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The influence of temperature on electrical conduction and space charge in LDPE

LAU W.S., CHEN G., University of Southampton, UK

Abstract: Electrical conduction processes in polymeric materials are very much temperature dependent. Using the improved Pulsed Electro-acoustic (PEA) system that is capable of measuring the external current and charge density concurrently under a controlled temperature environment, we have carried out tests on additive-free low density Polyethylene (LDPE) at a constant voltage and various different temperatures. The results clearly showed that the temperature affects charges behaviour in the sample.

Keywords: Temperature, space charge, transient current, LDPE

Résumé : Les phénomènes de conduction électriques dans les matériaux polymères sont extrêmement dépendants de la température. L'utilisation d'un système "électro-acoustique à impulsion" (PER) améliorée, qui est capable de mesurer simultanément le courant externe et la densité de charges dans un environnement à température contrôlée nous a permis de mener des expériences sur des polyéthylènes basse densité (LDPE) sans additif, à une tension constante et à des températures variées. Les résultats ont clairement montré que la température affecte le comportement des charges au sein de l'échantillon.

Mots clés : Température, charge d'espace, courant transitoire, isolant LDPE

1. Introduction

A slight change in operating temperature (few degrees Celsius) at a constant electric field would result a significant change in external measured current. This change reflects the amount of mobile charge carriers passing through the sample. Usually, proliferating of measured current and diminishing of electrical breakdown strength occurs with the escalating of temperature. The Pulsed electro-acoustic (PEA) technique measures the total net charge in the sample. Under the condition of application of the external voltage, the total net charge includes trapped and mobile charges. It has been reported [1] that if there is a major charge carrier movement caused by electrode charge injection at very high field (>100 kV/mm) it can be picked up by the PEA system and also reflected in the external measured current. High temperature is believed to encourage not only more mobile charges movement but also increase the probability of getting trapped charges detrapped, thereafter it might either recombine or get extracted by the counter electrode which therefore contributes to the external measured current.

When dielectric materials are subjected to a high electric field, charges can be injected from the electrodes into the bulk. The dynamics of injected charge in a material are affected by many factors such as defects, impurities and morphology. Additive-free LDPE was selected for testing to eliminate the influence of the impurities, which are present in crosslinked Polyethylene (XLPE). Generally speaking, there are two possible types of space charges, namely homocharge and heterocharge. Homocharge is formed when injected trapped and/or mobile charge carriers remain near to the vicinity of the injecting electrode. Heterocharge is formed either (a) by the dissociation of impurities exist in XLPE where the dissociated charge carriers moved and accumulated near to the vicinity of the opposite sign electrode or (b) when the injected homocharge travels through the bulk, reaches the opposite electrode and remains there, like for the case in additive-free LDPE. The electrode/LDPE interface plays an influential role in governing the injection process [2]. Space charge and current trend [3] rely on the injection process at the interface along side with variation of the applied electric field and also temperature. Variation of ascending temperature can also alters processes such as transient current in the dielectric.

Presently, there have been very few papers on reporting the likely causes for the current increase in