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Activated carbon characteristics of tabah bamboo that physically activated under different activation time

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Abstract. Activated carbon is a versatile porous material that widely applied to purify, deodorize, decolorize, remove or reduce some gases harmful constituents and storage of gas. For different application different characteristics of activated carbon is required. This paper concerns to find out the characteristics of activated carbons derived from tabah bamboo (*Gigantochloa nigrociliata*) that physically activated with different activation holding time. Prepared tabah bamboo was carbonized by heating up to the temperature of 800 °C for two hours. The char produced was powdered and then activated physically by heating up to 800 °C, soaked at that temperature during each 1, 1.5 and 2 hours under 100 mL/min N₂ flow. Activated carbons manufactured were characterized by proximate and ultimate analyses and SEM observation. The results show that the highest fix carbon (82.52%) and lowest ash (5.91 %) was obtained at 1 hour soaking time with moisture and volatile contents were 3.56% and 8.00 % respectively; the highest carbon (C) content of 84.16 % was yielded at soaked time of 1.5 hours; SEM observation shows that there were significant differences of morphology structure between raw material and activated carbons for all of the soaking time variations. The pores structures have been formed in the activated carbons produced.

1. Introduction

Activated carbon is a multifunction and versatile material. It is a very unique material due to having porosity in the size of molecules [1]. The pores of activated carbon have intense van der Waals forces and associated with its adsorption ability. Because of its high porosity [2] and very huge surface area [3], activated carbon has high adsorption capacity [4]. Activated carbons are widely used to purify water from industrial waste [5, 6], to storage of gas [7, 8], for water treatment [9], as a catalyst [10], as a material of double layer capacitor [11] and many others. Due to the wider range of its use, the need for activated carbon will continually increase.

Generally, commercial activated carbon is manufactured from coal, a non-renewable source, having a limitation of availability. To overcome this limitation, biomass has become one of alternative raw material for the production of AC. Various of biomass have been researched and produced as activated carbons, including palm [6], coconut shell [12, 13], bamboo [5, 6, 14-16], coffee endocarp [17] and fine cone [18]. Bamboo is a biomass resource naturally growth in Indonesia and traditionally used as a structural material at traditional building and as traditional tools. Especially in Bali, bamboo has been used to make handicraft and it is an important material in ceremony religion. Commonly, bamboo is very fast growth [19] and available in a large volume. Another aspect causing it suitable for a resource of activated carbon is its chemical composition. Commonly, the contents of lignin and alpha cellulose of bamboo are around 20 – 26% and 40-50%, respectively [20]. These cellulose and lignin contribute to the micropores and macropores formed of activated carbon, respectively.

In order to convert bamboo to activated carbon is undertaken through carbonization and activation processes. Carbonization is a process to convert of raw material become charcoal [21] and to create



initial porosity [22]. This process eliminates non-carbon elements through thermal decomposition creating the higher material carbon content [23]. Activation is indeed to develop advanced porosity [24] by opening inaccessible initial pores, development of new pores and widening of existing pores [25]. Carbonization temperature is generally carried out around 400 to 850 °C and activation temperature is usually in the range of 600 – 900 °C [26]. Characteristic of activated carbon is influenced by the chemical composition of raw material and parameters of the production process. In this paper, the characteristic of activated carbon prepared from tabah bamboo produced with different activation holding time was investigated. Tabah bamboo is original species of Balinese bamboo (Indonesia) having height, diameters and thickness are around 10 m, 5 cm and 6 mm, respectively. They can easily be found in almost all regency in Bali [27].

2. Method

Tabah bamboos (*Gigantochloa nigrociliata*) are used as the precursor. They are cut into small pieces, dehydrated by heating under the sunshine during 8 days and then heating for 1 hour in the electric furnace at a temperature of 110 °C. Carbonization was carried out by heating the samples until the temperature of 800 °C during 2 hours. Chars produced were powdered and continued to activation process which was undertaken by heating the samples up to a temperature of 800 °C, holding for each 1, 1.5 and 2 hours under 100 mL/min nitrogen flow. Activated carbons produced were signed as FA1, FA1.5, and FA2 for holding activation of 1, 1.5 and 2 hours respectively. They are then characterized by proximate test (TGA 701, 0.02 % RSD Precision), ultimate test (elemental determination machine CHN628S) and SEM observation. The chemical composition of tabah bamboo was determined by Van Soest analysis.

