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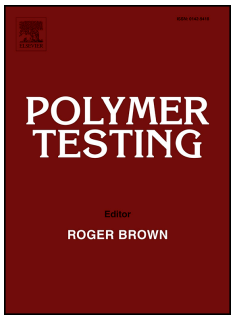

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Wear behavior of straw fiber-reinforced polyvinyl chloride composites under simulated acid rain conditions

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Abstract

In order to investigate the effect of simulated acid rain (SAR) corrosion on the wear-resistance properties of straw fiber/polyvinyl chloride (SPVC) composites, four types of straw fibers (wheat straw (WS), rice straw (RS), corn straw (CS), and sorghum straw (SS) fibers) were utilized and incorporated into poly(vinyl chloride) (PVC). The results show that the SS fibers have high levels of cellulose, lignin and crystallinity, and it also exhibited high adhesion strength with PVC matrix, which endow the SS/PVC with high wear-resistance compared with other three SPVC composites. After SAR corrosion, SPVC composites exhibited severe degradation of the physical, mechanical, and thermal properties, and the fibers were easily pulled out from the matrix to form abrasive particles. The high-speed fiber debris in high-temperature and high-loading environments can be deemed a kind of “incompressible lumps” that will form a certain abrasive wear.

Keywords: Straw fibers; Polyvinyl chloride; Acid rain; Corrosion; Wear

1. Introduction

Wood-plastic composites (WPCs), consisting of natural fibers embedded in a polymer matrix, are a type of natural-fiber composites (NFCs). Compared with other reinforcement materials, such as glass, carbon fibers, and other inorganic reinforcements, used in composites, natural fibers are abundant, lightweight, nontoxic, and ecofriendly. Thus, natural fibers endow WPCs of low cost, low density and environmentally-friendly which could be applied in various field (roofline products or wall cladding). However, the practical application of WPCs have been hindered by their poor durability, and which is directly or indirectly affected by the environmental factors, such as temperature, moisture, fungi, freeze-thaw action or a combination of these agents [1]. Previous studies have shown that WPCs can suffer physical and mechanical deterioration (color fading, surface roughing, weight loss, and dimensional deformation) when exposed to outdoor conditions [2-4]; by controlling moisture absorption, the degradation that occurs during weathering and fungal attack could be controlled [5,6].

A large number of studies on WPCs have been published; most of these works have focused on the relationship between the interfacial bonding in WPCs and their functional performance [7,8]. Researchers have also investigated how these composites are affected by the structures and chemical compositions of the natural fibers [9], surface modification of raw materials [10,11], manufacturing techniques and conditions employed [12,13], and types of polymer matrices used [14,15]. These published works aimed to improve the physical and mechanical properties of WPCs used in structural applications, so that WPCs could compete with natural woods. However, the wear behavior of WPCs is a relatively novel area of study, which could be considered to encompass three separate components, namely the wood, polymer, and WPC. Individually, the wear behaviors of woods [16,17] and polymers [18-23] have been extensively studied, whereas reports on WPCs have rarely been published [24-27]. This suggests that the wear behavior of WPCs can be further investigated, especially given the lack of experimental data regarding the wear behavior of WPCs under acid rain environments.

The aim of the present study is to evaluate the wear behavior of straw fiber/polyvinyl chloride (SPVC) composites under two typical water conditions, namely normal rain and acid rain. These experimental results will help to broaden the outdoor applications of SPVC composites, and also aid engineers in the design of WPC material formulations with high wear resistances.

2. Experimental procedure

2.1. Materials

Four different types of straw fibers, namely wheat straw (WS), rice straw (RS), corn straw (CS), and sorghum straw (SS) fibers, were collected from local farmland in Nanjing, China. The SG-5 PVC powder was purchased from Xinjiang

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