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RESEARCH ARTICLE

Thermal Properties of Epoxy Resins and Phenol Formaldehyde Component with Differential on the Mixing Ratios and Reinforced by Nanoparticles

Mustafa Ahmed Rajab[1*], Amera K. Asfor[2], Zainab S. Mahdi[2]

[1] *Technical Institute of Baqubah, Middle Technical University, Iraq.*

[2] *Faculty of Science, University of Diyala, Iraq.*

***Corresponding Author: Mustafa Ahmed Rajab**

Abstract

The research aims to study the mechanical properties (tensile strength, hardness, Impact) and thermal properties of epoxy resin and phenol formaldehyde by varying the mixing and strengthening ratios of the nanoparticles. First: (the effect of different mixing ratios between epoxy resins and phenol formaldehyde), and secondly: (nanoparticles containing both magnesium oxide and zirconium oxide) on both mechanical and thermal properties.

Keywords: *Mechanical and Thermal Properties, Composite Material, Mixing ratios.*

Introduction

Particulate Composites contain of a matrix reinforced with a dispersed phase in form of particles. The influence of the dispersed particles on the composite properties depends on the particles dimensions [1]. Particle-reinforced composites have two sub classifications such as large-particle Strengthening and dispersion-strengthened composites. The variation between these is depending on reinforcement or strengthening mechanism.

Reinforcement by particles causes increment in the resistances of the composite material against distortion and this depends on the way of the particles dispersion in the matrix material [2]. In this type of reinforcement the size of the particle is less than 0.1 µm and the mean free path ranges between 0.01 -0.3 µm [3]. Hybrid Composite materials are generally combined with two or more different kinds of fillers particularly fibers in a single matrix.

Hybridization is generally applied for enhance the properties and for decreasing the fee of classical composites materials [4]. Hybrid composites have different kinds of categorized according to the technique in which the composite materials are combined.

Hybrid composite materials are designated as i) sandwich type ii) interplay iii) intraply and IV) intimately mixed [5]. In sandwich hybrids, one from any kinds of material is sandwiched between layers of another, whereas in interplay, alternate layers of two or more materials are stacked in regular manner. Rows of two or more constituents are arranged in a regular or random manner in intraply hybrids while in intimately mixed type, these constituents are mixed as much as possible so that no concentration of either type is present in the composite material [5].

Polymer nanocomposites are defined as an interacting mixture of two phases, a polymer matrix and a solid phase which is in the nanometer size range in at least one dimension. Very significant feature for polymer nanocomposites is that the small size of the fillers leads to a dramatic increase in interfacial area creates significant volume fraction of interfacial polymer interaction with nano-fillers forming properties unlike from the bulk polymer until at low concentration of nano fillers[6].

In particle - polymer structure creation, two effects plays a significant roles in the reinforcement; particle- polymer and particle-

particle interactions, when particle-polymer interactions are generally the determining operator for the strength of the structure of polymers. Therefore polymer nanocomposites complete significant enhancements in mechanical, thermal, electrical and optical properties at low filler concentrations, without increase in density [7].

The thermal conductivity is the property of a material that indicates its ability to conduct heat. This physical constant is defined as the amount of heat that passes during a unit cube of a material in a unit of time, when the variance in temperature between the opposite sides of the cube is 1K. Along the direction of the heat flow [8].Polymer materials show a weak thermal conductivity. Thermal conductivities of insulating polymer materials are generally 1-3 orders lesser than those of ceramics and metals.

Due to the chain-like structure of polymers, the heat capacity involves of the contribution of two mechanisms: (a) lattice vibrations and (b) characteristic vibrations, which originate from inner motions of the repeating unit. The lattice (skeleton) vibrations are acoustic vibrations, which give the main contribution to the thermal conductivity at low temperatures. The characteristic vibrations of the side groups of the polymer chains are optical vibrations, which become visible at temperatures above 100 K [9].

For polymers reinforced with different kinds of fillers this is even more important.

