

# Mechanical & Thermal Properties of Epoxy Based Hybrid Composites Reinforced with Jute / *Sansevieria cylindrica* Fibres

Mala Ashok Kumar<sup>1,\*</sup>, G. Ramachandra Reddy<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, GATES Institute of Technology,  
Gooty, 515401, Andhra Pradesh, India

<sup>2</sup>Department of Polymer Science & Technology, Sri Krishnadevaraya University,  
Anantapur - 515055, Andhra Pradesh, India

\*E-mail address: ashokkumarmala7@gmail.com

## ABSTRACT

Tensile properties are studied to assess the influence of fiber weight. Room temperature cured epoxy was impregnated with jute/Sc in order to evaluate the performance of hybrid composites. Jute/Sc fibers are taken in the 1:1 weight ratios to suspend on epoxy resin with different fiber lengths such as 1, 2, 3 and 4 cm. The variations of aforementioned properties on hybrid composites with different fiber lengths have been studied. Significant improvement in tensile strengths of the jute/Sc hybrid composites has been observed by the alkali treatments. Thermal properties such as TGA and DSC are studied to investigate the influence of change in fibre length on treated and untreated hybrid composites in which 4 °C rise in decomposition temperature, 3 °C rise for glass transition temperature respectively.

**Keywords:** jute fiber; hybrid composites; mechanical properties; Sc fiber; thermal properties

## 1. INTRODUCTION

Thermoplastics occupy only a small percentage of the advanced composite market, while epoxy and other materials contribute to more than 70 per cent of the commercial growth. Epoxy resins are the most important matrix polymer when it comes to high performance. Its combination with glass fibers gives an advanced composite with properties like low weight, good mechanical properties and tribological properties. These materials make very attractive for use in aerospace applications. A rough estimate has it that for every unit of weight reduction in aircraft, there is a considerable less considerable fuel consumption or higher load capacity and hence material offers material saving. Due to low density they have good adhesive and mechanical properties, epoxy resins become a promising material for in the transportation 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. Some times it is necessary to modify the matrix and reinforcement for specific properties. Due to low density natural fibres are widely used as reinforcing agent as its high biodegradability. 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. Ashok kumar et al. [1] studied on epoxy hybrid composites reinforced with sisal/glass fibre on frictional co-efficient, impact, hardness and chemical resistance as function of fibre length. Hence proved that, mechanical properties were optimized at 2cm fibre length. Venkata Reddy et al. [2] were studied on hybrid composites of kapok/glass fiber in which they discovered tensile and hardness were increased by increase in fraction of glass fiber. Noorunnisa Khanam et al. [3] studied on tensile, flexural, and compressive properties of sisal/silk polyester hybrid composites with different variation of fiber lengths such as 1, 2, and 3 cm. They proved hybrid composites at 2 cm 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. Many research works had been carried out on hybrid composites, but few have been reported epoxy /natural fibres [4-7].

In this present work, the authors were synthesized and characterized the epoxy/hybrid composites in which sisal/glass are dispersed randomly onto the matrix. The effect of fibre lengths and the treatment of fiber on the mechanical properties, viz. tensile, flexural, and compressive properties, have been studied. The main aim of the authors is to present partially green-composites with high performance.

## 2. MATERIALS AND METHODS

### 2. 1. Materials

Commercially available epoxy (LY-556) and hardener (HY-951) supplied by Ciba-Geigy India Ltd. Company. Naturally available Sc fibers were retrieved from Enumuladoddi forest area, Anantapur, Andhra Pradesh, India. In addition, Jute fiber was (density: 300g/m<sup>2</sup>) supplied by Saint Gobain Industries Ltd., Bangalore.

