Purification Of Bioethanol With Bamboo Activated Carbon As Adsorben

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Abstract: Bioethanol purification techniques have developed very rapidly. Bioethanol purification techniques are usually carried out in several ways, namely distillation, membrane pervoration and adsorption. Purification technology is still being developed to obtain an efficient and easy to do purification technology. Purification technique by adsorption is one of the purification techniques that is very easy to do where the raw material of the adsorbent is very easy to obtain. This study used adsorbents from petung bamboo with sizes 80 and 200 mesh that were activated. This study was conducted to determine and characterize pellet-shaped bamboo carbon from bamboo activated carbon with a size of 200 mesh and obtain a bioethanol concentration greater than 99% through a distillation adsorption method simultaneously. The results of the adsorption process are expected to be one of the solutions for renewable energy raw materials replacing fuel oil sourced from non-renewable fossil materials.

Key words: adsorption, bamboo actived carbon, distilation,renewable energy

1 Introduction

BIOETHANOL is one of the renewable energy sources obtained from the fermentation process of sugars from carbohydrate sources that use microorganisms. Bioethanol is a good source of energy with a good prospect as a substitute for liquid fuels whose raw materials are renewable, friendly to the environment and very profitable in terms of macroeconomics in rural areas especially for farmers. Seeing fuel consumption is increasing while fossil-based energy cannot be renewed, it is necessary to alternative fuel substitution with renewable energy as a replacement solution. One of the basic ingredients of renewable energy which is now being carried out by research is bioethanol. Bioethanol purification techniques have developed very rapidly. Bioethanol purification techniques are usually carried out in several ways, namely distillation, membrane pervorasi and adsorption. Purification technology is still being developed to obtain an efficient and easy to do purification technology. Purification technique by adsorption is one of the purification techniques that is very easy to do where the raw material of the adsorbent is very easy to obtain. The adsorbent material which is usually used in bioethanol purification is zeolite, silica sand, starch material and activated carbon [8,12]. The characteristics of the adsorbent in bioethanol purification are very decisive in bioethanol purification[5,11]. One of the characteristics of the adsorbent that is very influential in the refining process is the specific surface area of the adsorbent.

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The greater the surface area of the adsorbent the better. The pore structure also determines the adsorption capacity of the adsorbent. The more pores in the micropore and messopore area the better absorption capacity of the adsorbent[6,7]. This study used adsorbents from petung bamboo with sizes 80 and 200 mesh that were activated. This study aims to obtain a bioethanol concentration greater than 99% (fuel grade ethanol) through a distillation adsorption method that runs simultaneously in columns with petung bamboo adsorbents. The results of the adsorption process are expected to be one of the solutions for renewable energy raw materials replacing fuel oil sourced from non-renewable fossil materials.

2 Material and Methods

2.1 Materials

The materials used in this study were petung bamboo adsorbents measuring 80 and 200 mesh, test apparatus, water pump, measuring cup, erlenmeyer tube, electric heater, mercury thermometer, digital thermometer, stop watch and scales. The test equipment used in measuring ethanol concentration after adsorption was Clarus 680 chromatograph gas and micromeritics tool for testing the characteristics of petung bamboo adsorbents in the form of pellets.

2.2 Preparation of the Test Apparatus

The test apparatus is made of quartz glass tubes which are resistant to high temperatures up to 1750oC. Before testing, calibration of the heater is carried out to determine the optimum temperature of ethanol evaporation with a temperature range of 78-80oC. The specifications of the purification device are designed as presented in Table 1.

***Table 1** Specifications for ethanol purification test apparatus*

No	Components	Size
1	Feed tank	100 mL
2	Water bath	15 cm x 20 cm
3	Adsorbent column	7 cm x 2.5 cm
4	Condensation tube	25 cm x 3.75 cm
5	Product container tank	100 mL
6	Heater source	-
7	Water pump	-
8	Filter size 350 mesh	-

The schematic drawing of the test apparatus used in this study is presented in Figure 1.

