

A study of Structural and Electrical Properties of (PVA-CMC-Bi₂O₃) Nano composites: as a Model of Antibacterial and Health Application

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Abstract

This paper represents the work on preparing (PVA-CMC-Bi₂O₃) nanocomposites by adding varying weight concentrations of Bismuth oxide is presented in this study (0,1,3,5, wt %). The structural and electrical properties of nanocomposites (PVA-CMC/Bi₂O₃) were investigated using an optical microscope. The results reveal that the dielectric constant declined as dielectric loss decreased, however, the frequency value increased when an electric field was applied. In terms of electrical conductivity AC, all samples' dielectric loss and dielectric constant increased as lead oxide concentration increased.

Keywords: Structural Properties, Electrical Properties, PVA, CMC, Bi₂O₃ nanocomposites

1. Introduction

The development and analysis of various polymer blends have received a lot of interest in recent years. The blending of different polymers represents a means of improving a material's performance. Polymer mixtures will have properties that differ from the constituent polymers. It is determined by the miscibility of the parent polymers. The polymer blends are fascinating because their characteristics can be adjusted by adding various salts and nanoparticles. Nanoparticles play an important role in the present era because of their unique characteristics. When nanofillers are incorporated into blends, they help to improve the constituent polymers' characteristics while also decreasing the cost [1-5]. PVA (polyvinyl alcohol) is a basic polymer. For its unique traits, such as environmental friendliness, nontoxicity, solubility in water, biodegradability, good electrical and optical properties, chemical stability, excellent dielectric strength, and charge storage capabilities. PVA contains a hydroxyl group that can help build an interpenetrating connection in a polymer composite by hydrogen bonding [6, 7]. Carboxy-methyl Cellulose (CMC) is a common industrial polymer used in a variety of applications such as flocculation, textiles, paper, medicine, and food [8]. It has a substantially higher viscosity and is nontoxic and allergic, among other properties. Water binding and moisture absorption are made possible by the presence of several hydroxyl and carboxylic groups. Because CMC hydro-gel has a strong biodegradability and high water content, as well as its low cost, it's employed in a variety of applications [9]. Bismuth (III) oxide is the most important industrial product of bismuth. In bismuth chemistry, it's also a typical starting point. Bismite (monoclinic) and sphaerobismoite (tetragonal, considerably rarer) are natural minerals, however, it is commonly obtained as a by-product of the smelting of copper and lead ores. As a substitute for red lead, dibismuth trioxide is widely used to create the "Dragon's eggs" effect in fireworks. [10]. The electrical properties considered as part of the present study, such as the dielectric constant (ϵ'), can be defined as follows [8, 11-13].

$$CP = \epsilon_0 \epsilon' A / d \quad (1)$$

Where d , C_p , ϵ_0 and A represent the thickness, sample capacity, vacuum permittivity, and surface area, respectively. In contrast, the dielectric loss is expressed by [11].

$$\tan \delta = I_p / I_q = \epsilon'' / \epsilon' \quad (2)$$

Where: ϵ'' represents the dielectric loss, and $\tan \delta$ represents the dielectric loss tangent.

2. Experimental Work

The Materials

Used PVA is the largest water-soluble polymer. It was created and commonly adopted on the basis of its size. Its molecular weight is (1200-1800g/ mol), and it has a melting point of (230 C). CMC is found in form of a powder that is obtained from the local market in high purity degrees (99.8%). The melting point of CMC is (50-90) 0C. The nanocomposites were prepared (PVA-CMC / Bi₂O₃) in different concentrations. The casting method was used in this preparation. The blend (PVA-CMC) samples were prepared with PVA and CMC. The Bi₂O₃ nano-particles were combined with the (PVA-CMC) according to a blending concentration of (0, 1, 3 and 5) wt%. For obtaining a uniform solution, the polymers are liquefied using magnetic stirrers in water distillation during the mixing process for preparation (PVA-CMC/ Bi₂O₃). Finally, the samples are ready for the appropriate measurements to be performed.

