Chemical Activation of Lignite by using a Combination of H_3PO_4-$NaHCO_3$

Alwathan[1], Muh. Irwan[1], Panji Satrio Utomo[1] and Yuli Patmawati[1]
[1]*Department of Chemical Engineering, Politeknik Negeri Samarinda*
Jl.Dr.Cipto Mangunkusumo*, Kampus Gn.Lipan Po.Box 1341 Samarinda, Kalimantan Timur - Indonesia*

Keywords: Activated Carbon, Activation, Coal, Lignite, Low-Rank Coal.

Abstract: Coal is divided into four classes: lignite, sub-bituminous, bituminous, and anthracite. Lignite is a low rank coal. About 30% of Indonesia's coal reserves are included in the low rank category. The use of low-rank coal is still limited for briquettes and as fuel for electricity generation. Improving the economic and usage values of low-rank coal, processing low-rank coal into activated carbon should be done because coal has a high carbon content. The purpose of this study is to determine the effect of activation time on the characteristics of the activated carbon produced by chemical activation process of lignite use a combination of activator H_3PO_4 - $NaHCO_3$. Lignite has been prepared -100 +120 mesh is carbonized at 600^0C for 3 h, then after cold it was activated using 2.5 M concentration of H_3PO_4-$NaHCO_3$ for 2, 4, 6, 8 and 12 h. Furthermore, proximate and iodine adsorption number analysis were used to investigate the characteristics of activated carbon produced refers to Indonesian National Standard (SNI 06-3730-1995) including moisture content, ash content, volatile matter, fixed carbon and iodine absorption number. The best results were obtained at 6 h of activation with the characteristics of activated carbon such as moisture content, ash content, volatile matter, fixed carbon and iodine absorption number respectively as follows 3.5%, 14.91%, 9.81%, 71.78% and 505.1 mg/g. Activated carbon is a well known material that is used extensively in industrial purification and chemical recovery operations. It offers an attractive and inexpensive option for removal of several solutes from aqueous solutions.

1 INTRODUCTION

Coals are raw materials for many chemical syntheses as well as cost-effective fuels for power plants due to their low cost; however, some coals such as low-rank coal (lignite) contain high amounts of moisture (Karthikeyan and Mujumdar, 2009).

Activated carbon is a well known material that is used extensively in industrial purification and chemical recovery operations. It offers an attractive and inexpensive option for removal of several solutes from aqueous solutions. Activated carbon can be produced from different sources, such as lignocellulosic materials, coal, baggase ash, activated sludge and others (Shawabkeh and Al-Ghamdi, 2014). Coal has the potential as a raw material to produce activated carbon because it has a high carbon content (Speight, 1994).

Activation processes are mainly categorized into two categories for the preparation of activated carbon i.e. physical and chemical activation. Physical activation usually involves the carbonization of pre-cursor followed by the gasification of the resulting char or direct CO_2/steam activation of the starting material. Chemical activation involves the impregnation of the given precursor with activation agent such as phosphoric acid (H_3PO_4), chloric acid (HC1), nitrit acid (HN_3), zinc chloride ($ZnCl_2$), alkaline metal compounds and salt.

The adsorption capacity of activated carbon is very important because this property determines how much of the substance can be absorbed per gram of carbon. The activator type directly affects the micropore structure, specific surface area and pore volume of the activated carbon, which makes its adsorption capacity vary obviously (Bilal, 2016). Activated carbon is sold at a high enough price if the adsorption capacity is large. The quality requirements for activated carbon refers to Indonesian National Standard (SNI 06-3730-1995) with max.15% moisture content, max.10% ash

Alwathan, ., Irwan, M., Satrio Utomo, P. and Patmawati, Y.
Chemical Activation of Lignite by using a Combination of H3PO4-NaHCO3.
DOI: 10.5220/0010025000002905
In *Proceedings of the 8th Annual Southeast Asian International Seminar (ASAIS 2019)*, pages 182-185
ISBN: 978-989-758-468-8

content, max.25% volatile matter, min.65% fixed carbon and min. 750 mg/g iodine adsorption number (Departemen Perindustrian dan Perdagangan, 2003).

