Effect of Chemical Treatments on Tensile and Flexural Properties of Bamboo Reinforced Composite

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Abstract

In the recent years composites are playing very crucial role in the field of engineering such as Aero industries, Power plants , Domestic vehicles etc,so the researchers have put in considerable effort to develop new materials as replacement of other engineering materials .In the research of composites development natural fibres have become more attractive as an alternative replacement to the manmade fibres, due to lessexpensive, biodegradable, non abrasive and abundance compared to other fibres. The main focus of this investigation is to improve the tensile and flexural properties of composite by means of chemical treatments and also compared by changing the volume fractions.The tensile and flexural properties were determined by using the electronic tensometerand compared the results by plotting the graphs between stress and strain for tensile properties and load –elongation for flexural properties.

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1. INTRODUCTION:

In the recent years there is requirement of materials with unusual combination of properties, the main objective is not only to improve the strength but also the high performance for the materials. In order to fill the above requirement the researchers are developing the new materials finally composites are developed for attain the required properties. Composite means "two or more distinct parts bound together .Thus a material having two or more constituent materials or phases may be considered as a composite material. In our present work the composites are prepared by using natural fibre as onereint for cement phase and polyester resin which is an ther moset as secondary phase.

A review on natural fibre reinforced composites by H Ku [1] stated certain drawbacks of natural fibers/polymers composites are the incompatibility between the hydrophilic natural fibres and the hydrophobic thermoplastic matrices. This leads to undesirable properties of the composites. There are many factors that can influence the performance of natural fibre reinforced composites. Apart from the hydrophilic nature of fibre, the properties of the natural fibre reinforced composites can also be influenced by fibre content / amount of filler.Ahmad.I,Baharum[2]stated that generally high fibre content is required to achieve high performance of the composites. Therefore, the effect of fibre content on the properties of natural fibre reinforced composite sisparticularly significant. It is often observed that the increase in fibre loading leads to an increase in tensile properties.A.V.Ratnaprasad[3] stated the composite sprepared by using Arecanut fibre with maximum volume fraction has shown the better mechanical properties compared to less volume fraction of the composites

Giuseppe Cristaldi,Albertalatteri,GiuseppaRecca and Gianlucaciala[4] has proposed the chemical treatment as one of the method to improve the mechanical properties. There are some physical fibre treatments, but now a days we speak about the surface treatment we almost mean chemical ones chemical modification may activate the groups effectively lead to chemical interface with matrix, Alkali treatment, Permanente treatment with various coupling agents and pretreating of the natural fibre have arrive the various levels of success for improving the fibre strength, fibre fitness and fibre adhesion. It is therefore necessary to modify the fibre surface by employing chemical modifications to improve the adhesion between fibre and matrix.Sherely Annie Paaul,Abderrahimbouderene[5] have also proposed that the effect of fibre loading and chemical treatment of fibre has improved the properties of the fibre

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N.Srinivasbabu,K..Muralirao,J.Sureshbabu stated that[6] ,the chemically treated okra fibre reinforced polyester composite showed better properties compared to untreated okra fibre composite.Nor AzwinbtAhad[7] stated During the chemical treatment the surface of the fibre has been modified that shows the high performance and this is studied under the SEM. M.M Haque[8]stated that Chemically treated fibre-reinforced specimens yielded better mechanical properties compared to the raw composites, while coir fibre composites had better mechanical properties than abaca fibre reinforced ones. Based on fibre loading, 30% fibre-reinforced composites had the optimum set of mechanical properties . Samia.S.Mir[9] stated that the raw material observed fromSEM is in the rough manner and after chemical treatment the surface observed to be smooth thus the performance of coir fibre has been improved

In this paper we studied the tensile and flexural properties of chemically treated bamboo fiber reinforced composites and compared with untreated fibre reinforced composite and also with variation in volume fraction of fibre.

2. Material and Method of Extraction

Bamboo stem collected and made in to number of thin strips and fibre is extracted by means of retting process.

