IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

The effect of NaOH concentration variation in the process of paper making from bamboo fiber

To cite this article: Dulmalik *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **535** 012008

View the article online for updates and enhancements.

This content was downloaded from IP address 223.215.103.236 on 13/10/2019 at 09:03

The effect of NaOH concentration variation in the process of paper making from bamboo fiber

Dulmalik[1], Dwiky MI[2],N Kumala S[3], Fety IR[4], FN Khaliq[5]

[1,2,3,5]Department of Chemical Engineering, Faculty of Industrial Technology, Islamic University of Indonesia, Yogyakarta, Indonesia
[4]Department of Industrial Engineering, Faculty of Industrial Technology Islamic University of Indonesia, Yogyakarta, Indonesia

E-mail: 815210102@uii.ac.id

Abstract. Bamboo cropping period is quite short compared to wood, but fiber and bamboo pulp have not been optimally used as a substitute for wood in composite industry, such as fiber board. It is worth to be investigated because of the availability of wood is declining. Therefore, this research aimed at revealing the use of fiber and bamboo pulp (G. apus) for fiberboard. The study was conducted using bamboo fibers from bamboo strips cooked with soda process and bamboo pulp from chips of bamboo cooked with soda process and Kraft process. Composite of bamboo fiber is made with a variety of fiber weight fraction to the epoxy resin matrix. Furthermore composite of bamboo pulp is made under optimal condition for making fiber composite. Based on the test results, it is known that the quality of the bamboo fiber composite from bamboo strips cooked with soda process is better than the composite of bamboo pulp. Besides, the produced bamboo fiber composites can be categorized as the high-density fiberboard meanwhile for the aspect of water content, water absorption, length and thickness changes, flexural strength and modulus of elasticity are in accordance with applicable standard for fiberboard (SNI 01-4449 - 2006).

1. Introduction

In line with the advancement of technology, the demand of paper is currently increasing for schools, offices, companies, households and others. Paper is a thin material made of wood and it has even become a daily necessity as a medium for writing, drawing, printing, wrapping and also used as a cleaning tool. The increasing request of paper in everyday life effects on massive deforestation for the raw material of papermaking. It impacts on the environment, as the lack of water consumption on the ground that can cause flooding, landslides and even declining oxygen contain in the air which can cause global warming. To overcome this problem, it is crucial to find an alternative solution by changing he raw material of paper from pine tree fiber into bamboo tree, especially Bamboo *tali* (rope) or called bamboo apus. It is a type of bamboo commonly used for making paper because the fibers are soft, strong and flexible so they are not easily broken. Usually, the process of making pulp is through the process of craft, sulfite, or soda. Considering the potential of bamboo which can be made into pulp and the lack of research on bamboo-based pulps with the Soda process, it is beneficial to investigate the use of bamboo as a raw material for pulp making.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

2. Literature Review

Bamboo apus (Gigantochloa apus) is a type of bamboo that is widespread in Indonesia and tropical Asia. This bamboo is widely cultivated for the manufacture of handicraft raw materials. The taxonomic system for bamboo rope or bamboo apus is Kingdom: Plantae **,** Divisi: Angiospermae**,** Klas: Liliopsida,Ordo : Poales, Famili : Poaceae, Genus: Gigantochloa, Spesies : Gigantochloa apus (Bl. ex (Schult F. Kurz.)

The origin of bamboo apus is from Burma and it has spreaded widely throughout the Indonesian archipelago. This kind of Bamboo grows well in the tropics in the lowlands to the mountains with altitudes up to 1,000 m above sea level. The of bamboo apus is planted with the rhizomes roots and it can also be propagated by cutting the reed. Berlian and Rahayu state that bamboo apus can reach up to 20 meters in height [1,2,3]. The color of bamboo stem is green to yellowish. It has no branch at the bottom part. The stem diameter is between 2.5 to 15 cm, the wall thickness is 3 to 15 mm, and the length of the segment or reed is 45 to 65 cm. Utilization of bamboo apus culms is between 3 and 15 meters of which flexural strength is 502.3 - 1240.3 kg / cm2, modulus of flexural elasticity is 57,515 - 121,334 kg / cm2, flexural strength of 1,231 - 2,859 kg / cm2, and firmness press of 505,3 - 521,3 kg / cm2. The mechanical properties of bamboo apus without books are bigger than those with books [4,5].