Many studies regarding the change in adsorption capacity of activated carbon as a function of the type of chemicals and activating conditions have been reported. Research conducted by Rahim and Indriyani using 5% NaOH activator solution produced activated carbon according to SII standard 0258-79 even though the ash content was still above the standard (Rahim and Indriyani, 2010). Another study was making of activated carbon from sengon wood with chemical activation using NH_4HCO_3 activator solution of concentration variation 0; 0.5; 1; 3; 5 and 10% by weight, produce activated carbon with moisture content of 6.39%, ash content of 9.15%, volatile matter of 8.81%, fixed carbon of 82.04% and iodine absorption number of 1154.4 mg/g. Meanwhile research with chemical activation of bituminous coal (Kusdarini and Ghafarunnisa, 2017) used a combination of H_3PO_4 - NH_4HCO_3 activator solution (concentration 2 M - 2.5 M) for 8 h followed by physical activation to produce activated carbon with a moisture content of 7.5%, ash content of 9%, volatile matter of 43.3%, fixed carbon of 40.2% and increased iodine absorption number to 1172.56 – 1238.544 mg/g (Kusdarini and Ghafarunnisa, 2017).

The purpose of this study is to determine the effect of activation time on the characteristics of the activated carbon produced by chemical activation process of lignite use a combination of activator H_3PO_4 - $NaHCO_3$.

2 METHODOLOGY

Lignite has been prepared -100 +120 mesh is carbonized at 600^0C for 3 h, then after cold it was activated using 2.5 M concentration of H_3PO_4-$NaHCO_3$ for 2, 4, 6, 8 and 12 h. Furthermore, proximate and iodine absorption number analysis of activated carbon refers to Indonesian National Standard SNI 06-3730-1995 was carried out including moisture content, ash content, volatile matter and fixed carbon. Table 1 summerizes the characterization of lignite before activation.

Table 1: Characteristics of Lignite.

Parameter	Value
Moisture Content, %	37.86
Ash Content, %	5.53
Volatile Matter, %	25.06
Fixed Carbon, %	31.55
Iodine Number, mg/g	215.75
Caloric Value, cal/g	3665

3 RESULT AND DISCUSSION

Table 2 summarizes the results of chemical activation of lignite by using a combination of H_3PO_4 - $NaHCO_3$ activators.

Table 2: Characteristics of Activated Carbon.

Parameter,%	Time, hours				
	2	4	6	8	12
Moist. Cont.	5.15	3.89	3.05	3.83	3.62
Ash Cont.	11.07	13.98	14.91	13.89	13.85
Vol. Matter	10.36	9.71	9.81	12.03	10.08
Fixed Crbon	73.42	72.42	71.78	70.25	72.45
Iodine Number, mg/g	479.2	492.1	505.1	492.1	453.3

The effect of activation time on characteristics of activated carbon is represented in Figure 1 and 2. In Figure 1 can be seen that the longer time of activation, the moisture content has decreased from 37.86% to 3.5% at 6 h of activation time. This is because water trapped into the cavity of activated carbon will be more dehydrated by combination of activator H_3PO_4- $NaHCO_3$. The increase in moisture content at 8 h and 12 h of activation time was due to the hygroscopic characteristic of the activated carbon so that in the cooling process water vapor in the air is absorbed into the pores (Bilgen, 2016).

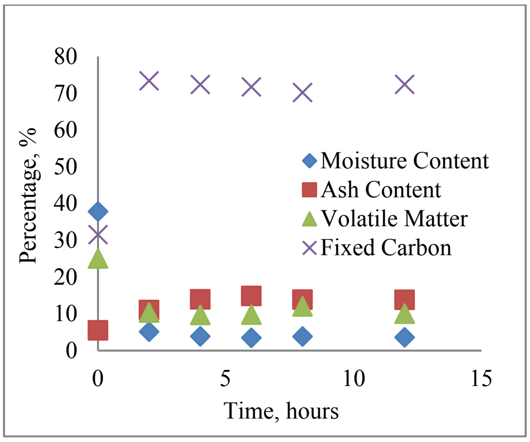

Figure 1: Characteristics of activated carbon versus time of activation.

Ash content represents the bulk of the mineral matter in the coal after losing the volatile components such as CO_2, SO_2, and H_2O. The ash content in Figure 1 was measured to be 11.07% ; 13.98% ; 14.91% ; 13.89% and 13.85% at 2, 4, 6, 8 and 12 h of activation time, respectively. The increase in ash content until 6 h of activation time was due to the presence of alkali elements which are absorbed in the low-rank coal pore during immersion with an activator H_3PO_4 - $NaHCO_3$ to form a silicate from the alkali elements. After showing its highest value at 6 h activation time, the ash content gradually decreased with activation time and was 13.85% at 12 h of activation.

