International Journal of Modern Science and Technology *Vol. 2, No. 12, 2017. Page 377-382.*
http://www.ijmst.co/ ***ISSN: 2456-0235***.

Research Article

Characterization of new natural Cellulosic Fiber from *Urera hypselodendron* Plant for Technical Textile Application

Aklilu Azanaw, Adane Haile, Rotich K. Gideon, G. Nalankilli*

Textile Chemistry Research and Innovation Centre, Ethiopian Institute of Textile and Fashion Technology (EiTEX), Bahir Dar University, Bahir Dar, Ethiopia.

*Corresponding author's e-mail: gnalankilli@yahoo.com

Abstract

Natural fibers are receiving a lot of consideration from researchers for their utilization in manufacture of technical textiles. This is due to their eco-friendly nature, sustainability and adequate physical properties. Most of the natural reinforced composites depend on jute and flax fibers which are not enough for world markets and not fully applicable for industrial application. This study aims at fiber extraction and characterization from *Urera hypselodendron* tree trunks. The fibers were successfully extracted by both water retting and chemically using sodium hydroxide. The extracted fibers were characterized for their breaking strength, breaking elongation, moisture regain, fineness and the diameter. The results indicated that the fibers had properties resembling those of traditional natural cellulose fibers (Flax and Jute); therefore can be viewed as a promising alternative source for natural cellulose bundle fibers that can be used for technical textile application.

Keywords: Natural cellulosic fibers; Retting; Chemical extraction; Reinforcement; Composites; Technical Textiles.

Introduction

Natural cellulose fibers are becoming an attractive alternative over synthetic fibers due to their advantages such as recyclability, biodegradability, renewability, low cost, high specific mechanical properties and low density [1-4]. Cultivation of fiber crops have been the traditional way of obtaining cellulose fibers. Most of the natural fiber reinforced composites depend on jute, Kenaf, Ramie, and Flax fibers. However, these fiber have their own limitation for example Kenaf fiberis brittle and difficult to process [5] while ramie fibers cannot be extracted sufficiently from the stem of the plant by both water retting and chemical treatment [6]. Jute has low extension at break of 1-2% [7] and flax fiber has a more crystalline structure therefore it cannot be twisted [8]. In addition, the range of these fibers is small; therefore finding of new natural fibers has turn out to be a dynamic research endeavor in the bio-composites materials society.

A big number of varieties of plants available in nature offer a prospect to extract new fibers. The challenge is to find suitable and sustainable resources for the expansion of bio-composites. The present study focuses on the exploration of *Urera hypselodendron* trunks fiber for technical textile applications. The fibers has been successfully extracted by both water retting [9] and chemically using sodium hydroxide (NaOH). The extraction process has a major impact on the final fiber quality and process ability of the fibers. For example, alkali treatment leads to fibrillation which causes the breaking down of the composite fiber bundle into smaller fibers thus reducing the fiber diameter. After treatment, the non-fibers components were removed by washing and the fibers subjected to mechanical processing to remove the soft tissues followed by drying to obtain the fibers. The non-cellulosic substances were sufficiently removed or reduced after both water retting and alkalization treatments. The extracted fibers were tested for their physical and thermal properties [10-12].

Materials and Methods

Materials

Urera hypselodendron trunk was collected from rural area of Ethiopia. NaOH used was of

Received: 03.12.2017; Received after Revision: 08.12.2017; Accepted: 09.12.2017; Published: xx.12.2017

commercial grade and it was used without alteration.

Extraction of fibers

The experimental procedure followed is shown in figure 1.

Figure 1. Experimental Procedure

Water retting

Water retting involves the degradation of non-fibrous matter which acts as glue between the fibers in trunk plant parts and fibers without damaging the fiber cellulose by using micro-organism found in river water. This process allows easy separation of individual fiber strands and the woody core. Since water retting is a biological process, it requires both moisture and warm temperature for microbial action to occur. The *Urera hypselodendron* trunk was immersed in a water bath for 10 days at room temperature, after which it was washed and combed with the aid of fine, long metal teeth to remove the digested non-fiber content followed by drying to obtain the fibers.

Alkali (NaOH)

The NaOH was used to dissolve the non-fiber material between fibers and separate structural linkages between lignin and cellulose. *Urera hypselodendron* trunk was treated for 2 hrs at different concentration of NaOH (3%, 5% and 10%) at boiling temperature with a material to liquor ratio (MLR) of 1:20.

Fiber characterization

Fiber diameter

Electron Microscope was used to measure the diameter of the fiber and to capture its surface morphology.

