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Characteristics of Activated Carbon from Oil Palm Fronds with the Addition of Sodium Carbonate (Na_2CO_3) and Sodium Chloride (NaCl) as an Activator

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Abstract. This paper aims to understand the difference in characteristics of activated carbon produced from oil palm fronds (*Elaeis guineensis Jacq)* through the addition of two different activators, namely sodium carbonate (Na_2CO_3) and sodium chloride (NaCl). To do this, activator concentration of 10 percent each with activation temperature of 600 °C were applied in the experiment. Moreover, to determine the quality of activated carbon produced, a morphological analysis of activated carbon surfaces as well as FTIR spectra analysis on activated carbon. Identification using FTIR spectrophotometer revealed that the activated carbon in this study contained functional groups of O-H, C = O, C = C, C-C, and C-H.

Keyword: activated carbon, oil palm fronds, sodium carbonate, sodium chloride

Abstrak. *Tulisan ini bertujuan untuk memahami perbedaan karakteristik karbon aktif yang dihasilkan dari daun kelapa sawit (Elaeis guineensis Jacq) melalui penambahan dua aktivator yang berbeda, yaitu natrium karbonat (Na2CO3) dan natrium klorida (NaCl). Untuk melakukan ini, konsentrasi aktivator masing-masing 10 % dengan suhu aktivasi 600 °C diterapkan dalam percobaan. Selain itu, untuk menentukan kualitas karbon aktif yang dihasilkan, analisis morfologi dari permukaan karbon aktif serta analisis spektrum FTIR pada karbon aktif. Identifikasi menggunakan FTIR spektrofotometer mengungkapkan bahwa karbon aktif dalam penelitian ini berisi kelompok-kelompok fungsional O-H, C = O, C = C, C-C, dan C-H.*

Kata Kunci: *Karbon aktif, pelepah sawit, natrium karbonat, natrium klorida*

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1 Introduction

Oil Palm fronds are part of the wet by-products since it still contains moisture content of about 70-75% [1][2]. The production amount of oil palm fronds about 5500 kg/(ha)(year)[3] or equivalent to 1.64 tons/year of dry matter. These figures indicate the great potential of palm fronds as livestock feed, but their utilization is constrained by low levels of digestibility due to high levels of NDF (Neutral Detergent Fiber) and Lignin [2]. The availability of palm oil and their wastes is very large and abundant. The waste of palm oil can be reduced by utilizing it as

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an alternative material in carbon manufacturing. In addition to increasing the benefits of waste, this approach is expected to provide more economic value as well.

Activated carbon is an amorphous carbon that has a surface area ranging from 300 to 3500 m^2/gram and has been treated with steam and heat. This treatment allows activated carbon to have a very strong affinity to absorb a variety of materials with a large capability, i.e. 25-100 percent of activated carbon weight [4]. This relates to the internal pore structure that makes activated carbon to act as an adsorbent. Activated carbons have selective adsorption properties and depend on the size or volume of the pores and surface area. Thus, activated carbon can only adsorb certain gases and chemical compounds.

There is a wide range of utilization of activated carbon, among others in the food and drug industry, petroleum chemical industry, water purifier, shrimp cultivation, the sugar industry, gas purification, a catalyst, and fertilizer processing. Activated carbon has a porous surface structure. According to IUPAC, pore sizes are classified as microporous, mesoporous, and macroporous [4]. Schematic of activated carbon pore structure can be seen in Figure 1.

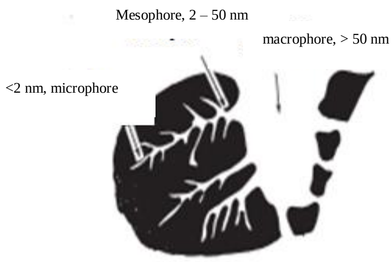

Figure 1. Pore structure scheme of activated carbon

The manufacture process of activated carbon consists of carbonization and activation. The activation process can be divided into two types, namely physics activation and chemical activation. The process of activation using gas generally use N_2, CO_2, and water vapor. Meanwhile, chemical activation generally uses class of hydroxide (KOH or NaOH), $ZnCl_2$, and H_3PO_4 as an activating agent.

This study aimed at comparing the morphology of the resulting activated carbon from oil palm fronds produced with sodium carbonate activator (Na_2CO_3) and sodium chloride activator (NaCl).

2 Methods

Material

In this study, oil palm fronds, Na_2CO_3, and NaCl were used for manufacturing activated carbon.

Equipment

The following equipment were used in this study: (1) furnace, (2) Elenmeyer, (3) measuring cylinder, (4) aluminum foil, (5) digital balance, (6) 32 mesh screen, (7) porcelain cup, (8) spatula, oven, (9) pH meter, (10) stopwatch, (11) stir bar, (12) tube jar, (13) stative and clamp, (14) beaker glass, (15) glass mouthpiece, (16) burette, desiccator, (17) thermometer, (18) dropper drop, (19) hot plate and magnetic stirrer, (20) Whatman filter paper, (21) FTIR spectrophotometer, and (23) Scanning Electron Microscopy (SEM).

