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Effect on Mechanical Properties of Epoxy Hybrid Composites Modified with Titanium Oxide (TiO2) and Silicon Carbide (SiC)

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Abstract:
Glass fibre reinforced polymer composites play an incredible role in almost all spheres day to day life and the field of glass composites is one of the prime research areas in recent decade. Polymers are mostly reinforced with fibre or fillers to obtain better mechanical properties. In this paper, the effect of filler material like titanium oxide (TiO2) and silicon carbide (SiC) particulates on mechanical properties of E-Glass fibre reinforced polymer has been studied out by varying filler materials. The effect of titanium oxide and silicon carbide fillers in modifying the mechanical properties of glass reinforced epoxy composites has been studied. It is found that the mechanical properties like Tensile strength, Flexural strength, Impact strength and Hardness of the glass reinforced composites are modified with the incorporation of the fillers.

Keywords: Epoxy, Mechanical Properties, Titanium oxide (TiO2) and Silicon carbide (SiC)

1. INTRODUCTION

Over the past decades, many Glass-fiber reinforced composite materials are used in manufacturing of various parts in automotive and aerospace industries. The major advantage of polymer composites is to offer easy processing, productivity, cost reduction, high strength and modulus-weight ratio etc. over metallic materials. Glass fiber composites have excellent surface finish, higher impact strength and high modulus to weight ratios compared with the other FRP Composite materials, so they are mainly used in industries. To enhance the mechanical properties i.e. tensile, impact and flexural properties of the polymers is the main concept of reinforcing the polymers [1, 3]. For thermoset matrices Glass fiber is the typical reinforcing material for various structural applications. For high ratios of strength and stiffness to weight in orthotropic direction Woven fabric reinforced epoxy composites are well known. In areas where light weight of structures and high performance are essential these good characteristics of the composites have resulted in numerous applications of the materials [4]. Cho et al. [5] investigated the special effects of particle loading particle medium interface adhesion and particle size, on mechanical properties of polymer matrix composites. Also, the use of epoxy resin for composite manufacture, being one of the most captivating and interesting materials are contemplated, because it is primarily used for preparing high-performance composites with advanced perfunctory properties, corrosive resistant to liquids and environments, superior electrical properties, high-quality performance at high temperatures, superior adhesion or a combination of above benefits. It is observed from the literature, the use of fillers in matrix gives rise to improve the mechanical properties, which acts as additional reinforcements and enhances their mechanical properties and also reduces the processing cost significantly. Ishidi et al.[6] have determined the physio-mechanical properties of the proposed polymer composite which is a combination of two distinct materials- HDPE and palm kernel nut shell particulate. The materials compounding and sample formation was done using Reliable Two Roll Mill Model 5183 and Carvers Hydraulic Hot Press. Tensile strength of the fabricated composites was tested using standard equipment in accordance to the ASTM standard specifications. Ahmad and Mahanwar [7] studied the effect of fly ash as filler on the mechanical properties of HDPE. Three different particle sizes of fly ash were used. Concentration of fly ash was varied up to 40 % by weight. The composites were prepared using twin screw extruder and then test specimens were prepared by injection molding. Tensile, flexural and impact properties were tested. Composites with smallest size fly ash particles proved to be better in enhancing strength and relative elongation. Modulus and impact resistance did not seem to depend much on particle size. Atikler et al.[8] studied mechanical and morphological properties of composites made up of recycled high-density polyethylene (HDPE) filled with calcium carbonate and fly ash. Effect of filler loading and treatment of FA with silane coupling agent on mechanical and morphological properties were investigated and it was found that silane treatment indicated significant improvement son the mechanical properties of the HDPE-FA composites.

2. EXPERIMENTAL DETAILS

2.1 Materials

In our study, Titanium oxide and silicon carbide fillers are used to modify the Epoxy matrix. The commercially available E-glass fiber (Woven Roving fabric type) with 360 grams weight per m^2 area is used as reinforcement. Araldite (LY-556) chemically belongs to epoxide family is used as resin and (HY-556) is used as hardener, these materials (E-glass fiber, Araldite and

Hardener) are supplied by Kotsan Engineering corporation, Hyderabad.

