MECHANICAL CHARECTERISATION OF MERCERIZED SISAL FIBER REINFORCED EPOXY POLYMER COMPOSITES

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ABSTRACT--*The objective of the current work is to study the Mechanical behavior of sisal fiber reinforced epoxy composites .In this work, the two i,e. treated and raw (untreated) sisal fiber are taken for the evolution of the composite material. The untreated sisal fiber is processed by sodium hydroxide to augment the wettability. The untreated sisal fiber and sodium hydroxide processed sisal fiber are used as reinforcing material for Epoxy resin matrix. In this activity, the sisal fiber is processed by 5% of sodium hydroxide for an hour and the specimen is produced via hand moulding technique. The mould utilized for manufacturing the composite material is by oil hardened steel material through a debonding agent spreading inside the interior. The quantity of sisal fiber is up to 30% of weight fraction for the whole composite material. The disparity in mechanical properties are examined and investigated. Over here, the tensile strength has computed by means of universal testing machine, and flexural strength has determined via universal testing machine along with flexural investigation setup of the specimen. Then the chemically treated and untreated specimens are evaluated and differentiated by means of Scanning Electron Microscope to learn regarding its bonding among fiber and resin along with surface morphology.*

Keywords-- *sisal fiber, Epoxy resin (LY 556) resin, industrial application hardener (HY951), hand layup process, sodium hydroxide.*

I. INTRODUCTION

Natural fibers are capable to be better-quality to the artificial fibers in the midst of the properties like low weight, light density, eco-friendly, steep specific strength etc. on the other hand, it has various demerits like indigent surface characteristics, higher moisture absorption, quality discrepancy etc. These natural fiber composites are generally utilized in automobiles, packaging factories, aerospace and construction. The tensile properties of oil palm empty fruit branches (EFB) and jute fiber reinforced with the epoxy resin polymer composites have been studied [1]. The sisal and banana combined reinforced polyester composites has disclosed better properties of mechanical like tensile strength 33Mpa, Flexural Strength 70 Mpa, and Impact strength 9kJ/m.[2] When the banana fiber is reinforced with epoxy resin there was an augment in tensile, flexural and impact strength of the composite due to alkali treatment.[3] Natural fibers such as coconut coir (short fibers) and sisal fibers (long fibers) were used as mixed combination and the fiber weight fraction of 20%, 30% and 40% were used for the production of the composite. Out of which 30 % showed increase properties [4] the consequence of alkali treatment on the mechanical

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properties of tensile, flexural, impact and water absorption analysis were accomplished using banana/epoxy composite where epoxy posses better mechanical properties. [5] The usual fibers such as carbon and glass are utilized as reinforcement to bear the loads in applications of engineering. Anyhow, their elevated price label has led to vigorous investigation to find substitute materials as reinforcement. In olden days, there has been evident growing interest in utilizing the natural resources as reinforcing in composite materials related to low-cost applications [6] the consequence of random EFB fiber/epoxy composite on mechanical properties all the way through a healthy controlled manufacturing method. Fiber mass fraction differing up to 30% was observed in term of the ultimate tensile strength (UTS), Young's modulus, and bending stiffness [7] analysis of the flexural properties of composites produced by means of reinforcing banana and pineapple as the novel natural fibers into epoxy resin. The combination of the reinforcement in the composite illustrates superior flexural strength in contrast with individual kind of natural fibers reinforced composites. [8] The consequence of sodium hydroxide treatment and fiber load on the tensile and hardness properties of coconut fiber unsaturated polyester composites showed noteworthy findings that alkali treatment improved the tensile and hardness properties of the composite. [9] The natural fiber reinforced polymer composites are probably environmental affable in contrast with glass fiber composites. on the whole , manufacturing of natural fiber has inferior impacts on environment in opposition to glass fiber production [10]

II. MATERIALS

2.1. Matrix Material

Epoxy LY 556 resin, associated to the "epoxide" group utilized as the resin material (matrix). Its general given name is Bisphenol-A-Diglycidyl-Ether. The lower temperature curing epoxy resin (Araldite LY 556) and the matching hardener (HY 951) are blended in a ratio of 10:1 by means of weight as endorsed. The epoxy resin along the hardener is provided by Javantheswar enterprises.

