

**Research Article**

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**DEVELOPMENT AND ASSESSMENT OF POLYESTER REINFORCED WITH SANSEVIERIA CYLINDRICA  
/ ZAWA FLOUR COMPOSITES**

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**Abstract**

This paper zero in on preparation of hybrid composites in which Polyester matrix filled with Sanseveria cylindrica fiber (SCF) and Zawa flour. SCF fiber was taken 10% volume constantly in all the samples. Camera ready samples were prepared using hand layup technique in which filler constituent proportions were taken by using rule of hybrid mixture (RoHM). The mail aim of the composites is to increase the tensile flexural, and impact strengths, TGA, DSC results by incorporating the filler. It was observed that, tensile strength was linearly increased up to 4wt.% zawa after that sudden falling was observed. On other hand, tensile modulus was increased linearly up to 5wt.% was the clear indication of addition of zawa imparts more stiffness to the composites. Flexural strength was increased up 3wt.% zawa flour after than it starts depreciating suddenly. Flexural modulus was increased linearly up to 3wt.% zawa four composites after that decreases. Impact strength was optimised at 4wt.% zawa flour after that it starts going down. In DSC analysis, for 3wt.% zawa flour composite registered good performance than the 2wt.%, whereas in TGA analysis 3wt.% composite was having good performance than 2wt.% zawa flour composites. Reasons attributed for increased glass transition temperature was due to the less moisture content or due to the deprived of void due to the good bonding strength.

Keywords: SCF, DSC, Composites, Zawa flour, Mechanical Properties

**Introduction**

Hybridization with two or more than two fibers in a single matrix leads to the development of hybrid composites. Usually a combination of two fillers proves to be useful in practice as it leads to achieve a balance between properties of single fiber reinforced composites. Till mid-1990s only glass, carbon and aramid fiber systems were worked upon. Bunsel, Harris, summer scales and Short and several other scientists have shown the characteristics of hybrid effects in the case of various glass and carbon fiber systems but the work on short fibers is limited. Scientists have explained in all these systems negative and positive hybrid effects in terms of mechanical properties. Short fiber composites are attractive structural materials for their relatively easy processability depending on resulting flow field and cooling conditions, a complex microstructure may result in different fiber orientations at different points of molded piece. Microstructure characteristics can only explain the local mechanical properties of short fiber composites. In a hybrid system various mechanical properties like stiffness strength and fracture toughness depend on the characteristics of constituent fibers like fiber length and fiber volume fraction. When fiber length is smaller than critical fiber length fiber pull out takes place but if fiber length is more than critical fiber length breaking of fiber occurs thus fracture mechanisms can be identified with the knowledge of critical fiber length. Polypropylene possess outstanding properties like low density, high softening point, good flex life, sterlisability, good surface hardness and excellent electrical properties but by itself does not meet the requirements of engineering applications due to low stiffness, low heat deflection temperature and poor melt

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strength. But when filled with mineral and glass fillers, properties improve to that of the extent of engineering plastics thus enabling usage in engineering applications. The typical reinforcing material used in polymer composites is glass fiber. It is a common reinforcement due to good strength properties lower price and relatively good adhesion to matrix but nowadays minerals are in more demand because of a few drawbacks of glass fibers such as lower dispersion, lower thermal and chemical stability and liberation of large amount of heat while processing. Wollastonite is a naturally occurring calcium silicate mineral. Earlier studies have shown that acicular wollastonite can be used as core in forcer in short fiber composites. Use of wollastonite in high fraction will reduce the cost of composite and improve tensile strength, impact properties and dimensional stability. High aspect ratio (15) of wollastonite is retained by appropriate milling thus its greater surface area better intercepts stress propagation. Reinforcement with wollastonite increases the starting crystallization temperature and induces a shorter processing time in injection molding and thus the effect of crystallinity of the composite for this reason reinforcement of rotational molded articles with wollastonite is an interesting possibility. These materials are interesting as they show an increase in flexural modulus, HDT, superior dimensional stability, reduced cost and ease processability. A certain mechanical property such as strength or modulus of a hybrid system consisting of two single systems can be predicted by the rule of hybrid mixtures (RoHM).