Activation stage

Firstly, 30 grams of sample were put into beaker glass for activation with 300 ml of sodium carbonate and sodium chloride solution at 10% concentration for 2 hours at 80 ^{o}C using hot plate. Thereafter, the sample was impregnated for 24 hours at room temperature and then filtered to separate the solid and solution. Then, the resulting solid was inserted into the oven to dry.

3 RESULT AND DISCUSSION

Morphological analysis of activated carbon surfaces

The structure of activated carbon surface morphology obtained from oil palm fronds by using Scanning Electron Microscopies (SEM) method, which is presented in Figure 2 and Figure 3.

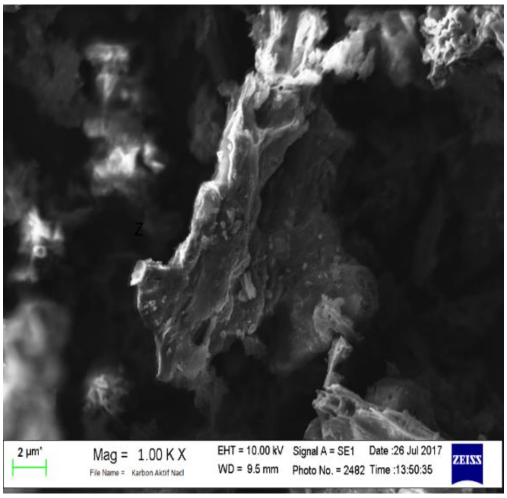

Figure 2. Scanning Electron Microscopy (SEM) results from activated carbon with Sodium Chloride activator at 1000x magnification

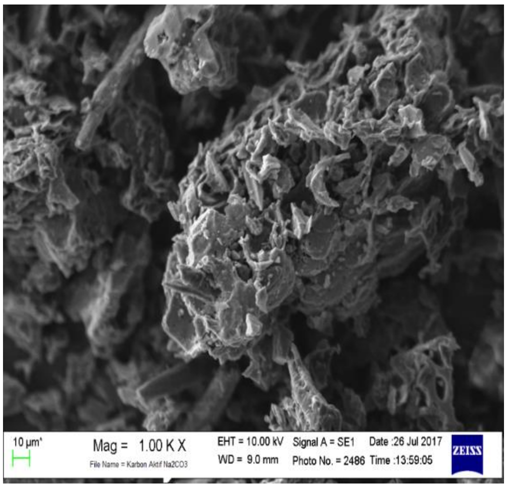

Figure 3. Scanning Electron Microscopy (SEM) results from activated carbon with Sodium Carbonate activator at 1000x magnification

Figure 2 and Figure 3 shows that the surface morphology of activated carbon produced from oil palm fronds has a rough and irregular pore surface. The activation process causes many volatile compounds to be released, thereby opening the carbon pores and reducing the hydrocarbon closure. This is consistent with the study of Novicio et.al. (1998) and Bonelli et.al. (2001), which found that pore formation and enlargement were caused by the evaporation of degraded cellulose components and the release of volatile substances. Reduction of hydrocarbon compounds makes the surface of activated carbon more visible. The activation process aims to enlarge the pore by breaking the hydrocarbon bond or the oxidation of the surface molecules, so that the carbon surface area becomes larger and affect the adsorption power [5].

During the carbonation process, Na_2CO_3 decomposes from sodium metal compounds into carbon in accordance with the following reaction:

$$Na_2CO_3 + 2C \longrightarrow 2Na + 3CO$$

Sodium metal atoms formed during the activation and carbonization process can get into the carbon structure that expands the pores and create new porosity. Based on the above figures, we can see that there are more pores formed with greater pore cavity depth in Na_2CO_3-based activated carbon in comparison with NaCl-based activated carbon. This is due to an activation process that produces a large outer pore surface with irregular surfaces and is scattered throughout the activated carbon.

Analysis of activated carbon functional groups

Analysis of the functional groups of activated carbon derived can be done using Fourier Transform Infrared (FTIR), which is the method of infrared spectroscopy equipped with a Fourier transform to analyze the results of the spectrum. The spectroscopic method used in this study is the adsorption method, which is based on differences in the adsorption of infrared radiation. Figure 4 shows the results of Fourier Transform Infrared (FTIR) analysis on the resulting activated carbon.

