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Novel Biobased Polylactic Acid/Poly(pentamethylene 2,5-furanoate) Blends as Sustainable Food packaging: Synthesis and characterization

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Abstract

As is well known, a promising alternative to petroleum-derived non-biodegradable plastic packaging could be represented by bioplastics, bio-based or biodegradable ones. Bioplastics possess similar properties to conventional plastics and offer interesting advantages such as reduced carbon footprint and waste management options. Despite this, today bioplastic market represents only 0.6 % of the total plastic production. One of the most promising biopolymers is poly(lactic acid) (PLA). Despite its interesting mechanical and optical properties, this polymer is relatively brittle, that limits its application as packaging material. To overcome this problem and improve the ductility, an interesting alternative can be blending PLA with other polymers. Furanoate polyesters represent a commercial biobased alternative to petrochemical polyesters such as PET, synthetized starting from furan-2,5-dicarboxylic acid (FDCA), obtained from biomass-derived sugars. Among a series of furan-based polyesters, poly (pentamethylene 2,5-furandicarboxylate) (PPeF) showed unexpected and interesting properties. In fact, despite being an amorphous rubbery polymer at room temperature, it can be easily processed by compression molding as a freestanding flexible film. In this contest, solution-cast blends of polylactic acid (PLA) and bioderived poly(pentamethylene 2,5-furanoate) (PPeF) in variable concentrations (1−50 wt %) were prepared and investigated. The characterization of the thin films (thickness 50 µm) highlights that PPeF strongly improves the UV-shielding properties of PLA, with a decrease in transmittance at 275 nm from 47.3% of neat PLA to 0.77% with only 1 wt % of PPeF, while the transmittance decrease in the visible region at these PPeF fractions is marginal, allowing the production of optically transparent films. Despite the complete immiscibility of PLA/PPeF blends, PPeF effectively enhances the ductility of PLA as the tensile strain at break increases from 7% of neat PLA to 200% of the blend with 30 wt %

of PPeF. This composition is the most promising, also from the gas-barrier point of view as the gas transmission rates of CO_2 and O_2 drop to one-fourth of those of neat PLA, comparable to those of poly(ethylene terephthalate). These results highlight that PPeF remarkably enhance the ductility of PLA but also it provided UV-barrier and gas-barrier properties, all fundamental for food packaging applications. Especially, sample containing 30 wt % of PPeF showed remarkable gas-barrier performance, with GTR values to O_2 and CO_2 comparable to those of PET, and slightly better than those of poly butylene succinate (PBS) and poly hydroxybutirate (PHB). Further, 30 wt % of PPeF in the blend revealed to be the optimal amount to effectively address the main shortcomings of PLA, that is, excessive brittleness and poor gas-barrier properties, and this paves the way for the production of very interesting biobased materials for sustainable packaging. It is worth mentioning that these promising results have been obtained despite the complete immiscibility between PLA and PPeF. A much greater improvement is expected by mixing the two homopolymers in the melt and using suitable compatibilizers.

Keywords: polylactic acid, poly(pentamethylene 2,5-furanoate), blends, thermal properties, mechanical properties, gas-barrier properties

References

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