A requisite for the occurrence of a hybrid effect is that the two types of fibers will differ by both their mechanical properties and by the interfaces they form with the matrix [1-12]. Carbon and glass fibers are often used in the same polymeric resin matrix to form hybrids. Carbon fiber provides a strong, stiff and low-density reinforcement but is relatively expensive, while glass fiber is relatively cheap, but its strength and stiffness are relatively low. With hybridization, it is possible to design the material to better suit various requirements. Since the mechanical properties of glass and carbon fibers and the interfacial properties of GF/polymer and CF/polymer systems differ greatly, the hybrid effect would very likely exist for their hybrid reinforced composites. For example, the fracture energy of hybrid glass/carbon/epoxy composites was observed to show a negative hybrid effect [13]. The compression modulus of hybrid glass and carbon reinforced composites was reported to exhibit a negative hybrid effect [14]. However, a review of the literature on carbon-fiber and glass-fiber-hybrid-reinforced plastics indicated that incorporation of both glass and carbon fibers into a single matrix sometimes would lead to better properties than would be expected from consideration of the RoHM [15]. The tensile modulus of glass-rich hybrids [16] and the flexural modulus of the sandwich hybrid beam [17] were found to show a positive hybrid effect. Also, in glass/carbon-reinforced polymer systems, a positive hybrid effect for the strain was calculated and is presented in Table 1 of the reference [18]. A positive hybrid effect (i.e. failure strain enhancement) in flexural tests on sandwich coupons with a high glass mat to carbon fiber content ratio was observed as well [19-23].

In the present research emphasized into PE/SCF/Zawa flour composites were prepared using hand layup technique. Tensile strength, flexural strength, Impact strengths were evaluated for this composites and also DSC and TGA analysis were also studied.

## MATERIALS AND METHODS

unsaturated polyester (Ecmalon 9911, Ecmas Hyderabad) with 2% cobalt naphthanate as accelerator, 2% Methylethylketoneperoxide (MEKP) as catalyst in 10% DMA solution, ratio of the resin/accelerator/catalyst/promoter:100/2/2/2. The system was processed by wet hand-lay up technique for making the test specimens. Sansevieria cylindrica fiber was used for reinforcing the composite which was extracted from the sansevieria leaves. The fiber was extracted using natural decomposition processes. Zawa flour was obtained from the former, Kalyanadurg, Anantapur the particle sizes was measured as 50-70 microns.

### Fabrication of composite

The Sansevieria cylindrica (SCF) and zawa flour were used for preparing hybrid composites. Fiber was chopped into small pieces like 2-2.1 cm length to get significant performance. A glass mould of dimensions 300 mm X 300 mm X 3 mm was used. The mould cavity was coated with a thin layer of polyvinyl alcohol (PVA) solution, which acts as a releasing agent. The PE composites were made first adding the methyl ketone peroxide (1.2mL) in to the VE resin (100g) and catalyst (2mL). Cobalt naphthanate (0.7mL), accelerator (2mL) was added with resin. SCF fibre mat was stacked randomly over the mould make sure to pour the modified matrix poured into the mould with small layer. It was then impregnated with polyester resin in mould upon the layer. Different layering pattern of fibers were maintained [20]. A neat polyester matrix (unfilled) sample was prepared and vinylester resin with SCF fibre composites was also prepared. The test specimens were cut from the composites according to ASTM standards. Samples from A to G were prepared as per the table 1 given below.

### Specimen Characterization

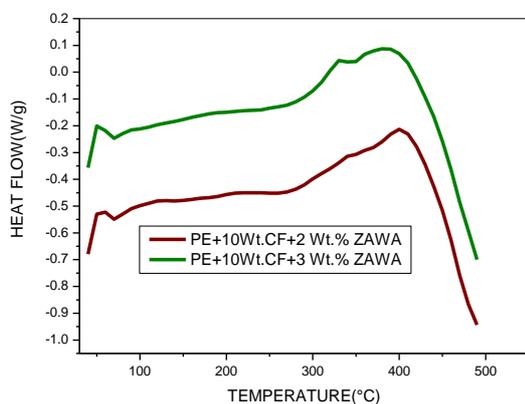
In the present work, the tensile strength and modulus of the plain matrix as well as PE/SCF/zawa flour reinforced composites were measured by using an INSTRON 3399 Universal testing machine. This test was conducted as per the ASTM D 3039 [26] specifications. Flexural strength and modulus were tested using an Instron Universal testing machine with a crosshead speed of 2 mm/min. The three-point bending test system was used for all samples. In each case, six samples were tested and the average value tabulated. Authors used 50 kN load cell used for testing. Furthermore the sample sizes 100 x 20 x 3 mm<sup>3</sup> was cut in accordance with ASTM D 618.