### 2. 2. 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 pouring in to the mould. Hand-lay up technique was used to impregnate the composite structures. In this technique a jute fibre and Sc fibers were wetted by a thin layer of epoxy suspension in a mould. Stacking of hybrid fibers were carefully arranged in a 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 fibres. 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 70°C for 1 hr and the test specimens of the required size were cut out from the sheet. Composites with different fiber lengths like 1, 2, and 3 cm, treated and untreated were prepared by keeping the weight ratio of sisal/glass at 1:1.

### 2. 3. Fiber Treatment

Jute and sisal fibers were 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 separately. 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 1, 2, and 3 cm for molding the composites.

### 2. 4. Mechanical Test

The tensile strength, flexural strength, and compressive strength of 1, 2, and 3 cm 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, seven samples were tested and the average value tabulated.

### 2. 5. Preparation of Samples

Tensile testing samples are prepared like dumbbell shapes and these dimensions are (100 mm x 20 mm x 3 mm) based on the ASTM D 638 standards. Authors used 50KN load cell for flexural testing in addition the sample sizes are cut in accordance with ASTM D 618 (i.e.100 mm x 20 mm x 3 mm). The compressive testing specimens (10 mm x 10 mm x 10 mm) were prepared in accordance with ASTM D 690 standard.

### 2. 6. Thermal analysis

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

## 3. RESULTS AND DISCUSSIONS

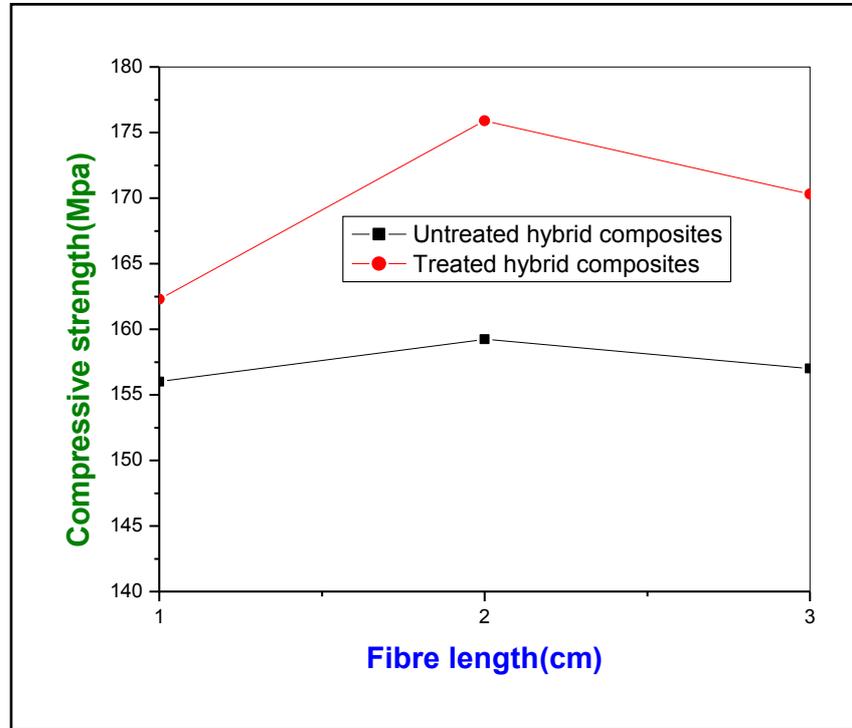
### 3. 1. Mechanical Characterization

Experimental results of epoxy hybrid (sisal/glass) fibre composites are prepared with different fiber length. It is obvious strength increases when 1 cm fibre length is impregnated with epoxy matrix.

