EFFECT OF CONDUCTIVE INORGANIC FILLER ON SPACE CHARGE CHARACTERISTICS IN XLPE AS A HVDC INSULATING MATERIAL

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ABSTRACT

We have investigated the space charge behavior in XLPE with the conductive inorganic filler, a nanocomposite used as a HVDC insulating material, in order to clarify the effect of the filler on the space charge behavior. The filler addition in XLPE has a remarkable effect in the stabilization of the space charge behabior and hence the electric field distribution. We have considered that the above effect of the filler in XLPE gives an excellent electrical property as a HVDC insulating material and makes it possible to realize a HVDC extruded cable up to 500 kV class.

KEYWORDS

space charge, pulsed electro-acoustic method, XLPE, nanocomposite, conductive inorganic filler

INTRODUCTION

Cross-linked polyethylene (XLPE) with the conductive inorganic filler, a nanocomposite used as a HVDC insulating material, has been reported to show the excellent dc electrical performance [1][2], so that we have developed not only a conventional type HVDC extruded cable up to 500 kV [2][3][4] but also a coaxial type extruded cable having the return conductor and insulation integrated coaxially up to 250 kV [5][6][7]. The above HVDC material, what we have called "SXL-A", has a homogeneous dispersion of the conductive inorganic filler having a typical size of 100 nm in XLPE. We have reported that the filler in XLPE suppresses the space charge formation in a cable insulation [2], but the effect of the filler on space charge characteristics has not been known in detail. On the other hand, the space charge characteristics in XLPE is also affected by the cross-linking byproducts remaining in XLPE such as an acetophenone (AP) and a cumyl alcohol (CA) [8][9].

In this work, we investigate the space charge characteristics in XLPE film with a various content of the conductive inorganic filler and cross-linking byproducts, using the PEA (pulsed electro-acoustic) method, and report the effect of the filler on the space charge characteristics in XLPE.

EXPERIMENTAL

We investigated the space charge profiles in XLPE film having a thickness of 150 to 340 μm with a various content of the conductive inorganic filler, i.e., 0, 0.05, 0.1, 0.2, 0.4 and 0.8 wt%. We also controlled the remaining cross-linking byproducts in the film samples as follows:

- The XLPE film samples with and without the filler were pressed and heated in the curing process, where the film samples were sandwiched between the aluminium sheets in order to confine the cross-linking byproducts in the samples because the byproducts are easily dispersed from the samples during and after the sample-making process.
- We obtained the time dependence of the remaining amount of the byproducts after removing both sides of the aluminium sheets on the film sample at room temperature prior to the space charge measurement. The remaining amount of the byproducts (AP and CA) in the film sample was exponentially decreased with the time after the removal of the aluminium sheets as shown in Figure 1, which allowed the remaining amount of the byproducts in the sample to be controlled by the exposure time to the ambient atmosphere from the removal of the aluminium sheets to the start of the space charge measurement. The samples treated for the exposure time of 0, 1, 2, 3, 4 and 24 h are referred to as "0h-after-sample", "1h-after-sample", "2h-after-sample", "3h-after-sample", "4h-after-sample" and "24h-after-sample", respectively. In particular, a 24h-after-sample had no significant amount of the cross-linking byproducts as shown in Figure 1.
- On the other hand, we also prepared a film sample degassed in a vacuum oven at 90 deg.C and 0.1 Pa for 12 h in order to reduce the amount of the cross-linking byproducts to 0 wt% or non-detected level. The sample after the degassing treatment is referred to as "degassed sample".

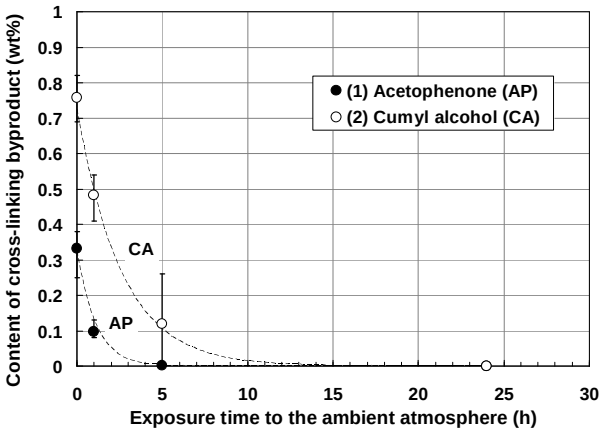

Figure 1: Time dependence of the remaining amount of cross-linking byproducts in the XLPE film sample after the exposure to the ambient atmosphere

The space charge profiles of the above samples were measured at room temperature in the applied dc electric field of 50, 100, 150 and 200 kV/mm, respectively, by using the PEA system reported in [10]. In the PEA system,