CHARACTERISTICS OF TABAH BAMBOO ACTIVATED CARBON PRODUCED BY PHYSICAL AND CHEMICAL ACTIVATIONS

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Abstract - In activated carbons (AC's) production, activation process has a significant role toward characteristics of AC's yielded. The aim of this research is to investigate the activated carbons (AC's) characteristics of tabah bamboo (Gigantochloc nigrociliata) manufactured by physical and chemical activations. Physical activation was carried out by heating up to 800° C, holding at that temperature during 1.5 hours under N_2 flow. Chemical activation was undertaken by mixing a carbon precursor with activating agent (H_3PO_4) with weight ratio 1:1 during 6 hours. The mixed carbon precursor and H_3PO_4 was then heated up to 700° C, soaked during 1.5 hours under N_2 flow. The results show that activated carbon (AC) provided by chemical activation has higher fix carbon and carbon (C) contents and lower ash, moisture and volatile then physical activation. AC manufactured by chemical activation yields 85.47 % fix carbon and 86.33 % carbon, meanwhile AC produced by physical activation has 82.28 % fixed carbon and 84.16.% carbon. Both types of activation give proximate analysis value that have fulfilled of Indonesian National Standard of AC (SNI 06-3730-1995)

Keywords: Activated carbon, physical activation, chemical activation, tabah bamboo, characteristics

I. INTRODUCTION

According to the International Union of Pure and Applied Chemistry (IUPAC), activated carbon is a porous carbon material that is a char associated to react with gas. In order to improve the nature of its absorption properties, sometimes it is added chemicals (eg $ZnCl_2$) before, during or after carbonization [1]. As an adsorbed material, AC is known as an adsorbent having a surface area of between 200 and 2000 m^2/g. This large surface area is due to its porous structure affecting it has good absorption ability [2]. AC is an adsorbent with high porosity and high surface area [3,4] and can be made from materials that containing carbon. AC is widely applied in many areas such as water purification, separation and purification of chemical elements in the industrial world. Other applications include the absorption of benzene [5,6], methane uptake [7,8,9,10] and used for the Litium-Sulfur baterry cathode [11]. Unfortunately, commercial AC is generally produced from non-renewable raw material sources, such as coal and petroleum residues which are very expensive. This condition encourages the development of AC from biomass such as from agricultural waste [5], coconut shell [9], sugar cane [10] and from bamboo [11, 12, 13, 14, 15, 16].

The quality of AC is strongly influenced by the chemical composition of raw materials and parameters of the manufacturing process. The chemical composition is very specific for each raw material. A good raw material should have high lignin, cellulose and carbon content. Production of AC includes three stages of the process; dehydration, carbonization and activation processes [17]. Dehydration is the process of removing the moisture content of raw material, usually done with drying under sun light, followed by heating in the electric furnace at a temperature of 105^0C during 2 hours. This treatment is expected to perfection the carbonization process. Carbonization is a process of heating that is carried out to a certain temperature until no more smoke comes out. The aims of carbonization are to enrich carbon content of carbon raw materials by eliminating non-carbon elements using thermal decomposition [18] and generating initial porosity in charcoal [19]. The charcoal produced from the carbonization process has pores that are still largely covered by hydrocarbons, tars and other components such as ash, water, nitrogen, and sulfur. This causes its low adsorption capacity

[20]. To increase the adsorption capacity, the charcoal is converted to activated carbon through the activation process that principally can be done in two ways, namely chemically and physically activations. In physical activation, the activation process is carried out using weak oxidizers, such as water vapor, CO_2, N_2 and O_2. Oxidators in the activation process only serve to oxidize the components that cover the pore surface of the charcoal, without oxidizing carbon atoms of the charcoal. The chemical activation is carried out by immersing the charcoal with certain chemical compounds (such as H_3PO_4, KOH) before heating. The immersion is carried out in the activating solution, then drained and heated to a certain temperature for 1 - 2 hours. At high temperatures the activator will enter between the hexagonal layers and then open the closed surface [20]. In this study, it was made of AC's carbon from tabah bamboo with physical and chemical activations. Characterization is carried out on raw materials and AC. At this stage, the initial characterization of the AC is carried out by proximate and ultimate analysis and observation of its morphology.

