Fabrication of Properties of Epoxy Resin by Adding Reinforcing Agent

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Abstract – Fiber reinforced polymer composites are most important class of structural materials due to their numerous advantages. Reinforcement in polymer is either engineered or characteristic. Engineered fiber, for example, glass, carbon etc. has high quality however use of these fibers is restricted because of higher expenditure in production. Human hair can also be utilized as a fiber reinforcement material. An attempt has been made to study the utilization of human hair which is very economical and easily available for making different products. The mechanical properties of human hair reinforced epoxy composites are studied. The polymer composites with different concentration of human hair fiber i.e. 0%, 5%, 10%, 15% were analyzed and it was observed that there is significant influence of human hair reinforcement on the mechanical properties of composites.

Keywords: Composites, Reinforcement, Mechanical, Fiber.

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INTRODUCTION

Composite materials are the materials made of two or more substances that differ in form and chemical composition and are insoluble in each other. When these are combined together, one of them is long and stiff fibers, whereas, other is a binder also known as matrix keeps the fibers in place (Ban, 2015).

Latest researchers are trying for manufacture of new materials used for production of packaging, furniture, automobiles etc. (Abdellaoui, et. al., 2015). Epoxy resins (Lee and Neville, 1982) also known as polyepoxides are polyether pitches containing more than one epoxy aggregates and these are thermosetting in nature. They are broad applications: glues, holding, development materials (ground surface, clearing, and totals), electronics, insulators, covers, coatings, and material wrapping up.

Hair has properties of solidness, rigidity and great glue properties. Hair is equipped for withstanding high loads and can withstand up to 125grams of load. Hair particles are comprised of polymer constituents. Keratin is the essential component of hair fiber. Keratins are proteins which are polymers of amino acids.

MATERIALS AND METHODS

Materials

Human hair fiber, Epoxy resin, Hardner

Fiber Material (Human Hair)

The common fiber human hair is taken out from the local sources (Vincent, 1971). It is a fiber which is easily available in India.

Hair is utilized as a fiber fortifying material for the following reasons:

1. It has a high elasticity equivalent to that of copper wire.

2. It is a non-degradable matter.

3. It is additionally accessible with ease.

MATRIX MATERIAL

Polymer networks are the most generally utilized due to cost viability, simplicity of manufacture. Polymer networks are either thermoplastic or thermosetting (Williams, 1978. Eckold, 2000). The most normally utilized thermosetting gums are epoxy, polyester, polyurethanes and phenolics. Epoxy resin is the most commonly used polymer due to numerous reasons like, strong attachment to wide assortment of filaments, mechanical and electrical properties and use at higher temperatures. Because of all these factors, epoxy is picked as the lattice material for present work.

METHODS

The low temp. curing epoxy resin (Araldite LY 556) and corresponding hardner (HY951) are mixed and stirred manually to disperse the fiber in the matrix. After some time the mixture is poured into mould having dimensions (10×10×3) cm. The composite is left untouched for sometime so that mixture get solidified. Few sheets of composite of different length are cut down for mechanical testing with dimensions 0.5 × 1× 1.5 cm.

Composite Fabrication

The human hair fiber is gathered from local sources. A mould of size (10×10×2) cm is utilized for fabrication of composites. The human hair fibers are blended with epoxy by mechanical mixing (Allcock and Lampe, 1981. Kaufman and Falcetta, 1977).

RESULTS AND DISCUSSION

Water Absorption Test

A piece of composite of known dimension is weighted. Then the specimen is dipped into water over night and weighted again. Difference of two weights of specimen gives the weight of water absorbed by the specimen. From which we can calculate the weight percentage of absorbed H_2O.

From the results it has been observed that the absorption of water is increased when epoxy composite is reinforced with human hair because of increase in spacing between molecules of epoxy and human hair and more water is absorbed as compared to pure resin.

Absorption of water by epoxy composite reinforced with human hair according to different weight percentage of fiber.

Percentage of water absorbed by pure specimen = 4.4%

Percentage of water absorbed at 5% weight of fiber loading = 6.01%

Percentage of water absorbed at 10% weight of fiber loading = 8.37%

Percentage of water absorbed at 15% weight of fiber loading = 11.45%

Percentage of fiber loading	Pure	5%	10%	15%
Percentage of water absorbed	4.4%	6.01%	8.37%	11.45%

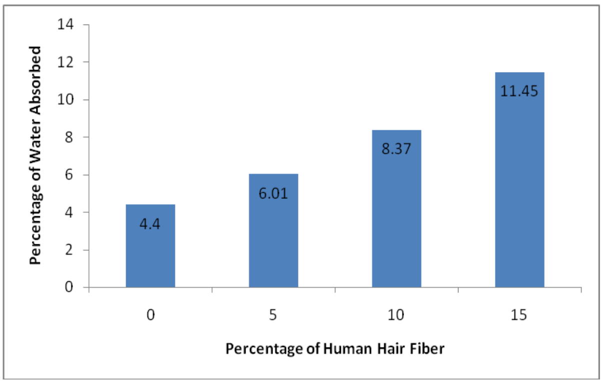

Fig. 1. Percentage of water absorbed by human hair epoxy composite at different percentage of fiber loading.

