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Mechanical Characterization of Areca husk-Coir fiber reinforced hybrid Composites*

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Abstract

Bio fiber based composite materials are gaining interest in the field of certain engineering applications because of their easy processing, low cost, low density and higher strength to weight ratio. In the present study, randomly oriented short Areca Husk and Coir fibers were reinforced with unsaturated polyester resin for the fabrication of composites. The fibers were pretreated with sodium hydroxide to enhance the interphase bonding between the fibers and matrix material. Specimens were prepared and tested for tensile strength, flexural, hardness and impact strength as per respective ASTM standards. The results revealed that individual areca husk fiber reinforced specimens shows improved performance in all properties over coir fiber reinforced specimens. However the hybrid composite specimens test results shows average values as compared to individual fiber reinforced composites.

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Keywords: Areca husk fiber; Tensile strength; Fiber Treatment; Alkali; Compression moulding

1. Introduction

In the recent year's environmental problems, new rules and legislations, pollution problems forcing the manufacturing sectors to decrease the dependence on synthetic materials. Over the past decades, biodegradable or natural resource based materials receiving more attention than synthetic materials. Plant based fibers considered to be as an alternate material for synthetic fiber for application such as interior door panels of a vehicle, household equipment's, construction field etc[1]. The tremendous increase of production and use of plastics in every sector of

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our life lead to huge plastic wastes. Disposal problems, as well as strong regulations and criteria for cleaner and safer environment, have directed great part of the scientific research toward eco- composite materials. Among the different types of eco-composites those which contain natural fibers (NF) and natural polymers have a key role. For a few years, polymeric biodegradable matrices have appeared as commercial products; however their high price represents the main restriction to wide usage. Currently the most viable way toward eco- friendly composites is the use of natural fibers as reinforcement. Natural fibers such as coir, hemp, jute, areca, cotton etc. represent a traditional class of renewable materials which, nowadays, are experiencing a great revival.

Recent studies on natural fibers like coir, hemp, sisal, banana shown that natural fibers have the potential to be used as alternative reinforcement material to replace synthetic fibers such as carbon, glass and aramid. Many efforts were made by researchers to reinforce natural fibers with thermoset and thermoplastic matrix material. Low density, availability, non-toxic, ecofriendly, biodegradability and cost are the reason to choose natural as alternate reinforcement material in the field of composite manufacturing sector [1, 2, 3]. Synthetic polymers are combined with ecofriendly natural fibers to obtain the desired properties for the required application. The main challenge in natural fiber based composites is bonding between matrix and fiber surface. To enhance the adhesion between fiber and matrix researchers are using various fiber surface modification methods. According recent researches fiber treatment with alkali solution can significantly improve adhesion at the fiber matrix interface and as a result the mechanical properties and water resistance properties of laminates increase by great extent.

In this paper mechanical property of short coir and areca husk fiber reinforced with unsaturated polyester resin was compared with hybrid composites of the same fibers. Areca husk and coir fibers were treated with sodium hydroxide (NaOH) solution to improve the wettability property of the fiber surface. The composites were prepared by using compression moulding method and laminates tested for various mechanical properties as per ASTM standards.

2. Materials and Methods

2.1 Materials

The unsaturated polyester resin (density of 1.13g/m^3), used as matrix material and supplied by Sri Mokambika Poly Products Udupi, Karnataka, India. The areca husk and coir fibers were collected from local areca plantations of the coastal region of Karnataka, India. Sodium hydroxide and acetic acid procured by Durga Chemicals Mangalore, India.

2.2 Fiber Extraction

Areca husk were immersed in water for water for about 5 days. Soaking process mainly used to loosen the fibers and fibers can be extracted out easily. The extracted fibers were washed in running water and allowed to dry in room temperature [4, 5]. The dried fibers designated as untreated fiber. Coir fibers were extracted from coconut husk by using a crusher. Crushed and soaked coconut husk fed into de-fibering machine to extract the fibers. The fibers obtained from de-fibering machine contained different lengths of fiber; to separate these fibers screener used. The fibers were segregated as short and medium according to length of individual fibers.

2.3 Fiber Treatment

The areca husk and coir fibers were treated in a solution of 10wt. % of NaOH. The fibers were kept in the alkaline solution for 30 hour at room temperature. After treatment fibers were thoroughly washed in running water and then neutralized with a 2% acetic acid solution [6]. Lastly, they were again washed in running water to remove the last traces of acid sticking to them, so that the pH of the fibers was approximately 7(neutral). Then they were dried at room temperature for 48h to obtain alkali treated fibers. The density of treated coir fiber was found to be 1.12g/m^3 and density of areca fiber was 0.9g/m^3.

2.4 Fabrication of Composites

In the present study unsaturated polyester reinforced with randomly oriented short treated fibers as follows.

