The chemistry of rubber modification and crosslinking: New approaches towards an old problem

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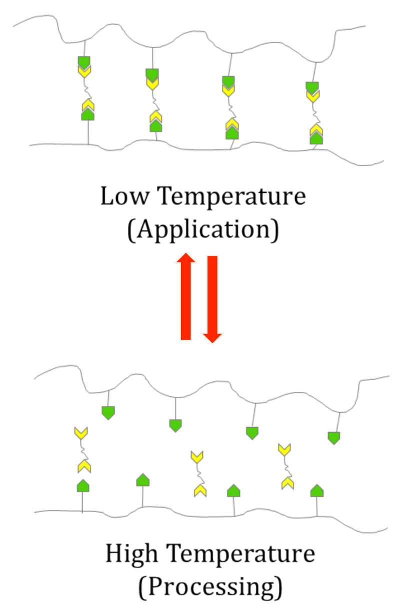
Description of research

The excellent properties of thermosets and cross-linked elastomers are unfortunately associated with the practical impossibility to reprocess these materials. The irreversible nature of the intermacromolecular bonds prohibits “cradle-to-cradle” re-usal of rubbers and factually limits their re-usal to thermal energy recovery after their product life. After decades of research on de-cross-linking conventional thermosets, this project tackles the societal need for recyclable elastomers from another perspective as know thermoreversible chemistry is used to cross-link rubbers in a novel way.

In this project, industrial maleinized ethylene-propylene rubbers are thermo-reversibly cross-linked in a simple two-step approach. In the first step, the pending anhydride rings (2,1wt%) are modified to incorporate furan moieties. The resulting grafted furans are then used to cross-link the rubbers with different aliphatic bismaleimides via a Diels-Alder coupling reaction. The mechanical properties and the temperature response of the resulting rubber products are typical for cross-linked rubbers and superior to those of their non-cross-linked precursors at low temperatures. The benefit of this system is that, in contrast to conventional thermosets materials, the system can be de-cross-links at elevated temperatures through the retro-Diels-Alder reaction. In short, the rubber can cross-link and de-cross-link on command, exerting excellent properties within its application window while softening upon (re)processing as is shown schematically on the right.



Reversibility and recyclability of the rubber can be proved by cutting used material into pieces and pressing those into new homogeneous samples with the same properties. The resulting system is flexible as it allows for tuning of its material properties by varying the cross-link density and the presence and type of cross-link agent. The chemistry was applied to different (polymer) systems and composites.

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