Production of Activated Carbon from Pineapple Crown Waste as An Adsorbent Through Activation Using 1 M NaOH (Variations in NaOH 1 M Soaking Time)

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Abstract

Pineapple crown waste is one of the biomass wastest that can be harnessed for various applications. One valuable application for this waste is its use an adsorbent. Pineapple crown waste contains various biopolymers that serve as natural adsorbents, including cellulose, hemicellulose, pectin and lignin; with cellulose content rangin from 69.5% to 71.5%, and lignin content from 4.4% to 4.7%. This research aims to investigate the characteristics of activated carbon adsorbent derived from pineapple crown waste through the activation process using 1M NaOH with variations in activation times of 1.5 hours, 2 hours, and 2.5 hours. The investigation includes proximate analysis (Fixed Carbon, Volatile Matter, Moisture, and Iodin adsorption capacity) as well as analysis using BET, SEM-EDX, FTIR and XRD. The study employs an experimental methodology. The activated carbon is produced through a carbonization process at 300°C, followed by a grinding process using a blender. Subsequently, it is sieved through a 100-mesh sleve and subjected to the activation. Activated carbon from pineapple crown waste can be employed for example, in heavy metal adsorption or the purification of crude palm oil.

Keywords: *pineapple crown, activated carbon, waste, Sodium hydroxide*

1. Introduction

With the growth of the pineapple processing industry, new challenges have emerged due to the increased volume of pineapple waste. Pineapple waste comprises pineapple peels, pineapples crowns, and pineapple leaves. A significant amount (45-65% of total production) of pineapple waste is generated after harvesting, presenting various issues for producers [1]. One of the ways to utilize waste form the processing industry is by using it as an adsorbent. Adsorption is the process of capturing a substance adsorbate) on the surface of a specific material (adsorbent). An adsorbent is substances used in the adsorption process. Adsorbents derived from pineapple waste can be in the form of activated carbon [2] or modified cellulose

[3]. Pineapple crown waste contains various biopolymers that serve as natural adsorbents, including cellulose, hemicellulose, pectin and lignin; with cellulose content ranging from 69.5% to 71.5%, and lignin content from 4.4% to 4.7% [4]. Several types of biopolymers found in pineapple waste act as natural adsorbents, including cellulose, hemicellulose, pectin and lignin [5].

Activated carbon is a material characterized by its high surface area, significant porosity, and desired surface functionalization capability. This material supports a wide range of applications, including use in adsorption process, as a catalyst support, in gas separation and storage, solvent recovery, color removal and more [6]. Activated carbon is a porous solid containing approximately 85-95% carbon, produced by heating carbon-containing materials at high temperatures. The manufacturing process involves the use pf gases, steam, and specific chemicals to open the pores of activated carbon. Activated carbon has a surface area ranging from 300 to 2000 m^2/gram. It processes highly complex pores, classified into three types based on IUPAC standards : a small pores with sixes less than 20 Å; medium pores ranging from 20 to 50 Å; and even larger cavities exceeding 500 Å in size [7]. Activated carbon falls into the category of non-graphitic carbon due to its law density and porous structure. Activated carbon is typically produced from various carbonaceous materials, such as coal, wood, coconut shells, pine nut shells, rice straw, bagasse and more. It is the most commonly used type of adsorbent in various adsorption processes [8].

Activated carbon is produced through several stages, starting with the carbonization process of pineapple crown waste. Carbonization is the process of burning organic materials into raw substances. Carbonization is the stage in which carbon content is enriched by eliminating non-carbon species through thermal decomposition. The carbonization process results in the decomposition of organic material within the raw material and the release of impurities. Most non-carbon elements will be lost at this stage. The release of easily volatile elements leads to the formation and opening of pores within the structure. During carbonization, the initial pore structure will undergo changes. The carbonization process is halted when no more smoke is generated. Additional heating is required to accelerate pore formation, but temperature control is essential. Excessively high temperature, such as above 1000°C, can produce a significant amount of ash that may clog the pores, reducing surface area and adsorption capacity [9].

The adsorption capacity of activated carbon is determined by the surface area of its particles. A larger surface area results in higher adsorption capacity. Activation processes, whether involving chemical agents or high-temperature heating, can increase the surface area and alter the physical and chemical properties of activated carbon. As a result, activated carbon becomes more efficient in adsorbing and removing various types of pollutants or desired substances from its environment [7]. The activation process aims to increase the pore volume, enlarge pore diameters, and enhance the porosity of activated carbon. There are three methods that can be used in activation process: physical activation, chemical activation, and physical-chemical activation [10]. Chemical activation is one of the methods used to produce activated carbon. In the chemical activation method, activation agents such as $ZnCl_2$, KOH, NaOH and H_2POH are used to activate the carbon [8].

