

The Dielectric Properties of (PVA-PEG-PVP-MgO) and (PVA-PEG-PVP-CoO) Biomaterials

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Abstract: In this paper, study of dielectric properties of two types of nanocomposites are (PVA-PEG-PVP-MgO) and (PVA-PEG-PVP-CoO) in frequency range (100 Hz- 5 MHz). The (PVA-PEG-PVP-MgO) and (PVA-PEG-PVP-CoO) nanocomposites have been prepared by casting technique. The dielectric parameters (dielectric constant, dielectric loss and A.C electrical conductivity) are increasing with the increase of concentrations of magnesium oxide and cobalt oxide nanoparticles. Also, the dielectric properties change with increasing of the frequency of applied electrical field.

Keywords: nanocomposites, dielectric properties, electrical conductivity.

1. Introduction

Nanotechnology can be defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale or one billionth of a meter. At these scales, consideration of individual molecules and interacting groups of molecules in relation to the bulk macroscopic properties of the material or device becomes important, since it is control over the fundamental molecular structure that allows control over the macroscopic chemical and physical properties. The applications of nanotechnology has only been increasing in the recent years, the highest potential application is in the field of materials, followed by electronics and medicine [1]. In recent years, polymer-nanoparticle composite materials have attracted the interest of a number of researchers, due to their synergistic and hybrid properties derived from several components. Whether in solution or in bulk, these materials offer unique mechanical, electrical, optical and thermal properties. Such enhancements are induced by the physical presence of the nanoparticle and by the interaction of the polymer with the particle and the state of dispersion. One advantage of nanoparticles, as polymer additives appear to have is that compared to traditional additives, loading requirements are quite low. Microsized particles used as reinforcing agents scatter light, thus reducing light transmittance and optical clarity. Efficient nanoparticle dispersion combined with good polymer-particle interfacial adhesion eliminates scattering and allows the exciting possibility of developing strong yet transparent films, coatings and membranes[2]. The composites have been widely used in the various fields such as military equipments, safety, protective garments, automotive, aerospace, electronics and optical devices. However, these application areas continuously demand additional properties and functions such as high mechanical properties, flame retardation, chemical resistance, UV resistance, electrical conductivity, environmental stability, water repellency, magnetic field resistance, radar absorption, etc [3]. A biomaterial is a synthetic material used to replace part of a living system or to function in intimate contact with

living tissue. The word “biomaterial” is generally used to recognize materials for biomedical applications. Biomaterials save lives, relieve suffering and improve the quality of life for a large number of patients every year. According to the use of materials in the body, biomaterials are classified into four groups: polymers, metals, ceramics and composites. Polymeric biomaterials (PB) are polysaccharides (starch, cellulose, chitin, alginate, hyaluronate etc.) or proteins (collagens, gelatins, caseins, albumins) and / or synthetic and biodegradable polymers (Polyvinyl alcohol (PVA), Polyvinyl pyrrolidone (PVP), Poly ethelene glycol (PEG), Polylactic acid (PLA), Poly hydroxy acid (PHA) etc.[4]. These papers deals with preparation of (PVA-PEG-PVP-MgO) and (PVA-PEG-PVP-CoO) nanocomposites and study their dielectric properties.

2. Experimental

The polymers (polyvinyl alcohol (90 wt.%), Polyethylene glycol (5 wt.%) and polyvinyl pyrrolidinone (5 wt.%) are dissolved in (30 ml) of distill water by using magnetic stirrer in mixing process to get homogeneous solution. The additive (magnesium oxide - cobalt oxide nanoparticles) was added to mixture of polymers with different weight percentages are (0,2 ,4 and 6) wt.% . The (PVA-PEG-PVP-MgO, CoO) nanocomposites were prepared by using casting technique with thickness (75-120) μ m. The dielectric properties of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites were measured using LCR meter in the frequency (f) range 100Hz-5MHz at room temperature.

The capacitance of a capacitor constructed of two parallel plates is given by the equation [5]:

$$C = \epsilon^{-} \epsilon_o \frac{A}{t} \quad (1)$$

Where: ϵ is Dielectric constant; t is Thickness of the sample and ϵ_o is Vacuum permittivity. The loss factor (D) is:

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

and this represents the lost electrical energy which is transformed to thermal energy in the insulator. The importance of determining the power factor is very useful in electrical applications. The dielectric constant is [5]:

$$\epsilon'' = \frac{C_p}{C_o} \quad (3)$$

Where: C_p is parallel capacitance and C_o is vacuum capacitor. The dissipated power in the insulator is

represented by the existence of alternating potential as a function of the alternating conductivity[6]:

$$\sigma_{A.C} = w \epsilon'' \epsilon_0 \quad (4)$$

Where: w is angular frequency and ϵ'' is dielectric loss.