3. Results and discussion

3.1. Characteristics of tabah bamboo

Characteristics of tabah bamboo have been evaluated at previous work [28] and illustrated in Figure 1. With its chemical contents (44.94 % cellulose, 22.92 % lignin), C content of 42.47% and low ash content (2.92%), tabah bamboo has great potential as a precursor in the production of high quality of activated carbon. Formation of micropores and macropores of activated carbon are strongly influenced by cellulose and lignin content of raw material [29]. The relatively high content of C has also high potency to yield activated carbon with high C content.

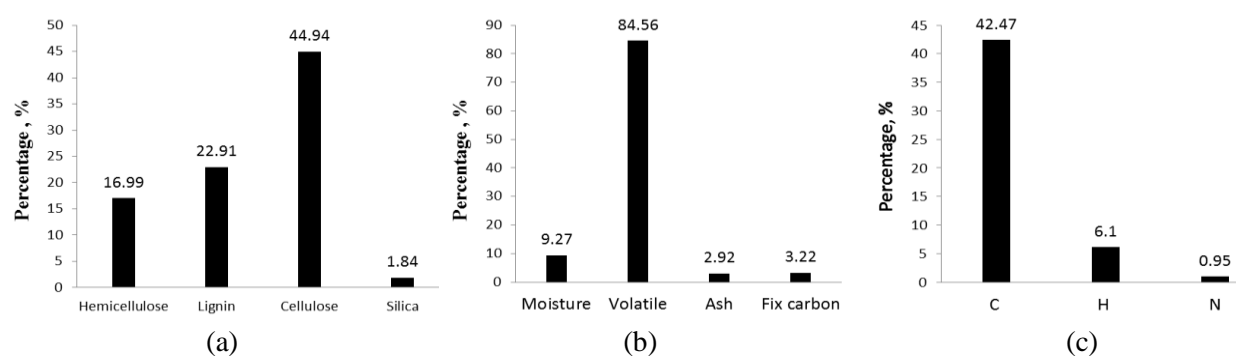


Figure 1. Characteristics of tabah bamboo, (a) Chemical composition (b) Proximate analysis (c) Ultimate analysis.

3.2. Characteristics of activated carbons produced

3.2.1. Proximate and ultimate analysis

Proximate and ultimate analysis of char and activated carbons produced (FA1, FA1.5, and FA2) are respectively shown in tables 1 and 2. From Figure 1 (b) and table 1 can be observed that fix carbon of swat bamboo increases around 96 % from 3.22 % to 80.55 % and ash content also increase by

approximately 53.35 %. After activation, fix carbon content increases 2.26 % on average from fix carbon of char. The fixed carbon of activated carbons produced has fulfilled the fixed carbon minimal requirement of Indonesian National Standard for activated carbon (SNI 06-3730-1995). Based on SNI 06-3730-1995, the content of fixed carbon is minimal of 65% and the maximal contents of ash, moisture and volatile is 10 %, 15 %, and 25% respectively. All of the activated carbons yielded qualified for this entire standard requirement.

Table 1. Ultimate analysis of char and activated carbons produced

Samples	Proximate Analysis Contents (%)			
	Moisture	Volatile	Ash	Fix Carbon
Char	5.58	7.61	6.26	80.55
FA1	3.56	8.00	5.91	82.52
FA1.5	3.31	7.59	6.81	82.28
FA2	3.58	7.48	6.50	82.44

Table 2. Proximate analysis of char and activated carbons produced

Samples	Elemental Contents (%)		
	C	H	N
Char	82.85	1.99	0.41
FA1	84.08	1.46	0.70
AF1.5	84.16	1.30	0.57
FA2	83.39	1.40	0.49

