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Influence of alkali treatment on the properties of the Vietnamese bagasse fiber

Bach Trong Phuc[1], Nguyen Thanh Liem[1]
[1](*Polymer Center, Hanoi University of Science and Technology, Hanoi, Vietnam)*

Abstract: This paper investigates the influence of alkali treatment on diameter and mechanical properties of the bagasse fiber. The bagasse fiber made from bagasse by using mechanical method. The physico-mechanical properties of the untreated and alkali treated NaOH at room temperature and changing time were determined. Scanning electron microscopy-analysis and thermal properties of these were determined.
Keywords: Bagasse fiber, alkali treatment, distribution, diameter of fiber, thermal property

I. INTRODUCTION

In recent years several studies have been conducted to investigate the possibility of using natural fibers as replacement of synthetic fibers in fiber reinforced composites. Natural fibers have the advantages of low density, low cost and are biodegradable, but they also possess some drawbacks when used in composites [1]. These fibers are sensitive to temperature and moisture and usually have irregular cross sections. The main bottlenecks in the broad use of natural fiber in various polymer composites are poor compatibility between the fibers and the matrix, and the inherent high moisture absorption, which brings about dimensional changes in the lignocellulose based fibers [2]. Sugarcane is a plant mainly grown in tropical countries. In 2016, 1.85 billion tons of sugarcane was produced worldwide with a total area of 27.2 million hectares and average yield is 68.08 tons per hectare [3]. Vietnam produced 15 million tons of sugarcane with a total area 268.300 hectares and average yield of 62.6 tons per hectare [4].

Bagasse is the solid lignocellulosic residue left after extraction of juice from the sugarcane stalk. The principal use of bagasse is as a combustible material for energy supply in sugarcane factories. It also is used in pulp and paper industries and for fiberboard materials. The average bagasse composition contains 48.7% of fiber and composed of 41.8% cellulose, 28.0% hemicellulose, 21.8% lignin and 2.3% soluble solids [5]. Short and long term compatibility of natural fibers with a polymer matrix depends mostly on the successful removal of lignin, hemicelluloses and other non-cellulose fibre components from fibre surfaces which prevent bonding and are sensitive to ultra violet radiation and moisture. Researchers have attempted various surface treatments of which alkali treatment using sodium hydroxide have been found to be the most feasible one [6]..

This research was carried out to investigate the effect of concentration of sodium hydroxide (NaOH) and treatment time at room temperature on the physical and mechanical properties of Vietnamese bagasse fibers.

II. EXPERIMENT

2.1 Materials

- Bagasse: waste product of the Lamson Sugarcane Joint Stock Company, Thanh Hoa Province, Vietnam.
- NaOH 98% pellets (China) were used for the alkali treatment of fibres.
- Acetic acid 99% (China)

2.2 Preparation of fibres

Bagasse is collected to be soaked in clean water for 24 hours to remove dirt and eliminate the sugar in the sugarcane. Then put the bagasse through the rolling machine to remove water along sugar inside the sugarcane. Repeat 3 or 4 times soaked in clean water and rolled to remove sugar in sugarcane to prevent moldy mold while preserving. Bagasse was then dried in an oven for 24 hrs at 70^0C and for spinning machine. The rakes will separate the bagasse into longer 5 cm fibers, shorter 5 cm and cane debris.

Alkaline treatment or mercerization is one of the most used chemical treatments for natural fibers that are to be used to reinforce thermoplastics and thermosets. The bagasse fibers were soaked in a 0, 0.1 and 0.5 N NaOH solution at room temperature, maintaining a liquor ratio of 10:1 (w/w). The fibers were then washed several times with fresh water to remove any NaOH sticking to the fiber surface, neutralized with dilute acetic acid and finally washed again with distilled water. A final pH of 7 was maintained. The fibers were then dried at room temperature for 48 hrs, followed by oven drying at 70^0C for 24 hrs.

