

Alkalichemical Treatment on the Surface of Natural Fiber

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ABSTRACT: The poor adhesion between fiber and matrix is commonly encountered problem in natural-fiber-reinforced composites. To overcome this problem, specific physical and chemical treatments were suggested for surface modification of fibers by investigators. Alkali treatment is one of the simple and effective surface modification techniques which are widely used in natural fiber composites. The alkali treatment found to be effective in improving the tensile and flexural properties while the impact strength decreased.

I. INTRODUCTION

The natural fibers are hydrophilic and have polar groups in their structure. Moreover, natural fibers also consist of several elementary fibers associated with cellulose, hemicellulose, pectin, lignin, etc. Hence, they cannot be considered as the mono-filament fibers. To remove the unwanted elements from the fiber, specific treatments are necessary. Many investigators found and reported that the interfacial bonding can be enhanced by the surface modification of the fiber through alkali treatment and treatment with coupling agents, which in turn will enhance the overall performance of the composites, after 2% alkali treatment, coir fiber-polyester composites shown improved tensile properties¹. There is a 15% increase in tensile strength. The role of the matrix is to keep the fibers in a desired location, orientation and to effectively transfer the stress to fibers. Also, they protect the fibers from mechanical and chemical damage. Epoxy is most commonly used matrix material because of high strength, low viscosity, low flow rate, low volatility during cure, low shrink rate, etc. The fiber-matrix interface plays an important role on the transformation of load from the matrix to the fiber.

Although mechanical properties the natural fibers are much lower than those of synthetic fibers such as carbon, aramid, glass, etc., their specific properties, especially stiffness, are comparable. But natural fibers are very light in weight when compared with the synthetic fibers. Most of the natural fibers are nearly 50% lighter than glass². The present work investigated the effect of fiber content in weight percentage and alkali treatment (with NaOH) on tensile, flexural and impact properties of natural fiber-epoxy composites. All types of natural fiber, such as hemp, jute, ramie, henequen, curaua, flax, etc., have been treated with the sodium hydroxide (NaOH) before mixed together with the polymer (thermoplastics or thermosetting) to produce composites³. The concentration of alkali solution that was used to treat the fibers is in the range of 0.5% up to 28%, but most of the researchers used below 10% alkali solution. The temperature and soaking time to treat the natural fiber in the solution are in the range of 20-180°C and 15 minutes to 48 h period of time, respectively. The required temperature to dry a natural fiber should be below 80°C for 24 to 48 h period of time

Table1: The alkali (NaOH) treatment of some natural fibers.

Fiber	NaOH (%)	Soaking time	Soaking temperature (°C)	Drying
Hemp	10 or 15	15 or 45 min	160 or 180	80°C for 48 h
Jute	Up to 28	30 min	20	-
Ramie	15	2 h	-	-
Henequen	2	1 h	25	60°C for 24 h
Curaua	10	-	-	-
Flax	1, 2, 3	20 min	Room temperature	80°C for 48 h
Kenaf	3, 6, 9	3 h	Room temperature	Room temperature for 48h
Sisal	2	4 h	60	80°C 24 h
PALF	5	30 min	-	60°C for 24 h
Bagasse	1, 3, 5	2 h	25	70°C for 72 h
Piassava	10	-	Room temperature	-
Oil palm	0.5, 1, 2, 4	-	-	70°C, until constant weight
Coir	5	48 h	-	-
Kenaf	6	48 h	19±2	110°C for 5 h
Henequen	2	1 h	25	60°C for 24 h
Hemp	6	48 h	20±2	60°C for 48 h
Jute	5	4 and 24 h	25	80°C, until constant weight
Sisal	10	1 h	-	-
Coir	2	1 h	70	70°C, until constant weight
Jute	2	1 h	70	70°C, until constant weight
Hemp	0.8-8	48 h	20±2	-

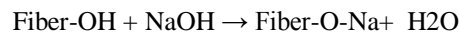
II. EXPERIMENTAL

2.1 Alkali treatment

The dry fiber was treated with 5% solution of NaOH for 2 hours to remove the unwanted soluble cellulose, hemi cellulose, pectin, lignin, etc. (Bledzi and Gassan 1999) from the fiber. The fiber to solution weight ratio was maintained at 1: 25. After 2 h the fiber was washed thoroughly in distilled water to remove excess of NaOH and dried at 60°C for 24 hours.



