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COMPARITIVE STUDY OF THE MECHANICAL PROPERTIES OF ALKALI TREATED AND UNTREATED SUGARCANE BAGASSE FIBER REINFORCED COMPOSITE MATERIAL

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Abstract - *Natural fiber composites are now a days being used in various engineering applications to increase the strength and to optimize the weight and the cost of the product. Various natural fibers such as coir, sisal, jute and sugarcane bagasse are used as reinforcement materials. Natural fiber reinforced composites are increasingly studied by researchers all over the world as an alternative reinforcement because of its superior properties such as high strength to weight ratio, eco-friendly and its biodegradable nature. This study was aimed at learning the improvement on mechanical behavior of the sugarcane bagasse reinforced composites when it is treated with alkali solution. Alkali treatment on fiber increases the wettability of fiber. So our work evaluates the improved performance of sugarcane bagasse fiber epoxy and polyester composites as a result of alkali treated and non-treated on sugarcane bagasse as reinforcing fibers. It is observed that Alkali treatment of Sugarcane bagasse reinforced composite improve its mechanical property.*

***Key Words*: Composite, Natural fiber, Mechanical Properties, Epoxy resin, Polyester resin, Alkali Treatment.**

1. INTRODUCTION

The use of green composites for engineering applications has gained high attention from industries in recent years as their potential to reduce waste from non-degradable synthetic materials and their carbon footprint. Natural fiber composites are also suitable materials to make panels, ceilings, blocks, and partition boards to substitute wood, flooring tiles, etc. in building and construction industry. In comparison with synthetic fibers like glass and carbon, these natural fibers are gaining importance due to its many advantages, such as environment-friendly, reduced greenhouse gas emissions, low energy consumption, low cost, low density and availability (M.Sakthivel et.al (2013)). Various researches are being done on the composite material. Alkali treatment is one of the simplest and most effective surface modification techniques which is widely used in natural fiber composites. Alkali treatment on fibers improves the wettability of fiber so that there is a strong attraction between the matrix and the fiber. In the present study, both untreated and alkali treated Sugarcane bagasse fibers were used as reinforcement in both epoxy and unsaturated polyester resin composites. Tensile, flexural and impact properties were determined at 10% of NaOH to increase the wettability (Merlini et al (2011) investigated "the effect of alkali treatment on the banana fiber and its polyurethane reinforced composite."). The alkali treatment was found to be effective in improving the tensile, flexural and impact properties of Sugarcane bagasse fiber reinforced Epoxy and Polyester resin.

2. MATERIALS USED

The materials which are used to fabricate the composite material such as matrix and reinforcing material are discussed below.

- Sugarcane Bagasse Fiber
- Epoxy Resin
- Polyester Resin

2.1 Sugarcane Bagasse Fiber

Bagasse is the fibrous residue which remains after sugarcane stalks are crushed to extract their juice. Sugarcane Bagasse wastes are chosen as an ideal raw material in manufacturing new products because of its low fabricating costs and high quality green end material. It is ideal due to the fact that it is easily obtainable given the extensive sugarcane cultivation making its supply constant and stable. It also satisfies the greening requirements by being biodegradable, recyclable and reusable (A.Balaji et.al (2014) "Bagasse Fiber – The Future Biocomposite Material: A Review").

2.2 Epoxy Resin

Epoxy resins, also known as poly epoxides, are a class of reactive pre-polymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homo polymerization, or with a wide range of co-reactants including poly functional amines, acids (and acid anhydrides), phenols, alcohols and thiols. These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of poly-epoxides with themselves or with poly-functional hardeners forms a thermosetting polymer, often with high mechanical properties, temperature and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics / electrical components, high tension electrical insulators, fiber-reinforced plastic materials and structural adhesives.

2.3 Polyester Resin

Unsaturated polyesters are condensation polymers formed by the reaction of polyols (also known as polyhydric alcohols), organic compounds with multiple alcohol or hydroxy functional groups, with saturated or unsaturated dibasic acids. The use of unsaturated polyesters and additives such as styrene lowers the viscosity of the resin. The initially liquid resin is converted to a solid by cross-linking chains. This is done by creating free radicals at unsaturated bonds, which propagate in a chain reaction to other unsaturated bonds in adjacent molecules, linking them in the process. The initial free radicals are induced by adding a compound that easily decomposes into free radicals. This compound is usually and incorrectly known as the catalyst. Initiator is the more correct term. Polyester resins are thermosetting and, as with other resins, cure exothermically. The use of excessive initiator especially with a catalyst present can, therefore, cause charring or even ignition during the curing process. Excessive catalyst may also cause the product to fracture or form a rubbery material.

