A.8.1. L'oxydation et ses effets sur les charges piégées dans le polyéthylène basse densité

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Résumé

La recherche présentée dans cet article traite de l'influence de l'oxydation sur le transport et le piégeage des charges dans l'isolant. Des échantillons de polyéthylène basse densité (PEBD), avec et sans antioxydant, ont été étudiés.

Des plaques des deux types de PEBD ont subi des traitements thermiques pour faire apparaître des degrés d'oxydation différents. Le degré d'oxydation a été mesuré par spectroscopie infrarouge afin de caractériser la présence de radicaux hydroxyle et carbonyle. Les plaques de polyéthylène oxydées ont ensuite été vieillies électriquement sous un champ de 60 kV mm^{-1} pendant 6 heures.

La distribution de la charge d'espace a été mesurée pendant le vieillissement électrique par la méthode de l'onde de pression impulsée par laser.

A.8.1. Oxidation and its effect on charge trapping in low density polyethylene

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Abstract

The research presented in this paper investigates how charge transport and trapping in solid polymeric insulation is affected by the oxidation of the polymer. Low density polyethylene (LDPE) samples, both with and without an antioxidant, were studied. Plaques of both LDPE types underwent various heat treatments to promote differing degrees of oxidation. The extent of the oxidation was assessed using Infra-red spectroscopy to determine the presence of hydroxyl and carbonyl groups. Plaques of the oxidised polymers were then electrically aged at a stress of 60kV.mm^{-1} for a period of 6 hours. Measurements of the bulk charge distributions were made throughout this period using a laser induced pressure pulse technique (LIPP).

Introduction

Attention is increasingly being focused on the use of solid extruded polymeric materials for underground high voltage power transmission. The advantages of such polymeric systems are their lower manufacturing costs, their ease of installation and handling, their high dielectric strength and high electrical resistivity, combined with their good physical properties such as a resistance to cracking and good moisture resistance. However, the retention of these good electrical and physical properties during service is of paramount importance, especially when the cost of excavating and repairing the cable is taken into consideration.

It is well known that LDPE insulation is susceptible to degradation and eventual failure under the conditions imposed by electric stress in the service environment. The long term electrical strength of polymeric insulated cable is predominately controlled by the degradation of the polymer insulation. This degradation can take many forms including the thermal degradation and oxidation of the polymer. The chemical stability of polymer dielectrics are dependant on temperature and since local electric currents raise the temperature through joule heating thermal ageing may be driven electrically. The working temperature of LDPE cable is nominally 70°C, however, this temperature is occasionally exceeded due to overload and unpredictable faults. In order to slow down or inhibit these degradation process antioxidant additives are added to the base polymer, hence increasing the life expectancy of the cable system. Polymeric cable life is often reported to be as long as the polymer insulation remains in an un-oxidised state.

In this paper the effect of oxidation and thermal degradation on the trapped charge distribution in LDPE plaques is considered. It is well known that by-products of the oxidation and degradation processes may act as charger traps[1] and can also promote the conduction of charge across the sample[2]. Furthermore charge trapping leading to space charge formations is known to reduce the long term electric strength of the polymer[3].

Experimentation

Sample Production

The polyethylene used in this study was Superclean HDFS-4201 supplied in granular form by Neste of Sweden. Two batches were prepared, one containing no additives and the other containing 1% antioxidant. Plaques of polyethylene 350μm thick were formed by a hot melt press process and were quench cooled whilst still inside the mould. Gold electrodes were sputter coated onto both the back and the front of the plaque in order to make the electrical contacts.

Material Characterisation

Samples from the plaques produced from both batches of the polyethylene have been extensively characterized, the results of which can be found elsewhere[4]. However, the only significant difference between the morphologies of the two polyethylene types was found to be at the spherulitic level. The polyethylene without the antioxidant was found to be consistent of large banded spherulites up to about 10μm in diameter. While the polyethylene with the antioxidant was made up of a very uniform microstructure consisting of a fine granular morphology corresponding to micro-spherulites of about 1μm in diameter. So in conclusion it can be assumed that the antioxidant additive has acted as a nucleating agent for the formation of the spherulites.

Oxidation

Once produced the samples were oxidised through an additional thermal treatment. This was achieved by placing the moulded samples, prior to the application of the electrodes, into an oven and heating them under various conditions for a period of 24 hours. The heating regimes were as follows;