

DEVELOPMENT AND TESTING OF A BASIC THERMOSET COMPOSITE REINFORCED WITH MOLLUCA NUT POWDER AND CARBON NANOFIBER

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Abstract - Molluca Nut shell powder and Carbon Nanofibers with 5wt % and 0.75wt % were incorporated into an epoxy resin named Bisphenol A. Tensile and flexural tests were performed for studying the mechanical behavior of the composites. The tensile and flexural strength of Molluca nut shell powder reinforced composite was found to be increased by 22% and 41% and that of CNF reinforced composite was found to be increased by 37% and 52% compared to neat epoxy. Microstructural analysis was studied with the help of scanning electron microscope.

Key Words: Molluca Nut Shell powder, Carbon Nanofiber, Bisphenol A.

1. INTRODUCTION

Composite materials are known to mankind several years ago and these materials are applied to improve the quality of life. Composite materials result from an examination and advancement from past few decades. Composites have advanced from glass fiber for car body parts to particulate composites for aviation and to extent different applications. [1]

Polymer matrix composites are usually produced using epoxy resins because of its good mechanical properties. There are several techniques which are being used to improve its mechanical properties and one of them is reinforcing of composites. The main aim of this work is to study mechanical behaviour of natural and nano reinforcements combined with epoxy matrix Bisphenol A. [2]

In this work two reinforcements namely Molluca nut shell powder and Carbon nanofibers were incorporated into epoxy named Bisphenol A. Epoxy resin was selected as a matrix because it is a desirable resin in the composite industry due to its good stiffness, strength, chemical

resistance as well as dimensional stability. Microstructural analysis was also done with the help of SEM images.

2. EXPERIMENTAL

2.1 Materials And Method

Bisphenol A supplied by "Naptha Chemicals Bengaluru". This is commonly abbreviated as DGEBA. This resin is cured at room temperatures with the help of hardners.

Molluca Nut shell powder was used as natural reinforcement (Scientific Name is *Caesalpinia Cristae*). Naturally available Molluca Nuts were collected and chopped using hammer. The chopped material was ground in electric grinder to obtain powder form. The powder obtained was wet and was allowed to dry in sunlight for 48 hours.

Carbon Nanofibres(CNF) are cylindrical nano materials which are layered with graphene and are arranged as stacked plates, cups or cones.

Fabrication of composite was done using hand lay-up method for natural and nano reinforcements.



Fig.1: Aluminium Mold

Mould was prepared using aluminium sheets (Fig. 1). Aluminium was selected as mould material since matrix material doesn't adhere with the mould and removal of slabs is easy. Also during the curing of composites, heat is generated since it is an exothermic reaction and

aluminium dissipates the heat generated. Mould was designed to accommodate three tensile test specimens and three bending test specimens of size as per ASTM standards.

Weighed proportion of resin was taken in a beaker and hardeners in the ratio 1:1:1.7 (1ml of accelerator, 1ml of promoter and 1.7ml of accelerator) were added. The resin with hardeners was stirred using an electric blender to obtain uniform mixing. The mixture was then kept aside for 10 mins to allow the bubbles to settle down. Silicon release spray was used to facilitate easy removal of the cast composite slab from the mould. Mould was placed on flat surface and the flatness was checked using spirit level. The mixture was then poured in the mould uniformly. After pouring rolling was done using a roller to remove entrapped air and bubbles. This mould was allowed to cure for 24 hours at room temperature. This process was followed to obtain the composites with molluca nut shell powder and CNF as reinforcements.

Three slabs were prepared and the combinations of slabs with their reinforcements were

- 1) Neat epoxy
- 2) 5wt% of molluca nut powder and 95wt% epoxy.
- 3) 0.75wt% of CNF and 99.25wt% epoxy.



Fig. 2 : Composite Slab

Prepared composite slabs were removed from moulds carefully to avoid damage during ejection. Markings were made on slab for tensile specimen and bending specimen according to ASTM standards. Slabs were then taken for cutting. Cutting was done using electrically operated hand held cutter (Fig. 3) at “ KLS Gogte Institute of Technology Belagavi”.



Fig.3 : Hand held cutter

2.2 Mechanical Testing

Tensile and Flexural tests were performed using Universal Testing Machine(UTM) available at “KLS Gogte Institute of Technology Belagavi”. The UTM has a maximum loading capacity of 40tons. For tensile testing of specimens ASTM Standard of D3039/D3039M was used. Tabbing was done at both ends of the specimen with 45° angled groove to ensure proper grip in the jaws of UTM. Fig.4 shows tabbing on tensile test specimens.

For tensile tests, three specimens were tested and the average of the three was considered. Tensile strength and Young's modulus were calculated using formula.

$$\sigma = \frac{P}{A} \dots \dots \dots (1)$$

$$E = \sigma/\epsilon \dots \dots \dots (2)$$

Where ' σ ' is tensile stress, P is load applied, A is cross sectional area, E is youngs modulus, ϵ is the strain. Elongation and load at fracture was recorded in UTM.



