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Structural Analysis and Mechanical Testing of Single Fiber from Ladies Finger Plant

S. Imam Hossain and MahbubHasan
Department of Materials and Metallurgical Engineering,
Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
Email:*imam_raihan94@yahoo.com*

Abstract

The use of natural fiber as a reinforcement material is increasing day by day due its low cost, easy availability and bio-degradability compared to other fibers such as synthetic fiber. In present research, raw fiber from ladies finger plant was characterized using structural analysis and mechanical testing. Under structural analysis, Fourier Transform Infrared Spectroscopic (FTIR) analysis and Scanning Electron Microscopic (SEM) imaging were performed. Tensile test of ladies finger single fiber was also conducted by varying the span length. The FTIR analysis showed broad picks for –OH group and hemicelluloses in raw ladies finger fiber. SEM imaging revealed a rough fiber surface. The Young's modulus increased, whereas the tensile strength and strain to failure decreased with increase in span length.

Keywords: *Ladies Finger Plant; Single Fiber; FTIR; SEM, Tensile Test*

1. Introduction

Increased awareness on the environmental protection and the interest in long term sustainability of construction materials have led to the development of environmental friendly alternatives to fiber reinforced plastic composites. In this regard, significant efforts were directed to investigate the use of natural fibers as reinforcement in thermoplastics. Typical reinforcements for composites with plastic matrix are various synthetic fibers such as glass, graphite, boron, metallic and ceramic materials. These materials are heavy, expensive and harmful to environment. Natural fibers such as wood, wheat, straw, jute and bagasse have several benefits viz., low cost, low density, high toughness, acceptable specific strength properties, enhanced energy, recovery and biodegradability. The use of natural fibers in plastic matrix leads to many benefits such as low volumetric cost, increase of heat deflection temperature, increase of stiffness of thermoplastics and improvement of fiber surface appearance [1].Wide range of research has been carried out on fiber reinforced polymer composites in recent years [2-9].
Fibers from ladies finger plant are extracted in a similar way to jute fiber. It has so far been used to produce ropes and mats which performs satisfactorily. In appearance, it is very much similar to jute. The objective of present research is to characterize raw ladies finger natural fiber by finding out their structural and mechanical properties.

2. Experimental Procedure

2.1. Tensile Test of Ladies Finger Single Fiber

Tensile test of single ladies finger fiber was carried out by varying span length at 5, 15, 25 and 35 mm using a tensile testing machine. The fibers were glued in a paper frame (**Fig. 1**) to ensure a good gripping and straight direction to the test clamps. Diameter of single fiber was measured by using a scanning electron microscope (SEM). The paper frame was carefully placed in between the jaws of the load cell. Load cell of 50N was used and cross-head speed was 4mm/min.

