Impact and Hardness Properties of Areca Fiber-Epoxy Reinforced Composites

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Abstract

Natural Fibers composites are considered to have potential use as reinforcing material in polymer matrix composites because of their good strength, stiffness, low cost, environmental friendly and biodegradable. In present study, mechanical properties for natural fiber composites were evaluated. Here, areca fiber is used as new natural fiber reinforcement and epoxy resin as matrix. The extracted areca fibers from areca husk were chemically treated to get better interfacial bonding between fiber and matrix. Composite were prepared with randomly orientated fibers with different proportions of fibers and matrix ratio. Mechanical tests i.e. impact and hardness tests were performed and the results are reported. The results showed that, as the fiber volume fraction and composite post curing time increases the mechanical properties of the composite increases.

*Key Words***:** Natural Fibers Composites, Areca Fibers, Mechanical Properties.

1. Introduction

For the past several years, public attention has gone on natural fibers as a resource due to the fast growth. Now a day, natural fibres are widely used as reinforcements both in partially and totally biodegradable Natural fiber Composites. Natural fibers are an alternative resource to synthetic fibres as reinforcement for polymeric materials for the manufacture of cheap, renewable and environmentally friendly composites.Waste plastic has caused unbearable stress to environment in recent years. Environmental awareness, new rules and legislations are forcing industries to seek new materials which are more environmentally friendly. Plant fibers from agricultural crops are renewable materials which have potential for creating green products and replacing synthetic materials which are currently being used such as glass fiber, carbon fiber and plastic fibers. The combinations of bio-fiber and bio-polymer could be the products of fully biodegradable composites [1]. Among others, natural fibers (e.g., flax, jute or sisal) reinforced materials have important significance for reduction of density in automobile construction components due to its higher specific stiffness and specific tensile strength.
Many attempts were made by the scientists and technologists to utilize natural fibers in the fabrication of composites. It has been found that theses natural fiber-reinforced composites possess better electrical resistance, chemical resistance, good thermal and acoustic insulating properties.

The increasing interest in introducing degradable, renewable, and inexpensive reinforcement materials, which have been environment-friendly, has stimulated the use of hard cellulose fibers. The low cost, less weight and density makes the natural fibers an attractive alternative. Among all the natural fiber-reinforcing materials, areca appears to be a promising material because it is inexpensive, abundantly available, and a very high potential perennial crop. In India, areca cultivation is coming up in a large scale with a view to attaining self sufficiency in medicine, paint, chocolate, chewable gutka, etc. The husk of the areca constitutes about 60–80% of the total weight and volume of the fresh fruit. The husk fiber is composed of cellulose with varying proportions of hemicelluloses (35–64.8%), lignin (13.0–26.0%), pectin and protopectin [2]. The average filament length (4 cm) of the areca husk fiber is too short compared to other biofibers. Mainly two types of filaments are
present – one very coarse and the other very fine. The coarse ones are about ten times as coarse as the jute fibers and the fine are similar to jute fiber. The fiber could be used for making value added items like thick boards, fluffy cushions and non-woven fabrics, thermal insulators and non-woven fabrics. The present use of this highly cellulose material is as a fuel in areca nut processing. Unmanaged areca husk left in the plantation causes bad odour and other decay-related problems [3]. Therefore, an extensive planning for the disposal of husk is required. Thus, the use of this husk as structural material required a detailed study of physical, chemical and thermal characteristics.

