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Measurements of Experimental Dielectric for Less Expensive Nanocomposites using Fuzzy Logic for Polyvinyl Chlorides

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Abstract*: If correctly prepared and constructed, polymer nanocomposites have promise high performances as engineering materials. Using the most recent developments in nanotechnology, samples of nanocomposite polymers have been prepared for use as electrical insulators on electric power cables. This study examined the improved electrical and dielectric qualities of polyvinyl chloride (PVC) as a matrix and found that the addition of inexpensive nanofillers like clay and fumed silica significantly alters the trapping properties. The new nanocomposite materials' capacitance and dielectric loss have been experimentally studied and contrasted with empty industry materials. A robust correlation between the percentage of nanofillers and capacitance and dielectric loss values is found. Consequently, the effect of affordable nanofiller material and concentration on the dielectric properties of composite systems based on commercial polymers has been investigated. Unfilled base polymers and systems of a single type of nanoparticles, clay or fumed silica, are compared in the host polymer at various concentrations.*

Keywords*: Insulation, Dielectric materials, Polymers, Nanoparticles, Nanocomposite*

I. Introduction

Composites that contain small quantities of nanometer-sized fillers uniformly distributed throughout polymers by a number of weight percentages are known as polymer nanocomposites. As said, there are extremely few fillers added to the matrix. Tanaka et al. [1] have attempted to compare polymer nanocomposites with polymer microcomposites in two additional key areas, namely the size of the fillers and the specific surface area of the composites, in order to gain a deeper understanding of the former. Compared to microcomposites, nanocomposites are three orders of magnitude longer and fall within the nanometer (less than 100 nm) size range. This would indicate that their number densities differ by almost nine orders [3-4].

As a result, compared to microcomposites, nanocomposites have substantially closer spacing between neighboring fillers. When it comes to fillers, nanocomposites have a high specific surface area (about three orders of magnitude bigger than microcomposites). As a result, nanocomposites should exhibit significantly greater interaction between polymer matrices and fillers [1]. Conventional microcomposites can change some of the desired features of the composite materials, but they frequently come at the expense of other properties, such as electrical properties. It's interesting to note that recently developed polymer nanocomposites offer notable enhancements in their combined mechanical, thermal, and electrical characteristics [2-4].

Particularly, the high voltage insulating industry benefits greatly from these significant effects, particularly in terms of improving electrical characteristics. Despite the fact that polymer nanocomposites have attracted attention from researchers studying high voltage electrical insulating society, little is known about the underlying physics and chemistry that underlie the property increase.

Apart from being inexpensive to manufacture, polymeric materials are characterized by excellent thermal, chemical, and dielectric properties meaning that they have become a key part of modern electric and electronic packaging systems [5, 6]. The electrical characteristics of polymer composites with inorganic fillers in the polymer matrix are of vital importance towards enhancing the insulation reliability and compact design of electric power equipment. It has recently been recognized, that nanoparticle fillers are useful for preventing insulation breakdown in long term characteristics [7].

II. Experimental Setup

The HIOKI 3522-50 LCR Electrical properties of nanometric solid dielectric insulation specimens have been tested at different frequencies using the Hi-tester equipment, as illustrated in Fig. (1).

Fig 1: Life photo for experimental HIOKI 3522-50 LCR Hi-tester device equipment's

III. Results and Analysis

PVC that has been made with nanoparticles is the industrial nanocomposites material under study. The commercially accessible material that serves as the foundation for all of these polymer materials is already utilized in the production of high-voltage (HV) industrial products and their characteristics. At the Nano-technology Research Centre in Aswan, Egypt, nanoparticle additives to base industrial polymers have been created through the use of mixing, ultrasonic, and mild heating techniques. The SOL-GEL process was utilized to prepare the polymers under study [1].

