TENSILE & FLEXURAL BEHAVIORS OF TREATED LEPTADENIA PYROTECHNICA (KHIMP) FIBERS REINFORCED PHENOL FORMALDEHYDE COMPOSITES

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Abstract- This research is to study the tensile and flexural behavior for treated Leptadenia pyrotechnica (Khimp) fiber reinforced phenol formaldehyde composites. Leptadenia pyrotechnica fibers were chemically modified and treated with 10 % triton x 100 solution at 60^0 temperatures for 4 hour to improve interfacial strength of the composites. In this paper , the triton x 100 treated 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 treated Leptadenia pyrotechnica (Khimp) fiber reinforced composites were characterized by UTM. The results are observed and graphically represented.

Keywords- Leptadenia pyrotechnica fibers, triton x 100 treatment, tensile test, flexural test.

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 devloped extensively. One of these is the broadly grown fiber harvest is Leptadenia pyrotechnica, belonging to the family 'Asclepiadaceae' and is popularly known as 'Khimp' in Rajasthan, 'Khip' in Gujarat , and 'Kip' in Punjab. Leptadenia pyrotechnica(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 pyrotechnica.

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 triton x 100 treated 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 [12].

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.

Fiber modification with Triton 100 treatment

The fibers were taken in a stainless steel pot. A 10% solution of triton 100 was mixed into the pot and stirred well. This was kept for 1 h with subsequent stirring. The fibers were then washed thoroughly with water to eliminate the excess of triton x 100 sticking to the fibers. Final washings were carried out with distilled water .The fibers were then air dried. The fibers were chopped into short fibers of length 2 to 15 mm for moulding the composites.

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 130oC 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 70oC for 1h to ensure complete curing. Composite samples were prepared by varying treated 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	STT 1	Triton 100 treated Khimp fibers	5%
2	STT 2	Triton 100 treated Khimp fibers	10%
3	STT 3	Triton 100 treated Khimp fibers	15%
4	STT 4	Triton 100 treated Khimp fibers	20%
5	STT 5	Triton 100 treated Khimp fibers	25%

Mechanical Test

In this part we have discuss about tensile test and flexural 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 tensometer that was utilized to carry out the tensile test. The experiment was performed on 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 treated Khimp/PF composites

Tensile stress-strain behavior of triton x 100 treated Khimp fiber reinforced phenol formaldehyde composites are shown in Figure 1. All the treated composites are found to have higher stress value at any particular strain. All the treated composites confirm ductile behavior. The effect of chemical treatments on tensile strength, Young's modulus and elongation at break values of the treated Khimp fiber reinforced PF composites are given in Figure 2-4. Using the experimental data, tensile properties such as tensile strength, tensile (Young's) modulus and elongation break of triton x100 treated Khimp/PF composites are tabulated in Table 3.

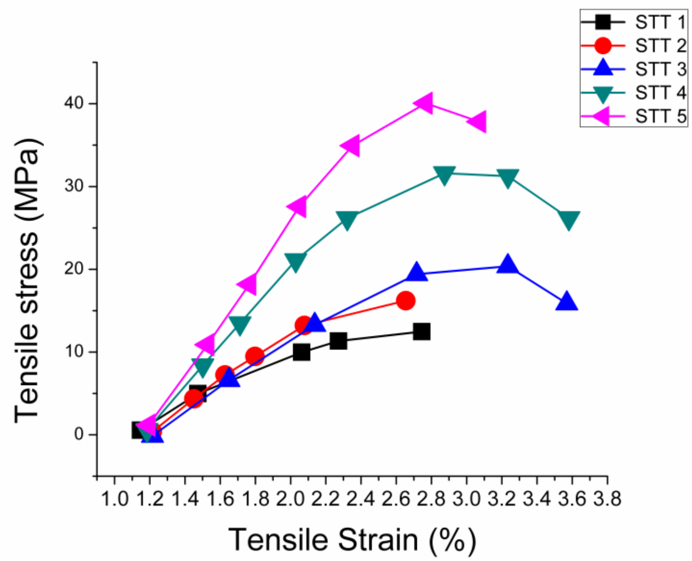

Figure 1: Tensile stress-strain behavior of triton x 100 treated Khimp fiber reinforced PF composites.

Table 3: Tensile properties of triton x 100 treated Khimp/ PF composites at different fiber loadings.

