Novel bio-based materials from vegetable oils

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Abstract

In recent years, the research on sustainable and bio-based polymers and their applications has gained considerable attention due to socio-economic factors and environmental concerns [1]. Vegetable oils are ideally renewable, abundant and low-cost resources to obtain sustainable polymers with different structures, properties and applications as they offer a great opportunity to tap into a pool of complex molecules in terms of carbon skeleton, double-bonds and functionalities availability [2,3]. In addition, the use of waste cooking oil to produce bio-based materials is a promising alternative to the exploitation of virgin vegetable oils since it is far cheaper and pursues waste valorisation and sustainability principles [4].

In this work, novel bio-based materials such as acrylated thermosetting resins and vitrimers are obtained from acrylated epoxydized soybean oil (AESO) while non-acrylic thermosetting resins are produced from epoxydized soybean oil (ESO).

The acrylated thermosetting resins were obtained by a multiple steps procedure such as epoxidation and acrylation of vegetable oil and curing in the presence of a radical initiator and in some cases of a terpenic co-monomer such as limonene, β-myrcene and α-pinene as alternative to traditional fossil co-monomers. Thermal, mechanical and dynamic-mechanical properties of the prepared materials were studied. The characterization highlighted high thermal stability, good mechanical performances and glass transition temperatures of about 50 °C. In addition, the proper choice of the co-monomer as function of the double bonds availability, allows to obtain thermosetting resins with tunable properties.

Preliminary experiments on the use of ESO in combination with different carboxylic acids, such as sorbic, fumaric, tartaric, succinic, adipic and azelaic acid, were carried out to obtain non-acrylic thermosetting resins. The materials were characterized by thermal analysis, infrared spectroscopy, and compression tests. Dicarboxylic acids and sorbic acid provided soft materials which showed a glass transition temperature close to -20 °C. Compression tests highlighted superior mechanical properties for the resins obtained by double bond-containing carboxylic acids, such as fumaric and sorbic ones.

Moreover, vitrimers from AESO and 2,2’-(1,4-Phenylene)-Bis[4-Mecaptan-1,3,2-Dioxaborolane] (DBEDT) as crosslinker were made to overcome the non-reprocessability and non-recyclability issues of thermosetting resins through the formation of a dynamic cross-linking that makes these materials reprocessable by network rearrangement after a stimuli’s application [5]. Vitrimers, formulated with different AESO/DBEDT ratio, were characterized by different techniques highlighting that they can be reprocessed several times without affecting their properties. In addition, the effect obtained by introducing a permanent cross-linking within the vitrimer network was studied.

In general, the results highlight the possibility of vegetable oil derivatives to be competitive with fossil building blocks, thus allowing to obtain materials with properties and performances even superior to those produced with fossil monomers.

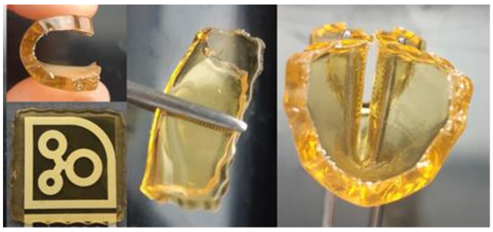

Figure 1. Non-acrylated resin from succinic acid

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