2.1. Chemical Process

The chemical pulping process is a pulping process that uses chemicals as the main ingredient to dissolve unwanted parts of bamboo. The principle of the chemical pulping process is to degrade and dissolve lignin so that the fibers contained in the raw material are easily removed. There are three types of chemical pulping processes, namely soda process, process of sulfate or kraft, and sulfite process, each process uses a different cooking solution. The sulfate process and the soda process are both called alkaline processes while the sulfite process called as acid process. Pulping process as a basic process, where the cooked solution used for soda process is NaOH, while the sulfate process used cooking solution NaOH, Na2S, and Na2C03. and for the sulfite (acid) process a sulfite salt cooking solution is used. The criteria for the success of the chemical pulping process are product quality and high pulp recovery with little water use as well as high chemical recovery rates. In practice, the methods of chemical pulping have succeeded in separating most of the lignin but also dissolving certain amounts of hemicellulose and cellulose to make pulp recovery is relatively low compared to mechanical pulping. The acquisition of chemical pulp is usually in the range of 40-50%.

2.2. Sodium Hydroxide (HaOH)

NaOH is a strong alkaline chemical. It is also known as Caustic soda in the form of solids (white chips / crystals) for trading. Sometimes, it called as soda, natronloog, white kostik, or sodium hydrate. NaOH widely used in making rayon, paper, soap, detergent, textile processing, etc. (Guidelines for Textile Chemistry Practicum: 8). In the process of cooking cellulose natural fiber, the function of NaOH is to dissolve fat and dirt contained in the fiber so that the fiber becomes clean (Soeparman, 1967: 265). However, because NaOH is corrosive, it may damages materials such as textiles, leather, or paper. So, the use of it must consider its concentration (Utari B, 1986: 12). In this study, NaOH concentration was 5%, 10% and 15%.

3. Research Method

3.1. Data Collection Technique

This research was using literature study method by collecting data by reading from the internet sources and books related to the problem being studied as well as laboratory study methods. It also used direct experimental data on the studied sample and test samples of experimental results in the laboratory.

3.2. Sampling metodology

The sample division conducted in this study was using: (1) 50: 10 gr bamboo fiber samples and used paper, 2000 mL of aquadest and NaOH of 5%. (2) 50: 10 gr sample of rami fiber and used paper, 2000 mL of aquadest and NaOH of 10%. (3) 50: 10gr sample of rami fiber and used paper, 2000 mL of aquadest and NaOH 15%

