ARPN Journal of Engineering and Applied Sciences

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MECHANICAL PROPERTIES OF NATURAL FIBERS REINFORCED HYBRID COMPOSITES

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ABSTRACT

Cellulosic (sisal, bamboo, coir, etc.) fiber reinforced polymer composites have played a dominant role for long time in a variety of applications (automobile, structural, etc.). Cellulosic fibers are bio-degradable, are of low cost and have high strength to weight ratio. In the present work, mechanical properties (tensile, flexural, compression and hardness) are tested for sisal/coir; sisal/hemp and sisal/flax fibers reinforced epoxy hybrid composites according to ASTM standard. Traditional hand-lay-up method was used to prepare the hybrid composite. Lignin, pectin and dirt were removed by NaOH treatment of fibers. The experimental results reveal that the sisal/hemp fiber reinforced hybrid composites exhibit more tensile and flexural strength and sisal/coir fiber reinforced hybrid composites exhibit more compression strength and hardness.

Keywords: cellulosic fiber, hybrid composite, mechanical properties, scanning electron microscope.

1. INTRODUCTION

The utility of polymer based composites are increasing day by day. The polymer matrix composites (PMC's) are used in industries, automobiles, ships, structural applications etc. due to the advantages of high strength to weight ratio, ease to fabricate, complex shapes, low cost and good resistance to corrosion and marine fouling [1, 2]. The polymer matrix composites are fabricated by reinforcing artificial (glass, carbon, aramid, etc.) fibers or natural cellulosic (bamboo, sisal, flax, etc.) fibers. Artificial fiber based composites are not easily degraded because of their high molecular mass and hydrophobic character. And also natural cellulosic fiber reinforced composites shows few drawbacks like low strength, poor interfacial bonding, moisture up-take compared to artificial fiber reinforced composites. Natural fibers are particularly sensitive to moisture because of fiber/matrix interface is critical zone for composite long term performance [3]. Recently, the natural fiber reinforced polymer composites have attracted the substitution attention as a potential structural material for low cost applications.

To achieve a good adhesion between fiber and matrix NaOH treatment on fiber surface is necessity. After the NaOH treatment of fibers, removal of hemicelluloses, pectin, lignin, wax and increases in roughness of fibers was observed [4] in addition to mechanical interlocking [5]. NaOH treated fiber reinforced composites show significant improvement in mechanical properties [6]. Karthikeyan *et al* [7] compared the impact property of sodium lauryl sulphate (SLS) and NaOH treated coir fiber reinforced epoxy composites. Result shows, SLS treated coir fiber reinforced composite shows more impact energy than NaOH treated coir fiber reinforced composite. Haishal *et al* [8] analyzed the mechanical properties of randomly oriented coir fiber/epoxy resin composite. The result shows tensile strength of 31.08 MPa, impact strength of 11.49 KJ/m^2 and suggested for low load applications. According to Akash *et al* [9] hemp fiber/epoxy resin composite exhibits more tensile strength than coir fiber/ epoxy resin composite and coir fiber/epoxy resin composite exhibits more bending strength than hemp fiber/epoxy resin composite. Narendra *et al* [10] suggested the presence of nylon fabric and chemically treated pith can contribute to longer durability of the panels in moisture condition. 18% NaOH treated sisal fiber reinforced composite shows higher tensile and flexural strength than 5%, 10% NaOH treated sisal fiber reinforced composites [11]. The tensile strength, tensile modulus and creep resistance of composite increases with increasing the sisal fiber content in composite up to a certain limit [12].

Hybrid composites are new conceptual composite material. Sisal and glass reinforced composites exhibits good mechanical properties [13]. Sisal/banana empty fruit bunch fiber (BEFBF) hybrid composite exhibits more tensile strength than sisal/bamboo and bamboo/BEFBF hybrid composites [14]. Dalbehra *et al* [15] investigated the mechanical properties of jute and glass fiber reinforced epoxy resin hybrid composites and noticed considerable improvement by the incorporation of glass fiber. According to Girisha C *et al* [16], the strength of hybrid composite increases with increasing the volume % of fibers in composite and hybridization has also increased the mechanical properties. The strength of hybrid composites depends on the properties of fiber, aspect ratio of fiber in composites, orientation of fiber, intermingling of fiber and fiber matrix interface [17].

