Processing of Browncoal from Kutai Kertanegara: East Kalimantan as Adsorbent Media

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Abstract: East Kalimantan is one of the provinces in Indonesia that produces the largest coal. Brown coal or known as lignite has less economic value, this is because of its poor quality, low heating value and high sulfur and ash content, so it is not suitable for use as an energy source. However, lignite coal has the potential to be used as activated carbon which is an absorbent medium because it has a fixed carbon content of 25-30%. As activated carbon, low rank coal will be very useful for absorbing impurities such as color and dissolved metals. The purpose of this study was to determine the adsorption of browncoal from East Kalimantan from the Kutai Kertanegara area which was activated using the H3PO4-NaHCO3 activator on the quality of the activated carbon produced. Coal is sifted with a size of -100+120 mesh and then carbonized at 600^{o}C for 3 hours. After that, 20 grams of charcoal was activated using 2.5M H_3PO_4-$NaHCO_3$ 2.5M with time variations of 2 hours, 4 hours, 6 hours, 8 hours and 12 hours, then washed to a neutral pH and then physically activated at 700^{o}C for 2 hours. The best results were obtained with chemical activation for 6 hours with a water content of 3.5%; volatile matter content 9.81%; ash content 14.91%; fixed carbon content 71.78% and iodine absorption 505.072 mg/g.

1 INTRODUCTION

East Kalimantan is one of the provinces in Indonesia that produces the largest coal. Production in 2017 was 86,101,658.68 tons (EMR Department, 2018). Low rank coal is the type that produces the most, which is 50% even though it has a low heat. Subbituminous and bituminous coal produced 36.6% while anthracite 11.6% (Geological Agency, 2016).

Lignite or brown coal is usually soft and has a brownish color that often contains plant parts that are easily recognizable from their cell structure. Brown Coal so far has not been utilized optimally even though the potential is quite large in the Kutai Kertanegara area of East Kalimantan, this is because the calorific value is low so that the combustion efficiency produced is low due to the high water content.

Lignite coal or brown coal has less economic value due to high transportation and storage costs and high sulfur content and ash content. Lignite coal has a calorific value composition of less than 7500 Btu/lb (5250 cal/g), 25-45% water content, 24-32% volatile matter content, 25-30% fixed carbon content and 3-15% ash content (Heriyanto *et al*., 2014). Based on the fixed carbon content of the coal, lignite coal has the potential to be used as activated carbon.

Activated carbon is an adsorbent that is needed in industrial processes, including the pharmaceutical industry, food, beverages, water treatment (water purification) and others (Rahim and Indriyani, 2010 and Kusdarini *et al.,* 2017). The application of the use of adsorbents is usually in adsorption technology, which is a process or phenomenon of accumulation of substances on the surface of other substances, such events are usually referred to as absorption of adsorbate molecules. to the adsorbent surface. (Treybal) , 1981) There are 2 types of adsorption consist of 1. Physical Adsorption Van Der Walls Adsorption Physical adsorption process is an adsorption process which is the result of intermolecular attractive forces between solid molecules and substances. does not penetrate into the crystal screen of the adsorbent and does not dissolve in it, but completely on the surface of the adsorbent. In highly porous solids containing many capillaries, adsorbed substances will enter these crevices when the adsorbate soaks the solid, (Treybal, 1981). 2. Chemical adsorbent or active adsorbent is the result of the interaction between solids and adsorbed

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substances. Chemical absorbers are often not reversible and the desorption of substances is often found to have undergone chemical changes, (Treybal, 1981).

Adsorbents are solid substances that can adsorb certain components of a fluid phase, One of the adsorbants is activated carbon which is amorphous carbon which has a large surface area and internal volume so that it has a high adsorption capacity (Ali I et al., 2012). Activated carbon was a material that has many very small pores (Liu *et al.*, 2019). These many pores will be able to make activated carbon have the ability to adsorp various other substances that are close to it. the wider the surface of the activated carbon, in principle, the more pores it has to increase the surface area, then a number of materials containing activated carbon will be present (Jawad *et al.*, 2019 ; Lilibeth, *et al.*, 1996). There were at least 2 ways that can be done for activation, the first is a physical process, namely by using a high temperature, and the second is through a chemical process, namely using certain chemicals that can be in the form of acids or bases, or even a combination of both (Han *et al.*, 2018 ; Yan *et al.*, 2020).

Research using lignite coal or browncoal has been carried out by Rahim and Indriyani (2010), obtained the best conditions for physical activation, namely a temperature of 800 ^oC while chemical activation using 5% NaOH for 2 hours. moisture content is 8.05%, ash content is 16.70%, volatile matter content is 9.92% and iodine adsorption is 24.88%. Another study used a temperature of 600^0C carbonization time and physical activation at a temperature of 800^0C, the best results were at 150 minutes with the results of water content, ash content, volatile matter and absorption of iodine as follows: 0.64%; 13.74%; 12.42% and 46.75%.

