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THE ISOLATION OF NANOCRYSTALLINE CELLULOSE FROM PALM EMPTY FRUIT BUNCHES

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ABSTRACT

Isolation and characterization of nanocrystalline cellulose (NCC) isolated from palm empty fruit bunches (EFB) have been done. EFB was delignificated with HNO3 3.5% and 10 mg NaNO2, precipitated with NaOH 17.5% and bleached with H2O2 10% to get α-cellulose. NCC was obtained by hydrolysis of α-cellulose of EFB by using H2SO4 45%. The surface of NCC was analyzed by Scanning Electron Microscopy (SEM), and from the result showed that the average diameter of NCC was 79 nm. Thermal degradation analysis by Thermogravimetry Analysis (TGA) recorded that NCC was decomposed at 160oC. It means that the process of hydrolysis of NCC from α-cellulose had been already occurred.

Keywords: *α-cellulose, hydrolysis, nanocrystal cellulose.*

INTRODUCTION

Indonesia has the largest of plantation of palm oil in the world approximately 34% from the total of world palm oil agriculture. Its production in 2044 - 2008 was 75.54 million tons of Fresh Fruit Bunches (FFB), or 40.26% from the total of world productions. The industry of palm oil productions in Indonesia rises significantly. By 2009, the number of these industries is 608 which is spread in the all provinces of Indonesia by total capacities of production Crude Palm Oil (CPO) reaching 35.280 tons FFB/hour (Yan, 2012). The construction for both of industries and plantations affect environment. For instance, the using of machine in processing of FFB to be CPO will produce smoke from it, so it will be effect the air. Furthermore, the process of washing, boiling, and purification will be result waste such as gas, liquid, and solid.

Waste solid which is caused by FFB is Palm Oil Empty Fruit Bunches (EFB). The number of EFB is 30 - 35% of FFB in every harvesting (Hambali, 2008). Nowadays, EFB is still burned in an Inneceator and the dust is used as potassium fertilizer in the agriculture. However, this burning is already prohibited because of the damage for the surroundings. Additionally, the cost of operation and maintenance of machine are expensive. (Nainggolan, 2011). The waste still can be used as a good material because the composition of α-cellulose of EFB is 40%. Therefore, it can be utilized as the source of cellulose.

Cellulose is a sustainable, renewable, and biodegradable material. It is a carbohydrate polymer made up of repeating β-D-anhydroglucose units (AGU) giving the cellulose molecule a

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high degree of functionality. The characteristic properties of cellulose, such as hydrophilicity, chirality, biodegradability and high functionality explain of prime importance of the molecular structure of cellulose. As a chemical raw material, cellulose and its derivatives have been used for more than 150 years in wide variety applications, such as food, paper production, biomaterials and pharmaceuticals (Coffey, at.al. 1995).

In recent years, both of researcher scientists and industrialists have significant interest on material based on nano sized and renewable for the amazing physicochemical properties and wide application. Nanocrystalline cellulose (NCC) obtained from acid hydrolysis of cellulose fibers, has been used as a new class of nanomaterials. NCC has been used as reinforcement of polymer matrix in nanocomposite materials because it is generally exhibit a significant improvement in thermal, mechanical and barrier properties (Silverio, H.A, et.al. 2012). In addition, it has many advantages such as low cost, low density, availability, renewability, light weight, nanoscale dimension, unique morphology, and environmental friendliness (Habibi, Y, et.al. 2010).

The objective this study is to provide the nanocrystalline cellulose of palm empty fruit bunches fiber which will be used as reinforcing and filler in composites.

METODOLOGY

Materials. Palm empty fruit bunches (EFB) fibers was obtained from PTPN 3 Deli Serdang, Medan. Regents used are: nitric acid, sodium nitrate, sodium sulphite, sodium hydroxide, sodium hyphoclorite, hydrochloride acid, sulphuric acid, and membrane dialysis.

Methods. There are three stages to provide NCC from EFB, namely (1) Provision of palm empty fruit bunches (EFB), (2) Isolation of α-cellulose from EFB, including delignification, precipitation and bleaching, and (3) Hydrolysis of NCC from α-cellulose by using 45% H_2SO_4 and filtration of NCC by membrane dialysis.

Morphological Analysis. A JEOL JSM-6300F field emission scanning electron microscope (FE-SEM) was used to observe the morphology of NCC.

