

Mechanical Testing of Plastoceramic (nPMC Sheet- SiC Reinforced Polyester Nano Composite)

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Abstract

Concept of nano-composite Technology has gained greater momentum in its recent engineering applications. Recent works on Nano-composite technology have proved the viability of its use and its importance in modern engineering fields of applications particularly in the field of materials and manufacture. When dissimilar materials are used with different compositions to obtain newer nano-composite materials, it has led to the production of novel products with unique properties. In the present study, the ceramic material SiC is used as reinforcement owing to its superior properties such as hardness, thermal conductivity and strength. And this has paved the way for using it in the making of polyester nano-composite sheet (nPMC) with aforementioned properties. Fabrication and characterization of Nano-composite sheet is carried out using a weight ratio of 30% so as to understand the molecular structure and mechanical behavior under external load. The synthetic procedure and characterization used in this study has made it possible to obtain SiC nano particles reinforced polyester nano-composites (nPMC) film with good thermal strength and chemical homogeneity over the traditional composite.

Keywords: Nano particulates, Nano composites film, polystyrene, nPMC

1. Introduction

Significant characteristics possessed by Nanocomposite materials have prompted researchers to go for its investigation. As Ceramic material dispersed in polymer nanocomposites exhibit interesting properties, extensive studies have been made in order to derive its usefulness in different areas of applications. The change over from micro - to Nano-silicon carbide particles has its impacts on physical property. The contact between matrix and reinforcement plays a predominant role on the nPMC.

According to Kicelbick, a crystal packing 16x16x16 atoms in a cubic structure contains 4096 atoms. Out of it, 1352 are located on the surface of the crystal which amounts to 33% of the total. When it is further separated into eight equal parts, the percentage of atoms present at the surface increased to 58%. This number increases significantly when the procedure is repeated. This surface energy causes the direct impact on material property. Different characterization techniques like tensile, compressive, flexural, impact, hardness, wear resistance and water absorption tests etc. are employed in order to study the characteristics nPMC sheet. The specific properties of the SiC nano particulate composite sheet were in some cases better than conventional composite.

The mechanical properties are analyzed and the optimum Polyester nano composite film found. Biodegradation of polyester is accomplished by adding some kind of bacteria which degrade them by producing enzymes. And by adding natural material like SiC the polymer based nano-composites is changed into compost.

1.1 Basic Properties of Polyester and Silicon Carbide and their Applications

Polyesters are in general heat-resistant, Light weight & high strength materials which find their applications in electrical package on account of their conductive barrier properties. Being corrosion resistant, they are used as coating for structure. The other applications are electro-magnetic field shielding and selective photo sensitivity, etc. Similarly silicon carbide has reasonable Thermal Conductivity, considerable Hardness, and Specific Gravity. Their Common applications incorporate metal lapping and cleaning, shake and stone cleaning, granulating of nonferrous materials, fortified grating instrument applications and glass drawing and glass cutting industries[1,3].

2. Methodology of Preparation of Silicon Carbide (SiC) Dispersed Polyester Nano Composite Film

- i. SiC nano particle preparation
- ii. Polyester Preparation
- iii. Polyester / SiC nano particle processing (Mixing)
- iv. Moulding and curing

2.1 SiC Nano Particle Preparation

Silicon carbide (SiC) powder utilized for this examination has an underlying molecule size of 12 μm . The molecule size of SiC is diminished from micron level to the nano level by utilizing a high-vitality planetary ball process.

The aggregate length of processing was 10 hours. The revolution speed of the planet bearer was 200 rpm. The ball process was stacked with ball to powder weight proportion (BPR) of 10:1. Toluene was utilized as the medium with an anionic surface dynamic operator to maintain a strategic distance from agglomeration. The processed example powder was taken out at a consistent interim of like clockwork of processing and dried with mechanical drier.



Fig. 2.1: a) transformation SiC nano particulates from Quarts ore

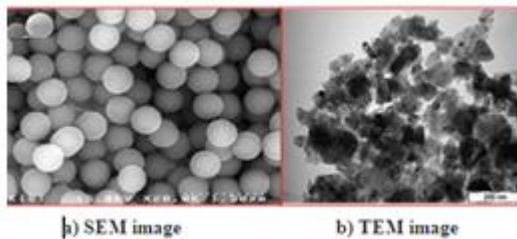


Fig. 2.1: b) TEM and SEM images of SiC

Examining electron microscopy is utilized so as to assess the morphological investigations of certain nano organized silicon carbide particles. The transmission electron magnifying instrument (TEM) is utilized to ascertain the correct structure of nano molecule by utilizing high determination attractive focal point.

