Investigation and comparison of Mechanical Properties of Natural Fibre and its Composite

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***Abstract*: The application of natural fibers such as bamboo, jute, banana, coir and linen Fibers Reinforced Polymeric (FRP) composites plays vital role due to their high effective stiffness and strength, availability, low cost, specific strength, better dimensional stability and mechanical properties, eco-friendly and biodegradable as compared to synthetic fibers. The interest in natural fiber reinforced polymers composites is rapidly springing up in terms of research and industrial applications. The increased applications of these natural fibers in such composites are a proof to this claim. Various tests like Impact test (IZOD and CHARPY test), Rockwell Hardness test were conducted on various process of bamboo reinforced polymers composite, bamboo-banana reinforced polymers composite and bamboo-linen reinforced polymers composite.**

***Keywords*: Natural Fibre polyethylene and biodegradability**

1. Introduction

Composite material is a material made from two or more materials with different physical and chemical properties but the individual components remain separate and distinct in final product. Fiber Reinforced Polymer is a composite material made of a polymer matrix imbedded with high strength fibers such as glass, basalt etc. The polymers are usually vinyl ester, polyethylene, reinforced polymers and polyester resins [1]. The use of natural fibers as a substitute for synthetic fibers in composites has gained an escalating importance in the recent years due to environmental concerns and growing cost of synthetic materials [2]. The center of study on natural fibers as substitute reinforcement in polymeric composites has created a vast attention of many researchers and scientists. The various advantages of natural fibers such as biodegradability, renewable, low cost, eco-friendly and comparable high mechanical properties make it more noticeable [3]. Bamboo-banana and linen fiber are some of the natural fibers that have high profitable potential and are extensively cultivated. Bamboo fiber is a regenerated cellulose fiber made from the starchy pulp of bamboo plants processed from bamboo culms [4]. It is found to have outstanding properties like high specific strength, high tensile strength, very resilient, durable, low cost, recyclable, etc. Banana plant not only gives the appetizing fruit but also provides banana fiber. It is a multiple celled lingo cellulosic fiber obtained from the pseudo stems of banana plant (Musa sepientum). The lumens are large in relation to the wall thickness, cross markings are rare and fiber tips either pointed or flat. Banana fiber is a natural fiber with high mechanical properties which can be blended easily with various other fibers or materials [5]. Linen is a long vegetable fiber which falls into the bast fiber category (fiber collected from bast, the phloem of the plant, sometimes called the skin) derived from the stems of flax plant, Linum usitatissimum. The fibers are mostly yellowish to grey and are 18-30 inches in length. Linen fiber is in great demand due to its high tensile strength, luster, specific gravity, evenness and length. Natural fiber reinforced polymeric composites are found in countless products including aerospace, civil, automotive, marine and textile applications [6]. As a result, increasing attention has been devoted to research on Natural Fiber Polymeric Composites (NFPC).

A. *Specimen preparation*

In this work, the bamboo fiber, banana fiber and linen fiber are cut into 2-4 mm of length, mixed with epoxy resin and kept for duration of 11-12 hours. Three samples are arranged named sample A, sample B and sample C. All the three samples are prepared by hand layup molding process. Firstly, wax coating is provided on the surface of the forming tool so as to prevent the fiber reinforced polymer to stick [7],[15]. Then, the fibers and the reinforced polymers; mixed thoroughly with a hardener is poured in the mold uniformly. For sample A, B and C, the combinations taken are in the ratio 90:10 (reinforced polymers: bamboo fiber), 90:5:5 (reinforced polymers: bamboo - banana fiber), 90:5:5 (reinforced polymers: bamboo-linen fiber) respectively. Further the addition of fiber layer is provided to get the necessary thickness of the fiber reinforced polymer. Figure 1&2 shows the orientation; composition and volume of sample A, sample B and sample C [8].

2. Material and methods

1) *Materials and equipment*

The composite materials used in the production of the specimens include: resin, fibers, wax, release agent, gel coat and miscellaneous items. The equipment used are weighing balance, cloth, stirrers, measuring cylinder, universal testing machine [19].