2.3Characterization

The diameter of the bagasse fiber is measured through an optical microscope. Tensile specimen was prepared by sticking the fiber on the cardboard paper frame to prevent damage and easy handling of a fiber during testing as shown in Figure 1. Tensile test was performed using Lloyd Instrument Universal Testing Machine (Model LR 50K – UK) with a 10N load cell. A cross head speed setting was 5.0 mm/min and gauge length of 20 mm was chosen. The tensile test was carried out according to ASTM D 3379-89 standards. The end of the cardboard paper frame were gripped by hydraulic clamps to align the fiber with the machine axis. The test begun after the cutting lines were cut off. The load displacement trace was recorded in order to determine the tensile strength of single bagasse fiber. Six specimens was tested under each conditions and the average value calculated .t

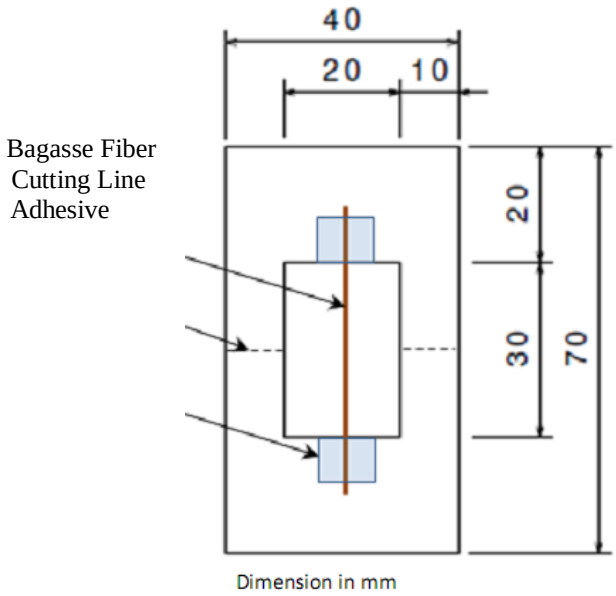


Figure 1. Bagasse fiber specimen setup for tensile test

SEM was performed with a Jeol JMS 6360 LV (Japan) apparatus operated at different voltages from 15 to 20 KV. Fibers were pasted onto a carbon tape to fix them on aluminum stubs. Fibers were coated with gold to make them conductive prior to SEM observation. The longitudinal surface and cross section of fibers were analyzed and measured by microscopic observation.

TGA analysis was carried out using a NETZSCH STA 409 thermogravimetric analysis from 50^0C to 600^0C in a platinum pan at a heating rate of 10^0C/min and a flow rate of 60 mL/min under a nitrogen atmosphere.

III. RESULTS AND DISCUSSION

3.1. Effect of concentration of sodium hydroxide on the diameter of bagasse fibers

Figure 2 showed the distribution of diameter of bagasse fiber untreated and treated NaOH at 0.1 and 0.5N at room temperature for 24 hrs treatment time.

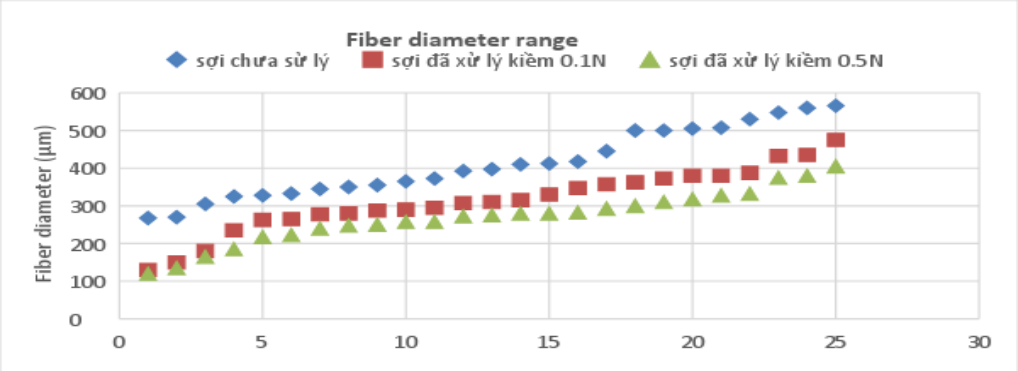


Figure 2. Change in bagasse fiber size after treated by NaOH 0.1 and 0.5N at room temperature in 24 hrs.

In the alkali treatment process, the size of the bagasse fibers varies considerably with the concentration of NaOH. The diameter of treated NaOH 0.1N bagasse fibers contribute in the range 262 to 387 µm (average in diameter 314 µm). The diameter of treated NaOH 0.5N bagasse fibers contribute in the range 217 to 332 µm (average in diameter 269 µm). Again, the diameter of untreated NaOH bagasse fibers contributes in the range 325 to 507 µm (average in diameter 412 µm. So the average diameter of bagasse fiber after treatment with NaOH was reduced by 40% (from 412 µm to 269 µm).

