PREPARATION AND CHARACTERIZATION OF EPOXY COMPOSITE REINFORCED WITH WALNUT SHELL POWDER

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Abstract - Modern manufacturing processes include making the products using composite materials. The present work is focused on using walnut shell powder as a reinforcement material for thermoset type polymer named Bisphenol-A as matrix material. Walnut shell powder was added with 5wt% to the epoxy resin to prepare composite test specimens. The hand layup method was used for making the composite. Composite test specimens were prepared as per ASTM standards and different tests like tensile, flexural and compression tests were conducted in order to determine the mechanical properties of composite. Addition of Walnut shell powder to the epoxy led to an increase in the tensile, flexural and compression strength by 10.4%, 17.6% and 42% respectively. Scanning electron microscope test was conducted to study the morphology of composite.

***Keywords**: Epoxy, Walnut shell powder, Bisphenol-A, Composite, hand layup, Mechanical characterization, Scanning electron microscope*

1. INTRODUCTION

A composite is a structural material that consists of two or more constituents that are combined at a microscopic level and are not soluble in each other in which one constituent is called the reinforcing phase and another one in which the reinforcement is embedded is called the matrix phase [1]. Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or in-organic) maintains the position and orientation of the reinforcement. [2]. Natural fibers are abundantly available in nature like sisal, jute, coir, wood dust etc [3]. The main advantages of these natural fibers include ease of availability, better strength, stiffness, good adhesive bonding, light weight, easily moldable for complex parts and low capital investment for manufacturing [4]. In most of the cases the natural fiber makes first choice because of their distinct characters like biodegradable, no odour, no respiratory irritation and environment friendly [5]. Mechanical Properties can be improved by hybridization of different materials with appropriate proportion. The attraction in natural fiber is increasing because these are replacing the synthetic fibers in some applications [6]. Natural fibers can be used for manufacturing defense parts, aerospace structures, and storage system and fabrication of automotive parts. Natural fibers are fillers materials added to polymers in order to improve mechanical, electrical, thermal properties [7]. Bisphenol A is a polycarbonate component mainly used for coating inner surface of the containers, storage systems and preparing polymer matrix components.

2. MATERIAL AND METHODS

2.1 Materials

Bisphenol-A is epoxy polymer commonly known as BPA. It is a thermoset type of polymer matrix material. Bisphenol A was supplied by Naptha resin traders, Bangalore. It is a resin type of material which can hold the reinforcement, bonding it together. Bisphenol-A of grade 220 and having a density 1.20gm/cm^3 was used. Promoter Andonox KP9, accelerator Polyflex 999-30 and catalyst Polyflex KP9 was also supplied by Naptha resin traders, Bangalore. Epoxy hardens at room temperature after adding promoter, catalyst and hardener in required quantities.

Walnut shell powder was used as reinforcement. The shell was crushed in a mixer to get the powder form to have a grain size of 65 as fine particle.

2.2 Methods

In the present work, composite specimens were fabricated by hand layup technique. The walnut shell powder of 5%wt was added to the epoxy matrix material. Catalyst, accelerator and promoter are added in the ratio of 100:1. Stirring was with the help of electrical hand blender at a constant speed of 1000rpm for proper mixing of reinforcement, matrix and hardener. Silicon release spray agent was sprayed on aluminum mould for easy removal of cast composite. The pouring was done in the mould at a constant rate to avoid any turbulence so as to prevent the formation of air bubbles. The mould was kept for cooling at normal room temperature for 24 hours. The cured test slabs were machined by hand cutter to get test specimens as per dimensions mentioned in ASTM standard. Commercially available adhesive named Araldite was used to fix the tabs to the test specimens. Tabs were provided at the ends of the tensile test specimens with 30^o angled grooves on it to ensure proper grip during testing.