Retting Process: In the retting process thin bamboo strips are immersed in the water for more than a week and by applying some mechanical force and by using knife it has extracted as a thin fibre.

Figure1. Extracted Bamboo Fibre

3. Fibre volume fraction:

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The volume fraction of fibre was calculated by a method which enables the rule of mixtures and analysis of measured composite properties. The method involves measuring the density of the composite (ρ_C) of mass M_C at a given mass fraction of the resin M_R. Volume fraction of resin (V_R) was calculated using the formula

$$V_R = \frac{M_R \times \rho_C}{M_C \times \rho_R}$$

Where R = density of resin in kg/m^3

Then the fibre volume fraction is determined by the relation

$$V_F = 1 - V_R$$

4. Chemical Treatments:

4.1 .Alkaline Treatment:

The Alkaline Treatment is also known as Mercerization. In alkali treatment the extracted fibre wassoaked in NaOH solution for two days and after washed thoroughly with water and dried for 3 to 4 hrs at room temperature. The alkaline treatment is carried out with different concentration of NaOH solutions that is 4% and8%.. Mercerization had a long-lasting effect on the mechanical properties of fibres, mainly on fibre strength and stiffness.

4.2 Permanganate treatment:

In this treatment fiber extracted is initially treated with NaOH for 5 min and then the fiber was soaked with acetone and 0.5% KMnO4 solution for an half hour and washed thoroughly with water and dried at room temperature. Permanganate treatment is indicated as one of the best method to improve the bonding at the fibre-polymer interface.

5. Sample Preparation

The samples were prepared for both the tensile and flexural testing are prepared by means of hand layup method in this method the samples are prepared as per ASTM D790.A layer of polyester resin has been placed and fibre was arranged in unidirectional manner with their respective volume fraction and dried at the room temperature conditions. The size of tensile specimen is 160*12*3 mm and the size of the flexural specimen is 104*25*3 mm

Figure 2. Prepared Samples

6. Mechanical Testing of Composites:

The fabricated specimens were tested using a 2 ton capacity - Electronic Tensometer, METM 2000 ER-I model, with a cross head speed of 2 mm/min in accordance with standard ASTM D790 under ambient conditions. The schematic representation of load application for flexural is as shown in Figure4.Load and elongation values is determined for the all samples. Utilizing the experimental values of load and elongation, flexural strength, flexural modulus (E_f) and tensile strength, tensile modulus (E_t) values were determined using the formulae. Reported values are the average of three samples in all measurements.

Figure 3. Testing Equipment Electronic Tensometer

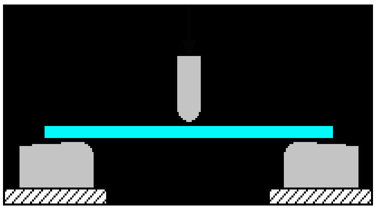

Figure 4.Flexural Test Arrangment

Figure 5.Tested Tensile Specimen on Electronic Tensometer

Figure 6. Tested Flexural Specimen on Electronic Tensometer

7. CALICULATIONS:

7.1 Tensile Properties:

The tensile stress and tensile strain of the composites were determined by substituting the load and elongation values in below formulae

Tensile stress $\sigma_t = P/bd$

Tensile strain $\varepsilon_t = \frac{L}{l}$

Tensile modulus $= \sigma_t / \varepsilon_t$

Following are the notations used in above formulae

P=Load, (N)

L=Support span, (mm)

b=Width of test beam, (mm)

d=Depth of test beam, (mm)

l=change in the length

7.2 Flexural Properties:

The flexural stress, flexural strain, flexural modulus and percentage of elongation at break values of the composites were determined by substituting load and elongation values in the below formulae.

