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Technology of Carbon : Effect of Activation Temperature on Characterization the Ultimate and Proximate Activated Carbon of Palm Bunches (Arenga Pinnata (Wurmb). Merr)

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Abstract*: This study aims to determine the effect of variations in the activation temperature on the quality of activated carbon palm bunches using proximate and ultimate analysis. In this research, the process of preparation activated carbon palm bunches with three stages in the process of dehydration, carbonization, and activation. The activation process uses temperatures of 600^{0}C, 650^{0}C, 700^{0}C, 750^{0}C, 800^{0}C with a time of 30 minutes, After activation, the sample is analyzed using proximate and ultimate analysis methods, Proximate analysis is an analysis to determine the content of water, ash, volatile substances and carbon bonded ultimate analysis is an analysis to determine the content of the elements carbon, hydrogen, nitrogen, oxygen, and sulfur. Proximate analysis methods use furnace equipment, ovens, and scales, while ultimate analysis uses CHN-2000 analyzers and SC-632 analyzers. Proximate analysis results show that the water content, volatile matter content, and ash content of activated carbon bunches with proximate analysis have decreased from the activation temperature 600^{0}C-700^{0}C, then increases the activation temperature 800^{0}C, whereas carbon bound has increased from the sample activation temperature 600^{0}C-700^{0}C then decreases in temperature 800^{0}C while the results of the ultimate analysis show that all samples have variable elemental content, the element carbon increases with increasing temperature of activation while the elemental content of hydrogen, oxygen, nitrogen, and sulfur decreases with increasing temperature of activation. So, for all conditions of the activation temperature, at a temperature of 700 ° C has the optimum value with the highest carbon content and meets the Indonesian National Standard (SNI) quality of activated carbon.

***Keywords* : Activated carbon, Palm bunches, Proximate analysis, Ultimate analysis, Nano Carbon**

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I. INTRODUCTION

Palm bunches is one part of the palm tree that consists of many stems that are about two feet long, filled with green fruit when young and brass yellowish brown when ripe. In one palm tree, there are 4 to 5 bunches. Palm bunches have two types of bunches, namely male bunches, which commonly used for tapping palm juice and female bunches, which usually used for processed foods. Palm bunches have high lignin and cellulose content that is equal to 33.79% cellulose content and lignin content of 27.74% [1][2].

The use of palm bunches produced by the palm kernel industry and ex-tapping palm sugar sap until now only used as firewood, [1][3] report, the use of palm bunches can be utilized in the pharmaceutical field, namely the manufacture of tablets in direct print. The utilization of palm bunches can also be processed into charcoal and activated carbon, which has a high economic and economic value that can be useful in people's needs such as drinking water filtration, air purification, waste filtering, fertilizer processing, and many other benefits. In the manufacture of activated carbon, there are organic materials containing lignin and cellulose, which can be used as raw materials for making activated carbon and other organic compounds whose components consist of bonded carbon, ash, water, hydrogen, nitrogen, and sulfur [4][5][6]. [7] state that the method used to determine the presence of certain elements in an active carbon material is the method of proximate analysis and ultimate analysis. Proximate analysis to determine water content, ash content, volatile substances and carbon bound to activated carbon while ultimate analysis to determine the content of carbon, oxygen, hydrogen, nitrogen, and sulfur in activated carbon[8][9].

High and low levels of water, ash content, levels of volatile substances, and bound carbon significantly affect the quality and quality of activated charcoal bunches, which are determined using proximate analysis. [10][11] concluded that the increase in the amount of carbon bound to activated carbon is higher along with the increase in the activation temperature while the increase in water content, ash, and volatile substances decreases with increasing activation temperature in activated carbon. The high amount of bound carbon and the low amount of water content, ash,

Volatile substances can increase the ability of activated carbon as an adsorbent (absorption) to improve the quality and quality of activated carbon.
[12]

state that the increase and decrease in the amount of bound carbon produced by activated carbon are in addition to being influenced by the high and low levels of water, ash, and flying substances also influenced by the content of cellulose and lignin, which can be converted to carbon atoms.