Enhanced thermal conductivity in polymers may be achieved either by molecular orientation or by the addition of highly heat conductive fillers [10]. There are many factors may affect the thermal conductivity of polymers: Temperature, pressure, density of the polymer, orientation of chain segments, crystal structure, the degree of crystallinity and many other. The thermal conductivity of filled polymers is primarily determined by the kind and amount of fillers used. The thermal properties of the filler, the size, shape, and orientation of filler particles or fibers in polymer matrix, and the percentage of fillers are all important factors that determine the thermal conductivity of reinforced polymers [11].

Experimental Produce

Materials

Epoxy resin (LEYCO-POX 103), Phenol formaldehyde (resole) resin .Samples preparation and Calculation of Thermal conductivity: epoxy and phenol formaldehyde resin were mixed with different weight fraction as shown in Table.1.Thermal conductivity measurements were made using the Lee's disc method; this instrument was manufactured by the Griffen and George Company.

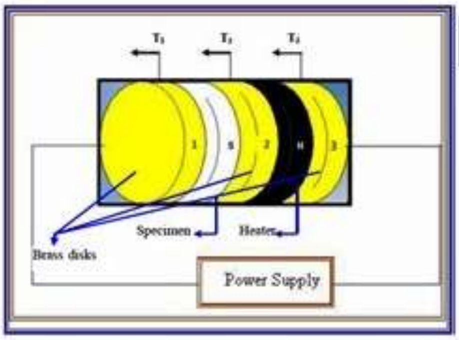

Fig. (1a): Lee's Disc [7].

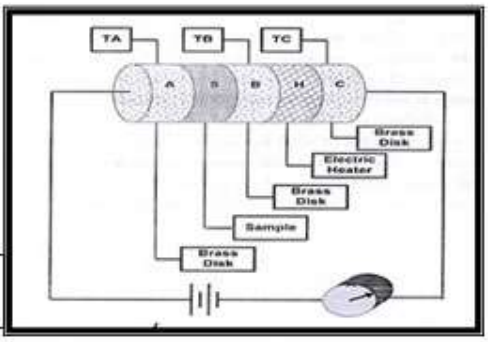

Fig. (1b) Schematic diagram Of Lee's disc.

Test	Samples Dimensions	Standard Specification
Thermal Conductivity	2 mm; 40 mm	Lee's Disk

Fig. (1d)

Fig. The samples dimension for thermal conductivity test.

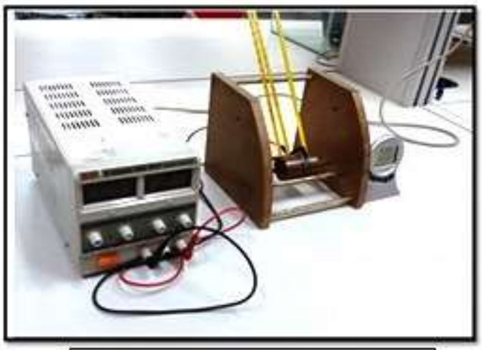

Fig. (1c) Lee's disc Equipment.

Results and Discussion

Figure 2 shows the thermal conductivity of composite materials by the ratio of epoxy resin and phenolic formaldehyde resin, and hence the effect of carbon fiber reinforcement. The figure shows that epoxy resins, without the addition of phenol formaldehyde, gave little thermal conductivity.

The presence of phenolic formaldehyde resin blocks the movement of particles that reduce heat conductivity, as evidenced by increasing the thermal conductivity value from 0.346 to 0.48 after phenol formaldehyde by 5%, but that value (0.35) after the addition of phenolic formal particles Hyde by (10%), this means that an increase in the amount of phenol formaldehyde does not always mean an increase in the viability of thermal conductivity. However, it was found that there is a completely different thermal behavior when carbon fiber reinforcement, since the presence of fiber means lower thermal conductivity compared to non-existence, and may be caused by the impediment caused by this fiber in thermal conductivity.

The thermal conductivity (K) of the samples was calculated based on the temperature obtained from the disk. In previous studies, a reduction in thermal conductivity values was observed by increasing the volume fracture of fiber due to the nature of some thermally insulated fibers [7].

