INCORPORATING BIOBASED MONOMERS INTO A TERPOLYMER DYNAMIC NETWORK

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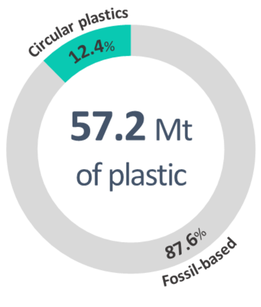


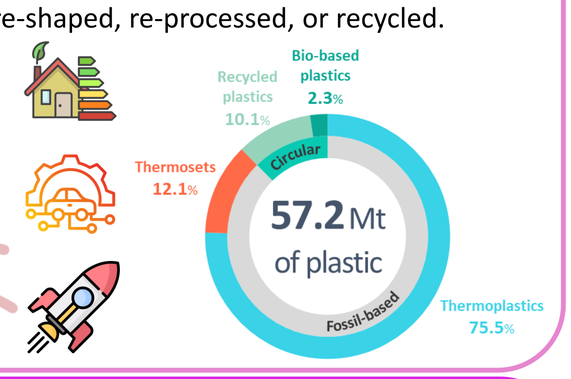
In 2021 the **production of plastics in Europe** was 57.2 Mt, and is expected to increase. The main source is fossil-based, whereas only a small portion is post-consumer recycled plastics or bio-based [1].

In 2021, the demand for plastics converters in Europe reached 50.3 Mt. The largest end-use markets are represented by Packaging (39.1%) and Building & Construction (21.3%). Other applications include Automotive (8.6%), Electrical & Electronics (6.5%), Agriculture, Farming and Gardening (3.1%), and Others (17%) [1].

Annual Plastic Production

In 2021 the **production of thermosets in Europe** was 12.1% [1]. Thermosets are cross-linked materials with enhanced mechanical properties, high chemical, and thermal resistance. Therefore, thermosets are employed in many advanced light-weight applications, such as automotive, aerospace, electronics, wind turbine blades, coatings, thermal insulation.

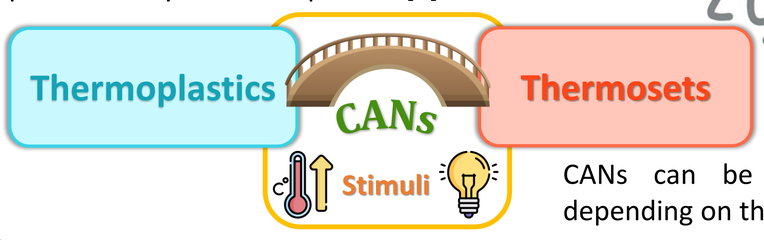
Despite the peculiar features of thermosets, they have a drawback: they cannot be re-shaped, re-processed, or recycled.



Thermosets Production

Dynamic Networks

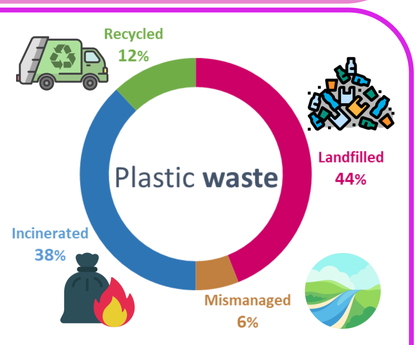
Covalent Adaptable Networks are a new polymer class which overcome the problem with recyclability of thermosets due to the presence of exchangeable chemical bonds activated by simple external stimuli, such as light or heat, making them fully re-processable. Thus, CANs are able to combine the peculiar properties of thermosets and the re-processability of thermoplastics [4].



CANs can be associative or dissociative depending on the exchange mechanism. [4]

Plastic Recycling

Since 1950, 6.300 Mt of **plastic waste** has been produced [2]. In 2019 only 12% of the total plastic production is recycled to give a second life. The remaining 44% is discharged in landfills, 38% is incinerated to gain energy and 6% is mismanaged [2].



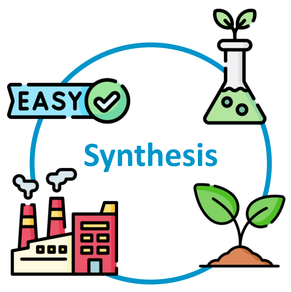
In 2021, European converters used 5.5 Mt of post-consumer recycled plastics, accounting for 9.9% [1]. The total volume of thermosets composites waste in Europe is currently around 400 ktons/year and it has been estimated that 40-70% of this waste ends up in landfills or is incinerated without energy recovery [3]. Furthermore, they are design and built to have a long shelf-life and, since thermosets cannot be recycled, in few years we will have to deal with the disposal of large amount of un-recyclable waste.

