Characterization of Activated Carbon from Mangrove Propagule Waste (Rhizophora Mucronata) Activated by Hydrochloric Acid (HCL)

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Abstract

The development of industry often raises problems related to the waste produced. The waste produced causes odor, color, and taste. One way to overcome this problem is by the adsorption method. The adsorption method that is oftenly used is using activated carbon as an adsorbent. The study aims to determine the characteristics of activated carbon from mangrove propagules activated using hydrochloric acid (HCl). Activated carbon is an amorphous carbon with a very large surface area, which is 200 to 2000 m^2/g. The basic material of activated carbon is Lignocellulose. Mangrove propagules waste is a biomass containing lignocellulose. Hydrochloric acid (HCl) which acts as an activator is hygroscopic, so it can reduce the water content in the activated carbon produced. Testing is carried out by SNI and SII, including physical tests and absorption of Iodine. The carbonization temperature variables used three temperature variables: 300, 400, and 500 °C, and HCl concentrations: 1, 2, 3, and 4 N. In general, it had met the quality standards set by SII No. 0258-79 and SNI No. 06-3730-1995.

Keywords: Activated carbon, Mangrove, Propagules, HCl activation

INTRODUCTION

Indonesia is a maritime country with the potential of forest resources, namely mangroves. Mangroves often known as mangrove trees in Indonesia are plants of the Rhizophora type that can function as filters for hot air from the sea and absorb carbon gas in the air. Every year mangrove forests can absorb 42 million tons of carbon in the air or equivalent to carbon gas emissions from 25 million cars. As these mangroves grow, there is mangrove propagules fruit waste that can disrupt activities in the waters, and cause rotting and shallowing in rivers. The solution that can be applied to the case of mangrove propagules fruit waste is to make it into activated carbon.

Activated carbon is a porous solid containing 85-95% carbon, produced from carbon-containing materials by heating at high temperatures (Nafi'ah, 2016, Khuluk 2016). Activated carbon can be made from organic or inorganic materials that contain carbon (Rasdiansyah et al,

2014). The process of making activated carbon from lignocellulosic materials involves two procedures, namely carbonization and activation. There are two activation methods in making activated carbon, namely physical activation and chemical activation (Asrizal et al, 2013, Imawati and Adhitiyawan, 2015). Activators that are often used in making activated carbon include hydrochloric acid (HCl), sulfuric acid (H_2SO4), and nitric acid (HNO_3). Among other chemical activation agents, HCl is usually preferred because HCl can dissolve larger impurities so that more pores are formed and the adsorption process is maximized.

HCl is a compound that can chlorinate hydrocarbon materials, decomposes in water and releases heat during the dissolution process. HCl dissolves in water at atmospheric pressure and room temperature, which is 42% by weight. HCl which acts as an activator is hygroscopic, so it can reduce the water content in the activated carbon produced.

Testing the quality of activated carbon so that it can function properly. According to SII No. 0258-79 and SNI 06-3730- 1995, good activated carbon has the requirements listed in Table 1.

Table 1. Activated Carbon Requirements

Description	Quality Requirements	
	SNI	SII
Missing part in heating 950°C, (%)	Max. 25	Max. 15
Water content, (%)	Max. 15	Max. 10
Ash content, (%)	Max. 10	Max. 2,5
Bonded Carbon Level (%)	Min 65	-
Absorption capacity against I_2, (mg/g)	Min. 750	Min. 200

METHODOLOGY

Materials

The materials used in this study include mangrove propagules fruit waste, concentrated HCl, distilled water, fine filter paper, 0.1N sodium thiosulfate ($Na_2S_2O_3$) solution, 0.1N iodine solution, 1% amylum indicator, and aluminum foil.

Apparatus

The tools used include a pyrolizer, furnace, oven, electric bath, analytical balance, 100 mesh sieve, porcelain cup, desiccator, magnetic stirrer and glass equipment.

Production of activated carbon

Preparation of the materials

The first step is to clean the mangrove propagules fruit waste and dry it under the hot sun.

Carbonization process

Carbonization in a pyrolizer with temperature variations of 300, 400, and 500°C for 1 hour. During the carbonization process, the temperature indicator uses a gun thermometer. By pointing the infrared sensor towards the bottom of the pyrolizer. Cool in a desiccator, then weigh 30 grams for the activation process (Polii, 2017).

Activation

The weighed charcoal is chemically activated by soaking it in an acid activator, namely HCl. The concentrations determined are 1 N, 2 N, 3 N, and 4 N for 24 hours, then drained (Yulianti et al, 2010).

Analysis

The quality testing of activated carbon includes analysis of water content, analysis of volatile matter content, analysis of ash content, analysis of fixed carbon content, and analysis of iodine absorption capacity.