2.1.1. EPOXY RESIN

(Araldite LY 556) having the subsequent exceptional properties has been utilized as the matrix material owing to extraordinary bonding with variety of materials, immense defender to chemical and atmospheric intrusion, dimensionally stable, minimal internal stresses, outstanding mechanical and electrical properties, odourless, flavorless and totally nontoxic, insignificant shrinkage.

2.1.2. HARDNER (HY951):

Epoxy hardener is not a stimulant and may act in response with the epoxy resins, significantly devoting to the eventual properties of the cured epoxy resin. Epoxy hardeners offers; Gel time; blended viscosity; remold time of the epoxy resin system. Mechanical properties of the epoxy resin such as tensile, compression, flexural properties, etc., are also changed by epoxy hardeners.

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2.2. SISAL FIBERS

Sisal fiber was provided through vibrant nature, Chennai, Tamil Nadu .Sisal fibers were first detached from objectionable foreign material and pith. The fibers were held in an oven at 60^0C for 24 hrs to decrease the amount of moisture.

Figure1: Matrix: Epoxy resin (Araldite LY 556) and the hardener (HY 951)

Figure 2: Image of raw(untreated) Sisal fibers

III. RAW SISAL FIBERS – CHEMICAL TREATMENT

3.1 Mercerization of fibers

Mercerization treatment is the prime treatment for natural fibers which is used in composites. The consequence of sodium hydroxide treatment over natural fibers is it disturbs the occurrence of bonding of hydrogen in the system arrangement, pertaining to extra spots for mechanical interlinking, thus favoring roughness of surface and enhancing matrix and fiber dispersion between them. Moisture minimize the adhesion between cellulosic reinforcements (sisal) and hydrophobic matrix (epoxy), and bring about to a loss of stress transfer and thus to deprived mechanical properties in the composite material. Sodium hydroxide can be used to reduce the hydrophilic character of cellulosic fibers.

Pretreatment (mercerization**)** of sisal fibers enhanced the overall properties of the fiber due to the removal of impurities from the .As a result, the surface is made easily wettable by the epoxy resin, leading to good fiber impregnation and better fiber and matrix bonding in the composite .

The sisal fibers were modified to NaOH treatment in order to get rid of the lignin, hemicelluloses, pectin, wax and other unnecessary deposit materials from the fibers, so as to give adequate roughening to the fiber surface. The SF’s were soaked in 5 wt% NaOH solution at room temperature for 2 h. Moreover, the SF’s were washed several times with distilled water to take out NaOH solution attaching on the SF surface. As a final point, acetic acid was utilized to adjust the pH value of the fibers. Consequent to acetic acid treatment, SF’s were taken out and dried for 2 days at room temperature and after that dried at 80°C for 24 h in a hot air oven.

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IV. MANUFACTURING OF EPOXY/SISAL COMPOSITES - HAND LAY-UP METHOD

The manufacturing of the untreated and treated sisal fiber augmented epoxy composite materials is accomplished by means of the hand lay-up technique. Short sisal fiber are reinforced with Epoxy LY 556 resin in the ratio of 70:30

Specimens of proper dimension are incised by means of a diamond cutter for mechanical testing.

Figure3: Oil hardened steel mould to make epoxy/sisal composite specimens

Figure4: Untreated sisal fiber reinforced epoxy composite

Table 1: List of pure epoxy &fiber filled composites produced via hand-lay-up method

samples	composition
1	Epoxy (100%)
2	Epoxy (70%) +untreated sisal fiber (30%)
3	Epoxy (70%) +NaOH treated sisal fiber (30%)

Figure5: Raw(Untreated) sisal fiber reinforced epoxy composite

Figure6: Mercerized sisal fiber reinforced epoxy composite

Figure 7: Untreated & alkalized sisal fiber reinforced epoxy composite specimens as per ASTM D638

