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The Effect of Aluminum Oxide Nanoparticles on Dielectric Properties of Polyvinyl alcohol

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ABSTRACT

Effect of aluminum oxide nanoparticles on dielectric properties of polyvinyl alcohol nanocomposites has been studied. The experimental results show that the dielectric properties (dielectric constant, dielectric loss and A.C electrical conductivity) of polyvinyl alcohol are increased with the increase of concentrations of aluminum oxide nanoparticles. The dielectric properties are changed with the increase of frequency of applied electrical field.

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INTRODUCTION

Nanocomposites on base of semiconductor nanoparticles and polymer matrix are prospective materials for application in optoelectronics, for creation of luminescent materials, sensor electronics and etc. Introducing semiconductor nanoparticles into polymer matrix volume changes physicochemical properties of the system. The properties of the obtained structures depend on a semiconductor particle type, dimensions of particles. Furthermore, the physicochemical properties of the system will be under influence of the effects of interaction of nanoparticles with polymer matrix, interphase phenomena in polymer-nanoparticle [1]. Polymer- inorganic nanocomposites have attracted much attention recently due to their unique size dependent chemical and physical properties. Recently there have been many efforts to produce nanosized materials because the electrical and optical properties can be varied via chemical control over size, stoichiometry and interparticle separation [2]. Nanotechnology is the engineering science that can change the material properties. Nanoparticles have a ratio between surface area and volume of a larger, this makes the nanoparticles are more reactive. Reactivity of the material is determined by the atoms on the surface, because only these atoms are in direct contact with another material. Application of nanotechnology used in many fields including high-resolution screen, creating an anti-stain clothing, health and automotive areas [3]. The dispersion of reinforcing nano-sized particles into a continuous polymer host to form a nanocomposite has attracted great attention in recent years, because it can provide important enhancements in physical properties at very low levels of the nano-sized fillers. Utilizing mechanically robust nanosized reinforcements, for example inorganic nanoparticles, into polymer hosts to enhance polymers properties has been widely exploited [4]

Experimental:

Polyvinyl alcohol is dissolved in distill water by using magnetic stirrer in mixing process to get homogeneous solution. The additive aluminum oxide nanoparticles was added to polymer with different weight percentages are (0,1.5 ,3 and 4.5) wt.% . The nanocomposites were prepared by using casting technique. The dielectric properties of nanocomposites were measured using LCR meter in the frequency(f) range100Hz-5MHz at room temperature.
The dialectic constant is [5]:

$$\varepsilon' = \frac{C_p}{C_o} \qquad (1)$$

Where: C_p is parallel capacitance and C_o is vacuum capacitor.
The loss factor (D) is [6]:

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$$D = \frac{\varepsilon''}{\varepsilon'} \quad (2)$$

Where ε'' is dielectric loss.

The dissipated power in the insulator is represented by the existence of alternating potential as a function of the alternating conductivity[7]:

$$\sigma_{A.C} = w\,\varepsilon''\,\varepsilon_0 \quad (3)$$

Where: w is angular frequency and ε_o is vacuum permittivity.

RESULTS AND DISCUSSION

Figure 1: shows the variation of dielectric constant with the frequency for ($PVA-Al_2O_3$) nanocomposites. The dielectric constant is decreased with the increase of frequency, this behavior attributed to decrease the polarization with the increase of frequency for all samples of nanocomposites. The dielectric constant of polyvinyl alcohol is increased with the increase of concentrations of aluminum oxide nanoparticles which due to the increase of the carriers of charge in nanocomposites[8] as shown in figure 2.

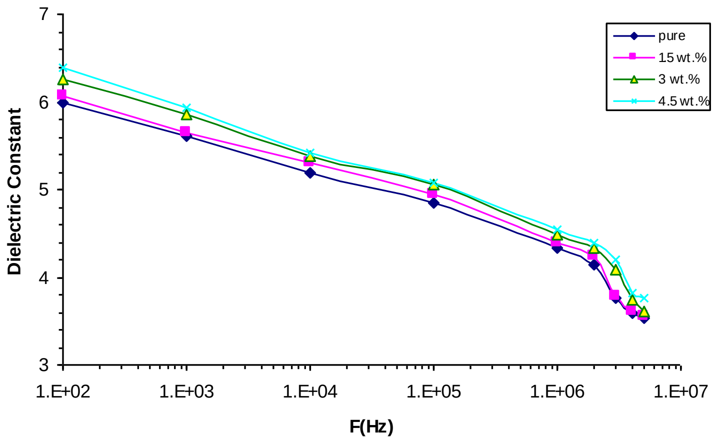

Fig. 1: variation of dielectric constant with the frequency for ($PVA-Al_2O_3$) nanocomposites.

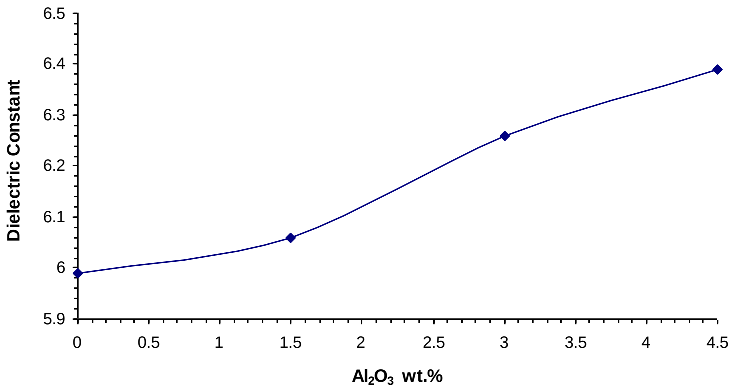

Fig. 2: variation of dielectric constant with the concentration of Al_2O_3 nanoparticles.

