Fabrication of SiC particulate reinforced polyester matrix composite and investigation

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Abstract. Polymer composite provokes a new alternative material to engineering and domestic application. Polymeric nano composite have been intensively investigated due to the performance improvement when a small amount of nano sized particulates are added to matrix. The distinguished properties of SiC particulates influence to make a polymeric composite. This composite material has many application such as mechanical, automobile, marine, appliances and packaging. The composite material is fabricated in deferent weight ratio and it is characterized to understand the mechanical behavior, which was studied by various testing method under external load.

Keywords: dispersed, polyester, biodegradable

1. Introduction
Polyester contributes significantly to the composite as the liaison agent, which has led to bind the particulates closer. Thermosetting plastics, such as polyester resins are widely used as matrix material which distributes the stresses uniformly in all direction and it resists shocks and vibration . Polyester resin found to be the most widely used resin system, particularly in the marine industry. Thermosetting plastic systems consist of liquid mixtures of low molar mass reactants, such as monomers, which upon polymerization from highly cross linked network polymers [1, 2, 10].

The particulate filler dispersed in composite exhibits improved properties. Polymer composites fabricated so have made them possible to find major application as high strength low weight materials.

In recent years nonmetals are used as reinforcement in polymer composite, SiC particles are prospective reinforcing material for various composites. This study concerned about evaluation of mechanical properties such as tensile, flexural, compressive and impact strength for different weight ratio of SiC particulate and polyester composite. This reveals that the PMC have a potential to replace conventional material in many application.

1.1 General character of SiC and Polyester

1.1.1 Biodegradability of PMC

The synthetic polyester are among the most promising materials of environmental friendly biodegradable polymer composite. They are adding natural inorganic material like SiC.
Aliphatic polyester degrades the polyester by using bacteria. Recently Lee et al [1] reported the biodegradation of aliphatic polyester based composites under compost.

### 1.1.2 Properties of SiC

Silicon carbide was the hardest synthetic material. It has Mohs hardness rating of 9. In addition to hardness, it has fracture characteristic that make them extremely useful in abrasive wheel. Its high thermal conductivity, together with high temperature strength, low thermal expansion and resistance to chemical reaction, makes silicon carbide is valuable in the manufacture of high temperature bricks and other refractory. It is also classed as a semiconductor, having an electrical conductivity between that of metals and insulating materials [6,7]

### 1.1.3 Properties of Polyester

The density of polymer is between 1.22-1.38 g/cm$^3$. It is able to form desired shape. It can be wet or dry and still remain strong and it dries very quickly. It has resistance to stretching and wrinkling. More over polyester offers resistance to shrinking, abrasion, colorless and transparent. The other hand, when burned it gives off a strong odour. The molten residue can cause many harmful burns when it comes in contact with human skin. Polyester melts at a temperature of 249 – 288 °C [5,6,7].

## 2 Fabrication of SiC particulate reinforced polyester matrix composite

- Preparation of SiC particles
- Preparation of polyester resin
- Fabrication of PMC

### 2.1 Preparation of SiC particles

Silicon carbide is produced from quarts by carbo thermal reaction, see figure 1. A mixture of pure quarts (SiO$_2$) sand and carbon in the form of finely ground coke is built up around a carbon conductor within a refractory kiln electrical resistance type furnace. There SiC is produced by high temperature around 2700°C for 40 hours [7,8]

![Figure 1 Conversion of SiC from quartz](image)

### 2.2 Preparation of polyester

Polyester resin is prepared by condensation polymerization method. Malice acid and ethylene glycol are used to make the resin, which are diacid and dialcohol. Malice acid (C$_4$H$_6$O$_3$)
is an organic compound made from living organism. Polymerization relies on the reaction between malic acid and ethylene glycol, since the water is released during formation of polymer chain has been produced, refer the figure 2.

![Diagram of Polyester Formation](image1)

**Figure 2 Formation of Polyester**

The curing agent methyl e ethyle keton peroxide and rthe accelerator copalt napthanate are procured and measured its Ph values using the Ph meter, whose values obtained are 4.23 for resin, 7.35 for MEKP and 6.33 for copalt napthanate. Refere the figure 2.1 amd 2.2

![Figure 2.1 Resin, Accelerator, Catalyst and Releasing agent](image2)

![Figure 2.2 Checking pH value](image3)

**Figure 2.2 Checking pH value**

2.3 *Fabrication of PMC*

The PMC is prepared for different weight ratio of SiC particulates and resin. Specimen 1 is pure polyester, specimen 2 has 30% of SiC and specimen 3 has 40% of SiC refer table 1.
The composite is fabricated by in situ process and shaped into the required form as per ASTM standard for further testing. The dimension of the mould is shown in the table 2 and 3.