3. PREPERATION OF COMPOSITE

The composite are fabricated by hand lay-up technique. A group of sample is manufactured by 50% of volume fraction of fiber. Since it was found that 50% volume fraction of sugarcane bagasse fiber reinforced in the composite gives optimum results. A calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. For quick and easy removal Vaseline and OHP sheet is applied on both glass plates. After applying that on glass plate the mixture of resin and hardener was poured. Then the required amount of fibers was distributed on the mixture. The remainder of the mixture was then poured into the mould. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 24 hours. After 24 hours the samples were taken out of the mould, cut into different sizes and kept in air tight container for further experimentation. Now the prepared composite were cut for testing conform to the dimensions of the specimen as per ASTM standards.

4. TESTING

The prepared specimens of suitable dimensions are cut using by machine (according to ASTM standards) for physical characterization. On thus fabricated specimens following tests are performed.

- Tensile test
- Flexural test
- Impact test

4.1 Tensile test

Testing is done by using Universal Testing Machine(UTM) to measure the force required to break a test specimen and the extent to which the specimen elongates to the breaking point. Fig-1 shows the UTM for tensile testing.

Fig-1: Universal Testing Machine

4.2 Flexural test

Flexural strength is defined as the materials ability to resist deformation under load. In three-point loading consists of a support point near each end of the beam and one load point at the mid span. Flexural strength is about 10 to 20 percent of compressive strength depending on the size, volume and type of coarse aggregate used. The maximum stress on the failure on the tension side of a flexural specimen is considered as the flexural strength of the material. Fig-2 shows the UTM with flexural test arrangement.

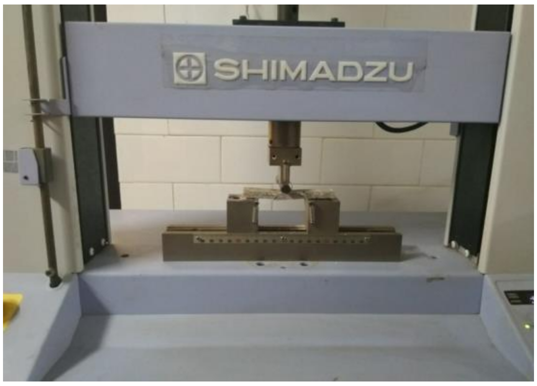


Fig-2: UTM with Flexural test arrangement

4.3 Impact test

Impact resistance is the ability of a material to withstand a shock loading or an applied stress at high speed. Impact behavior is an important mechanical property of engineering materials that are used for many popular applications including interior and exterior components of automobiles, buildings, aircrafts and many more. Impact test is a single point test that measures the materials resistance to impact from a swinging pendulum. Fig-3 shows the pendulum izod impact testing machine.

Fig-3: Pendulum izod impact testing machine

5. RESULTS AND DISCUSSION

This chapter presents the mechanical properties of the treated/un-treated Sugarcane Bagasse fiber/epoxy resin and treated/un-treated Sugarcane Bagasse fiber/polyester resin composites prepared for this present investigation. The Details of processing of these composites and the tests conducted on them have been described in the above section. The results of various characterization tests are reported here. These include evaluation of tensile strength, flexural strength and impact strength that has been studied and discussed.

5.1 Tensile Test

Tensile testing specimens are prepared according to the ASTM standard D638. According to ASTM standards specimen have the Gauge length, width and thickness of 80mm, 12mm and 7mm respectively. Representation of tensile properties were represented in the Table 1 and Table 2.

