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Influence of Nano Fillers in the Development of Glass Epoxy –Nano Alumina Hybrid Nano Composite

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Abstract

The research is carried out to develop a new polymer matrix hybrid Nano composite. The effect of alumina Nano particles between the glass fibre and epoxy resin was investigated. Well-dispersed Nano particles enhanced significantly the mechanical strength between fibre and matrix. The experimental analysis demonstrated that the quality of fibre/matrix interface was improved after the addition of alumina Nano particles to glass fiber.

Keywords: glass fibre, Nano alumina powder

Introduction

Nowadays enormous effects are undertaken to improve the mechanical, thermal and other properties of polymers. To achieve this property upgrade Nano composites are produced using fillers of various shape factors and dispersing them on Nano-scale resulting in the formation of Nano composites. Nano materials possess high strength, hardness, excellent ductility and toughness. Undoubtedly, more attention is being paid to the applications of Nano materials. Gadakaree [1] improved the mechanical properties of fibre-reinforced composites by improving the toughness of the glass matrix with micro-scale particle fillers. Oladapo Akinyede [2] employed Nano particles as reinforcement for an advanced composite comprised of fibre glass and epoxy matrix and study tensile and double cantilever beam test to understand the effect of particulate reinforcements on the damage mode. A significant improvement in performances of FRPs in which Nano particles were incorporated was obtained [3-5]. However, the Nano particles agglomerate was inevitable in some work; and the relative reinforcing mechanisms are still not well understood. The Nano particle provides additional supports to fibre-reinforced polymer composites which show the improvement in flexural and compressive strength at higher temperatures [6]. Uddin et al. [5] has reported that the silica Nano particle loading improves the compressive strength and modulus of the epoxy composite. Nano composites are materials that are created by introducing Nano particulates into a microscopic sample material. This is part of the growing field of Nanotechnology. The Nano materials tend to drastically add to the electrical and thermal conductivity as well as to the mechanical strength properties of the original material. In general, the Nano substances used are carbon Nano tubes, Nano particles and they are dispersed into the other composite materials during processing. Much research is going in to developing more efficient combinations of materials and to impart multi functionalities to the Nano composites. A Nano composite is the hybrid material consisting of a polymer matrix reinforced with a fibre, platelet, or particle having one dimension on the Nanometre (nm) scale (10-9 m).

In the present study an attempt has been made to prepare a glass fibre hybrid Nano composite. Efforts are made to study the effect of filler percentage variation of Nano-alumina in the glass epoxy composites. Experiment wear also carried out to study the mechanical properties of the developed composite.

Fabrication of Nano Particles

Materials used for the preparation of Nano particles of Alumina (Al_2O_3)

- Barosil glass beaker 1000ml, 500ml, 250ml, 100ml (each 5)
- Aluminium nitrate Al $(NO_3)_3.9H_2O$ (500gm)
- Ammonia solution $NH_3$30 % GR (2.51)
- Citric acid (monohydrate) GR (500gm
- Glycine GR (500gm)
- EDTA (100gm)
- Cumi silica powder (250gm)

Procedure for synthesis of Alumina (Al_2O_3) Nano particles

Alumina Nano particles are synthesized by auto combustion process from Aluminium nitrate and Citric acid is shown in figure 1. In this process involves heating and stirring up of the solution until the solution changes to gel form and once the solution changed to gel then stop stirring and heating is continued till it forms foamy mass and still heated up to remove all the water molecules present in the solution.

Figure 1 magnetic hot plate used for Auto combustion synthesis

Fabrication of Composite

Raw materials

Raw materials used in this experimental work are listed below

1. Epoxy Resin
2. Hardener
3. E-Glass Fibre
4. Alumina Nano

Method to prepare Nano alumina with glass fibre polymer hybrid composite

New layered Hybrid Composite slabs are prepared with 150×60×5 mm^3 by using high strength E-glass fibre and alumina with Epoxy as a matrix by hand lay-up technique. Different set of composites are prepared those are given in table 1. Composites were prepared by using resin to hardener ratio as 10:1. Test specimens of suitable dimensions are cut with a diamond cutter from the composite sheets for mechanical and thermal test as per ASTM standard.

