Pyrolisis of Kapok (*Ceiba pentandra*) Pods Wastes as Sources of Potassium Oxide (K_2O)

Lilis Sukeksi[1,2], Chandra Sitorus[1] and Andy Junianto Sidabutar[1]

[1]*Department of Chemical Engineering, Faculty of Engineering, Universitas Sumatera Utara, Jl. Almamater Kampus USU, Medan 20155, Indonesia*

[2]*Natural Produk Base of Technology, Centre of Excellent, Universitas Sumatera Utara, Jl. Dr. T. Mansur No. 9 Kampus USU, Medan 20155, Indonesia*

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Abstract: Nowadays, various combinations of agricultural waste and others material have been successfully made into commercial products. Kapok pods can be processed into a source of potassium oxide which may have an impact on the reduction of environment pollution caused by industrial kapok. The purposes of this works were to determine the best of combustion time and temperature to produced potassium oxide from ash that made from kapok pods. The kapok pods were dried at 110˚C for 24 hours to obtain the dry of kapok pods. Those kapok pods were burned at 500˚C, 550˚C, 600˚C, and 650˚C by muffle furnace, with a burning time of 3, 4, 5, and 6 hours. The potassium that contained in ash had been extracted by distilled water for 24 hours. The highest content of Potassium Oxide (K_2O) resulting from the 3 hours of combustion at 500˚C was 35.91%. Atomic Absorption Spectroscopy (AAS) was used to analyse the Potassium Oxide (K2O).

1 INTRODUCTION

Kapok tree (*Ceiba pentandra*) is a tropical tree comes from South America and has spread to the rain forests of West Africa and Southeast Asia from the Malay Peninsula to the Indonesian archipelago (Mojica, 2002), (Chaiarrekij, 2011).

Kapok tree has many uses for humans, for example wood is light and porous, so good for carving, casket and canoeing. Delicate fibers can be used as mattresses and pillows, and the seeds can be used as bio diesel (Putri, 2012) (Bates, 2004), (Orwa, 2009). Other parts of the tree can also be used as a drug for example by drinking a decoction of cured skin can be useful as a diuretic, aphrodisiac, and to treat headaches, as well as type II diabetes (rainforest-alliance.org, 2018), (Wikipedia, Ceiba Pentandra, 2017).

Kapok plantations are common in Indonesia, spreading from the region Lebak Wangi, Bandung, Pati, Kudus, Jepara, in west and center of Java. Meanwhile in East of Java are Tulung Agung, Blitar, Pasuruan, and Banyuwangi area. According to the estate agency, Pati is the most spacious area of kapok, ranges about 15,020 hectares, meanwhile Kudus reach about 4,000 hectares. Total area for the territory development of Kapok in region Centre of Java covering area of 95,107.17 hectares. This area can produce kapok fiber 340 kg, seed 220 kg, pods or shell 540 kg (Wibowo, 2012). Research conducted by Anigo and others also says that the content of the kapok pods is 57.87% of the total weight of the fruit of the kapok. Obviously, it can be concluded that industry generates waste kapok pods in bulk that can pollute the environment. Therefore, it is necessary to explore the potential of waste kapok pods can be different types of products that have economic value. In addition to economic value, the kapok tree can also be used as a buffer against erosion, flood control, as well as green plants that can also be used to conserve natural resources. Indonesia is the largest producer of kapok before World War I in the world, where the biggest kapok production is from the island of Java. Kapok plantations in Indonesia are owned by, private and government plantation estates.

Agricultural waste is the result of agricultural activities, may be in the form of chaff, straw, cob or fiber (Abba, 2013). In recent time, industry must move towards a green industry and sustainable development, global warming and the depletion of natural resources has occurred and will continue. Kapok pods is kapok industrial waste that still

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containing potassium 20% -25% (Purbasari, 2008). The potassium compounds contained in the kapok pods, can be manufactured into useful products, such as raw materials for the manufacture of soap and shampoo (Chekuboyina, 2012).

Pyrolysis is a process of thermo chemical that can be done on the conversion of biomass which has a low density or organic materials into the biomass has a high energy. Pyrolysis involves the heating of organic material to temperatures over 400 ° C in the absence of oxygen. At this temperature, organic material normally decompose generating steam phase and phase residual solid (bio char). On cooling the steam pyrolysis, polar compounds with high molecular weight condensed as a liquid (bio-oil) while the molecular weight volatile compounds remains low in the gas phase (Laird D. A., 2009).

