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RESEARCH ARTICLE

Mechanical Behaviors of Epoxy Resins with Phenolic Formaldehyde Resin Reinforced by Nanoparticles

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Abstract

The importance of Nano molecular polymers has grown in the industry, depending on its mechanical and physical properties. With the development and growth of technology, engineering applications of polymers have increased, combining light weight and high density, enabling them to be used in high performance applications. The present research aims to study the mechanical behavior of epoxy resin with phenol formaldehyde resin and the reinforcement of Graphite nanoparticles (10 nm) and weight loss (0-40%). These characteristics include compressive force, flexural force, and elastic coefficient. The results showed an improvement in the properties of composite materials after reinforcement by graphite (Nano and micro), which will increase the properties by increasing the proportion of nanoparticles compared to micro particles.

Introduction

The fracture is characterized by significant deformation near the advanced fracture (the fracture occurs after reaching the maximum load and neck formation). Moreover, the process continues relatively slowly as the length of the incision is extended (such as this). That is, it resists any other extension unless there is an increase in the force applied. Figure 1 shows a pattern of fractional and fragile fractures. The configuration shown in Fig. 1c represents high elasticity metals, such as pure gold and lead at room temperature, and other metals, polymers and inorganic isotopes at high temperatures. Figure 1 (B) is a mild mitotic fracture after neck formation [1, 2].

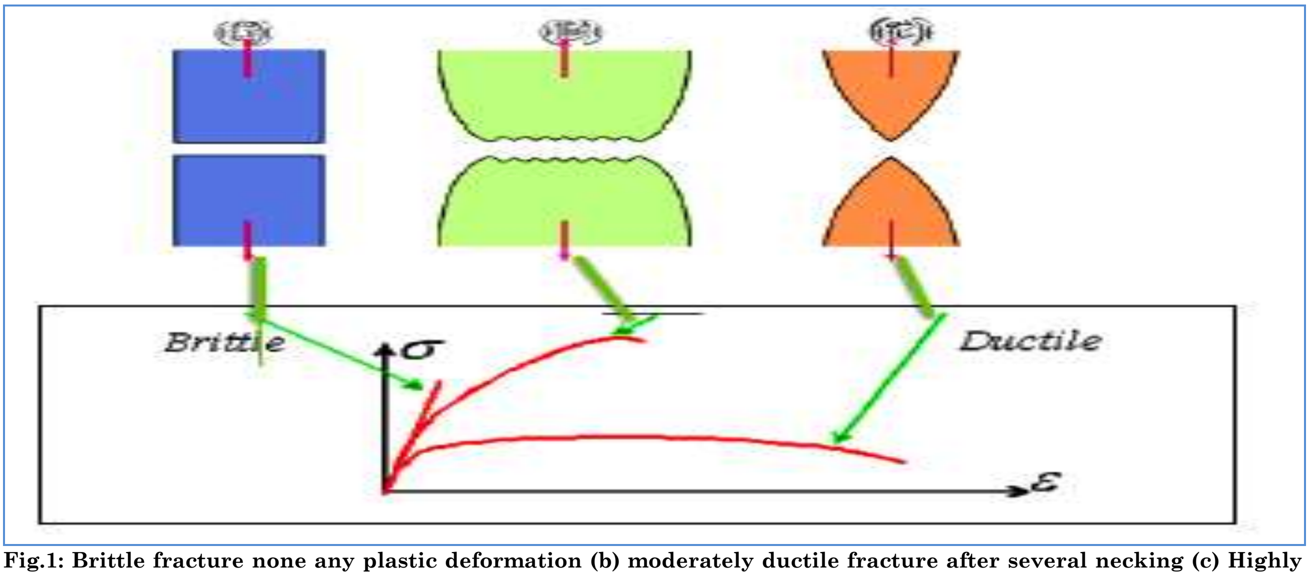

Fig.1: Brittle fracture none any plastic deformation (b) moderately ductile fracture after several necking (c) Highly ductile fracture in which the sample necks down to a point [2]

Particle size in this type of booster is higher than 1 micron. Where the reinforcement is based on dispersion because it prevents distortion of composite materials. In addition, the strength applied to the compound is due to its large size. Fig. 2 shows the relationship to resistance to inversely proportional to the square root of the distance between particles [3, 4].

