A Survey About an Extraction of Fruit Fibers from Borassus Flabellifer L and Composite Characteristics

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Abstract - Natural fiber reinforced composite materials are used to develop the best outcome materials because of their easy availability, capacity to be recycled, and environmental friendliness. Both urban and rural areas can benefit from the products developed from this material. Borassus flabellifer L fruits, leaves and leaves stems are utilized economically, and part of them is thrown away as trash. This Borassus Flabellifer byproduct can be used as a source of fibers and as the primary component of natural fiber polymer composites with reinforcement. This article aims to provide a thorough understanding of Borassus fibers and their composites. Studies have been done on Borassus fibers and its composites' chemical, mechanical, thermal, and morphological characteristics as well as alkali treatment approaches and various production methods. Overall, this review paper analyzes and pinpoints gaps in the earlier studies' work, and it offers valuable data for additional investigation in various streams using reinforcement from Borassus fiber.

Keywords - Natural Fiber Reinforced Polymer Matrix Composites, Alkaline Treatment, SEM Analysis, Laminated Composites.

I. INTRODUCTION

Natural fibers are utilized in composite laminates because they are commonly available, ecofriendly, economic, and biodegradable. Natural fiber-based goods successfully adhere to the current green production ethos. The attention in the academic and industrial sectors has recently shifted to natural fiber-based goods. While being more common in India, Borassus fruit palm trees may be widespread across the globe [1]. These fruits have fibers from the Borassus fruit that help to enhance their semisolid appearance. The fibers from this fruit are discarded after it has been consumed as food. Because the fibers from the fruit of the tree is inexpensive, renewable, and environmentally beneficial, it is crucial to investigate their possibilities in the technical world. Based on the survey, the main objective of this work is to scrutinize the characteristics of the Borassus flabellifer L which is also named by palmyra palm fruit fibers with and without chemical treatment and present them as a natural reinforcement to composites. [2]

II. NATURAL FIBER COMPOSITE

From the dawn of modern civilization, natural fibers and their composites have been used in a variety of applications because they are less dense, more corrosion resistant, and stronger, have a higher modulus, require less maintenance, and are more environmentally friendly than synthetic fibers. By combining natural fibers along with a thermoplastic or thermosetting polymer that offers high strength and stiffness, natural fiber-reinforced composites may be created [23]. As renewable reinforced composites, natural fibers are utilized to make composite parts for construction, sports, automobile, and other sectors. The length, treatment, adherence to the matrix, and the fiber inside the matrix all affect the characteristics of composites with fibre reinforcement. Natural fiber surfaces are improved and moisture uptake is reduced when chemical and physical treatment procedures are used.[3]

The matrix material is essential for the effectiveness of polymer composites. Both Thermoplastic materials and thermosets are viable options for composite matrix materials [28]. Because to the large number of ingredients employed, including base resin and hardeners, the creation of thermoset composites is challenging. Chemical curing of these composite materials creates a three-dimensional, highly cross-linked network structure. Strong, hard, and creep-resistant cross-linked structures with good solvent resistance. Up to 80% of the fibers may be loaded, and the characteristics are noticeably improved due to the alignment of the fibers. The fibers' characteristics, their aspect ratio, and the fiber-matrix interaction control the composites' characteristics. The fiber's and the polymer's surface adhesion, which is essential in the distribution of stress to the fibre, affects the performance of the composite.[4]

The current experimental inquiry is to comprehend how natural fibre composites respond mechanically. Natural fibers are gaining popularity as a replacement reinforcement among engineers, research scholars, experts, and scientific experts across the globe due to their superior qualities such as high strength, less weight, high mechanical properties, eco-friendly, and biodegradable[30].A fast evaluation was conducted to use of natural fibers that are available in India, such as abaca, jute, sisal, banana, cotton, coir, hemp, and so on. The mechanical properties of Borassus flabellifer are discussed in this essay.[5]