3. Results and Discussions

Structural Properties

The OM images of the pure (PVA- CMC) polymer blend surface and its nano-composites film at magnification strength (40X) are shown in Figure (1). It indicates good homogeneity and fine incorporation of Bi₂O₃ particles in the polymer [14, 15]

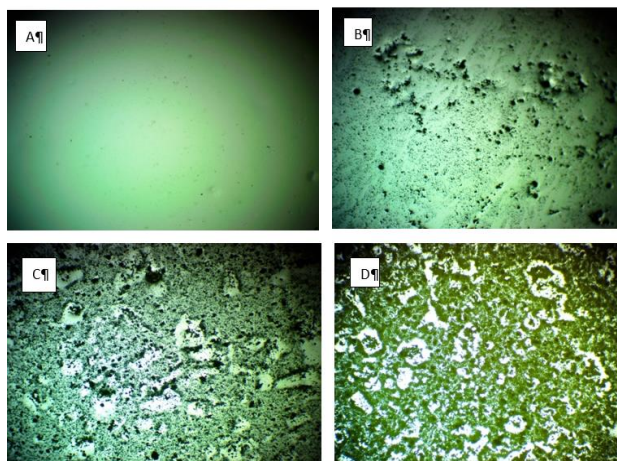


Figure 1. Photomicrographs (40x) for (PVA-CMC /Bi2O3) nanocomposites A. (PVA-CMC) blend B. 1 wt%, C. 3wt%, D. 5 wt%, Bi2O3 nanocomposites

Electrical Properties

Figure (2) illustrates the effect of adding Bismuth oxide (Bi2O3) on the dielectric constant. It has been observed that a positive correlation exists between the dielectric constant and the Bismuth oxide nanoparticles, as both tend to increase simultaneously. This aspect can be traced back to the creation of a continuous network of Bismuth oxide nano-particles within the nano-composites. This is well illustrated in microscopic images taken for samples of (PVA-CMC/Bi2O3) nanocomposites at various concentrations.

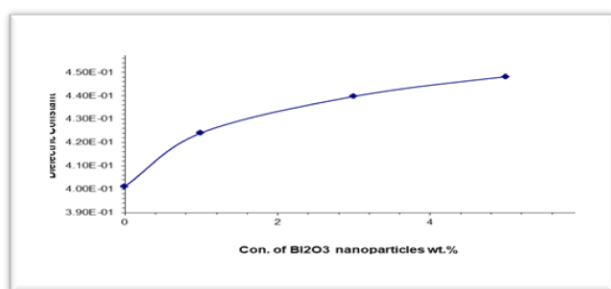


Figure 2. Variations in dielectric constant at different concentrations of (Bi2O3) nano-particles at 100Hz of (PVA-CMC/ Bi2O3) nano-composites

Figure (3) illustrates the variation in dielectric constant for the (PVA-CMC/Bi2O3) nano-composites of the samples at different frequencies. It is apparent from the figures that the ϵ' rate declines when applied frequency increases, as a result of the forms of polarization (ionic and electronic, dipolar, space charge) at low frequencies. The polarization of the space charge plays a significant role in increasing the dielectric constant, as it becomes less contributing to the rise in frequency and more contributing of polarization. This action induces the decrease in the ϵ' values for the samples with a rise in the frequency of the electrical field. The alternative forms of polarizations take place at a subsequent frequency [16, 17].

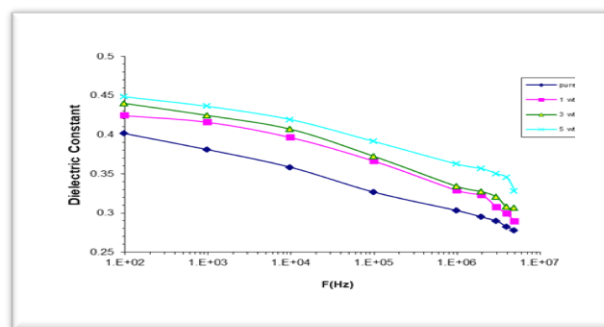


Figure 3. Variations in the dielectric constant of (PVA-CMC/Bi2O3) nano-composites at different frequencies

Figures (5) and (6) show the ϵ'' values as a function of the frequency of nano-composites. The loss of nanocomposites (PVA-CMC/Bi2O3) seems to decrease when the applied electric field increases. This behavior is due to a decline in the contribution of space charge polarization, as well as a high value of dielectric loss for (PVA-CMC/Bi2O3) nanocomposites at lower frequencies. The dielectric loss of (PVACMC/Bi2O3) nano-composites increases with the rise in Bi2O3 nano-particle concentrations. When the frequency is increased the dielectric loss is approximately constant for (PVA-CMC/Bi2O3) nanocomposites [17, 18].