Sample code	Tensile strength (MPa)	Young modulus (GPa)	Elongation Break (%)
STT 1 (5% fiber weight fraction)	17	0.372	3.7
STT 2 (10% fiber weight fraction)	20	0.457	3.9
STT 3 (15% fiber weight fraction)	22	0.643	4.3
STT4 (20% fiber weight fraction)	27	0.689	4.7
STT 5 (25% fiber weight fraction)	33	0.724	5.2

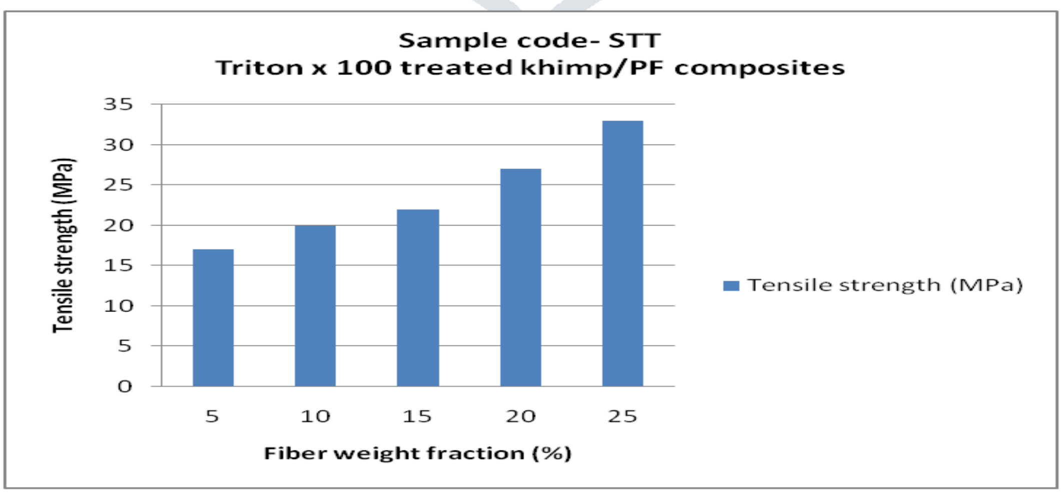

Figure 2: Tensile strength-fiber weight fraction behavior of triton x 100 treated Khimp fiber reinforced PF composites (Sample STT).

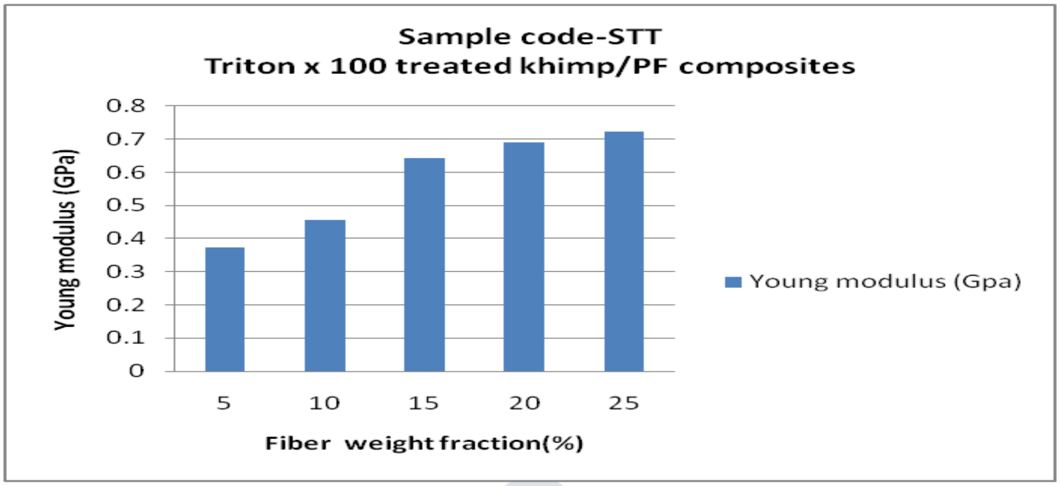

Figure 1: Young modulus (GPa)-fiber weight fraction behavior of triton x 100 treated Khimp fiber reinforced PF composites (Sample STT.

