Effect of Type of Activator and Ultrasonic Waves on the Chemical Activation Process on the Characteristics of Activated Charcoal from the Rubber Fruit Shell (Hevea Brasiliensis)

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Keywords: Activation, Shell for Rubber, Ultrasonic Waves, Type of Activator, Activated Carbon.

Abstract: The potential for rubber fruit shells in East Kalimantan Province in 2019 was 95.327 tons/year. Rubber fruit shells contain 48.64% cellulose. The content of cellulose are organic compounds that can be used as activated carbon. The purpose of this study was to determine the effect of the type of chemical activator with the help of ultrasonic waves on the characteristics of activated carbon according to the SNI 06-3730-1995 standard. Activated carbon is obtained through 4 stages, namely preparation of raw materials, carbonation at 500°C for1 hour, chemical activation with variations in the types of activators H_3PO_4, H2SO4, KOH and Na2CO3 with a concentration of 10% b/v for 4 hours, then physically activated at a temperature of 600°C for 1 hour. The best results were obtained in the variation of H_3PO_4 activator types with I_2 absorption results of 771.3263mg/g, water content of 0.5745%, ash content of 0.4045%, and 9.8200% volatile matter content.

1 INTRODUCTION

Rubber shells are biomass-dense waste and currently have no commercial value (Harun et al., 2010). The solid waste is left and not utilized so that it is bad for the environment (Ngah and Hanafiah, 2008). The content of cellulose is relatively large so that rubber shells are very potential to be processed into useful and high-value activated carbon-making raw materials (Ioannidou and Zabaniotou, 2007). Activated carbon can be produced materials containing cellulose such as wood, hazelnut shells, peat, coal, bamboo and others. Activated carbon is widely used in both large and small industries as coagulation (Stephenson and sheldon, 1996), chemical oxidation (Salem and El-Maazawi, 2008), photo catalysts (Bukallah et al., 2008), electrochemistry (Somasekhar et al., 2001), and membrane separation (Porter and McKay, 1997).

Pyrolysis processes as one of the most reliable thermochemical processes for the conversion of solid waste raw materials into high-value activated carbon (Somasekhar et al., 2001). Pyrolysis is usually done in the absence of oxygen depending on the temperature applied and the rate of heating (Chen et al., 2018). However, slow pyrolysis often causes the resulting activated carbon to contain a lot of oxygen and affects a variety of applications and takes more than 6 hours (Lee at al., 2017). Current methods that can produce activated carbon that have high quality use ultrasonic waves in the chemical activation process. Ultrasonic is a process that aims to increase mass transfer through the utilization of sound waves to produce pressure fluctuations. The cavitation effect of the wave can increase the temperature thus accelerating the catalyst into the activated carbon to remove impurities so that the activated carbon pores enlarge and cause the active carbon absorption to increase. Research on the utilization of ultasonic waves on the manufacture of activated carbon has been conducted using waste tobacco rods, waste tea, wood and cotton rods (Ji.Y et al., 2007),(Wang et al., 2009). The results showed that the process of making activated carbon using ultrasonic waves in the chemical activation process had advantages over conventional pyrolysis methods such as low energy use, easier to control, and shorter time.

In this study, variations in the type of activator (H_3PO_4,H_2SO_4,Na_2CO_3 and KOH) with a concentration of 10% b/v each with the process of carbonization using furnaces at a temperature of 500ºC for 1 hour. The process of chemical activation using the help of ultrasonic waves for 4 hours as well as adding the physics activation process at a temperature of 600℃ for 1 hour so that activated carbon is obtained in accordance with the standard.

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The purpose of the study was to find out the types of activators namely H_3PO_4, H_2SO_4, KOH and Na_2CO_3 with the help of ultrasonic waves against the activated carbon characteristics of rubber fruit shells resulting in activated carbon that conforms to the standard of activated carbon quality that refers to the standard (SNI, 1995).