For producing interpenetrating networks between inorganic and organic moieties at lower temperatures sol-gel processing of nanoparticles within the polymer dissolved in either non-aqueous or aqueous solution is THE best technique for achieving good compatibilities and effective interfacial interactions between two phases. Applying this method, effective nanocomposites including nanoparticles in different polymer matrices are produced. To synthesize the hybrid materials, a number of sol-gel process techniques are utilized. One method borrows a prepared sol-gel network and polymerizes organic functional groups.

IV. Properties of Nanofillers

Clay nanofillers include nanomer 1.30E, and the best filler among industrial nanofillers is cost-free clay catalyst. Significant amounts of additional nanoclays can frequently be found in the primary component of nanofiller clays. The most crucial feature of nanoclay for polymer applications is its spherical particle form. Because of its platy nature, clay fillers have a higher impact on qualities including strength, stiffness, and viscosity. Clay is chosen for this study because it provides significant degrees of flame retardancy to the composite that is formed [3-6].

The most effective filler of industrial nano-fillers do cost less and it is clay catalyst. Fumed silica nanofillers, which are traded under names, such as Aerosil, and Cab-o-sil, are a fluffy white powder that has very little density. It is typically used as a rheology modifier yielding highly thixotropic properties with low percentages; and is provided in both hydrophobic and hydrophillic grades. Some of the most commonly used thermoplast is polymerized vinyl chloride which is referred to as PVC. It is produced out of ethylene and anhydrous hydrochloric acid [4]. When compared with other general purpose thermoplastic polymers, PVC is more strong and stiff. Both its modulus of elasticity and tensile strength are high. Frequent presence of various volumes of different nanoclays in the primary element of the clay nanofillers is not uncommon.

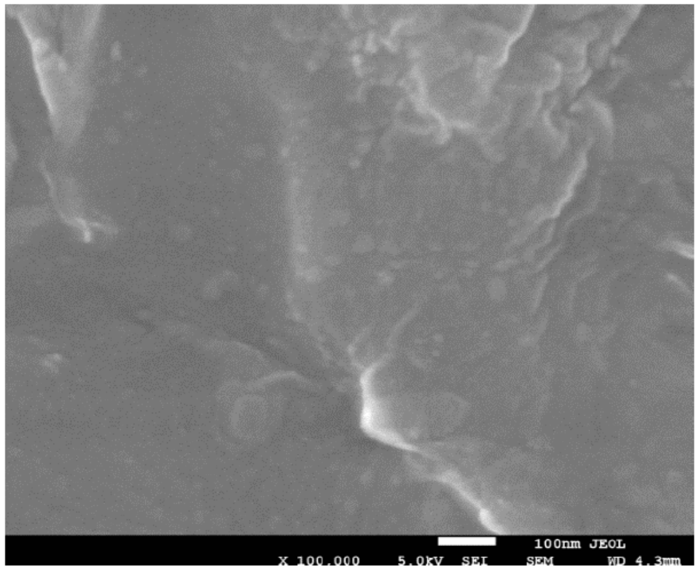

Fig 2: SEM images for dispersion of clay and fumed silica nanoparticles in PVC (Clay/PVC nanocomposites)

V. Results and Discussion

The loss tan for clay/PVC nanocomposites at room temperature (25 °C) is presented in a graph of the loss tan against frequency in Figure 3. In addition, considering this figure, it can be seen how the fraction of clay nanofillers in the new nanocomposite rises with the measured loss tangent. It is observable that the loss tangent of clay/PVC nanocomposites increases with more clay percentage nanofillers, but decreases with an increase in frequency. The capacitance of clay/PVC nanocomposites with room temperature (25 °C) is plotted in Figure 4 as a function of frequency.

Further, the observed capacitance and an increasing fraction of clay nanofillers in the nanocomposite are compared in this figure. It is proven fact that capacitance of clay/PVC nanocomposites increases with increasing clay 5% nanofillers and decreases with increasing frequency. However, it has been noted that as the percentage by weight of the clay nanofillers increases from 1%wt to 10%wt the capacitance of clay/PVC nanocomposites has decreased. The value of the loss tangent of the Fumed Silica/PVC nanocomposites was recorded at room temperature (25° C) against the frequency and was presented in Figure 4.

