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Harnessing Bagasse Fiber via Wet Spinning Method

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Abstract

This study investigates the effect of treatment of sugarcane bagasse, a fibrous waste byproduct, into fibres via wet spinning. Sugarcane bagasse, typically abandoned or incinerated, releases greenhouse gases and pollutes the air. By transforming this agricultural waste into eco-friendly fibres, this research aims to enhance resource efficiency and environmental sustainability in the textile industry. The study systematically applied acid and alkaline hydrolysis treatments to bagasse fibres, improving their texture, softness, and homogeneity. Comparative tests evaluated the impact of various treatments on fibre characteristics. Fibres treated with NaOH and HCl exhibited enhanced softness and homogeneity, making them suitable for wet spinning extrusion. Further treatments with glucomannan and acetone successfully reconverted optimised fibres into continuous filaments, demonstrating their potential in textile applications. The findings indicate that sugarcane bagasse can serve as a viable alternative to synthetic fibres, fulfilling global demands for eco-friendly materials.

1. Introduction

Bagasse, a residue from sugarcane process often discarded which contibutred to environmental pollution and greenhouse emissions. With growing demand for sustainability in textile industry, repurposing agricultural by-products like bagasse offered solution to reduce environmental impact and reduced reliance on synthetic fibers [1]. This study explores potential of bagasse fibers as regenerated fibers through wet spinning method by using treated bagasse for textile applications.

Previous studies have explored different methods to create regenerated fibers from bagasse for textile applications. One of these involves extracting fibers with combination of alkali treatment with NaOH and bleached using hydrogen peroxide. These methods showed improvements in mechanical properties and moisture absorption [2]. Another approach utilized soda-anthraquinone pulping and acid hydrolysis of bagasse to obtain purified cellulose, followed by regeneration into lyocell fibers using N-methylmorpholine-N-oxide (NMMO) as a solvent. The fibers exhibit high tenacity and water absorption properties comparable to commercially available lyocell [3]. Both methods aim to utilize sugarcane bagasse as a sustainable and renewable source for high-quality textile fibers.

Different treatments influence the properties of the bagasse pulp. In this study, bagasse fibres were treated using sodium hydroxide (NaOH), sodium chlorite ($NaClO_2$) and hydrochloric acid (HCl) for chemical treatment. Sodium hydroxide was used for delignification to remove lignin and hemicellulose, producing bagasse pulp. Sodium chlorite used to bleached and enhanced fiber whiteness.[4] Hydrochloric acid employed for acid hydrolysis to enhance fiber flexibility. The treated fibers were then extruded using wet spinning process to produce into fibers. This research aims to investigate the effects of different treatments on bagasse fiber towards possibility to turn the bagasse waste into textile fibers.

2. Materials and method

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Bagasse from sugarcane species *Saccharum Officinarum* used in this study, was collected from a local roadside sugarcane juice stall. The raw bagasse was manually inspected to remove debris, cut into smaller pieces approximately 2 cm in length, and blended using a blender to reduce particle size. Excess liquid was removed through straining, and the material was evenly spread on a tray and dried at 140°C for 1 hour in a conventional oven. The dried bagasse was further milled using a dry mill to achieve finer particles and sieved through a 40-mesh screen to remove large fragments, and stored in an airtight container to prevent contamination. The process is illustrated in Figure 1, which outlines the steps from raw bagasse to prepared particles.

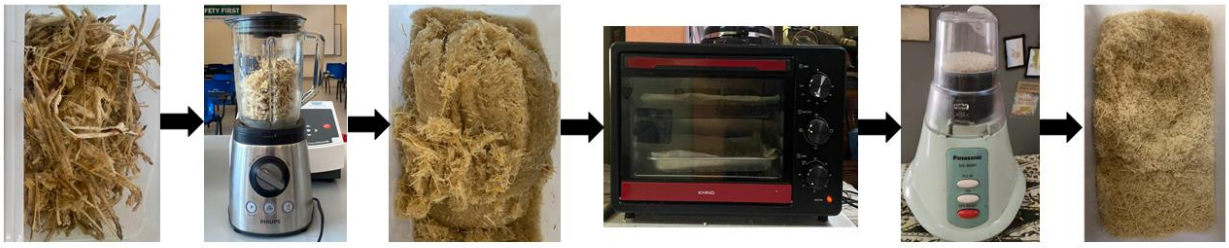

Fig. 1: Bagasse particle preparation: (a) Raw bagasse, (b) Bagasse in the blender, (c) Finer bagasse, (d) Drying process in the oven, (e) Dried bagasse, (f) Bagasse in dry mill

