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Investigation of Mechanical Properties of Palmyra Palm Leaf Stalk/Carbon Fiber Reinforced Polyester Hybrid Composite

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Abstract— In this investigation, the Mechanical valuables of short inconstantly oriented Borassus flabellifer leaf stalk fiber [BFLSF/PPLSF] and carbon fiber strengthened Polyester hybrid composite were predicted based on various weight percentage. The Hybrid composite were fabricated by Resin transfer moulding or compression moulding technique. The durability, bend strength and crash properties of the composite were evaluated. The fractured surface of the hybrid synthesized material were analysed by used Scanning Electron Microscopy [SEM] and also studied the water absorption performance of the fabricated composite. Experimental results were compared with other natural fiber and it has high strength to weight ratio. In future designing and fabrication the Manned and Unmanned Aerial, Marine and Surface Vehicle structures.

I. INTRODUCTION

Nowadays synthesized materials are used in many advanced applications. The performance of composite materials depends upon the selection of the constituent fibers Such as sisal, coir, cotton, banana, bamboo, palmyra fibers. The valuables of Natural fibers are low solidity, high toughness, resistance to breakage during processing, biodegradable, non-abrasiveness, easy processing and non-toxicity and free from health-hazardous. When natural fiber are compared to the synthetic fibers it have less mechanical property. It reinforced polymer and it used from as 1868 for seats in aircraft, and later in 1941-1946 for bearing, fuselage in aircraft and bearing in ships.

Unnatural fibers such as glass fiber, carbon fiber, boron fiber, aramid, and Kevlar have lighter and good mechanical properties. The demerits of the synthetic fiber were more expensive and non-renewable resource. Both natural, synthetic fibers have to intersperse in a common matrix form that called as hybrid composites and it has superior properties and economical one.

Natural and natural base hybrids composite have good mechanical properties, But moisture observation behaviour is high. To overcome this problem natural/synthetic fiber based hybrid composite materials are suggested by many researchers. It has superior mechanical properties and low-level water observation behaviour. Although of all these superiorities, the unnatural fiber strengthen composites taken in different aspects like reprocessing and biodegradability after the end of their natural life. It will increase fibers enervation life, better rupture toughness and lower indentation compassion compared to single fiber stiffen composites. The glass fiber has high unambiguous strong suit and rigidity [1]. The natural fiber strengthened with glass fiber composite materials have light weight and high environmental awareness. They are naturally available in abundance and can be used to reinforced polymers. [2]. The fibers from the natural planet are utilized for commercial application. [3]. Many surveys have been conveyed on quite a lot of types of natural fibers and their mechanical properties of composite materials. [4]-[7]. Paiva Junior et al premeditated the effect of hybridization of these fibers on the perfunctory properties [8]. At the same time the fixed mechanical properties of unsystematically oriented mixed short banana/sisal hybrid fiber covered polyester composite were investigated by Marie et al [9]. Jacab Maya et al[10] have been studied the effects of fiber external in sisal/oil palm hybrid fiber armored rubber composite . It used in many automobiles, aircraft industries also studied the water fascination behaviour of hybrid composite [11]. The stagnant and active mechanical properties of kenaf fibers and wood flour hybrid polypropylene were studied by Mehdi Tajvidi et al [12]. In this present investigation, PPLSF/CF various length short fiber are reinforced polyester hybrid composite fabricate and determined the workable, flexural, impression and water immersion behaviour of the fabricated composite.

II. EXPERIMENTAL DETAILS

Materials: Palmyra palm (Borassus fiabellifer) extracted from the Borassus fiabellifer tree. The spines on the sides of the leaf stem and the skin of the leaf stem were removed manually. The leaf stem was dipped in H2O for 20 days followed by gentle beating to separate the fibers by hand from the Palmyra palm leaf stalk. The detached fibers were then cleaned and become dry in sunlight.