Thermal Analysis. Thermogravimetric analysis (TGA) was conducted using Shimadzu TGA 50 equipment. The sample (-10mg) were heated from 25oC to 800oC at heating rate of 20oC/min under nitrogen flow (50mL/min).

RESULTS AND DISCUSSION

Isolation of cellulose. There were some steps to isolate □-cellulose from EFB. Firstly, delignification with 3.5% HNO_3 and 2mg $NaNO_2$, this solution caused EFB losing a part of its matter, leaved fibrous solid which was named cellulose. Lignin was disappeared by solution of

2% NaOH and 2% Na2SO3. In this step, it was obtained pulp white yellowish until brownish white. To disappear the color from cellulose, it was bleached by 1.75% NaOCl. In the next step, cellulose was precipitated with 1.75% NaOH to get □-cellulose which had the same color with the delignification process. To obtain the white one, it was bleached with 10% H2O2. Finally, □-cellulose which has been obtained was heated on the oven 60oC and then it was kept on the desiccator. Figure 1 shows the physical feature of the EFB fiber before and after bleached with peroxide and alkaline solution.

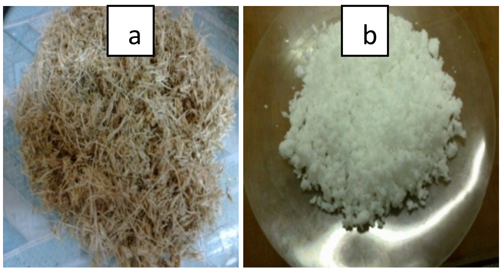

Figure 1. (a) The original of EFB fiber and (b) after belaching

Isolation of Nanocrystalline Cellulose (NCC). Nanocrystalline cellulose which was isolated from α-cellulose by using 45% H2SO4 was transparent crystalline. The reaction between α-cellulose and H2SO4 was complex heterogenic which involved not only the factor of reaction (concentration and temperature) but also physics

Figure2. Nanocystalline cellulose of palm empty fruit bunches

Scanning Electron Microscopy (SEM). The morphology of NCC was analyzed by Scanning Electron Microscopy (SEM). From the result, as shown in figure 3, the diameter of NCC was 79 nm.

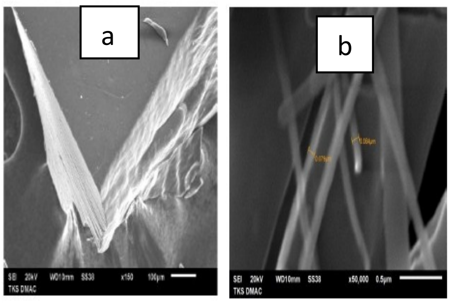

Figure 3. (a) Aggregate of NCC (150x), (b) NCC (50000x)

Figure 4 elucidates the thermal properties of EFB NCC, it illustrates that NCC began to decompose at 160oC with 28% of residue.

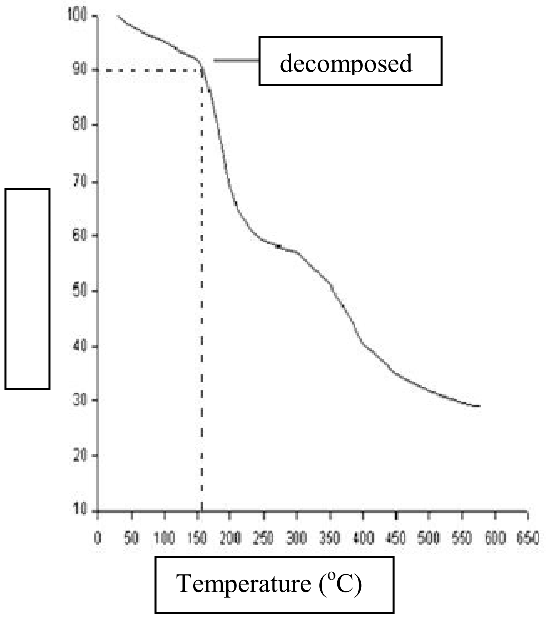

Figure4. TGA nanocrystalline cellulos from EFB

CONCLUSIONS

NCC of EFB can be isolated and used as reinforcement in composites due to the mechanical properties. From the results of the SEM analysis, the average of nanocrystalline cellulose of EFB was 79 nm, but has not been uniform. In addition, the TGA analysis shows that the decomposed thermal of the NCC was 160oC and the %residue was 28. It means that the NCC cannot melt permanently.

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