The effect of adding Ag nanoparticles on the electrical properties (A.C) of the PMMA-SPO-PS blend

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Abstract. This paper investigates the Effect of Ag Nanoparticles on the PMMA-SPO-PS Blend, the samples of nano composition were prepared by adding Ag nano particles percentages of (1,3,5,7 mgm)wt % to the (SPO-PS-PMMA) blend, the thick films , It was the best blend when forgetting to mix (7mgm) silver nanoparticles were prepared by solvent with pure benzene at different time , The dielectric constant increases with increasing concentration and at frequency (from 100Hz to 3.E06Hz), and decreases with increasing frequency , the A.C electrical conductivity increases with increasing the frequency of applied electric field and concentrations of the (Ag) nanoparticles.

Keywords: Nano Ag, Ethylene-alpha olefin, electrical Properties, A.C, Poly(methyl methacrylate).

1.Introduction:

Generally, essential information about the band structure and the energy gap in crystalline, semi crystalline and mono crystalline polymers [1,2]. Polymers have been widely applied in various industries and are attributed to their distinctive properties, their inexpensive costs, and their desirable physical properties, in order to increase their efficiency. the use of most polymers was limited to the manufacture of cheap products which were used for simple purposes. However, the speedy technical development has required the replacement of some materials being used in industry with others having better specifications; consequently, in recent years, studies of electrical and optical properties of the polymer have attracted much attention in view of their application in electronic and optical devices. The optical absorption spectra of polymers provide. In recent years, it has been observed that when we add nanoparticles into polymers leads to dramatic changes in structural, optical and electrical properties of the polymer [3]. Polymers have been introduced throughout our lives because it is difficult to imagine a reasonable life with all services without the polymer[4]. Polymers can be divided into two categories: natural and industrial. The natural polymers include proteins, cellulose, starches and rubber, either the industrial include poly(vinyl chloride) (PVC), nylons polyethylene (PE), polypropylene (PP), polysters (PS) polycarbonate (PC), poly(ether ether ketone) (PEEK), polyimide (PI) and polyethylene glycol etc. [5]. Polymers have many characteristics such as easy configuration, low cost, high resistance, flexibility, as well the different important properties, so it is being carried out in the various application of electronic strategy [6].
The use of nanomaterials is considered a leap in improving the specifications of materials in general, and this gives a new special characteristic characterized by structural, electrical and mechanical properties. Like silver [7]

2. Computational details:

We have melted polystyrene (PS), co-polymer(SPO) know (and Ethylene-alpha olefin), and Poly(methyl methacrylate) (PMMA) in 70 mL of pure benzene, by using magnetic stirrer in 75°C. When the polymers are completely melted we add the silver(Ag) by different concentrations (0.001, 0.003, 0.005, 0.007) gm to the polymer mixture and complete the mixing process and when fully blend and dissolved and took approximately 14 hours to fully dissolve the solution so that it remained in the baker about 20 ml. Put the solution in ultrasonic processor for 2 minutes 20 MHz to fully homogenize and then 20 ml put in the Petra dish and put on a bright level to dry and get the membranes.

A.C conductivity measurement is different from the D.C conductivity, where the frequency of electric field is constant during D.C conductivity but during A.C conductivity, frequency of the electric field will be variable. When an insulator is placed in a low frequency electrical field, where induced or permanent electrical dipoles can go along with the variation of the applied electrical field with no residue, the dielectric constant value becomes equal to its value in a static field [8]; that is, the insulator becomes ideal (ohmic conductivity equals to zero). On the other hand, when the frequency of electric field is greater measurement, where the electric polarization is depends on frequency, there will be complex dielectric constant [9]

The current can be found through the capacitor which has a phase difference π/2 [8]:

\[ I = \omega j C V \]  \hspace{1cm} (1)

Where, \( I \); current, \( j \); current density, \( \omega \); angular frequency, \( C \); capacitor, \( V \); potential

![Image](image.png)

Figure (1) The circuit equivalent to non-ideal capacitor [9].

The capacitance of a capacitor constructed of two parallel plates is given by the equation[12]:

\[ C = \varepsilon \varepsilon_0 \frac{A}{d} \]  \hspace{1cm} (2)
Where, $\varepsilon, \varepsilon_0$; The permeability of the dielectric and the air, respectively. $A$; area, $d$; The space between the electric capacitive panels

By substituting equation (2) in (1), get:

$$I = jw \varepsilon_0 \varepsilon_0 (A/d)$$  \hspace{1cm} (3)

The dielectric permeability is two parts real and imaginary [11] and thus the current conductivity equation can be reformulated from the equation (3) resulting;

$$I_p = w \varepsilon'' \varepsilon_0 (A/d)V$$ \hspace{1cm} (4)

Where $\varepsilon''$ represent dielectric loss, It is figure (1) while the capacitance current ($I_q$) is;

$$I_q = w \varepsilon' \varepsilon_0 (A/d)V$$ \hspace{1cm} (5)

From the equation (4) and (5) the loss factor can be found by the formula;

$$\tan \delta = \varepsilon'' / \varepsilon'$$ \hspace{1cm} (6)

And by compensations for the resistance and dielectric constants of the capacitance, the alternating conductivity $\sigma_{A.C}$ can be found [12];

$$\sigma_{A.C} = w \varepsilon'' \varepsilon_0$$ \hspace{1cm} (7)

3. RESULTS AND DISCUSSIONS;

After adding the polymer SPO, we can deduce special properties of electrical constants. The study of the electrical properties of alternating current of nanocomposites (PMMA-SPO-PS-Ag) were analyzed at a frequency range of $(100-5\times10^6)$ Hz.

