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Effectiveness of Kepok Banana Peel Waste With Potassium Hydroxide Activation as Methylene Blue Dye Adsorbent

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ABSTRACT

Banana peels are usually considered as waste and cause environmental pollution. However, banana peels can be used as an adsorbent material to reduce the impact of methylene blue dye use because they contain high lignocellulose. This study aims to determine the characterization, optimum mass and optimum time. The adsorbent was made using dried and carbonized banana peels at a temperature of 400°C for 2 hours. After the carbonization process, the adsorbent was activated using 5 M potassium hydroxide for 2.5 hours. Based on the results of the study, it showed an optimum mass of 0.121 grams and an optimum time of 90 minutes. The efficiency of methylene blue dye absorption on activated carbon was higher than that of banana peel carbon.

Keywords: banana peel, adsorbent, KOH, characterization

1. INTRODUCTION

People's material living standards continue to rise due to rapid urbanization and industrialization. However, there are negative effects of urbanization and industrialization on the environment. In the clothing and textile sector, there is an increase in synthetic dyes.[1] One of the textile industries that uses dyes produces industrial wastewater containing dyes that can pollute waterways.

There are several colors that are often used in the textile industry with varying chemical properties such as rodamin B, methylene violet, methylene blue, tartrazi, sunset yellow and allura red.[2] One of the synthetic dyes that is often used in the textile industry process is methylene blue. The adverse health effects of methylene blue include vomiting, increased heart rate, cyanosis, digestive system irritation and skin irritation because methylene blue is a heterocyclic aromatic molecule.[3]

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Efforts to reduce the impact of pollution from dyes are needed in reducing water pollution that affects the environment and human health. The use of adsorbents can overcome water pollution with adsorption methods. One agricultural waste that can be used as an adsorbent is banana peel waste.

Banana peels are usually thrown away as waste and can be used as adsorbent for dye absorption. Banana peels contain high amounts of hemicellulose, pectin, cellulose, and lignin. Banana peels also contain polar functional groups such as phenolic, carboxylic and hydroxyl acid groups.[4] Based on Sa'diyah's research (2020), kepok banana peel carbon was activated with NaOH and H_2SO_4 the results showed that the value of water content, ash and volatile matter from basic activators was higher than that of acid activators.[5] In Lantang's research, activated carbon of goroho banana peel can absorb methylene blue dye 92.63% with a contact time of 90 minutes.[6]

Based on previous research, this study will use kepok banana peel as raw material for activated carbon and carbonization process. Then banana peel carbon will be activated using 5 M KOH by varying the mass of carbon and KOH-activated activated carbon, carbon contact time and KOH-activated kepok banana peel activated carbon which will be tested for its adsorption ability against methylene blue using UV-Vis spectrophotometry.

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

Banana peel waste collected from around the campus, potassium hydroxide (KOH) 5 M (Germany), methylene blue ($C_{16}H_{18}ClN_3S$), distilled water (H_20). The tools used were a furnace, measuring flask, magnetic stirrer bath, whatman 41 filter paper, desiccator, measuring cup, 120 mesh sieve, grinder, analytical balance, stopwatch, pH paper, UV-Vis spectrophotometer, FTIR and SEM (SEM TM3000),

2.2. Research Procedure

2.2.1 Preparation of banana peel

Preparation of adsorbent derived from kepok banana peel is done by cleaning the banana peel using water to remove dust and dirt. The banana peels were then cut into small pieces. The banana peels were oven dried at 103°C for 24 hours, then cut and sieved to less than 120 mesh.

2.2.2 Preparation of kepok banana peel activated carbon

The preparation of banana peel activated carbon was carried out by carbonizing the banana peel at 400°C for 1.5 hours and sieving. The banana peels were soaked with 5 M KOH activator in a ratio of 4:1 for 2,5 hours and then dried using an oven at 110°C. The activated carbon was washed using distilled water and filtered. Activated carbon was oven dried for 2 hours.

2.2.3 Characterization of Carbon and Activated Carbon

Characterization was carried out using FTIR to determine the functional groups present in banana peel carbon and 5 M KOH-activated banana peel activated carbon.

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2.2.4 Adsorption Test of Carbon and Activated Carbon of Kepok Banana Peel on Methylene Blue

Adsorption test on methylene blue was conducted by varying the optimum mass of adsorbent and contact time variation. A total of 0.05 grams of banana peel carbon was immersed in 50 ml of 20 ppm methylene blue solution. Then stirring with a magnetic stirrer at 60 minute intervals. The same was done at masses of 0.1; 0.3; 0.5 and 0.7 for carbon and kepok banana peel activated carbon. Then filtered and tested using UV-Vis spectrophotometry at 665 nm.

Contact time variations were carried out by weighing 0.1 gram of kepok banana peel carbon then immersed in 20 ppm methylene blue solution as much as 50 ml. Then stirring with a magnetic stirrer at time intervals of 30, 60 and 90 minutes. The same was done with kepok banana peel activated carbon. Then filtered and tested using UV-Vis spectrophotometry at 665 nm.

