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Investigation on Mechanical Properties of Bamboo and Coconut Fibre Reinforced with Polyester and Epoxy Resin

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The present study focused to analyze material characteristics in terms of the $Ca(ClO)_2$ concentration for treating the coconut and bamboo fiber to enhance the mechanical properties of natural fiber polymer-based hybrid composites. The $Ca(ClO)_2$-treated fibres were washed thoroughly using distilled water and allowed to dry for 24 hours. Composition of each specimen, bamboo (B) and coconut (C) fiber with epoxy and polyester composites were prepared by hand layup process as per the American Society for Testing and Materials (ASTM) standard. The proportionality of the material was carefully fulfilled according to the previous literature reports. The weight fraction of the composite material content was set to be bamboo (B) with matrix material (M), coconut (C) with matrix material (M) and 50% bamboo (B) + 50% coconut (C) with matrix material (M). Four distinct criteria were used to calculate mechanical parameters such as Tensile strength, Flexural strength, Material Hardness and Impact strength.

Key Words: Bamboo Fiber, Coconut Fiber, Epoxy Resin, Polyester Resin, Matrix Material.

1. Introduction:

The past few decade materials accrued from the surrounding nature such as wood, sticks, bricks, stones, animal skins, and bones. However, the people are fascinated to weave natural fibres to make cloths with composed materials which are silk and cotton. Highly, the synthetic materials from plastics can be organic and inorganic category or natural fiber or synthetic material. The researches encountered the need of the customer represented as synthetic organic plastics and essentially termed as polymers. Some other elements contained nitrogen, oxygen, silicon, chlorine, etc. In general, polymers are regulated by the process of polymerization, and monomers are bonded in line chain mode. Composite material is defined as a mixture of matrix and reinforcement to make superior properties of the components. Based on the material dimension, alignment and angle position which will affect the properties of material [1].The past decade composite materials were dominated as emerging materials such as plastics, mica, and ceramics. However, in order to establish applications of composite materials, the market focused on cost, availability, and safety. As a result, the market has steadily grown and penetrating acquired materials. Recently, several innovative techniques were done in composite industries and overcome certain cost hurdles. Accordingly, different essential things should be followed up with respect to designing, tooling, quality control/assurance, material process, etc. [2]. Fiber- reinforced polymer offered cost effectiveness to overcome the market dream, and certain applications may cover both cost and weight such as cascades for engines, replacements for welded metallic parts, cylinder, and ducts. Usage of composite is increased day by day, and adoption increased throughout the industry, and composites are lightweight, more stiffness, more strength, etc., and additionally, their corrosion and chemical resistant in nature functions with increasing the service life during the cycle and all-natural composite structure using many applications and materials used based on resin soybean oil and natural fibers such as flax, recycled paper, and cellulose. Then, the researcher team focused on the next gen of biocomposites with the example of fiber-reinforced composite with the combination of matrix and reinforcement from natural and renewable resolution termed as hybrid composite. Recently, the bamboo can be significantly used because of its easy availability. It has appreciable mechanical characteristics. It can be recyclable. In addition, wastes from bamboo can be effectively utilized in the form of fibers, ash, and particulates. Different studies have reported that the bamboo fibers can be accompanied effectively for the corresponding increase of the mechanical properties of the composites. As reported elsewhere, biodegradability and thermal stability of the matrix can be significantly improved with the addition of bamboo fiber. Similarly, the coconut fiber is known as a no edible, which is widely considered as waste material and usually

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Dumped in landfills. Also, this possesses good strength and modulus. Previous researches have shown that coconut fiber has the ability to improve the compressive strength when incorporated into epoxy matrix. The tremendous factors were considered to invent new manufacturing lightweight composites [3]. Figure 1 displays the methods and stages of fabrication. In the present study, the $Ca(ClO)_2$ concentration for treating the coconut and bamboo fiber to enhance the mechanical properties of natural fiber polymer-based hybrid composites was investigated.

