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Effect of Agave Leaves Fibers (ALF) Content on Thermal, Mechanical, and Surface Properties of Poly(3-Hydroxybutyrate-co-3-Hydroxyhexanoate) (PHBHHx) Biocomposites

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The development of new bio-based and biodegradable composites with enhanced performances is an efficient route to achieve a sustainable materials production. In this work, biocomposites materials based on PHBHHx reinforced with Agave leaves fibers (ALF) are elaborated by melt compounding at various filler content ratios, i.e., 10, 20, and 30 wt%. Thermal stability, tensile, and surface properties are investigated aiming to evaluate the effect of the ALF content on the material properties. The results show that the addition of ALF leads to reinforcement effect on PHBHHx, which is more pronounced at 30 wt%. Conversely, thermal stability of the biocomposites slightly decreases compared with the neat polymer, while the surface properties are almost unchanged whatever the filler content.

1. Introduction

Recently, biodegradable biocomposites based on biopolymers and natural fibers are gaining considerable interest.[1] Due to their numerous advantages, biodegradable biopolymers can be adapted to different types of industrial applications, such as automotive, biomedical, and food packaging.[2] Indeed, the literature reported that this new class of biodegradable biocomposites exhibit interesting mechanical, thermal, and barrier properties.[3,4] As a matter of fact, polyhydroxyalcanoates (PHAs) are naturally synthesized polyesters that attracted a lot of attention owing to their extensive array of properties, which are similar to those of polyolefins.[5,6] A long with this family of bio-polyesters, PHBHHx is a random block copolymer, which exhibits better performances compared with other PHAs such as toughness, and ease of processability.[7] However, its high cost and poor stiffness limit its widespread applications.[8] To overcome these drawbacks, several methods are proposed in literature and one of these consist of reinforcing PHBHHx with different fillers.[9–11] On the other hand, natural fibers extracted from Agave plant leaves (ALF) received little interest for their use in polymeric matrices despite their good properties.[12,13] Therefore, this work aims to study the effect of ALF content, i.e., 10, 20 and 30 wt% on the mechanical, thermal, and surface properties of PHBHHx-based biocomposites.

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2. Results and Discussion

2.1. Thermal Stability

Thermal stability of PHBHHx and PHBHHx/ALF biocomposites was investigated by thermo-gravimetric analysis (TGA) and the thermograms are shown in (**Figure 1**) with respect to filler content. It is observed that the onset degradation temperature of neat PHBHHx begins at almost 254 °C, while the TGA curve exhibits a single step degradation with nearly no residue. This phenomenon is due to the random cleavage of ester linkages to vinyl ester and carboxyl groups.[14] After adding ALF, the onset degradation temperature shifts towards a lower temperature by around 10 °C, whatever the filler content. Indeed, the incorporation of ALF results in aggregates formation in the matrix, which could be responsible for the degradation of the biocomposites. Furthermore, Figure 1 shows the presence of a second degradation step in the TGA thermograms of PHBHHx-based biocomposites around 288 °C, which is assigned to cellulose degradation in the fibers. This is in agreement with the literature data.[15,16]

2.2. Tensile Properties

Figure 2 shows representative stress–strain curves of PHBHHx and PHBHHx/ALF biocomposites plotted at 10, 20, and 30 wt% filler content. From Figure 2, it is observed a drastic reduction in tensile strength and nominal strain at break. Indeed, tensile strength decreases from about 18.2 MPa for neat PHBHHx to almost 11.4 MPa at 10 wt%. Further, the decrease is however negligible beyond 20 wt% fiber content. On the other hand, Young's