V. MECHANICAL CHARACTERIZATION OF SISAL FIBER REINFORCED EPOXY COMPOSITES

5.1. Mechanical Testing

Subsequent to fabrication, the test specimens were used in a variety of mechanical tests as per ASTM standards. Analysis of tensile property was performed on a computer controlled universal testing machine in accordance with the procedure of ASTM D638 standard. Universal testing machine (UTM, model 5565) by means of a load cell of 5 kN, a crosshead speed of 10 mm/min, and a gauge length of 80 mm. The flexural tests were conducted by means of the 3-point bending technique conforming to ASTMD790 standard. The testing of flat tensile specimen is done by

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applying a uni axial load from end to end of it. Four sample specimens were used for every property test and their average values are considered to decide the tensile and flexural strength.

VI. RESULTS AND DISCUSSION

6.1. Mechanical Characterization of the raw (untreated) and mercerized sisal fiber reinforced epoxy composites

Table 2: Properties of the cured epoxy and epoxy filled banana/sisal composites

Materials	Tensile Properties			Flexural Properties	
	Tensile Strength (MPa)	Elongation at break (%)	Tensile Modulus (GPa)	Flexural strength(MPa)	Flexural modulus(GPa)
Epoxy (70%) +Untreated sisal fiber (30%)	52.7	3.5	1.7	77.4	2.76
Epoxy (70%) +treated sisal fiber (30%)	64.4	4.7	2.6	85.6	2.98

The influence of mercerized sisal fiber reinforced Epoxy composites have been studied. Tensile properties of the sisal fiber-reinforced composites also enhanced with the mercerization of fibers. Table 2. displays the tensile and flexural properties of raw (untreated) and NaOH treated sisal fiber reinforced epoxy composite of the composites.

From the table, it is clear that as the NaOH treated sisal fiber reinforced in epoxy resin, the values of tensile strength (MPa), Elongation at break (%), Tensile Modulus(GPa), Flexural strength (MPa) & modulus(GPa) increases in comparison with pure epoxy and untreated sisal fiber reinforced epoxy composite. The raise in all mechanical properties is caused by alkali treatment of cellulosic fibers, also called mercerization, is the normal technique to manufacture high quality fibers. Alkali treatment leads to progress of the fiber-matrix adhesion as a result of the elimination of natural and artificial impurities. Besides, alkali treatment brings out fibrillation which causes the breaking down of the composite fiber bunch into smaller fibers. Particularly, alkali treatment diminishes the fiber diameter and thereby enhances the aspect ratio. So, the improvement of a rough surface topography and development in aspect ratio tender healthier fiber-matrix interface sticking together and an augment in mechanical properties. Mercerization of fibers boosts the surface roughness ensuing in improved mechanical interlocking and the amount of cellulose exposed on the fiber surface. This adds the value by increasing the number of achievable reaction sites and permit better fiber wetting. The likely reaction of the fiber and NaOH is as below.

$$\text{Fiber- cell-OH} + \text{NaOH} \longrightarrow \text{Fiber cell - }O^{-}Na^{+} + H_2O + \text{impurities}$$

Figure 8: Scheme -Sodium hydroxide reaction with fibers

Mercerized natural fibers privileged the reinforcement in the epoxy matrix in the composite give an idea about ideal chemical bond and better interface adhesion and thus superior tensile strength of composite samples. The

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mechanical properties of untreated composites are due to improper sticking of fiber with matrix and also the infusion of untreated sisal fibers is inadequate to hold back the epoxy matrix, huge stresses will be developed at low strains and the sharing of these stresses will not be identical and leads to low withstanding capability of loads compared with untreated composites. This observation is true and supports well with SEM micrographs.

