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Mechanical Behavior of Palmyra Palm Leaf Stalk Fiber Based Polymer Composites

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ABSTRACT

Now a days natural fibers having excellent chemical and physical properties provide new hope for researchers to substitute hazardous synthetic fibers. The use of natural fibers reinforced polymer composite material in various applications has increased tremendously. In this study, an attempt has been made to fabricate Palmyra Palm (botanically called Borassus flabellifer) Leaf Stalk fiber based polymer composite and evaluation its mechanical performances. For this composite preparation, Palmyra Palm Leaf Stalk fiber was used as reinforcement and the epoxy resin (Araldite AW 106) was used as the matrix. The fibers were extracted from the leaf stalk portion of the Palmyra Palm tree which is available in Bangladesh, India as well as in Asia. The fabrication of the composite is accomplished by hand layup techniques. Then the fabricated composite was taken for various mechanical properties testing like flexural test, impact test and hardness test. Results showed that there is a huge scope of using palmyra palm leaf stalk fiber based polymer composite in manufacturing automotive parts for vehicles.

Key words: Polymer composite, Palmyra Palm Leaf Stalk fiber, Mechanical performances

INTRODUCTION

Nature is the source of collecting natural fiber form different parts of plants (stems, leaves, roots, fruits, seeds etc). Natural fiber are abundantly available in the nature, easy to collect, cheap, eco-friendly and flexible [1-3]. Several effort has been taken to use natural fibers as reinforcements in polymer composites since many years [4-7]. In the recent few years natural fiber got more importance from the researchers and scientists. Natural fibers are replacing glass fibers for fabricating composite materials [8-10]. Natural fiber reinforced polymer composite includes the natural fibers which are collected from palmyra palm, pineapple, jute, abaca, kenaf, coir, sisal, cotton, bamboo, banana, hemp etc [11-18].Palmyra Palm fiber is a natural fiber obtained from various portions of Palmyra Palm tree (Borassusflabellifer), which is found abundance in Bangladesh, India as well as in Asia. Sudhakara et al. [19], achieved more tensile strength, modulus, flexural strength, modulus and impact strength for alkali treated/MAPP composites by 4.5, 17, 17.2, 9 and 10 % respectively increase of borassus fruit fiber reinforced polyester composites. Nadendla Srinivasababu et al. [20] introduced Palm Tree Sprout Leaf (PTSL) fiber reinforced polyester composites. The author has characterized the fiber for its tensile properties and morphological study. Pradeep P. et al. [21], showed that the characterization of palm fibers provides new hope for natural fiber research to compete with hazardous synthetic fiber with its excellent properties. The characterization results firmly confirm the possibility of using this fiber for the manufacture of sustainable fiber reinforced polymer composite. in this study, the palmyra palm fiber is collected from the leaf stalk portion of the palmyra palm tree (*Borassus flabellifer*). Mechanical properties of Palmyra Palm Leaf Stalk Fiber Based Polymer Composites are evaluated and compared with other polymer composites.

MATERIALS AND METHODS

Materials

In this study, the epoxy resin named Araldite AW 106 was used as matrix and Palmyra Palm Leaf Stalk fiber was used as reinforcement. Hardener HV 953 IN was also used with the matrix to enhance the interfacial adhesion of the composites.

The hardener and resin were collected from a chemical company of Bangladesh. The fibers were extracted from the leaf stalk portion of the Palmyra Palm tree which is available in Bangladesh, India as well as in Asia.

Extraction of Palmyra Palm Leaf Stalk Fiber

The Palmyra Palm fibers were extracted from the leaf stalk by simple manual method. The whole extraction process of this fiber is shown in figure 1 and the descriptions of this process are as follows.

1. To extract the fiber from leaf stalk, at first the fully matured and old leaf stalks were collected.
2. Then the leaf stalk was divided into small pieces with knife.
3. Then the fiber was extracted by hands.
4. Extracted fiber then dried in sun light.