- Composite with 20% by weight alkali treated coir fiber
- Composite with 20% by weight alkali treated areca husk fiber
- Composite with 20% by weight alkali treated coir and areca husk fiber

Treated coir and areca husk fiber chopped into 5cm of length to maintain the uniformity in the fiber dimensions. The sufficient amount of treated fibers mere combined with required amount of unsaturated polyester resin. Methyal Ethyl Ketone Peroxide (MEKP) and Cobalt used as catalyst and accelerator. Addition of MEKP to cobalt premixed polyester started the cross linking of polymer chains and resulted in gelation of matrix material. Composite specimen's cured under room temperature and to maintain the uniform thickness of laminate pressure of 30kgf applied on the specimen by using compression moulding machine.

2.5 Mechanical Testing

Tensile tests were conducted as per ASTM D 3039 using BiSS make universal fatigue testing machine and dimensions of the specimens maintained as 200mmx25mmx4mm [7]. The tests were performed at a loading rate 1kN/min. Static three point bending tests were conducted according to ASTM D 790 in 10kN capacity Instron universal testing machine; and dimensions of the specimens were maintained as 125mmx12.7mmx4mm [7]. Figure 1 represents the set up used to carry out tensile and flexural test. The dynamic charpy impact tests were conducted on specimens as per ASTM D 6110 and by using impact testing machine [8]. Notched specimen with dimensions 127mmx12.8mmx4mm were used to carryout impact test. Micro Vickers hardness tests conducted as per ASTM E384 by using Matzusawa micro Vickers machine.

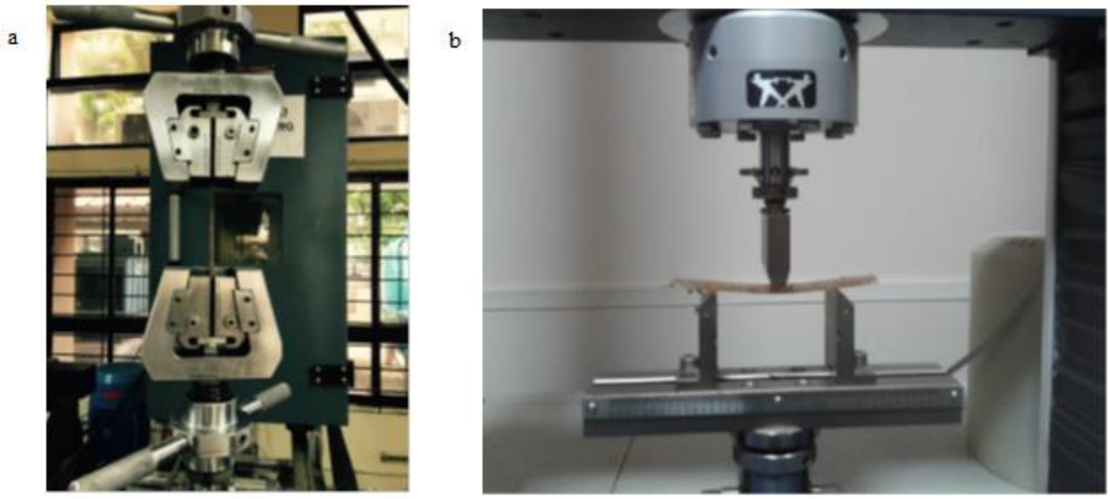

Fig.1 (a) Tensile test setup; (b) Flexural Test setup.

3. Results and Discussion

3.1 Tensile Properties

The tensile strength versus strain plot of coir, areca and hybrid polyester composites is shown in figure 2. It is observed that areca husk fiber reinforced composites has taken a maximum tensile strength of 21.2MPa, coir reinforced composites has able to take maximum stress level of 19.83MPa and hybrid composite shown improvement in the tensile properties by 6% and 9% with respect to areca and coir fiber reinforced composites. Maximum tensile stress for hybrid composite was 22.32MPa. Tensile properties of the composites mainly depend on the aspect ratio of fiber, distribution of fibers and bonding between the matrix and fibers. The aspect ratio of areca fiber found to be higher than the coir fiber; and resulted in higher tensile properties than coir/polyester composites.

