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Mechanical Characterization with Morphological Analysis of Dry Flower Waste Bio Filler Reinforced Epoxy Composite

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Abstract: ***Dry flower waste powder is incorporated in the Epoxy resin matrix to study the effect of the bio filler in Epoxy composites. Composite Specimens were prepared by using different volume fractions (0.4, 0.8, 0.12, 0.16, 0.20 v/v) of Dry flower waste bio powder in the Epoxy resin by hand layup method. Experiments were conducted to evaluate the mechanical properties such as Tensile Properties, Flexural properties and Impact strength of the epoxy composite. The results indicated that the bio filler had significant influence on the tensile and flexural modulus whereas tensile and flexural strength and impact strength of the composite are not significantly affected by the addition of the filler. Better mechanical properties were obtained at 12% v/v of Dry flower waste bio powder. Morphological properties were examined using the SEM images of tensile fractured specimen.***

Keywords :Bio filler, Dry flower waste bio filler, Mechanical Properties, morphological analysis, Polymer Composite

I. INTRODUCTION

Composite materials have been used in several applications for the past few centuries. The use of naturally available bio materials as a reinforcing fiber and filler in the polymer composites had evoked lot of interest among researchers [1] – [3]. It has been shown that natural fibers and bio fillers can be used as an appropriate replacement for synthetic fibers such as glass fibers, carbon fibers and Kevlar fibers [4] – [6]. Researchers have shown interest in the manufacture of composites from various agricultural and natural waste materials due to the growing demands for environment - friendly and recycled materials. Natural fibers and fillers have several advantages such as less weight, lower price, high strength to weight ratio, ease of availability and ecological advantages of using natural resources, which are renewable and degradable. Natural fibres and fillers are also safer to handle compared to processing glass fibres.

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Kokta et al. [7] studied the mechanical behavior of wood flour-incorporated polypropylene (PP) composites and found that the addition of filler material in the polypropylene matrix enhanced the mechanical properties of the composite material. Onuegbu et al. [8] have studied the effect of snail-shell powder on the polypropylene composites.

The results indicated an increase in the tensile, flexural, and impact properties with an increase in the filler content and filler size. Sarki et al. [9] incorporated the coconut shell powder as filler material in the epoxy composite and the incorporation of coconut shell powder was found to improve the tensile strength and modulus with a slight decrease in the impact strength. Chun et al. [10] used coconut shell powder as filler in recycled polypropylene and Sodium Dedecyl Sulfate was used as the coupling agent. The addition of the filler caused an increase in the tensile properties, thermal stability, crystallinity and lowered the water absorption compared to the unmodified composite.Sudheer et al.[11] have reported that the effect of potassium titanate filler on the epoxy composites resulted in the reduction of tensile strength. Singla et al. [12] analyzed the effect of fly-ash loading on the mechanical properties of the epoxy resin and concluded that the filler loading and filler material size affect the compressive and impact strength of the composites material. Rajini et al. [13] fabricated polyester composites by incorporating nano clay and coconut sheath at different volume fractions. The addition of natural filler and fibre resulted in improvement in mechanical properties. Raju [14] studied the use of groundnut powder as a bio filler. Groundnut shell particles incorporated composites were fabricated with different grain sizes and volume fractions. The study indicates a volume ratio of 60:40 and 0.5 micron particle sizes providing a good reinforcement effect. Vimalanathan et al. [15] developed a polymer matrix composite by incorporating Shorea Robusta a natural filler in Polyester matrix. The effect of Shorearobusta volume fraction on the mechanical, dynamic mechanical properties of polyester was studied. It was shown that the addiditon of bio filler resulted in marginal improvement in tensile strength, flexural strength of the composite. The tensile modulus and flexural modulus were greately influenced by the addition of bio filler upto 20% v/v in polyester matrix. UdhayaSankar et al. [16] did research on coconut shell powder reinforced polymer composites. The Results revealed an improvement in the mechanical properties like tensile strength and impact strength as a result of the filler addition.

Chandramohan et al. [17] had reported that the addition of coconut shell powder, walnut shell and rice husk in the epoxy matrix resulted in better mechanical properties. Higher value of tensile strength and modulus were obtained at 20% v/v of the bio filler content in the composite.

Hence in this work, dry flower waste powder was used as bio filler material in Epoxy matrix. Tests were conducted to assess the effect Dry flower waste bio filler on the mechanical properties of the Epoxy composite.

