

*Preparation and Characterization of Activated Carbon from Banana Peels (*Musa Acuminata* L.)*

Ahsanul Husna, Ananda Putra

Universitas Negeri Padang



Abstract - The purposes of this experiment were to prepare and characterize activated carbon from the peels of Banana “pisang kepok” (*musa acuminata* L). Carbon from the peels of Banana “pisang kepok” was prepared by pyrolysis at 300⁰C for 1 hour. This carbon was activated using chemical activation process with various activating reagent and concentration. The activated carbon was characterized using Indonesian National Standard, SNI 06-3730-1995, that is maximum water content of 15%, maximum vapor content of 25%, maximum ash content of 10% and bounded carbon content at least 65%. The results showed that the highest bounded carbon content obtained from pyrolysis was 73.2%. The best activating reagent was H₂SO₄ with concentration of 4N that improved the bounded carbon to 89.8%. The water content, ash content, and vapor content of activated carbon was obtained as follows, 0.6%, 2.2%, and 8%. Based on these results, activated carbon of banana peel conformed the SNI 06-3730-1995 values and will be applied as a thermoelectric material.

Keywords - Activated Carbon, Pyrolysis, Banana Peel, H₂SO₄, SNI 06-3730-1995.

I. INTRODUCTION

Organic waste has a problem for society and government; this is due to the environmental pollution. Organic waste can be divided into two types, first it is easily to decompose organic waste (garbage) because it has relatively short chemical chains and the second that does not easily rot (Rubbish) because it has relatively long chemical chains. One way that may be the best solution for processing of this waste by utilizing into activated carbon. Activated carbon is a porous solid containing 85 - 95% carbon; carbon-containing materials can produce activated carbon by pyrolysis. Carbon-containing materials come from plants, animals and minerals[1], it was affective become activated carbon such as banana peel [2], apple peel [3], date palm seeds [4], potato peel [5], cacao shell [6], cassava peel [7], durian peel [8], jackfruit peel [9], watermelon skin [10], melon peel [11], avocado peel [12], bamboo, palm fiber, coconut shell, coconut fiber, sunflower, algae sea, rice husk and plastic waste [13]. The function of activated carbon is color

removal, deodorizing, purifying agents in the food industry [14].

Kepok banana peel is untapped organic waste. Therefore, kepok banana peel can be processed into activated carbon. Activated carbon can applied as a thermoelectric material [15] and is relatively cheap and easily obtained. The first stage of making activated carbon is carbonization, which is an imperfect combustion process. Generally the carbonization process occurs at temperature 300⁰C, but this situation also depends on the raw material and how it is processed. The next stage is the process of making carbon by activation, there are two activation methods, namely chemical and physical activation. Chemical activation use several activating reagents such as NaOH, KOH, H₃PO₄, H₂SO₄, HCl, HNO₃, ZnCl₂, NaCl, Na₂CO₃, and K₂CO₃[1]. The function of the activating reagent is to be able to expand the pores on the carbon surface [16]. Physical activation using a weak oxidizing agent, such as CO₂ gas, water vapor,

nitrogen, and others [1]. The advantages of chemical activation are time needed for activation is relatively short, low temperature from 300-700 °C, more activated carbon is produced, the adsorption capacity of an adsorbate will be better, good development of the pore structure, and changes in surface functional groups [4].

The optimized activated carbon reagent was obtained by applying Indonesian National Standard measurement, SNI 06-3730-1995 (maximal water content 15%, maximal ash content 10%, maximal vapor content 25% and minimal bounded carbon 60%) [17].

The purpose of this research was to determine the good pyrolysis temperature, effective activator reagents and concentration of activator substances to make activated carbon that is good, environmentally friendly, fast and economical.

II. RESEACH METHOD

2.1 Preparation Activated Carbon of Banana Peel

Banana peel was obtained from cadger around Universitas Negeri Padang. Banana peel were dried in sunlight to reduce their water content to produce good activated carbon.

2.2 Carbonization and Activation of Banana Peel

The carbonization stage, banana peel was weighed 500 grams, the pyrolysis process was carried out in the furnace at temperatures of 3000C and 350°C for 1 hour. The banana peel of the carbonization stage was smoothed using mortar and pestle, then filtered using a 150 µm sieve.