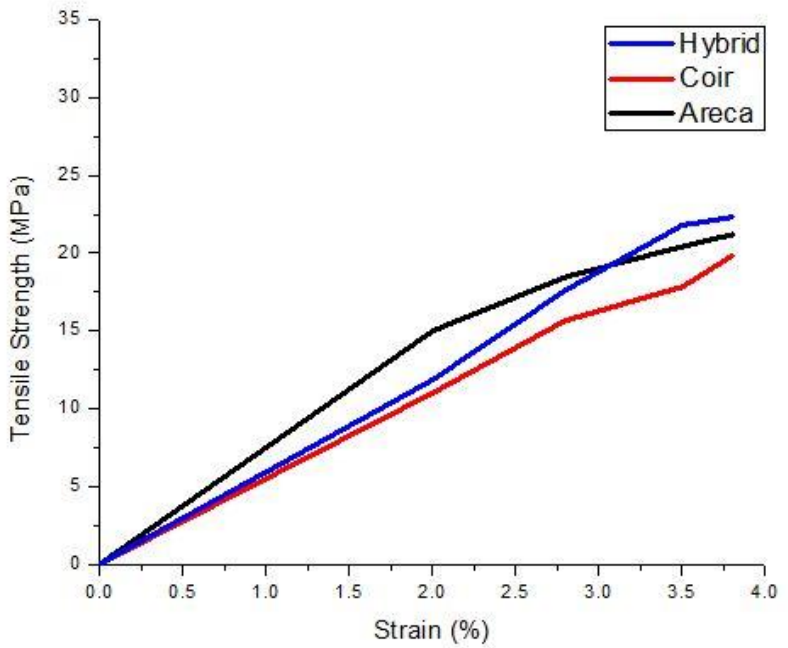

Fig.2 Stress vs Strain Graph of different composite materials

3.2 Flexural properties

Variation of flexural modulus of polyester matrix based composite specimens shown in figure 3. It is seen from the figure that the flexural modulus of areca husk fiber composites higher than the coir fiber based composites. Areca husk fiber reinforced specimens showed 41% higher flexural modulus than coir fiber based composites. Since the areca husk fiber is of higher modulus; incorporation of areca fiber with coir fiber with polyester matrix resulted in increase of the modulus of hybrid composites than coir fiber based composites.

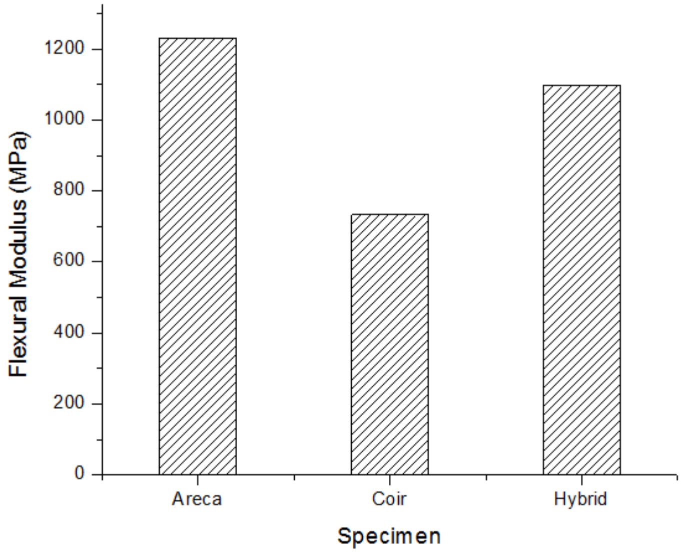

Fig. 3 Flexural modulus variation of different composites

3.3 Impact and Hardness results

Variation of impact energy absorbed by different specimens by charpy test method shown in table 1. Areca husk fiber reinforced composites absorbed maximum energy compared to other two specimen. Impact energy absorbed by the fiber reinforced composites mainly depends upon the nature of fiber, modulus of fiber and interfacial bonding between fiber and matrix.From the results obtained by charpy impact test it is clear that natural fiber composites are capabale to absorb energy because of the strong bonding between fiber surface and matrix.

Table 1: Variation of impact energy

Specimen	Energy absorbed (KJ/m^2)
Areca husk fiber composite	44
Coir fiber composite	22.2
Hybrid composite	34.2

Hardness is a measure of resistance to shape changes when force applied on the composite material. Hardness value of composites depends distribution of fiber, void content of the specimen. Diamond indenter of cone angle 136° was impinged on the specimen surface with a force of 100gram. Table 2 shows the hardness values of different composite material measured by Matsuzawa MMT-X micro Vickers hardnes test equipment. Results shows that reinforecment of areca husk fibers in polyester matrix reduced the flexibility of matrix and resulted in more rigid composite material.

Table 2: Hardnes values of different composite specimens

Specimen	Hardness Value (H_v)
Areca husk fiber composite	20.6
Coir fiber composite	14.5
Hybrid composite	16.3

4. Conclusions

In the present research, mechanical properties of short areca husk and coir fiber reinforced with unsaturated polyester was studied. Composites with modified areca husk fiber have superior mechanical properties than the modified coir fiber reinforced composites. Hybrid composites also showed promising results as compared to areca husk fiber reinforced material. Hence from the obtained results, availability of areca husk fiber, coir fiber, low cost of fiber, these composites positively considered as alternative material for the fabrication of office furniture's, partition panels and internal door panels.

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