2 METHODOLOGY

Tools used in this study include furnace, ultrasonic, oven, desiccator, balance sheet analytics, hotplate and magnetic stirrer, screening 100 mesh, 120 mesh, crusher, porcelain cup, mortar stamper, beaker cup clamp, spatula, funnel, rubber bulp, clamps and statives, aquades bottle, buret 25 mL, drop pipette, 5 mL, and 10 mL measuring pipette, 10 mL, and 50 mL volume pipette, erlenmeyer 100 mL and 250 mL, pumpkin measuring 100 mL and 1000 mL, while the material used rubber fruit shell, aquadest, solution (H_3PO_4,H_2SO_4,Na_2CO_3 and KOH) 10%, iodine solution 0.1021 N, thiosulfat sodium solution 0.1033 N, amylum indicator 1% b/v, whatman filter paper No.42, universal indicator.

The research began from the stage of collecting dry old rubber shell raw materials. Dry old rubber shell are cleaned and carbonated at a temperature of 500°C for 1 hour. Furthermore activated carbon is screened and activated with H_3PO_4,H_2SO_4,Na_2CO_3 and KOH with a concentration of 10% b/v each with the help of ultrasonic waves with a frequency of 47 kHz for 4 hours and adds the physics activation process at 60℃ temperatures for 1 hour. The Analysis stage is conducted based on standards (SNI, 1995), covering moisture content (ASTM D-3173), ash content (ASTM D-3174), volatile matter (ASTM D-3175), and iodine numbers (SNI 06-3730-1995).

Figure 1: Picture of the raw material and the resulting activated carbon.

3 RESULT AND DISCUSSION

The purpose of the study was to determine the influence of activator types H_3PO_4, H_2SO_4, KOH and Na_2CO_3 with the help of ultrasonic waves against the activated carbon characteristics of rubber fruit shells resulting in activated carbon that conforms to the activated carbon quality standards that refer to the standard (SNI, 1995).

In this study the raw material used is a rubber fruit shell. The raw material of rubber fruit shells has a yield of 24.17%, proximate analysis of water content values of 4.73%, ash levels of 2.65%, volatile matter levels of 17.62%, and iodine absorption of 469.72mg/g. Rubber fruit shells were previously carbonated using furnaces with a temperature of 500℃ for 1 hour so that it becomes charcoal. After the carbonization process is obtained charcoal is then chemically activated for 4 hours with the help of ultrasonic waves and without ultrasonic waves. Then the activation of physics using the help of a furnace with a temperature of 600℃ for 1 hour. Furthermore, activated carbon obtained by proximate analysis includes water content values, ash levels, volatile matter, and analyzed the absorption of activated carbon against iodine.

3.1 Moisture Content

Determination of water content aims to find out the hygroscopic properties of activated charcoal and to find out the water content in the cavity or cover the pores in activated charcoal shown with a high water content in charcoal. Low water content indicates many cavities or gaps that can be occupied by adsorbate so that the absorbs process will take place properly.

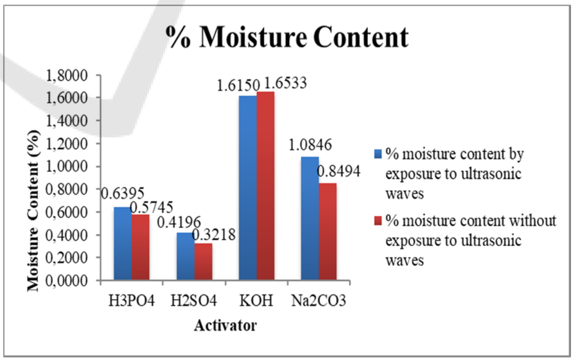

Figure 2: Graph of the relationship of activator types with water content.

Based on the graph in figure 1 it can be seen that the moisture content of activated carbon samples for each type of activator substance has different values. The type of activator substance is influential in the activation process of activated carbon. The presence of activator agents in relation to water content is as a hydrating agent. How it works as a binder of water molecules contained in raw materials so as to enlarge the pores of activated carbon and expand the surface of absorption. Low levels of activated carbon water indicate the success of chemical activator agents in binding to water molecules contained in the material as well as the release of the free water content and bound water contained in raw materials during the carbonation process (Ahmed and Theydan, 2013).

Based on the analysis data to find out the effect of the addition of ultrasonic wave assistance in the analysis of water content, chemical activation is carried out with the same treatment without the help of ultrasonic waves. Based on figure 1 it is known that the water content is better obtained from activation with the help of ultrasonic.