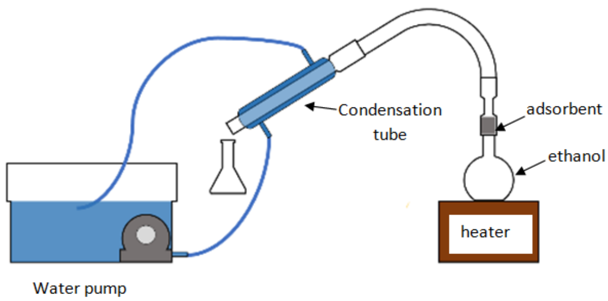

Fig. 1. *Scheme of the purification process in the test apparatus*

2.3 Bamboo Adsorbent Preparation and Feed Ingredients

The adsorbent before being used in the refining process is first heated with an oven at 110°C. This is done to evaporate the water content contained in the adsorbent. Then the 80 and 200 mesh adsorbents were weighed 3 grams each. 96% ethanol is put into the feed tank as much as 10 mL. The adsorbent is inserted into the adsorbent column which is given a 350 mesh filter so that the adsorbent does not fall on the bait tube. The purification process is carried out until the adsorbent is saturated so that it is no longer able to absorb water in the 96% ethanol evaporation process.

2.4 Measurement of ethanol concentration

The measurement of purified ethanol concentration was carried out on Gas Chromatograph test equipment. The number of samples tested was 1 mL from the purification of each adsorbent used. The purification results are in the form of plot area obtained from the relationship between time (minutes) and response (mV) which will be converted into concentration (% v/v).

2.5 The process of making bamboo activated carbon pellets

The Making activated carbon pellets is done by manual pelletizer by inserting 0.5 gram fine powder of 200 mesh active carbon into the printer. Pressure is given when printing 5 ton pellets. Activated carbon pellets made are pure pellets without any other mixture of ingredients.

2.6 Testing the Characteristics of Activated Carbon Pellets

The test is carried out using a micromeritics device where the tool is a Surface Area Analysis (SAA) which serves to determine the material surface area, the pore distribution of the material and the gas isotherm on a material. The working principle of this tool uses the gas adsorption mechanism generally nitrogen, argon and helium, on the surface of a solid material which will be characterized at a constant temperature usually the boiling temperature of the gas. The surface area testing in this study used gas nitrogen (N_2). The sample weight to be tested is usually in the range 0.1 to 0.01 grams. The main preparation of the sample before being analyzed is by removing degassing gases. The surface area analyzer consists of two main parts, the degasser and analyzer. Degasser functions to give initial treatment to the test material before being analyzed with the aim of removing gases that are absorbed on the surface of the solid by heating under vacuum. Usually degassing is carried out for 6 hours with temperatures ranging from 200-300°C depending on the characteristics of the test material.

3 Result and Discussions

3.1 Purification of Ethanol with Bamboo Activated Carbon

Ethanol purification with activated carbon adsorbent of petung bamboo measuring 80 and 200 mesh has specific surface area of 1516.34 ± 84.38 m^2/g and 194.95 ± 184.97 m^2/g, respectively. This is in accordance with the research of Misri Gozan et al.(2017). The amount of ethanol from the adsorption and distillation process in the test apparatus is shown in Table 2.

Table 2 *The total of ethanol purified by adsorbent of activated carbon*

Size adsorbent (mesh)	Weight adsobent (g)	Total feed ethanol (mL)	Total etanol after adsorption (mL)
80	3	10	2.5
200	3	10	3.5

The remaining 96% ethanol feed in the feed tank after the refining process for 80 and 200 mesh adsorbent sizes were 4 mL and 2 mL, respectively. This shows that the surface area of the adsorbent affects the amount of ethanol water absorbed in each adsorbent. The difference in the amount of ethanol produced in the purification process on the two adsorbents used was also influenced by the saturation conditions of the two adsorbents during the refining process. The time needed to purify ethanol after the adsorption and distillation process for 80 and 200 mesh adsorbents is 30 minutes and 50 minutes, respectively. The difference in purification time is influenced by the second pore structure of the adsorbent where the number of micro-sized pores in the adsorbent measuring 200 mesh is more. The purification results of the two bamboo adsorbents after being tested by the gas chromatograph method can be presented in Table 3. The concentration of ethanol obtained from the purification results from the value of the area of detection peak in each of the adsorbents used.

Table 3 *Purification with gas chromatograph test*

Size adsorbent (mesh)	Time (min)	Area (uV*sec)	Etanol concentration (%v/v)
80	4.282	784972.63	98,23
200	4.286	796320.09	99.65

The adsorption and distillation process carried out to purify ethanol 96% as shown in Table 3 proves that the size of the adsorbent affects the concentration of ethanol produced. The purification results also showed that using a petung bamboo adsorbent with 200 mesh particle size was able to produce 99.65% ethanol concentration and this was in accordance with the minimum requirements of Fuel Grade Ethanol (FGE) which is 99.5% as one of the fuel solutions to replace fuel oil especially gasoline. This agrees with Novitasari and Kusumaningrum(2012) but the material used for the adsorbent is different, namely zeolite.