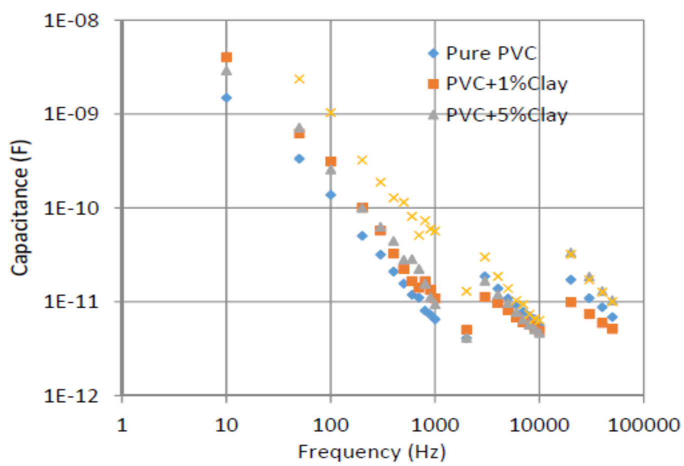

Fig 3: Measured capacitance as a function of frequency for Clay/PVC nanocomposites at room temperature (25^0c)

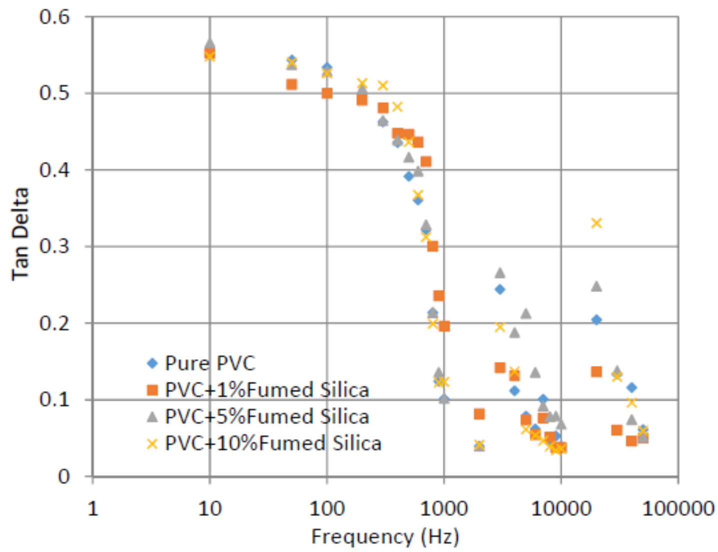

Fig 4: Measured loss tangent as a function of frequency for Fumed Silica/PVC nanocomposites at room temperature (25ºC)

VI. Conclusion

In polypropylene and polyvinyl chloride, introducing clay nanoparticles causes the polymer's permittivity to decrease and its resistivity to increase, whereas fumed silica nanoparticles cause the polymer's permittivity to increase and its resistivity to decrease. The capacitance and loss tangent of polypropylene nanocomposites increase with the amount of clay nanoparticles. On the contrary, the capacitance and loss tangent of the polyvinyl chloride nanocomposites increase with the fraction of clay nanoparticles. Nonetheless, polyvinyl chloride decreases, when one increases the weight percentage of clay nanofillers from 5%wt to 15%wt. Capacitance and loss tangent in nanocomposites of polypropylene are increasing with addition of fumed silica nanoparticles to 7%wt and are decreasing as fumed silica nanoparticles are added up to 20%wt. In contrast, in polyvinyl chloride nanocomposites, the addition of up to 7%wt of fumed silica nanoparticles decreases capacitance and loss tangent, but when added up to 20%wt, capacitance increases .

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