Experimental Investigations on Mechanical Properties of treated and Untreated Natural Fibre Reinforced Polymer Composite

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Abstract

Advanced fibrous polymeric composites are one of the most successful composite material systems due to its wide range of advantages such as high specific strength and stiffness, fatigue properties and corrosion resistance. The polymer matrix is more susceptible to these changes than the fiber and thus dominates the mechanical behavior of FRP composites. Polymers are characterized as visco-elastic materials that their mechanical properties are strain rate dependent. The present experimental study aims at learning the mechanical behaviour of alkali treated chopped palm leaf stalk natural fiber polymer composites. Samples of are manufactured using hand layup method and the weight fraction of matrix and fiber is kept at 30% to 70%.Specimens are cut from the fabricated laminate according to the ASTM standards for different experiments like tensile test, flexural test, impact test and hardness test. Experiments are performed in a computerized Universal testing machine, Charpy Impact tester and Hardness tester. Result shows that, the trend in all the properties increased for alkali treated chopped fibers except for hardness value.

Keywords: *Composites, Palmyra, Alkali, Mechanical Properties, Visco-elastic materials*

INTRODUCTION

Composite materials are constituents of two or more materials namely a binder or matrix and reinforcement. Usually the reinforcement material is normally stronger and stiffer as compared to the matrix and is added to enhance the property of binder or matrix. The binder also protects the reinforcement from environment. Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, coefficient of thermal expansion, corrosion resistance, improved wear resistance etc [1].

One of the advantages of composite is that two or more materials could be combined to take advantage of the good characteristics of each of the materials. Favorable properties of the composites motivated the researchers to make research and development in composite materials [2].

There are two classification systems of composite materials. One of them is based on the matrix material (metal, ceramic and polymer) and the second is based on the reinforcing material structure (particle and fiber)

Among these matrix materials, the polymer composites have high stiffness, strength, toughness, design flexibility, and low density comparable with structural metal alloys and ceramics. Out of the two reinforcing materials fiber reinforcing is popular.

Fiber is a class of materials that are continuous filaments or are discrete elongated pieces similar to long threads and these fibers carry the loads along their longitudinal directions, Fibers can be either natural or synthetic fibers.

Automotive and transportation industry benefits significantly from lighter materials and recyclable components due to improved energy efficiency. Natural fibers like (bamboo, coir[3], banana [4], jute, hemp[5,6], date palm[7,8], flax[9], oil palm [10-12], etc.) are renewable and posses several advantages like low cost, low abrasivity, low density, non corrosive, high biodegradability and good abatement capability so that these natural fibers shall replace to some extent the more expensive and nonrenewable synthetic fibers[13-15].

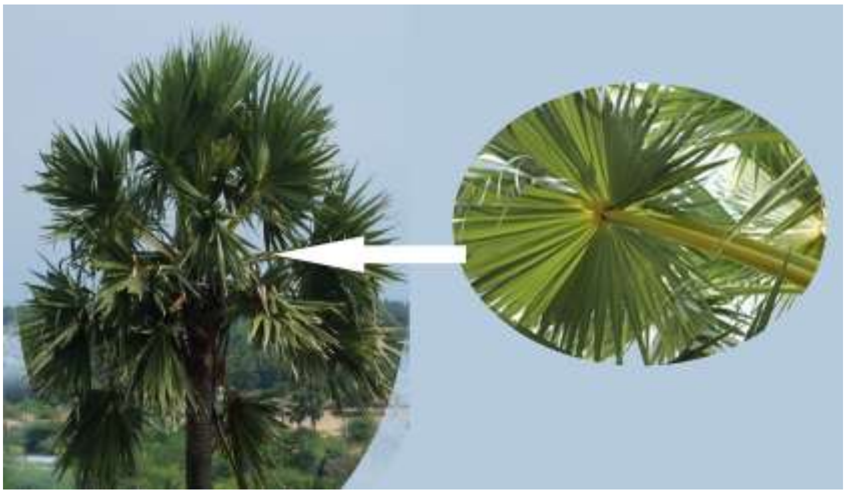

Figure1 Palm leaf stalk spotted on a Palmyra tree

Palmyra leaf stalk fibers shown in figure 1are obtained from (borassus flabellifer) palmyra trees [16-17]. These are not only cheaper but also posses high specific strength, modulus, low specific weight, low density, good resistance to friction, heat and will withstand many chemicals and solvents [18-23].

Palmyra fibers are not only cheaper but also posses high specific strength, modulus, low specific weight, low density, good resistance to friction and heat and will withstand many chemicals and solvents. Although the properties of natural fibers vary with their source and treatment, Alkali treatments have been proven effective in removing impurities from fibers and improving mechanical properties.