The Activation was done by soaking 6 grams of carbon of banana peel into 25 mL of different activator reagents (H₂SO₄, KOH and ZnCl₂) with concentration of 4 N for 24 hours. Then these activated carbon were filtered using whatmann filtered paper and washed with aquades until neutral condition obtained, then heated at 110°C for 2 hours. The optimized activated carbon reagent was obtained by applying Indonesian National Standard measurement, SNI 06-3730-1995 (water content, ash content, vapor content and bounded carbon). Then variations in concentration of optimized activated carbon reagent were carried out from 2 N, 4 N, 6 N, 8 N, and 10 N to produce optimized activated carbon.

2.2.1 Characterization of Activated Carbon

The activated carbon obtained is tested with the following parameters:

1) Water Content Analysis

The activated carbon was weighed 1 gram and put into a dried crucible porcelain, then was heated in the oven at 105°C for 1 hour. The activated carbon was then cooled in the desiccator and weighed. Water content can be calculated by the following equation:

$$\text{Water content} = \frac{a-b}{a} \times 100\%$$

Where:

a = the weight of the initial activated carbon (gram)

b = activated carbon weight after drying (gram)

2) Ash Content Analysis

The Activated carbon was weighed 1 gram and put into dried crucible porcelain, Then it was tarnished into furnace and heated slowly until ashes appeared. The flame of furnace was enlarged up to 800°C and kept it at that temperature for 2 hours. When all the carbon has been changed to ashes, cool it in a desiccator and then weighed to obtain permanent weight. Ash content can be calculated by the following equation:

$$\text{Ash content} = \frac{\text{weight ash}}{\text{weight of sample}} \times 100\%$$

3) Vapor Content Analysis

The activated carbon was weighed 1 gram and put into a dried crucible porcelain, then was heated up to 310°C and then turn off the furnace. After the temperature of the furnace reached below 100°C, the activated carbon was removed and then put in to desiccator and cooled. Vapor content can be calculated by the following equation:

$$\text{Vapor content} = \frac{a-b}{b} \times 100\%$$

Where:

a = the weight of the initial activated carbon (gram)

b = activated carbon weight after heated (gram)

4) Bounded Carbon Content Analysis

The bounded carbon content of activated carbon was obtained from the results of the reduction of parts lost on heating 310°C (vapor content) and ash content.

$$\text{Pure activated carbon} = 100\% - (A+B)$$

Where :

A = ash content (%)

B = vapor content (%)

III. RESULTS AND DISCUSSION

3.1 Preparation of Activated Carbon of Banana Peel

The preparation of activated carbon from banana peel was carried out through two stages: carbonization and activation stage. Samples of prepared banana peel were carried out by a washing process which aimed to remove impurities contained in the peel. After washing, the sample was dried under sunlight before taken into pyrolysis process. The aimed of this treatment was to reduce the water content and smoke during the pyrolysis process.

3.2 Carbonization and Activation of Banana Peel

1) Temperature Variation

The carbonization stage was a change in the peel banana into carbon. Banana peel samples were pyrolyzed at temperatures of 3000C (CA) and 3500C (CB) for 1 hour and were tested: water content, ash content, vapor content and bound carbon content. CA was symbolized for banana peel carbon by pyrolysis process at 3000C for 1 hour. And CB was symbolized for banana peel carbon by pyrolysis process at 3500C for 1 hour

2) Water Content Analysis

Water content analysis was carried out to determine the content of water remaining in carbon after going through the carbonization process.

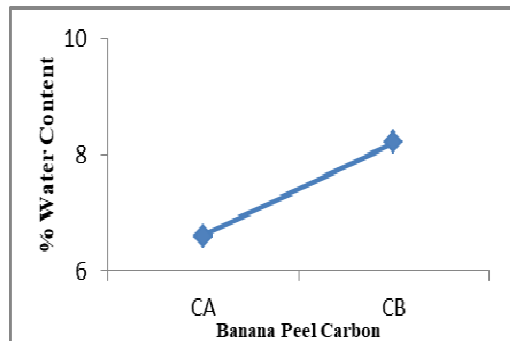


Fig.1 Water content analysis of carbon from pyrolysis process of banana peel for 1 hour.

Fig. 1 showed the water content analysis of carbon from pyrolysis process at two different temperature for 1 hour. Higher the pyrolysis temperature, the greater water content obtained for banana peel carbon. At temperature of 300⁰C the water content was found at 6.6% and at 350⁰C was 8.2%.

a) Ash Content Analysis

The ash content analysis aimed to determine the metal oxide content which was still present in the carbon.