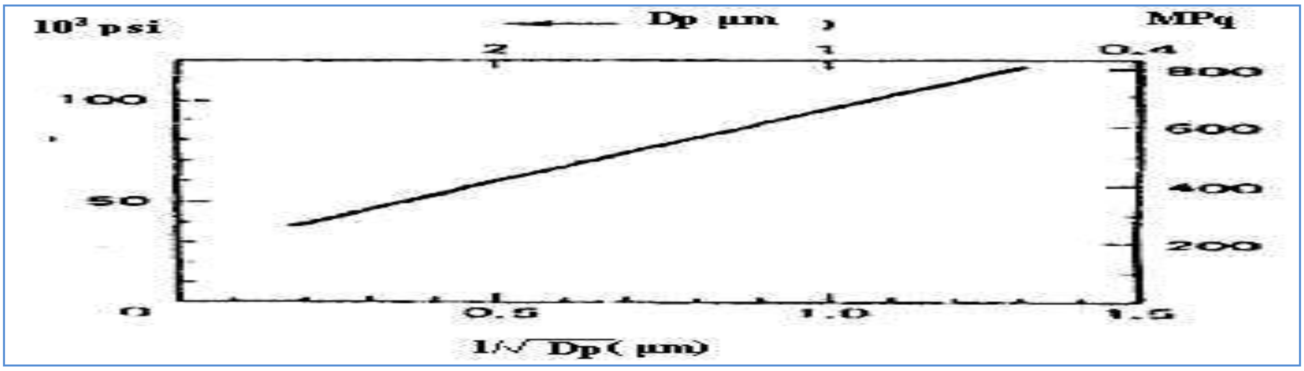

Fig 2: the relation between the yield resistance □cu Vs 1/ (Dp) 1/2 [4]

Hybrid composite materials are generally combined with two or more types of fillers, especially fibers and particles, where hybridization is generally applied to improve properties and reduce the costs of conventional materials. Hybrid vehicles contain different types of materials classified according to the technology in which composite materials are incorporated. Hybrid composite materials are classified as (1) Type Sandwiches (2) Fibers (3) Particles (4) Interaction. In hybrid types of agglomerates, one of each type of material is combined into other layers, while in the interaction, the alternative layers are stacked from two or more objects in a systematic way, and the rows are arranged in two or more components in a systematic or random manner, Mixed These ingredients are mixed as much as possible so that there is no concentration of any kind in the composite material [5, 6].

Nanoparticles are defined as a two-phase reaction, the polymer phase and a solid phase within the nanometer scale. A very important feature of polymeric nanoparticles is that the small size of the filler leads to a significant increase in the interstitial area and thus creates an important part of the polymer interaction between the nanoparticle padding [7, 8]. In the structure of polymeric particles, two effects have an important role in the reinforcement. The first is the particle - the polymer and the other particles interact with each other to strengthen the structure of the polymers, so the mechanical, thermal, electrical and optical properties of polymeric nanoparticles improve without increasing the density [9, 10]. Nanomaterials formed by the introduction of micro-fillers with different structural, physical and chemical properties in solid compounds (e.g. polymers), as well as the unique properties of nanoparticles, thus lead to many promising applications [11]. Because of electrostatic particle-particle and polymer–particles interactions, two kinds of structures were usually creating in filled polymers, namely: (i) coagulated network, formed by particle–particle aggregation; and (ii) structural network, created by the absorbed polymer layers and the filler particles percentage, [9]. At low filler content, weak coagulated structures of particle aggregates are created through a bound polymer layer leading to a reinforcement of the matrix polymer. At sufficiently high filler content, the entire amount of polymer come from the bulk is absorbed at the inorganic interfaces, resulting in the creation of a structural network, which involves of a coagulated network of particles and absorbed polymer layer. The process of structure creation in filled polymers is commonly dominates by chemical modification of the filler [10].

Methodology

The graphite Nanoparticle particles were used (99.99%, 10 nm) and micro particles (10 microns) were used as fillers, nanoparticles were supplied by Nano Amor - Nanostructured & Amorphous Materials, Inc. , Where the particles were supplied of epoxy resin and phenol formaldehyde,. Table 1 represents the specifications of graphite particles. The composite material samples are made of epoxy resin and phenol formaldehyde resin supported by standard

Nano graphite particles (ASTM-D618) to be used to determine the elasticity factor according to standard dimensions(model WDW-5E, max load 5KN), compressive strength according to the standards(ASTM-D790) and bending in rectangle samples (10 mm x 135 mm) . , Where the universal tensile testing machine was used. . The force of flexion and pressure can be measured by a three-point test using hydraulic pressure to calculate the maximum load in the middle of the sample as in Fig. (3).