The impact strength of the composites was measured using an Izod impact tester supplied by M/s. PSI sales (P) Ltd., New Delhi. The samples were made to 63.5x12.7x12.7mm<sup>3</sup> dimension using glass molds having the dimension 100x12.7x12.7mm<sup>3</sup> and the notch was made according to ASTM D256 specifications. This test was carried at ambient conditions. In each case, five identical specimens were tested and their average load at first deformation was noted and the average value tabulated. The variation of impact strength with different fiber lengths is given in Table2. The thermal characteristics of the polyester modified with SCF/Zawa flour hybrid composites are measured using both thermo gravimetric analysis (TGA) and differential scanning calorimetry (DSC-2010 TA Instrument). Thermogravimetric analysis (TGA) was used to investigate

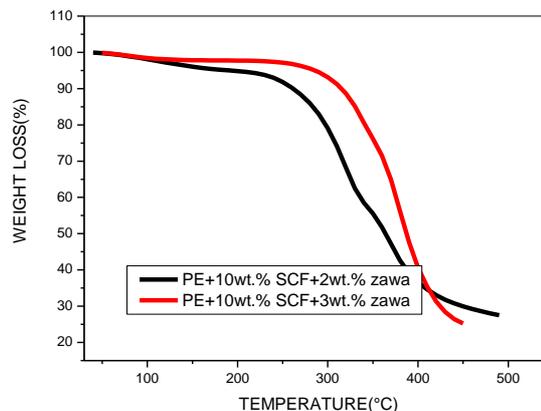
thermal decomposition behaviour of the composite. Differential scanning calorimetry (DSC-2010 TA Instrument) was used to study the glass transition temperature ( $T_g$ ) of the material. Tests were done under nitrogen at a scan rate of  $10^\circ\text{C}/\text{min}$  in a programmed temperature range of 30 to  $600^\circ\text{C}$ . A sample of 5 to 10 mg was used. The weight change was recorded as a function of temperature.

## RESULTS AND DISCUSSIONS

Fig.1 shows that the 2 and 3wt.% zawa flour hybrid composites were evaluated to check the glass transition temperature and it was observed that, for 2wt.% composite has highest glass transition temperature when compared with 3wt.% zawa flour hybrid composites. It was increased up to  $370^\circ\text{C}$  for 3wt.% whereas for 2wt.% composite  $T_g$  increases up to  $390^\circ\text{C}$ . The reasons attributed that due to good bonding and de-voids in the composite it could thermal stability was increased. Similar approaches were observed by the other authors. Fig.2 shows that the 2 and 3wt.% zawa flour hybrid composites were evaluated to check the thermal stability and it was observed that, for 3wt.% composite has highest thermal stability temperature when compared with 2wt.% zawa flour hybrid composites. It was increased up to  $300^\circ\text{C}$  for 3wt.% whereas curve was straight after that curve starts going down which represents composite weight starts decreasing and it was stalled when it reaches  $400^\circ\text{C}$ . 20% of the composites was left unburnt for both 2 and 3wt.% composites. Whereas for 2wt.% composites the curve was linearly increased up to  $150^\circ\text{C}$  then it starts decreasing the curve further and ended the endothermic reaction.



**Fig.1 Glass transition temperature measurements using DSC for EP filled sugar cane fiber and zawa flours hybrid composites as a function of temperature.**



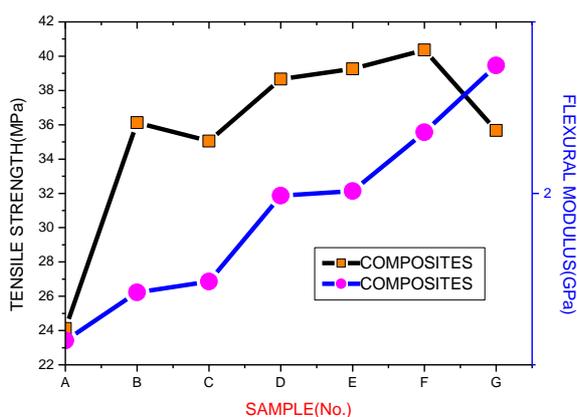
**Fig.2 Thermal stability measurements using TGA for EP filled sugar cane fiber and zawa flour hybrid composites as a function of temperature.**

Seven hybrid composites are prepared by polyester filled with sansevieria cylindrica and zawa flour to gain the combined effect of all the properties are shown in the Table1. Tensile, flexural, impact, thermal properties were evaluated and the results for tensile, flexural and impact strength results were tabulated in the Table 2. The total % weight of SCF was taken as 10wt.% in all the composites and the zawa flour was taken with different % weight ratio's.