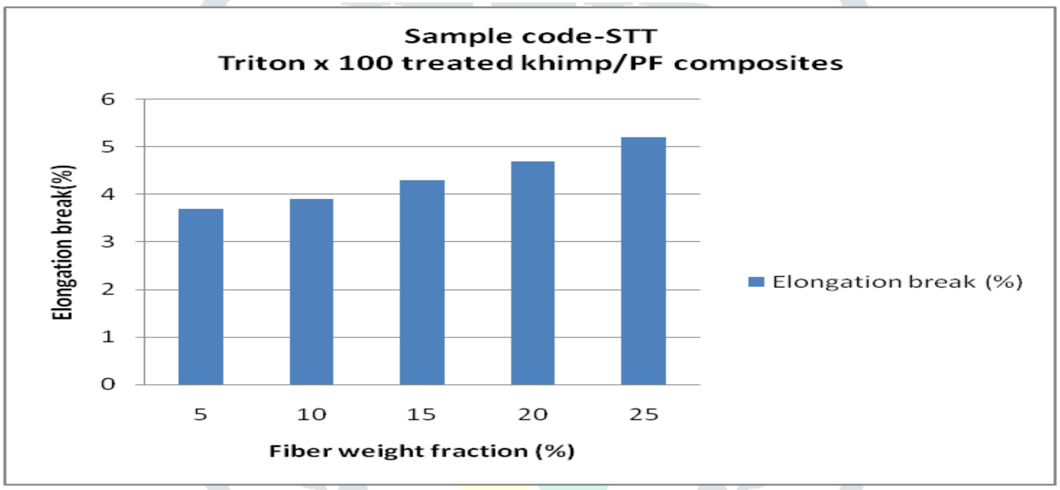

Figure 4: Elongation break (%) – fiber weight fraction (%) of triton x 100 treated Khimp fiber reinforced PF composites (Sample STT).

The following observations were made in evaluation of mechanical properties of treated Khimp fiber reinforced PF composites.

A. The maximum value of tensile strength, Young's (tensile) modulus and elongation break are found 33MPa, 0.724 GPa and 5.2%, respectively for the sample STT 5 (having 25% triton x 100 treated Khimp fiber weight fraction in PF resin).
B. The tensile strength, Young's modulus and elongation break are found to have 94%, 95% & 400 % increased with increasing triton x 100 treated Khimp fiber loading up to 25% in PF resin (STT sample), respectively.
C. Triton x100) treatment of Khimp/PF composites demonstrates the better mechanical properties in comparison to untreated Khimp/PF composites.
D. In triton x 100 treated Khimp/PF composites, the maximum tensile strength, Young's modulus are found 43 % and 61% higher than those of untreated khimp/PF composite (Data for untreated composites are not given in this paper), respectively.

Interfacial bonding between fiber and matrix plays a vital role in determining the mechanical properties of composites. Since stress is transferred between matrix and fibers across the interface, good interfacial bonding is required to improve the mechanical properties. However, for plant based Khimp fiber composites there is usually limited interaction between the hydrophilic fibers and matrices, which are commonly hydrophobic leading to poor interfacial, bonding limiting mechanical performance. Triton x 100 treatment remove fiber constituents including hemicelluloses, lignin, pectin, fat and wax which exposes cellulose and increases surface roughness/area providing for improved interfacial bonding.

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

The flexural stress-strain behavior of triton x 100 treated Khimpfibre/PF composites are shown in Figure 5. Both treated fiber composites are found to have brittle failure, indicating a high fiber-matrix interaction.The flexural strength and modulus of treated Khimp/PF composites are tabulated in Table 4. In the case of composites, the flexural properties are controlled by the resistance to inter laminar failure. Therefore, high flexural strength and modulus of treated fiber reinforced composite is due to better interfacial adhesion in the composite. It is observed [14] a slight increase in flexural properties for triton x 100 treated natural fiber reinforced composites which is attributed to improve mechanical interlocking by the removal of outer surface of the fibers with the exposition of the inner fibrillar structure and consequent increase of the fiber surface area. The improved flexural properties of the treated fiber composites can be explained due to the physical and chemical changes in the fiber surface induced by the treatments, which enhance the adhesion between the fiber and matrix as in the case of tensile properties.

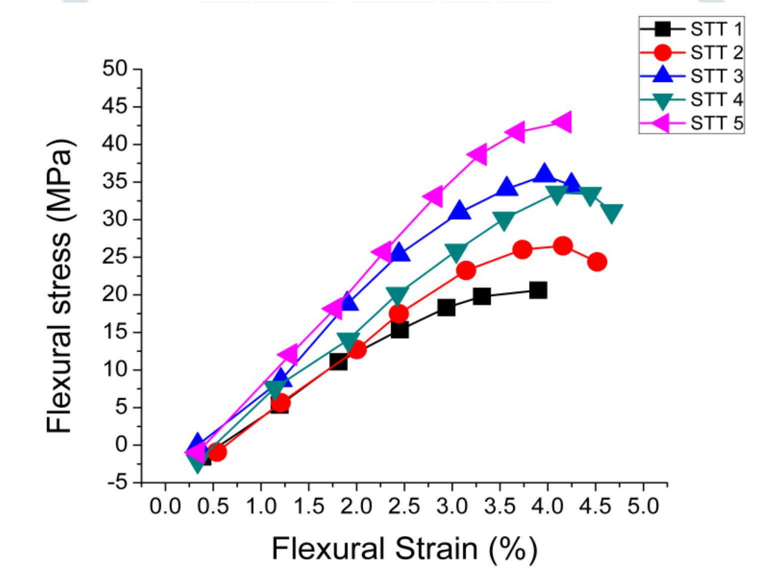

Figure 5: Flexural stress-strain behavior of triton x 100 treated Khimp fiber reinforced PF composites.