III. BORASSUS FLABELLIFER

In South Asia, Borassus flabellifer is extensively distributed. It develops quite slowly and takes more than 15 years to mature and produce an inflorescence. The Borassus flabellifer has a trunk diameter of up to 1.3 meters/s and can reach heights of up to 20 meters. Its thick mass of long adventitious roots that are bordered with small petiole scars at the base of the plant. It produces one leaf every month, each of which is split into 60–70 segments and is 3 m broad, making it a good source of raw material for a variety of industrial uses. Petioles range in length from 0.7 to 1.2 meters and have woody fibers and serrated borders. The leaf's laminas are divided along their radii, and each one has around 30 duplicate leaflets. The four most popular Borassus flabellifer species include coryphe, sabal maritima, and Raphia farinifera, often known as the raffia palm.[6]

We used various strengths of aqueous sodium hydroxide solutions to treat the fine fibers of Borassus fruit. In every situation the tensile characteristics of fibre is noted. Using a scanning electron microscope, morphologies were compared. Due to alkali treatment, the surface of the fiber turned rough. Moreover, the amount of char content was found in fibers that was treated with alkali at concentrations of 15percent and higher. According to the chemical composition, the amount of -cellulose was at its highest when 15percent aqueous solution of sodium hydroxide was applied to treat the fibers, and it then started to decline, suggesting that the fibers were starting to degrade at greater concentrations. Consequently, 15% was found to be the ideal NaOH concentration for alkali-treating Borassus fibers.[7]

In recent years, the use of eco-friendly composites has grown in popularity due to their relative lightness and moderate strength. Natural palmyra fibre is derived from the palmyra (Borassus flabellifer) tree. Studying the mechanical characteristics of composites made of randomly mixed short fibers, ideal fibre length and weight percentage estimates are made. This study examines the characteristics of hybrid composites made from palmyra and glass fibers that were blended at random. The preparation of two different specimen kinds involves sandwiching palmyra fibre between glass fibre mats and combining palmyra and glass fibre in one case. Several weight ratios of glass fiber and palmyra are used to make composite plates. As a matrix, roof lite resin is utilized. The use of glass fibre in addition to palmyra fibre in enhances the composites' mechanical characteristics. Studies on moisture absorption are carried out, and the outcomes are displayed. The matrix's ability to absorb moisture is decreased when glass fibre and palmyra fibre are added.[8]

IV. FIBER’S EXTRACTION

The species of the Borassus fruit, Borassus flabellifer L, is a member of the Aceraceae family. Fruits that were dried and matured were used to create the Borassus fibers. The black skin was removed after the fruits had been submerged in water for two weeks. The fruit nut was edge to edge with coarse fibers, while the fruit shell was covered with fine fibers [24]. Both kinds of fibers were properly cleaned with normal water and then boiled water before being dried for a several days in sun light. The moisture was then removed from the fibers by placing them in a hot air furnace for more than 20 hours at 105–110° C. [9]

After weeks of submerging the fruits in water, the darkcell was gone. Under it, two types of fibers were discovered: large fibers and small fibers. The large fibers were distributed throughout the edges of the fruit nut, whereas the microscopic threads were attached to the fruit's shell. Both kinds of fibers were properly cleaned with normal water and then boiled water before being dried for a several days in the sun light. The moisture was then removed from the fibers by placing them in a hot air furnace for more than 20 hours at 105-110C. In order to eliminate the hemicellulose and other oily elements, a part of the Borassus fibers were treated at ambient temperature with a 5percent aqueous NaOH solution while maintaining a ratio of 30:1. The fibers were then placed in NaOH solution for 30 minutes. The fibers were thereafter repeatedly rinsed in water. The fibers were then dried in a hot air furnace for more than 20 hours after being cleaned with boiled water.[10]

Chemical Treatment

The primary problems with natural fibre composites are caused by the hydrophilic of the nature fibre and the hydrophobicity of the matrix. These two phases' intrinsic mismatch causes the interface's connection to deteriorate. Reducing the hydrophilic propensity of reinforcing fibre by chemical treatments can increase matrix compatibility. Many research projects have been carried out to enhance the matrix adhesion qualities of the fibers by chemical processing of certain of the natural fibers (1) Alkaline treatment (2) Silane treatment (3) Acetylation treatment (4) Benzoylation treatment (5) Peroxide treatment (6) Sodium chlorite treatment (7) Acrylation and acrylonitrile grafting. This process cleans and roughens the surface of the fibre by removing surface particles.