Table-1: Tensile test result for untreated/treated sugarcane bagasse fiber epoxy composites

Specimen	Max force Calc. at Entire Area N	Max Stress Calc. at Entire Area N/mm²	Max Strain Calc. at Entire Area %	Energy break-Max. J	Elastic Force N/mm²
UNTREATED SUGARCANE BAGASSE FIBER - EPOXY COMPOSITES					
S1	481.841	5.73620	2.28150	0.00424	662.545
S2	372.755	4.43756	1.13538	0.00317	602.324
TREATED SUGARCANE BAGASSE FIBER – EPOXY COMPOSITES					
S1	497.969	5.9280	1.14642	0.00449	736.384
S2	487.179	5.71189	1.22896	0.00407	837.763

Fig-4: Variation of tensile strength of sugarcane bagasse fiber epoxy composite

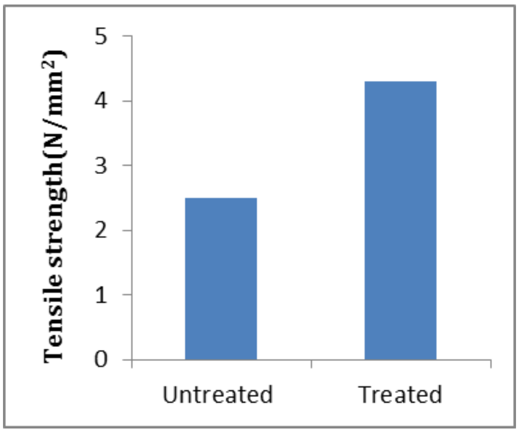
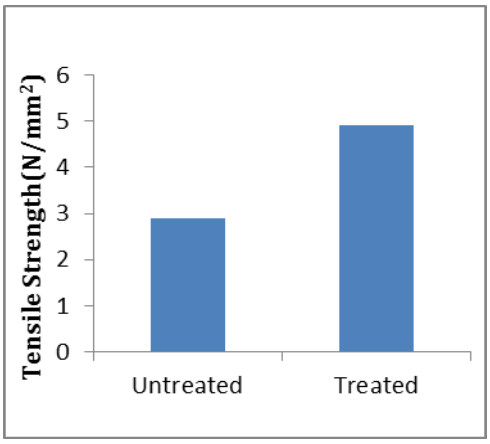


Table-2: Tensile test result for untreated/treated sugarcane bagasse fiber polyester composites

Specimen	Max force Calc. at Entire Area N	Max Stress Calc. at Entire Area N/mm²	Max Strain Calc. at Entire Area %	Energy break-Max. J	Elastic Force N/mm²
UNTREATED SUGARCANE BAGASSE FIBER - POLYESTER COMPOSITES					
S1	327.579	3.89974	0.78840	0.00467	802.380
S2	329.762	3.92573	0.85433	-	778.347
TREATED SUGARCANE BAGASSE FIBER - POLYESTER COMPOSITES					
S1	658.016	7.83355	0.65642	0.00553	1387.97
S2	871.492	10.3749	1.05188	0.00714	1266.52

Fig-5: Variation of tensile strength of sugarcane bagasse fiber polyester composite



Two specimens were tested for each set of samples and mean values were reported.

As expected, from Fig-4 and Fig-5 the surface modification by chemical treatment of fibers resulted in a significant increase in tensile strength. From the table it can be easily found that the alkali treatment provides better improvement in the tensile strength. The range of the tensile strength was between 567.79 – 787.07N/mm² for sugarcane bagasse epoxy composites and 898.43 – 1327.245N/mm². Untreated fibers causing the bond between matrix and fiber is poor to break, leaving the matrix diluted by non-reinforcing deboned fiber.

5.2 Flexural Test

Flexural testing specimens are prepared according to the ASTM standard D790. According to ASTM standards specimen have the Gauge length, width and thickness of 60mm, 13mm and 7mm respectively. Representation of flexural properties were represented in the Table 3 and Table 4.

Table-3: Flexural test results for untreated/treated sugarcane bagasse fiber epoxy composites.

