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Production of activated charcoal from sugarcane bagasse using physical activation

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ABSTRACT

Activated carbon is a material containing 85% – 95% carbon elements and is a porous solid. This activated carbon is the result of heating materials containing carbon at high temperatures but not oxidized. In this study, the material used is sugarcane bagasse, and its activator is NaOH. The purpose of this research is to examine the production of Activated Carbon from Sugarcane Bagasse with different concentrations of NaOH activator, analyze the moisture content, ash content, volatile matter content, and fixed carbon content. Carbonization is carried out using a furnace at a temperature of 500°C for 1 hour. Carbon activation is done using NaOH solution with concentrations of 0.3%, 0.5%, and 0.7%. Irradiation is done using a microwave with a power of 630 Watts for 20 minutes. The results of this study indicate that the NaOH concentration affects some characteristics of the activated charcoal produced from sugarcane bagasse. A NaOH concentration of 0.7% produces activated charcoal with the best characteristics, with a moisture content of 3.1%, volatile matter content of 20.4%, total ash content of 5.9%, and carbon content of 62.2%.

Keywords: Activated charcoal; activator; concentration; NaOH; sugarcane bagasse

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INTRODUCTION

Bagasse is one of the organic wastes produced from the processing of sugar cane into sugar. This waste generally contains a large amount of organic matter such as cellulose, lignin, and hemicellulose, as well as other compounds that can be used for various purposes. However, bagasse can also be a source of environmental problems if not managed properly, because it can pollute water and soil and become a source of greenhouse gas emissions [1].

One method that can be used to manage bagasse is by carrying out physical activation. Physical activation is a processing process that uses heat or mechanical energy to change the physical and chemical properties of a material. In the context of bagasse processing, physical activation can increase the porosity and surface area of bagasse, thereby increasing its ability to absorb certain substances, such as heavy metals in wastewater or dyes in the textile industry [2].

The physical activation process on bagasse generally involves heating using high temperatures or the use of mechanical energy, such as grinding or crushing. This can cause cell rupture in the bagasse and increase accessibility to the pores in the bagasse structure. As a result, the absorption capacity and adsorption ability of bagasse can be significantly increased [1].

In addition, physical activation can also increase the regeneration or reuse of bagasse after the absorption process is complete. Thus, the use of physical activation in bagasse management can be an effective and environmentally friendly solution in reducing the negative impact of this waste on the environment. By utilizing physical activation technology, it is hoped that bagasse can be managed more efficiently and has the potential to become a value-added raw material in various industrial applications, such as wastewater treatment, alternative fuel production, or as a raw material in the production of environmentally friendly composites and construction materials [3].

RESEARCH METHODS

Preparation of Activated Carbon from Sugarcane Bagasse

The preparation of activated carbon from sugarcane bagasse waste is done by cutting the bagasse to a size of ± 1 – 2 cm, then air-dried for 4 days. After the bagasse is dry, the carbonization process is carried out which aims to convert the bagasse into carbon. Where carbonization is carried out at a temperature of 300°C for 1 hour. This temperature is the optimum temperature in the bagasse carbonization process, then the carbonized bagasse charcoal is ground using a mortar and pestle and then sieved using a 100 mesh sieve.

The activation process uses a chemical activator, namely NaOH with different concentrations and different charcoal temperatures, to see the best-activated carbon results from changes in temperature and concentration factors. Through this activation process, carbon will have a higher absorption capacity because the dirt that covers the carbon pores is released (evaporated) as the activation temperature increases.

RESULTS AND DISCUSSION

Relationship of Water Content to NaOH Concentration

The determination of water content aims to determine the hygroscopic properties of activated carbon [1]. Activated carbon has hygroscopic properties so that it easily absorbs water vapor from the air. The water content of activated carbon is expected to have a low value because high water content can reduce the absorption capacity of activated carbon to gas or gas liquids [2]. Activated carbon can absorb water vapor in very large amounts, this very hygroscopic property is often proposed that activated carbon is a material that is very suitable to be used as an adsorbent, the water content of all NaOH-activated activated carbon meets the requirements of the Indonesian national standard which is less than 15% [3].