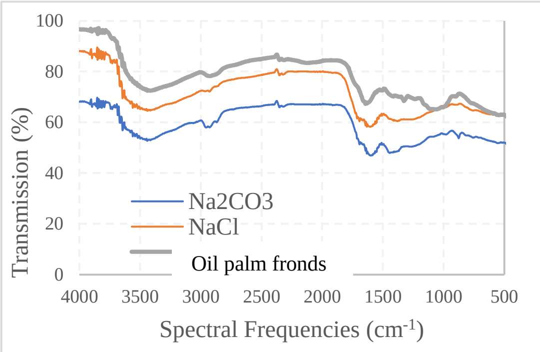

Figure 4. Fourier Transform Infrared (FTIR) on oil palm fronds, Na_2CO_3 activated carbon and NaCl activated carbon

The adsorption peak occurs is 3,421.72 cm^{-1}, which is owned by palm oil fronds and activated carbon of NaCl. The absorption peaks occurring in the number 3500-3200 cm^{-1} (referring to O-H stretching) indicate the presence of an O-H functional group (hydroxyl). The results showed a decrease in the adsorption peak due to the decomposition of the OH groups on holoselulose and lignin of palm oil fronds. The increase in temperature during carbonization process causes the OH group to break down to form a new structure of carbon chain. The magnitude of the hydroxyl group is a reflection of the number of chemical compounds in the molt shell containing OH groups such as alcohols and phenols [6]. The decrease of the absorption peak is an indication of the start of the formation of an aromatic compound which is the constituent element of activated carbon [7].

The use of chemical activators during activation is still instrumental in identifying O-H groups on activated charcoal. The O-H group tends to derive from the reaction between the activator and the free compound on the activated carbon surface [8]. The functional group on activated charcoal surfaces activated with steam will form a polar active charcoal.

In the FTIR wave spectrum of activated carbon with NaCl activator, an absorption peak appears with wave numbers of 1,600.92 cm^{-1}. The absorption peaks occurring in the numbers of 1820-1600 cm^{-1} indicate the presence of C = O groups which are typical groups of activated carbon. In addition, it also shows that palm oil fronds form carbon-active substances [6].

The activation process on activated carbon using NaCl as activators has also formed a C = C bond, which is indicated by the occurrence of spectra at wave numbers of 1,403.17 cm^{-1}. The absorption peaks occurring in the number 1,500-1,400 cm^{-1} indicate the presence of the C = C group, which means that there is an increase in carbon substance.

Meanwhile, adsorption peaks with wave numbers of 2,951.09 cm^{-1} and 2997,38 cm^{-1} indicate the presence of C-H groups (3,000-2,850 cm^{-1}) as well as alkane compounds [8]. There are four types of functional groups contained in the palm-oil activated carbonyl, namely C = O, C = C, C-C and C-H groups.

4 CONCLUSION

The study concluded that compared to NaCl-activated carbon, Na_2CO_3-activated carbon created more pores with larger cavity depths. Moreover, identification with the FTIR spectrophotometer showed that the activated carbon contained the functional groups of O-H, C = O, C = C, C-C, and C-H.

REFERENCES

[1] G. S. Pambayun, G. S. Pambayun, R. Y. E. Yulianto, M. Rachimoellah, and E. M. M. Putri, “Pembuatan Karbon Aktif Dari Arang Tempurung Kelapa Dengan Aktivator Zncl2 Dan Na2co3 Sebagai Adsorben Untuk Mengurangi Kadar Fenol Dalam Air Limbah,” *J. Tek. ITS*, 2013.

[2] A. F. Ramdja, M. Halim, and J. Handi, “Pembuatan Karbon Aktif dari Pelepah Kelapa (Cocus nucifera),” *J. Tek. Kim.*, 2008.

[3] M. Ternak, “Perubahan Kandungan Lignin , Neutral Detergent Fiber (NDF) dan Acid Detergent Fiber (ADF) Pelepah Sawit Melalui Proses Biodegumming sebagai Sumber Bahan Pakan Serat Ternak Ruminansia,” *Jitv*, vol. 14, no. 4, pp. 284–287, 2009.

[4] M. A. Lillo-Ródenas, D. Cazorla-Amorós, and A. Linares-Solano, “Understanding chemical reactions between carbons and NaOH and KOH: An insight into the chemical activation mechanism,” *Carbon N. Y.*, 2003.

[5] J. A. Menéndez, A. Arenillas, B. Fidalgo, Y. Fernández, L. Zubizarreta, E. G. Calvo, and J. M. Bermúdez, “Microwave heating processes involving carbon materials,” *Fuel Processing Technology*. 2010.

[6] M. Soleimani and T. Kaghazchi, “Low-Cost Adsorbents from Agricultural By- Products Impregnated with Phosphoric Acid,” *Adv. Chem. Eng. Res.*, 2014.

[7] C. Saucier, M. A. Adebayo, E. C. Lima, R. Cataluña, P. S. Thue, L. D. T. Prola, M. J. Puchana-Rosero, F. M. Machado, F. A. Pavan, and G. L. Dotto, “Microwave-assisted activated carbon from cocoa shell as adsorbent for removal of sodium diclofenac and nimesulide from aqueous effluents,” *J. Hazard. Mater.*, 2015.

[8] J. Mohammed, N. S. Nasri, M. A. A. Zaini, U. D. Hamza, H. M. Zain, and F. N. Ani, “Optimization of microwave irradiated - coconut shell activated carbon using response surface methodology for adsorption of benzene and toluene,” *Desalin. Water Treat.*, 2016.