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Charaterization of Epoxy Hybrid Composition: Effect of Glass/ Sansevieria Cylindrica Fiber on Mechanical & Thermal Properties

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Abstract: In the present work, the epoxy-based hybrid composites have developed by combining the Sansevieria cylindrica and Glass fibers into epoxy matrix. Tensile strength, compression strength, TGA and DSC properties of hybrid composites without alkali treatments have been studied. Variations of the mechanical and thermal properties have been studied with different combinations of Sansevieria cylindrica and glass fibers as reinforced into epoxy matrix. The aforementioned mechanical properties optimally improved by increasing the natural Sansevieria cylindrica fiber percentage. The observation established good miscibility of epoxy and homogenous dispersion of Sansevieria/Glass fibers in the epoxy matrix.

Keywords - Sansevieria Cylindrica fiber, TGA, DSC, UTM.

I. Introduction

The tremendous progress in science and technology brought about the industrial revolution in the 19th century. As this revolution progressed and encompassed, every aspect of human life, be it travel, was felt for materials capable of resisting fatigue, environmental. Corrosion, opessoure, stress and exposure to chemicals. They also have to be adaptable for use under extreme temperature versatile materials in the form of composite were evolved as answer to this need. Their emergence has a tremendous impact in several fields like transportation, marine engineering chemical industry and machinery, construction, electrical and electronic equipment, space technology sports goods and medical engineering. The aerospace and deference industries were also benefited greatly from the light weight yet extremely hard composites that have evolved a lot. These alternatives to traditional materials took the industry by storm. Composites manufacturing is one of the fastest growing industries major consumer of these materials.

II. Materials and Methods

What is commonly known as "fiberglass" today, however, was invented in 1938 by Russell Games Slayter of Owens-Corning as a material to be used as insulation. It is marketed under the trade name Fiberglas, which has become a genericized trademark. A somewhat similar, but more expensive technology used for applications requiring very high strength and low weight is the use of carbon fibre.

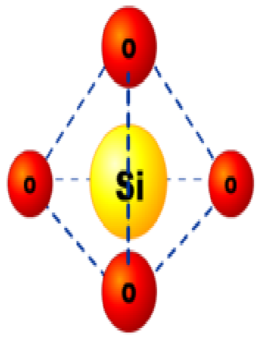

Fig 1: Molecular Structure of Glass

Sansevieria cylindrica, also known as the Cylindrical Snake Plant, African Spear or Spear Sansevieria, is a succulent plant native to Angola. Sansevieria cylindrica has striped, round leaves that are smooth and a green-gray color. A single leaf is about 3 cm (1 in) thick and grows to a height between 1 m (3 ft) and 2 m (7 ft). The Spear Sansevieria grows fan-shaped, with its stiff leaves growing from a basal rosette. The species is interesting in having rounded instead of strap-shaped leaves caused by a failure to express genes which would cause the cylindrical bud to differentiate dorsoventrally or produce a distinctive and familiar top and bottom surface to the leaf blade. The plant blooms once a year in the spring or mid-summer, producing 3 cm (1 in) greenish-white tubular flowers tinged with pink. The species is drought-tolerant and in captivity needs water only about once every other week during the breeding season. The species was described by Wenceslas Bojer in 1837. Sansevieria cylindrica received its name from a competition in a Dutch national newspaper. It is popular as an ornamental plant as it is easy to culture and take care of in a home.

Table: 1.1 Materials type

Description	Raw Materials
Matrix	Epoxy resin (LY-556)
Hardener	Hardener (HY-951)
Reinforcing agent	E-Glass Fiber (wool type)
Mould releasing agent	Polyvinyl alcohol (PVA) / Wax
Micro filler	Graphite Powder, Wollastonite
Casting	Glass moulds

Fig. 2: Snake Plant

III. Composite Manufacturing

Resin and hardener stirred for 1 hr before pouring into the mold. The hand lay-up technique was used to impregnate the composite structures. In this technique, the glass fiber and the sisal fibers were wetted by a thin layer of epoxy suspension in a mold. A stack of hybrid fibers were carefully arranged in a unidirectional manner after pouring some amount of resin against the mold to keep poor impregnation at bay. The remaining mixture was poured over the hybrid fiber. Brush and roller were used to impregnate fiber. The closed mold was kept under pressure for 24 hrs at room temperature. To ensure complete curing, the composite samples were post-cured at 70^0C for 1 hr and test specimens of required size were cut out from the sheet. Composites with different fiber weight ratio are viz.1:2, 2:1, 1.5:1.5, 0:3 and 3:0 percentages, treated and untreated were prepared by keeping the weight of resin is 97%.