The chemical treatment process followed the method outlined by Fahmy et al. (2020). The materials used to make the regenerated bagasse fibre included 9.09 and 13.04 wt.% sodium hydroxide, 35 wt.% hydrochloric acid, and 25 wt.% acetone. All of the chemicals were purchased from Liangtraco & Sons Sdn Bhd. NaOH solutions (3.75 M and 2.5 M) were prepared by dissolving caustic soda flakes in distilled water. Bagasse particles were subjected to three different chemical to compare the effects of chemical modifications on fiber properties. The chemical used, concentration, soaking time and sample list are provided in Table 1.

Table 1: Sample list, chemicals used, concentration and soaking time.

Sample	Chemical	Chemical Concentration (wt.%)	Soaking time (hour)
A	NaOH	9.09	1
		13.04	1
	HCl	35	1
B1	$NaClO_2$	25	3
	HCl	35	1
B2	$NaClO_2$	25	3
	HCl	35	1
C	NaOH	9.09	3
		13.04	3
	HCl	35	1

For Sample A, 0.25g of the particles underwent treatment with 100 ml of 9.09 wt.% NaOH for 1 hour, followed by 13.04 wt.% NaOH for 1 hour, and finally 35 wt.% HCl for 1 hour. After each soaking, the bagasse particles were strained and thoroughly washed with distilled water to remove excess chemicals then dried at 140°C for 5 minutes after each step. This procedure can be seen in Figure 2.

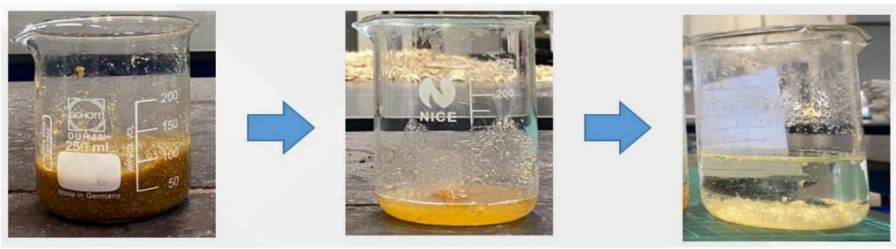

Fig. 2: Sample A: (a) bagasse powder soaked in NaOH 9.09 wt% for 1 hour; (b) bagasse powder soaked in NaOH 13.04 wt% for 1 hour; (c) acid hydrolysis using HCL 35%

Sample B was treated by soaking 0.25 g of bagasse in 100ml of 25 wt.% $NaClO_2$ solutions for 3 hours at room temperature. . After soaking, the particles were strained, washed, and divided into two parts: B1, which was dried at 140°C for 5 minutes, and B2, which remained undried. Both parts were then soaked in 35 wt.% HCl for 1 hour, followed by straining, washing, and drying of B1 while B2 remained undried. The preparation process for Sample B is shown in Figure 3.

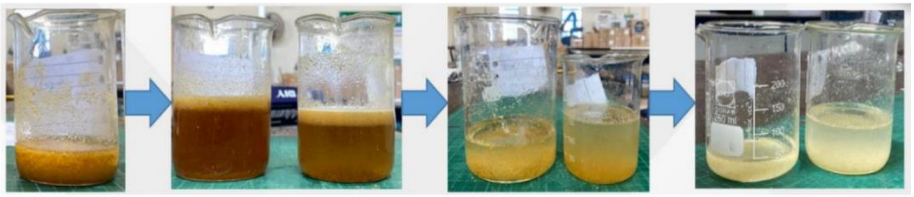

Fig. 3: Sample B: (a) bagasse particle soaked in $NaClO_2$ 25% for 3 hours; (b) bagasse powder soaked in NaOH 9.09 and 13.04 wt% for 1 hour; (c) acid hydrolysis using HCL 35%.