The existence of an activator agent in water content is a dehydrating agent [4]. How it works as a binder of water molecules contained in the raw material to enlarge the pores of activated carbon and expand the absorption surface [5]. The low water content of activated carbon indicates the success of the activator agent in binding water molecules contained in the material and the release of free water and bound water contained in the raw material during the carbonation process [2].

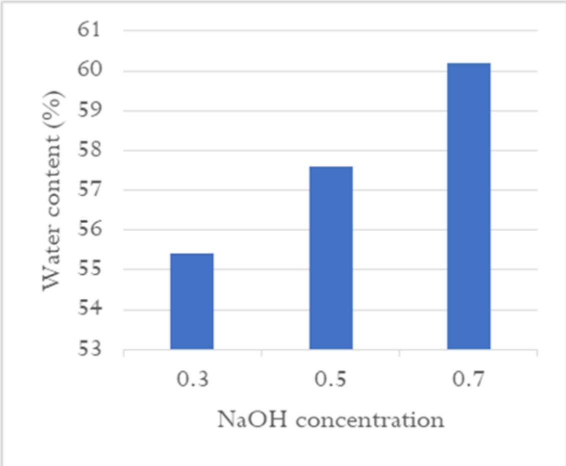

Figure 1. Water content value graph.

Figure 1 shows that the higher the concentration of the activator, the lower the water content tends to be. At a concentration of 0.3%, the water content reaches 4.2%. This value decreases further at a concentration of 0.5%, which is 3.7%, and at a concentration of 0.7% it is smaller, namely 3.1%. Soaking with an activating agent is carried out to reduce the tar content in carbon, as a result, the higher the concentration of the activator, the tar content will decrease but the surface of the activated carbon will also be wider, causing the water content in the carbon pores to be released. The quality requirements for activated carbon for water content are a maximum of 15% (SNI 06-3730-1995), so the water content results obtained in this study have met the requirements [3].

Relationship of Ash Content to NaOH Concentration

The purpose of determining the ash content is to determine the metal oxide content in activated carbon. Ash is a metal oxide in carbon consisting of minerals that cannot evaporate (nonvolatile) during carbonation. The ash content greatly affects the quality of activated carbon [1]. The presence of excess ash will clog the pores so that the surface area of the carbon is reduced [6,7]. The varying relationship between the high and low ash content in each activator is likely caused by the reaction that occurs between the type of activator and the environment. In the event of a basic NaOH activator, the reaction is less formed. It is evident from the value obtained which is lower than the acidic activator agent. While acidic compounds will react with groups containing oxygen so that the ash content produced is higher than the basic activator.

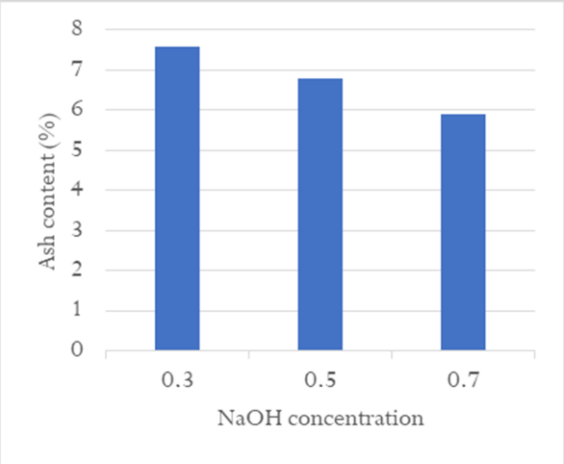

Figure 2. Ash content value graph.

Figure 2 shows that the increasing concentration tends to decrease the ash content value. The ash content values at different NaOH variations in samples of 0.3%, 0.5%, and 0.7% have respective values of 7.6%, 6.8%, and 5.9%. The lowest ash content value at a concentration of 0.7% is 5.9%, while the highest ash content value obtained at a concentration of 0.3% is 7.6%. This is because the higher concentration of activator can expand the surface of bagasse-activated carbon. During pore formation, in the activation process, crystals are burned which will become ash, so the more pores are formed, the more ash is produced.

