New Fabrication (PVA-PVP-C.B) Nanocomposites: Structural and Electrical Properties

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Abstract. In this present study, polymer blend (PVA-PVP)-Carbon black (C.B N375) nanocomposites have been investigated. The (PVA-PVP-C.B) nanocomposites are organized by via casting procedure. The optical microscope, FTIR and electrical properties have been studied. The constant of dielectric with the dielectric loss of the samples were reduced with increasing the value of frequency during the application of electric field, while an increasing in the A.C electrical conductivity results existed with the rising the value of the frequency. The electrical conductivity (A.C), dielectric loss and constant of all the samples were increased with the increasing of the carbon black concentrations.

Keywords: carbon black nanoparticle, dielectric constant, dielectric loss, polyvinyl alcohol, polyvinyl pyrrolidone.

1. Introduction
Nanocomposites are ingredients with high enactment show unusual stuff combinations [1]. With the fastest request to be in elastomers and engineering plastics, their possibilities are so outstanding that they are beneficial in many ranging areas from packaging to different applications [2–4]. Nanotechnology includes the manufacturing and nanocomposites application proposal new technics and chances of trade for several subdivisions of the automotive, aerospace, superconductor, electronics, physical and chemical at rulers reaching from singular molecules or atoms to submicron dimensions [5–7]. It is broadly felt that nanotechnology is the next manufacturing revolt [8,9].

Nanocomposites polymers containing polymers organic and nanoparticles inorganic in a nano-scale region signify novel types of resources that have interested significant interest in last year’s [10–12]. These composites materials differ from unpolluted polymers concerning some of the chemical and physical properties [13,14]. The influences of impurity polymers on the polymer properties, bring more advantages and make it able to the enhancement of desirable properties. That could be very important and useful for the variable and wide applicant in several kinds of applications [15]. The combination of nanoparticles in polymers matrix offers the possibility of substantial’s improvement to the optical possessions of the material with individual minor amounts on the nanoparticle [16]. Since they can affect strongly the physical, one advantage of nanoparticles, as polymer additive appears comparing to old-style additive, loadings requirements are fairly low [13,17]. The polymers' optical properties institute
significant aspects in the study of electronics transitions and the possibilities of their applications as an optical filter. The pieces of information about the electronics structures of amorphous and crystalline semiconductors typically accrued from the study of optical property in extensive frequency ranges [5]. Polyvinyl pyrrolidone (PVP) and polyvinyl alcohol (PVA) are comprised in the lists of synthetics polymer used in medicines. PVP has a decent repute owing to its unresolved absorptions and complex ability, while PVA is used as composites with other material to improve its property, offerings significant structures, recognized fine processability on sample formations [18]. Additionally, these synthetics polymers are easy dissolved in water that give amazing characteristics for film formations. However, these characteristics are a difficulty as the materials are dissolved in contact with fluid into the mean form [19]. Dissimilar carbon black grades are shaped by the chemical decomposition of hydrocarbons at the raised temperature. The most wanted enforcing fillers where resistances to abrasion, cutting and aged must be at an extreme [20]. The four chief processes of the formations of four types of carbon black that are Lamp-black, Channel-black, Furnace black such as, (N110 to N762) with thermal black for instance, (N990 and N991) [21–24]. The electrical property deliberate in this research such as The constant of dielectric $\varepsilon$ is determined by [5,25]:

$$C_p = \frac{\varepsilon' \varepsilon_0 A}{d}$$

Where $C_p$, d and A mean the capacity, thickness of the sample and surface area, respectively. Whereas, $\varepsilon'$ is represented the Dielectric loss is [25]:

$$\tan \delta = \frac{I_p}{I_q} = \frac{\varepsilon' \varepsilon}{\varepsilon}$$

Where the metric of loss is represented by $\tan \delta$. The equation below is used to calculate the AC conductivity $\sigma_{ac}$ [26].