Sample C was treated by soaking 0.25 g of bagasse in 100 ml of 9.09 wt.% NaOH solution for 3 hours. After that the bagasse was strained and washed, the particles were then soaked again in 13.04 wt.% NaOH for another 3 hours, then strained and washed again. and finally treated with 35 wt.% HCl for 1 hour, with drying at 140°C for 5 minutes after each step. The complete preparation process for Sample C is illustrated in Figure 4.

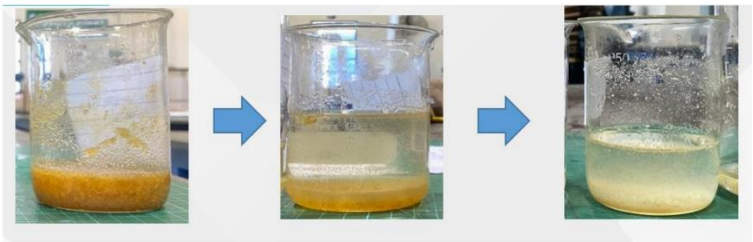

Fig. 4: Sample C: (a) bagasse particle soaked in $NaClO_2$ 25% for 3 hours; (b) bagasse powder soaked in NaOH 9.09 and 13.04 wt% for 1 hour; (c) acid hydrolysis using HCL 35%

2.1 Wet spinning process

The bagasse pulp obtained from each sample was collected, and 10 g of the produced bagasse pulp from each sample was used. Each sample was mixed with 5 g of glucomannan and 100 ml of distilled water to form a viscous liquid. This liquid was then extruded using an 18G syringe into a tray filled with acetone, facilitating the formation of regenerated bagasse fibers. Figure 5 shows each sample, ample A, sample B1 and B2 and sample C extruded to acetone bath in a tray.

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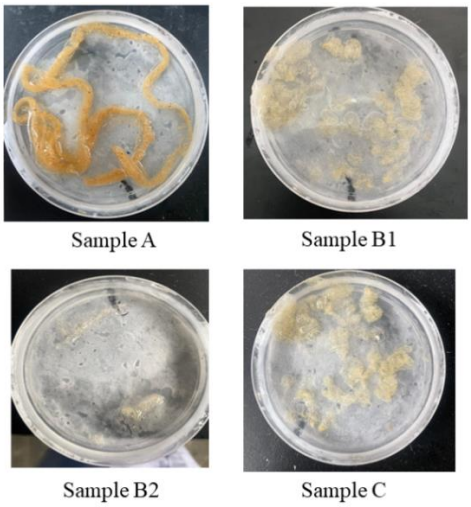


Fig. 5: Bagasse pulp mixed with glucomannan extruded in acetone bath

2.2 Morphological test

The morphogical test was conducted to examine using optical microscope. Samples of approximately 0.02g, placed on a microscope slide and spread evenly to ensure a flat and non overlapping layer. The fiber sample was carefully placed beneath the microscope lens, ensuring it was securely fixed to prevent any movement during the examination. The base of the microscope was precisely adjusted to obtain the best focus, offering a clear and sharp view of the sample's intricate features. This procedure was essential for acquiring precise and detailed images of the fiber's microstructure. Rather than using a conventional camera, an Extended Depth of Focus (EDF) camera was utilized to improve the observation. The analysis was conducted at a magnification of 20x the morphology of four sample (A, B1, B2 and C). The optical microscope analysis aimed to evaluate the structural changes in the bagasse pulp resulting from the different chemical treatments.. The process of analyzing the bagasse pulp shown in Figure 6. Optical microscope used in this study located at material science laboratory, UTHM Pagoh.