First the releasing agent and non binding polymer is coated on to the mould it will make the finished and cured part release easily from the mould. The gel coat polyvinyl alcohol is sprayed on to the mould and then the mixture of polyester resin and SiC is poured into the mould. Hand roller is employed to spread the material and dead weight (10 kg) is used to compact the composite and get homogeneity and flat surface. Curing time given to the product is around 4 hours. The specimen are lapped and kept in a closed container for further testing [6, 10].

In the beginning at the interfacial region, properties of the particle differ from those of the matrix. But after the passing of sometime the properties of both particulate and matrix become same. Most critical processing parameters are dispersion of clumps or agglomeration of particulates which create defect sides that will initiate failure & limit the efficiency of particulate to carry load [5].

2.3.1 Mould Preparation

For the sample preparation the first and foremost step is the preparation of the mould which has the dimension as per ASTM where the composite to be prepared.

Table 2. ASTM Standard for Specimen Preparation

| S.No | Name of Test | ASTM STD | Specimen size |
|------|--------------|----------|---------------|
|      |              |          | X (Length) | Y (Width) | t (Thickness) |
| 1    | Tensile test | D638-03  | 250        | 25        | 3            |
| 2    | Compressive test | D695 | Refer Table 4.2 |
| 3    | Flexural test | D790     | 154        | 13        | 3            |
| 4    | Impact test  | D756     | 64         | 17.7      | 3            |

Table 1 Quantity of SiC and Polyester as 30% and 40% composite

| Sample No | Mixing Of Macro Size SiC & Polymer Matrix % | Weight Of Macro Size SiC (gm) | Weight Of Polymer Matrix (gm) | Curing Time hours |
|-----------|-------------------------------------------|-------------------------------|-------------------------------|-------------------|
| 1         | 30.70                                     | 1.05                          | 2.45                          | 4                 |
| 2         | 40.60                                     | 1.40                          | 2.10                          | 4                 |
3 Testing and Investigation

After the composite specimen made to finish as standard was tested under various condition. The specimens for the mechanical testing are shown in table 4.

Table 4 Specimen for testing as per ASTM standard

| S.No | Specimen photograph | Name test       |
|------|---------------------|-----------------|
| 1    |                     | Tensile test    |
| 2    |                     | Flexural test   |
| 3    |                     | Compression test|
| 4    |                     | Impact test     |

3.1 Tensile Test

The tensile test specimen as per ASTM D368 was tested in UTN. The stress strain curve was plotted for the determination of ultimate tensile strength [3,4,6].

From the test, the tensile strength of pure polyester is 22.89 N/mm², 30% SIC and polyester composite is 12.41 N/mm² and 40% SiC is 16.41 N/mm². From this report interaction between particulates and the matrix is less under tensile load by comparing tensile strength of pure polyester refer the figure 3.1.
3.2 Compression Test

Compression test is carried out in universal testing machine. The graph is plotted between stress and strain by using the software. Figure 3.2 shows stress and strain diagram for the composite of 30\% SiC which has compressive strength of 557.72 N/mm\(^2\) and it is seen that the compressive strength of composite without SiC and 40\% SiC are 476.47 N/mm\(^2\) and 675.91 N/mm\(^2\) [3,4,6].
3.3 **Flexural Test**

Flexural test were conducted using 3-point bending method according to ASTM D7264. Flexural test was performed to study the behavior and ability of material under bending load.

The beams were suitably instrumented for measuring deflections at several locations including the midspan deflection with dial gauges and LVDTs. The flexural strength of pure polyester is 1.865 N/mm$^2$, 30% of SiC is 1.509 N/mm$^2$ and 40% of SiC is 1.304 N/mm$^2$

![Figure 3.3 Comparison of Flexural strength with test chart](image)

3.4 **Impact Test**

Impact test was performed by using Chorpy test according to the ASTM D256. This test was used to check and determine whether the material meets specific impact strength. Here the impact strength was observed 2J for all the three specimens.

![Figure 3.4 Comparison of Impact strength](image)
4 Conclusion

Interfacial region in beginning at the points of particulate and the matrix properties differ. Polymer Composite having interface size as small as in nano scale the tensile and flexural strength could be increased.

Most critical processing parameters having the ability to disperse, agglomerations of particulates which lead failure & limit the efficiency of composite to carry load.

These Materials have good compressive strength, wear resistance. Hence we can use this material for piston, impeller etc. SiC Polymer composite is one of the alternate materials for the engineering, industrial application. The polymer composite material will replace the demand for other materials like aluminum, steel etc which are going to vanish in the near future as per the statistical survey.

Based on the results obtained from this study, it is concluded that 40% of SiC and 60% of polyester is suitable for light weight and compressive load applications; also it is very good for shock absorption application. Composite properties further improved by particulate size and shape, which enhances adhesion between reinforcement and matrix.

5 References

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