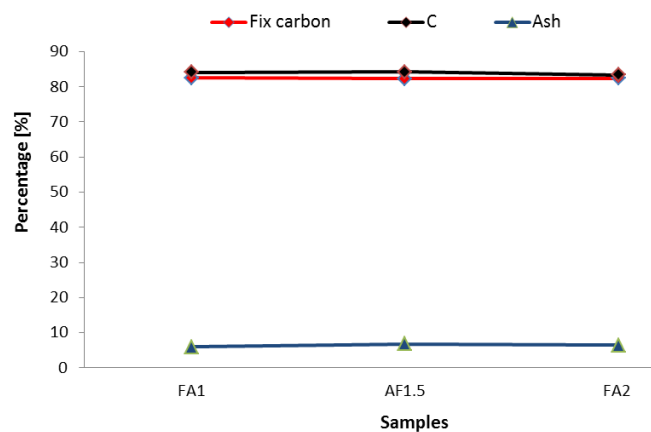


Figure 2. The fixed carbon, carbon and ash contents of activated carbons produced

Ultimate analysis (Table 2) shows that C content of activated carbons also increases compared to the C content of char. However, there is no trend can be observed associated relation between activation holding time and fix carbon and carbon contents of activated carbons yielded. The highest fix carbon is obtained when activation holding time is 1 hour (sample FA1), meanwhile, the highest C content is reached at activation holding time of 2 hours. From figure 2 can be seen that there is no significant difference in fix carbon and carbon contents of activated carbons under different activation soaking time (1, 1.5 and 2 hours).

3.2.2. Morphology microstructure

SEM observations on the char and activated carbons result in the morphology microstructure as shown in Figure 3, 4, 5 and 6 for char, FA1, FA1.5, and FA2 respectively. Morphology microstructure of tabah bamboo, as shown in Figure 3, is smooth and no porosity can be observed. After activation, the morphology microstructure changed significantly, as shown in Figures 4, 5, and 6. Porosities appear as a result of carbonization and activation. The porosities formed due to different activation soaking time are also difficult to be distinguished. These morphology microstructure images are qualitative data that is difficult to make a comparison accurately. Advanced study is needed in order to find out quantitative data such as pore diameter, pore volume and surface area of activated carbons. However, clearly can be said that in the activated carbons produced have formed porosities, the place where the adsorption process occurred.

