Study of Electrical Properties of Poly (Vinyl Alcohol)/ Alumina (PVA/Al_2O_3)Nanocomposites

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Abstract

In the present work, nanocomposites of polyvinyl alcohol and alumina nanoparticles, have been prepared by casting technique. The alumina nanoparticles were added to polyvinyl alcohol with different concentrations are(0, 4, 8, 12 and16) wt.% .The electrical properties of nanocomposites were studied. The experimental results showed that the D.C electrical conductivity increases with increase the alumina nanoparticles concentrations and temperature. The activation energy of D.C electrical conductivity decreases with increase of alumina nanoparticle concentrations," and by find the samples by the microscopic photographs.

Keywords: Nanocomposite, Nanoparticles, Electrical Properties

1. Introduction

The growing demand to nanomaterials is due to the fact that new chemical and physical properties are attainable when nanosized fillers added into polymer matrixes where a single molecule or the same material without nanofiller does not show such advantages. In the past decades an extensive research activities have been devoted on incorporating poly- mers with nanoparticles since polymer-based nanocomposites showed much better thermal and mechanical properties compared to the polymer matrixes having micron sized particles. This is due to the effect of the unique nature of the nanosized filler on the bulk properties of polymer-based nanocomposites [1].Nanocomposites technology has now reached the stage where basic research is being applied towards material and process development, aimed at specific products or semi-finished materials .A number of new product are appearing on the market (automotive components, sport equipment, consumer goods); existing processes are being improved with the applications of nanocomposites technology and material. [2] Nanoparticles embedded in polymer matrix have attracted increasing interest because of the unique mechanical, optical, electrical and magnetic properties displayed by nanocomposites. Due to nanometer size of these particles, their physicochemical characteristics differ significantly from those of molecular and bulk materials .Nanoparticle reinforced polymers, synergistically combine the properties of both the host polymer matrix and the discrete nanoparticles. The approach demonstrates the potential to change characteristics of thermosetting and thermoplastic polymers fundamentally to improve their general performance. However, the

polymer matrix must withstand high mechanical loads; it is usually rein- forced with fillers [3]. There are many factors that affect the polymer nanocomposites proper- ties":(i)Synthesis methods.(ii)Polymer nanocomposites morphology.(iii)Types of nanoparticles and their surface treatments.(iv)Polymer matrix such as crystallinity, molecular weight, polymer.(v)Chemistry, and whether thermoplastic or thermosetting. Nanocomposites includ- ing Al_2O_3 exhibit excellent properties such as high thermal resistance, good chemical stability and moderate to high mechanical strength, Annual demand for alumina has been growing steadily [4].This paper deals with results of the effect of alumina nanoparticles on the D.C electrical properties of poly-vinyl alcohol."

2. Material and Methods

The materials used in this study arepoly-vinyl alcohols matrix it was obtained as powder from(Tuttlingen/Germany) andalumina nanoparticlesas a filler it was obtained as powder from (Nano shel USA) company.

The weight percentages of alumina nanoparticles are (0,4,8,12 and 16)wt.% these samples were prepared by solution casting method. These are mixed for (30-60) minutes then cast on the glass dimensions (2.5x7.5)cm^2 by using the electronic method of films thickness measurement. The thicknesses of the film were 10μm for all samples .The resistivity was recorded by temperature from(30 to 90)^{0}C by using keithley electrometer type (2400 sours mater).The samples are examined by using the optical microscope, which is supplied from Olympus type (Nikon-73346)and equipped with light intensity automatic controlled camera. under magnification(x320).The surface electrical conductivity (σ_s) defined by : [5].

$$\sigma_s = \frac{1}{\rho_s} = \frac{l}{R_s bt} \qquad \text{.....(1)}$$

Where ρ_s: is thes urface resistivity

R_s : the electrical resistance of the prepared films(ohm)

l, band ***t*** are the length, width and thickness of the sample, respectively(cm).

The activation energy was calculated using equation: [6]

$$\sigma_s = \sigma_0 \exp\left(\frac{-E_a}{kT}\right) \qquad T \to \infty\ \sigma_o \text{.....(2)}$$: the asymptotic value of σ for Where

K : Boltzmann constant

E_a:Activation energy

3. Results

The observed variation of electrical conductivity of PVA-Al_2O_3nanocomposites with increasing alumina nanoparticles concentration at room temperature is illustrated in figure(1).From these figure we note that the electrical conductivity is increasing with the in- crease of the concentrations of aluminanano particles."

