Preparation and Characterization of Activated Carbon From Mangosteen Peels (*Garcinia Mangostana L*)

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Abstract — The purpose of this experiment was to prepare and characterize activated carbon from Mangosteen peels (*Garcinia mangostan L*). Carbon from Mangosteen peels was prepared by pyrolysis method at 300°C for 1 hour. This carbon was activated by chemical activation process with various activating reagent and concentration. The activated carbon was characterized using Indonesian Industry 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 78,09%. The best activating reagent was HCl with concentration of 4N that improved the bounded carbon to 87,84%. The water content, ash content, and vapor content of activated carbon was obtained as follows, 6,11%, 1,97%,and 10,19%. Based on this results, activated carbon of mangosteen peels conformed the (SNI 06-3730-1995) values and will be applied as a thermoelectric material.

Keywords - Pirolisis, Activated Carbon, HCl, Mangosteen Peels

I. INTRODUCTION

Activated carbon is a porous material consisting of 85-95% carbon. Activated carbon can be obtained in various ways. One of them is through the use of organic waste which is currently a problem for the community and government because it can cause environmental pollution. This pollution continues to increase, along with the growth of large and small industries that make carbon a source of industry or a much needed life necessity.

Active carbon can be used as a fragrance (odor remover), fuel, fine art medium and as a dye as well as thermoelectric material [1]. Active carbon can be produced from wastes such as zalacca shell, kakao shell, durian shell, coconut shells. In this study, active carbon is used from zalacca shell, zalacca shell is a waste that can be converted into active carbon because have high cellulose content [2].

Activated carbon can be produced through a 2-stage process. The first stage is carbonization and the second stage is activation. Carbonization stage is a process of incomplete combustion until carbon is obtained [3]. Meanwhile, the activation stage is the process of removing peripherals and opening carbon pores [4]. The activation stage is divided into two, namely chemical activation and physical activation. Chemical activation is an activation that uses reagent activation [5]. Meanwhile, physical activation is activation using oxidizing reagents such as CO2, gas and water vapor [6].

The advantage of chemical activation is that it takes less time, and uses a temperature of 300-700 ° C [7]. The activators used are HCl, ZnCl2, and KOH whose function of this activation reagent is to expand the pores on the carbon surface. In the process of making this active carbon a few things to keep in mind are can be seen in table.

TABLE 1
ACTIVE CARBON QUALITY REQUIREMENTS INDONESIA
(SNI 06-3730-1995)

Test type	Requirements
Water content	Max 15%
ubtances Evaporates	Max 25%
Ash content	Max 10%
Fid carbon	Min 65%

The purpose of this study was to utilize alternative raw materials, determine the activation temperature, determine the best activator reagent and activator concentration to obtain high quality and environmentally friendly activated carbon.

II. RESEARCH METHOD

A. Preparation of Activated Carbon from Mangosteen peels

Mangosteen peels were obtained from the Padang area. Mangosteen peels was dried to dry in sunlight to reduce their water contentto produce good activated carbon.

B. Carbonization and Activation of Mangosteen peels

The carbonization stage, the salts were weighed 500 grams, the pyrolysis process was performed with furnaces at 300 °C and 350 °C for 1 hour. The carbon from mangosteen peels in this stage of carbonization was filtered using mortar and almonds, then filtered using 150 µm fixation The Activation was done by soaking 6 grams of carbon of mangosteen peels into 25 mL of different activator reagents (HCl, ZnCl2 and KOH) with concentration of 4N 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 2N, 4N, and 6N to produce optimized activated carbon.

C. Characterization Of Activated Carbon

The activated carbon obtained is tested with the following parameters:

a. 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 = initial activated charcoal weight (gram)
b = weight of activated charcoal after drying (gram)

b. 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 550°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:

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

c. 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 = initial activated carbon weight (gram)
b = activated charcoal weight after heating (gram)

d. Bound 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.