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Take out the wetness and other uncleanness, spearing to the fibers. The retting process finally got the 0.5-1m length of the Palmyra palm fiber. To get the good quality of fibers the Borassus fiabellifer ripeness stalk. Carbon fibers were supplied by Hindustan composite solutions, Mumbai, Maharashtra. The perfunctory properties of the Palmyra palm and Carbon fiber in given as Table 1. In this present work, Palmyra palm and carbon fibers with weight percentage 5%-15% and length 20, 30, 50 mm were used as reinforcements to unsaturated polyester resin, cobalt naphthalene (catalyst), methyl ethyl ketone peroxide (hardener). The polyester resin was obtained from Covai Seenu and company Coimbatore India.

Table 1: Mechanical Stuffs of BFLSF-CF

Properties	BFLSF/PPLSF	CF	Polyester
Average diameter (µm)	300-320	-	-
Density (g/cm3)	1.2	1.8	1.15
Tensile strength (MPa)	276±5	3450	17±0.7
Modulus (MPa)	8990±12	230000	850±22
Strain at break (%)	3.08	1.5	1.5±0.02

Preparation of Composite Specimen: The carbon fiber and palmyra palm leaf stalk fiber are mixed. Short randomly oriented Palmyra palm leaf stalk and carbon fiber was prepared by changing the fiber weight ratio. Before the fiber arrangement inside the die, the silicon spray was spread on the male and female die. The fibers are miscellaneous and spread consistently in the mold 165 X 165 X 3 mm3. Resin diverse with accelerator and chemical agent is mixed thoroughly and transferred over the compressed moulding. The mold is shut applying enough pressure. The closed mold was kept under 24 h. The great care is taken to get identical distribution of fibers. After curing composite was separated from the mold and the specimen were cut according to the ASTM Standards. Later the composite plates were fabricated with varies fiber composition. Details are given in table2.

Table 2: Description of BFLSF/CF crossbreed composites

Composite	Length of the fiber (cm)	BFLSF Content (%)	CF Content (%)	Total fiber content (wt%)
P100	5	100	-	15%
P50C50	2,3,5	50	50	5%
P50C50	2,3,5	50	50	10%
P50C50	2,3,5	50	50	15%
C100	2	-	100	15%

III. MECHANICAL PROPERTIES OF COMPOSITES

(A) Tensile Test: Workable tests were performed ensuing ASTM D638 using an Instron universal testing machine (model 5569) at a crosshead velocity of 2 mm/min at 20^{0}C Nine trials were tried for each case and the middling tensile strength value described. The stretchable strength and stretchable modulus were determined from the stress-strain curve in table3.

(B) Flexural Test: Flexural assets were dignified in accord with ASTM D 790 using an Instron universal testing machine (model 5569) at a crosshead speed of 5 mm/min. The dimensions of the specimens were 127 X 12.7 X 3 mm3. The flexural properties are reported in table 3.

(C) Impact Test: ASTM: D256 was used for defining the impression properties of the mixture composites. Serrated rectangular specimens of size 64 mm x 13 mm x 3 mm were cut from made-up composite plates. The average values are reported in table3.

(D) The Scanning Electron microscopy: The SEM microscope is detected that the Interfacial between fiber and matrix, fiber de-bonding, fiber fracture, fiber pull out and matrix breakage also observed in the specimen. JEOL JSM 6390 model at an accelerating voltage of 10 kV. The fractographic studies were carried out in detail on tensile, flexural, and impact fracture surfaces of hybrid composites.

(E) Moisture Absorption Test: The composite samples to be used for the wetness immersion investigation were first dried in an air oven at 50o C. Then these conditioned composite samples were dipped in distilled water at 30oC. At systematic intermissions, the samples were detached from the water and sponged with filter paper to remove external water and weighed with a digital balance of 0.01 mg perseverance. The samples were re-immersed in water to permit the furtherance of absorption until fullness limit was grasped. The weighing was done within 30 s, in order to escape the error due to vaporization. The trial was carried out conferring to ASTM D570. Every 12 hours the test samples were over again taken out of the water immersion and weighed.

