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Experimental study on the characteristics of surface treated luffa fiber composites

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ABSTRACT

Luffa fibers were used to fabricate natural fiber composite material. The luffa fibers were surface treated with NaOH, HCl and the combination of both NaOH and HCl. The fiber was pretreated with 4% of NaOH and 3% of HCl solution and then it was allowed to dry for 24 hours. After the treatment the composites has been fabricated. The mechanical properties have been evaluated for the prepared composite material and then the results are discussed. The mechanical properties which have been evaluated are the tensile properties. It is found that the fibers treated with the NaOH solution is showing higher strength compared to other surface treatments.

KEY WORDS: Luffa fiber, NaOH, HCl treatments, Isophthalic polyester resin.

1. INTRODUCTION

The demand in the non-renewable resources is in the rise in recent times has led to the importance in the usage of renewable resources in all places. The fiber composites find greater applications in many industries and machines worldwide. It is a section under research in many countries. The poor biodegradability of synthetic FRPs is a serious issue, as of today. There are renewable, cheap, completely or partially recyclable and biodegradable. Their availability, lower density and price as well as satisfactory mechanical properties made them attractive alternative to synthetic fibers for manufacturing of composites. The natural fibers are more eco-friendly and are used in transportation applications, military applications, building and construction industries, packaging, consumer products etc. There are some drawbacks such as their poor mechanical properties and high moisture absorption. The latter is due to their hydrophilic nature that is detrimental to many properties, including dimensional stability. In many investigations it has been seen that using natural fibers as reinforcements for composites will shows results with high and good stiffness. But it will not reach the strength equal to that of the glass fibers and other synthetic fibers. Matrix has been used in the fiber reinforced composites which will hold the reinforcements in the orderly pattern and it will transfer the stresses between the reinforcements. It also protects the surface from mechanical degradation. Polymer matrix has been mostly used in the fiber reinforced composite materials. Matrices used for structural composite are mainly thermosetting plastic, it can be easily mixed, since initially resin system is available in liquid form. The polyester resins used in moulding applications are viscous liquid require the addition of catalysts and accelerators to complete the curing process. Polyester resins are viscous, pale coloured liquids consisting mixture of ethylene glycol and maleic anhydride. Hardener is a substance of mixture added to a plastic composition to take part in and promote or control the curing action, also a substance added to control the degree of hardness of the cured film. The resin was cured using 1% of methyl ethyl ketone peroxide catalyst and 0.5% of cobalt–naphthanate accelerator. Generally less temperature and pressure are required for the preparation of composite compared to thermoplastic polymers. Also curing time is less for polyester matrix when compared to epoxy matrix.

The fruit of sponge guard (Luffa Cylindrica) is a forest product available in many countries. Luffa belongs to Cucurbitaceous family. Luffa cylindrical is available in mat form naturally. The fibres are composed of 84% of holocellulose, 66% of cellulose, 17% of hemi cellulose, 15% of legnin, 3.2% extractives, and 0.4% of ashes. The physical properties of luffa fibre are: density 820 kg/m3, diameter 25–60 lm, and crystallinity index 59.1. Generally natural fibers are hydrophilic in nature it may absorb the water easily and it will affect the mechanical and thermal properties of the fiber. Hence fiber surface treatments are done in the fibers to enhance the interface bond between the fibers and the matrix and it will reduce the water absorption. During alkali treatment, changes in physical structure of the fibers may occur as a result of alkali action which removes waxy materials and impurities. Generally surface treatment has been done with NaOH solutions at various proportions. It has been found that treated surface fiber is smoother when compared to the untreated fiber.

In this present work, luffa fiber in mat form and polyester resin has been used to prepare the composite. The fibers has been surface treated with NaOH, HCl and combination of NaOH & HCl solutions. The tensile test has been conducted on the composite material and the results has been discussed.

2. MATERIALS AND METHODS

The materials used for the preparation of composite are luffa fiber, polyester resin, MEKP as catalyst and cobalt napthanate as accelerator. The NaOH and HCl are used for the surface treatments of the fiber. The luffa fiber is shown in figure 1.

Figure.1. Luffa fiber

Material Preparation: Raw luffa fibers were cut lengthwise and the middle part was removed. The fibers were cut into 250 mm length and 100 mm width. The luffa fiber which is prepared in mat form is shown in figure 2. Once the fiber has been prepared then it has undergone the surface treatments. The base treatment has been done with the 4% of NaOH solution. The fiber is placed in the 4% NaOH solution for 1 hr and it has been taken out and washed in the distilled water. After the NaOH treatment the fibers has been changed in to pale yellow colour. The fiber after surface treatment has been shown in figure 3. Then it has been allowed to dry for 24 hours at room temperature. Similarly the fiber has been treated with 3% of HCl solution for 1 hr and washed in the distilled water and dried at a room temperature for 24 hours. And another set of fibers has been taken and treated with 4% of NaOH and dried at room temperature for 1 day and then it has been again treated with 3% of HCl solution and dried at a room temperature for 24 hours. For HCl treatments after the surface treatments the color will not be changed as it is changed in the NaOH treatments.