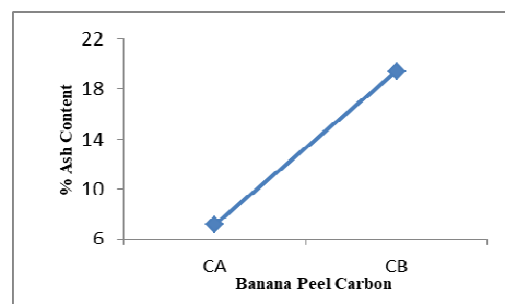


Fig. 2. Ash content analysis of carbon from pyrolysis process of banana peel at 800 C for 2 hours

Fig. 2 showed the ash content analysis of carbon from pyrolysis process at two different temperature for 2 hour. Higher the pyrolysis temperature, the greater ash content obtained for banana peel carbon. At temperature of 300⁰C the ash content was found at 7.2% and at 350⁰C was 19.4%.

b) Vapor Content Analysis

Vapor content analysis aimed to determine the amount of substances or compounds that have not evaporated in the carbonization process.

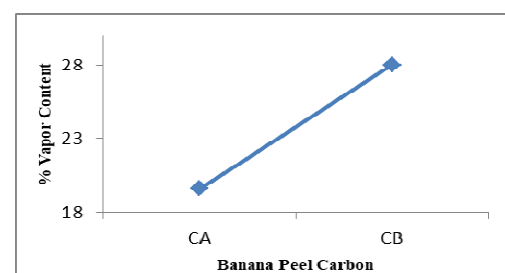


Fig. 3 Vapor content analysis of carbon from pyrolysis process of banana peel

Fig. 3 showed the vapor content analysis of carbon from pyrolysis process at two different temperature. Higher the pyrolysis temperature, the greater vapor content obtained for banana peel carbon. At temperature of 300⁰C the vapor content was found at 19.6% and at 350⁰C was 28%.

c) Bounded Carbon Content Analysis

Bounded carbon content analysis aimed to determine the bounded carbon content after carbonization process.

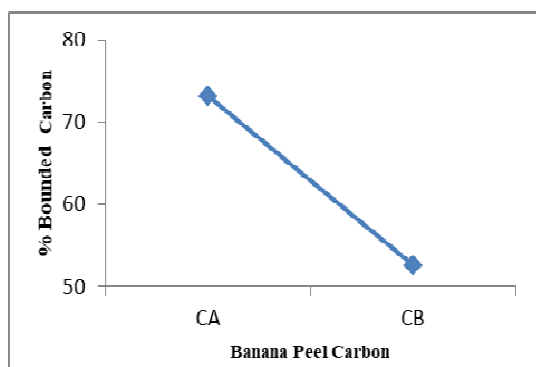


Fig. 4 Bounded carbon content analysis of carbon from pyrolysis process of banana peel

Fig.4 showed the bounded carbon content analysis of carbon from pyrolysis process at two different temperature. Higher the pyrolysis temperature, the lower bounded carbon content obtained for banana peel carbon. At temperature of 350°C the bounded carbon content was found at 52.6% and at 300°C was 73.2 %

3.2.2 Variation of Reagents

From the process pyrolysis, obtained the best carbon from banana peel at 300°C was obtained. After that, carbon from banana peel carbon was activated by various activated reagent.

The activation stage was a change in carbon into activated carbon. Banana peel samples were activated reagent at KOH, ZnCl₂ and H₂SO₄ for 24 hours with 4N concentrations and were tested: water content, ash content, vapor content and bound carbon content.

a) Water Content Analysis

Water content analysis was carried out to determine the content of water remaining in activated carbon after going through the activation process .

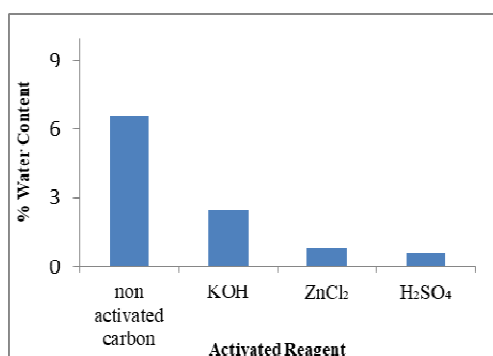


Fig. 5 Water content analysis of banana peel CA at various activated reagent at 4N concentration

Fig 5 showed the water content analysis of activated carbon from various activated reagents at 4N concentration with KOH, ZnCl₂ and H₂SO₄. At activated reagent of H₂SO₄ the water content was found at 0.6% and at non activated carbon was 6.6%. The Water content of activated carbon according to SNI 06-3730-1995 which is lower than 15%.

b) Ash Content Analysis

The ash content analysis aimed to determine the metal oxide content which is still present in the banana peel activated carbon after going through the activation process.

