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The Production of Activated Carbon From Palm Oil Trunks With Phosphoric Acid Activator (10%, 20% and 30%)

Dian Dwi Lestari[a]*, Sulton Amna[a], Achmad Faisal F[a]., Asmike[a] , Dimas Zuliat S.[a]

Abstract. Activated carbon is charcoal which can be used as an adsorbent by activated using chemicals to open the pores. In making activated carbon, three stages They were dehydration, carbonization and activation using Phosphoric Acid (H3PO). From the results of the characteristic testing. it was obtained water content, ash content, volatile matter and iodine absorption capacity. The results of these tests indicated that at each concentration of phosphoric acid (10%, 20% dan 30%) activated carbon complied with SNI 06- 3730-1995 and The results of SEM (Scanning Electron Microscope) testing before activation were of size 6.66 µm and after activation of phosphoric acid (HPO4) concentrations of 10% (14,79 µm), 20% (21,87 µm), dan 30% (23,25 µm) respectively.

Keywords : Oil Palm Trunks, Activated Carbon, Adsorbent, Phosphoric Acid

[a]*Program Studi Teknik Pengolahan Minyak dan Gas, Jurusan Teknik Kimia, Politeknik Akamigas Palembang*
Correspondence and requests for materials should be addressed to Dian Dwi Lestari (email: dian@pap.ac.id)

Introduction

Oil palm plants are plantation crops that play an important role in Indonesia as a major producer of vegetable oil in the world [1]. However, old oil palm trunks remain an underutilized byproduct that has not been economically exploited. Generally, these oil palm trunks are burned, resulting in smoke that can cause air pollution. One way to utilize the waste from oil palm trunks is to process them into activated carbon for use as an adsorbent. The biomass of oil palm trunks has a high content of hydrocarbon compounds, namely lignin (12.50%), cellulose (25.88%), hemicellulose (16.40%), holocellulose (12.28%) and pentose (10.06%), making it a viable raw material for the production of activated carbon[2]. Therefore, the utilization of oil palm trunks as activated carbon is expected to help address the problem of oil palm trunk waste and can eventually contribute to the economy by transforming it into valuable products.

Oil palm trunks are produced from monocotyledonous plants that have several disadvantages, including relatively low specific gravity and strength, very high moisture content, and relatively high starch content [3]. Oil palm is one of the important industrial plants in Indonesia; the oil from this plant can be consumed and also used as fuel and for other derivative products. Activated carbon is carbon that can be used as an adsorbent with further processing at high temperatures using CO_2, steam or chemicals aimed at opening its pores, and can be used as an adsorbent. There are 3 criteria for raw materials that can be made into activated carbon, namely: The raw material must contain carbon, impurities in the raw material should be minimized as much as possible, and the raw material must have constant quality. The quality of activated carbon is assessed based on the requirements of the Indonesian National Standard SNI 06-3730-1995. The process of making activated carbon from palm oil waste involves 3 stages, namely Dehydration, Carbonization and Activation [4].

Dehydration is the process of reducing/ decomposing the water contained in oil palm trunks as raw material for the production of activated carbon. This aims to perfect the carbonization process, which is usually done by drying the raw material under direct sunlight or drying it in an oven until the desired weight is achieved [4]. The dehydration stage aims to remove water so that during the carbonization stage, not too much smoke is produced during heating. The dehydration stage is carried out by heating at a temperature just above the boiling point of water, which is 105°C, until the weight of the sample is constant. At this stage, a physical change occurs in the raw material where the sample becomes light dry and the color turns pale yellow [2].