Fig.4 : Tensile Specimen with tabbings at the end

For Bending Test ASTM Standard D790-02 was used. Three point bending test was carried out using UTM machine. The specimen was kept on supports with distance between supports i.e. the span length to depth in the ratio of 16:1 and loaded gradually. Load was applied at the centre of the span length.



Fig.5 : Specimen loaded for bending test

Load was noted from UTM machine and deflection was also recorded. The bending strength and bending modulus were calculated using formulae

$$BS = 3Fl/2b \dots\dots\dots(3)$$

$$BM = 3Fl^3 / 4bh^3d \dots\dots\dots(4)$$

Where BS-bending strength, BM-bending modulus, F-load in kN, l-span length, b-breadth, h-thickness, d-deflection.

3 RESULTS AND DISCUSSIONS

3.1 Tensile And Compressive Testing

Tensile strength, bending strength and Youngs modulus of neat epoxy and composites is tabulated as shown in Table 1.

Table 1: Tensile Test Results

SL No	Type of Composite	Tensile Strengt h(MPa)	Bending Strengt h(MPa)	Youngs Modulu s(GPa)
1	Neat Epoxy	116.78	74.184	2.1
2	Molluca Nut Shell Powder	142.61	105.72	5.7
3	Carbon Nanofiber(C NF)	160.10	113.25	6.4

Role of Molluca nut powder in tensile strength and bending strength.

From Fig. 6 it was seen that there is an improvement in tensile properties of the composite. The tensile strength for Molluca nut shell powder reinforced composite was 142Mpa which exhibits a rise of 22.15% compared to neat epoxy. The powder reinforcement disperses well with the epoxy, providing localized reinforcement. However in flexural test, from fig. 7 it was observed that there was a nominal increase in flexural properties compared to neat epoxy. Obtained flexural strength was 105.72 Mpa exhibiting an rise of 42%.

Role of Carbon Nanofiber in tensile strength and compressive strength.

Carbon Nanofibre has capability of dispersing well in the epoxy since it is in nano form. Also the Carbon Nanofibres adhere well with the epoxy compared to powder reinforcement. Tensile strength obtained was 160.1MPa. There was an improvement in the tensile strength and modulus. Tensile strength was increased by 37.01% compared to neat epoxy. Improvement in the flexural strength and modulus was seen compared to neat epoxy. Flexural strength obtained was 113MPa exhibiting 52% increase in strength.

Microstructure observation of the fractured surfaces from the tensile tests was done using scanning electron microscope available at Shivaji University Kolhapur. Images of composites after tensile tests are shown in Fig. 8 a) and b).

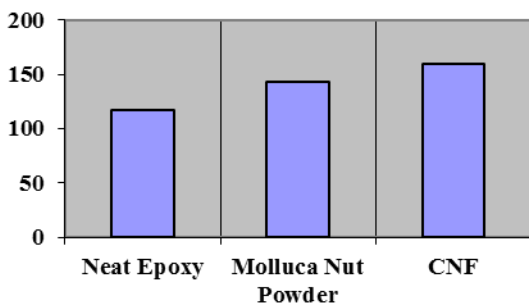


Fig. 6 : Tensile Strength

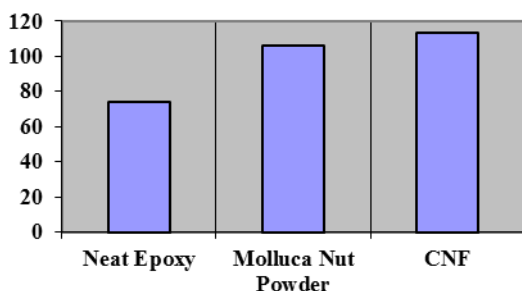


Fig.7 : Flexural Strength

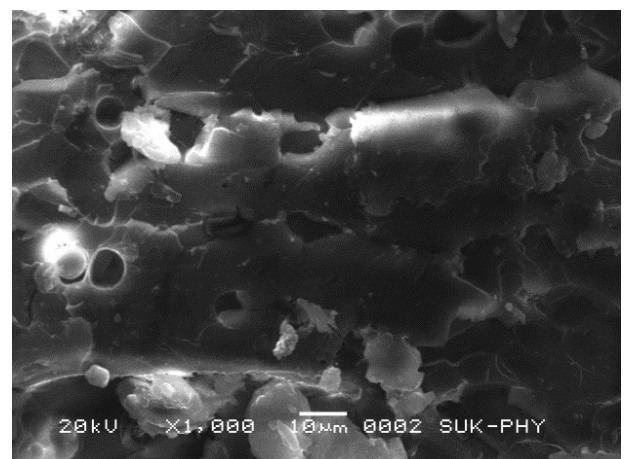


Fig. 8 a)

