Evaluation of surface degradation of PVC under electrical aging using Dielectric Spectroscopy, SEM and FTIR analysis

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ABSTRACT

Polyvinyl chloride is one of the most polymers used in electrical cable insulation. It has a greater resistance to abrasion and an excellent resistance to high temperature and good electrical and chemical properties.
Under the action of electric field, the surface of the polymer is degraded. This degradation caused by irreversible changes in the material can rapidly shorten lifetime. The chemical reactions occurring in the process are: cross-linking reactions between the chains, oxidation, hydrolyze...etc. The kinetics of degradation depends on the concentration of the different constituents of the polymer. Several modifications of polymer structures have been observed: change in color, reduction in volume, brittleness.

This paper presents an experimental study the effect of electrical aging on surface degradation of the polyvinyl chloride. In this study we have subjected the samples PVC to AC voltage. For each applied voltage, we have studied the variations of the dielectric loss factor, the relative permivitty and the volume resistivity as a function of aging time and frequency (1-10 kHz). Based on the obtained results, the electrical aging influences slightly the dielectric constant. However, we observed a significant degradation of the used material (PVC) under the aging conditions abovementioned. This degradation is characterized by the dissipation factor increase and the decrease of volume resistivity. The morphology of the samples was studied by electron microscopy (SEM), and the Fourier transform infrared (FTIR) is used to determine the chemical changes to the surface of PVC.

KEYWORDS

– *Characterization techniques*, *Electrical aging*, *Electrical properties*, *PVC*.

I. INTRODUCTION

The insulating polymers have important assets then the classic alones, as the glass, porcelain and the impregnated paper, they have the best mechanical properties, a weaker wettability, to be more easily lighter and set in work[1]. However, they present the inconvenience to be more vulnerable to the surface discharges that cause their deterioration [2]. A discharge that appears in the surface of the polymer constitutes a factor of ageing responsible for the destruction of the insulation[3], where, The physical and chemical processes are not very known again[4,5].
In the present work, we will put in evidence the effects of electric ageing on the deterioration of PVC's surface using different methods of characterization.

II. EXPERIMENTAL SETUP

Fig.1. shows the experimental setup used in our study. The electric discharges have been gotten by nourishing the two electrodes with an alternating voltage delivered by a transformer whose features are :
U = 100 kV, f = 50 Hz, P = 10 kVA.
The voltage variation was obtained with an auto-transformer placed in the control desk.

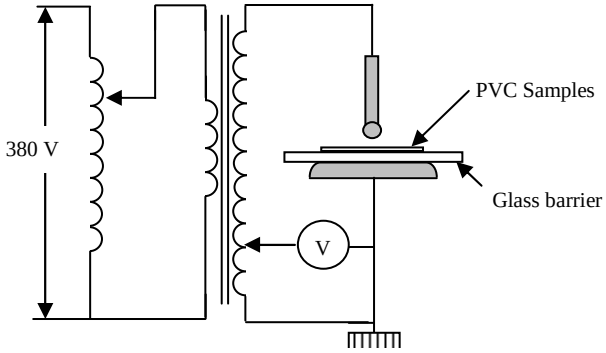

Fig.1. experimental setup

III. RESULTS AND DISCUSSION

In our analysis, we have used two kinds of polymer samples: plates of 3 mm thick and PVC's films of a few microns thick, for FTIR analysis.
We studied the effect of electric ageing on the permittivityεr, the loss factor tgδ and the resistivity of PVC according to the frequency in the range of 500 Hz to 10 Hz.
The permittivity is deduced from the measurement of the capacity using the following relation:

$$\varepsilon_r = \frac{e.C}{S.\varepsilon_0} \qquad (1)$$

Where
e : sample thickness(m) C : capacity between two electrodes(C) ε0 : the permittivity of vacuum, ε0= 8,85 10-12 F/m S : the sample surface (m2)

The resistivity is deduced from the measurement of the capacity using the following relation:

$$\rho = R.\frac{S}{e} \qquad (2)$$

Where :
e : sample thickness[m]
S : the sample surface [m2]
R : resistance between the two electrodes[Ω].