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Application of Microwave Absorbent from East Kalimantan Lignite on Microwave Pyrolysis of Waste Lubricating Oil

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Abstract : This research was conducted to prove the ability of activated carbon as microwave absorbent, which was made from East Kalimantan lignite, on microwave pyrolysis of waste lubricating oil. Improving lignite characteristics has been successfully performed. However, the natural properties cause this material to still have relatively low fixed carbon content compared to commercial microwave adsorbent. To resolve that conditions, the mass influence investigation was carried out to find out the best mass which can produce the highest gasoline fraction. Improving characteristics of East Kalimantan lignite was done by immersing lignite sizing 12 mesh in chemical activators i.e. 3 % $NH_4H_2PO_4$ and was continued in 20 % $(NH_4)_2SO_4$. Immersing process in each activator was undertaken as long as 9 hours with ratio lignite to activator is 1:1.25 (m/v). Chemical activation treatment was followed by physical activation by heating to a temperature of 450 ^OC for 30 minutes and 950^OC for 10 minutes. Activated carbon produced has 78.50% fixed carbon content. Activated carbon was than utilized as microwave absorbent on waste lubricating pyrolysis oil by adding it with mass varies i.e. 80, 83, 90, 95, dan 100 g,into the 250 ml waste lubricating oil. Pyrolysis of waste lubricating oil which assisted microwave was undertaken for 1 hour. GC-FID analysis shows that the best result is obtained at using 90 g activated carbon with 87 % composition of gasoline gain.
Keywords : activated carbon, gasoline, lignite, microwave absorbent, pyrolysis, waste lubricating oil.

Introduction

This experiment was conducted based on the successful result of Lam et al.'sresearch[1,2] and the fact of the potential resource of lignite in East Kalimantan. Utilization of lignite into more beneficial material such as activated carbon,has to be done to increase its value. In this experiment the lignite coal was activated by physical and chemical treatments, and then used as microwave absorbent in waste lubricating oil (WLO) pyrolysis to produce gasoline. Microwave irradiation aid is used not only to decrease the processing time, but also to increase the yield[3].It is also beneficial for treating WLO, thereby reducing the negative impact if waste lubricating oil is discharged directly into the environment, due to the fact that WLO contains hazardous material.

The purpose of this research is to determine the influence of the mass of activated carbon prepared from lignite coal, in the pyrolysis of waste lubricating oil whichis assistedby microwaves, to produce high gasoline fraction. This is necessary because the natural characteristics of lignite causes activated carbon produced to be

not as good as commercial activated carbon used by Lam et al. Lignite has less carbon content (60-75 %) and higher volatile matter (45-65%) compared to other coal ranks[4].

Experimental

A. Production of Activated Carbon

Lignite raw material was taken from coal mining in Samarinda, East Kalimantan. Lignite sized 12 mesh was immersed in 3 % $NH_4H_2PO_4$as long as 9 hours. The process was continued with immersing it in 20% $(NH_4)_2SO_4$during the same period. The ratio lignite to each activator is 1:1.25 (m/v). After chemical activation, the lignite was washed with H_2SO_4 and aquadest. The last treatment to make activated carbon is by heating the lignite at 450^oC as long as 30 minute and at 950^oC for 10 minute in furnace. Some part of those procedures was taken fromthe experiment conducted by Zouet al.[5].

The quality of activated carbon was analyzed through parameters i.e. moisture content

(ASTM D 3173), ash content (ASTM D 3174), volatile matter (ASTM D 3175), fixed carbon (ASTM D 3172), bulk density, surface area (BET), and surface morphology (SEM).

B. Pyrolysis of Waste Lubricating Oil (WLO)

WLO used in this experimentwas taken from motorcycle service stations in Samarinda. WLO was treated by mixing 250 mL WLO with activated carbon. Mass of activated carbon was variedby80, 83, 90, 95,and 100 g. That mixture was then pyrolysedat a temperature of 550$^oC$for 1 hour in a microwave oven which has power of 400 V.

To obtain the gasoline fraction data, product was analyzed by using GC FID. GC-FID chromatogramsproduct was further compared with GC-FID of RON 88 gasolinestandard.

Results and Discussion

The change properties of lignite and activated carbon, are shownin this table below:

Table 1.Properties of lignite and activated carbon

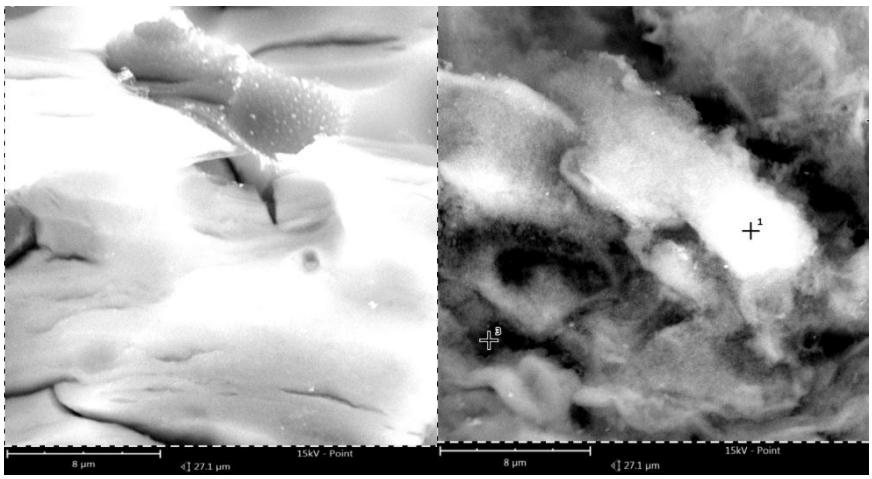
Properties	Lignite	Activated Carbon
Moisture Content (%)	18.91	2.09
Ash Content (%)	7.79	0.91
Volatile Matter (%)	47.23	18.50
Fixed Carbon (%)	26.07	78.50
Bulk Density (g/cm^3)	0.72	0.506
Particle Size (mm)	1.425	1.143
Surface Area m^2/g	102.045	286.023

From the data presented in table 1, it shows that activated carbon has better quality than lignite. Those are indicated by the decrease in moisture, ash, and volatile matter content of activated carbon. This resulted in increase of fixed carbon and surface area and also in lowering bulk density.

The chemical activation processes with soak lignite in $NH_4H_2PO_4$ and $(NH_4)_2SO_4$ able to increase lignite characteristics. In addition, both have a function to increase the results of carbonate, $(NH_4)_2SO_4$ also has a function to open the pores while $NH_4H_2PO_4$ used for cleaning surfaces[5].

Meanwhile, the physical activation by heating lignite in furnace has a function to maintain the large pores in the activated carbon. Furthermore, reheatingactivated carbonwill harden carbon as well as activate its performance of the application process.The heating also serves to remove all volatile organic compound[6].

Figure 1 describes the change of surface morphology between lignite and activated carbon.



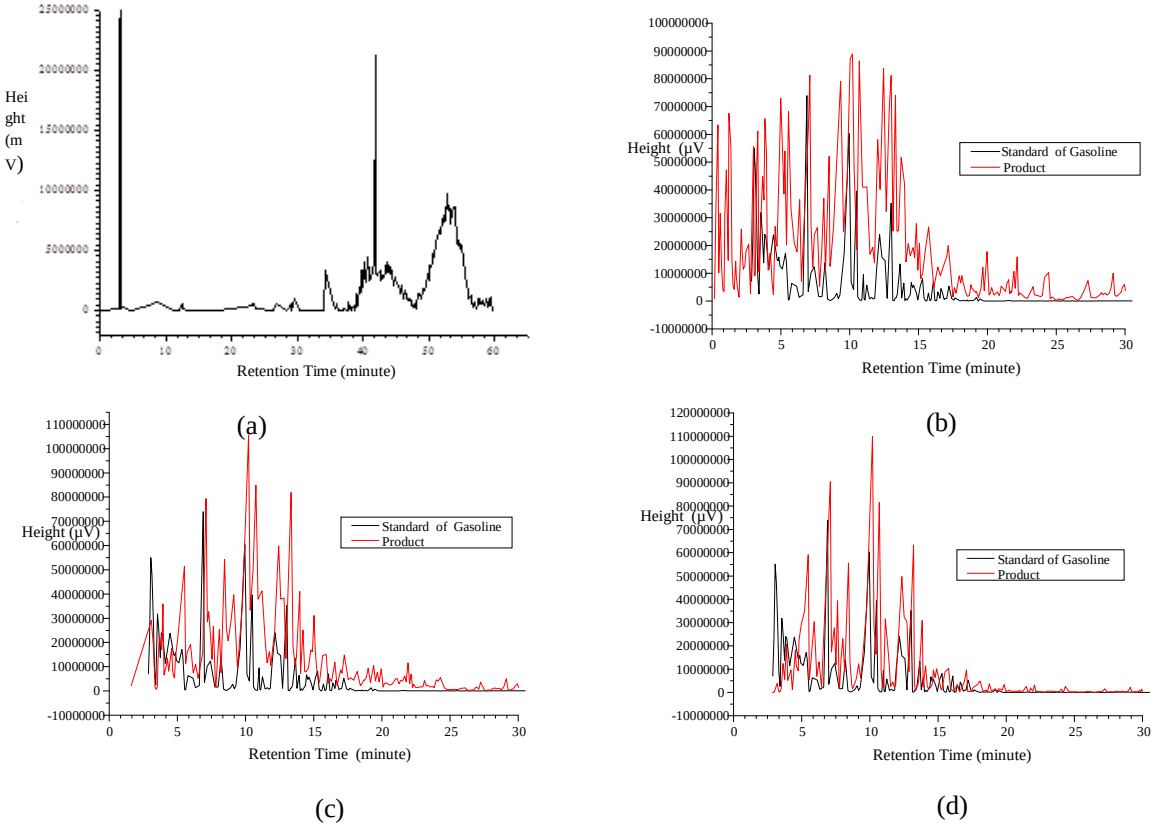
(a) **(b)**

Figure 1. Surface morphology (enlargement 10,000 x), (a) lignite, (b) activated carbon

Nevertheless, the quality of activated carbon produced, still lower than commercial activated carbon which was produced by Timcal Ltd.[7], especially on surface area.The percentage of fixed carbon is also still lower than that done by Lam et al.[1]. Even the heating time and temperature can affect yield of carbon,but it still depends on property of lignocellulosic material component[8].

