

## Synthesis and Characterization of Natural fibers Reinforced Fiber Epoxy Composites

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**ABSTRACT.** In the current work epoxy resin is chosen as matrix, treated Sacharum offinarum (SugarCane) fiber, Pennisetum typhoides (Jowar)/ Fillet miller (Ragi) filler are chosen as reinforcement. Room temperature cured Epoxy System filled with Sacharum offinarum fiber and Pennisetum typhoides (Jowar)/ Fillet miller (Ragi) filler are synthesised by mechanical shear mixer, then kept in a Ultra sonic Sonicator for better dispersion of Pennisetum typhoides (Jowar)/ Fillet miller (Ragi) filler in the matrix. Different weights of modified Pennisetum typhoides (Jowar)/ Fillet miller (Ragi) filler (1,2,3,4,5 gm wt) has been incorporated into the Epoxy matrix in order to study the variation of Mechanical and Thermal properties.

Mechanical properties like Flexural strength, Tensile strength and impact strength of the micro hybrid composite are studied by UTM (Universal Testing Machine). Thermal properties of micro hybrid composites are studied using Thermo Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC).

### 1. INTRODUCTION

Thermoplastics occupy only a small percentage of the advanced composite market, while other and epoxy thermoset materials contribute to more than 70 per cent. Epoxy resins the most important matrix polymer when it comes to high performance. Its combination with natural 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 around 1.3g/cm<sup>3</sup>, 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. Sometimes 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 it is 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.

The Fiber / Filler reinforced composites improve strength, fatigue, stiffness and strength to weight ratio by incorporating strong, stiff, brittle Fibers into a softer, more ductile matrix. The matrix material transmits the force to the Fibers and provides ductility and toughness.

## 2. MATERIALS AND METHODS

**Materials:** Commercially available epoxy (LY-556) and hardener (HY-951) supplied by Ciba-Geigy India Ltd. Company. Naturally available sugar cane fibers were retrieved from Regadikothuru village, Anantapur, Andhra Pradesh, India. In addition, naturally available jowar /Ragi are used as filler is also retrieved from Regadikothuru village, Anantapur, Andhra Pradesh, India.

**Fiber Treatment:** Sugar cane fiber was taken in a plastic tray and a 5% NaOH solution was added into 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

**Composite Manufacturing:** Moulds are prepared for different castings that are made from resin as per ASTM standards. The pre – calculated amount of Jowar/Ragi and Epoxy (resin) is mixed together in suitable beaker. Jowar/Ragi is mixed with stipulated quantity of resin based on the predetermined ratio and mixed thoroughly with mechanical shear mixing for about 1 hour at ambient temperature conditions. Then the mixer is carried out through a high intensity ultra-Sonicator for one and half hour with pulse mode (50s on / 25s off). External cooling system is employed to avoid temperature during the sonication process, by submerging the beaker containing the mixer in an ice bath. Once the irradiation is completed, hardener is added to the modified epoxy in the ratio of 10:1 parts by weight. A glass mould with required dimensions is

use for making sample as per the ASTM standards and it is coated with mould releasing agent enabling easy removal of the sample. In this technique sugar cane fiber is wetted by a thin layer of epoxy/ jowar/Ragi and epoxy suspension in a mould. Stacking of sugar cane fiber is carefully arranged side by side all over the mould. Stacking of sugar cane fiber is carefully arranged after pouring some amount of resin against the mould, to keep the poor impregnation at bay. Left over quantity of mixture is poured over the sugar cane fiber. Brush and roller are used to impregnate fiber. The closed mould is kept under the pressure for 24 hours at room temperature. To ensure complete curing, the composite samples are post cured at 70<sup>0</sup>C for 1 hour and the test specimens of the required size is cut out from the sheet. The removed castings are cut into the samples in accordance with ASTM standards for further testing. Direct processing technique has been used for the above micro hybrid composites preparation.

**Mechanical Tests:** In the present research work, specimens are prepared to study various tests which include tensile test, impact test and flexural test. In fact, all these samples are cut as per ASTM standards. Test specimens ASTM D638 for tensile test of dimensions of (100 x 20 x 3) mm<sup>3</sup>, ASTM D618 for flexural test of dimensions of (100 x 20 x 3) mm<sup>3</sup> and ASTM D695 for impact test of dimensions of (150 x 150 x 3) mm<sup>3</sup>. In each case, samples were tested on UTM and its values are tabulated in the following table 1.

**Thermal analysis:** The thermal characteristics of the epoxy/hybrid composites were measured using both Differential Scanning Calorimetry (DSC) and thermo gravimetric Analyses (TGA) at a rate of 10<sup>0</sup>C/min under nitrogen flow.