Pure activated carbon= 100%- (A+B)

Where:
A = ash content (%)
B = vapour content (%)

III. RESULTS AND DISCUSSION

A. Preparation of Activated Carbon from Mangosteen peels

Sample preparation is the first step to carry out this research. The sample preparation phase begins with the provision of activated carbon from the mangosteen peel in two stages, namely the carbonization stage and the activation stage. The collected mangosteen (garcinia mangostana) shells are cut into cubes and then cleaned of dirt with water. After washing, samples of mangosteen peel are dried in the sun for 1 week before being taken to the pyrolysis process, which aims to reduce the moisture content of the mangosteen peel and reduce smoke during the pyrolysis process. The carbonization process is a process of incomplete combustion of mangosteen peel into carbon which is pyrolyzed at 300 ° C and 350 ° C for 1 hour. Finally, several tests were carried out, namely: moisture content, ash content, vapor content and carbon absorption.

B. Carbonization and Activation of Mangosteen Peels

a. Temperature Variation

The carbonization stage was a change in the mangosteen peels into carbon. Mangosteen peels samples were pyrolyzed at temperatures of 300°C (CA) and 350°C (CB) for 1 hour and were tested: water content, ash content, vapor content and bound carbon content. CA was symbolized for mangosteen peels carbon by pyrolysis process at 300°C for 1 hour. And CB was symbolized for mangosteen peels carbon by pyrolysis process at 350°C for 1 hour.

1. Water Content Analysis

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

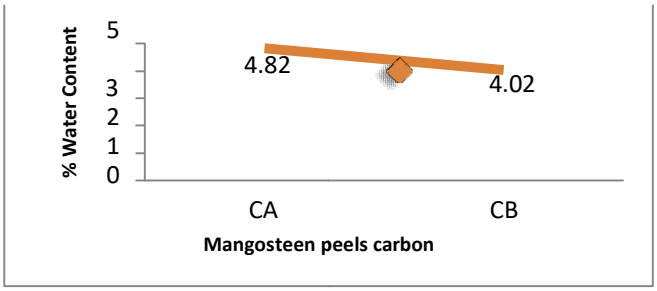


Fig 1. Water content analysis of carbon from pyrolysis process of mangosteen peels for 1 hour

Fig 1 showed the water content analysis of carbon from pyrolysis process at three different temperature for 1 hour. Higher the pyrolysis temperature, the greater water content obtained for

mangosteen peels carbon. At temperture of 300°C the 4,82%. Several factors can affect the water content of carbon, where humid conditions can cause absorption of surrounding water vapor. [8].

2. ***Ash Content Analysis***

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

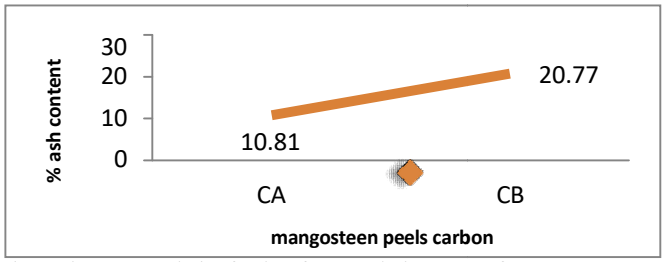


Fig 2 Ash content analysis of carbon from pyrolysis process of mangosteen peels at 550°C or 2 hours

Fig 2 shows the analysis of carbon ash levels from the carbonization process, the higher the temperature, the higher the ash content obtained at 300°C 10.81% and 350°C 20.77%. The increase in ash content is influenced by the oxidation of volatile substances including carbon in line with the increase in temperature [9].

3. Vapor Content Analysis

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

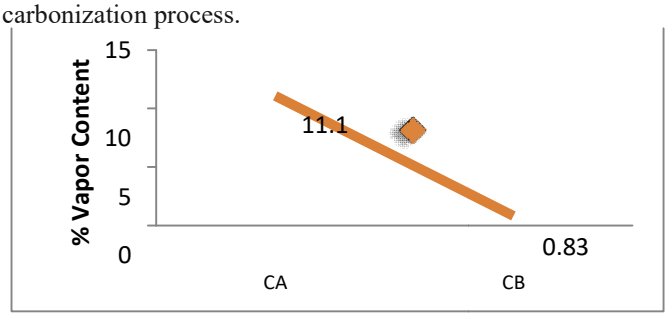


Fig 3 Vapor content analysis of carbon from pyrolysis process of mangosteen peels

Fig 3 shows the analysis of steam levels from the carbonization process at two different temperatures. The higher the carbonization temperature, the lower the vaporization rate. this decrease in vapor rate is due to the volatility of some volatile compounds being removed or removed resulting in a decrease in vapor rate [10].