**Table: 1 Sample designation of EP/SCF/Zawa flour hybrid composites.**

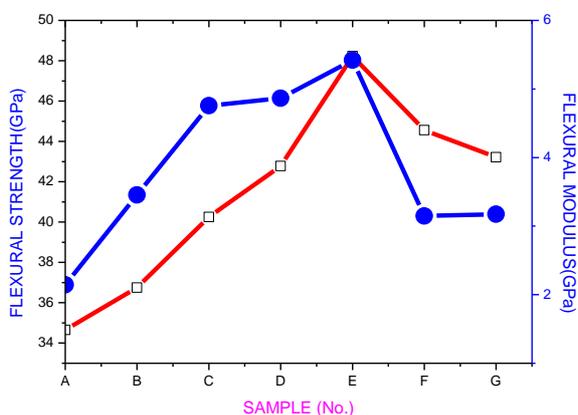
Sample designation	Sample description
A	PE
B	PE+SCF(10%)
C	PE+SCF(10%)+(1% Zawa flour
D	PE+SCF(10%)+(2%)Zawa flour
E	PE+SCF(10%)+(3%)Zawa flour
F	PE+SCF(10%)+(4%)Zawa flour
G	PE+SCF(10%)+(5%)Zawa flour

From the Fig.3 shows that tensile strength was increased with increasing zawa % weight up to 4wt.% and at that point it was observed as 40.36 MPa whereas for 5wt.% zawa flour composites strength was 35.67MPa. It was nearly 11.6% tensile strength was decreased for thereof and the reason was addition of more filler tends to difficult to flow the matrix in addition to that it will left the voids while it is being pouring into the mould and it will also causes agglomeration (i.e. filler form like small spheres which does completely isolated by the matrix. Similar observations were noticed by the other papers [2, 5, 6, 10].



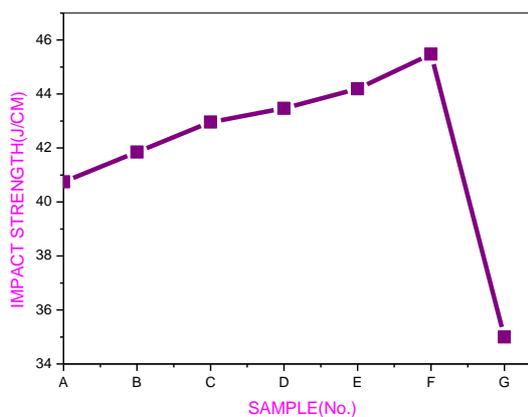
**Fig.3** Tensile strength measurements for EP filled sugar cane fiber and zawa flours hybrid composites as a function of filler variation.

Tensile modulus was linearly increases with increasing zawa flour up to 5wt.% zawa flour. It is obviously addition of fillers does increase the stiffness of the composites. Similar observations were noticed by the literature [4, 10, 12]. Flexural strength was also increases with increase in filler content up to 3wt.% and decreases with further increase in filler. Flexural strength was observed at 3wt.% is 48.23MPa is the ultimate flexural strength, whereas flexural modulus was increase up to 3wt.% zawa flour then it starts reducing due to higher viscosity of the modified matrix Polyester was shown in the Fig.4. Flexural modulus was increased up to 3wt.% and then it decreases. The reasons attributed for the increased modulus was due to the moisture content in the filler or the poor interface between the fiber and the matrix.



**Fig.4** flexural strength measurements for EP filled sugar cane fiber and zawa flours hybrid composites as a function of filler variation.

Fig.5 shows that the impact strength as a function of filler loading. It was noticed that increase in filler was increases the impact strength on one hand, but decreases on other hand after 4wt.% zawa flour.



**Fig.5** Impact strength measurements for EP filled sugar cane fiber and zawa flours hybrid composites as a function of filler variation.

## Conclusions

This paper presents hybrid composites in which Polyester is filled with *Sansevieria cylindrica* and zawa flour was synthesised and characterized. Hand layup technique was used for this composite preparation. It was observed that the tensile strength was increased up to wt.% then decreases further increase in filler, whereas in tensile modulus was also increased up to 4wt.% then later no appreciable deformation took place. Flexural modulus was increased up to 3wt.% but decreases after. Similarly impact strength was also increased up to 4wt.% and then decreases when further increase in filler content. Authors were also noticed that increase in thermal stability and glass transition temperature of these hybrid composites. These composites can be used as structural materials for automobile and aerospace applications.

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