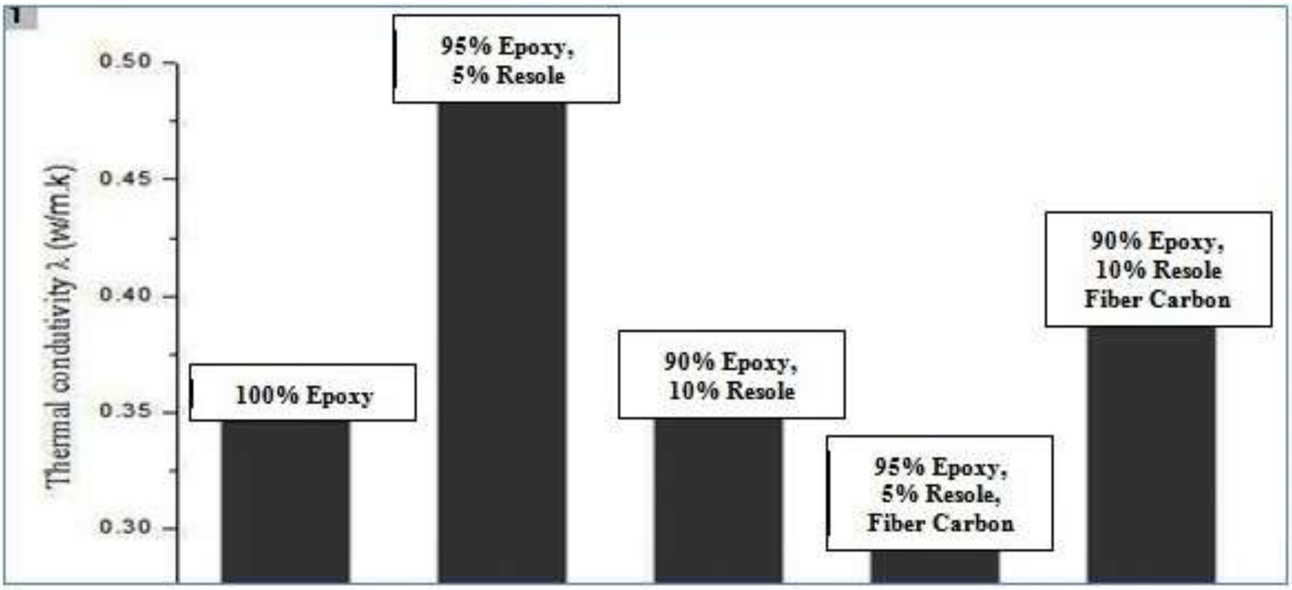

Figure 2: Thermal conductivity of composite materials according to the percentage of mixing between epoxy resin and phenol formaldehyde resin, and then the effect of Carbon fiber reinforcement

In isolation, there are threads of fine fibers, which lead to the transfer of heat energy in two ways (conductivity and load), such as the transfer of elastic waves (photons) through the basic material and the hard part of the fibers through the movement of vibration of atoms and the effect of covalent signals, and when the photons reach the part of the sun Irrigation of fibers. Photons suffer from blockage because of the different structural structure of this method because they contain atoms and bonds different from the previous medium, which will lead to a decrease in the value of thermal conductivity [3].

Studies indicate that the conductivity values are reduced by increasing the volume of fibers. The rate of reduction in the thermal conductivity values of the random samples in the fiber arrangement is greater than the samples with the specified pattern. Fiber is distributed in all directions. Depends exclusively on the type of fiber and the direction of the material [9, 10].The effect of multiple layers of fiber on the thermal conductivity values of fixed volumetric fracture is that it reduces thermal conductivity values and the rate of decrease depends on the nature of the fiber material for the outer layers.

The samples, whose outer layers are armed with Kevlar fibers, have a higher thermal conductivity, due to the nature of the Kevlar fibers, which helps to transfer thermal energy because it contains in its internal structure an ionic and covalent bond, resulting in the ease of movement of the photons within the fiberglass [3]. Thermal energy of polymers is transmitted by vibrations, and plastics are strongly affected by temperature changes depending on the type of plastics.