II. EXPERIMENTAL DETAILS

A. Materials

The Epoxy resin (LY556) with hardener (HY951) was used as the matrix material in this research work. Flower waste was collected from the local vendors including all types of natural flowers and it was dried for about 3-4 days under sun till the moisture is completely removed. The dried flower waste is ground to a fine powder with a grain size of about 10-25 microns using ball milling process. The density of Dry flower waste bio powder was assessed and its value was estimated to be 1.02 g/cm^3. Composite samples were fabricated by using hand layup method followed by lightcompression. Composite specimens were prepared by varying the volume percent of Dry flower waste bio filler as 4%, 8%, 12%, 16% and 20% v/v in the Epoxy matrix.

B. Testing Standards

The Epoxy composite specimens were subjected to various mechanical tests as per ASTM standards. ASTM-D638 standard was followed while carrying out the tensile test with a test speed of 5mm/min, Flexural properties of the composites were estimated by using three point bending test as per ASTM-D710 procedure with the test speed of 1.5mm/min. The impact strength of the composite specimen was determined using an IZOD Impact tester as per ASTM-D256 standard. Five composite specimens were tested in each testing and the average of the test values was considered for further investigation.

SEM images were taken to study the morphological features of the specimen. The fractured surface of the tensile test specimen was used to analyze the interfacial bonding between the matrix and bio filler material. SEM images were taken by using Hitachi – S 3400N scanning electron microscope. The samples were cut and carbon coated before analysis. The accelerating voltage was given as 20kv.

III. RESULTS AND DISCUSSION

A. Mechanical Properties

The tensile and flexural properties of the composites were calculated using the stress-strain plots obtained from tensile test and three-point bending test. The test results are presented in Figs. 1- 3. Fig. 1 shows the effect of Dry flower waste powder bio filler on the tensile properties of Epoxy resin composite. It was observed from the plot that Epoxy composite sample with 12% v/v volume percentage of bio filler exhibited a maximum tensile strength of 24.9 MPa, whereas neat Epoxy resin showed better tensile strength of 25.2 MPa. A marginal reduction in the values of tensile strength and flexural strength was observed for the composites with dry flower waste powder filler; this may be due to the formation of voids in the composite material.

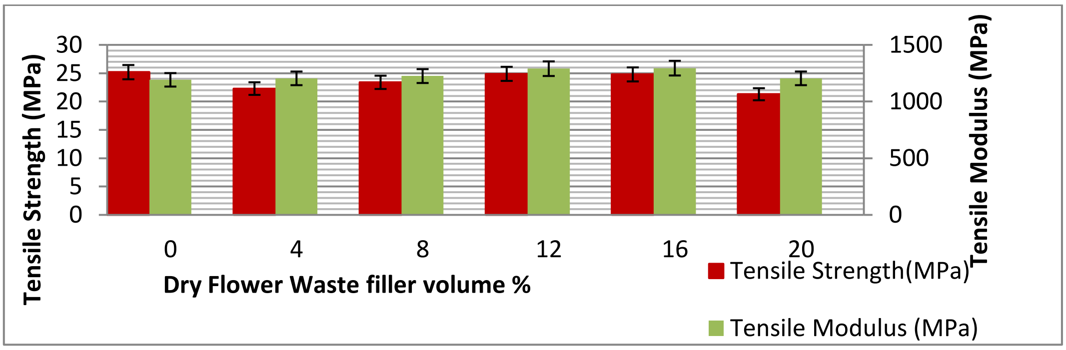

Fig. 1. Tensile properties of the Neat Epoxy and Dry flower waste powder-Epoxy composite

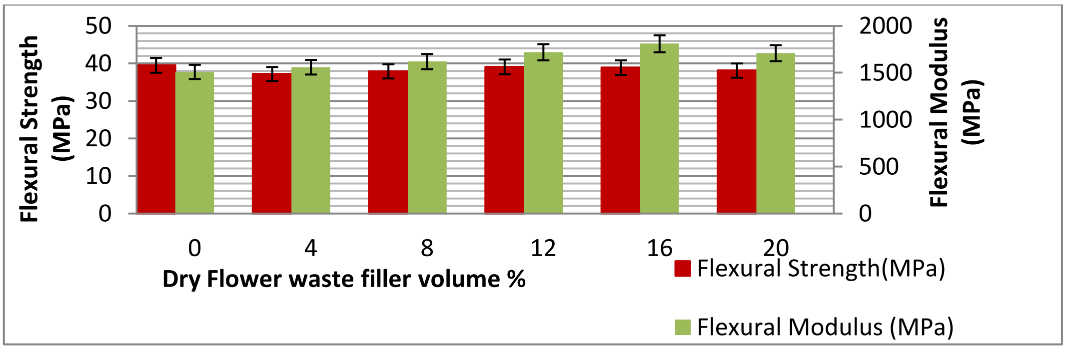

Fig. 2. Flexural properties of the Neat Epoxy and Dry flower waste powder-Epoxy composite

