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Tensile & Flexural behaviors of Untreated Leptadenia Pyrotechnica (Khimp) Fibers Reinforced Phenol Formaldehyde Composites

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ABSTRACT

Natural fibers are forthcoming reinforcing materials and their use until now has been more conventional than procedural. In this paper, the untreated Leptadenia pyrotechnica (Khimp) fiber reinforced phenol formaldehyde resin matrix have been developed to manufacturing of composites by hand lay-up process with varying fiber weight fraction (5%, 10%, 15%, 20% and 25% by weight) and cut into that as per ASTM for testing the materials. The prepared Leptadenia pyrotechnica (Khimp) fiber reinforced composites were characterized by tensile and flexural test. The results are observed and graphically represented.

KEYWORD- Leptadenia pyrotechnica fibers, tensile test, flexural test.

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INTRODUCTION

There are many plant fibers containing high-quality potentiality, are not being appropriately developed. If these fibers have taken to proper exploit, the rural economy of the country could be developed extensively. One of these is the broadly grown fiber harvest is Leptadenia pyrotechnic a, belonging to the family 'Asclepiadaceous' and is popularly known as 'Khimp' in Rajasthan, 'Khip' in Gujarat , and 'Kip' in Punjab. Leptadenia pyrotechnic a(Khimp) fibers is widely grown in the northern-west part of India, particularly in the states of Rajasthan, Gujarat, Punjab and Haryana.Physical and mechanical properties of Khimp fiber are summarized in Table 1.

Table 1: Physical and mechanical properties of of Leptadenia pyrotechnic a (Khimp).

Properties / Name	Leptadenia Pyrotechnica Fibres	Leptadenia Pyrotechnica Stem
Density	1.03 (g/cm^3) 1030(kg/m^3)	.69 (g/cm^3) 690(kg/m^3)
Length (cm)	0.67±.019	1.03
Breath (μm)	12.9±.272	24
Length/ breath ratio	519	-
Tensile strength (MPa)	280	70
Tensile modulus (MPa)	9	35
Specific modulus (MPa)	4	18
Elongation %	3.4	1.5
Moisture (%)	14	9
Gravemetric Fineness (tex)	1.01±.21	-
Tancity (gm/tex)	45.8	-
Degree of Crystallinity (%)	60	-

(Reference- Jute institute, NIRJAFT Kolkata)

This paper examines the tensile and flexural properties of the Leptadenia pyrotechnica (Khimp) fiber reinforced composites. There has been a lot of research work on different combination of natural fiber with polymer matrix composites. Few researches are going on the combination of Leptadenia pyrotechnica (Khimp) /PF resin based composites, which individually has achieved lot of draw attention for industries. Keeping this in view the present work has been under taken to develop a phenol formaldehyde composite using Khimp fiber as reinforcement and to study its tensile and flexural properties.

MATERIAL AND EXPERIMENTAL TECHNIQUE

Leptadenia pyrotechnica(Khimp) fibers-

Commercially, Khimp plant was collected from the local area of Bikaner district situated in the state of Rajasthan. The fiber was extracted from the green stem of the khimp plant by crushing, followed by retting and combing. These raw fibers were washed with water to remove undesirable materials and dried in an air oven at 80°C for 6 h. After that these fibers were chopped into the desired length ranging from 2 to 15 mm for the characterization of fibers.

Preparation of composite samples

Composites were formulated using hand lay-up methods, which are the methods of solution mixing. The mould was polished and mould-releasing agent was applied. The dimensions of the mould were (150x50x10) mm. The cleaned fibers were prearranged in the mould in the form of mats and pressed. After that, the resin was poured into the mat until it was completely soaked. The mould was closed and hot pressed at a temperature of 130^{o}C and at a pressure about 8 MPa. The resin spread through the mould and impregnates the fiber by pushing the air if any, left in the mould. Thus the resulting composite has low void content and better interfacial adhesion. The samples were subjected to post curing operation at 70^{o}C for 1h to ensure complete curing. Composite samples were prepared by varying untreated fiber loading (5, 10,15,20,25 wt %). It is then cut to specimens as per requirement for various tests. Sample cut into dog bone shape (150x10x5) mm for tensile test and cut into of rectangular flat shape having dimension of (150x20x5) mm for flexural test.

Table 2: Details of Sample Code of prepared Composites.

