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Additives for the suppression of electrical treeing in polyethylene

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Abstract: The principal objectives of the work were to identify additives that improve the electrical tree resistance of polyethylene and to understand how they work. Using a needle test protocol, tree inception voltage (TIV) and thermally stimulated current (TSC) measurements were performed on LDPE containing a number of commercially available antioxidants and UV stabilisers. One additive, an excited state quencher, was found to raise the TIV significantly. The TSC results indicate that the trapping of electrons is at least one of the mechanisms responsible.

Keywords: Electrical treeing, additives, polyethylene, tree inception voltage (TIV), thermally stimulated current (TSC)

1. Introduction

The suppression of electrical treeing is important to the cable industry and to the end users. Tree resistant cables can transmit power at higher voltages, or the thickness of the insulation layer could be reduced. Both of these factors could lead to reduced costs. Alternatively, the development of insulation that is more resistant to electrical treeing could lead to a lower incidence of faults during service.

Numerous organic additives have been shown to raise tree inception voltage, and several mechanisms for their efficacy have been proposed.

A wide range of additives is available to stabilise polyethylene under conditions of heat, oxygen and UV light. These compounds are not usually added to polyethylene or XLPE specifically for their electrical tree inhibiting properties (although they clearly must not be detrimental). It would be useful, however, if it could be shown that some of these additives do suppress treeing.

This paper describes the effect of adding five commercially available stabilisers on the tree inception voltage. Thermally stimulated current measurements were then made to gain some understanding of the mechanisms involved.

2. Experimental

2.1 Materials

Two grades of low density polyethylene (LDPE) were used for the experimental work. The first (non-cable grade) polyethylene was used in preliminary work to establish the effect of using different needles and various needle insertion temperatures on tree inception voltages. The second LDPE grade used for the project was a cable grade polymer with a nominal density of 930 kg/m^3 and a melt flow index of 0.8-1.2 g/10min. This PE was supplied additive free by AEI Compounds, and was compounded with various additives to examine their effect on treeing inception voltage.

The polyethylene and additives were mixed prior to being processed by a Brabender twin-screw extruder. After extrusion, the polyethylene was cooled in a water bath prior to being fed through a granulator. The granules were then compression moulded to form plaques of 4 mm thickness.

The chemical formulae of additives selected for study, are shown in Table 1. All of these compounds have been widely used for stabilising LDPE. Additive A is an antioxidant widely used in polyethylene and cross-linked polyethylene (XLPE) cable insulation. The other additives are UV