An ingredient to become activated carbon must meet several standard elements contained in activated carbon, such as the content of elements carbon, hydrogen, oxygen, nitrogen, and sulfur. To find out which palm sugar bunches are suitable to be activated carbon, an analysis is used to determine the presence of these elements. [13] concluded in temperature activation of coconut shell activated carbon led to an increase in the content of the elements carbon (C), the elements hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S) have decreased with increasing activation temperatures. Likewise, with [14] inactivated carbon nyamplung seed shell. From the explanation that has been described, the researchers are interested in assessing the analysis of the quality of activated carbon from palm bunches using proximate and ultimate characterization. The purpose of this study is to identify the effect of variations in the activation temperature on the quality of activated carbon from palm bunches using proximate and ultimate analysis.

A. Problem of Study

- How does the effect of variations in the activation temperature on the quality of activated carbon from palm bunches using proximate analysis?
- How does the effect of variations in the activation temperature on the quality of activated carbon from palm bunches using ultimate analysis?

II. METHOD

A. Types of Research

This research included in the type of experimental laboratory research. In this study, an analysis of the effect of the activation temperature on the quality of activated carbon from palm bunches uses proximate and ultimate analysis. The independent variable (X) is the activation temperature, and the dependent variable (Y) is the quality of activated carbon palm bunches with proximate analysis including (water content, vapor, ash, and carbon bound) And ultimate analysis includes (the content of carbon, hydrogen, oxygen, nitrogen, and sulfur). The research sample was analyzed :

- Laboratory of Development of the Department of Chemistry Education FKIP Halu Oleo University for the carbon activation process using a kiln
- Forensic and Bimolecular Laboratory of F-MIPA University of Halu Oleo for proximate analysis of activated carbon palm bunches in powder-shaped samples
- Bandung Mineral and Coal Technology Laboratory (TEKMIRA) for the process of analyzing ultimate carbon activated palm sugar bunches in powder-shaped samples

B. Materials

The research material consisted of palm bunches (Arenga Pinnata (Wurmb). Merr), pyrolysis reactor, mortar, digital balance, sieve (mesh), distilled water, alcohol, LECO CHN 2000 and LECO SC 632, porcelain cup, infrared thermometer.

C. Research Stages

The stages of the research are described in Fig. 1 :

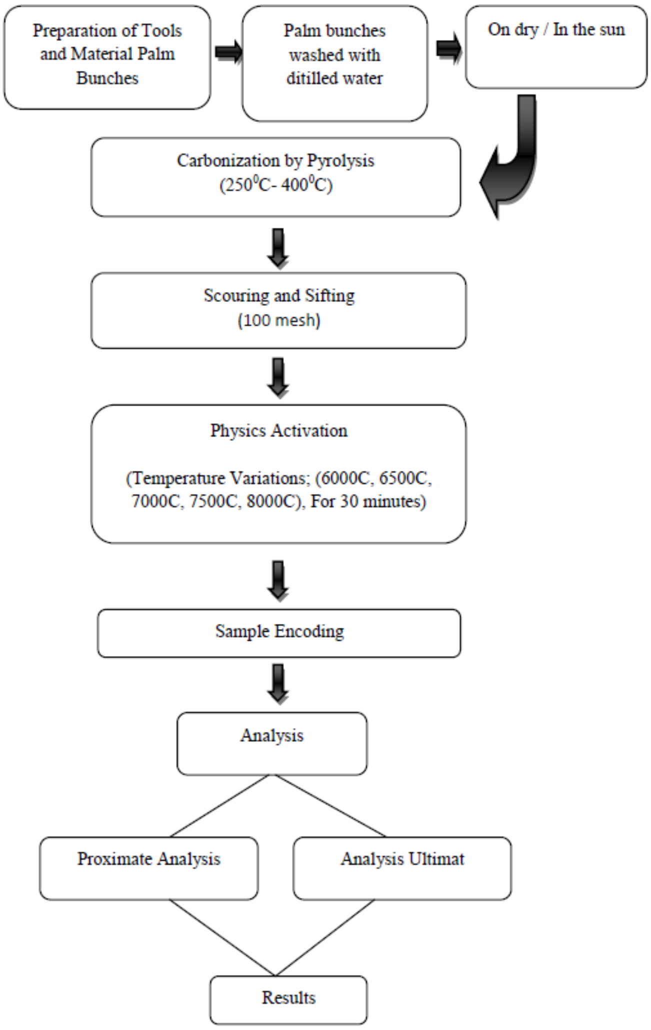

Fig. 1. Research stages

D. Data Analysis Technique

Data analysis techniques used in this study are as follows.