Activated carbon was then applied on WLO pyrolysis which is assisted by microwave to produce gasoline. Adding activated carbon into the WLO is needed to overcome the low dielectric property of the WLO. Activated carbon can act as aproper microwaveabsorber because its nature of high dielectric loss tangent[9].

The following GC-FID chromatograms describe the course of pyrolysis of WLO.



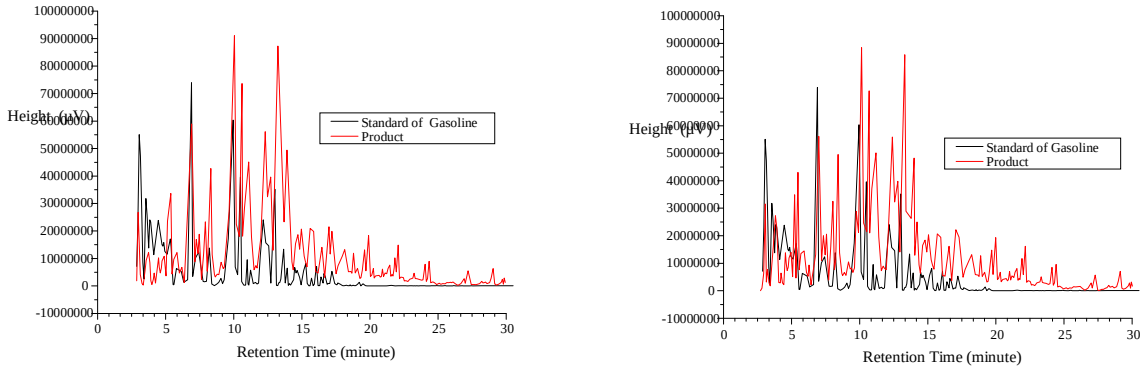


Figure 2.GC-FID chromatograms, (a) WLO, (b) Pyrolysis product with 80 g absorbent, (c) Pyrolysis product with 83 g absorbent, (d) Pyrolysis product with 90 g absorbent, (e) Pyrolysis product with 95 g absorbent, (f) Pyrolysis product with 100 g absorbent

From the GC analysis results, gasoline product obtained has retention time of peak which differs significantly from the WLO. Significant peaks of the product occur at a retention time which is faster than the retention time of a significant peak in WLO which shows that there has been a pyrolysis process in which the WLO cracked into fractions that have a shorter chain. The products havedefinite retention time between 3-15 minutes such as retention time of standard gasoline. The chromatogram productis most similar to the standard gasoline chromatogram as shown in figure 2 (d). This signifies that the additional of 90 g activated carbon is the best absorbent amount in the pyrolysis of WLO to produce gasoline.

Table 2. Composition of pyrolysis products

Mass of Absorbent (g)	Percentage of Fraction Lower Than Gasoline (%)	Percentage of Gasoline Fraction (%)	Percentage of Fraction Higher Than Gasoline (%)
80	5.542	66.706	27.752
83	0.650	73.498	26.437
90	0.007	88.726	11.267
95	-	70.930	29.070
100	-	69.264	30.736

In table 2 it can be seen that the absorbent mass variations can affect the composition of the product. It is shown that the addition of microwaves absorbent in the mass variation of 80 to 90 g can increase the amount of gasoline content on the product up to 88.726%.However, the usage of absorbentbelow 90 g would increase product fraction lower than gasoline while increasing the product fraction higher than gasoline.But adding an absorbent amount equal to 90 g can reduce lower as well as higher fraction than gasoline, thus upgrading the composition of the gasoline.The composition of the gasoline on the product decreased in the absorbent mass variations over 90 g. The decrease in these compositions, due to an increase number of products that has a hydrocarbon chain which is relatively longer than the gasoline hydrocarbon chains, thereby increasing the composition of a higher fraction than gasoline.

Variations in the type and amount of absorbent is added to the pyrolysis process which is assisted by microwaves can be used to change the products of pyrolysis, making it possible to control the type of product desired. It is related to the dielectric properties of materials that influence the heating mechanism. Microwave absorbent is a major factor in using microwave pyrolysis that directly affect the pyrolysis conditions, mainly includes profiles of temperature and heating rate[10].

Conclusions

From the research conducted, it can be concluded that:

1. Lignite activation process has succeeded in improving its quality into activated carbon and serves as a microwavesabsorbent.
2. Massof activated carbon from lignite as much as 90 g is the best number added to the waste lubricating oil pyrolysis to produce gasoline with the highest composition of 85%.

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