Sustainable implementation of industrial rubber waste recycling: chemical and thermo-mechanical joining for a selective devulcanization

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Abstract: Rubber elastomers are extensively used in our daily lives. Vast amounts of them are continually manufactured, causing a big problem in the world regarding the discarded end-of-life. Jumping from a linear economy, in which the 'take-make-dispose' model is followed, to a circular one, where products are designated to be recycled, recycling has become a critical issue in terms of limiting the use of finite resources and the need to manage waste disposal.[1] Usually, the recycling process for rubber waste is complex, and an appropriate process could introduce new solutions.

In the last years, the problem of recycled rubber was attempted to be solved by several methods leading to products ready to be used in specific conditions, most economically and ecologically.[2] Often, the necessary devulcanization process for recycling rubber waste leads to a total or partial cleavage of mono-, di-, and polysulfide crosslinks.[3] During this process, the crosslink density is reduced, and carbon-carbon bonds undergo division and chain breaking, forming free radicals and the subsequent reduction in molecular weight and mechanical properties. In order to be able to add the recycled rubber to the virgin polymer in specific amounts and be subjected to the vulcanisation process for obtaining new rubber profiles, selective cleavage of the C-S and S-S bonds must be achieved (Fig. 1).[4]

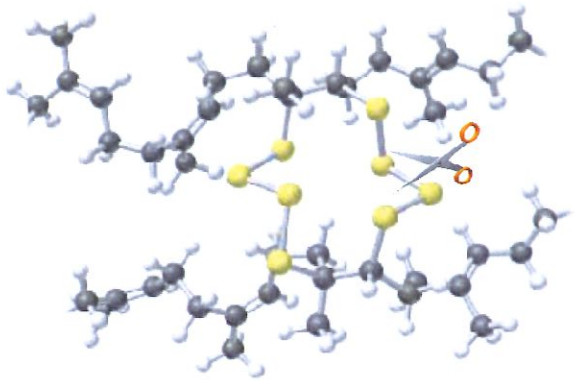

Figure 1 – Selective scission devulcanisation process.

This work, we developed a selective chemical and thermo-mechanical devulcanisation process in order to obtain high added-value products. The process conditions were optimised, and the devulcanisation's goodness was determined by chemical, thermal and mechanical characterisation. The percentage of devulcanisation and the crosslink density (CLD) before and after the process were also determined.[5] The results show that adding a chemical agent in the thermo-mechanical process leads to better devulcanisation, and the recycled product could be vulcanised again. The final product show mechanical and chemical properties comparable to virgin rubber, confirming the development of a closed-loop recycling process.

Keywords: Sustainability: Recycling; Devulcanisation: Selective scission; chemical-thermo-mechanical treatment

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