Extraction and Characterization of Cellulose from Abaca Pseudo Stem (Musa textile)

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Abstract, cellulose was extracted from abaca fibre which proceed with different alkalization technique, such as with and without heating treatment. The aim of this research is to extract and characterize the cellulose fibre that obtained from abaca fiber as the alternative of textile fibre. The characterization for the cellulose fibre including FT-IR, SEM, and XRD. The FT-IR spectra showed the heating treatment around 70-80°C can separate the lignin and hemicellulose from the abaca fiber. SEM analysis showed the similar result, the heating process during the alkalization treatment able to separate lignin from the cellulose matrix, that was shown with the smoothest surface of cellulose fibre. Crystallinity degree of the obtained cellulose was 65 and 43% for without and with heating process, respectively.

1. Introduction
Cellulose is organic compound that abundance in nature. This biopolymer was introduced by a chemist from France, Anselme [1]. Cellulose has unique properties, such as biocompatible and biodegradable, and that properties make cellulose to be very important material for wide area of application. The other properties of cellulose are rigid, high crystalline, not soluble in most organic solvent [2].

Cellulose is main component of plant, it can be found almost 30-50% in plant tissue and it was a renewable material that obtained from photosynthesis process [3] [4]. Cellulose as main component of plant tissue, it also gives a strength and stability to the plant cell wall (Dufresne, 2006) that arranged as microfibril in the cell wall, among hemicellulose and surrounded by lignin. Depend on the kind of plant, the cellulose, lignin and hemicellulose mostly 40-55%, 15-35% and 25-40%, respectively. Cellulose is a linear polymer that arranged by anhydroglucose unit and linked through β-glycosidic. This was confirmed by the presence of three hydroxyl group with the different acidity, whereas the secondary hydroxyl group is on C-2 and C-3 position, and the primary hydroxyl group is on C-6 position. This statement also verified by the formed of strong intermolecular and intramolecular hydrogen bonding [3] [4]. In the recent years, the demand of material based on cellulose was increase because of their awareness to the green chemistry concept [5].
The development of nanocomposite nowadays is directed to the utilization of material which has advance properties such as easy to obtain, low density, strength, flexible, renewable and biodegradable. That properties usually can be found in natural fiber. That fiber mostly used in wide area of application, such as paper, textile, cosmetic, composite for medicinal application, air filter, automotive, and aerospace. The newest research used natural fiber for the developing in science technology area, especially high absorbance material, anti-radar, solar cell substrate. Commonly, natural fiber has three components, such as hemicellulose, lignin and cellulose, the composition of those components depends on the fiber source, the age of plant, and the extraction method [6] [7]. Celluloses is consisted by microfibril structure which has advantage on the mechanical properties [7]. The strengthen of Abaca fiber (Musa textilis) is above average of other fiber commodities also the quality is high [6]. The Abaca fiber mostly used as pulp paper [8]; [9].

Abaca (Musa textilis) is categorized into Musaceae family which is male banana with a little uneaten fruit filled with seeds. The Pseudostem can grow to 6.5 m and build 10-25 sheaths that grow from the central core [10] [9] [11].

2. Methodology

Materials
Abaca fiber was obtained from Peunaron district, Aceh Timur – Indonesia. Aquadest, NaOH, NaOCl, acetic acid was obtained from Merck. In this research, some equipment was used, such as analytical balance, filter paper, thermometer, hot plate, oven, universal indicator, desiccator, centrifugator, SEM (Scanning Elektron Microscope)Jeol Model JSM-6510LA. FT-IRIR (Fourier Transform Infrared) Bruker Opus Alpha 7.5., DSC (Diffrential Scanning Calorimetry)DSC-60. XRD (X-Ray Diffractometer) XRD-6100.

Preparation of abaca fiber
Abaca fiber was extracted using microbial degradation [12]. Abaca pseudostem was separated and soaked in water, after that the obtained fiber was washed and dried for 3 days.

Extraction of cellulose
The extraction of cellulose was performed following this method [13] that has been modified. The extraction was performed through 2 steps, such as (i) the formed of holocelluloses through chlorinating or bleaching process and (ii) alkalization process.