4. Bounded Carbon Content Analysis

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

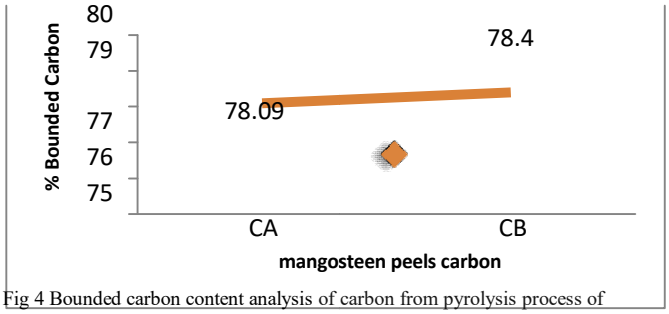


Fig 4 Bounded carbon content analysis of carbon from pyrolysis process of mangosteen peels

Figure 4 shows the analysis of carbon levels bonded from the pyrolysis process with two different mixtures. The higher the temperature, the higher the carbon content is bound to the mangosteen peels At 300°C bounded carbon 78.09% and at 350°C bounded carbon at 78.4%. The higher the carbon bond the better the carbon is produced, but the dehydration occurs perfectly which eliminates vapor products [11].

b. Variation of Reagents

From the process pyrolysis, obtained the best carbon from mangosteen peels at 300°C was obtained. After that, carbon from mangosteen peels was activated by various activated reagent. The activation stage was a change in carbon into activated carbon. Mangosteen peels samples were activated reagent at HCl, ZnCl2 and KOH for 24 hours with concentrations 4N and were tested: water content, ash content, vapor content and bound carbon content.

1. 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.

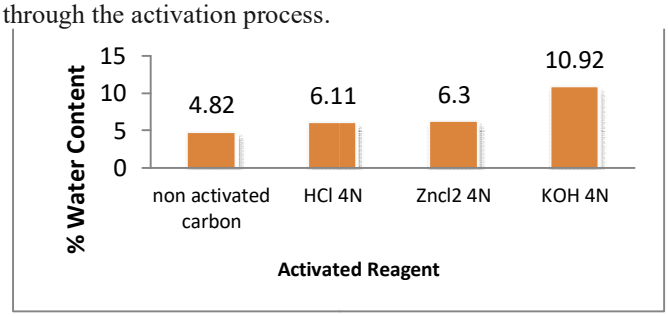


Fig 5 Water content analysis of mangosteen peels CA at various activated reagent at 4N concentration

Fig 5 shows the analysis of water levels of activated carbon of mangosteen peels from various HCl, $ZnCl_2$, KOH activation reagents with 4N concentration. here you can see the water level rise. Water levels are affected by storage time, storage conditions where moisture conditions will cause the absorption of water vapor on carbon.

2. Ash Content Analysis

The ash content analysis aimed to determine the metal oxide content which is still present in the mangosteen peels activated carbon after going through the carbonization process and activation.

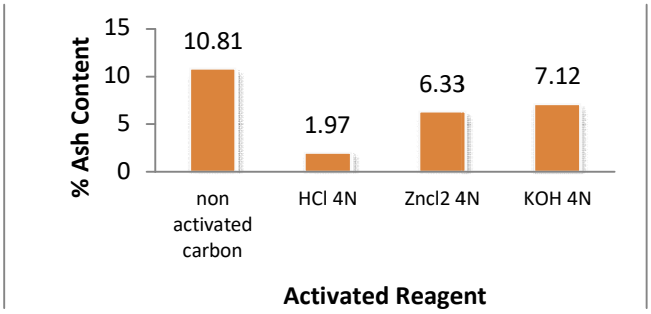


Fig 6 Ash content analysis reagen of mangosteen peels CA at various activate reagentat 4N concentration.

Fig 6 shows the analysis of the active carbon content of HCl, ZnCl2, KOH activation reagents with 4N concentration. on the HCl activation reagent was 1.97% ash. and on inactive carbon it has a 10.81% ash content. The rate of active carbon

10%.

3. Vapor Content Analysis

Vapor content analysis aimed to determine the amount of substances or compounds that have not evaporated in the carbonization and activation process but evaporate at 310°C.

