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An investigation of mechanical and thermal properties of reinforced sisal-glass fibers epoxy hybrid composites

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Abstract— **In this paper, fabrication of hybrid composites reinforced with sisal and glass fibers is treated form and are mixed in the proposition 1:1 in order to reinforce in epoxy resign. Mechanical properties viz., tensile, compressive and hardness are studied to assess the influence of fiber lengths such as 10,20 and 30 mm. The variations of aforementioned properties on hybrid composites with different fiber lengths have been studied. Thermal properties such as Thermo Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) are studied to investigate the influence of change in fiber length on treated and untreated hybrid composites. Significant improvement in tensile, hardness and compressive strengths of sisal/glass hybrid composites has been observed by the alkali treatments. In TGA investigation 3^{o}C rise in decomposition temperature, 4^{o}Crise for glass transition temperature is considered for DSC analysis.**

Keywords— **Epoxy resin, Glass fiber, Hybrid composites, Mechanical properties, Sisal fiber, Thermal properties**

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I. Introduction

Composites filled with micro particles in epoxy system gained significant importance in the development of thermosetting composites [1]. Epoxy resins the most important matrix polymer preferred when it comes to high performance. Its combination with glass fibers gives an advanced composite with properties like low weight, good mechanical and tribological properties. In aerospace applications a rough estimate has it that for every unit of weight reduction in aircraft, there is a considerable reduction in fuel consumption or high load capacity else with material saving.

Due to low density around 1.3g/cm^3, good adhesive and mechanical properties, epoxy resins become a promising material for in the transportation [2-3].

Industry, usually in the form of composite materials. The performance of these composites not only depends on the selection of its components, but also on the interface between fiber and resin [4]. Sometimes it is necessary to modify the matrix and reinforcement for specific properties.

Natural fibers are largely divided into two categories depending on their origin: plant based and animal based. Therefore, natural fiber can serve as reinforcements by improving the strength and stiffness and also reducing the weight of resulting biocomposite materials, although the properties of natural fibers vary with their source and treatments.

In the present investigation, sisal-glass hybrid composites as a function of fiber length are considered and six different samples were prepared in which three treated hybrid composites samples and three untreated hybrid samples as a function of fiber lengths of 10, 20, and 30 mm, respectively.

They proved hybrid composites at 20 mm fiber length are more predominant on properties than the rest. They have found NaOH treated fibers with 1:3 ratios were good at compressive properties[4-7].

The effect of fiber lengths and the treatment of fiber on the mechanical properties, viz. tensile, hardness, and compressive properties, have been studied. The main aim of the authors is to present partially green-composites with high performance.

II. Materials and Methods

Materials

The type of epoxy resin used in this investigation is LY-556 and hardener HY-951 supplied by Ciba-Geigy of India Ltd. Different glass molds were fabricated in order to cast the composite sheets in accordance with ASTM standards. Sisal fibers were obtained from the villagers at Enumuladoddi, Anantapur, Andhra Pradesh, India. In addition, the glass fiber was (density: 350 g/m^2) supplied by Saint Gobain Industries Ltd., Bangalore

Composite Manufacturing

A glass mould with required dimensions was used for making sample on par with ASTM standards and it was coated with mould releasing agent enabling to easy removal of the sample. The resin and hardener is taken in the ratio of 10:1 parts by weight respectively. Then pre-calculated amount of hardener is mixed with epoxy resin and stirred for 1hr before poring in to the mould. Hand-lay up technique was used to impregnate the composite structures. In this technique a glass fiber and sisal fibers were wetted by a thin layer of epoxy suspension in a mould. Stacking of hybrid fibers were carefully arranged random manner after pouring some amount of resin against the mould to keep the poor impregnation at bay [5]. Left over quantity of mixture is poured over the hybrid fibers. Brush and roller were used to impregnate fiber. The closed mould was kept under pressure for 24 hrs at room temperature. To ensure complete curing the composite samples were post cured at 70ºC for 1 hr and the test specimens of the required size were cut out from the sheet. Composites with different fiber lengths like 10, 20, and 30 mm, treated and untreated were prepared by keeping the weight ratio of sisal/glass at 1:1.

