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Comparison of Functional Group and Morphological Surface of Activated Carbon from Oil Palm Fronds Using Phosphoric Acid (H_3PO_4) and Nitric Acid (HNO_3) as an Activator

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Abstract. This paper discuss about the comparison of the functional groups and morphological surface of carbon that activated using H_3PO_4 and HNO_3 as an activator. This study intends to compare the functional group and morphological surface of activated carbon with activator H_3PO_4 and HNO_3 from oil palm fronds. The analysis was carried out included analysis of the morphological surface of activated carbon using SEM and FTIR analysis of activated carbon with the best characteristics. The results from the identification in this study, showed that the activated carbon comprised functional groups C-H, C = C, C = O, C-N, C-C, N = O and O-H, by using FTIR spectrophotometer.

1. Introduction

The largest source of biomass as solid waste produced by oil palm plantations throughout the year are oil palm fronds [1][2]. Oil palm frond is categorized as a wet waste (wet by-products) because they still contain water content of 70-75% [3]. The amount of oil palm frond production is around 5500 kg / (ha) (years) [4].

Oil palm frond contains chemical elements such as cellulose, lignin, and hemicelluloses. It causes the oil palm frond can be done as an alternative raw material in producing activated carbon [5]. Component and composition of the oil palm fronds is presented in table 1 [6].

Table 1. Component and Composition of Oil Palm Frond

Component	Composition (%)
Lignin	16,77 ± 0,30
Cellulose	36,33 ± 4,10
Hemicellulose	30,34 ± 4,54
Others	6,66

Activated carbon is a solid or powder carbon with a large surface area produced by pyrolysis using physical or chemical activation methods[7]. Activated carbon is widely used by various fields of industry for many purposes, including gas purification, water purification, wastewater treatment, adsorption of odor, colors, gases and metals [8].



This study will analyze the comparison of morphological surface and functional groups of activated carbon using activators of phosphoric acid and nitric acid.

2. Materials and Method

2.1. Materials

Oil Palm Fronds, H_3PO_4 , HNO_3 .

2.2. Equipment

Furnace, erlenmeyer flask, graduated cylinder, aluminium foil, analytical balance, sieve of 32 mesh, evaporating dish, scoopula, oven, pH meter, stopwatch, stirring rod, tube clamp, stative and clamp, beaker glass, funnel glass, burette, desiccator, thermometer, dropper pipette, hot plate and magnetic stirrer, filter paper of whatman, Scanning Electron Microscopy (SEM) and FTIR spectrophotometer.

3. Result

3.1. Morphological Analysis of Activated Carbon Surfaces

Analysis of morphological surface from the activated carbon was characterized by using Scanning Electron Microscopy. The results obtained are shown in Figure 1.

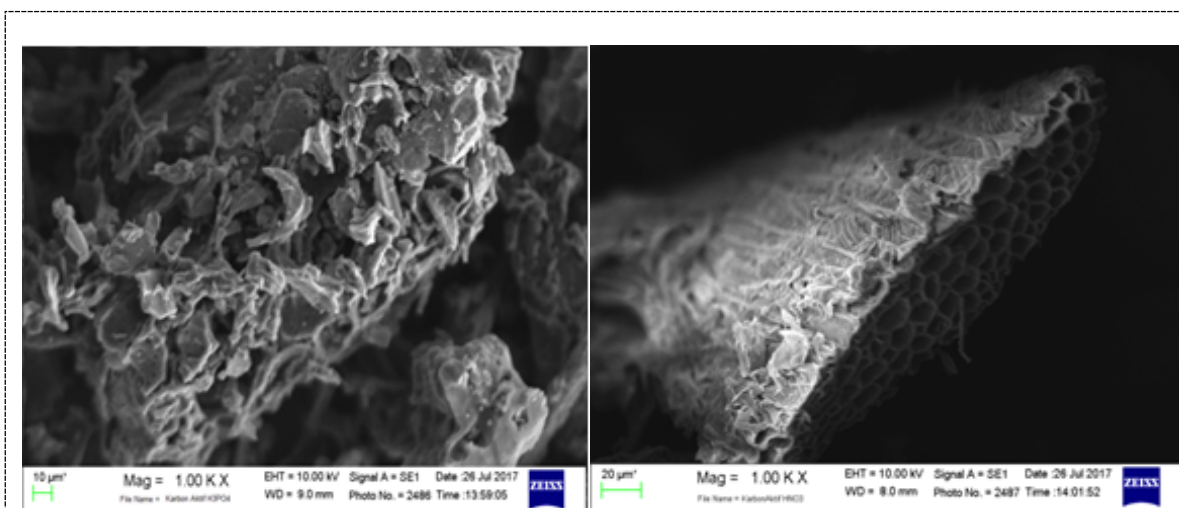


Figure 1. The Result of Morphological Surface Using SEM (a) Phosphoric Acid Activation (b) Nitric Acid Activation).