Generally acids and alkalis have been used for modifying the properties of natural fibers like jute, coir, sisal etc. Strong alkali solutions lead to a reduction in strength and an increase in elongation does not cause significant lowering in strength. Akhila Rajan et.al [4] extensively studied bio softening of areca nut fibers and concluded that the bio softened areca nut fibers can be exploited commercially for the production of furnishing fabrics, textiles etc by blending with cotton and polyester. D. Guinez1 and et.al [5] studied the chemical treatment on sisal fibers to produce composite materials with polyethylene and polystyrene. Mechanical properties of jute/glass fiber-reinforced unsaturated polyester hybrid composites were studied by Abdullah-Al-Kafi and et.al [6]. The influence and effect of surface modification by ultraviolet radiation were reported in their studies. Prasad S.V et al. [7] reported the effect of alkali treatment on coir–polyester composites and it was found that, the flexural strength, modulus, and impact strength of composites containing alkali-treated fibers were higher than those containing the same volume fractions of untreated fibers. Combined alkali treatment and irradiation of jute can also be achieved by treatment of the fibers with 2% sulfuric acid solution followed by alkali of mercerizing strength. A. K. Mohanty and et.al [8] studied the chemical surface modifications of jute fabrics involving bleaching, dewaxing, alkali treatment, cyanoethylation and vinyl grafting are made as reinforcing meterials in composites based on a biodegradable polyester matrix. The effect of different fiber surface treatments and fabric amounts on the performance of resulting composites are investigated. The mechanical properties of composites like tensile and bending strengths increase as a result of surface modification. Kalaprasad [9] investigated the chemical surface modifications such as alkali, acetic anhydride, stearic acid, permanganate, maleic anhydride, silane and peroxides given to the sisal fibers. Fibers and matrix were found to be successful in improving the interfacial adhesion and compatibility between the fiber and matrix.

Although there have been numerous studies on mechanical behaviour of natural fiber-reinforced composites, only a few references are available on areca fiber-reinforced composites [10]. In order to develop composite made from natural fibers with enhanced strength, stiffness, durability and reliability, it is necessary to study the mechanical behaviour of natural fiber composites. The mechanical properties of a natural fiber-reinforced composite depend on many parameters, such as fiber strength, modulus, fiber length, orientation, and fiber-matrix interfacial bond strength. A strong fiber-matrix interface bond is critical for high mechanical properties of composites. A good interfacial bond is required for effective stress transfer from the matrix to the fiber whereby maximum utilization of the fiber strength in the composite can be achieved. Most research reviewed indicated the effect of alkali treatment in improving fiber strength, fiber-matrix adhesion and the performance of the natural fiber composites.

The present work emphasis on the effect of alkali treatment on mechanical behaviour of areca fibers reinforced epoxy composites. Finally, the effects of fiber volume fraction and composite curing time on mechanical properties of areca fibers reinforced epoxy composites are studied.

2. Materials and Methods

2.1 Materials

The Epoxy-556 resin and the hardener (HY951) are supplied by Ciba Geigy India Ltd. Areca empty fruit bunch Fibers (husk) were obtained from Madhu Farm House Nilogal, Karnataka, India.

2.2 Methods

2.2.1 Fiber extraction

Selected areca fruit husks were used to prepare the composites. Dried areca husk was soaked in deionised water for about five days. The soaking process loosens the fibers and can be extracted out easily. Finally, the fibers were washed again with deionised water and dried at room temperature for about 15 days. The dried fibres are designated as untreated fibres.

2.2.2 Alkali treatment

First, the areca fibers were treated in a solution of 10% KOH (Potassium Hydroxide) where the total volume of solution. The fibers were kept in this alkaline solution for 36 hours at a temperature of 30° C; it was then thoroughly washed in running water then neutralized with a 2% acetic acid solution. Lastly, it was again washed in running water to remove the last traces of acid sticking to it, so that the pH of the fibers is approximately 7 (neutral). Then, they were dried at room temperature for 48 hrs to get alkali treated fibers.

2.2.3 Preparation of composites

Fiber configuration and volume fraction are two important factors that affect the properties of the composite. In this work, the randomly distributed fibers are reinforced with epoxy resin in two different weight proportions (50 wt. %, and 60 wt. %) to prepare the composites. First, the mould is polished and then a mould-releasing agent (Polyvinyl alcohol) applied on the surface is used to facilitate easy removal of the composite from the mold after curing. The low temperature curing epoxy resin LY556 and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as recommended. The mixing is done thoroughly before the mixture filled into the mould of 300 x 300 x 50 mm size and pressed in a hydraulic press at the room temperature and a pressure of 0.5MPa for 30 minutes is applied before it is removed from the mould. Then, this cast is post-cured in the laboratory at standard atmosphere for different hours to study the effect of post curing time on mechanical properties.

2.2.4 Characterization

The prepared composite boards were post cured for 15(360 hours), 30(720 hours) and 45(1080 hours) days at standard laboratory atmosphere prior to preparing specimens and performing mechanical tests. The appropriate ASTM standards were followed while preparing the specimens for test. At least five replicate specimens were tested and the results were presented as an average of tested specimens. The tests were conducted at a laboratory atmosphere of 27^{o}C and 46% relative humidity.