Table 4: Flexural properties of triton x 100 treated Khimp /PF composites at different fiber loadings.

Sample code	Flexural strength (MPa)	Flexural modulus(GPa)
STT 1 (5% fiber weight fraction)	29	0.782
STT 2 (10% fiber weight fraction)	32	0.983
STT 3 (15% fiber weight fraction)	37	1.539
STT4 (20% fiber weight fraction)	44	2.749
STT 5 (25% fiber weight fraction)	50	2.918

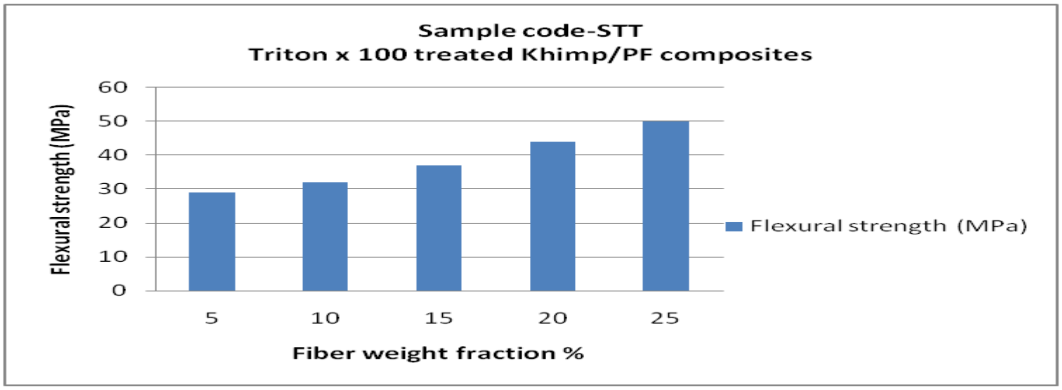

Figure 6: Flexural strength-fiber weight fraction behavior of triton x 100 treated Khimp fiber reinforced PF composites (Sample STT).

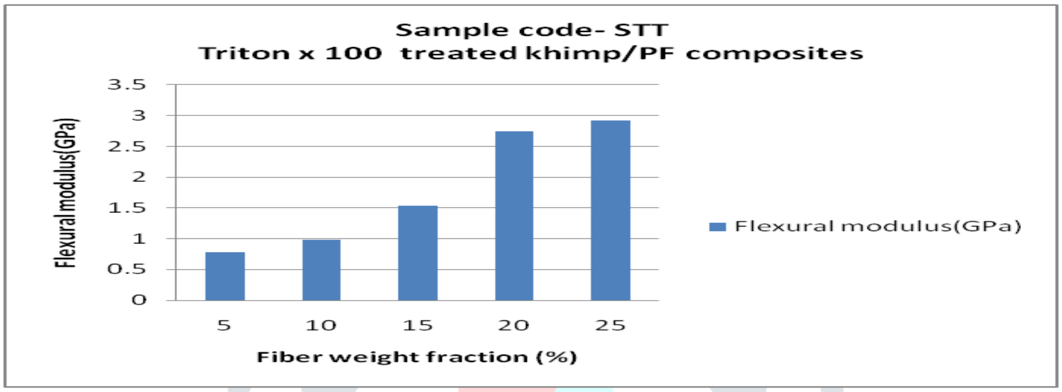

Figure 7: Flexural modulus -fiber weight fraction behavior of triton x 100 treated Khimp fiber reinforced PF composites (Sample STT).

The following observations were made in evaluation of flexural properties of treated Khimp fiber reinforced PF composites.

A. The maximum value of flexural strength &flexural modulus are found 50 MPa &2.918 GPa, respectively for the sample STT 5 (having 25% triton x 100 treated Khimp fiber weight fraction in PF resin).
B. The flexural strength &flexural modulus are found to 72% & 273 % increased with increasing triton x 100 treated Khimp fiber loading up to 25% in PF resin (STT sample), respectively.
C. Triton x100 treatment of Khimp/PF composites demonstrates the better flexural properties in comparison to untreated Khimp/PF composites.
D. Similarly in triton x 100 treated Khimp/PF composites, the maximum flexural strength & flexural modulus are found 5 % and 12% higher than those of untreated Khimp/PF composite(Data for untreated composites are not given in this paper), respectively.

