

EFFECTS OF CHEMICAL TREATMENT ON CONSTITUENTS, TENSILE STRENGTHS AND MICROSTRUCTURAL CHARACTERISTICS OF NATURAL FIBERS

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Abstract Recently, natural fibers have distinguished themselves as an exceptional material that provides a cheap and plentiful substitute for synthetic fibers which are expensive and non-renewable. In this study, selected natural fibers from banana, plantain, and sisal were examined in order to ascertain the possibility or otherwise of plantain fiber which is common in Nigeria but are yet to be recognized globally. Selected fibers were extracted and treated to modify their constituents and surface morphology using sodium hydroxide solution. Both treated and untreated fibers were characterized and, from the results, improvements in fiber properties were noticed. The impact of this chemical modification on constituents, tensile strengths and surface morphology of fiber were examined using an Instron testing machine and scanning electron microscope (SEM). The results showed that chemical treatment increased the fiber's tensile strength with plantain having optimum value of 689 MPa after treatment while the removal of some fiber constituents caused the surface morphology to be rough. Its cellulose contents before and after treatment was 45.64 and 51.11 %, respectively. Thus, it was found that alkaline treatment improved the quality of the fiber making the fiber an acceptable replacement for synthetic fibers in composite creation.

Keywords: Banana, plantain and sisal, alkaline treatment, surface morphology; composite materials.

I. INTRODUCTION

In recent years, natural fiber reinforced composites have essentially replaced synthetic fiber reinforced composites in a range of

technical applications due to their low cost, high specific strength, biodegradability, renewability, and efficient thermal and acoustic insulating characteristics. [1-5]. Natural fiber-based composites have dominated this market because of the need for materials in the industrial sector that are affordable, environmentally benign, lightweight, and long-lasting. The use of natural fibers as a reinforcing element in composite manufacturing improves the mechanical, structural, and physical properties of the

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finished products. Artificial or natural materials with notably longer lengths than widths can be called fibers. While artificial fibers are made in labs, natural fibers are mostly derived from minerals, plants, and animals. [6,7]. This material has a variety of applications in engineering since it enhances the mechanical and chemical properties of materials that are currently in use. Natural fibers have garnered the interest of scientists and engineers more recently because of their relative effectiveness in comparison to synthetic fibers. [8, 9] These investigations have been conducted throughout several decades due to the advancement of material characteristics by material scientists, engineers, and chemists. In particular, research has been done on the use of natural fiber as reinforcement in composites.

Natural fibers are derived from plant and animal bodies or from geological processes. [10 - 13]. They can be a part of composite materials, in which the qualities are affected by the orientation of the fibers. High-tech uses for natural fibers include composite parts for the automotive industry. One of the main arguments in favor of natural fibers' employment in automobiles is that, unlike glass fibers, they are susceptible to bacterial countermeasure after being put out of service.

Because it finds a new purpose for materials that would otherwise be wasted and are readily available in large numbers, the use of sisal and

banana fibers as reinforcing materials is a recent trend. Natural fiber can be utilized to create a fiber reinforced composite material that is used in the sports equipment, aerospace, and automotive industries. In comparison to most metals and unreinforced plastics, composites based on sisal and banana fibers may offer a high strength to weight ratio, corrosion resistance, and termite resistance [14 - 18]. Natural fiber composites offer benefits such improved heat insulation, decreased skin irritation, and lower density. [19 - 25]. Natural fibers are also excellent absorbents and have a broad range of textures. For instance, clothing made of cotton derived from the shrub's fibers is lightweight, has a delicate touch, and is available in a range of colors and sizes. People who live in hot, humid climates usually like clothing made of natural fibers, such as cotton, over synthetic clothing [26]. For polymer matrix composites, sisal, jute, banana, flax, coir, ramie, kenaf, hemp, and palmyra are the most often utilized plant fibers. [27].

The strength of adhesion between the fiber and matrix polymer is the most crucial factor to take into account when selecting the appropriate fiber reinforcement for composites.

Packaging, consumer products like mailbags, fishnets, ropes, wall coverings, and mats, and transportation (cars, trains, aircraft, and boats) all use natural fiber reinforced composites. [13, 28 - 32].