These Polymer composite materials shall be used in aerospace, automotive, marine, infrastructure, military, leisure boats, aircraft industry and sport equipment[24].

In this work palmyra leaf stalk fiber is extracted, it is then alkali treated, chopped and rolled into mats. Then the fabrication of alkali treated chopped palmyra leaf stalk fiber reinforced polymer composites are done by hand lay up moulding technique.

The mechanical properties of treated and untreated samples of chopped palmyra leaf stalk fiber reinforced polymer composites are compared.

EXPERIMENTAL PROCEDURE

Extraction of palm leaf stalk fiber

The natural fibers extracted from the leaf stalk of the palm tree are used in this study.

To enhance the properties of palm leaf stalk fiber, it is chemically treated with alkali solution (5% NaOH) and then chopped to 1cm fiber length

Fiber processing

Palmyra leaf stalk fibers are taken in a glass tray, to which alkali (5% NaOH) solution is added and the fibers are soaked in this solution for about 1 hour.

The fibers are then washed thoroughly with pure water to remove the excess of NaOH sticking to the fibers. Final washing is carried out with distilled water and the fibers are then dried in hot air oven at 70 °C for 4 hours.

The palm leaf stalk fibers are then chopped to 1cm fiber length which is then dried and rolled in form of mat to fit the size of molding box 200mm × 150 mm

Fabrication of Composites:

Molding box of required size 200 × 150 ×10 mm is made in wood and the inner portion of the moulding box is coated with wax polish which acts as releasing agent.

Two different types of composite plates one with pure or chemically untreated chopped palm leaf stalk fiber reinforced into the polyester resin matrix and the other with chemically treated chopped palm leaf stalk fiber reinforced into the polyester resin matrix are prepared.

The method adopted for fabricating composite plates is hand layup process. Polyester resin is mixed with required amount of cobalt napthanate(oxidizer) and then with catalyst (methyl ethyl ketone peroxide).

The chemically untreated palm leaf stalk fiber mat is placed inside the mould box and the required amount of polyester resin is poured over it and then a roller is used to roll over the fiber in order to remove the air bubbles from it. This process of adding fiber mat is continued until the FRP composite plate with required thickness and volume percentage is obtained.

The composite plates are allowed to dry at room temperature for 24 hours. Finally the FRP composite plates are removed from the mould.

TESTING OF MECHANICAL PROPERTIES

Polyester resin along with cobalt napthanate (oxidizer) methyl ethyl ketone peroxide (catalyst) is used for preparing matrix material and chemically treated and untreated chopped palm leaf stalk fibers as the reinforcing material.

The composite plates are fabricated in combination of polyester resin and the natural fiber in weight percentage according to the following table.

The Table 1 shows the combinations of Polyester resin and the natural fiber in weight percentage and the specimens A and B are fabricated in this combination as per ASTM standards and tested in computerized Universal Testing Machine (UTM) in 50 mm/min at room temperature 28 °C.

Tensile properties

Tensile test measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile testes produce a stress – displacement diagram and load-displacement diagram, which is used to determine tensile modules. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials.

Table 1 Combination of Polyester resin and the natural fiber in weight %

Specimen	**Combinations**	**Weight**	
		%	**(gm)**
A	Polyester resin +	70	1050
	chemically un treated palm leaf stalk fiber	30	450
B	Polyester resin +	70	1050
	Chemically treated palm leaf stalk fiber	30	450

Tensile properties of treated and untreated samples of palmyra leaf stalk fibers reinforced polymer composites are performed using tensile test on a computerized servo controlled UTM machine with specimen standard ASTM D 638 as shown in figure2 .The cut specimens are placed in the grips of the UTM, the gauge length and cross head speeds are fixed to 50mm and 2mm/min respectively and pulled apart for measuring strength and elongation until the specimen got fractured.