3.2. Effect of alkali treatment time on the diameter of bagasse fibers

Figure 3 showed the distribution of diameter of bagasse fiber untreated and treated at 0.1N at room temperature with treatment time 24, 48, 72 hrs.

As observed in Figure 3, after treatment in NaOH 0.1N with time 24 hrs, the bagasse fibers contribute in the range 262 to 387 µm (average in diameter 314 µm). The diameter of treated bagasse fibers contribute in the range 250 to 350 µm (average in diameter 297 µm) in treatment time 48 hrs. Finally, the diameter of treated bagasse fibers contribute in the range 225 to 305 µm (average in diameter 278 µm) in treatment time 72 hrs.

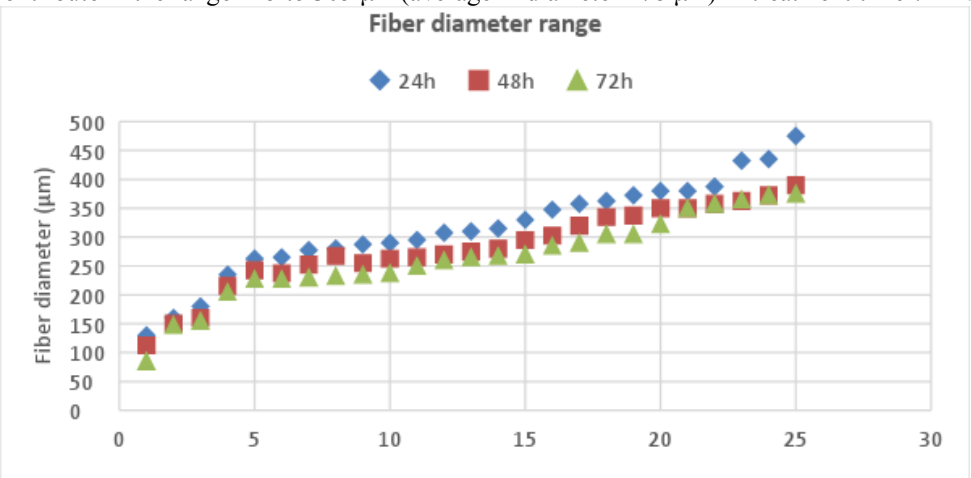


Figure 3. Change in bagasse fiber size treated by NaOH 0.1 N at room temperature for 24, 48, 72 hrs

3.3. Effect of concentration of sodium hydroxide on the tensile strength of bagasse fibers

Figure 4 showed the distribution the tensile strength of untreated and treated bagasse fiber NaOH at 0.1 and 0.5N at room temperature with treatment time 24 hrs.

The tensile strength of untreated bagasse fiber distributed mainly at 28 to 73 MPa with the average 59 MPa. The tensile strength of alkali treated 0.1N bagasse fiber distributed mainly at 82 to 281 MPa with the average 176 MPa. The highest tensile strength distributed for bagasse fiber after alkali treatment obtaining at NaOH 0.5 N at room temperature and time 24 hrs with value from 103 MPa to 326 MPa (average 228 MPa).

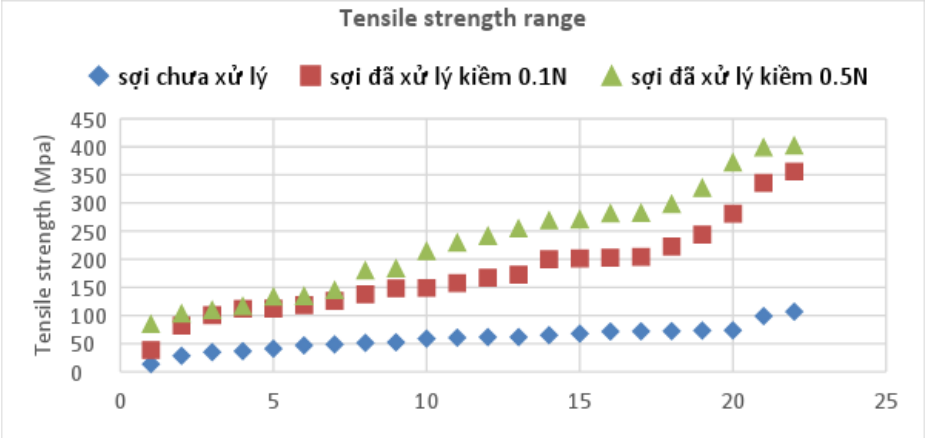


Figure 4. Change in the tensile strength of bagasse fiber size treated by NaOH 0.1N and 0.5N in 24 hrs.

