and curing, but pure gum rubber can be obtained on request from the suppliers. Pure gum requires fillers and vulcanizing agents, usually benzoyl peroxide. According to the pigments used, these rubbers can be either red or white. The pigments are iron oxide and silica, carbon black is generally avoided since it inhibits cure by peroxides. The vulcanization of silicone rubbers differs from normal curing; 3–6 min curing at 130°C is normally needed to set the gum rubber in a mold

Figure 3.1.1 Silicon rubber RTV

3.1.2 EPOXY/HARDNER

Diglycidyl ether of bisphenol A (DGEBA) epoxy prepolymer with an amine-based hardener systemand .The epoxy system is 90% a clear epoxy resin and 10% a hardener. These are mixed with varying amounts of GO to obtain the composite. Clear epoxy resin has a viscosity ranging from 11,000 to 14,000 cps.The L12 and K6 resin and hardener acts as a curing agent,that rebond the material

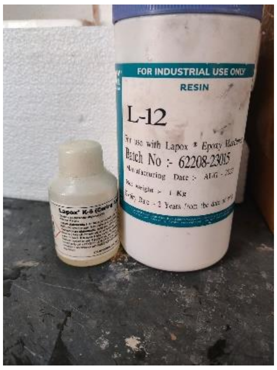


Figure 3.1.2 epoxy/hardner

Table 1. Specification of Lapox L-12[14]

Property	Unit	Value
Epoxide Equivalent	gm/eq	182-192
Epoxy Value	eq/kg	5.2-5.5
Viscosity at 25^0 C	mPa.s	9000-12000

Table 2. Specification of K6[14]

Property	Value
Refractive Index at 25^0 C	1.4940-1.5000
Water Content	1% max

3.1.3 SURFACE MODIFIED GRAPHENEOXIDE (GO)

Graphene oxide is a 2d material which consists of graphene nanoplatelets containing functional organic groups with less than 5% of oxygen.Grapheneoxide specification that we having 2-6 layers with daimeter of 1-5 micron.

Table 3. Specifications of Grapheneoxide

Property	Units	Value
Color	**-**	**Amber**
No.of layers	**-**	**2-6**
Diameter	μ	**1-5**
Thickness	**nm**	**0.5-2**
Bulk Density	**g/cc**	**0.241**

3.2 METHADOLOGY

3.2.1 PATTERN ARRANGMENT

The tensile sample in dumb-bell shapes and these dimensions are 90.40*9.53*4 and flexural sample in rectangular shapes and these dimensions are 70*15*patterns and Rectangular plane slab glasses with 30mm*15mm*3mm are used for pattern arrangement .Take a glass slab place the clay on the glass on the above of it ,place the specimen and press by the hand and remove the overpart of clay from specimen. By using clay here the patterns can be removed easily from the glass after the moulding .The wall like a mould cavity is attached by using other four rectangular glasses by adding glue at the edges of glasses to stick each other.

3.2.2 SILICON RUBBER MOULD

For Silicon rubber mould take the composition ratio(90:10) 1613part-a(130gms)and1613 part-b(14.44gms) on weighing machine and pour the synthetic rubber liquid in the glass mould and The material is then vulcanized by prolonged exposure to the air. A step cure is used for articles more than 0.125 inch (0.3 cm) thick, e.g. 12 h at 150°C followed by 12 h at 200°C. . Hot air curing must be in a well-ventilated oven. Molding shrinkage of silicone rubbers during cure is high, so molds of precise oversize which take into account the high shrinkage are designed, to achieve correct dimensions after vulcanization.

3.2.3 COMPOSITION PREPARATION

Different percentages by volume of GO (0, 0.25, 0.50, 1,) were used to obtain epoxy blends with 90:10 equivalent epoxy ratio. The composites of epoxy and graphene oxide were mixed the uniformly with a mini stirrer at 1000-1200 rpm for 10-15 minutes at 25 °C as in Fig 3.2.3.This mixture contains air bubbles which may defect the samples,to remove or to reduce the bubbles use vaccum desiccator after that add hardner according to ratio and stir it with a spatula,finally the mixture is ready and the mixture is poured in mould ,The mould were placed in an oven at 40 °C. The samples were held inside oven for 3.5 h at 40 °C to get rid of moisture that may be adsorbed on the surface. After 24 h at the room temperature (25 °C), the GO reaction with epoxy was complete.The samples are collected from the mould.samples can be seen in fig 3.2.4