Alkaline Treatment

The most popular NaOH treatment for natural fibre is this one. This covers four possible techniques, including 1) using a constant NaOH concentration for a fixed amount of time, 2) using various NaOH concentrations for a certain amount of time, and 3) maintaining a constant NaOH concentration throughout a range of NaOH concentrations. To find the ideal circumstances for natural fibre alteration, the second and third practice procedures are the most often used treatments. The fibers should be treated with 2% to 5% (w/v) NaOH solutions at various NaOH concentrations for a continuous amount of time while liquor ratio is 20:1 that allows the removal of other fatty substances. The fibers are neutralized, washed, and dried after this chemical procedure. The Borassus fibers are kept in a 5% NaOH solution for maintaining a constant NaOH concentration. A few drops of 0.1 N hydrochloric acid are then added after the treated natural fibers have been rinsed with deionized water to eliminate any remaining contaminants.[11]

The fibers from the Borassus fruit were treated with 8 hours in a 5% sodium hydroxide solution to assist them in overcoming hydroxyl bonding, enhance fiber-matrix bonding, and get rid of surface impurities. They were then rinsed with normal water and dried for more than 20 hours at 105°C in afurnace. Chemical analysis was used to assess the percentage of cellulose. After subjecting the fibers of the Borassus fruit to 5%, 10%, and 15% in NaOH solution for 60 minutes and washed with normal water. Also, the dried Borassus fruit fibers were treated for 8 hours at room temperature with 4, 8, and 12% sodium hydroxide solutions. Then fibers were roasted in a furnace for more than4 hours at 100 C. Then dipping the fibre surface in sodium hydroxide solution for 4 hours, to eliminated the wax and hemicellulose from the outer layer. After washing the fibers with tap water and neutralizing them with 2.5% diluted hydrochloric acid, they were then rinsed with distilled water to eliminate the extra HCl acid. To eliminate the excess moisture, the fibers were then dried for 24 hours while being stored in a 50°C oven.[12] **Fig 1** shows Fiber treated with 5% NaoH, 10% NaoH and 15% NaoH.

Fig 1. Fiber treated with 5% NaoH, 10% NaoH and 15% NaoH[29]

Three equal weight portions were made from the acquired fibers. These three fibre groups underwent various time periods of treatment with 5% NaOH solution. Each group receives treatment for two hours, four hours, and six hours, respectively. By removing moisture from the fibers through chemical processing with NaOH, the fibers' strength is increased. The molecular orientation is stabilized and all contaminants that are near the fibre material are removed by the chemical treatment. Following the alkali treatment, the fibers underwent a thorough washing in distilled water before being allowed to air dry for a full day. Following that, these lengthy strands were sliced into small fibers of various lengths. Likewise, short fibers were also cut from the NaOH-treated fibers that had been exposed for 4 and 6 hours.[13]

V. PROPERTIES OF BORASSUS FLABELLIFER FIBERS

Cellulose, hemicelluloses, and lignin are the three primary components of cellulosic fibers in nature, which are hydrophilic. Physical treatment improves through mechanical, chemical, electrostatic, and interdiffusion bonding the wet ability and interfacial strength of fibers [25]. If the fibre surface is rough then Mechanical interlocking while occurs, and it enhances the strength of interfacial shear. Lignin, hemicelluloses, waxes, oils, cuticles, and other impurities that coat the surface of external fibers are some of the materials that are removed during the alkaline treatment of fibers by NaOH. Natural fibers can be treated with NaOH to ionize alcohol's hydroxyl groups. OH + NaOH for fibre Fiber O, Fiber O, and Na + H2O.