2.2. Fabrication of composites

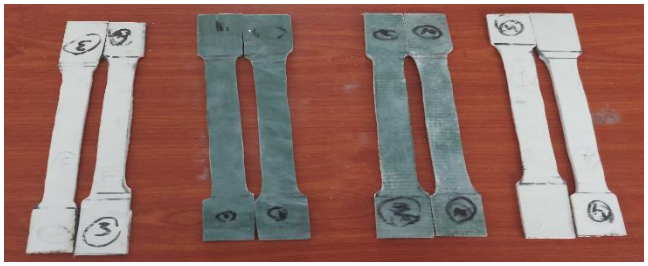
Five types of composites are prepared with different fillers are processed/ prepared using hand layup technique. The weight percentage of Epoxy, E-glass fiber, hardener and metallic fillers titanium oxide and silicon carbide are fixed and their designations are written in Table-1. Initially the filler materials in powder form are dried before mixing with the epoxy resin for the removal of moisture, before the addition of hardener the fillers are mixed with epoxy resin and it is stirred manually using a mechanical stirrer. This mixer is coated on the work side of the mold with a brush. A layer of E-glass fiber cloth is placed on it and then resin and filler mixture is coated on that E-glass fiber. To remove entrapped air and to get uniform thickness a mild steel roller is rolled on each layer of the glass sheet. This procedure is continued until the eight layer of glass fiber is placed and then laminates are cured for at least 72 hours at room temperature. The same procedure is followed to fabricate the composite without filler material

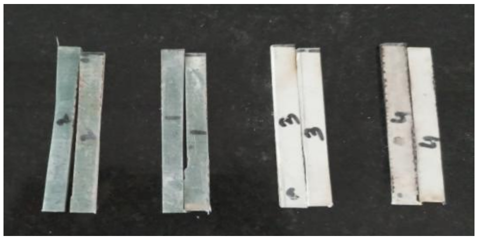
Table.1. Designation and Composition of Epoxy Composites

Designation of Composite	Composition
C1	60 wt % Epoxy + 40 wt % G.F
C2	55 wt% Epoxy + 40 wt % G.F + 5 wt % TiO2
C3	50 wt % Epoxy + 40 wt % G.F + 10 wt % TiO2
C4	55 wt% Epoxy + 40 wt % G.F + 5 wt % SiC
C5	50 wt % Epoxy + 40 wt % G.F + 10 wt % SiC

2.3 Specimen Preparation

The fabricated sheets are removed from the molds and as per ASTM standards the sheets are cut in to specimens for mechanical characterization (i.e. Tensile strength, Flexural strength, Impact strength and Hardness). The sample test specimens are shown in figure-1





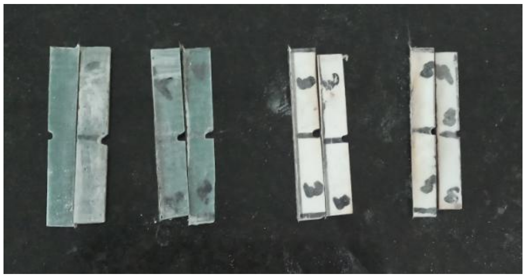


Figure.1.Tensile, Flexural and Impact test Specimens

2.4 Material Test Details

2.4.1 Tensile Strength

As per ASTM –D-638-III the dog bone type specimen with end tabs is used for tensile test. On MCS 60 UTE-60 machine tensile test was performed.

2.4.2 Flexural Strength

By using three point bend test on universal testing machine UTE-60T for the specimen of size as per ASTM D-790-2003, we can determine the flexural strength.

