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CHARACTERISTIC PHYSICOCHEMICAL OF BAMBOO-BASED ACTIVATED CARBON FOR COAL RUN-OFF WATER TREATMENT USED AT PT.BUKIT ASAM SLUDGE SETTLEMENT POND

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ABSTRACT
The aim of this research were investigated bamboo-based activated charcoal (ABT)characteristics using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared (FTIR). ABT has been successfully synthesized through physico-chemical activation at 700°C with H_3PO_4 10% solution as activator. The resulted were porous surface structure of bamboo charcoal causes an absorption interaction of pollutants (cations, anions, and suspended solids/TSS) in wastewater. Bamboo charcoal has different physical characteristics from charcoal from other types of raw materials because the structure with lignin composition is different from charcoal from other wood. The spectral patterns of AB and ABT are similar but differ in intensity. The functional groups detected in the two materials are the same, but there are differences in the absorption intensity where the ABT is relatively lower, especially in the hydroxyl functional groups at around 3400 and 1600 cm-1. This decrease in intensity is due to the dehydration process that occurs during both physical and chemical activation processes so that the hydroxyl groups come out of the bamboo charcoal structure.

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1. INTRODUCTION

The common method used in treating coal mine acid water is neutralization by adding alkaline chemicals such as $Ca(OH)_2$, CaO, NaOH, Na_2CO_3, and NH_3, but this treatment is expensive, and requires equipment and supporting facilities [4]. Another commonly used method is coagulation using alum ($Al_2(SO4)_3$). Alum is a coagulant material that works effectively in accelerating the removal of suspended solids in wastewater. However, excessive use of alum can cause the release of aluminum metal ions (Al) at certain levels which can be toxic and thus harmful to the environment [5]. Activated carbon is a material that is widely used in contaminant removal in wastewater treatment [6]. High adsorption capacity, easy application, and relatively low cost are the advantages of using activated carbon in wastewater treatment [7]. Various sources can be used as precursors in the production of activated carbon such as coal, lignite, peat, and agro-industrial waste. Agro-industrial waste is a very potential precursor because it has high cellulose content, abundant availability, cheap, biodegradable, non-toxic, and is thermally and mechanically stable to support clean and sustainable development [8].

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The general method of synthesizing activated carbon consists of two steps, namely carbonization and activation. Carbonization is carried out using controlled pyrolysis/gasification at high temperatures (400-1000℃) to remove volatile matter [10] and activated using physical or chemical activation. The activation process causes an increase in the volume and pore diameter as well as the surface area by breaking the hydrocarbon bonds or oxidizing the surface molecules which have an impact on the adsorption capacity [11]. Several types of chemicals commonly used as activators in the activated carbon activation process such as H_3PO_4 [12], $ZnCl_2$ [13], and KOH [14]. Santana et al. [12] reported that the combination of physical and chemical activation with H_3PO_4 was able to produce bamboo-based activated carbon with a high surface area (1196.30 m^2/g) and excellent adsorption capacity for pesticide waste in surface water.

Activated carbon derived from bamboo has become an important and promising adsorbent in wastewater treatment. Various previous studies have reported the synthesis of bamboo-based activated carbon and reported good performance for the removal of various contaminants in wastewater such as pesticides [12], heavy metals [15–17], and dyestuff [18,19]. The use of bamboo-based activated carbon in coal runoff wastewater has not been found yet, so this research studied the characterization of activated carbon with bamboo industrial waste materials and its effectiveness against several parameters of coal wastewater quality standards.

2. METHODS

Equipment and Materials

The equipment used in this study included beakers, volume pipettes, grinders, mesh filters, ovens, analytical balances, pH meters, Fourier Transform Infra Red (FTIR). The material used is bamboo charcoal which is produced from bamboo waste by PT. Hanan Alam Utama as UMKM fostered by CSR PT. Bukit Asam Tbk, The chemicals used include HNO_3 p.a. (Merck), distilled water, $Al_2(SO_4)_3.18H_2O$ (alum), CaO, H_3PO_4 p.a., CaO (quicklime), Whatman 42 filter paper and 1821-025.