- Determining water content, vapor content, ash content and calculating bound carbon can be done using equation (1):

$$\text{Content (\%)} = \frac{m_3 - m_1}{m_2 - m_1} x\ 100\,\% \qquad (1)$$

Where,

m_1 = Cup massa (gram)

m_2 = Cup massa + massa carbon sample (gram) / before

m_3 =Cup massa + massa carbon sample (gram)/ after

- Calculate proximate analysis

Iskandar [13] reported that the results obtained from the ultimate analysis method in the form of a percentage of elements on an ADB basis (%) were not yet of real value. To get the real value must be converted ADB (%), it becomes dB (%) where ADB (air-dried basis) as wet weight while dB (dried base) as dry weight. The formula used to calculate the conversion of ADB (%) to DB (%), as presented in equation (2).

$$DB(\%) = ADB(\%)\left(\frac{100 - IM}{100}\right) \qquad (2)$$

Where,
DB = *dried basis* (%)
ADB = *air-dried basis* (%)
IM = *Inherent Moisture*

- Make a diagram of the variation of the activation temperature on the content of the content in activated carbon palm bunches using proximate analysis
- Make a diagram of variations in the activation temperature of the activated carbon element content of the palm bunches using ultimate analysis

III. RESULTS AND DISCUSSION

A. Proximate Analysis

The results obtained from the effects of proximate analysis are the content of water content, ash content, levels of evaporating substances, and carbon bound in the activated carbon of palm sugar bunches that can be seen in Fig. 2 dan Fig. 3.

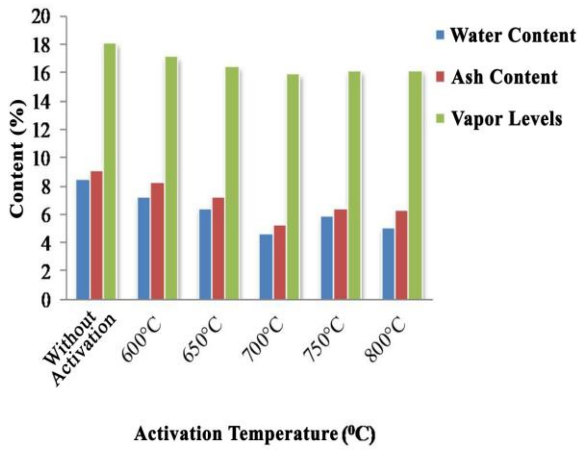

Fig. 2. Variation of activated carbon activation temperature to content levels in palm bunches activated carbon using proximate analysis

Based on Fig. 2 in the test of water content shows the content of water content in activated carbon palm bunches has decreased from the sample without activation to temperature 700°C. Based on Fig. 2 in testing the moisture content shows 750°C and 800°C. More detailed analysis results are shown in Table-I.

Table-I. Proximate analysis results of activated carbon bunch of palm sugar

Temperature Activation (^{0}C)	Content of Activated Carbon			
	Water Levels	*Ash Levels*	*Levels of Evaporated Substances*	*Carbon Bound*
Without activation	8,46	9,01	18,09	64,43
600°C	7,23	8,18	17,10	67,49
650°C	6,41	7,24	16,43	69,92
700°C	4,56	5,21	15,90	74,32
750°C	5,87	6,35	16,11	71,66
800°C	5,03	6,22	16,16	72,59

From the results of this study (Table-I) at a temperature of 700°C has low water content. So overall, all samples of the test results of the water content of activated carbon bunches of palm sugar meet the Indonesian national standard (SNI) a maximum of 15%. Next, test the ash content in Fig. 2 shows the ash content has decreased from temperature without activation to 700°C and then has increased at temperatures of 750°C and 800°C. Overall, all samples from the test results of activated carbon ash content of bunches meet the Indonesian national standard (SNI), which is a maximum of 10%. As for the carbon composition at each activation, the temperature is presented in Fig. 3

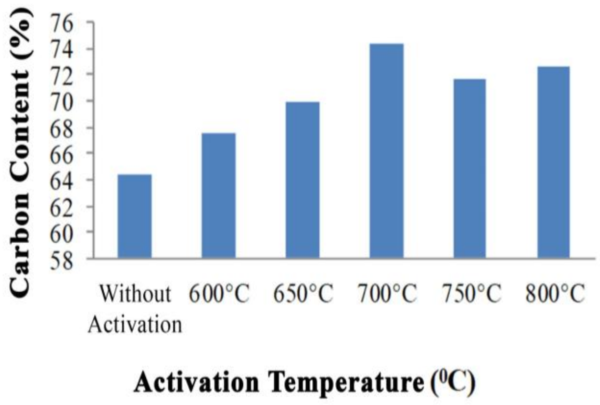

Fig. 3. The variation of the activation temperature on the carbon content is bound to the activated carbon of the palm bunches

