Enhancement of Dielectric and Mechanical Properties of Polyvinyl Chloride Nanocomposites Using Functionalized TiO_2 Nanoparticles

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ABSTRACT

The current study is to investigate the influence of inserting chemically modified titanium oxide (TiO_2) nanoparticles on the dielectric and mechanical properties of the commercial compound Polyvinyl Chloride (PVC) used in insulating power cables. The surface modification of TiO_2 nanoparticles was performed using vinyl silane coupling agent after activating their surfaces with methane-sulfonic acid. The PVC pellets were first dissolved using suitable solvent. Then, PVC/TiO_2 nanocomposites, with different loadings of nanoparticles, were synthesized with the aid of ultra-sonication for better dispersion of nanoparticles. The morphology of the prepared nanocomposites was studied by field emission scanning electron microscopy (FE-SEM), and their mechanical properties were studied by performing tensile test at speed of 50 mm/min. The results showed that the insertion of functionalized nanoparticles is able to increase the tensile strength and the Young's modulus of the prepared samples, however it decreases their elongation. The dielectric properties, such as dielectric constant and dielectric loss, were also studied in a range of frequencies between 20 Hz and 1 MHz. Moreover, AC breakdown voltage of prepared samples was measured under uniform and semi-uniform field, and then, AC dielectric strength was evaluated using Finite Element Method (FEM) for semi-uniform field. For further evaluation, DC breakdown voltage was also measured under uniform field. PVC/TiO_2 nanocomposites with functionalized TiO_2 exhibited better dielectric properties compared to that with un-functionalized TiO_2 or that of base PVC. This may be attributed to the low surface energy of the functionalized TiO_2 nanoparticles that prevented the agglomeration of nanoparticles and restricted the mobility of polymeric chains.

Index Terms — **Cable insulation, polymer nanocomposites, PVC, functionalized nanoparticles, dielectric and mechanical properties.**

1 INTRODUCTION

THE tendency to enhance the properties of insulating materials used in cables has become necessary in order to design new insulation systems that can withstand different stresses. Polyvinyl Chloride (PVC) is one of these electrical insulating materials because it is thermoplastic polymer that is easy in processing and curing. It also has stable chemical properties, excellent aging resistance, high flexibility and low cost [1]. However, for wide application of PVC, its dielectric and mechanical properties need further improvement.

In recent decades, nanodielectrics have attracted a great attention as a substitution for conventional dielectrics.

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