III. Experimental Details

Fiber Treatment

Sisal fiber was taken in a glass tray and a 5% NaOH solution was added in to the tray and the fibers were allowed to soak in the solution for 1 hr. The fibers were then washed thoroughly with water to remove the excess of NaOH sticking to the fibers. Final washing was carried out with distilled water and the fibers were then dried in hot air oven at 70°C for 4 hrs. The fibers were chopped into short fiber lengths of 10, 20, and 30 mm for molding the composites.

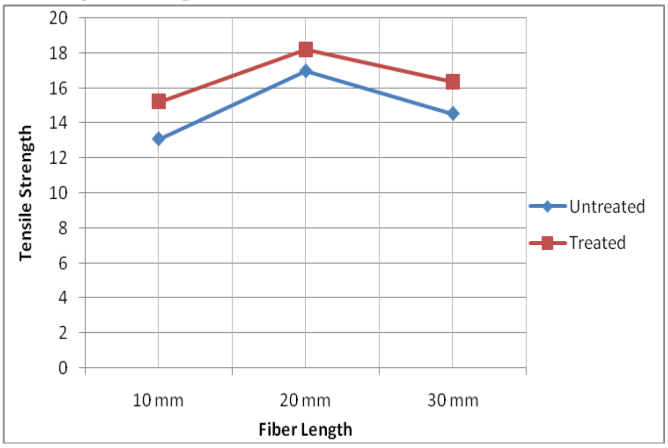

Figure 1. Tensile strength results for Untreated /Treated hybrid composites (Sisal/Glass) as a function of fiber length

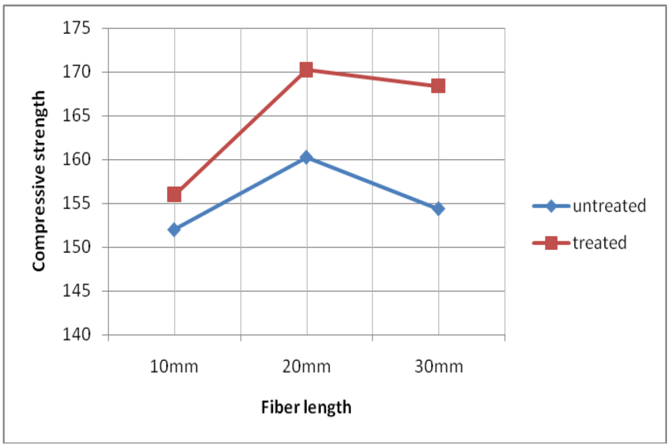

Figure 2. Compressive strength results for Untreated /Treated hybrid composites (Sisal/Glass) as a function of fiber length.

Mechanical Test

The tensile strength, hardness, and compressive strengths of 10, 20, and 30 mm lengths of treated and untreated sisal/glass epoxy based hybrid composites were carried out on INSTRON Universal Testing Machine (UTM), model 3369. In each case, six samples were tested and the average value tabulated.

Rockwell Hardness Test

The hardness of treated and untreated samples reinforced with sisal_glass epoxy-based hybrid composites was measured using Rockwell hardness testing machine supplied by M/s. PSI sales (P) Ltd., New Delhi. In each case, five samples were tested and the average value tabulated. Test specimens were made according to the ASTM D 785 (10_10_6mm3). The diameter of the ball indenter used was 0.25 inches and the maximum load applied was 60 kg as per the standard L-scale of the tester. The testing was carried out at room temperature for all the samples. All the readings were taken 10 s after the indenter made firm contact with the specimen. All the sample surfaces were rubbed with smooth emery paper, which facilitates accurate reading. Sisal_glass fibers impregnated in a unidirectional manner with different fiber lengths are given in Table 1. From Table 1, it was observed that 2-cm fiber length composites had a higher hardness than 1 and 3 cm fiber length composites. It was observed that the treated composites possess