After that, testing for volatile substances seen in Fig. 3. shows that levels of volatile substances decrease from activation temperature to 700°C and then increase at temperatures of 750°C and 800°C. The results of this study at a temperature of 700°C has low levels of volatile substances. As a whole, all samples from the test results of the volatile activated carbon content of palm bunches meet the Indonesian national standard (SNI), which is a maximum of 25%.

In a proximate analysis, there are four parameters tested, namely water content, volatile matter content, ash content, and bound carbon. Water content is a parameter that significantly affects the quality and quality of activated carbon produced. High and low water content is closely related to temperature because the higher the temperature, the less water content contained in activated carbon so that it can produce a more significant pore. The bigger the pores, the wider the surface area of activated carbon. Resulting in increased adsorption capacity of activated carbon [15][16]. Fig. 2. shows the sample without activation until the temperature of 700°C the water content decreases with increasing temperature of activation, although at temperatures of 750°C and 800°C the water content has increased again. This increase in water content is not only due to a rise in the hygroscopic nature of activated carbon against water vapor, it also caused by the binding of water molecules by 6 activated carbon atoms while the low water content contained in activated carbon indicates that the free water content and bound water provided in carbon actives have evaporated during the carbonization process [17].

Also, [18][8] reported that the size of coal also influences the low water content of activated carbon because the smaller the size of activated carbon, the water content decreases. It is since during drying after neutralization, small-sized activated carbon experiences maximum drying because the particles have small pores. Based on these results, it shows that the quality of activated carbon palm bunches produced in this study is quite good because all the water content contained inactivated palm bunches activated carbon meets the requirements of the Indonesian activated carbon quality standard (SNI 06-3730-1995) which is a maximum of 15%.

Testing the levels of volatile substances will affect the quality and quality of activated carbon produced. The lower the level of evaporating materials, the better the quality of activated carbon because unstable high concentrations will cause more smoke [19]. The levels of volatile substances that are produced by activated palm bunches of carbon are in the range of 15,90 % – 18,09 %. Fig. 2. shows that in samples without activation until the temperature of 700°C, the level of the vaporizer decreases with increasing activation temperature, although at temperatures of 750°C and 800°C the water content has increased again. The lowest levels of volatile substances are in the sample temperature of 700°C and the highest standards of volatile elements in the sample without activation. From these results, it can be seen that the higher the activation temperature, the lower the volatile substances, the results are by [17] explaining that the increase in the activation temperature tends to decrease the levels of volatile substances.

It happens because, at high temperatures, the release of compounds absorbed on the surface pores of activated carbon such as CO_2, CO, CH4, and H_2 can take place correctly. Then strengthened again by [20][21], this volatile matter can be reduced if it goes through a heating process because the unstable thing will evaporate. The higher the temperature given, the less volatile matter content will be (slightly). Low levels of volatile substances and high carbon content indicate that activated carbon produced is more positively charged with alkaline nature [22]. Based on these results it shows that the quality of activated carbon palm bunches produced in this study is quite good because all levels of volatile substances contained in palm bunches enabled carbon to meet the requirements of the Indonesian activated carbon quality standard (SNI 06-3730-1995) which is a maximum of 25%.

Ash content testing aims to determine the metal oxide content in activated carbon. Fig. 2. showed that in samples without activation until the temperature of 700°C, the ash content decreased with increasing activation temperature, and at temperatures of 750°C and 800°C, the ash content increased. The ash content obtained in activated carbon bunches is not stable due to the oxidation of activated carbon, especially at high temperatures. The lowest ash content was produced at 700°C and the highest ash content in the sample without activation. The results of this study should indicate a tendency for higher activation temperatures to increase ash content rather than a decrease [23] concluded that the decrease in ash content along with the increase in the activation temperature due to devolatilization at the time of activation causes the formation of charcoal containing a little ash content, so the higher the activation temperature will reduce the ash content of charcoal formed from the carbon. [24] reported that the increase in the ash content again at high temperatures in activated carbon because it still has the remains of organic material that has not had time to evaporate, which is more than the ash content.