Fig-6: Variation of flexural strength of sugarcane bagasse fiber epoxy composite

Specimen	Max force Calc. at Entire Area N	Max Stress Calc. at Entire Area N/mm²	Max Strain Calc. at Entire Area %	Flexural Strength N/mm²	Break Force sensitivity N	Break Strain Sensitivity %
UNTREATED SUGARCANE BAGASSE FIBER - EPOXY COMPOSITES						
S1	76.9043	10.8656	3.21506	643.071	-	-
S2	180.761	25.5392	6.37498	582.114	174.456	6.49149
TREATED SUGARCANE BAGASSE FIBER – EPOXY COMPOSITES						
S1	317.493	44.8577	4.52278	1418.50	203.640	6.00044
S2	254.564	35.9667	5.0002	1498.68	114.838	7.39577

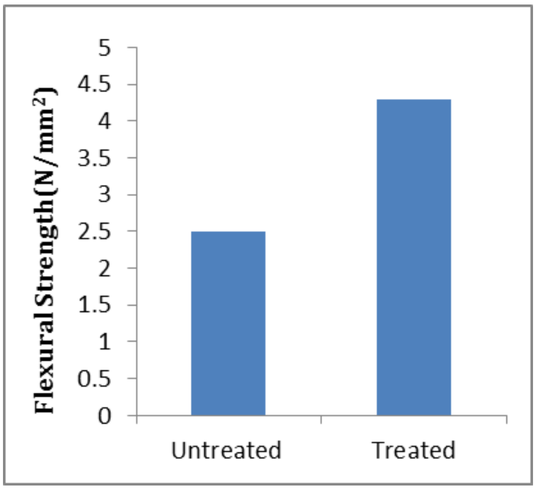
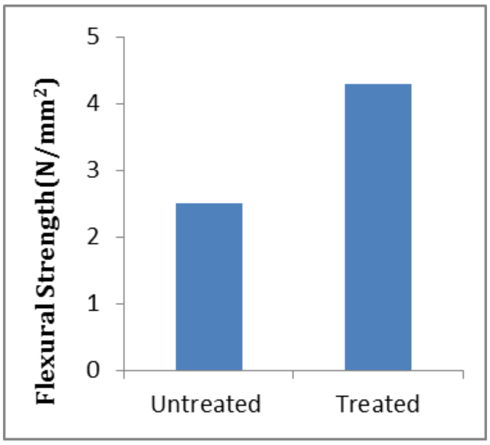


Table-4: Flexural test results for untreated/treated sugarcane bagasse fiber polyester composites

Specimen	Max force Calc. at Entire Area N	Max Stress Calc. at Entire Area N/mm²	Max Strain Calc. at Entire Area %	Flexural Strength N/mm²	Break Force sensitivity N	Break Strain Sensitivity %
UNTREATED SUGARCANE BAGASSE FIBER - POLYESTER COMPOSITES						
S1	140.236	19.8136	3.08887	1165.18	139.809	3.09851
S2	136.035	19.2201	3.83775	1161.86	136.035	3.83775
TREATED SUGARCANE BAGASSE FIBER - POLYESTER COMPOSITES						
S1	383.350	54.1625	2.71977	1486.68	383.350	2.71977
S2	341.737	48.2830	3.13285	2304.46	320.605	3.19091

Fig-7: Variation of flexural strength of sugarcane bagasse fiber polyester composite



Two specimens were tested and the average was calculated. The flexural properties of untreated/alkali treated Sugarcane bagasse fiber/epoxy composites are shown in Fig-6. Flexural strength is a combination of the tensile and compressive strength and varies with the interfacial shear strength between the fiber and matrix. In order to achieve effective fiber reinforcement, interfacial strength between the fiber and matrix is the most essential factor.

The flexural properties of untreated/alkali treated Sugarcane bagasse fiber/polyester composite is shown in Fig-7. Flexural test in various mechanisms such as tensile, compressive, shearing etc. will take place simultaneously. In order to achieve effective fiber reinforcement, interfacial strength between the fiber and matrix is the most essential factor.

5.3 Impact Test

Impact testing specimens are prepared according to the ASTM standard D256. According to ASTM standards specimen have the Gauge length, width and thickness of 60mm, 12mm and 3 -4mm respectively. Representation of tensile properties were represented in the Table 5 and Table 6.