$$\sigma_{ac} = \omega \varepsilon'' \varepsilon_0$$

2. Experimental Work

2.1. The material used

(PVA) the polymer is the largest synthesis and water-soluble polymers shaped in the world founded on volumes. The melting point of PVA is 230°C and its molecular weight (18000 g/mol). The provenance of PVA is Spain Industrial development, PVP is a white and hygroscopic powder with a weak characteristics order Provenance of PVP is Anhui Leaf chem. Co., Ltd, China (mainland) and high purity (99.8%). The melting point of PVP is (150-180) °C. Carbon black (C.B) (N375 -32 nm) abounding by Doudah, Iran. It is inspected in agreement with DBP absorption (ASTM D 136) and Iodine absorptions (ASTM D 135) and preparations of (PVA-PVP-C.B) nanocomposites and studies the optical and structural possessions. The matrix polymer has been prepared by using PVA (90 wt. %), and polyvinyl pyrrolidone (10 wt.%) as a matrix. The polymers are liquefied in water distill with magnetic stirrers in mixing procedure to get uniform solutions. The C.B nanoparticles added with different weight percentages to the solution were (0, 5, 1, 1.5 and 2) wt.%. In order to prepare the (PVA- PVP- C.B) nanocomposites using the casting method.

3. Results and Discussions

FTIR spectra were noted using vertex-70-FTIR (Bruker Company, German). The FTIR spectra of nanocomposites (PVA-PVP-C.B) are listed at room temperature with wavelength (500-4000) cm⁻¹, Fig 1. (A, B, C, D and E) explained (PVA-PVP-C.B) nanocomposites FTIR spectra, its exhibited distinctive band of stretched and bonded vibration of the function group formed in the nanocomposite. From the spectrum demonstrated, the broad bands at about 3272 cm⁻¹ is given to the stretch vibrations of groups (C-H) of polymers, which may be due to the intermolecular or intramolecular types of the polymers of
hydrogen bonds and the nanoparticle. The band absorption of the – CH2 asymmetrical stretch vibration at about 2940 cm⁻¹, The functional peak at 1650 cm⁻¹ is associated to the stretching aromatic (C=C). At about 1422 cm⁻¹, this peaks is assigned to (CH2) bending or bending (O-H), and 1245 cm⁻¹ attributed to (CH2) wagging twisting (out-of-plane) bending vibrations, whereas the group (C- O) single band at about 1088 cm⁻¹ [27].
Figure 1. Spectrum FTIR for (PVA-PVP-C.B) nano-composite. (A) blend polymers, (B) 0.005 wt.% C.B nanoparticles, (C) 0.01 wt.% C.B nanoparticles, (D) 0.015 wt.% C.B nanoparticles and (E) 0.02 wt.% C.B nanoparticles.

In Figure 2, the images of (PVA-PVP-C.B) nanocomposites film at the energy of magnifications for a specimen of distinct level (100x) were exhibited a good homogeneity and fine distributions of carbon black. When carbon black nanoparticles are increasingly presenting moves of PVA with PVP. The concentration of carbon black nanoparticles presented an impact factor to form a significant interaction network within polymers when the concentration increased to 0.02 wt.% of the (PVA-PVP-C.B) nanocomposites. The formed network included several tracks within the samples that could help to enables carriers of charging cross these tracks through the polymer matrix in the nanocomposites [22].
Figure 2. Photomicrographs (100x) of (A) blend polymers, (B) 0.005 wt.% C.B nanoparticles, (C) 0.01 wt.% C.B nanoparticles, (D) 0.015 wt.% C.B nanoparticles and (E) 0.02 wt.% C.B nanoparticles.