Chemical Composition

Chemical study has assessed the Borassus flabellifer fibers. Fibers from unprocessed Borassus fruit contain cellulose, lignin, and hemicellulose [22]. This fibre content has been determined to be 40-75% cellulose, 15-35% hemicellulose, and 5-25% lignin. Plant fibers are made up of three basic components: cellulose, hemicellulose, and lignin. According to several studies. The chemical makeup of the fibre from the leaf stalks of the Borassus flabellifer, or palmyra palm, was investigated by Shanmugam and Thiruchitrambalam. In the fibers of the palmyra palm leaf stalks, cellulose, hemicellulose, lignin, and wax were found to be present in amounts of 58.58%, 22.8%, 13.48%, and 0.35 percent, respectively.[14]

Following a brief description, the conventional approach was followed to conduct the chemical analysis of the fibers. The reweighed chopped fibers were dewaxed for three hours at 70°C using a 2:1 combination of benzene and ethanol. The dewaxed fibers underwent a 30-minute ethanol wash, followed by drying and weighing. The dewaxed, reweighed samples were cooked for 60 minutes in a 0.7% aq. NaCI solution with a ratio of 1:50. After a wash with sodium solution and boiled water, they were dried in a hot air furnace at 105° C. The lignin was eliminated in this process, and the weight difference that followed corresponded to the lignin concentration. To get rid of the alkali soluble hemicellulose, 17% aqueous sodium hydroxide solution was applied to the residual holocellulose (hemicellulose and beta-cellulose). The contents of hemicellulose and -cellulose were associated to losing weight and maintaining weight, respectively.[15]

Surface Morphology

The scanning electron microscope may be used to analyses the surface morphology (SEM). The Borassus fiber indicates the significant changes in surface that was treated with the alkali treatment [29]. The surface of the Borassus fruit fibers was investigated. In SEM pictures, they indicate that whereas the untreated raw Borassus fruit fibers were smooth, perfect, and free of leaves, the surfaces of alkali-treated fibers showed roughness and fibrils of the surface. The relationship between the polymer matrix and Borassus fibre has enhanced as a result of the taking away of hemicellulose and contaminants from the fibre, according to an examination of the SEM analysis of the fruit fibers.[16]

The requirement to rapidly conduct tests, make an appropriate design decision, and establish the motivating reasons behind this research were operating circumstances on a group of controllable factors that result in an optimum reaction. The use of linear polynomial models, primarily models of the first and second degrees, the fundamental concepts of the classical RSM are created [27]. Continuous response variables are considered to be, individually and normally distributed, and to have error variances that are constant. This approach has undergone a number of rounds of development meant to increase its applicability to a larger range of experimental circumstances. RSM is a group of statistical and mathematical techniques that may be useful for modelling and evaluating situations. As an illustration, suppose the researcher wants to determine the values of the two input variables x1 and x2 that will increase the process yield.[17]

VI. SEM ANALYSIS

SEM to evaluate the fiber's suitability as a reinforcement. By scanning with an electron beam directed over the surface and picking up the secondary or backscattered electronic signal, SEM produces precise, high-resolution pictures of the fibers. To avoid the potential buildup of electrical charges after analysis, the sample utilized for the SEM has to be coated with a thin coating of gold.[18] **Fig 2** shows (a) Raw fiber (b) Cross section of raw.

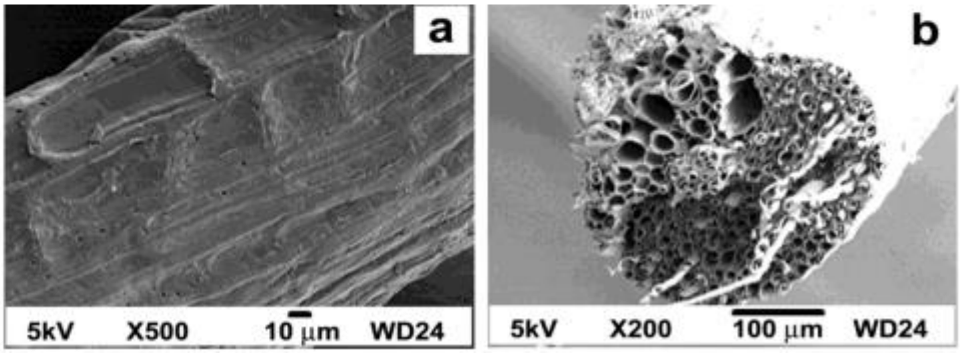

Fig 2. (a) Raw fiber (b) Cross section of raw fiber [31]

