Effect of Gamma Radiation on the Thermal Conductivity of (SiC-Graphite) Nano Composite Materials

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Abstract
In the recent years, modern materials have been needed that will have a lasting impact in modern applications. The need for radiation therapy as an important means of modifying nanoscale structures in the manufacture of high performance polymer compounds has important advantages. The aim of this research is to measure the thermal conductivity for epoxy resin as a base material, Nano ceramic powder (SiC) with particle size (64.85nm), and nano Graphite powder with particle size (87.85 nm) are used as a reinforcement materials in composites preparing in different weight fractures (2%, 4%, 6%),while the Hybrid (SiC-Graphite) model are prepared by another weight fractures of (SiC and Graphite), Hand-casting method was used in preparation the research samples. The thermal conductivity tests were measured for all weight fractures in normal conditions (before irradiation). we find the values of thermal conductivity is increased with the increase of weight fractures because of the presence of the reinforcement material, including high thermal conductivity graphite compared to silicon. Tests of the thermal conductivity are measured after irradiation of Gamma rays emitted from the CO60 with energy rate of 1.33MeV and different irradiation doses (6,8,10)Kg. The results show an increase in the thermal conductivity values after the irradiation compared with the results of thermal conductivity in normal conditions. It is worth noting that an atomic force microscope (AFM) has been used to measure the particle size of nanomaterials.

Keywords: radiation doses, gamma rays, thermal conductivity, epoxy resins,Nano composite materials, Atomic force microscope, silicon carbide, graphite.

Introduction
Due to the extensive use of polymeric materials in coating, packaging, shipbuilding and aircraft wings, as well as their use in various fields of life, These materials are exposed to the sun and the various environmental conditions. Because As they are important in our daily life, it is necessary to study the effect of radiation on composite materials. The use of polymer materials composite of our time is a significant shift for the characteristics of these materials as many characteristics lead be widely used in various fields. These characteristics include the low cost of fabrication, durability, low density, high thermal and electrical insulation, resistance to chemicals and moisture, corrosion resistance, shapes and sizes, and high surface strength [1,2].

As already mentioned, it is necessary to study the mechanical and physical properties of these materials so that researchers can develop and use them in their practice fields [3]. Polymeric polymers can be defined simply as those systems resulting from the mixing of two or more substances with specific rules to obtain new materials possessing distinct physical and mechanical properties that differ radically from the properties of their basic material [5,4]. At present the effect of radiation on composite materials whether ionizing radiation or non- ionizing radiation, Ionizing radiation results in wide variations in the properties of composite materials.
Radiation has a significant effect on radiation when it penetrates the radiation, causing a change in the order of atoms and molecules in the composition of matter [6]. The effect of photon radiation in the composite material causes changes in the structure of these materials as a result of the interaction between the photons and their absorbent material. The reaction type depends on the energy of the photons and the atomic number of the target [7]. The evolution of the use of composite materials in the development of advanced computer science and software has motivated scientists to create specialized software in the design and analysis of composite materials and test most of their properties without resorting to traditional methods [8].

This research is carried out to determine the thermal conductivity property pre-and to post exposure Gamma which emitted from the cobalt source (Co ⁶⁰) for the SiC, Graphite and Hybrid (SiC+Gr) composites and study the effect of these rays in different doses (6, 8 and 10) KGy on these properties. The effect of these radiations varies depend on the mixed of the materials with these rays.

MATERIALS AND METHODS

Used materials

Matrix material: Epoxy resin belongs to the thermoplastic resin group. Resins cannot be re-formed by heat forming long intertwined polymer chains (cross-link). Epoxy resins contain two or more groups (Epoxide), consisting of an oxygen atom associated form a three-dimensional network with a tangential link to the processing process. (Epoxy Sikadur-52), manufactured by Henkel, Australia, is used as a base material in the preparation of composite material. Epoxy resins are characterized by transparent liquids and a density of 1.1-1.4 g/cm³. The epoxy resins are converted to the solid state after the addition of a metapnenylDiamine (MPDA) and a plant of the same company by 1:2.