Flexural stress $\boldsymbol{\sigma_f = 3PL/2bd^2}$ (for a rectangular cross section)

Flexural modulus $\boldsymbol{E_f = L^3 m/4bd^3}$

Following are the notations used in above formulae

σ_f = Stress in outer fibres at mid point, (MPa)

E_f =Flexural Modulus of elasticity, (MPa)

P=Load, (N)

L=Support span, (mm)

b=Width of test beam, (mm)

d=Depth of test beam, (mm)

m= The gradient (i.e., slope) of the initial straight-line portion of the load deflection curve,(P/D), (N/mm)

8.Results And Discussion:

From the result obtained the Flexural modulus, Flexural strength, tensile modulus and Tensile strength values are compared between the chemically treated and the untreated fibre reinforced composites.

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The flexural properties of the NaOH treated fibre composite are better compared to the untreated fibre and with an increase in the concentration of NaOH again there is a decrease in the properties. During the KMnO4 the flexural modulus and flexural strength values are reduced compare to the untreated fibre.

The tensile properties of KMnO4 treated fibre is better compared to the untreated fibre and NaOH treated fibre properties has been reduced compared to the untreated fibre.

Table:1**Comparison of flexural modulus values with respective to the volume fractions and chemical treatments**

CHEMICAL TREATMENTS↓	**FLEXURAL MODULUS**(GPa)		
	V_f=11%	V_f=18%	V_f=25%
Bamboo	11.621	11.835	12.039
KMnO4	7.401	7.748	9.558
NaOH (4%)	11.735	11.935	12.884
NaOH (8%)	7.856	9.816	11.758

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8.1Effect of alkaline treatment on flexural properties:

The Alkaline treatment reduce the diameter of the fibre there by Increasing the aspect ratios which leads to development of rough surface topography that results in better fibre/matrix interface adhesion ,more over the Alkali treatment increases the number of possible reactive sites allow better fibre wetting and gets an effect on chemical treatment compositions of fibre ,degree of polymerization and molecular orientation of the celleoulus which are removed during the Mercerization process, as aresult long lasting mechanical properties of fibre mainly of strength and stiffness . Athigher alkali concentration, excess delignification of natural fibre occurs resulting in a weaker or damaged fibre. The tensile Strength of the composite decreased drastically after certain optimum NaOH concentration.

8.2Effect of permanganate treatment on flexural properties:

As a result of permanganate treatment, the hydrophilic tendency of the fibres is reduced, and thus, the water absorption of fibre reinforced composite decreases with KMnO4 treatment. Permanganate treatment is indicated as one of the best method to improve the bonding at the fibre-polymer interface.

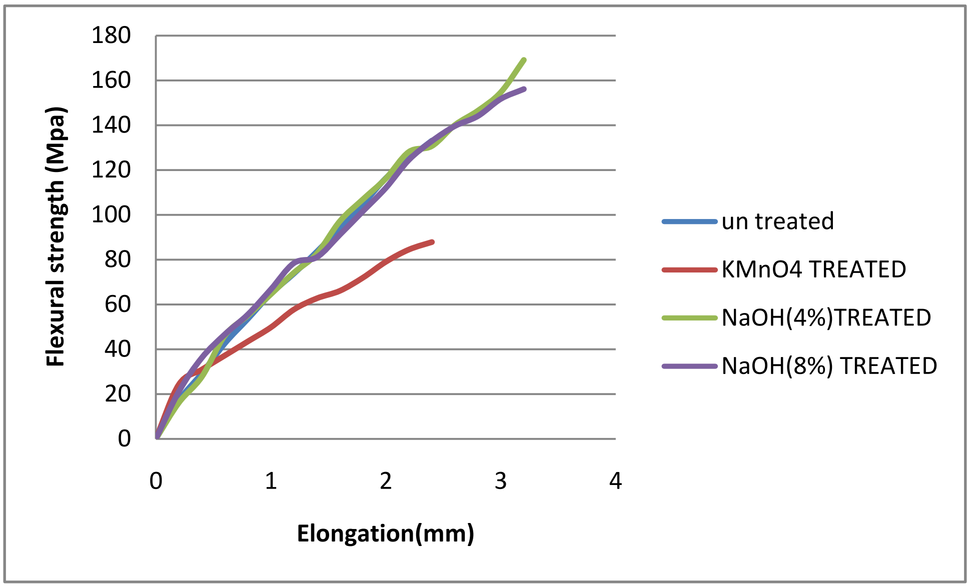

Fig.7Flexural strength comparison for volume fraction of 11% with respect to chemical treatments.