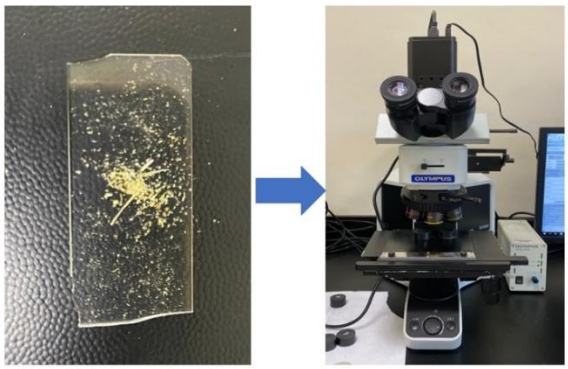
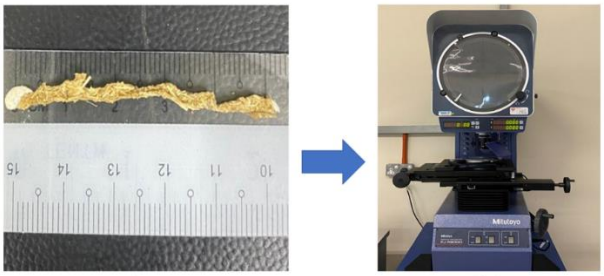


Fig. 6: The process of morphology analysis for bagasse pulp: (a) Bagasse pulp spread on microscope slide, (b) analysis of treated bagasse pulp

2.3 Diameter measurement

The regenerated spun fibers formed were air-dried to ensure consistent conditions prior to dimensional analysis. The diameter of the fibers was measured using a profile projector to obtain precise and accurate dimensional data. The profile projector utilized in this study is housed in the Metrology Laboratory at UTHM Pagoh. For measurement, the fiber was carefully placed on a calibrated ruler, and readings were taken at 15 distinct points along its length to capture variations in diameter. At each point, the diameter was recorded, and the average

value was calculated to provide a representative measurement of the fiber's size. The process of measuring the diameter of the spun fiber is illustrated in Figure 7, which provides a visual representation of the measurement setup and methodology.



(a) (b)

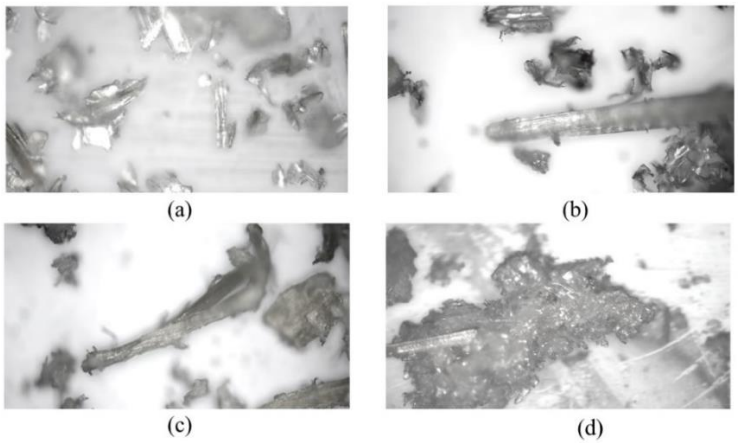
Fig. 7: The process of diameter measurement using profile projector: (a) Spun bagasse fiber placed on a ruler to get accurate 15 point along the fiber, (b) Profile projector used to measure the spun fiber diameter

3. Results and Discussion

A total of four samples were created for each treatment type, including Sample A, Sample B1, Sample B2, and Sample C, with specific chemical treatments applied as outlined in 2.

3.1 Morphological Structure of Bagasse Pulp

The morphology of bagasse pulp was analyzed using an optical microscope at magnifications 20x as shown in Figure 8. The pulp appeared in various sizes aligns with the findings of Rezende et al. (2011), which shows variation in chemical treatment affect the bagasse fiber structure. The results emphasize the importance of bagasse pulp structure in effectiveness for further processing and applications.



(a) (b) (c) (d)

***Fig. 8*:** Optical microscope images at magnification 20x.
(a) Sample A, (b) Sample B1, (c) Sample B2, (d) Sample C

3.2 Diameter measurement

Measurements were recorded at 15 different points along the length of spun fiber, and the average of these readings was calculated. Table 1 shows values of the readings. The spun fiber produced are not uniform and have an uneven surface, causing significant difference in between the 15 measurement points. Figure 9, diameter of spun bagasse fiber measured.

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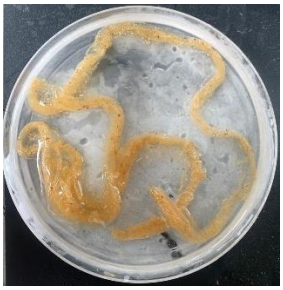

***Fiq. 9*:** Sample A extruded in acetone bath

Produced regenerated fibers was air dried then the fiber diameter was then measured using a profile projector, to get precise measurements of the spun fibers dimensions.

