Studies on the Tensile Properties of Naturally-Occurring Banana Fibers.

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ABSTRACT

This study deals with the tensile assessment of chemically retted banana fiber from banana trunk, twisted to form twill of 1, 6, and 10 strands. The trunk was allowed to ret in 0.1M NaOH for a period of 1008 hours, then washed thoroughly with distilled water and left to dry at room temperature. Universal tensile testing machine was used to assess the tensile property and from the result, it was observed that the number of twill has a direct impact on the maximum load and thus the stress the fiber can absorb before failure over a certain extension limit. The sample with 10 strands is observed to possess the highest load absorption of about 20N in comparison with the sample with 1 strand that has the least maximum load of 5N. This indicates that the number of strand has relevance in the assessment of tensile properties of naturally occurring banana fiber.

(Keywords: retting, fiber, sodium hydroxide, NaOH, banana, alkaline treatment)

INTRODUCTION

Natural cellulose based fibers are increasingly gaining attention in the development and enhancement of composites mechanical properties [4, 8] in various engineering applications – building materials, motor vehicle body and structural parts where reduction in weight is required. Prominent source of this fibers are agricultural wastes like banana pills, coffee husk straw residue, bagasse and much more.

The advantages of natural fibers arise from their renewability, low cost, readily availability and stiffness, when compared to synthetic fibers like glass and carbon [9]. The process of obtaining natural fiber from plant stem is known as Retting – the microbial decomposition of pectin, which binds the fibers to the woody inner core of the stem of the plant. The process employs water and microbial action to separate fiber from the woody core and surrounding the epidermis as well. This process has major impact on the final product quality. Besides differences in variety, the influences of climatic conditions and soil, ripeness at harvest and harvesting method, the retting procedure is of crucial importance to the process ability of the fibers.

High quality fibers are always achieved by adopting the alkali treatment technique. Alkali treatment improves the fiber-matrix adhesion due to the removal of natural and artificial impurities. Moreover, alkali treatment leads to fibrillation which causes the breaking down of the composite fiber bundle into smaller fibers. In other words, alkali treatment reduces fiber diameter and thereby increases the aspect ratio.

Alkali treatment increases surface roughness resulting in better mechanical interlocking and the amount of cellulose exposed on the fiber surface. This increases the number of possible reaction sites and allows better fiber wetting. The chemical constituents of natural fibers can be classified into cellulose and lignin. Lignin plays the role of binding the fibers of cellulose. Alkaline treatment is one of the standard procedures in the pulp and paper industries for lignin removal, lignin can be dissolved in sodium hydroxide (NaOH) solution and the cellulosic fibers can be extracted with relative ease. NaOH causes dissolution of lignin by breaking it into smaller segments whose sodium salts are soluble in the medium [2].

In most developed and developing nations, banana plant fibers are used in basket making process [6]. Because of its huge economic importance, pulp and paper are products of fibers that are commercially gaining public attention in the USA [5].

Retting can be achieved mechanically (i.e., by hammering) or chemically (by boiling and applying chemicals). The choice depends on the availability of water and the cost of retting process. In “water retting” plants such as flax, jute, hemp, or kenaf are submerged in water, soaked for a period of time to loosen the fibers from the other components of the stem.

Retting can also be done by letting the cut crop stand in the fields in well fall called “dew retting” [7]. In either approach, bacterial action attacks pectin and lignin, freeing the cellulose fibers. To that end therefore, retting required monitoring so as to avoid excessive degradation of the fiber material [1] which subsequently affect the fiber strength as a results of microbial attack of the cellulose.

Extraction processes of natural fibers can be performed by different procedures that include mechanical, chemical and biological methods. Each method presents different advantages or drawbacks according to the amount of fiber produced or the quality and properties of fiber bundles obtained [3]. The rapid increase in banana and plantain growth will surely result to a direct banana plant waste (the trunk) which thus amount into pollution in any society. This, coupled with the current drive to convert waste to wealth serves as an impetus to this research which centered on the conversion of banana waste (stem) into a useful fiber.

METHODOLOGY

Banana plants were obtained and a trunk weighing 2kg cut. Sodium hydroxide solutions of 0.1M was prepared and poured into a container with seal. The trunk were completely immersed into the containers of the said aqueous NaOH solution and covered. The samples were left to ret for 1008 hours. At the end of the retting, the samples were immersed and washed in distilled water to remove any composite around the fiber, thus, reduces brittleness that could ensue after retting. The fibers obtained were subsequently dried at room temperature. The morphological view and was observed.

