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Production of Activated Carbon from Durian Peel Waste using KOH Activator

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ABSTRACT

Durian, a widely consumed fruit in Indonesia, produces substantial peel waste during the harvest season, contributing to environmental problems due to its strong odor and rapid decay. Notably, durian peel contains approximately 57.42% carbon, making it a promising raw material for activated carbon production. Activated carbon is a porous adsorbent, typically composed of 85–95% carbon, and available in granular, pellet, or powdered form. This study investigates the effect of activator type on the characteristics of activated carbon derived from durian peel waste, aiming to identify the optimal activator. The research was conducted at the Environmental Physics Laboratory of the State Polytechnic of Cilacap, using potassium hydroxide (KOH) as the chemical activator. The activated carbon was evaluated based on moisture content, ash content, and iodine absorption capacity. The results indicated a moisture content of 1.62%, ash content of 6.9%, and iodine absorption of 1186.5 mg/g. These values meet the Indonesian National Standard (SNI 06-3730-1995) for high-quality activated carbon. The findings suggest that the use of alkaline activators such as KOH significantly influences the carbon's pore structure and overall quality. The produced activated carbon demonstrates potential for various applications, particularly in adsorption processes, owing to its high surface area and favorable physicochemical properties. This study supports the valorization of durian peel waste into valuable environmental remediation materials, contributing to both waste reduction and sustainable resource utilization.

1. Introduction

Durian (*Durio zibethinus*), a native Indonesian fruit, is known for its hard, thorn-like skin. The community loves this native Indonesian fruit so much that durian peel waste is produced in abundance during the durian season. This waste can pollute the environment, as discarded durian peels decompose and emit an unpleasant odor [1]. According to previous research, durian peels can be used as raw materials for the production of activated charcoal because they contain 57.42% carbon (C), which acts as an adsorbent [2]. Activated carbon is a black adsorbent in the form of granules, pellets, or powders. Activated carbon is made from various natural materials with around 85-95% carbon [3], [4], [5], [6].

Activated carbon is made from carbon materials that have previously been physically or chemically activated so that the pores are open and the absorption of substances, color, and odor increases. Coal, lignin, agricultural waste, lignocellulose materials, and synthetic polymers are among the materials that can be used as carbon-making materials. Activated carbon has a high adsorption capacity, about

25-100% of its weight. Carbon can absorb certain gases and compounds [7]. Activated carbon's increasing popularity is due to its versatility, efficiency, and the simplicity of its production process. Its wide range of applications and cost-effectiveness make it a valuable material across many industries. Activated carbon is obtained using chemical activators (e.g., H_2SO_4, KOH, Na_2CO_3, H_3PO_4, $ZnCl_2$, and K_2CO_3) and is widely used in various applications, including water and air purification, medical treatments, industrial processes, and environmental remediation [8], [9].

Making activated carbon generally consists of three stages: drying, carbonization, and activation. The activation process can occur in two ways: chemical activation with a chemical solution as the activator and physical activation [10]. The physical activation method is a two-step process: carbonizing organic matter into charcoal by heating it at 800-1000°C in the absence of oxygen or steam, using weak oxidants such as water vapor, CO_2, N_2, and O_2. Chemical activation is mixing chemicals and carbon, then drying and heating the mixture [11].

Activators can be hydrochloric acid (HCl) and phosphoric acid (H_3PO_4). The alkaline activators are potassium hydroxide (KOH) and sodium hydroxide (NaOH) [12]. Previous research shows that breaking the carbon chain of organic compounds in durian peels is more effective with KOH than with NaOH, leading to increased carbon content during activation because a large amount of carbon forms many pores that absorb pollutants [13]. Chemical activation of charcoal with KOH was very effective in expanding pore sizes to micropore levels and favoring the formation of surface oxygen functional groups [14].

Previous research found that KOH activator solutions, when combined with strong alkaline solutions, can remove hydrocarbons and impurities that can cause pores to form on the surface of the carbon [15]. Another research indicates that H_3PO_4, as an activator, creates more pores by reacting with charcoal and damaging the carbon's interior [16].

This research aims to determine the characteristics of activated carbon from durian peel waste using a KOH activator, in accordance with SNI 06-3730-1995 regarding the quality requirements and testing of activated charcoal. This research is carried out as one of the alternatives to reduce environmental pollution from durian peel waste and to add economic value.

