Indian J.Sci.Res. 15 (2): 210-214, 2017 ISSN: 2250-0138 (Online)

AN EXPERIMENTAL STUDY ON SOME MECHANICAL PROPERTIES OF EPOXY/GLASS FIBER HYBRID COMPOSITES MODIFIED BY 10 Wt% SiO_2 MICRO PARTICLES

ALINA DASH[a1], BIKASH RANJAN MOHARANA[b] AND AYUSMAN NAYAK[c]

[abc]Gandhi Institute For Technology, Bhubaneswar, Odisha, India

ABSTRACT

Improvements on mechanical properties of composite materials are still under research for different applications. Fiber reinforced polymer composite is playing an vital role for interdisciplinary research. This paper summarizes the experimental results of epoxy matrix which is modified by 10 wt % SiO_2 micro ceramic particles in glass fiber/epoxy composite. The composites are fabricated by hand lay-up method. It is observed that mechanical properties like flexural strength, flexural modulus, hardness and toughness increase compare to neat epoxy but inter laminar shear strength (ILSS) decreases. Agglomeration of SiO_2 micro particles is observed in SEM analysis. The mode of failure is the combination of crack in matrix, deboning and fiber pull out.

KEYWORDS: Polymer Matrix Composite, Glass-fiber, Flexural strength, SiO_2.

From the recent and relevant published work in the area of fabrication and characterization of glass fiber reinforced composite, it is well documented that majority fillers have a positive influence on mechanical properties. Development of new composite materials or modification of existing composite material is the real challenge for most of the materials engineers. This modification can be done by addition of different ceramic powders of different sizes to achieve the required mechanical properties.

The modern use of FRP composite began in the world war-ii . Metals and ceramics are available as matrix are currently expensive so polymer are much more commonly used. And processing of PMC need not require high pressure and high temperature also equipment requires for manufacturing are simpler so PMC developed rapidly and become popular. Different materials are suitable for different applications. The use of additives can greatly affect the FRP/Composite properties. Epoxy resin has been widely used in many industrial products due to its advanced properties such as higher modulus, higher adhesive strength. Development of new composite materials or modification of existing composite material is a real challenge for most of the materials engineers. This modification can be done by addition of different ceramic powders of different sizes to achieve the required mechanical properties.

C.M. Manjunatha et al.(2010) studied the tensile fatigue behavior of a silica nano particle-modified glass fibre reinforced epoxy composite.They found that the fatigue life increased about three to four times by addition of the silica nanoparticles. In 2011 Bin Wei et al observed Strengthening of basalt fibers with nano-SiO2–epoxy composite coating. They compared by coating the basalt fiber with SiO2 nanoparticle–epoxy composite and with the pure epoxy . And found that the SiO2 nanoparticle–epoxy composite coating gave a significant increase in the tensile strength of the basalt fibers as compared with the pure epoxy coating which is an effective way in improving the mechanical properties of basalt fibers. A systematic study on the effects of silica and rubber nano-particles on the fracture toughness behavior of epoxy was conducted by Hong-Yuan Liu et al (2011) and it is observed that fracture toughness of epoxy can be significantly increased by incorporating either rubber or silica nano-particles. T.H. Hsieh et al (2010) studied The mechanisms and mechanics of the toughening of epoxy polymers modified with silica nanoparticles.Firstly they found that Young's modulus steadily increased as the volume fraction, of the silica nanoparticles was increased. And Secondly, the presence of silica nanoparticles also increase the toughness of the epoxy polymer. . Rongguo and Wenbo Luo (2008) studied the effect of nano silica filers on mechanical properties of epoxy composite. They found that elastic moduli of the nano-SiO_2/epoxy composite are more than those of the neat epoxy resins. However, the elongation of the composites decreases with increasing SiO_2 mass fraction. Chen et al. (2008) studied effect of highly dispersed nano silica-epoxy resins with enhanced mechanical properties. It is seen that there is substantial improvement on mechanical properties of the composite with nano SiO_2 fillers. Ahmad et al. (2008) studied the effect of SiO_2 particle shape on mechanical properties of SiO_2/epoxy composite. They observed that the elongated shape of silica mineral shows the

[1]Corresponding author

highest mechanical properties compare to other shapes and also the mechanical properties increases with increase in filler percentage. This is because of filler agglomeration, filler-matrix compatibility, bonding at interface and aspect ratio of the fused silica in the epoxy system. Johnsen et al. (2007) studied the toughening mechanisms of silica nano particle-modified epoxy polymers. They found that the glass transition temperature (T_g) was unchanged by the addition of the nano particles. However at the same time the modulus and toughness were increased with nano SiO_2 fillers.