2. Literature Review

Based on the previous experimental results, the highest mechanical properties, with tensile strength of 39.16 MPa and flexural strength of 61.10 MPa measurement (date palm hybrid composites), can be achieved by non hybridization. The properties of bamboo/palm hybrid polymer composites varied depending on hybridization or non hybridization. Water absorption treatment has shown a significant result of the reduction of hydrophilic characteristics

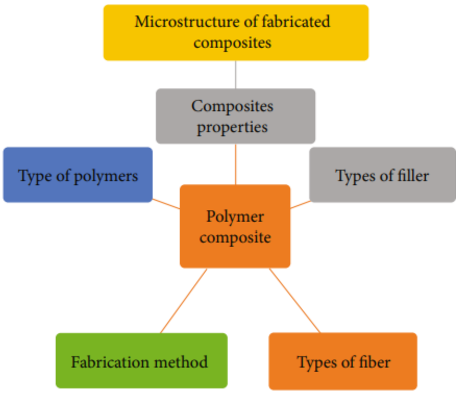

Figure 1: Methods and stages of fabrication.

followed by the material treatment to agglomerate the particle and achieve excellent adhesion between the materials [4]. The effect of fiber loading on the performance of sisal and bamboo epoxy resins. They used NaOH to remove the hydrophilic characteristics of the hybrid composite hydroxyl groups in hemicellulose, cellulose, and lignin. As a result, the material had achieved high adhesion between fiber and matrix [5]. Alkaline treatment reduces the mechanical strength of bamboo. The contact between untreated bamboo and epoxy resin is poor. If the tensile strength and Young's modulus of the bamboo fiber fall, the adhesion between bamboo fiber and epoxy resin could be enhanced by alkali treatment [6]. Unidirectional fiber pattern, different overlapping length of adjacent fiber bundle, and randomized of individual fiber end. Tensile stiffness is unaffected by discontinuity pattern, but inserted randomized fiber and discontinuity resulted in a loss of 85% longitudinal tensile strength in comparison to unidirectional bamboo fiber composite [7]. Six distinct random oriented fiber-reinforced polyester composite samples were created. Tensile strength and Young's modulus both reduced coir fiber inclusion, however, increasing the stiffness and ductility of coir fiber composites [8]. Effect of bamboo fiber- reinforced epoxy and rice husk filler loading on modulus of elasticity, flexural strength, and impact strength was evaluated. 15% filler loading resulted in higher modulus of elasticity, flexural strength, and impact strength. The modulus of elasticity increases linearly with filler loading [9]. When coconut coir fiber was combined with epoxy, it resulted in a plastic material with corresponding tensile strength, input strength, and hardness strength. The hardness of the material increases as the weight percentage of the coir fiber increases. The maximum tensile strength of bamboo fiber was 84.61 MPa [10, 11].

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3.Table 1: Properties of Epoxy & Polyester Resins

Property	Epoxy	Polyester
Viscosity at 25 °C	12000 - 13000	250 - 350
Density ρ ($g.cm^{-3}$)	1.16	1.09
Heat Distortion Temperature HDT(°C)	50	54
Modulus of Elasticity E (GPa)	5.0	3.3
Flexural strength (MPa)	60	45
Tensile strength (MPa)	73	40
Maximum elongation(%)	4	1

4.Experimental Work

4.1. Specimen Preparation. The experimental work was designed and constructed in accordance with the American Society for Testing and Materials (ASTM) standard plate dimensions of 200 ∗ 200 ∗ 10 mm. First stage of work is mixing resin and hardener with tabulated/calculated proportion and assured by weight measuring equipment. All the components are completely reacted on the specific container.