The consider factors in conducting pyrolysis:

a. Temperature pyrolysis, which affect the resulting product, it is caused the increase of the temperature then the process will be more perfect.
b. Time of pyrolysis, the longer the pyrolysis time will improve the results of liquid and gas, whereas the solid of results generated will decrease.
c. Moisture content of materials, if the moisture content higher cause the time used will be longer so that more energy is needed.
d. The size of the material, when the bigger size of material, the equipment used is greater.

The steps that must be done to get the minerals that formed in the ash during combustion is still unclear, but for obvious reasons it is assumed that the conversion of mineral changed based on the temperature of combustion. Carbonate is formed at low temperatures while the ashes will be formed at high temperatures in an atmosphere containing oxygen, which is the main form of metal oxides. At high temperatures, potassium oxides formed will react with other elements to form chemical bonds, in the same situation would occur dissociation of sodium and potassium oxide compounds and will undergo rapid vaporization. While at low temperatures, the heat will move to the surface of KOH, will then form K2CO3.

Soda Q is extracts combustion results from the Kapok pods. There are several stages of process to manufacture Soda Q maximum. The stages are extraction, evaporation, and crystallization. Soda Q generally contains 50.78% K_2CO_3, 26.27% Na_2CO_3, and 4.37% NaOH (Wibowo, 2012).

This study will evaluate the effect of temperature and time pirolis on the quality and amount of K_2O produced. Temperatures used in the pyrolysis process are 500, 550, 600 and 650 C, while the burning time are 3, 4 and 5 hours.

2 METHODOLOGY

2.1 Raw Materials and Equipment's

The materials used in this research are the skin or pods of the fruit of the kapok (*Ceiba Pentandra*), aquadest, acetic acid (CH_3COOH), and phenolphthalein indicator.

The instrument used was a muffle furnace as burner sample, oven as a drying to calculate the moisture content, porcelain bowls as a sample container while burning, analytical balance to measure the mass of the material, a beaker glass as a container to extract the ashes, a measuring cup to measure the volume of the solution.

2.2 Procedure of Making the Ashes

In the process of making the ashes, first step, the kapok pods was inserted into the oven at a temperature of 110˚C for 24 hours in order to reduce the moisture content. Then the kapok pods was weighed as much as 20 g, and was inserted into the muffle furnace combustion, with temperature and time that have been determined.

2.3 Determination of Normality

To determine the normality of aqueous alkaline extracts by the method of titration of acid base. 1 gr ash dissolved in 30 ml aquadest and soaked for 24 hours, the solution is then filtered using filter paper and the filtrate accommodated in an erlenmeyer flask. Then do a titration using acetic acid (CH_3COOH) 0.1 N by adding phenolphthalein as an indicator. The normality from the extract can be calculated from the total volume of titration.

2.4 Determination of pH

1 gr ash dissolved in 30 ml of aquadest and soaked for 20 minutes, the solution is then filtered using filter paper and the filtrate was accommodated in a beaker glass. Then the pH of each extract was measured using a pH meter.

2.5 Determination of Ash Yield

In the process of making the ashes, kapok pods were inserted into the oven at a temperature of 110˚C over the past 24 hours to reduce the moisture content. Then the kapok pods weighed as much as 20 g, inserted into the muffle furnace with the time and temperature which has been specified. Results of the combustion ash was weighed and ash yield can be calculated by the equation:

Ash Yield = (M2 / M1) × 100 % ………. .(1)

Where:
M1 : weight of the initial sample (g)
M2 : weight of the end sample or ash (g)

Then the ash yield as a sampling was taken as 1 gr and it would be analyzed to determine the levels of K_2O using an Atomic Absorption Spectrophotometer (AAS).

3 RESULT AND DISCUSSIONS

3.1 Moisture Content of Kapok Pods

Utilization of kapok pods as alkaline source can be done in 2 stages, the first step was process reduction moisture content of the kapok pods and the second was process pyrolysis kapok pods using the muffle furnace. On the process of reduction of moisture content, the kapok pods are dried in the oven until the kapok pods become dry and until the fixed weight. Moisture content of the kapok pods down to 90% from the initial weight, with drying time 24 hours in the oven.