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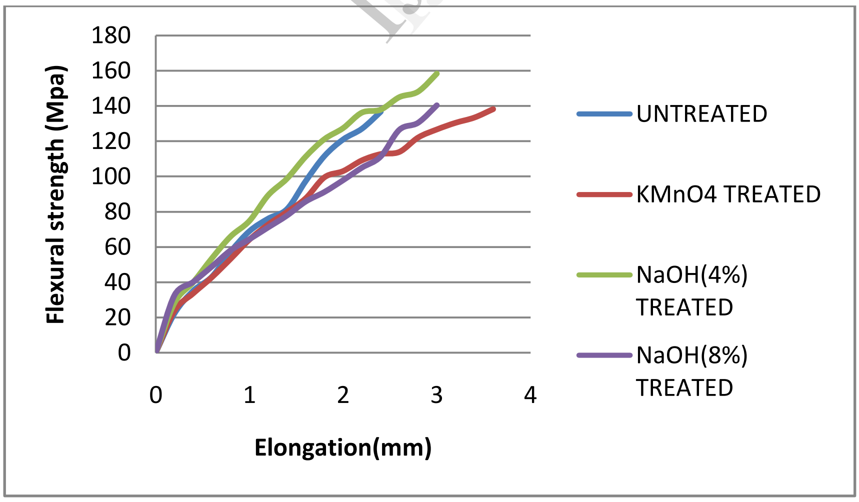

Figure 8. Flexural strength comparison for volume fraction of 18% with respect to chemical treatments.

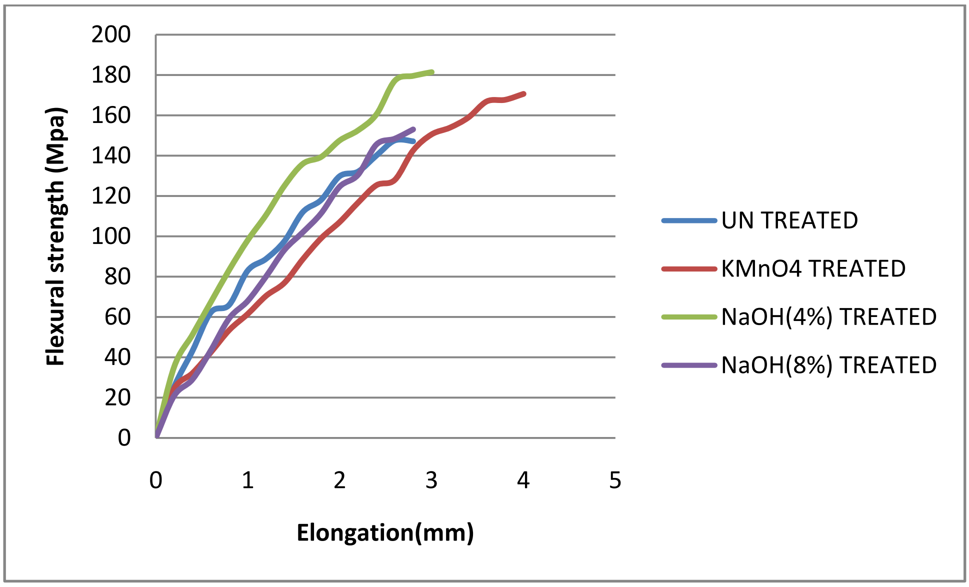

Figure 9.Flexural strength comparison for volume fraction of 25% with respect to chemical treatments.

