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The Raman Spectroscopy Analysis of Electrically Aged Polyethylene

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Polymeric insulating materials have excellent electrical properties such as low conductivity and high breakdown strength and are progressively replacing traditional insulation used in power engineering. However, these properties deteriorate over the time when the materials are subjected to high electric stresses. Different techniques have been used to monitor the deterioration taken place in the materials. Recently, the Raman spectroscopy has been employed to analysis the structure changes in polyethylene. It has been found that unsaturated C=C bonds have been generated in the region adjacent to high electric field in a point-plane electrode system. Raman fluorescence is indicative of defect states in the polymer. Modification on the fluorescence just prior to failure has also been reported. Investigation on an electrical tree revealed the presence of pronounced fluorescence in the tree region, suggesting a degree of material deterioration. However, the nature of these changes is still poorly understood. Therefore further research is required to understand the mechanisms of electrical ageing and breakdown so proper measures can be taken to improve the performance of polymeric insulation.

In the present report, the chemical structure change of low-density polyethylene (LDPE) subjected to electric stress at power frequency has been investigated by means of Raman microprobe method. LDPE films of 100 (m thick were used and they were electrically stressed under different stress levels from 40 kV/mm to 100 kV/mm. The Raman spectra of the aged samples were obtained at different aged times, from 0.5 hrs to 45 hrs. The changes of Raman spectrum in electrically aged samples were observed, especially in those samples subjected to stress for a longer time. Electrical failures have taken place during ageing and the examination of Raman spectra around the failure site has been carried out. The results were compared with those obtained from the sample containing an electrical treeing. The results showed that when the sample was subjected to higher electrical stress, about 50 kV/mm, the visible change of Raman spectra could be observed only after the 40 hrs electrically aged term. In the sample where electrical failure occurred during long-term ageing, the obvious differences in Raman spectra have been found around the breakdown channel/hole and the region close to the channel centre less than 2 mm in radius. By comparing with those obtained from treeing sample similar features have been observed. The changes of Raman spectra in the electrically aged samples were related to the fluorescence effects of polyethylene. Then the changes of Raman spectra in the aged and final breakdown samples were probably related to, except of the fluorescence, the crystal or morphologic changes of polyethylene.