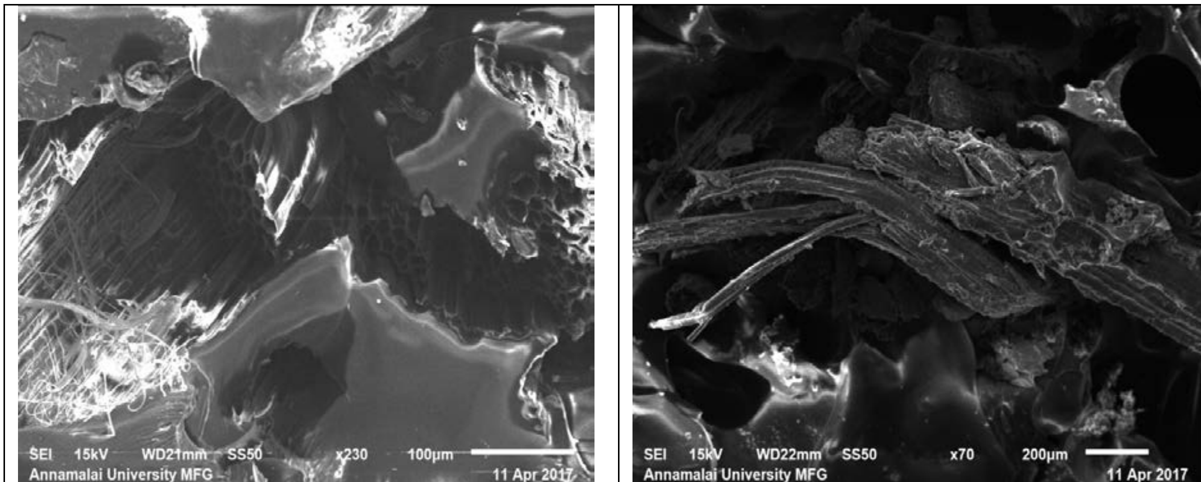

Figure 9:(a & b) The SEM Micro-graphs of the surface of untreated Sisal fiber reinforced epoxy composite

The mechanical way of behaving of sisal fibers reinforced epoxy composites proved that superior outcome when judge against with pure epoxy.Fig.9.(a & b) shows micrographs by SEM ,the fractured surfaces of the composites .Sisal fibers were effortlessly dragged out from the untreated sisal fiber reinforced epoxy composite while the composites fractured in tension. If that is the situation, interfacial collapse between fibers and resin took place first and was pursued by the breaking of the fibers. As untreated fiber has impurities in the surface leads to congregation of fibers which occurred in its place of dispersion of the fibers in the epoxy matrix, thus improper wetting the nearby fibers appropriately .This is because of the inferior interfacial union strength between the fibers and epoxy resin.

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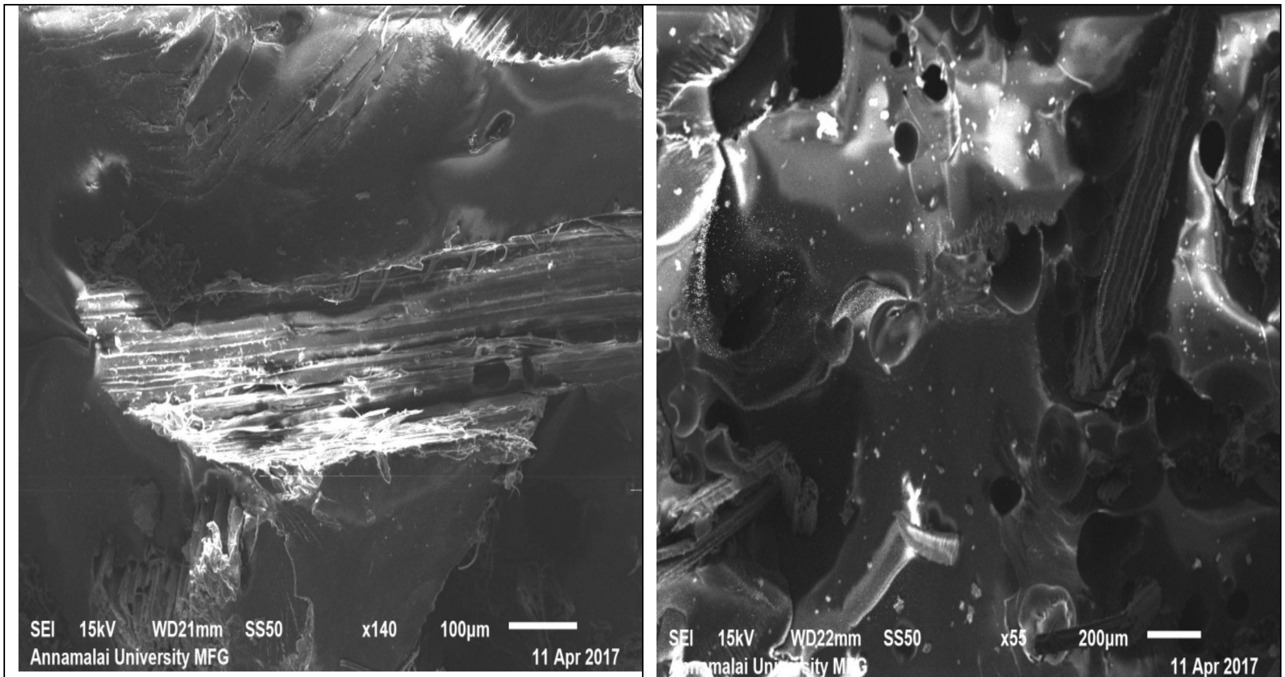