Table 4. Composition for preparing specimen samples

Sample panels	Wt (%) GO	Epoxy(L12) Content	Graphene oxide (GO) Content	Hardner (K6) content
1	0	200 gm	0	20 gm
2	0.25	170 gm	0.45 gm	17 gm
3	0.5	120 gm	0.6 gm	12 gm
4	1	170 gm	1.7 gm	17 gm

Figure 3.2.2 Silicon rubber mould

Figure 3.2.3 GO/Epoxy composite

Figure 3.2.4 Specimens

4**.** MECHANICAL TESTING

4.1 TENSILE TEST

The tensile test, also known as the tension test, is a common mechanical test used to determine the behavior of materials under tensile loading. This test is often used to evaluate the mechanical properties of materials such as strength, modulus, and ductility. The test is performed on UTM

Nano composites are materials that are made up of nanoparticles and a matrix material. The addition of nanoparticles can significantly enhance the mechanical properties of the matrix material. The tensile test can be used to evaluate the mechanical properties of nano composites, including the effects of the nanoparticles on the properties of the composite.The Test is performed for the 0%,0.25%,0.50%,1% of GO/Epoxy composite

Figure 4.1 Tensile Test on UTM

4.2 FLEXURAL TEST

The flexural test, also known as the three-point bending test, is a mechanical test used to determine the flexural properties of a material. In the case of nanocomposites, the flexural test provides valuable information about the material's stiffness, strength, and resistance to bending.The load is applied at middle of the specimen.

Figure 4.2 Specimen on UTM

5. RESULTS AND DISCUSSION

5.1 The Tensile Properties Of Nanocomposite Specimens

Table 2: Facture Loads Of Tensile Nanocomposite Specimens

Tensile Specimens	Tensile load (N)	Tensile Strength (Mpa)
GO 0%	65.5	9.2
GO 0.25%	70.5	10.1
GO 0.50%	58	7.9
GO 1%	55.5	7.3

The tensile strenght is more at the ratio of 0.25% GO ,as we see that if filler material ratio increases the strength of the material decreases ,so the require filler material The results of the tensile tests showed that adding GO increased the tensile strength, load, Young’s modulus and elongation. The fracture strain was seen to go down. Addition of GO to the epoxy composite induced a rise in tensile strength from 65 MPa. When GO content was 0.25 vol.%, the maximum strength was 70 MPa. An increase of GO content beyond this amount caused a reduction in tensile strength to 57Pa. To further analyze the influence of GO addition to the mechanical properties of the composite, the following variables were assessed, both independently and in terms of their mutual interaction: structure, oxidative treatment and concentration level.The effect of GO content on the Young’s modulus of the epoxy composite. content between 0 vol.% and 1 vol.% concentration range. While the surface functionality and dispersion of the material is initially inadequate, addition of GO improves the properties of the composite. The interfacial adhesion also improved due to the compatibility between GO and the epoxy matrix

5.2 The Flexural Test Properties Of Nano composite Specimens

Flexural strength or bending strength is the mechanical parameter of material, which is defined as the material’s ability to resist deformation under load. The flexural properties are calculated by using a three-point bending configuration, where the sample was supported from both ends, and the load was applied at the middle of the sample. The maximum stress applied to the tension side of the sample to break it is known as the ultimate flexural strength of a sample’s content varied at 0, 0.25, 0.50, 1 wt.% with respect to matrix in the composites. It is found that the flexural strength of the composite goes on decreasing when the content of filler increases, while the flexural modulus increases

Table 3: Facture loads of Flexural Nanocomposite specimens

Flexural Specimens	Flexural load (N)	Flexural Strength (Mpa)
GO 0%	560	23.35
GO 0.25%	420	17.24
GO 0.50%	340	16.26
GO 1%	390	16.98

Fig 1: Max. load of GO/epoxy composite at different contents of (GO).