Research has been conducted on the utilization of pineapple waste (pineapple crowns, pineapple peels, and pineapple leaves) by [2] as an adsorbent for Pb2+. The pineapple waste was activated using sodium hydroxide (NaOH) with the influence of pH (2, 4, 6), contact time (15, 30, 60, 90), and temperature (30°C, 60°C, 90°C). The research results showed that the optimum contact time for the adsorption process 60 minutes, with an adsorption efficiency

85.88%. Biosorption capacity increased significantly from pH 2.0 to pH 4.0 and at temperature of 90°C compared to non-activated pineapple waste adsorbent with NaOH. This research demonstrates that pineapple waste can be effectively used to remove Pb^{2+} metal ions from aqueous solutions and has the potential for application in wastewater treatment.

2. Method

This research employs an experimental methode based on existing journals. There are several stages in the production of activated carbon from pineapple crown waste, as follows:

2.1. Preparation of Sample

The samples were cut into 2-3 cm pieces and cleaned with water. Subsequently, the samples were dried in sunlight until they were completely dry. The dried samples were further dried in an oven at 105°C for 60 minutes. The result was dried pineapple crown samples.

2.2. Carbonization

The dried pineapple crown samples were weighed, and their weight were recorded. The samples were carbonized at a temperature of 300°C for one hour, and the weight after carbonization was recorded. The samples were then sieved using a 100-mesh sieve [11].

2.3. Activation

The carbon samples were activated using a 1M NaOH solution with a sample-to-solution ratio of 1:10. Activation was carried out for 1.5 hours, 2 hours, and 2.5 hours. The samples were then washed with deionized water (aquades) until neutral pH was achieved, followed by drying at 105°C for 12 hours [2].

3. Results and Discussion

Activated carbon will be tested using proximate analysis, which includes testing for moisture content, ash content, fixed carbon content, volatile matter content, and iodine number. Proximate analysis of activated carbon involves several critical parameters to assess its quality according to reference standards such as SNI (Indonesian National Standard) 06-3730-1995 [12]. The maximum moisture content for activated carbon is 15%. The maximum ash content of 10%. The minimum volatile matter content should be 25%. The minimum fixed carbon content is 65%. And the minimum iodine number should be 750 mg/g. Additionally, the activated carbon will be characterized using several instrumental techniques, including BET, SEM-EDX, FTIR and XRD.

3.1.1. BET (Brunauer-Emmet-Teller) Test

The BET (Brunauer-Emmet-Teller) test is common method used to measure the specific area of a material, including activated carbon. Generally, the higher the BET surface area, the greater the microporosity of the activated carbon. Microporosity is a desirable property in activated carbon because these microscopic pores can efficiently capture target molecules [13].

3.1.2. SEM-EDX (Scanning Electron Microscopy-Energy Dispersive X-Ray)

Scanning Electron Microscopy (SEM) is a microscopic technique used to observe the surface morphology of the adsorbent derived from pineapple crown waste. SEM is used to examine the surface of a specific material with the aim of obtaining a more detailed understanding of its structure, both at the micro and macro levels [14]. Energy Dispersive X-Ray (XRD) is an analytical method typically integrated with SEM. EDX is used to identify the chemical elements present in a sample [15]. By combining SEM and EDX, it is possible to analyze the surface morphology of the sample and identify the elements present in the sample.

3.1.3. FTIR (Fourier-Transform Infrared Spectroscopy)

The FTIR analysis is used to examine activated carbon to identify the functional groups present in the sample and any functional groups that may be lost or altered during the carbonization and activation process. FTIR is an infrared spectroscopy technique that measures moleculer interaction with infrared radiation [16].

3.1.4. XRD (X-Ray Diffraction)

The XRD analysis is a method used to identify crystalline phases in a material. This method works by exposing the sample to X-Rays and measuring how far the X-Rays are diffracted by the crystal lattice structure of the sample. Therefor, XRD can provide information about the crystal structure parameters, such as interatomic distances and lattice plane angles. Additionally, XRD can provide information about particle size within the sample and determine the mineral composition of the sample [17].

From the results of the proximate analysis and characterization tests mentioned above, a comparison of the quality of activated carbon from three different treatments will be evident. These findings are expected to be valuable considerations for future applications. Pineapple crown waste-derived activated carbon can be applied in various fields, such as heavy metal adsorption and palm oil purification.

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