Plastic materials with linear strings are more effective because of the weak interstitial forces between their chains that are easily overcome. They have a three-dimensional grid structure, although they change their properties and behavior but maintain their structure at temperatures [6]. Thermal conductivity increases with increased angular bonding, which is significantly affected by the amount of padding. As the distances between the polymer chains decrease, this leads to increased interstitial bonding, making the transition from one side to another through plastic materials easy (Fig. 3).

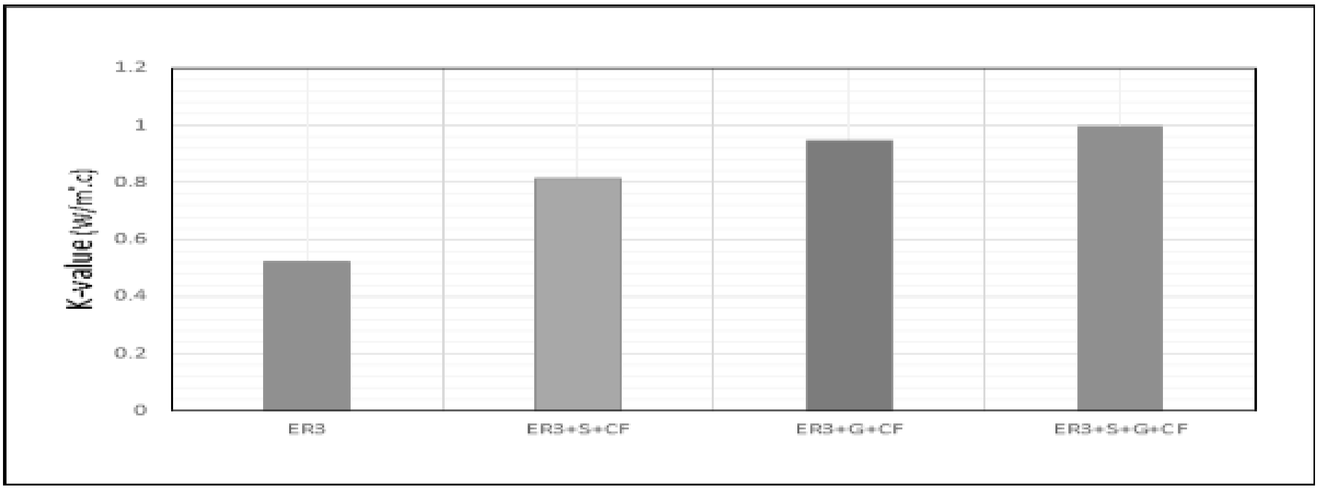

Fig.3: Thermal conductivity of composite material

The amount of thermal conductivity depends on the degree of crystallization. Vibration increases and becomes more efficient for the molecules of the chains in the crystallized state. The transfer of energy through the material (thermal conductivity) is one of the main physical phenomena that can be studied and interpreted. Thermal conductivity is obtained when there is a difference in temperature, which leads to the continuation of the thermal flow until the amount of temperature at temperatures equal to zero due to the transfer of energy by the upper temperature as well as low temperature [5, 7].

The thermal conductivity of overlapping material has been affected by bonding density, which increases heat conductivity, but sometimes the addition of some particles may reduce the density of the interstitial bond. This leads to the formation of pores and gaps within the material. In addition, previous studies show that the thermal conductivity of the overlapping material is affected by the volumetric fraction, where the highest thermal conductivity value of the sample can be obtained when enhanced. This is due to an increase in the proportion of enhanced substances containing percentage of conductive materials compared to a sample that does not contain this [10]. The results showed a significant reduction in the conductivity values due to the low ratio of the bonding material to the reinforcing material.

Conclusions

- The thermal conductivity coefficient of the compound material is affected by the volumetric fraction of the additive.
- Thermal conductivity is significantly affected by fiber reinforcement, due to the different fiber's ability to conduct heat conduction.
- A significant reduction in the delivery values of the samples due to the low percentage of bonding material for the enhanced substances, leading to a decrease in the density of the bond between the sample components.

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