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Communication

Effect of Fiber Treatment and Nanoclay on the Tensile Properties of Jute Fiber Reinforced Polyethylene/Clay Nanocomposites

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Abstract: The tensile properties of chemically treated jute fiber reinforced polyethylene/clay nanocomposites were investigated. Nanocomposites were prepared using hot press moulding technique by varying jute fiber loading (5, 10, 15 and 20 wt%) for both treated and untreated fibers. Raw jute fibers were chemically treated with benzene diazonium salt to increase their compatibility with the polyethylene matrix. Physical and mechanical properties were subsequently characterized. Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM) analysis was utilized to study physical properties. Tensile test was conducted for mechanical characterization. FTIR and SEM study showed interfacial interaction among jute fiber, polyethylene and nanoclay. It was observed that at optimum fiber content (15 wt%), treated composites exhibited improvements in tensile strength and modulus by approximately 20 % and 37 % respectively over the raw ones. On the other hand, this composite exhibited improvements in tensile strength and modulus by approximately 8 % and 15 % respectively over the composites without nanoclay. However, treated jute fiber reinforced composites showed better tensile properties compared with untreated ones and also nanoclay incorporated composites enhanced higher tensile properties compared without nanoclay ones.

Keywords: Jute fiber, Chemical treatment, Nanocomposites, Tensile properties, FTIR, SEM

Introduction

As a result of the increasing demand for environmentally friendly materials and the desire to reduce the cost of outdated fibers, many natural fiber composites have been developed [1,2]. Natural fibers such as banana, cotton, coir, sisal, and jute have attracted the attention of scientists and technologists for applications in consumer goods, low-cost housing, and other civil structures [3]. Jute performs relatively better properties among the others natural fibers because of it are relatively inexpensive and commercially available in a required form. It has higher strength and modulus than plastic [4] and is a good substitute for conventional fibers in many applications and has been applied as reinforcement to eco-composites and bio-composites. The compositions of jute fibers include mainly cellulose (45.0-71.5 wt%), hemicelluloses (13.6-21.0 wt%), and lignin (12.0-26.0 wt%) [5]. The elementary units of cellulose macromolecules are anhydro-d-glucose which contains three hydroxyls (-OH) [6]. These hydroxyls form the hydrogen bonds inside the macromolecule itself (intramolecular) and between the other cellulose macromolecules (intermolecular) as well. Therefore, the fibers are hydrophilic in nature, and their moisture contents can reach up to 3-13 % [7], which is one of the reasons for the degradation of the fibers. As with most of the other plant-based natural fibers, cellulose forms the main structural components, lignin and hemicelluloses also play an important part in determining the characteristic properties of the fibers.

In spite of the good properties of the natural fibers, one difficulty that has prevented a more extended utilization of natural fibers is the lack of strong adhesion to most polymeric matrices [8]. Natural fibers are highly hydrophilic because of the presence of hydroxyl groups (OH) of anhydroglucose repeating units in the cellulose structure [9]. The hydrophilic nature of natural fibers adversely affects adhesion to a hydrophobic matrix, and as a result, there may cause a loss of strength. Natural fibers are covered with pectin and waxy substances, thus hindering hydroxyl groups from reacting with polar matrices and forming mechanical interlocking adhesion with non-polar matrices [10]. In order to remove non-cellulosic constituents to produce reactive hydroxyl groups for interacting with the polymers, the surface characterization of plant fibers need to be modified by chemical treatments [5,11]. The surface treatments can increase the surface roughness of the fiber and also alter the crystalline structure of the cellulose as well as fiber tensile properties [9,12]. The chemicals or coupling agents used hereby contain chemical groups where one group can react with the fiber and the other one with the polymer. The bonds are covalent and hydrogen bonds improve the interfacial adhesion [13]. In this study, the chemical surface treatment of jute fibers was carried out using benzene diazonium salt in an alkaline medium to improve interfacial adhesion between fiber and matrixes as well as to reduce the hydrophilic nature.

The matrix phase plays a vital role in the performance of polymer composites. Both thermosets and thermoplastics are

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