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Bio-based random copolyesters of poly(butylene trans-1,4-cyclohexanedicarboxylate) by copolymerization with camphor for sustainable food packaging

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Abstract

The development of a sustainable society, with the so-called “zero-impact” on the environment, requires the adoption of specific conducts. Among them, any kind of waste should be minimized, in particular when food is concerned. Indeed, according to FAO’s reports, between 720 and 811 million people in the world faced hunger in 2020 (FAO, 2021). In addition, malnutrition and food insecurity remain a widespread problem, far from being solved. For this reason, from the packaging point of view, the development of solutions able to preserve and prolong the shelf-life of food can guarantee a reduction in food waste. To lower the environmental impact, the use of flexible packaging should be preferred to rigid one, in order to minimize the consumption of sources during production and transport of material that in the short term will become waste. Another challenge in the field of packaging is the eco-design of new plastic materials which can be obtained from renewable sources and characterized by properties comparable to those of the traditional fossil-based plastics. It must be considered that, to date, the starting bio-based monomers are grown in land which covers only the 0.015 percent of the global agricultural areas, confirming that there is no competition between the renewable feedstock for food and the production of bioplastics (Plastics Europe, 2020). In the aforementioned scenario, the present work aims to propose new bio-based cycloaliphatic

copolymers of trans-1,4-cyclohexanedicarboxylic acid and containing different amount of camphoric acid (from 0 to 15 mol %), a cheap and bio-based building block. This chemical modification was carried out by 2-step melt-polycondensation, without the use of any solvents. The copolymers were then processed in the form of films by compression moulding. A deep molecular (NMR spectroscopy and GPC analysis), thermal (DSC and TGA analyses), diffractometric (wide angle X-ray scattering) characterization was carried out. Mechanical (through tensile tests), and barrier properties to O_2 and CO_2 (permeability measurements) were also analysed. Last, all the results obtained were related to the amount of camphoric moiety introduced and a different microstructure in the copolymers was evidenced: indeed, in these samples a different crystalline form developed (the so-called β-PBCE). This latter was the kinetically favoured and less packed form, as proven by the lower equilibrium melting temperature determined for the first time by Baur's equation.

Keywords: cyclohexanedicarboxylic acid; copolymerization; flexible packaging; barrier properties; mechanical properties;

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