Carbonization is the process of burning organic materials present in the raw materials for producing activated carbon [5]. This process triggers the decomposition of organic material in the raw material and will release impurities from the raw material. Most non-carbon elements will be lost at this stage. The decomposition of these volatile elements leads to the formation of pores, and along with this process, there will be a change in pore structure. During the activation process, the release of hydrocarbons, tar, and organic compounds attached to the carbon occurs. The activation of activated carbon can be carried out in 2 ways, namely chemical and physical activation. Chemical Activation Chemical activation can be understood as the process of breaking carbon chains in organic compounds with the help of chemical substances [6]. In this chemical activation process, it is very likely to obtain a very high surface area, this is one of the advantages of chemical activation. Physical activation can be defined as the process of breaking the carbon chain from organic compounds with the assistance of steam, heat, and CO_2 [6]. The physical activation process can be carried out using nitrogen, oxygen, carbon dioxide, and water gases. These gases are useful for enlarging the pore structure in charcoal to increase the surface area of carbon. Meanwhile, heating serves to remove volatile impurities and eliminate contaminating hydrocarbons from the carbon. The activated carbon activation process aims to increase the pore volume, enlarge the pore diameter, and enhance the surface area of the activated carbon [7]. This results in better absorption properties. This process is carried out by soaking activated carbon with a chemical substance in the form of phosphoric acid to remove particles and metal oxides present in the carbon.

Experimental

Testing the characteristics of activated carbon based on SNI 063730-1995.

Moisture Content. Water evaporates at

temperatures above 100. The loss of weight of the sample after heating at 115 is calculated as the water contained in the sample. The stages of testing moisture content are: Prepare a clean porcelain dish and activated carbon that will be used. Accurately weigh 1 gram of activated carbon into the known weight porcelain dish using an analytical balance. Next, place the dish + activated carbon into an oven at 115 for 3 hours. Then, the dish + carbon is cooled in a desiccator for 1 hour. After that, weigh the dish + carbon that has gone through the oven again using an analytical balance. Moisture content was determined by equation 1.

$$\text{Moisture content} = \frac{W_1}{W_2} \times 100\ \% \qquad (1)$$

Description: W_1 = Activated carbon after drying (g); W_2 = Initial activated carbon (g).

Ash Content. Samples were incinerated at high temperatures, and the residue from the incineration is counted as ash in the sample.The stages of the ash content testing are: Prepare a clean porcelain crucible and the activated carbon to be used. Carefully weigh 1 gram of activated carbon into the porcelain crucible, the weight of which is known, using an analytical balance. Next, place the crucible + carbon into the furnace at a temperature of 800° for 2 hours. Then cool the crucible + carbon in a desiccator for 1 hour. After that, weigh the crucible + ash that has passed through the furnace using an analytical balance. Ash content was determined by equation 2.

$$\text{Ash Content} = \frac{W_1}{W_2} \times 100\ \% \qquad (2)$$

Description: W_1 = Weight of activated carbon after being ashed (grams); W_2 = Initial weight of activated carbon (grams).

Iodine Absorption (I_2). Carbon has the capacity to absorb iodine solution. The decrease in the concentration of 0.1 N iodine solution is calculated to determine the absorption capacity for I_2. The stages of testing iodine absorption are: Prepare the tools and materials to be used in the test. Weigh 0.5 grams of activated carbon, then place it in a beaker and homogenize using 25 ml of 0.1 N iodine solution for 15 minutes. Next, take 10 ml of the iodine solution that has been homogenized with activated carbon. Then, add 2 drops of starch indicator to the 10 ml iodine solution until the solution changes color from clear yellow to blue. After that, titrate using 0.1 N sodium thiosulfate solution until the blue color becomes clear. Iodine Absorption was determined by equation 3.

$$\frac{\left(10 - \frac{V \times N}{0{,}1}\right) \times 12{,}69 \times 5}{W} \text{ X } 100\% \qquad (3)$$

Description : V = Volume of sodium thiosulfate required (ml); N = Concentration of sodium thiosulfate solution (0.1 N); 12.69 = Amount of iodine equivalent to 1 ml of sodium thiosulfate solution; W= Activated carbon used (grams); 5 = Dilution factor; 10 = Volume of iodine used (ml); 0.1 = Concentration of iodine solution (N).

SEM (Scanning Electron Microscope) is an electron microscope used to view the surface of a material, and it can also provide information related to the chemical composition of a material, whether it is conductive or non-conductive [8]. This capability is what makes SEM widely used for research and industrial purposes. This type of microscope uses electromagnetic and electrostatic fields instead of light to control the incoming light and the appearance of the images produced.

Result and Discussion

The tests that have been carried out, the results showed at Table 1. These results indicate that activated carbon meets the quality standards of activated carbon based on SNI 06-37301995.