The flexural strength equation is

Flexural strength= $3PL/2bd^2$

Where,

P= maximum load applied on the specimen

b = width of the specimen

d=thickness of the specimen

L=span of the specimen

2.4.3 Impact strength

On Impact testing machine (Krystal Elmec) mode: K1 300 of range -168 Joules for I-20D as per ASTM D-256 impact test was done. The values of different specimens are recorded from the dial indicator of IZOD impact testing machine.

2.4.4 Hardness

By using shore hardness tester, hardness of the specimen were found for the specimen as per ASTMD 2240-2003

3. RESULTS AND DISCUSSIONS

Table.2. Mechanical properties

Designation	Tensile Strength (Mpa)	Flexural Strength (Mpa)	Impact Strength (Joules)	Hardness (shore)
C1	232.6	321.8	8	80
C2	286.8	348.6	12	86
C3	265.7	326.9	14	88
C4	246.2	471.4	16	90
C5	204.2	405.8	12	92

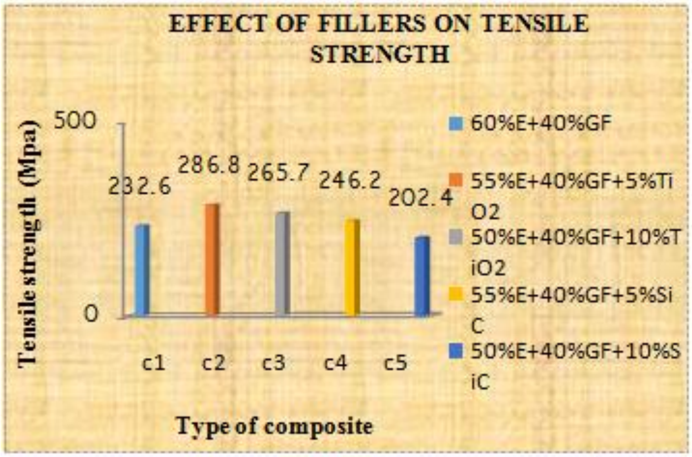


Figure.2. Graph for type of composite Vs Tensile Strength

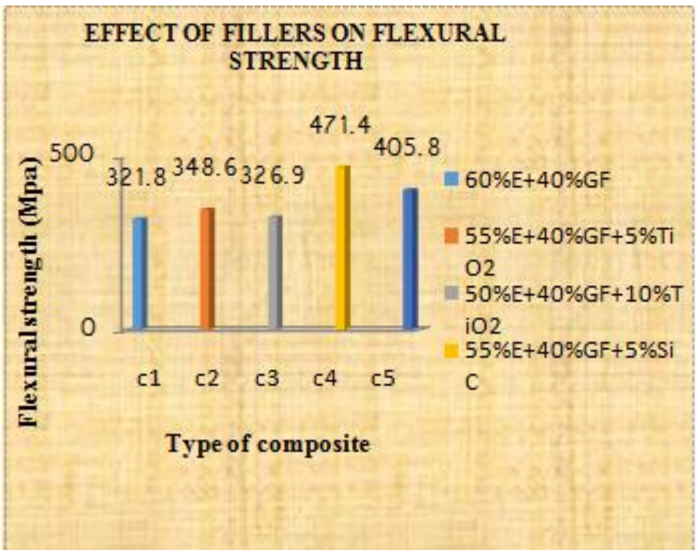


Figure.3. Graph for type of composite Vs Flexural Strength

The test results for tensile strengths are shown in fig -2. It can be seen that the tensile strength of the composite decreases with increase in filler material has strength of 232.6MPa in tension; this value drops to 204.2MPa with the addition of 10wt% of silicon powder compared to pure composite respectively. There are two reasons for dropping strength compared to filled composites to unfilled composites.

