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Materials Prepared from Thermosetting Resins and Natural Fibers: Bio-Composites

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ABSTRACT
In this study banana and coir fibers were selected as reinforcement materials extracted manually for bio-composite preparation. The extracted fibers were treated by following the mercerization process to improve surface roughness. The treated fibers exhibited good adhesion properties with the thermosetting resins. Open casting and hand lay-up technique was used for preparing the biocomposites. As the more fibrous nature of natural fibers, compression or vacuum casting process is needed for the good structure of bio-composites.
Keywords: Natural fibers, Alkaline treatment, Bio-composites

I. INTRODUCTION

Bio-composites, for example, are composite materials made from natural sources, and their research and marketing are thought to be of utmost importance since they will lessen reliance on materials made from non-renewable resources and are preferable for both environmental and financial reasons. Numerous studies have been conducted recently with the intention of creating composite materials that are reasonably affordable, have good performance, and have a minimal environmental impact (Ramires, et al., 2010). Because they are safe for the environment and a solution to the issue of petroleum supply, lignocellulosic fibers are particularly appealing for use in manufacturing. Jute, coconut, sugarcane, cotton, bamboo, sisal, and curaua are just a few of the natural fibers that have been used to reinforce composite materials in recent years. Natural fibers are strong, lightweight, and non-abrasive, making them great reinforcing materials for thermos-plastics and thermosetting resins. Natural fibers are used in applications that are economically appealing because of their low cost and variety of sources (Barbosa, et al., 2010).

cellulose, hemicellulose, and lignin are the main components of lignocellulosic fibers like bamboo, banana, and coir. Hemicelluloses are copolymers of various monosaccharides, and cellulose is made up of a linear chain of linked cellobiose. Three fundamental units, in various ratios, make up the structure of lignin. If the matrix possesses hydrophobic characteristics, the hydrophilic properties of lignocellulosic fibers, which are predominantly a result of hydroxyl groups, can present a problem in the creation of composites that they reinforce (Megiatto, et al., 2008). The treatment of natural fibers improves the adhesion characteristics to eliminate the incompatibility between hydrophilic natural fibers and hydrophobic polymers (Mutasher, et al., 2011, Shalwan and Yousef, 2014). This paper provides the treatment of fibers and the biocomposite preparation process with natural fiber reinforcements and thermosetting resins.

II. EXPERIMENTAL

1.1. Materials

Banana spices (Musa Balbisiana colla) were selected and fibers were extracted by using the boiling and hand stripping method. The banana stem layers were boiled for 2 h. After cooling banana stem layers, the fibers were extracted by hand scraping using 0.15 m long blunt blades on a soft wooden plank. The pith was then removed continuously until the fibers appear clean. The extraction of the banana fiber from the stripped layer sheath cut to a size of 0.5–0.9 m long and 0.06 m wide. The yield was obtained 200 to 300 g of each fresh pseudostem. Hand-stripped banana fibers are generally of better quality than those obtained by raspador, chemically, and soil retting (Chand and Fahim, 2021).

Coir fiber was extracted from locally available fully ripened dried coconut sheath by retting process. To separate the fibers, the coconut sheath was boiled for 2 h and then buried in wet

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soil for 30 days to allow microbial degradation of the softer tissues. The degraded sheaths were then beaten with sticks and washed to separate the coir fibers and pit. The length of fibers varied from 0.095 to 0.2 m.

These coir fibers (cocos Nucifera) and banana fibers (Musa balbisiana) were selected as reinforcement material and polyester resin as a matrix material for this study.

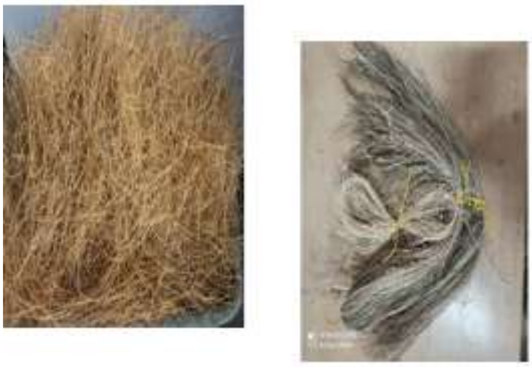

Figure 1: Natural fibers (a) banana fibers (b) coir fibers

1.2. Alkaline treatment of natural fibers

NaOH pellets were employed for the alkaline treatment. With a 5% concentration of NaOH aqueous solution made with distilled water, selected natural fibers were treated for 24 hours at room temperature. The dissolve sodium hydroxide with distilled water will create an aqueous solution. Treated fibers were washed with distilled water until they return to pH 7 to 7.5. After that, treated fibers were dried at 105^{o}C for 24 hours in the oven to remove the moisture content. Alkaline treatment, also known as mercerization, can remove the lignin, hemicellulose, wax, and oils that cover the fiber surface as well as shrink the diameter of the fibers (Ismail et al., 2021). The treated fibers were shown in figure 2.

Figure 2: alkaline treated fibers (a) Banana fibers (b) coir fibers

III. BIO-COMPOSITE PREPARATION

Open casting and hand lay-up technique was used in the current experiment to fabricate the bio-composite. The polyester resin was mixed with 0.3% of cobalt naphthenate, silica powder, and 5% of MEKP as an accelerator, a filler material, and a catalyst, respectively. The weighed natural fibers were arranged bi-directionally (90° and 90°) in the mold. The matrix solution (resins) was mixed properly with the silica powder and kept in the oven at a temperature of 90 ±10°C for two hours as per the recommendation of Singh et al., 2015 and D'SOUZA 2015. The solution has been taken out at the interval of 30 minutes from the furnace and steered manually. After two hours, the whole solution was taken out and kept aside to cool up to the temperature of 45°C. At this temperature catalyst (5 % MEKP for polyester) was added to the resin mix and manually stirred for 3 minutes. The stirred mixture was immediately poured into the mold cavity at room temperature. The mixture was evenly spread throughout the mold and the surface was closed by the aluminum wrapper. When needed, the pressure was applied over the specimen for proper settling of resin with the reinforcements and to avoid an air gap between them. Casting was allowed to solidify for 24 hours at room temperature, followed by post-curing in an oven at 80°C for 4 h. post-curing helps the relieving the internal stresses, refines the structure by making it homogeneous, and induces the ductility of specimens. And also prolonged curing time gives slightly better thermal stability and thus constant mechanical properties over a large range of temperatures (Singh and Gope, 2010, Rizal et al., 2021). The obtained composites were cooled to ambient temperature in a desiccator containing granulated silica gel. The prepared bio-composites were shown in figure 4.

Figure 4: Natural fiber-reinforced bio-composites

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IV. CONCLUSION

The yield of banana fibers extracted manually was obtained from 200 to 300 g of each fresh pseudostem with 0.5 to 0.9 m long and 0.06 m wide. The coir fiber length varied from 0.095 to 0.2 m long. The alkaline treatment of natural fibers improved the surface roughness and removed the wax, oils, and dust particles from the surface of the fibers. the color of natural fibers exhibits yellowish color after the treatment. the surface roughness of natural fibers improved the adhesion between the reinforcements and matrix material. Due to the more fibrous volume of natural fibers, compression pressure is necessary to get a proper composite structure during composite preparation.

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