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Biobased phase transition plasticizers for long term applications in polylactic acid

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PURPOSE OF THE ABSTRACT

Plasticizers are chemicals incorporated into polymeric matrix in order to soften them and to adapt their physico-chemical properties to fit industrial applications.1 The most common plasticizers are most of the time oily and/or waxy under standard conditions. The incorporation of such viscous additives in polymer is quite hard and tricky since it requires specific pumps and injectors to regulate the flow accurately during hot melt process. The difference in viscosity between the additive and the melted polymer could also reduce the homogeneity of the resulting blend decreasing the properties of the final material. The use of an additive which would be incorporated as a powder then would turn into a viscous oil only during the process could be an interesting alternative to ease the hot melt process of plasticized polymers.

To this aim, we have synthesized four ferulic acid derivatives (FADs) which turned from a crystalline structure to an amorphous phase only after being melted.2 These four FADs where then blended in polylactic acid (PLA) by single-screw extrusion. PLA is a suitable polymeric matrix because it is commonly processed at temperatures permitting the phase transition of our FADs during the process,3 and our FADs have strong chemical affinities with polyesters.2 Finally, plasticized PLA with enhanced flexibility or reduced brittleness are of great interest for commercial applications,1,3 especially in packaging and 3D printing.

The mechanical properties of the compounds were measured by tensile tests to investigate the plasticizing effect of the FADs and showed a decrease up to 60% of the Young's modulus. The effect of the structural design and of the solubility parameters of the derivatives on the plasticizing effect was also investigated. The molecular weight and the thermal properties were then deeply investigated to measure the impact of the additives on the PLA matrix according to the chemistry of the FADs and their respective content. No leaching phenomenon was noticed even after one year. No migration of the additives was noticed even after ageing tests conducted above glass transition temperature. The transparency of the PLA was fully preserved with one of the additives.

(1) Rahman, M.; et al. Progress in Polymer Science (Oxford). December 2004, pp 1223?1248.
(2) Gallos, A.; et al. ACS Sustain. Chem. Eng. 2017, 5 (11), 10352.
(3) Gallos, A.; et al. RSC Adv. 2017, 7 (55), 34638.
(4) Mekonnen, T.; et al. J. Mater. Chem. A 2013, 1 (43), 13379.

FIGURES

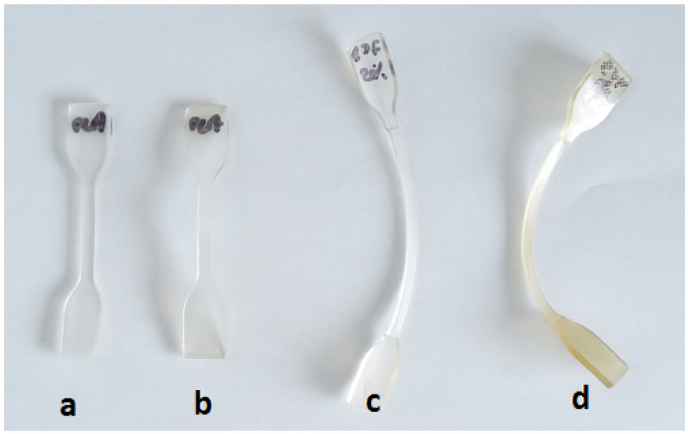

FIGURE 1

Tensile tests

Specimen of crude PLA prior tensile test experiment (a) and of crude PLA (b) and PLA containing 20 wt% of additives (c, d) after tensile test experiments

FIGURE 2

KEYWORDS

plasticizer | biopolymer | ferulic acid

BIBLIOGRAPHY

(1) Rahman, M.; et al. Progress in Polymer Science (Oxford). December 2004, pp 1223–1248.
(2) Gallos, A.; et al. ACS Sustain. Chem. Eng. 2017, 5 (11), 10352.
(3) Gallos, A.; et al. RSC Adv. 2017, 7 (55), 34638.
(4) Mekonnen, T.; et al. J. Mater. Chem. A 2013, 1 (43), 13379.