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Synthesis and Characterization of (Go-Mgo-Popda- Pva) Quaternary Nanocomposite Film with Thermal Conductivity Performance

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Abstract

In this work, a pure polyvinyl alcohol (PVA) polymer film reinforced with magnesium oxide(MgO) ,graphene oxide (GO) and poly(o-phenylene diamine) (PoPDA) with different weight ratios (0, 2, 4, 6, 8, 10 wt%) prepared by the solution casting method. Fourier-transform infrared spectroscopy (FTIR), scanning electron microscope (SEM) and X-ray were used to characterized the nanocomposite. And study the thermal conductivity for the quaternary hybrid composite films (GO -MgO-PoPDA-PVA), it was noticed that there is a rise in the rate of the thermal conductivity coefficient (k) with a rise in the weight ratios of reinforcement.

Keywords: Hybrid Nanocomposites, Magnesium Oxide (MgO), Graphene Oxide (GO), FTIR, SEM, X-ray, Thermal Conductivity Coefficient.

تحضير وتشخيص أفلام المركب النانوي الرباعي (GO-MgO-PoPDA-PVA) وقياس التوصيل الحراري

تبارك احمد جاسم وعامر فاضل داود

قسم الكيمياء - كلية العلوم - جامعة ديالى

الخلاصة

في هذا العمل تم تحضير غشاء بوليمر نقي مقوى بأكسيد المغنسيوم وأكسيد الجرافين بنسب وزنية مختلفة (0، 2 ، 4 ، 6 ، 8 ، 10wt%) باستخدام طريقة الصب بالمحلول. ان تأثير إضافة الجسيمات النانوية (أكسيد المغنسيوم (MgO) وأكسيد

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الجرافين (GO) بنسب وزنية مختلفة على الموصلية الحرارية للأغشية المركبة الهجينة الرباعية (GO -MgO-PoPDA-PVA) ، نلاحظ زيادة في قيمة معامل التوصيل الحراري (k) مع زيادة نسب وزن التدعيم ، واستخدمت تقنيات FT-IR ، SEM و X-RAY لتشخيص المركب النانوي.

الكلمات المفتاحية: مركبات النانو الهجينة ، أكسيد المغنيسيوم (MgO) ، أكسيد الجرافين (GO) ، طيف الأشعة تحت الحمراء (FT-IR) ، مجهر المسح الإلكتروني (SEM) ، الأشعة السينية ، معامل التوصيل الحراري.

Introduction

In recent years, polymer Nano composites (PNC) have been discovered to be very important materials due to the numerous applications they have in different domains, such as optical/optoelectronic materials, polymer dielectrics, polymer ferroelectrics, polymer piezoelectrics, polymer magnetoelectrics, and polymer magneto-dielectrics, as environmental remediation materials, etc. [1–6] . Because of their potential commercial use in sensors, actuators, transducers, capacitors and memory systems, these materials are gaining interest, etc. The importance of these materials is fundamentally due to the complex interfacial region between the filler/polymer due to the large surface area of the fillers giving rise to tremendous variation in their intended physical properties required for various multifunctional applications. From the perspective of energy storage, they have developed into very clever materials[7–22], or any other multifunctional applications, owing to their natural flexibility, they are able to solve even the most challenging design issues .In previous studies conducted in the laboratories of our department ,some Nano composites were prepared and their thermal and electrical properties were studied and applied as super capacitors[23,24] .The aim of this study synthesis new ternary Nano composite (GO-MgO-PoPDP-PVA**) ,** and measurement its thermal conductivity coefficient (k) by using (Lee's Disc) Method.

Experimental part

Synthesis of binary nanocomposite

The (GO) synthesized using the modified Hummer process[25].The (MgO) nanoparticles were synthesized using (Sol-Gel) method.The binary nanocomposite(GO-MgO) was prepared by

dispersing (0.5 g) of GO in 100ml of deionized water using an ultrasonic water bath at (25ºC) for 1 hour to form a GO solution. Followed by addition (0.5 g) of MgO to(GO) solution. After addition, Stirring for (2h) at 25ºC and then diffuse for another (1h) .The precipitate formed was separated by centrifugation and dried at (80ºC) for (2h) [26].

Synthesis of the Ternary nanocomposites

The ternary nanocomposites was prepared by dispersing (0.5 g) of the (GO-MgO) binary composite in (50 ml) of deionized water using an ultrasonic bath at 25ºC for (1h) followed by mixing (1.62 g) of o-PDA dissolved in (100 ml) of HCI (HCl acid 0.1M) with continuous stirring for (1 h) in an ice bath. The oxidizing agent solution were prepared by dissolving (6 g) of (APS) in 100 ml (HCI) with a concentration of (0.1M). It is gently added dropwise to the main mixture with fast stirring. Then the new mixture kept in an ice bath under stirring for (4 h). Then, moderate stirring for (20 h) at (25ºC), the precipitate filtered and washed with acetone and deionized water several times, and dried in the oven at (80ºC) for (2 h)[26].