Preparation of Samples

Tensile Testing samples are prepared and the dimensions are (100mmX20mmX3mm) based on the ASTM D 638 standards. The compressive testing specimens (10mmX10mmX10mm) were prepared in accordance with ASTM D 690 standard. For hardness testing specimens were made according to the ASTM D 785 (10X10X6 mm^3). The diameter of the ball indenter used was 0.25 inches and the maximum load applied was 60 kg as per the standard L-scale of the tester.

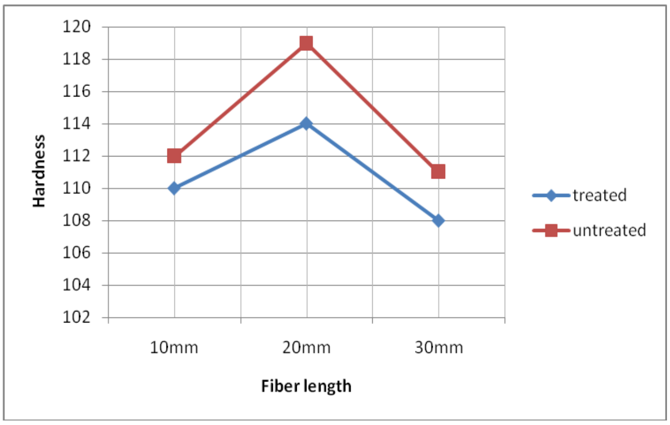

Figure 3. Hardness of Untreated/Treated hybrid composites (Sisal/Glass) as a function of fiber length.

Thermal analysis

The thermal characteristics of the epoxy/hybrid composites were measured using both Differential Scanning Calorimetry (DSC-2010 TA Instrument) and thermo gravimetric Analyses (TGA) at a rate of 10°C/min under nitrogen flow.

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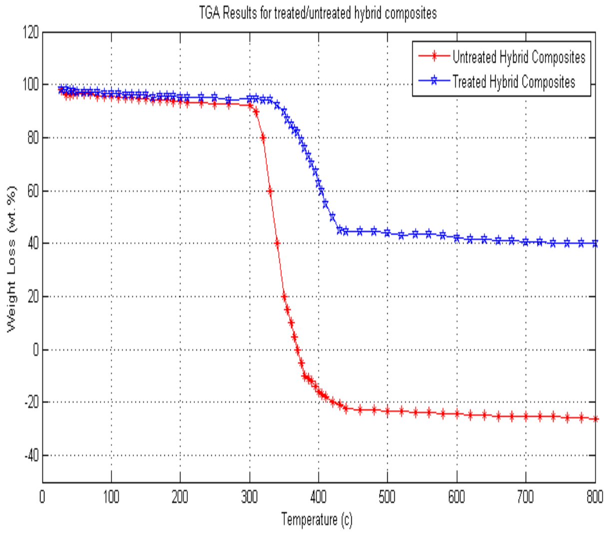

Figure 4. TGA results for Untreated/Treated hybrid composites (Sisal/Glass) at 2cm fiber length.

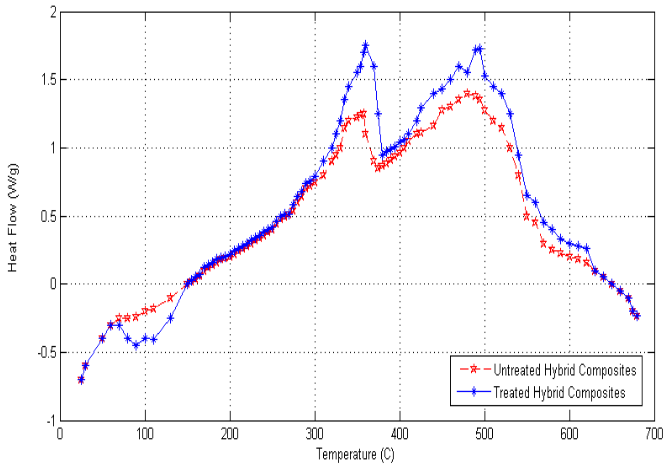

Figure 5. DSC results for Untreated/Treated hybrid composites (Sisal/Glass) at 2cm fiber length.