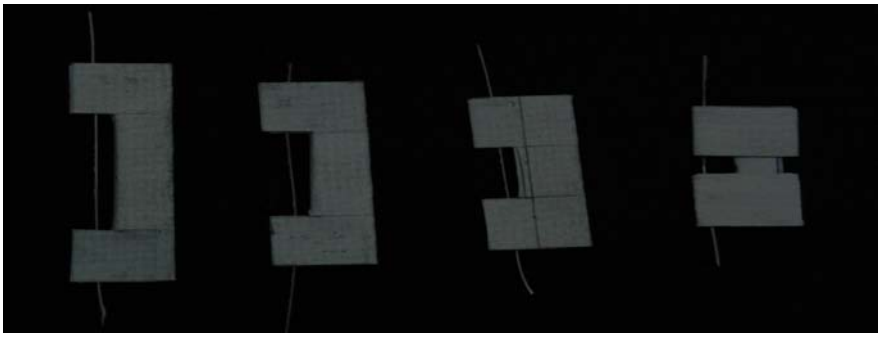

Fig. 1. Specimen for Tensile Test of Fiber

2.2. FTIR Spectroscopy

FT-IR stands for Fourier Transform Infra-Red, the preferred method of infrared spectroscopy. In infrared spectroscopy, IR radiation is passed through a sample. Some of the infrared radiation is absorbed by the sample and some of it is passed through (transmitted). The resulting spectrum represents the molecular absorption and transmission, creating a molecular fingerprint of the sample. Like a fingerprint no two unique molecular structures produce the same infrared spectrum. This makes infrared spectroscopy useful for several types of analysis.
Some powder sample was collected from the fiber surface and mixed properly with Potassium Bromide (KBr) at a ratio of KBr:sample =100:1. A pellet was made using that mixture and placed in a sample holder. After that the holder along with the pellet placed into the IR spectrograph.

2.3. Scanning Electron Microscopy

Surface morphology of fibers was observed under a scanning electron microscope. The diameter of the fiber was also measured using the same microscope. Gold sputtering was carried out to make the fiber surface conductive.

3. Results and Discussion

3.1. Tensile Properties

The raw ladies finger fiber had been characterized using 5mm, 15mm,25mm and 35mmspan length separately. For each span length several samples were tested and the Young's modulus and tensile strength were measured. Due to the occurrence of slip during test, the Young's modulus seemed to increase with the increase in span length as percentage of slip is higher for smaller span length (Fig. 2). The Young's modulus values were corrected by correcting strain using the following formulas [10]:

$$1.\quad \Delta L_{total} = \Delta L_{fiber} + \Delta L_{grip}$$

$$2.\quad \alpha_i = \Delta L_{total} / F - L_0 / E_0 . A_i$$

$$3.\ \Delta L_{\mathbf{total}} / F = \varepsilon . L_0 / \sigma . A_i = 1 / E . L_0 / A_i$$

$$4.\ \Delta L_{\mathbf{grip}} / L_o = \alpha_l (A_i . \sigma) / L_o$$

$$5.\quad \Delta L_{\mathbf{fiber}} / L_o \text{ (Corrected)} = (\Delta L_{\mathbf{Total}} / L_o - \Delta L_{\mathbf{grip}} / L_o)$$

Where $L_0$is original length of fiber, A_i is cross- section area of each fiber and $E_0$is extrapolated modulus.

The variation of the corrected Young's modulus and tensile strength are shown in Figures 3 and 4 respectively. The tensile strength decreased with increase in span length [11,12]. As mentioned by

Bledskiand Gassan [13], the longer the stressed distance of the natural fiber, the more inhomogenities (flaws) will be in the stressed fiber segment that weakening the structure. Thus increasing fiber length inevitably reduces the strength of the fiber.

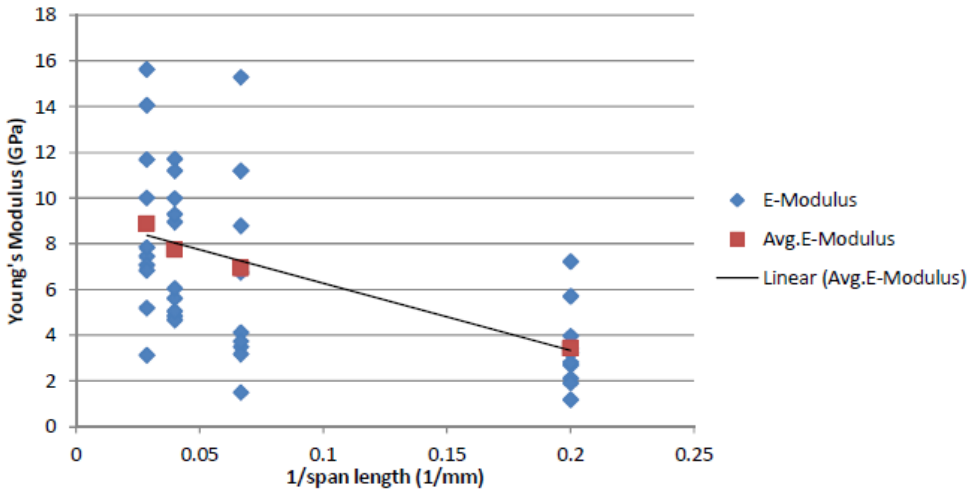

Fig. 2. Young's modulus vs 1/span length curve for ladies finger fiber (uncorrected).