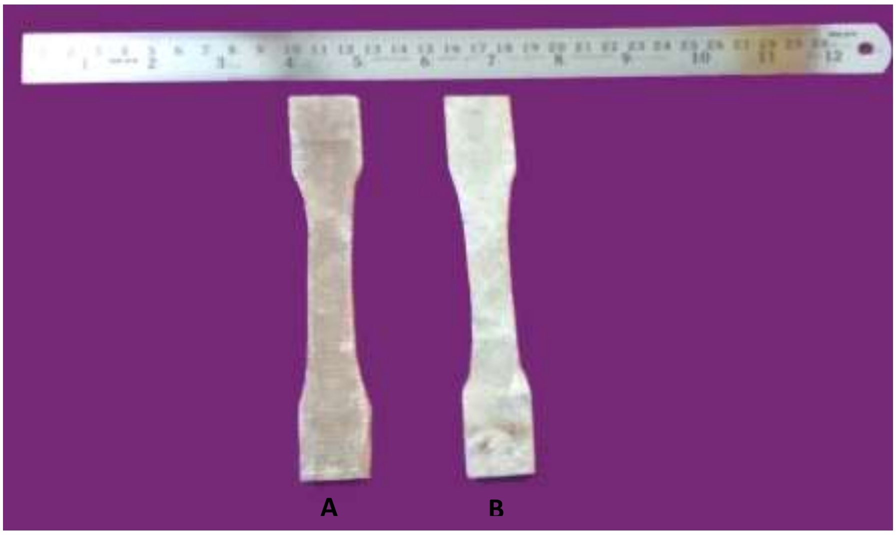

Figure2. Specimen for tensile test

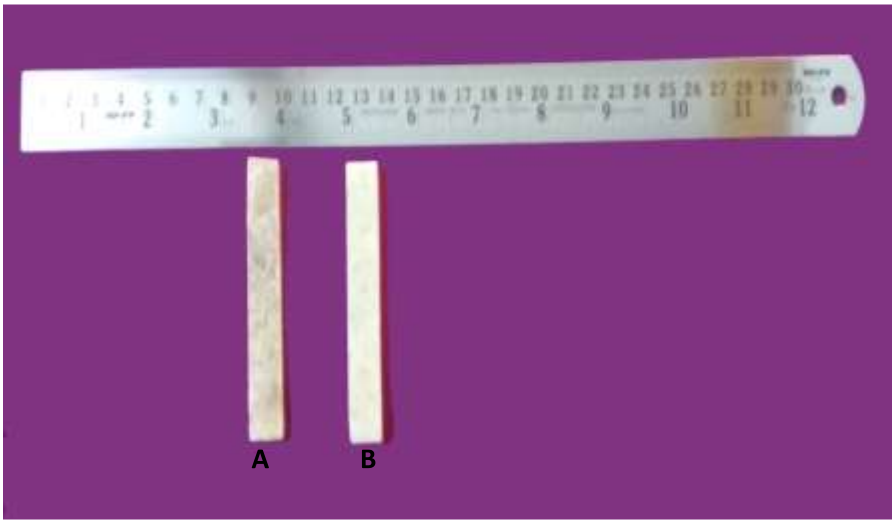

Figure3. Specimen for flexural test

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Flexural Properties

The flexural properties of treated and untreated samples of palmyra leaf stalk fibers reinforced polymer composites are measured by conducting

Flexural test on computerized UTM using special attachment with specimen standard ASTM D 790 as shown in figure 3 .The span to depth ratio is fixed as 16:1 and the speed of test is set as 2mm/min at room temperature.

Impact Strength

The impact strength of composites is measured using a charpy impact tester with specimen standards ASTM D 6110 as shown in the figure 4. The fracture values are calculated by dividing the energy by cross sectional area of the specimen.