From these results it is found that percentage of water absorption increase with increase in percentage of fiber loading. This increase of water absorption was due to the formation of spacing between molecules of epoxy and human hair fiber.

The Flexural Test

The flexural test measures the force required to bend a beam under three point loading conditions. Flexural modulus is used as an indication of a material's stiffness when flexed (Simpson and Bidstrup, 1995. Barton et. al., 1998). Flexural strength is calculated from the maximum bending moment by assuming a straight line stress-strain relation to failure.

Flexural and three point bending test is used to measure elasticity of the materials. The fluxral and three point bending test shows that elasticity of the material increases on addition of human hair. The effect of fiber length parameter on flexural strength of epoxy composite at various percentage of human hair fiber has also been noticed.

Effect of fiber length at weight percentage of 5%

The flexural strength for the composites with 5% fiber loading increase upto 1.5 cm of fiber length after that starts decreasing. The increase in flexural strength was due to improved interfacial adhesion between the matrix and the fiber.

The overall performance of any fiber reinforced polymer composite depend to a large extent upon the fiber matrix interface which is governed by the surface topography of fiber and the chemical compatibility of fiber surface and resin properties.

Fiber length (cm)	Pure	0.5 cm	1 cm	1.5 cm	2 cm
Flexural Strength (Mpa)	79.5	89.5	101.2	108.5	98.2

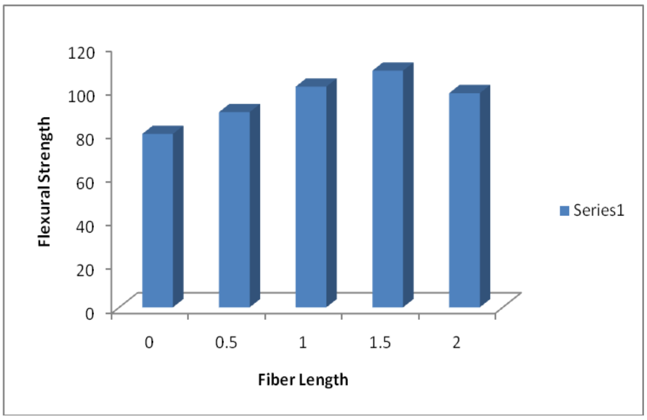

Fig. 2. Effect of fiber length at weight percentage of 5%

Effect of fiber length at weight percentage of 10%

For 10% fiber loading the flexural strength increases upto 1.5 cm after that it starts decreasing The increase in flexural strength was due to increase in interaction between fiber and matrix. Further decrease was due to increase in fiber-fiber interaction. The flexural strength at 20% fiber loading was lower than that the 10% fiber loading. It was due to the random short fiber distribution inside the composites matrix and also lack of adhesion between matrix and fiber.

Fiber length (cm)	Pure	0.5 cm	1 cm	1.5 cm	2 cm
Flexural Strength (Mpa)	79.5	91.2	101.2	108.7	95.2

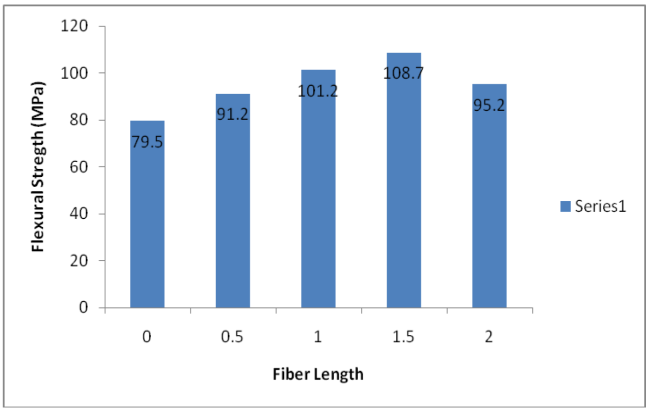

Fig. 3. Effect of fiber length at weight percentage of 10%

Effect of fiber length at weight percentage of 20%

For the 20% fiber loading the flexural strength initially increases upto 1 cm of fiber length and then starts decreasing. The increase in flexural strength was due to improved interfacial adhesion between the matrix and the fiber and whereas the decrease was due to increase in fiber-fiber interaction. Flexural strength at 20% loading was less than that of 5% and 10%. It was due to the random short fiber distribution inside the composite matrix and also lack of adhesion between matrix and fiber.