II. METHOD

Tabah bamboo dried during 10 days under the sun light, cut into small pieces with the size of 1 x 1 x 1 cm, heated in an electric furnace at a temperature of 105^0C for 1 hour. Chemical composition, proximate and ultimate tests are then undertaken to the samples. Others samples, bamboos with a size of 1 x 1 x 1 cm were carbonized by heating to 800^0C for 1.5 hours. Furthermore, the charcoals produced were powdered and meshed with a 250 mesh and then activated by physical and chemical activation. Physical activation was carried out by heating to a temperature of 800^0C, held at that temperature for 1.5 hours under N_2 100 mL/min flow protection. The others powder was chemically activated by soaking in 15% H_3PO_4 solution, for 6 hours, and then heated to a temperature of 700^0C for 1.5 hours under a N_2 100 mL/min flow. The AC's obtained were then tested by use of TGA 701 ASTM D7582 MVA In Coal for proximate analysis and use of CHN628 Series Elemental Determinator (ASTM D5373) for ultimate analysis. Scanning Electron Microscope (SEM), JSM-651OLA, was used to observe morphology of microstructure of AC's.

III. RESULTS

Characterization of raw materials (tabah bamboo) including of chemical composition, proximate and ultimate analysis and morphology microstructure have been obtained at previous work [21] and shown in Table 1, Table 2, Table 3 and Fig. 1 respectively.

Table 1. Chemical compositions of raw material

Chemical content	Percentage (%)
Cellulose	44.94
Hemicellulose	16.99
Lignin	22.91

Table 2. Proximate analysis of raw material

Moisture (%)	Volatile (%)	Ash (%)	Fixed Carbon (%)
9.27	84.56	2.92	3.22

Table 3. Ultimate analysis of raw material

Content	Percentage (%)
C	42.47
H	6.10
N	0.95

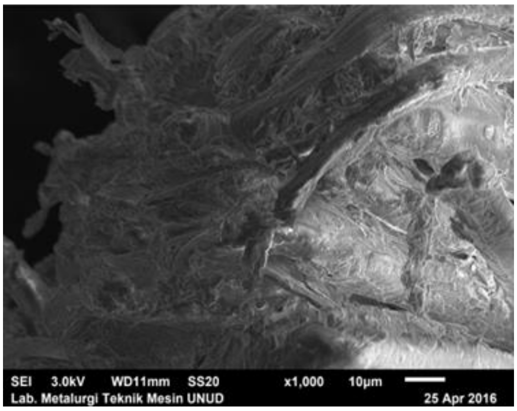

Fig 1. Microstructure Morphology of raw material

Meanwhile, proximate and ultimate analyses of tabah bamboo AC with physical and chemical activation are shown in Table 4 and 5 respectively. In Table 4 is also presented the Indonesian National Standard of AC (SNI 06-3730-1995) in order to evaluate AC yielded. The morphology microstructure of tabah bamboo AC manufactured with physical and chemical activations are shown in Fig. 2 and Fig. 3 respectively.

Table 4. Proximate analysis of tabah bamboo AC

Content	Physical Activation	Chemical Activation	SNI 06 -3730-1995
Moisture (%)	3.31	2.27	15 (max)
Volatile (%)	7.59	7.4	25 (max)
Ash (%)	6..1	4.42	10 (max)
Fix Carbon (%)	82,28	85.47	65 (min)

Table 5. Ultimate analysis of tabah bamboo AC

Activations	C (%)	H (%)	N (%)
Physical activation	84.63	1.30	0.57
Chemical activation	86.33	1.51	0.11

