Tunable FDM 3D printing of flexible poly(butylene adipate terephthalate)-based biocomposite filaments

TUNABLE FDM 3D PRINTING OF FLEXIBLE POLY(BUTYLENE ADIPATE TEREPHTHALATE)-BASED BIOCOMPOSITE FILAMENTS

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Introduction

Poly(butylene adipate-co-terephthalate), PBAT, is a synthetic and 100% biodegradable polymer based on fossil resources, with high elongation at break and high flexibility[1]. These properties are comparable to low-density polyethylene, making PBAT a very promising biodegradable material that could replace it in some industrial applications[2]. However, its lower mechanical properties have limited its application range. The reinforcement of PBAT with rigid filler, such as zein-TiO_2 (ZTC) complex microparticles, has the purpose to expand its application field, especially in the food and agricultural packaging sector.
This study reports on the development of bio-based composite filaments at high ZTC content (5 to 40 wt%), where zein was used to raise the interaction between the filler and the matrix and improve the structural properties of the final composite. These flexible filaments were then 3D printed to produce complex and completely bio-based solid systems, with remarkable bio-compatibility properties, according to the carried-out cytotoxicity tests. The advantages of these eco-friendly materials can thus be combined with the production of customizable design objects by additive manufacturing, with numerous potential applications in biomedical and healthcare research[3].

Results and discussion

ZTC complex was compounded with the polymer at the increasing concentration by solvent casting: 0, 5, 10, 20, and 40 wt% (Figure 1). The biocomposite pellets were injection-molded to obtain model 1BA specimens, according to standard UNI EN ISO 527, for subsequent characterization (Figure 2).

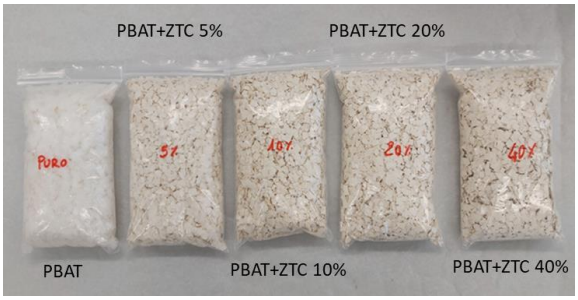

Figure 1. PBAT-based composite pellets at different ZTC content, after solvent casting preparation.

Figure 2. Injection-molded specimens at different ZTC content: from left to right the ZTC wt% varies from 0 to 40% (the dimensional marker is equal to 1 cm).

The PBAT-ZTC pellets were also employed to produce composite filaments for 3D printing through a single screw extrusion system, equipped with a cooling fan array, to cool down the polymer melt, and a spooler, equipped with an optical sensor, to collect the produced filament with a constant diameter (Figure 3). The extruded filaments of pure and loaded PBAT