The fiber was placed on a ruler, and readings were taken at five different points along the fiber. At each point, measurements were recorded three times, and the average of these readings was calculated. Table 1 below presents the average values of the readings.

***Table 2*:** Diameter of spun fibre

Point	Diameter (mm)			Average Diameter (mm)
1	1.155	1.235	1.198	1.196
2	2.334	2.399	2.385	2.373
3	2.578	2.532	2.513	2.514
4	2.968	2.945	2.862	2.925
5	4.158	4.247	4.106	4.170

The spun fiber produced are not uniform and have an uneven surface, causing significant difference in the average diameter between the five measurement points. The average diameter for the whole spun fiber was 2.636 mm.

4. Conclusion

To conclude, the research objectives have been achieved. The research successfully demonstrated the production and evaluation of bagasse pulp and regenerated fibers through various chemical treatments and wet spinning methods. Among the four samples (A, B1, B2, and C), Sample A, treated with optimal NaOH concentrations and soaking times, achieved a nanocrystalline structure and sufficient firmness, allowing successful fiber extrusion into an acetone bath. The morphological analysis confirmed the effectiveness of the delignification process for Sample A, while improper treatments on the other samples led to fiber degradation and softness, making them unsuitable for extrusion. This study underscores the critical role of chemical treatment parameters, such as concentration and soaking time, in producing high-quality bagasse fibers. Future research should focus on further optimization of these parameters and exploring alternative treatments to enhance fiber regeneration and extrusion processes for broader applications in various industries.

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References

[1] Jalalah, M., Khaliq, Z., Ali, Z., Ahmad, A., Qadir, M. B., Afzal, A., Ashraf, U., Faisal, M., Alsaiari, M., Irfan, M., Alsareii, S. A., & Harraz, F. A. (2022). Preliminary Studies on Conversion of Sugarcane Bagasse into Sustainable Fibers for Apparel Textiles. *Sustainability*, *14*(24), 16450. https://doi.org/10.3390/su142416450

[2] Mahmud, M. A., & Anannya, F. R. (2021). Sugarcane bagasse-A source of cellulosic fiber for diverse applications. *Heliyon*, *7*(8).

[3] Amaresh, P., Suresha, G.S., Krishnappa, G., Palanichamy, M., Mahadeva Swamy, H.K., Kuppusamy, H., & Govindakurup, H. (2024). Sugarcane bagasse: Transforming waste into renewable and bio-compostable materials for a sustainable future. In G.S. Suresha, G. Krishnappa, M. Palanichamy, H.K. Mahadeva Swamy, H. Kuppusamy, & H. Govindakurup (Eds.), *Value addition and product diversification in sugarcane* (pp. 177-190). Springer. https://doi.org/10.1007/978-981-97-7228-5_12

[4] Kundu, S, Mitra, D. & Das, M. Influence of chlorite treatment on the fine structure of alkali pretreated sugarcane bagasse. *Biomass Conv. Bioref.* 13, 567–581 (2023). https://doi.org/10.1007/s13399-020-01120-2

[5] S. M. Costa, S. A. Costa, R. Pahl, P. G. Mazzola, J. P. P. Marcicano, and A. Pessoa Jr., "Textile fiber produced from sugarcane bagasse cellulose: An agro-industrial residue," *International Journal of Textile and Fashion Technology (IJTFT)*, vol. 3, no. 2, pp. 15-28, Jun. 2013.

[6] Bagis, F. H., & Setiadi, S. (2020, September). Nanocellulose filament fabrication from Sugarcane Bagasse through wet spinning method. In *AIP Conference Proceedings* (Vol. 2255, No. 1). AIP Publishing.

[7] P. Prabhu *et al.*, "Variation in chemical treatment affecting the lignin structure," *Cogent Engineering*, vol. 9, no. 1, pp. 2014025, 2022.

[8] Wang, J., & Zhang, Y. (2008). *Bioresource Technology, 99*(16), 7580-7585. https://doi.org/10.1016/j.biortech.2008.06.043