The samples were then subjected to tensile test using a universal tensile testing machine of model number 3369. The test was conducted at a regular strain rate of 20mm/min for all the samples so as to assess their respective response to external load.

RESULT/DISCUSSION

Figure 1: A Photograph of Banana Fiber.

Figure 2: Cross-Sectional Area of 0.1M NaOH Retted Banana Fiber (x400).

Figure 1 shows fibers that have been completely retted from banana trunk. A cross sectional area of strand of the fibers obtained (Figure 2) reveals a white strands thus indicating the presence of cellulose in the fiber while the sparsely distributed dark spots indicates a microbial attack of the cellulose [1].

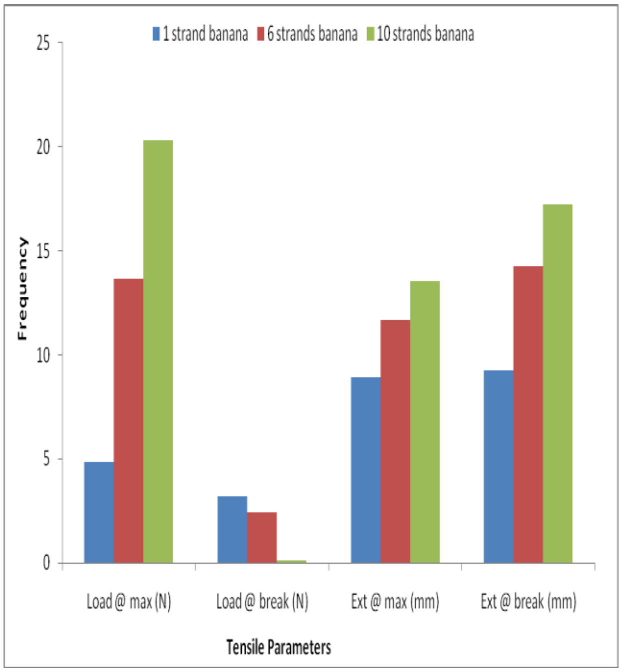

Figure 3: Response of Banana Fibre to External Load before and at Failure Point.

Tensile test specimens were made according to the ASTM – D638M to measure the tensile properties. The samples were with average initial length of 263mm and cross sectional area of 0.01327mm^2. The fibers were firmly mounted on the tensile testing machine to avoid datum point error. Two identical specimens were tested for each strand(s) and average tensile strength has been taken. The samples were tested at a cross speed of 2mm/min and the corresponding extension and other necessary parameters captured automatically.

From the result (Figure 3), the relationship between the number of banana fiber strands and its tensile properties is clear. As the fiber strands loading increases, the value of maximum tensile load is observed to increase correspondingly. Girisha in his research explained that the increment continue until a level where the stress distribution will be uniform and then the fibers can be used in reinforcing matrix [4]. This observation is true for other cases as in the case of extension at maximum load and break. The values of the *'load at break*' at the point of the fiber failure is however decreasing with respect to increment in the number of strands.

The load or force the fiber can endure before it begins to yield to compromise its inherent and induced maximum load is explained with the load at maximum of the bar chart. The single strand fiber exhibited the least maximum load of about 5N which thus implies that a single strand of banana fiber cannot accommodate external load beyond 5N, this principle also applies to other number of strands (i.e., 6 and 10). A direct relationship is also recorded between the load at maximum and its corresponding extension values. Thus, indicating that the failure of the material is never sudden.

CONCLUSION

In order to assess the mechanical properties of naturally occurring fiber, this study deals with the tensile assessment of banana fiber gotten from plantain trunk, twisted to form twill if 1, 6, and 10 strands. The fibers were allowed to ret for a period of 1008 hours and subsequently washed thoroughly with distilled water and dried at room temperature.

Universal tensile testing machine was used to assess the tensile property and from the result, it was observed that the number of twill has a direct impact on the maximum load and thus stress the fiber can absorb before failure at a certain extension limit. The sample with 10 strands is observed to possess the highest load absorption of about 20N over an extension limit of about 14mm before yielding to external force. This is in comparison with the 1 strand sample that has the least maximum load of 5N and an extension of 9mm. thus indicating that the number of strand has relevance in the assessment of tensile properties of naturally occurring fiber.

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