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STUDY OF DIELECTRIC PROPERTIES ON $BaCO_3$/ POLYMER NANOCOMPOSITES

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ABSTRACT

Nanodielectric composites have been developed in recent years attempting to improve the dielectric properties such as dielectric properties such as dielectric constant, dielectric strength and voltage endurance. Conventional dielectric material development followed the paths of organic polymers, inorganic ceramics and thin films separately, due to type of capacitors, manufactured, polymeric film and multilayer ceramic capacitors, polymer dielectrics show very high dielectric strength (> 300 kv/mm), lover dielectric losses (< 0.01) and adequate mechanical flexibility in processing, which is important in thin film capacitors. However they have low relative dielectric permittivity or constant (< 4) and low operating temperature (< 200^{o}C) compared to ceramic materials. Ceramic dielectrics tend to have very high dielectric permittivity (> 100) but relative low dielectric strength (< 50 kv/mm) or may be piezoelectric associated with the structure of ceramic. Nanodielectric composites belong to a new type of materials, engineered for improved specific functionality such as better performance in electrical insulation. In the present study, $BaCO_3$ as a filler has been dispersed in polycarbonate in various concentration, Dielectric constant and loss has been measured as a function of frequency.

Key words: Nanocomposites, Polymer, Dielectric constant.

INTRODUCTION

Barium carbonate is an important raw material, which is widely used in electronics, ceramics and glasses industry. For instance, from the combination of different fibers or fillers with polymer matrices one can produce polymer-matrix composites, a material important to the electronic industry for its dielectric properties in the use of capacitors[1-3]. The particular focus is on materials: polymers serving as the matrix, inorganic fillers

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used to increase the effective dielectric constant, and various recent investigations of functionalization of metal oxide fillers to improve compatibility with polymers. It is also used for controlling the chromate to sulfate ratio in chromium electroplating baths[4,5]. The ideal solution would be a high dielectric constant material that is mechanically robust and process able at ambient temperatures.

In this paper, the effect of filler content to make polymer/ceramic composite, for enhancing the charge storage capacity of the system has been checked by measuring dielectric constant.

EXPERIMENTAL

In present study, $BaCO_3$ from SIGMA Aldrich (purity-99.9%) has been used as filler and polycarbonate (Garda Chemicals Ltd., Bharuch India) has been used. Solution cast method has been adopted for synthesis of composites. The concentration of filler ($BaCO_3$ has been varied from (0.01-0.05 wt%) in the base matrix of polycarbonate. For measuring dielectric constant Impedance Analyzer (6500B) has been used in the frequency range (10 kHz-1MHz). The dielectric properties of the samples were measured by using impedance analyzer.

The dielectric constant was calculated by using the formula –

$$\in' = Cd/\in_0 A \quad \ldots(1)$$

Where C, is capacitance of nanocomposite, d is sample thickness and A, is surface area of composite, ε_0 is dielectric constant in vacuum (8.854×10^{-12} F/m), A (effective area) = πr^2

RESULTS AND DISCUSSION

The frequency dependence of dielectric constant and dielectric loss of $BaCo_3$ and polycarbonate composite were measured at room temperature as a function of the ceramic volume fraction. In Fig. 1, it can be seen that the dielectric properties with frequency change greatly. Initially the dielectric constant (ε_0) in composite with more ceramic volume fraction reduce with frequency quickly at frequency < 200000 Hz. This is due to contribution of space charge at low frequency. At high frequency, the dielectric constant increases. Increasing the ceramic induce more space charge, which increases the dielectric constant at low frequency[6]. The increase in filler content and higher frequency is an expected increase and is attributed to interracial effect appears in complex system due to accumulation of charges at the interfacial to the system[7,8].