2.2 Polyester Preparation

Polyester resins are formed by the condensation polymerization of diacid and a dialcohol. Diacid means presence of two organic acid groups and Dialcohol two alcohol groups in a molecule. Here Maleic acid is used as diacid and ethylene glycol as dialcohol. The ingredients taken as acid value 23 to 27 mg koH /gm and Gel time 10 to 20 min. Methyl Ethyl Ketone Peroxide is used as Curing agent (catalysts) and Cobalt Naphthenate is accelerators of Polyester resin. Polyester resin curing time is approximately 4 hours based on catalysts mixing ratio. Figure 2.2 shows the formation of polyester where R indicates the group of hydro carbon.

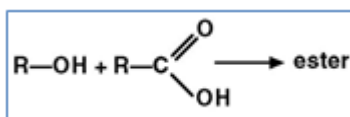


Figure 2.2: Formation polyester

2.3 Polystyrene / SiC Nano Particle Processing (Mixing)

There are three sorts of general ways:

1. Direct blending of polymer and nano particles either as discrete stages or in arrangement.
2. In-situ polymerization within the sight of nano particles.
3. Both in-situ developments of nano particles and half and half nano composites because of cozy blending of two particles

2.3.1 In-Situ Polymerization

Nano scale particles are scattered in the monomer or monomer arrangement. Coming about blend is polymerized by standard polymerization strategies. Potential to join the polymer onto the molecule surface is high. Scattering is simpler since it is in fluid frame instead of in a thick dissolve. Settling process is more fast.

2.3.2 Interfacial Area

Interfacial area starts at the point in the particulate/fiber at which the properties vary. The properties wind up parallel at the point where the filler and grid met. Interfacial district can be changed through polymer chain portability and crystalline. Interface estimate shifts from as little as 2 nm to 50 nm. The handling of nano particulate/polymer composites is still in its earliest stages. Huge issues have emerged when the handling of nano particulate/polymer composites is expert particularly amid its refinement, scattering and mass preparing. Most critical processing parameters such as ability to disperse and clumps or agglomerations of nano particulates creates defective sites which will initiate failure and consequently limit the performance of polymer nano composite.

A transparent film formation takes place. This film is detached from glass slide by using polar solvent such as distilled water. A uniform SiC dispersed polystyrene nano composite film was obtained. The Nano composites film was then characterized for structural morphology, thermal and other behavior.

3. Preparation of nPMC - Silicon Carbide Dispersed Polystyrene Nano Composite

A known weight of polyester is blended with cobalt naphthenate (quickenning agent) and methyl ethyl ketone peroxide the restoring specialist (impetuses) and the blender is mixed well to influence polymer to gel. SiC nano particulate prepared was added to it and mixed to make the nano composite test specimen[7,8,9].



Fig. 3.1: Silicon carbide dispersed polystyrene nano composite sheet

The characterization of nPMC was accomplished 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 as shown in table 2.2. The test specimen prepared as per ASTM are given in table 2.2 with photograph.

4. Testing and Investigation

4.1 Tensile Test

The tensile test specimen (Figure 4.1) according to ASTM D 368 was mounted in universal testing machine to find the tensile

strength. The pressure strain bend was plotted for the assurance of extreme rigidity.

From the test, it is inferred that the polyester with 30% nano sized SiC has a tensile strength of 106 N/mm^2 .



Fig. 4.1: Tensile test specimen (polyester with 30% nano sized SiC) after tested

4.2 Compression Test

Pressure test is completed in all inclusive testing machine. The diagram is plotted amongst anxiety by utilizing the product. It is found that the polyester with 30% nano sized SiC has a compressive strength of 515.5 N/mm^2 . [4,6].



Fig. 4.2: Compressive test specimen (polyester with 30% nano sized SiC) after tested

4.3 Flexural Test

Flexural tests were directed utilizing 3-point bowing technique as per ASTM D7264 with a view to ponder the conduct and capacity of material under bowing burden. The heap was connected to the example until the point when it is completely broken.

The beams with suitable instrumentations such as dial gauges and LVDTs were used for measuring deflections at various points of the beam.



Fig. 4.3: Flexural test specimen (polyester with 30% nano sized SiC) after tested

4.4 Impact Test

Impact test was performed by using Charpy 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. The polyester with 30% nano sized SiC the impact strength is found to be 29 J [1,9,10].