Fiber fineness

The fiber fineness was determined according to ASTM D-1577:07 test standard. It was done by single-fiber weighing method. This test method is recommended for measurement of the linear density of single fibers and is not suitable for fibers shorter than 30 mm. The length of a single fiber was measured and the fiber was weighed.

Tenacity and elongation

Tenacity of the fibers was tested using ASTM D- 3822:07 standards. The gauge length between the jaws was 5cm. The fiber was preconditioned at, 20 +/- 2°C and 65 +/- 2 % relative humidity. The fiber specimen was mounted in the jaws of the clamps. All slack was removed without really stretching the specimen. Care was taken to keep the specimen straight within the jaws and it was ensured that the fiber sample lay on the line of action between the force-measuring device and the point where the fiber left the moving jaw face.

Fiber length

The simplest direct way of measuring single fiber length by hand and the fiber alongside a rule tension applied should be sufficient to remove fiber crimp without stretching the fiber too much. 30 random samples from the extracted fibers for each extraction method were measured using meter scales.

FTIR characterization

Fourier Transform Infrared (FTIR) spectra of the samples were recorded using the Perkin Elmer FTIR instrument in the frequency range 4000 - 500 cm^{-1}using 20 scans and recorded in the transmittance mode as a function of wave number.

Thermal characterization

To analyze the thermal stability of extracted fibers, the Thermogravimetry (TG) technique was used. Tests were carried out using Perkin Elmer TGA 4000 model. Measurements were conducted from ambient temperature to 50°C at a heating rate of 20°C/min in a nitrogen atmosphere to 500°C. Samples weights were approximately between 2 – 4 gm. To verify the accuracy of the results, two sample runs were performed under the same experimental conditions.

Results and discussion

Fiber characteristics

Fiber diameter

The thickness or diameter is one of the most important properties of a fiber. Fiber diameter is usually measured with a Projection Microscope. An image of fiber scrap was magnified and projected onto a screen, from which the diameter was measured. The diameter of the fiber was calculated as 106 µm for water retted fibers but alkaline extracted fibers showed reduced diameter as the concentration of NaOH was increased. The diameter was 117 µm at 3% concentration, 109.0 µm at 5% concentration and 97.9 µm at 10% concentration as shown in table 1 and figure 2. From the result, it can be seen that increasing the concentration of NaOH increases the removal of non-fiber parts.

Table 1. Fiber diameter of fibers by different extraction methods

Parameter	Water retting	NaOH treated		
		3%	5%	10%
Diameter (µm)	106.0	117.0	109.0	97.9

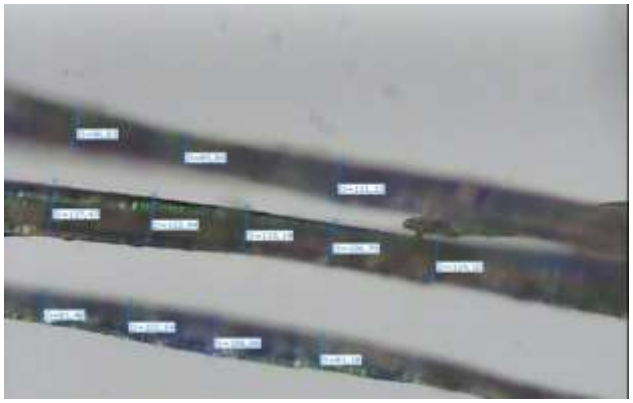

Figure 2. Fiber diameter and its morphology

Fineness

The fineness of fibers determines how many fibers are present in the cross-section of a yarn of given thickness. Table 2 show the linear density of the fiber as calculated in Tex units. It can be seen that water retted fibers had fineness of 2.58 Tex but the alkaline extracted fibers had lower fineness as shown figure 3. As the concentration of NaOH increased, fineness was increased. This was due to the fact that as concentration of NaOH increased, more and more non-fiber parts were removed thus resulting in the increase in fiber fineness.

