FABRICATION OF HYBRID COCONUT FIBRE WITH EPOXY COMPOSITE

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ABSTARCT-Coconut fibers are gaining importance in the manufacturing of hybrid Fiber laminates. Coconut coir fibers should be chemically treated with diluted sodium hydroxide solution before using it to manufacture the composite material. The effect of surface modification on chemically treated fiber for mechanical properties such as tensile strength, flexural strength, impact strength and hardness of the composites were evaluated. Compared with the untreated coir composite and treated epoxy composites it was found that the tensile strength increased by 33% and elongation at break was found to be 20% greater. The flexural strength increased by 35% and impact strength doubled compared to the untreated coir composite material, The Scanning Electron Microscope was used to analyze the fractured surface feature as well as interfacial bonding strength of the composites. The results showed that the chemical modification in the coir fiber led to easier permeating of the coir fiber and epoxy resin and promoted effective interfacial adhesion. It was concluded that the mechanical properties enhanced after chemical treatment and improved the formation of chemical bonds between the coir/nylon epoxy resins with the coupling agent.

Keyword: *Hybrid composites, Nylon fiber, Coconut fiber and Hand layup method.*

I. INTRODUCTION

The concept 'green think green' has been introduced to raise the awareness of using environment friendly products in product development. There is increase in demand for environment friendly materials around the globe. These materials are generally cheaper than synthetic reinforcement composites. Natural fiber reinforced composites are green composites[1] which are used in automobile industries, since these materials have good impact strength, flexural strength and low density. These composite materials can be produced with low cost and have good characteristics such as renewability, easy to process, low energy requirement for its manufacture [2]. Synthetic fibers are being replaced by natural fibers because of their beneficial properties such as light weight and high strength [3].Coconut coir is a natural fiber which has been used for many applications such as manufacturing of ropes, floor mats, thermal insulators and also as fuel due of its huge availability (10 x 10-6 tons per year) in India. Research activities in the field of natural fiber materials resulted in this material having found applications in the manufacture of composite particle boards, thermal insulators and building materials [4]. The potential of incorporating natural fiber in polymers has been addressed well in many literatures. The hydrophilic nature of natural fiber materials because of the presence of lignin and pectin causes adverse affects. It results in issues with adhesion with polymers and reduces the mechanical properties of the produced composite material. Chemical treatment can improve the adhesion between natural fibers and polymers [5]. The mechanical properties of jute reinforced epoxy composite. It was found that the tensile strength and flexural strength improved as a result of alkali treatment [6]. Study conducted on Kenaf reinforced epoxy composite material revealed that the flexural strength of the chemically treated composite material was higher than its non-treated counterpart [7]. The tensile strength of composite material with palm fiber treated with Sodium Hydroxide was higher than the composite specimen which was not subjected to any treatment [8-9]. The Sisal fiber reinforced epoxy composites and found that alkali treatment removed the hydrophilic nature of the fiber and improved the bonding strength of composites [10]. Hybrid composite materials are relatively new class of composite material which incorporates two or more reinforcement materials in a single matrix [11-13]. These materials are a step ahead of composite materials with single reinforcement element. Hybrid composite material posses improved mechanical properties at low cost and have gained research interest around the globe during the recent years [14]. The combined effect of properties of synthetic and natural fiber enhances the overall properties of the hybrid composite material and also reduces the environmental impact [15-16]. In this paper the effect of mechanical properties on the behavior of hybrid composite material is studied and the resulting property modifications on the prepared composite materials subjected to chemical treatment are discussed. Tensile strength, flexural strength, impact strength and morphological analysis were made on the hybrid composite material containing coconut coir and nylon mat as reinforcement materials on epoxy resin matrix.

II. EXPERIMENTAL WORK

2.1. Materials Used

Hybrid composite material comprising of a natural fiber and a synthetic fiber were to determine the changes in its mechanical properties and morphological behavior. An attempt was made to find the potential of using these unique combinations for making parts such as trays and containers for holding goods, doors, window panes, buckets and mugs. The reinforcement materials were composed of coconut fibers and nylon fibers in woven roving mat form. Epoxy resin provided the necessary binding as well as acted as the matrix material. The coconut coir fibers used in this research work was procured from local coconut husk processing unit in Chennai. Coconut fibers were selected as reinforcement material because of its affordability and biodegradable characteristics. The coconut coir fibers were chopped into whiskers of length 10 ~ 20mm and diameter 0.3 mm respectively. To remove moistures from the whiskers it was dried under the sun light for 3 days. The nylon fiber mat measured 300 mm long and 300 mm wide. The diameter of nylon fibers was 0.3 mm approximately. Commercial grade Sodium hydroxide NaoH was purchased from local supplier. Ethanol, distilled water was purchased from chemical lab Pliogrip, Chennai, Tamil Nadu. Epoxy resin 205 was selected as the resin and Diethelenetriamene as the hardener was mixed in the ratio of 10:1. The combination of resin and hardener provided dual purpose of acting as binding agent and also as matrix element in the hybrid composite material