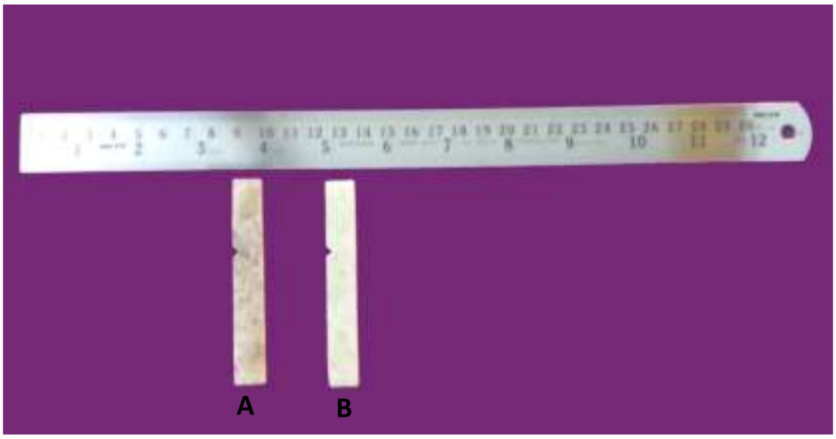

Figure4. Specimen for impact test

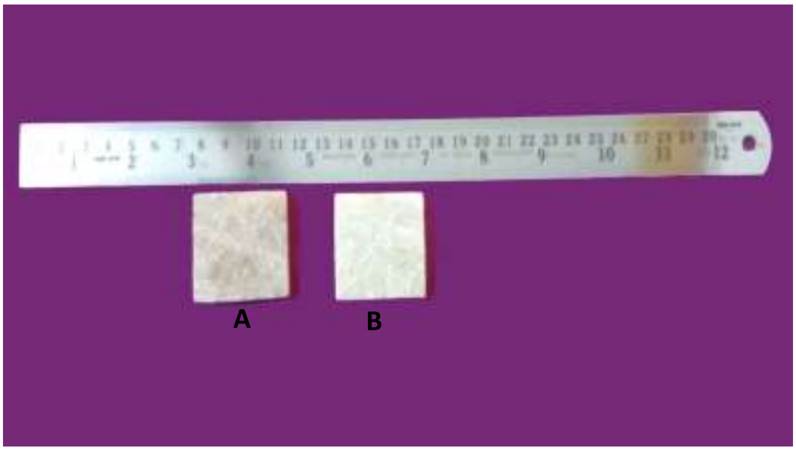

Figure5. Specimen for hardness test

Hardness Value

The hardness test is conducted by using a Rockwell hardness tester as per specimen standard ASTM D 785 shown in the figure 5. Load is applied for 15 seconds and the hardness is measured.

RESULTS AND DISCUSSION

The interfacial strength depends on the surface topology of the fibers, because each fiber forms an individual interface with the matrix. Alkali treatment also causes fibrillation i.e., breaking of fiber bundles into smaller fibers which would increase the effective surface area available for wetting by the matrix material. After fibrillation due to the reduced diameter of fibers, the aspect ratio of fibers increases and yields a better fiber-matrix interface adhesion.

Specimen Vs UTS

Figure 6 illustrates the plots of Ultimate Tensile Strength (UTS) in N/mm2 versus specimens combinations, it can be seen that the untreated palmyra leaf stalk fiber reinforced polymer composites (specimen A) yielded 266 N/mm2 and alkali-treated palmyra leaf stalk fiber reinforced polymer composites (specimen B) yielded 274 N/mm2.

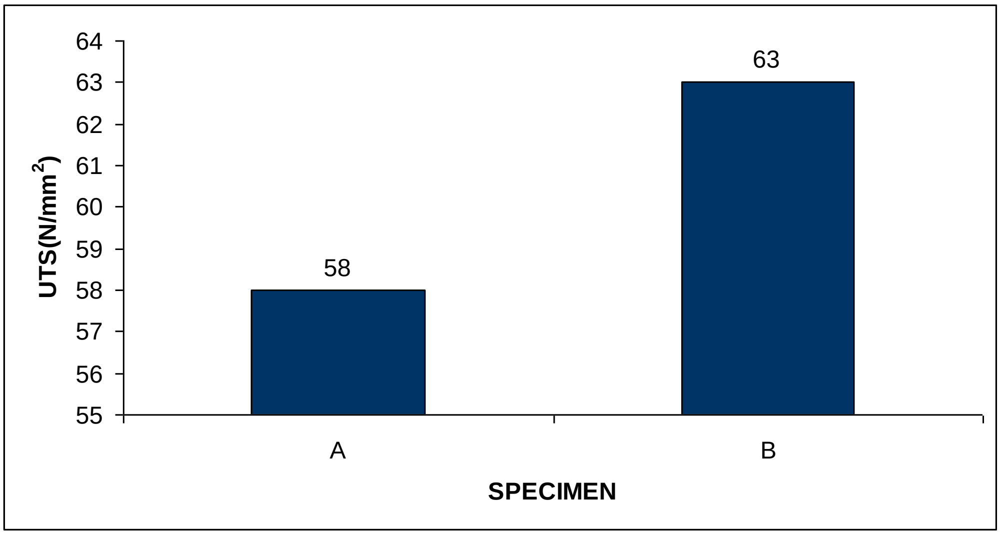

Figure6. Comparison of Ultimate Tensile Strength

Specimen Vs Flexural strength

The variation of flexural strength for the specimens with and without alkali treatment is shown in Figure 7. The alkali-treated palmyra leaf stalk fiber reinforced polymer composites recorded increase in flexural strength than the untreated palmyra leaf stalk fiber reinforced polymer composites. This is due to high fiber-matrix compatibility, good fiber-matrix interaction and wetting.