Impact tests on specimens were performed by using both Charpy and Izod methods as per ASTM D 256. According to ASTM D 785 standard for composites, the specimens were prepared for Rockwell-B hardness test. The specimen size is of 25mm diameter and a length of 20mm. The hardness properties of the composites along and across the fibers are carried out.

3. Results and discussion

The investigation of mechanical properties of composites is one of the most important techniques in studying the behaviour of composite materials. Mechanical properties of fiber-reinforced composites depend on the nature of matrix material and the distribution and orientation of the reinforcing fibers, the nature of the fiber-matrix interfaces and of the interphase region. Even a small change in the physical nature of the fiber for a given matrix may result in prominent changes in the overall mechanical properties of composites. It is well known fact that, different degrees of reinforcement effects are achieved by the addition of hydrophilic fibers to different polymers. This may be due to the different adhesion strength between matrix and fibers.

3.1 Mechanical properties

3.1.1 Impact properties

Impact resistance is the ability of a material to resist breaking under a shock loading or the ability to resist the fracture under stress applied at high speed. Impact behaviour is one of the most widely specified mechanical properties of the engineering materials. Both Izod and Charpy methods perform impact tests on areca fibers reinforced with epoxy composite specimens as per ASTM-D256-90. The variations of impact strength with respect to fiber volume fraction and composite curing time as shown in Figures 1 and 2 for Charpy and Izod method of impact test respectively. These figures indicate that, the impact strength of composites increases with curing time at a greater degree when compared to fiber volume in the composite. The important aspect regarding impact strength of the areca composite is that, as the composite curing time increases the alkali treated composites becomes more brittle than the untreated fibers.