Scanning electron microscopes are the most effective tool for analyzing the composition of natural fibre (SEM). Untreated fibre exhibits Using composite reinforcement, there is low fibre adhesion, as has been seen Inadequate interfacial connection between matrix and fibre is caused by the weak fiber/matrix adhesion, which leads to poor mechanical characteristics of composites. reported that the composites' crystalline content and the contact between the Borassus fruit powder and polymer were both boosted by the alkali treatment of the powder [29]. SEM analysis was also used to evaluate the morphology of composites reinforced with fibers from the Borassus fruit. They looked at whether fibre surface modification might strengthen the connection between the reinforcement and matrix. It was discovered through SEM study of fibre composites made from Borassus fruit that stick between the fibre and matrix strengthens fibre composites whereas poor 57 fibre dilation and heap impair their mechanical characteristics. Displays SEM images of the composites made using fibers from the Borassus fruit that have been shattered at the interface. At various magnifications, SEM analysis was utilized to evaluate the surface of handled and unhandled coarse and fine fibers. In contrast to the cross section of the fibre, which shows multicellular structure, the SEM images of the treated fibers show roughening of the surface. Each fibre unit cell is made up of tiny cellulose particles that are bound together by lignin and hemicelluloses.

VII. PREPARATION OF COMPOSITE LAMINA

Uses of polymers (epoxy)

Due of their superior mechanical, thermal, and electrical properties, modified epoxy resins are used for manufacture of natural fibre reinforced composites [19]. The most appealing technique to change epoxy resin is to use natural fibers. In the past several years, both in the fields of engineering and research technology, interest in and applications for employing natural fibre as reinforcement in polymers have grown significantly. Borassus flabellifer are employed as reinforcements in the current work together with epoxy resin and hardener as the matrix material.[20]

Fabrication Method

Extrusion molding, open molding, injection molding, and compression molding processes are used to create natural fibre polymer composites. Polymer composites with short fibres are included using certain traditional techniques as hand lay-up molding are some examples. Nails were used to fasten wooden patterns with a thickness of 4 mm to a wooden board that measured 300 mm by 300 mm. Wax was then sprayed to the inside sides of the molds, allowing the composite to be released easily without adhering to the mold walls, once the molds had been produced to the requisite proportions. The matrix was then created by combining epoxy and hardener [26]. The hardener to epoxy ratio was held constant at 10:1. For around 10 minutes. The epoxy resin and hardener mixture were first poured into the bottom layer of the mold, and then the proper number of fibers was added, ensuring that the epoxy mixture covered the fibers entirely.

Open Molding Process

Composites and thermoset goods are produced via open molding. In this procedure, the gel coat is strengthened to prepare the surface for molding, and the previously gel-coated surface is then manually or spray-up onto. More addition of layers to increase hardiness as needed, and after that, air is removed from the lamina using a roller while leaving the mold to cure. This method may be utilized for any type of composite fabrication and for huge objects that cannot be made using automated techniques.

Product Fabrication

Palmyra fibber is sliced into little pieces after being thoroughly cleaned. It is not feasible to improve the qualities until they are completely blended. The epoxy resin and hardener are mixed together. To ensure appropriate mixing, this mixture was carefully swirled. The hardener has a greater density than epoxy, which makes combining the hardener with the epoxy easier. Oil poured to the tile also guarantees that the product has a high surface finish. The mold cavity was then put on the tile. The mold cavity was then filled with thoroughly mixed material. The cavity was filled with great care. The substance is removed from the cavity with care the laminated natural composite was allowed to dry. Then material is cut into pieces for various mechanical tests.

VIII. RESULT AND DISCUSSION

The proposed research will investigate the influence of process factors on the tensile strength of composites reinforced with short, randomly oriented Palmyra fibres. The following results are drawn from the experimental examination of the physical behavior of Palmyra fibre composites: Tensile strength (TS) of the Palmyra fiber - reinforced polymer composite material is significantly influenced by alkali treatment duration, fibre length, and fibre volume. The tension test is the most fundamental mechanical test. Tensile characteristics are crucial components of the material design permissible for the majority of structural materials. According to ASTM standards, the composite specimens underwent testing [21]. Tensile testing was performed in accordance with ASTM D 3039M using a Universal Testing Machine and a speed of crosshead is 2 mm in 60 sec, and to evaluate the tensile strength of composite samples, the results were analyzed.

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