The high ash content produced can reduce the adsorption power of activated carbon, because of the pores of activated carbon filled with metal minerals such as K, Na, Ca and Mg. [7]concluded that carbon bound in activated carbon influenced by water content, ash content, and volatile matter content, where the more significant the water content, ash, and volatile substances will reduce the quality of activated carbon and vice versa. In this study, the best-fixed carbon content produced by a temperature of 700°C, which is 74.32% because, at this temperature, it provides water content and low ash content and small volatile substances to produce high fixed carbon. The carbon content bound to activated carbon bunches of palm sugar without activation results in the carbon content of 64.43%, this value does not meet the requirements as a quality standard for Indonesian activated charcoal (SNI 06-3730-1995) which is a maximum of 65% and regularly rises to reach 74.32% at an activation temperature of 700^0C while at a temperature of 750^0C a decrease in carbon content is 71.66% and then an increase is not too significant at a temperature of 800^0C which is 72,59%.

High and low levels of bound carbon produced are not only influenced by high levels of ash and flying matter but also influenced by the content of cellulose and lignin, which can be converted to carbon atoms [25]. Bound carbon of activated carbon strongly influenced by raw materials (charcoal), if the charcoal contains high bound carbon, then naturally the pure activated carbon content in activated carbon is high and vice versa, but several other factors influence the pure activated carbon, including the way of activation, activation temperature, cellulose and lignin content in the activated carbon raw material.

Based on the test results of water content, ash content, and the level of evaporating substances in the activated carbon of the palm bunches. Overall that the temperature sample without activation does not meet the requirements of activated carbon Indonesian National Standards, while the temperature of 600°C-800°C meets the Indonesian national activated carbon standard of minimum 65%.

B. Ultimate Analysis

The results of the analysis obtained by the ultimate report in the form of the elements of carbon, hydrogen, oxygen, nitrogen, and sulfur in activated carbon palm bunches. The relationship of activated carbon bunches of palm with activation temperatures using ultimate analysis can be seen in Fig. 4 and Fig. 5

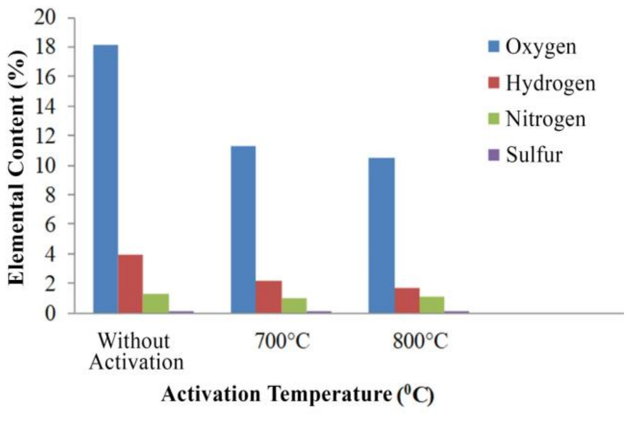

Fig. 4. Variation of activation temperature to the content of activated carbon bunches of palm sugar using ultimate analysis

Based on the test results of the content of activated carbon elements of sugar palm bunches from temperature samples without activation, 700^{0}C, and 800^{0}C. For more details about the ultimate content of activated carbon palm bunches is presented in Table-II.

Table-II. Results of ultimat analysis on activated carbon of palm bunches

Temperature Activation (^{0}C)	Percentage of Elemental Content (%)				
	Carbon (C)	*Hydrogen* (H)	*Oxygen* (O)	*Nitrogen* (N)	*Sulfur* (S)
Without activation	65.26	3.89	18.18	1.25	0.11
700°C	69.72	2.15	11.29	0.99	0.09
800°C	65.58	1.69	10.47	1.13	0.10

in Table-II shows that the percentage of hydrogen and oxygen content decreases as the activation temperature increases. While the percentage of nitrogen and sulfur content decreased at 700^{0}C and then increased again at 800^{0}C although the increase was not much while the highest carbon content was at 700^{0}C, Thus a decrease in the content of the elements hydrogen, nitrogen, oxygen, and sulfur as the activation temperature increases, this is consistent with the theory that the element content is in the form of gas so that it quickly released in high temperatures. As for the carbon content in the ultimate analysis is presented in Fig. 5.