IV. RESULTS AND DISCUSSION

Influence of fiber length and content on tensile and flexural strength

(A) Tensile Properties: The tested tensile strength values of the neat resin 5%, 10%, 15% given in Table 4 and Figure 1. The tensile asset of crossbreed composite depends on the asset of the fibers and the interaction between the matrix and fiber. The neat resin (Polyester) had 16.3MPa tensile strength. 5%, 10%, 15% in 5cm of value 40, 41 & 48 MPa respectively. It shown that if the rise in the fiber content increasing the tensile properties. The maximum workable strength were obtained 15% combination composite. The extreme tensile strength value was 48MPa. This were 200% higher than the neat resin. It shows the variant of tensile properties with reverence to increasing in fiber packing on the composite. The tensile fracture specimen SEM image was shown in figure 4. It shows that fiber pulls out. It was the evident of the tensile strength. The interaction between fibers and matrix were improved maximum tensile strength.

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(B) Flexural Properties: The flexural stuffs of the randomly oriented PPLSF/CF/Polyester hybrid composite are present in Table 3 and Figure 2. The PPLSF/CF 15% hybrid composites achieved supreme flexural strength, which is more than 100% of the neat resin.

Table 3: Experimental values of Tensile, flexural and impact strengths

SI. No	Fiber Variation	Fiber length in (cm)	Fiber content in wt%	Matrix proportion in wt%	Tensile strength in (MPa)	Flexural strength in (MPa)	Impact strength in (KJ/m^2)
1	P50C50	2	5	95	23.858	43	6.41
2	P50C50	2	10	90	28.900	49.737	7.692
3	P50C50	2	15	85	30.255	51.464	8.974
4	P50C50	3	5	95	31.613	55.014	10.256
5	P50C50	3	10	90	33.079	65.696	12.82
6	P50C50	3	15	85	36.886	71.961	24.358
7	P50C50	5	5	95	40.604	78.767	25.641
8	P50C50	5	10	90	41.849	103.821	30.769
9	P50C50	5	15	85	48.089	117.094	34.615
10	P100C0	5	15	85	17.200	44.8	8
11	C100P0	5	15	85	55.560	141.18	34
12	-	Neat resin	-	-	16.300	36.61	6

The flexural strength of 5%,10%,15% were 78MPa, 103MPa, 117MPa respectively. The main reason for improved flexural strength was an increase in fibers content in the hybrid composite and stress transfer between fibers & matrix. The fiber pulls out was the evident of the flexural strength. PPLSF/CF achieved 117MPa flexural strength with 15% fiber content. The maximum fiber pulls out to occur in 5% PPLSF/CF composite. The minimum fiber pull-out to occur in 15% PPLSF/CF fractured specimen is shown in figure 4 (B). the reason for less fiber pull out was a determination between fiber and matrix bonding.