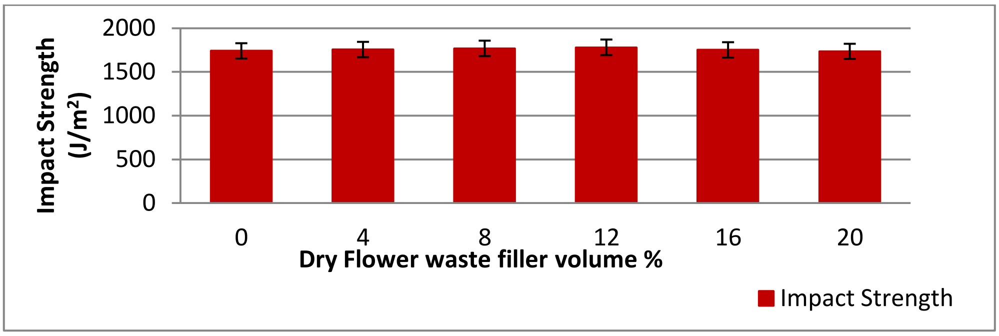

Fig. 3. Impact properties of the Neat Epoxy and Dry flower waste powder-Epoxy composite

Similarly, the maximum value of flexural and impact strength was observed as 39.1 MPa and 1781 J/m^2 from Fig. 2 & Fig. 3 respectively for 12% v/v volume percentage of bio filler in Epoxy composite. Fig. 1- Fig. 3 also reveal that the additions of bio filler have an insignificant effect on the mechanical properties of the epoxy resin. This is because of the particulate structure of the filler material.

The results also revealed that, the addition of filler material had shown improvement in tensile and flexural modulus of the composite material. But, a significant drop on the mechanical properties was observed for the composite with bio filler volume of more than 20% v/v. This is due to the poor wetting of the matrix material with Dry flower waste bio filler.

B. Fractography Study

To study the interfacial adhesion and dispersion of the Dry flower waste powder in the Epoxy matrix, SEM image of the broken surface of the tensile fractured specimen was taken and the same is presented in Fig. 4, Fig. 5 and Fig. 6. SEM image of composite with 4% v/v bio filler is presented in figs 4 (a) & (b).

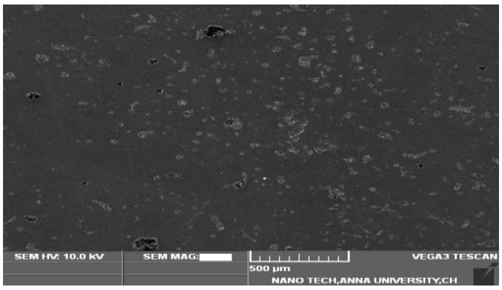

Fig. 4 (a)SEM image of Dry flower waste powder - Epoxy composites with 4% v/v bio filler.

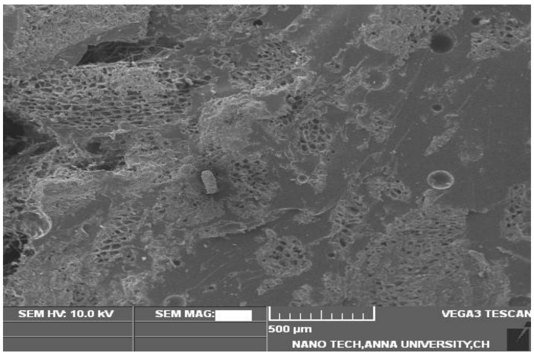

Fig. 4 (b) SEM image of Dry flower waste powder - Epoxy composites with 4% v/v bio filler.

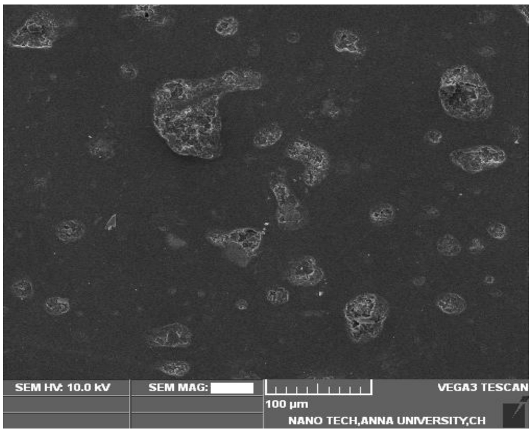

Fig. 5 (a) SEM image of Dry flower waste powder - Epoxy composites with 12% v/v bio filler.

