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New copolymers and blend of poly(octylene 2,5-furanoate) and poly(triethylene 2,5-furanoate): the importance of the materials' design for sustainable food packaging

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Abstract

Although plastic packaging is often considered one of the main responsible of environmental impact, in case of food some valuable effects must be considered. Indeed, packages can protect food, extending its shelf life and reducing food waste, which is one of the main plagues of the modern era (Brennan et al., 2021). Another current concern is the accumulation of wastes in the environment, which is pushing governments and society towards an efficient management of plastic and to the transition towards the circular economy. However, recycling is not always a cost-effective or a feasible alternative, due to the lack of proper recycling policies (in developing countries) and, in case of food packaging, due to organic matter contamination. Thus, biodegradable plastics represent the only alternative to landfill. In this scenario, 2,5-furandicarboxylic acid (FDCA) is an interesting monomer to realize flexible mono-material packaging, with excellent mechanical and barrier properties. Indeed, it has been demonstrated that flexible packaging is very effective in protecting food with the minimum amount of material and waste, helping to reduce food waste by offering optimum protection (Flexible Packaging Europe, 2021). In the present work the effect of chemical structure, chemical composition and molecular architecture on the design of sustainable materials for food packaging was investigated. To this aim, copolymers and a physical blend based

on poly(octylene 2,5-furanoate) (POF) and poly(triethylene 2,5-furanoate) (PTEF), were successfully prepared. The homopolymers were obtained by 2-step melt polycondensation, starting from the dimethyl ester of FDCA and 1,8-octanediol and triethylene glycol, respectively, while copolymers with fix equimolar composition and different molecular architecture (block or random) were obtained through reactive blending by changing mixing time. In addition, a random copolymer containing 20 mol% of TEF co-units was synthesized by polycondensation, and a physical blend was prepared by mixing equimolar amounts of POF and PTEF. All the materials were then compression-moulded to obtain free-standing films, and a preliminary molecular (^{1}H-NMR and GPC) and thermal characterization (DSC and TGA) was carried out. As to the functional properties, mechanical and barrier performances to dry and humid O_2 and CO_2 food grade were also checked. As to the main results obtained, it is worth mention the good mechanical properties and low GTR values, which means low permeability to gases. These features are of particular importance for the design of materials that will be used for packaging purposes. Lab scale composting experiments were also carried out with promising results.

Keywords: Furandicarboxylic acid; copolymers; blending; composting studies; barrier properties;

References

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