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Mechanical And Water Absorption Properties of Madar And Bauhinia Racemosa Natural Fiber Composites

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Abstract: ***This paper focus on Madar and Bauhinia Racemosa fibers has high potential as reinforcing agents in polymer composites. The composites plates were fabricated by hand layup method with varying the fiber weight percentage of 5%,10%,15% and 20% on mechanical and water absorption properties are analyzed. The mechanical properties of such as tensile, flexural and impact properties of madar and Bauhinia Racemosa fiber mat reinforced polyester composites were studied at first time in this work. The tensile, flexural and impact strength of Bauhinia Racemosa fiber mat reinforced polyester composites had proved higher strength performance than the madar fiber mat reinforced polyester composites.***

Keywords**:** ***Bauhinia Racemosa fiber, Madar fiber, Mechanical Properties; Water Absorption test***

I. INTRODUCTION

Now a days, Natural fibers as reinforcement in polymer composites to replace man – made fibers like glass, carbon and aramid because of the advantages, including low density, high specific strength, good thermal properties, economical and bio gradable [1,2]. Variety of natural fibers is available in the earth. Natural fibers are also cost effective, less abrasive, non-toxic, renewable, recyclable and consume less energy in processing. Many researchers in the past have developed composites using natural fibers such as bamboo, coir , sisal and banana to name the few [3-5]. The performance of natural fibers is reinforced with polymers usually analyzed depends upon the mechanical properties such as tensile, flexural and impact strength and hardness along with its bonding characteristics [6,7].

High-density poly ethylene (HDPE) reinforced sisal composites with a maximum fiber concentration of 7.5%. That the impact energy decreased from 6.5 to 2.9 J due to fiber addition, while tensile strength remained unchanged (14 MPa) studied by Torres and Aragon [8]. Anuar et al 2008 [9] studied the effect of thermo plastic natural rubber (TPNR) hybrid composites with kenaf fiber (KF) and glass fiber (GF). The result of tensile strength showed that increasing kenaf fiber content substantially reduced the tensile strength and modulus.

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From the above review of natural fiber reinforced polymer composites confirms that few number research works are carried out the processing of fibers into yarn mat. Based on the above concern, in this experimental work, a new identified fiber as extracted Madar fiber from Madar plant and Bauhinia Racemosa fiber as extracted from Bauhinia Racemosa tree. First time the madar fiber was reinforced polyester composite in this work. Here, the tensile, flexural and impact strength and water absorption properties of Madar fiber and Bauhinia Racemosa reinforced polyester composites were evaluated and the above properties of both fibers are compared with unreinforced polyester. Finally, to prove the strength and applications of the above composites (Madar plant and Bauhinia Racemosa fiber) 2 composite gears have been fabricated.

II. MATERIALS AND EXPERIMENTS

Materials

Table.1 shows the physical and chemical Properties of Madar plant and Bauhinia Racemosa when compared with other natural fibers. Bauhinia Racemosa is a small twisted, bushy tree with drooping branches found throughout India. The stem bark was collected from the Kolli Hills.

Madar plant does not have any separate stem but branches itself serve the purpose of support and connection with the roots. When grows to its fullest can reach the height of more than 2.5 or 3 meters. Unsaturated polyester resin, accelerator Methyl Ethyl Ketone Peroxide (MEKP) and catalyst Cobalt Naphthalene were purchased from Kovai Seenu Fabrics Ltd, Coimbatore.

Extraction process of Natural fibers

The Madar plants as shown in Fig.1(a). The Madar plant stems are cut to a length of 50 mm and immersed it water a duration of one week. Then peel the outer layer of the stem manually as shown in the Fig.1 (b). From the layer Madar fiber is peeled as represented in the Fig.1 (c) and extracted Madar fiber from Madar plant as shown in Fig.1(d).

From the bark of the Bauhinia Racemosa tree the outer surface of the stem is peeled manually from that the Bauhinia Racemosa fiber get extracted as shown in the Fig. 2 (a-d).

Preparation of composite specimen

The portion of a fiber in a laminate composite is given by Equation (1)

Where V_f is volume fraction of fibers, n is number of layers in the shield, A_f refers areal density of fibers, ρ_f is density of fibers and t is shield thickness.Table.1. physical and chemical Properties of Madar plant and Bauhinia Racemosa

Fibers	Cellulose (wt %)	Hemi cellulose (wt %)	Lignin (wt %)	Moisture content (wt %)
Madar	65	13	5	12
Bauhinia Racemosa	77	12	11	14

