

Abstract

Effect of Nanocellulose Type on the Properties of a Bio-Based Epoxy System [†]

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Abstract: With the continuous depletion of fossil oils and resulting environmental concerns, there is an urgent need to develop polymeric materials from renewable resources [1,2]. Epoxy resins are thermoset polymers that are recognized for their tunable properties (adhesiveness, tensile and electrical strength, stiffness, heat and chemical resistance) and for their various industrial and domestic applications. Still, the main drawback of epoxy resin is its brittleness. Thus, the addition of functional vegetable oils, such as epoxidized linseed oil (ELO), can improve the toughness of epoxy resin, while increasing the bio-based content of the final materials [1]. The goal of this work is to study the influence of composition, cross-linking conditions, and addition of reinforcing agents on the properties of a bio-based epoxy resin, obtained from epoxidized linseed oil (ELO), and a commercial hardener. Nanocellulose from common sources (microcrystalline cellulose MC) and agro-industrial residues (plum seeds shells-SC) were used as fillers in the epoxy-systems. Epoxidized linseed oil (ELO, TRAQUISA, Barcelona, Spain), Epilox—Hardener H 10–30 (G) (NANOCHEM, București, Romania), microcrystalline cellulose (MC) (20 μm, Aldrich, St. Louis, MO, USA) and plum seed cellulose (SC) (laboratory obtained via acidic hydrolysis) were used as raw materials. A 2/1 weight ratio of ELO/G was used to obtain the cross-linked materials. Two types of cellulosic modifiers, MC and SC, were used to reinforce the epoxy systems. The resulted epoxy composite systems were characterized by means of FT-IR, TGA, DMA and water contact angle analysis. TGA analysis showed that the onset and maximum degradation temperatures were increased upon employing an extra cross-linking step at 140 °C or by addition of the cellulosic fillers. Moreover, an increase in the storage modulus of the final epoxy systems was attained as a result of the addition of cellulosic filler, as seen in the DMA results. The addition of a low-weight percentage (0.5%) of cellulose modifiers (MC and SC) enhanced the thermal stability of the epoxy system and had a reinforcing effect by increasing the storage modulus of the final materials.

Keywords: nanocellulose; epoxidized linseed oil; thermal properties



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References

1. Di Mauro, C.; Malburet, S.; Genua, A.; Graillet, A.; Mija, A. Sustainable Series of New Epoxidized Vegetable Oil- Based Thermosets with Chemical Recycling Properties. *Biomacromolecules* **2020**, *21*, 3923–3935. [[CrossRef](#)] [[PubMed](#)]
2. Tang, Q.; Chen, Y.; Gao, H.; Li, Q.; Xi, Z.; Zhao, L.; Peng, C.; Li, L. *Soybean—Biomass, Yield and Productivity*; Kasai, M., Ed.; IntechOpen Limited: London, UK, 2019.