2) *Fiber treatment*

In this study, chemical resetting was used. The procedure involves NaOH solution treatment, water washing and drying. Natural fibers are extracted from their parent plant. The ukam, sisal and banana are extracted from the back of their stems, while hemp and coconut are extracted from their fruits. The natural fibers, after being extracted, are washed with water to remove gums. The fibers are then treated with sodium hydroxide solution and rammed. The treated fiber was allowed to dry in the sun for 3 days [9], [17]. After which the fibers are laid in the mold with the resin at the ratio of 30% to 70%. It was allowed to cure for about 20 days.

3) Impact test

Fiber Reinforced Polymeric (FRP) composites are prone to impact damage. Therefore, impact testing has been performed to study the effect of impact as a little impact can lead to catastrophic failure in various industrial applications where these composites are being used. Impact testing is used to determine Toughness [10], [22]. Toughness is the ability of a substance to absorb energy without breaking. It is considered as one of the most significant mechanical property of thermoplastics because it relates to lifetime of materials, product safety and legal responsibility. Impact test consists of various tests out of which Izod and Charpy are the ones [11]. Izod test is used for determining the impact resistance of materials whereas Charpy test is a standardized high strain rate test which determines the amount of energy absorbed by a substance during fracture. Fig. 1.(a, b) shows bamboo reinforced polymers composite before and after break, Fig. 1.(c, d) shows bamboo-banana reinforced polymers composite before and after break and Fig. 1.(e, f) shows bamboo-linen reinforced polymers composite before and after break for Izod test. Fig. 2.(a, b) shows bamboo epoxy resin composite before and after break, Fig. 2.(c, d) shows bamboo-banana reinforced polymers composite[20], [25].

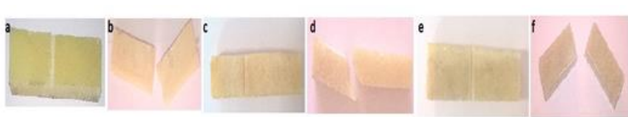

Fig. 1. Specimen for IZOD test

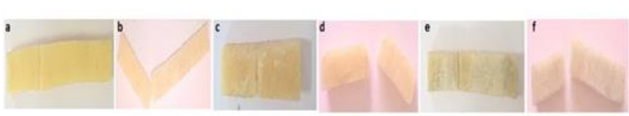

Fig. 2. Specimen for CHARPY test

4) Compressive and tensile strength

Figures 3 and 4 show the compressive and tensile strength of the alkalized treatment of banana, sisal, coconut, hemp and E-glass fibers. From the histograms, it is obvious that sisal laminate displayed the highest (42.0 MPa) compressive strength, followed by ukam laminate, then E-glass laminate, while the banana showed the lowest (16.75 MPa) compressive strength [18'23]. Fig. 2 shows the measured tensile strength of treated natural fibers. The tensile strength decreases from E-glass laminate with highest (63 MPa) tensile strength, ukam laminate (16.25 MPa), while hemp laminate showed the least (7.0 MPa) tensile strength. However other parameters that are important are assessed for good suitability [12], [13].

5) Bending strength

Fig. 5 shows the bending strength of alkalized natural fibers. E-glass displayed highest (0.50 MPa), next to it is sisal laminate, followed by coconut and hemp, while ukam and banana showed the least (0.0013 MPa) bending strength [14].

Table 1
Mechanical properties of natural fibre

Mechanical properties	Ukam fibre Laminate	Banana fibre laminate	Sisal fibre Laminate	bamboo fibre laminate	E glass laminate
Compressive strength (MPa)	39.25	16.75	42.00	30.35	37.75
Tensile strength (MPa)	16.25	6.50	5.40	3.20	63.00
Bending strength (MPa)	0.0013	0.0013	0.0036	0.0021	0.500
Impact strength (J/m^2)	9.89	7.47	8.36	8.36	17.82