Figures (3) show the effect of adding the (C.B) nanoparticles on the constant of the dielectric at 100Hz at 25°C. The results in the figure exhibited improvement in the dielectric constant with the growing of the ratio of (C.B) nanoparticles in the matrix. The possible reason behind the increase the value of the dielectric constant was the formation of a continuous network between the (C.B) nanoparticles with blended polymers in the nanocomposites, whereas, at lower loading ratio, the nanoparticles take place to form the clusters and as a separated group at high concentrations that exhibited lower values of the dielectric constant. (C.B) nanoparticles procedure a continuous network in the matrix this also could improve the ($C_p$) increment for the storage charges, and enhance the dielectric constant corresponding to the volumetric rate of the (C.B) nanoparticles in agreement with other the researchers finding [28].
Figure 3. Dielectric constant against the (C.B) nanoparticles concentration at 100Hz of (PVA-PVP-C.B) nanocomposites.

The dielectric constant variation of (PVA-PVP-C.B) nanocomposites with frequency for all samples are shown in Figure (4). Where, in the low-frequency range, the dielectric constant exhibited the higher values at low-frequency range and the higher dielectric constant was due to Maxwell-Wagner polarization, whereas this went to reduce with an increase in the frequency. This behavior was similar for all samples.

Interfaces of insulator conductor have originated this kind of polarization originates, where at the interfaces, this space charges accumulation or dipoles may result in this interfacial polarization. Where there is plenty of time at low-frequency regions of the space charges to react and the applied electric field, whereas it is too quick to react to the higher frequency range and does not exist of the polarization effect. Meanwhile, other polarization types are presented at high frequencies. In comparison, a slightly reacts of the ionic polarization variation in the field frequencies to the electronic polarization that could be related to the greater mass of ion compared to the electron. Even at high frequency, the electrons respond to the field vibrations. At higher frequencies only, the low electron mass helped to the electronic polarization and turned the dielectric constant about a constant of the all nanocomposites [27,29].

Figure 4. The dielectric constant of (PVA-PVP-C.B) nanocomposites with the frequency.
In Figures (5, 6), the dielectric loss exhibited a reduction decrease in the value with rise in frequency. At low frequency, the polymer chain displayed the highly mobile charge carriers, whereas at high frequency, the space charges are noted not to react through the electric field and because the reduction in polarization led to the accumulation of the charge, as well as the dielectric loss, is reduction. That was generally lead to loss of the power in the dielectric material. Whereas, the dielectric loss of (PVA-PVP-C.B) nanocomposites is approximately constant within the rise of the value of frequency to 1 MHz.

Additionally, the high frequencies attributed the mechanisms of other polarization types. The contribution increasing the loading ration of C.B nanoparticles was responsible of improve the dielectric loss due to the rise of the ionic charge carriers, as revealed in Figures (5 and 6), in agreement with other finding [27,29].
region, the interfacial polarization is attributed to the improvement in the AC electrical conductivity with angular frequency, whereas at intermediate besides higher frequencies, the tunneling/hopping between two equilibrium sites is considered the main reason to enhance the conductivity during the electrons or atoms motion. In general, in the case of the band conduction, the AC conductivity is reduced with the rise of the value of frequency, while it improves with if the frequency is increased in the hopping conduction case.

From figures (7,8), it can be shown an increasing the loading ratio of (C.B) nanoparticles is associated to improve in the conductivity of nanocomposites as an outcome of the rice of the ionic charge carriers, in addition to the (C.B) nanoparticles formed a continuous network of ions inside the samples [12,13].

![Figure 7](image1.png)

Figure 7. The A.C electrical conductivity for (PVA-PVP-C.B) nanocomposite with frequency.

![Figure 8](image2.png)

Figure 8. The A.C electrical conductivity with different concentrations of (C.B) nanoparticles for (PVA-PVP-C.B) nanocomposites.

4. Conclusions

The dielectric constant of the samples reduced with the rise of the frequency of the applied electric field as well as this behavior was similar for the dielectric loss. The A.C electrical conductivity was enhanced after increasing the value of the frequency. The A.C electrical conductivity of (PVA-PVP-C.B) nanocomposites and dielectric constant and the dielectric loss for all concentrations increases with the increasing the ratio of carbon black.
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