Fig.1. (a- d) Extraction process of Madar fibers

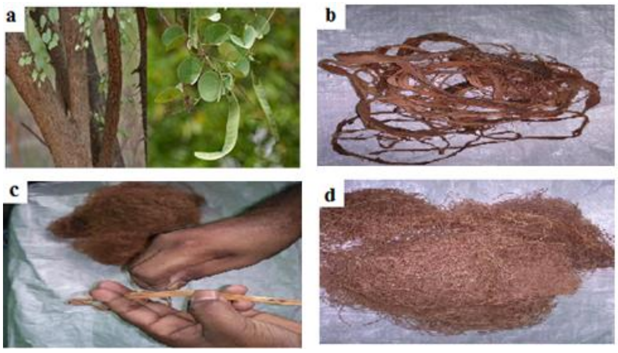

Fig.2. (a- d) Extraction process of Bauhinia Racemosa fibers

Based on the following Equation (1), the number of layers is premeditated for composite plates. Number of layers (np) essential for reinforced plates is shown in Table 2.

$$V_f = nA_f / \rho f^{t} \qquad (1)$$

Where V_f is volume fraction of fibers, n is number of layers in the laminate, A_f refers areal density of fibers, ρ_f is density of fibers and t is laminate thickness. Based on the Equation (1), the number of layers is calculated for composite plates.

In this work, the Madar and Bauhinia Racemosa mat fibers is used as reinforcement to fabricate the composites by using hand layup technique.

The composite plates were fabricated with a mould of measuring 300 mm length , 300 mm width , 3mm thickness were used for making specimens with different weight percentage Then, the resin was mixed with curing agents, poured into the mould cavity and the composites were allowed to cure for 24hours at room temperature.

Extreme care was taken to make a plate to obtain a uniform distribution of Madar and Bauhinia Racemosa mat fibers in mat composite preparation. Madar and Bauhinia Racemosa mat fibers reinforced polyester composites fabricated composite specimen as shown in Fig.3. Table.2. displays the Sample designation of unreinforced and reinforced composites.

Table.2 Sample Designation Of Reinforced And Unreinforced Composites

Name of fiber	Designation of specimen	Volume fraction of Fiber (%)	Volume fraction of Polyester (%)
Madar Fiber	M1	5	95
	M2	10	90
	M3	15	85
	M4	20	80
Bauhinia Racemosa gears	BR1	5	95
	BR2	10	90
	BR3	15	85
	BR4	20	80
Unreinforced Polyester	URPE	---	100

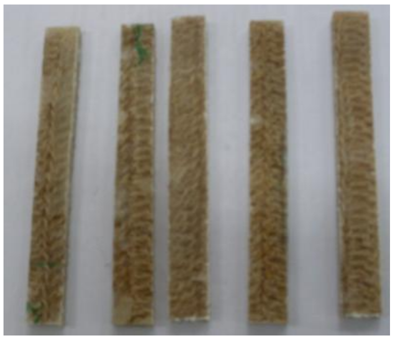

Fig.3. Fabricated Composite Specimen

III. DETAILS OF EXPERIMENT

Tensile tests were conducted for the specimens using the Electronic Tensometer– Model PC – 2000. For testing, load cell of 20 kN was utilize in the tensometer with the annoyed head speed of 5 mm/min. The gauge length maintained was 50 mm. The tensile test was conducted at 28°C and at a relative humidity of 50 ± 2%. Eight different composite specimens for tensile testing (M1, M2, M3, M4, BR1, BR2, BR3 and BR4) were organized according to the ASTM D 638 - 10 – Type I standard [10]. For flexural test, the Lloyd instrument LR 100 kN was used for conducting the flexural test. The cross-head speed was 2 mm/min. The flexural testing was organized according to ASTM D790-03 standard.

The Izod digital impact tester, Model: Frank-53568 was engaged for conducting the impact test. The impact test was conducted at 28°C and at a relative humidity of 50 ± 2%. The impact test was prepared according to ASTM D 256-05 standard.
The water absorption test of the composites was conducted as per ASTM D 570-98. METTLER TOLEDO digital weighing machine of resolution 0.1 mg be used for weighing the

samples. This test is decided out for 24 hours, 48 hours and 72hours.

IV. RESULTS AND DISCUSSION

Tensile strength

The different layer of Madar and Bauhinia Racemosa mat fiber reinforced polyester composite specimen were tested in digital universal testing machine until the ultimate tensile strength occurs. Figure 4. Shows the tensile strength results of madar and Bauhinia Racemosa fiber mat polyester composites. The tensile strength of M1 and BR1 composite specimen was measured as 17.26 MPa and 18.91 MPa. It was about Bauhinia Racemosa fiber mat reinforced polyester composites (BR1) had performed slightly higher tensile strength the madar fiber mat reinforced polyester composites (M1). The elongation percentages during fractures were recorded as 3.19% and 7.45% for M1 and BR1 composite specimens in that order. Moreover, The tensile strength of M2 and BR2 exhibits 18.32 and 18.9MPa.