Figure2: Bamboo and coconut fiber

Figure 2 shows the bamboo and coconut fiber, Table 1 shows the properties of the epoxy and polyester resins and Table 2 show the properties of coconut fiber and bamboo fiber which were determined as per the standard procedure. In the present study, the epoxy and polyester resins were used as matrix binders. Epoxy resin, polyester resin and hardener mixed thoroughly with the proportions of 2:1 & 10:1 respectively. Primary matrix content is distributed uniformly over the plate and rolled up. Secondary layer fiber content was placed over the surface and matted up uniformly by process of rolling. Excess air was evacuated and contained by the rolling tool while under brief pressure. The final stage of the process ensures the ASTM dimensions with agreement to close the mould by wooden plate or steel plate with uniformly applied specific load. It has been considered for curing the matrix after loading. All of the specimens were constructed to provide ASTM standard dimensions and are sliced to perform various tests to evaluate the composite.

Table 2: Properties of coconut fiber and bamboo fiber

Properties	Coconut fiber	Bamboo fiber
Density	1.288 g/cm3	0.9 g/cm3
pH	11.6	6
Moisture content	10% max.	14.01%
Sp. gravity	1.33	0.68
Water absorption	23%	26.2%
Length	150 – 200 mm	150 – 200 mm
Diameter	0.1 - 1.5 mm	0.1 – 1 mm

5. Result and Discussions

Table 3: Results for different combinations

Test	Epoxy			Polyester		
	B+M	C+M	B+C+M	B+M	C+M	B+C+M
Izod	2	3	3	2	3	4
Hardness	78.33	81.66	85.33	71.33	73.33	77.33
Tensile	46.2	17.6	58.4	38.2	15.3	48.6
Flexural	17.3	46.2	16.3	14.8	38.6	13.5

Note:

