Evaluation of "Payne Effect" in Radiation-Induced Modification of Chlorobutyl Rubber

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ABSTRACT

Butyl rubber (isobutylene and isoprene copolymer) has good properties including low permeability to gases and good stability. Partially halogenated (Br and Cl) butyl rubber has been used in a great variety of applications, such as tires parts (inner tube, internal coating of tires, etc) and various products (lids, gaskets, etc.). In these compounds carbon-halogen bonds are weaker than carbon-carbon and carbon-hydrogen bonds, and the main effect of radiation is to break the carbon-halogen bond to give an organic free radical. Irradiations of certain alkyl chlorides can bring about isomerism in which the location of the halogen atom is changed, the carbon skeleton of molecule remaining unaltered. Irradiation of n-butyl chlorides gives high yields of tertiary carbon. Due to the above behavior of low-molecular–weight alkyl halides, butyl rubber, when exposed to high energy radiation exhibits significant degree of degradation under ionizing radiation. The major effect of high energy photon, such as gamma rays, in organic polymers is the generation of free radicals, along changes in electrical, optical and mechanical properties. This work aims to the study of a controlled degradation of a chlorobutyl rubber compound after irradiation at: 25, 100 e 200 kGy doses. Effects of irradiation on a rubber compound were investigated via DMA (Dynamic Mechanical Analysis) tests using the so-called Payne effect, which is directly related to the dynamic properties of the vulcanized rubber. The test begins in a low strain excitation upwards to a maximum programmed strain, and then downwards to a minimum strain at room temperature. The dependency of the material related to the strain amplitude is illustrating by Payne effect. Material behavior presents a non linear evolution on both modulus and Tan delta when increasing the strain (Payne effect) (Fig. 1). It can be observed a difference on G' and tangent delta values at low strain between the way up and the way down of the sweeping. The difference between new material and irradiated material at 25 kGy doses is not very significant. Nevertheless, it is verified the chain scission for higher irradiation doses (≥ 25 kGy). Another interest in strain sweep is to make possible the detection of strong breaking in materials linkage at high strain amplitude.

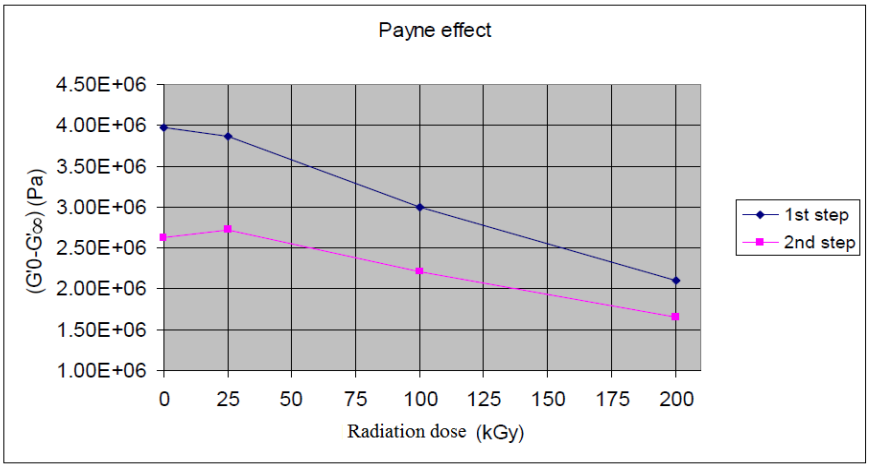

Figure 1: Payne effect – Storage shear modulus variation (G′₀-G′∞) vs radiation dose.

Keywords: Chlorobutyl rubber; Degradation; gamma radiation; DMA; Payne effect