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Effect of Alkali Treatments on Mechanical Properties of Prosopis Juliflora Fiber Reinforced Composites: A Comparative Study

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Abstract : Composite materials consist of two or more constituent materials, the fibre(s) and the matrix. Fibre reinforced epoxy composites have become very popular by replacing conventional materials because of their excellent properties suitable, which are suitable for various applications. The drawbacks of using natural fibres, shows incompatibility between fibres and matrices can be reduced by chemical modifications and treatments. The aim of the present study is to compare two different alkali treatments (KOH and NaOH) on the mechanical properties of Prosopis Juliflora fiber reinforced composites. Bonding nature of these two alkali treated reinforced composites are observed by Scanning Electron Microscopy (SEM). NaOH treated Prosopis Juliflora fiber reinforced composites possessed higher mechanical properties when compared to non-treated and KOH treated Prosopis Juliflora fiber reinforced composites.

Keywords: Alkali Treatment, Mechanical Properties, SEM, Natural Fibers

1. INTRODUCTION

Global environmental concerns as rising average global temperature, rising sea levels, decrease in polar ice caps, rapidly depleting petroleum resources have put the pressure on human and industry. Sustainable development has become a major issue in now days and the depletion of oil-based resources will force the researchers to develop biopolymer materials from renewable resources [1]. Nor et al. [2] studied the effect of fibers treated with sodium hydroxide (NaOH) on the thermal properties of PLA/kenaf green nano composite. It was found that the 1.0M treated fibers composites gives the better thermal properties than the 0.5M and 1.5M treated fiber composites. Krishnudu et al. [3] also investigated on the effect of alkali treatment on mechanical properties and concluded that the alkali treatment by NaoH improves the tensile and impact properties. Raghavendra Rao et al. [4] investigated on bamboo fiber reinforced composites by studying the effect of alkali treatment on mechanical properties. Krishnudu et al. [5, 6] also investigated on the optimization of mechanical properties for natural fiber reinforced hybrid composites.

Only few of the researchers have focused on comparison of the different alkali treatments on the natural fiber composites to improve the mechanical properties. Alkali treatments makes the fiber matrix bonding stronger by removing the hemi-cellulose content and greasy nature over the natural fibers, thereby the mechanical properties can be improved.

2. MATERIALS AND METHODS

Materials

The Epoxy resin (LAPOX L-12) of medium viscosity is used as matrix material, and a room temperature curing polyamine hardener (K-6) both are supplied by ATUL Limited (Polymers division), Gujarat, India. It is generally preferred in hand-lay-up applications. The reinforcement is Prosopis Juliflora is a kind of natural fibre, which can be agriculture waste locally available through the water retting and mechanical extraction.

Alkali Treatment

Reinforcing fibers can be modified by physical and chemical methods. Physical methods, such as stretching, calendaring, thermo treatment, and the production of hybrid yarns do not change the chemical composition of the fibers. The dry fibre was treated with 5% solutions of NaOH and KoH separately for 2 h to remove the unwanted soluble cellulose, pectin, lignin, etc. from the fibre. After 2 h the fibre was washed thoroughly in distilled water containing 1% acetic acid to neutralise and remove excess amount of NaOH or KoH and dried at 50°C for 20 h. The fibres are dried to remove free water and placed in a glass container in a conditioning chamber.

Composite Preparation

The mould box was made with the dimension of 160 mm (L) 160 mm (W) 3 (T) mm. The required equipment for making the mould for hand-lay-up process were glass, sticker, spacer frames and a transparent plastic film to keep on the top of the uncured composite before it was closed and compressed. The treated and untreated fibres were cut according to the mould size. Then, the matrix was prepared by mixing the hardener to epoxy. The epoxy and hardener ratio was maintained at 10: 1. To get the well-cured and a standard-quality specimen, the matrix is mixed smoothly and slowly for approximately 10-15 min. Initial layer of the mould was filled with resin mixture and then the appropriate quantity of fibres was placed such that matrix is completely spread over the fibres. Again, resin is poured on the fibre. Thus, the starting and ending of the layers were of matrix. The plastic releasing film was placed on the top of the uncured mixture. Before applying compression, efforts were made to remove all bubbles with roller. Finally, the compression pressure was applied uniformly to achieve the uniform thickness of 3 mm and cured for 24 h at room temperature. The obtained composite laminates are of the size 160 x 160 x 3 mm^3.

