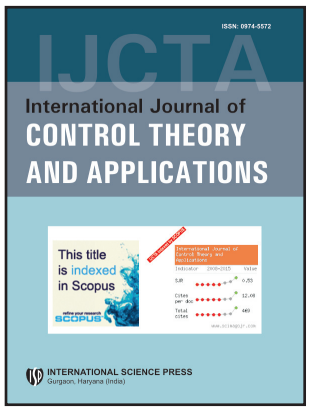

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Comparative Analysis of Micro and Nano Silicon Carbide Particulate Reinforced Polyester Composite

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Abstract: In focus to well interconnected network of both micro and nano SiC particulates with polyester matrix to fabricate the composite, the idle application in engineering. This Homogeneous nPMC exhibits stronger, more resilient, self lubrication and more damping capacity. The Nano size of the particle influences homogeneity in structure of nPMC. It reduces stress concentration, fracture failure and not lean to material failure during service where as the micro particulate composite is greater compressive strength and less tensile strength. The different size and percentage of SiC particulate polyester composite test specimen is made to test and understand the mechanical behavior such as Tensile, compressive, flexural and impact strength.

Keywords: interconnecting, interface, nPMC, synthesis, particulates

1. INTRODUCTION

The transition from micro - to Nano-silicon carbide particles influences physical property. The contact between matrix and reinforcement plays a prominent role on the nPMC. As per Kiclelbick study a crystal packing 16x16x16 atoms in a cubic structure contains 4096 atoms in that 1352 are located on the surface of the crystal which is in 33%. If it is further separated into eight equal parts the number of atoms at the surface is increased to 2368 which is numerically 58%. When repeating this procedure we get more atoms at the surface. This surface energy dominates the direct impact on material property. [8] R.A. Andrievski, who synthesis and analysis the structure and properties of Nanosized silicon carbide at 2009 and [7] Lorenzo H. Mancini prepare Nanocomposite and investigated its properties and performance.

The formation of cluster and agglomeration in the composite is formed due to vander Waal's attraction. To conquer these adopt a good production process and the new kind of technology, this controls both chemical bonding and morphology of nPMC.

The size of the nano particle may not incite stress concentration and not lean to material failure at loading condition. The factor such as surface area to volume and the size of the particle influences behavior of material in nano technology.

SiC nano particulates dispersed polyester nano composite is prepared by in situ polymerization method and it has been thoroughly studied using different characterizations techniques like physical and morphological aspects. nPMC is comparatively better than usual material. This suggests that nPMC have a prospective element to replace the material in many engineering applications [4,5,6].

2. PREPARATION OF NPMC-SILICON CARBIDE DISPERSED POLYSTYRENE NANO COMPOSITE

The polystyrene gel was prepared by addition polymerization by methyl ethyl ketone peroxide, cobalt naphthenate with polyester resin. SiC nano particulate which is prepared by high-energy planetary ball mill was added. A known quantity of SiC (1%) is separated to individual particle (Sonic Vibra cell) for 0.5 hour in separate container. A known weight of polyester is mixed with of cobalt naphthenate (accelerator) and methyl ethyl ketone peroxide as curing agent (catalysts) is stirred well to make polymer gel. Both the solutions were mixed to make the nano composite test specimen [7, 8, 9].

Table 1
pH value Gel material

Description	*pH value*
Polyester resin	4.2
Accelerator	6.33
Catalyst	7.35
Releasing agent	7.00

A pH meter measures the hydrogen – ion concentration (or PH) in a solution, indicating its acidity or alkalinity and also measures the difference in electrical potential between a pH electrode and reference electrode.

The nPMC was characterized as per size and percentage of particulate present over the matrix by mechanical testing. The materials used to prepare the resin have the pH values shown in Table 2. The test specimen were prepared as per ASTM are given in Table 2 with photograph.

Table 2
Detail of Test Specimen

S.No.	*Test*	*ASTM standard*	*Speciment size (mm)*	*Photograph*
1	Tensile test	D638-03	250 × 25 × 3	
2	Flexural test	D790	154 × 13 × 3	
3	Impact test	D256	64 × 14 × 3	
4	Compression test	D695	75 × 10 × 2	

3. TESTING AND NVESTIGATION

3.1. Tensile Test

The tensile test specimen (Figure 1) according to ASTM D 368 was mounted in universal testing machine to find the tensile strength. The stress strain curve was plotted for the determination of ultimate tensile strength.

From the test, the tensile strength of pure polyester is 22.89 N/mm^2. The composite having 30% of micro sized silicon carbide is 12.41 N/mm^2. The specimens have 40 % of micro sized SiC is 16.21 N/mm^2 The polyester with 30% nano sized SiC is 106 N/mm^2.

Figure 1: Tensile test specimen (polyester with 30% nano sized SiC) after tested.