Physical and chemical properties of Palmyra Palm Leaf Stalk Fiber are shown in table 1.

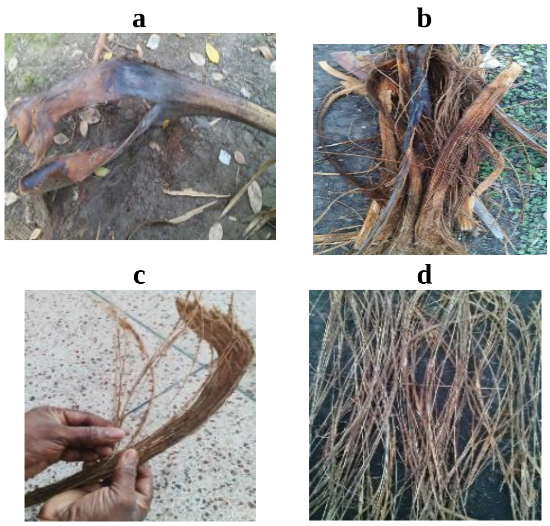

Fig.1 Fiber extraction Procedure (a) Leaf Stalk (b) Small pieces of leaf stalk (c) Fiber extraction (d) Dried fiber

Table -1 Physical and chemical properties of Palmyra Palm Leaf Stalk Fiber [21]

Density (g/cm^3)	1 - 1.2
Elongation (%)	2 – 4.50
Cellulose (%)	40 - 52
Hemi cellulose (%)	42 - 43
Tensile strength (MPa)	97 - 196
Young's modulus (GPa)	2.50 – 5. 40

Composite Fabrication Procedure

There are many procedures available for fabricating composites such as compression molding, resin transfer molding, vacuum molding etc. The hand lay-up technique is one of the simplest and easiest manual methods for fabricating composites. In this study, the composites were fabricated by the hand lay-up method. The whole sequential fabrication process is shown in Fig. 2 and descriptions of this process are as follows.

1. First of all the mold was made using small pieces of several wooden block.
2. A releasing agent was applied to the mold surface.
3. Then the 3:1mixtureof resin and hardener is poured into the mold.
4. Hand rollers were used to spread the mixture evenly throughout the mold surface.
5. Then the fiber was properly set throughout the existing surface.
6. At this, the 3:1 mixture of resin and hardener was poured into the mold again and hand rollers were used to spread the mixture evenly throughout on the previously set fiber.
7. Finally this mold was taken to the simple press to force the air gap to remove any excess air present in between the fibers and resin, and then kept for 72 hours to get the perfect samples.
8. After the composite material gets hardened properly, the composite material is taken out from the mold. Then the rough edges are neatly cut and removed.
9. The fabricated composites were cut using a grinding machine to obtain the specimen for mechanical testing as per the ASTM D3039 standards.

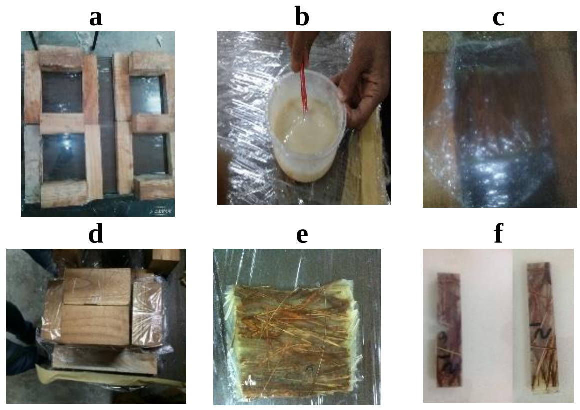

Fig. 2 Composite fabrication Procedure (a) Mold (b) Mixing resin and hardener (c) Matrix-Fiber-Matrix layer (d) Pressed to force the air gap to remove any excess air present and kept for 72 hours (e) After taken out from mold (f) Specimen for mechanical testing as per the ASTM D3039 standards