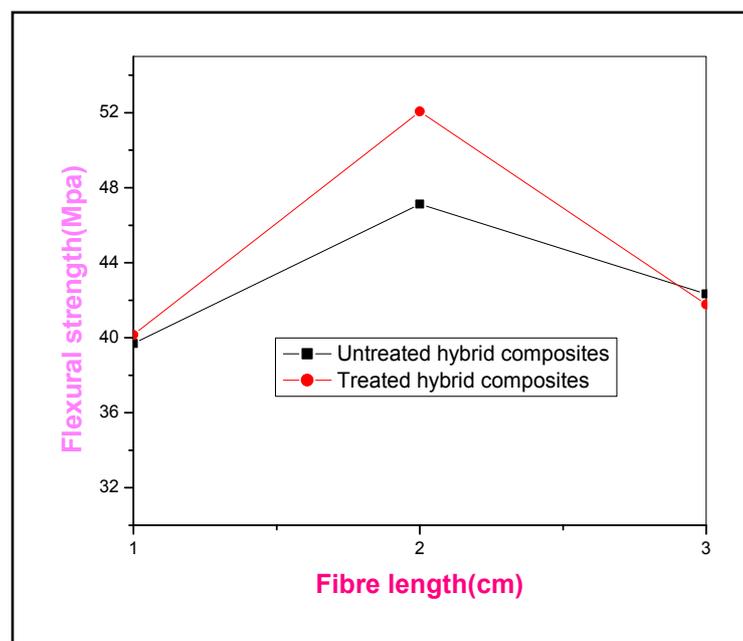
Mechanical properties (i.e. tensile, flexural and compression) increased when epoxy matrix impregnated with 2 cm fibre length of each as mentioned above [1]. Mechanical properties are degraded when fibre length is further increased. It is observed that, tensile, flexural and compression strengths are optimally improved at 2 cm fibre length over 1 and 3 cm fiber length.

Further treated hybrid composites possessed 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, flexural, and compression strength properties as function of fibre length. Thus, mechanical properties are promoted due to increase in fibre length from 1 to 2 cm.



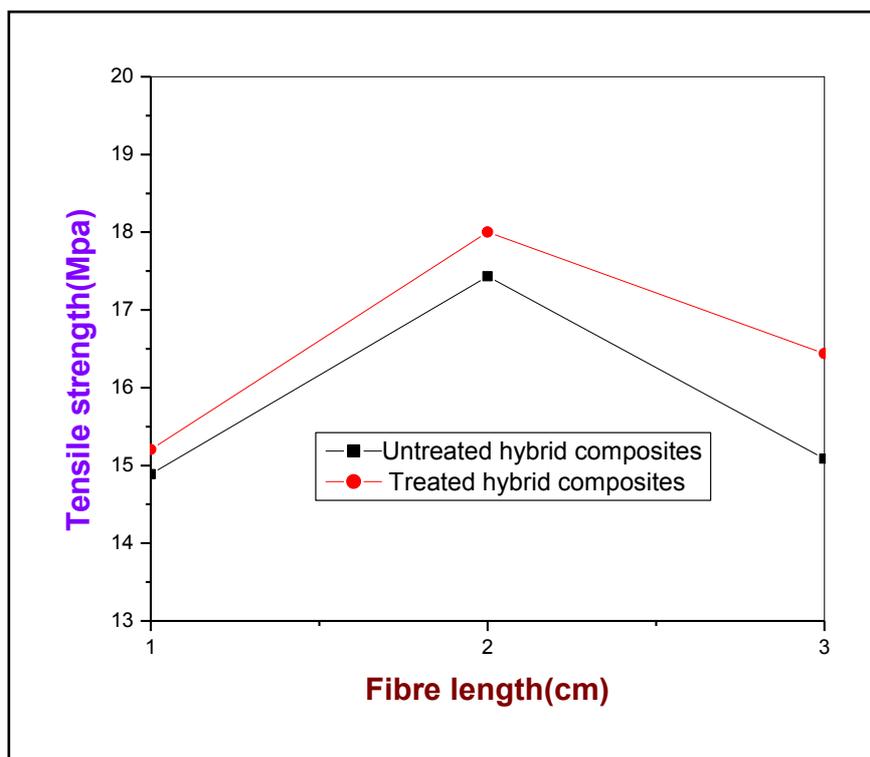
**Figure 1.** Compressive strength results for untreated/treated hybrid composites (sisal/glass) as a function of fibre length.