3. Results and Discussion

Figure(1) and figure (2) show the variation of the dielectric constant of the (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites with the frequency in range (100Hz-5 MHz) respectively. The figures show that the dielectric constant decreases with increasing the frequency which attributed to decreasing of space charge polarization to the total polarization. The dielectric constant of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites increases with increase of the weight percentages of the magnesium oxide and cobalt oxide nanoparticles as shown in figures (3 and 4), this behavior attributed to increase the carriers of charge and formation of a continuous network of magnesium oxide and cobalt oxide nanoparticles [7,8].

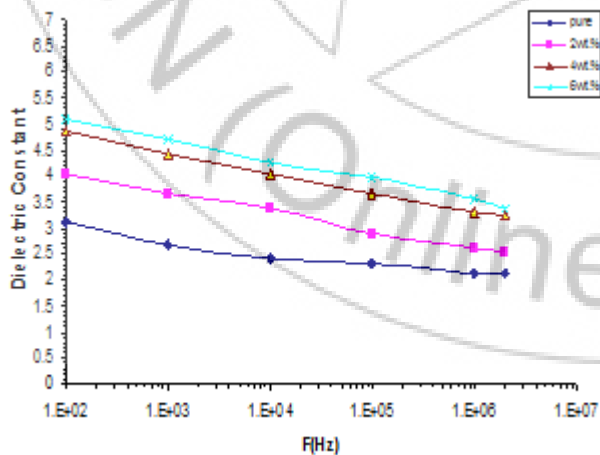


Figure 1: The variation of the dielectric constant of (PVA-PEG-PVP- MgO) nanocomposites with the frequency

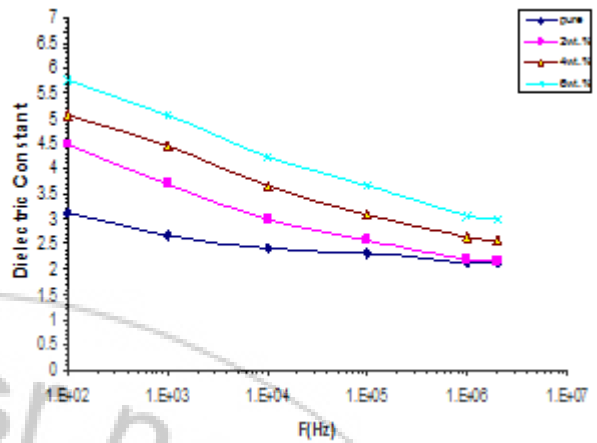


Figure 2: The variation of the dielectric constant of (PVA-PEG-PVP-CoO) nanocomposites with the frequency

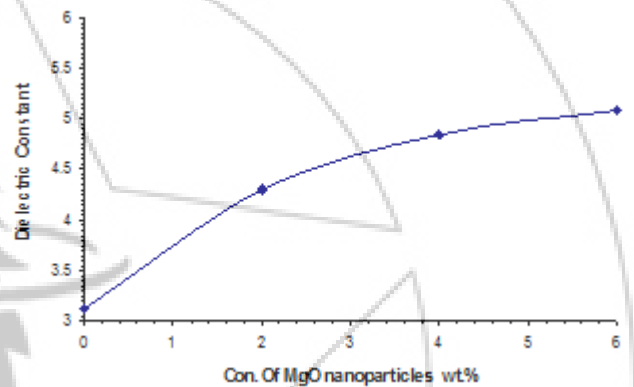


Figure 3: The variation of the dielectric constant of (PVA-PEG-PVP- MgO) nanocomposites with the concentration of magnesium oxide nanoparticles at 100Hz.

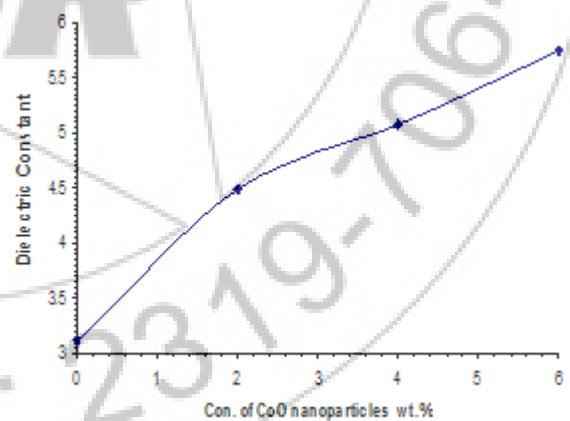


Figure 4: the variation of the dielectric constant of (PVA-PEG-PVP-CoO) nanocomposites with the concentration of cobalt oxide nanoparticles at 100Hz.

The relationship between the dielectric loss of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites with the frequency are shown in figures (5 and 6) respectively.. From these figures, the dielectric loss decreases with the increasing the frequency which due to the decrease of the space charge polarization.