Tensile Test

The tensile tests were performed according to ASTM D3039-76 standard using Universal Testing Machine at a crosshead speed of 0.5 mm/min. length of the test specimen is 125 mm and five specimens for each sample were tested for accuracy. The tensile strength calculated using the following equation:

Tensile strength (Mpa) = $\frac{P_{max}}{bh}$ (1)

Where P_{max} = maximum load applied on test specimen (N)

b = Specimen width (m)

h = Specimen thickness (m)

3.4 Flexural Test

The flexural tests were performed according to ASTM D2344-84 using Universal Testing Machine INSTRON H10KS at a crosshead speed of 0.5mm/min. The span length was 70mm and five specimens for each sample were tested for accuracy. Flexural strength calculated using the following equation:

Flexural strength (Mpa) = $\sigma_{max} = \frac{3P_{max}L}{2bh^2}$ (2)

Where P_{max} = maximum load at failure (N)

L= Span length (mm)

b= Width of specimen (mm)

h= Thickness of the specimen (mm).

Inter-laminar Shear Strength (ILSS)

The value of inter-laminar shear strength (ILSS) was found out by using short beam shear test method as per the ASTM standard D 2344-84. A small beam of 45mm length which width and thickness are equal is loaded under three point bending at the rate of 1.3 mm/min. The force applied at the time of failure was recorded and the stresses were determined using the equation 3.

$$SH = \frac{(0.75P_B)}{bh} \quad (3)$$

Where SH inter laminar shear strength (N/mm^2), 'P_B' is the breaking load (N), 'b' and 'h' is width and depth of the specimen (mm). Span to depth ratio of 5:1 was selected for the test. A minimum of five samples of each type were tested and the average ILSS values were determine.

Results and Discussion

Tensile strength

Tensile strength of glass epoxy composite at different Nano filler loading is shown in figure 2. As the Nano alumina content increases with glass fibre in polymer, the strength of the composite also increases. Glass fibre having 2% alumina shows maximum tensile strength than other composites.

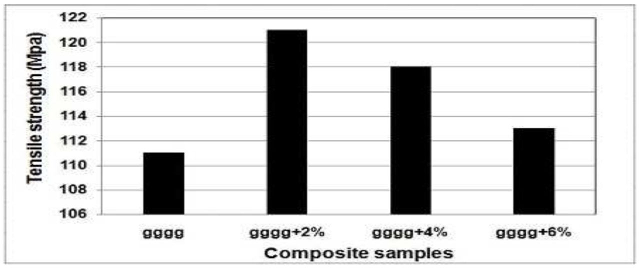

Figure 2 Tensile strength of glass polymer composite with different Nano alumina content

Tensile modulus

Tensile modulus of the glass polymer composite with different Nano Alumina content is shown in figure 3. In general, it is noted that the tensile modulus of the matrix material is lower than those of the glass epoxy Nano alumina composite. Glass fibre having 2% alumina shows maximum tensile modulus than other composites.

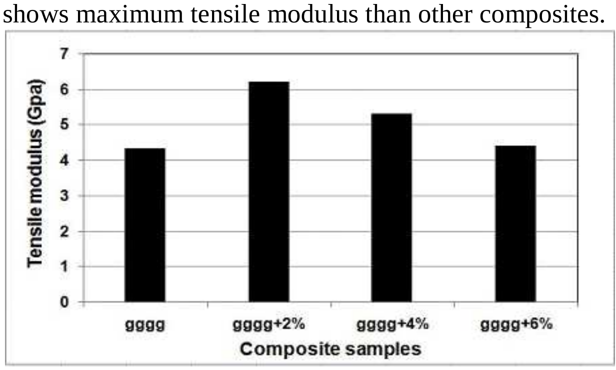

Figure 3 Tensile modulus of glass polymer composite with different Nano alumina content

Flexural strength

Flexural strength of glass epoxy composite at different filler loading is shown in figure 4. As the alumina content increases with glass fibre, the strength of the composite also increases in both the cases. Glass fibre having 4% alumina shows maximum flexural strength than other composites.

