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RESEARCH ARTICLE

Mechanical Properties of Epoxy Nanocomposite

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Abstract

Depending on the specific characteristics of polymers, it has found a wide range of engineering applications at the present time. With the growth of Nano technology increased importance of polymers in industry, as it combines the lightweight and high mechanical properties, which qualifies it for use in high performance applications. Current research aims to study the mechanical behavior of epoxy resin reinforces by alumina nanoparticles (10nm) and alumina microparticles (10µm) with a weight fraction (0-40 %) ,and these properties were included: compressive strength ,flexural strength, and elastic modulus. The results showed an improvement in mechanical properties of epoxy after reinforcement by alumina (nano and micro),where these properties will increase with an increase in the proportion of reinforcements. But the improvement in mechanical characteristics of epoxy was better in the case of reinforced by nanoparticles ,due to the high surface to volume ratio of the nanoparticles and/or its exceptionally high aspect ratio.

INTRODUCTION

We can define Nanocomposite as a multiphase solid material where one of these phases has one or more dimensions of nano-scale less than 100 nm [1]. This definition can be more comprehensive as it also includes each of porous media, colloids, gels and copolymers, but is more usually taken to mean the solid combination of a bulk matrix and nano dimensional phase differing in properties due to dissimilarities in structure and chemistry[2-6]. The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the nanocomposite will differ markedly from that of the component materials [7-9]. Size limits for these effects have been proposed, less than 5 nm for catalytic activity, less than 20 nm for making a hard magnetic material soft, less than 50 nm for refractive index changes, and less than 100 nm for achieving superparamagnetism, mechanical strengthening or restricting matrix dislocation movement[10].The preeminent mechanical properties of nanocomposites due to high specific surface areas of their nanoscale reinforcements (particles or fibers). This warrants significant material–nanofiller interaction and a essential interference region and, combined with the theoretical homogeneity possible at this scale, gives mechanical properties distinctly different and better from that of the conventional materials. In addition, these effects can be accomplish at low particle loadings, typically on the order of a few volume percentage[11-13]. Although a wide range of nanoparticles are available at the present time, but only a few materials /morphologies have been extensively used in nanocomposites [13].

2. Methodology

2.1.Materials: Alumina nanoparticles (Al_2O_3, gamma, 99.99%, 10 nm) and microparticles (10 µm) were used as a filler, nanoparticles was supplied by NanoAmor - Nanostructured & Amorphous Materials, Inc. ,where microparticles was supplied by Microspheres-Nanospheres ,Inc.; Epoxy resin LY 556 and the hardener HY 951/Accelerator DY 070, and was supplied by Ciba Specialty Chemicals. Table.1 represent the specification of alumina particles.

2.2. Samples and Tests

The standard dumb bell samples are cast according to (ASTM D 638) and was used to determine the modulus of elasticity. Universal Tensile Testing Machine (model WDW-5E, max load 5KN) (Fig.1) was used to analyze the composites, samples were tested. Samples of flexural strength were fabricated according to (ASTM-D790) standard as a rectangular shape(10mm×135mm). Samples of compressive strength were fabricated according to (ASTM-D618) standard. Flexural and compressive strength can be measured by three point test by using universal hydraulic press (Leybold Harris No.36110) to calculate the maximum load exposed on middle of the sample. Fig.1 represent the particles distribution in epoxy resin.

3. Results and Discussion

Table.1: Specification of alumina particles

Property	Value	
	Nanoparticles	Microparticles
Average nanoparticle size	10 nm	10 µm
Molecular weight	101.96 g/mol	101.96 g/mol
Specific surface area	120+ m^2/g	2-3 m^2/g
Density, true	3.7 g/cm^3	3.75 g/cm^3