3.3. Research Framework

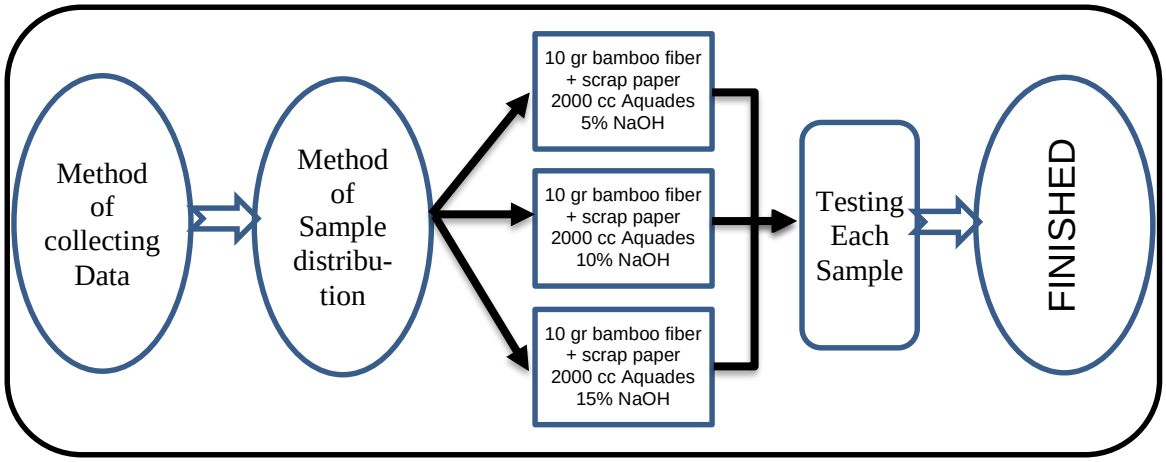

Figure 1. Research Framework

4. Result and Discussion

4.1. Advantages and Benefits

There are several advantages and benefits of bamboo fiber rope for paper making, including: (1) Flexibility - high elasticity so that it is not easily damaged, (2) Resilient-elastic so that the formation of paper becomes stronger (3) The fiber is long so it has great potential to be formed with various variations (4) It is environmentally friendly so that it easily breaks down in the soil.

4.2. Application

In the process of kraft paper making, bamboo apus fiber is used as the main raw material. This kind of bamboo has high flexibility or elasticity which is not easily broken and resilient so that it is very appropriate to be used for paper making.

This study is using chemical process (soda process), i.e pulping process with chemicals as the main ingredient to dissolve discarded parts of bamboo. The principle of this chemical pulping process is to degrade and to dissolve lignin so that the fibers contained in the raw material can be easily removed. The pulping process with basic processes of which the pulp is cooked using NaOH solution. The criteria

of the successful chemical pulping process are on product quality and high pulp recovery with little water use as well as high chemical recovery rates. Based on research on paper which consists of a pulping process that uses a mixture of bamboo fiber and used paper with a variable of (50: 10%), and variation of bamboo fiber length ± 3 cm. The raw material for making paper is cellulose which is chemically treated, rinsed, decomposed, bleached formed into sheets after pressing and drying. The optimum cooking time in the delignification process was about 60-120 minutes with the lignin content fixed after this range. The longer the cooking time, the lignin content in the pulp is high, because the lignin that has been separated from the raw pulp due to reduced concentration of NaOH will re-join with the fused raw pulp and it is difficult to separate. The immersion time is varied for the paper formation in order to softening the used paper to form into pulp.

Table 1. Test result of the paper with NaOH concentration of 5%,10%, and 15%.

Sample	Test of	Test score of flexural strength and modulus of elasticity		Thickness Test Score (mm)
		Flexural Strength Score (Gr)	Modulus of Elasticity Score (%)	
5 ml	1	900.00	0.60	1,222
	2	900.00	0.466	1,284
	3	800.00	0.466	1,290
Mean score		866.667	0.511	1,265
10 ml	1	3100.00	0.866	2,232
	2	3200.00	0.733	2,546
	3	3100.00	0.666	2,345
Mean score		3133.333	0.755	2,374
15 ml	1	2700. 00	0.666	1,109
	2	2600. 00	0.60	1,130
	3	2200.00	0.60	1,193
Mean score		2500. 00	0.22	1,144

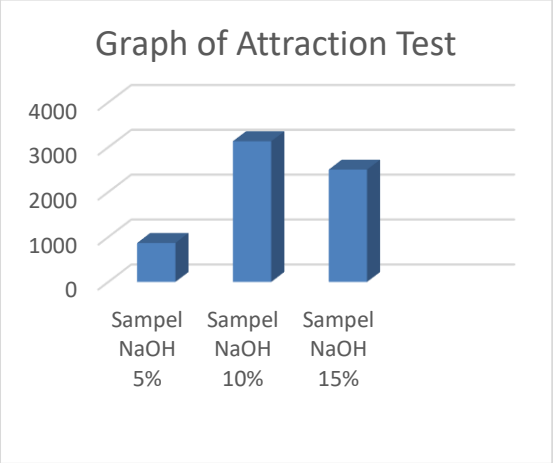

Figure 2. The relationship between the percentage of NaOH concentration and the flexural strength of the paper