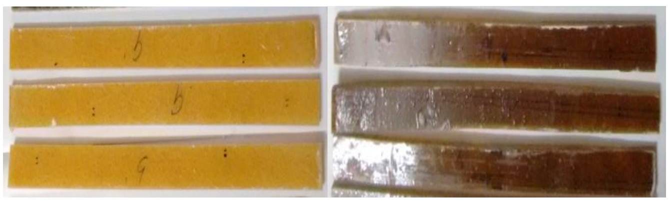
3. EXPERIMENTATION

3.1 Tensile, Flexural and Compression Test

In order to determine the mechanical properties of the composite, experiments were carried out using universal testing machine having maximum capacity of 400kN. Tensile test specimens are prepared as per ASTM standard D3039/3039M [8]. Tensile test was carried out by applying axial load on test specimen (fig. 1a and 1b) in the longitudinal direction. Corresponding load and deflection were noted. For obtaining the flexural strength, three point bending test was carried out. As per ASTM standard D790-02 [9] specimens (fig. 2a and 2b) were supported with two cylindrical surfaces with a support span to the depth in the ratio of 16:1. For compression test, specimen (fig. 3a and 3b) was held between bottom fixed head and load was applied by moving upper crosshead. Specimens were prepared as per ASTM standard D695-02a [10].

a) b)

Fig-1: Tensile test specimens of a) Epoxy b) Epoxy and Walnut shell powder



a) b)

Fig-2: Flexural test specimens of a) Epoxy b) Epoxy and Walnut shell powder

a) b)

Fig-3: Compression test specimens of a) Epoxy b) Epoxy and Walnut shell powder

4. RESULTS & DISCUSSIONS

The strength of the composite was obtained by performing the tests with three samples for each combination of materials and the results are tabulated in Table 1. For the composite samples made by adding 5wt% of walnut shell powder to pure epoxy the load carrying capacity was increased. In case of the tensile test, load carrying capacity was increased from 4.74kN to 5.29kN. In flexural test the load carrying capacity was increased from 0.14kN to 0.17kN and in compression test load carrying capacity was increased from 6.8kN to 13.32kN. It was found that for pure epoxy the load carrying capacity was lower compared to the composite.

Material	Sample No	Tensile test		Flexural test		Compression test	
		Load(kN)	Deflection(mm)	Load (kN)	Deflection(mm)	Load(kN)	Deflection(mm)
Pure Epoxy	1	4.70	8.20	0.14	32.12	6.6	1.72
	2	4.84	7.90	0.15	29.90	6.8	1.66
	3	4.68	8.00	0.13	30.60	7.1	1.98
	Avg.	**4.74**	**8.03**	**0.14**	**30.87**	**6.8**	**1.79**
Epoxy and Walnut shell Powder	1	5.30	6.94	0.18	29.80	13.44	1.92
	2	5.26	6.80	0.16	26.66	13.02	1.80
	3	5.32	6.98	0.17	30.00	13.51	1.86
	Avg.	**5.29**	**6.91**	**0.17**	**28.82**	**13.32**	**1.86**

Table-1: Results of Tensile, Flexural and Compression Test

The material strength obtained from tensile, flexural and compression tests are reported in Table 2. Results of tensile strength are presented in Chart 1. It is clearly seen that addition of walnut by 5%wt increases the tensile strength of the composite moderately. Chart 2 shows the flexural strength of the samples. It was seen that the compression strength of composite increases by adding walnut shell powder to the epoxy resin. Compression test results are depicted in Chart 3. Addition of 5wt% of walnut enhanced the compression strength significantly.

Table-2: Strength Comparison

Material	Sample no.	Tensile strength (MPa)	Flexural strength (MPa)	Compression strength (MPa)
Epoxy	1	78.33	89.91	40.92
	2	80.67	96.33	42.16
	3	78.00	83.49	58.28
	Avg.	**79.00**	**89.91**	**47.12**
Epoxy and Walnut shell powder	1	88.33	115.60	83.33
	2	87.67	102.76	80.72
	3	88.67	109.18	83.76
	Avg.	**88.22**	**109.18**	**82.6**

