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The Investigation of Thermal Conductivity for Graphene Nanocomposite

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Abstract

The research includes the investigation of thermal Conductivity for Graphene nanocomposite. Nano grapheme (6-8 nm) has been prepared with different weight ratios (1%, 2%, 3%, 4%,5%) with epoxy. All samples prepared by Hand lay-up method and measure the value of thermal conductivity by Lee disc method. The result show that increased the weight fraction of Graphene will gradually increase of the thermal conductivity coefficient (K) of Graphene and the maximum value for thermal conductivity at 5% (K= 1.861 watt/m^2.kelivn).

Keywords: Nanocomposite, Thermal conductivity of polymers, Thermal conductivity coefficient.

Introduction

Nanocomposite are compounds that show at least one of the stages dimensions in the nanometer range (1 nm = 10^{-9} m). Nanocomposite materials emerged as suitable substitutes to overcome the limitations of micro composite and monolithic [1]. Polymer nanocomposite are compounds that have a dimension of less than 100 nm. These nanocomposites have characterized unique and interesting properties that distinguish them from other materials. A small volume of filler leads to a significant increase in the interior area compared to traditional composite materials [2]. Nanocomposite are a very good alternative to traditional composite materials because the distinct properties and to find a wide range of applications in various fields. Nanocomposite systems containing carbon nanotubes have been the subject of modern research and development since their discovery in 1991.

Nanocomposite are substances that add Nano-filler components to improve the properties of the resulting materials. Nanocomposite consists of two or more different components or phases that have different physical and chemical properties, separated by a distinct interface [3]. Thermal conductivity of polymers are important thermal Properties for both polymer applications and processing. Most of the materials have a good conductivity such as metals, while others have very little connectivity such as polymers [4]. Thermosets is a compound that has thermal conductivity due to their easy molding capability and high thermal resistance.

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However, some types of epoxy resins are amorphous resin and have low heat conductivity ranged from 0.15-0.25 W/m^2.K[5]. Polymers and plastics are naturally have low in thermal conductivity. Polymers are light weight, high strength / weight ratio and Easy mold ability, etc.[6]. The aim of this study was to control the values of thermal conductivity for polymers using Nano graphene materials.

Experimental Work

Epoxy resin of a trademark (Euxit 50 KI) is a liquid of low viscosity resin as compare with other thermosets and it is converted to solid state by adding hardener (Euxit 50 KII) at ratio of (5:2), which were supplied by Egyptian Swiss chemical industries company .The properties of epoxy resin used in this work show in table (1) according to the properties of Product Company ASTM D-543 and ASTM C-881-87.

The Graphene used produced by the Company Sky-spring Nanomaterials. The properties of graphene used in this work shown in table (2) according to the properties of Product Company.

Lee's disc apparatus performed the measurements of the thermal conductivity (k)using the following equation[7]:

$$I.V= \pi.r^2.h. \quad (T_1+T_2)+2\pi r.h \quad [d_1T_1+d.(T_1+T_2/_2+d_2T_2+d_3T_3... \ldots \qquad (1)$$

Calculate the amount of thermal energy (h) passing through the disc through the following equation:

$$K\,(T_2-T_1)/d=h\,[T_1+2/r\,(d_1+d/2).T_1+1/r\,.d.T_2] \ldots \qquad (2)$$

Where:
K= Thermal conductivity coefficient ($w/m^2.k$)
I = Electric current (A).
V=voltage (volt).
r = Radius of disk (mm).
h = amount of thermal energy.
d = Thickness of disk (mm).
d_1,d_2,d_3 = Thickness of spacemen (mm).
T_1,T_2,T_3=temperature in kelvin.

Preparation for Graphene Nanocomposite

Five samples were prepared for each test**.** The weight of graphene calculated according to the required weight fraction **(**1**,**2**,**3**,** 4**,** and 5 %wt.**)** ratios of epoxy resin**.** Each ratio of graphene**,** epoxy and hardener was weighted separately using a sensitive balance then the Nano graphene manually mixed with epoxy resin for about 15 minute at room temperature continuously and slowly to avoid bubbling during mixing until a homogeneous state of the mixture**.** Intermingling the mixture by electric mixer for 10 minutes to avoid heat generated during mixing which is effect on the properties of epoxy resin and to disperse the nanoparticles homogeneously**.** The mixture placed in the desiccator to remove the bubbles and then the sample was poured into the glass and plastic molds that were previously prepared**.**

Adding of hardener to the mixture with gentle mixing, and then mixture was poured from one corner into the mold **(**to avoid bubble formation which causes cast damage**)** and the uniform pouring is continued until the mold is filled to the required level**.** The mixture was left in the mold for **(**24**)** hours at room temperature to solidify**.** The plastic molds made of Teflon in circularform for thermal tests**(**dimensions 4*3 mm**)**and then extract the samples from the molds and softened and work for thermal properties tests as shown in Figure I.

Results and Discussions

Thermal Conductivity for Graphene (Nano structure)

Heat is one a form of energy**,** associated by the movement of atoms or particles or any particle involved in the composition of matter[8].Where heat are transmitted through the conductivity method from high-energy molecules into least energy molecules. In the epoxy, thermal conductivity is due to the phonons, and consider graphene are good materials for thermal conductivity. When adding percentages of graphene to the epoxy as shown in the tables (3) and Figure (II), thermal conductivity coefficient (K) increased as shown in the previous tables the reasons of Epoxy into the following:

When mixing the epoxy with the graphene will spread the particles of graphene in parts mixture at a randomly, depending on the process of manufacturing and the presence of these grains will play an important role in the process of thermal conductivity. When applied heat energy into surface module, this energy will transfer from the upper heat to the lowest heat and the mechanism of heat transfer depends on two phenomena: First: heat transfer by the phonons (generated by vibration of the polymer chains). Second: Free electrons (graphene).