**Figure 2.** Flexural strength results for untreated/treated hybrid composites (sisal/glass) as a function of fibre length.

### 3. 2. 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 2 cm fibre length.

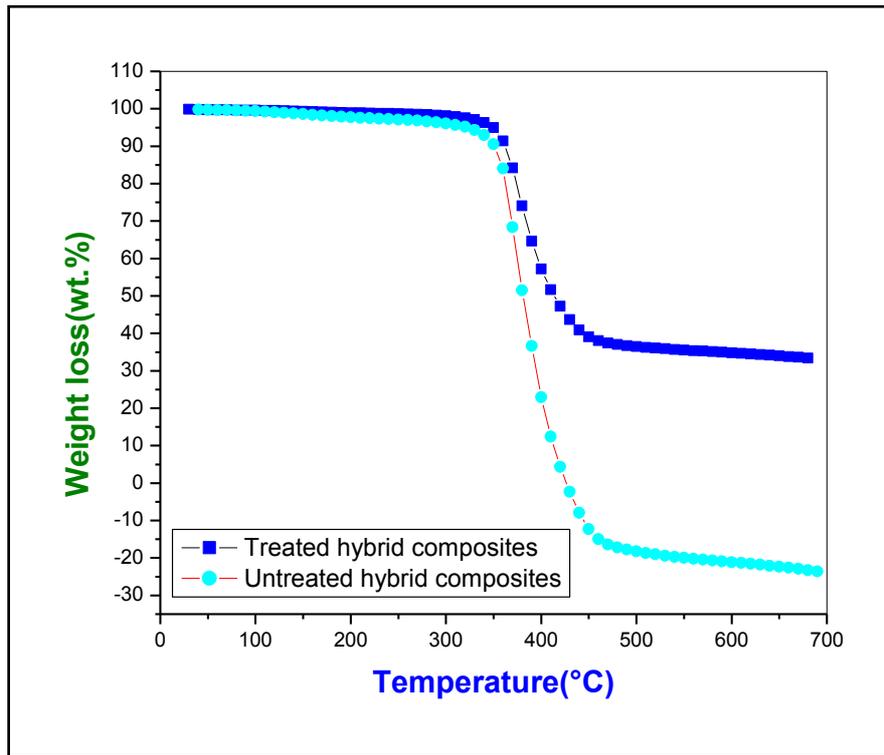


**Figure 3.** Tensile strength results for untreated/treated hybrid composites (sisal/glass) as a function of fibre length.

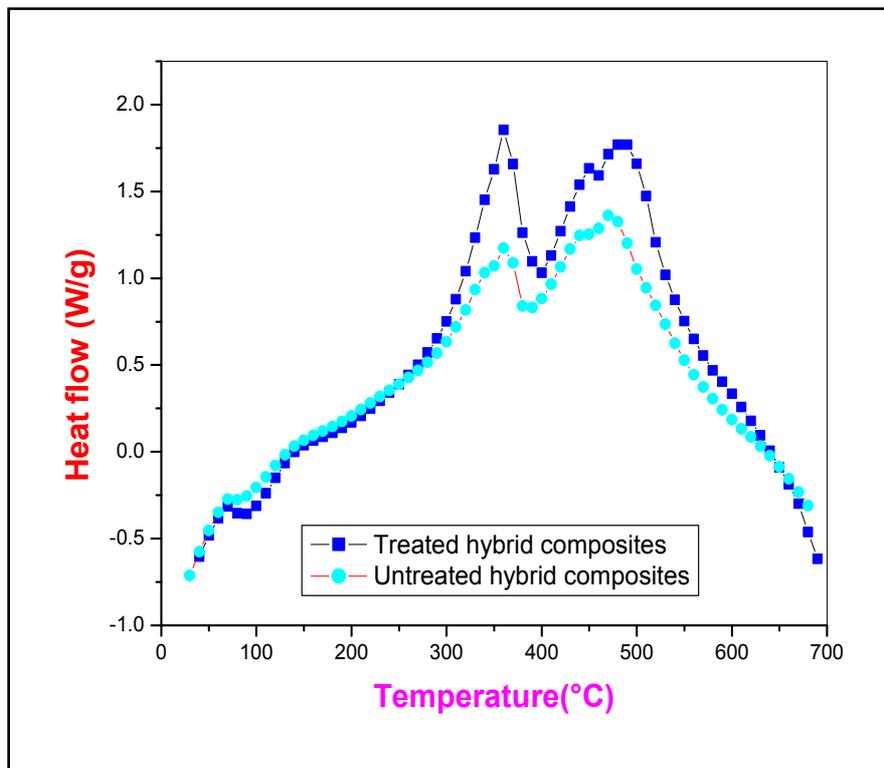
**Table 1.** Tensile strength, flexural strength, and compressive strength of untreated and treated epoxy based sisal/glass hybrid composites with different fiber lengths.