Water content analysis

Activated carbon as much as 1 g is dried in an oven for 3 hours to a constant weight at a temperature of 105°C until the weight is constant. Then put into a desiccator until the weight is constant. Every 1 hour of drying, weigh the sample until the weight is constant (Rizky et al, 2015).

Volatile substance content analysis

As much as 1 gram of activated carbon is put into a porcelain cup with a lid and put into a furnace at a temperature of 950°C for 6 minutes. After evaporation is complete, the cup is put into a desiccator until the weight is constant, then weighed (Lestari, dkk., 2017).

Ash content analysis

The cup containing the activated carbon sample of each variable is placed in a furnace, and heated to a temperature of 600°C for 6 hours. Then cooled in a desiccator until the weight was constant, then weighed (Lestari dkk., 2017).

Fixed carbon analysis

Pure activated carbon is made by calculating the difference between one hundred percent and the value of the sum of the ash content and the evaporated substance (Lestari et al., 2017).

Iodine absorption analysis

Weigh 0.5 g of dry activated carbon and put it in an Erlenmeyer flask. Then add 25 ml of 0.1 N iodine solution and shake for 15 minutes. The mixture is filtered and takes 10 ml of filtrate. Furthermore, the filtrate is titrated with 0.1 N Sodium Thiosulfate ($Na_2S_2O_3$) solution until the color becomes light yellow. Then add a few drops of 1% starch indicator and titrate again until the blue color disappears (Suhendrawati dkk., 2013). Iodine absorption capacity is counted using Eq (1).

$$DSI = \frac{\left(ml\ sample - \frac{T\ x\ C1}{C2}\right) x\ WI\ x\ Fp}{mass\ of\ activated\ carbon} \qquad (1)$$

Where:
DSI = iodine absorption capacity (mg/g)
ml sample = titrated filtrate sample (ml)
T = titration volume of $Na_2S_2O_3$ (ml)
C1 = $Na_2S_2O_3$ concentration (N)
C2 = iodine concentration (N)
WI = iodine weight (12.693 mg/ml)
Fp = dilution factor (5)

RESULT AND DISCUSSION

Effect of HCl concentration on activated carbon water content

Figure 1. showed the effect of HCl concentration on activated carbon water content.

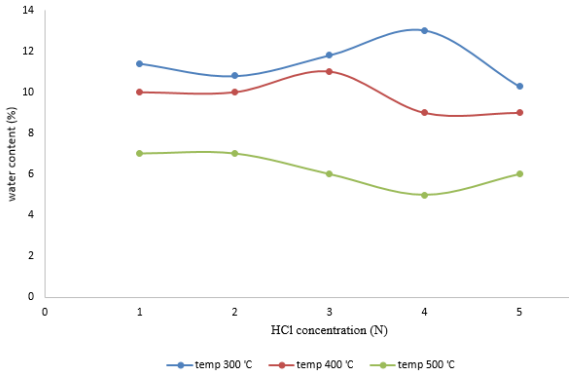

Figure 1. Effect of HCl concentration on activated carbon water content

Based on Figure 1, it can be seen that the water content ranged from 5% to 11.8% and the highest evaporation at a temperature of 300 ºC with an activator concentration of 3N and the lowest at a temperature of 500 ºC with an activator concentration of 3N. The results of this analysis indicate that the higher the activator concentration, the lower the percentage value of water

content. Based on Figure 1 above, the analysis of water content according to SNI 06-3730-1995 had met the standard, which is a maximum of 15%.

Effect of HCl concentration on volatile substance content

Figure 2 shows that the lowest volatile substance content is at a carbonization temperature of 300ºC with an activation concentration of HCl 4N. Based on the results obtained, the higher the carbonization temperature, the more volatile substances in activated carbon will increase. This is because at high temperatures the decomposition process of non-carbon compounds takes place perfectly (Purbacaka et al., 2017). According to SNI and SII standards, the results of this study were still met the applicable standards, namely a maximum of 25% and 15%.