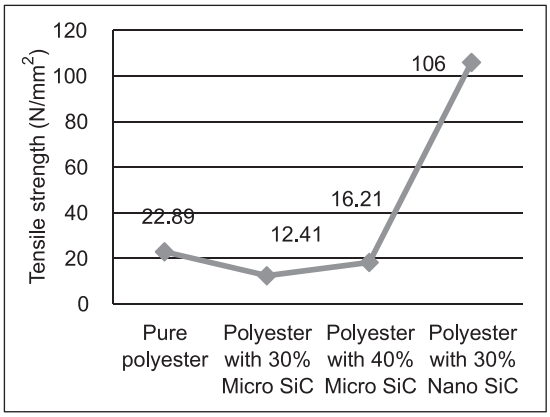

Chart 1: Tensile strength of polyester matrix composite in perspective of SiC particulate

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 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. The polyester with 30% nano sized SiC is 515.5 N/mm^2. [4, 6].

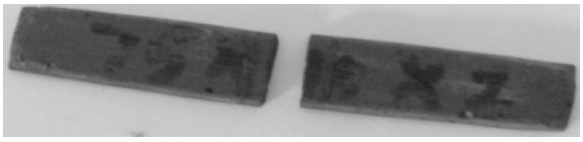

Figure 2: Compressive test specimen (polyester with 30% nano sized SiC) after tested

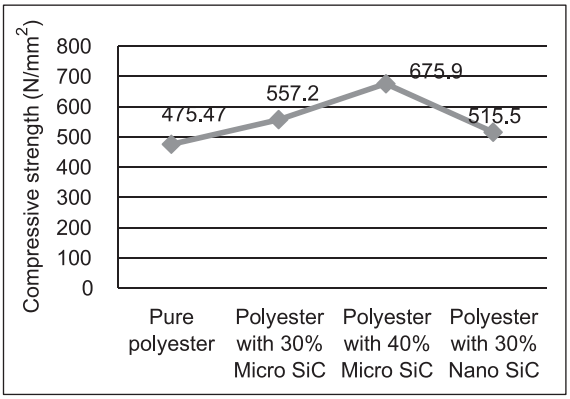

Chart 2: Compressive strength of polyester matrix composite in perspective of SiC particulate

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 load was applied to the specimen until it is totally broken.

The beams were suitably instrumented for measuring deflections including the mid span deflection with dial gauges and LVDTs. The flexural strength of pure polyester is 1.62 N/mm^2, 30% of SiC is 1.25 N/mm^2 and 40% of Sic is 1.92 N/mm^2. The polyester with 30% nano sized SiC is 12.3 N/mm^2 [1, 9, 10].

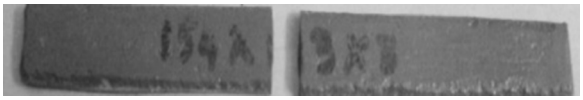

Figure 3: Flexural test specimen (polyester with 30% nano sized SiC) after tested

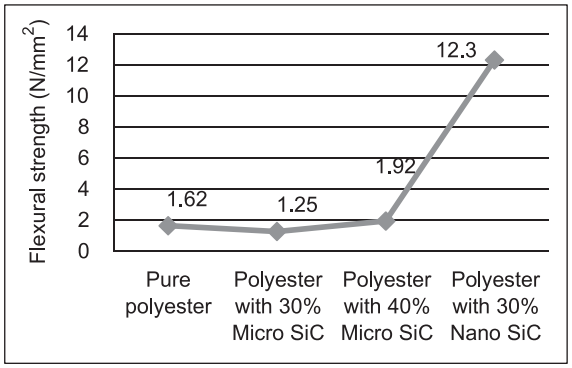

Chart 3: Flexural strength of polyester matrix composite in perspective of SiC particulate

3.4. Impact Test

Impact test was performed by using Chorpy test according to the ASTM D256. The specimen is placed horizontally in the test bed. When the pendulum is allowed to swing and break the specimen. This test can be used to check and determine the impact strength of material. Here the impact strength is 2J for all the three specimens except n PMC. The polyester with 30% nano sized SiC is 29 J [1, 9, 10].

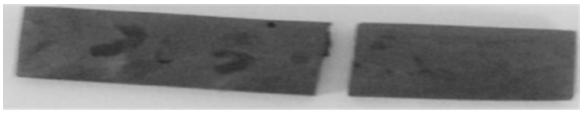

Figure 4: Impact test specimen (polyester with 30% nano sized SiC) after tested

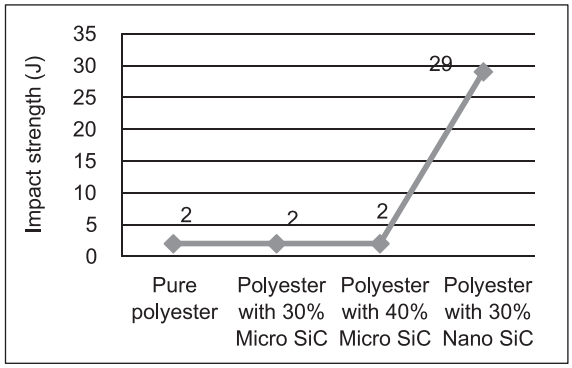

Chart 4: Impact strength of polyester matrix composite in perspective of SiC particulate

3.5. Scanning Electron Microscope Analysis

Scanning electron microscopy was used to assess the morphological changes of certain phases in the nPMC. The observation in the fresh as well as nano structured silicon carbide particles in the polyester nano composite is made.