Table 1: Tensile strength, Compressive strength and hardness of Untreated/Treated epoxy based hybrid composites (Sisal/Glass) with different fiber lengths

Fibre Length	Tensile Strength (Mpa)		Compressive strength (Mpa)		Hardness	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
10 mm	13.089	15.209	152.01	158.943	98	108
20 mm	16.980	18.198	160.259	170.250	110	119
30 mm	14.543	16.352	154.397	160.387	102	111

Thermal Analysis

TGA use to obtain the thermal properties of the epoxy hybrid composites. **Figure 4** shows the weight loss curves of various composite materials with temperature. The derivative weight loss curve shows only one peak. The decomposition temperature is 355 °C for untreated and 358°C for the treated hybrid composite at 2cm fiber length. It is clear that the decomposition temperature of the hybrid composite shifted towards higher temperature indicating higher thermal stability of the treated hybrid composite. The existence of inorganic materials in treated hybrid, generally, enhances the thermal stability of the nanocomposite. In the present case also, the thermal stability increases due to the presence of the inorganic phase and its interaction with the matrix reinforced

IV. Results and Discussions

Mehanical Characterization

Experimental results of epoxy hybrid (sisal/glass) fibers composites are prepared with different fiber length. It is obvious strength increases when 10mm fiber length is impregnated with epoxy matrix. Mechanical properties (i.e. tensile, flexural and compression) increased when epoxy matrix impregnated with 20mm fiber length of each as mentioned above [1]. Mechanical properties are degraded when fiber length is further increased. It is observed that 20mm fiber length composites were optimal tensile, hardness and compression strength than 1 and 3cm fiber length composites. Further it is observed that treated composites possess higher aforementioned properties than untreated. This is due to the alkali treatment improves the adhesive characteristics of sisal fiber surface by removing hemicelluloses and lignin. This surface offers the excellent fiber-matrix interface adhesion as a results improved mechanical properties. **Figures 1-3**, represents graphical variations on tensile, hardness, and compression strength properties as function of fiber length. Thus, it is observed that the mechanical properties are degraded due to increase in fiber length.

with hybrid fibers. The weight-loss temperature curve shows that the residue left beyond 450 °C is in line with the fiber content of each sample. The result clearly indicates that enhanced interface of treated resulting in an increased thermal stability of the composite.

The thermal transitions of the pure polymer and the composites were also investigated by DSC. A thermogram for the untreated and treated hybrid composites at 20mm fiber length are shown in **Figure 5.** It is observed that, two exothermic peaks were observed for treated & untreated hybrid composites. In the first peak the glass transition temperature (Tg) of treated and untreated hybrid composites is observed at a temperature of 310°C, where as in the second peak glass transition temperature (Tg) of treated hybrid composite has been increased to 479°C, but for untreated hybrid it is slightly reduced 375°C. An endothermic peak at 400°C is observed for the treated hybrid composites is 375°C, but for untreated hybrid composite is 366°C.

V. Conclusions

The variation of tensile strength, hardness, and compressive strength of epoxy based sisal-glass hybrid composites has been studied as function of fiber length. It is observed that 20 mm fiber length hybrid composites are observed optimal tensile, hardness, and compressive strength than 10 and 30 mm. The effect of alkali on the tensile, hardness, and compressive properties have also been studied. It is found that treated hybrid composites showed higher strength than untreated composites. In TGA investigation, 3°C rise in decomposition temperature, 4°C rise in glass transition temperature in DSC analysis.

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