Volatile matter show the portion of coal that is released as gases and volatile liquids when heated in the absence of air at prescribed conditions. The decrease in volatile matter from 25.06% until 10.36% at 2 h of activation time but the longer time of activation (2 h – 6 h) of low- rank coal does not have a significant effect on volatile matter. At 8 h activation, the volatile matter has increased because the decomposition of H_2CO_3 into H_2O and CO_2. After 8 h activation, the volatile matter decreased and was 10.08% at 12 h of activation.

Fixed carbon is composed of carbon with lesser amounts of H, N, and S. It is generally described as a coke-like residue. It can be used to give a forecast of heating value of the coal (Speight, 2013a). Activation of lignite by using combination of H_3PO_4 - $NaHCO_3$ activators has succeeded in increasing the fixed carbon from 31.55% to 70.25% -73.42%. This can be seen in Figure 1. The increase in fixed carbon was due to decrease in moisture content and volatile matter, while the ash content does not contribute too much.

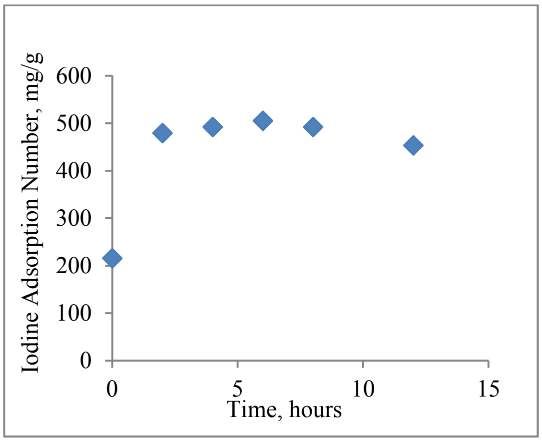

Figure 2: Iodine absorption number of activated carbon versus time of activation.

The iodine adsorption number reflected the adsorption per-formance of activated carbon, as shown in Figure 2. It tends to increase from 215.75 mg/g to 505.1 mg/g at 6 h of activation time. Furthermore at 8 and 12 h of activation time there was decrease until finally obtained an iodine absorption number of 453.3 mg/g. In general, the iodine absorption number of activated carbon, which represents its adsorption capacity. When activation was carried out longer than 6 h the decrease in iodine absorption number probably due to higher ash content so that inorganic substances left on the activated carbon cover the pores of the activated carbon.

4 CONCLUSION

1. Chemical activation of lignite by using a combination of H_3PO_4 - $NaHCO_3$ activators was evaluated taking activation time as the major influential parameters were obtained the best condition at 6 h of activation time with the characteristics of activated carbon such as moisture content, ash content, volatile matter, fixed carbon and iodine absorption number respectively as follows 3.5%, 14.91%, 9.81%, 71.78% and 505.1 mg/g.
2. Ash content and iodine absorption number was still below the standards referred to Indonesian National Standard (SNI 06-3730-1995).

REFERENCES

Bilal Khalid et.al., 2016. Effects of KOH Activation on Surface Area, Porosity and Desalination Performance of Coconut Carbon Electrodes. *Desalination and Water Treatment Journal* 57. pp. 2195–2202.

Bilgen, S., 2016. The effects of Chemical Characteristics of Coal on Coal-Based Industry. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects.* 38:22. pp. 3324-3331.

Departemen Perindustrian dan Perdagangan, 2003. Syarat Mutu dan Uji Arang Aktif SNI No. 06-3730-1995. *Balai Perindustrian dan Perdagangan*.

Karthikeyan, M., Zhonghua, W. and Mujumdar, S.Arun, 2009. Low-Rank Coal Drying Technologies—Current Status and New Developments. *Drying Technology: An International Journal*.

Kusdarini, E., Budianto, A. and Ghafarunnisa, 2017. Produksi Karbon Aktif dari Batubara Bituminus dengan Aktivasi Tunggal H_3PO_4, Kombinasi H_3PO_4-NH_4HCO_3, dan Termal. *Jurnal Reaktor. UNDIP*.

Rahim, M. and Indriyani, O., 2010. Pembuatan Karbon Aktif dari Batubara Peringkat Rendah. *Jurnal Teknologi Media Perspektif.* Politeknik Negeri Samarinda.

Shawabkeh, R.A., Al-Harthi and Al-Ghamdi, 2014. The Synthesis and Characterization of Microporous, High Surface Area Activated Carbon from Palm Seeds. *Energy Sources, Part A*. 36:93–103.

Speight, J.G., 1994. The Chemistry and Technology of Coal. Marcel Dekker. Inc. New York.

Speight, J. G., 2013a. Coal-Fired Power Generation Handbook. Beverly, USA. Scrivener Publishing.