The production of activated carbon from palm oil trunks using phosphoric acid (H_3PO_4) activators with concentrations of 5%, 10%, and 15%. The quality of activated carbon produced from palm oil trunk waste meets the Indonesian National Standard (SNI 06-3730-1995). This can be seen from the results in the figure 1.

Moisture Content. Moisture content can be seen from the table above that there is a significant difference in moisture content where activated carbon with a 10% H3PO4 concentration produces a moisture content of 1.19%, 20% produces a moisture content of 0.43%, and 30% produces a moisture content of 0.29%. The 20% and 30% concentrations have a significant difference due to the variations in the concentrations used; the higher the concentration, the lower the moisture content. For the 10% concentration, there is an increase in moisture content; this is assumed to be influenced by the

Table 1. Results of Activated Carbon Characterization Testing

No .	Testing Parameters	SNI 06- 3730-1995	Concentration H_3PO_4 (%)	Test Results
1	Moisture Content	Maks. 15 %	10	1,19
			20	0,43
			30	0,29
2	Ash Content	Maks. 10 %	10	9,10
			20	1,66
			30	0,94
3	Volatile Matter	Maks. 25 %	10	0,47
			20	1,86
			30	2,97
4	Iodine Absorption	Min. 750 mg/g	10	1.230 mg/g
			20	1.230 mg/g
			30	1.211 mg/g

washing and drying processes because, during washing, it cannot be guaranteed that all minerals are removed. This is in accordance with the statement other researcher that the hygroscopic nature of activated carbon will lead to an increase in its moisture content due to the influence of the amount of water vapor in the air, the duration of the cooling process, and sieving [9].

Ash Content. Ash content is a mixture of inorganic components or minerals found in activated carbon [8]. The ash content greatly affects the quality of activated carbon; an excessive amount of ash can cause blockage of the pores in activated carbon. From the data table of test results above, it can be stated that the ash content of activated carbon with a concentration of 10% H3PO4 produces an ash content of 9.10%, a concentration of 20% H3PO4 produces an ash content of 1.66%, and a concentration of 30% H3PO4 produces an ash content of 0.94%. This indicates that besides being influenced by temperature during carbonization, concentration also plays a role in reducing the ash content of activated carbon. The high ash content at a concentration of 10% H3PO4 is as much as 9.10%. This indicates that the pores of the activated carbon are blocked by phosphoric acid as an activating agent, where it is assumed that there are still miner-

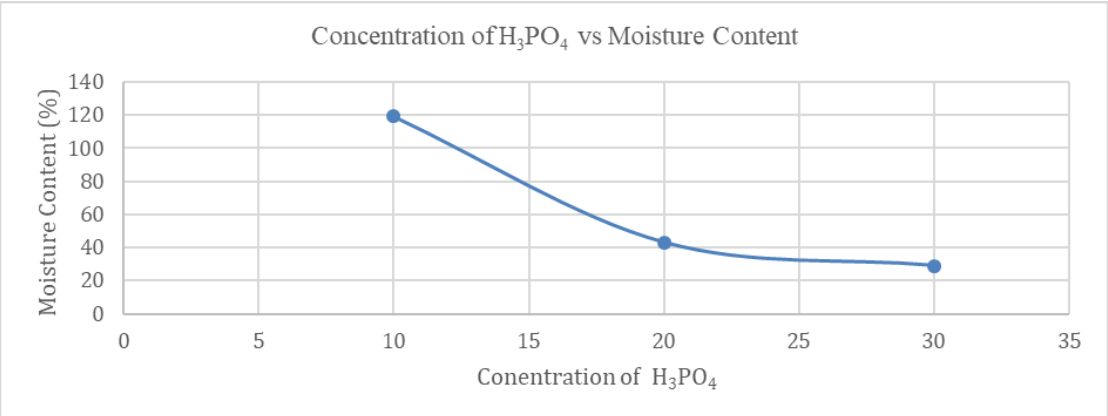

Figure 1. The relationship between H_3PO_4 concentration and water content

al and phosphoric acid residues left during the incineration process, resulting in a significant ash yield due to oxidation processes. The ash content will increase and then decrease with the increasing concentration of the phosphoric acid activator [10].This proves that the activation process will yield higher ash content with increasing activator concentration. The decrease in ash content, as seen at a concentration of H_3PO_4 30%, is due to the molecular transfer process occurring during activation, which can push out the phosphoric acid that still covers the activated carbon pores [11].