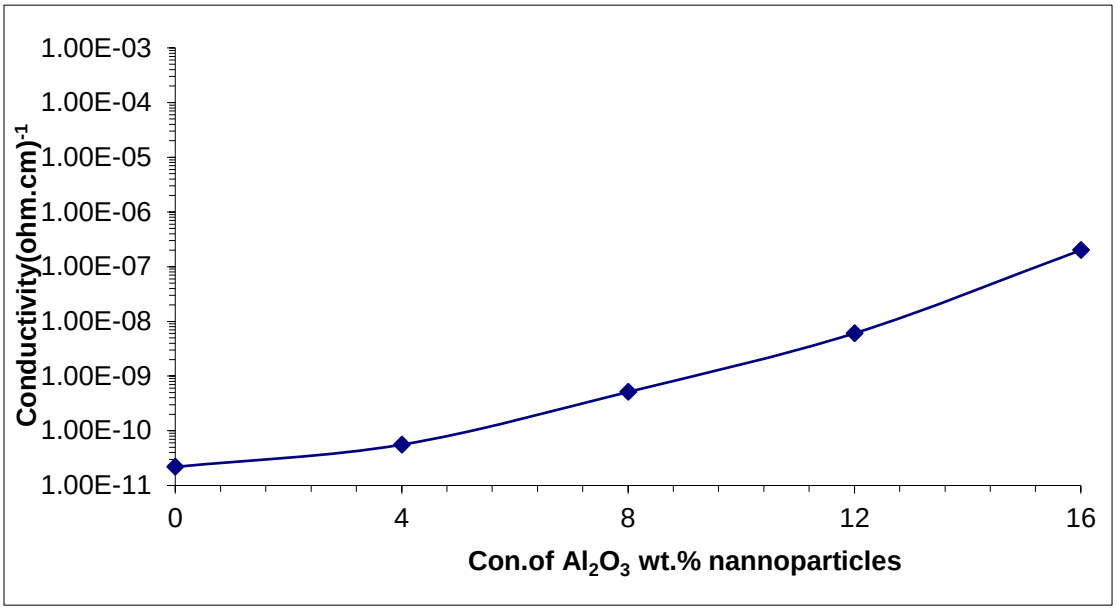
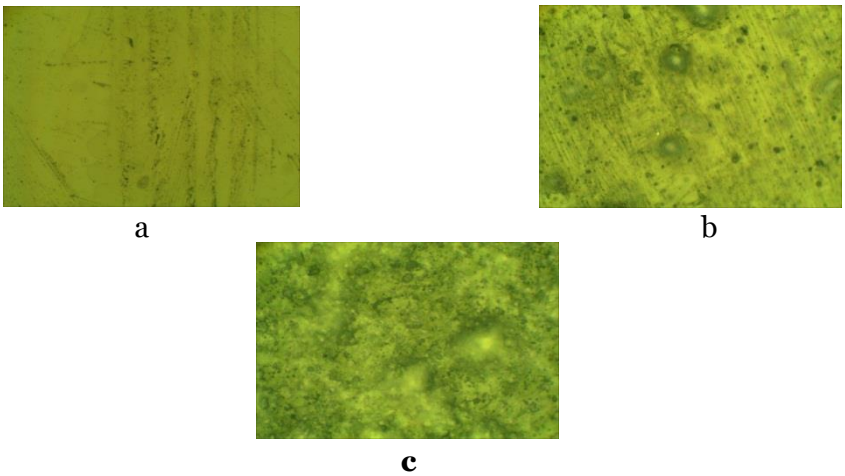


Figure1:Variation of D.C electrical conductivity with Al_2O_3 concentration wt.% for(PVA-Al_2O_3) nanocomposites at room temperature."

The increase of conductivity can be explained as follows: at low concentration the (Al_2O_3) nanoparticles are located in separated groups or cluster inside the polymer, as illustrated in the microscopic photographs in figures (2) taken for samples of different concentrations. However, at the high concentration for nanocomposites the nanoparticles form a continuous network inside the polymer .This network has paths where charge carriers are allowed to pass through the paths that have low electrical resistance [7].



a b

c

"Figure 2: Photomicrographs for PVA-Al_2O_3nanocomposites (a) for pure,(x320). (b) for 4wt.% Al_2O_3 ,(x320). (c) for 16wt.%Al_2O_3 ,(x320).

Figure (3) shows the behavior of electrical surface conductivity of the samples with the temperature. Note that the electrical conductivity increases with increasing temperature and that any of these materials has a negative thermal coefficient of resistance. The interpretation of this fact is that the polymeric chains and alumina nanoparticles act as traps of the charge carriers, which transit by hopping process, on increasing the temperature, segments of the polymer beg in to move, releasing the trapped charges .The released of trapped charges is intimately associated with molecular motion .The increase of current with temperature is attributed to two main parameters charge carriers and mobility of these charges. The increase of temperature will increase the number of charge carriers exponentially. The mobility depends on the structure and the temperature [8]."