Reinforcement materials

(1) Silicon Carbide (SiC) In the present research, a SiC Nano powder is used. It is classified as a semiconductor and has two phases (α and β). The α phase is more stable than the β phase and is sometimes called Carborundum, while the β phase is classified as a semiconductor. The SiC powder used in this study is the β type. Sic Powder Factory is a Chinese company (EV NANO) Technology Co., Ltd. The properties of SiC Nano powder are particle size (64.85nm) fig(1), purity (99%), Density 3.22g/cm³.

Figure (1): Test of Grain Size of SiC by Atomic Force Microscopy.
Graphite (Gr) Graphite amorphous from carbon has a distinctive crystalline structure differs from diamonds and is more stable than diamonds at natural temperature and pressure. The crystal structure consists of carbon atoms arranged hexagon within the layers. Each carbon atom is linked to three atoms united by covalent bonds.

The fourth electron is connected with the forces of Nanoparticles (Gr) of American origin are manufactured in the size of (87.85nm) fig (2) gray nano particles with good purity(93%), Vander walls Weak between layers. The nano particles manufactured by Skyspring specific surface.

Samples preparation: In this research, hand lay-up molding method is used for preparing the samples, as follow:

1. The samples which composed from graphite (Gr) and silicon carbide (SiC), are prepared as a reinforced material (2%, 4%, 6%) with epoxy resin as a base material mixed with a (1: 2) compound. The mixture is then poured into the mold until the mixture leaks all over the mold and leaves for 48 hours to solidify.

2. After 48 hours, samples are placed in the convection oven at a temperature of 50 ° C for 6 hours. This reduces the internal stresses produced during shrinkage, as well as obtaining the best interlock and completing the solidification process.

3. The samples are left in the convection oven, then extinguished until returned to their normal temperature to obtain a good crystallization of the samples[9].

Tests

Thermal conductivity:

The phenomenon of heat transfers from high-temperature zones to low-temperature zones of the material is called thermal conduction. The characteristic that characterizes the material's heat transfer is called thermal conductivity, Circular samples are cut for the purpose of conducting the thermal conductivity test in a (40mm) diameter and 5mm thickness by(Lee's Disk (fig.3) are manufactured by (Griffin and George) for testing. The test sample (S) is between the two disks (A and B) and place the heater (H) between the two disks (C, B) where the heat transfer from the disk(H) to the next disc until reaching the last disc. On reaching the thermal stability state, we measured the temperature of the three disks (T_A, T_B, T_C) from the thermometers. The thermal conductivity of the samples in fig (4) is calculated from the following relation(1-2)[10]:
Gamma ray Instrument: Gamma ray is emitted from "natural radioactive" sources or from "industrial" sources during nuclear decomposition, as the excited nucleus returns to its state of stability when it loses energy in the form of gamma rays. The spectrum of gamma rays is not continuous (as in the X-ray spectrum) but is in the form of single-energy radiation. This spectrum can be used to know the compounds of radioactive elements, and to know the different isotopes of the same element, because the gamma-ray spectrum is a characteristic of the nucleus [11]. In this research, we used a gamma ray consisting of a steel rod filled with metal cobalt (Co $^{60}$). The diameter of each rod is (1 cm) and (20.3 cm) long as in fig (5-b) [12].

(2) Irradiation chamber: Irradiation chamber is a thin-walled hollow cylinder made of good conductive, aluminum with a door closed by a chrome-plated steel lock ring around the top of a door and locking ring to ensure proper the room positioning before machine operation [11].

(3) The Protective radiation Shield: The protective shield contains steel coated with a thick lead to saving the cobalt source (Co $^{60}$), which is in the center of the protective shield, which represents the outer structure of the gamma cell.

The Irradiation shield chamber: A bullet-filled cylinder with lead, their location is central to the protective shield. This shield prevents radiation leakage when the irradiation chamber is in the radiation position. Fig. (5) Gamma cell and Cobalt source (Co $^{60}$).
Gamma Cell: The Gamma cell is a radiant source of gamma ray -type (gamma Cell220) made in Canada at (1982) as in fig (5-a) and consists of the following parts:

(1) Cobalt source (Co$^{60}$): Cobalt source(Co$^{60}$) consists of 48 linear sources Model(C198) placed in the form of a radiator cylinder with a (20.9cm) diameter and each linear element is

b-Cobalt source

Interaction of Radiation Gamma with Matter: Gamma rays interact as they pass through the material depending on their energy with the atomic electrons in different ways as follows:

1- photoelectric effect 2- Compton effect 3-pairproduction

A cosmic or wave emission and its effect in the medium that penetrates depends on energy radiation and its nature where particles and radiation emits different cards and decay over a given time and according to the following equation:

$$A_t = A_o e^{-\lambda t} \quad (3)$$

$A_t$: the radioactivity of the element at time $t$.
$A_o$: Radiation activity at primary time.
$\lambda$: the decay constant and given by the relation:

$$\lambda = \frac{0.693}{T_{1/2}}$$

The radiation)natural or industrial) is classified according to its effect in two types [13,14]:

a- Ionizing Radiation.

This type of radiation has the ability to ionize the atoms passing through it such as electromagnetic radiation (x-rays, ultraviolet rays, and Gamma rays) and particle radiation such as particles of alpha, beta, neutrons and protons. The radiation is in the form of $T_{1/2}$: Is the half-life of the radionuclide

b- Non-Ionizing Radiation

This type of radiation does not have the ability to ionize the atoms passing through it such as infrared waves (IR), lasers, visible light, radio and television waves, radar waves and microwave wavelengths.
RESULTS AND DISCUSSION

Results and discussion of the thermal conductivity before irradiation:

The thermal conductivity values of all composites prior to irradiation are increased with the increase of the weight fractures\((2\% ,4\% \,6\%)\). The maximum thermal conductivity values are at the weight fracture\((6\%)\) due to the presence of a small amount of base material \((EP)\) is an insulating material, and the thermal conductivity will be higher than in the rest of the other fractions, which contains a base material in large quantities, so we find that the weight of the base material affects in the thermal conductivity, whenever their quantity is higher the thermal conductivity coefficient was less as shown in figure\((6)\). The \((EP+Gr)\) composites at the weight fractures\((2\%, 4\%, 6\%)\) show a higher thermal conductivity than the \((EP+SiC)\) composites, because the presence of nano graphite is conductive to heat this leads to increase the thermal conductivity of \((EP+Gr)\) composites, this result is consistent with Ref \([15,16,17]\).

Results and discussion of the thermal conductivity after irradiation:

The exposure of polymeric composite material to Gamma radiation with high energy leads to happened excitation and ionization of molecules, this causes broken in chemical bonds and leading to production of free radicals, and the effect of radiation effects in the properties of polymeric materials \([18]\).

From the figures \((7,8,9,10,11)\) we observe an increase in thermal conductivity values by increasing the rate of the weight fracture and radiation doses for \((SiC ,Gr (Gr+SiC))\) composites samples due to:

The breakage of weak polymer bonds and the formation of free radicals lead to increased vibration of the network or free polymer chains, such as increasing the movement of heat transfer photons, which increases the thermal conductivity of all samples by increasing radiation doses.

Reinforcement materials are nanomaterials penetrates the polymer chain and leads to its reinforcement which causes to higher thermal conductivity. Figure \((12)\) shows the effect of Gamma radiation on thermal conductivity in the mixed material \((SiC+Gr)\) for the weight fracture \((4\%, 6\%)\). This figure shows that the values of the thermal conductivity increase with increase of Gamma radiation dose, and weight fraction because of the presence of materials, including high thermal conductivity such as Graphite which is agreed with the findings of the researchers Tatterasall & Al Rawi \([19,20]\).
Figure (7) The relationship between thermal conductivity and weight fraction (2, 4, 6)%
Figure (8) The relationship between thermal conductivity and weight fraction (2, 4, 6)%

Figure (9) The relationship between thermal conductivity and weight fraction (2, 4, 6)%

Figure (10) Influence of $\gamma$-radiation dose on the thermal conductivity of SiC composite for weight fractures (2, 4, 6)\%
Conclusion:

The thermal conductivity of the (EP+SiC),(EP+Gr) and Hyb (Gr+SiC) composites increased when radiation doses increase. The thermal conductivity of the composite (EP+SiC) and (EP+Gr) and Hyb(SiC+Gr) increases by increasing the reinforcement ratios, results from others at weight fracture (2%, 4%, 6%). The (EP+Gr) composite gives best results in weight fractures (2%, 4%, 6%). From the other.

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