2. Research Methodology

2.1. Materials

This research used a scanning electron microscope, analytical balance, furnace, detergent, grinder, mortar and pestle, 100-mesh sieve, magnetic stirrer, crucible, petri dish, measuring flask, measuring pipette, drop pipette, buret, Erlenmeyer, funnel, and beaker. The materials used were durian peel, 35% KOH solution, iodine solution, sodium thiosulfate, amylum solution, filter paper, aquades, and aluminum foil.

2.2. Procedures

The production of activated carbon was divided into three stages. The first stage was drying, also known as the dehydration process. This stage was carried out using sunlight or an oven to reduce the water content in durian peel waste. The next stage was the carbonization or charcoaling stage. This stage involved breaking down organic materials into carbon using a furnace at 400°C for 2 hours. At this temperature, water and volatile compounds, such as those in durian, would evaporate, leaving carbon. The last process was activation. This process aimed to open the pores of the carbon and decompose the charcoal from the impurities. The purpose of this activation was not only to increase the surface area but also to enhance adsorption capacity [17].

This research procedure involved drying the durian peel under the sun, then carbonizing it for 2 hours at 400°C. Next, the sifted carbon measuring 100 mesh was activated with a 35% KOH activator. The activated carbon was neutralized with aquadest and then baked for an hour at 105°C to a constant weight. Dried activated carbon was ready to use for testing.

The analysis of the activated carbon test was carried out based on the SNI method 06-3730-1995. The first moisture content test weighed 1 gram of carbon, placed it in a cup, and baked it at 115°C for 3 hours. Ash content testing was carried out by weighing 2-3 grams of activated carbon, which was put into a cup and then placed in a furnace for 2 hours at 800°C – 900°C until it became ash. The iodine absorption test was carried out by drying using an oven at a temperature of 115°C for 1 hour, then weighing 0.5 grams, then adding 50 mL of homogeneous iodine solution using a magnetic stirrer for 15 minutes, then taking 10 ml of the solution and titrating it with natrium thiosulfate solution until it was yellow and adding an amylum indicator, then titrating it back from dark blue to clear color. Next, pore size and activated carbon content were tested using SEM-EDX [18].

This research used a data collection method presented as tables and figures. If the results exceeded the SNI 06-3730-1995 standards, the activated carbon was considered unsuitable as an adsorbent. Fig. 1 shows the synthesis of activated carbon.

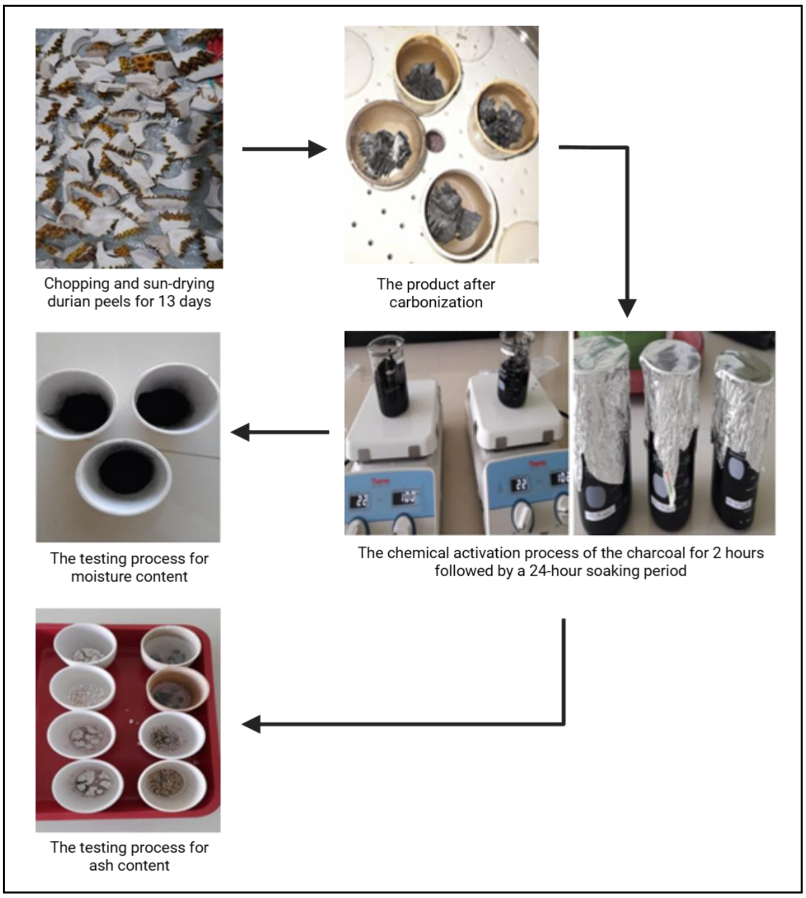

Fig. 1. Synthesis of Activated Carbon

3. Results and Discussion

3.1. Characteristics of Water Content, Ash Content, and Iodine Absorption

This test aimed to analyze the water-absorption characteristics of activated carbon, as residual water within the carbon cavities can obstruct pores and affect moisture and ash content [19]. Durian skin-activated charcoal has a water content of 14.2%, an ash content of 5.46%, and an iodine solution absorption capacity of 580.27 mg/g [20]. Table 1 shows the results of the activated carbon test with the KOH activator.

