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The Raman spectroscopy analysis of electrically aged polyethylene

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Abstract : The electrical properties of polymeric insulation deteriorate in service, when subjected to electrical stresses over a period of years. Possible chemical changes in low-density polyethylene (LDPE) subjected to electric stresses at power frequency have therefore been investigated, using Raman microprobe spectroscopy. Although no significant specific chemical changes were detected when samples were subjected to high stresses for short periods of time, a clear increase in background fluorescence was seen in samples aged for longer periods of time. Raman spectra have also been obtained from around failure sites and compared with those obtained from unaged samples and specimens containing electrical trees.

Keywords: PE, Raman spectroscopy, Electrical Ageing, Dielectric breakdown

Résumé : Les propriétés électriques d'un polymère isolant se déteriorent à l'utilisation, lorsqu'il est soumis à des contraintes électriques dont la période s'étend sur quelques années. D'éventuelles altérations chimiques du polyéthylène basse densité (LDPE), soumis à des contraintes électriques à hautes fréquences, ont par conséquent été étudiées, à l'aide d'une sonde spectroscopique de type Raman. Bien qu'aucune altération chimique notable n'ait été détectée lorsque les échantillons furent soumis à de telles contraintes sur de courtes périodes, un accroissement visible du phénomène de fluorescence a été observé sur des échantillons traités sur des périodes plus importantes. D'autres spectres Raman ont également été acquis au voisinage de zones ayant subi un claquage, avant d'être comparés à ceux obtenus à partir d'échantillons non vieillis, ainsi qu'à ceux de spécimens comprenant des arborescences électriques.

Mots clés : PE, spectroscopie Raman, vieillissement électrique, claquage diélectrique

1. Introduction

Polymeric insulating materials have excellent electrical properties, including low conductivity and high breakdown strength, and are consequently progressively replacing traditional insulation in many power engineering applications. In service, electrical insulation may be subjected to several types of stresses, including electrical, thermal, environmental and mechanical. It is known that electrical ageing may cause chemical or structural changes within insulating materials, such that the insulating ability of the material deteriorates with time, eventually leading to electrical failure. Over the years, many efforts have been been made to understand the ageing mechanisms and different models have been reported [1-6]. Several diagnostic techniques for monitoring ageing have also been proposed, one of which is spectroscopic analysis. Indeed, infrared (IR) analysis is a commonly used diagnostic tool; Raman spectroscopy has also been employed recently to examine changes in polyethylene induced by electric fields [7]. However, despite these efforts, electrical ageing of polymeric materials is still poorly understood, despite the potential benefits a thorough understanding of electrical ageing mechanisms may bring, through the development of improved insulating systems.

Raman spectroscopy is an analytical technique that yields information about the molecular structure of materials, based upon the observation of scattered light. As such, it is non-contacting and non-destructive and, in theory, has the potential to provide spatially resolved three-dimensional information. Consequently, since laser sources became available in the early 1970s, it has been used extensively in investigations of polymer structure and composition. The use of a laser as a light source also confers a further advantage on the approach, in that the incident beam, which can be