Testing of the Composites

The composite specimens were tested as per ASTM standards. Tensile testing was done as per ASTM D 3039-76 with the help of Universal Testing Machine at a crosshead speed of 10 mm/min. The temperature was conditioned at 24°C with the humidity of 50%. The specimen dimensions were 150 x 15 x 3 mm^3. Flexural testing was done as per ASTM D 5943-96 standards using three point bending method at a crosshead speed of 5 mm/min and at a temperature of 24 C with the humidity of 50%. The specimen dimensions were 100 x 15 x 3 mm^3. The impact testing was done as per ASTM D 256-88 by IZOD impact machine with un-notched specimen. The specimen dimensions were 67.5 x 12.7 mm^3.

3. RESULTS AND DISCUSSION

This section discusses the results of all the experimental investigations. Once the composite laminates are prepared the samples were cut as per ASTM standards to test their mechanical properties. The results of all the mechanical properties (Tensile, Flexural and Impact) were discussed in this section.

Tensile Strength

Specimens are cut as per ASTM D 3039-76 to evaluate the tensile test results with the help of Universal Testing Machine (INSTRON 3369) at a crosshead speed of 10 mm/min. the obtained results are shown in Fig.1. The tensile properties of the composite specimens are increased with increase in fiber content into the composite laminate. Moreover NaOH treated composite sample possessed higher tensile properties when compared to the KOH treated composite sample.

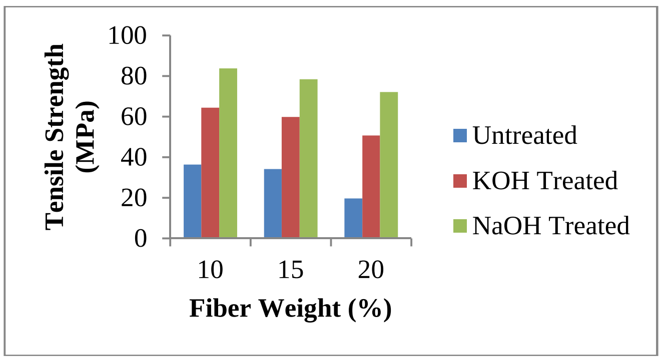

Fig.1 Tensile test results of the composite sample with fiber content variation and fiber treatment

Flexural Strength

Specimens are cut as per ASTM D 5943-96 to evaluate the flexural test results (three point bend test) with a span length of 50mm using Universal Testing Machine (INSTRON 3369) at a crosshead speed of 5 mm/min. The obtained results are shown in Fig.2. The flexural properties of the composite specimens are increased with increase in fiber content into the composite laminate similar to the tensile test results. Moreover NaOH treated composite sample possessed higher flexural properties when compared to the KOH treated composite sample.

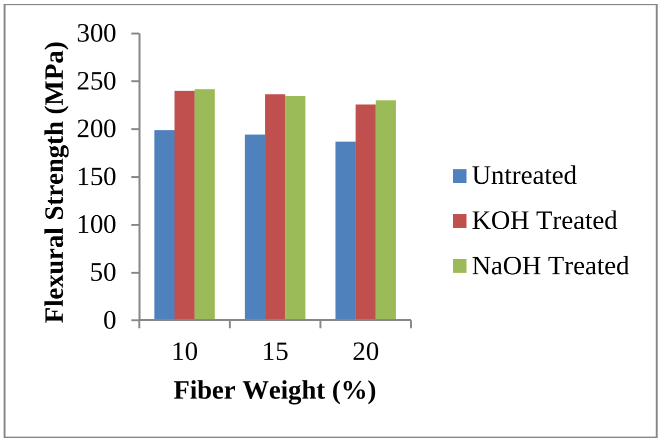

Fig.2 Flexural test results of the composite sample with fiber content variation and fiber treatment

Impact Strength

Impact test of the composite specimens are tested using IZOD impact tester. The specimens are cut as per the ASTM D 256-88 to test for impact properties. Similar to the tensile and flexural results, impact test results are also improved with the NaOH treatment and fiber weight content. The obtained results are shown in Fig. 3.

