International Journal of Advanced Research and Review

www.ijarr.in

INVESTIGATING THE EFFECT OF AN ALTERNATING ELECTRIC FIELD ON DIFFERENT PROPERTIES OF THERMOPLASTIC POLYMERIC COMPOSITES

HM Shaker[a]

[a]Building Physics Institute, Housing and Building National Research Center (HBRC), 87 El –Tahrir St., Dokki, P.O. Box 1770. ,Giza, Egypt

ABSTRACT

In this paper we have studied the effect of adding zinc oxide (ZnO) in its micro size on the dielectric parameters of polyvinyl chloride (PVC), such as dielectric permittivity and dielectric loss factor, as they are very important parameters characterizing the dielectric materials. Using Broad Band Dielectric Spectrometer (BDS) in the frequency range (0.1Hz – 10^7 Hz), we have measured both dielectric constant (ε′) and dielectric loss (ε″) of PVC composites containing different contents of zinc oxide (5%, 7%, 9% and 11%) by weight of polymer. We have found that ε′ of PVC sample with (5%) ZnO is higher than that of Pure PVC one, and then a decrease in the dielectric constant (ε′) for the rest of concentrations is observed. Meanwhile, dielectric loss (ε″) increases over the frequency range for all composites comparing to pure PVC.

Key words: PVC; Dielectric Constant; Dielectric Loss

1. INTRODUCTION

Polymeric materials have become the main category of huge number of industrial and highly applicable materials which have an amazing interest in the world now. Addition of some inorganic additives either in micro size or nano size into the polymeric material is greatly very important, because these additives or fillers influence greatly many important properties such as thermal, mechanical or dielectric properties of the bare polymer [1-3]. As a pronounced polymer, PVC is utilized widely in many fields and enormous applications. Floors, windows, door frames, water pipes, packaging films, electrical wires and cables are the most common industrial products of PVC.

Owing to many reasons such a slow cost, easy to process and very good mechanical characteristics, PVC is strongly used in these applications [4, 5]. Multicomponent polymeric composites are greatly make some sort of combining the amazing and unique optical, thermal magnetic and electric and properties of the added inorganic fillers into the polymeric matrix. Either these additives in microscale or nano scale size, such multicomponent materials take the valuable characteristics of polymers such as excellent processability and flexibility [6-10].

Among the huge progress of material technology, such advanced property tailored composites can greatly give the industry highly improved properties that are for sure differ from the traditional ones. Scientists can vary shape, size and concentration of aforementioned fillers and consequently measure the filler dispersion and interaction, so such improvement in smart advanced materials will result in a big growth in manufacturing of 3D printing technology that are of great applications in the world now [11-15].

Among a large number of transition metal oxides, zinc oxide (ZnO) is considered as extremely important material. Zinc oxide (ZnO) has been used in many and versatile applications for large number of years in disparate fields, and we can consider it feasibly as a major attractive engineering material [16,17].For example, in rubber industry, ZnO is used as vulcanizing activator in order to increase the effectiveness of vulcanizing process. While, in the field of electronics, ZnO is considered as a major component in light emitting diode (LED) especially in blue LED [18].

2. EXPERIMENTAL WORK

2.1 Materials

Commercially available white powder zinc oxide (ZnO) in its micro size is used here, and it is insoluble in water. The host matrix is poly vinyl chloride (PVC). Different ratios of (ZnO) were prepared by weight percentage of pure polymer. Extra pure zinc oxide was purchased from Alpha chemika (India), and PVC was purchased also from Advent for chemicals (India).

2.2 Samples preparation

In this paper, we have prepared these composites of (PVC / ZnO) via simple solution casting method with different amounts of zinc oxide powder by weight percent of poly vinyl chloride (PVC) matrix. These ratios are (5%, 7%, 9% and 11%).

2.3 Characterization Technique.

We have measured the dielectric properties of (PVC / ZnO) samples such as dielectric constant (έ) and dielectric loss (ε") using Broad Band Dielectric Spectrometer (BDS) in the frequency range (0.1Hz – 10^7 Hz) at room temperature. The frequency dependent dielectric properties were obtained by dielectric spectroscopy utilizing a high resolution Alpha analyzer with an active sample head (Novocontrol GmbH) [19].

3. RESULTS AND DISCUSSION

3.1 Frequency Dependence of Dielectric Properties.

Experimentally obtained dielectric constant (έ) and dielectric loss (ε") as a function of frequency for (PVC/ZnO) samples with different contents of zinc oxide (5%, 7%, 9% and 11%) are shown in Figure1and Figure 2 respectively. From Figure (1) only sample with (5%) ZnO exhibit higher dielectric constant than the pure polymer, then by increasing the content of ZnO within the polymeric matrix, an apparent decrease is observed.

Starting with analysis for the behavior of dielectric constant with frequency change, it can be seen that at lower frequency range, all composite exhibit higher values of dielectric constant (έ). The permittivity is gradually decreased with the increase of frequency. Such behavior can be explained as follows [20-22]: a typical dielectric medium is composed of conducting grains that are separated by resistive grain boundaries. When we apply an external alternating electric field, the charge carriers began to migrate through the conducting grain and are piled up at the resistive grain. As a results, large polarization takes place and sometimes it termed as (space charge polarization) within the dielectric medium, so we observe high dielectric constant at the beginning. In the low frequency region, all of the four polarization mechanisms i.e. (electronic, ionic, dipolar and interfacial) contribute to the total polarization of the composite. But with increasing the frequency, the contribution of some of the previously mentioned polarization mechanisms to the total polarization is terminated which leads to the lower value of dielectric constant at higher frequency range. Such a decrease in dielectric constant could be attributed to the fact that there is a decrease in the number of dipoles which is the main contribution to polarization, in other words dipoles become no longer able to respond to the applied alternating field, so we observe a decrease in the value of dielectric constant έ.