3.4. Effect of alkali treatment time on the tensile strength of bagasse fibers

Figure 5 showed the distribution the tensile strength of untreated and treated bagasse fiber NaOH at 0.1N at room temperature with treatment time of 24, 48 and 72 hrs.

The tensile strength of treated bagasse fiber distributed mainly at 108 to 329 MPa with the average 244 MPa in 24 hrs. The tensile strength of alkali treated 0.1N bagasse fiber distributed mainly at 57 to 316 MPa with the average 176 MPa in 48 hrs. The tensile strength distributed for bagasse fiber after alkali treatment obtaining at NaOH 0.1N at room temperature and time 72 hrs with value from 70 MPa to 299 MPa (average 302 MPa).

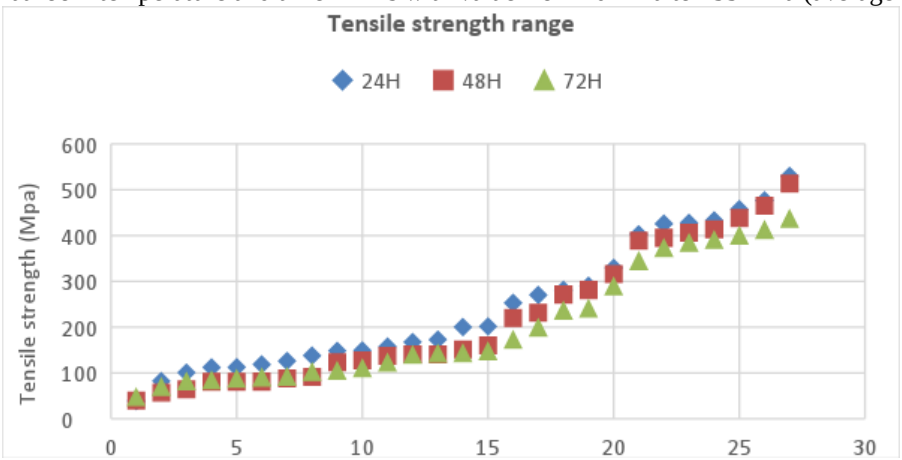


Figure 4. Change in the tensile strength of bagasse fiber size treated by NaOH 0.1N in 24, 48, 72 hrs.

3.5. Influence of alkali treatments to the thermal strength of bagasse fibers

The thermal property of bagasse fibers with and without alkali treatment NaOH 0.1N was determined by TGA method. The results of the investigation were showed on Figure 5. From the results on Figure 5 indicated that the weight of alkali untreated bagasse fiber (Fig. 5a) decreased 2.1% at 290^{0}C, then loss 58.73% at 338.62^{0}C, while the weight of alkali treated bagasse fiber (Fig.5b) decreased 3.65% at 290^{0}C and loss 56.59% at 340.31^{0}C.