In this study, H_3PO_4-NaHCO3 activator was used, the use of this activator will produce H_2CO_3 and Na_3PO_4 compounds where Na_3PO_4 can reduce ash because it can bind calcium magnesium and silica (Saragih, 2009) while H_2CO_3 can dissolve calcium (Tahriri, *et al*, 2009). The results to be achieved from this study are focused on the effect of chemical activation time on brown coal using H_3PO_4-$NaHCO_3$ activator on the quality of activated carbon in order to increase the economic value of brown coal which is abundant in East Kalimantan as an alternative raw material for making activated carbon.

2 METHODOLOGY

First, the brown coal is reduced to -100+120 mesh, then carbonized at $T=600^0C$ for 3 hours, then chemical activation of the carbonized brown coal is soaked using 2.5 M H_3PO_4 solution - 2.5 M $NaHCO_3$ with a variation of immersion time of 2 hours, 4 hours, 6 hours, 8 hours, 12 hours. The immersion results obtained were then washed with distilled water until the pH was neutral and then placed in an oven to remove the water content at a temperature of 105^0C and physical activation was carried out by heating at $T=700^0C$ for 2 hours. remove it and let it cool in a desiccator then perform proximate testing including analysis of inherent moisture, ash content, volatile matter, fixed carbon, and iodine absorption test,

The proximate analysis to determine the content contained in brown coal activated carbon includes water content analysis using the ASTM D-3173 test method, ASTM D-3174 ash content, ASTM D-3175 volatile matter content and ASTM D-3175 iodine adsorption.

3 RESULT AND DISCUSSION

The coal used in this study is lignite or brown coal The calorific value test of brown coal obtained the result that the calorific value of the coal used was 3665 cal , The results obtained were analyzed after the carbonization process was carried out to determine the effect of carbonization on brown coal and used as the basis for the initial conditions of brown coal before further activation, proximate analysis includes analysis of water content, ash content, volatile matter content and iodine absorption. like table 1 below

Table 1: The effect of carbonization brown coal analyzed.

Brown Coal	Before carbonization	After Carbonizatio
Moisture Content, (%)	37.86	0.68
Volatile Matter (%)	5.53	34.25
Ash Content (%)	25.06	20.80
Fixed Carbon (%)	31.55	44.27
Iod Absorption (mg/g)	215.73	279.18

The characteristics of brown coal that have been carbonized are affected by high temperatures causing the surface area of brown coal to open but it is not significant to become activated carbon, obtained water content of 0.68%, volatile matter content

34.28%, fixed carbon content 44.27%, ash content 20.80% and iodine adsorption 279.18 mg/g. The value of iodine adsorption has a correlation with the surface area of activated carbon, the greater the iodine number, the greater its ability to adsorb adsorbate or solutes. the carbonization process has a significant effect due to the decomposition of organic compounds that make up the structure of the material to form methanol, vapor, tar, and hydrocarbons, this is characterized by reduced volatile matter and increased moisture content when carbonization is carried out.

Table 2: The effect of Time Activation.

Parameter	Time activation (h)				
	2	4	6	8	12
Moisture Content, (%)	5.15	3.89	3.5	3.83	3.62
Volatile Matter (%)	10.36	9.71	9.81	12.03	10.08
Ash Content (%)	11.07	13.98	14.91	13.89	13.85
Fixed Carbon (%)	73.42	72.42	71.78	70.25	72.45
Iod Adsorption (mg/g)	479.17	492.12	505.07	492.12	453.28

Table 2 shows how the effect of activation time on brown coal, the activation carried out includes chemical and physical activation. The following graph below shows the effect of activation based on variations in activation time.

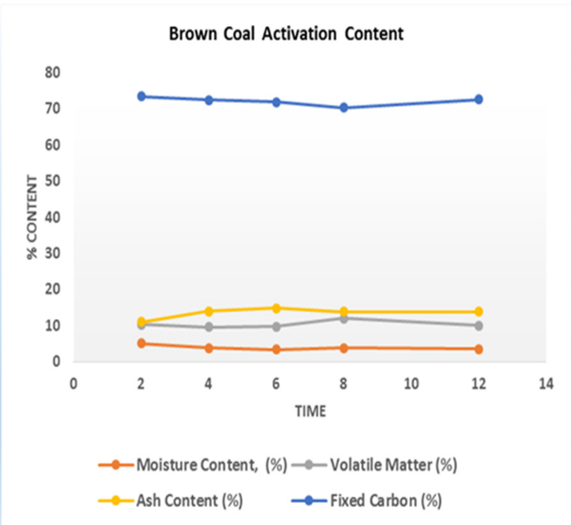

Figure 1: The time effect of brown coal activation.

Figure 1 The water content tends to decrease with the duration of activation, this is because the longer the activation time, the water trapped in the cavities of the activated carbon will be more dehydrated by the activating agent which results in more water being taken up by the activator because Na_3PO_4 is a compound that is a dehydrating agent.