S.No.	Sample Code	Fiber types used in composites	Fiber loading wt% fraction
1	SUT 1	Untreated Khimp fibres	5%
2	SUT 2	Untreated Khimp fibres	10%
3	SUT 3	Untreated Khimp fibres	15%
4	SUT 4	Untreated Khimp fibres	20%
5	SUT 5	Untreated Khimp fibres	25%

Mechanical Test

Tensile test

Tensile testing is also known as tension tests. The samples for the tensile test were carried out on UTM machine in accordance with ASTM standard. According to this standard, the samples were cut into dog bone shape (150x10x5) mm. The specimens were conducted on an electronic tensometer. From the experimental data, the stress strain curve is plotted to calculate the tensile strength, young's modulus and elongation at break of fiber/PF composite material. A total of 5 different specimens were prepared for each weight fraction.

Tensile Strength:-It is the defined as maximum stress that a material can withstand while being stretched or pulled before failing or breaking.

Tensile strength = P/A

Where P = Maximum load (N),

A = Area of cross section (mm^2).

Tensile strain = dL/L

Where dL = change in length (mm),

L = original length (mm).

Flexural test

The samples for the flexural test were was examined in an UTM machine in accordance with ASTM standard to measure the flexural strength and flexural modulus of the composites. All the samples were cut into of rectangular flat shape having size of (150x20x5) mm. The span length was 75mm. The flexural test examined on the same electronic tens meter that was utilized to carry out the tensile test. The experiment was performed on both samples of untreated and treated fiber/PF composites. A total of 5 various samples were formulated for each weight fraction. Load and deformation values are celebrated and flexural modulus and flexural strength are noticed.

Flexural Strength:-It is defined as a material's capability to resist deformation under bending load.

Flexural strength $S = (3PL)/(2bt^2)$

Flexural modulus $E_B = (mL^3)/(4bt^3)$

Where L = span length of specimen (mm)

b = width of the specimen (mm)

t = thickness of specimen (mm)

P = maximum load

m = slope of load deflection curve (N/mm)

ANALYSIS OF RESULT

Effect of fiber loading on tensile properties of untreated Khimp/PF composites

The stress-strain curve of untreated Khimp fiber reinforced PF composites at varying fiber weight fraction loading is given in Figure 1. It is found [8] that stress-strain graph of pure PF is similar to that of brittle materials. The behavior is elastic in nature. However, increase of fibers percentage load in PF resin makes the matrix ductile as shown in stress-strain curves. This is clear from the high elongation at break value of Khimp/PF composites.

The tensile strength, Young's modulus elongation break of said untreated composites are recorded in Table 3.

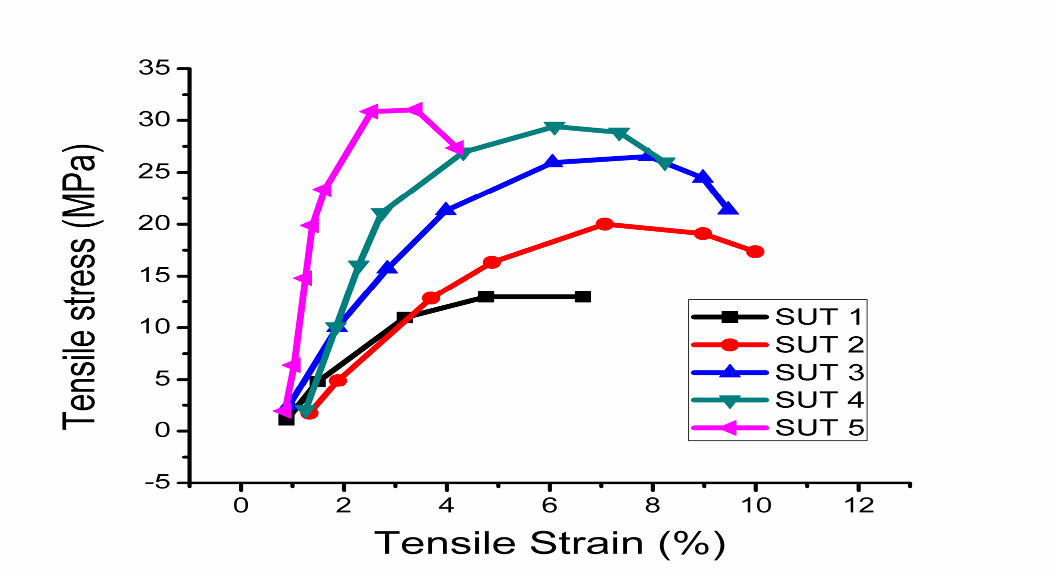

Figure 1: Tensile stress-strain behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

Table 3: Tensile properties of untreated Khimp/ PF composites at different fiber loadings.