3.2 Characteristics of Bamboo Active Carbon in the Form of Pellets

The use of activated carbon has been widely used as an adsorbent, water filter and as a catalyst. Making pellet-shaped activated carbon made from bamboo has been carried out by Liu and Jiang(2013) by looking at the effect of the carbonation process and the physical properties of bamboo activated carbon making it suitable for commercialization. Bamboo pellets made in this study use a manual pelletizer. Forms of pellets that have been printed like tablets with a thickness of 1.5 mm and a diameter of 10 mm as presented in Figure 2.

Fig. 2. *Pellet bamboo activated carbon*

The surface area of bamboo pellets after being tested by the BET method using a micromeritic device at an analysis temperature of -195.79^{o}C with an interval of 5 seconds equilibration is presented in Table 4.

Table 4 *The results of the surface test of bamboo pellets using the BET method*

Relative Pressure (P/Po)	Quantity Adsorbed (cm3/g STP)	1/(Q(Po/P-1))
0.0675	67.3526	0.001075
0.1173	68.8705	0.001930
0.1691	69.8043	0.002916
0.2199	70.3970	0.004006
0.2695	70.8472	0.005209

The graph of Nitrogen (N_2) desorption adsorption isotherm from pellet shaped activated carbon is shown in Figure 3.

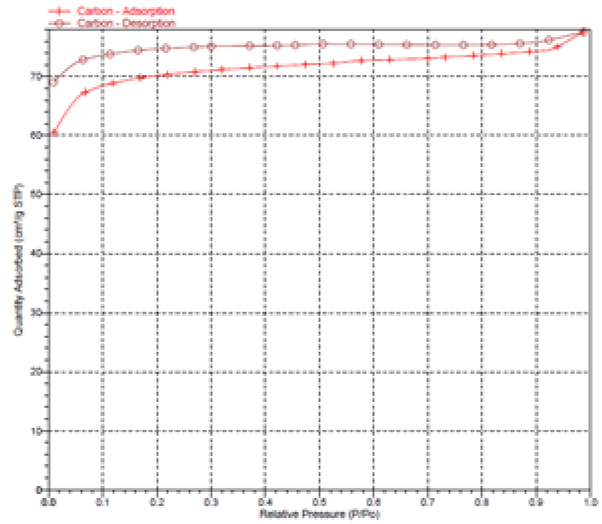

Fig. 3. *Nitrogen desorption adsorption isotherm on bamboo activated carbon pellets*

Nitrogen adsorption carried out is physical adsorption used in the BET method to determine the surface area and pore structure of activated carbon[4]. The relative pressure values in this study ranged from 0.06 to 0.26. This is consistent with the study of Adamson(1990) where the BET equation can only be used for the adsorption of isotherms which have a relative pressure value (P/Po) ranging from 0.05 to 0.3. Bamboo activated carbon is very well used in adsorption isotherms and this agrees with the research conducted by Byoung *et al.*(2008). Adsorption of desorption of the cumulative surface area of the pores of activated carbon between 1.7nm and 300nm each is 21,941m^2/g and 11,9387m^2/g. Changes in surface area that occur in desorption are caused by changes in the pore structure that occurs in activated carbon during the release of ions or molecules that have been attached to the active group of previous adsorbents. The surface area using the BET and Langmuir methods was obtained for 217.738m^2/g and 330.,384 m^2/g, respectively. Both methods compared to the surface area of activated carbon used before dipping decreased due to compaction, resulting in a reduction in the number of pores of activated carbon, especially in the micropore and mesopore regions. The difference in surface area between the BET method and Langmuir occurs because of the different assumptions used in the mathematical relationship where the BET method assumes that the adsorbate molecule can form more than one layer of adsorbate on the surface while the Langmuir method assumes that the adsorbate molecules form one layer on the surface when adsorption takes place. The value of the correlation coefficient (R^2) of the two methods is 0.997 in the BET method while 0.999 in the Langmuir method. The langmuir method is usually better when applied to chemical adsorption while the BET method is better used for physical adsorption. Both methods also show a good linearity relationship so that it can be applied to nitrogen gas adsorption on pellet-shaped activated carbon from petung bamboo.

4 Conclusion

Pellets from activated carbon in petung bamboo measuring 200 mesh is very well applied to the nitrogen gas adsorption and desorption process. The value of the correlation coefficient (R^2) of the two methods is close to 1. This proves that the adsorption process carried out fulfills the mathematical equations of the two methods carried out.

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