

Study of dielectric properties of (PVC-MWCNTs) Polymer nanocomposite.

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ABSTRACT

Thermal pressure is one of the easiest methods fabricating polymers nanocomposites bulk. In this study the range of 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of weight percentages of Multi walled carbon nanotube (MWCNT) were added to polyvinyl chloride (PVC) powder . Final mixing of each of any concentration has pressured under temperature 80 C^o.

Dielectric properties were measured at room temperature and different frequencies; it was found that the dielectric constant increased with increasing the carbon nanotubes content, but decreasing with increasing frequency. This may be due to polarization effects of the nanocomposite. Also the dielectric loss of polymer composites has been measured. The results refer that the dielectric loss is reduced with increasing of frequency and The A.C conductivity is increases with the increasing of the concentration of Multi walled carbon nanotube because of the increase of the charge carriers and the formation of a continuous network of Multi walled carbon nanotube inside the nanocomposites. .

Key words: dielectric constant, dielectric loss, AC conductivity, nanocomposites.

1.INTRODUCTION

Polymer composites can be defined as materials that consist of two or more chemically and physically different phases separated by a distinct interface [1]. Many types of nanofiller can change not less one of important property when we are adding to polymer like this nanofiller is carbon nanotube [2, 3, 4]. The development of nanotube, platelet and particle reinforced polymer composites has grown in importance in recent years due to their attractive applications in various fields. Two and three-dimensional nanofillers into a polymer matrix giving high aspect ratios and large surface area to volume ratios [5]. Materials that contain a polymer matrix with conductive filler are known as conductive polymer composites [6, 7]. These composites are known for having high dielectric constants and for being extremely conductive. This is achieved by the conductive filler forming a network throughout the composite which allows for the flow of current through the composite. The conductivity of these composites can increase by several orders of magnitude. Since the matrix consists of a polymer, these composites have the potential of increasing in flexibility, if the polymer used in the matrix is flexible. The composite can be brittle and weak due to the amount of filler that is needed to produce a highly conducting material. The main advantage of conductive polymer composites is that they display characteristics of both a metal and of a polymer [6, 8].

2.PREPARATION METHOD

Multi walled carbon nanotube (MWCNTs) were supplied by Material and Electrochemical Research (MER) Corporation, U.S.A, the diameter of (MWCNTs) was (140 ± 30 nm) and a length of (7 ± 2) microns.. It were mixed with weight percentages (5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%) of Polyvinyl chloride (PVC) was supplied as a powder form by pars petrochemical with density 1.16 gm/cm³ using an electronic balance of accuracy 10⁻⁴ gm. Mixing device was used to mix the (MWCNT) and polymer (PVC) for (3-5) minute to get more homogenous mixture, then it is placed in a thermal mold and heated to (100c). After that the mixture was cooled to 80c^o and compressed under pressure (2000N/cm²) in the form of a disc with (2cm) diameter and (0.2) cm thickness after the sample cooling to 30c^o.

3.RESULTS & CONCLUSIONS

3.1 Dielectric constant

The dielectric constant (ϵ'), which is the most important for A.C properties, was calculated by using the equation (1) which gives the ratio of the capacitance of a dielectric-filled capacitor (C_p) to a capacitor of free space (C_0).

$$\epsilon' = \frac{C_p}{C_0} \quad (1)$$

The dielectric constant is determined with various frequencies at room temperature.

Figure (1) shows the variation of the dielectric constant of (PVC-MWCNTs) nanocomposites with frequency. This figure shows that the dielectric constant values decrease when the applied field frequency increases. The increase of frequencies results in decreasing of space charge polarization (interfacial polarization) to the total polarization. The space charge polarization becomes the more contributing type of polarization at low frequencies, and less contributing with the increase of frequency; this would result in the decrease of dielectric constant values for all samples of (PVC-MWCNTs) nanocomposites with the increase of the electric field frequency (f) [9].

The other types of polarizations appear at high frequencies. The ionic polarization reacts slightly to the variation in the field frequencies compared to the electronic polarization. This is because the mass of ion is greater than that of the electron. The electrons respond to even the high frequencies of the field vibrations. The low mass of electron makes the electronic polarization, the only type of polarization at higher frequencies. This makes the dielectric constant approximately constant for all samples at high frequencies. The results agree with [10].