2.2. Alkaline Treatment of the coconut coir

The hydrophilic nature of coconut coir acts as undesirable characteristics which makes it unsuitable for many industrial applications. Some of the ill effects of hydrophilic nature of coconut coir include the growth of pathogens and enlargement of coir by absorption of moisture from the surrounding air. The coconut coir was chemically treated in order to remove the lignin and pectin capable to degrading its properties under the influence of moisture.

The alkali treatment of the coconut whiskers were carried out in a conical flask. A solution containing 5 to 6% Sodium Hydroxide (NaOH) in water was added to 10 g of coconut whiskers. The solution was allowed to react with the whiskers for 60 mins and then drained. The chemical reaction that takes place during the treatment of the coconut fiber is shown in equation (1).

$$\text{Coconut fiber} + NaOH\ O + Na + \text{Coconut threads} \qquad (1)$$

The resulting coconut whiskers with its hydrophilic nature removed were washed in distilled water to remove the traces of NaOH. The whiskers were then dried under sunlight for three days to remove excess moisture in its surface

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2.3. Fabrication Procedure

The specimens were manufactured to evaluate the variation in its mechanical properties and compare the same with the existing material for desired appliance. The composite materials were manufactured using hand layup technique because of its capability of making large sized composite material at relatively lower cost. Shows the composition of the composite material used in the research.