IV. Fiber Treatment

Sansevieria cylindrica fiber was taken in a glass tray, which a 10% NaOH with 1 liter of distilled solution was added, and the fibers were soaked in the solution for 3 hrs. 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 h. The fibers were chopped into short fiber lengths of 2 cm for molding the composites.

V. Characterization

A tensile property measured in this study includes tensile modulus, tensile strength and elongation to break, were determined in accordance with the ASTM D638 taking specimens of dimensions (165x13x3) mm^3. The tensile testing was carried out using a Instron Universal Tensile Testing Machine (UTM) series-3369 at a cross-head speed of 50mm/min. Flexural properties were measured using a three-point bending test method according to ASTM D790 and tests were carried out using the same UTM, with rectangular bars of dimension (80x12.7x3) mm^3. Gf/Sc epoxy hybrid composites conducted at a jaw speed of 0.8mm/min at room temperature. Charpy impact tests were performed using a 2.7 J pendulum and striking velocity of $3.46m^2/s$ on an Avery Denison Impact tester (model 6709), according to ASTM D256. The specimen dimension was (127x12.7x3) mm^3. The dialectic strength was measured as per ASTM D149 using Zaran Instruments Ltd. India, with a 3mm thick composite disc. The thermal characteristics TGA/DSC was measured on Gf/Sc reinforced epoxy hybrid composites using SDT Q600 TGA/DSC (TA Instruments) at a rate of 10°C/min under nitrogen flow. Measurements were carried out at 22°C temperature, 40% relative humidity. Scanning electron microscopy (SEM) studies of the fractured surface of the tensile specimen were carried out on a Jeol (6380LA, Japan). The specimen was sputter-coated with gold to increase surface conductivity. The digitized images were recorded.

Specimens of Untreated Sansevieria Cylindrica Fiber:

Fig. 3: Specimen 1

Fig. 4: Specimen 2

Fig. 5: Specimen 3

Fig. 6: Specimen 4

Fig. 7: Specimen 5

Specimens of Treated Sansevieria Cylindrica Fiber:

Fig. 8: Specimen 1

Fig. 9: Specimen 2

Fig. 10: Specimen 3

Fig. 11: Specimen 4

Fig. 12: Specimen 5

VI. Results and Concusion:

The flexural strength and flexural modulus is calculated by using following formula.

F .S = (3*F*L) / (2*b*d^2) ------------- →(I)

F.M = (L^3*F) / (4*b*h^3*d) ------------ →(II)

- F is the load (force) at the fracture point.
- L is the length of the support span.
- b is width.
- d is thickness.
- h is height.

The results are tabulated at table 6.1.and 6.2. And the graphs are plotted for the specimens. It is shown in figure 13 and figure 14.

Table 6.1: System 1, Untreated Sansevieria Cylindrica fiber

Specimen combinations	Flexural strength (N/mm2)	Flexural modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	208.30	1161.80
Epoxy + GF+SF 97% 2% 1%	206.60	1152.60
Epoxy +GF+ SF 97% 1.5% 1.5%	204.10	1166.50
Epoxy + GF+SF 97% 0% 3%	212.50	1185.90
Epoxy + GF+SF 97% 3% 0%	202.50	1150.30