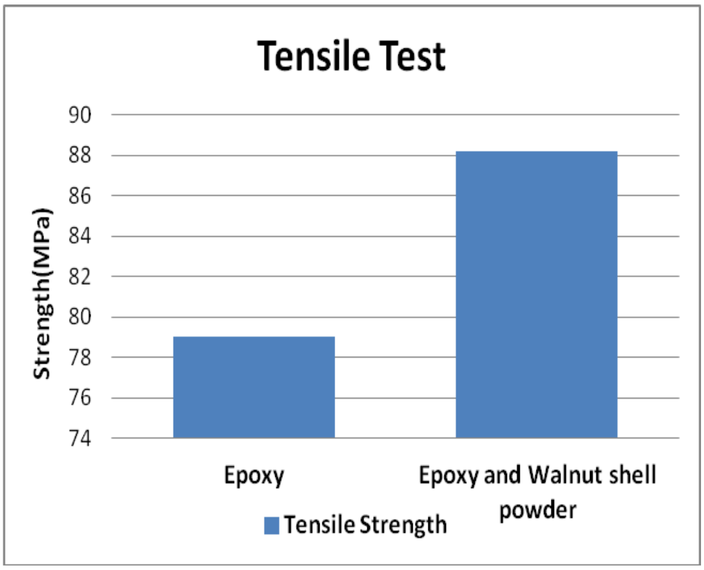


Chart-1: Tensile Strength

As observed from Chart 1 the addition of walnut shell powder (5wt%) enhances the tensile properties. The addition of walnut shell powder to epoxy results in the formation of heterogeneous mixing and thus offers more stiffness to the epoxy material. Neat epoxy and composite of epoxy and walnut shell powder shows tensile strength

79MPa and 88.22MPa, which shows an increase by 10.4% respectively for the composite.

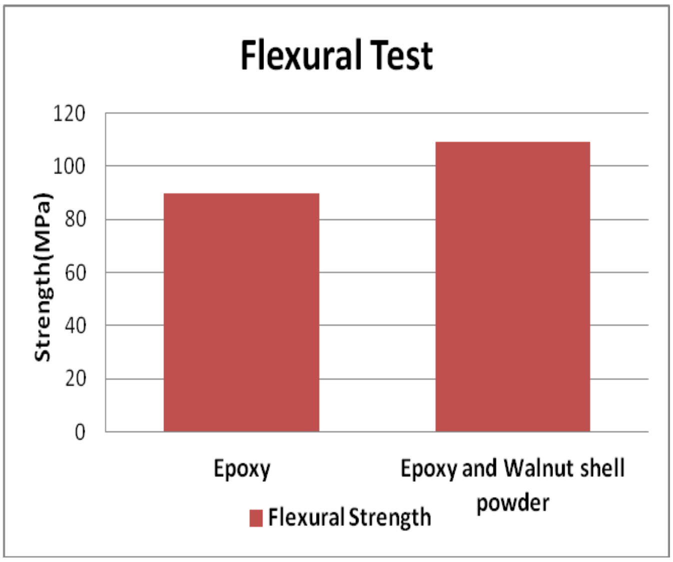


Chart-2: Flexural Strength

The flexural strength for epoxy and composite of epoxy and walnut shell powder was found to be 89.91MPa and 109.18MPa respectively (Chart 2) exhibits a rise of 17.6% in the flexural strength of the composite.