The percentage of increase in tensile strength between M1 and M2 composites were 5.07 %. The percentage of increase in tensile strength between BR1 and BR2 were 9.13%. Similarly, the ultimate tensile strength of 23.72 MPa and 30.83 MPa were recorded for M3 and BR3 composite specimens in that order. The elongation percentages during break of M3 and BR3 composite specimens were recorded as 4.52% and 11.52%. The percentage of increase in tensile strength between M1 and M3 composites were 27.2%. The percentage of increase in tensile strength between BR1 and BR3 were 38.6%.

Finally, the ultimate tensile strength of 29.48MPa and 38.76MPa were recorded for M4 and BR4 specimens in that order. It was observed that Bauhinia Racemosa fiber mat reinforced polyester composites (BR4) had performed higher tensile strength than the madar fiber mat reinforced polyester composites (M4).

It was prominent that M4 and BR4 specimens performed well during tensile loading when compared to 5%, 10% and 15% V_f specimens, due to presence of high fiber content in the composites. The percentage of increase in tensile strength between M1 and M4 composites were 41.4%. The percentage of increase in tensile strength between BR1 and BR4 were 51.2%. Fig.5. shows the tensile modulus of madar and Bauhinia Racemosa fiber mat composites. It was found that Bauhinia Racemosa fiber mat composite has better tensile modulus than madar mat composites. The tensile modulus of madar mat composites were increase from 369 MPa to 1458 MPa. The tensile modulus of Bauhinia Racemosa fiber mat composites were increase from 329MPa to 932 MPa. Table.3. represents the tensile strength and tensile modulus of madar and Bauhinia Racemosa fiber mat reinforced composite samples.

Table.3. Tensile, Flexural And Impact Strength Of Reinforced And Unreinforced Composite Samples

Sample Designation	Tensile strength (MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Impact Strength (kJ/m^2)

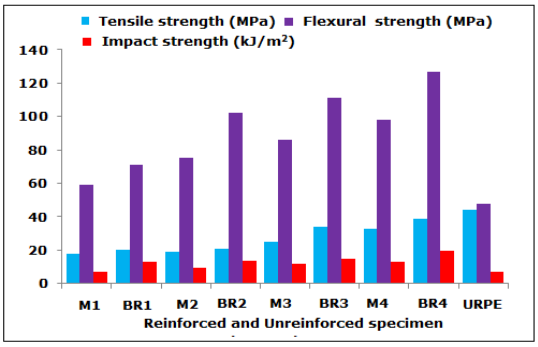

Fig.4. Tensile, Flexural and Impact strength for different volume fractions of the specimens

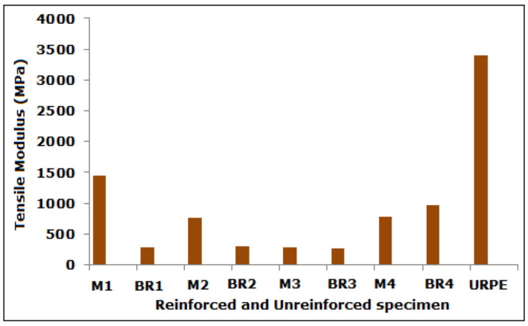

Fig.5. Tensile Modulus For Different Volume Fractions Of The Specimens

Flexural Strength

Fig.4. shows the flexural strength results of madar and Bauhinia Racemosa fiber composites. For madar fiber mat composites, It is found that the M1 specimen is found to be lowest flexural strength is obtained at 56.82 MPa and high flexural strength were obtained at 96.2MPa. It was observed that madar fiber mat composites reinforced polyester composites (M4) had performed higher flexural strength than other madar fiber mat reinforced polyester composites of M1, M2 and M3. It was about 1.69 times that of M1, 1.29 times of M2,1.13 times of (M3) madar fiber mat composites reinforced polyester composites.
For Bauhinia Racemosa fiber mat composites, BR4 composites has performed highest flexural strength of 119.04 MPa. It about 1.64 times that of BR1,1.22

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times that of BR2,1.11 times that of (BR3) Bauhinia Racemosa fiber mat composite. It was observed that flexural strength of madar and Bauhinia Racemosa fiber composites showed clearly as increased in flexural strength with increase in fiber weight content.