Synthesis of the Quaternary Composites

Pure PVA polymer films supported by triple nanocomposite (GO-MgO-PoPDA) were prepared with six different concentrations as follows:

Table 1: Concentrations of Polymer and GO-MgO-PoPDA

CONCENTRATIONS WT%	POLYMER (GM)	GO-MGO-POPDA (GM)
0%	1	Zero
2%	0.98	0.02
%4	0.96	0.04
%6	0.94	0.06
%8	0.92	0.08
%10	0.90	0.10

Where the PVA dissolved in (15 ml) deionized water with stirring at (60°C) to form a homogeneous solution ,the triple composite dispersed in (3 ml) of deionized water and slowly added to PVA solution. The mixture stir for (1h) and with heating up to a temperature of (50°C) to form a homogeneous solution. Then it was poured into a petridish and dried at room

temperature. Finally, the films of the nanocomposites were peeled off to study their physical properties.

Results and discussion

1. FTIR of the ternary composite films (GO-MgO-PoPDA)

Figure (1) shows the FTIR spectrum of the triple composite, which shows the presence of several distinct bands for the ternary hybrid composite, as the absorption bands at the region (3440.8 cm^{-1}- 3110 cm^{-1}) belong to the group (NH,NH2) , the band's (1680.7.1 cm-1) appearance, which is connected to the stretching vibrations (C=O) group (which is related to graphene oxide). The two bands centered at the area (1617.7 cm^{-1}-1531 cm^{-1}) belongs to the stretching vibrations of the group (C=C) . As for the absorption bands (1361.7 cm^{-1} - 1247.5cm^{-1}) they belong to (C-N) in the quinoid and benzoide groups, in addition to the peaks (1137.3 cm^{-1}-1393 cm^{-1}) belong to epoxy alkoxy group, while the peak (436.29cm^{-1}) belongs to Mg-O.

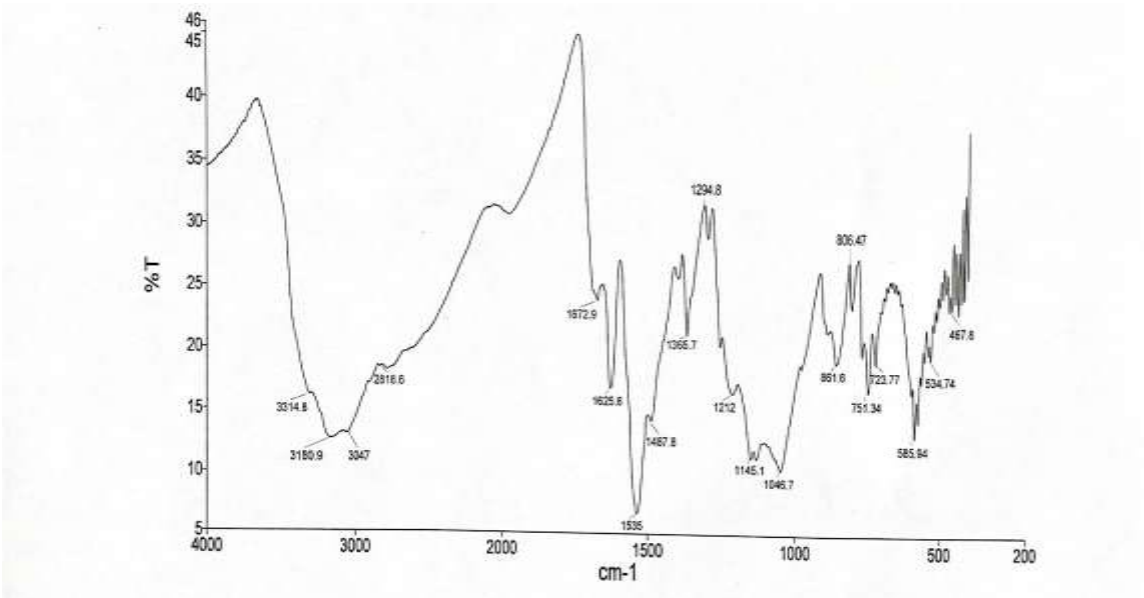

Figure 1: FTIR spectrum of the triple composite films (GO-MgO-PoPDA).