**Table 1: Tensile strength, flexural strength and impact strength of treated sugar cane and epoxy/jowar hybrid composites with different proportions.**

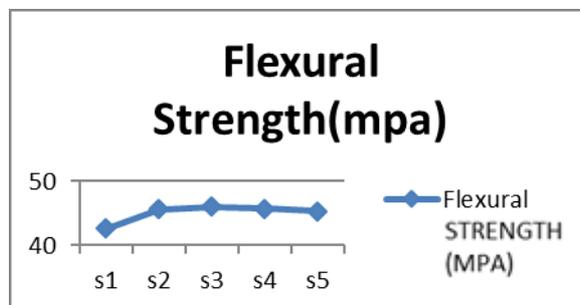
Sample (wt.%)	Tensile strength (MPa)	Tensile Modulus (GPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Impact strength (J/Cm)
EP	25.32	1.135	35.25	2.452	40.69
EP+SCF(10%)+(1%) jowar flour	36.48	1.457	42.68	4.895	42.56
EP+SCF(10%)+(2%) jowar flour	39.14	1.536	45.68	4.968	43.56
EP+SCF(10%)+(3%) jowar flour	40.15	1.689	46.05	5.025	44.52
EP+SCF(10%)+(4%) jowar flour	42.69	1.956	45.78	3.245	45.86
EP+SCF(10%)+(5%) jowar flour	36.96	1.969	45.36	3.125	35.05

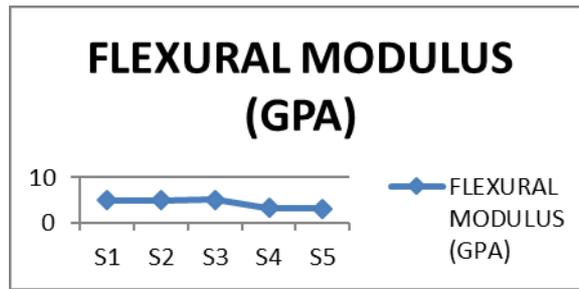
EP=Epoxy; SCF=sugarcane fiber

**Table 2: Tensile strength, flexural strength and impact strength of treated sugar cane and epoxy/Ragi hybrid composites with different proportions.**

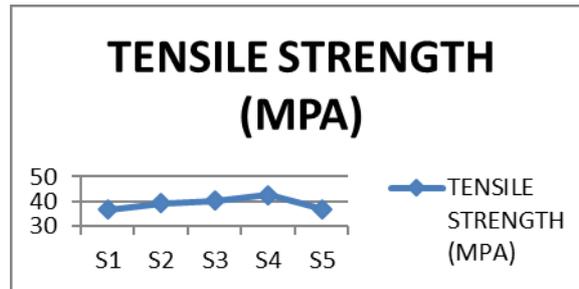
Sample (wt.%)	Tensile strength (MPa)	Tensile Modulus (GPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Impact strength (J/Cm)
EP	25.32	1.135	35.25	2.452	40.69
EP+SCF(10%)+(1%)Ragi flour	37.56	1.568	35.26	2.765	43.56
EP+SCF(10%)+(2%)Ragi flour	38.61	1.695	42.25	2.986	45.78
EP+SCF(10%)+(3%) Ragi flour	39.11	1.745	43.65	3.146	49.15
EP+SCF(10%)+(4%) Ragi flour	41.02	1.345	44.21	3.369	50.63
EP+SCF(10%)+(5%)Ragi flour	34.14	1.427	45.78	3.895	52.36

EP=Epoxy; SCF=sugarcane fiber

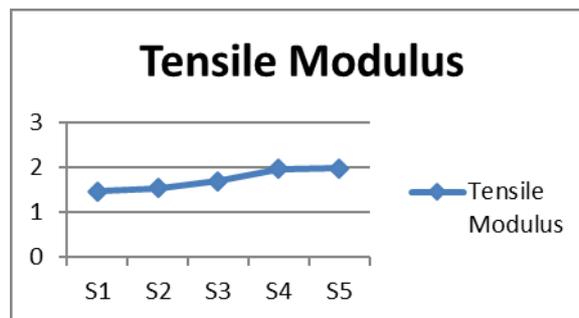
**Fig 1: Flexural strength variations for different proportions of jowar**



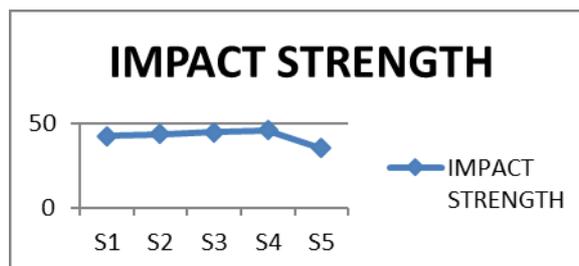
**Fig 2: Flexural modulus variations for different proportions of jowar**