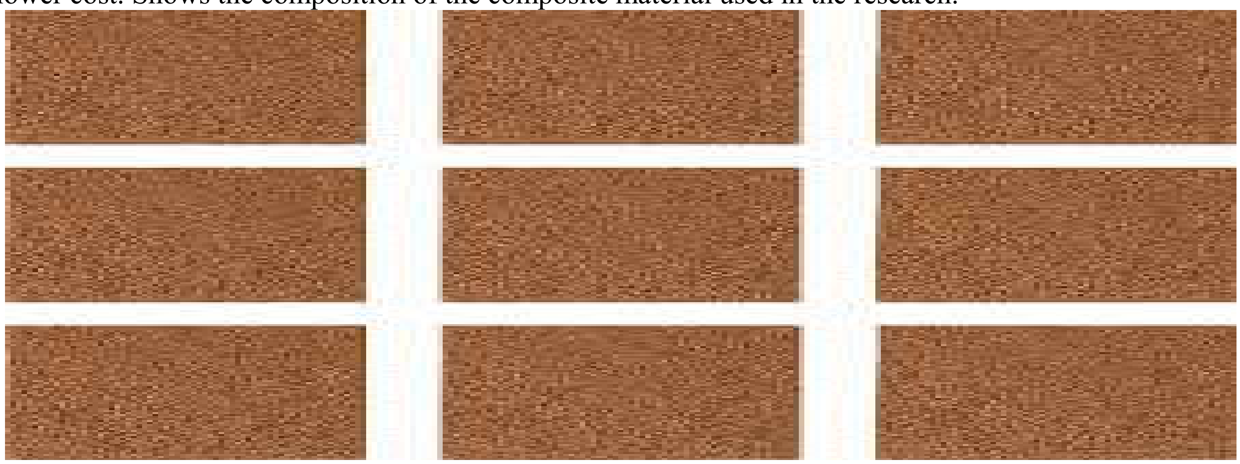


Figure 1: Samples of hybrid coconut with epoxy resin

Table 1: Sample code Composite Materials

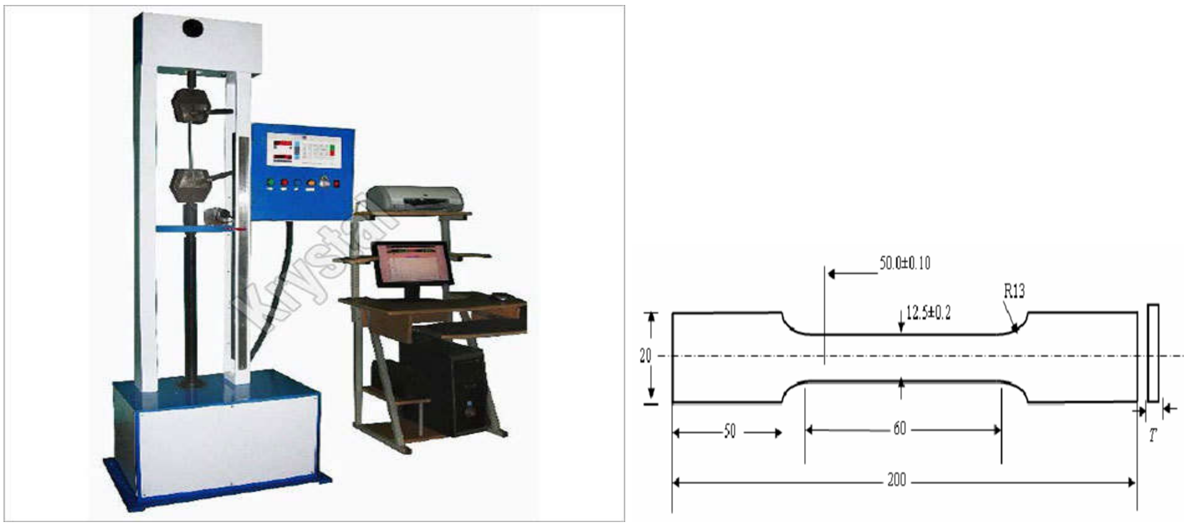
EHUTC	Epoxy resin hardener and untreated coir
EHTC	Epoxy resin hardener and treated coir
EHTCN	Epoxy resin hardener and treated coir with nylon

A flat metallic mould plate of size 300 X 300 mm was used for manufacturing of the composite materials. Polyethylene sheets covered with wax were used as separating layers to avoid sticking of the composite material to the mould. The binder cum matrix composing of resin and hardener mixture was taken in the ratio of 10:1. Hence 100 ml of hardener was added to one liter of epoxy resin. 8 vol. %of chemically treated coconut whiskers was mixed to the epoxy resin and hardener mixture. The resulting mixture was poured evenly over the polyethylene sheet which was laid over the metal mould plate. The nylon mat was placed over the binder cum coconut whisker mixture. The nylon mat was topped with a second layer of the binder cum coconut whisker mixture. This arrangement gave 2/1 layup for the produced composite laminate. The polyethylene sheet was used as cover over the top layer of binder and whisker mixture. A flat wooden plate was place over the top polyethylene sheet. Then weights were kept over the surface of the wooden plate. The weights gave the necessary force to press the components of the composite material and spread it evenly along the nylon mat.

The excess materials which came out along the sides of the mould were scrubbed out. The layup was left untouched for duration of 24 hours so as to allow sufficient setting time and curing. Then the cured composite material was removed from the mould. The thickness of the composite material was measured as 8 mm. A second composite material was manufactured through the same process, but without the addition of nylon mat. The thickness of the resulting composite material was same as the one produced with nylon mat. A third composite material was prepared with the absence of nylon mat. However this composite material had untreated composite whiskers to compare the variation of its properties under the influence of hydrophilic nature of the whiskers. Figure 2.1 shows the composite material manufactured using hand layup technique.

2.4. Mechanical Characterization

The mechanical properties such as tensile strength,flexural strength, impact strength and hardness were measured on the produced composite material. FIE Universal Testing Machine as shown in Fig. 2.2a having loading capacity of 10kN was used to conduct the tensile test on the composite materials. The specimen was cut into dog bone shape as per ASTM standard ASTM: D638-10 for taking the tensile test as shown in Figure 2.2b.



UTM machine *specimen*

Figure 2.2b. Tensile testing of composite materials

3. RESULTS AND DISCUSSION

3.1. Mechanical properties of the composites

Mechanical properties of the three composite materials were evaluated to determine its capability to withstand externally applied load. The tensile strength as well as the percentage of elongation was noted to increase with the applied load after the solution treatment using NaOH. Impact strength of the solution treated component was found to decrease when compared with that of untreated counterpart. The mechanical properties were at its peak for the composite material having 20 % by weight of the reinforcement composition. However for the composite material having 30% by weight of its reinforcement material, the properties were noted to be lower. This was because as the reinforcement material which possessed higher hardness was included in the matrix element, it affected the overall properties of the composite material. The phenomenon was noticed with the presence of defects as the reinforcement composition increased. In comparison between the treated and untreated composite materials, the former had superior mechanical properties. The tensile strength increased by 33%, elongation was found to increase by 20%, while its impact strength lowered by 35%. The good bonding between the coir and epoxy was one of the reasons for this improved property modifications.