Number of papers have been published on glass/bamboo fiber, glass/sisal fiber, glass/banana etc. hybrid composites. But limited research work has been done on the natural fibers hybridized composites. This paper focuses on the mechanical properties of sisal/coir, sisal/hemp and sisal/flax fiber reinforced epoxy resin hybrid composites.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

The coir fibers were collected from local resource, sisal; hemp and flax fibers were procured from Sreelaxmi groups, Vijayawada, Andhra Pradesh, India. The epoxy resin AW 106 and hardener HV 953 standards were used for the experimentation. Mechanical and physical properties of selected fibers are discussed in [18-21].

2.2. Fiber treatment

All selected fibers were chopped into small size around 10-15mm. Chopped fibers were initially washed in distilled water and soaked in 10% NaOH solution for 10 hours to remove lignin, pectin and dirt from the fiber surface. The NaOH treated fibers were again washed in distilled water to completely remove the sticking of NaOH on the fiber surface and then dried for 3 days in sunlight to completely remove moisture.

2.3. Preparation of composites

Composite specimens were prepared by traditional hand-lay-up method according to ASTM standard procedure. Epoxy resin and hardener were used as composite matrix which is low temperature curing epoxy system [22]. Wax polish was applied to the mould cavity to get a good surface finish of hybrid composite specimens and after 10 minutes a thin layer of Poly Vinyl Alcohol (PVA) was applied to mould inner surface for easy removal of specimens. Two glass sheets were used to seal upper and lower opening of the mould. A calculated amount of epoxy resin and hardener (10:1 ratio) was mixed in a bowl with a gentle stirring to minimize air entrapment and fibers are added in to the matrix and mixed well in a bowl. A well mixed matrix and fibers are poured into the mould cavity and care was taken to avoid the formation of air bubbles. About 5kg of load was placed on the upper glass sheet and allowed to cure at room temperature for 24 hours.

3. RESULTS AND DISCUSSIONS

3.1. Characterization of fibers

Scanning Electron Microscope (SEM) provides an excellent technique for studying the surface morphology of fibers. Figure-1 shows the SEM micrographs of NaOH treated sisal, coir, hemp and flax fibers surface. After NaOH treatment on fibers, it was observed that there was a removal of wax, lignin, dirt and hemicelluloses on fiber surface and an increase in roughness of fibers surface and increase in the contact area of exposition of fibrils, which can increase the adhesion between fiber and matrix.

Tensile, flexural and compression tests were carried out according to ASTM D-3039, ASTM 790-03 and ASTM D-695 standards respectively. The average values of the four test results were recorded. Hardness of hybrid composites was measured by shore-D (Durometer) test according to ASTM D-2240 standard in Bangalore Analytical Research Centre Pvt. Ltd.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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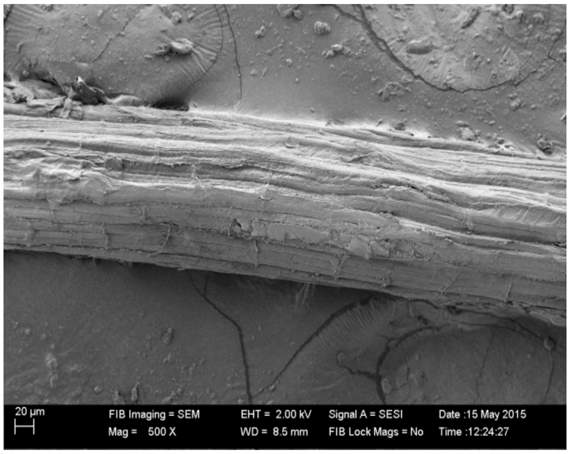
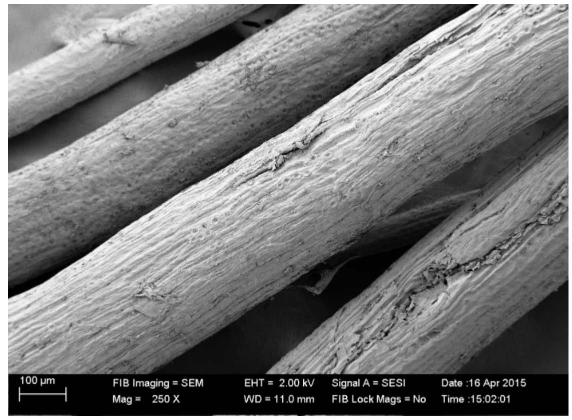
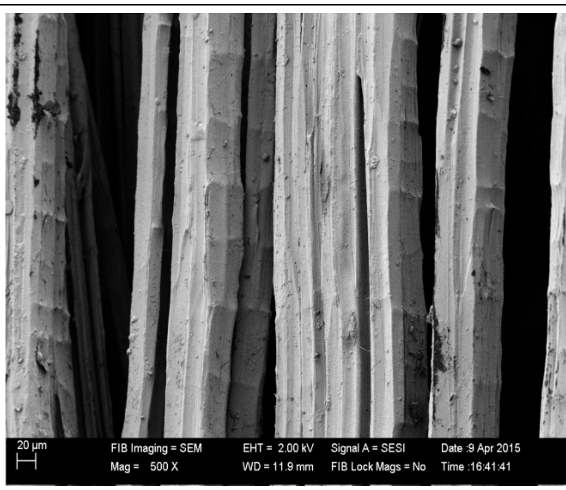


