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The Temperature Influence on Sisal Fiber Activated Carbon

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Abstract

Sisal fiber is a natural fiber with a high cellulose content. Furthermore, Sisal fiber also contains hemicellulose and lignin, so it has a good potential to be an activated carbon. In this study, the activated carbon made of from Sisal fibers was performed through dehydration, carbonization, chemical activation, and physical activation. The dehydration process was carried out in the oven machine for 90 minutes at 120 ^{O}C. After that, the carbonization was done at a temperature of 400 ^{O}C for 2 hours. Furthermore, the activation process was conducted through two steps, namely a chemical and physical activation. The chemical activation used the KOH 25 % solution, while the physical activation with heating at the temperature of 700 ^{O}C, 750 ^{O}C, and 800 ^{O}C for 90 minutes. The activated carbon was characterized by scanning electron microscope (SEM) to see the morphology and pore size and the blue methylene absorption test with ultraviolet-visible (UV-VIS) spectrophotometer to determine the active carbon surface area. The SEM image showed that a uniform and small-sized cavity structure on the surface of activated carbon was achieved by the physical activation at the temperature of 800 °C. Meanwhile, the surface area test with blue methylene absorption resulted in a maximum surface area of 574.92 m^2/ g.

Keywords : temperature, activation process, activated carbon, Sisal fiber

INTRODUCTION

Activated carbon has been used broadly to water purify, gas purification, and pharmaceutical waste [2][8][9] due to the characteristics of the wide total areas that have many pores. The carbon characteristic can be activated charcoal through three processes such as dehydration, carbonization, and activation. Dehydration process is the process of removing the water content, then to be carbonized. The carbonization is to convert a material to become carbon. A physical and chemical process has been used to activate carbon through heating at high a chemical reaction. The previous study investigated the temperature effects on the activated carbon at the temperature up to 600 ^{o}C, and the results showed that the higher temperature increased large surface area activing the carbon [3][10]. Activated carbon depended on the raw material containing high cellulose content due to the role in the carbonization process [5]. A potential material used to activated carbon is Sisal fiber because of the cellulose content achieved to 88 % [1][4][9]. This study conducted an investigation of the effects of high temperature on activated carbon using a material with the high cellulose of Sisal fibers to obtaine a high quality of activated carbon.

METHOD

We used Sisal fiber as the sample. The Sisal fibers were cut into 2-3 cm in size. Then, the Sisal fibers were washed with pure water to remove the impurities. After washing, the dehydration process was done to remove the water content. The fibers were then heated at temperature 120 ^{o}C for 90 minutes. After that, the Sisal fibers were ready to be carbonized. In the carbonization process, the Sisal fibers were wrapped tightly with an aluminum foil, then placed in a stainless container and sealed to be free of oxygen.Then, the carbonization process was carried out with an oven machine at 400 °C for 120 minutes. The chemical activation was carried out with using a fine carbon fiber Sisal then weighed as much as 35 grams. The carbon was then put into a measuring cup containing 150 ml of pure water and mixed with KOH 25%. The mixture was stirred using a spatula to obtain a homogeneous mixture. After that, it was left for 24 hours. The next processes were the washing and drying process at 105 ^{o}C for 1 hour. After the chemical activation process, the physical activation was carried out by heating in furnaces at the temperatures of 700 ° C, 750 ° C, and 800 ° C, for 90 minutes. The activated carbon was then characterized to determine the porosity by using a SEM and the surface area by using a blue-methylene absorption test with the UV-VIS.

RESULTS AND DISCUSSION

Preparation and Dehydration

Cutting of Sisal fibers was done in order to facilitate the washing process. We found that the result of preparation and dehydration that the fibers are dry and brownish-white color as shown in Figure1. The fiber is in a clean and waterless condition and is ready for the carbonization process. In the carbonization process, the fibers were placed into the containers made of stainless and heated in an oven machine with the airtight condition. The presence of oxygen produces a perfect combustion reaction of the Sisal fiber and to produce an ash. The carbonization process lasted for 120 minutes with a

temperature of 400 ºC. The result of this carbonization is the charcoal of Sisal fiber as presented in Figure 2.

Figure 1. Dry and clean Sisal fibers

Figure 2: Charcoal of Sisal fibers resulted in the carbonization

CARBONIZATION

The carbon that produced from the carbonization process was further smoothed by using the mortals and iron pestle to reduce its size to be carbon grains. For the homogeneity of the size, the carbon grains were then sieved using a 150 mesh of size. The resulted fine carbon Sisal fibers from the process are presented in Figure 3.

