Chapter 6
Design, Development, and Testing of Eco-Friendly Natural Fiber-Reinforced Composites for High Temperature Applications:
Eco-Friendly Biocomposites

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ABSTRACT

In recent years, there has been a growing demand for development of eco-friendly material for long-lasting, lightweight, superior strength and fire retardant. This drawn the researchers to use various natural fiber as a reinforcing agent in a matrix material. The use of bio-fibers as reinforcement in place of synthetic fibers (carbon and glass fiber) in the creation of polymer matrix composites has garnered a lot of interest in the last few years. Several natural fibers have been exploited as reinforcing materials by researchers in the past. Excellent adhesion to various materials, high strength, toughness, resistance to chemical assault, humidity, and moisture resistance, superior electrical insulating properties, odorlessness, non-toxicity, and minimal shrinking are only a few of the qualities of epoxy resin to be used a matrix material. Information regarding environmentally acceptable materials that can be used in high-temperature applications is needed by numerous sectors.

INTRODUCTION

Biocomposites derived from biofibers and biopolymers are known as eco-friendly composites. Eco-friendly composites are widely used in various sectors because of their biodegradability and low environmental effect. In contrast to synthetic composites, eco-friendly composites may be readily disposed of and recycled at the end of their useful lives without having a negative environmental impact.

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Biocomposites made from biofiber and biopolymers are therefore very appealing since they may provide the necessary features and attributes at a fair price. The increasing demand for the use of nonrenewable resources has led to recognition of eco-friendly products, recycling, and reuse by the scientific and industrial communities. Eco-friendly composites comprise of matrix material and reinforcing fiber in addition to fire retardant and other mixer to enhance the applicability at higher temperature. Hemp, wood, basalt, rice husk, coir, sisal, ramie, flax, kenaf, jute, and other biofibers have garnered a lot of attention as possible substitutes for synthetic fibers like carbon and glass as a reinforcement material (Andrew and Dhakal (2022). Important findings about the methods of use, manufacturing, and potential directions for future development are found in literature [Michael et al (2014)]. However, because of a number of disadvantages, including poor moisture resistance, poor adhesion quality with many matrix materials, flammability, difficult manufacturing, poor bond strength, and highly anisotropic mechanical properties, the fibers are not a perfect substitute for glass fiber or other reinforcing materials or particles. Generally all biofibers contains huge amount of cellulose, hemicelluloses, pectin, lignin, etc. These constituents make the fiber hydrophilic, as a result the resulting composites has a limited application. Many strategies, including surface modification techniques, hybridization strategies, and nano-engineering, have been used to address these issues. Even with several studies, it still requires understanding the structurally and morphologically when these methods are applied.

In recent years, the demand of bio-composites for high temperature application has gained the demand by many industries for different applications such as aerospace, automobiles, etc which are generally fulfilled by thermoplastic polymers and reinforced with glass fiber, carbon fiber, etc. These materials are not environmentally suitable and induced several after use issues to the society. Environmental pollution including water pollution is due to the use of such plastics or thermoplastic made components. This chapter briefly discussed the feasibility of manufacturing ecofriendly biocomposite for high temperature application. Material design, fabrication process, and different testing methodologies are presented. The main factors that affect the thermal properties of natural fiber reinforced composite such as fiber type, matrix material, fiber orientation, filler material, manufacturing process, etc was presented.

BIOFIBERS

Natural fibers are derived from many sources such as plants, leaves, seeds, animals, minerals, microbes, etc. Man-made synthetic fibers are often produced by petrochemicals or other chemical processes. Natural fibers are costly and less long-lasting, but they are often more biodegradable, and ecologically beneficial. Although synthetic fibers are generally more affordable, strong, and wear-resistant, they also have a greater environmental effect since they are frequently not biodegradable and are derived from fossil fuels. Natural fibers are classified as plant based fibers, animal based fibers, and mineral based fibers. Classification of different plants based natural fibers is shown in Figure 1. The structure of biofibers may vary depending on their origin, but they show some common characteristics. The primary elements of most plant fibers, with the exception of cotton, include cellulose, hemicelluloses, lignin, waxes, and a few water-soluble substances (Bledzki & Gassen, 1999).These constituents of fibers have different functions. The fibers are essentially an amorphous lignin and/or hemicellulose matrix reinforced with a stiff, crystalline cellulose microfibril. The chemical structure of bio-fibers is shown in Figure 2. The chemical structure of cellulose shown in Figure 2(a) consisting of three OH groups, two of them form hydrogen bonds within the cellulose macromolecules and third one form hydrogen bond with other

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