Characterization

Bamboo charcoal before (AB) and after activation (ABT) were characterized. The surface morphology of both was analyzed by Scanning Electron Microscope (SEM). Functional group analysis was performed using Fourier Transform Infra Red Spectroscopy (FTIR) and crystallinity was analyzed using X-Ray Diffraction (XRD).

3. RESULTS AND DISCUSSION

AB and ABT characteristics

Coal is one of the biggest sources of energy to date. A common problem in coal mining activities is acid mine drainage which is produced by rainwater mixed with rock containing sulfide. The acid mine drainage that is formed generally has a high level of acidity, contains sulfates, heavy metals (such as Fe and Mn), and total suspended solids (TSS) which can cause havoc to the community. Environment so that it must be processed according to quality standards before being discharged into the environment [1–3].

One of the agro-industrial wastes that can be processed into activated carbon is bamboo industrial waste. So far, the main use of bamboo has been limited to building materials and handicrafts, whereas bamboo is a very potential raw material for activated carbon because of its fast growth, low cost, and good mechanical properties. In addition, activated carbon made from bamboo exhibits good surface characteristics and porosity properties [9].

In addition, ABT material appears to have a flatter and smoother surface compared to AB. This is because the activation process removes organic substances or impurities on the surface and pores of the bamboo charcoal. In Fig 1a, you can also see lots of pictures of residue flakes from the carbonization process for making charcoal. This residual flake could be due to agglomeration of organic volatile compounds on the carbon surface [23]. The physicochemical activation process can increase the availability of interaction sites on the activated charcoal surface.

The surface morphology of AB and ABT is shown in Fig 1. Bamboo charcoal has unique pores. The porous surface structure of bamboo charcoal causes an absorption interaction of pollutants (cations, anions, and suspended solids/TSS) in wastewater. Bamboo charcoal has different physical characteristics from charcoal from other types of raw materials because the structure with lignin composition is different from charcoal from other wood.

The functional groups in AB and ABT were confirmed based on the spectra presented in Fig 2. The spectral patterns of AB and ABT are similar but differ in intensity. The functional groups detected in the two materials are the same, but there are differences in the absorption intensity where the ABT is relatively lower, especially in the hydroxyl functional groups at around 3400 and 1600 cm-1. This decrease in intensity is due to the dehydration process that occurs during both physical and chemical activation processes so that the hydroxyl groups come out of the bamboo charcoal structure. Meanwhile, the C-H functional groups of methyl or methylene compounds did not appear to decrease in intensity at a wave number around 2900 cm^{-1}. From the results of FTIR characterization it is known that

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the activation process can remove volatile compounds that cover the active side on the surface of the bamboo charcoal so that it can work more optimally.