The increase in ash content was due to the fact that the water content in activated charcoal was much reduced when heated, but the inorganic compounds which were the components of the ash remained relatively constant so that the percentage of ash content would increase. The activator substance succeeded in reducing the ash content from 20.80% to 11.07%-14.91% after chemical activation because the ash component was soluble in the activator substance.

The decrease in volatile matter levels is because the volatile compounds dissolve with the activator and evaporate during physical activation at a temperature of 700ºC. The compound H_2CO_3 breaks down into H_2O and CO_2. CO_2 trapped in activated carbon can increase volatile matter levels

Fixed carbon content is determined by the content of other impurities such as water content, ash content and volatile matter. The higher the water content, ash content and volatile matter, the lower the fixed carbon value. From the results of the study, it can be seen that the increase in fixed carbon content was caused by a decrease in water content and volatile matter content, while the ash content did not significantly contribute to the increase in fixed carbon content.

Another important parameter is the iodine number, as shown in the figure below which shows a significant increase in iodine adsorption after activation.

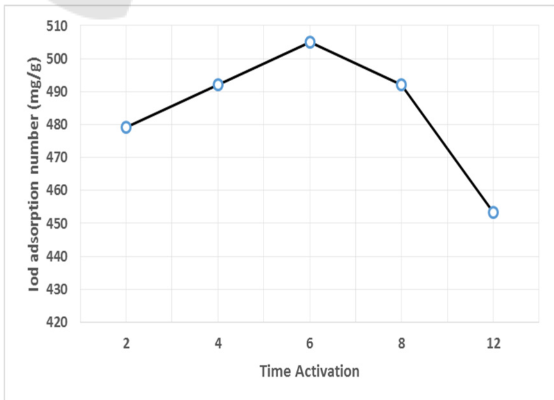

Figure 2: The effect time activation for iodin adsorption number.

Based on Figure 2, shows an increase in iodine absorption at each time variation when compared to before activation, of course there is a very significant difference, the iodine adsorption before activation is at 279.18 mg/g and after activation was in the range of 453.28 mg/g - 505.07 mg/g. The use of chemical compounds in the activation process causes the activating mineral elements to enter between the hexagon plates of the crystallites and separate the initially closed surface and break the carbon chain of organic compounds, contact time or immersion time has a significant impact on the activation process. When physical activation is carried out by heating at high temperatures, the contaminant compounds that are in the pores become more easily released. This causes the active surface area to increase and increases the adsorption of brown coal activated carbon.

4 CONCLUSIONS

The best results in the process of making activated charcoal from browncoal from Kutai Kertanegara, East Kalimantan based on variations in activation time using the H_3PO4-$NaHCO_3$ activator, the best conditions were obtained at 6 hours of activation with a water content of 3.5%; volatile matter content 9.81%; ash content 14.91%; fixed carbon content 71.78% and iodine adsorption 505.072 mg/g.

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REFERENCES

AH Jawad, K Ismail, MAM Ishak, LD Wilson (2019). Conversion of Malaysian low-rank coal to mesoporous activated carbon: structure characterization and adsorption properties. *Chinese Journal of Chemical Engineering 27 (7), 1716-1727.*

Kusdarini, et al, (2017). Production of Activated Carbon from Bituminous Coal with H3PO4 Single Activation, Combination of H3PO4-NH4HCO3, and Thermal. *Adhi Tama Institute of Technology Surabaya. Mining Engineering.*

Lilibeth l, Shigehisa I, Yuji I, Toshimitsu M (1996) Research and Development of Carbon Compositesfrom Wood Charcoal for Environmental Clean-up and their Applications. *Wood research Journal 83*: 43-46.

Liu, J., Zhang, Q., Liang, L., & Huang, W. (2019). Study on the Catalytic Pyrolysis Mechanism of Lignite by Using Extracts as Model Compounds. *Catalysts,* 9(11). doi:10.3390/catal9110953

Patmawati, Y and Kurniawan, A. (2017). Utilization of East Kalimantan Lignite Coal into Activated Carbon. Samarinda State Polytechnic. *Chemical Engineering.*

Rahim, M and Indriyani, O.S. (2010). Production of Activated Carbon from Low Rank Coal. *Journal of Perspective Media Technology. Thing.* 40-44.

Saragih, R. (2009). Determination of Phosphate Levels in Recovery Boiler Feed Water by UV-VIS spectrometry method at PT Toba Pulp Lestari, Tbk- Porsea. *University of Northern Sumatra.* Medan.

Tahrini, W et al. (2009). Effect of Carbonic Acid (H2CO3) on the impact strength of limestone aggregates. *Udayana University.* Denpasar.

Treybal, R. E. (1981), Mass Transfer Operation. *SingaporeMcGraw-Hill Book Company*

Yan, J., Liu, M., Feng, Z., Bai, Z., Shui, H., Li, Z., Yan, H (2020). Study on the pyrolysis kinetics of low-medium rank coals with distributed activation energy model. *Fuel, 261. doi:10.1016/j.fuel.2019.116359*