Sample code	Tensile strength (MPa)	Young's modulus (GPa)	Elongation Break (%)
SUT 1 (5% fiber weight fraction)	5	0.177	4.5
SUT 2 (10% fiber weight fraction)	13	0.315	5.4
SUT 3 (15% fiber weight fraction)	20	0.343	7.8
SUT4 (20% fiber weight fraction)	21	0.382	9.3
SUT 5 (25% fiber weight fraction)	23	0.449	9.7

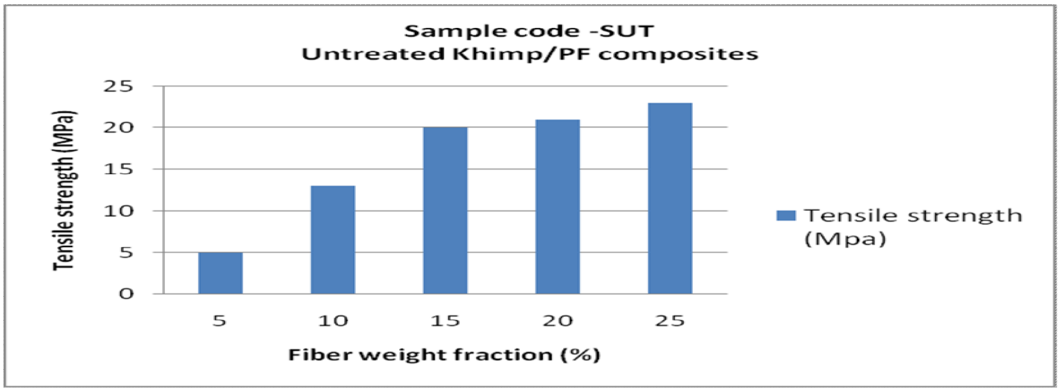

Figure 2: Tensile strength-fiber weight fraction behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

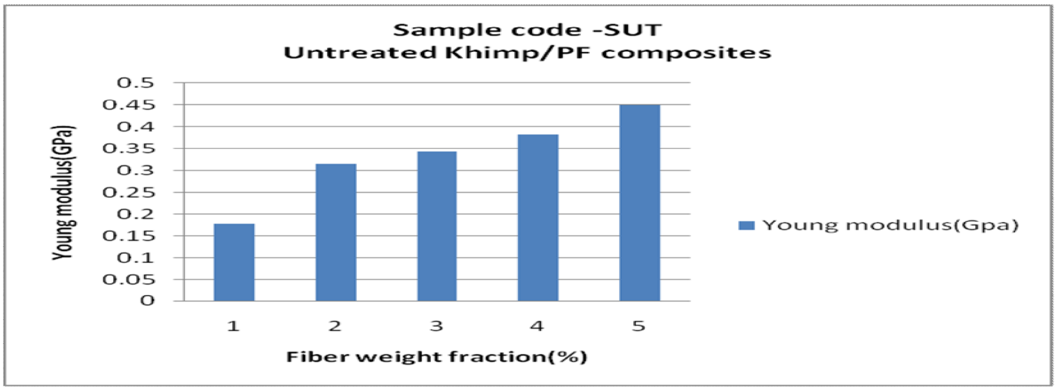

Figure 3: Young modulus -fiber weight fraction behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