Fig 1: Alkali treatment for natural fibers



2.2 Chemical analysis for alpha (α)-cellulose

Chemical analysis was done for the determination of alpha (α)-cellulose as per Indian standards (IS: 6213, PART III-1971) with 17.5% and 8.3% (by weight) sodium hydroxide reagents. The residual high-molecular weight fraction was left behind when a mixture of fiber and 8.3% NaOH solution is filtered after the fibers have been initially swollen in a 17.5% NaOH solution. The residue was washed with distilled water followed by acetic acid solution at 20°C and soaked for 5 min. Again, it was washed with the distilled water to free it from the acetic acid and dried in the oven at 105°C. Next, the contents were transferred to a weighing bowl and dried to a constant weight. % alpha (α)-cellulose can be calculated as follows:

$$x = 100a/m,$$

where, x = % alpha (α)-cellulose by weight; a = weight of precipitate in grams; m = weight of fiber in grams calculated on oven dry basis.

2.3 Composite preparation

The mould box was made with the dimension of 200 mm (L) \times 150 mm (W) \times 3.0 mm (T) mm, 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 epoxy and hardener must be mixed smoothly and slowly. Initial layer of the mould was filled with epoxy resin mixture and then the appropriate quantity of fibers was placed such that epoxy mixture completely spread over the fibers (PALF). Before applying compression, efforts were made to remove all bubbles with roller.

Finally, the compression pressure was applied evenly to achieve the uniform thickness of 3 mm and cured for 24 h at room temperature. The obtained composite laminates are of the size 200 \times 150 \times 3 mm³.

2.4 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 (INSTRON-3369) model Universal Testing Machine at a crosshead speed of 10 mm/min. The temperature was conditioned at 22°C with the humidity of 50%. The specimen dimensions were (150 \times 15 \times 3) mm³. 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 22°C with the humidity 50%. The specimen dimensions were (100 \times 15 \times 3) mm³. (INSTRON-3369) model Universal Testing Machine is specially designed for the automated material testing of polymer composites by INSTRON Corporation. The impact testing was done as per (ASTM D 256-88) by Izod impact machine with unnotched specimen. The specimen dimensions were (122 \times 13 \times 3) mm³. In each case, five samples were tested and the average values were reported.

III. RESULTS AND DISCUSSION

Tensile strength, tensile modulus and % elongation at break of untreated (UTRF)-reinforced and alkali-treated fiber (ATRF)-reinforced composites were presented in table 1 at different fiber contents (5, 10, 15 and 20% wt.). For proper understanding of the effect of fiber content on tensile strength, tensile modulus and percentage elongation at break separate charts have been plotted for untreated and alkali-treated specimens

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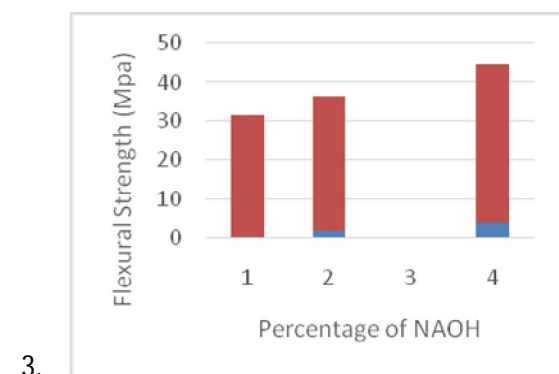
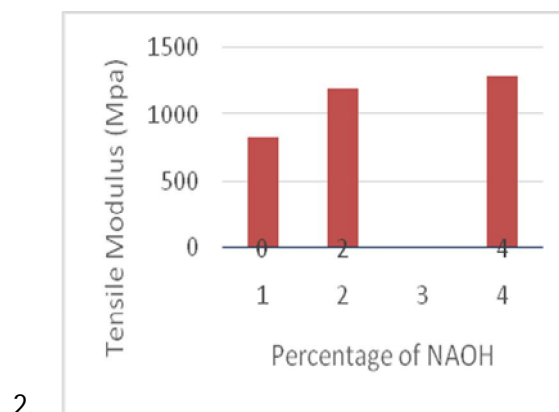
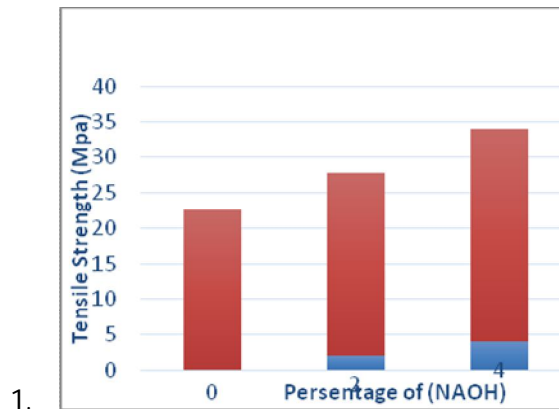
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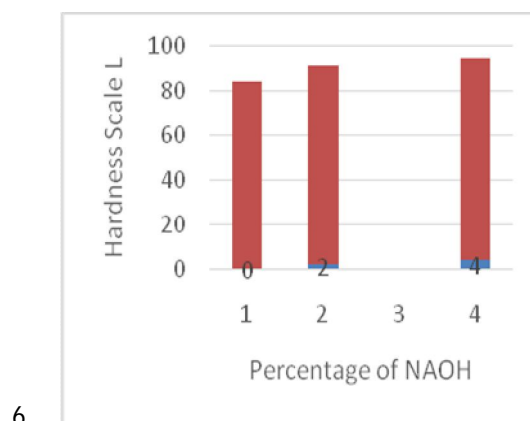
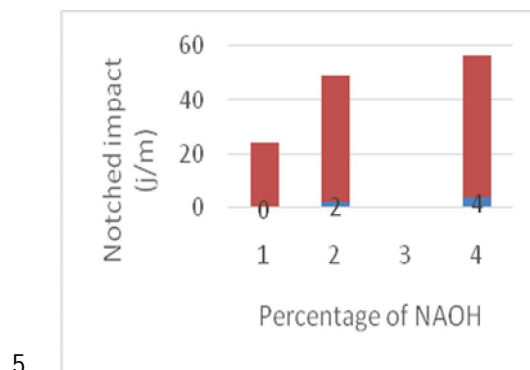
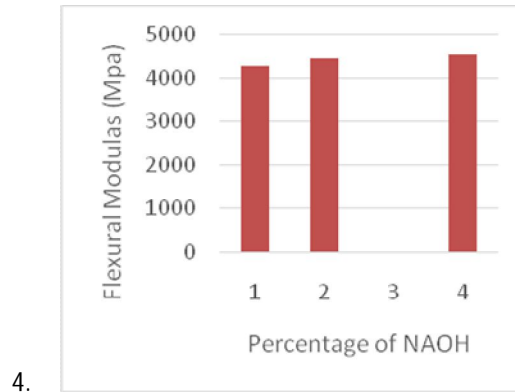
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Table2: The effect of the mechanical properties by alkali treatment on short PALF fibers.