Figure 3: shows the effect frequency on dielectric loss of polyvinyl alcohol for different concentrations of aluminum oxide nanoparticles. The figure shows the dielectric loss is decreased with the increase of frequency, this is due to decrease of the space charge polarization. The dielectric loss is increased with the increase of concentrations of aluminum oxide nanoparticles as a result of the dipole charge increase [9] as shown in figure 4.

Figure 5: shows the variation of conductivity of nanocomposites with the frequency. The conductivity is increased with the increase of frequency which due to the charge carriers which travel by hopping process. Also, the conductivity increases with the increase of the concentrations of aluminum oxide nanoparticles as shown in figure 6, this due to forms a continuous network inside the inanocomposite [10].

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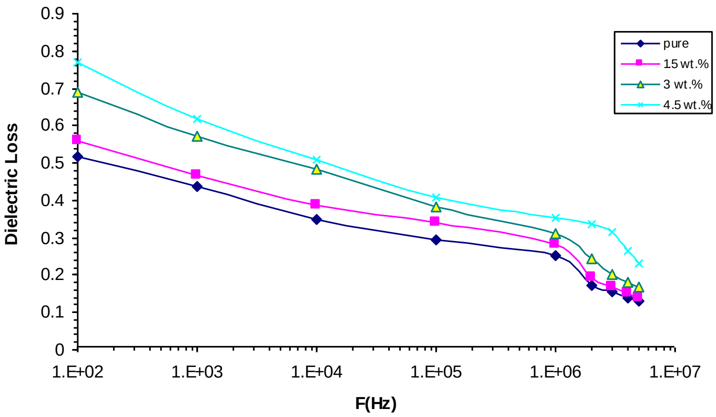

Fig. 3: variation of dielectric loss with the frequency for (PVA-Al_2O_3) nanocomposites.

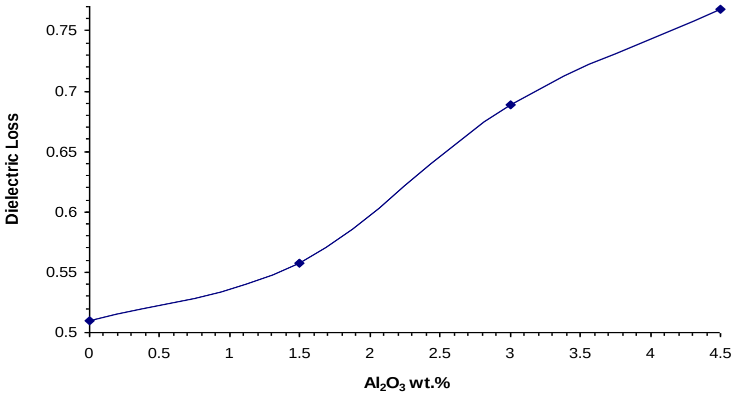

Fig. 4: variation of dielectric constant of nanocomposites with the concentration of Al_2O_3 nanoparticles.

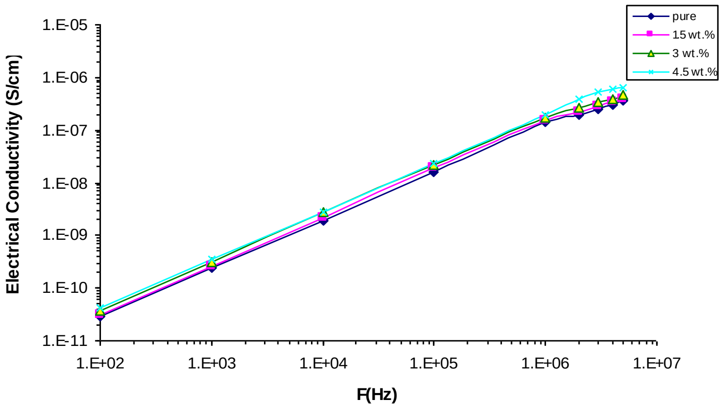

Fig. 5: variation of A.C electrical conductivity with the frequency for (PVA-Al_2O_3) nanocomposites.

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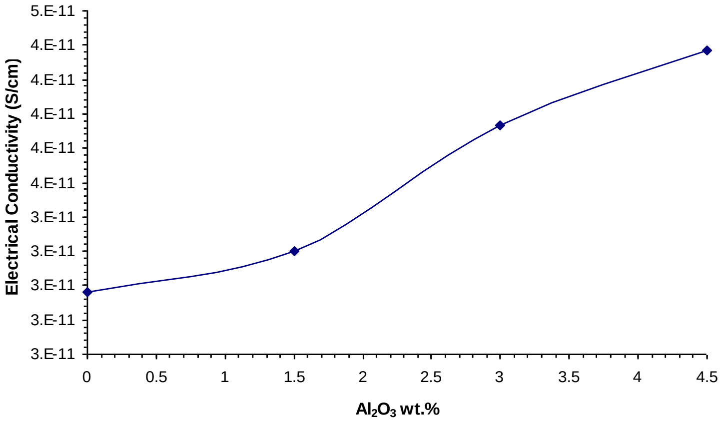

Fig. 6: variation of A.C electrical conductivity of nanocomposites with the concentration of Al_2O_3 nanoparticles.

Conclusions:

1. The dielectric constant of polyvinyl alcohol is decreasing with the increasing of the frequency, and increases with the increase of the aluminum oxide nanoparticles concentrations .
2. The dielectric loss of nanocompsites decreases with the increase of the frequency, and increases with the increase of the aluminum oxide nanoparticles concentrations .
3. The A.C electrical conductivity of polyvinyl alcohol increases with the increase of the frequency and aluminum oxide nanoparticles concentrations.

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