Research Article

Effect of UV Radiation on Thermal Conductivity of the (Epoxy – Polyurethane) Blend Reinforced with the Micro and Nano Clay

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Abstract

This research involves using epoxy and polyurethane resins to form a blend (Epoxy+ Polyurethane) with different ratios (90 – 10) %, (80 – 20)%, (70 – 30)%, and (60 – 40)% to get the best ratio for impact strength as a function of material toughness; then reinforced with micro and nano (Clay) and with weight fraction (2%, 4%, 6%, 8%). Thermal conductivity were studied in natural condition and after exposure to UV irradiation for (24h). Results showed that the composite (polymer blend / nano clay) had better properties compared with (micro Clay+ blend) composite. Also thermal conductivity show increases with increasing the weight ratio for all samples and values in the case of UV radiation are higher than values in natural condition.

Key words: UV radiation, thermal conductivity, epoxy resin, polyurethane resin, particulate and nano Clay.

الخلاصة

يتضمن هذا البحث استخدام راتنج الإيبوكسي وراتنج البولي يوريثين لتشكيل مزيج (ايبوكسي + بولي يوريثين) بنسب مختلفة (٩٠ - ١٠) ٪ ، (٨٠ - ٢٠) ٪ ، (٧٠ - ٣٠) ٪ ، (٦٠ - ٤٠) ٪ الحصول على أفضل نسبة لمتانة الصدمة التي هي دالة لمتانة المادة ؛ واعتماد هذه النسبة لتدعيمها مع مادة الطين الدقائقية والنانوية وبنسب وزنية (٢ ٪ ، ٤ ٪ ، ٦ ٪ ، ٨ ٪). درست التوصيلية الحرارية في الحالة الطبيعية وبعد التعرض للأشعة فوق البنفسجية لمدة ٢٤ ساعة. أظهرت النتائج أن المركب (طين نانوي + الخليط) كان له خصائص أفضل مقارنة مع مركب (طين دقائقي + خليط). تظهر أيضًا التوصيلية الحرارية تزايد في القيم مع زيادة النسب الوزنية لجميع العينات والقيم في حالة الأشعة فوق البنفسجية تكون أعلى من القيم في الحالة الطبيعية.

Introduction

Due to the rapid development taking place in the world, the world cannot be imagined without a polymer used in many industrial applications because it possesses special advantages that other types of materials (mineral and ceramic) do not possess. The most important features of polymer are easy to manufacture, light weight and resistance to oxidation [1].

Polymers a macromolecule has a persistent backbone of covalently bonded atoms and may have any number of side groups attached to its [2]. Thereafter, macromolecules are composed of monomeric units which are joined by chemical bond to each other [3]. Polymers as macromolecules are long chain molecules prepared from small molecules called monomers [4].

Polymer blend are defined as any combination of two polymers with no covalent bonds between them resulting from common processing step [5].

Composite materials are important and have been studied extensively for a long time. When the particles composites become nanosized, they are called Nanocomposites. Nanocomposites are generally polymer (e.g., thermoplastics, thermosets, or elastomers) composites with nanoscale building blocks. They combine the advantages of the filler materials (e.g., rigidity, thermal stability) and the advantages of polymer (e.g., flexibility, dielectric, and ductility). Moreover, when filler become nanosized the composites usually contain special properties of nanofillers leading to improved materials properties [6].

The clay is naturally alumina silicate which has a structure sheets. They are widely used as catalysts in alkyl reactions, reductions, polymerization, and as a component of carbon-free carbon papers, Probably the most widely used acid-activated clays are the bleaching earths ,which are capable of removing color, odor and other impurities from cooking oils of vegetable or animal origin. Although there are many type of clays such as bentonite, kaolin, auto pulgite, ball clay, montrimolinite are known for a long time, there characterization by novel techniques is scarce [8].

In this research Kaolin type was taken It is characterized by (Al_2O_3 . $2SiO_2$. $2H_2O$) and its laminate structure which helps to move the granules one on top of another .It is white in color and has a melting point of (1770) ^{o}c in its pure state and melting point is (1545) ^{o}c in the case of impurities whose . Kaolin's are one of the most important materials used in the ceramic industries, as its materials are found in different areas within the Iraq and the area of (Dweikhla) is one of the places where this crude is found in large quantities [9].

Nanoclay is usually in form of layered material with a thickness in the order of 10 Å and with a width extending up to 100 nm. One gram of powdered material can have billions of nanoparticles with a surface area of many square meters [11] .The particle size is one of the most important aspects of nanoclay and the knowledge not only the average size but also understanding how the sizes are distributed. It has great importance in nano-compositing. Nanoclay increases stiffness, strength and heat resistance but decreases moisture Absorption, flammability and permeability of gas and water. This leads to significant weight reduction which is evident in many applications such as military, boat building and aviation [12].

