RETASTE Conference Abstracts
Vol. 2 RETASTE-PLW-251-Poster
Herakleion, Greece, 20-21 October, 2022

Biobased poly(hexamethylene furanoate-co-camphorate)s from 2,5-furandicarboxylic acid and camphoric acid: improvements in mechanical properties for sustainable food packaging

[1]Enrico Bianchi, [1]Michelina Soccio, [2]Valentina Siracusa, [3]Massimo Gazzano and [1]Nadia Lotti

[1]*Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via U. Terracini 28, 40131 Bologna, Italy.*
[2]*Department of Chemical Sciences, University of Catania, Viale A. Doria 6, Catania, 95125, Italy.*
[3]*Organic Synthesys and Photoreactivity Institute, CNR, Via Gobetti 101, Bologna, 40129, Italy.*

Abstract

Nearly half of all food is wasted in the food chain each year, from farm to consumer. In addition, about a third of the planet's food goes to waste [1]. Advancements in packaging technology are providing one of the main solutions to food waste, since one of the most important features of food-packaging is its capacity to preserve and protect food, and specifically plastic packaging helps reducing packaging weight, which in turn reduces delivery costs, energy consumption and greenhouse gas emissions [2]. Moreover, biobased polymers from waste biomass have been gaining increasing importance recently, and LCA studies confirm that the substitution of petrochemical plastics with biobased ones leads to a relevant decrease in CO_2 emissions [3], paired with no exploitation of agricultural land, and while supporting the sustainable development model of circular economy. This work is part of this complex, constantly evolving scenario, with the aim of proposing new polymeric materials obtained from 2,5-furandicarboxylic acid (2,5-FDCA) and camphoric acid, polymerized with 1,6-hexanediol, for the realization of sustainable, monolayer food packaging. The optimization of the solvent-free synthetic method made it possible to obtain high molecular weight polyesters with a percentage of camphoric acid up to 17 mol%, which could be compression moulded into films and were subjected to NMR, FT-IR, GPC, WAXS, TGA, DSC analyses and mechanical and gas barrier tests. The results showed a remarkable improvement compared to the mechanical properties of poly(hexamethylene furanoate) (PHF), the homopolymer of reference: in particular, the polyester containing 15 mol% of camphoric acid (PHF85HC15) was found to have higher flexibility, higher toughness and a 430% improvement of elongation at break. O_2 and CO_2-transmission rates were also found to be

comparable or superior to those of commercially available packaging materials. From these insights, it was possible to establish scientific structure-properties relationships, confirming the suitability of this polymeric system for the production of biobased, sustainable, flexible food packaging. The high gas barrier and mechanical performances of PHF85HC15 were found to allow size-efficient, customizable design and increased shelf life for the prevention of food loss and food waste.

Keywords: Sustainable food packaging, biobased polyesters, 2,5-furandicarboxylic acid, mechanical properties, gas barrier properties

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