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Effect of Preservative Pretreatment on the Biological Durability of Corn Straw Fiber/HDPE Composites

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Abstract: The effects of alkaline copper quaternary (ACQ) and zinc borate (ZB) on the resistance of corn stalk fiber (CSF)-reinforced high-density polyethylene (HDPE) composites to biodegradation were examined. Both biocides could inhibit termites, mold fungi, and wood-decay fungi, even at high CSF formulations (i.e., 60%). Additionally, ACQ enhanced the resistance of the composite materials to certain biotic stresses better than ZB. The CSF/HDPE composites treated with ACQ at the 3.0% level exhibited a superior performance against termites, white rot fungi, and brown rot fungi. ACQ treatment at the 1% level was optimal for inhibiting soft rot fungi. Furthermore, mold growth was not observed on ACQ-treated CSF/HDPE samples. The untreated CSF/HDPE composites were more susceptible to mold infections and decay than the untreated poplar/HDPE composites, likely because of an incomplete removal of the pith. The chemical features of the corn stalk may also have influenced these differences, but this possibility will need to be explored in future investigations. Furthermore, the CSF component of CSF/HDPE composites is highly susceptible to fungal attacks, with the soft rot fungus inducing the largest mass losses, followed by the white rot fungus, and then the brown rot fungus.

Keywords: corn stalk fiber; high-density polyethylene; alkaline copper quaternary; zinc borate; termite; mold; wood-decay fungi

1. Introduction

Corn is an important agricultural crop in northeastern China, and its annual production in the Heilongjiang province of 33.43 million tons accounts for more than 14.5% of the total yield in China [1]. Corn stalks, which are the agricultural residues of corn crops, comprise more than half of the crop yield. With an annual production of nearly 207 million tons, corn stalks have been burned in large quantities on farmlands, producing seasonal smog and aggravating the air pollution in China [2]. Agricultural fibers, such as corn stalk [3–5], sunflower stalk [4] and oilseed stalk [5], contain an abundance of lignocellulosic fibers, making them a potential raw material for manufacturing composite materials.

Because of a shortage of available wood resources and the detrimental environmental impact of burning agricultural residues, studies have been conducted over the last few decades regarding agricultural fiber-based composites in China [6,7]. One viable solution involves using agricultural residues as raw materials for making agricultural fiber-plastic composites (AFPCs). At similar densities, AFPCs are comparable to wood-plastic composites (WPCs) regarding their physical and mechanical properties [8–10]. The potential benefits associated with recycling agricultural residues to produce