Specimen Vs Impact strength

The variation of impact strength for the specimens with and without alkali treatment is shown in Figure 8. The alkali-treated palmyra leaf stalk fiber reinforced polymer composites recorded increase in impact strength than the untreated palmyra leaf stalk fiber reinforced polymer composites which results in obtaining the enhanced impact properties

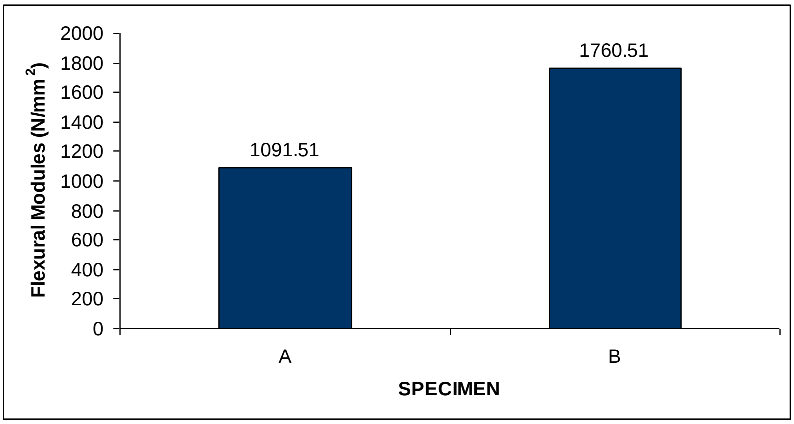

Figure7. Comparison of flexural strength

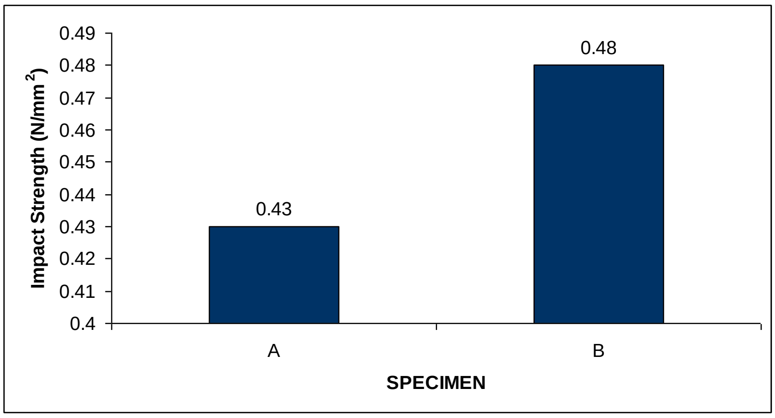

Figure 8. Comparison of impact strength

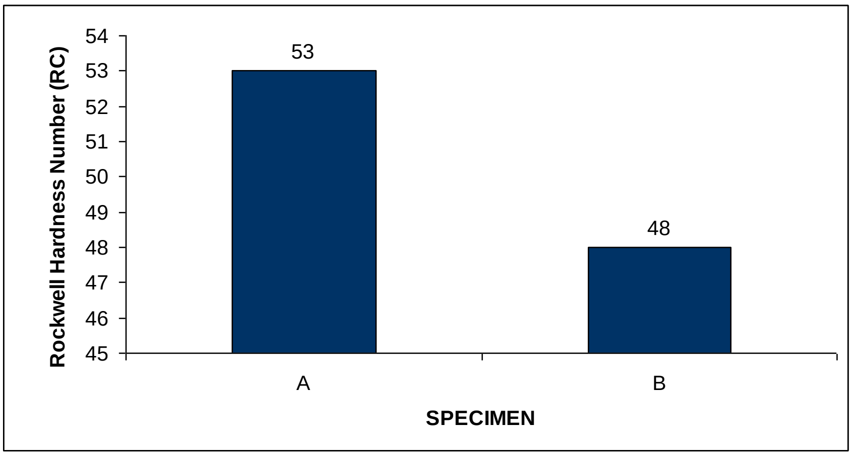

Figure9. Comparison of hardness value

Specimen Vs Hardness

The variation of hardness for the specimens with and without alkali treatment is shown in Figure 9. The untreated palmyra leaf stalk fiber reinforced polymer composites recorded increase in hardness than the alkali-treated palmyra leaf stalk fiber reinforced polymer composites

CONCLUSIONS

This work shows the successful fabrication of alkali treated chopped palmyra leaf stalk fiber reinforced polymer composites by hand layup moulding technique.

The cheaper natural fibre chopped palmyra leaf stalk fiber can be used to make an effective fibre polymer composite.

From both the tensile test, flexural test and impact test the alkali treated chopped palmyra leaf stalk fiber is found to be superior to the non treated chopped palmyra leaf stalk fiber.

From the hardness test, the non treated chopped palmyra leaf stalk fiber is found to have more strength than the alkali treated chopped palmyra leaf stalk fiber.

It can be concluded that the performance of the alkali treated chopped palmyra leaf stalk fiber is found to be superior to the non treated chopped palmyra leaf stalk fiber.

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