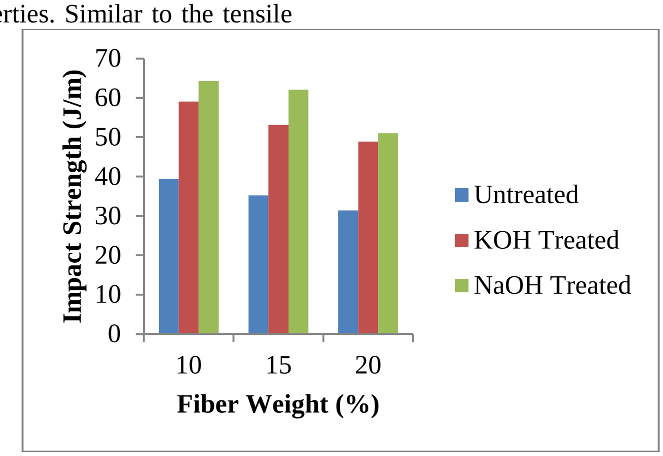

Fig.3 Impact test results of the composite sample with fiber content variation and fiber treatment

SEM Analysis

To probe the bonding between the reinforcement and matrix, the Scanning Electron micrograms of fractured surfaces of Prosopis Juliflora fiber reinforced epoxy composites were recorded. These micrograms were recorded for both NaOH and KOH trested composite specimens at different magnifications. Fig.4 represents the SEM image of the NaOH treated composite sample at 100x magnification. Fig.5 represents the KOH treated composite sample SEM image at 100x magnification. When compared to Fig.5, Fig.4 NaOH treated fiber reinforced epoxy composite has better bonding nature than the KOH treated fiber reinforeced composite. Less fiber pull outs is observed in Fig.4, this led to higher mechanical properties.

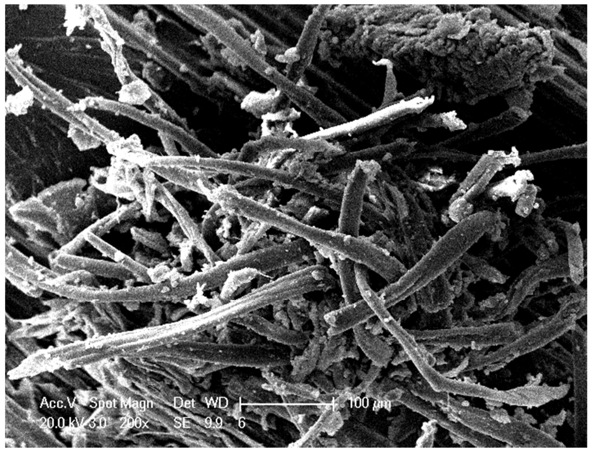

Fig. 4 NaOH treated Prosopis Juliflora fiber reinforced epoxy composite

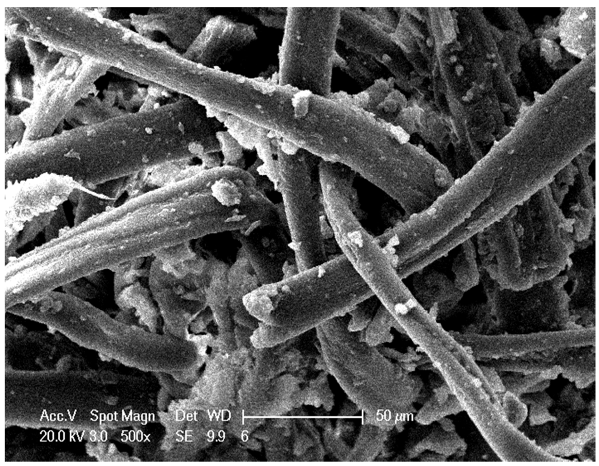

Fig. 5 NaOH treated Prosopis Juliflora fiber reinforced epoxy composite

4. CONCLUSION

The Prosopis Juliflora fiber reinforced epoxy composites were fabricated and their mechanical properties (Tensile, Flexural and impact properties) were studied. The effect of fiber percentage on these properties was studied. The strengths of the composites were improved with increase in fiber content of the composite samples for all the tests. Effect of alkali treatments by NaOH and KOH were also studied on these mechanical properties. The NaOH treated composites were found to exhibit good mechanical properties. The elimination of amorphous weak hemi cellulose components from the fibers may be responsible for the improvement in the mechanical properties. The bonding nature of the fiber and matrix with NaOH treated samples is good when compared to KOH treated samples. One can conclude that the NaOH treatment modifies the fiber surface for higher bonding with the matrix material.

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