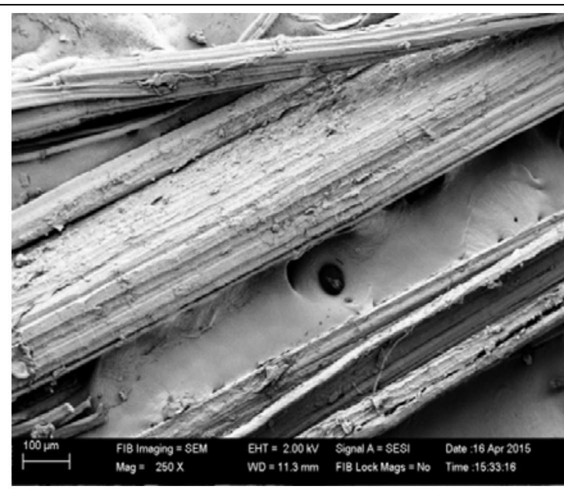
(a) Sisal fiber



(b) Coir fiber



(c) Hemp fiber



(d) Flax fiber

Figure-1. Scanning Electron Micrographs of NaOH treated fiber surfaces.

Natural cellulosic fibers are hydrophilic in nature and epoxy matrix is hydrophobic in nature. Thus, hydrophilic cellulosic fibers do not interact well with the hydrophobic epoxy resin as compared to synthetic fibers. Sisal/hemp hybrid composite specimen's exhibits more tensile and flexural strength and sisal/coir hybrid composite exhibits low strength as shown in Figure-2 (a) and (b). The combination of sisal/coir fibers detach easily from the resin surface due to very poor interfacial bonding compared to sisal/hemp and sisal/flax fibers combination. Tensile and flexural strength of hybrid composite depends on density of reinforced fibers. For the same reason, Sisal/coir hybrid composites exhibits more compression strength and harness and sisal/hemp exhibits low values as shown in Figures 2 (c) and (d).

