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Research Article

Thermomechanical Properties of Jute/Bamboo Cellulose Composite and Its Hybrid Composites: The Effects of Treatment and Fiber Loading

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Jute cellulose composite (JCC), bamboo cellulose composite (BCC), untreated hybrid jute-bamboo fiber composite (UJBC), and jute-bamboo cellulose hybrid biocomposite (JBCC) were fabricated. All cellulose hybrid composites were fabricated with chemical treated jute-bamboo cellulose fiber at 1 : 1 weight ratio and low-density polyethylene (LDPE). The effect of chemical treatment and fiber loading on the thermal, mechanical, and morphological properties of composites was investigated. Treated jute and bamboo cellulose were characterized by Fourier transform infrared spectroscopy (FTIR) to confirm the effectiveness of treatment. All composites were characterized by tensile testing, thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC). Additionally, surface morphology and water absorption test was reported. The FTIR results revealed that jute and bamboo cellulose prepared are identical to commercial cellulose. The tensile strength and Young's modulus of composites are optimum at 10 weight percentage (wt%) fibers loading. All cellulose composites showed high onset decomposition temperature. At 10 wt% fiber loading, JBCC shows highest activation energy followed by BCC and JCC. Significant reduction in crystallinity index was shown by BCC which reduced by 14%. JBCC shows the lowest water absorption up to 43 times lower compared to UJBC. The significant improved mechanical and morphological properties of treated cellulose hybrid composites are further supported by SEM images.

1. Introduction

Cellulose is the world's most abundant natural raw material with renewable sources for composite fabrication. Natural cellulose fibers have attracted global researchers owing to their unique properties such as biodegradability, low weight, easy availability, easy processing, being environmental friendly, flexibility, high strength, and stiffness [1–3].

Jute is commonly grown in India, China, and Bangladesh. Jute fibers contain mainly cellulose (58~63%), hemicellulose (20~24%), and lignin (12~15%) [4]. It has been used as packaging material, geotextiles, household textiles, and carpet backing. Bamboo is a fast-growing species and a high-yield renewable resource. Bamboo fiber consists of cellulose (73.8%), hemicellulose (12.5%), lignin (10.1%), pectin (0.4%), and aqueous extract (3.2%) [5]. Bamboo fibers have been widely used in the household, transport, and composite manufacturing industries [6]. However, all cellulose fibers have similar drawbacks which include being polar, hydrophilic in natural, low thermal stability and poor compatibility with polymer matrix. Those limitations contributed to weak fiber-matrix interfacial bonding, leading to decrease in mechanical properties [7].

To improve the interfacial bonding, researchers have attempted various surface treatments, such as alkali treatment [8–10], silane treatment [11, 12], acetylation [13], and different coupling agents. Among various treatments, alkali treatment has been found to be most effective method [14, 15]. The surface treatments of cellulose fibers provide advantages which include increased hydrophobicity, increased surface roughness, reduced water uptake, and increased reactivity towards polymeric matrices [16, 17]. Alkaline treatment or