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EFFECT OF NANOSILVER PARTICLES ON THERMAL AND DIELECTRIC PROPERTIES OF (PVA-PVP) FILMS

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ABSTRACT

In this work, study of the effect of nanosilver particles on A.C electrical and thermal properties of polymer matrix consisting of polyvinyl alcohol and polyvinyl- pyrrolidone. The samples of (PVA-PVP-Ag) nanocomposites were prepared by using casting method. The weight percentages of nanosilver are (0, 5,10, 15 and 20) wt.%. The experimental results show that the dielectric and thermal properties of (PVA-PVP) are changed with increase of the nanosilver concentrations.

KEYWORDS: Dielectric Properties, Thermal Properties, Polyvinyl Pyrrolidone, Nanosilver

INTRODUCTION

Conductive polymeric composites obtained by the addition of metal powders to thermoplastic polymers represent an important group of engineering materials, with a great number of applications, such as discharging static electricity, heat conduction, electromagnetic interference shields, electrical heating, and converting mechanical signals to electrical signals. These materials are inexpensive, offer better corrosion resistance than metals, and in most cases require only one-step processing, compared to the great number of steps involved in metal processing. Additionally, the conductivity level can be "fixed" in order to satisfy the various requirements of the end user [1]. Polymers can act as thermal and electrical insulators, which is the basis for their application in many areas. But in certain cases the thermal and electrical conductivity of polymeric materials are required, and such materials are attractive for applications and the development of friction–antifriction materials. They provide inherent electromagnetic interference (EMI) and radiofrequency interference (RFI) shielding to protect aerospace components. Methods currently used to increase the conductivity of polymers are to fill them with specific conductive additives such as carbon blacks, metallic fibers, ionic conductive polymers, intrinsically conductive polymers and incorporation of metallic powders [2]. Composite materials have been increasingly used for various other technical tasks, where it is beneficial to apply lightweight construction materials which have high strength and stiffness characteristics. The favorable specific properties of fiber reinforced polymer composites are based on the low density of the matrix resins used, and the high strength of the embedded fibers. Fabrication of fiber reinforced polymer composites relatively low cost. These composites are considered as replacements for metal materials. Polymer matrix reinforced by fiber is probably the most commonly used form of composites in structural application, such as air craft's, boats, automobiles [3]. There are three principal thermal properties used to describe heat transport through a material: thermal conductivity, specific heat, and thermal diffusivity. Knowledge of the thermal conductivity is essential for the prediction of heat flow rates and temperature distributions for steady state conditions. The thermal diffusivity determined the time-dependent conditions for the unsteady state: the transient heat flow and the temperature distribution in the material. These properties are very important from the standpoint of polymer processing and the use of polymer products [4]. Various kinds of polymers and polymer matrix composites reinforced with metal particles have a wide range of industrial applications such as heaters, electrodes, composites with thermal durability at high temperature etc. These engineering composites are desired due to their low density, high corrosion resistance, ease of fabrication and low cost [5].

MATERIALS AND METHODS

The materials used in this paper are polyvinyl pyrrolidone (PVP) and polyvinyl alcohol as a matrix and nanosilver particle as filler. The polyvinyl pyrrolidone and polyvinyl alcohol (75 wt.% polyvinyl alcohol, 25 wt.% polyvinyl pyrrolidone) were dissolved in distill water. The nanosilver was add to the polymer matrix by different weight percentages are (0,5,10 and 15) wt.% . The casting technique was used to preparation the nanocompsites. The thermal conductivity of samples has been determined by Lee's by a method. The thermal conductivity (*K)* is calculated by[6] :

$$Q = -K \frac{dT}{dx} \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where Q denotes the heat flux, per unit time per unit area, K is the thermal conductivity, and dT/dx is the temperature gradient through the conductive medium.