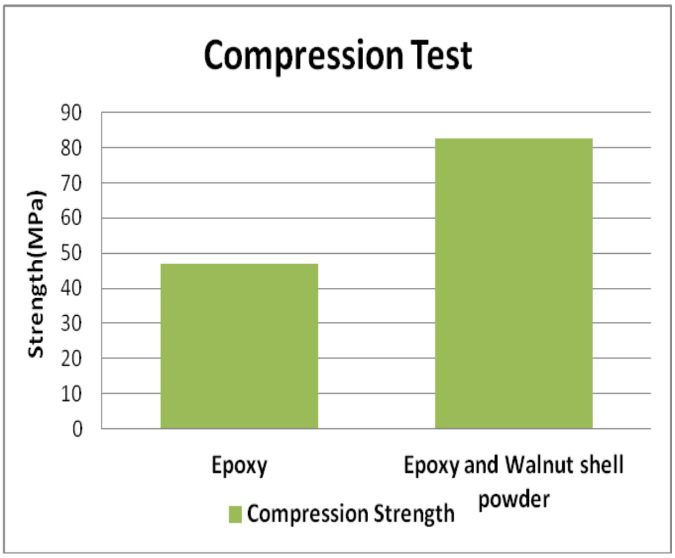


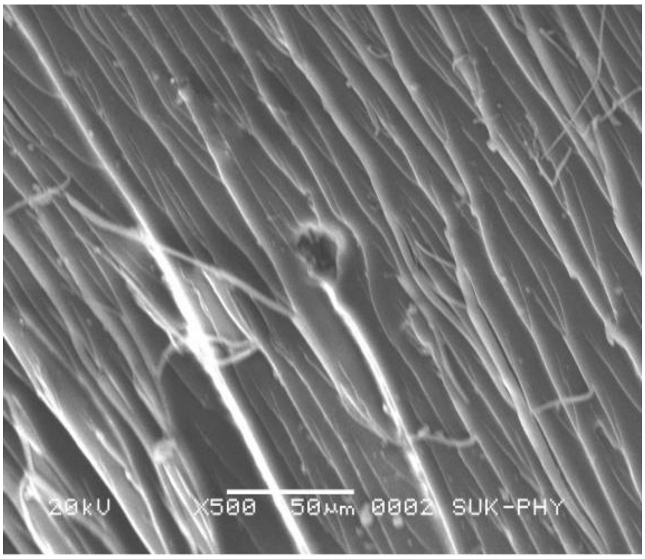
Chart-3: Compression Strength

Addition of walnut shell powder as reinforcement enhances the properties like strength and stiffness of composite. Compression strength almost doubles with addition of walnut shell powder (Chart 3). The compression strength for epoxy and composite of epoxy and walnut shell powder are found to be 47.12MPa and 82.6MPa respectively. There is an increase in the compression strength by 42% for the composite.

4.1 Scanning electron microscope

To understand the details of the strengthening

Mechanisms and also the morphology of epoxy and composite of epoxy and walnut shell powder surfaces scanning electron microscope (SEM) study was performed with the help of machine of make JEOL JSM-6360LV.



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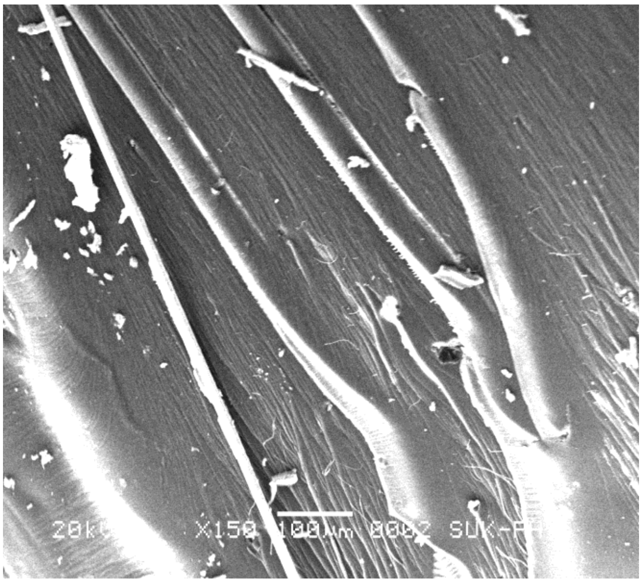

b

Fig-4 a) and b): Scanning electron microscope images of Walnut shell powder and epoxy at different magnifications.

The SEM test was performed to examine the fractured region of tensile test specimen as shown in Fig.4. The addition of walnut shell powder to epoxy increases the crack deflection sites, visible through a rough fracture zone (fig. 4(a)). The fractured surface (fig. 4(b)) reveals a smooth matrix surface, typical of a brittle fracture surface of the composite.

5. CONCLUSION

The characterization of mechanical properties of composite reinforced with walnut shell powder is being reported. The Epoxy/walnut shell powder composite samples possess good tensile strength and can withstand the stress up to 88.22MPa. The epoxy/walnut shell powder specimen can withstand max flexural load of 0.17kN slightly higher than the epoxy samples. The Compression test strength value of walnut shell powder almost doubled than the epoxy i.e. 47.12Mpa to 82.6Mpa. The increase of the strength is due to the presence of dispersed walnut shell powder in the epoxy. The morphology of tested samples was examined by using scanning electron microscope. This study showed that walnut shell powder can be used to enhance the mechanical properties of the epoxy. Present work composite specimens were prepared by hand layup process and curing was done at room temperature. Different manufacturing techniques can be adopted and curing at higher temperature can be done in order to get better stiffness and strength in composites.

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