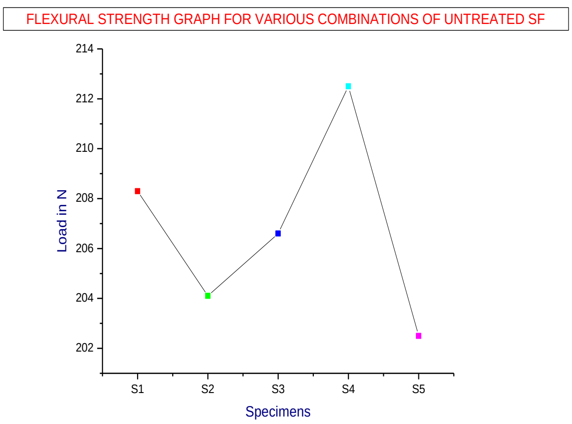

Fig. 13: Flexural strength Graph

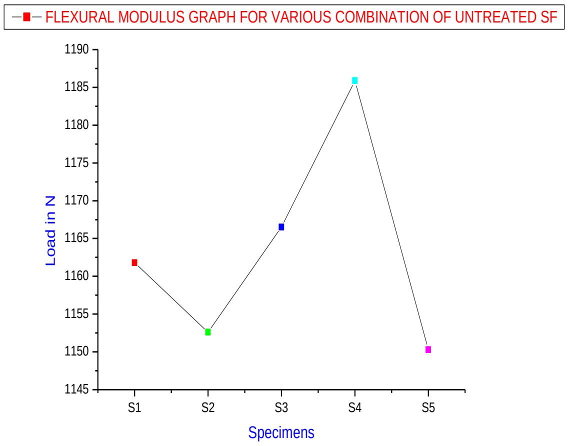

Fig. 14: Flexural Modulus Graph

Table 6.2: System 1, Treated Sansevieria Cylindrica fiber

Specimen combinations	Flexural strength (N/mm2)	Flexural modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	212.41	1181.32
Epoxy + GF+SF 97% 2% 1%	210.74	1174.30
Epoxy +GF+ SF 97% 1.5% 1.5%	211.58	1178.08
Epoxy + GF+SF 97% 0% 3%	213.24	1185.00
Epoxy + GF+SF 97% 3% 0%	209.0	1166.90

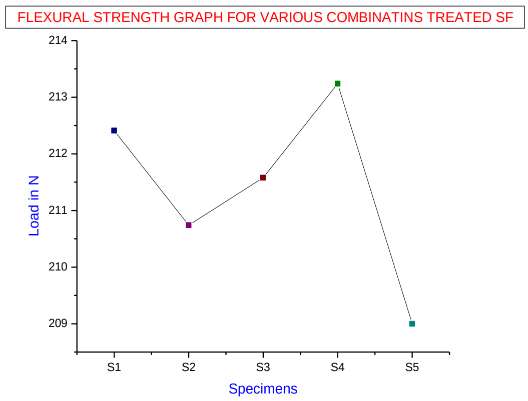

Fig. 15: Flexural Modulus Graph

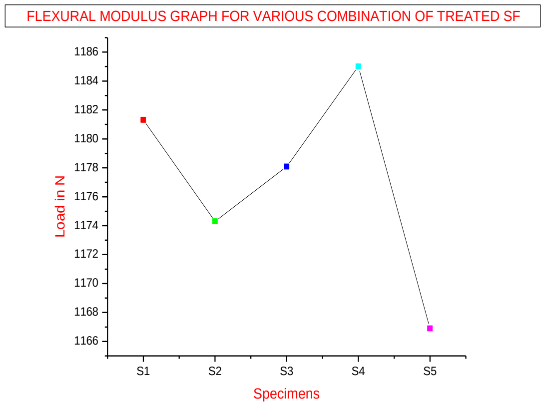

Fig. 16: Flexural Modulus Graph

The above result says that the flexural strength and flexural modulus are increases by increasing the percentage of Sansevieria cylindrica fiber (i.e 0% wet. of glass fiber and 3% wet. Of Sansevieria cylindrica fiber). The higher Sansevieria cylindrica fiber increase the flexural strength & modulus.

Tensile Test:

The Tensile strength and tensile modulus are done on the system1 and system2 specimens. The results are tabulated (table 6.3, 6.4) and graphs also plotted as shown in figure 17 and figure 18.

Table 6.3: System 1, Untreated Sansevieria Cylindrica fiber

Specimen combinations	Tensilel strength (N/mm2)	Tensile modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	93	81
Epoxy + GF+SF 97% 2% 1%	115	85
Epoxy +GF+ SF 97% 1.5% 1.5%	120	117
Epoxy + GF+SF 97% 0% 3%	95	85
Epoxy + GF+SF 97% 3% 0%	75	75