The purpose of this study was to determine whether using more natural fiber, such as plantain fiber, as reinforcement in blended materials is feasible. Selected natural fibers were separated and chemically treated to change some of their properties before being compared

II. MATERIALS AND METHODS

Following the harvest season, natural fibers (plantain, banana, and sisal) were harvested from a farm in Ekiti State, South-West, Nigeria.

A. Dew retting process

By using a technique called dew retting, which involves exposing the chopped stem to both constant and sporadic moisture and sunlight for 30 days, banana and plantain fiber was recovered. The procedure involved the natural separation of fibers from xylem and cortex, which was carried out by microorganisms. The fibers underwent five days of hand stripping, washing, and sun drying.

B. Soil retting process

Soil retting is a method used to obtain sisal fiber. In this method, the plant's leaves are soaked in humus soil for 30 days, which encourages microorganisms to attack the leaves. The use of humus soil, which retains moisture and heat, facilitated the breakdown of the plant fiber. After that, the fermented leaves were removed, cleaned, and allowed to dry for five days in the sun.

C. Alkaline treatment

One treatment method used on some of the recovered fibers was sodium hydroxide solution. The fibers were treated by soaking in a 2 M NaOH solution in an electric oven set to 50°C for 4 hours. To get the fibers to a neutral state, they were rinsed with distilled water after being cleaned with tap water. pH paper was used to verify the fibers' neutrality. During the dry season, the mercerized fibers were subsequently sun-dried in a matter of five days.

D. Tensile test of the fiber

According to ASTM D 3822, a tensile test was conducted on both treated and untreated fibers using general-purpose Instron testing apparatus, model 3369, which has a full range of 25 N load cells. In their as-received state, fibers were measured at an 8 mm gauge length with displacement control and a 1 mm/min crosshead speed.

E. Scanning electron microscopy

The morphology of the fiber surface was investigated using scanning electron microscopy (SEM) both before and after treatment. Following gold coating the natural fibers for appropriate conductivity, a Zeiss Gemini Scanning Electron Microscope (SEM) was utilized.

III. RESULTS AND DISCUSSION

A. Fiber constituents

The cellulose, hemicelluloses, lignin, and ash contents of treated and untreated banana, plantain, and sisal fibers were ascertained chemically. Sodium hydroxide (NaOH) treatment is a common method for altering the molecular structure of natural fibers. By allowing chemicals to permeate the fiber, the treatment decreases the hydrophilic hydroxyl groups and improves the fiber's ability to withstand moisture. Alkaline solutions hydrolyzed components such as hemicelluloses during chemical treatment. The

process also modifies the components of the fiber by removing certain hemicelluloses, lignin, pectin, and waxes.

Figure 1 shows how each ingredient's amount decreases as a result of the treatment. Sisal fiber that has been treated had the highest cellulose concentration (56.25%), followed by plantain fiber (51.11%). But with a hemicellulose value of 35.64%, treated plantain fiber was the highest, followed by treated banana fiber with 21.89%. The results demonstrated that, in comparison to other fibers, treated plantain fiber had the highest value when cellulose and hemicellulose were mixed.