9. TENSILE RESULTS:

From the results we have observed that the tensile strength and tensile modulus values compared between the Untreated and treated fibres, when compared untreated fibre the fibre treated with KMnO4 is having better tensile strength and tensile modulus values NaOH treated is reduced compared to the untreated fibre composites

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9.1 Effect of alkalinetreatment on tensile properties:

During the Alkaline treatment the diameter of the fibre has been reduced and there is excessive extraction of the ligin and hemicellouse thus it weakens the fibreso the tensile strengthand tensile modulus have been reduced.

9.2 Effect of permanganate treatment on tensile properties:

The permaganent treatment improves the bonding strength between the fibre and matrix. The hydrophilic tendency has been reduced in the fibre and thus the reduction of fibre water absorption tendency of the fibre as the bonding strength increased between the fibre and matrix it is showing better tensile properties compared to untreated fibre.

Table 2.Comparision of tensile modulus values with their respective volume fraction and chemical treatments

CHEMICAL TREATMENTS ↓	TENSILE MODULUS(MPa)		
	V_f=11%	V_f=18%	V_f=25%
Bamboo	113.9	125.1	142.9
KMnO4	137.6	161.2	155.7
NaOH(4%)	109.3	138	142.9
NaOH(8%)	95.86	102.8	143.1

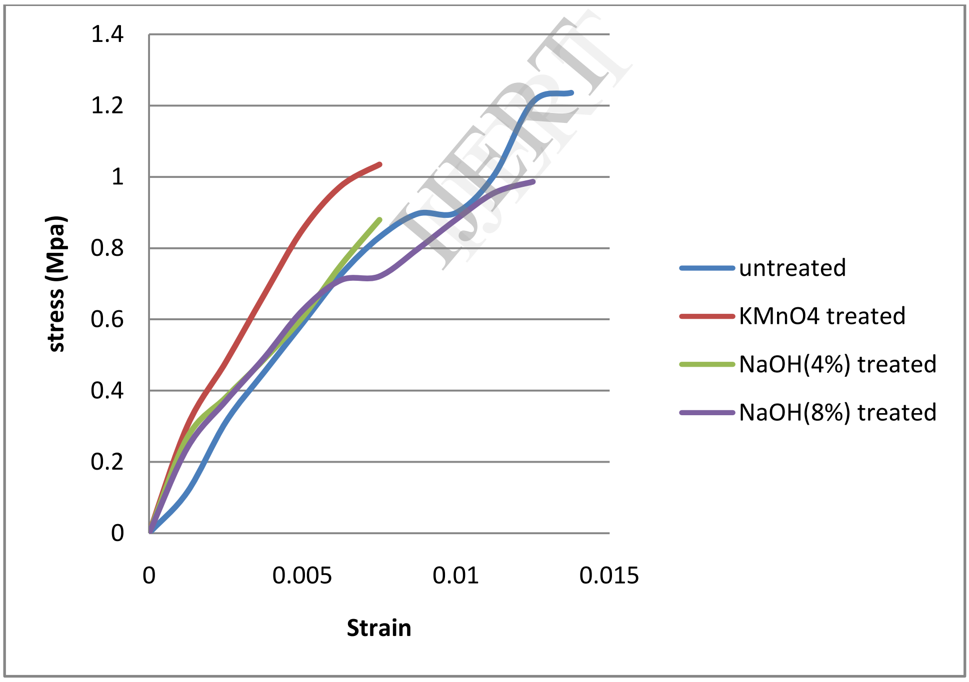

Figure 10. Tensile strength comparison for volume fraction of 11% with respect to chemical treatments.