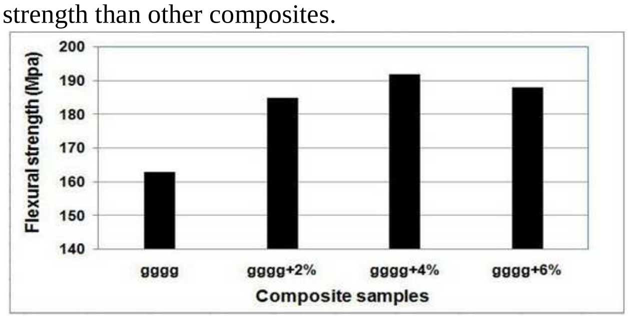

Figure 4 Flexural strength of glass polymer composite with different Nano alumina content

Flexural modulus

Flexural modulus of the glass polymer with different Nano alumina is shown in figure 5. Figure indicates that the addition of Nano alumina particulate with epoxy resin increases bending strength of the composite. Glass fibre with 4% alumina particulate composite shows maximum strength 192 MPa.

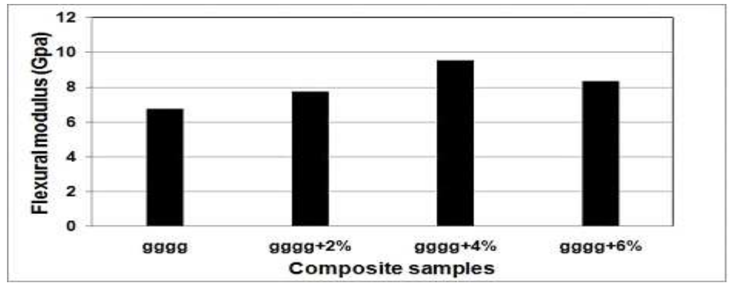

Figure 5 Flexural modulus of glass polymer composite with different Nano alumina content

Inter laminar shear strength

Generally ILSS increases with the reduction of void fraction. From the ILSS results shown in Figure 6, it is seen that increasing the filler content leads to the increase of the ILSS of the composites, which can be related to the effect of increasing the degree of adhesion at interfaces among the filler and matrix material. The factors that caused to improvements in ILSS properties is the load transfer capability between the matrix and filler materials and strong interfacial bonding between filler and matrix. Inter laminar shear strength of glass fibre polymer composite with 4% Nano alumina shows maximum shear strength at the interface of composite.

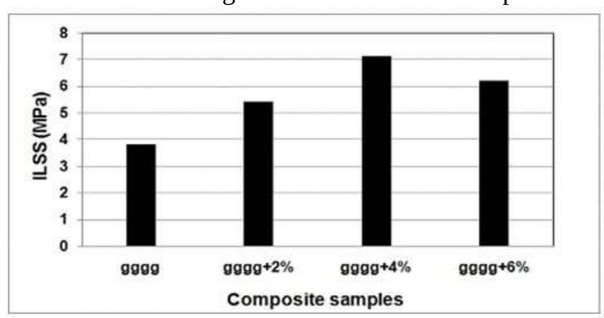

Figure 6 ILSS of glass polymer with Nano alumina composite with different Nano alumina content

Conclusions

The present work deals with the preparation and characterization of glass epoxy reinforced with Nano alumina composite. The experimental investigation that includes mechanical and tribological properties of glass fibre can significantly be improved by in cooperating ceramic particulates with it, such as. For Nano alumina filler composite tensile strength and tensile modulus, flexural strength 193(MPA) and flexural modulus 9.5(GPA) of the glass fibre polymer composite is found to be maximum with 4 volume percent Nano alumina.

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Inter laminar shear strength of the glass fibre polymer with 7(MPA) for 4 volume percent Nano alumina composite has maximum shear strength. The erosive response of the glass fibre reinforced with Nano alumina composites has ductile behavior

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