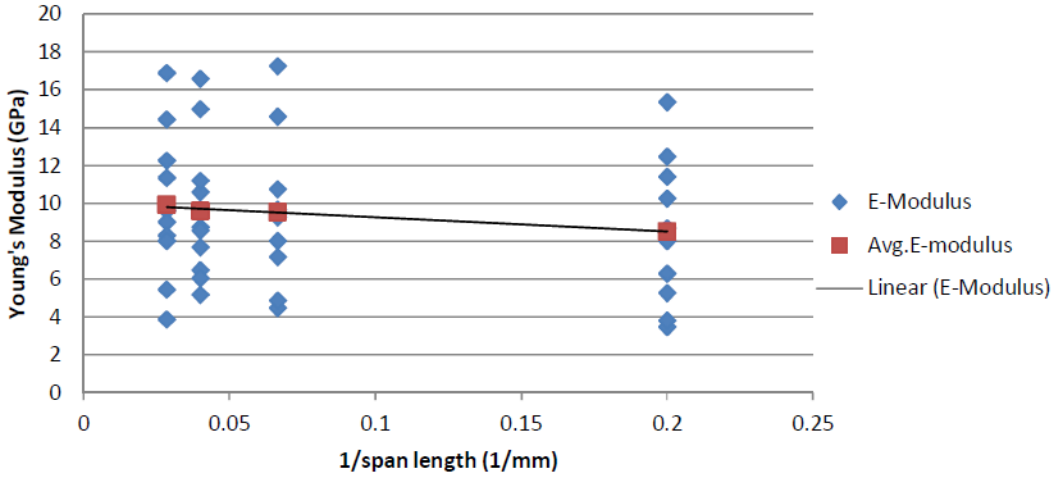

Fig. 3. Young's modulus vs 1/span length for ladies finger fiber (corrected)

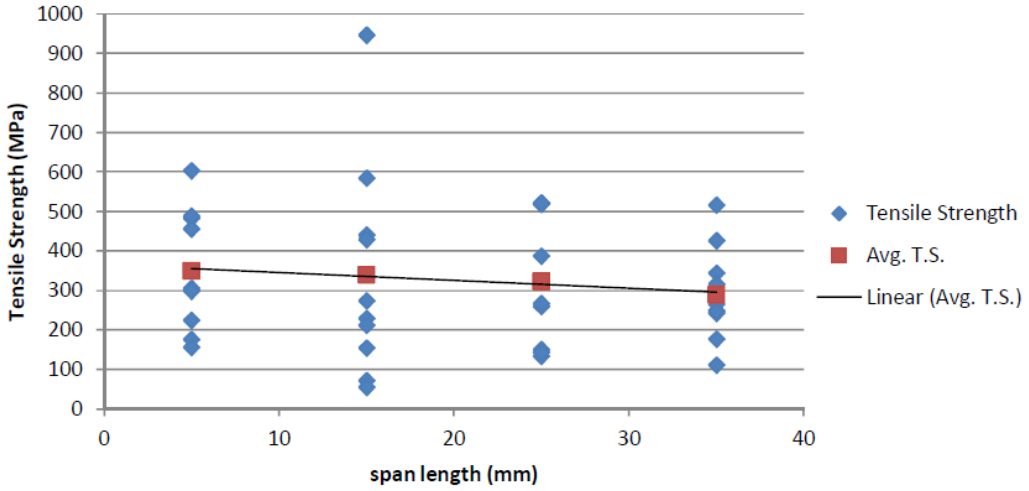

Fig. 4. Tensile strength vs span length curve for raw ladies finger fiber

3.2. FTIR Spectroscopic Analysis

The IR spectrum for raw ladies finger fiber (**Fig. 5**) clearly shows the characteristics band of (OH) broad, strong band from the constituents of fiber at the regions of 3600-3200 cm^{-1}, lignin and hemicelluloses at near about 1731.5 cm^{-1} ,(C-H) aromatic rings and alkane at 2920.5 cm^{-1} [14].