20 g of durian rinds was added with 500 mL aquadest and 150 mL of 5% NaOCl4. After 2 hours, the lignin will separate. The holocellulloses fibre were filtrated and washed with water until pH 7. The alkalization process was performed in two methods, such as with and without heating process (70-80°C). The obtained holocelluloses was soaked in 80 mL of 17.5% NaOH. Every 5 minutes into that solution 40 mL NaOH was added, this step was repeated until the total volume of NaOH reached 200 mL. After 30 minutes, 240 mL of aquadest was added into that solution and it was filtrated after 1 hour. The alkali content was neutralized with the addition of 120 mL acetic acid 10%. The cellulose fiber then filtrated, washed and rinsed until it free from acid. The cellulose fibre was dried in oven at 80°C. The yield of cellulose was calculated using the following equation:

\[
\text{Cellulose (\%) } = \frac{W_2}{W_1} \times 100\% \\
\text{Where, } W_1 : \text{ weight of durian rinds} \\
\text{W}_2 : \text{ weight of cellulose}
\]  

(eq. 1)

Characterization
The analysis of FTIR spectra was performed using FT-IR spectrophotomere Bruker Opus Alpha 7.5. All spectrum that obtained was recorded as transmittance with resolution of 4 cm⁻¹ in the range 4000-
600 cm\(^{-1}\). FT-IR spectra was used to determine the presence of specific functional group. The surface of cellulose was characterized using scanning electron microscope, Jeol Model JSM-6510LA. Thermal stability of cellulose was measured using DSC-60 with the temperature range 30-600°C and airflow rate 30 mL/min.

3. Results and Discussion

Result of Cellulose
Bleaching process was performed using NaClO\(_4\) and followed with alkalization process that performed in two ways, such as (i) room temperature (called as Sel A) and (ii) with heating process (70-80°C) (called as Sel B) using NaOH 17.5%. The cellulose yield was 61.9% and 62.65% for Sel A and Sel B, respectively. These yield values have similar value with the yield of cellulose fiber from hemp (45-63%), jute (57-77%) and sisal (47-62%) [14].

FTIR
FTIR spectroscopy is a technique that suitable to evaluate the influence of heating process on obtained cellulose (Zuluaga et al., 2009). Figure 1 showed that FTIR spectra for (a) Sel A and (b) Sel B.

The FTIR spectra of Sel A showed peak at 3340, 2880, 1600, 1300 and 1000 cm\(^{-1}\) than Sel B at 3340, 2880, 1600, 1200 and 1000 cm\(^{-1}\). The peak at 3340 refers to the presence of hydroxyl group which most common functional group of cellulose [13]. Peak at 2880 cm\(^{-1}\) indicated the presence of stretching vibration of CH. And the peak at 1600, 1300 and 1000 indicated the presence of the CH, CH\(_2\) and C-O-C vibration (Spiridon et al., 2010; Penjumras et al., 2014; dan [12]). The presence of peak at 1600 confirmed the contamination of lignin.
Figure 1. a) Sel A and b) Sel B

Figure 2 showed the microphotograph of two cellulose that obtained in this work. The heating process during alkalization process give an influence on the morphology of abaca fiber cellulose. It can be seen from the width of the fiber. In Sel A, the width was in the range of 75-145 µm. but in Sel B it was 35-167. This size of width showed that the reduction in the number of widths have a direct impact to L/D ratio and this impact will give a better result when it applied as filler for the nanocomposite. The rough surface of the obtained cellulose indicated the contamination lignin.

XRD analysis was performed to determine the crystallinity degree of obtained cellulose, the diffractogram was shown in Fig 3. XRD diffractogram showed the obtained cellulose has crystalline and amorph region. The crystallinity of Sel A and Sel B is 65.45 and 42.66%, respectively. The different of that value was influence by the different on the alkalization process.
This result indicated the extraction of cellulose during the alkalization process with the heating process is more effective to separate lignin and hemicellulose matrix than without heating process. Lignin and hemicellulose are polymer with amorph phase. The removal of those components from the cellulose fibre led to the increase of crystallinity degree. In this work, the crystallinity of the Sel A is higher than Sel B, it can be caused by the influence of heating process that led to the depolymerization of cellulose. This depolymerization structure of cellulose influences the crystallite size [16]. The obtained cellulose has similar properties with the cellulose that obtained from any kind of sources, such as hemp, sisal, cotton, banana, etc.

\[ \theta (^\circ) \]

![Figure 3. X-Ray Diffraction](image)

4. Conclusion
The alkalization process on plant fiber can change the topography of the fibre and the crystallography of fibre. The temperature of alkalization process has a big influence on the rate of alkalization. The obtained result showed that the obtained cellulose from two types alkalization process has different properties (FT-IR, SEM, and XRD). The FT-IR spectra of Sel B showed that the alkalization with heating process was success to remove lignin and hemicellulose from the cellulose matrix. SEM microphotograph showed the Sel B has a smoother surface than Sel A, indicated the lignin was removed from the matrix. The crystallinity degree of Sel A and B was 65 and 43%. The obtained cellulose has similar properties with the cellulose that obtained from any kind of sources, such as hemp, sisal, cotton, banana, etc.

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