Experimental Procedure

Flexural testing, that is commonly known as three point bending testing was carried out as per ASTMD790. Composite specimens of dimensions 120 × 20 × 5 mm were horizontally placed on two supports and load was applied at the center of the specimen. Then varying the deflection, the required load was measured till the failure had been occurred. Impact testing of the specimen was carried out on Charpy impact machine. For impact testing, composite specimens were placed in horizontal position and hammer was released to make impact on the specimen. CRT reader gave the reading of impact strength. The Rockwell hardness test was performed using a hardness testing machine. All experimental tests were repeated three times to generate the data. Bending, Impact and hardness testing arrangements are shown in figure 3.

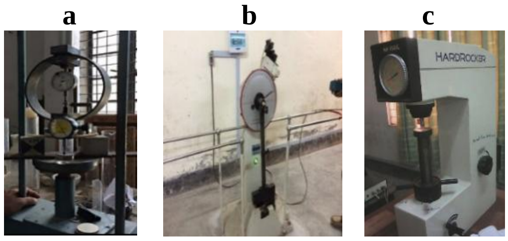

Fig. 3 (a) UTM machine for bending test (b) Impact test machine (c) Hardness test machine

EXPERIMENTAL RESULTS AND DISCUSSION

Flexural Test

The Flexural strength was obtained varying the displacement until the failure of the composites had been happened. The all experimental data are presented in Table 2. The flexural stress vs displacement curves for all three samples are shown in Fig. 4. From figure 4 it can be seen that the average maximum flexural strength is 127.89 MPa.

Table -2 flexural strength results

Displacement, mm	Flexural Strength, MPa		
	Sample 1	Sample 2	Sample 3
0	0	0	0
0.2	5.292	2.646	2.646
0.4	8.82	4.41	5.292
0.6	13.23	6.174	8.82
0.8	17.64	8.82	13.23
1	22.05	11.466	15.876
1.5	30.87	17.64	22.05
2	41.454	24.696	30.87
2.5	52.92	30.87	39.69
3	61.74	39.69	47.628
3.5	74.088	48.51	53.802
4	83.79	57.33	62.622
4.5	92.61	65.268	68.796
5	104.076	72.324	75.852

5.5	112.896	80.262	82.908
6	123.48	86.436	90.846
6.5	132.3	92.61	97.02
7	140.238	101.43	103.194
7.5	148.176	107.604	110.25
8		116.424	114.66
8.5		120.834	

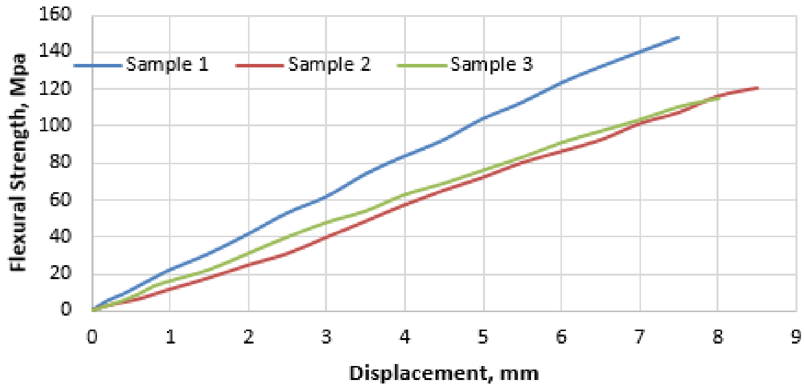

Fig.4 Flexural strength vs displacement curve

Impact Test

In impact testing, the energy loss was found out from the Charpy impact machine. Then the impact strength was calculated. Experimental results of impact testing of three specimens are presented in Figure 5.