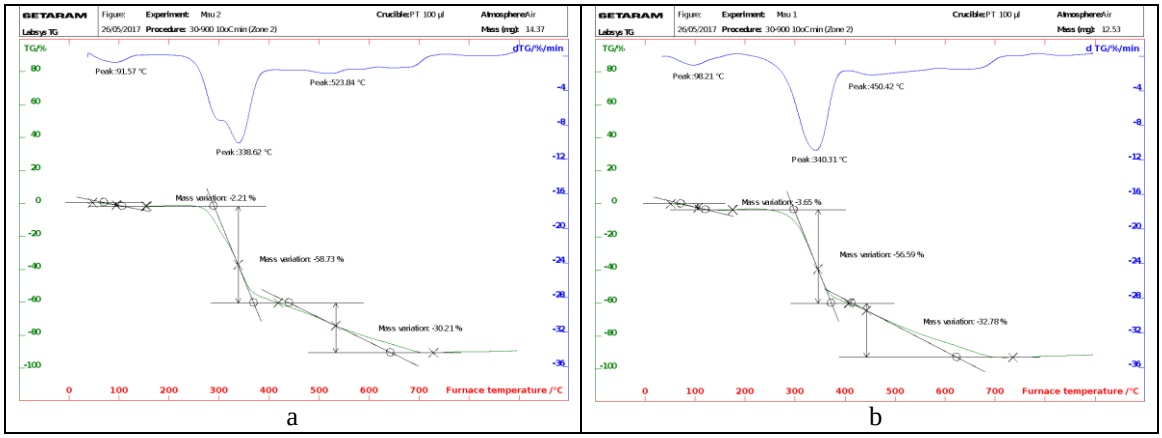
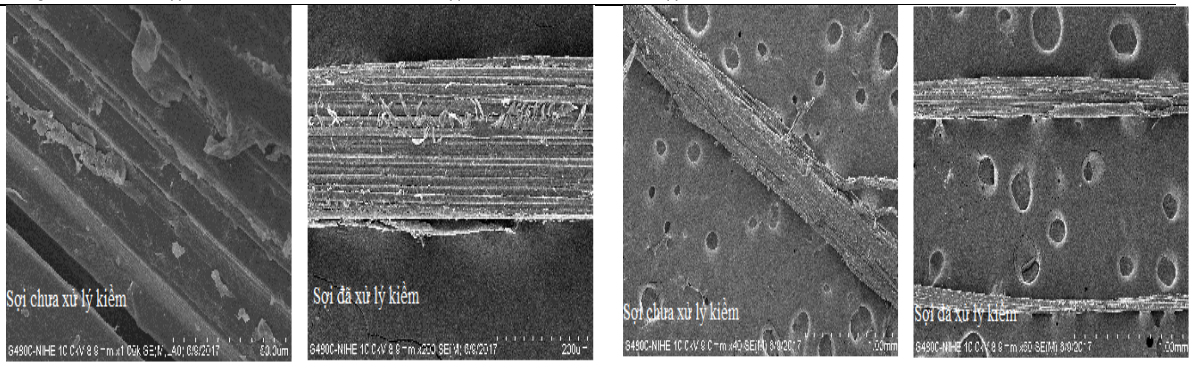


Figure 5. TGA curves of untreated (a) and alkali treated NaOH 0.1N bagasse fiber

3.6. Observations by SEM

Figure 6 shows the bagasse fiber surface before and after alkali treatments NaOH 0.1N at room temperature and treated time 24 hrs. The SEM in Figure 5 was observed that the filaments in the untreated fiber were packed together but became split after the alkali treatment. This phenomenon is termed fibrillation, and it involves breaking the untreated fiber bundle down into smaller ones by the dissolution of the hemicellulose. In comparison with the untreated bagasse fiber (Fig. 6a and Fig. 6c), the microscopic analysis of alkali treated bagasse fiber (Fig. 6b and Fig. 6d) demonstrated that the alkali treatments at room temperature and treated time 24 hrs removed various quantities of lignin. The longitudinal view of alkali treated bagasse fiber at NaOH 0.1N in Fig. 6b shows a smooth surface.



a b c d

Figure 6. SEM images of untreated (a, c) and alkali treated NaOH 0.1N bagasse fiber (b,d) at room temperature and treated time 24 hrs
a,b: longitudinal view;
c,d: cross cut view

IV. CONCLUSION

In this study, the tensile strength and the it's distribution of the bagasse fiber were determined using Universal Testing Machine. This fibers were been treated with different concentration of NaOH and with changing time at room temperature. The results showed that In the alkali treatment process, the size and distribution of the bagasse fibers varies considerably with the concentration of NaOH. The highest tensile strength distributed for bagasse fiber after alkali treatment obtaining at NaOH 0.5 N at room temperature and time 24 hrs with value from 103 MPa to 326 MPa (average 228 MPa).

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Corresponding authors:
Bach Trong Phuc
Polymer Center, Hanoi University of Science and Technology, Hanoi, Vietnam

Nguyen Thanh Liem
Polymer Center, Hanoi University of Science and Technology, Hanoi, Vietnam