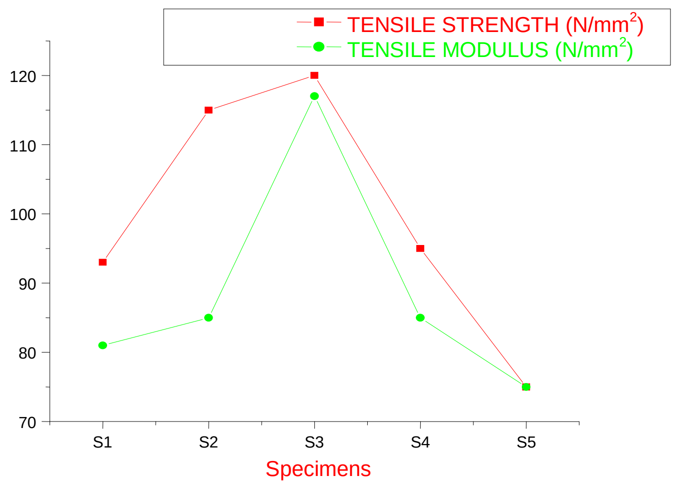

Fig. 17: Tensile Strength & Tensile Modulus Graph for UntreatedSF

Table 6.4: System 2, Treated Sansevieria Cylindrica fiber

Specimen combinations	Tensilel strength (N/mm2)	Tensile modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	95	85
Epoxy + GF+SF 97% 2% 1%	120	89
Epoxy +GF+ SF 97% 1.5% 1.5%	130	120
Epoxy + GF+SF 97% 0% 3%	110	95
Epoxy + GF+SF 97% 3% 0%	100	87

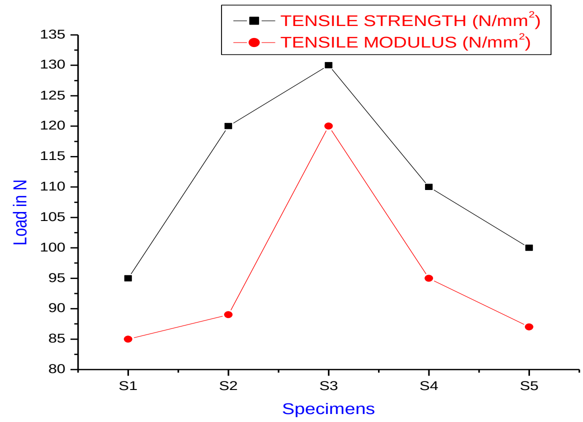

Fig. 18: Tensile Strength & Tensile Modulus Graph for Treated SF

The above result depicts the change in tensile strength and tensile modulus with varying Glass fiber and Sansevieria cylindrica composition. As the Glass fiber concentration with Sansevieria cylindrica increases, the tensile strength increases up to the 1.5Gf1.5Sc (1.5 wt% Gf: 1.5wt% of Sc) at higher glass fiber concentration, the tensile strength decreases and remains almost constant at higher concentration of glass fiber.

Compression Strength

The compression strength and compression modulus are done on the system1 and system2 specimens. The results are tabulated (table 6.5, 6.6) and graphs also plotted as shown in figure 19 and figure 20.

Table 6.5: System 1, Untreated Sansevieria Cylindrica fiber

Specimen combinations	Compression Strength (N/mm2)	Compression modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	90	89
Epoxy + GF+SF 97% 2% 1%	87	90
Epoxy +GF+ SF 97% 1.5% 1.5%	95	97
Epoxy + GF+SF 97% 0% 3%	96	96
Epoxy + GF+SF 97% 3% 0%	89	85

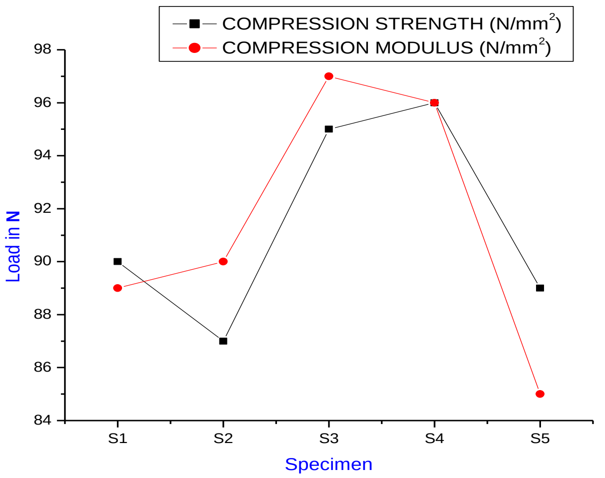

Fig. 19: Compression Strength & Compression Modulus Graph for Untreated SF

Table 6.6: System 2, Treated Sansevieria Cylindrica fiber

Specimen combinations	Compression Strength (N/mm2)	Compression modulus (N/mm2)
Epoxy + GF+SF 97% 1% 2%	91	90
Epoxy + GF+SF 97% 2% 1%	88	88
Epoxy +GF+ SF 97% 1.5% 1.5%	95	97
Epoxy + GF+SF 97% 0% 3%	97	95
Epoxy + GF+SF 97% 3% 0%	90	91