By using the equation (6) for the phase difference variable ($\delta$), the dielectric loss and the dielectric constant can be found, as well as through those changes the amount of electrical conductivity ($\sigma_{A.C}$) was found after substituting the values of $(\varepsilon'', \varepsilon')$.

3.1 Structure

The microscopic photographs in figure (2) taken for samples of different concentrations at magnification power(100x). However, when the concentration reaches to 16wt.% for PS-SPO-PMMA-Ag 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.
Figure (2): Photomicrographs for (PS-SPO-PMMA-Ag) nanocomposites (A) 0.001Ag (100 x),(B) for 0.003 Ag ,( 100 x), (C) for 0.005 Ag ,( 100 x), (D) for 0.007 Ag

2. The dielectric constant of (PMMA-SPO-PS-Ag) nanocomposites

Figures (3) show the effect of adding silver nanoparticles at 100Hz and 30 °C on the dielectric constant. From these figures, we realize that, with the rising concentration of silver nanoparticles, the dielectric constant increases. The explanation for this increase in dielectric constant value is the creation of an ongoing bond network of silver nanoparticles within the nanocomposites. In the lowest concentration, silver nanoparticles take the form of groups, the dielectric constant is less than the first level, and at high concentrations, silver nanoparticles form a continuous network within nanocomposites, and the increase of (Cp) for storage charges increases with the volumetric rate of silver.

Figure (3): Variation of dielectric constant with concentration of silver nanoparticles at 100Hz of (PS-SPO-PMMA-Ag) nanocomposites.
Figure (4): Variation of the dielectric constant of (PS-SPO-PMMA-Ag) nanocomposites with frequency

Figure (4) shows the dielectric constant variation with frequency in nanotubes (PMMA-SPO-PS-Ag), respectively. So the shapes show that dielectric constant values decrease when the frequency of the applicable field rises. When the frequencies are increased, the polarization process is reduced for the charged particles (polarization), and this leads to a mass polarization. The polarization of the space charge in the low frequency becomes the most polarized type of input, and the least contribution to the increase in frequency. This will result in lower values for all PMMA-SPO-PS-Ag's electrolytic constant with increasing frequency of the electric field. At high frequencies other types of polarization appear. The polarization with respect to the ions is almost non-existent with the variation in field frequencies compared to the electron's polarization. Since the mass of the ions is greater than that of the electron. Electrons respond to field oscillations, even at high frequencies. The low mass of electrons causes electronic polarization, Only type of high frequency polarization. This makes isolation fast constant at high frequencies for all samples. This is similar to the researchers findings [13,14].

Figure (5): Variation of the dielectric loss with frequency of (PS-SPO-PMMA-Ag) nanocomposites.
3. The dielectric loss of (PMMA-SPO-PS-Ag) nanocomposites

Figure (5) shows the loss of insulation as a frequency function (PMMA-SPO-PS-Ag), indicating that the loss of nanoparticles decreases with increasing frequency of the electrical field. This behavior indicates a low contribution to the polarization of the space charge, a high-value buffer loss for (PMMA-SPO-PS-Ag) at low frequency and a decrease in frequency increases. (PMMA-SPO-PS-Ag) nanoparticles with a higher nanoparticles concentration correlated with an increase in the number of carriers of the charge. Nanoparticles create a continuous network of nanocomposites at low concentrations of nanoparticles, creating clusters, when the concentration of nanoparticles exceeds its high proportion[15,16]. Those results are similar to the previous results researcher [17,18].

4. The (A.C ) electrical conductivity of (PS-SPO-PMMA-Ag) nanocomposites

Figure (6) shows the difference in the A.C relation of (PMMA-SPO-PS-Ag) nanotubes, with silver concentration below room temperature 300°C at 100 Hz respectively. An increase in nanoparticles (Ag) conductivity increases the conductivity of the increase in the number of vectors in the charge. These results conform to other researchers' results[18,19].

Figure (7) show the conductivity variation with the frequency of the (PMMA-SPO-PS-Ag). The shapes show that, with frequency increase (f) from 100 Hz to 3 x 10^6 Hz, the A.C conductivity increases considerably. This is due to the mobility of freight carriers in the local state and also to the raising of freight carriers in connection with the upper states, And at a higher frequency for most of the additives of silver nanoparticles for (PMMA-SPO-PS-Ag) nanoparticles, conductivity increases. This is close to the researchers findings [14,20].

Figure (6): Variation of (A.C ) electrical conductivity with additive Silver nanoparticles wt. % concentration at 100Hz of (PS-SPO-PMMA-Ag) nanocomposites.
5. Conclusions:

. The best homogeneity in the composition of the nanomaterial is the ratio of 5%.
. An increase in the dielectric constant of the mixture occurs with an increase in the concentration of the nanoparticle (Ag).
. Likewise, the process of increasing the concentration of the silver nanoparticle leads to an increase in the dielectric loss,
. And the last results, when the concentration of silver nanoparticles increases, the polymer approaches to become a semiconductor material, which is represented by an increase in electrical conductivity.

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