The dielectric properties of nanocomposites were measured using LCR meter in the frequency(f) range100Hz-5MHz at room temperature. The dielectric constant ,έ(w) using the following expression[7]:

$$\frac{dC(w)}{\varepsilon_o A} \quad \acute{\varepsilon}(w)= \quad (2)$$

Where: C(w) is capacitance, d is sample thickness and A is surface area of the sampl, whereas for dielectric loss

$\varepsilon''(w)$: : $\varepsilon''(w) = \acute{\varepsilon}(w) \times \tan\delta(w)$ …………………… (3)

Where $\tan\delta(w)$ is dissipation factor . The AC conductivity σ_{ac} Can be calculated by the following equation:

$\sigma_{ac}(w) = \varepsilon_o \, w \, \varepsilon''$ ………………… (4)

RESULTS AND DISCUSSIONS

The variation of thermal conductivity of (PVA-PVP-Ag) nanocompsites with the concentration of nanosilver particles at temperature 50C is shown in figure(1). From figure (1) the thermal conductivity is increased with increase of the nanosilver particles, this behavior attributed to increase of the electrons in nanocompsites which increase with the increase of nanosilver particles[8].

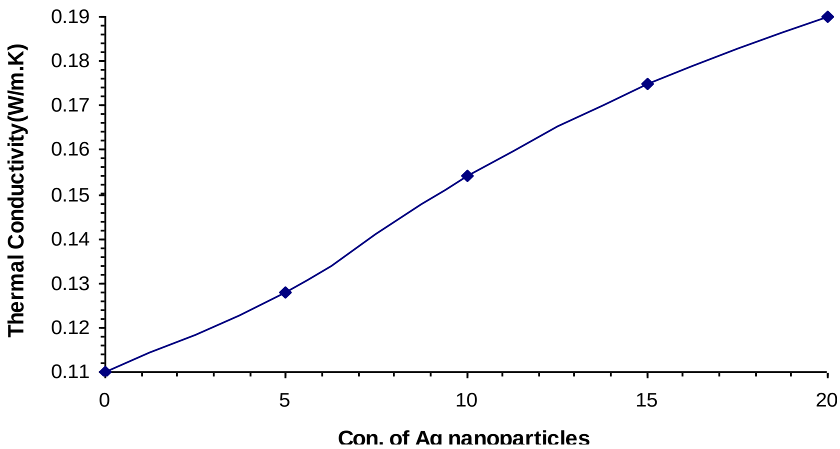

Figure 1: Variation of Thermal Conductivity of (PVA-PVP-Ag) Nanocompsites with the Concentration of Nanosilver Particles

Figure (2) shows the relationship between the thermal conductivity of the nanocompsites with temperature for different concentration of nanosilver particles. Note that the thermal conductivity increases with increasing of temperature.

The interpretation is that the polymeric chains and nanoparticles act as traps for the charge carriers. The increase of the temperature releasing the trapped charges.

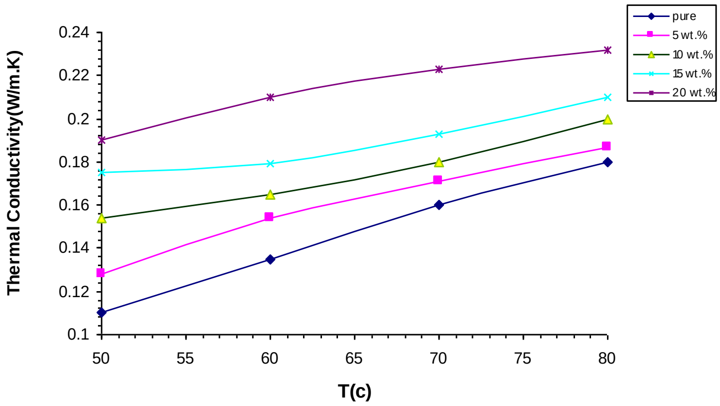

Figure 2: Variation of Thermal Conductivity of (PVA-PVP-Ag) Nanocompsites with the Temperature

Figure (3) shows the variation of the dielectric constant of (PVA-PVP-Ag) nanocomposites with the frequency. The figure shows that the dielectric constant is decreased with increasing of frequency which attributed to decrease the space charge polarization[9]. Also, we can see the dielectric constant is increased with increase of nanosilver concentration which due to increase the charge carries numbers[10], as shown in figure(4).