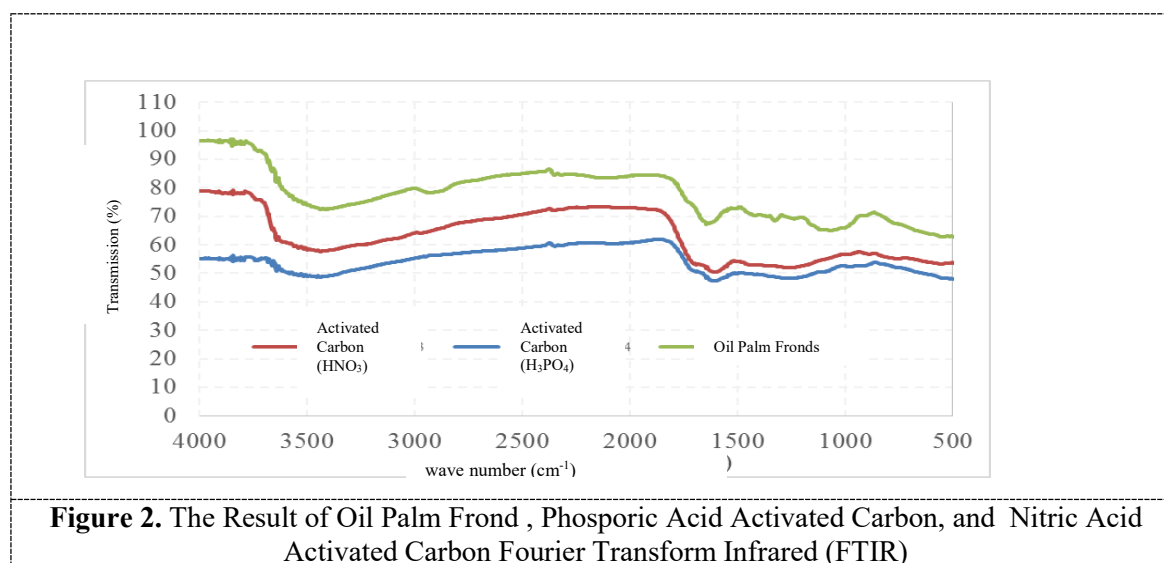
Figure 1 showed that the morphological surface of activated carbon from oil palm fronds has a rough and irregular pores. Pore formation and enlargement is caused by evaporation of degraded cellulose components and release of volatile substances. Reduction of hydrocarbon components cause increasingly apparent on the surface of activated carbon. The purpose of activation process was to enlarge the pore by oxidizing the surface molecules or breaking the bond hydrocarbon of and the charcoal undergoes to change its surface and the adsorption capacity [9].

The pores of activated carbon by phosphoric acid activation has a more and greater depth of the pores when compared to activated carbon by nitric acid activation.

3.2. Functional Group Analysis of Activated Carbon

The functional groups of activated carbon can be analyzed by the Fourier Transform Infrared (FTIR) method, which is an infrared spectroscopy method which is equipped with Fourier transform for analysis of the spectrum results. Using the absorption method, which is a spectroscopic method based on the difference in absorption of infrared radiation.

Figure 2 is the result of Fourier Transform Infrared (FTIR) analysis on activated carbon.



Oil palm frond and activated carbon, either by phosphoric acid activation or nitric acid activation has the same absorption peak of 3734.19 cm^{-1} . The adsorption peak at numbers $3500 - 3200\text{ cm}^{-1}$ (referring to O-H stretching) indicates the presence of hydroxyl, O-H functional groups. The result shows that there is a decrease in absorption peak, it is due to decomposition of adsorbed water and hydroxyl groups. The size of the hydroxyl group indicates the presence of a strong hydrogen bond (from carboxyl, phenol or alcohol). The decreasing in absorption peak is an indication of the start of the formation of aromatic compounds which are constituent elements of activated carbon [10]. In wave spectrum of activated carbon by nitric acid and phosphoric acid activation, absorption peaks appeared at wave numbers of 1600.92 cm^{-1} and 1608.63 cm^{-1} . The absorption peak at $1820-1600\text{ cm}^{-1}$ indicates the presence of C = O group. Group C = O is a typical group found in activated carbon and shows that the oil palm frond forms an active carbon substance [11].

Activation process on activated carbon by nitric acid activation has formed a C = C bond which is indicated by the appearance of the spectrum at wave numbers of 1431.18 cm^{-1} . The absorption peak at $1500-1400\text{ cm}^{-1}$ indicates the presence of C = C group. Group C = C indicates an carbon content increasing.

Activated carbon by nitric acid forms an amine bond which is indicated by the presence of a spectrum at wave number of 1253.73 cm^{-1} signifies the existence of C-N groups ($1350-1000\text{ cm}^{-1}$) [11]. At the absorption peak of 1431.18 cm^{-1} of activated carbon by nitric acid activation signifies the existence of N = O ($1550-1350\text{ cm}^{-1}$) which signifies the existence of nitro groups.

While at the absorption peak with wave numbers 2970.38 cm^{-1} and 2904.60 cm^{-1} indicates the presence of C-H group ($3000-2850\text{ cm}^{-1}$) which signifies the existence of alkane compounds [11]. The functional group found in the palm fronds activated carbon are groups of C = O, C = C, C-C and C-H.

4. Conclusion

Based on the research and analysis of morphological surface and functional groups of activated carbon is obtained on the pores of activated carbon by phosphoric acid activation formed more pores and cavities with a greater depth when compared with activated carbon by nitric acid activation.

The results of spectrophotometer FTIR identification showed that the activated carbon in this study comprised functional groups of C-H, C = C, C = O, C-C, C-N, N = O and O-H.

It was concluded that the conversion of oil palm fronds into briquette charcoal is effective to manage this solid wastes. Furthermore, due to the abundance of waste agricultural biomass and, which mostly fulfill the calorific value of SNI, briquetting by oil palm frond carbonized has the potential to develop.

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