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Fabrication and characterization of silane surface treated nano zno/ vinyl ester nanocomposites

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ABSTRACT

A composite material is made by combining two or more materials to give an unique combination of properties. Composites based on a polymer matrix have become more common and are widely used in many industries due to the advantageous properties offered by the polymers. Filling polymers with mineral dispersion has long been a practice in the plastic industry as a way to reduce overall production costs and enhance certain properties. Polymer Matrix Composites were prepared by blending vinyl ester resin with silane surface treated ZnO nanoparticles of various weight percentages. They were characterized by Fourier Transform Infrared Spectroscopy, Scanning Electron Microscopy, and TGA-DTA. Measurement of mechanical properties like Tensile strength, impact strength, flexural Strength, hardness and physical properties like water absorption, density, specific gravity, etc. have been carried out. The effect of particle size, particle distribution on mechanical properties, thermal properties and physical properties has also been studied. The changes in the properties of the composites with and without coupling agent have been compared. The results of the studies reveal that surface treated composites found to have nice improvement in overall properties than the untreated one.

KEYWORDS

Nano composites;
Polyester;
Silane coupling agent;
Mechanical properties.

INTRODUCTION

Polymer nanocomposites have been paid much attention by researchers for more than a decade since their unique properties like good mechanical strength, light weight, good thermal stability and superior electrical properties. Such properties have made the composites to extend their applications to a wide range viz. medicine, aerospace, construction, automobile, electronics, communication, etc. So Polymer nanocomposites represent a new alternative to conventionally filled polymers.

Polymer nanocomposites are materials in which nanoscopic inorganic particles, typically 1-100 nm in at least one dimension are reinforced in an organic polymer matrix. Because of their nanometre sizes, filler dispersed nanocomposites exhibit markedly improved properties when compared to the pure polymers or their traditional composites. These include increased modulus and strength, outstanding barrier properties,

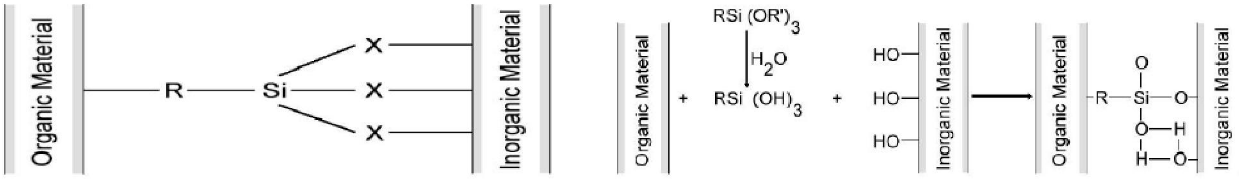


Figure 1 : Coupling mechanism of nanoparticles by organic silane

improved solvent and heat resistance and decreased flammability. In this work, general purpose unsaturated polyester resin was used as polymer matrix and Zinc Oxide nanoparticles were used as reinforcement. Unsaturated polyester resins are the most commonly used thermoset resins in the world. More than 2 million tonnes of unsaturated polyester resins are utilised globally for the manufacture of a wide assortment of products, including sanitary-ware, pipes, tanks, gratings and high performance components for the marine and automotive industry.

Unsaturated polyester resins are produced by chemical reaction of saturated and unsaturated dicarboxylic acids or anhydride with alcohols. The resin used in this work was made from maleic anhydride, ortho phthalic acid and propylene glycol and premixed with styrene monomer (30% by weight). The curing process of polyester resin involves crosslinking of resin backbone through the styrene monomer. Crosslinking of styrene monomer occurs through the –C=C- bond of the resin backbone. The number of this group in the main chain determines the properties of the product. Methyl Ethyl Ketone Peroxide (MEKP) is used as catalyst and Cobalt Naphthenate is as accelerator.

When Zinc Oxide nano particles are blended with unsaturated polyester resin, it reduces the interfacial adhesion of the finished product since they are bonded physically with the resin. Hencethe properties of the finished product may deteriorate. But when the surface treated zinc oxide blended with polyester resin, it enhances the properties of the finished product. Generally, organic silanes are used as coupling agent, which bridges nanoparticles and the resin by means of chemical bond as shown below:

EXPERIMENTAL

Materials

Generalpurpose unsaturated polyester resin (Ortho), Methyl ethyl ketone peroxide catalyst and Cobalt naphthenate accelerator were received from M/s. Vasavibala Resins, Chennai, India and used as received without any further purification. Zinc oxide nanoparticles of <90 nm (Sigma Aldrich, India) also were used as such without any further purification.