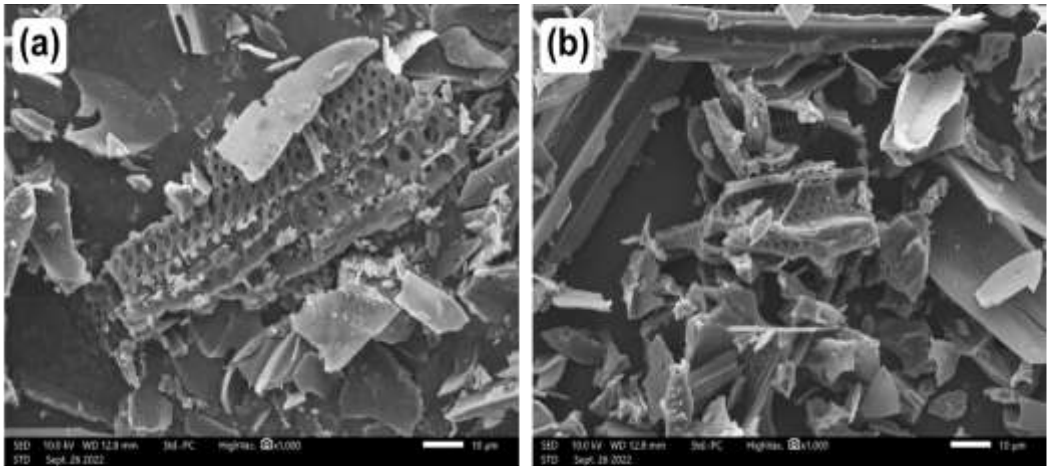

Fig 1. Morphology of (a) AB and (b) ABT with SEM at 1000x magnification

The crystal structures of AB and ABT were characterized using XRD. The diffractograms of both are shown in Fig 3. The AB and ABT diffractogram patterns are similar in that there are 2 peaks at 2θ around 23° and 43°. The diffraction peaks shown have a widened character indicating that the bamboo charcoal has an amorphous structure which means it has an irregular arrangement (amorphous). The diffraction peak at around 23° represents the (002) diffraction plane while at 43° represents the presence of (100) or (101) fields [24]. In terms of crystal structure, there is no difference between bamboo charcoal before and after activation. This is because activation plays more of a role in expelling organic compounds and impurities on the surface and pores of the bamboo charcoal and does not allow the crystal structure to reorganize.

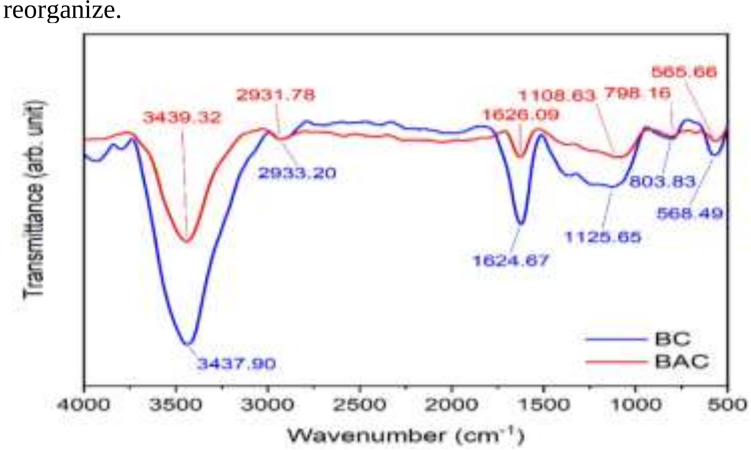

Fig 2. FTIR spectrum of bamboo charcoal (BC) and activated bamboo charcoal (BAC).

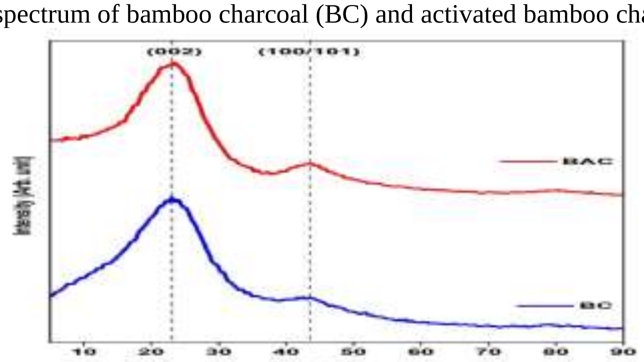

Fig 3. X-ray diffractogram of bamboo charcoal (BC) and activated bamboo charcoal (BAC).

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4. CONCLUSIONS

Activated charcoal made from bamboo waste (ABT) has been successfully synthesized were characterization too. The surface morphology of ABT is smoother than AB with pores that are evenly distributed on the surface. Physicochemical activation increases the availability of interaction sites on the ABT surface by removing volatile compounds which are identified through decreasing the intensity of the hydroxyl functional groups in the FTIR spectra. ABT can neutralize the pH of wastewater quickly, namely in a contact time of 10 minutes. The diffraction peak at around 23° represents the (002) diffraction plane while at 43° represents the presence of (100) or (101) fields [24]. In terms of crystal structure, there is no difference between bamboo charcoal before and after activation.

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