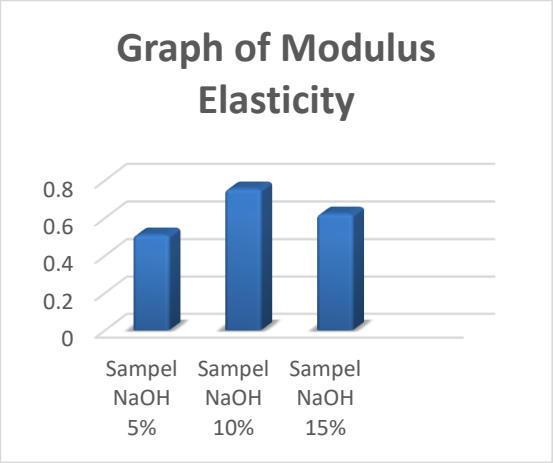

Figure 3. The relationship between the percentage of NaOH concentration and modulus of elasticity.

Figures of Paper surface

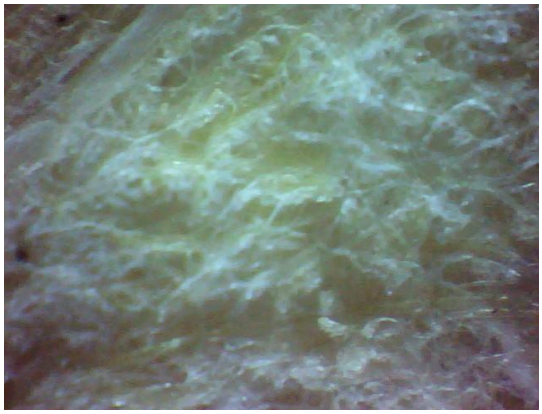

Figure 4. Sample NAOH 5 %

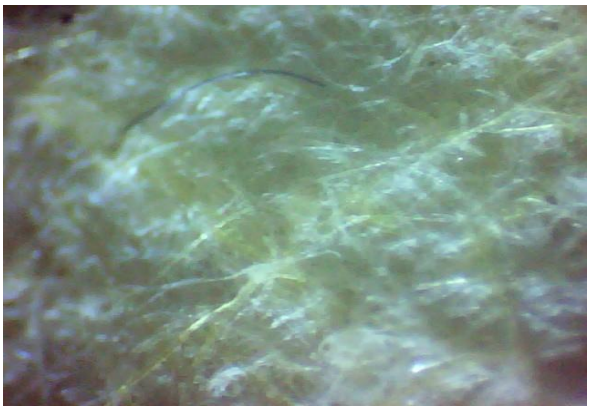

Figure 5. Sample NAOH 10%

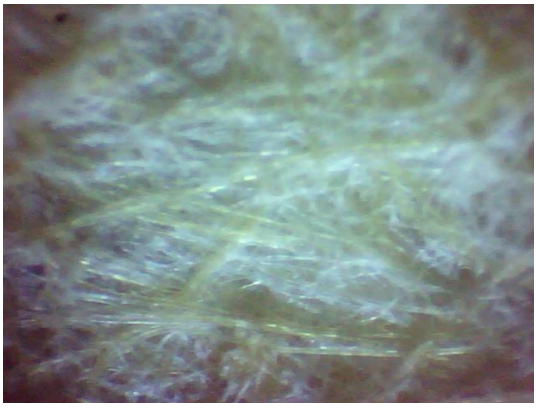

Figure 6. Sample NAOH 15%

Tenso Lab is used to test the flexural strength and paper modulus of elasticity of the paper. It works by clipping a sample of 2x20 cm paper into a clamp that is already available in the tool. Based on the test results of the lab that flexural strength was conducted test three times, the average paper attractiveness at 5% NaOH concentration was 866,667, the 10% NaOH concentration obtained the mean score of 3133,333 while on the NaOH concentration of 15%, the mean score was 2500,000 the mean gap with NaOH concentration of 5% and a concentration of 10% of 2266.666. Meanwhile, the gap with NaOH concentration of 10% and 15% was 633,333, the mean difference on 10% and 15% NaOH concentration was not too far. It is caused by the less levels of cellulose and hemicellulose contained in a fiber that cause the fibers to be shorter and easier to break so that the paper strength may decrease. Referring to the paper thickness test in NaOH concentration of 5%, it was obtained thickness score of 0.511% while for concentration of 10%, the score was 0.755% and 0.622% for the concentration of 15%. From the results of the paper thickness test, it can be seen that the higher the NaOH concentration used, the more dissolved cellulose because cellulose is the main component in making paper. Besides, the thickness test can be seen at a concentration of 5% with thickness value of 1.265 mm and 2.374 mm for concentration of 10%. Furthermore, the thickness score in the concentration of 15% was 1.144 mm. The results of the thickness test were not similar for each sample because during the compression process the researcher used a simple paper printing device made by the researcher which was done manually. The lab graph test showed the score of flexural strength was not linear following the Langmuir equation so that it can be concluded that the optimum NaOH concentration in paper making is at the addition of 10% NaOH concentration. In this case, with NaOH concentration of 10%, it was obtained the highest flexural strength.