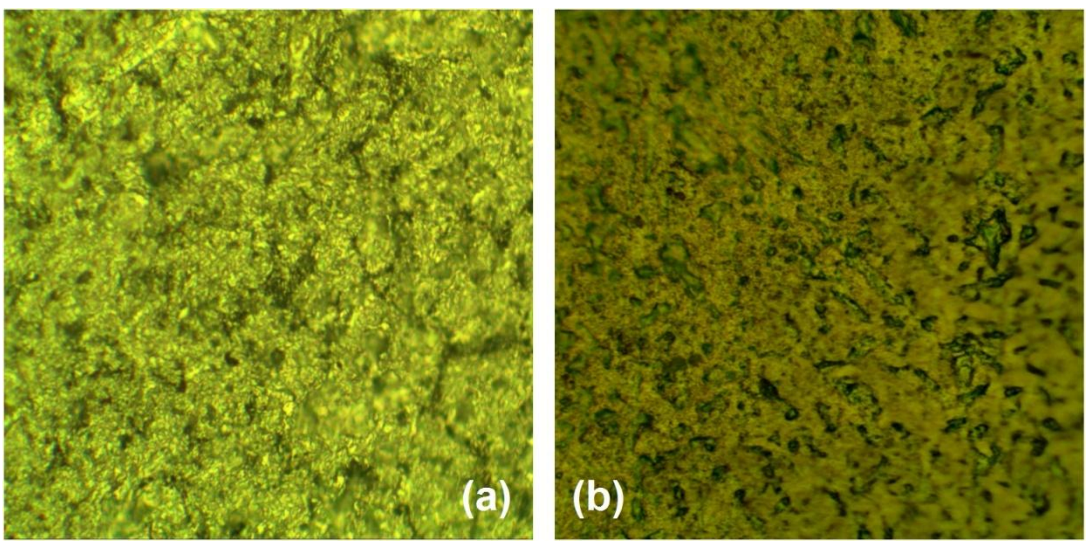

Fig.1: Particles distribution in epoxy resin: (a) nanoparticles ; (b) microparticles

The results are presented and discussed under various between size of particles of alumina (Micro and Nano) and mechanical properties (compressive strength , elastic modules and flexural strength).

3.1. Compressive Strength Test.

The relationship between compressive strength and particles of alumina appears in Fig. 2. This figure shown when increase amount of Nanoparticles of alumina increase compressive strength , also increase amount of Microparticles of alumina increase compressive strength , but the better increment was with Nanoparticles because high specific surface areas of nanoscale reinforcements, this warrants significant material–nanofiller interaction and a essential interference region and, combined with the theoretical homogeneity possible at this scale, offers mechanical properties distinctly different and better from that of the conventional materials [14 ,15].

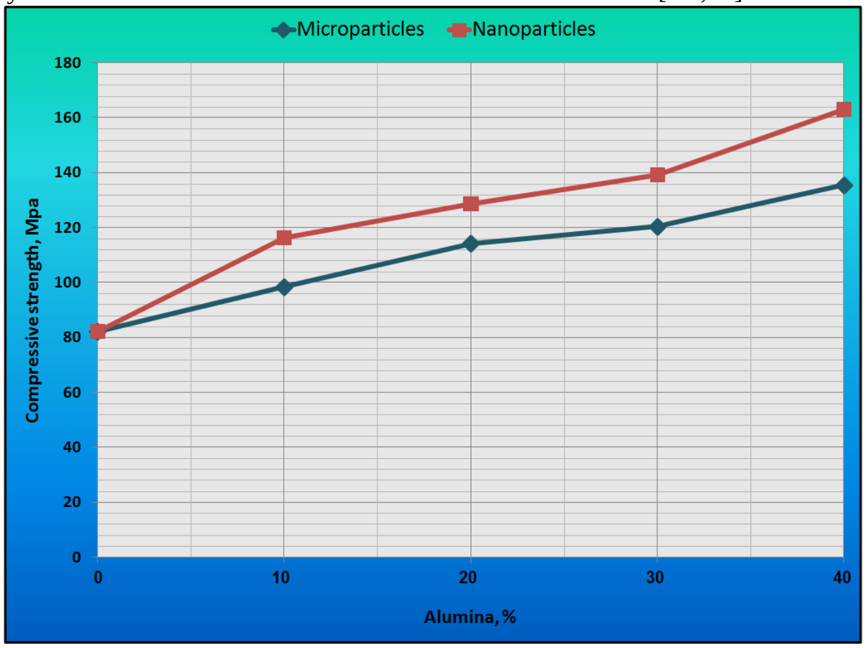

Fig.2: Relationship between compressive strength vs. particles size of alumina

3.2. Elastic Modules Test

The relationship between elastic modules and particles of alumina appears in Fig. 3. This figure shown when increase amount of Nanoparticles of alumina increase elastic modules, also increase amount of Microparticles of alumina increase elastic modules, but the better increment was with Nanoparticles because the interaction that happen between a essential interference region and material–nanofiller because high specific surface areas of their nanoscale reinforcements In addition, these effects can be accomplish at low particle loadings, typically on the order of a few volume percentage.