Volatile Matter. The purpose of volatile matter content is to remove the amounts of substances or compounds such as water, ash, nitrogen, and sulfur that have not evaporated during the carbonization and activation processes, but evaporate at a temperature of 950. The increase and decrease of volatile matter at a concentration of 10% H3PO4 is 0.47%, at 20% is 1.86%, and at 30% is 2.97%. The increase in volatile matter content from 10% to 30% is caused by the activator binding mineral salts and the duration of activation. The duration of activation can lead to carbon being worn away and lost during washing. The volatile matter content will increase with the increase in activation time [12].

Iodine Absorption

Capacity (I_2) The purpose of testing iodine absorption capacity is to determine the ability of activated carbon to absorb colored solutions. The extent of activated carbon's absorption capacity for iodine can be seen from the number of micropores formed in the activated carbon. The iodine absorption at a concentration of 10% is 1.230 mg/g, at 20% concentration is 1.243.63 mg/g, and at 30% concentration is 1.192.86 mg/g. Thus, it can be said that the higher the concentration, the lower the absorption capacity of activated carbon for iodine, which is due to the fact that the higher the concentration used, the larger the surface area and pores of the activated carbon, thereby increasing its ability to adsorb [13]. For the iodine absorption capacity of the produced activated carbon,it meets the quality standard SNI 06-3730-1995, which is a minimum of 750 mg/g.

SEM (Scanning Electron Microscope). SEM (Scanning Electron Microscope) is an electron microscope used to view the surface area of a material, and it can also provide information regarding the chemical composition of a material, both conductive and non-conductive materials. SEM is used for the characterization of activated carbon by examining

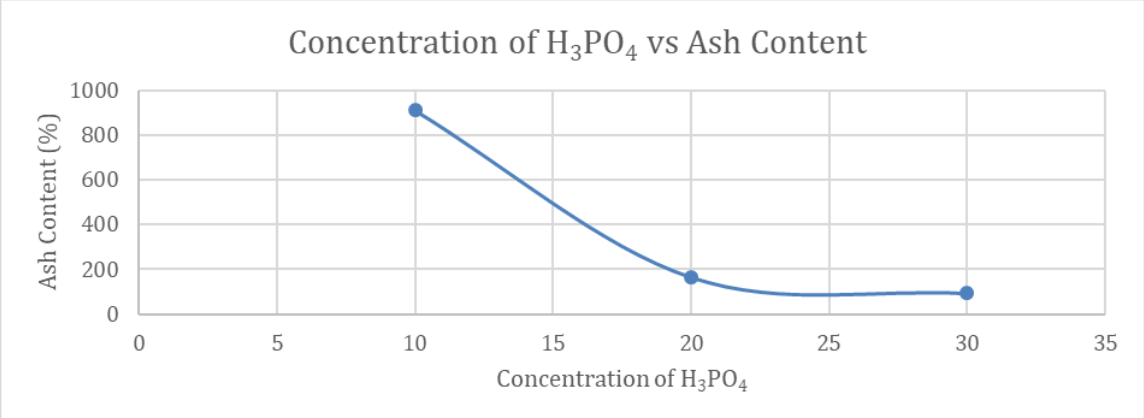

Figure 2. The relationship between H_3PO4 concentration and ash content

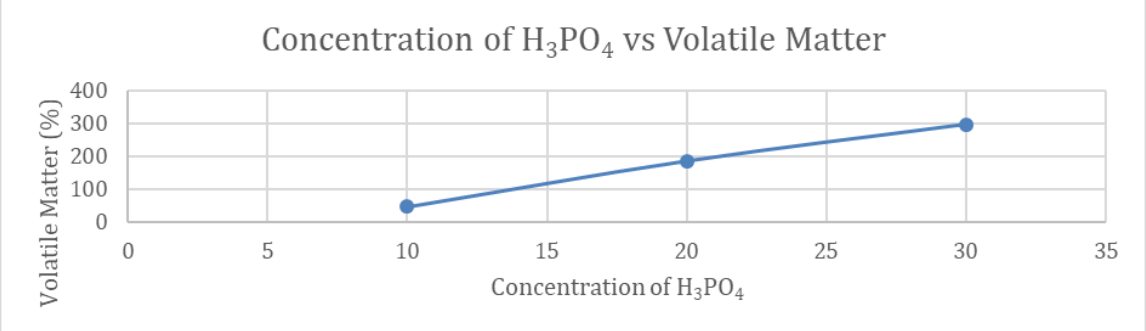

Figure 3. The Relationship Between H_3PO_4 Concentration and the Content of Volatile Substances