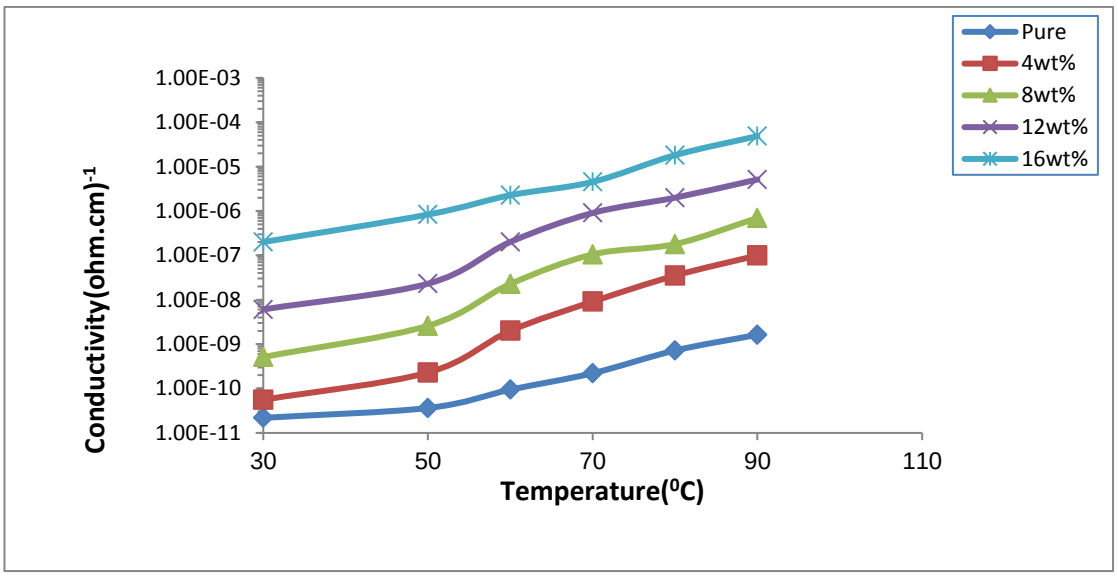


Figure 3: Variation of D.C. electrical conductivity with temperature for (PVA-Al_2O_3)nanocomposites

Figure(4) shows the relationship between the ln(conductivity) and inverted absolute temperature of the (PVA-Al_2O_3) nanocomposites, using equation(2)was calculate activation energy, the high activation energy values for neat sample and low aluminanano particles concentration sample can be attributed to the thermal movement of the ions and molecules, whereas the low activation energy values as illustrated in the Table(1) for the samples of higher aluminanano particles can be attributed to the electronic conduction mechanism which is related to the decreasing of the distance between the aluminanano particles [9].