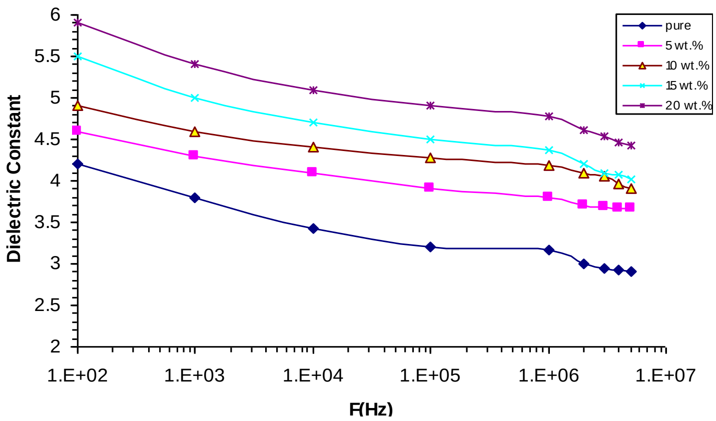

Figure 3: Variation of the Dielectric Constant of (PVA-PVP-Ag) Nanocomposites with the Frequency

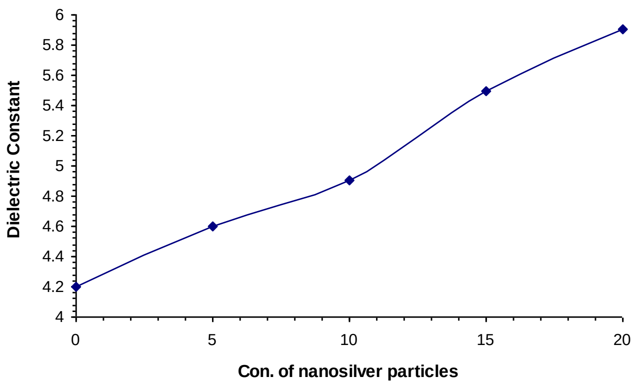

Figure 4: Variation of the Dielectric Constant of (PVA-PVP-Ag) Nanocomposites with the Concentration of Nanosilver Particles

The effect of frequency on the dielectric loss of (PVA-PVP-Ag) nanocomposites for different concentration of nanosilver particles is shown in figure (5). The dielectric loss is decreases with increasing the frequency which due to decrease the dipoles in nanocomposites[11]. The dielectric loss is increased with the increase of the weight percentages of nanosilver particles which attributed to increase the numbers of electrons in nanocomposites which is increase the electrical conductivity of polymer matrix[12], as shown in figure (6).

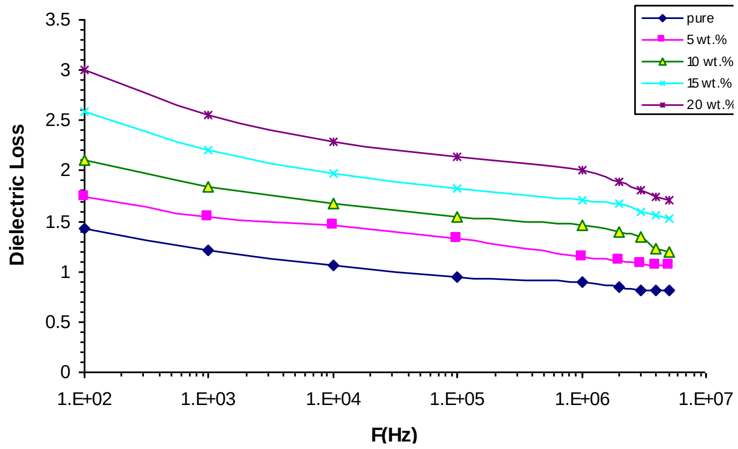

Figure 5: Variation of the Dielectric Loss of (PVA-PVP-Ag) Nanocomposites with the Frequency

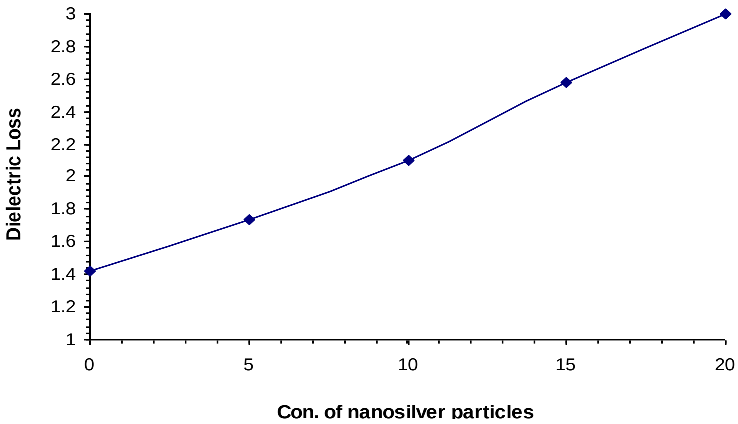

Figure 6: Variation of the Dielectric Loss of (PVA-PVP-Ag) Nanocomposites with the Concentration of Nanosilver Particles