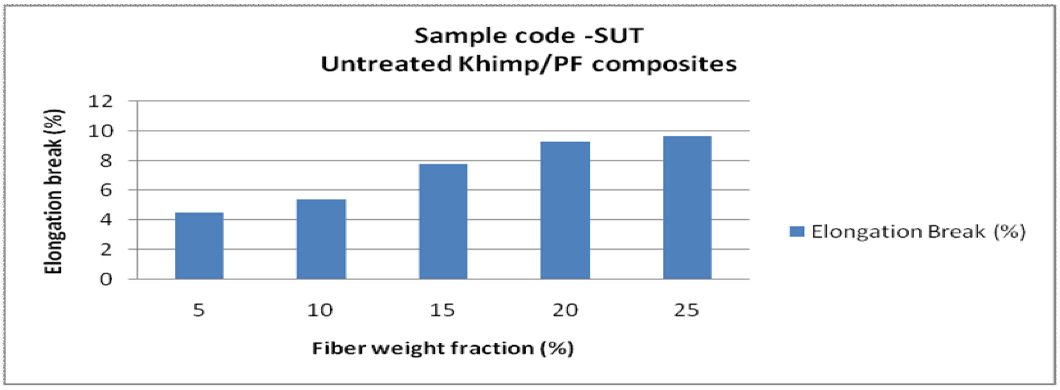

Figure 4: Elongation break – fiber weight fraction behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

The maximum value of tensile strength, Young’s (tensile) modulus and elongation break are found 23 MPa, .449 GPa and 9.7%, respectively for the sample SUT 5 (25% untreated Khimp fiber weight fraction in PF resin). The tensile strength, Young's modulus and elongation break are found to have 360%, 153% and 115 % increased with increasing Khimp fiber loading up to 25% in PF resin respectively. This experimental report shows the increased value of tensile strength, Young’s modulus elongation break with increase in fiber weight fraction loading in Khimp/PF composites. It is observed [10] that the percentage elongation at break is very low in pure PF (3%). The brittle nature of PF resin decreases with the addition of Khimp fiber and therefore elongation value increases with fiber loading. It is interesting to note that the elongation at break of the composite is much higher than that of the individual components at sample composites.

Effect of fiber loading on flexural properties of untreated Khimp/PF composites

By the application of flexural force, the upper and lower surface of the specimen under three point bending load is subjected to compression and tension and axisymmetric plane is subjected to shear stress. Therefore, there are two failure modes in the materials; compression and shear failure.

The specimen fails when bending or shear stress reaches the corresponding critical value. Figure 5 represents the stress-strain curve of untreated Khimp fiber PF composites under flexural loading. The variation of flexural strength and flexural modulus values with fiber loading in untreated Khimp/ PF composites are shown in Table 4.

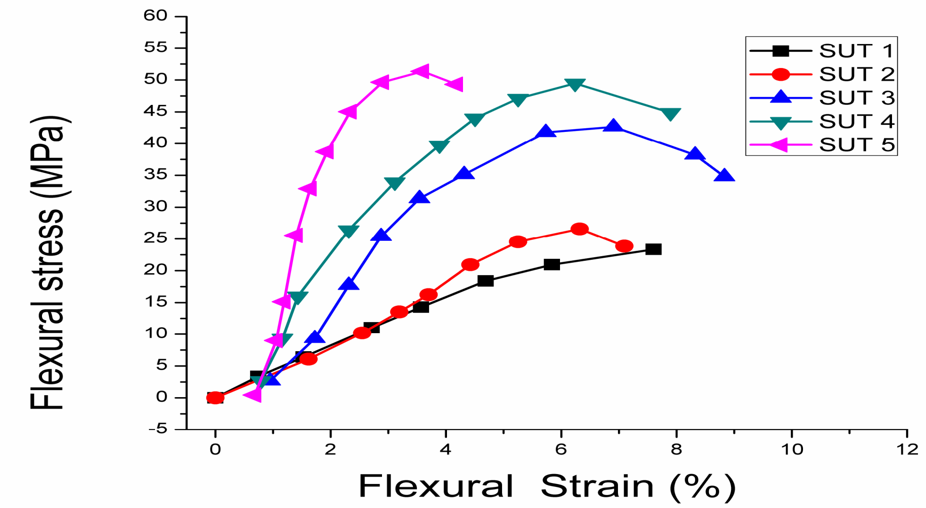

Figure 5: Flexural Stress-strain behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

Table 4.: Flexural properties of untreated Khimp /PF composites at different fiber loadings.