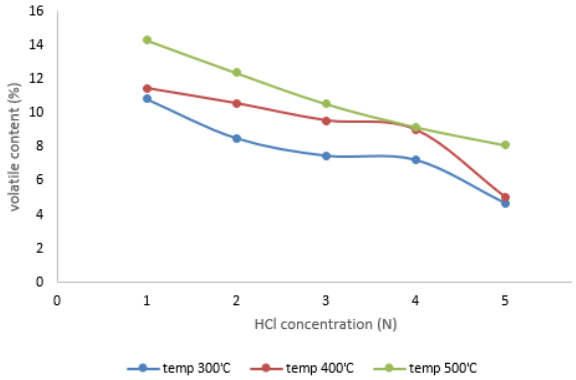

Figure 2. Effect of HCl concentration on volatile substance content

Effect of HCl concentration on activated carbon ash content

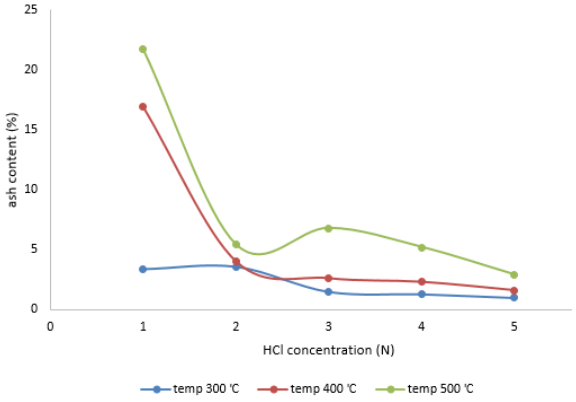

Figure 3. Effect of HCl concentration on ash content

Based on the data in Figure 3, the temperature is 300 ºC and the normality of the 4N activator, the analysis results obtained are 1.0%, the results of this analysis are still by the SNI 06-3730-1995

standard with a maximum ash content of 10%. The high ash content of activated carbon is due to the oxidation process, the longer the activation process, the lower the yield of activated carbon. The amount of ash content can affect the absorption capacity of activated carbon to gas or solution because the mineral content in ash such as calcium, potassium, magnesium, and sodium will fill the activated carbon lattice (Huda et al, 2019).

Effect of HCl concentration on activated carbon-bound carbon

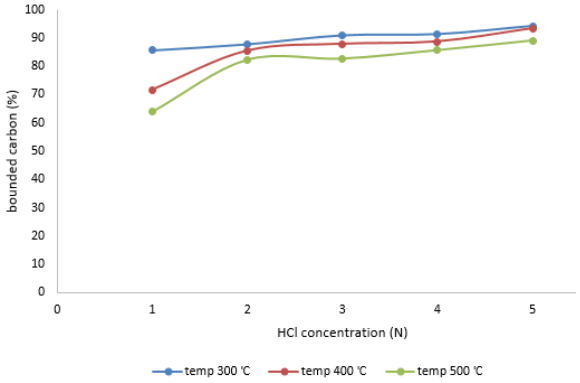

Figure 4. Effect of HCl concentration on bound carbon

The determination of bound carbon content aims to determine the carbon content after the carbonization and activation process, the bound carbon content ranges from 63.999 to 94.318%. The lowest bound carbon content is at a temperature of 500ºC non-activator and the highest content is at a temperature of 300ºC with an activator concentration of 4N. The results of the analysis obtained almost all of these values meet SNI requirements, namely more than 65%. The amount of bound carbon content is influenced by the ash content and volatile matter content, because the bound carbon content is the result of subtracting the two analyses of ash content and volatile matter content. The higher the ash or volatile matter content, the lower the bound carbon content.

Effect of HCl concentration on the absorption capacity of iodine solution

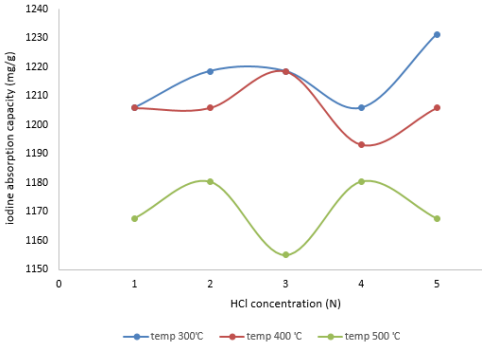

Figure 5. Effect of HCl concentration on the absorption power of iodine solution

Based on Figure 5, there is a tendency that the greater the absorption power, the better the quality of the activated carbon (Rahmadani and Kurniawati, 2017), because it shows the number of micropores formed, namely pores that can only be entered by molecules with a diameter smaller than 10 Å. The results of this analysis have met the requirements of SNI and SII, namely a minimum of 200 mg/g and 750 mg/g.

CONCLUSION

Based on the research data that has been analyzed and discussed, it can be concluded that mangrove propagules fruit waste can be used as an alternative raw material for making activated carbon, as the results obtained from the bound carbon analysis are still by the SNI No. 06-3730-1995 and SII No. 0258-79 quality standards, namely between 63.99% and 94.31%. The best results are at a carbonization temperature variable of 300 ºC with a concentration of 4N HCl, with analysis results according to the standards obtained, namely water content of 10.3%, volatile matter content of 4.682%, ash content of 1.0%, bound carbon of 94.318%, and iodine absorption of 1,231.22 mg/g, in general the results obtained are still in accordance with SNI standards, and the results of this analysis are quite good compared to the results of previous studies using original bamboo raw materials, namely ash content and iodine absorption have not met SNI standards.

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