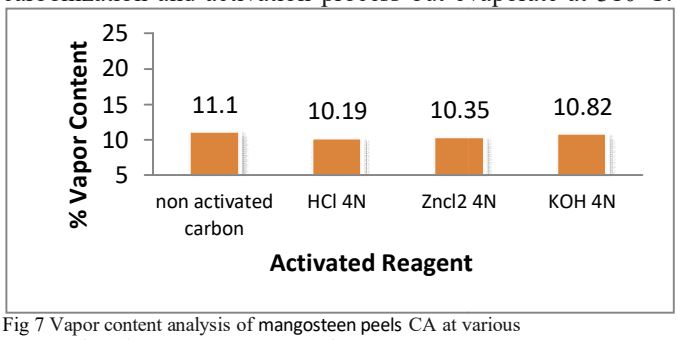


Fig 7 Vapor content analysis of mangosteen peels CA at various activated reagent at 4N concentration

Figure 7 shows the analysis of vapor levels on activated carbon of the mangosteen peels with variations of HCl, ZnCl, KOH reagent with 4N concentration. The HCl activation reagent was found to be 11,19% vapor, and 11.1% non-carbon vapor. the steam rate obtained in accordance with SNI 06-3730-1995 is less than 25%.

4. Bounded Carbon Content Analysis

carbon content after carbonization and activation process.

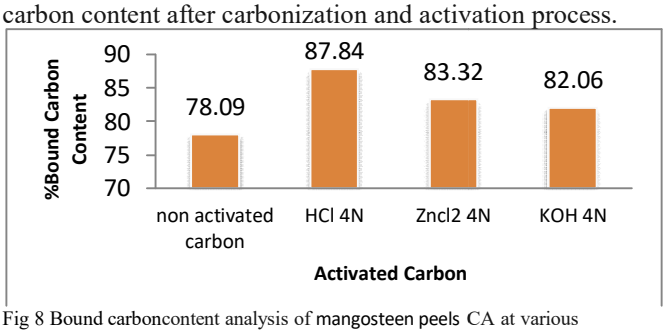


Fig 8 Bound carboncontent analysis of mangosteen peels CA at various activated reagent at 4N concentration

Figure 8 shows the analysis of the levels of carbon-bound mangosteen peels with the activation of HCL, ZnCl2, KOH activation with 4N concentration. The HCl activator reagent obtained a bound carbon rate of 87.84%. and in non active carbon obtained carbon bond 78.09% in accordance with SNI 06-3730-1995 which is greater than 60%

C. Variations in Concentration

From the reaction of the reagent that has been made, the best activating reagent of carbon from mangosteen is HCl. the next, from the best activation reagent was performed by varying the concentration of 2N, 4N, 6N, 8N concentration.

1. 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.

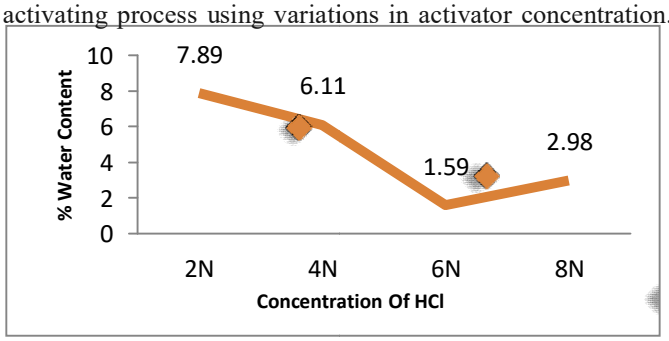
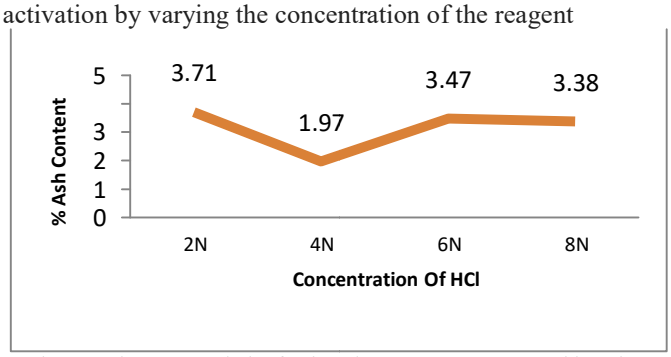


Fig 9 Water content analysis of activated mangosteen peels CA with HCl at various concentration

Fig 9 shows the analysis of water levels of activated carbon with different concentrations of 2N, 4N, 6N, 8N, HCl reagents. From various concentrations of activated carbon the water content of 4N HCl was 6.11% and HCl 6N was 1.59%. Water rate analysis is influenced by storage time, storage length, and humidity conditions which can cause water vapor absorption in the cabin.The water level obtained in accordance with SNI 06-3730-1995 is up to 15%.