Table-5: Impact test results for untreated/treated sugarcane bagasse fiber epoxy composite

Specimen	Theoretical impact Velocity m/s	Total Mass Kg	Work Capacity J	Impact Energy J/m	Impact Strength J/m2	Type of Failure
UNTREATED SUGARCANE BAGASSE FIBER - EPOXY COMPOSITES						
S1	3.458	0.9198	5.50	51.64	4690.67	"c"
S2	3.458	0.9198	5.50	62.07	6008.94	"c"
TREATED SUGARCANE BAGASSE FIBER – EPOXY COMPOSITES						
S1	3.458	0.9198	5.50	104.84	10013.13	"c"

Fig-8: Variation of Impact strength of sugarcane bagasse fiber epoxy composite

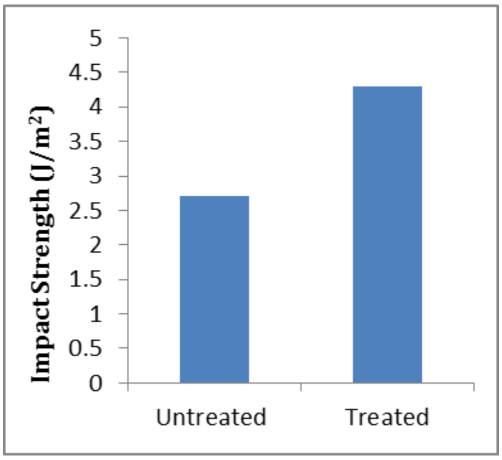
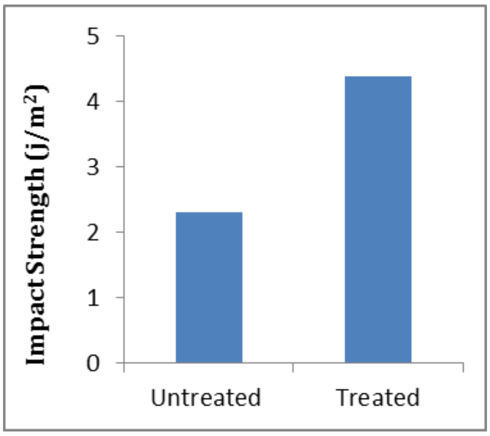


Table-6: Impact test results for untreated/treated sugarcane bagasse fiber polyester composite

Specimen	Theoretical impact Velocity m/s	Total Mass Kg	Work Capacity J	Impact Energy J/m	Impact Strength J/m2	Type of Failure
UNTREATED SUGARCANE BAGASSE FIBER – POLYESTER COMPOSITES						
S1	3.458	0.9198	5.50	22.97	2529.23	“c”
S2	3.458	0.9198	5.50	22.62	2094.84	“c”
TREATED SUGARCANE BAGASSE FIBER – POLYESTER COMPOSITES						
S1	3.458	0.9198	5.50	44.54	4170.47	“c”
S2	3.458	0.9198	5.50	44.04	4213.88	“c”

Fig-9: Variation of Impact strength of sugarcane bagasse fiber polyester composite



The Impact properties of untreated/alkali treated Sugarcane bagasse fiber/epoxy composites are shown in Fig-8.The impact property of a material shows its capacity to absorb and dissipate energies under impact or shock loading. The impact energy level of the composites depends upon several factors such as the nature of the constituents, construction and geometry of the composites, fiber arrangement, fiber/matrix adhesion, and test conditions. The matrix fracture, fiber matrix de-bonding, fiber breakage and fiber pull out are important modes of failure in the fiber composites due to impact loading. The applied load, transferred by shear to the fibers, may exceed the fiber/matrix interfacial bond, and deboning may occur. The frictional force along the interface may transfer the stress to the deboned fiber. If the fiber stress level exceeds the fiber strength, fibers may breakage. The breakage fibers may be pulled out of the matrix, and this involves energy dissipation.

6. CONCLUSION

In this work, Mechanical properties of untreated/alkali treated Sugarcane bagasse fiber/epoxy and untreated/alkali treated Sugarcane bagasse fiber/polyester composites were investigated. The tensile, flexural and impact properties of the composites as a function of fiber content were analyzed.

The surface modification by alkali treatment has improved the Mechanical properties than untreated fiber composites. The alkali treatment of Sugarcane bagasse fiber has improved the mechanical properties like tensile, flexural and impact strength of both the epoxy and polyester composite. Therefore it is conclusive from the above result that the alkali treatment has provided better mechanical properties on sugarcane bagasse reinforced composite.

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