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Effect of Sisal Fibre Loading on Mechanical Properties of Jute Fibre Reinforced Epoxy Composite

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Abstract

The main purpose of this paper is to investigate the effect of sisal fibre loading on mechanical properties of jute fibre reinforced epoxy composite. The hybrid sisal /jute fibres reinforced epoxy composites are prepared by hand lay-up technique at different loading of fibres. Scanning electron microscopy is used to study the interfacial studies of prepared composites. A positive effect of hybridization is observed in this study. The results show that mechanical properties (tensile test, flexural test and impact test) of hybrid composite increase with increase in fibre loading up to 30 wt.%.

Keywords: **Hybrid, Polymer, Mechanical properties, SEM.**

I. Introduction

To protect our environment has promoted the research on natural fibre reinforced polymer composite. Natural fibres have gained a considerable attention due to benefits such as low cost, low density, availability in abundance, environmental friendly, renewability, biodegradability, high specific strength and easy processing. Natural fibres also have some limitations such as lower impact strength and higher moisture absorption [1-4].

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Hybridization technique is used by many researchers to reduce the limitations of natural fibre composite and to increase its mechanical strength. Jawed et al. [5] studied the effect of jute fibre loading on tensile properties of oil palm epoxy composite. They suggested that the tensile properties of hybrid composites are found to increase with increasing jute fibre content as compared to oil-palm epoxy composite. Jacob et al. [6] studied the sisal and oil palm hybrid fibre reinforced rubber composite and found that addition of sisal fibre to oil palm fibre lead to decrease in tensile and tear strength but increase in tensile modulus. Venkateshwaran et.al [9] investigated the mechanical properties of hybrid banana/sisal reinforced epoxy composite. They found that addition of sisal fibre with banana fibre increased the mechanical properties.

Potential of jute and sisal fibre, hybridization technique and industrial (automobile, building and packaging) use of natural fibre reinforced polymer composite motivated us to investigate the mechanical properties of hybrid sisal / jute fibre reinforced epoxy composite.

II. Materials and methods

A. Materials

Sisal and jute fibres are used as reinforcement and epoxy AY 105 as a matrix in this paper. Sisal fibres, jute fibres and epoxy matrix are purchased from local resource. The properties of jute and sisal fibre are given in Table 1.

TABLE 1. PROPERTIES OF JUTE FIBRE AND SISAL FIBRE [7, 8]

Properties	Jute fibre	Sisal fibre
Density (g/m³)	1.3	1.5
Diameter (μm)	25-200	50-200
Elongation at break (%)	1.5-1.8	2-2.5
Tensile strength (MPa)	393-773	511-700
Young's modulus (GPa)	26.5	9.4-22
Cellulose (%)	61-71	65
Lignin (%)	12-13	9.9
Microfibrillar angle	8^0	22^0
Wax (%)	0.5	2
Hemi- cellulose (%)	14-20	22

B. Fabrication method of composites

Unidirectionally aligned bi-layer hybrid composites are fabricated by reinforcing the sisal and jute fibres in epoxy matrix by hand lay- up technique. The epoxy resin AY 105 and corresponding hardener HY 951 are mixed in a ratio of 10:1 by weight as recommended. The mixture is stirred manually to disperse the resin and the hardener in the matrix. A stainless steel mould having dimensions of 500 mm × 300 mm × 3 mm is used for casting of the composites. Silicon spray is used to facilitate easy removal of the composite from the mould after curing. The cast of each composite is cured under a load of 50 kg for 24 hours before it is removed from mould. Dimension of specimens are cut as per ASTM standard using a diamond cutter for analysis of mechanical properties of hybrid composite. The composites are manufactured with varying wt. % of fibres and have been given notations as shown in Table 2.

TABLE 2. NOTATIONS FOR PREPARED COMPOSITE.

Composite	Jute fibres content (%)	Sisal fibres content (%)	Total fibre content (wt. %)
J 30	100	0	30
H 15	75	25	15
H 20	50	50	20
H 25	25	75	25
H 30	0	100	30
S 30	50	50	30

III. Testing of composites

A. Tensile test

Tensile test of the composite samples are performed on Tinius Olsen H 10 K-L (Bi-axial testing machine) with a crosshead speed of 2 mm/min. Tests are conducted as per ASTM D638. Extensometer is used to measure the strain, which is calculated as the change in length of a specimen divided by gauge length. Five specimens of each composite are tested and average values are reported.

B. Flexural test

Flexural test of the composite are carried out using a three point bending test on Tinius Olsen H10 K-L (Bi-axial testing machine). The sample for the flexural test with dimensions is 80 mm × 12.7 mm × 3 mm as per ASTM D790. The flexural test is carried out at room temperature with the crosshead speed of 2 mm/min. Calculation of flexural strength and flexural modulus are done using following equation.