2. Ash Content Analysis

The ash content analysis was performed to determine the amount of metal oxide still present in the carbon dioxide after activation by varying the concentration of the reagent



Gambar 10 Ash content analysis of activated mangosteen peels CA with HCl at various concentration

Figure 10 shows the ash content analysis of the variations of the 2N, 4N, 6N, 8N HCl reagent concentrations. of the

various concentrations tested, it obtained 4N HCl ash of 1.97% and HN 6H ash of 3.47%. The greater the concentration then the pores of the carbon become larger, but the greater the concentration will result in the blockage of the pore on the carbon.

3. *Vapor Content Analysis*

Vapor rate analysis is intended to determine the amount of substance or compound that has not evaporated during the activation process at various concentrations.

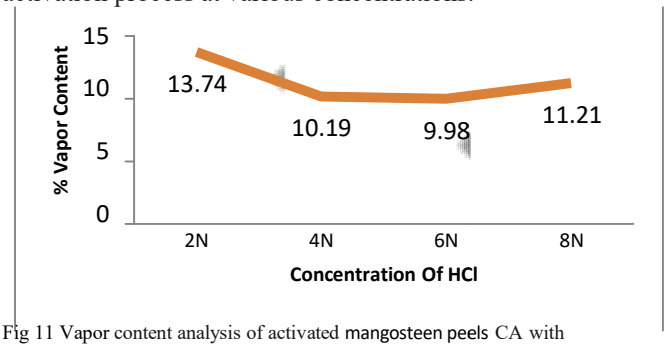


Fig 11 Vapor content analysis of activated mangosteen peels CA with HCl at various concentration

Fig 11 shows the analysis of the active carbon vapor levels of the 2N, 4N, 6N and 8N HCl reagent concentration variations. From the reaction mixture 4N HCl reagent was found to be 10,19% vapor and HCl 6N 98.98%. The greater the concentration then the pores of the carbon become larger, but the greater the concentration will result in the blockage of the pore on the carbon.

4. *Bounded Carbon Content Analysis*

The bonded carbon content analysis was performed to determine the pure carbon content after activation with varying concentrations of reagent.

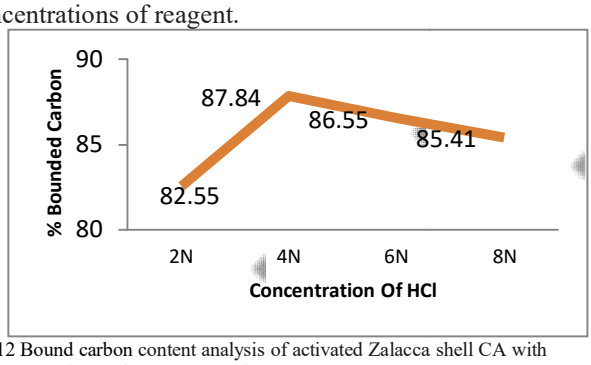


Fig 12 Bound carbon content analysis of activated Zalacca shell CA with HCl at various concentration

Fig 12 shows the analysis of the bounded carbon at which various concentration and reagent HCL 2N, 4N, 6N, 8N .at variuos concentration and reagen HCl 4N bounded carbon 87.84% and the HCl 6N bounded carbon 86.55%. 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 [12]. The active carbon obtained in accordance with SNI 06-3730-1995 in which carbon is bound to be greater than 60%.

IV. *CONCLUSION*

Activated carbon obtained from mangosteen peel is in accordance with SNI 06-3730-1995 regulations. The optimum temperature of the pyrolysis process is to make zalacca shell activated carbon at a temperature of 300 ° C for 1 hour. With the activator of the HCL 4N moisture content 6.11%, the ash content of 1.97%, the vapor rate of 10.19% and the carbon bond of 87.84% in accordance with the applicable rules in SNI 06-3730-1995

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