Properties of Thermoplastic Composites Based on Wheat-Straw Lignocellulosic Fillers

F. Le Digabel,[1] N. Boquillon,[2] P. Dole,[3] B. Monties,[3] L. Averous[4]

[1]*Unité Mixte de Recherche (UMR), Institut National de la Recherche Agronomique (INRA)/Université de Reims Champagne-Ardenne (URCA), École Supérieure d'Ingénieurs en Emballage et Conditionnement (ESIEC), Boite Postal (BP) 1029, 51686 Reims Cedex 2, France*
[2]*Agro-Industrie Recherche et Développement (ARD), Route de Bazancourt, 51110 Pomacle, France*
[3]*UMR INRA/URCA, Centre de Recherche en Agronomie (CRA), BP 1039, 51687 Reims Cedex 2, France*
[4]*École Européenne en Chimie, Polymères et Matériaux (ECPM) [Laboratoire d'Ingénierie des Polymères pour les Hautes Technologies (LIPHT)], 25 Rue Becquerel, 67087 Strasbourg Cedex 2, France*

Received 3 June 2003; accepted 14 January 2004
DOI 10.1002/app.20426
Published online in Wiley InterScience (www.interscience.wiley.com).

ABSTRACT: Lignocellulosic fractions from wheat straw were used as natural fillers in composites of a polyolefin (a copolymer of polyethylene and polypropylene) and a biodegradable polyester [poly(butylene adipate-*co*-terephthalate)]. The mechanical properties of these injected composites were investigated with tensile and impact testing. A reinforcing effect of wheat-straw residues was found for both types of composites. Compared with the polyester-based composites, the polyolefin composites were more brittle. The addition of compatibilizing agents (γ-methacryloxypropyltrimethoxysilane, maleic anhydride modified polypropylene, and stearic acid) did not improve the properties of the polyolefin composites. The surface properties were studied with contact-angle measurements, and poor interfacial adhesion was found between the hydrophilic lignocellulosic filler and the hydrophobic polyolefin matrix. Thermal characterization revealed the formation of low intermolecular bonds between the polyester matrix and the lignocellulosic filler, in agreement with the surface tensions results and scanning electron microscopy observations.
 J Appl Polym Sci 93: 428–436, 2004

Key words: composites; biodegradable; polyesters; biofibers; interfaces

INTRODUCTION

For several years, natural fibers have been used as reinforcing additives for polymers. Wood fibers have been commonly combined with thermoplastic[1–7] or thermoset[8] matrices to enhance mechanical properties such as the stiffness and impact strength. In recent years, annual crop fibers have been increased in value through their incorporation into various polymers. Agricultural waste can originate from different sources, such as sisal, jute, coconut, and flax,[9–28] and it has significant potential as a source of low-cost reinforcements for polymers, particularly polyolefins such as polyethylene (PE) or polypropylene. However, polyolefins are not the most appropriate matrices for natural fibers because of their nonpolar character and the polar properties of agricultural waste. Several solutions have been proposed to improve interfacial compatibility, such as chemical or physical treatment of the fibers. Different coupling or compatibilizing agents have been widely used to modify the surface tension of fibers.[21–29] Another alternative for obtaining good compatibility between natural fibers and a matrix is to use more polar thermoplastic matrices such as poly(methyl methacrylate), polyacrylate, poly(vinyl chloride), and biodegradable polyesters.[30–38]

Wheat-straw waste is a natural byproduct of the industrial fractionation of wheat straw. To enhance the value of this residue, we propose its incorporation into thermoplastic polymers. Two matrices and different polarities have been tested. Composites based on a hydrophobic matrix such as a polypropylene–polyethylene copolymer require chemical modification, whereas composites based on a more hydrophilic matrix such as a biodegradable polyester are likely to present better interfacial compatibility. The mechanical and thermal properties of these wheat-straw-waste-based composites have been investigated. The crucial importance of interfacial interactions has been studied.

Correspondence to: L. Averous (averousl@ecpm.ustrasbg.fr).
Contract grant sponsor: Europol'Agro (Reims, France).

Journal of Applied Polymer Science, Vol. 93, 428–436 (2004)

EXPERIMENTAL

Materials

Two thermoplastic matrices were used. The polypropylene–polyethylene (6%) copolymer was supplied by