A Review of Leakage Current to Surface Tracking and Erosion of Sir Containing Nanofiller for High Voltage Outdoor Insulator

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Abstract
Nowadays inorganic material is replaced by polymer material such as Silicone Rubber (SiR) for outdoor insulation application. SiR has better performance than most organic polymers. By adding nano-filler in polymeric composite could improve the insulation capability. This review papers will discuss the effect of leakage current (LC) to surface tracking and erosion of SIR containing nanofillers blended for outdoor insulator. The main characteristics of LC to surface tracking and erosion to SIR containing Nanofillers is discussed and concluded here such as Surface tracking pridiction and thermal conductivity effect.

Key Words: leakage current; nanotechnology; nanocomposites; nano-fillers; high voltage outdoor insulator

1.0 INTRODUCTION

Electrical power system consists of three main components, such as power generation, transmission and distribution. In general, the transmission line consist three key components such as tower support structure, conductor and insulator. Among the three components, most significant part in electrical power system is the insulator. Practically, outdoor insulator such as string insulator, pin insulator and suspension insulator are installed at electrical tower or pole. The main function of this insulator is to hold the conductor from one pole to the other pole and to prevent electrical current flow directly to the ground through the tower or poles. The traditional insulator was made of ceramic and glass material, known as inorganic material.

Nowadays inorganic material is replaced by polymer material such as Silicone Rubber (SiR). SiR has better performance than most organic polymers for outdoor insulation application. Furthermore, SiR exhibits the ability to restore its hydrophobicity even after a pollution layer has built up on the surface, which can suppress the development of leakage currents, dry-band arcing and flashover. By adding nano-filler in polymeric composite could improve the insulation capability. For an example, the epoxy containing Al2O3 nanofiller has higher ac breakdown voltage compared with the unfilled epoxy. In another example, the study conducted by S. Singha et al revealed that the epoxy blended with silence coated SiO2 nanofiller has higher breakdown strength compare with the unfilled one. In this paper the effect of nanofiller to SiR outdoor insulator towards leakage current is reviewed.

2.0 MATERIAL

2.1 Silicone Rubber

Polydimethylsiloxane (PDMS) is the basic chemical polymer inside silicone rubber (SIR), the hydrocarbon methyl groups can be hydrophobic and water repellent. According to G. Momen and M. Farzaneh (2011), SIR is capable to restore its hydrophobicity even after a pollution layer has built up on the surface, which can suppress the development of leakage currents, dry-band arcing and flashover. The chemical structure of PDMS inside SiR is shown in figure 1 below.

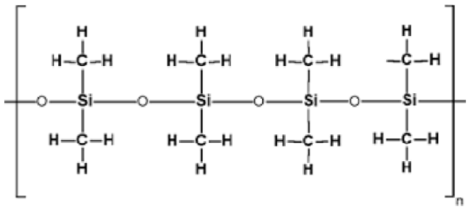

Figure 1: Chemical structure of PDMS

2.2 Fillers

Pure silicone rubber has little tracking and erosion resistance. To make the service life and to improve service effect, SiR can be added with some fillers properties so SiR can be improved. The fillers are added to the SiR to improve specific properties and also to reduce costs. For example some combination of SiR with fillers can make higher tracking performance, but this could hinder its hydrophobic properties. There are several type of fillers used to mix with SiR such as Alumina trihydrate and silica(Al2O3), Zinc oxide (ZnO), Titaniumoxide(TiO2), Calcium carbonate(CaCO3) and Bariumtitanate(BaTiO3). Each of the fillers has certain field modification if mixed with SiR. Table 1 below shows the properties modification.

Table 1: Role of common fillers in property modification

Filler	Property Modification
Al_2O_3	Thermal conductivity, anti-tracking & erosion
SiO_2	Thermal conductivity, anti-tracking & erosion
TiO_2	Relative permittivity, thermal stability, photocatalytic
ZnO	Electrical conductivity, relative permittivity, thermal conductivity, mechanical property
$CaCO_3$	Flame retarding, hydrophobicity
$BaTiO_3$	Relative permittivity, thermal stability

3.0 EXPERIMENT SETUP

In order to evaluate tracking and erosion resistance in LC, Inclined –Plane Test (IPT) method is used according to IEC 60587 standard. The procedure is usefull to evaluate new and different materials under electric stress for dielectric surface of an insulator. The IPT experiment setup is shown in figure 2 below. According to the setup, all data measured will be analyzed by a computer using LABVIEW application program.