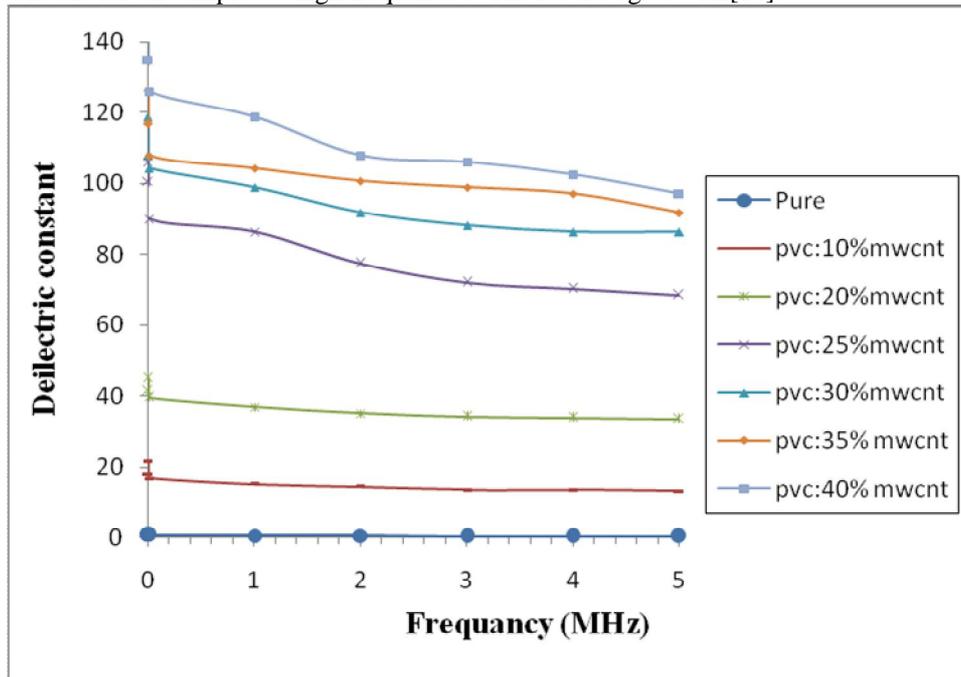


Figure (1): Variation of the dielectric constant of (PVC-MWCNTs) nanocomposites with frequency

The dielectric constant increases with the increasing of the concentration of Multi walled carbon nanotubes [11].

The reason for this increase in the value of dielectric constant is the formation of a continuous network of carbon nanotube inside the nanocomposites; at low concentrations of additive like pure (0%), 5%, 10% and 15% take the form of clusters or separated groups; hence, the dielectric constant becomes approximately low, and at high concentrations like 20%, 25%, 30%, 35% and 40% form a continuous network inside the nanocomposites and because increase (C_p) for the storage charges, and so the value of dielectric constant increases with the volumetric rate of the nanotube. The results agree with [12, 13].

3-2 Dielectric loss

The dielectric losses (ϵ'') are calculated by followed equation (2):

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

Where $\tan \delta$ is loss factor.

The figure (2) represented to dielectric loss increases again until it reaches to the highest value at (f=100 Hz) of (PVC-MWCNTs) nanocomposites.

This value represents the highest dielectric loss at certain frequency; that is the highest absorption of applied field. [14]. When the frequency (f) is increases to 3 kHz, the dielectric loss is approximately constant of (PVC-MWCNTs) nanocomposites.

This is attributed to the mechanisms of other types of polarization that occurs at high frequencies. The value of dielectric loss increases by increasing the concentration of nanotubes; this is due to the increase of the charge carriers caused by the increase of concentration of nanotube. The results agree with [11, 15].