Figure.2. Luffa fiber in Mat form

Figure.3. Fiber after NaOH treatment

Fabrication of Composites: The composite has been prepared by the hand layup method. The composite plate has been made with the dimension of 250mm x 100mm x 5mm. It has been made with the unidirectional orientation of two and three layers of luffa fiber. The mould made of rectangular mild steel plates of 270 x 120 x 7 mm. Then the polyester resin mixture has been poured in the mould and luffa fiber was placed. The fiber is placed in such a way so that no gap is in between fiber. The resin and hardener is added and it has been poured in the mould over the fiber. Once the resin is applied then the weight around 50kg is placed over the mould and it has been allowed for curing for 24 hours. After 24 hrs the weight was taken and the laminates are taken carefully without any damage. Specimens are cut for testing as per ASTM standards. The different samples which are chemically treated has shown in table 1.

Table.1. Chemical treatments of Luffa fiber

Chemical treatment	Sample 1	Sample 2
NaOH treated	Two layers of luffa	Three layers of luffa
HCl treated	Two layers of luffa	Three layers of luffa
NaOH & HCl treated	Two layers of luffa	Three layers of luffa

Characterizations of composite materials:

Tensile Test: The tensile test has been done as per ASTM D3039 standard on the computerized universal testing machine. The specimens with dimensions of length 250 mm and width 25 mm are used. The specimens has been cut into the dumbbell shape and then it has been placed in the UTM [22]. The specimen is held in the grip and the load is applied and the corresponding deflections are recorded. Load is applied until the specimen breaks and the tensile strengths are noted. The tensile test specimens and then the loading arrangement of the specimen has been shown in the figure 4 and figure 5 respectively.

Figure.4. Specimen for tensile test

Figure.5. Loading arrangement of specimen

The specification of the universal testing machine has shown in table 2.

Table.2. Specification of Universal Testing Machine

Maximum Capacity (KN)	400
Maximum Range (KN)	0-400
Dimension	2100mm x 800mm x 2060mm

3. RESULTS AND DISCUSSION

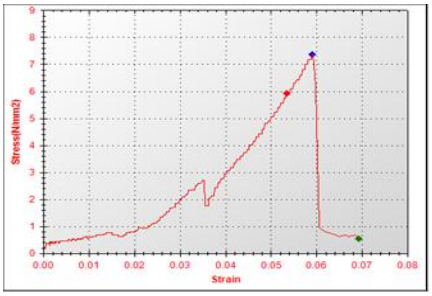
Tensile test: The tensile test has been performed on the surface treated luffa fiber composites. The work piece has been made on the following ASTM standard D3039. Comparing all the three chemical treated results of the tensile tests the NaOH results is showing good results compared to other two chemical treatments. The NaOH treated composite with three layer of luffa fiber is showing higher strength compared to two layer of luffa fiber. The specimens after tensile test is shown in figure 6.

Figure.6. Specimens after testing

Untreated composites: The raw untreated composites have been fabricated using two and three layers of fibers. In this is showing higher results compared to two layers of luffa fiber. Generally raw untreated fibers has been having higher amount of cellulose, hemicellulose and lignin contents. This affects the interaction properties between fiber and the matrix materials and reduces the mechanical properties of the composite materials. Hence treating the fiber will improve its mechanical properties of the composite material. The tensile test results have been shown in table 3. The stress strain graphs and tensile test values have been shown in figure 7 and 8 respectively.

Table.3. Tensile test values of untreated composites

Data	Double layer	Triple layer
Tensile strength (MPa)	6.857	7.347
Breaking strength (MPa)	0.468	0.543
Yield stress (MPa)	5.351	5.761



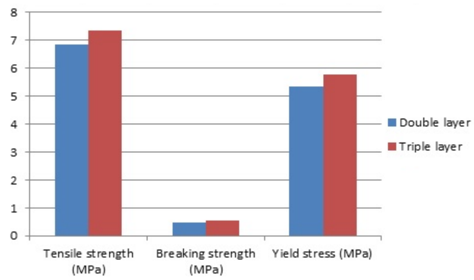


Figure.7. Stress strain graph of untreated composite **Figure.8. Tensile results of untreated composite**

NaOH treated composites: In the case of NaOH treated fibers, sample 2 is showing higher tensile strength compared to sample 1. The tensile result values of NaOH treated fibers have been shown in table 3. The NaOH treated composites is giving higher strengths compared to both HCl treated and both NaOH and HCl treated composites. It is due to the fact that NaOH is the base so that it will donate the electron pair to the fiber material. So this surface treatment improves the matrix and fiber interaction and improves its tensile properties. The stress strain graph and tensile test values has been shown in figure 9 & 10 respectively.