Table 2. Fiber Fineness of fibers by different extraction methods

Parameter	Water retting	NaOH treated		
		3%	5%	10%
Fineness (Tex)	2.58	1.80	1.05	0.98

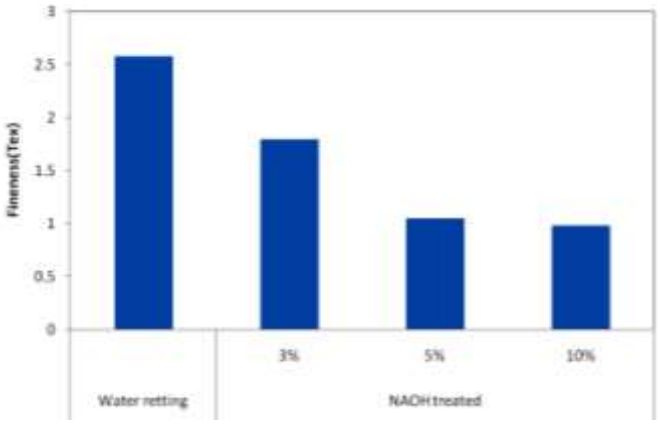

Figure 3. Fineness Comparison

Tensile strength and elongation

Figure 4 shows the strength and elongation of fibers extracted by water retting and alkaline extraction methods. The fiber strength can be expressed either by breaking strength or tenacity while elongation percentage is determined by the extension of fiber at break. Fiber strength and elongation at break are important parameters of a fiber because they determine the use-ability and spin-ability of the textile fibers. From Figure 4, it can be seen that the water retted fibers had the highest fiber strength than the alkaline extracted fibers. For alkaline extracted fibers, as the concentration of the NaOH was increased, the tensile strength and elongation of the extracted fibers decreased. This was because the alkaline treatment removed some components of the fibers which could otherwise have contributed to the fiber strength.

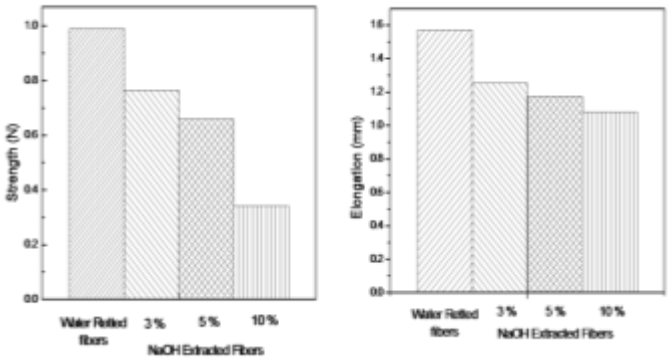

Figure 4. Fiber Strength and elongation of fibers by different extraction methods

Fiber length

Table 3. Fiber length of fibers by different extraction methods

Parameters	Water retting	NaOH treated		
		3%	5%	10%
Length	44.47 cm	no effect	no effect	no effect

From table 3, it can be seen that the fiber length was not affected by the extraction method used. The length remained the same for both water retted and NaOH extracted fibers at all the concentration.

Moisture content and Moisture regain

Moisture content is the amount of water in a material or substance. The weight of textile materials will continually increase or decrease in weight depending on the losing or gaining of moisture content. This is referred to as its hygroscopic action which is the amount of moisture a material absorbs relative to the ambient temperature and humidity conditions. Temperature and humidity can be controlled in laboratory environments. From the study, it can be observed in table 4 that as the concentration of NaOH increased, the moisture regain and moisture content decrease due to alkalization of *Urera hypselodendron* fiber which leads to reduction of OH group in the extracted fibers.

Table 4. Moisture content and moisture regain of fibers by different extraction methods

Parameters	Water Retting	NaOH treated		
		3%	5%	10%
Moisture content (%)	7.5	6.3	5.8	3.0
Moisture Regain (%)	8.3	7.0	6.4	3.5

FTIR characterization

FTIR spectra with the standard peaks of *Urera hypselodendron* fibers are shown in figure 5. A broad absorption peak at around 3350 cm^{-1} corresponds to the O-H stretching vibrations of alpha cellulose and hydrogen bond of the hydroxyl groups. It can be seen that water retted fibers had a higher peak than the alkaline extracted fibers. The peak at 2850 cm^{-1} is the characteristic band for alkyl C-H symmetric and asymmetric stretching vibrations of α-cellulose. Additionally, the peak at 1735 cm^{-1} can be attributed to the carbonyl C=O stretching vibration mainly due to hemicellulose group, whilst the peak of C=C aromatic skeletal vibrations in lignin shows around 1550 cm^{-1}. The peak at 1450 cm^{-1} is associated with the CH_2 symmetric bending found in cellulose.