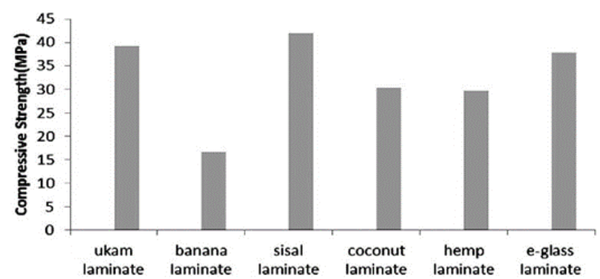

Fig. 3. Compressive strength of alkalized treatment of natural

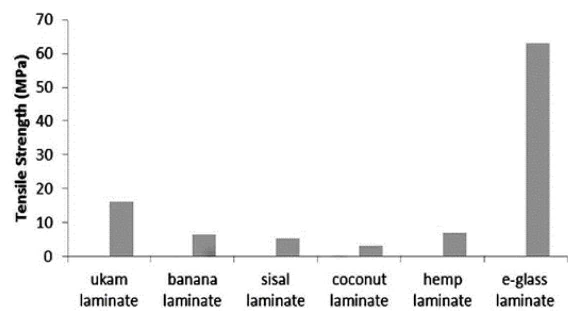

Fig. 4. Tensile strength of alkanized treatment of natural fiber reinforced laminate samples

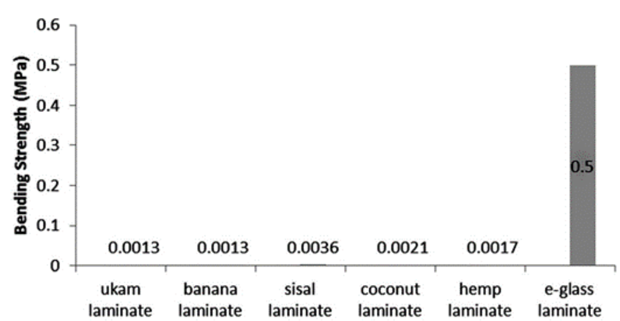

Fig. 5. Bending strength of alkanized treatment of natural fibre reinforced laminate samples.

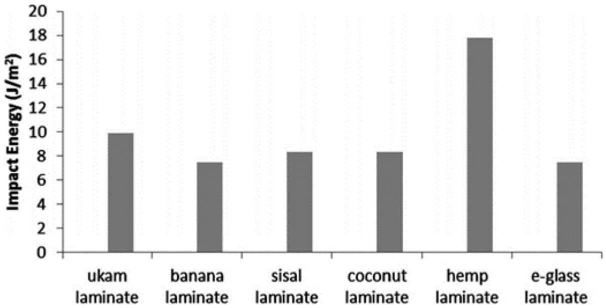

Fig. 6. Impact strength of alkanized treatment of natural fibre reinforced laminate samples.

6) *Rockwell hardness*

Rockwell hardness testing is an indentation testing method. It measures the permanent depth of a groove produced by a force/load on an indenter. The Rockwell Hardness Number (RHN) is calculated from the depth of permanent deformation of the indenter into the sample [24]. The indenter is either a conical diamond or a hard steel ball. Although Rockwell Hardness test does not give a straight measurement of any performance properties; hardness of a material correlates directly with its strength, wear resistance and other properties [21], [16].

Table 2
Hardness of natural fibre

Specimen	Hardness[RHN]
Bamboo reinforced polymers composite	20
Bamboo – banana reinforced polymers composite	30
Bamboo –linen reinforced polymers composite	40

3. Conclusion

In this paper, mechanical behavior of Natural Fibre Polymeric Composites (NFPC) was presented. Impact test and Hardness test of bamboo reinforced polymers composite, bamboo-banana reinforced polymers composite and bamboo-linen reinforced polymers composite showed significant results. According to the Impact results, bamboo-banana reinforced polymers composite showed the highest value of 4 Joules and 5 Joules while bamboo reinforced polymers composite showed the lowest value 2 Joules and 3 Joules for IZOD and CHARPY test respectively. According to the results, the functional groups of bamboo reinforced polymers composite and bamboo-banana reinforced polymers composite are same except one extra Alcohol/Phenol OH stretch and one less Alkyl CH stretch and Aromatic CH bending functional groups. According to the hardness results, bamboo-banana reinforced polymers composite had the highest Rockwell hardness test value of 30 RHN while bamboo reinforced polymers composite had the lowest Rockwell hardness test value of 20 RHN. In the future, we are going to carry out tests with a variety of compositions and various sizes of fibers of bamboo-banana reinforced polymers composites, bamboo-linen reinforced polymers composites and banana-linen reinforced polymers composites.

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