Table 1. Test Result of Activated Carbon

Parameter	Activated carbon	SNI
Water Content	1.62	Max 15%
Ash Content	6.9	Max 10%
Iodine Absorption	1186.5	Min 750 mg/g

The activated carbon moisture content from durian peel waste, to meet the quality requirements of activated charcoal, was limited to 15%, and the moisture content of the KOH-activated sample was 1.62%. The moisture content indicated that durian peel waste still met quality standards, and the water

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content of the activated carbon derived from it was within acceptable limits. This moisture content evaporated during the carbonization process. If the moisture content was high, the adsorbent's adsorption capacity decreased [21].

The purpose of the ash content analysis was to determine the amount of metal oxides in the material that were minerals and did not evaporate during the evaporation process. High ash content can clog activated carbon pores, causing a decrease in the surface area [22]. The ash content test result for the KOH activator was 6.90%, which still met the SNI 06-3730-1995 standard, with a maximum ash content limit of 10%.

The adsorption capacity of activated carbon was determined by the absorbing power of iodine. The higher the iodine absorption, the greater the adsorbent or solute adsorption [23]. Based on the technical activated charcoal standard SNI 06-3730-1995, iodine absorption must meet at least 750 mg/g. This type of KOH activator met technical activated charcoal standards. The result of iodine absorption in KOH-activated samples was 1186.5 mg/g.

3.2. Test Result of Surface Morphology

The activated carbon morphology, including pore size, can be determined using Scanning Electron Microscopy (SEM) as shown in Fig. 2.

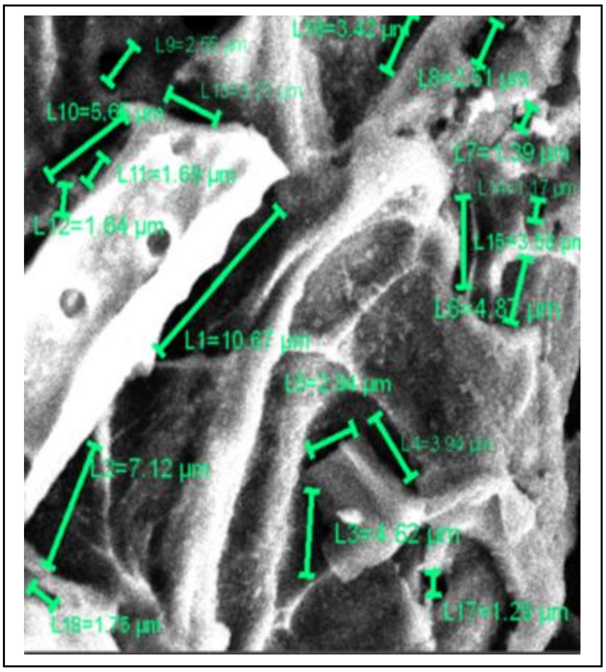

Fig. 2. KOH Activated Carbon Surface Structure

The results of activated carbon characterization using SEM with the KOH activator were at an average magnification of 2000-3000x. The morphology results for pore size showed that the KOH-activated sample has a pore size of 10.67 µm. The best result is that, if the activated carbon has a larger pore size, the KOH activator provides the best pore structure.

4. Conclusion

The use of KOH activators affects activated carbon, including moisture content, ash content, and iodine absorption, and these three parameters still meet the requirements of technical charcoal SNI 06-3730-1995, with activated charcoal at a maximum of 15%. The moisture content test result for the KOH activation sample was 1.62%. Then, the ash content test result for the KOH activator was 6.90%, which still met the SNI 06-3730-1995 standard, with a maximum ash content limit of 10%. Based on the technical activated charcoal standard SNI 06-3730-1995, iodine absorption must meet at least 750 mg/g. This type of KOH activator met technical activated charcoal standards. The result of iodine absorption in KOH-activated samples was 1186.5 mg/g. In addition, a surface morphology with a pore size of 17.12 µm is shown.

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