More work is still needed to get a clear comparative study for better understanding of the mechanical response of epoxy composites modified with SiO_2 particles. Hence in this paper the mechanical properties of E-glass fiber reinforced epoxy composites with SiO_2 filler and without filler have been investigated. The analysis of the results and the relationship among composite samples are also reported. The mechanical properties are evaluated.

EXPERIMENTAL DETAILS

Materials

Both thermosetting and thermoplastic, are used as matrix materials for the composites. Glass is described as a thermoset plastic resin that is reinforced with glass fibers. Fibers provide strength, dimensional stability, and heat resistance. Additives provide colour and determine surface finish, and affect many other properties such as weathering and flame retardance.

All samples in this work were prepared by,

Fiber Material

Commercially available woven roving fabric E-glass fiber with silane-coupling sizing system (Saint-Gobian Vetrotex) with fiber thickness of 8 micron is used as re-inforcement.

Figure 1: Woven roving E-Glass fiber Matrix Materials.

The epoxy resin are being widely used for many advanced composite due to their excellent adhesion to wide variety of fibers, superior mechanical and electrical properties and good performance at elevated temperature and also they have low shrinkage upon curing and good chemical resistance. . The epoxy which is used was Araldite(LY-556) an unmodified epoxy resin based on biphenyl-A-diglycidyl-ether and chemically belongs to ‘epoxide’ family and hardener (HY -951),aliphatic 951, aliphatic primary amine are supplied by Ciba-Geigy ,India .

Figure 2: Epoxy LY-556

Filler Material

While ceramic powder such as alumina (Al2O3), silicon carbide (SiC), silica (SiO2), titania (TiO2) etc. are widely used as conventional fillers. In this study, SiO2 (< 10 micron)) particleis used to modify the epoxy matrix, purchased from Alfa Aesar, India.

Composite Fabrication

Two types of composite, one modified with silica nano filler and other one without filler material was fabricated by hand lay-up method. Before mixing with epoxy, initially the silica powders are dried at 60 oC for 2hrs. The required amount of filler is weighted and mixed with neat epoxy.The mixture is stirred manually using a glass rod for a time period of 30 minutes. Then hardener added. After fabrication of each layer, to remove entrapped air and to achieve uniform thickness, rolling is done with a MS roller . The castings are put under load for about 72 hrs for proper curing at room temperature.

As per the ASTM standard, Specimens are cut for description by using a diamond cutter. The designations of the composites are reported in Table -1. Where C1 is the composite with filler and C2 is the composite without filler.

Figure 3: Composite after Fabrication

Table 1: Designation and composition of composite

Designation of composites	Composition
C_1	Epoxy + 60 Wt% Glass fiber + 10 Wt % SiO_2
C_2	Epoxy + 60 Wt% Glass fiber

RESULTS AND DISCUSSION

The fabricated composite is cut by means of a diamond cutter of required dimensions as per the standard and the waste part of the composite are eliminated.