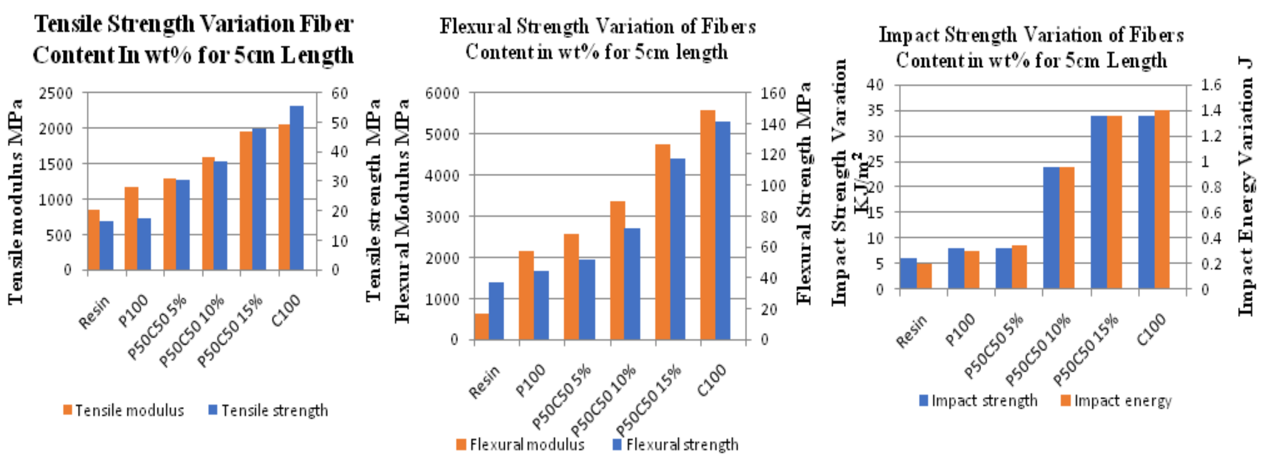

Figure 1, 2 & 3: Variation of Tensile Strength & Tensile Modulus, Flexural Strength & Flexural Modulus and Impact Strength & Impact Energy increased in Fiber Content

(C) Impact Properties: The impression failure of a composite happens with aspects such as matrix breakage, fiber /matrix debonding, and fiber departure. The impact strength details of PPLSF/CF/Polyester hybrid composite are given in Table 3. The maximum impact strength obtained for 15% hybrid composite. This is more than 100% of neat resin and the similar results are observed for PALF/glass/Polyester [07], Roselle/Sisal/Polyester [13], Sisal/glass/Polypropylene [14] composites.

The impact strength of the composites 10%15% are 24KJ/m2,34 KJ/m2 respectively. The impact properties of the various fiber length and content P50C50 (2,3 &5 cm) (5,10 & 15)wt% evaluated from this evaluation. The high impact strength had obtained 5cm fiber length 15% combination composite .the Impact strength value was 34MPa. It is 100% higher than neat resin. The result illustrates that a positive hybrid effect obtained in impact properties due to increase in fiber content.

(D) Scanning Electron Microscopy: The SEM micrograph for the tensile, flexural, impact ruptured PPLSF/CF/Polyester hybrid composite specimen are shown in figure 4. The 15% of fiber pull-out are visualized. It is a evident of fibers content available in hybrid composite. The underprivileged bond between fiber and matrix shown in figure 4 A. the low interaction strength were produced a large cracks in the matrix.

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Figures 4 (A, B & C) explain the Fiber Pulled out from the tested fractured surfaces.