Impact Strength

The impact strength of a material is the measure of the sum of energy which the material can absorb before its breakdown. Figure.4. shows the impact strength of the composite. It shows that M4 and BR4 specimens have highest impact strength of 11.03 and 16.03 kJ/m2 correspondingly. Also, it obviously indicates that impact strength of madar and Bauhinia Racemosa fiber mat composites increased with increase in weight percentage. Though, Bauhinia Racemosa fiber mat reinforced composites have higher impact strength than madar fiber mat composites. This is owing to matrix fracture, fiber matrix de-bonding; fiber breakage and fiber drag out through impact loading this causes energy dissipation in the material [11]. It was about 31.7% that of M1, 16% of M2, 5.7 % of (M3) madar fiber mat composites reinforced polyester composites. It about 13.9% than that of BR1, 8.2% than that of BR2, 3.8% than that of (BR3) Bauhinia Racemosa fiber mat composite. The results of Bauhinia Racemosa fiber mat reinforced polyester composites seems to be capable of fascinating energy due to strong interfacial bonding between the fiber and matrix.

Water Absorption test

Madar and Bauhinia Racemosa fiber mat reinforced polyester composite specimens were allowed to dry in sunlight for 3 days before testing. The specimens were originally weighed using weighing machine. After initial weighing, the specimens were wrapped up in a container of distilled water maintained at room temperature. At the end of every day, the specimens be removed since the water and their surfaces were wiped off with a dry cloth, and weighed again. This process was repeated for every 24 hours.

The percentage of water absorption for composite materials is given in the Equation (2).

$$W_{abs} = (m_2 - m_1) / m_1$$

where

m_1 is mass of the model before test and

m_2 is the mass of the model after test.

Water absorption is one of the major concerns in using natural fiber composites in a lot of applications. In this study, 24, 48 and 72-hour water ingestion percentage was measured by the weight change method for all specimens. The results of Madar and Bauhinia Racemosa fiber mat reinforced polyester composite specimens are shown in Table.4. It is obviously indicated that URPE specimen doesn't show any major water absorption rate up to72 hours due to lack of fibers. Water absorption rate at 24 hours of all specimens is unimportant. Starting the results, it is inferred that M1 and BR1 specimens have the smallest amount water absorption rate due to less fiber content during all 3 days. However, a drastic change in boost of water absorption rate for M1 and BR1 in 48 and 72 hours is pragmatic. With regard to M2 and BR2 specimens, the percentage of increase in water ingestion ranged from 0.98% to 2.41% for the next two days. M3, BR3, M4 and BR4 specimens show radical increase in water ingestion percentage due to more fiber content. More number of layers in the specimen was exposed to water atmosphere which absorbed more water, thus causing increase in weight. Here, it is finished that water absorption rate increases with increase in volume fraction. As well, it should be noted that Bauhinia Racemosa fiber mat reinforced composite has a smaller amount water absorption percentage compared to madar fiber mat reinforced composites. This is owing to a greater number of madar fiber mat layers stacked in the specimen, based on the breadth and areal density of the mat.

Table.4 Water Absorption % For Different Volume Fractions Of The Composites

Sample Designation	Water absorption %		
	24 hours	48 hours	72 hours
M1	0.0780	1.0956	2.0157
BR1	0.0750	0.8426	1.1875
M2	0.1067	1.4105	2.5965
BR2	0.0968	1.1014	1.6985
M3	0.1105	1.4895	2.7652
BR3	0.0988	1.3086	1.9356
M4	0.1526	1.7265	2.8956
BR4	0.1095	1.5065	2.3025
URPE	0.0305	0.0396	0.0337

Fabrication of composite gears for various application

Madar and Bauhinia racemosa fiber reinforced composite gears have been fabricated with the help of gear hobbing machine as shown in Fig.6. This grade of composites was useful for broadening of industrial applications (e.g., to increase their durability of polymer gears).

Fig.6. Madar And Bauhinia Racemosa Composite Gears

V. CONCLUSION

For reinforcement in polyester resin, madar and Bauhinia Racemosa fibers were chosen as the base material. Through weaving process Madar and Bauhinia Racemosa fibers were made into mat. For better bonding with the matrix material the mats were subjected to alkali treatment. Using hand layup technique, composite plates are fabricated and tested. The results of these composites are as follows;

- BR4 composite tensile specimens showed better tensile strength of 35.71 MPa during tensile test in higher weight percentage with better interfacial bonding between fiber and matrix.
- The Bauhinia Racemosa fiber mat reinforced composite specimen shows better flexural strength and load carrying capacity when compared to madar mat reinforced polyester composites.
- The highest impact strength of 16.03 kJ/m^2 was observed in BR4 composites specimen. M4 was recorded with impact strength of 11.03 kJ/m^2which is slightly higher than the madar mat reinforced polyester composites.
- In the water absorption test, Water absorption rate increases with increase in fiber volume fraction for composite plates. It is due to the fact that fiber content increases the hydrophilic nature of the composites. This shows that the fiber content has greater influence on the water absorption rate.
- Furthermore, this work confirmed that Bauhinia Racemosa and Madar fiber have been fabricated the composite gear for real time applications.

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