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Influence of Green Chemical Treatments on Morphology and Mechanical Properties of Poly(3-Hydroxybutyrate-*co*-3-Hydroxyhexanoate)–Agave Americana Fibers Biocomposites

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This work aims at investigating the effect of two eco-friendly chemical treatments of Agave Americana fibers (AAFs) on morphology and mechanical properties of poly(3-hydroxybutyrate-*co*-3-hydroxyhexanoate) (PHBHHx) biocomposites prepared by melt compounding. Acid citric and sodium bicarbonate treatments are used separately to modify the fiber surface before their incorporation into PHBHHx matrix at 30 wt%. The study reveals through SEM observations that the fracture surface of untreated PHBHHx biocomposite shows a poor fiber-matrix adhesion with the presence of many microvoids at interface and also some fibers pullout. However, less surface defects with a finer morphology are observed on the treated biocomposite samples resulting in improved tensile and flexural properties compared with neat polymer, being however, more pronounced for those modified with sodium bicarbonate. The study highlights the beneficial effect of the green treatments investigated to enhance the mechanical properties of PHBHHx biocomposites.

1. Introduction

Due to the widespread use of composite materials made from synthetic fibers and polymers, both industrials and scientists have recently been confronted with issues related to environmental imbalance and global warming. As a result, the development of natural fiber reinforced polymer composites (NFRPC) gained a keen interest.[1] Indeed, natural fibers exhibit very good features such as biodegradability, eco-friendliness, and excellent mechanical properties, which make them the most suitable for replacing synthetic fibers. However, the disadvantage of natural fibers lies in the weak interfacial interaction between the polymer matrix and the fibers due to the hydrophilic nature of the natural fibers resulting in a poor fiber-matrix interfacial bonding, poor wettability, water absorption, and moisture absorption. Hence, it is required to optimize the fibers by chemical treatments and surface treatments.[2] In this topic, most of the research focuses focus on structure–property interrelationship, fibers dispersion quality, and compatibilization for optimal performance of the resulting biocomposites materials.[3,4] Indeed, there are many approaches reported in literature to elaborate biocomposite materials with good interfacial properties.[5] Among these, chemical treatments are considered to optimize the interface of fibers by activating hydroxyl groups or introducing new moieties that can effectively interlock with the hydrophobic polymer matrix.[6] Indeed, various chemical treatments are reported in literature involving alkaline treatment, silane treatment, acetylation of natural fibers, benzoylation treatment, acrylonitrile grafting, and others achieving different levels of success in improving adhesion between the matrix and the fibers.[7] However, very limited papers are published on the use of green chemical treatments to modify the natural fibers reinforced biocomposite materials. Therefore, in this paper, which is a continuation of works published recently, Agave Americana fibers (AAFs), previously treated with eco-friendly citric acid and sodium bicarbonate solutions, are melt compounded with poly(3-hydroxybutyrate-*co*-3-hydroxyhexanoate) (PHBHHx) at filler content of 30 wt%. The effect of each chemical treatment of AAF on morphology and mechanical properties of PHBHHx biocomposites is investigated. The results are reported and compared between each treatment and with untreated PHBHHx-AAF biocomposites.

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2. Experimental Section

2.1. Materials

PHBHHx (Aonilex X151A) in pellets form was purchased from Kaneka Corp. (Japan). AAFs were extracted by water retting from Agave Americana leaves that were collected in the vicinity of Bejaia region (Algeria). Citric acid and sodium bicarbonate were

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