2.2.5 Determination of Adsorption Efficiency and Adsorption Capacity

Determination of adsorption efficiency is done to determine the percentage of absorption of Methylene Blue adsorbed by carbon and activated carbon.

$$E = \frac{(C_O - C_e)}{C_O} \times 100\%$$

2.2.6 Determination of Adsorption Capacity

Determination of adsorption capacity is carried out to determine the ability of carbon and activated carbon as adsorbents in adsorbing Methylene Blue.

$$q_e = \frac{(C_O - C_e)}{m} \times V$$

3. RESULTS AND DISCUSSION

3.1. Analysis of Characterization Results

3.1.1 Characterization of Functional Groups

The FTIR spectrum shows the vibrations of the bonds contained in the compound. This analysis was carried out in the range of wave numbers 4000-500 cm^{-1}. Based on Figure 1, the results of FTIR analysis on carbon show the absorption at wave number 3171.41 cm^{-1} identifying the presence of O-H groups derived from cellulose and lignin. There is an absorption peak at wave number 2922.39 cm^{-1} which identifies the presence of aliphatic C-H bonds. The absorption at wave number 1563.88 cm^{-1} is usually associated with the stretching of C=C functional groups in aromatic rings. Activated carbon shows the presence of O-H groups at the 3188.09 cm^{-1} wavenumber region which indicates the presence of free bonds and intermolecular bonds. Aliphatic C-H bonds were identified at wave number 2911.50 cm^{-1}. The absorption at wave number 1565.39 cm^{-1} is usually associated with the stretching of the C=C functional group in aromatic rings. C-H group absorption was seen in kepok banana peel activated carbon at wave number 1373.52 cm^{-1}. The O-H group absorption in kepok banana peel carbon and kepok banana peel activated carbon showed a shift in wave number from 3188.09 cm^{-1} to 3171.41 cm^{-1}. The existence of a wave number shift to a smaller value

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identifies the reduced strength of the bond between two atoms in one molecule that is being vibrated, which in this case is the hydrogen bond of the hydroxyl group.[7]

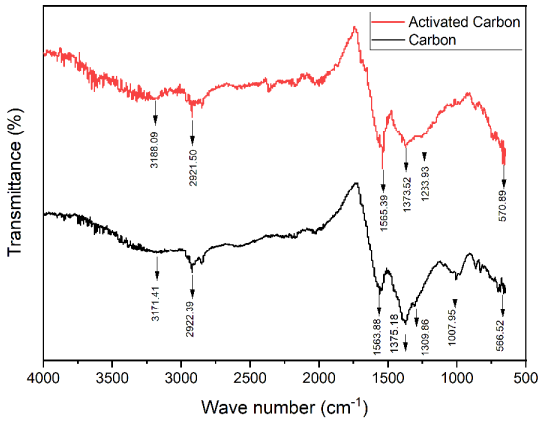

Figure 1. FTIR of Carbon and Activated Carbon from Kepok Banana Peels

3.2 Adsorption Test Results of Carbon and Activated Carbon of Kepok Banana Peel against Methylene Blue

3.2.1 Determination of the Optimum Mass of Carbon Adsorption and Activated Carbon of Kepok Banana Peel against Methylene Blue

One of the things that affects the adsorbent's adsorption of dyes is the weight of the adsorbent. To optimize the adsorption power, it is necessary to determine the optimum weight of the banana peel used.

Table 1. Adsorption Capacity Calculation Results Based on Variation of Carbon Mass and Activated Carbon

Mass (grams)	C_e (PPM)		Adsorption Capacity (mg/g)		Adsorption Efficiency (%)	
	Carbon	Activated Carbon	Carbon	Activated Carbon	Carbon	Activated Carbon
0,05	19,7642	19,8527	19,7642	19,8527	98,8212	99,2633
0,1	19,8422	19,9674	9,92109	9,98369	99,2109	99,8369
0,3	19,7747	19,8625	3,29579	3,31041	98,8736	99,3124
0,5	19,6221	19,7531	1,96221	1,97531	98,1107	98,7656
0,7	19,6117	19,6811	1,40083	1,40579	98,0583	98,4054

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In Table 4.5, it can be seen that the optimal adsorbent mass is 0.1 gram for carbon and activated carbon. At a mass of 0.05 grams, it increased to 0.1 grams with an adsorption efficiency of 99.2109% on carbon and 99.7577% on activated carbon. Then, at a mass of 0.1 grams to 0.7 grams began to experience a decrease or saturation of the adsorbent. The decrease in absorption efficiency is due to overlapping events during the adsorption process as a result of the density of adsorbent particles. The density causes the surface area of the adsorbent to become smaller so that the active side of the adsorbent decreases.

3.2.2 Determination of Optimum Time for Carbon Adsorption and Activated Carbon of Kepok Banana Peel against Methylene Blue.

One of the factors that can affect the absorption process is contact time. Determination of adsorption equilibrium time aims to determine the optimum time required by kepok banana peel carbon adsorbent in the absorption of methylene blue dye.

Table 2. Adsorption Capacity Calculation Results Based on Contact Time Variations

Time (Minutes)	C_e (PPM)		Adsorption Capacity (mg/g)		Adsorption Efficiency (%)	
	Carbon	Activated Carbon	Carbon	Activated Carbon	Carbon	Activated Carbon
30	19,8034	19,9299	9,90170	9,96496	99,0170	99,6496
60	19,8422	19,9515	9,92109	9,97577	99,2109	99,7577
90	19,9136	19,9674	9,95678	9,98369	99,5678	99,8369

The longer the contact time used, the higher the percentage of adsorption efficiency on methylene blue. This can occur due to the collision between the adsorbent and the methylene blue dye, so that the methylene blue dye absorbed by carbon and activated carbon from kepok banana peel is getting more and more. The more active groups on the kepok banana peel activated carbon that binds to methylene blue. When there are many collisions, the reaction will take place quickly as well.

4. CONCLUSION

The conclusion of this research is that the FTIR results of carbon and activated carbon from kepok banana peel have similar functional groups as the constituent components which indicate that the carbon and activated carbon do not eliminate the original functional groups or the original nature of the constituent components. The optimum mass of carbon and activated carbon is obtained at a mass of 0.1 grams and the effectiveness of adsorption decreases with the addition of the mass used. The optimum time obtained in methylene blue adsorption using carbon and activated carbon is 90 minutes and the longer the time used, the more the effectiveness of adsorption obtained increases.

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