On the graph can be seen the lowest percent water content value obtained by activator substance H_2SO_4 with and without the help of ultrasonic waves, respectively, which is 0.32% and 0.42 percent respectively. The highest water content obtained KOH activator substances with and without the help of ultrasonic waves, respectively, is 1.65% and 1.62% respectively. Based on the data, it is known that acid activators H_2SO_4 are more able to dehydrate water bound in activated carbon when compared to activators H_3PO_4, Na_2CO_3 and KOH.

3.2 Ash Content

Determination of ash levels aims to find out the content of metal oxides in activated carbon. Ash levels are assumed to be residual minerals left behind from the rubber shell carbonization process. The results of the analysis of ash level can be seen at figure 3.

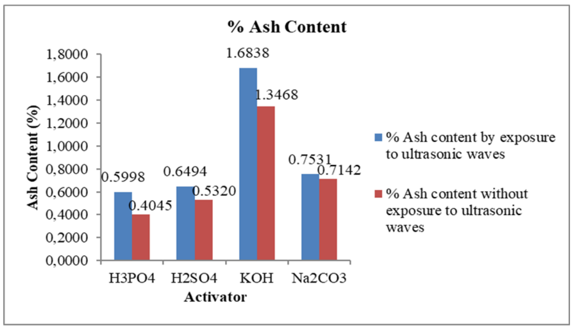

Figure 3: Graph of the relationship of type of activator with ash levels.

Based on the graph in figure 3 it can be seen that the ash levels of activated carbon in each type of activator substance have different values. Activated carbon consists of layers stacked against each other that make up pores. Where in the pores of charcoal there are usually impurities in the form of inorganic minerals and metal oxides that cover the pores. Ash levels can occur due to the formation of mineral salts during the process of authoring which when continued will form fine particles of the mineral salts. The use of activator materials can dissolve substances still present in charcoal such as hydrocarbons, ash, nitrogen and sulfur. The process of washing on chemical activation can dissolve metals or minerals present in activated charcoal so that the ash levels become relatively lower.

Based on the analysis data to find out the effect of adding ultrasonic wave assistance to the analysis of ash levels, chemical activation is carried out with the same treatment without the help of ultrasonic waves. Based on the graph in figure 3 it is known that ash levels are better obtained from activation with the help of ultrasonic for each type of activator. This is because ultrasonic waves cause mechanical effects that can increase reaction speed (Kentish and Ashokkumar, 2011)

On the graph can be seen the lowest percent ash levels obtained by activator substance H_3PO_4 with and without the help of ultrasonic waves of 0.40% and 0.60% respectively. The highest ash content obtained KOH activator substances with and without the help of ultrasonic waves by 1.35% and 1.68% respectively. Based on the analysis data it is known that acid activator H_3PO_4 has the lowest ash levels when compared to activators H_2SO_4, Na_2CO3 and KOH.

3.3 Volatile Matter

The level of vaporizing substances in carbon is the amount of substance that evaporates from a material, which evaporates consisting of flammable gases, such as hydrogen and carbon monoxide and a small portion of vapor that can condense. The results of the analysis of vaporized substance levels using activators H_3PO_4,H_2SO_4,KOH and Na_2CO3 can be seen in figure 4.

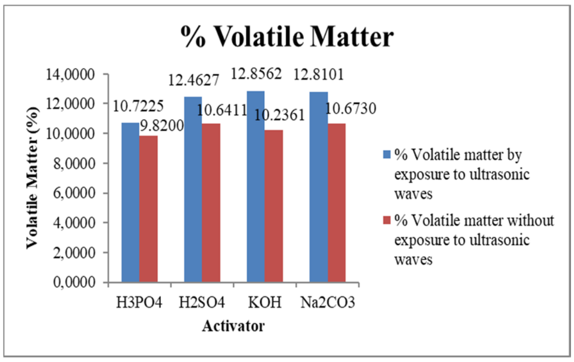

Figure 4: Graph of the relationship of activator types with volatile matter levels.

Based on the graph in figure 4 it can be seen that the volatile matter levels of the activated carbon sample for each type of activator substance have different values. The high levels of the resulting flying substance indicate that the surface of activated charcoal is still covered by non-carbon compounds, affecting its absorption. The levels of volatile matter obtained are better with the help of ultrasonic waves for each type of activator. Ultrasonic waves give rise to cavitation energy that can increase pores more in activated charcoal (Hamdaoui et al., 2008).