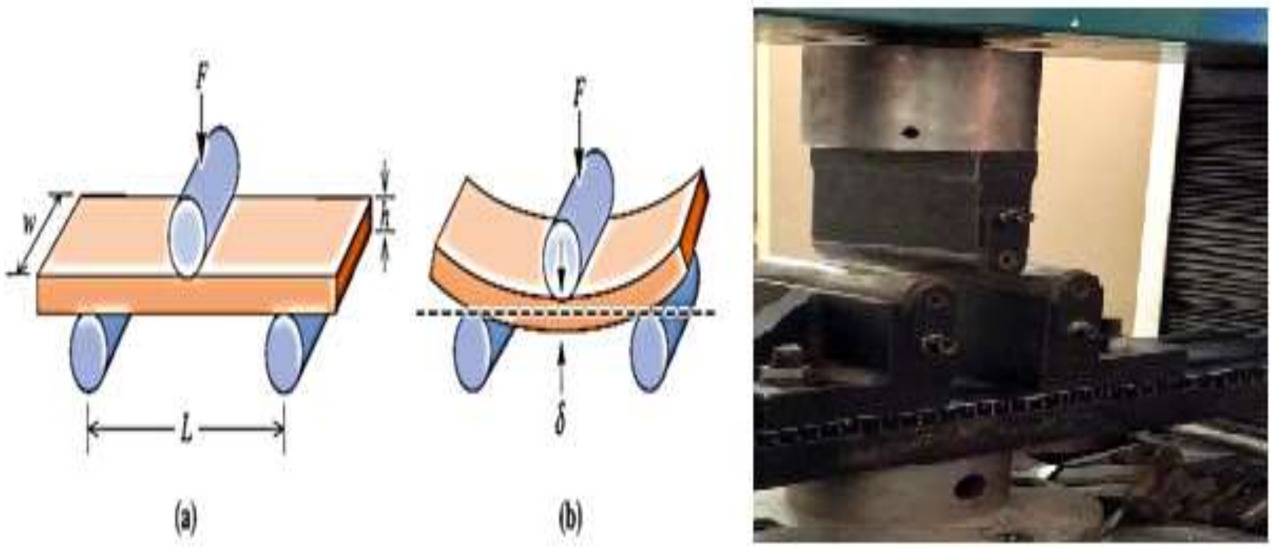

Fig.3: The three-point bend test (b) the deflection d obtained by bending [11]

Table 1: Specification of graphite Particles

Property	Value	
	Nano Particles	Micro Particles
Average nanoparticle size	9 nm	9 µm
Molecular weight	98.93 g/mol.	98.94 g/mol.
Specific surface area	110+ m^2/g	3-4 m^2/g
Density, true	2.9 g/cm^3	3.82 g/cm^3