Aim and scope

The ever-increasing number of dynamic exchange mechanisms, coupled with the wide variety of monomers exploited to obtain polymer chains, enables the tailored synthesis of advanced materials with desired mechanical properties for specific applications.
Herein, we present a new dynamic network formed through the dissociative amide-imide exchange mechanism on a terpolymer containing also a biobased monomer.

Efficiency. The reactions must be kept as simple as possible, starting from the polymerization until the network formation.

The entire process is design to be **scalable.**

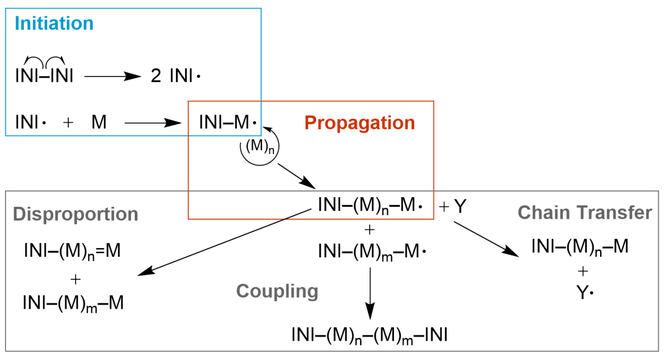


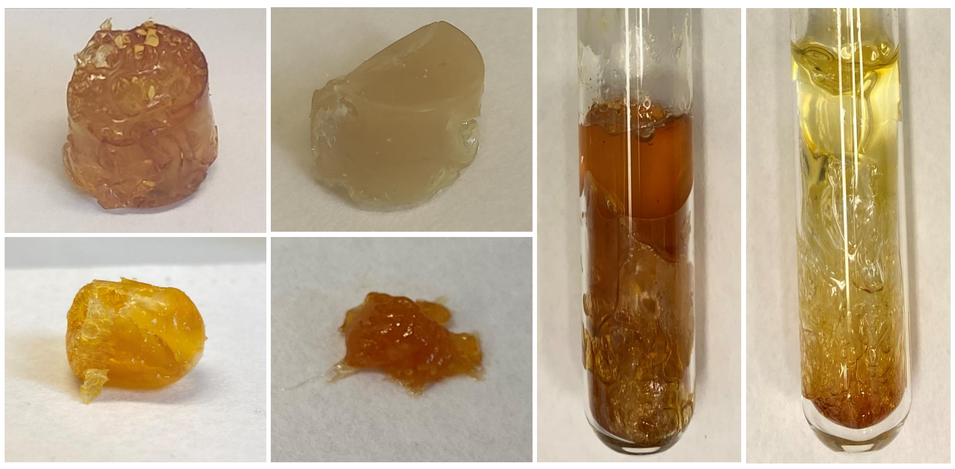
Solvent. Reactions are carried out without solvent whenever possible. When solvent is necessary, it is chosen to be as environmentally friendly as possible.

Bio-based. The objective is to reduce the percentage of fossil-based materials in the backbone by using bio-based co-monomers.

Materials and Methods

Free radical polymerization (**FRP**) represent the most important industrial polymerization techniques. This is the reaction of choice for the terpolymer synthesis.

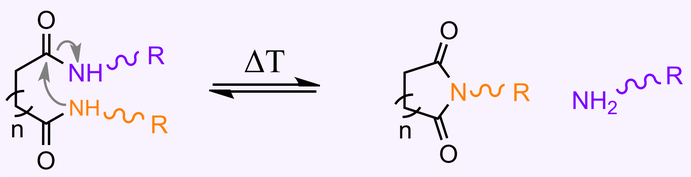




Crosslinking

Swelling tests were conducted to confirm the successful formation of the network.

Amide-Imide bond exchange mechanism



The nature of the **amide-imide exchange mechanism** is dissociative. Therefore, during the reprocessing there is a decrease in cross-link density [5]. This system is a combination of two driving force [4].

Reprocessability

The materials were processed using a hot press to evaluate their dynamic properties. However, the homogeneity needs to be improved, and further studies on the reactivity and network composition will be conducted.

Future outlook

Rheological measurement will be carried out, in order to assess the decrease in the viscosity of the dynamic bond, and its dynamic properties. Furthermore, the terpolymer composition and the cross-linking will be tune to achieve a fully re-processable material.

References:
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