

Impulse Breakdown Strength of Nano-ZnO/XLPE Nanocomposite Material on Temperature Rise

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Received 2012

ABSTRACT

Development of new materials using composite materials has been much interest. XLPE is a kind of power cable in high voltage insulation. Recently research for cable insulating material has shown that nano-size filler added to XLPE is electrically and physically stable. In this paper, Impulse strength was measured in XLPE that composite by adding nano-ZnO with different mass proportions. There is positive and negative impulse voltage. However, there is no difference between them on the film specimen. Therefore we tested only positive voltage. In order to understand temperature properties of XLPE nanocomposite sample, experiment of impulse breakdown strength were measured at room temperature and maximum allowable temperature (90°C). From this result, it can be considered that the breakdown strength of addition of the nano-ZnO is increased in a corresponding degree at high temperature, but almost unchanged at low temperature.

Keywords: XLPE; Nano Composite; Nano-ZnO; Impulse Breakdown Strength

1. Introduction

Studies that are involved in impulse breakdown for the DC insulation materials have plenty. Nevertheless, it is mostly the polymer insulation materials in low electric fields.

In this study, a nanocomposite material of nano-Zinc oxide (ZnO) added to a cross linking-polyethylene (XLPE, used for high voltage cable insulation) was subjected to impulse property investigation. The purpose of this study is to investigate the electrical properties influence on temperature rise. In this paper, the experimental preparation of ZnO/XLPE nanocomposite is described. And the impulse breakdown strength of ZnO/XLPE is measured under quasi-uniform fields.

2. Experiment

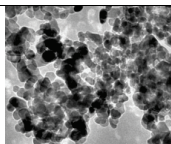
2.1. Specimens

The details of nanocomposite sheet specimens containing different filler concentrations are included in Table 1. Silane treated nano-ZnO (Nanostructured and Amorphous Materials, Inc) with the diameter of 90-210nm was incorporated in XLPE. The samples were diluted to the prescribed concentration of 1, 3 and 5 phr. And XLPE was also prepared as 0 phr sample for comparison. The dispersion state of ZnO was estimated by using a transmission electron microscope (TEM) as shown in Table 2.

Table 1. Details of nanocomposite dielectrics

Base Polymer	XLPE
Filler	Nano-ZnO
Filler concentrations(phr)	0, 1, 3 and 5
Dielectric thicknesses	100~150 μm
Surface treatment on filler	Silane treated
Test temperatures	Room temperature, 90°C

Table 2. Dispersion state of Zinc Oxide

	TEM	Particle size	Purity	Morphology
ZnO		90-210nm	99.9%+	Irregular

2.2. Experimental Procedures

In order to temperature dependence of XLPE nanocomposite sample, Impulse breakdown strength were measured at room temperature and maximum allowable temperature (90°C). Samples were sandwiched between stainless steel sphere electrodes with a diameter of 8mm. The sample and electrodes were soaked in silicon oil because of avoiding breakdown in air. The experiments were done more than 10 times under each condition. The

impulse breakdown test was performed at the wave front of the one shot impulse.

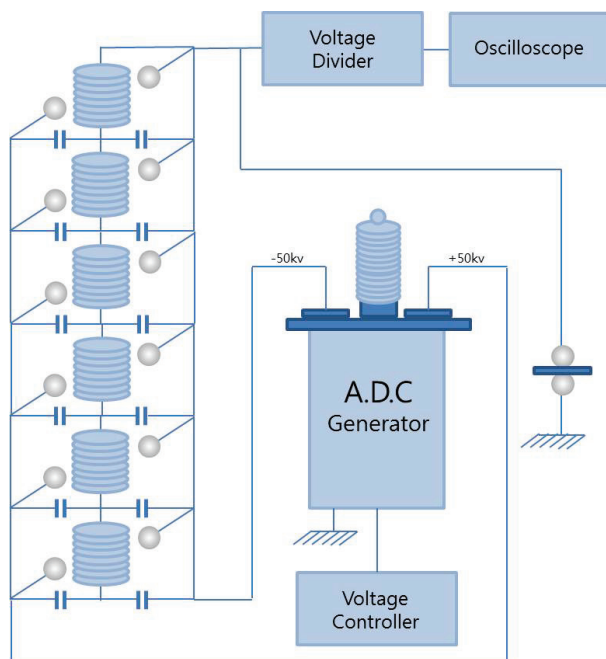
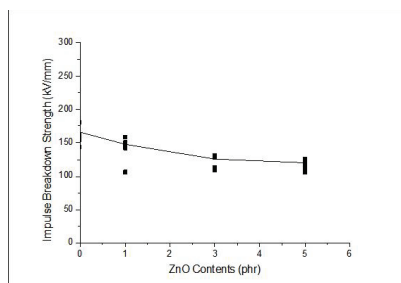
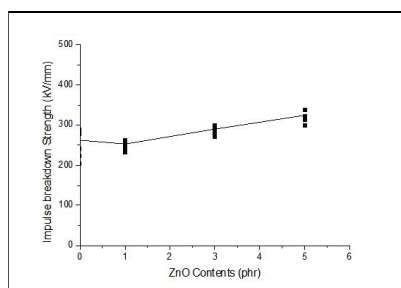


Figure 1. Experimental setup for Impulse breakdown test

3. Results and Discussion



(a) Room temperature(25°C)



(b) High temperature(90°C)

Figure 2. ZnO content dependence of impulse breakdown strength of ZnO/XLPE nanocomposite material

Figure 2 shows the influence of nano-ZnO on temperature

rise using sphere-sphere electrode. The breakdown strength was calculated by dividing the breakdown voltage by the film thickness. The scatter and weibull scale parameter plot are appeared as dots and line.

Figure 2(a) shows that the impulse breakdown strength is similar to ZnO content of 3 phr or more. By comparison, less than 3 phr is decreased.

The impulse breakdown strength at 90 degrees Celsius is shown in Figure 2(b). The breakdown strength of Adding ZnO is higher than XLPE by observation.

The addition of a few ZnO nano-filler brought the improvement of the impulse breakdown strength at high temperature(90°C). However, adding nano-ZnO couldn't be huge exchange of XLPE.

4. Conclusions

We investigated impulse breakdown strength in XLPE and its composite by adding nano-ZnO with different mass proportions. The impulse breakdown strength of nanocomposite was measured with sphere-sphere electrode at room temperature and maximum allowable temperature (90°C). In this study, specimens of addition of the nano-ZnO were similar to XLPE in impulse breakdown strength at room temperature, however, appeared excellent results at 90 degree Celsius. We considered that temperature dependent was relatively low. This means that the decrease in breakdown strength at high temperature is relatively small.

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