S.no.	Fiber length (cm)	Compressive strength (Mpa)		Flexural strength (Mpa)		Tensile strength (Mpa)	
		Untreated composites	Treated composite	Untreated composites	Treated composites	Untreated composites	Treated composites
1.	1	156.009	162.290	39.690	40.149	14.887	15.205
2.	2	159.233	175.900	47.122	52.067	17.433	18.001
3.	3	157.012	170.306	42.330	41.771	15.088	16.440

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.



**Figure 4.** TGA results for treated/untreated hybrid composites (sisal/glass) at 2 cm fibre length.



**Figure 5.** DSC results for treated/untreated hybrid composites (sisal/glass) at 2 cm fibre length.

In the present case also, the thermal stability increases due to the presence of the inorganic phase and its interaction with the matrix reinforced with hybrid fibres. The weight-loss temperature curve shows that the residue left beyond 450 °C is in line with the fibre 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 2 cm fibre 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 ( $T_g$ ) of treated and untreated hybrid composites is observed at a temperature of 355 °C, where as in the second peak glass transition temperature ( $T_g$ ) 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.

#### 4. CONCLUSIONS

The variation of tensile strength, flexural strength, and compressive strength of epoxy based sisal-glass hybrid composites has been studied as function of fiber length. It is observed that 2 cm fiber length hybrid composites have optimal tensile, flexural, and compressive strength than 1 and 3 cm. The effect of alkali on the tensile, flexural, 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.

#### References

- [1] Ashok Kumar M., Ramachandra Reddy G., Siva Bharathi Y., Venkata Naidu S., Naga Prasad Naidu V., *Journal of Composite Materials* 44(26) (2010) 3195-3202.
- [2] Venkata Reddy G., Venkata Naidu S., Shobha Rani T., *Journal of Reinforced Plastics and Composites* 27 (2008) 1775-1787.
- [3] Noorunnisa Khanam P., Mohan Reddy M., Raghu K., John K., Venkata Naidu, S., *Journal of Reinforced Plastics and Composites* 26 (2007) 1065-1075.
- [4] Raghu K., Noorunnisa Khanam P., Venkata Naidu S., *Journal of Reinforced Plastics and Composites* 49 (2008) 100-105.
- [5] Venkata Reddy G., Venkata Naidu S., Shobha Rani T., *Journal of Reinforced Plastics and Composites* 28 (2009) 2035-2044.
- [6] Venkata Reddy G., Venkata Naidu S., Shobha Rani T., *Journal of Reinforced Plastics and Composites* 27 (2008) 1789-1804.
- [7] Noorunnisa Khanam P., Ramachandra Reddy G., Raghu K., Venkata Naidu S., *Journal of Reinforced Plastics and Composites* 61 (2009) 112-118.