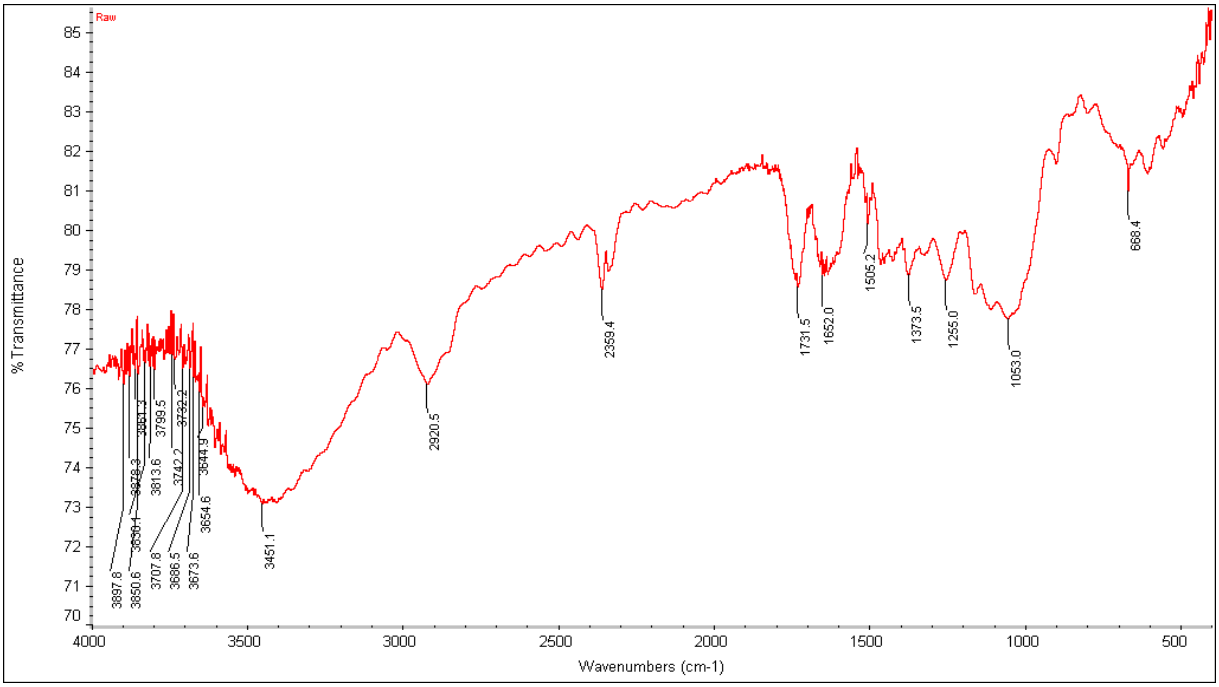

Fig. 5. FTIR analysis of ladies finger fiber

3.3. Surface Morphology

SEM imaging revealed the surface morphology of the fiber, which was a bit rough.