Relationship of Volatile Substances to NaOH Concentration

Based on the results of measuring volatile substances from bagasse activated carbon, the graph data of volatile substance content values is obtained as in Figure 3

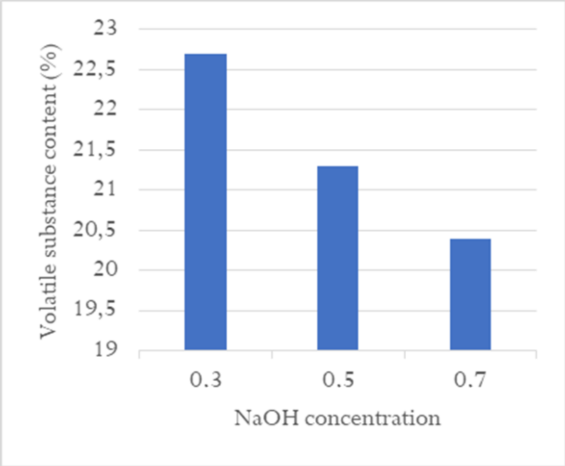

Figure 3. Volatile substance value graph.

Figure 3 shows that the higher the NaOH concentration, the more volatile substance content decreases. High volatile content indicates that the surface of activated carbon contains volatile substances originating from the interaction between carbon and water vapor. The volatile content produced by activated carbon with a concentration of 0.3% is higher than the volatile content produced at a concentration of 0.5%. The highest volatile content (22.7%) was obtained from activated carbon with a concentration of 0.3% and the lowest volatile content (20.4%) was obtained at a concentration of 0.7%. The quality requirements for activated carbon for volatile content according to SNI 06-3730-1995 are a maximum of 25%, so the volatile content at each concentration has met the quality requirements for activated carbon.

Relationship between Carbon Content and NaOH Concentration

The results obtained, the results of measuring the bound carbon content of bagasse activated carbon are shown in Figure 4. Figure 4 shows that the bound carbon content produced by activated carbon with a concentration of 0.3% is smaller than that of 0.5% and 0.7% concentrations. The amount of carbon content is highly dependent on the amount of ash content and volatile matter content. If the activated carbon has a high ash content and volatile matter content, the carbon content will be smaller, and vice versa. In the test, it can be seen that the highest carbon content was obtained from activated carbon with a concentration of 0.7% of 60.2% and the lowest carbon content was obtained at a concentration of 0.3% of 55.4%. The quality requirements for activated carbon for carbon content according to SNI 06-3730-1995 are a minimum of 65%, so the results of the bound carbon content obtained in this study have met the requirements.

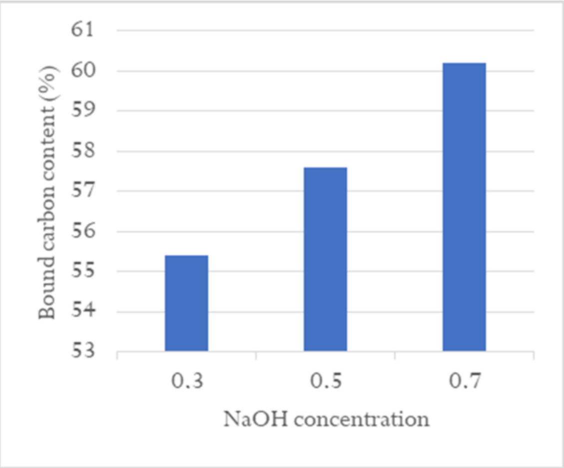

Figure 4. Graph of bound carbon value.

CONCLUSION

From the research results obtained the characteristics of activated carbon with the lowest water content of 3.1% with 0.7% NaOH activator, the lowest ash content of 5.9% with 0.7% NaOH activator, the lowest volatile matter content of 20.4% with 0.7% NaOH activator and the highest bound carbon content of 62.2% with 0.7% NaOH activator. The addition of concentration greatly affects the manufacture of activated carbon. The characteristics of the activated carbon produced are by SNI 06-3730-1995 for activated carbon. The suggestion that can be given is the need to vary the raw materials and temperature used to manufacture activated carbon.

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