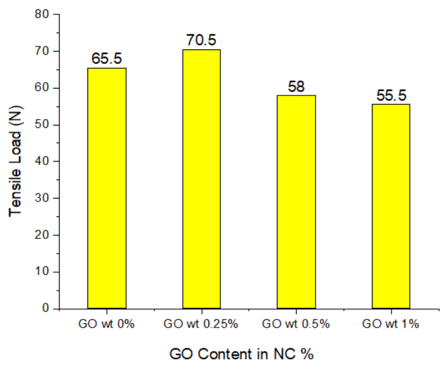


Fig 2: Tensile strength of graphene oxide/epoxy composite at different contents of (GO).

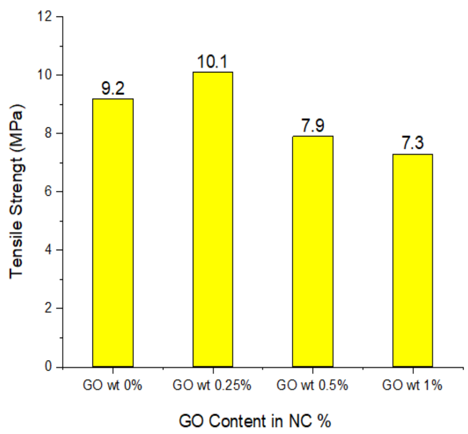
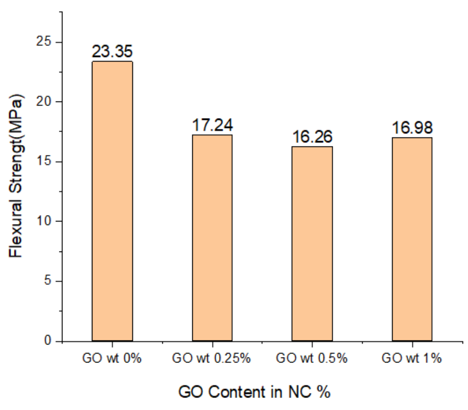


Fig 3: Flexural strength of graphene oxide/epoxy composite at different contents of (GO)



5.3 SEM RESULT

SCANNING ELECTRON MICROSCOPY (SEM) is versatile tool for visualizing, analyzing, and understanding nanocomposite materials. Its ability to provide detailed images and elemental information, SEM reveals the texture of the nanocomposite surface. This information is crucial for understanding adhesion, roughness, and interfacial interactions.

Here the SEM is done for tensile fracture sample which resits the high facture load in fig 5.3(A). A fracture surface is seen at 100× magnification, which indicates a brittle fracture shows how with 0.25% GO, the fracture surface becomes cloud-like and rough. The cracks become more randomly dispersed, indicating that the GO network acts as an obstacle to crack propagation. It is clear from the SEM image that GO is generallydispersed properly in the matrix.

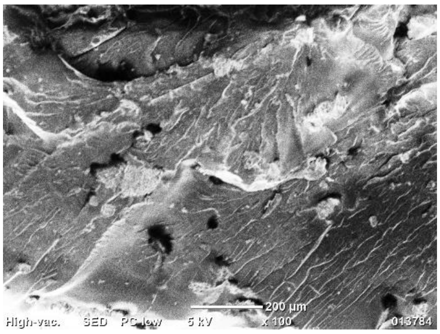


Figure 5.3(A) Sem image of GO 0.25%

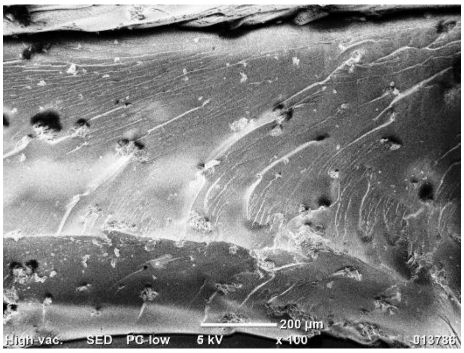


Figure 5.3(B) Sem image of 1 %

Figure 5.3 Sem Image Of Tensile Samples

CONCLUSION

Graphene oxide (GO) has great potential due to its excellent mechanical properties and high aspect ratio. In this study, the influence of graphene oxide (GO) on epoxy matrix composite was investigated. Adding 0.25% GO to the epoxy matrix increased the tensile strength of the composite compared to the pure epoxy matrix. The significance of the homogeneity of the composite for the mechanical properties of composites was demonstrated by an flexural test. While the Tensile strength and Flexural strength increased with GO addition. Considering their advantageous properties, GO/epoxy composites would work very well in applications in the electronic, aerospace and automobile industries.

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