Effect of thermally induced material structure modifications on fracture onset and propagation: a study on a silica filled NBR

Bianucci A., Denora I., Marano C.

Fracture toughness of elastomers is usually assessed using a fracture mechanics approach and evaluating energy-based parameters, such as J-integral or tearing energy, at the crack onset. During fracture tests, two crack propagation phases can be identified: (i) stable propagation, which ceases if the crosshead is stopped, providing no further energy to the specimen; (ii) catastrophic propagation, in which the crack continues propagating even without any further increase in the overall deformation. Thus, the evaluation of fracture toughness at catastrophic rupture onset has also been proposed.

In this work, fracture tests in pure shear configuration were performed on silica-filled NBRs cured at T=170°C for different times, ranging from 5 to 33 minutes. Tests were video recorded to identify the crack onset and measure the crack advancement. The J-integral was evaluated until catastrophic rupture and it was plotted against the crack advancement, obtaining the resistance curve. Although the applied thermal history had no significant effect on crosslink density (evaluated by swelling measurements), uniaxial tensile response and fracture toughness at crack initiation, it did affect the resistance curve: longer curing times led to lower resistance at any crack advancement.

A whitening of the material under stretching was observed, in the whole specimen during uniaxial tensile tests and close to crack tip in pure shear fracture tests. As suggested in literature, since no strain-induced crystallization can occur, whitening was correlated to formation of cavities in the material. A preliminary characterization of the strain-induced cavity formation was performed by (i) defining a strain-induced whitening index, and (ii) evaluating the whitening index dependency on the applied strain in uniaxial tension. It resulted that a longer curing time induced a more pronounced whitening for the same applied deformation, suggesting that more cavities are formed. A correlation with the material's fracture response was also attempted.