Fiber length (cm)	Pure	0.5 cm	1 cm	1.5 cm	2 cm
Flexural Strength (Mpa)	79.5	93.5	97.2	101.2	97.5

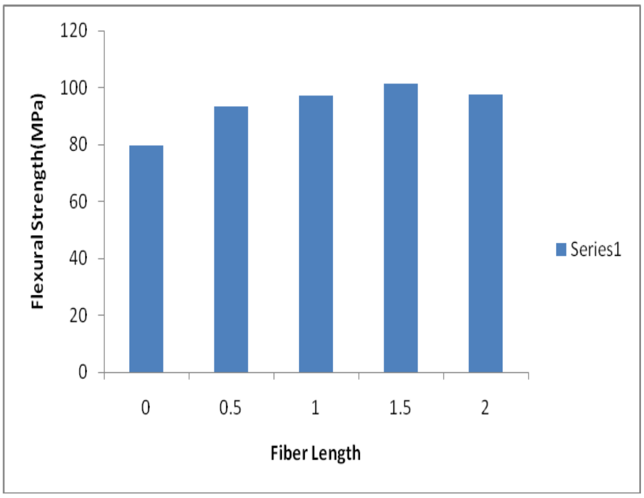

Fig. 4. Effect of fiber length at weight percentage of 20%

FTIR

Chemical structure of human hair epoxy fiber was evaluated by fourier transform infrared spectroscopy (FTIR) (Xu and Schlup, 1998). The FTIR were obtained on FTIR spectrophotometer. The closer investigation of the spectra reveals a difference in relative intensities of the C-H bands around 2900 cm^{-1} compared with the intensities of the amide (I) and (II) in the region at 1700 – 1500 cm^{-1} Even simple plotting of the ratios of the integrated areas of the amide (I) and (II) shows same structure within the individual samples. It was well known from the detailed band assignment of the amide group vbrations that the observed band contour was a superposition of a number of distinct band due to –C=O, N-H and C-N and these were coformationally senstile.

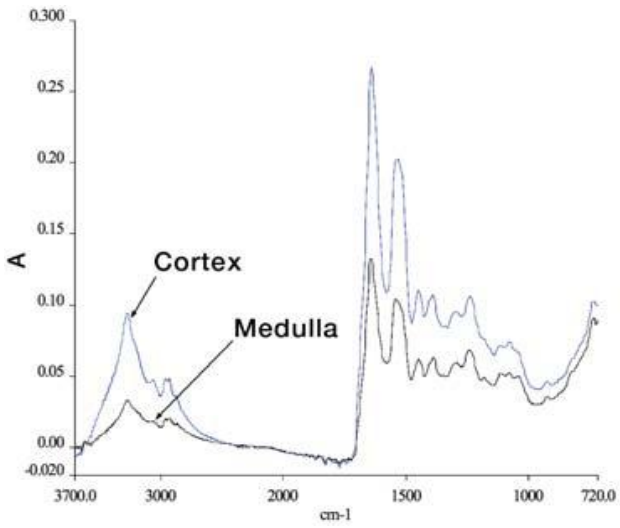

Fig. 5. FTIR Spectra

CONCLUSION

It has been observed that the fiber loading has critical impact on the mechanical properties of the composites. The mechanical properties like water absorbing tendency, flexural strength results are found best for reinforced composites.

Another way to enhance the composite properties is to determine an effective treatment to eliminate lack of adhesion between matrix and fiber.

After a point, strength of composite starts decreasing because interface bonding between fiber and resin goes on decreasing as fiber weight percentage increases in composite.

REFERENCES

Abdellaoui H., Bensalah H., Echaabi J. (2015). Fabrication, Characterization and Modelling of laminated composites based on woven jute fibers reinforced epoxy Resin, Mater Des, 68: pp. 104-113.

Allcock H. R., Lampe F. W. (1981). Contemporary Polymer Chemistry, Prentice-Hall, Inc.

Ban B. A. (2015). Effect of Fiber Loadings on Mechanical Properties of Coir Fiber Reinforced Epoxy Resin Composites, The 3rd National Graduate Conference (Nat Grad) University Tenaga Nasional, Putrajaya Campus.

Barton J. M., Hamerton I., Howlin, B. J., Jones, J. R., and Liu S. (1998). Studies of Cure Schedule and Final Property Relationships of a Commercial Epoxy Resin Using Modified Imidazole Curing Agents, Polymer, vol. 39, pp. 1929-1936.

Eckold G. (2000). Design and Manufacture of Composite Structure, McGraw-Hill Book Company, England.

Kaufman H. S., and Falcetta J. J. (1977). Introduction to Polymer Science and Technology: An SPE Textbook, John Wiley & Sons, INC.

Lee H.; Neville K. (1982). Hand Book of Epoxy Resins, McGraw Hill: New York, NY, 1982.

Simpson J. O. and Sue Ann Bidstrup S. A. (1995). Rheological and Dielectric Changes During Isothermal Epoxy-Amine Cure, Journal of Polymer Science, Part B: Polymer Physics, vol. 33, pp. 55-69.

Vincent P. I. (1971). Impact test and Series Performance of Thermoplastics, Plastic. Inst., pp. 584-628, London.

Williams J. G. (1978). Linear Fracture Mechanics, Advances in Polymer science, Springer-Verlag, Berlin, Heidelberg, New York, vol. 27, pp. 69-82.

Xu L. and Schlup J. R. (1998). Etherification versus Amine Addition during Epoxy Resin/Amine Cure: An In Situ Study Using Near-Infrared spectroscopy, Journal of Applied Polymer Science, vol. 67, pp. 895-900.

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