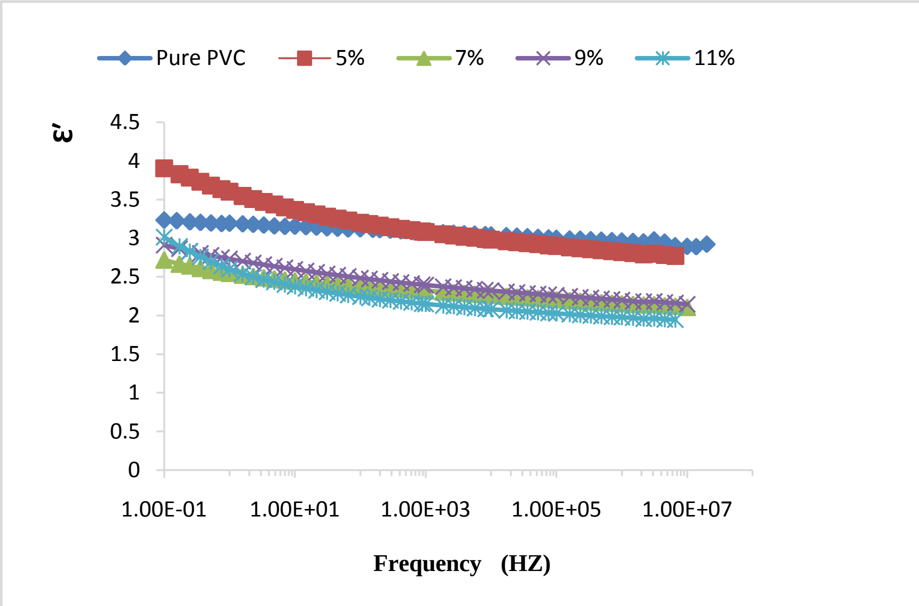

Figure 1. Frequency dependence of dielectric constant of (PVC/ZnO) composites with ZnO content (5, 7, 9 and 11 %).

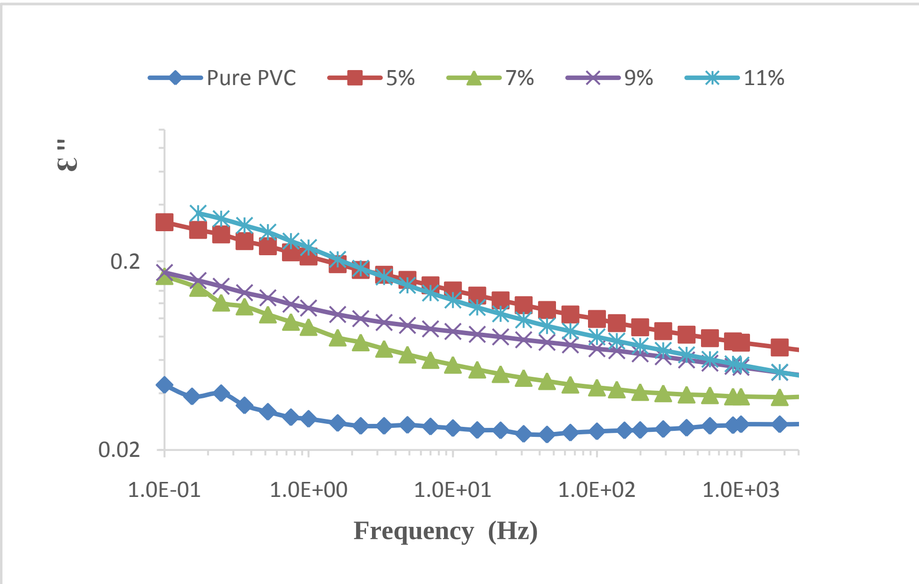

Figure 2. Frequency dependence of dielectric loss of (PVC/ZnO) composites with ZnO content (5, 7, 9 and 11 %).

The dielectric loss is defined as inherent dissipation of electromagnetic energy as a form of heat from a dielectric material. Here, dielectric loss (ε″) of (PVC-ZnO) samples is measured as a function of frequency (0.1 Hz - 10^7 Hz).in the dielectric material, the dielectric loss, the dissipation of energy is caused by the movement of charges in an alternating electric field. It is well known that polarization switches the direction. Dielectric loss is high at resonance, and the polarization lags behind the applied filed which causes an interaction between the applied field and the dielectric polarization that result in heating of the dielectric material under investigation [23]. Materials having higher dielectric constant, generally will give higher values of dielectric losses.

CONCLUSION

The dielectric frequency spectroscopy has been studied for poly vinyl chloride composites containing ZnO with different concentration (5,7, 9 and 11%) beside Pure PVC sample. Simple casting method was used to prepare PVC samples. The two important dielectric parameters dielectric constant and dielectric loss have been studied over the frequency range (0.1 Hz-10^7 Hz) using Broad Band Dielectric Spectrometer (BDS) at room temperature. We have noticed that at lower frequency range, all composite exhibit high values of dielectric constant (έ). The permittivity is gradually decreased with the increase of frequency. While dielectric losses of PVC – ZnO composites exhibit higher trends than pure poly vinyl chloride matrix.

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