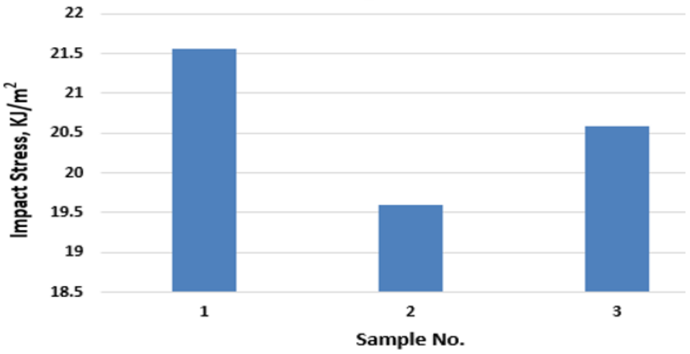

Fig. 5 Impact strength results

The average impact strength 20.5 KJ/m^2 is found.

Hardness Test

The hardness test was conducted in Rockwell hardness testing machine. The testing machine can withstand a maximum load of 60 kg and with a minor load of 10 kg. Three specimens were examined in this machine. The results are presented in the figure 6. The average hardness is found to be 71.

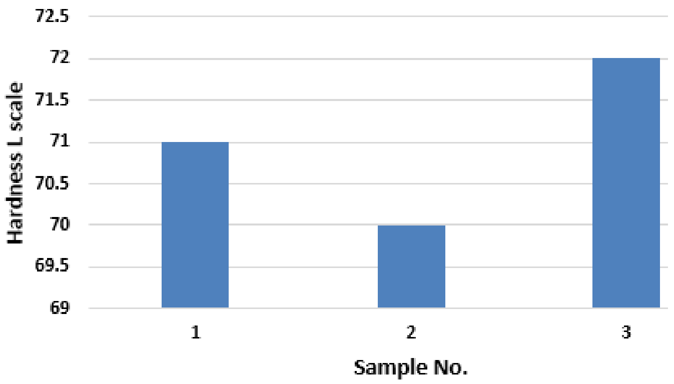

Fig. 6 Hardness test results

3.4. Comparison results

In this study the obtained results are compared with others study and the comparison results are shown in Table 3. It is observed that Palmyra Palm leaf stalk fiber based polymer composites possess average flexural strength than other composites. However, it is exhibit lower flexural strength than sisal fiber reinforced polymer composite. It is observed that Palmyra Palm Leaf Stalk Fiber Based Polymer Composite possess higher impact stress than banana fiber, sisal fiber and aluminum powder reinforced polymer composite. However, it is lower impact stress than jute fiber reinforced polymer composite and glass fiber reinforced polymer composite. The average hardness is 71, which is than aluminum powder reinforced polymer composite. However, it is observed less hardness than banana fiber and sisal fiber reinforced polymer composite.

Table -3 comparison results [22-24]

Name of the composites	**Flexural Strength (MPa)**	**Impact Stress (KJ/m^2)**	**Hardness**
Palmyra Palm Leaf Stalk Fiber (40% of total weight) Based Polymer Composite	127.89	20.5	71
Banana Fiber (12% of total weight) Reinforced Polymer Composite	126.67	2.5	106.4
Sisal Fiber (12% of total weight) Reinforced Polymer Composite	371.33	1.3	103.5
Aluminum Powder (16% of total volume) Reinforced Polymer Composite	-	0.088	7.9
Jute Fiber (40% of total weight) Reinforced Polymer Composite	65.87	178.56	-
Glass Fiber (40% of total weight) Reinforced Polymer Composite	89.67	235.13	-

CONCLUSIONS

The use of natural fiber reinforced polymer composites is increasing and spreading out to all fields rapidly. Though there are various sources from which natural fibers can be extracted to fabricate various composites, these are not completely sufficient to satisfy the emerging needs in respective applications. So, there is a huge possibility of using palmyra palm leaf stalk fiber based polymer composites as it is obvious from this study that the composite shows comparatively very good results during mechanical loading conditions. The automotive parts for vehicles such as door handles, door switch, door panels, various seat components, steering wheel and other exterior and interior parts can be made by this fiber based composites. They may last long and have good mechanical performances.

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