Study of processing via gamma rays and further shear for bromobutyl rubber recycling

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Abstract
Polymeric materials (plastics and rubber) have been contributing in a continuously and raising way for the generation of litter and industrial wastes discarded in landfills. The implementation of new technologies for the reduction of polymeric materials, acceptable from the environmental viewpoint and at an effective cost, proved to be a great problem, due to complexities inherent for the re-use, especially of rubbers. Gamma ionizing radiation has capacity for changing structure and properties of polymeric materials and can be applied to almost all types of polymers; irradiation is an expectation for problem-solving of rubber wastes that can be utilized as raw-materials or chemical additives. Bromobutyl rubber has excellent mechanical properties and oxidation resistance, as well as low gas and water vapor permeability. At the initial stage of irradiation the degradation of bromobutyl rubber occurs predominantly via random chain-scission and chain-crosslinking may occur caused by isoprene copolymerized units. This work aims to the introduction of a new recovery technique for bromobutyl rubber, by using processing via gamma-rays followed by shear. Rubber samples were irradiated at 5 kGy, 15 kGy, 25 kGy, 50 kGy, 100 KGy, 150 kGy and 200 KGy doses, in order to study the feasibility of bromobutyl rubber for recycling. 25 kGy doses applied to butyl rubber and further shear pointed toward a less degraded material, indicating that this type of elastomer is able to be incorporated into a new rubber compound, replacing this way some parts of pristine rubber in formulations, without imparting great losses in physical-chemical properties.

Polymeric materials (plastics and rubber) attain a comprehensive and rising continuous proportion of litter and industrial wastes discarded in landfills. The implementation of new technologies for reduction of polymeric residues, acceptable under environmental viewpoint and at an effective cost, proved to be a great problem, due to inherent complexities for polymers re-use1.

Rubbers have a very low natural decomposition, due to their chemical structure weathering conditions and to enzymatic and microorganisms degradation resistant. Rubber recovering is made difficult by its insolubility due to its crosslinked structures. In addition, this tridimensional structure causes various problems related to recovering and reprocessing of these materials.

So, as previously mentioned the most of rubber wastes, especially tires, are discarded and disposed in landfills. In other situations, they are used as combustible and incinerated to produce power; in addition, costs for these operations are very high. Other ways of re-use of rubbers include: asphalts, shoe

soles manufacturing, rubber gaskets, rainwater pipelines, floor paints on sport courts, industrial floors, besides carpets for autos. Consequently, recycling and recovering are the best options for management of these residues. Gamma ionizing radiation is capable to change structure and properties of polymeric materials and can be applied in almost every type of polymers; irradiation is an expectation for management problem-solving of rubber residues that can be used as raw-materials or chemical additives.

Rubbers products recovering can be accomplished by means of several processes.

In Chemical processes, they are carried especially in high pressure reactors with specific solvents at high temperatures in order to increase reactions output. These processes presents the advantage of make viable the selective rupture of polysulfidic crosslinkings, without significant rupture of main chain.
In Biological processes, they are selective processes, in which chemical bonding of vulcanized rubbers are broken and sulfur is removed by bacterias bio-treatment. Some of them have been using in NR, SBR and BR de-vulcanization, as Nacardia, Thiobacillus e Mycolata, without causing significant degradation of polymeric hydrocarbon. In Literature, these methods are cited as of de-vulcanizing low output, because they attack just samples surface and are not viable to be applied at industrial-scale.

In physical processes, most of them generate rubber in powder, prone to be used as inert filler. Consequently, it is desirable a physical system that makes possible obtaining recycled rubbers that act as active filler.
This study intended for rubbers recovering and/or recycling employed processing with gamma-rays and further shear in an open roll-mill. As a major purpose it was studied the obtaining de-vulcanized rubbers that allow a new crosslinking (or vulcanization).

Bromobutyl rubber compound shows an equivalence trend between scission and crosslinking. These results are proved by strong hydrogen bonding in their molecules.

Mechanical essays of tensile and elongation at rupture showed chain-scission for doses up to 25 kGy; for doses higher than 50 kGy, an intense degradation.

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Swelling tests showed that bromobutyl rubber shows trend to chain-scission. Mechanical shear for irradiated bromobutyl rubber helped in reduction of values for maximum torque and minimum torque.

Processing with gamma rays followed by shear in bromobutyl rubber showed a great technical feasibility for application in industrial processes of recovering for this type of rubber, especially irradiated rubber at 25 kGy and sheared, that showed intense chainscission without a high degradation.

Considering difficulties in recycling of vulcanized rubbers, especially related to their processing, it should be emphasized the relevance and efficiency in the incorporation of residues from these materials in their original process without none additive addition.

Key words: Recycling, gamma rays, butyl rubber, irradiation.