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Sustainable development of biobased thermoset materials from renewable raw products and industrial waste or side-products

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PURPOSE OF THE ABSTRACT

The need to establish effective solutions to reduce the consumption of non-renewable fossil products and to develop new innovative environmentally friendly products have become the main focus of our research, thus we developed epoxy resins and composites based on bio-based and renewable products (e.g., vegetable oils, bio resourced synthons, vegetal fibers) or industrial wastes (e.g. chicken feathers), that can be used in a wide range of industrial sectors.

The present work describes two different strategies for the sustainable development of green and eco-friendly epoxy thermoset materials, starting from bio-renewable raw materials and industrial wastes. In the first strategy, the polymeric matrix was developed by crosslinking a bio-renewable aliphatic epoxy monomer such as epoxidized linseed oil (ELO) with dodecenylsuccinic anhydride (DDSA) and with various ratios (1-10 wt.%) of keratin from chicken feathers, a valuable biopolymer with reactive functional groups (disulfide, amino and carboxylic acid) obtained as by-product from poultry industry. The influence of keratin and of its content on ELO crosslinking reaction was followed by DSC and FTIR analyses showing the chemical contribution of the protein during the network formation. The influence of keratin on the physico-chemical and thermo-mechanical properties of the designed bio-based epoxy materials were analyzed by TGA, DMA, tensile tests, Shore hardness tests and water absorption tests. Based on the DMA analyses, it was found that the addition of keratin reduces the brittle character of the epoxy resins at low temperatures by its chemical interaction with the matrix, but also, increase the stiffness of the designed material in the elastic region, revealing its properties of good reinforcing material. The increase in materials' stiffness with the amount of keratin was confirmed by the tensile tests results corroborated with Shore D hardness tests values. Keratin addition showed a positive effect on the overall performances of the designed materials, proving its potential to develop sustainable materials with industrial applicability.

In the second strategy, fully bio-based thermoset materials were elaborated by copolymerization of an aromatic epoxy compound from wood biomass, such as resorcinol diglycidyl ether (RDGE), with two biopolymers such as keratin and lignin. Bio-based epoxy thermoset materials were developed by using about 30 wt.% of biopolymer. In-situ FTIR kinetic analyses showed that the keratin and the lignin produced an increase of epoxy groups conversion during crosslinking. Also, the physical and mechanical tests showed that the properties of the final materials containing keratin or lignin were improved. The good compatibility between the components lead to materials characterized by ? relaxations ranged between 85-92 °C. The good thermomechanical performances, comparable with those of the commercial resins could recommend them as sustainable materials.

Therefore, we successfully designed new green epoxy thermosets based on aromatic/ aliphatic bio-based epoxies and bio-renewable/ wastes co-monomers, which can be substantial candidates as structural resins or matrix in composites in the replacement of fossil-derivatives materials existing in various industrial sectors such as aerospace structures, automotive sector (inside car materials), in construction area for various equipment (hard hat, pipe, trolley wells), furniture or flooring, or in electronical/electrical components.

FIGURES

FIGURE 1

Sustainable thermosets based on renewable raw materials.

Bio-resins materials designed by combining epoxidized linseed oil (ELO) and keratin from chicken feather waste, obtained without supplementary chemical modification or treatment .

FIGURE 2

KEYWORDS

chicken feathers | keratin | lignin | epoxidized linseed oil

BIBLIOGRAPHY

1/ R. Dinu, N. Briand, A Mija, “Influence of keratin on epoxidized linseed oil curing and thermosets performances”, ACS Sustainable Chemistry & Engineering, https://doi.org/10.1021/acssuschemeng.1c06112, 2021

2/ R. Dinu, A. Mija, " Bio-Based Composites from Industrial By-products and Wastes as Raw Materials”, J. Mater. Sci. Res., 9(2), 29-45. (2020).

3/ R. Dinu, C. Cantarutti, A. Mija, ”Design of sustainable materials by crosslinking a biobased epoxide with keratin and with lignin”, ACS Sustain Chem Eng, 8(17), 6844-6852, (2020).