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Evaluation of mechanical characteristics of treated and untreated sugarcane fiber composites

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ABSTRACT

The work was initiated using natural fiber as reinforcement in composites, after the several ideas it was planned to start using sugarcane fiber as a natural reinforcement in composites. This study was focused to observe the mechanical properties of sugarcane fiber. The sugarcane fibers used in fabricating a composite material was untreated and surface treated with NaOH and HCl. The fibers has been pretreated with 4% of NaOH and 3% of HCl solution and then it has been allowed to dry for 24 hours. After the treatment the composites has been fabricated. The mechanical properties has been evaluated for the prepared composite material and then the results are discussed. The mechanical properties which has been evaluated are the tensile properties. It is found that the fibers treated with the NaOH solution is showing higher tensile strength compared to other surface treatments.

KEY WORDS: Sugarcane fiber, NaoH, HCl treatments, Isophthalic polyester resin.

1. INTRODUCTION

Fiber reinforced polymer composites are becoming very popular and replacing conventional materials nowadays, because of their excellent properties suitable for various applications. The properties of fiber reinforced polymers are comparable to most conventional materials like metallic materials. This is due to their lower density compared to the higher density in metals which leads to higher strength to weight ratio for the composites compared to that of the metallic materials. These composites are also easier to obtain in desirable shape and require much less energy in making the required product. There are number of fibers available for making composite material including synthetic as well as natural fibers.

Natural fibres have different origins such as cotton, pulp, wood, bark, bamboo, bagasse, cereal straw, and vegetables (e.g., jute, flax, hemp, ramie and sisal). These fibres are mainly made of cellulose, hemicelluloses, lignin and pectin's, with a small quantity of extractives. Natural fibre composite has a potential to be widely applied alternatively to a fibre glass composites in sustainable energy impact absorption structures. By the comparison, a better behaviour in terms of damage was noted on bidirectional fabric but in general only high impact energies produced severe damages and no delamination propagation was noted in all the analysed configurations. By incorporation of natural and synthetic fibres into the polymer, the mechanical properties almost enhanced to greater extent. The fiber length greatly influences the tensile properties of reinforced composites. It is observed that fibers with large length provides better tensile properties when compared to the fibres with small length. Pineapple Leaf Fibre (PALF) has good potential as a reinforcement in bio-composites. By comparing with fibres treated with other concentrations, the fibres with 10% conc. NaOH displays higher strength with lower elongation.

The accumulation of the hazardous synthetic byproducts and waste, started polluting the environment and once again led the scientists towards natural fibers due to their distinct advantages. Geopolymers are aluminosilicate inorganic polymers which are formed from polymerisation of alumina silicates with alkaline solutions. Geopolymers have several desirable attributes which include good mechanical properties and durability. The crystallinity and the type of cellulose define the efficiency of the reinforcement of plant fibres. The rigidity and flexibility of plant fibres arise from the lignin and pectin components of the fibres, respectively. In some studies they conclude that, for the environment plant fibres are better than glass fibres and also plant fibres are suitable replacement for synthetic fibre-reinforced materials. The fiber degradation is contributed to the hydrophilicity of natural fibers, which leads to the diffusion of water molecules into micropores between polymer chains of natural fibers and induces the mechanical degradation of fibers themselves. Modern techniques like optimizations, informative decisions, and expert systems are utilized to end up with proper material selections.

Greater efforts are being made to seek more eco-friendly materials which could replace fossil fuel based polymeric materials. One solution is to replace the synthetic reinforcing material with natural fibres such as bast fibre. However, most of these natural fibre reinforced composites still use nonbiodegradable petroleum-derived polymer matrix, such as polypropylene (PP) and polyethylene (PE). In order to produce fully biodegradable composites, there have been increasing interests in the development of composites based on biodegradable matrix materials such as poly (lactic acid) (PLA) and poly (butylene succinate) (PBS). The interfacial bonding created chemically between natural fibres and thermoplastic polymers directly influences the tensile properties of the composites, different treatments have been applied to enhance the interfacial adhesion and significantly improved properties of lignocellulose fibre composites have been achieved.