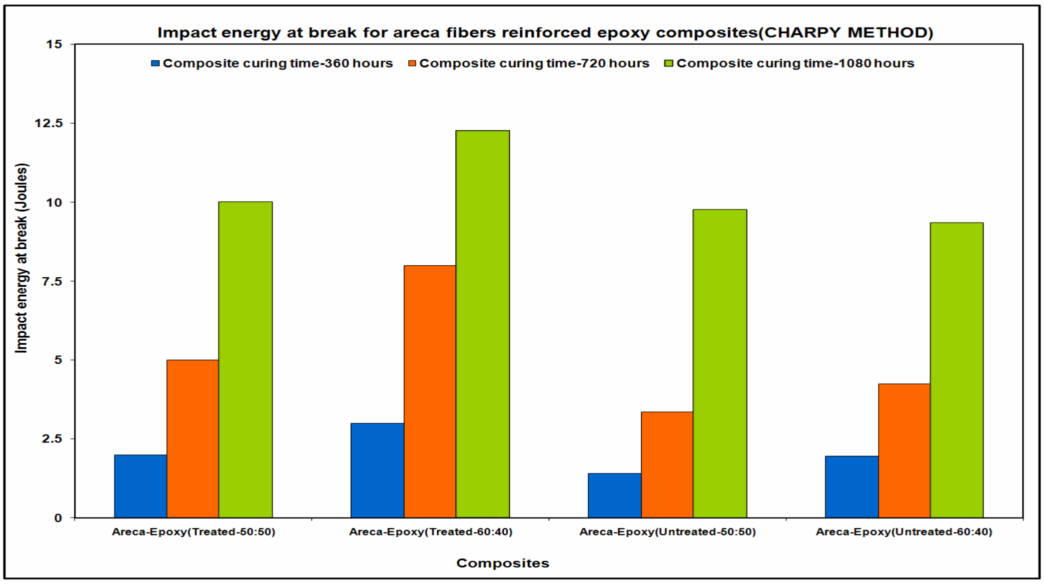

Figure 1. Shows impact energy of composites in Charpy impact test

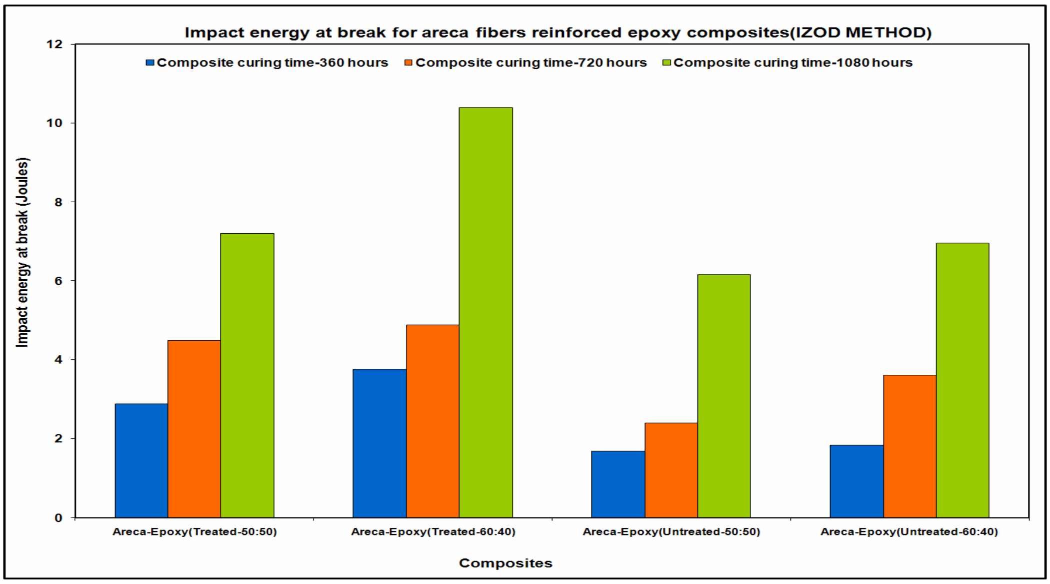

Figure 2. Shows impact energy of composites in Izod impact test

3.1.2 Hardness properties

According to ASTM D 785 standards for composites, the specimens were prepared for Rockwell-B hardness test, the specimen is of 25mm diameter and a length of 20mm.Fiber configuration and volume fraction are two important factors that affect the properties of the composite. In this test, the configuration is limited to unidirectional and continuous fibers equal to the length of the specimen.The hardness properties of the composites are studied by applying indentation load normal to fibers diameter and normal to fiber length.The effect of fiber loading and post curing time on Rockwell hardness is illustrated in Figures 3 and 4. Generally, fibers that increase the moduli of composites increase the hardness of the composite. This is because hardness is a function of the relative fiber volume and modulus.

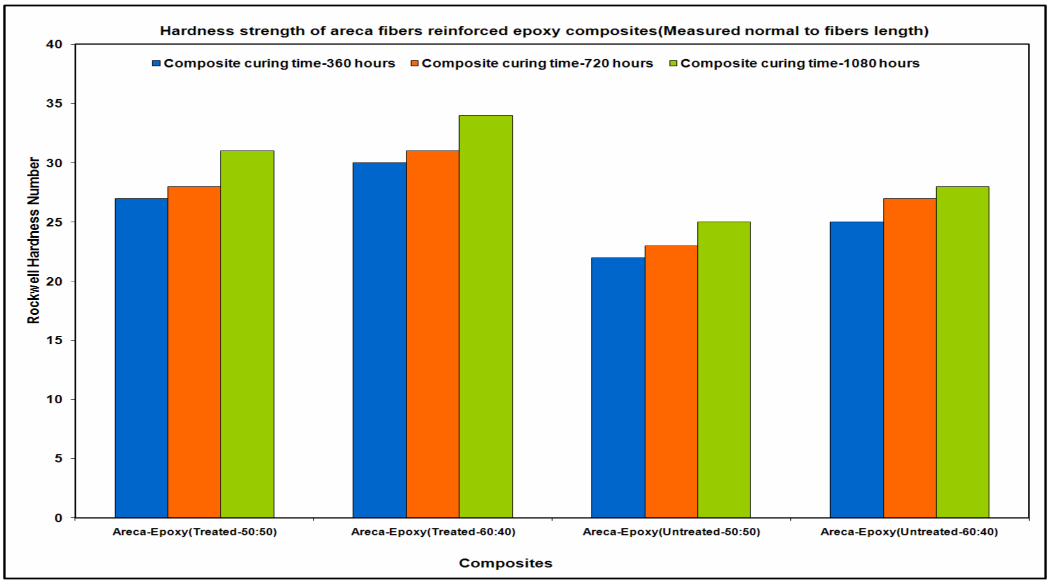

Figure 3. Shows the hardness strength of composites (Measured normal to fiber length)