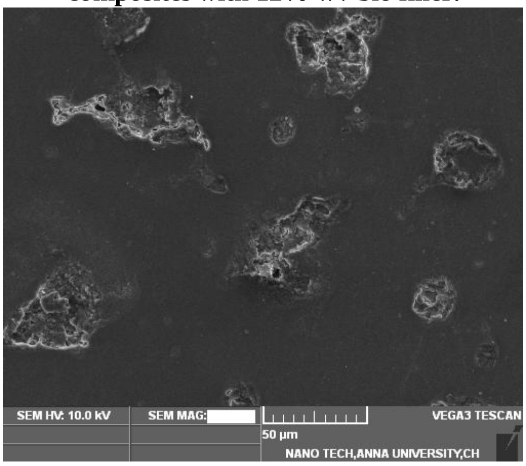

Fig. 5 (b) SEM image of Dry flower waste powder - Epoxy composites with 12% v/v bio filler.

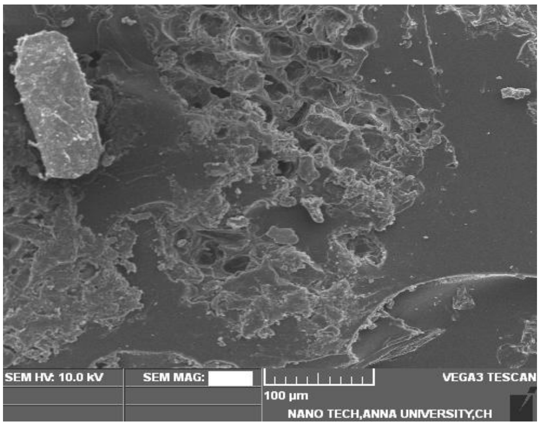

Fig. 6 (a) SEM image of Dry flower waste powder - Epoxy composites with 20% v/v bio filler.

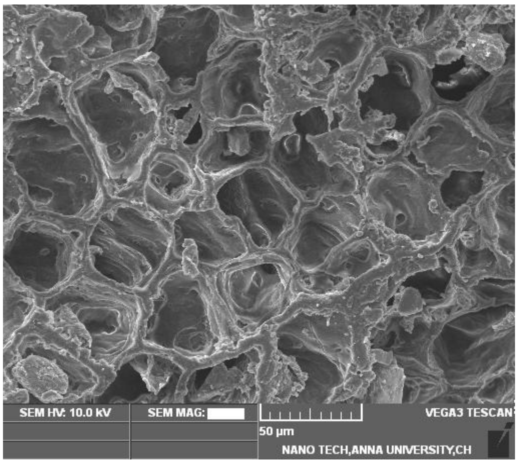

Fig. 6 (b) SEM images of Dry flower waste powder - Epoxy composites with 20% v/v bio filler.

The voids present in the Epoxy matrix due to the addition of natural filler was observed in the SEM images, which results in the poor adhesion between the matrix and reinforcement filler material resulting in ineffective stress transfer between the matrix and Dry flower waste bio filler. Also most of the stress is carried by the matrix. SEM image of the composite material with 12% v/v bio filler is presented in Fig 5 (a) & (b). Ridged fracture surface and presence of voids in the Epoxy matrix was observed in the SEM image, this indicates the better surface adhesion between the filler material and Epoxy matrix at this filler volume fraction. Excessive addition of Dry flower waste bio powder material resulted in poor surface wetting of the filler which is evident from the SEM image given in Fig 6 (a) & (b). Poor surface wetting of the filler particles results in weaker interfacial adhesion between Epoxy and Dry flower waste bio powder, thereby poor load transfer between the matrix and filler. Hence addition of Dry flower waste bio powder in excess of 20% v/v results in reduction in mechanical properties

IV. CONCLUSION

In this work, the effect of Dry flower waste bio powder filler on the mechanical properties of Epoxy resin had been investigated. Epoxy Composites were fabricated by incorporating Dry flower waste bio powder at various volume fractions in the matrix. Mechanical properties were evaluated and better values of tensile, flexural and impact properties were found as 24.9 MPa, 39.1 MPa and 1781 J/m^2 respectively for the composite with 12% v/v bio filler content. Though addition of bio filler showed insignificant effect on the tensile strength and flexural strength, tensile and flexural moduli had shown significant improvement showing stiffening of the composite. SEM images of the tensile fractured surfaces were also taken to study the morphological features of the composites. Accumulation of the bio filler was observed for the volume fraction of 16% and above.

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