Flexural strength = $\dfrac{3FL}{2bd^2}$ and

Flexural modulus = $\dfrac{mL^3}{4bd^3}$

where F is ultimate failure load (N), L is span length (mm), b and d are width and thickness of specimen in (mm) respectively and m is slope of the tangent to initial line portion of the load-displacement curve. Five specimens of each composite are tested and average values are reported.

C. Impact test

Impact test of composite are performed on Tinius Olsen Impact 104 machine. The sample for the impact test with dimensions is 65 mm × 12.7 mm × 3 mm and 2.5 mm notch thickness as per ASTM D

256. Five specimens of each composite are tested and average values are reported.

IV. Results and discussions

A. Tensile test

The tensile properties of prepared composites are compared and tabulated in Table 3. A positive hybrid effect is observed for the composites. The maximum value of tensile strength and tensile modulus are found to be 102.08 MPa and 2.026 GPa respectively for the hybrid composite H30. The tensile strength and tensile modulus of hybrid composite H30 are 23% and 25% more than those of composite J30. Tensile strength and tensile modulus of hybrid composite H 30 are 17% and 22 % more as compared to those of composites S30. The hybrid composite H30 shows the maximum value of tensile strength and modulus due to strong adhesion between fibres and matrix as seen in Figure 3.

B. Flexural test

The flexural properties of prepared composites are compared and tabulated in Table 4. The hybrid composite H30 shows the maximum value of flexural strength and flexural modulus as compared to those of others composites. Flexural strength and flexural modulus of hybrid composite H30 are found to be 361.90 MPa and 17.506 GPa respectively which are 43% and 44% more as compared to those of composite J30. Flexural strength and modulus of hybrid composite H30 are 30% and 35 % more than those of composites S30.

C. Impact test

The impact properties of prepared composites are compared and tabulated in Table 5. Similar to tensile and flexural results, impact strength is also found maximum for hybrid composite H30. The higher value of impact strength (30.10 kJ/m^2) is observed for hybrid composite H 30. The hybrid composite H30 shows 70% more value of impact strength as compared to composite J30. Impact strength of hybrid composite H 30 is 26% more than those of composites S30.

Table 6 show the comparison of tensile, flexural and impact properties of present work with different hybrid composites from published work. It can be observed that hybridization can increase the mechanical properties of single fibre content composite. The tensile strength of the present hybrid composite sisal/jute/epoxy is found to be higher by 81%, 81%, and 37% as compared to those of composites banana/sisal/epoxy [9], jute/banana/epoxy [10] and palmyra palm leaf stalk/jute/polyester [11] respectively. Flexural strength of present hybrid composite sisal/jute/epoxy is observed to be higher by 83%, 83% and 60% as compared to those of composites banana/sisal/epoxy [9], jute/banana/epoxy [10] and palmyra palm leaf stalk/jute/polyester [11] respectively. Impact strength of present hybrid composite sisal/jute/epoxy is 40%, 39% and 10% more than those of hybrid composites banana/sisal/epoxy [9], jute/banana/epoxy [10] and palmyra palm leaf stalk/jute/polyester [11] respectively.

V. Scanning electron microscopy

Figs. 1-3 show the micrographs of composites J30, S30 and H30 respectively. Fig. 3 shows that hybrid composite H30 have strong adhesion between fibres and matrix as compare to composite J30 and S30.

TABLE 3. TENSILE PROPERTIES OF COMPOSITES

Composite	Tensile strength (MPa)	S.D.	Tensile modulus (GPa)	S.D.
J 30	78.21	6.12	1.523	0.18
H 15	46.13	2.95	0.545	0.05
H 20	54.25	5.18	0.803	0.07
H 25	80.11	6.70	1.027	0.11
H 30	102.08	8.15	2.026	0.24
S 30	83.96	6.94	1.580	0.10

S.D. represents the standard deviation

TABLE 4. FLEXURAL PROPERTIES OF COMPOSITES

Composite	Flexural strength (MPa)	S.D.	Flexural modulus (GPa)	S.D.
J 30	203.48	17.34	9.762	0.81
H 15	131.22	10.66	5.860	0.58
H 20	189.00	18.05	8.586	0.95
H 25	285.00	23.9	12.830	1.15
H 30	361.90	24.22	17.506	1.03
S 30	252.39	12.11	11.316	1.02