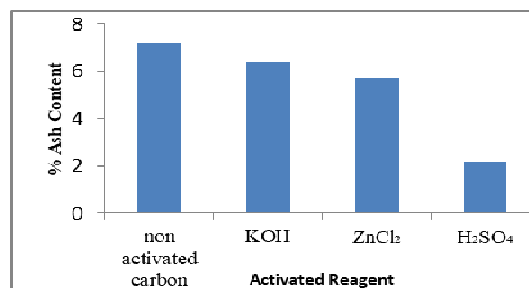


Fig. 6 Ash content analysis reagen of banana peel CA at various activated reagent at 4N concentration

Fig. 6 showed the ash content analysis of activated carbon from various activated reagents at 4N concentration with KOH, ZnCl₂ and H₂SO₄. At activated reagent of H₂SO₄ the ash content was found at 2.2% and at non activated carbon was 7.2%. The ash content of activated carbon according to SNI 06-3730-1995 which is lower than 10%.

c) Vapor Content Analysis

Vapor content analysis aimed to determine the amount of substances or compounds that have not evaporated in the activation process.

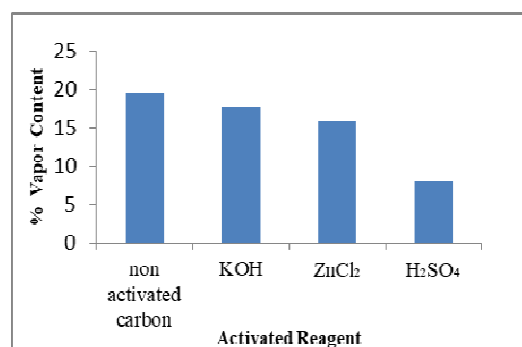


Fig. 7 Vapor content analysis of banana peel CA at various activated reagent at 4N concentration

Fig. 7 showed the vapor content analysis of activated carbon from various activated reagents at 4N concentration

with KOH, ZnCl_2 and H_2SO_4 . At activated reagent of H_2SO_4 the water content was found at 8% and at non activated carbon was 19.6%. Vapor content of activated carbon according to SNI 06-3730-1995 which is lower than 25%.

d) Bounded Carbon Content Analysis

Bounded carbon content analysis aimed to determine the bounded carbon content after activation process.

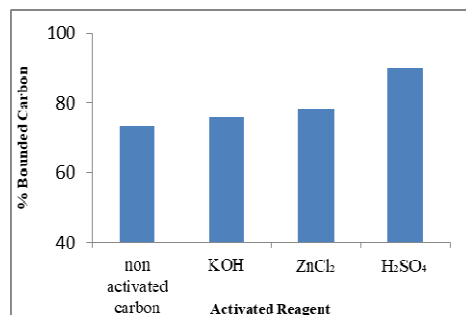


Fig.8 Bound carbon content analysis of banana peel CA at various activated reagent at 4N concentration

Fig. 8 showed the bounded carbon content analysis of activated carbon from various activated reagents at 4N concentration with KOH, ZnCl_2 and H_2SO_4 . At activated reagent of H_2SO_4 the bounded carbon content was found at 89.8% and at non activated carbon was 73.2%. The bounded carbon content of activated carbon according to SNI 06-3730-1995 which is greater than 60%.

3) Variations in Concentration

From the various activated reagent, obtained the best activated reagent from banana peel carbon used H_2SO_4 was obtained. After that, various activated reagent from banana peel was activated by various concentration. H_2SO_4 activating reagents were varied in concentration, which were 2N, 4N, 6N, 8N and 10N.

a) Water Content Analysis

Water content analysis is carried out to determine the content of water remaining in activated carbon after going through the activating process using variations in activator concentration.

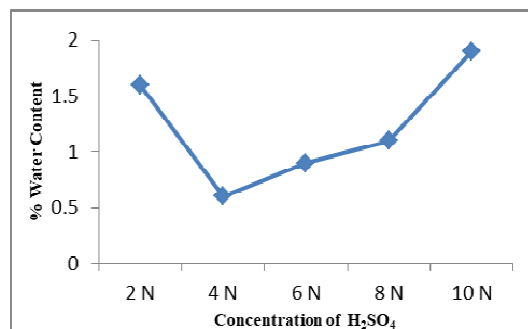


Fig. 9. Water content analysis of activated banana peel CA with H_2SO_4 at various concentration

Fig. 9 showed the water content analysis of the activated carbon from various concentration at activated reagent H_2SO_4 with 2N, 4N, 6N, 8N and 10N. At various concentration activated carbons H_2SO_4 4N the water content was found 0.6% and the activated with H_2SO_4 10 N is at most 1.9%. The greater the concentration of the activated carbon pores will be greater, but the water content value increases with increasing concentration of activator substances, because too many activator substances from chemical compounds will cause clogged pores in activated carbon causing the characteristics of the activated carbon to increase [18].

b) Ash Content Analysis

The ash content analysis aimed to determine the metal oxide content which is still present in the banana peels activated carbon after going through the variations process in activator concentration.

