Bio-based covalent adaptable networks designed for facile recycling

The world is full of plastics. In fact, whether you realize it or not, almost everything you see and use on a daily basis is wholly or partially plastic material: packaging, insulation materials, adhesives, coatings, construction materials and many more. Considering the huge increase in plastic waste resulting from difficulties in dealing with the end-of-life usage of polymeric materials, there is an urgent need for a new generation of polymers that can be recycled as thermoplastics but still retain the beneficial properties of crosslinked thermosets, mainly high chemical and temperature resistance, dimensional stability, and so forth. The main drawback of conventional thermosets and elastomers results from their chemically crosslinked structure that forms a covalent irreversible network. Thus, the impossibility of reprocessing them in melt prevents their recycling and reuse.

Vitrimers are a relatively new class of polymeric materials which combine properties of traditional thermosets and thermoplastics. These materials are covalently crosslinked (red-yellow symbols on the scheme), but rather than being permanent, the crosslinks are dynamic and can change its topology without decreasing its connectivity because of the fast exchange reactions e.g. under increased temperature. It could be said that vitrimers are organic materials that behave just like glass.

The project aims to develop vitrimers by incorporation of renewable building-blocks i.e. chemical substances derived from biological sources. Natural itaconic acid, isosorbide and terpenes will be converted into monomers, which will then be used to synthesize polymers. The scientific challenge is to design their structures and work out how to recycle them efficiently.

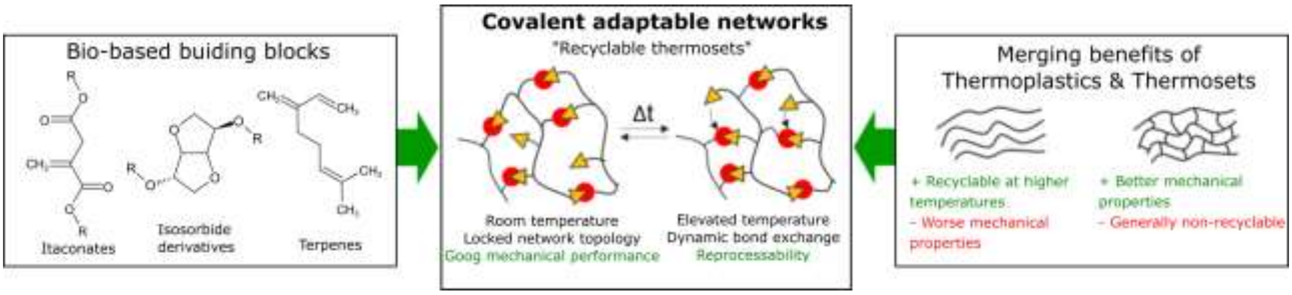

Figure 1. General overview of the project showing the starting materials (left panel), the structure of the vitrimer and main features of commonly used plastics (right panel).

The novel vitrimers developed within this project show substantial potential application. The use of biobased feedstocks could be taken to reduce reliance on non-renewable fossil fuels and contribute to a more sustainable future. Additionally, the development of recyclable thermosets can reduce waste and contribute to a more circular economy, as these materials can be reprocessed and reused instead of being discarded. Furthermore, the versatility of vitrimers means that they have potential applications in a wide range of areas, from automotive, construction, and packaging to biomedical. By using biobased feedstocks to synthesize recyclable vitrimers, it is possible to create new and innovative materials that are both environmentally friendly and economically viable, contributing to a better future for all. Finally, the scientific advancement in the field of covalent adaptable networks chemistry gained within this project can lead to a better understanding of these materials and their properties.