On the graph can be seen the lowest volatile matter levels obtained by activator substance H_3PO_4 with and without the help of ultrasonic waves of 9.82% and 10.72%, respectively. Volatile matter levels is highest obtained by activator substance Na_2CO_3 with and without the help of ultrasonic waves by 10.67% and 12.81% respectively. Based on the data of the analysis it is known that acid activator H_3PO_4 has the lowest volatile matter levels when compared to other activators. This suggests that acid activators are more able to reduce non-carbon compounds attached to the surface of activated carbon when compared to activators H_2SO_4, Na_2CO_3 and KOH.

3.4 Absorption of Iodine

The absorption of Iodine solution in activated carbon is a parameter to determine the ability of activated charcoal to absorb molecules of small molecular weight and substances in the liquid phase. The determination of activated carbon adsorption power to iodine has a correlation with the surface area of activated charcoal. The results of the analysis for iodine absorption are shown in figure 5 below.

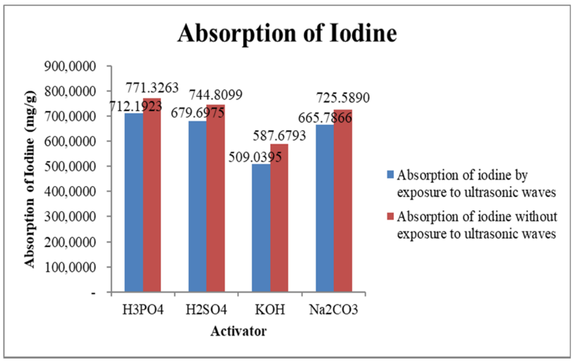

Figure 5: Graphic of activator type relationship with iodine absorption.

Based on figure 4 it can be seen that the iodine absorption of the activated carbon sample for each type of activator has different values. The activated carbon absorption of rubber fruit shells activated with and without the help of ultrasonic waves in the study ranged from 575.57mg/g-755.13mg/g and 498.45mg/g-697.38mg/g, respectively. Activated carbon with the highest iodine absorption capability is activated carbon with activation using activator H_3PO_4 with iodine absorption of 755.13mg/g. A solution of phosphoric acid (H_3PO_4) as anactivator also affects the surface area because it is a strong acid capable of lifting hydrocarbon compounds or impurities causing the formation of pores on the surface of carbon. Iodine absorption is affected by water content, ash content and volatile matter of activated carbon. The lower the water content, the water molecules that fill the activated carbon pores the less so that, the pores are not closed and the ability of activated carbon in absorbing iodine will be better. Volatile matter the presence of volatile substances attached to the surface of activated carbon affects iodine power. The lower the levels of volatile substances that cover activated carbon so that activated carbon can absorb iodine more effectively. Low water content will increase the effectiveness of activated carbon in absorbing iodine. The addition of ultrasonic wave assistance to the absorption of iodine absorption is better obtained from activation with ultrasonic assistance for each type of activator. ultrasonic waves gives the effect of the phenomenon of cavitation, namely the formation of small bubbles in the intermediate medium, which over time the bubbles that get bigger and burst and release large forces that can be used for chemical processes in ultrasonic. It is this bubble breakdown that then forms more pores within the activated carbon, resulting in a greater surface area of activated carbon. (Ahmed and Theydan, 2013), Hamdaoui et al., 2008). This increased surface area results in increasing adsorption capabilities from activated carbon. The increasing adsorption capability of activated carbon, the better the quality of the activated carbon.

4 CONCLUSIONS

In this study it can be concluded that all types of activators used for the manufacture of activated carbon from rubber shells meet the standards (SNI., 1995) for proximate analysis while for iodine absorption only H_3PO_4 activators meet technical activated charcoal quality standards namely H_3PO_4 activators at 0.57% moisture content, 0.40% ash content, 9.82% volatile matter and iodine absorption of 755.13mg/g. Exposure of ultrasonic waves at the time of chemical activation for all types of activators indicates the effect of ultrasonic waves seen from the comparative data of proximate analysis and iodine absorption in each activator with and without the help of ultrasonic waves.

The use of rubber shells as raw material for making activated charcoal can reduce environmental pollution and increase the economic value of rubber shell.

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