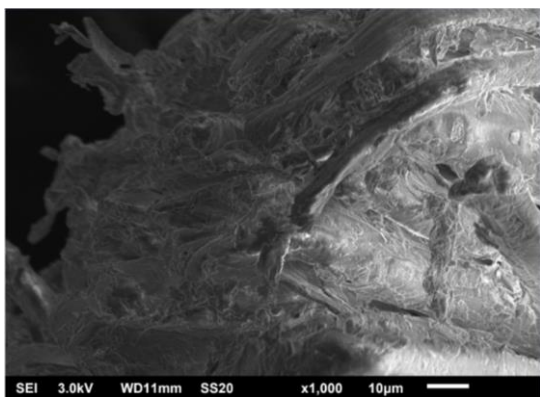


Figure 3. Morphology microstructure of tabah bamboo

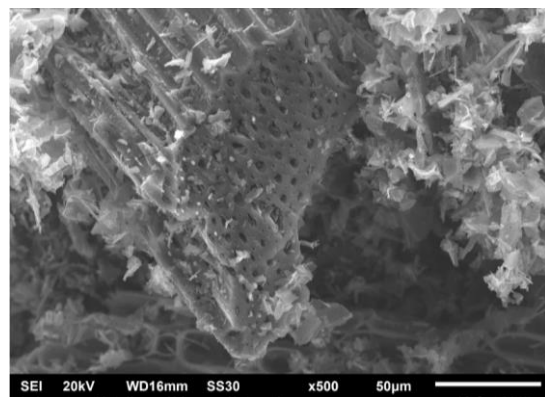


Figure 4. Morphology microstructure of FA1

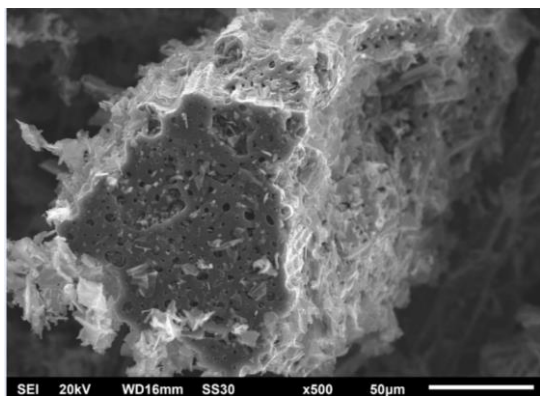


Figure 5. Morphology microstructure of FA1.5

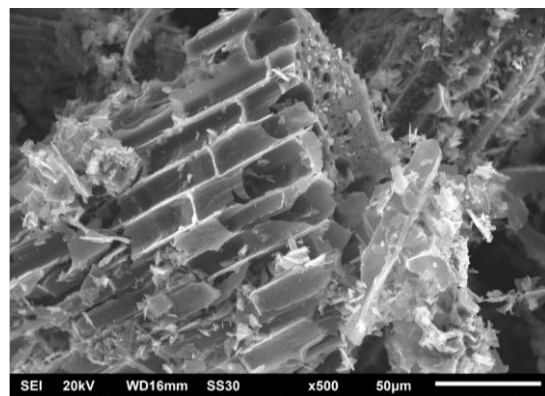


Figure 6. Morphology microstructure of FA2

4. Conclusions

Activated carbons produced have qualified to fulfill the Indonesian National Standard of activated carbons (SNI 06-3730-1995) such as the contents of ash, moisture, fix carbon, volatile and carbon. The effect of activation soaking time on the proximate and elemental components of activated carbon yielded is no obviously can be observed. Based on SEM observation, it clearly can be said that in the activated carbons yielded have formed of pores wherein these pores the adsorption process take place.

References

- [1] Jin X J, Yu Z M and Wu Y 2010 Preparation of activated carbon from lignin obtained by straw pulping by KOH and K₂CO₃ chemical activation *Cellul. Chem. Technol.* **46** 79-85.
- [2] Hu Z and Srinivasan M P 2001 Mesoporous high-surface-area activated carbon *Micro. Meso. Mater.* **43** 267-75.
- [3] Sahu J N, Acharya J and Meikap B C 2010 Optimization of production conditions for activated carbons from tamarind wood by zinc chloride using response surface methodology *Bioresource Technology* **101** 1974-82.
- [4] Idris S, Iyaka Y A, Dauda B E N, Ndamitso M M and Umar M T 2012 Kinetic study of utilizing ground nut shell as an adsorbent in removing chromium and nickel from dye effluent *Am. Chem. Sci. J.* **2** 12-24.
- [5] Cheung W H, Lau S S Y, Leung S Y, Ip A W M and McKay G 2012 Characteristics of chemical modified activated carbons from bamboo scaffolding *Chinese Journal of Chemical Engineering* **20** 515-35.
- [6] Isabel A A C E, Marta S S L, Pedro M C N and Jos'e P B M 2008 Adsorption of natural gas and biogas components on activated carbon *Separation and Purification Technology* **62** 281-96.
- [7] Inomata K, Kanazawa K, Urabe Y, Hosono H and Araki T 2002 Natural gas storage in activated carbon pellets without a binder *Carbon* **40** 87-93.
- [8] Diana C S A, J Cassia S A, Moisés B N, A Eurico B T, Emerson F J and Celio L C 2007 Microporous activated carbon prepared from coconut shells using chemical activation with zinc chloride *Microporous and Mesoporous Materials* **100** 361-64.
- [9] Zhang T, Walawender W P and Fan L T 2010 Grain-based activated carbons for natural gas storage *Bioresource Technology* **101** 1983-91.
- [10] Joanna S N, Weronika K, Beata M and Zvi C K 2013 Production, characterization and methane storage potential of KOH-activated carbon from sugarcane molasses *Industrial Crops and Products* **47** 153-59.
- [11] Patil B S and Kulkarni K S 2012 Development of high surface area activated carbon from waste material *International Journal of Advanced Engineering and Studies (IJAERS)* **1** 109-13
- [12] Dipa D, Debi P S and Meikap B C 2015 Preparation of activated carbon from green coconut shell and its characterization *J. Chem. Eng. Process Technol.* **6** 248 doi:10.4172/2157-7048.1000248
- [13] Ahmadpour A, Okhovat A, and M J Darabi M 2013 Pore size distribution analysis of activated carbons prepared from coconut shell using methane adsorption data *Journal of Physics and Chemistry of Solids* **74** 886-91.
- [14] Koo W K, Gani NA, Shamsuddin M S, Subki N S, and Sulaiman M A 2015 Comparison of wastewater treatment using activated carbon from bamboo and oil palm: an overview *Journal of Tropical and Resource Sustainable Science* **3** 54-60.
- [15] Mahanim S M A, Asma I W, Rafidah J, Puad E and Shaharuddin H 2011 Production of activated carbon from industrial bamboo waste *Journal of Tropical Forest Science* **23** 417-24.
- [16] Ademiluyi F T and Braide O 2012 Effectiveness of Nigerian bamboo activated with different activating agents on the adsorption of BTX *J. Appl. Sci. Environ. Manage.* **16** 267-73.
- [17] Tianfu H, Zehai Q, Dewu W and Zhibiao H 2015 Bamboo-based activated carbon @ MnO₂ nanocomposites for flexible high-performance supercapacitor electrode materials *Int. J. Electrochem. Sci.* **10** 6312 - 23.
- [18] Itoh T and Shimaji K 1981 Lignification of bamboo culm (*phyllostachys pubescens*) during its growth and maturation *Bamboo Production and Utilization Proc. XVII IUFRO Congress Group 5.3. Ed. T. Higuchi Kyoto Japan* **10** 101-4
- [19] Lus A S C, Giovanna A, Diana R and Mario E R G 2014 Correlation between chemical compounds and mechanical response in culms of two different ages of *guadua angustifolia kunth*, *Madera Bosques* **20** 87-94.

