Lifetime prediction of an external protection of cold-shrinkable joint in EPDM rubber subjected to thermal ageing

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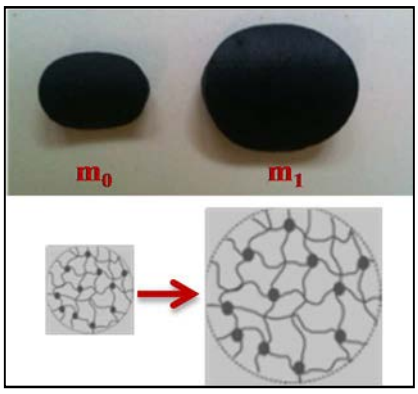
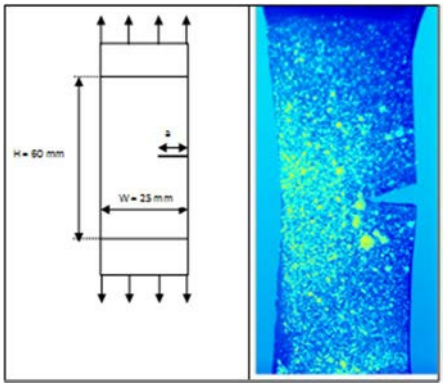
The aim of the present work is to study the consequences of thermal oxidation on the chemical structure and mechanical behavior of an industrial Ethylene-Propylene-Diene Monomer (EPDM) used as an external protection of a cold **shrinkable joint.** Based on these results, a chemo-mechanical tool has been developed for predicting the stretch ratio at failure. This tool is composed of two complementary levels: First of all, the "chemical" level that calculates the alteration kinetics at both the molecular and macromolecular scales. The average molar mass of the elastically active chains (i.e. between crosslinks) M_c is used as the main indicator of the macromolecular network degradation. In the other hand, the "mechanical" level deduces the ultimate mechanical properties.

Experimentally, the changes in M_c have been determined by swelling tests in cyclohexane solvent and the changes in ultimate mechanical properties have been determined by combining the fracture mechanics theory with the intrinsic defect concept (Fig.1).



EPDM swelling in the cyclohexane solvent.



Specimen for fracture mechanics tests.

Fig. 1: (a) Swelling tests and (b) fracture mechanics measurements

In our approach, the time-temperature equivalence principle is introduced, a shift factor obeying to an Arrhenius law is derived, and master curves are built as well for the average molar mass as for the ultimate mechanical properties.

We have pointed out the square root dependence of the fracture energy (in term of critical integral J) with M_c. Moreover, it is shown that the mechanical law behavior could be approximated by the phantom network theory, which allows to relate the strain energy density function to M_c. Assuming that the fracture of a smooth specimen (not notched) is the consequence of a virtual intrinsic defect which size can be easily estimated, the stretch ratio at break can be therefore computed for any thermal ageing condition.

Finally, the developed tool predicts satisfyingly ultimate properties of thermally aged EPDM based rubbers in air between 130 and 170°C, making this approach a useful tool for predicting life time when designing different rubber components for moderate to high temperature environments.