S.D. represents the standard deviation

TABLE 5. IMPACT PROPERTIES OF COMPOSITES

Composites	Impact energy (Joule)	S.D.	Impact Strength (kJ/m^2)	S.D.
J30	0.35	0.02	13.88	0.98
H 15	0.69	0.05	18.51	1.70
H 20	0.72	0.06	19.75	2.09
H 25	0.97	0.07	24.44	1.18
H 30	1.17	0.10	30.10	1.74
S 30	1.09	0.09	22.03	1.66

S.D. represents the standard deviation

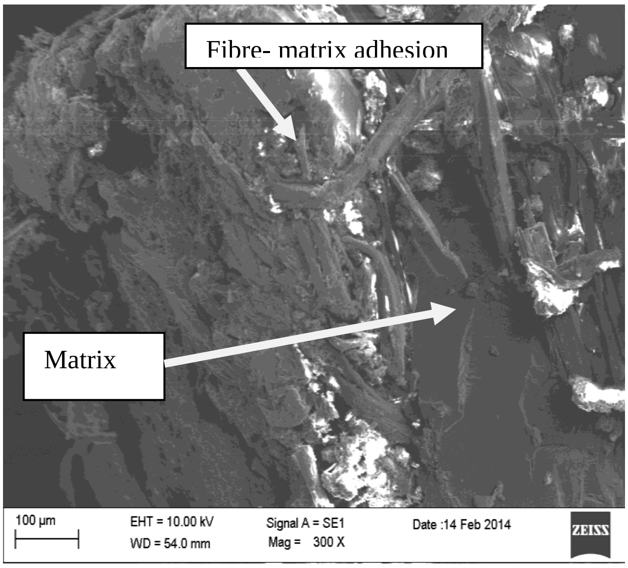

Figure 1. SEM image of composite J30

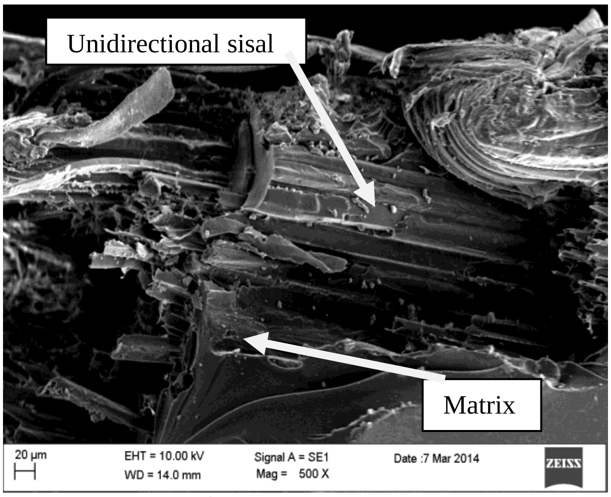

Figure 2. SEM image of composite S30

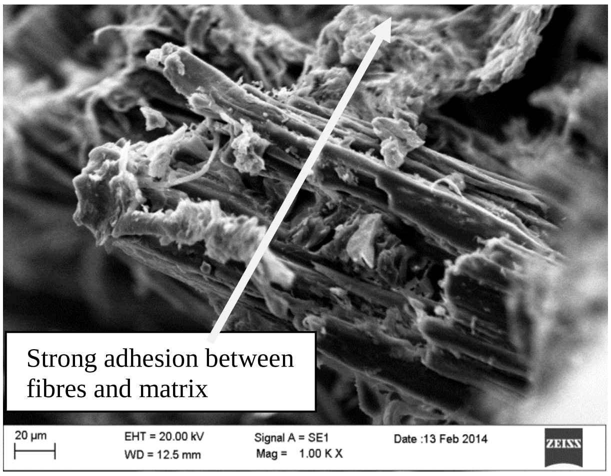

Figure 3. SEM image of hybrid composite H30

VI. Conclusions

A positive effect of hybridization of sisal fibre on mechanical properties of jute fibre reinforced epoxy composite is found in this work. On increasing the fibres content up-to 30wt.% mechanical properties is found to increase. The hybrid composite H30 shows the maximum value of tensile, flexural and impact strength.

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TABLE 6. COMPARISON OF MECHANICAL PROPERTIES OF SOME HYBRID COMPOSITES WITH PUBLISHED WORK.

Composites	Tensile strength (MPa)	Tensile modulus (GPa)	Flexural strength (MPa)	Flexural modulus (GPa)	Impact strength (kJ/m^2)	Ref.
Banana / sisal/ Epoxy	18.66	0.682	59.68	9.130	17.90	[9]
Banana / jute/ Epoxy	18.96	0.724	59.84	9.170	18.23	[10]
Palm Leaf /jute/ Polyester	64.30	2.450	145.66	17.950	27.01	[11]
Jute / sisal/ Epoxy	**102.08**	**2.026**	**361.90**	**17.506**	**30.11**	**Present work**

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