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2. Scanning Electron Microscope (SEM) of Triple Composite films (GO-MgO-PoPDA)

Figure (2) Shows Scanning Electron Microscopy examination with magnification power of (µm1), (500nm) and (200nm). It was observed from the examination that there are irregular structures in shape and dimensions in all the images. It is noted that graphene oxide and magnesium oxide did not appear clearly in this examination as a result of polymerization of the monomer (oPDA) on the surface of the binary compound (GO-MgO).These irregular shapes resulted from the random monomer diffusion between the oxides surfaces in the first step and also the polymerization after the addition of (APS) in the second step.

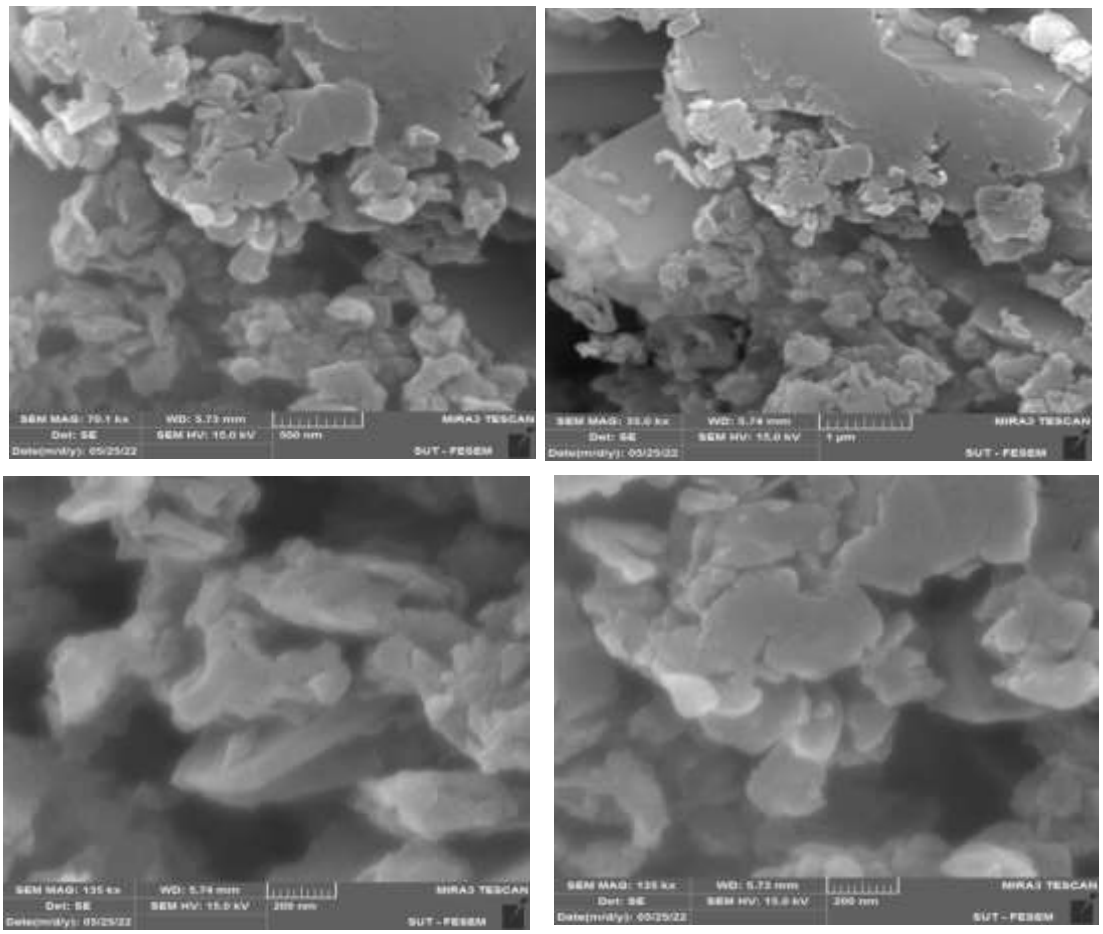

Figure 2: SEM of Triple Composite films (GO-MgO-PoPDA)

3. X-ray diffraction of the (GO-MgO-PoPDA) nanocomposite films

Fig.(3) shows the XRD of the (GO-MgO-PoPDA) nanocomposite films. It has is noted that the highest values of diffraction peaks centered at (2θ=26.7460, 27.9421, 19.7250) and it is clear from the figure below that the prepared ternary nanocomposite films can distinguish the peaks of magnesium oxide (MgO). The PoPDA polymer is clearly overlapped by the diffraction peaks and no graphene oxide peaks appear due to the overlap of the polymer peaks with the magnesium oxide peaks.