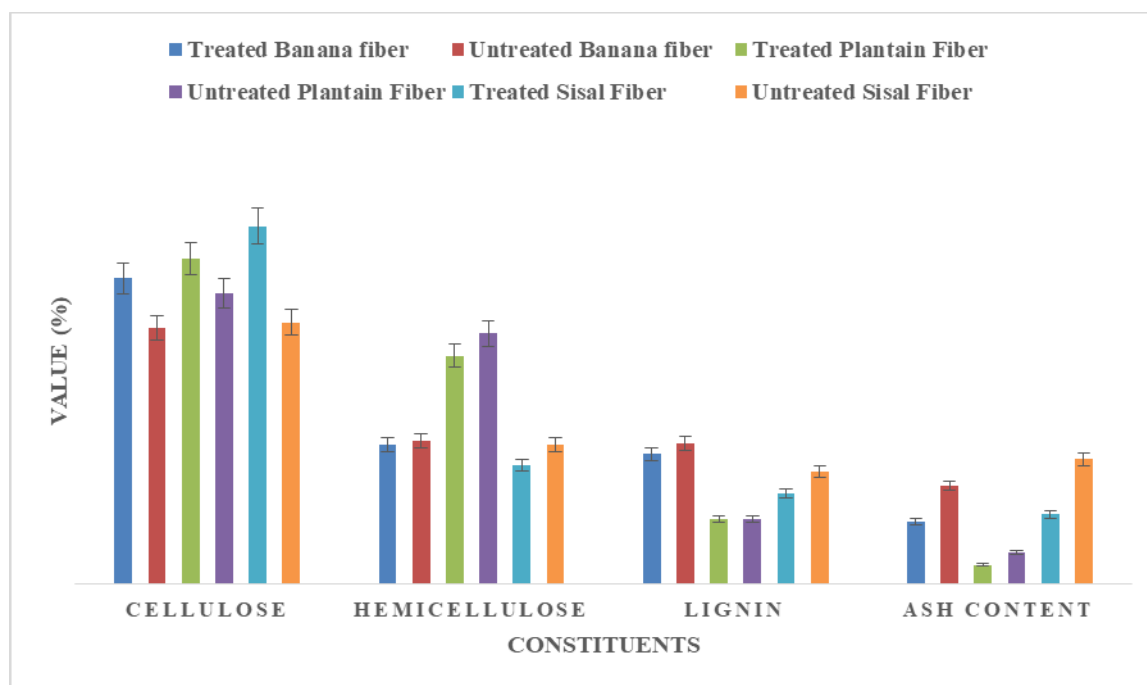


Figure 1: Variation of fiber constituents for treated and untreated banana, plantain, and sisal

B. Ultimate tensile strength

Figure 2 displays the data for the ultimate tensile strength of the natural fibers under investigation. It was discovered that the fibers

of plantains (PFTD), bananas (BFTD), and sisals (SFTD) treated with alkali had more strength than the fibers of the untreated plants. This could be explained by the fibers being

chemically strengthened by the alkali treatment. It was demonstrated, however, that PFTD had

the highest tensile strength value of 689 MPa when compared to other treated fibers.