In the manufacture of composite structures voids are an unavoidable fact and have been investigated by many authors. Investigations can be divided in studies on the mechanism of void formation and in studies on the effect of voids on the mechanical behaviour. The formation voids is greatly influenced by the manufacturing technology. Organic fillers such as residues from saw mills and agricultural operations are derived from renewable natural resources; they are abundant and inexpensive. When these fillers are used in thermoplastics, they reduce the manufacturing cost with minimum loss of properties. In the unidirectional plant fiber composite, the route of heat flow is more concise in the direction of fiber than that across the fiber due to the quasi-uniform microstructure along fiber. It has been found that sugarcane fibre reinforced polyester SCRP composite offers a good degree of wear resistance and friction coefficient comparable to glass fibre reinforced polyester GRP when sliding against stainless steel. Thus, sugarcane fibre has a strong potential to reinforce polyester and proved to be a quite competitive to glass fibre. To improve fibers and polymer matrices compatibility there are several methods of surface modifications, which can be physical or chemical according to modification technique to reduce the hydrophilic character. Frequently used treatments are bleaching, esterification, silane treatment, use of compatibilizer, plasma treatment, acetylation, alkali treatment and treatment with other chemicals. Giving insight in the spring performance under cyclic loads considering as parameters: material type, wire diameter, recommended time and other Specifications It has been shown experimentally as well, that Static limit depends on the Torsional stress field.

In this experimental work, Sugarcane bagasse fibers are used to prepare a specimen using a thermosetting polymer unsaturated polyester accelerator and catalyst for the improvement of the process, then Tensile test of the composite material under various conditions are carried out. ASTM standards are followed for carrying out the tests. The raw sugarcane bagasse and the prepared sugarcane fiber was shown in Figures 1(a) & 1(b).

Figure. 1(a). Raw Sugarcane fiber

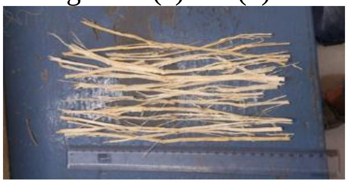

Figure. 1(b). Prepared Sugarcane fiber

2. MATERIALS AND METHODS

The materials which are used for the preparation of composite are sugarcane fiber, polyester resin, MEKP as catalyst and cobalt napthanate as accelerator. The NaOH and HCl are used for the surface treatments of the fiber.

Material Preparation: The sugarcane baggase was collected then it was sundried for 2days to remove the wetness present in it. Then the sugarcane fibres separated by manually and cut into the dimensions of 250mm length. 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. 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. It has been observed that the sugarcane fiber turns into yellowish in color when it was treated with NaOH solution for 1 hour. Then in the case of HCl treated sugarcane fiber there is no color change identified. The sugarcane fibers before and after surface treatment was shown in Figure 1(a) & (b).

Figure. 2(a). Before NaOH treatment

Figure. 2(b). After NaOH treatment

Fabrication of composites: The pretreated fibers are then used to fabricate a composite material. The composite material was prepared for the size of 250mm X 100 mm using hand layup method. The mould made of rectangular mild steel plates of 250 x 100 mm. Here the unidirectional sugarcane bagasse is used to fabricate the composite material. To prevent sticking of matrix with the mould wax is applied to the inner side of the mould. Then the polyester resin mixture has been poured in the mould and sugarcane 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, the wooden slab is placed to provide the uniform distribution of the load applied. The weight around 50kg is placed over the wooden slab which was already in the mould above the composite and it has been allowed to cure for 24 hours. After 24 hrs the weight was taken and without damage the laminates are taken carefully. As per ASTM standards specimens are cut for testing. The different samples which are chemically treated has shown in table 1. The fabrication process from raw material to the final product and the preparation of the specimen from the fabricated composite is clearly explained in the following Figures of 3 & 4.

Figure.3. Flowchart for fabrication process

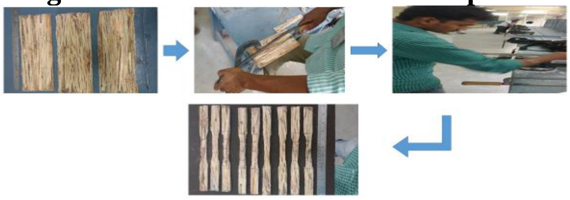

Figure.4. Flow chart for specimen preparation

Table.1. Three types of sugarcane fiber composites

Chemical treatment	Description
Untreated	1 layer of sugarcane fiber
HCl	1 layer of sugarcane fiber
NaOH	1 layer of sugarcane fiber

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 [7]. 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 loading arrangement of the specimen in UTM for tensile test has been shown in the Figure 5 respectively. The specification of the universal testing machine has shown in Table 2.

Figure.5. Specimen during testing

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

The tensile results obtained for the three types of sugarcane bagasse composites of untreated, HCl treated and NaOH treated. These results are briefly discussed in the following passages.

Tensile test: The tensile tests has been performed on the untreated, HCl treated & NaOH treated sugarcane bagasse fiber composites. The sample piece has been fabricated manually as per the ASTM standard D3039. Comparing all the three tensile tests such as Untreated, HCl and NaOH, NaOH treated composites giving the better tensile results. It is also observed that breaking occurs nearly at middle of all the specimen. Specimen after tensile test was shown in figure 6.