Table.4. Tensile test values of NaOH treated composites

Data	Double layer	Triple layer
Tensile strength (^{MPa})	17.938	23.893
Load at break (KN)	2.540	2.340
Breaking strength (MPa)	3.380	17.581
Yield stress (MPa)	11.245	19.084

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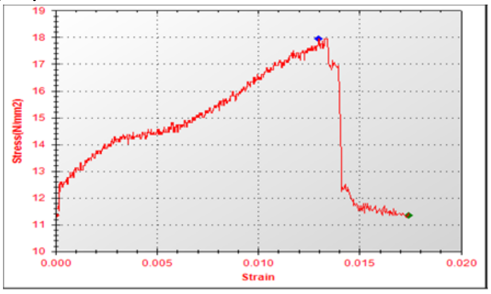

Figure.9. Stress strain graph for NaOH treated composite

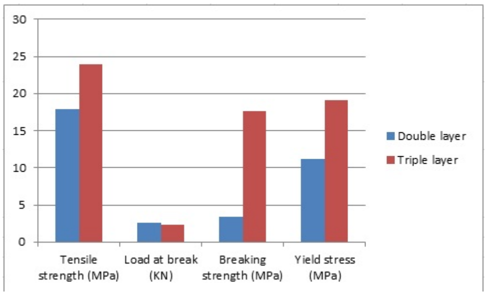

Figure.10. Tensile test results of NaOH treated composites

HCl treated composites: For HCl treated fibers, sample 2 is showing higher tensile strength compared to sample 1. The tensile result values of HCl treated fibers has been shown in table 4. The tensile test results of HCl treated composites is showing less values compared to NaOH treated composites since HCl is an acid, its main property is to absorb the electrons from the other materials, so that it will absorb the electrons from the fiber material. It will reduce the matrix and fiber interaction since acid treatment changed the properties of fiber and it reduces the tensile strength of the fiber. Hence compared to NaOH treatment HCl treated fibers are showing lesser results. The stress strain graphs and tensile test values has been shown in figures 11 & 12 respectively.

Table.5. Tensile test values of HCl treated composites

Data	Double layer	Triple layer
Tensile strength (MPa)	10.487	12.173
Load at break (KN)	0.20	0.80
Breaking strength (MPa)	0.181	5.938
Yield stress (MPa)	3.797	9.649

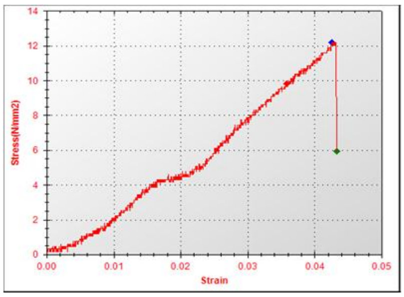

Figure.11. Stress strain graph of HCl treated composite

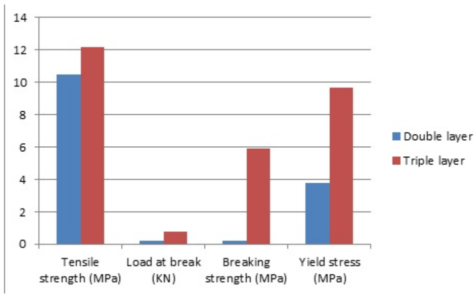

Figure.12. Tensile test results of HCl treated composite

Both NaOH and HCl treated composites: In the case of NaOH and HCl treated fibers, sample 2 is showing higher tensile strength compared to sample 1. The tensile result value of these treated fibers has been shown in table 6. Also the stress strain graphs and tensile test values has been shown in figure 13 and 14 respectively.

Table.6. Tensile test values of both NaOH & HCl treated composites

Data	Double layer	Triple layer
Tensile strength (MPa)	9.320	11.882
Load at break (KN)	1.360	1.080
Breaking strength (MPa)	9.320	8.333
Yield stress (MPa)	7.401	9.413

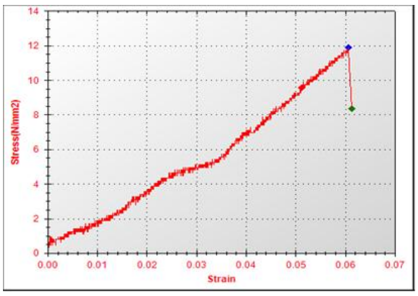

Figure.13. Stress strain graph of NaOH and HCL treated composite

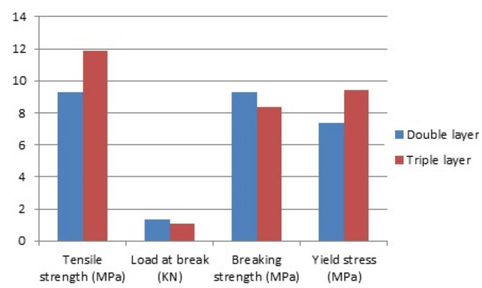

Figure.14. Tensile test results of NaOH and HCl composite

4. CONCLUSION

In recent decades, most research globally wide were concerned with the different methods of incorporating natural fibers into various types of polymer compositions, in order to modify their properties and to decrease their costs. The composite material made of NaOH surface treated fiber is showing higher tensile strength compared to other surface treated fibers in HCl and both NaOH and HCl treated fibers. The results showed that the NaOH treated fibers will give higher interaction bonding between the fibers and the matrix materials and leads to high strength of the composite compared to other two treatments. The luffa fiber composites appears to be bright because they are cheaper, lighter and environmentally superior to glass fiber or other synthetic fiber composites in general. Future research should hence focus on achieving equivalent or superior technical performance and component life.

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