Figure 4: Specimen for Silica modified Composite

Flexural and Inter laminar Shear Strength

The inter-laminar shear strength (ILSS) and Flexural strength (FS) are conducted as per the ASTM-D2344/D2344M-00 by short beam shear (SBS) test. The dimension of the specimen for the test is 28 mm X 11 mm X 5.5 mm and span length of 22 mm. Universal testing machine Instron 5967 is used to conduct the test. The cross head speed is maintained at 1 mm/min .The ILSS and flexural strength (FS) are calculated as per the following equations:

$$ILSS = \frac{3P}{4bt}$$

$$FS = \frac{3PL}{2bt^2}$$

Where P → Maximum load (N)

B → Width of the specimen (mm)

T → Thickness of the specimen (mm)

L → Span length (mm)

It is observed that both flexural strength and modulus of is more But Inter laminar shear strength is less for SiO2 modified epoxy as compared to neat epoxy. This may be because of finer particle size (<10 micron) of silica. As decrease the particle size, increases the surface area and better adhesive bond between matrix and filler, therefore SiO2 particles gives better adhesive strength and improve the mechanical properties. Figure 1(a),(b)and(c) shows comparison of flexural strength, flexural modulus and ILSS with silica modified epoxy and neat epoxy respectively.

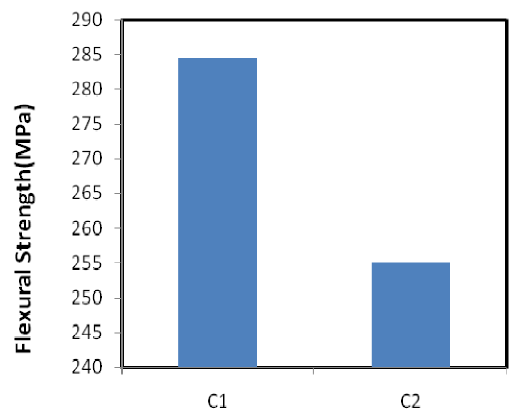

Figure 5: Comparision of flexural strength VS micro filler

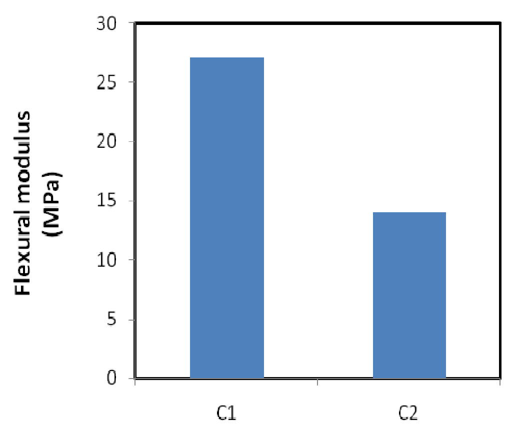

Figure 6: Comparison of flexural modulus VS micro filler

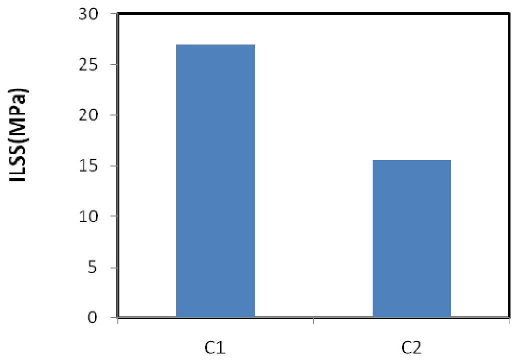

Figure 7: Comparison of ILSS VS micro filler

Micro-Hardness

Digital Leco micro-hardness tester is used to measure the micro-hardness of the composite. It is observed that the hardness is more for SiO2 modified epoxy as compared to neat epoxy

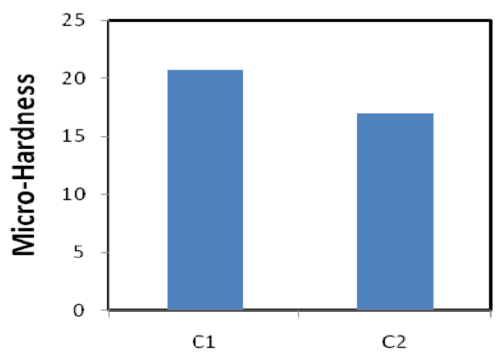

Figure 8: Comparison of micro-hardness VS micro filler.

Impact Test

The tests are done as per the ASTM D6110 using an impact tester. This is also reported that the Impact strength of neat epoxy is more. Fillers disturb the matrix continuity which can act as a micro crack initiator.