Fig. 4.4: Impact test specimen (polyester with 30% nano sized SiC) after tested

4.5 Scanning Electron Microscope Analysis:

The morphological changes of specific stages in the nPMC were evaluated by Scanning electron microscopy. The perceptions were made in the crisp and in addition in the polyester nano composite with nano organized silicon carbide particles. The picture was magnified with a magnification factor of 60000X. Polyester nano composite with 75% uniform particle distribution was observed. The dark region indicates the particle rich locations and the white shows the resin rich locations [2,9,10].

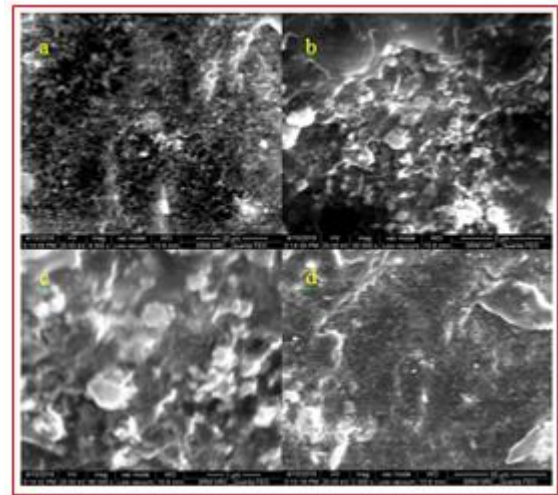


Fig. 4.2: SEM image of nPMC

4.6 X-Ray Diffraction Pattern of Sic Nano Particulate

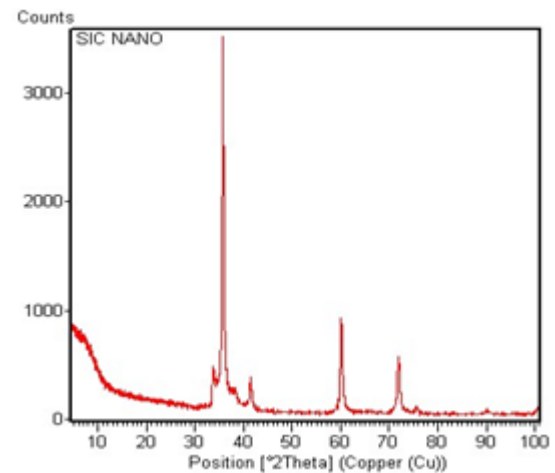


Chart 4.1: X-RD analysis of SiC nano particulate

X-beam diffraction is a non-damaging system performed for recognizable proof of the crystalline stages show in strong materials and for investigating auxiliary properties of the stages, for example, push, grain measure, stage arrangement, precious stone introduction and imperfections. From the graph 3.1, the diffraction tops were focused at the points specifically 35° , 60° , 72° taken from x hub.

The examples have affirmed the nearness of coherence of SiC nano particles. As SiC is normally non indistinct, sharp pinnacles are available in the X-RD design. The normal crystallite measure was assessed from the power of the X-RD utilizing the Scherer's condition [8]

5. Result and Discussion

At the Interfacial region of particulates and the matrix of polyester nano composites differ in their properties. And it is proved by conducting various mechanical tests such as tensile, compressive, and flexural and impact tests. When the contacting surface of particles is increased, the matrix material such as polyester will interact more with the particles. Polymer composites with particulates have more surface vitality and subsequently they have expanded malleable and flexural quality. Most basic handling parameter is to have the capacity for uniform conveyance and agglomerations of particulates lacking of which will prompt disappointment and will constrain the effectiveness of composite.

And this problem can be eliminated by adding Tulane when synthesizing the nano particulates.

Table 5.1: Mechanical properties of nPMC

S.No	Tensile Strength (N/mm ²)	Compressive Strength (N/mm ²)	Flexural Strength (N/mm ²)	Impact Strength (J/m)	Hardness HRB	Water absorption (%)
1	106	515.5	12.3	29	75	.001

The nPMC have great malleable, flexural and affect quality. Thus we can utilize this material for the produce of cylinder, impeller and so on. SiC Polymer composite is one of the substitute materials for the designing, modern applications. In light of the outcomes acquired from this examination, it is inferred that 30% of nano SiC and polyester composite is appropriate for light weight high quality applications; likewise it is useful for stun ingestion application. Composite properties further can be enhanced by particulate size and the handling strategy. In X-RD picture shown in figure 3.6 the peak 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.

6. Conclusion

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

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