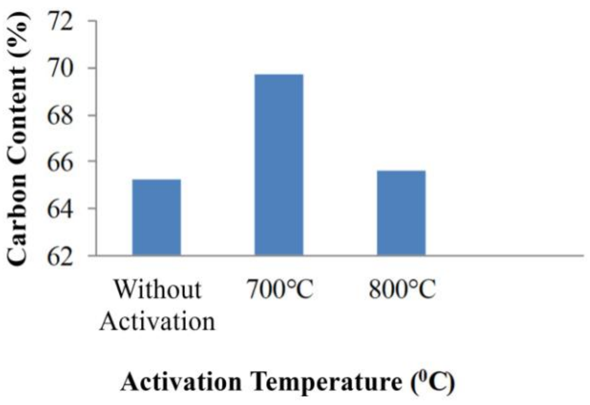

Fig. 5. Variation of the activation temperature of the carbon content in the activated carbon palm bunches

In Fig. 5 shows that the content of the element carbon (C) contained in palm bunches of activated carbon for all samples meets the requirements for the Indonesian activated carbon quality standard (SNI 06-3730-1995), which is a maximum of 65%. It influenced by the raw material for making activated carbon from palm bunches. The content of the carbon element before activation is 65.26% and then rises at 700^{0}C, which is 69,72% and decreases at 800^{0}C to 65,58 %. It shows that the increase in temperature affects the high amount of carbon content in the activated carbon of the palm bunches. [5][26][27] stated that the increase in carbon content in cashew activated carbon is in line with the increase in activation temperature. Furthermore, reinforced by [14] states, with the increase in the activation temperature, the carbon content of the active carbon of nyamplung seeds is high. In this study showed an increase in carbon content before activation and after activation at 700^{0}C and 800^{0}C.

Based on the results of the ultimate analysis of the amount of elemental carbon (C) obtained in the activated carbon palm bunches is lower than the amount of carbon content bound to the results of the proximate analysis. It is known that in proximate analysis the bound carbon is carbon left after volatile substances are released from the combustion process so that the amount of proximate carbon content is high because many of the remaining carbon is different from the content of the ultimate carbon element which is lost with hydrocarbons due to its volatility so that the number of carbon elements is low. The content of the carbon element in the activated carbon bunches is higher than the content of the carbon element in the activated carbon oil palm bunches

The content of hydrogen and oxygen in Fig. 4 shows a decrease with an increasing activation temperature. It shows that the hydrogen and oxygen elements quickly released with increasing activation temperatures in heating the formation of hydrocarbon compounds. [13]states that the high temperature of carbonation and activation causes the content of hydrogen and oxygen to decrease due to the volatile nature of high heating. High activation temperatures indicate that more non-carbon elements (leading hydrogen) are oxidized because the heat stabilization for carbon is more elevated than hydrogen and other items in the charcoal

The content of nitrogen (N), in this analysis, does not lead to a clear cycle in which the sample without activation of the nitrogen element 1.25%, at a temperature of 700^{0}C, decreased by 0.99% and at a temperature of 800^{0}C experienced an increase of 1.13%. The result of the content of nitrogen (N) is not by the theory should be with the increase in the activation temperature, the higher nitrogen content [28]. Furthermore, the elemental content of sulfur (S), based on the results of the analysis of activated carbon bunches of palm sugar, that with the increase in the activation temperature, the content of the element sulfur is lower. It is because, in the process of sample activation, all sulfur content decreases due to high-temperature heating [13]. In this known that this research shows that activated carbon from palm bunches has better quality than activated carbon with other ingredients.

IV. CONCLUSION

Based on the description that has been described, it can be concluded that:

- Moisture content, ash content, and levels of activated carbon vapor active palm bunches with proximate analysis decreased from samples without activation until the activation temperature of 700°C then increased at an activation temperature of 750°C-800°C, whereas carbon bound increases from the sample without activation to a temperature of 700 °C and then decreases at a temperature of 750°C-800°C. All parameters examined using proximate analysis (water content, ash content, volatile matter content, and bound carbon) meet the requirements of activated carbon of the Indonesian National Standard (SNI) and have an optimum value at a temperature of 700°C.
- The content of the active carbon palm fruit bunch using ultimate analysis for the carbon (C) element increases with the temperature of the activation period while the hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S) elements decrease with an increased activation temperature

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