Some researcher have examined about the moisture content of kapok pods and they said that moisture content significant influence the nature of biomass that would serve as a source of energy especially its influence the heat generated value. The higher moisture content resulting in the more low value biomass heat. This is due to more heat is needed to remove the water in the biomass to be steam so the remaining energy will be smaller in the fuel (Haygreen and Bowyer 1996). Good biomass for energy is to have a low moisture content, its because at the time of the burning they not a lot of smoke (Hendra dan Wirnani 2003). Putra has reported that kapok pods moisture content at dry air around of 9.54-14.04% (Putra, 2014; Hendra D, 2003; Haygreen, 1996).

3.2 Influence of Combustion Temperature of Dry Kapok Pods to the Normality (N)

The results obtained from the combustion experiments, was extracted using aquadest as a solvent, and soaking for 24 hours, then filtered with filter paper and the filtrate was analyzed using titration method by acid to determine the concentration of base that conceived from the results of the combustion. The influence of the temperature of combustion versus normality extract from the ashes can be seen in Figure 1.

From Figure 1, it can be seen that at the same of extraction time, increasing the temperature of combustion will increase the normality of extracts from the ash. Similarly, with increasing of extraction time, normality obtained is also increasing. Extract lye from ashes are alkaline hydroxide, this can be explained as K_2O or Na_2O is formed on the burning of material a plant and dissolves in the water during extraction, become a hydroxide. It can be said that the order of K_2O or Na_2O formed by the combustion of pure metals (K or Na) in the air, where K or Na in plant material bound in his organic matrix (Babayemi J. O., 2010).

In addition, the ability of ash to dissolves is a function amount of alkali metal compounds and others salts can dissolve more (such as chloride and sulphate of K and Na) that contained in the ashes, its depend on the type of plants that burned. The components that are not soluble in the ash contain silicates and other metals are insoluble in water. When the ash dissolved in water, only the carbonate and sulfate and chloride may be of

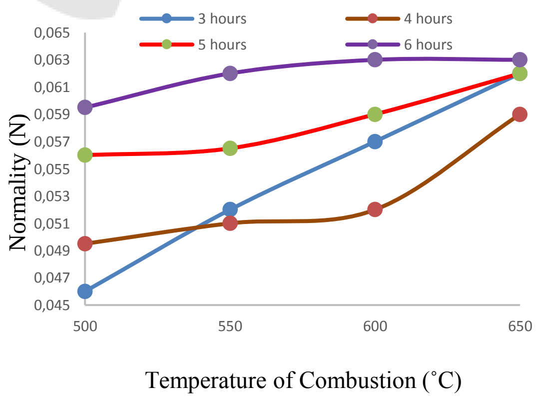

Figure 1: Influence of Time and Temperature of Combustion (˚C) versus Normality (N).

In addition, the ability of ash to dissolves is a function amount of alkali metal compounds and others salts can dissolve more (such as chloride and sulphate of K and Na) that contained in the ashes, its depend on the type of plants that burned. The components that are not soluble in the ash contain silicates and other metals are insoluble in water. When the ash dissolved in water, only the carbonate and sulfate and chloride may be of alkali metals in solution, includes a small portion of other metals that insoluble or a little soluble (Babayemi J. O., 2010).

3.3 Influence of Time and Temperature of Combustion to the pH of Ash

The results obtained from the pyrolysis experiment were extracted using aquadest as a solvent, and then the filtrate was filtered and analyzed to measure the pH of ash.The influence of burning temperature versus the pH of ash can be seen in Figure 2.

From the Figure 2 it can be seen that the increase combustion temperature generate an increasing of pH. Carbonate formed at low temperatures, while ash formed at high temperature in the state of atmospheric oxygen which is the main form of metal oxides. With the formation of alkaline carbonate compound as well as alkali oxides in ash water added, the mixture will become the alkaline solution (Misra, 1993).

Similarly, by increasing the burning time will also increase the pH of the resulting solution. This is due to the longer burning time, will increase the amount of alkali is formed, thereby increasing the pH of the solution.