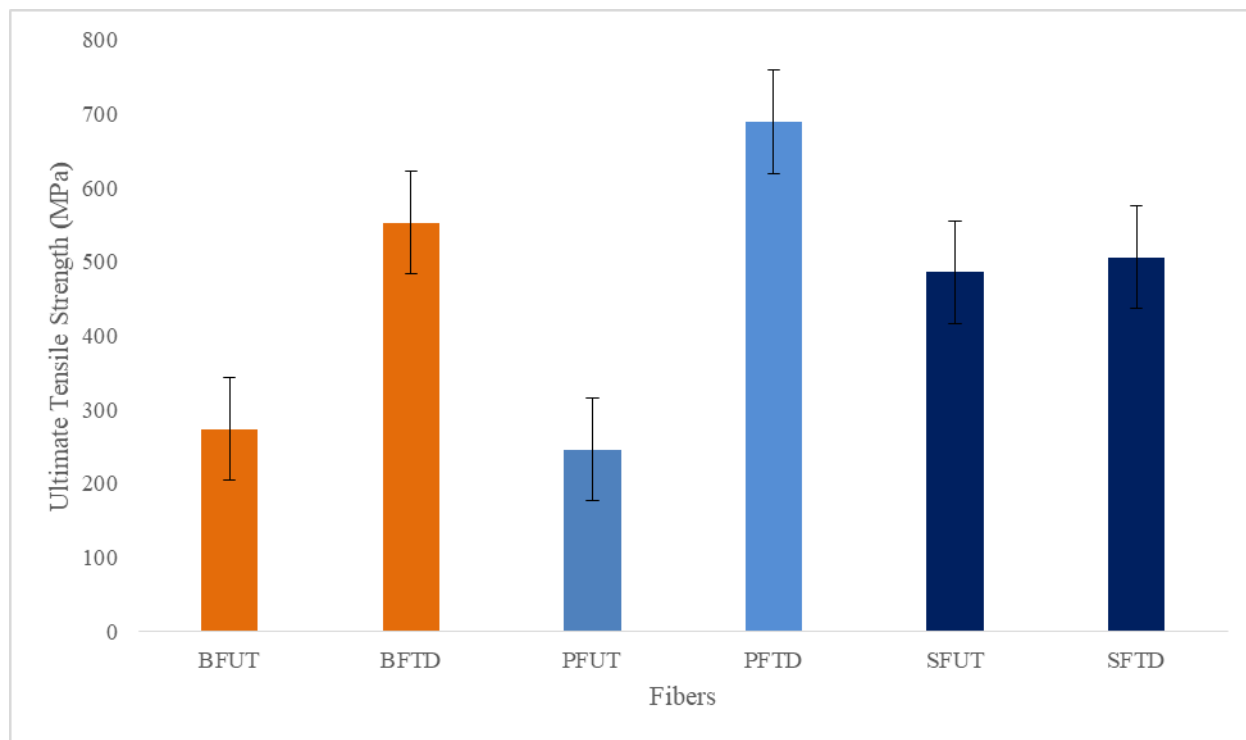


Figure 2: Shows the ultimate tensile strength of a few fibers both treated and untreated.

C. Water absorption characteristics

The percentages of water absorption (Figure 3) in three natural fibers banana, plantain, and sisal have been investigated. It seems that banana fibers have the greatest capacity to absorb water when left untreated. Plantain and sisal fibers follow in that order. Out of the three fibers, banana exhibits the highest percentage of water absorption after being scoured with varying alkali concentrations. Compared to banana

fiber, sisal fibers treated with alkali absorb less water. Plantain and sisal fibers treated with alkali exhibit very similar behavior. Compared to banana fiber, their percentage of water absorption is smaller. Technical textiles may benefit from banana fiber's porosity nature and water-absorbing qualities. Simultaneously, sisal fibers can also draw attention in fields where a lower level of water absorption is necessary.

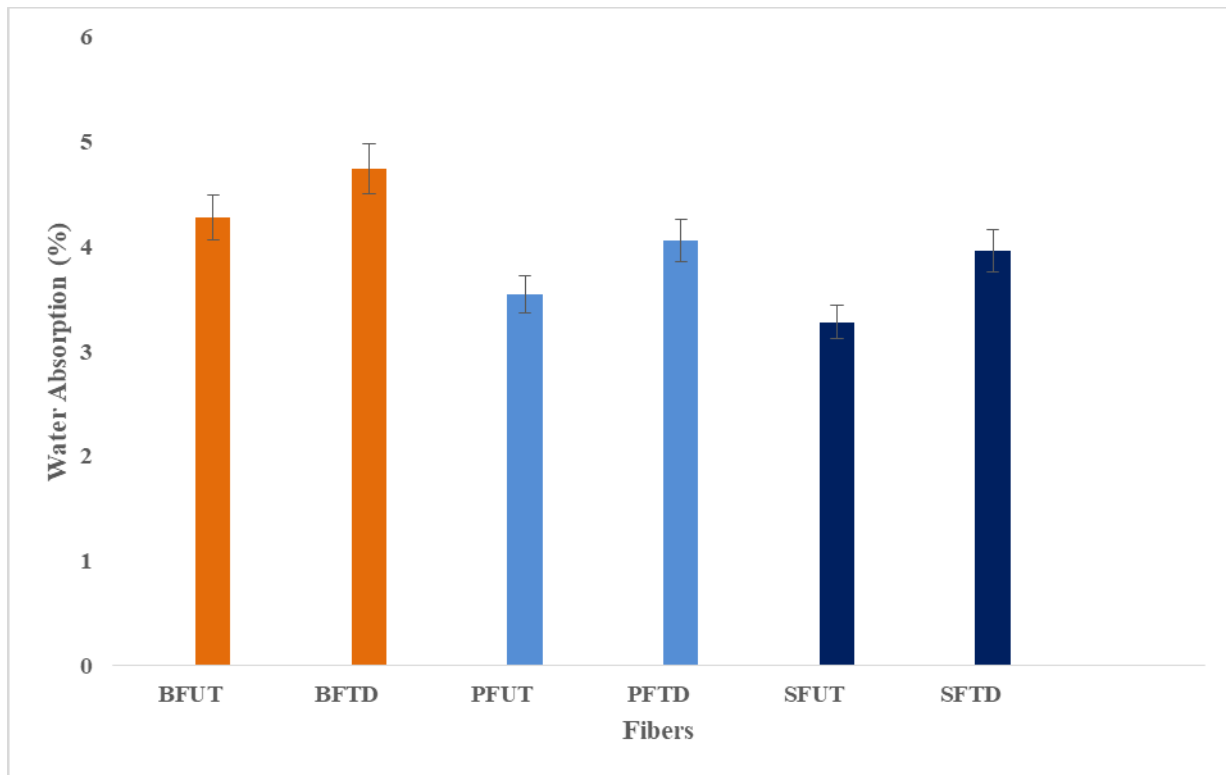
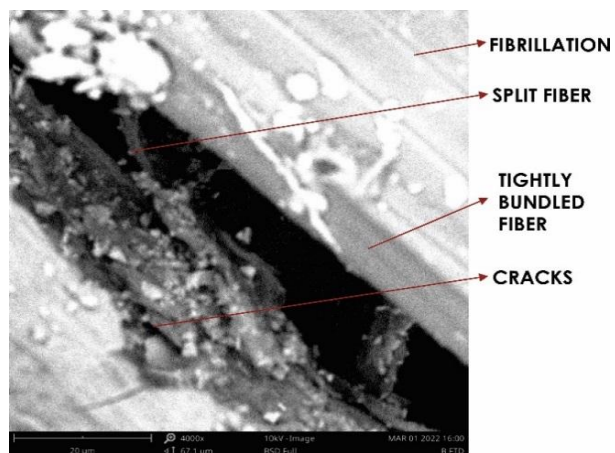