1. The interfacing adhesion is too weak to transfer the tensile stress, due to the presence of pores at interface between filler particles and the matrix.
2. The corner points of the irregular shaped particulates result in stress concentration in the matrix base the test results for flexural strengths are shown in figure-3 Graph for composites VS flexural strength. It is observed that the unfilled composites exhibited flexural strength of 321.8 Mpa which is lower than all filled composites. In this test results C4 exhibited maximum flexural strength (471.4 Mpa) compared to other filler composites duet good adhesive strength of matrix and glass fiber reinforcement. The reduction in the flexural strengths of the composites with filler content is probably caused by an incompatibility of the particulates and the epoxy matrix, leading to poor interfacial bonding. The lower values of flexural properties may also be attributed to fiber to fiber interaction, voids and dispersion problems. There are two reasons for dropping strength compared to filled composites to unfilled composites

1. The lower values of flexural strength may also be attributed to fiber to fiber interaction, voids and dispersion problems.
2. The in compatibility of the particulates and the polyester matrix, leading to poor interfacial bonding.

However, it also depends on other factors such size, shape, type and loading on filler on material

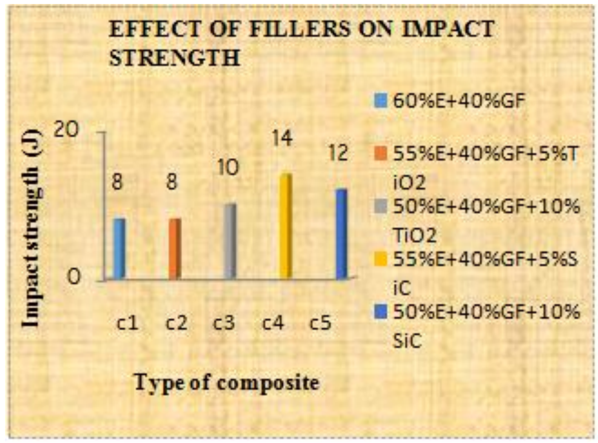


Figure.4. Graph for type of composite Vs Impact Strength

From the fig-4, the maximum impact strength was observed more in Epoxy modified composite, at 5wt% silicon carbide filled composites, than the other composites. It was found that wt% of the other fillers increases, the energy absorbed on impact decreases. The fall in those ranges are believed to be a result of inter-particle spacing which often tends to slow down the nucleation of cracks by absorbing some fraction of energy.

There can be two reasons for this decline in the impact energies of the particulate filled composites compared to unfilled ones.

1. The incompatibility of the particulates and the epoxy matrix leading to poor interfacial bonding.
2. The corner points of the irregular shaped particulates result in stress concentration in the matrix base.

The test result shows in figure-5, the effect of hardness of the hybrid composite is improved with the addition of filler materials. As far as the composite with 10wt% titanium oxide as well as Silicon carbide used as a filler material shows better hardness value compared to other composites. The increase in hardness value is may be due to the incorporation of brittle fibres in the epoxy resin.

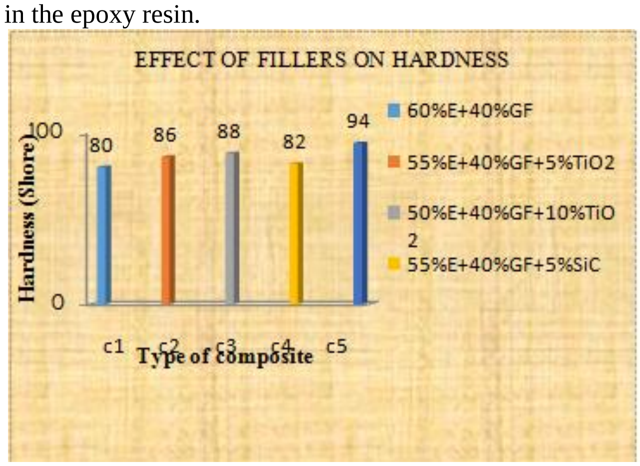


Figure .5. Graph for type of composite Vs Hardness

4. CONCLUSIONS

The experimental investigation on mechanical characterization of glass fiber reinforced epoxy based hybrid composites lead to the following conclusions:

1. Fabrication of epoxy based glass reinforced particulate filled composites has been done successfully by hand layup technique.
2. Mechanical properties like tensile strength, flexural strength, impact strength and Hardness were determined as per ASTM standards.

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