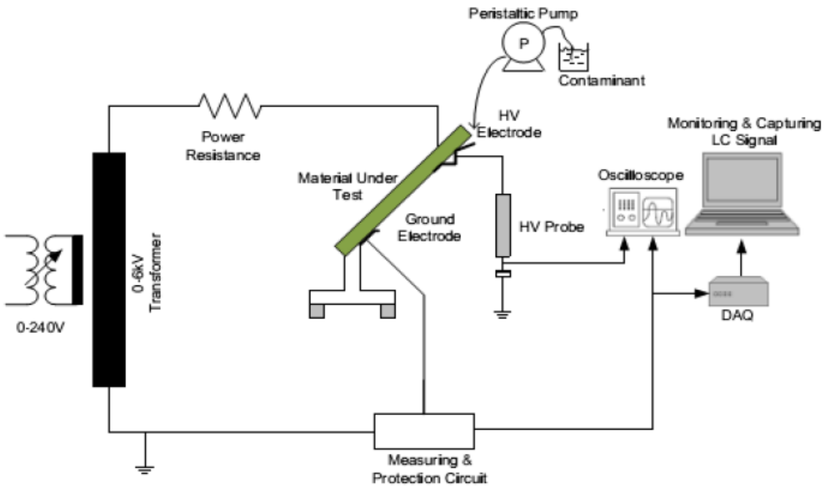

Figure 2: Experiment setup for IPT Test

4.0 DISCUSSION

There are many studies have reported on the benefits of using nanofiller in SiR. To understand the effect SiR is prepared with different sample and tested with IPT equipment test. From many study conducted, they came out with different result showing the effect of nanofiller added to SiR. A study conducted by A. H. El-Hag, L. C. Simon, S.H. Jayaram and E.A. Cherney show a few sample SiR with nanofiller. The sample used is shown in table 2 below:

Table 1: Chemical composition of the tested samples in IPT test

Filler Type and median size	Concentration of filler by weight (%)
12 nm fumed silica	5
12 nm fumed silica	10
5 µm ground silica	10
5 µm ground silica	30
5 µm ground silica	50

The erosion of filled SIR samples is very closely related to the third harmonic component of the leakage current (LC), which occurs during dry band arcing. The LC was continuously monitored during the IPT tests, and Figure 3 shows the recorded LC during the IPT for both nano- and micro- filled samples. However, regardless of the degree of surface damage, the fundamental component of LC saturated at about 6 mA. This could be attributed to the controlled flow of contaminant on the sample surface in the IPT, which results from a controlled surface resistance and hence, a controlled magnitude of the fundamental component of LC.

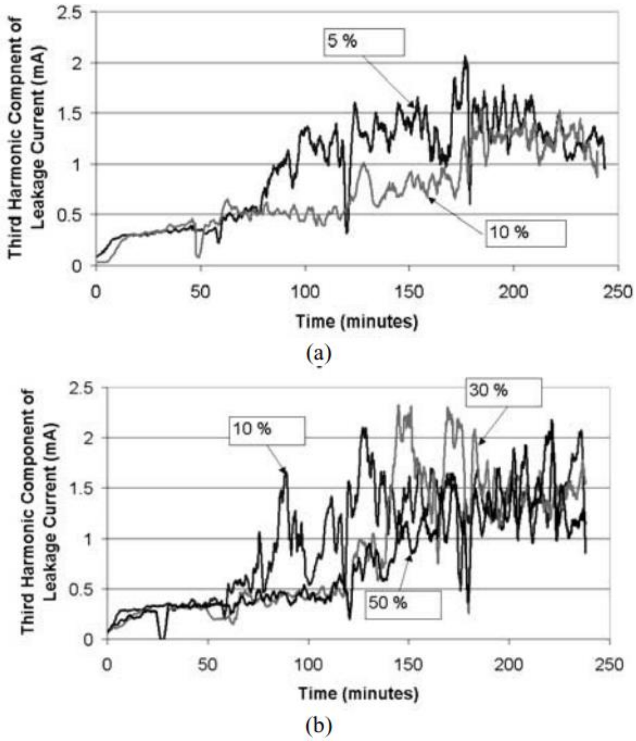

Figure 3: Third harmonic component of leakage current during the IPT test.

From another study, Joseph Vimal Vas et al. show the comparison between SiR containing nanofiller and without nanofiller and tested using IPT. Figure 4 shows the average of the r.m.s value of the leakage current measured at every hour of the IP test for positive and negative dc voltages at 2.5 kV. It can be seen that the leakage current gradually increases with time as the IP test progresses for both positive and negative dc voltages. For the negative dc, the instantaneous current immediately after the starting of the test has spikes which are due to the sudden flow of pollutant in the form of droplets. This occurred before the loss of hydrophobicity of the surface. Gradually the surface loses its hydrophobicity and a continuous current is observed as can be seen in all the other current waveforms. Continuous scintillation occurs on the surface of the sample once hydrophobicity is lost. For positive dc, the hydrophobicity was completely lost within 15 minutes of the test. The current waveform shows a continuous current and the breaks in current happens after dry band arcing. The average current continuously rises from there on. During the last hours of the test, the current is seen to be fairly constant. This can also be seen in the instantaneous values.

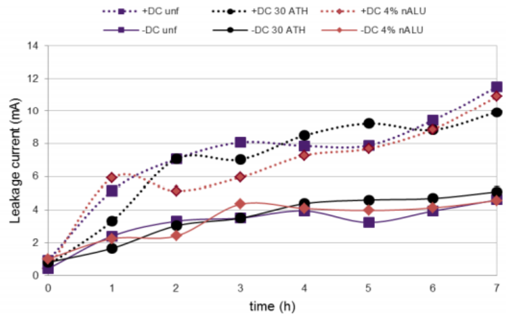

Figure 4: Leakage currents measured at every hour of the IP test for 7 h under positive and negative dc for unfilled, 30 % ATH filled and 4% nALU filled samples.

5.0 CONCLUSION

In this review, a detail search about SiR containing filler that has been done by many people were studied. After a brief description about SiR and filler commonly used as an outdoor insulator and method of testing by using IPT test, the result were discussed. as we know from research conducted adding filler to SiR will changed the property of SiR. The filler chosen is depend on how we want to change the property of SiR. By conducting the IPT test on LC, we found that SiR with filler can produced low LC then SiR without or less filler.

6.0 ACKNOWLEDGEMENT

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