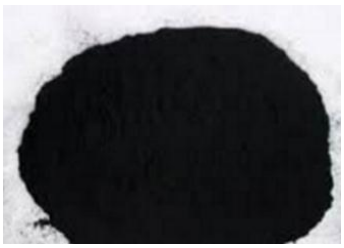


Figure 3. Refined Sisal carbon fiber

Figure 4. Carbon that resulted in chemical activation

Figure 5. Activated carbon after physical activation process

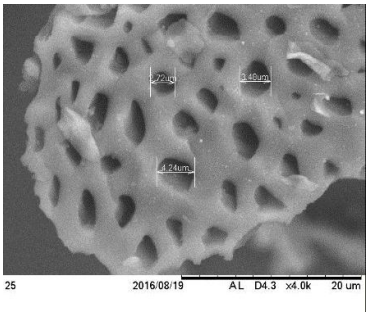
After carbonization and smoothing process of carbon fiber Sisal, the next steps were the process of chemical and physical activation. In the chemical activation process, it was used KOH 25% solution. By the stage, the carbon surface erosion occurs [6][7]. The process causes the carbon has a different structure than before. The carbon that has been chemically activated has a pitch black color as shown in Figure 4.

PHYSICAL ACTIVATION

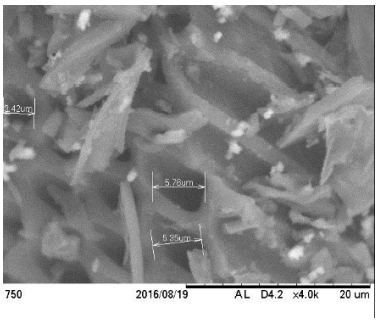
The process of physical activation was done by variation of temperature: 700 ° C, 750 °C, 800 °C in the airtight condition. This physical activation process produces carbon with a relatively black color than before and grain size is more subtle than when the process was conducted by the chemically activated process. The carbon resulted in the chemically activated then physically activated is shown in Fig. 5. It shows that on the physical activation, there is a further breakdown of carbon chains that remains at the time of the carbonization process. The visual observation results show that carbon grains resulted in the higher activation temperatures produce carbon with the finer structure. It can be said that the higher the activation temperature, the activated carbon is free from the impurities. This has the same pattern with the results of research conducted previously [3].

SEM TESTING

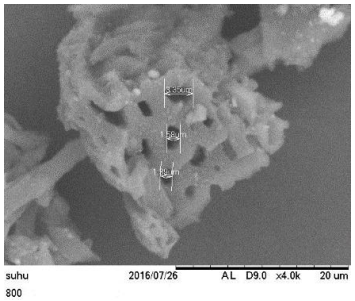
The result of the SEM test of the activated carbon is shown in Figure 6. The SEM image shows that there are differences of the carbon characteristic produced in each treatment. In the results of SEM test presented in Figure 6, the image of carbon surface resulted in the physical activation at the temperature of 700 ° C shows that the formed pores are still small and the distance between the pores is still far, and the pore distribution is uneven. Figure 6 (b) shows the result of the physical activation at the temperature of 750 ° C, the formed pores have a diameter greater than those conducted at the time of the physical activation at the temperature of 700 ° C. Figure (c) shows the most densely formed pore structure resulted in the physical activation at the temperature of 800 ° C. This is in accordance with the research conducted previously that state the higher the temperature of the physics activation, the pores of the activated carbon are formed evenly and widely distributed [10].



(a)



(b)



(c)

Figure 6: Image of SEM with 4000x magnification of activated carbon morphology with (a) physical activation temperature of 700 °C, (b) temperature of 750 °C, and (c) temperature of 800 °C

The SEM results give the information of the hole size of the pores. Table 1 presents the pore diameter of the activated carbon at the different temperature. The data shows that the size of the cavity of carbon produced belongs to the category of macro porous because they have the size above 50 nm. It appears that the activated carbon has the smallest cavity size at the temperature of 800 ° C,

Table 1: The diameter of pores that have formed in the activated carbon

No	Activation Temperature	D_1 (μm)	D_2(μm)	D_3 (μm)	Average of d (μm)
1.	700	2,7	3,4	4,2	3,5 ± 0,4
2.	750	3,4	5,7	5,3	4,8 ± 0,6
3.	800	3,3	1,6	1,9	2,3 ± 0,5

BLUE METHYLENE ABSORPTION TEST WITH UV-VIS

The blue methylene absorption testing with UV-VIS was used to determine the size of surface area of the Sisal fiber active carbon. The usage of blue methylene in this study was due to its ability to adsorb substances very well. Based on the results of the absorption test of the activated carbon with the varied temperature 700 °C, 750 °C, and 800 °C against the blue methylene with a concentration of 120 ppm, the surface area is calculated and presented in Table 2.

Table 2: Surface Area of Activated Carbon

No.	Activation Temperature (°C)	Surface Area (m^2/g)
1.	700	567,8
2.	750	571,4
3.	800	574,9

Table 2 shows the active carbon surface area at the different temperatures. The largest surface area is found at the activation temperature of 800 ° C by 574,9 m² / g of the area. It proves that the higher of the physical activation temperature, the greater the surface area of the activated carbon is obtained. The large surface area is found at the activation temperature of 800 ° C. It shows that physical activation produces the activated carbon with large surface area and regularly pattern of pores [8].

CONCLUSION

Based on the results of the research, it can be concluded as follows.

a) The activated carbon has successfully synthesized from Sisal fibers with the chemical activation process using KOH 25% solution and physical activation process at the different high temperature

b) The temperature affects the surface area of the activated carbon in which higher temperature causes the wider surface area that impacts on the activated carbon quality.

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