Figure 10:(a & b) The Micro-graph surface of Sodium hydroxide Treated Sisal fiber reinforced epoxy composite

For alkalized fiber(treated sisal) related composites, in spite of that, the majority fibers were still linked to the resin and the fiber pull out lengths were much smaller than untreated sisal fiber reinforced epoxy composite as shown in Fig.10.(a & b)

These outcomes show that the evident of mercerized natural fibers be evidence for healthier interfacial adhesion with epoxy resin. The key basis of the superior interfacial adhesion between mercerized fibers and epoxy resin is that the hydroxyl groups of the fiber surface amplified by taking away of the hemicelluloses and lignin throughout the mercerization ensuing in better resin dispersal over the fibers. Besides, the composite with alkali treated sisal fibers shows the evidence of an elevated tensile strength than the one with untreated sisal fibers. The alkali treatment of natural fibers beneficially increases the excellence of the fiber/matrix interface. It is also observed that the waxy layer and contaminations are entirely removed from the fiber surface. The treated surface of fiber turn out to be smoother as compared to that of untreated fiber and also the alkaline treatment of natural fibers produce fibrillation and collapse of the cellular structure as a result of the elimination of the cementing material, which leads to a better packing of cellulose chains. A part from this alkali treatment also leads to fiber bundle fibrillation that is, breakdown of the composite fiber bundle into smaller fibers, which increases the effectual surface area accessible to get in touch with with the wet matrix . Tensile & flexural test results illustrated that both NaOH treatment used have a considerable effect on the mechanical properties of sisal fiber reinforced composites than pure epoxy and untreated sisal fiber reinforced composites which validates with SEM micrographs

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VII. CONCLUSIONS

It has been perceived that the mechanical properties of the sisal fiber composites like tensile strength and flexural strength etc. have an effect through the treatments of fiber. The outcome of the experiments discovered that sodium hydroxide fiber treatment augmented the affinity between the epoxy matrix and treated sisal fiber. The tensile strength properties of the mercerized sisal fiber reinforced epoxy composites materials were extensively superior than those of untreated sisal fiber reinforced epoxy composites. The fractured surface was observed in sisal fiber reinforced epoxy composite subsequent to the tensile test has been completed. The micrographs by SEM of untreated sisal fiber reinforced epoxy composites and treated sisal fiber reinforced epoxy composites evidently pointed out the extent of the fiber matrix interface strong bond. From this study it is concluded that the meager interfacial adhesion is liable for lower mechanical properties for untreated sisal fiber reinforced epoxy composites where as it is convinced that the fiber treatment lead to better the interfacial contact thus ensuing in good strength and stiffness of the biocomposite materials. Finally, the inference is based on the alkali treatment of the sisal fibers is essential to get composites with sensible mechanical properties as well as better adhesion between fibers and matrix.

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