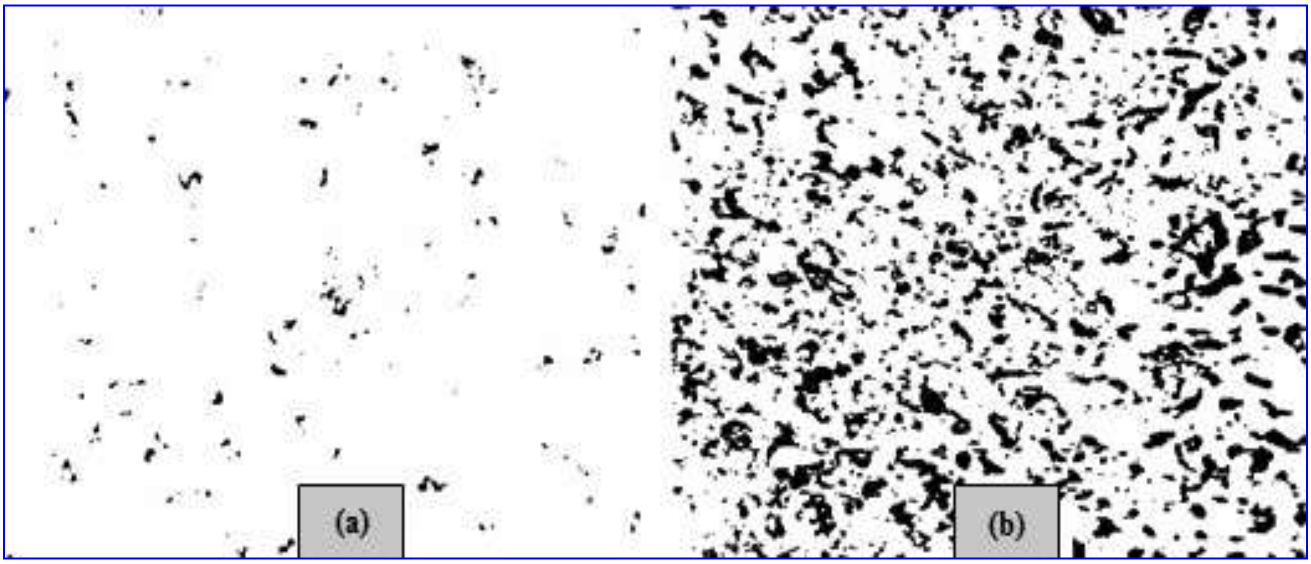

Fig. 4: Particles distribution in epoxy resin: (a) nanoparticles ; (b) micro particles

Results and Discussion

Compressive Strength Test

Figure 5 shows the relationship between compressive resistance and graphite particles. As the amount of nanoparticles increases in graphite, the compressive strength increases, but the best increase was with nanoparticles due to the increase of the surface area of the nanoparticles. This results in a significant interaction between the nanoparticles and the primary interference zone, In addition to the homogeneity of this scale, leading to better mechanical properties than those of traditional materials [7, 11].

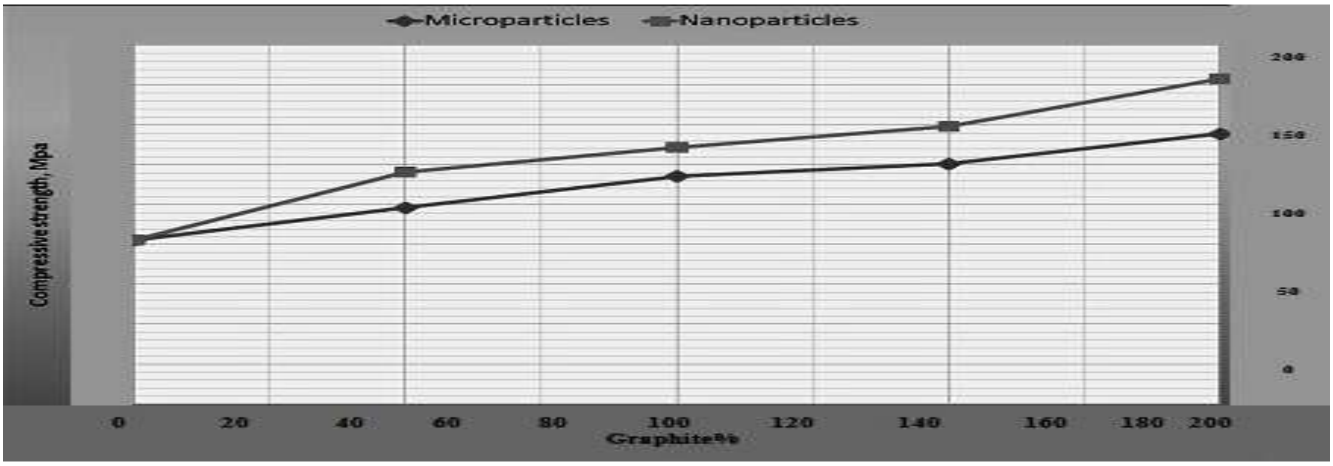

Fig. 5: Relationship between compressive strength vs. particles size of graphite

Elastic Modules Test

Figure 6 shows the relationship between the elasticity coefficient and the graphite particles. When the amount of nanoparticles from graphite increases, the elasticity coefficient increases, but the best increase is with the nanoparticles that occur between the primary interference zones because the surface area increases with the nanoparticle reinforcements, the limits of a small percentage of size.

