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成绩报告单

CET®

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考试时间：2024年6月

总分	听力 (35%)	阅读 (35%)	写作和翻译 (30%)
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Sustainable engineering polymer composites fabricated using delignified bamboo fiber as reinforcement and walnut shell powder as filler

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ABSTRACT

Developing sustainable engineering materials using renewable resources and agro-wastes represents an effective method for reducing carbon emissions and environmental pollution. In this study, a novel approach to fabricating high-performance biomass-based polymer composites was presented. Specifically, partially delignified bamboo fiber (DBF) and walnut shell powder (WSP) were incorporated into the matrix, namely melamine-hexamethylenediamine-urea (MHU) resin which was previously known for its excellent interfacial compatibility. Mechanical property investigations show that the DBF, acting as the reinforcement, provided the hybrid composites with high flexural and tensile strength up to 220 and 120 MPa, respectively, greatly surpassing those of commercial wood-plastic composites, wood-based composites, and natural wood, making them promising structural materials. As the filler, walnut shell powder endowed the composites with high hardness (Shore D > 90) and an appealing mirror-like surface gloss. Owing to the protection provided by the MHU matrix, the composite containing 38 % MHU exhibited outstanding flame retardancy (UL 94-V0 grade), which was further supported by cone calorimeter test (CCT) results. An unexpected and intriguing finding is that the composites exhibited fluorescence under UV irradiation. The rare silvery-grey fluorescence color imparted self-anticounterfeiting property to the composites. This study demonstrated the significant potential of bamboo fiber and walnut shell in the development of sustainable engineering materials.

1. Introduction

Composite materials in engineering are extensively utilized across various industries owing to their beneficial features such as lightweight, high strength, and exceptional environmental durability [1]. However, mounting concerns regarding environmental pollution and the depletion of fossil resources have sparked increased interest in the development of sustainable composite materials [2]. In particular, the reinforcements and fillers derived from biomass have demonstrated considerable potential in the creation of environmentally friendly composites [3]. Among various bioresources, agro-wastes have come to the forefront. Global agricultural production yields billions of tons of agro-wastes annually [4]. Due to the absence of efficient utilization strategies, these agro-wastes are typically either incinerated or disposed of in landfills, leading to severe environmental pollution. Consequently, repurposing agro-wastes and transforming them into high-performance, high value-added materials would offer substantial environmental and economic benefits.

Walnut shell is one of the bulky agro-wastes. According to recent statistics [5], global walnut production reached 2.31 million tons in 2022, and approximately 67 % of the walnut mass, predominantly in the form of shells, is either discarded into the environment or incinerated. Due to its substantial lignin content (32–44 %) [6], relatively high density, and a unique interlocked packing polylobate sclereid cell microstructure, walnut shells possess high hardness and stiffness [7,8]. As such, walnut shells are well-suited as biomass reinforcement or filler for composites, whether in particle or powder form. Several studies have demonstrated that the incorporation of ground walnut shells enhanced the thermal insulation capacity of both thermoplastic and thermosetting matrices [9], while also increasing stiffness and hardness [10].

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