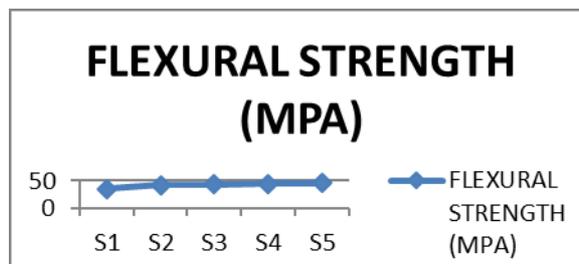
**Fig 3: Tensile strength variations for different proportions of jowar**



**Fig 4: Tensile modulus variations for different proportions of jowar**



**Fig 5: Impact strength modulus variations for different proportions of jowar**



**Fig 6: Flexural strength variations for different proportions of Ragi**

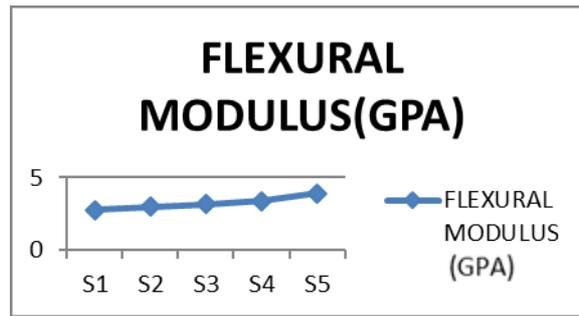


Fig 7: Flexural modulus variations for different proportions of Ragi

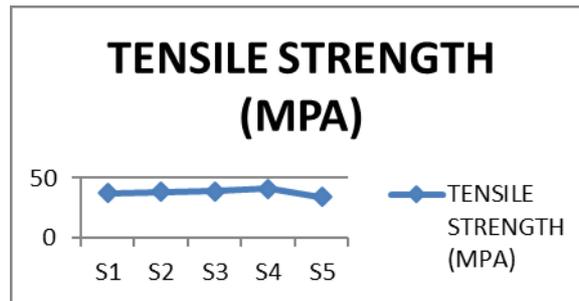


Fig 8: Tensile strength variations for different proportions of Ragi

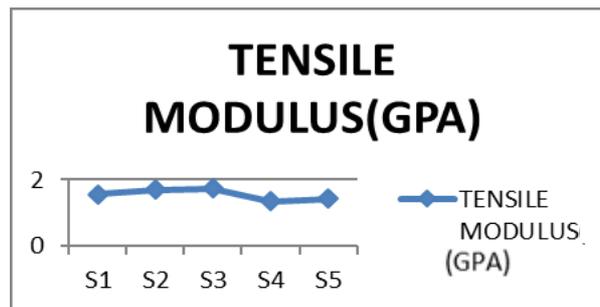


Fig 9: Tensile modulus variations for different proportions of Ragi

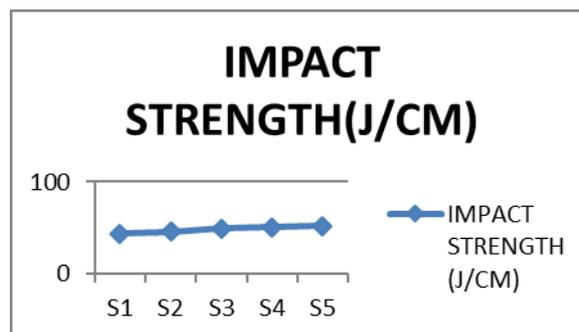


Fig 10: Impact strength variations for different proportions of Ragi

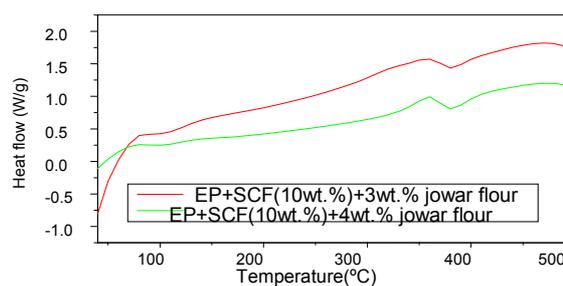
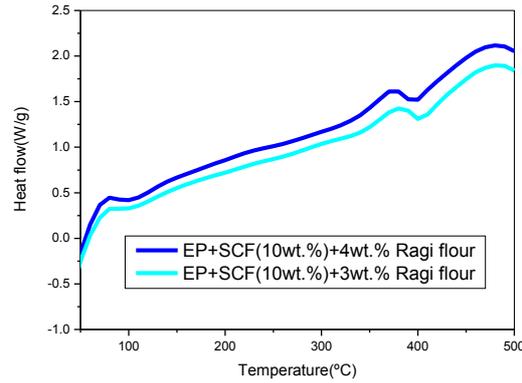
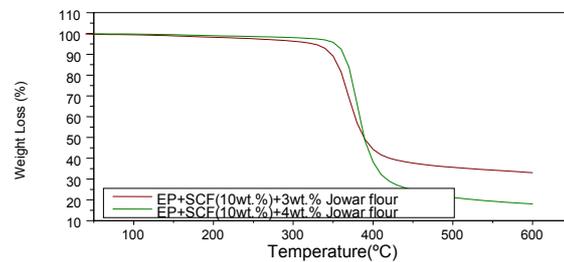