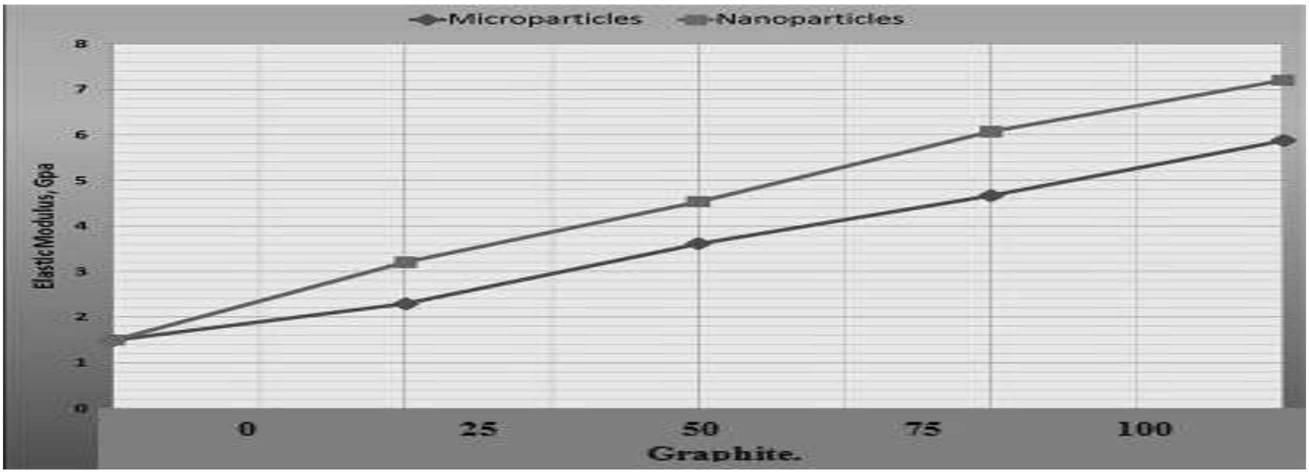

Fig. 6: Relationship between elastic modules with different particles size of graphite

Flexural Strength Test

Figure 7 illustrates the relationship between flexural force and nanoparticles. When the amount of nanoparticles from graphite increases, the bending resistance decreases, but the reduction in nanoparticles of the graphite causes a difference in the polarity that causes weakness in the padding areas and the epoxy matrix [6].

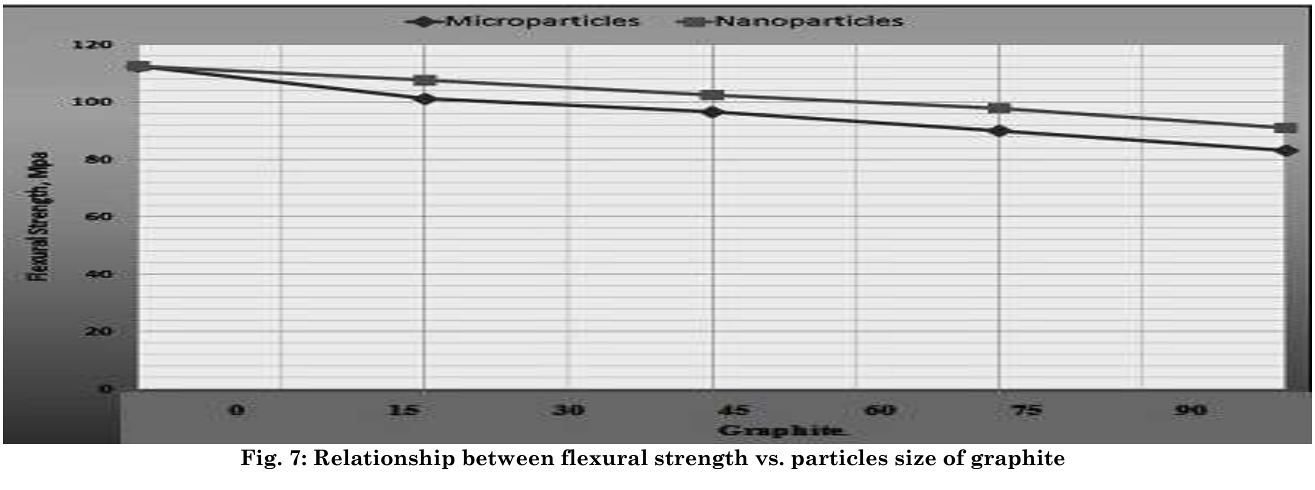

Fig. 7: Relationship between flexural strength vs. particles size of graphite

Conclusions

The results showed that the use of nanoparticle particles would improve the mechanical properties of epoxy resins with phenolic formaldehyde resin supported by nanoparticles as a result of increasing the surface area to the size of nanoparticles. The comparison in the results showed that the efficiency of the nanoparticles in the consolidation would be much higher than the microscopic particles.

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