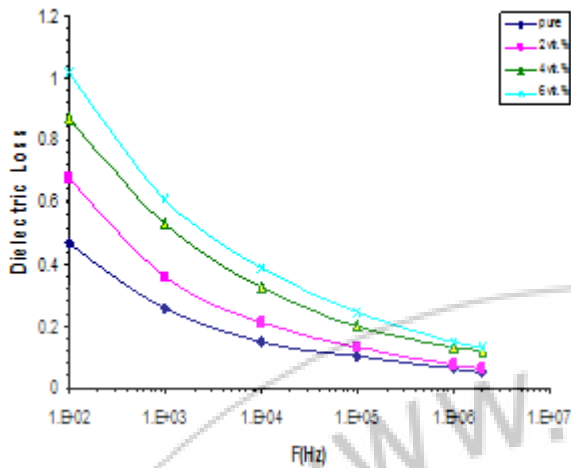


Figure 5: the variation of the dielectric loss of nanocomposites with the frequency

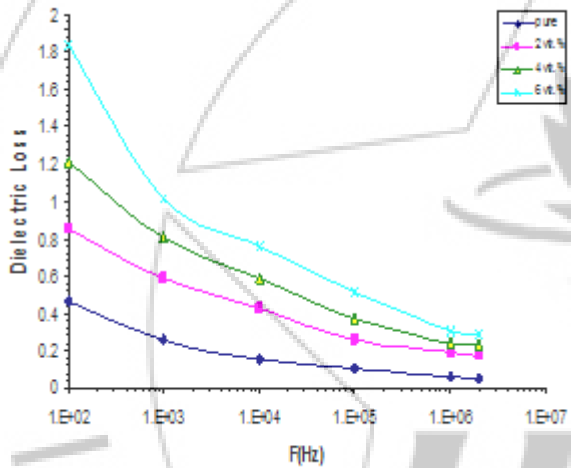


Figure 6: The variation of the dielectric loss of (PVA-PEG-PVP- CoO) nanocomposites with the frequency

The dielectric loss of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites increases with increasing of the concentration of the magnesium oxide and cobalt oxide nanoparticles as a result of the dipole charge increase [9,10] as shown in figures (7 and 8) for (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites respectively.

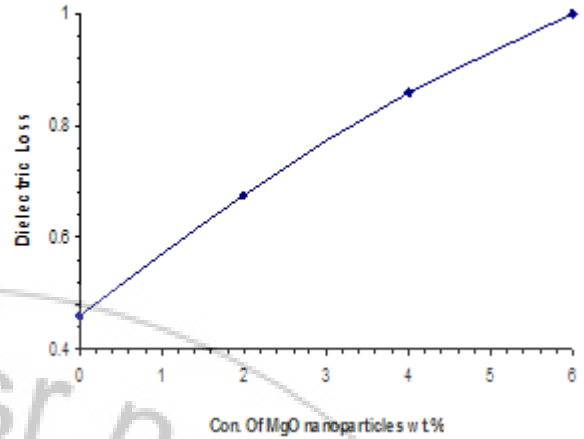


Figure 7: The variation of the dielectric loss of (PVA-PEG-PVP- MgO) nanocompsites with the concentration of magnesium oxide nanoparticles at 100Hz.

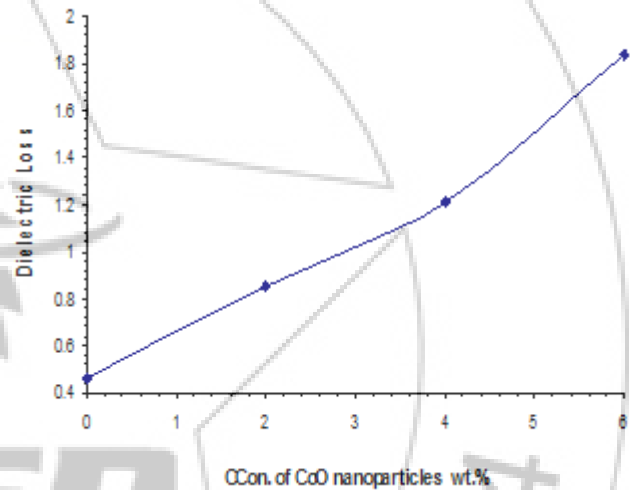


Figure 8: the variation of the dielectric loss of (PVA-PEG-PVP-CoO) nanocompsites with the concentration of cobalt oxide nanoparticles at 100Hz.