Figure 3: Water absorption of treated and untreated selected natural fibers

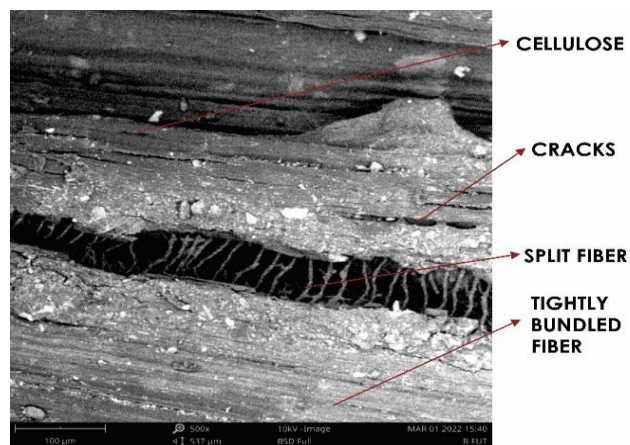
C. Morphological study

Alkali treatment has been shown to induce a process called fibrillation, or fiber separation, which breaks down the bundles of the fiber composites into individual fibers. [33]. There is a discernible difference in the surfaces following the alkali treatment. It was demonstrated that

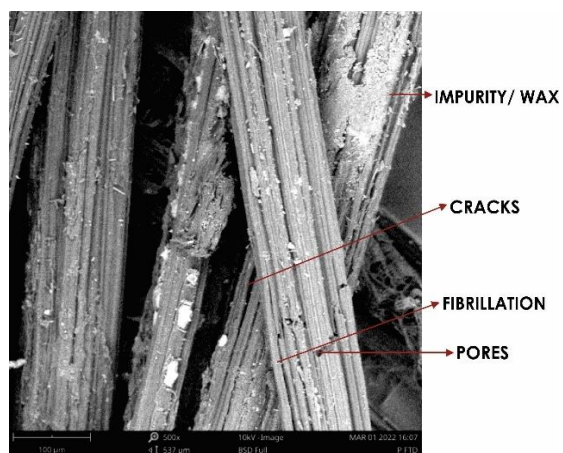
after the alkali treatment, the cementing components, such as lignin and hemicellulose, were eliminated, resulting in the removal of surface impurities and the separation of the final cells. The dissolution of waxy components improved the interfibrillar region and created a surface with a rougher texture. Certain contaminants and waxes are visible in untreated natural fiber.