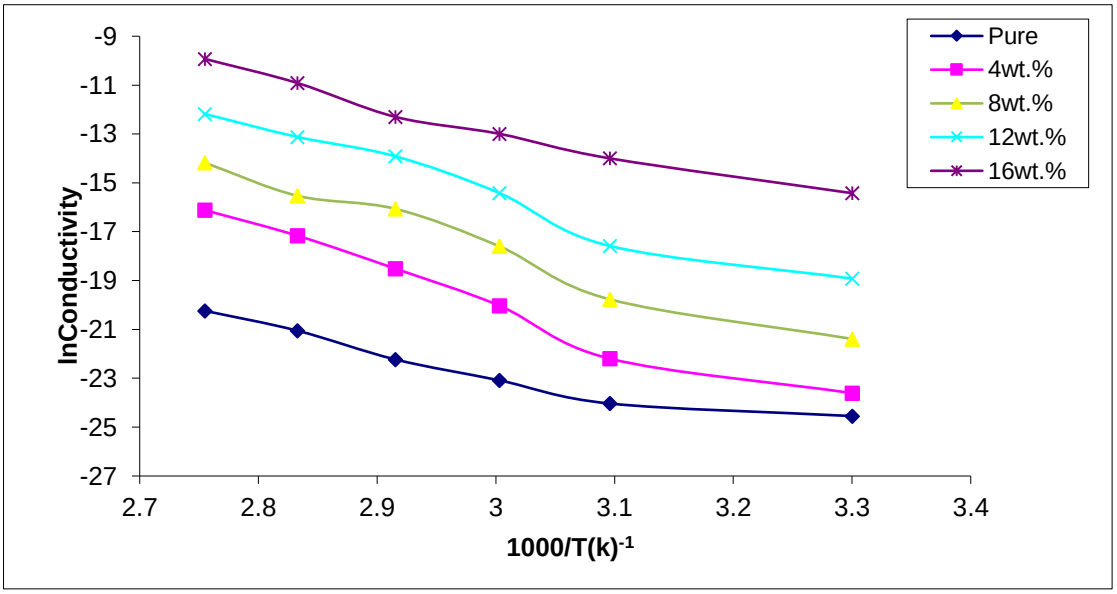


Figure 4: Variation of D.C. electrical conductivity with reciprocal absouretemperature for (PVA-Al_2O_3) nanocomposites.

The concentration increases of alumina nanoparticles less the result of the activation energy as shown in the figure (5) of (PVA-Al_2O_3) nanocomposites for which is a reasonable support for the above discussion[5].

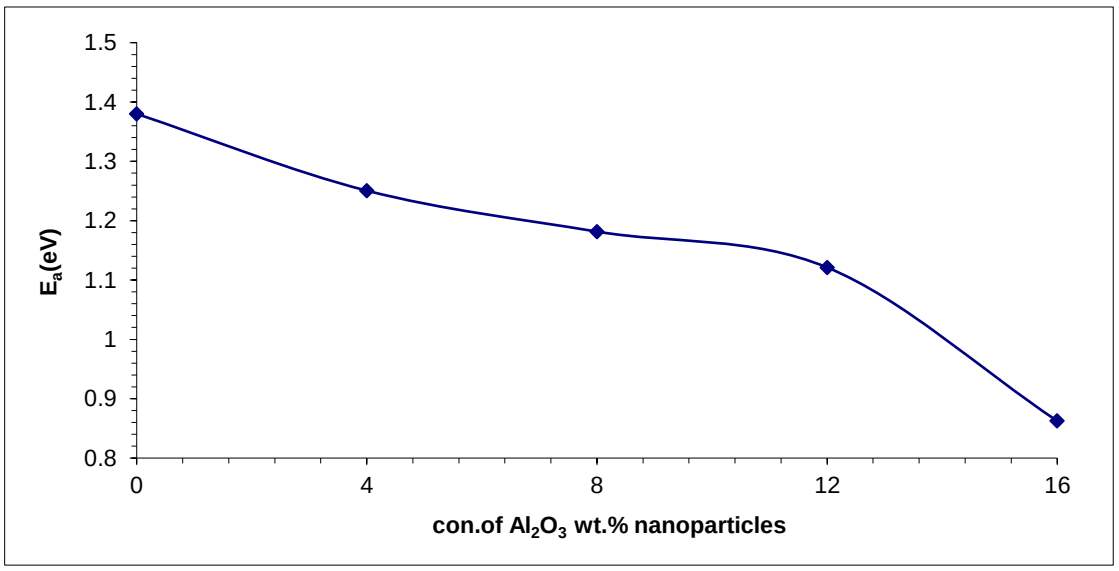


Figure 5: Variation activation energy for D.C. electrical conductivity with Al_2O_3wt.% concentration for (PVA-Al_2O_3) nanocomposites.

Table:(1)Variation activation energy for alumina nanoparticles concentration.

E_a(eV)	Con.Wt.% of Al_2O_3Nanoparticles
1.38	0
1.26	4
1.20	8
1.10	12
0.86	16

4. Conclusions

1. "The D.C electrical conductivity of the polyvinyl alcohol increases by increasing the alumina nanoparticles concentrations and the temperature.
2. The activation energy of D.C electrical conductivity is decreased by increasing ."nanoparticles concentrations alumina

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الخلاصة

في العمل الحالي تم تحضير المتراكبات النانوية من بولي فاينيل الكحول وجسيمات الالومينا النانوية بطريقة الصب. جسيمات الالومينا أضيفت الى بولي فاينل الكحول بتراكيز مختلفة (0,4,8,12,16) بنسب وزنية, ودرست الخصائص الكهربائية للمتراكبات النانوية. حيث أوضحت النتائج العملية أن التوصيلية الكهربائية المستمرة تزداد مع زيادة تراكيز جسيمات الالومينا النانوية ودرجة الحرارة, وطاقه التنشيط للتوصيلية الكهربائية المستمرة تقل مع زيادة تراكيز جسيمات الالومينا النانوية ,وتم فحص العينات بواسطة المجهر الالكتروني.

الكلمات المفتاحية: المتراكبات النانوية ,الجسيمات النانوية ,الخصائص الكهربائية.