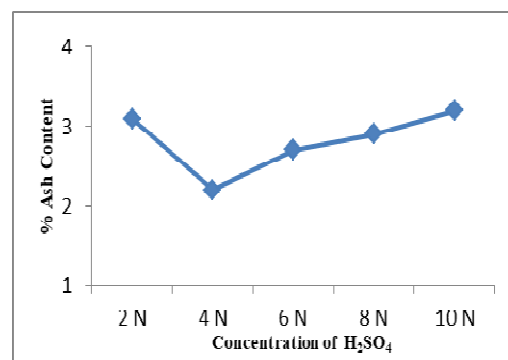


Fig. 10. Ash content analysis of activated banana peel CA with H_2SO_4 at various concentration

Fig. 10 showed the ash content analysis of activated carbon from various concentration at activated reagent H_2SO_4 with 2N, 4N, 6N, 8N and 10N. At various concentration activated carbon H_2SO_4 4N the ash content was found 2.2% and the activated with H_2SO_4 10 N is at

most 1.9%. The greater the concentration of the pores of the activated carbon will be greater, but with increasing concentration of the activator reagent, it can cause clogging of the pores on the carbon and damage.

c) Vapor Content Analysis

Vapor content analysis aimed to determine the amount of substances or compounds that have not evaporated in the variations process in activator concentration.

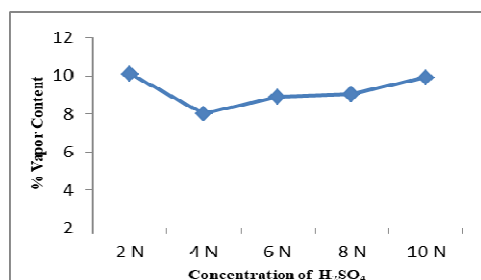


Fig. 11 Vapor content analysis of activated banana peel CA with H₂SO₄ at various concentration

Fig. 11 showed the vapor content analysis of activated carbon from various concentrations at activated reagent H₂SO₄ with 2N, 4N, 6N, 8N and 10N. At various concentration activated carbon H₂SO₄ 4N the vapor content was found 8% and the activated with H₂SO₄ 2N is at most 10.1%. The greater the concentration of the pores of the activated carbon will be greater, but with increasing concentration of the activator reagent, it can cause clogging of the pores on the carbon and damage.

d) Bounded Carbon Content Analysis

Bounded carbon content analysis aimed to determine the bounded carbon content after in the variations process in activator concentration.

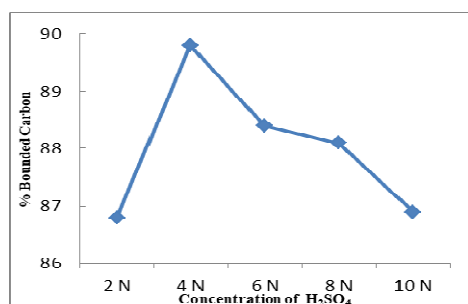


Fig. 12 Bound carbon content analysis of activated banana peel CA with H₂SO₄ at various concentration

Fig. 12 showed the bounded carbon content analysis of activated carbon from various concentrations at activated

reagent H₂SO₄ with 2N, 4N, 6N, 8N and 10N. At various concentration activated carbon H₂SO₄ 4N the bounded carbon content was found 89.8% and the activated with H₂SO₄ 10N is at lowest 86.9%. The greater the concentration of the pores of the activated carbon will be greater, but with increasing concentration of the activator reagent, it can cause clogging of the pores on the carbon and damage.

IV. CONCLUSIONS

Activated carbon made by Kepok banana peel applies SNI 06-3730-1995 quality standards. The optimal temperature for making carbon by pyrolysis process is 300°C for 1 hour. H₂SO₄ 4N is better activated reagent with produces 0.6% water content, 2.2% ash content, 8% vapor content and bounded carbon 89.8%.

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