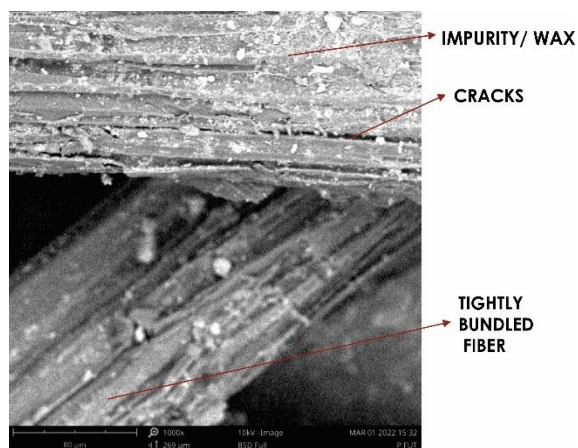
(Treated banana fibre)



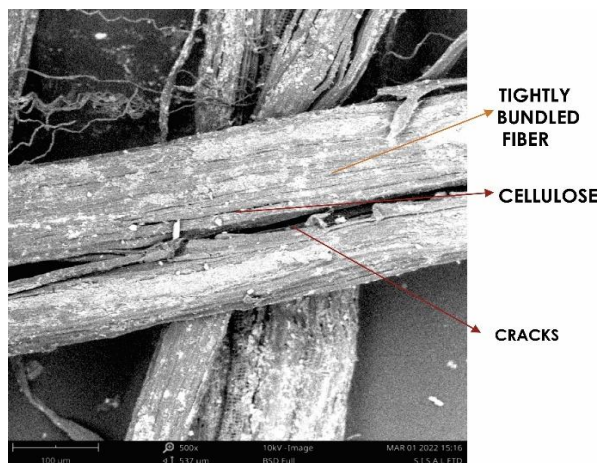
(Untreated banana fibre)



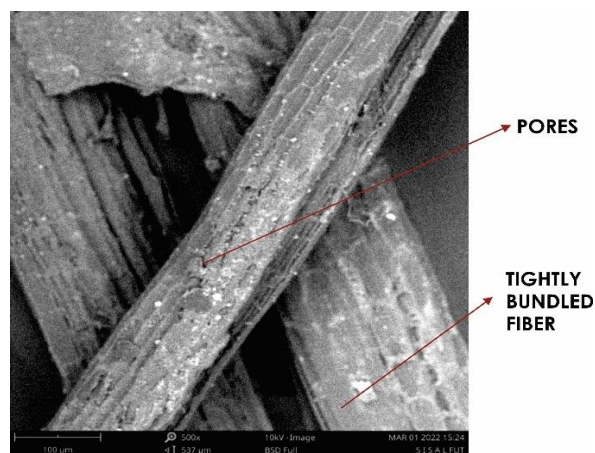
(Treated plantain fibre)



(Untreated plantain fibre)



(Treated sisal fibre)



(Untreated sisal fibre)

SEM Images of Both Treated and Untreated Banana, Plantain, and Sisal Fibers

IV. CONCLUSION

The purpose of this study was to evaluate the suitability of plantain fiber, which is widely farmed as a reinforcement material in composites in Nigeria and other places of the world where bananas are also widely grown. Comparative analysis was done between the fiber qualities and those of acceptable, currently available fibers, such as sisal and banana fibers. According to the findings, plantain fiber has a higher cellulose content and tensile strength than established fibers when compared to the fiber.

As a result, it was found that this fiber might be utilized in applications where sisal and banana fibers have been utilized for composite construction. The tensile result indicates that alkaline modification of material characteristics enhances mechanical qualities and improves adhesion potential through surface roughening, as revealed by scanning electron microscopy. It is anticipated that in the future, this natural fiber will emerge as one of the composite industry's sustainable and renewable resources, capable of displacing synthetic fibers in a variety of applications.

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