Fracture behavior and thermo-oxidative ageing of EPDM

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Insulating materials of LOCA qualified electric cables in nuclear power plants are constituted by rubbers having good ageing resistance properties, like ethylene and propylene copolymers (EPR, EPDM …), to ensure the conductive material. In service these cables are submitted to low irradiation and temperatures that could reach 50°C in the reactor building. The prediction of the life time and the control of cables properties by innovative and non destructive methods are the aims of numerous experimental and numerical studies at EDF R&D.

An accelerated thermal ageing has been applied to model materials, constituted by an EPDM matrix filled with different proportions of aluminum trihydrate fillers (ATH), some of them having a surface treatment to improve the adhesion between the EPDM matrix and the fillers.

It has been observed that the main consequence of the thermal ageing is a chain scission phenomenon identified by: a decrease of the elastic modulus, obtained by tensile tests, an increase of the degree of swelling and of the sol fractions (in xylene), and an increase of the chains network mobility, characterized by 1H NMR.

The consequences of this thermal degradation on the viscoelastic behavior have been studied by DMA and cyclic tensile tests. Finally, infrared spectroscopy has confirmed the oxidation due to thermal ageing, showing the formation of carbonyls and hydroxyls species, which are the both main oxidative products of the carbonated chains of polyolefin.

The study of materials with different filler proportions pointed out that higher amount of fillers lead to a decrease of the ageing consequences on the properties of the networks. The results obtained with the materials containing surface treated fillers show that the ATH/matrix interface may be deteriorated.

Finally, crack propagation measurements under cyclic loadings have been done on pre-crack pure-shear samples and have showed that the thermal ageing leads to an increase of the crack growth rate at constant energy release rate.

The cracking tests may offer the possibility to link the elongation at break of the elastomer with its crosslink density, by comparing the energy needed to reach the failure in uniaxial tensile tests (nowadays used to predict the life time of cables) and the energy release rate needed to propagate a crack in cyclic tensile tests. The oxidation state, and therefore the crosslinking of the network will be related to the needed energy.