CONCLUSION

A systematic and comprehensive study on the mechanical behavior of chemical treated 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 & Young's modulus are found 43 % and 61% higher than those of untreated khimp/PF composite. Moreover, maximum flexural strength & flexural modulus are found 5 % and 12%

higher than those of untreated Khimp/PF composite. Increase in tensile and flexural performance 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.

REFERENCE

1. Yao, L., et al., Thermal properties and crystallization behaviors of polylactide/redwood flour or bamboo fiber composites. Iranian Polymer Journal, 2017. 26(2): p. 161-168.
2. Mwaikambo, L.Y. and M.P. Ansell, Mechanical properties of alkali treated plant fibres and their potential as reinforcement materials II. Sisal fibres. Journal of Materials Science, 2006. 41(8): p. 2497-2508.
3. KhalilA.S., RahimA.A., TahaK.K., and AbdallahK.B., "Characterization of Methanolic Extracts of Agarwood Leaves," Journal of Applied and Industrial Science, vol. 1, no. 3, pp. 78-88, August 2013.
4. Das, M. and D. Chakraborty, Influence of alkali treatment on the fine structure and morphology of bamboo fibers. Journal of Applied Polymer Science, 2006. 102(5): p. 5050-5056.
5. Rojo, E., et al., Effect of fiber loading on the properties of treated cellulose fiber-reinforced phenolic composites. Composites Part B: Engineering, 2015. 68: p. 185-192.
6. Cai, M., et al., Influence of alkali treatment on internal microstructure and tensile properties of abaca fibers. Industrial Crops and Products, 2015. 65: p. 27-35.
7. Alawar, A.M. Hamed, K. Al-Kaabi "Characterization of treated date palm tree fiber as composite reinforcement Compos". Part B-Eng, 40 (7) (2009), pp. 601-606
8. Wei, C., et al., Mechanical properties of phenol/formaldehyde resin composites reinforced by cellulose microcrystal with different aspect ratio extracted from sisal fiber. Polymers for Advanced Technologies, 2017. 28(8): p. 1013-1019.
9. Sair, S., et al., Effect of surface modification on morphological, mechanical and thermal conductivity of hemp fiber: Characterization of the interface of hemp –Polyurethane composite. Case Studies in Thermal Engineering, 2017. 10: p. 550-559.
10. Biswas, S., et al., Physical, Mechanical and Thermal Properties of Jute and Bamboo Fiber Reinforced Unidirectional Epoxy Composites. Procedia Engineering, 2015. 105: p. 933-939.
11. Braga, R.A. and P.A.A. Magalhaes, Analysis of the mechanical and thermal properties of jute and glass fiber as reinforcement epoxy hybrid composites. Materials Science and Engineering: C, 2015. 56: p. 269-273.
12. Srisuwan, S., et al., The Effects of Alkalized and Silanized Woven Sisal Fibers on Mechanical Properties of Natural Rubber Modified Epoxy Resin. Energy Procedia, 2014. 56: p. 19-25.
13. Fiore, V., G. Di Bella, and A. Valenza, The effect of alkaline treatment on mechanical properties of kenaf fibers and their epoxy composites. Composites Part B: Engineering, 2015. 68: p. 14-21.
14. Cai, M., et al., Effect of chemical treatment on interfacial bonding in abaca fiber-reinforced composites. Composites Part A: Applied Science and anufacturing, 2016. 90: p. 589-597.
15. Yan, L., et al., Effect of alkali treatment on microstructure and mechanical properties of coir fibres, coir fibre reinforced-polymer composites and reinforced-cementitious composites. Construction and Building Materials, 2016. 112: p. 168-182.
16. Orue, A., et al., The effect of alkaline and silane treatments on mechanical properties and breakage of sisal fibers and poly(lactic acid)/sisal fiber composites. Composites Part A: Applied Science and Manufacturing, 2016. 84: p. 186-195.
17. Rojo, E., et al., Effect of fiber loading on the properties of treated cellulose fiber-reinforced phenolic composites. Composites Part B: Engineering, 2015. 68: p. 185-192.
18. Wei, C., et al., Mechanical properties of phenol/formaldehyde resin composites reinforced by cellulose microcrystal with different aspect ratio extracted from sisal fiber. Polymers for Advanced Technologies, 2017. 28(8): p. 1013-1019.
19. Venkatarajan, S., et al., Effect of addition of areca fine fibers on the mechanical properties of Calotropis Gigantea fiber/phenol formaldehyde biocomposites. Vacuum, 2019. 166