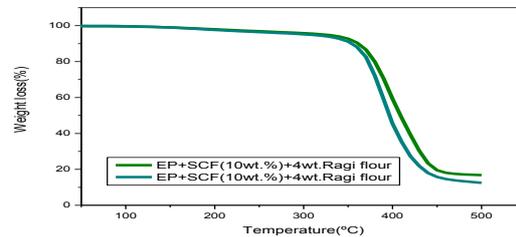
Fig 11: Differential Scanning Calorimetry (DSC) for Specimen 3 and Specimen 4 of jowar



**Fig 12: Differential Scanning Calorimetry (DSC) for Specimen 3 and Specimen 4 of Ragi**



**Fig 13: Thermo Gravimetric Analysis for Specimen 3 and Specimen 4 of jowar**



**Fig 14: Thermo Gravimetric Analysis for Specimen 3 and Specimen 4 of Ragi**

### 3. RESULTS AND DISCUSSIONS:

#### Mechanical Characterization:

Experimental results of epoxy hybrid (treated sugar cane and jowar/Ragi) composites are prepared with different proportions. It is obvious strength increases when increasing jowar upto 3gm impregnated with epoxy matrix and up to 4gm for ragi. Mechanical properties (i.e. tensile, flexural and impact) increased when epoxy matrix impregnated with 2gm fiber of each as mentioned above [1&2]. Mechanical properties are degraded when jowar is further increased. It is observed that 3gm jowar composites were optimal tensile, flexural and impact strength than the other proportions of jowar composites and also for ragi. **Figures 1-10**, represents graphical variations on tensile, flexural, and impact strength properties as function of sugar cane fiber and epoxy/jowar and epoxy/Ragi. Thus, it is observed that the mechanical properties are degraded due to further increase in jowar weight and mechanical properties are increased by further increase in Ragi weight but here our main intention is that as much as possible we has to decrease weight of the composite.

**Thermal Analysis:**

**Differential Scanning Calorimetric (DSC) analysis** is done to the epoxy filled with jowar/Ragi & sugar cane fiber reinforced composites. From **fig 11-12** it is observed that both the composites specimen3 (epoxy (50gm) + jowar(3gm)+sugar cane fiber(2gm) and specimen 4 (epoxy (50gm)+ragi(4gm) + sugar cane fiber(2gm) properties degrade as the heat flow and temperature increases. specimen 3 has the higher glass transition temperature  $100^{\circ}\text{C}$  in jowar compared to specimen4  $50^{\circ}\text{C}$  in ragi. Hence specimen 3 in jowar has more durability compared to specimen 4 in Ragi.

**Thermo Gravimetric Analysis** is observed From the **Figure 13-14** it is observed that the system 1 specimen 3 (Epoxy(50gm) + jowar(3gm) + sugar cane fiber (2gm)) can resist up to  $350^{\circ}\text{C}$ . The weight loss takes place above  $350^{\circ}\text{C}$ . The system2 specimen4 (Epoxy(50gm) + ragi (4gm) + sugar cane (2gm) can resist up to  $250^{\circ}\text{C}$ . The weight loss takes place above  $250^{\circ}\text{C}$ . The system1 specimen 3 has good thermal stability compared to system2 specimen 4.

**4. CONCLUSION:**

The mechanical properties (tensile, flexural and impact) properties of Epoxy filled with jowar and sugar cane fiber reinforced hybrid composites is higher than the Epoxy filled with Ragi and Sugar cane fiber reinforced composites. Epoxy (50gm) filled with Jowar (3gm) and Sugar cane fiber (2gm) reinforced hybrid composite showed remarkable improvement in flexural strength and flexural modulus. The Thermal properties of Epoxy filled Jowar and Sugar cane fiber reinforced hybrid composites are higher than the Epoxy filled Ragi and Sugar cane fiber reinforced composites. Both the Jowar and ragi are well dispersed in the epoxy. System1 Specimen 3 (Epoxy (50gm) + jowar (3gm) + Sugar cane fiber (2gm) has high glass transition temperature. Both system1 (Epoxy filled with Jowar and Sugar cane fiber reinforced composites) and system2(Epoxy filled with Ragi and Sugar cane fiber reinforced hybrid composites) can be used in reverse engineering process. System1 composites are more efficient. It can be used in the manufacture of automobile fuel tanks, car doors, aero plane wings and also in high strength to less weight applications.

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