B = Bamboo fibre

C = Coconut fibre

M = Matrix material

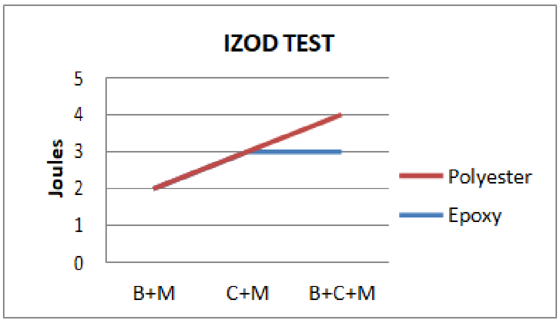

Figure 3: Samples testing for impact strength

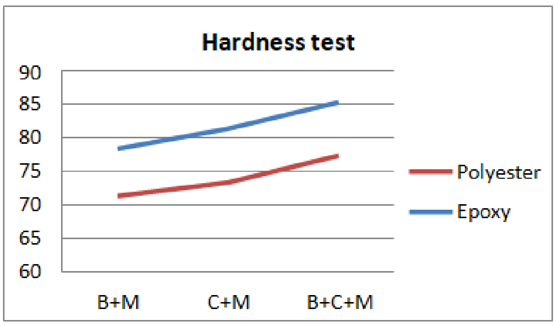

Figure 4: Samples testing for hardness strength

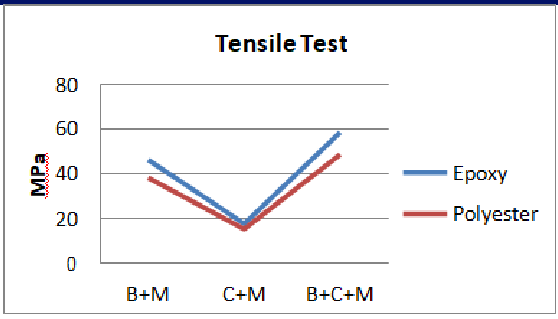

Figure 5: Samples testing for Tensile strength

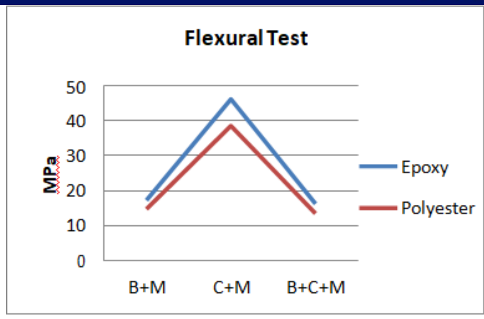

Figure 6: Samples testing for Flexural strength

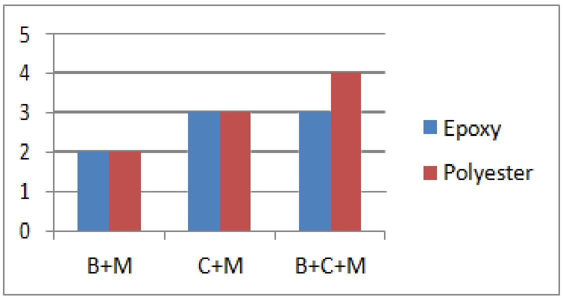

Figure 7: Impact strength

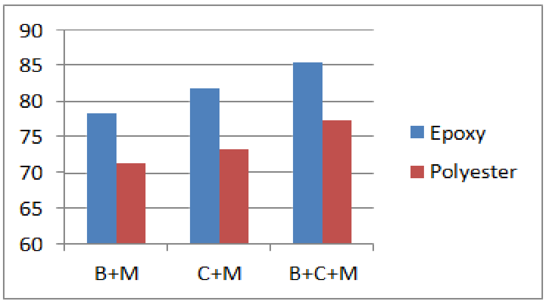

Figure 8: Hardness

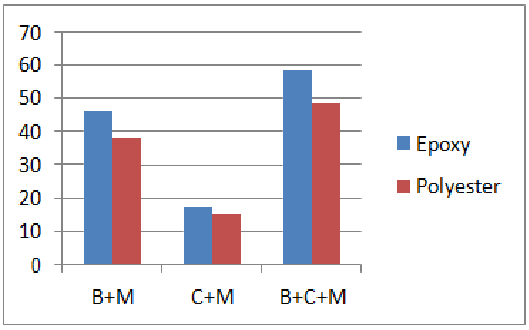

Figure 9: Tensile Strength

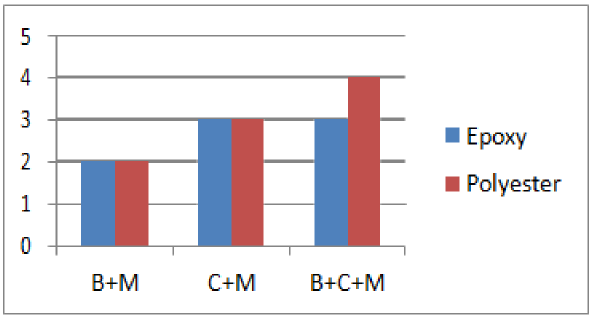

Figure 10: Flexural Strength

Mechanical testing is performed on three separate samples (tensile, hardness, and flexural testing). The testing ranges may vary depending on the amount of samples. Figures 5 & 9 show the average values for each testing result variation for three different combinations of changed surfaced material, maximum tensile strength is 58.4MPa. Similarly, Figures 4 and 8 show the maximum hardness for which the sample was suitable. For samples 3 and obtained the ideal range and sustained 85.33, obtained the consistent range. Figures 3 & 7 show the average values for each impact strength result variation for three different combinations of changed surfaced material, maximum Izod strength is 4 joules. Figures 6 & 10 show the average values for each flexural result variation for three different combinations of changed surfaced material, maximum flexural strength is 46.2MPa.

Conclusion

The present study is aimed at improvising the mechanical properties of coconut and bamboo fiber. Accordingly, in order to attain the best mechanical qualities, three alternative fiber loadings were

Examined. It was found that the material configuration comprised flawless orientation of the fiber was retained after the surface treatment followed by sun light exposure that was made ideal crystal structure forms. From the studies, the experimental results of the bamboo and coconut epoxy hybrid composites demonstrated the highest mechanical performance compared to bamboo and coconut polyester hybrid composites without hybridization. Significantly, the maximum tensile strength of the hybrid composite was observed to be 58.4MPa. Likewise, Maximum hardness of 85.33 and flexural strength of 46.2MPa by coconut composite. But polyester hybrid composite has the highest impact strength compared to the epoxy hybrid composite of 4 joules.

Acknowledgments

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