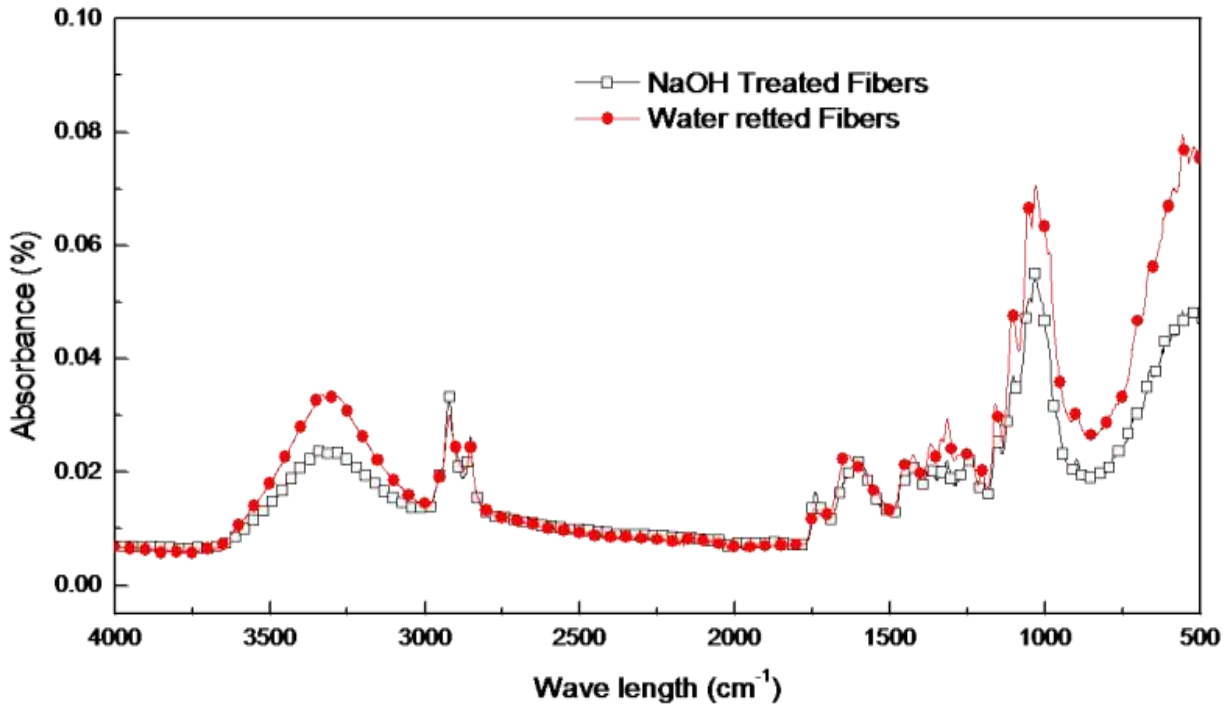

Figure 5. FTIR curve of NaOH and water retted fiber

The peaks at 1375 cm^{-1} and 1246 cm^{-1} correspond to the C-O stretching vibration of the acetyl group in lignin and hemicellulose component, respectively. Around 1050-1160 cm^{-1}, the absorptions can be attributed mainly to the carbohydrates (cellulose and lignin) [13]. On the whole, the FTIR peaks shows *Urera hypselodendron* fibers compares well with other reported values for natural cellulosic fabric [14].

Thermal characterization

From Thermo Gravimetric Analysis (TGA) curve shown in figure 6, it may be observed that the extracted fibers decompose between 300°C and 350°C.