Sample code	Flexural strength (MPa)	FlexuralModulus (GPa)
SUT 1 (5% fiber weight fraction)	28	0.510
SUT 2 (10% fiber weight fraction)	33	0.597
SUT 3 (15% fiber weight fraction)	38	1.413
SUT4 (20% fiber weight fraction)	44	2.346
SUT 5 (25% fiber weight fraction)	48	2.598

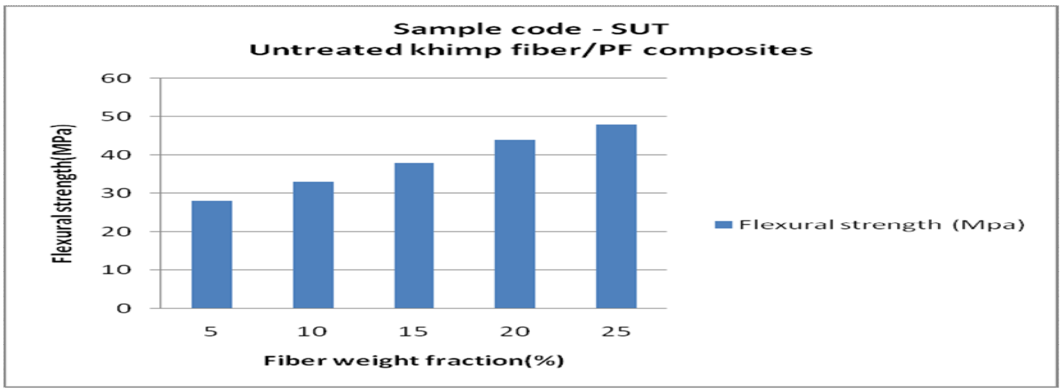

Figure 6: Flexural strength-fiber weight fraction behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

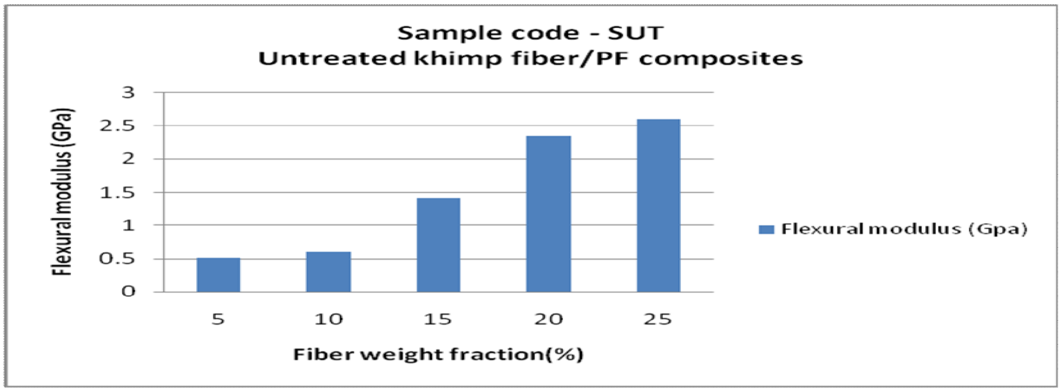

Figure 7: Flexural modulus -fiber weight fraction behavior of untreated Khimp fiber reinforced PF composites (Sample SUT).

In Khimp fiber reinforced PF composites, the flexural strength and modulus values are found to increase about 71% and 409 % with increasing 25% fiber weight fraction loading. The maximum value of flexural strength and flexural modulus are found 48 MPa and 2.598 GPa for sample SUT 5 respectively. Like tensile properties of SUT sample, flexural strength and modulus are also found the increased value with increase in fiber weight fraction in phenolic resin.

The flexural properties have to be higher than tensile properties, as in flexural test load is applied on a point, where least number of flaws are possible, however for the tensile test the load is applied over a longer length where many number of flaws are possible.

CONCLUSION

A systematic and comprehensive study on the mechanical behavior of untreated Khimp fibers presented in the paper concluded that- Natural fiber can be a potential candidate in making of composites, especially for partial replacement of high cost glass fibers for load bearing application. From the point of view of wood substitution, natural fiber composites boards could offer an excellent eco-friendly solution as wood substitutes. From the results, when Khimp fibers are used with reinforcement in PF resin matrix, it has been shown that the highest value of tensile strength is obtained at 25% weight fraction of fiber and its strength at 360% (Sample code-SUT5). Moreover, maximum flexural strength was also obtained in Khimp reinforced composite materials at 25% weight fraction of fibers (Sample code – SUT 5). Increase in tensile strength and flexural strength may be due to strong fiber-matrix adhesion bonding. Possibility of using these types of composites is where ever required a light weight such as in building and construction industry and as well as storage devices.

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