Preparation of nanocomposites

Nanocomposites, in the form sheets, were prepared by blending various % by weight ratio of nano zinc oxide (0.0, 0.5, 1.0, and 1.5) with Unsaturatedpolyester resin (UPE). To these mixtures, 1 % by weight of Methyl Ethyl Ketone Peroxide (MEKP) and 0.5% by weight of cobalt naphthenate were added. The mixtures were casted into sheets by resin transfer moulding and allowed to cure in atmospheric air for 72 hours. Another set composite were prepared by blending surface treated nano zinc oxide with UPE resin following the same procedure.γ-Amino propyl trimethoxysilane was used as coupling agent in the surface treatment of nano Zinc oxide. Polymer Nano Composites containing nano zinc oxide treated with 1%, 2% and 3% by volumeof γ-Amino propyl trimethoxysilane in ethanol. The composites were cut into required dimensions as per ASTM standard and were characterized.

Characterization

The composites so prepared were characterized by various techniques such as Fourier Transform Infrared Spectroscopy, Scanning Electron Microscopy, Thermal analysis like TGA and DTA and mechanical characterization.

RESULTS AND DISCUSSION

Mechanical properties

TABLE 1 shows the results of characterization

TABLE 1 : Mechanical properties of ZnO (untreated)/UPE composites

Sample	UPE Resin (%)	Zinc Oxide (%)	Mechanical Properties			
			Tensile Strength (MPa)	Impact Strength (KJ/m^2)	Flexural Strength (MPa)	% Elongation at Break
GPZO – 00	100	0	44.05	4.27	75.08	1.8
GPZO - 05	99.5	0.5	43.68	3.46	72.85	1.2
GPZO - 10	99	1	39.32	3.79	71.65	1.1
GPZO - 15	98.5	1.5	38.13	2.79	66.28	1.1

TABLE 2 : Mechanical properties ZnO (surface treated)/UPE composites

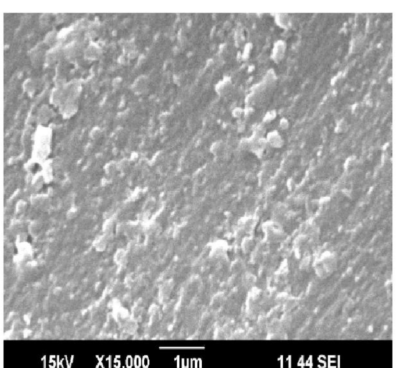
Sample	Zinc Oxide (%)	% by volume of APTMS	Mechanical Properties		
			Tensile Strength (MPa)	Impact Strength (KJ/m^2)	Flexural Strength (MPa)
GZC – 00	0	0	44.05	4.27	75.08
GZC - 10	1 (UT)	0	39.32	3.79	71.65
GZC - 10	1	1	44.08	5.02	79.24
GZC - 20	1	2	48.69	5.63	81.08
GZC - 30	1	3	51.24	6.32	82.14

of mechanical properties of ZnO (Untreated)/UPE composites. The trend shows that a gradual decrease of tensile strength, impact strength and flexural strength have occurred as the percentage of nano filler is increased. This is due to the fact that the incorporation of fillers reduces the interfacial adhesion and extent of crosslinking in the polymeric network.

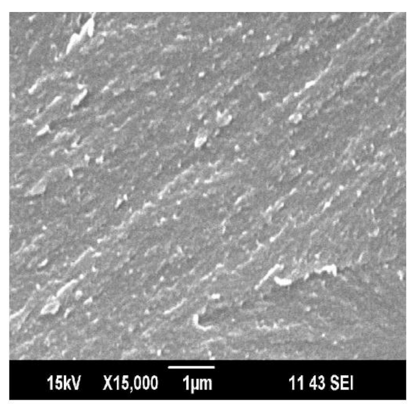
TABLE 2 shows the results of characterization of mechanical properties of ZnO (Suface treated)/ UPE composites. The results reveal thatthere is an appreciable enhancement in the tensile strength, impact strength and flexural strength of surface treated ZnO/UPE composites when compared to surface untreated ZnO/UPE composites. This is attributed by the fact that the incorporation of surface treated filler enhances the interfacial adhesion by forming chemical bonds with polymeric network.

Scanning electron microscope

The SEM image of tensile fractured UPE / ZnO composites are shown above. The particle size of the fillers and its distribution in the polymer matrix is the main key aspect of the mechanical strength of polymer matrix composite. When compared to SEM image of surface untreated ZnO / UPE composite that of treated ZnO/UPE composite, the later has uniform particle distribution and hence smooth surface which is the main reason for the enhancement of mechanical strength.



SEM image of UPE / ZnO Untreated Composite



SEM image of UPE / ZnOSurface treated Composite

CONCLUSIONS

In this work, a set of APTMS coupled ZnO / Unsaturated Polyester resin composites were prepared with various concentration of coupling agent. The mechanical properties of such composites were compared with that of surface untreated ZnO/UPE composites. From the experimental observations, it was found that APTMS coupled ZnO/UPE composites have better mechanical strength than the untreated ZnO/UPE composites.

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