The thermal conductivity factor for the test sample, in this device the heat is move out from the heater to the followed disc until it reaches the last disc, and the temperatures (T_A, T_B, T_C) for the three discs can be specified by using the thermometers inside them respectively.

To obtain the best heat transfer through the discs which consider one of the most important influences is to ensure that the surfaces of the copper discs are clean and compatible. The dimension of specimen (disc) (r = 4 cm, d = 0.5 cm). The value of thermal conductivity (K) can be calculated by the following equation (1) [13]:

$$\frac{K\,(TB - TA)}{ds} = e[TA + \frac{2}{r\left(dA + \frac{1}{4ds}\right)TA} + \frac{1}{2r\,ds\,TB}]$$

$$\frac{K(T_B - T_A)}{d_s} = e\left[T_A + \frac{2}{r\left(d_A + \frac{1}{4d_s}\right)} + \frac{1}{2rd_sT_B}\right] \quad (1)$$

Where (e) represents the amount of thermal energy transferred through unit area of the disc per second ($W/m^2.K$) and it calculated from the following equation (2) [14]:

$$IV = \pi\, r2e(TA + TB) + 2\,\pi\, re\,[dATA + dS\,\frac{1}{2}(TA + TB) + dBTB + dcTc \quad (2)$$

$$IV = 2\pi re(T_A + T_B) + 2\pi re\left[d_AT_A + d_S\frac{1}{2}(T_A + T_B)d_BT_B + dcTc\right] \quad (3)$$

Where; (T_A, T_B, T_C) represent the temperature of discs (A, B, C) respectively.

d: disc thickness (cm), r: disc radius (cm), I: current (Amp), V: voltage (volt).

When putting sample between (A, B) discs and applied power for circuit and let it for l hours. To reach all discs at equilibrium case in temperature and recorded the values of (T_A,T_B,T_C) and let it (discs) to cool gradually for 45 min. and repeat the experimental again for all discs.

In (2002), Al-Khazraji studied the mechanical, thermal and electrical properties of epoxy resin reinforced with different clays and minerals namely Bentonite, Koalinite, Zeolite, Selenium oxide, Barium titanate and Calcium carbonate.

The hardness of the sample reinforced with 5% Barium titanate was increased by 7% and the modulus of elasticity of the sample reinforced with 5% zeolite was increased as compared with untreated sample [15].

In (2007), Mondal and Khakhar studied the properties of high-density (140–160 kg/m3) rigid PU-clay nanocomposite foamsmade frompolyether polyol. They found that the compressive modulus increased and the mean cell size decreased with addition of clay [16].

In 2009, Ismaeil and his group studied the effect of water absorption on the age of the use of wood, nano clay composites with polymer were they improved specifications ester and Polyethylene composite to resist the entry of water into the body of composite [17].

In (2017), Rana M. S, studied some mechanical and physical properties (i.e. the impact strength, hardness, flexural strength, thermal conductivity and diffusion coefficient) of (epoxy / polyurethane) blend reinforced with nano silica powder (2%wt.). Results showed that water had affected the bending flexural strength and hardness, while impact strength increased and thermal conductivity decreased [18].

Materials and methodology

Epoxy resin used in this work was Sikadur - 105 which is a two component, low viscosity epoxy resin system in the form of transparent liquid (which transforms into solid state after adding the hardener to it in a percentage of (2:1).

Polyurethane were used in this study (PU) which has two components composed of a base resin and curing agent (hardener), low viscosity polyurethane system in the form of transparent liquid, which transforms into solid state after adding the hardener to it in a ratio (1:2). Which supplied by Fosroc Company, UK. It has density equal to (1.1-1.3)gm/cm^3.

Micro Kaolinite clay used in this with particle size (53 µm) and density (2.65 mg/cm^3) were supplied from (England), from Don Construction Products Ltd. UK. Company. The kaolin used in this study was hydrated Aluminum silicate was used in this work as a reinforcement material. Chemical analyses of kaolin are shown in table 1 and the specifications show in the Table 2.

Table 1: Chemical composition for kaoline clay.

Constituents	Concentration %
SiO_2	48.57
Al_2O_3	35.05
CaO	0.6
MgO	0. 77
K_2O	0.08
Fe_2O_3	1.34
TiO_2	1.19

Table 2: Specifications of micro clay.

Density	Particle gran size	Color
2.65(g/cm^3)	53 (µm)	White

kaoline clay Nano Particles powder prepared from a company (NANOSHEL ,USA), powder and the specifications show in the table 3.

Table 3: Specifications of nano clay.

Product	Nano kaoline Clay
Molecular Weight	258.2 g/mol
Molecular Formula	$Al_2Si_2O_5(OH)_4$
Specific Gravity	~2.6
Melting Point	> 1500ºC
Solubility	Insoluble in cold water
Purity	> 99%
Particle Size	< 80nm
Color	White

Hand Lay-Up method was used to prepare the samples. The epoxy was mixed with the hardener by 2:1 ratio by mixer for (7-10 min.) and mixing the polyurethane with the hardener by 2:1 for the same time, then mixing the materials with each other to form Polymer blends were prepared with different ratios (90-10, 80-20, 70-30, 60-40) %, and selected the optimum ratio (80-20) % by using impact test and reinforced with mico and nano clay with weight ratio (2, 4, 6, 8) %.