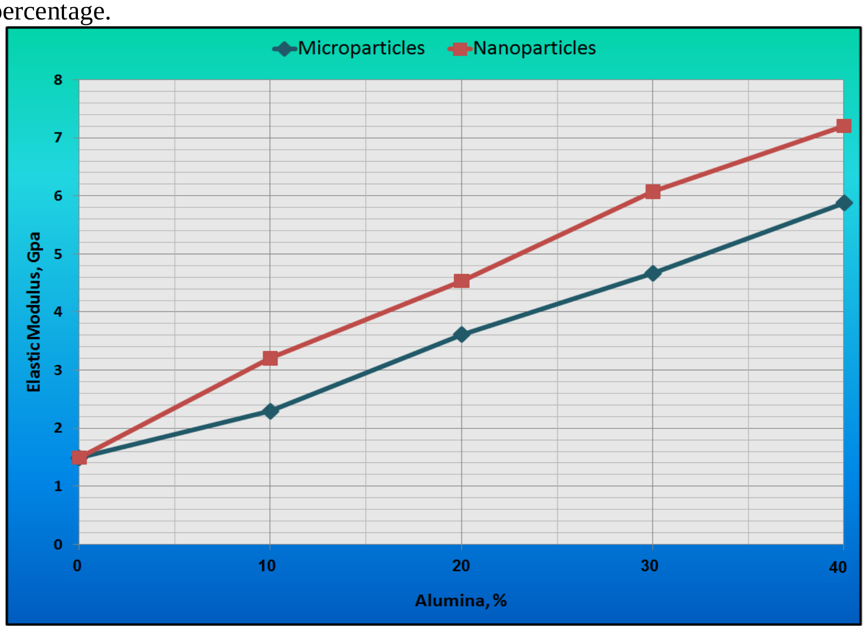

Fig.3: Relationship between elastic modules with different particles size of alumina

3.3. Flexural Strength Test

The relationship between flexural strength and particles of alumina appears in Fig. 4. This figure shown when increase amount of Nanoparticles of alumina decrease flexural strength , also increase amount of Microparticles of alumina decrease flexural strength , but the better decrement was with Nanoparticles because that particles of alumina and the matrix (epoxy) have different in polarity that cause weak in interface regions between filler (nanoalumina) and matrix (epoxy) [16, 17, 18].

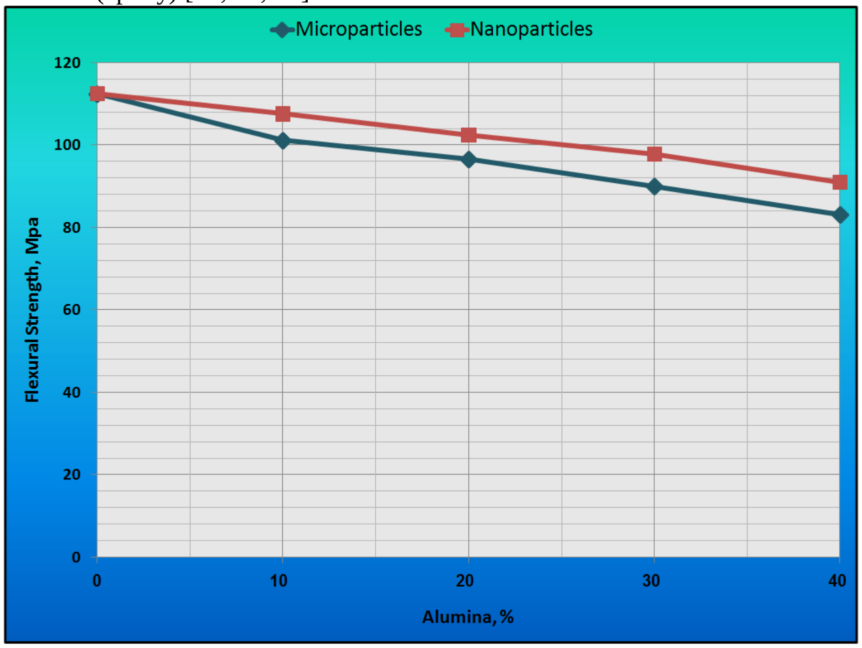

Fig.4: Relationship between flexural strength vs. particles size of alumina

4.Conclusions

The results obtained from mechanical tests shows that, the use of alumina nanoparticles will improve mechanical properties of epoxy resin better than microparticles due to the high surface to volume ratio of the nanoparticles and/or its exceptionally high aspect ratio. Comparisons with microparticles results revealed that the reinforcing efficiency of the nanoparticles will be much higher than the microparticles.

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