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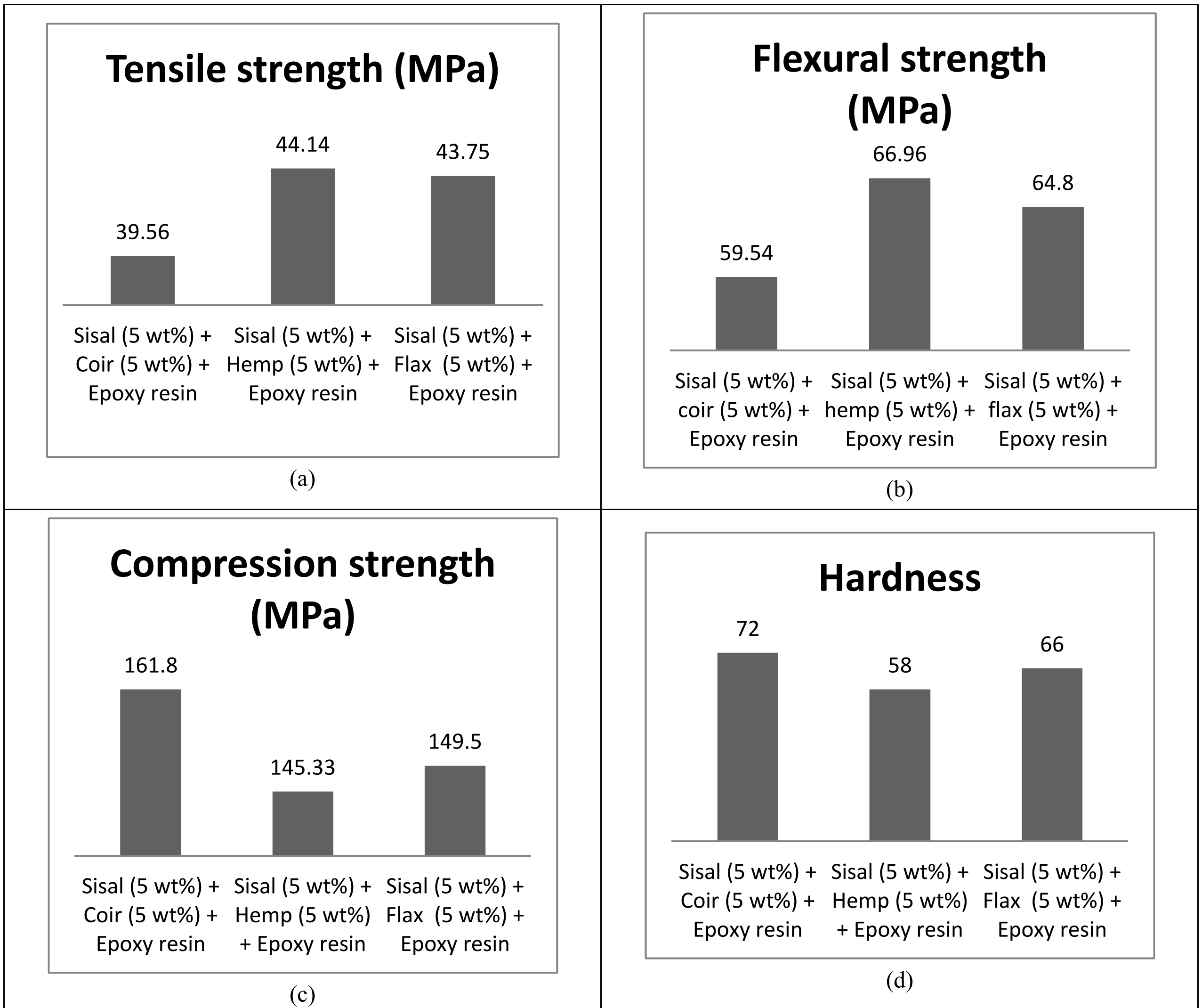

Figure-2. Mechanical properties of hybrid composites (a) Tensile, (b) Flexural, (c) Compression and (d) Hardness.

4. CONCLUSIONS

Experimental investigation of mechanical properties of sisal/coir, sisal/hemp and sisal/flax fibers reinforced epoxy hybrid composites lead to the following conclusions.

- Successful fabrication of cellulosic fibers reinforced hybrid composites can be achieved by traditional hand-lay-up method.
- Sisal/hemp fibers reinforced hybrid composite exhibits more tensile and flexural strength than sisal/coir and sisal/flax fiber reinforced hybrid composites.
- Sisal/coir fiber reinforced hybrid composite exhibits more compression strength and hardness number than sisal/hemp and sisal/flax fiber reinforced hybrid composites.
- Increasing in density of reinforcement in composites increases the tensile and flexural strength and decreases the compression strength and hardness.

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