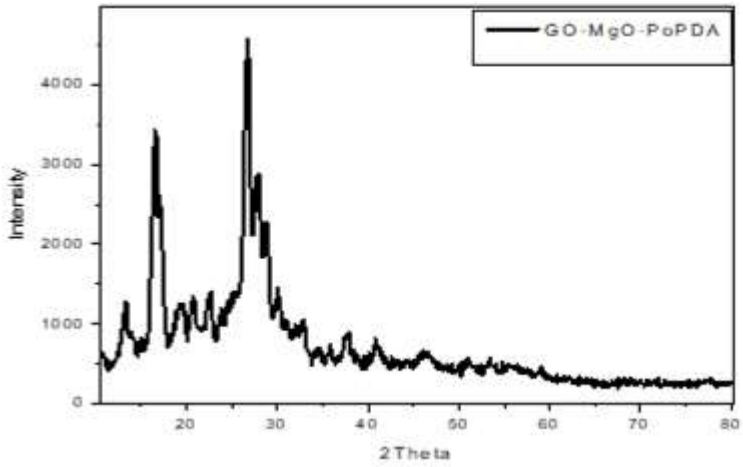

Figure 3: XRD of the (GO-MgO-PoPDA) nanocomposite films

Thermal conductivity coefficient

Thermal conductivity coefficient (k) were using (Lee's Disc) Method. Figure (4) shows thermal conductivity coefficient of the pure PVA film and the films of the hybrid nanocomposites (PVA: POPDA-GO-MgO) with different weight ratios. It was noted from the figure that the value of the thermal conductivity coefficient of the pure PVA film is (9.04×10^{-5} W/m.oK) and when reinforced with nano-oxides (magnesium oxide (MgO) and graphene oxide (GO)) it was noticed an increase in the value of the thermal conductivity coefficient (k) with an increase in the percentage of reinforcement, the reason of these results are because of the heat that passes inside The composite substance and the grains come into contact (Magnesium Oxide (MgO) and Graphene Oxide (GO)) which begin to absorb heat and this absorption leads to an increase in the passage of heat through the material, which increases (k) but after a period of time and

an increase temperatures these granules begin to vibrate as a result of their high temperature. This vibration causes heat to rush through the overlapping material, which leads to the rise in its heat conductivity. The absorption of heat from (Magnesium Oxide (MgO) and Graphene Oxide (GO)) increases with increasing its proportion within the composite material and this leads to an increase in conductivity [27]. The addition of nano-oxides can act as a factor to increase the crystallization rate of the polymer, which results in a thermal conductivity coefficient greater than the thermal conductivity coefficient of the pure (PVA) polymer film [28]. Table (2) shows the thermal conductivity coefficient values for all the prepared hybrid nanocomposites films.

Table1: Thermal conductivity coefficient values of hybrid nanocomposites.

THERMAL CONDUCTIVITY COEFFICIENTS (K) (W/M.^{O}K)		
Concentrations wt%	**e (W/m^2.^{o}K)**	**k (W/m.^{o}K)**
0%	0.080445	$9.04x10^{-5}$
2%	0.079437	$2.55x10^{-4}$
4%	0.078649	$3.01x10^{-4}$
6%	0.079755	$3.78x10^{-4}$
8%	0.079632	$4.22x10^{-4}$
10%	0.077502	0.00125

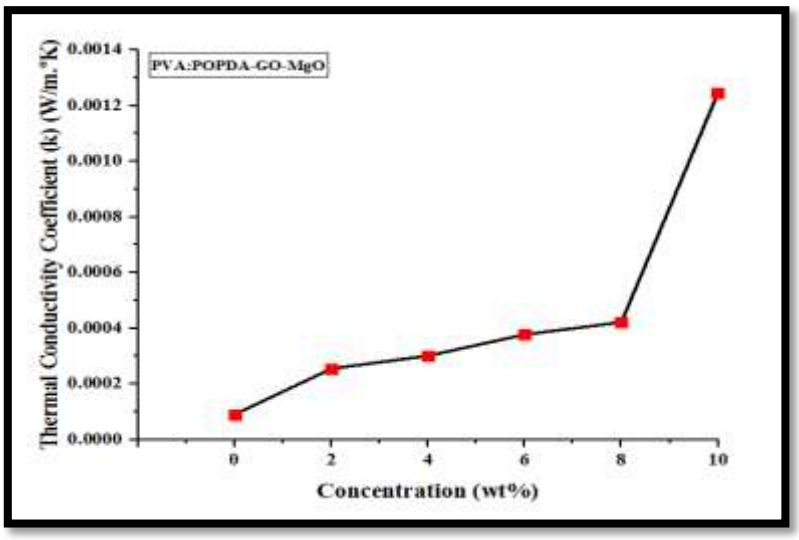

Figure 4: Thermal conductivity coefficient of the hybrid nanocomposite with different weight ratios of (GO, MgO).

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