Recycling of passenger car tires rubber compounds via (reactive) devulcanization

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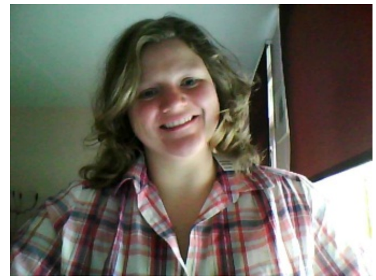

Description of research

How to deal with old and spent passenger car tires? What can be changed about the current waste processing? With an annual worldwide production of approximately 800 million waste tires per year, this poses a serious issue.

Currently, the waste tires processing is considered to be “cradle-to-grave”, i.e. from a high-tech product to a low-tech product. Unlike thermoplastics, rubbers cannot be melted and reused. This is related to their three-dimensional structure, a result of the vulcanization (i.e. crosslinking) process. The rubber chains are connected via sulfur bridges, also known as crosslinks. An added difficulty here is the fact that tires are not composed of a single type of rubber, but are actually mixture of different base polymers. The main components are natural rubber (NR) and styrene butadiene rubber (SBR), shown in Figure 1 and Figure 2 respectively.

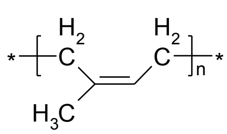

Figure 1 - Chemical structure natural rubber

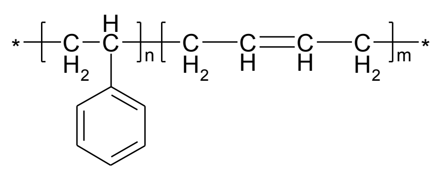

Figure 2 - Chemical structure styrene butadiene rubber (monomers randomly distributed)

During vulcanization sulfur bridges are formed on some of the double bonds in the backbone, creating a three-dimensional network. In order to be able to effectively recycle rubber products (i.e. according to a “cradle to cradle” approach), it is necessary to selectively break the crosslinks in the rubber network. In combination with heat and mechanical stresses, a compound known as the devulcanization agent is used to devulcanize the rubber. Figure 3 shows the schematic representation of the cleaving of the sulfur bridges without (or only slightly) affecting the rubber carbon backbone. As a result, the treated rubber can be revulcanized.

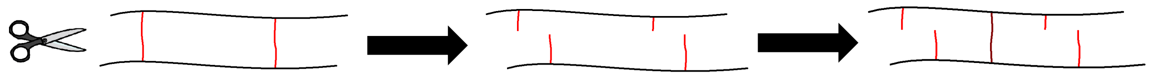

Figure 3 - Schematic representation of the devulcanization and revulcanization of rubber

The initiative of this research is to develop a process capable of producing a devulcanized rubber suitable for revulcanization.
The investigation was initially focused on SBR, since this rubber is the most difficult to devulcanize. The corresponding model compound is vulcanized SBR containing Carbon black as filler. The presence of the filler entails many difficulties in the (chemical and spectroscopic) characterization of the devulcanized rubber while ensuring a closer resemblance (e.g. of the material behavior during processing) with the real-life rubber products. The final step of the project consists in the use of a real life waste tire compound. This part of the investigation is ongoing.

This research project is part of a combined investigation of the University of Groningen and the University of Twente generously sponsored by the RecyBem b.v. The University of Twente has investigated the devulcanization of sulfur-vulcanized, unfilled rubber on which we have based our initial experimentations.