When the amount of heat to the polymer chains will vibrate, these chains and molecules form a group of phonons that transmit heat and free electrons move through the molecules**,** causing heat to pass through the materials.

Conclusions

1. When increased the weight fraction of Graphene will increased the thermal conductivity coefficient (K) of graphene.
2. Particle size has a significant role and influence on thermal conductivity coefficient (K).
3. The graphene has a high thermal conductivity coefficient (K).

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Table 1
Show the properties of epoxy material

***Density At 20 C°* (gm/ cm3)**	***Viscosity At 20C°***	***Colour***
1.05	***300***	***colorless***

Table 2
Show the properties of grapheme

Appearance	***Particle size (nm)***	***Surface Area(m^2/g)***	***Purity Carbon***	***Morphology***
Black Nano powder	***6-8***	***120-150***	***99.5%***	***Flake***

Figure I
Show the specimens prepared in this work according to stander specification

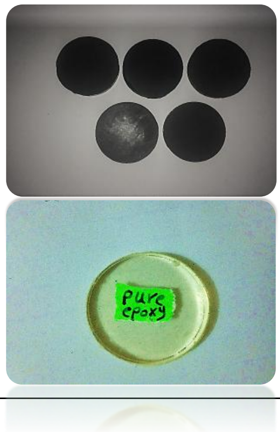
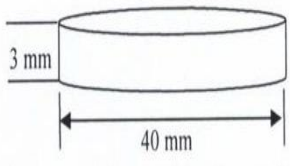
Thermal Conductivity		***This test is not destructive specimens***	

Table 3
Show the ratio weight Fraction and values of Thermal conductivity coefficient (K) (watt/m^2.kelivn) of Graphene and pure Epoxy

Weight Fraction (W %) of Graphene	Thermal conductivity coefficient (K) **(watt/m^2.kelivn)**
Pure Epoxy	0.294
1%	0.897
2%	0.929
3%	1.09
4%	1.344
5%	1.861

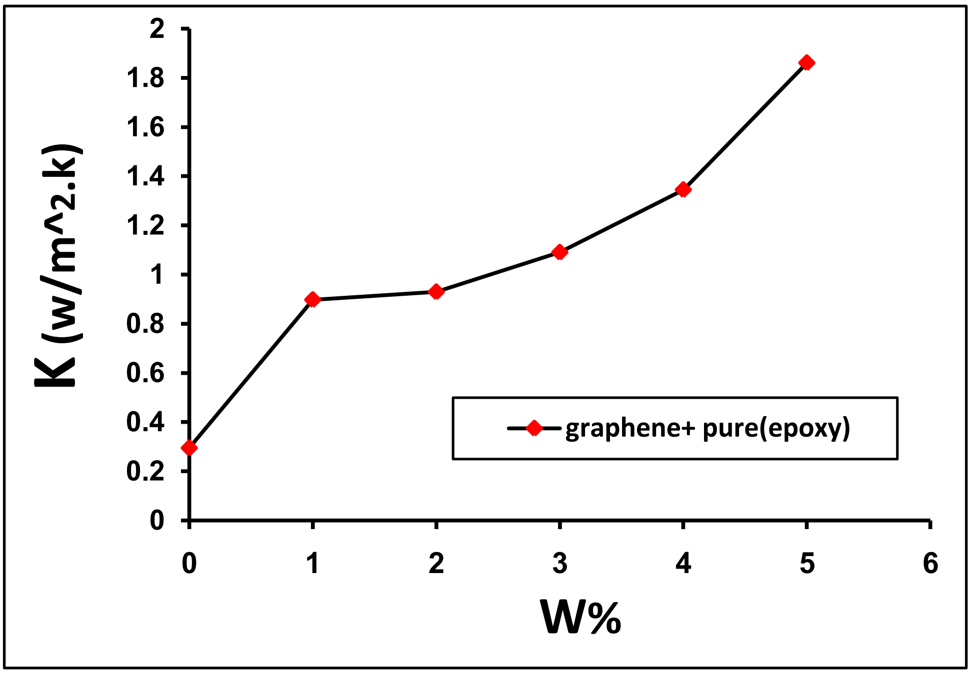


Figure II
Show the value of Thermal Conductivity for Graphene

فحص التوصيلية الحرارية للمركب النانوي الگرافين

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الخلاصة:

يتضمن البحث فحصالتوصيلية الحراريللمركب النانويالگرافين. تم تحضير الگرافين بنسب وزنية مختلفة (1%, 2%, 3%, 4%, 5%) مع الايبوكسي. جميع العينات الخاصة بالتوصيل الحراري حضرت بأستخدام طريقة القولبة اليدوية وتم حساب معامل التوصيل الحراري لها بأستخدام قرص لي .النتائج أظهرت انه كلما ازدادت النسب الوزنية للگرافين سوف يزداد معامل التوصيل الحراري تدريجيا وتكون قيمته اعلى ما يمكن عند النسبة 5%.

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