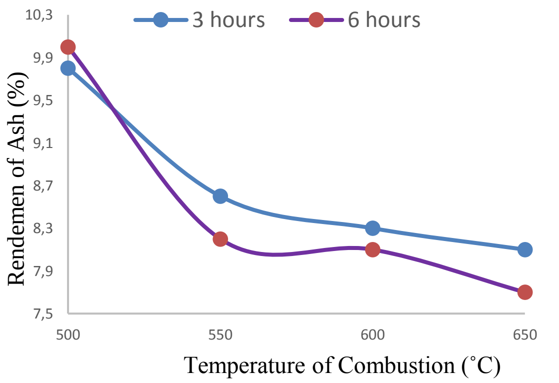

Figure 2: Influence of Time and Temperature Combustion versus the pH of ash.

3.4 Influence of Extraction Time and Temperature Combustion to the Ash Yield

The influence of extraction time and temperature combustion can be seen in Figure 3 below. Ash combustion results were weighted, to calculate the yield or rendemen of ash by using the Formula 1

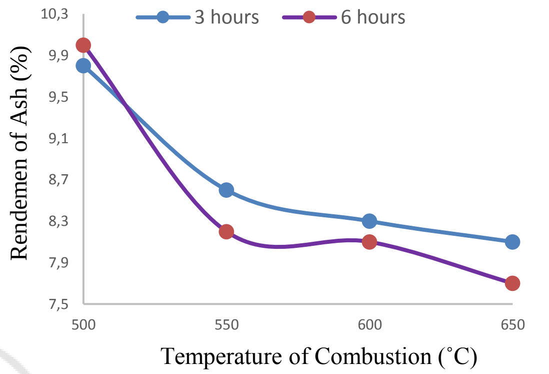

Figure 3: Influence of Time and Temperature Combustion Versus the Ash Yield.

From Figure 3 it can be seen that the addition of the combustion temperature generate reduce yield of ash, so was against the addition of the combustion time generate yield ash decrease. The cause of the low yield in this ash because of the reaction of carbon with water vapor increasing with increasing temperature and the length time of the combustion, so the carbon reacts to become CO_2 and H_2 be a lot, otherwise will produced the less amount of ash (Siahaan, 2013). The results of this study in accordance with previous research that has done on burning coconut shell, in which increasing temperature and combustion time, the results yield burning decrease (Tirono, 2011).

3.5 Influence of Extraction Time and Temperature of Combustion to the Concentration of K_2O

The resulting level of K2O from the ashes was analyzed using Atomic Absorption Spectrophotometer (AAS) can be seen in Figure 4.

Figure 4 shows the graph that the increase of temperature of combustion significant influence to the yield of K_2O on the ash. Increase temperature will decrease the yield of K_2O, but the time of combustion are not significant different such as at low temperature or higher temperature. The higher the time used at low temperature 500°C the rendemen of

K_2O was lower. But at temperature combustion at 650° the rendemen both of sample for 3 hours and 6 hours time of combustion are same at 15.7% of rendemen. It is caused not due to potassium is lost or evaporates, however, the decrease in K_2O levels may occur with increase temperature, because the amount other alkaline components increases with increasing temperature at the longer time (Perry, 1999).

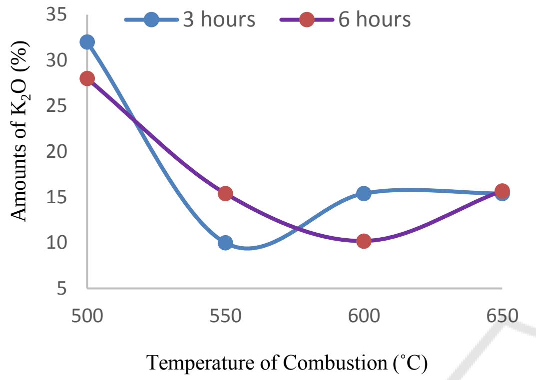

Figure 4: Influence of Time and Temperature Combustion versus levels of K2O.

4 CONCLUSIONS

The conclusions from this research are the highest yield of K_2O from kapok pods on the pyrolysis combustion for 3 hours at 500˚C with levels of K_2O of 35.91%. Pyrolysis process time 6 hours is better, because the ash was obtained in the form of oxide. While the process time is 3 hours the resulting ash still contain abundance elements of carbonate. Increase the temperature of pyrolysis will also improve the normality and pH, as well as increasing the time of pyrolisis also will raise the pH and normality. Potassium content in ash kapok pods can be used as a source of alkaline solution.

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