Mechanical property	NaOH concentration		
	0%	2%	4%
Tensile strength (MPa)	21.307	23.814	28.732
Tensile modulus (MPa)	793.568	1143.259	1233.768
Flexural strength (MPa)	29.651	31.265	37.961
Flexural modulus (MPa)	4138.325	4236.098	4326.28
Notched impact (J/m)	22.58	45.349	50.237
Unnotched impact (J/m)	44.589	63.246	74.984
Hardness scale L	82.240	87.384	88.167



Graph 1: Mechanical properties of composite with NaOH percentage



IV. ADVANTAGES

The following conclusions are drawn from the above studies.

- The composites reinforced with alkali treated fibers showed improved mechanical properties. The improvement was maximum for the composite prepared with 4 hours alkali treated fibers.
- The flexural strength was found to be maximum for composites with treated fiber and red mud.
- Less percentage of water absorption was observed after the alkali treatment of fibers.

This may be due to the chemical treatment which reduces the hydroxyl group in the cell wall of natural fiber molecules, thus decreasing the water absorption of the composite.

- The effect of red mud as far as strength is concerned is well visualized. It acts as a barrier due to which the moisture did not get a chance to attack the jute fiber and deteriorate the strength.
- From the aesthetic point of view the fabricated composite promises a wide use in making doors, windows, panels, false roofing, floor tiles etc.
- From this work it is found that chemical modification of the fiber with alkali significantly improves the mechanical performance of the composite. Other chemical modification methods such as silane treatment, acetylation treatment, isocyanates treatment, permanganate treatment, maleated coupling agents could be tried and final conclusions can be drawn thereafter.

V. CONCLUSION

Tensile strength, tensile modulus and percentage of elongation of untreated and alkali-treated natural fiber-reinforced composites were increased with increase in fiber content and are highest at 20% wt. fiber content. Alkali-treated fiber composites have shown superior tensile properties than untreated composites. Also flexural strength and flexural modulus of untreated and alkali-treated fiber composites were increased with increase in fiber content and are highest at 20% wt. fiber content. Alkali-treated composites have shown superior flexural properties than untreated fiber composites. For both untreated and alkali-treated fiber composites, there is an increase in impact strength with increase in fiber content and found to be highest at 20% wt. fiber content.

But, the impact strength of alkali-treated fiber composites was decreased at all fiber contents when compared with the untreated fiber composites. Study demonstrated that natural-fiber-reinforced composites could be successfully produced with good mechanical properties and the tensile and flexural properties can be further enhanced by alkali treatment. This study also reveals that maximum strength and maximum toughness cannot be achieved simultaneously and optimum combinations of desired mechanical properties are possible only through careful design of composites. The NaOH concentrations of 2% and 4% used to treat the fiber increased the value of all mechanical properties of composites such as tensile strength, tensile modulus, flexural strength, flexural modulus, notched and impact and hardness. It can be concluded that the adhesion of fiber/matrix can be improved by treating the short PALF fibers with alkali solution before production of a composite.

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