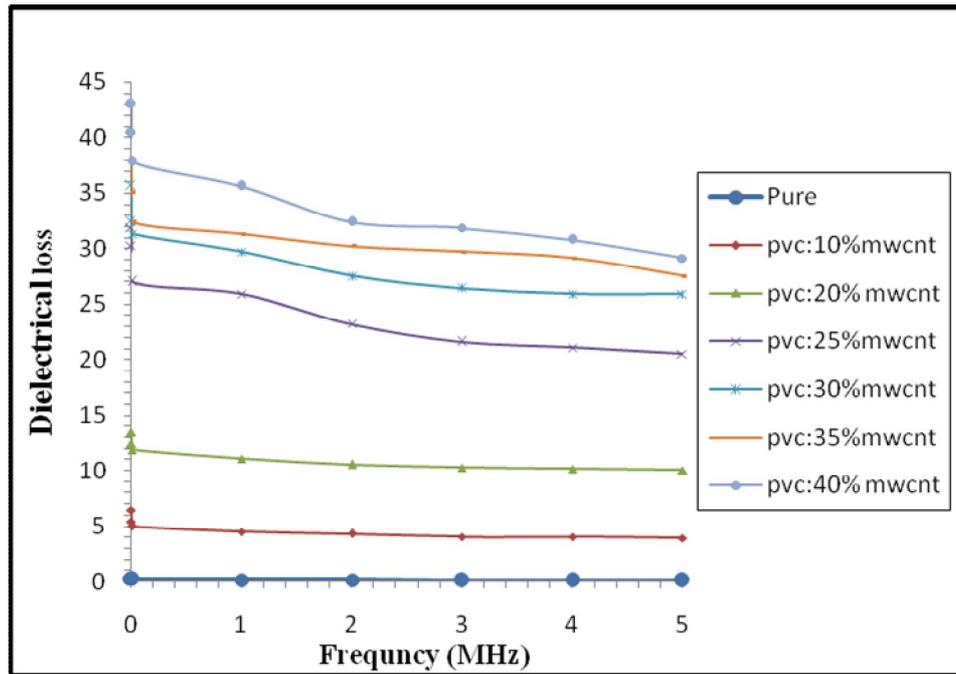


Figure (2): Variation of the dielectrical loss with frequency of (PVC-MWCNTs) nanocomposites

3-3 The A.C electrical conductivity

The A.C electrical conductivity is calculated by followed equation (3)

$$\sigma_{A.C} = \omega \epsilon'' \epsilon_0 \tag{3}$$

where ω is the angular frequency of the applied field ($\omega = 2\pi f$).

Figure (3) shows the variation of the conductivity for PVC-MWCNT with frequency. The figure shows that AC conductivity increases considerably with the increase of frequency (f) from 100Hz to 5×10^6 Hz. This is attributed to the space charge polarization that occurs at low frequencies and to the motion of charge carriers by hopping process. The increase of the conductivity is small at high frequencies; this is attributed to the electronic polarization and the charge carriers, which travel by hopping process [15]. Consequently, the conductivity is increasing when the frequency increases for all different rates of (MWCNT) for PVC-MWCNT nanocomposites.