The picture was magnified the image 1 micron to 60000 times larger. There are 75% uniform particle distribution was observed. The dark region indicates the particle rich and the white shows the resin rich location [2, 9, 10].

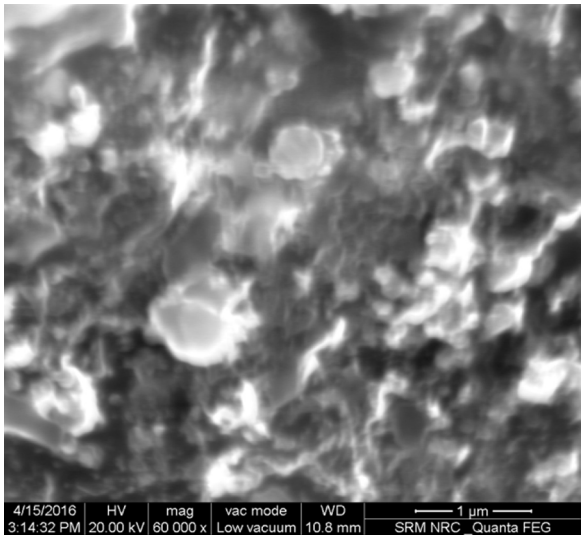

Figure 5: SEM image of nPMC specimen (polyester with 30% nano sized SiC) at fractured area

3.6. X-ray diffraction pattern of SiC nano particulate

X-ray diffraction is a multipurpose and non-destructive technique used for identification of the crystalline phases present in solid materials and for analyzing structural properties of the phases such as stress, grain size, phase composition, crystal orientation and defects. From the chart 3.5, the diffraction peak were centered at the angle taken from *x* axis is 35°, 60°, 72°.

The pattern were confirmed the continuation of SiC nano particles. SiC is naturally non amorphous and therefore the sharp peaks present in the X-RD pattern. The average crystallite size was estimated from the intensity of the X-RD using the Scherer's equation [8]: $D = 0.89\ \lambda/\beta \cos\theta$ where D is the average diameter of the crystals in angstroms. When the peak at $2\theta = 35°$ was selected for calculating the average diameter. The average diameter size of the SiC crystal was obtained as around 70 nm [2, 9, 10].

4. RESULT AND DISCUSSION

Interfacial region of particulate and the matrix properties differ thus it is proved by the various mechanical test such as tensile, compressive, flexural and impact. When the contacting surface of particle is increased the matrix material such as polyester will interact more with the particles. Polymer composite having the particulate with more surface energy as in nano scales the tensile and flexural strength was be increased. Most critical processing parameters having the capability to distribute the particulates in uniform and agglomerations of particulates which lead failure & limit the efficiency of composite which can be eliminate by adding Tulane when synthesizing the nano particulates.

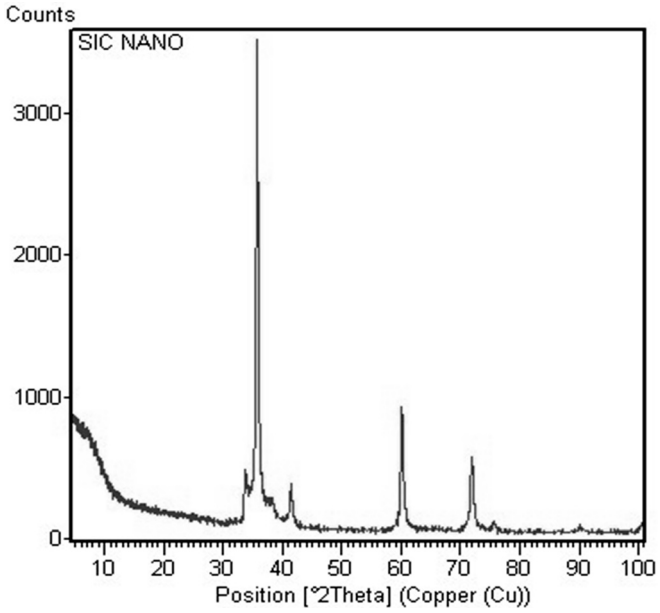

Chart 5: X-RD analysis of SiC nano particulate

The nPMC have good tensile, flexural and impact strength. Hence we can use this material for piston, impeller etc. SiC Polymer composite is one of the alternate materials for the engineering, industrial application.

Based on the results obtained from this study, it is concluded that 30% of nano SiC and polyester composite is suitable for light weight high strength applications; also it is very good for shock absorption application. Composite properties further can be improved by particulate size and the processing method.

In X-RD picture shown in figure 3.6 the peek and valleys represent the crystal structure of SiC particulates. nPMC is shown in figure 3.5 the spectrum of the nano composite indicates that major dark are associated with reinforcement. The magnified picture of polyester and SiC evidently indicate the formation of composite and thus the nPMC is chemically homogeneous, transparent and well dispersed.

5. CONCLUSION

This material has good strength and low weight; hence we can use this material for modern engineering application. Nano polymer matrix composite is one of the alternate materials for the engineering, industrial application.

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