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A Review on Ceria Epoxy Nanocomposites with a New Research Proposal

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Abstract: *This study deals with reviewof mechanical properties of epoxy matrix using Nano ceria (ceo_2) as filler in metal oxide epoxy Nano composites. Effect of varying wt. % of ceria filler on mechanical properties of epoxy matrix was studied.Flexural strength,Compressive strength,Vickers micro-hardness and Density were studied for varying wt % of ceria filler. As the wt. % of ceria is increased, the mechanical properties showed improvement till a maximum value and then, these properties decreased with further increase Nano filler content. However,density continued to increase with increase in wt % of ceria,compared with commercial ceria filled composites, the composites made with, morphology-controlled ceria show a higher impact strength. This paper also presents a new research proposal for future study.*

Keywords: *Nano ceria particles, Ceria epoxy Nano composites, Mechanical properties.*

I. Introduction

In recent years metal oxide epoxy Nano composites have been an active area of research due to their enhanced mechanical properties. Ceriais having wide range of applications including catalysis[1],bio-medicine[2], fuel cell[3],sensor[4],mechanical properties[5] in rocket motors and energy formuations[6].however,the mechanical properties of Nano ceria are known to be different from the parent (bulk) material[8].It is well know that structure play a pivotal role in with respect to mechanical properties[9] . Suresh and li acknowledge that a lack of understanding of the deformation mechanisms that operate in ultra strong materials severely limits one's ability to create nanomaterials with the desired mechanical properties[10]. Epoxy resins are well established thermosetting matrices of advanced composites, displaying a series of interesting properties like good stiffness and specific strength, dimensional stability, chemical resistance, ease of processing and strong adhesion to the embedded reinforcement[11, 12]

Incorporating Nano particles of metal oxide can significantly improve the mechanical properties of host matrix by getting uniformly embedded in the thoroughly cross linked chains of the thermoset polymer[13-15] .Metal oxide nanoparticles possess high surface to volume ratio which increases interfacial interaction between Nano-filler and host epoxy matrix, thus better adhesion between matrix and filler is obtained. These nanoparticles present good wettability with the thermoset polymer and fill in the small gaps between cross-linked polymer chains providing the chains with high resistance to deform under stress. Nanoparticles filler can reduce thermal expansion coefficient and increase thermal and wear resistance of epoxy resin. By uniformly distributing these fillers in epoxy resin, the reinforcement material can impart superior mechanical properties to every region of the host matrix in a uniform manner[16, 17].

Fabrication Of Polymer Nano Composite:

Nano ceria filler was added to epoxy resin and stirred manually in a beaker using a glass rod followed by sonication. Sonication of the mixture was done by using ear probe-type ultrasonic processor at 20 kHz frequency for duration of 15 minutes. Sonicated mixture was cooled and polyamine hardener was added. The mixture poured in moulds and cured at room temperature for 48 hrs[18].The resin to hardener weight ratio is 10:1.
Ceria nanostructures with various shapes and size such as Nano rod,nanotubes and Nano plates were prepared,is used to synthesize ceria epoxy Nano composites by using ethanol dispersion.
The different ceria nanostructures were dispersed in ethanol with various solid contents before adding the epoxy resin and the mixture was ultra-sonicated for 1 hour at 60^o c and 80^o c respectively. The mixture was then degased at 80^o c for 5 hours to eliminate the entrapped air and the residual ethanol .the stoichiometric amount of into the mixture. The composite was molded and cured at 50^o c for 12 hours.

Characterisation:

The powder XRD patterns of Nano ceria samplesand composites were obtained by X-ray diffract-meter. The surface morphology of the powder and composites was examined using TEM, SEM, FTIR spectra. The mechanical properties flexural test, compression test, micro hardness test, density test and impact strength are studied for the composites with various ceria contents.

It is obvious that all the composites have improved impact strength. The reduction of impact strength at higher ceria content might be due to presence of agglomerates of nanoparticles. The agglomerates constitute weak points that break fairly easily when force is applied. In addition, the high solid content of nanoparticles in the epoxy resin leads to too much plastic deformation and crack propagation, which also tempers the improved impact strength of the composites. All ceria nanoparticles show better performance than commercial ceria because they have more contact area with epoxy resin at the same particle loading and also because more interaction forces can occur, such as hydrogen bonding and VanderWaal's interaction.

II. Results And Discussion

According to Xiaoping he et al, (2011), by introducing ceria nanoparticles with controlled shapes and sizes into epoxy resin, the enhancement in impact strength of the composite was achieved. The ceria Nano rods/epoxy Nano composites showed the highest impact strength up to 17.27 kJ/m^2.which is about four times that of the neat epoxy resin, due to their special one-dimensional nanostructure. These epoxy Nano composite materials possess good mechanical performance and might be potentially applied in various fields [19].

According to siddhant data et al (2012),Nano ceria reinforcement synthesized by combustion method significantly improved the mechanical properties of epoxy matrix.42.6% increase in compressive strength,42% increase in flexural strength and 29% increase in micro hardness suggest that this Nano ceria reinforced epoxy can be used as host matrix for fabricating better FRPS(FILTER REINFORCED PLASTICS) Enhancement of mechanical properties uniformly throughout the polymer composite slabs at filler content lower than 1 wt.% suggests that sonication process successfully dispersed the Nano ceria particles in the resin matrix. Negligible increase in density was observed when filler content increased from 0 to 3 wt%. Since low Nano ceria content is needed to achieve this improvement in properties, there is scope of accommodating additional reinforcement materials.e.g: carbon fiber, glass fiber, carbon nanotubes, into the epoxy host matrix[18].

According to K.S.Harishanand et al (2013) metal oxides such as ZnO, ZrO2 and CeO_2 are the excellent Nano fillers; that can improve density and mechanical properties of neat epoxy metal oxide filler addition shows significant improvement in tensile and flexural properties only at certain content (up to 1 wt.%).Compressive strength of the metal oxide/epoxy Nano compositesshowed improved results up to 0.5 wt. % and no significant improvement with additional wt%.Negligible increase in density was observed when filler content increased from 0 to 3 wt%[20].

New Proposal:

Hybrid Nano composites containing more than one (ZnO,ZrO_2 and CeO_2)Nano-particles of different proportions in epoxy will be developed.Further studies are being conducted to study the exact morphology and properties of the formed Hybrid Nano composites. Especially more than one metal oxide based epoxy composites will show good results in mechanical,chemical and electrical properties and hence preferred for all practical applications.

New Scheme:

The new scheme for the hybrid Nano composites containing more than one (ZnO, ZrO2 and CeO) nanoparticles of different proportions in epoxy is given as follows

Hardener: Acid Anhydride
Epoxy Resin: Diglycidyl Ether Of Bisphenol-A
Mould Dimension: 10x8x1.5 Cm
Resin To Hardener Ratio:10:1

Future Scope: Since low nanoparticles in the resin is needed to achieve the mechanical properties there is a scope of accommodatingadditional reinforcement materials like carbon fiber, glass fiber, carbon nanotubes, glass wool, jute fiber, coconut coir fiber in the epoxy matrix.

III. Conclusion

Metal oxide have immense scope on the fabrication of Nano filler reinforced polymer composites having vast number of industrial applications .Especially CeO_2 based epoxy composites showed good chemical ,mechanical and electrical properties in all tested properties and hence preferred for all practical applications. To

enhance the mechanical properties further we are planned to go for hybrid Nano composites containing more than one metal oxide.

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