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Biocomposites based on plasticized starch: thermal and mechanical behaviours

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Abstract

The paper is focusses on the study of the thermal and mechanical behaviour of reinforced agro-materials. Various formulations based on plasticized starch matrix have been carried out, varying matrix formulation, filler content, fibres length and nature. Cellulose and lignocellulose fibres, which show unequal surface tensions, have been tested. After extrusion and injection moulding, the properties of these wheat starch-based biocomposites are analysed. Mechanical properties (tensile tests), thermo-mechanical properties (DMTA) and thermal degradation (TGA) are analysed. DMTA analysis shows important variations of main relaxation temperature, which can be linked both, to interactions resulting in a decrease of starch chain mobility and to a regular reinforcing effect. These results are consistent with the static mechanical behaviour, which vary according to the filler content (up to 30 wt%), fibre nature (cellulose vs. lignocellulose) and fibre length (from 60 μm to 1 mm). Besides, we have shown that the addition of cellulose fillers improves the thermal resistance of these biocomposites. Finally, we have tested the impact of the addition of biodegradable polyesters into these composites without significant effect on the post-processing stability.

Keywords: Composite; Plasticized starch; Cellulose fibres; Mechanical properties

1. Introduction

Ecological concerns have resulted in a renewed interest in natural and compostable materials, and therefore issues such as biodegradability and environmental safety are becoming important. Tailoring new products within a perspective of sustainable development or eco-design, is a philosophy that is applied to more and more materials. It is the reason why material components such as natural fibres, biodegradable polymers can be considered as ‘interesting’—environmentally safe—alternatives for the development of new biodegradable composites.

Biocomposites (biodegradable composites) consist of biodegradable polymers as the matrix material and biodegradable fillers, usually biofibres (e.g. lignocellulose fibres). Since both components are biodegradable, the composite as the integral part is also expected to be biodegradable (Mohanty, Misra, & Hinrichsen, 2000c). Fig. 1 shows a classification of biodegradable polymers in four families. Except the fourth family, which is of fossil origin, most polymers (family 1–3) are obtained from renewable resources (biomass). The first family are agro-polymers (e.g. polysaccharides) obtained from biomass by fractionation. The second and third families are polyesters, obtained, respectively by fermentation from biomass or from genetically modified plants (e.g. polyhydroxyalkanoate: PHA) and by synthesis from monomers obtained from biomass (e.g. polylactic acid: PLA). The fourth family are polyesters, totally synthesised by the petrochemical process (e.g. polycaprolactone: PCL, polyesteramide: PEA, aliphatic or aromatic copolyesters). A large number of these biodegradable polymers (biopolymers) are commercially available. They show a large range of properties and they can compete with non-biodegradable polymers in different industrial fields (e.g. packaging).

Cellulose-based fibres are the most widely used, as biodegradable filler. Intrinsically, these fibres have a number of interesting mechanical and physical properties

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