the surface area of the pores in the activated carbon, because SEM is a type of electron microscope that produces images of samples by scanning the surface with a focused beam of electrons at magnifications of up to 250–500 times. This can be seen in Figure 7 SEM Testing of Activated Carbon, as follows :

(a) SEM of palm oil trunk activated carbon before activation.

(b) SEM of palm oil trunk activated carbon after activation with 10% phosphoric acid (H_3PO_4)

(c) SEM of palm oil trunk activated carbon after activation with 20% phosphoric acid (H_3PO_4).

(d) SEM of palm oil trunk activated carbon after activation with 30% phosphoric acid (H_3PO_4).

In the image (a) before activation, it shows the pore size of activated carbon to be 6.66µm, and the activated carbon pores have not opened perfectly due to the presence of many particles within the activated carbon pores because they were not activated using the chemical material phosphoric acid. In comparison with images (b), (c), and (d), the third image has significantly more open carbon pores due to the effect of the concentration of the activator using the chemical material phosphoric acid (H_3PO_4). Phosphoric acid is a strong acid that can remove impurities in carbon such as volatile matter and tar, making the carbon more porous. From pictures (b), (c), and (d), there are differences in pore sizes due to different concentrations of phosphoric acid among them as follows: (b) 10% size 11.11 µm, (c) 20% pore size 14.79 µm, and (d) 30% size 21.87 µm. It can be seen from these pore sizes that as the concentration of phosphoric acid increases, the quality of the activated carbon produced improves as indicated by the size of the pores in the activated carbon.

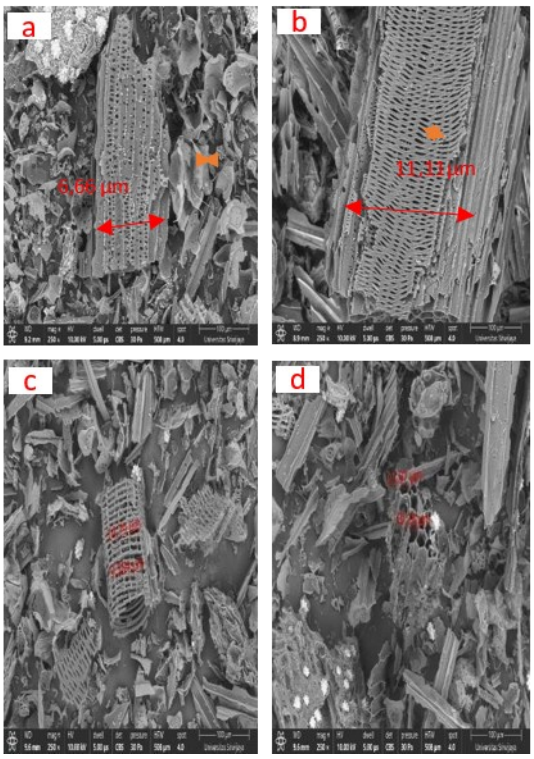

Figure 5. SEM Testing of Activated Carbon

Conclusion

Based on the results of the research on the Production of Activated Carbon as an Adsorbent from Oil Palm Stems Using Phosphoric Acid Activator Concentrations of 10%, 20%, and 30%, it can be concluded that the results of the characterization tests of activated carbon with all concentrations of H_3PO_4 activator 10%, 20%, and 30% meet the activated carbon standards based on SNI 06-3730-1995. The higher the concentration of the activator used, the lower the moisture content produced. For the results of the SEM (Scanning Electron Microscope) test, the higher the concentration of phosphoric acid, the larger the pore size in the activated carbon from oil palm stems.

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