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On the Mechanical Properties of Composites Based on Wheat Husk and Polyvinyl Chloride

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This work is aimed to valorize the agricultural waste based on the wheat husk (WH) by its incorporation as the reinforcing filler in the polyvinyl chloride (PVC) matrix. To improve interfacial adhesion, the fiber is chemically treated with acetic anhydride (AA). Various composite samples made of PVC and WH fibers at different loading rates, i.e., 10, 20, and 30 wt% are prepared. The transmission Fourier transform infrared spectroscopy IRTF results revealed that the reaction of acetylation has occurred. The results indicate a reduction in the mechanical properties according to the load factor as well as an improvement for the treated composites compared to the untreated composites. There is a reduction in the modulus according to the load factor for PVC/WHAA composites compared to the PVC/WH for both the 20 and 30 wt% formulations.

1. Introduction

Lignocellulosic fibers have several advantages. One can cite, for example, their biodegradability and their neutrality in respect to CO_2 emission.[1] However, there are several problems associated with incorporating such fibers into thermoplastic matrices, most notably fiber-matrix incompatibility where no polar polymers are concerned. There are various methods for promoting interfacial adhesion in systems where lignocellulosic materials are used.[2–5] Esterification by means of acetylation is a chemical modification. Acetylation describes a reaction introducing an acetyl functional group (CH_3COO–) into an organic compound. Chemical modification with acetic anhydride (CH_3-C(=O)-O-C(=O)-CH_3) substitutes the fiber hydroxyl groups of the cell wall with acetyl groups, modifying the properties of these fibers so that they become hydrophobic.[6–8]

The goal of our study was to modify the surface of wheat husk used as reinforcement in PVC composites by acetylation. The reactions were confirmed by FT-IR. PVC composites were prepared from the modified fiber and they were characterized by various methods.

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2. Experimental Section

2.1. Materials

All the PVC/WH formulations used in this work were based on PVC type SE-1200 provided by CABEL "'Cablerie Electrique"' located in Algiers (Algeria). The additives used in the preparation of the various formulations were dioctyl phthalate as a plasticizer, a thermal stabilizer system based on Ca/Zn, and stearic acid as a lubricant. The fiber used as reinforcing filler was wheat husk and its average particle size is between 315 and 500 μm.

2.2. Fiber Surface Treatment

According to the procedure reported previously by Luz et al.,[9] fiber was placed with glacial acetic acid, at 35°C for 45 min under continuous magnetic agitation, then glacial acetic acid and 0.1 mL of concentrated H_2SO_4 were added; the reaction continues during 1 h at 35°C. After cooling of the mixture at ambient temperature, 41 mL of acetic anhydride and 0.6 mL of H_2SO_4 were added and is maintained at ambient temperature during 15 min, then the temperature was increased to reach 50–55°C, and the reaction continues during 3 h. Finally, the mixture was filtered, washed by distilled water, dried at ambient temperature then in the oven at 50°C for 24 h to obtain cellulose acetate.

2.3. Preparation of the Composites

PVC powder and the various additives were placed in a high-speed twin steel-wall mixer and processed at a speed of 3000 rpm at 70°C, below the glass transition temperature of PVC. The different PVC formulations obtained were used to prepare films by the calendaring process (**Table 1**). The temperature of the two rolls was maintained at 140°C. All the samples were performed in a preheated press at 170°C under a pressure of 250 KN.

3. Methods

3.1. Fourier Transforms Infrared Spectroscopy (FTIR)

FTIR spectra of the untreated and treated WH fiber were recorded using an FTIR HIMADZU FTIR-8400S in the range of 4000–400 cm^{-1} with a resolution of 4 cm^{-1}. The samples were analyzed using the KBr pellet method.