Figure.6. Specimen after tensile test

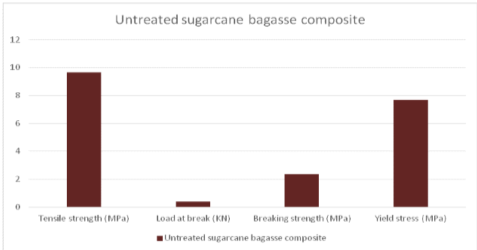

Figure.7. Tensile properties of untreated sugarcane bagasse composite

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Table.3. Tensile results of sugarcane composites

Data	Untreated Sugarcane composites	HCl treated Sugarcane composites	NaOH treated Sugarcane composites
Tensile strength (MPa)	9.671	23.829	45.502
Load at break (KN)	0.390	2.120	2.340
Breaking strength (MPa)	2.343	8.122	20.014
Yield stress (MPa)	7.689	8.582	20.527

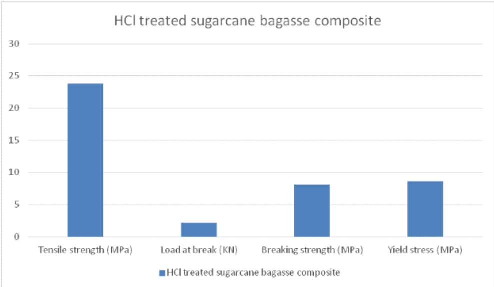

Figure.8. Tensile properties of HCl treated sugarcane bagasse composite

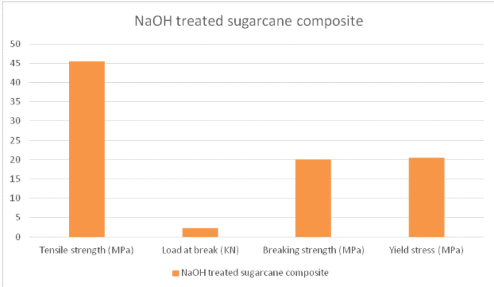

Figure.9. Tensile properties of NaOH treated sugarcane bagasse composite

From the above Figures 7, 8 & 9 it is observed that the untreated sugarcane fiber composite providing least tensile strength when comparing surface treated composites. Surface treated composites providing improved tensile results, among surface treated composites NaOH treated composites providing improved tensile properties when compared to HCl treated composites. From this it is observed that NaOH surface treatment to sugarcane bagasse fiber provides better tensile properties. The stress strain graphs of above results are shown in figure 10 (a-c).

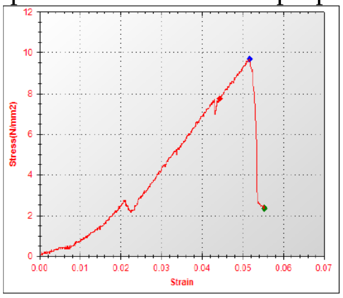

Figure. 10(a). Stress vs strain graph of Untreated Sugarcane fiber composite

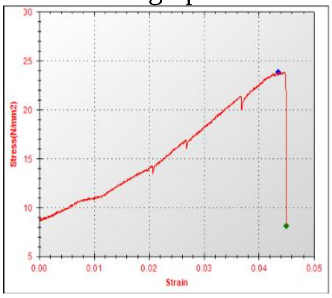

Figure. 10(b). Stress vs strain graph of HCl treated Sugarcane fiber composite

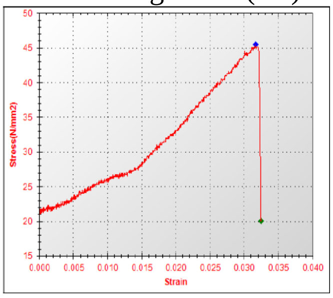

Figure. 10(c). Stress vs strain graph of NaOH treated Sugarcane fiber composite

4. CONCLUSION

Natural fibers created a great impact in a modern era due to its abundant availability in better economical investment, low density and manufacturing cost for natural fiber composites is very much low compared to other manmade fibers. These factors head the natural fiber for better fuel economy due to low density in an automotive sectors and it also reduce most of the manufacturing cost for same desirable properties provided by other materials.

From this work it is observed that sugarcane fiber with NaOH treated composites provides the better tensile results when comparing to Untreated & HCl treated sugarcane fiber composites. The surface treatment with NaOH is improving the mechanical properties, so the sugarcane bagasse with various proportions of NaOH treatment is suggested to find the best proportion of NaOH for sugarcane bagasse. It is suggested that the future of sugarcane fiber is bright due to its abundant availability in India compared to other natural fiber for cheap price, low density and fully degradable. The sugarcane fiber composites are quite competitive to other manmade fiber for same desirable properties in future. The main motive of this paper is to provide the valuable material by using the agro wastes such as sugarcane baggase fibers.

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