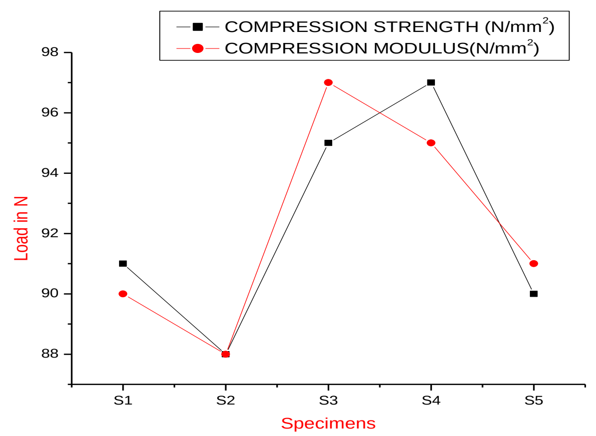

Fig 20: Compression Strength & Compression Modulus Graph for Treated SF

The above result depicts the change in compression strength and compression modulus with varying Glass fiber and Sansevieria cylindrica composition. As the Glass fiber concentration with Sansevieria cylindrica increases, the compression strength increases up to the 1.5Gf1.5Sc (1.5 wt% Gf: 1.5wt% of Sc) at higher glass fiber concentration, the compression strength decreases and remains almost constant at higher concentration of glass fiber.

Thermal Analysis:

TGA analysis was carried out to estimate the amount of resin present in the hybrid composite and their thermal stability. Figure 21 shows the weight loss curves of various hybrid composite materials of different combinations as a function of temperature. It is clear that the decomposition temperature of the composite shifted towards the lower temperature due to increase in Glass fiber. The derivative weight loss shows only one peak. The decomposition temperature is 353°C for 3Gf0Sc, 398°C for 0Gf 3Sc, 400°C for 1.5Gf 1.5Sc hybrid composite whereas not much variation was found for other loadings. It is clearly noted that decomposition temperature was increased up to 2°C. It is clear that the decomposition temperature of the composite is shifting towards higher temperature indicating higher thermal stability of the polymer with higher Sc loading. The existence of inorganic materials present in the polymer matrix, generally enhance thermal stability of the composite. In the present case also, the thermal stability increases due to presence of inorganic phase and its interaction with the polymer. The weight loss vs temperature curves shows that the residue left after 450°C is in line with the epoxy content of each sample. Thermal transition of the pure polymer and the hybrid composites were also investigated by DSC.

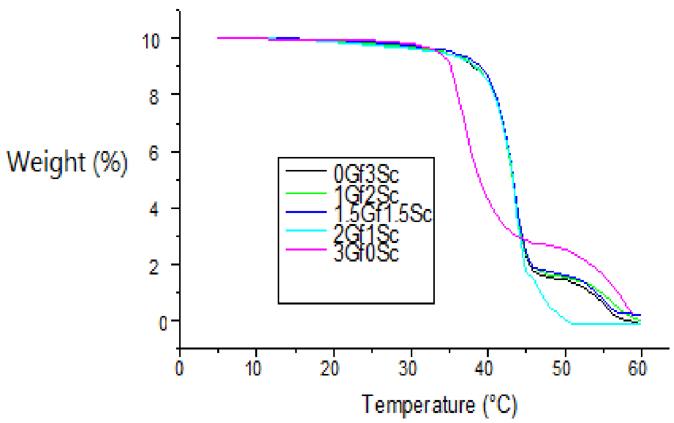

Fig 21: TGA curves of the different samples positions in a hybrid composite

VI. Conclusion:

The following conclusions have been drawn from the present study. The tensile and flexural property of epoxy glass/Sansevieria hybrid fiber composites was improved by increasing percentage of Sansevieria cylindrica fiber. The optimum strength improvement was observed in the composition of 1.5Gf1.5Sc (1.5 wt% glass fiber and 1.5 wt% Sansevieria cylindrica) filled epoxy hybrid composites. Epoxy filled with glass fiber and Sansevieria cylindrica showed remarkable improvement in flexural strength and modulus. Finally, it can be concluded that the addition of the small and stiff uniform fiber played the vital role in bringing up the performance as hybrid reinforcement in optimum amount and structure can be adjusted so that the composites act as an effective damper at that temperature range of interest with high processing and mechanical performance. Decomposition and glass transition temperatures were also lifted on TGA and DSC respectively.

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