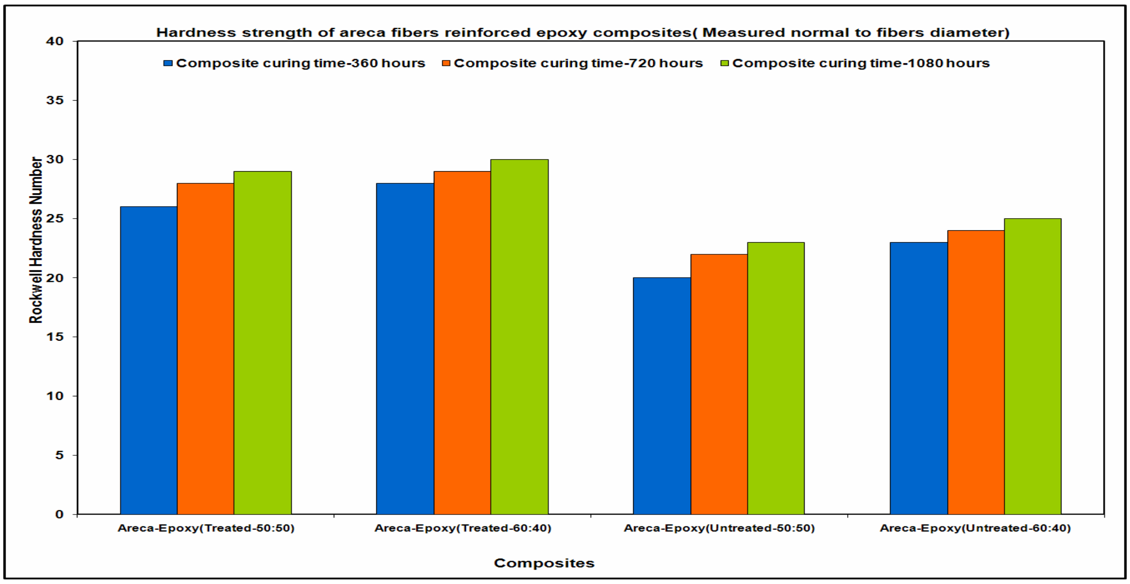

Figure 4. Shows the hardness strength of composites (Measured normal to fiber diameter)

Conclusion

The results in the present work indicate that, it is possible to enhance the properties of fiber-reinforced composites through fiber surface modification. The mechanical properties of composites of chemically treated areca fibers show better results when compared to natural untreated fibers. It is also worth noticing that the strength of areca fiber composites increases with increase in volume fraction of fiber in the composite and post composite curing time. This is a very rare phenomenon which is not observed in many of the natural fiber composites. Hence, based on the availability, cheaper and good strength of areca fiber composites investigated in the present research work. The composite can certainly be considered as a very promising material to fabrication of lightweight materials used in automobile body building, office furniture, packaging industry, partition panels, etc. compared to conventional wood based plywood or particle boards.

References

1. Andrzej K. Bledzki, Wenyang Zhang. *Journal of Reinforced Plastics and Composites*, 20 (2001) 1263-1274.
2. Kaleemullah, S., John Gunasekhar, J. *Biosystems Engineering*, 82 (2002) 338.
3. Rasheed, S., Dasti, A.A. *Pak. J. Biological Science*, 6 (2003) 840–843.
4. Akhila Rajan, Jayalakshmi Gopinadha Kurup. *Biochemical Engineering Journal*, 25 (2005) 237-242.
5. Guinez, D., C. *proceeding of the 8th polymers for advanced technologies*, Hungria (2005).
6. Abdullah-Al-Kafi. *Journal of Reinforced Plastics and Composites*, 25 (2006) 575-588.
7. Prasad, S.V., Pavithran, C., Rohatgi, P.K. *Journal of Material Science*, 18 (1983) 1443-1454.
8. Mohanty, A.K., M. Misra, L.T. Drzal. *Composite Interfaces*, 8 (2001) 313-343.
9. Kalaprasad, W.G., Bejoy Francis, Selvin Thomas. *Polymer International*. 53 (2004) 1624 –1638.
10. R.P Swamy**,** C. Mohan Kumar, Y. Vrushabhendrappa, *Journal of Reinforced Plastics and Composites*. 23 (2004) 1372-1382.

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