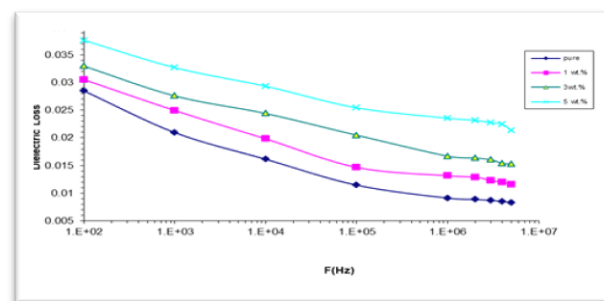


Figure 4. Variations in ϵ'' for (PVA-CMC/ Bi2O3) nano-composites at different frequencies

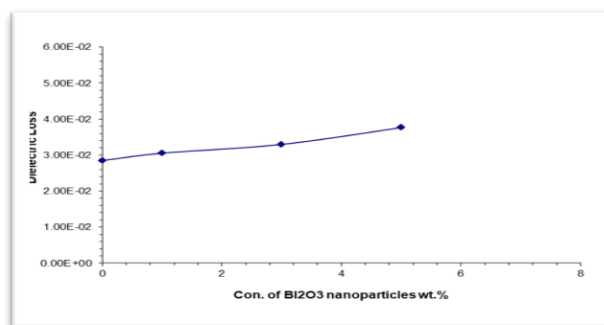


Figure 5. Variations in ϵ'' at different (PbO) nano-particle concentrations for (PVA-CMC /Bi2O3)

The variations in AC electrical conductivity as a function of frequency for (PVA-CMC/ Bi2O3) nanocomposites at 100Hz, are depicted in Figure (6). It is demonstrated that the σ a. c. of nano-composites rises whenever the frequency increases in (low, moderate, and higher) frequency regions. This is due to the hop-up of charge carriers and also to charge carrier energization within the conduction band in the upper regions. Figure (7) demonstrates that the conductivity of nanocomposites has increased with increasing the (Bi2O3) nano-particle concentrations, as a consequence of the rise in ionic

charge carriers and forming a continuous network of (Bi₂O₃) nano-particles within the composites [15, 17-19].

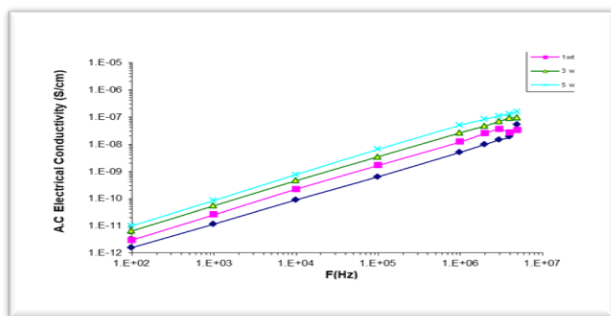


Figure 6. Variations in A.C electrical conductivity at different frequencies for (PVA-CMC /Bi₂O₃)

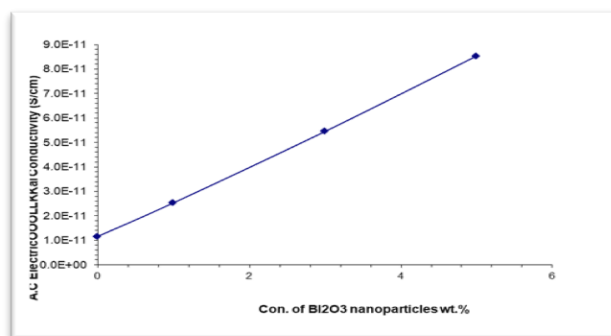


Figure 7. Variations in A.C electrical conductivity at different concentrations for (PVA-CMC Bi₂O₃)

4. Conclusion

Throughout conducting the present experiment, it has been noticed that the dielectric constant ϵ' of the specimens decreased as the frequency of the induced electric field increased, which is the same behavior observed with the dielectric loss ϵ'' . After increasing the frequency value, the AC electrical conductivity of (PVA-CMC/Bi₂O₃) nanocomposites improved. In addition, the dielectric constant and loss values increased at all ratios of concentration, along with the increase in Bismuth oxide rates.

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