- [20] Keith K H C, John P B and Gordon M 2005 Production of activated carbon from bamboo scaffolding waste-process design, evaluation and sensitivity analysis *Chemical Engineering Journal* **109** 147–65.
- [21] Norhusna M N, Lau L C, Lee K T and Abdul R M 2013 Synthesis of activated carbon from lignocellulosic biomass and its applications in air pollution control: a review *Journal of Environmental Chemical Engineering* **1** 658–66.
- [22] Sheng F L, Song Y W, Ming J T and Lang D L 2012 Adsorption capacity and removal efficiency of heavy metal ions by moso and ma bamboo activated carbons *Chemical Engineering Research and Design* **90** 1397–406.
- [23] Lozano-Castello D, Alcaniz-Monge J, M. A. de la Casa-Lillo, Cazorla-Amorós D and Linares-Solano A 2002 Advances in the study of methane storage in porous carbonaceous materials *Fuel* **81** 1777-803.
- [24] Edward L K M, Cheung W H, Vinci K C L and Gordon M 2008 Kinetic study on bamboo pyrolysis *International Engineering Chemical Resources* **47** 5710-22.
- [25] Li X B, Shupe F T, Peter G F, Hse C Y and Eberhardt T L 2007 Chemical changes with maturation of the bamboo species *phyllostachys pubescens* *Journal of Tropical Forest Science* **19** 6-12.
- [26] Zhao R S, Yuan J P, Jiang T, Shi J B, and Cheng C C 2008 Application of bamboo charcoal as solid-phase extraction adsorbent for the determination of atrazine and simazine in environmental water samples by high-performance liquid chromatography-ultraviolet detector *Talanta* **76** 956-59.
- [27] Scurlock J M O, Dayton D C and Hames B 2000 Bamboo: an overlooked biomass resource *Biomass & Bioenergy* **19** 229-44.
- [28] Putra Negara, D N K, Tirta Nindhia, T G, Surata, I W and Sucipta, M. Chemical, Strength and Microstructure Characterization of Balinese Bamboos as Activated Carbon Source for Adsorbed Natural Gas Application. 7th International Conference on Key Engineering Materials (ICKEM). IOP Conf. Series: Materials Science and Engineering 201 012033, 2017.
- [29] Sánchez-Echeverri L A, Aita G, Robert D and Garcia M E R 2014 Correlation between chemical compounds and mechanical response in culms of two different ages of *guadua angustifolia kunth* *Verano* **20** 87-94.