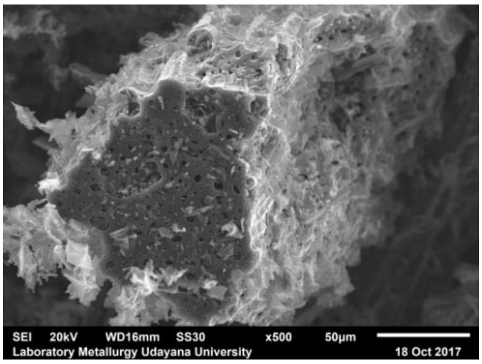

Fig 2. Microstructure morphology of bamboo AC with physical activation

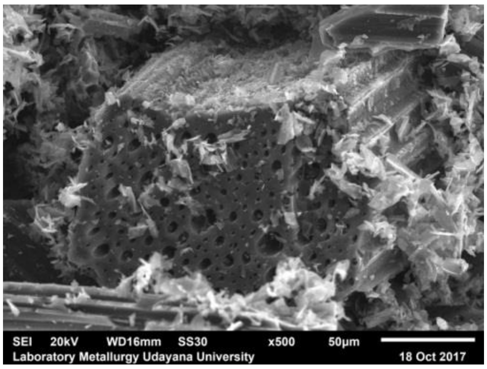

Fig 3. Microstructure morphology of bamboo AC with chemical activation

IV. DISCUSION

Tabah bamboo has a chemical composition with a high enough cellulose (44.94 %) and lignin (22.91 %) contents, as shown in Table 1. It has low ash and moisture contents as shown in Table 2. Although fixed carbon content of this raw material is low enough, as shown in Table 2, high volatile content possessed guarantees this precursor has high carbon content. This due to most of carbons in this raw material are still bounded in the volatile form and will be decomposed become more carbon at ultimate analysis process. This is shown at ultimate analysis results, as shown in Table 3, where the carbon content of this raw material is high enough, that is 42.47%. After carbonization and activation processes, the fixed carbon and carbon contents of the precursor increase significantly as shown in Table 4 and 5. This condition is caused by during the process of carbonization occurs water evaporation process, decomposition of cellulose into wood gas (CO, CO_2), tar and piroligant solution. These last two components are an organic acid with low boiling point such as vinegar acid and methanol. In addition, there is also process of decomposition of lignin into CH_4 and H_2. The end of the process occur purification of charcoal that causes high carbon content [17]. Furthermore, the activation process serves to increase carbon content again and increase porosity by oxidizing substances that still cover the carbon. From Table 4 are shown that fixed carbon of tabah bamboo increase from 3.22% to 82.28% after physical activation and to 85.47% after chemical activation. Evaluation of AC's produced is undertaken by comparison with Indonesian National Standard of AC, SNI 06-3730-1995. The minimal content of fixed carbon of SNI 06-3730-1995 is 65%, meanwhile the maximal contents of ash, volatile and moisture of SNI 06-3730-1995 required are 10 %, 25% and 15% respectively. The AC's manufactured in this research by physical and chemical activation have fulfilled all of the SNI 06-3730-1995 required, as shown in Table 4.

The ultimate test results, as shown in Table 5, show that the carbon content (C) also increases after the carbonization and activation process. However, the increase of carbon contents from carbonization to activation processes are only 2.28% (from 82.28 to 84.63 %) for physical activation and 1% (from 85.47 to 86.33 %) for chemical activation. It is also found that the fixed carbon content is proportional to the carbon content, where the AC produced by chemical activation that have higher fixed carbon than the AC produced by physical activation has also a higher carbon content, as shown in Table 4 and 5.

From the SEM observation results, there are changes of raw material morphological after activation processes, as shown in Fig. 1, 2 and 3. After activation can be seen that have been formed pores for activated carbon produced by both physical and chemical activations. The pores formed will significantly affect the adsorption ability of the AC. To investigate the pores characteristics of these AC's, the advance analysis have to be carried out. Characteristics such as surface area, pore diameter, pore volume and N_2 adsorption/desorption can be evaluated by Surface Area Analyzer test that will be done in next work.

V. CONCLUSIONS

Proximate test, with parameters are ash, volatile, moisture and fix carbon, is a method to evaluate the quality of AC. Based on these parameters, the AC's carbon produced physically and chemically (with activating agent H_3PO_4) in this research qualified in order to fulfill the standard of AC as standardized according to Indonesian National Standard SNI 06-3730-1995. Higher fixed carbon and carbon contents, lower ash, moisture and volatile of AC's are generated by use of chemical activation processes. SEM observation shows that pores have been formed in the morphology of microstructure AC's produced. Further characterization (surface area analysis) is required to know the advance characteristic of pores AC such as surface area, pore volume, pore diameter, and isotherm adsorption/desorption of N_2 that can be used to predict the AC ability in adsorption and desorption other gases.

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