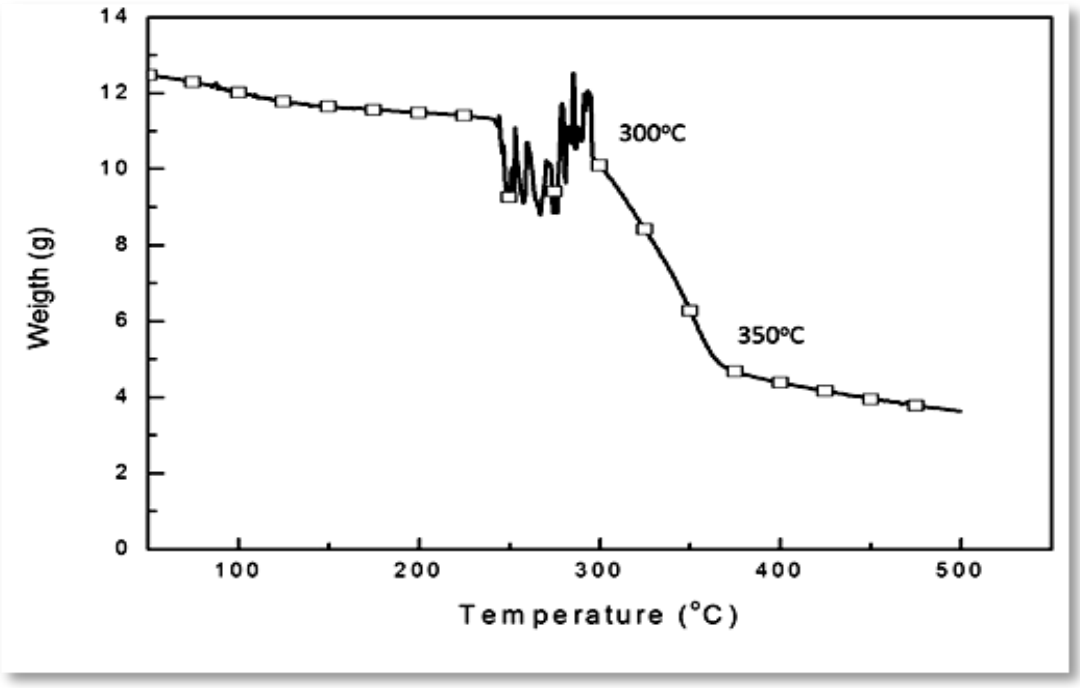

Figure 6. TGA curve of extracted fibers

Conclusion

The fiber was extracted from natural source i.e. *Urera hypselodendron* plant trunk using both water retting and chemical methods. The results showed that the fiber had good strength especially the water retted fibers, fineness and good elongation. Due to its greater strength, cost-effective and renewable source, the fiber can be used to make technical textiles products like packaging material [bags], carpet backing, ropes, yarns and wall decoration among other wider verity of technical textiles applications.

Acknowledgement

This work was supported by Ethiopian Institute of Textile and Fashion Technology [EITEX].

Conflicts of Interest

Authors declare no conflict of interest

References

[1] Balan V. Development ofpreparatory processes for making of banana fibre blended fabrics and their evaluation. Mumbai, Iindia: SNDT Women's University; 2008.

[2] Samrat Mukhopadhyay RF, Yusu Arpac, Ulkusendurk. Banana Fibers - Variability and Fracture Behavior. Journal of Engineered Fibresand Fabrics 2008;3(2):39 -45.

[3] Fortunati DP, Monti M, Santulli C, Maniruzzaman M, Kenny JM. Cellulose Nanocrystals Extracted From Okra Fibers In PVA Nano composites. Journal of Applied Polymer Science 2013;128(5):462-480.

[4] Saravanakumar SS, Nagarajan T, Sudhakar P, Baskaran R. Characterization of a novel natural cellulosic fiber from Prosopis juliflora bark. Carbohydrate Polymers 2013;92(5):1928-1933.

[5] Mohanty AK, Drzal LT. Natural fibers, Biopolymers and Biocomposites: CRC Press, Taylor & Francis Group; 2005.

[6] Maher RR, Wardman R.H. The Chemistry of Textile fibres. Chemistry, Rso (ed.). Cambridge, RSC Publishing; 2015.

[7] Mwaikamno LY. Tensile Properties of Alkalized Jute Fibers. Bioresources 2009;4(2):566-578.
[8] Thygesen LG, Hoffmeyer P. Visualisation of dislocations in Hempfibres: A comparison between scanning electron microscopy [SEM] and polarized light microscopy [PLM]. Industrial Crops and Products 2006;24(2):181–185.
[9] Mwasiagi JI, Yu CW. Phologolo T, Waithaka Kamalha AE, Ochola JR. Characterization of the Kenyan Hibiscus sabdariffa L. [Roselle] Bast Fibre. Fibres and Textiles in Eastern Europe 2014;105(3):31-4.
[10] Natarajan T, Kumaravel A, Palanivel R. Extraction and Characterisation of Natural cellulosic fibre from Passiflora Foetida stem. International Journal of Polymer Analysis and Charecterisation 2016;2(6):478-485.
[11] Balasundar P, Narayanasamy P, Senthamarai kannan P, Senthil S, Prithiviraj R, Ramkumar T. Extraction and Characterisation of new natural cellulosic Chloris Barbata fibre. Journal of Natural fibres 2017;15(8):1-9
[12] Baskaran PG, Kathiresan K, Senthamaraikannan P, Saravanakumar SS. Charecterisation of new natural fibre from the bark of Dichrostachys Cinera. Journal of Natural Fibres 2017;15(4):62-68
[13] Guimaraes J, Da Silva C, Wypych F, Satyanarayana K. Characterization of banana, sugarcane bagasse and sponge gourd fibers of brazil. Industrial Crops and Products 2009;30(3):407-415.
[14] Bezazi A, Belaadi A, Bourchak M, Scarpa F, Boba K. Novel extraction techniques, chemical and mechanical characterisation of Agave americana L. Natural fibres. Composites, Part B: Engineering 2014;66(7):194-203.

****