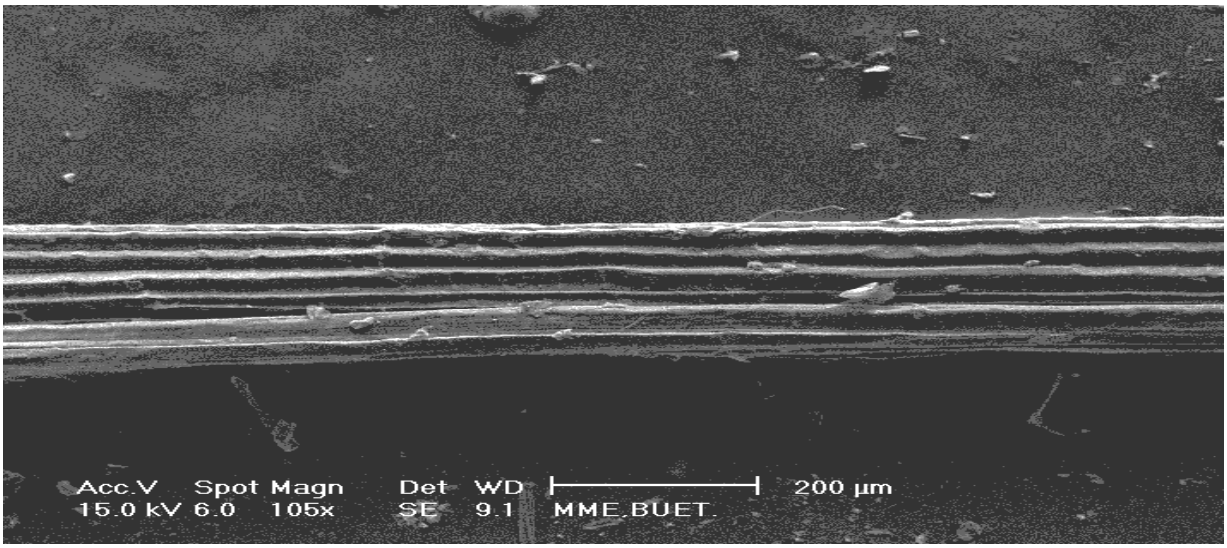

Fig. 6.SEM micrograph of ladies finger fiber.

4. Conclusion

The tensile strength of the fiber seemed to decrease with the decreasing span length. FTIR analysis of the fiber evidenced the presence of hemicellulose in fiber structure which is the main reason of hydrophilic nature of the natural fiber. It may cause problems like poor adhesion and therefore poor mechanical properties when combined with hydrophobic matrix. However, with proper treatment, this problem can be solved.

Reference

1. J. Jayaramudul, D. J. P. Reddy, B. R. Guduri and A. V. Rajulu, "Tensile Properties of Polycarbonate Coated NaturalFabric *SterculiaUrens*: Effect of Coupling Agent" (introduction, FTIR)
2. B. C. Mitra; R. K. Basak; M. Sarkar; *Journal of Applied Polymer Science*, 67, 1093-1100 (1998).
3. A. N. Netravali; "Natural Fibers, Plastics and Composites", Kluwer Academic Publisher, USA (2004).
4. A. Kelly; *Journal of Ceramic Processing Research*,2, 147-154 (2004).
5. P. Wambua; J. Ivensand; I. Verpost; *Composite Science and Technology*, 63, 1259-1264 (2003).
6. C. N. Singleton; *Composite: Part B*, 34, 519-526 (2003).
7. M. T. Moe;, K. Liao; *Composite Science and Technology*,63, 375-387 (2003).
8. E. M. F. Aquino;, L. P. S. Sarmento;, W. Oliveira; *Journal of Reinforced Plastics and Composites*, 26, 219-233 (2007).
9. M. T. Moe; *Composite: Part A*, 33, 43-52 (2002).
10. S. Biswas; "Characterization and Performance Analysis of Natural Fibers as Reinforcement in Polymer Composite", M.Phil Thesis, Bangladesh University of Engineering and Technology, Bangladesh, (2010).
11. S. Biswas; Q. Ahsan; I. Verpoest; M. Hasan; *Advanced Materials Research*, 264-265, 445-450 (2011).
12. S. S. Mir; M. N. Hasan; Md. J. Hossain; M. Hasan**;** *Engineering Journal*, 16, 73-83 (2012).
13. K. Bledzki; J. Gassan; *Progress in Polymer Science*, 24, 221-274 (1999).
14. N. Nafsin, Manufacturing and Characterization of Coir Fiber Reinforced Polypropylene Composites, Bachelor Thesis, Dept. of MME, BUET.