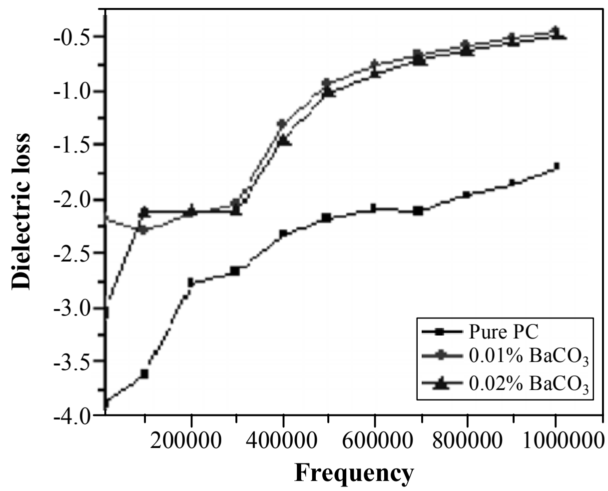

Fig. 1: Variation of dielectric constant with frequency

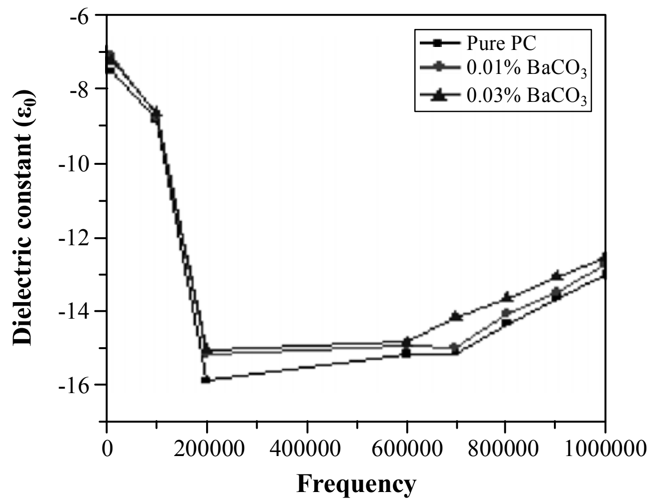

Fig. 2: Variation of dielectric loss with frequency

The frequency dependence of the dielectric constant ε_0 and dielectric loss of $BaCO_3$ and polycarbonate composite were measured at room temperature as a function of the ceramic volume fraction. In Fig. 1, it can be seen that the dielectric properties with frequency change greatly. Initially the dielectric constant (ε_0) in composite with more ceramic volume fraction reduce with frequency quickly at frequency < 200000 Hz. This is due to contribution of space charge at low frequency. At high frequency, the dielectric constant increases. Increasing the ceramic induce more space charge which increase the dielectric constant (ε_0) at low frequency[6]. The increase in filler content and higher frequency is an expected increase and is attributed to interracial effect appears in complex system due to accumulation of charges at the interfacial to the system[7,8].

The variation of dielectric constant (ε_0) with frequency is shown in Figure 1 at the room temperature. The differences in dielectric constant (ε_0) of $BaCO_3$ and polycarbonate were found at room temperature. Figure shows that the dielectric constant is high at high frequency (1000000Hz)[9]. Dielectric relaxation is due to reorientation process of dipoles in polymer, which show a peak in for electrolyte with higher ion concentration, the movement of ions from one side to another perturbs, the electrical potential of surroundings. Motion of the other ions in this region will be affected by perturb potential[10]. This type of cooperative motion of ions exhibits a conduction processes with distribution of relaxation time[11].

Fig. 2 shows the decrease in dielectric with increase of frequency at room temperature in all samples due to coulomb blockade effect of $BaCO_3$ filler. The coulomb blockade effect is a novel method, which control to dielectric loss of nanoparticles in insulating matrix. When a metal particle is in an insulating matrix, only a special condition makes an electron probably to tunnel through the particle from outer. The magnitude of dielectric loss is an important material parameter for making the capacitors. Ideally, in a capacitor the dielectric losses should be as low as possible.

CONCLUSION

In the present work, the samples were prepared by the solution cast method. The dielectric study of the samples has been carried out using the impedance analyzer. The following conclusions have been drawn from the results.

This study points to fact that upon introducing filler, there is an improvement in the dielectric properties. At room temperature, the experimental results indicate that addition of filler particles to polymer leads to increase in the dielectric constant of the composite specimens. At room temperature frequency dependence of dielectric constant, in pure polymer- ceramic composites with various concentration of powder as filler has been studied in the frequency range (10000 Hz-1000000 Hz). Thus the finding of materials with high dielectric constant (ε) is one of the ways to achieve miniaturization besides the lowering of dielectric loss is important to improve the performance of embedded capacitor.

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