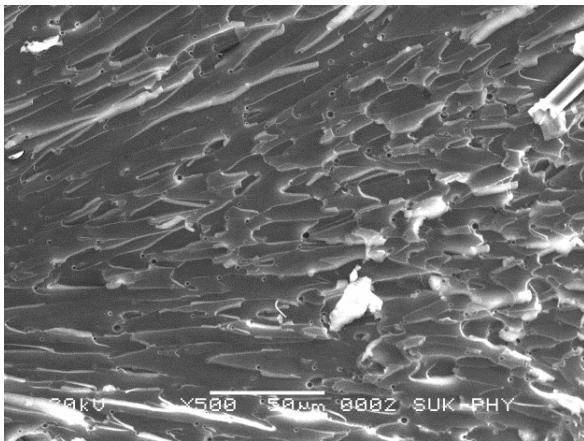

Fig. 8 b)

Fig. 8 : Fractured surfaces of a)Molluca nut shell powder b)CNF

It can be distinguished that the Molluca nut powder particles and CNF particles adhered well with the epoxy resin and from the image it is observed that the particles are stretched due to tensile load. Some agglomerates are seen due to improper involvement of Molluca nut shell powder in epoxy. This is due to several conditions such as improper curing, mixing speed, and mixing time (Fig 8a)). The Molluca nut granules are seen adhered with epoxy exhibiting better adhesion between epoxy and reinforcement. Complete dispersion of CNF in epoxy controls the agglomerates formation.(Fig 8b)).

4 CONCLUSIONS

Tensile strength was increased by 22% and flexural strength was increased by 42% for molluca nut shell powder reinforced composite. The use of natural reinforcement has many advantages like it is freely available, biodegradable, light in weight etc.

Cost of Carbon Nanofibers is higher compared to natural reinforcement. Using CNF as the reinforcement, the tensile strength was increased by 37% and flexural strength by 52% as the nano particles can disperse and support the matrix at nanometric level and adhere well with the resin.

SEM images show that Molluca nut powder and CNF particles adhered well with the epoxy resin and because of some abrupt conditions and mixing speed, some agglomerates are seen.

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REFERENCES

- [1] Krishna K Chawla, Composite Materials, Springer, 2nd edition, 1998.
- [2] B. Qi, Q.X. Zhang, M. Bannister, Y.W. Mai: Investigation of the mechanical properties of DGEBA-based epoxy resin with nanoclay additives: Composite Structures 2006: 75:514–519.
- [3] S.Pichi Reddy et al, "TENSILE AND FLEXURAL STRENGTH OF GLASS FIBER EPOXY COMPOSITES", International Conference on Advanced Materials and manufacturing Technologies (AMMT), December 18-20, 2014.
- [4] Ahmed J. Mohammed, "Study the effect of adding powder Walnut shells on the Mechanical Properties and the flame resistance for Low Density Polyethylene (LDPE)", International Journal of Science and Technology Volume 3 No. 1, January, 2014.
- [5] Paul Wambua, "Natural fibres: can they replace glass in fibre reinforced plastics?", Department of Metallurgy and Materials Engineering, Katholieke Universiteit Leuven, Kasteelpark Arenberg 44 B-3001 Leuven, Belgium
- [6] Siti Shuhadah, "LDPE-Isophthalic Acid-Modified Egg Shell Powder Composites (LDPE/ESPI)", Journal of Physical Science, Vol. 20(1), 87–98, 2009
- [7] Jacob Olaitan Akindapo et al, "Mechanical Properties of Polymer Matrix Composites Developed from Fibre Glass (E-Class) and Bisphenol-A-Co-Epichlorohydrine", International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 12, December – 2013, ISSN: 2278-0181.
- [8] Dr.P.K.Palani et al, "Analysis Of Mechanical Properties Of Chopped Strand Mat E-Glass Fiber Epoxy Resin Nanoclay Composites", The International Journal Of Engineering And Science (Ijes), Volume2 Issue 2 Pages 185-189, 2013.
- [9] Prof.Ashish Khandelwal et al, "Mechanical And Tribological Characterization Of Short Fibers Reinforced Polymer Composites", IOSR Journal of Engineering (IOSRJEN), Vol. 04, Issue 04 (April. 2014), PP 28-40.
- [10] Smrutisikha Bal, "Experimental study of mechanical and electrical properties of carbon nanofiber/ epoxy composites", Journal of materials and design 2009.
- [11] Jiahua Zhu et al, "In situ stabilized carbon nanofiber (CNF) reinforced epoxy nanocomposites", Journal of Materials Chemistry, 2010
- [12] Yuanxin Zhou et al, "Improvement in mechanical properties of carbon fabric–epoxy composite using carbon nanofibers", Journal of materials processing technology 198(2008)445–453.
- [13] A. Allaoui et al, "Mechanical and electrical properties of a MWNT/epoxy composite" Composites Science and Technology 62 (2002) 1993–1998.