Table 4: Sample's dimensions and standard specification.

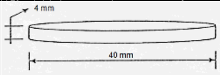
Test	Sample's dimensions	Standard Specifica-tions
Thermal con-ductivity		ISO-179

Figure 1: Photographic image Thermal conductivity test specimens.

Results and Discussion

Lee's disc instrument is used to calculate thermal conductivity of the samples under test using equations (1) and (2) to measure thermal conductivity of samples in natural condition and after exposure (24 hours) to UV irradiation from figures (2, 3) and tables (5, 6), we see the experimental results in natural condition (N.C) and UV case.

By using equations, thermal conductivity ware calculated the experimental results for particle and nanocomposites in Natural condition and UV Irradiation show increases with increasing weight fraction for all samples**.** This due to a significant effect is given by the dispersed phase and the adhesion between the components. An increase in the adhesion between the components in the polymer or filled polymer produces a decrease in the heat resistance at the component boundaries and an increase in the coefficient of heat transfer of the material**.**

The value of thermal conductivity for (Nano Clay) samples more than that of (micro CdO) for the same weight fraction [19].

The reason of that is related to the small size of Nano particle which penetrate into the blend (EP+PUR) this lead to high stacking density of Nano particles, which leads to reduce air spaces already exist in composite material (manufacture during) this results in reduced air spaces that work as insulator so increasing thermal connectivity of composite.

Table 5: Thermal Connectivity value for particle and Nano of (Clay) samples at natural condition.

Wight Fraction Wt%	Thermal Connectivity (W/m.°C)	
	Clay	Nano Clay
(2 + 98 Blend)	0.36446	0.37457
(4 + 96 Blend)	0.38391	0.41321
(6 + 94 Blend)	0.40282	0.43468
(8 + 92 Blend)	0.44547	0.45273

Table 6: Thermal Connectivity value for particle and Nano of (Clay) samples exposure to UV.

Wight Fraction Wt%	Thermal Connectivity (W/m.°C)	
	Clay	Nano Clay
(2 + 98 Blend)	0.38214	0.39573
(4 + 96 Blend)	0.41536	0.44681
(6 + 94 Blend)	0.42047	0.45359
(8 + 92 Blend)	0.47143	0.48211

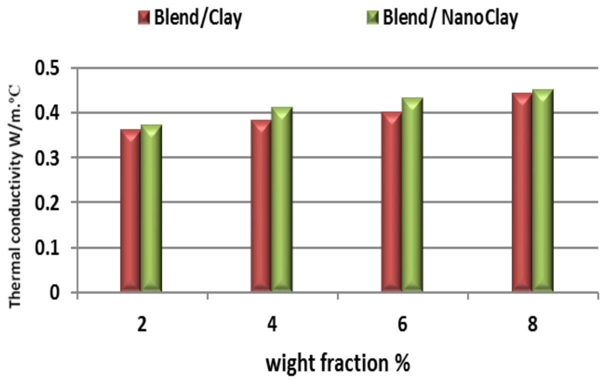


Figure 2: The Thermal Connectivity value relation with weight fraction for particles and nano (Clay + Blend) at natural condition.

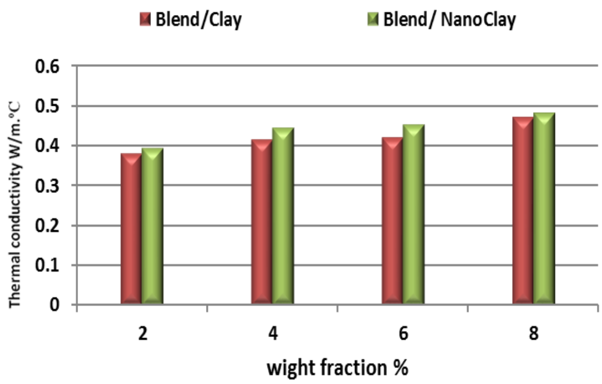


Figure 3: The Thermal Connectivity value relation with weight fraction for particles and nano (Clay + Blend) exposure to UV.

In the case of UV irradiation for the time interval (24 h). From table 6, and figure 3, we find that the thermal conductivity value for all samples exposure to UV irradiation are more than that in natural condition, belong to reforming polymer that ultraviolet radiation completed polymerization process and polymer bonding and thus improved thermal conductivity [20].

Conclusions

Thermal conductivity increases with increasing the weight fraction for (micro and Nano clay/blend) in natural condtion and after irradiation by(UV), values of Thermal conductivity for (Nano CdO) samples more than that of particulate (CdO) for the same weight fraction values in the case of UV radiation are higher than values in natural condition.

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