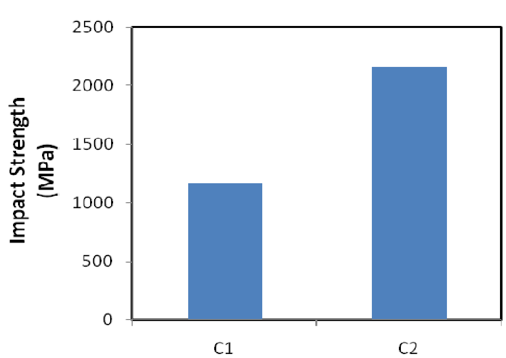

Figure 9: Comparison of Impact strength VS micro filler.

SEM Analysis

Fracture surface of SBS tested samples have been investigated using Scanning Electron Microscope (SEM). Figure shows the fracture surface of SiO2 modified epoxy composite. It is observed that there are pot holes in the matrix because of fabrication by hand layup technique. It is also observed that because of smaller particle size, the interface bond between filler and matrix is better.

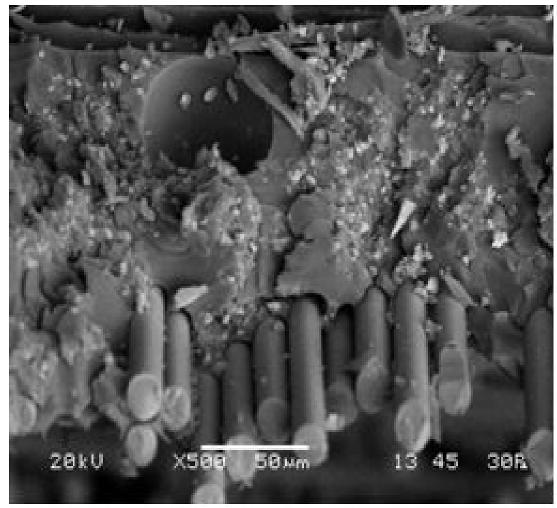

Figure 10: SEM micrograph for SiO2 particle modifier

CONCLUSION

The experimental investigation concluded the following points:

- Mechanical properties like flexural strength and flexural modulus are more in case of SiO2 modified epoxy composite compare to neat epoxy.

- SEM analysis clearly indicates the mode of fracture is the combination of matrix crack, matrix/fiber debonding and fiber pull out for all types of composite.

REFERENCES

Manjunatha C.M., Taylor A.C., Kinloch A.J. and Sprenger S., 2010. The tensile fatigue behaviour of a silica nanoparticle-modified glass fibre reinforced epoxy composite, Composites Science and Technology, **70**:193–199.

Wei B., Song S. and Cao H., 2011. Strengthening of basalt fibers with nano-SiO2–epoxy composite coating. Materials and Design, **32**:4180–4186.

Zhaoa R. and Luoa W., 2008. Fracture surface analysis on nano-SiO2/epoxy composite. Materials Science and Engineering A 483–484 (2008) 313–315.

Chen C., Justice R.S., Schaefer D.W. and Baur J.W., 2008. Highly dispersed nanosilica–epoxy resins with enhanced mechanical properties. Polymer, **49**:3805–3815.

Zamanian M., Mortezaei M., Salehnia B. and Jam J.E., 2013. Fracture toughness of epoxy polymer modified with nanosilica particles:Particle size effect. Engineering Fracture Mechanics, **97**:193–206.

Hsieh T.H., Kinloch A.J., Masania K., Taylor A.C. and Sprenger S., 2010. The mechanisms and mechanics of the toughening of epoxy polymers modified with silica nanoparticles. Polymer, **51**:6284-6294.

Ahmad F.N., Mariatti J., Samayamutthirian P., Khairun A. and Azizli M., 2008. Effect of particle shape of silica mineral on the properties of epoxy composites. Composites Science and Technology, **68**:346–353.

Johnsen B.B., Kinloch A.J., Mohammed R.D., Taylor A.C. and Springer S., 2007. Toughening mechanisms of nano particle-modified epoxy polymers, Polymer, **48**:530-541.