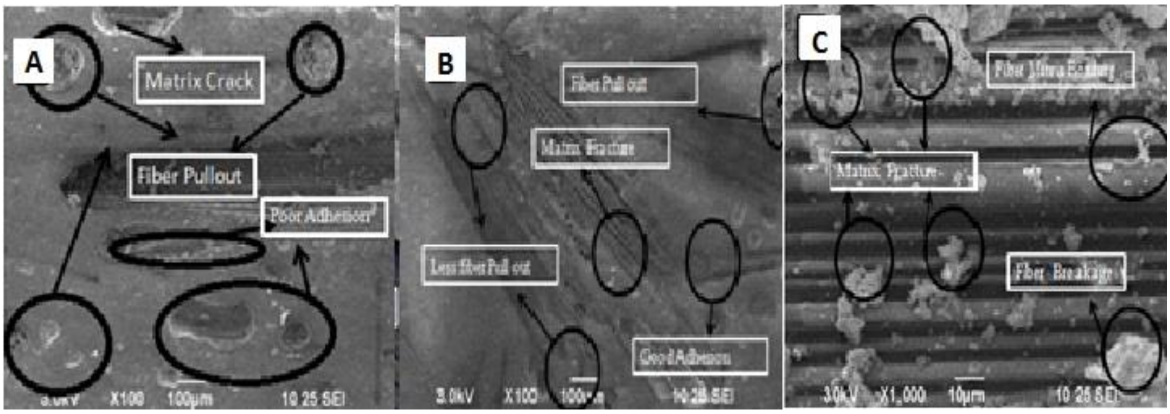

figure 4: (A, B &C) Tensile test, Flexural test and Impact test

(E) Moisture Absorption Test: The results of the water absorption tests conducted on PPLSF/CF/Polyester composites is shown in Figure 5,6&7. Three types of water are taken for moisture absorption tests like Sea water, Rain Water, and Dam water. It records the measurement of made after every 6 Hours interval. The fewer amounts of water uptakes occur in C100 composites by reason of good bond between Synthetic Fibers (CF) and matrix. Similar results also observed in 5% composite. It can be shown that the rise in fiber packing decreases the water uptake of the composites. The maximum water uptake obtained for P100 Composite due to the Hemicelluloses and wax in the composite. The major drawback is swelling and degradation of the fibers and matrix interphase. But the only small amount of CF are added in the PPLSF composite to get better mechanical property 5%, 10%, 15% composite have observed the fewer amount of water uptake properties.

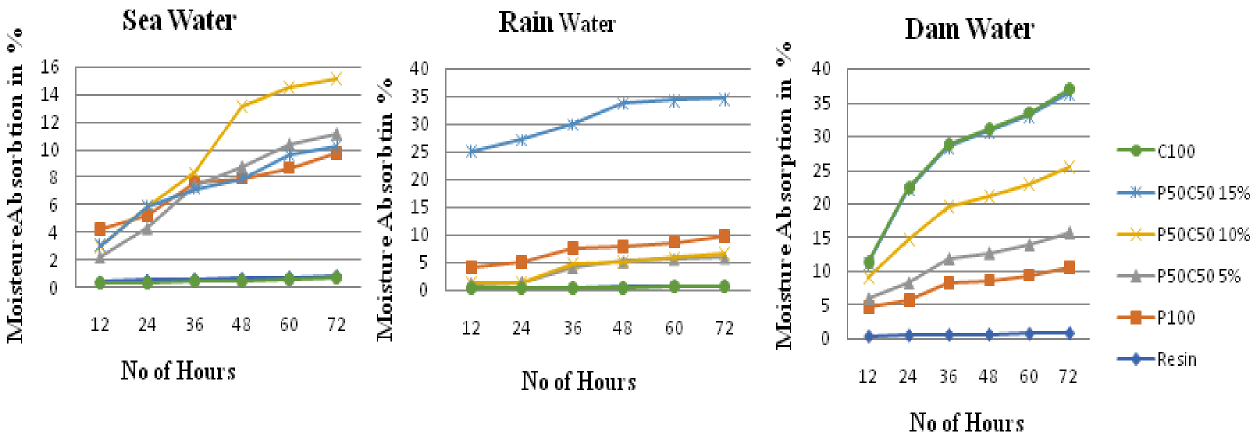

Figure 5, 6 &7: Specimens are immersed in Sea Water, Rain Water & Dam Water

V. CONCLUSION

Randomly oriented PPLSF/CF hybrid polyester composite was fabricated. The following conclusion was made from the study. The mechanical valuables such as tensile, flexural and impact properties of Palmyra palm leaf stalk and carbon fiber strengthened polyester composite were evaluated by changing the relative volume segment.

The enactment of the PPLSF/CF/ Polyester syntheses materials very much prejudiced by the material goods of the fiber content. It has improved the mechanical assets. The maximum tensile, flexural and impact strength are 48 MPa, 117 Mpa and 34KJ/m2 respectively obtained by 15% fiber content and 5Cm length.

The 15% composite had a growth of 200% in tensile strength. Even though the flexural, impact raised by 100% respectively. It had enhanced flexural and impact strength compared to other natural fiber reinforced hybrid composite. Which was caused by better load transmission between fibers and matrix.

The PPLSF have decrease the amount of water absorption by the composite. 5% content 5 Cm length had least water absorption of 2.1%compared to neat resin. The morphological changes were also examined using scanning electron microscopy. It displayed the proof of better fiber-matrix bond due to interaction. Hybridization of PPLFSF/CF fibers can be another alternative that can be used to improve the properties further.

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