5. Conclusion

(1) The bamboo stem mainly contain cellulose. It is a polysaccharide composed of D-glucose monomers. It has three hydroxyl groups that can be substituted because the basic material for paper making is cellulose. It means bamboo can be used as material for paper and cellulose is a photosynthetic product of plants. (2) Bamboo apus has special features on its stems and leaves in which the fiber is smooth, long and strong so that it is suitable as the raw material of the paper making. (2)The longer the cooking time, the bamboo fiber can be shorter and fragile so that the flexural strength the paper decline, the long cooking time may cause the cellulose to break down so that the produced yield and pulp is low. (3) Based on the graph of lab test, the score of flexural strength and modulus of elasticity is not linear with Langmuir equation. It can be concluded that the optimum NaOH concentration in making paper is in the addition of NaOH concentration of 10%. (4) In 5% of NaOH concentration and 10 g of used paper mixture, the flexural strength test score was 866.667 g with the flexural test score was 0.511% and the thickness test was 1.265 mm. (5) In 10% of NaOH concentration and 10 g of used paper mixture, the flexural strength test score was 3133,333 g with the flexural test score was 0,755% and the thickness test was 2,374 mm. (6) In 15% of NaOH concentration and 10 g of used paper mixture, the flexural strength test score was 2500,000 g with the flexural test score was 0,622% and the thickness test was 1.144 mm.

For further research, it important to add a sample of NaOH concentration (>3 samples) with different concentration in the range of adjacent distances to obtain more accurate results.

6. References

[1] Berlian, Nur V. A. dan Estu Rahayu. 1995. Jenis dan Prospek Bisnis Bambu. Penebar Swadaya. Jakarta.
[2] Dransfield, S and E. A Widjaya. 1995. Plant Reourch of South East Asia (PROSEA) no. 7: Bamboo, Bachuys Publisher. Leiden
[3] Liese, W. 1985. Anatomy of Bamboo Proceding Workshop Bamboo Research in Asia, Singapore 28-30 May 1980. International Development Research Center. Ottawa.
[4] Heyne. 1987. Tumbuhan Berguna Indonesia. Badan penelitian dan Pengembangan Kehutanan. Bogor.
[5] Sastrapraja, S, E A. Widjaja, S. Prawiroatmodjo, ddan S. Soenarko. 1980. Beberapa Jenis Bambu. Lembaga Biologi Nasional-LIPI. Bogor.