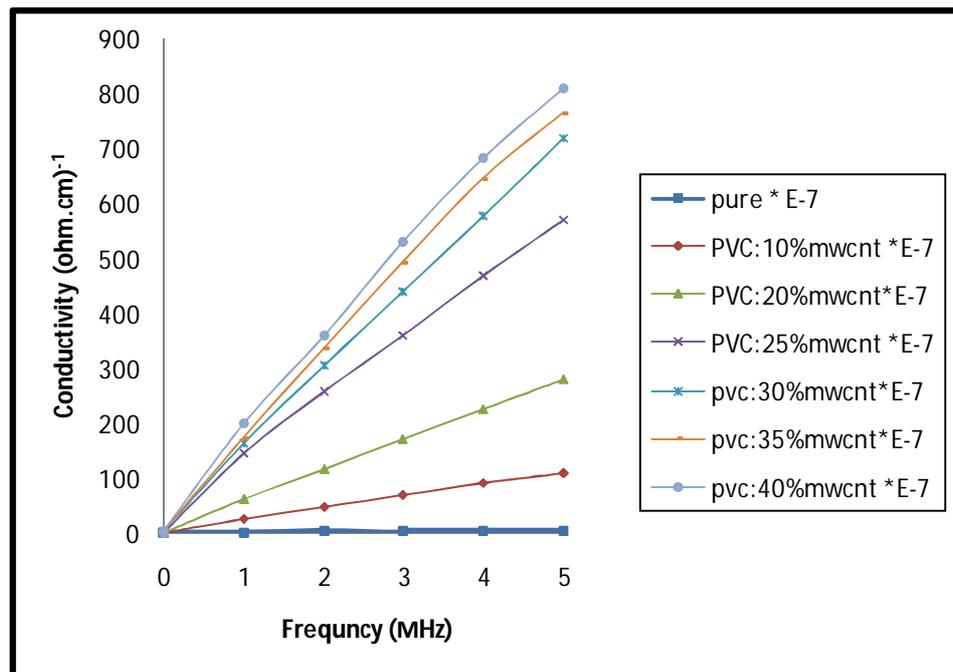


Figure (3): Variation of A.C electrical conductivity with frequency of (PVC-MWCNT) nanocomposites.

Figure (4) shows the variation of A.C conductivity PVC-MWCNT nanocomposites, with Multi walled carbon nanotubes concentration at 100 Hz under room temperature 30°C. The A.C conductivity slightly increases at low concentrations of the Multi walled carbon nanotube (MWCNT). This increase is due to the effect of the space charge. The Multi walled carbon nanotube takes the form of clusters or separated groups.

The conductivity is increases with the increasing of the concentration of MWCNTs because of the increase of the charge carriers and the formation of a continuous network of MWCNTs inside the nanocomposites. Consequently, the conductivity is increases with the increasing of MWCNTs concentration for PVC-MWCNT nanocomposites. The results agree with [11].

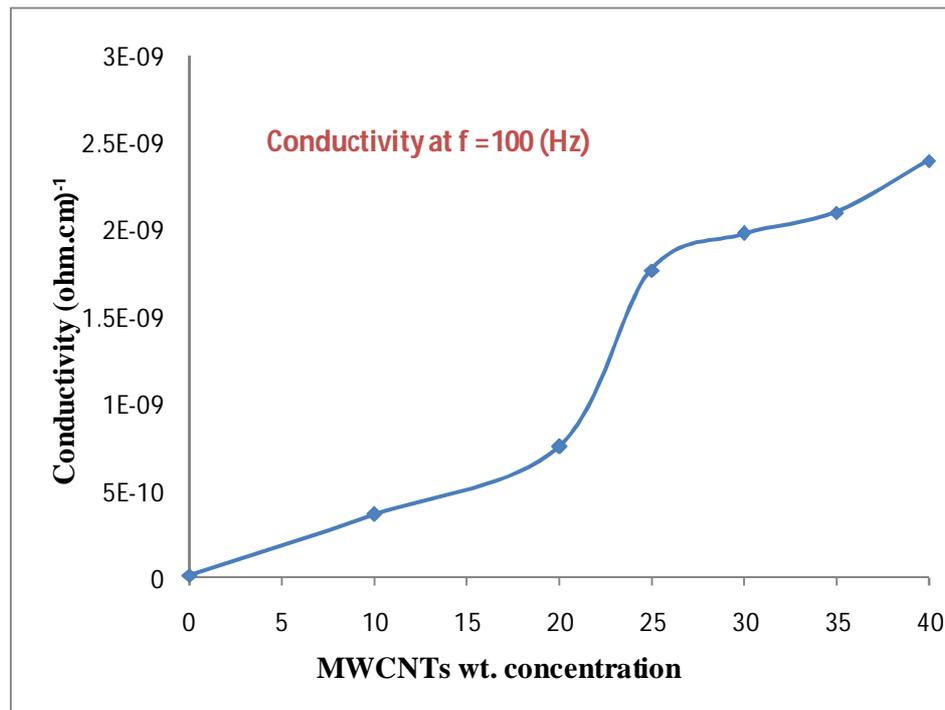


Figure (4): Variation of A.C electrical conductivity with MWCNT wt. % concentration at 100 Hz of (PVC-MWCNT) nanocomposites

3.4 conclusions

The dielectric constant behaviors were decreasing with increasing of frequency and increasing with carbon nanotube concentrations, this effect may be due contribute the polarization and form network inside the polymers, the dielectric loss of the (PVC-MWCNTs) nanocomposites decrease with the increase of frequency of the applied electric field and The A.C conductivity is increases with the increasing of the concentration of Multi walled carbon nanotube because of the increase of the charge carriers and the formation of a continuous network of Multi walled carbon nanotube inside the nanocomposites.

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