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Electrical Treeing and Morphological Analysis of Epoxy Nanocomposites with Different Concentrations of Silica Nanofillers

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Abstract. In high voltage equipments, insulation systems are the most vital parts to prevent any discharges from occurs around the protected systems. However, the discharges in the form of electrical treeing can easily occur when there are existences of impurities, voids or defects in the insulation bulk. This phenomenon can lead to the insulation breakdown when subjected to prolonged electrical stresses. This paper discusses about the effects of silica nanofillers on the electrical treeing growth in epoxy resin. The silica nanofillers were dispersed in epoxy resin matrices homogeneously by using ultrasonication method based on weight percentage (wt %) which the weight percentages used in this study were 0 wt%, 1 wt%, and 3 wt% respectively. The influence of these nanofillers on the electrical tree breakdown resistance was investigated experimentally. The electrical tree data such as tree inception voltage, tree breakdown voltage and tree propagation time were tabulated and appropriate comparative analysis were made and presented. Last but not least, scanning electron microscopy images were captured and discussed based on its dispersion state and also the morphological features of the epoxy nanocomposites. In this study, it was found that the existence of different silica nanofiller concentrations have profound effects on insulation strength and could exhibit significant improvement of tree characteristics of epoxy nanocomposites.

Introduction

In the coming years, polymer nanocomposite studies focusing on improvement of electrical properties are rapidly progressing. It has started from a paper published by T.J. Lewis in 1994 in IEEE Transactions of Dielectrics and Electrical Insulation entitled “Nanometric Dielectrics” [1], and then it has inspired many researchers globally to investigate the electrical property enhancement by adding nanoparticles into the polymer matrix. Thus, it can be said that nanocomposite has given promising future to the electrical insulation especially to overcome degradation processes in polymeric insulation such as partial discharge, space charge build-up, surface tracking erosion, water treeing, as well as breakdown. In addition, application of nanocomposite to enhance the partial discharge erosion was firstly performed by Kozako et al. [2] in 2003 as well as to suppress electrical treeing in 2004 by Ding and Varlow [3] and also by Imai et al. [4]. Therefore, the theoretical aspects of partial discharge and electrical tree formation mechanisms should be studied distinctly to know the way to solve these polymeric degradation processes. It is given clearly in literature [5], [6] that electrical treeing is mainly caused by the charge carrier injection and extraction during negative and positive half cycle of AC voltage. Then, after this charge carrier has achieved sufficient energy, it will start to attack the polymer chain which causes chain scission and thereby form the microcavities. After prolonged stresses, these microcavities will coalesce and form bigger cavities which are sufficient enough to cause partial discharge. From this partial discharge repetition, electrical tree will start to occur and then it propagates in the direction of electric field direction towards the ground. Therefore, the presence of