The variation of A.C electrical conductivity of nanocomposites as a function of frequency is shown in figure(7). The A.C electrical conductivity is increased with increase of the frequency which attributed to the electronic polarization and the charge carriers which travel by hopping[13]. The A.C electrical conductivity is increased with increase of the concentration of nanosilver particles, as shown in finger(8), which attributed to increase the numbers of charge carries[14,15].

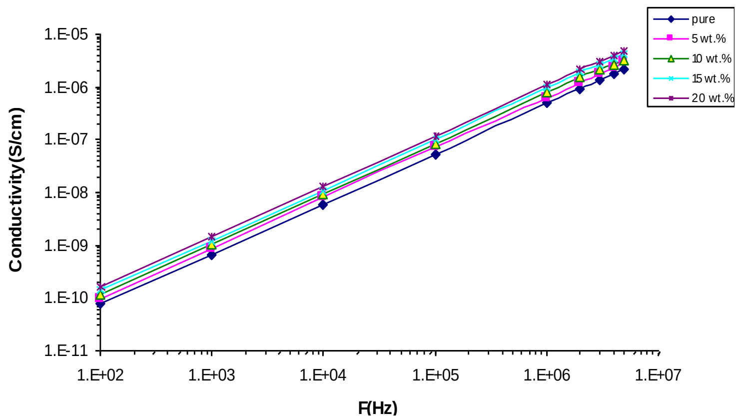

Figure 7: Variation of the Electrical Conductivity of (PVA-PVP-Ag) Nanocomposites with the Frequency

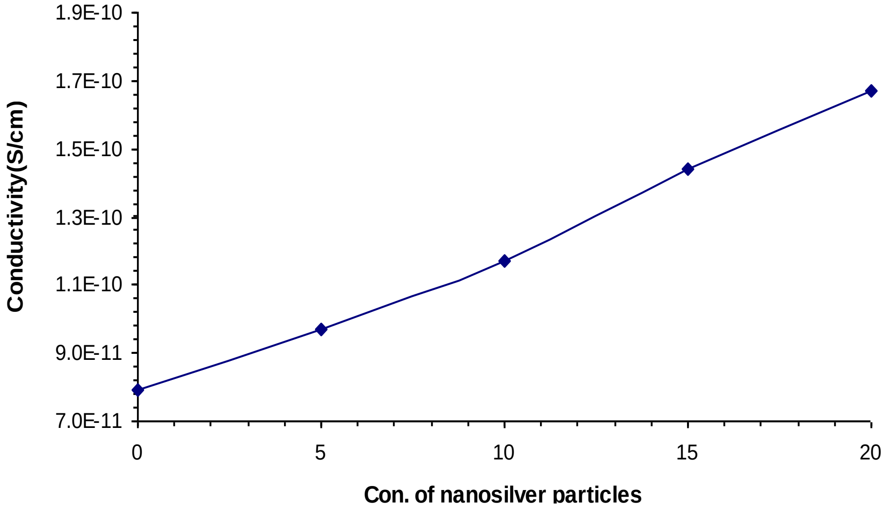

Figure 8: Variation of the Electrical Conductivity of (PVA-PVP-Ag) Nanocomposites with the Concentration of Nanosilver Particles

CONCLUSIONS

- The thermal conductivity of polymer composite is increased with increasing of the concentration of nanosilver.
- The thermal conductivity of nanocomposites increases with increasing of the temperature.
- The dielectric constant of (PVA-PVP-Ag) nanocomposites is decreased with increasing of the frequency and it increases with increasing of the concentrations nanosilver.
- The dielectric loss of nanocomposites decreases with increasing of the frequency and increasing with increasing of the concentrations nanosilver.
- The A.C electrical conductivity of nanocomposites is increasing with increasing of the frequency and concentrations of nanosilver .

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