3.1.1. Tensile strength

The tensile strength of three different composite samples is given in Table 3.1. The yield strength and the ultimate strength of the composite

Material with untreated coir was found to be 0.01 kN/mm2 and 0.016 kN/mm2 respectively. The corresponding mechanical properties of the composite material with treated coir showed an increase of 40% and 12% respectively. However the same properties were found to increase by 61% and 51% after inclusion of nylon fibers as the reinforcement in the composite material. This indicates that the elastic nature of the nylon fabrics integrated into the overall properties of the produced composite material. The plot shown in Fig. 3.1 indicates that the yield strength increased linearly due to chemical treatment of the coir and also the inclusion of nylon fibers as its constituents. However the ultimate strength of the composite materials was noted to increase at a different rate. The chemical treatment of the coir resulted in improving its mechanical strength. However the treatment process on the coir made it to shift its nature towards brittle. This drawback was avoided by including the nylon fiber, which successfully shifted the composite material behavior to act as ductile material. Fig. 3.2 proves this claim, in which it can be observed that the chemically treated composite material had lower percentage of elongation (7.67%) compared to the composite material with non treated coir (9.67%). The plot indicates that by adding nylon fibers the percentage of elongation of the resulting composite material increased to 10.54% [17].

Table 2.1Tensile test results of different composites

Sl.no	Sample code	Yield strength (kN/mm²)	Ultimate strength (kN/mm²)	Elongation (%)
1.	EHUTC	0.010	0.016	9.56
2.	EHTC	0.015	0.018	7.37
3.	EHTCN	0.020	0.024	10.11

The relationship between stress and strain between the three composite materials are noted. Besides the brittle nature of composite material containing chemically treated coir the capacity to withstand higher stress was found to be higher than its counterpart with untreated coir. The addition of nylon fiber improved the stress bearing capacity of the composite material. The synthetic reinforcement material in the composite had higher mechanical properties compared to the natural matrix element. This resulted in the improvement of its stress bearing capability.

3.1.2 Effect of chemical treatment

The hydrophilic nature of coir induces undesirable properties such as increasing the porosity between the fiber and the epoxy resin matrix. This will hinder the transfer of stress evenly along the matrix and reinforcement, leading to mechanical failure during the usage of the composite material. The coir has to be treated chemically in order to remove the hydrophilic nature. If the epoxy resin flows properly around the coir fibers then the fibers will be held tight and grip within the matrix element [20]. Manyauthors have indicated an increase in mechanical properties with chemical treatment [21-22]. Increase in mechanical properties and fiber wettability was observed with chemical treatment [23]. In this experiment, composite samples with chemically treated coir pith showed better tensile strength values compared to the samples with untreated coir pith. Treatment of coir pith in alkaline environment promotes the activation of hydroxyl groups of cellulose unit by breaking hydrogen bonds, which in turn makes its less hydrophilic [24].

3.1.3. Chemical resistance tests

The chemical resisting behavior of the composite material. The ability of the composite samples to remain impervious in acid, alkali, solvent and water were tested and discussed. The incorporation of raw coir pith decreased the chemical resistance of epoxy resin. However, chemically treating the coir pith and inclusion of nylon fabric enabled to overcome the undesirable property reductions in the composite material. It was noted that though the values were found to be higher than raw coir epoxy the hybrid composites showed a lesser solvent uptake which increased chemical resistance compared to coir pith/epoxy composite without nylon fiber. Composite samples with chemically treated samples showed better solvent resistance which was higher than pure epoxy resin. This was due to increased interfacial bonding between pith and epoxy on chemical treatment resulting in reduced void content and also due to reduction in its hydrophilic nature. These factors offer higher resistance to solvent movement of solvent molecules into the composites system [25]. Restricted equilibrium technique has been used as a tool by many researchers to analyze the filler-matrix bonding in the composites system [26]. It was reported that increased interfacial interaction resulted in lower solvent uptake by composites systems. Therefore the solvent uptake in solvent resistance for composites systems with treated coir pith may due to the increased interfacial interaction between filler and matrix.

4. CONCLUSION

The hybrid coconuts coir fiber with epoxy composite materials were prepared using hand layup technique successfully and it is a natural hybrid fiber and it very eco friendly and it is biodegradable and have high mechanical properties.

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