The variation of A.C electrical conductivity of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites as a function of the frequency are shown in figures (5 and 6) respectively at room temperature. The A.C electrical conductivity of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites increases with increasing of the frequency. This behavior attributed to the polarization and the charge carriers which travel by hopping process. The A.C electrical conductivity of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites increases with increasing of the weight percentages of the magnesium oxide and cobalt oxide nanoparticles as shown in figures (7 and 8) for (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocompsites respectively, this behavior attributed to:; the magnesium oxide and cobalt oxide nanoparticles forms a continuous network inside the composite[11,12].

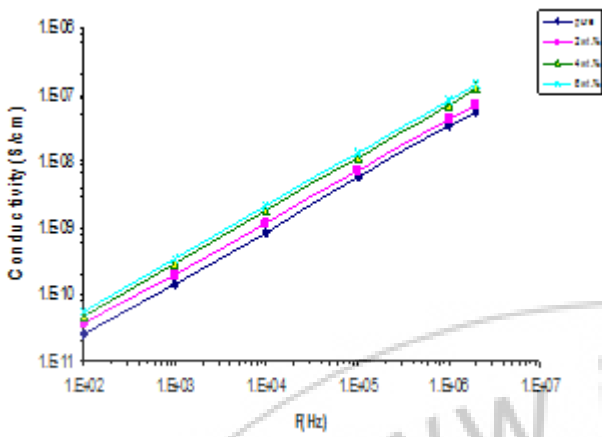


Figure 9: The variation of the A.C electrical conductivity of (PVA-PEG-PVP- MgO) nanocomposites with the frequency

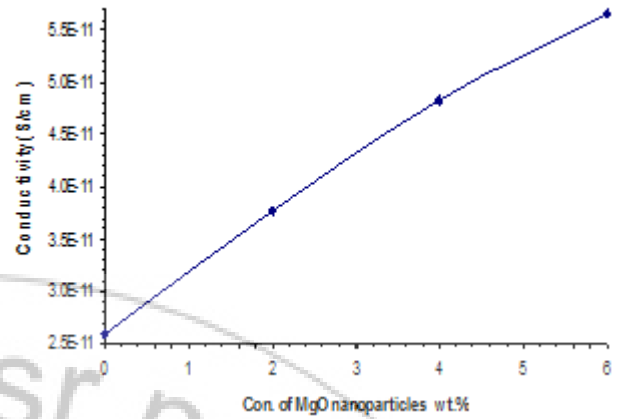


Figure 12: the variation of the A.C electrical conductivity of (PVA-PEG-PVP-CoO) nanocomposites with the concentration of cobalt oxide nanoparticles at 100Hz.

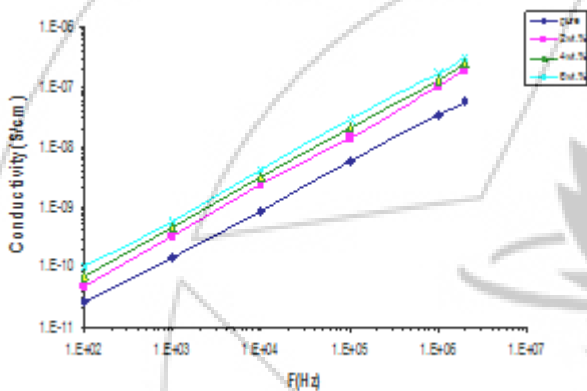


Figure 10: The variation of the A.C electrical conductivity of (PVA-PEG-PVP- CoO) nanocomposites with the frequency

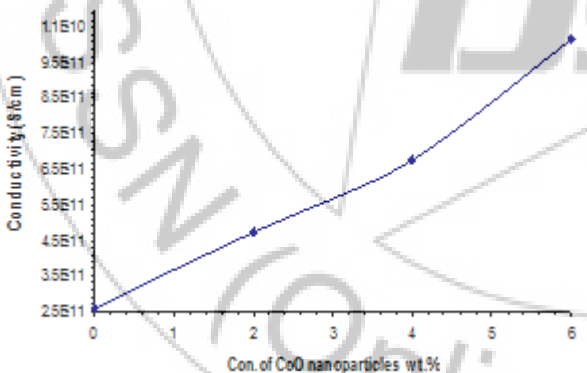


Figure 11: the variation of the the A.C electrical conductivity of (PVA-PEG-PVP- MgO) nanocomposites with the concentration of magnesium oxide nanoparticles at 100Hz.

4. Conclusions

1. The dielectric constant of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites is decreasing with the increasing of the frequency, and it increases with the increase of the magnesium oxide and cobalt oxide nanoparticles concentrations.
2. The dielectric loss of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites decreases with the increasing of the frequency, and it increases with the increase of the the magnesium oxide and cobalt oxide nanoparticles concentrations.
3. The A.C electrical conductivity of (PVA-PEG-PVP- MgO) and (PVA-PEG-PVP-CoO) nanocomposites increases with the increasing of the frequency and magnesium oxide and cobalt oxide nanoparticles concentrations.

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