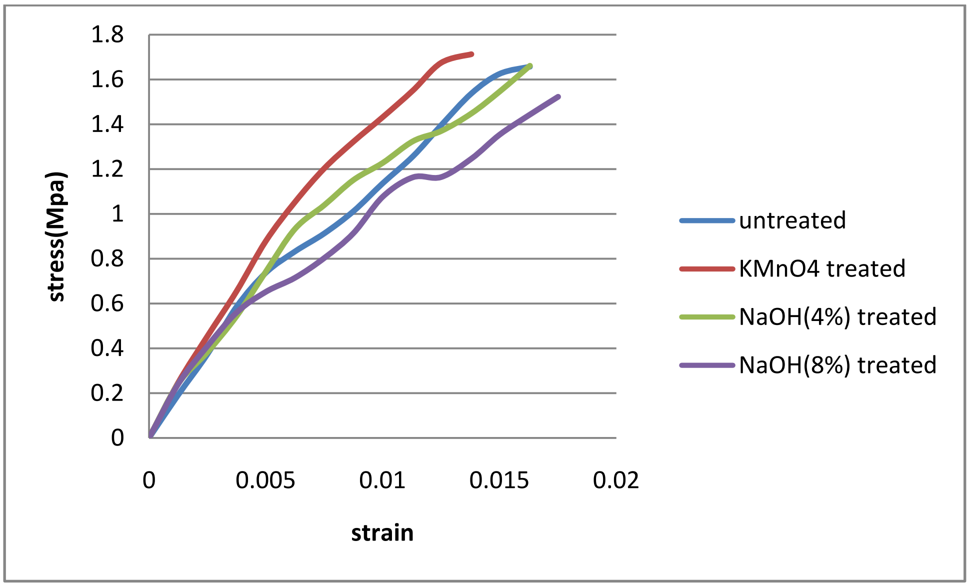

Figure 11.Tensile strength comparison for volume fraction of 18% with respect to chemical treatments.

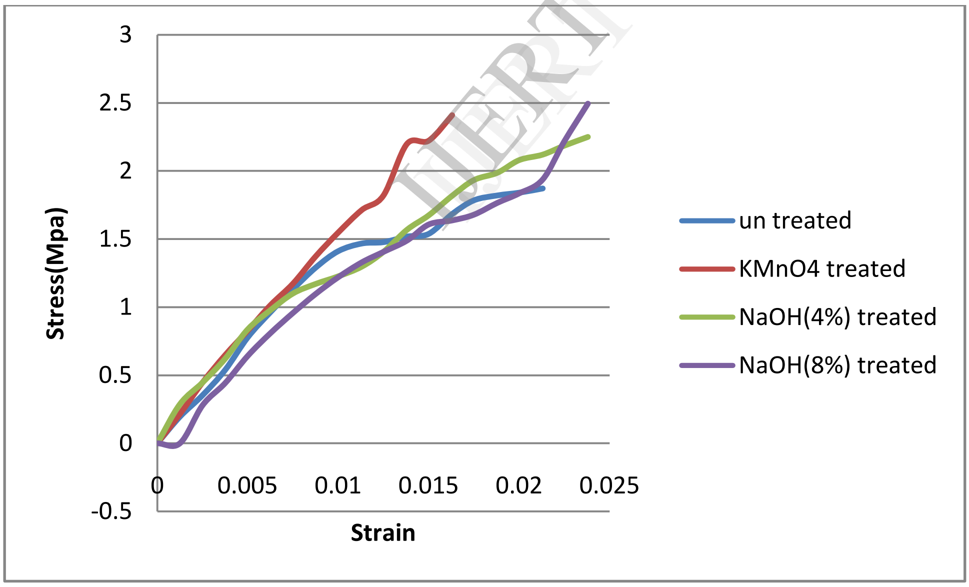

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Figure 12. Tensile strength comparison for volume fraction of 25% with respect to chemical treatments.

CONCLUSION:

The tensile and flexural properties are evaluated and compared between untreated and chemically treated fibre reinforced composites in this paper. By the treatment of fibre with NaOH solution the flexural properties are improved compared to the permanganate treated and untreated fibre reinforced composite, during the alkaline treatment the surface topography of fiber was changed that yields better fiber matrix interface and with the increase in the concentration of NaOH there is decrease in the properties because during the treatment at higher NaOH there is excess extraction of hemicelleous and ligin from the fiber thus finally it causes the damage to the cell walls. With treatment of permanganate the tensile properties are improved compared to the untreated and alkali treated fibre reinforced composite because during the permanganate treatment there is an increase in the bonding strength between the fiber and matrix.

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