Removal of methylene blue though activated carbon made from non-fibrous materials

Names of members: Tew Yang Zhi, Coen, Lin Fangzhe, Brian Lee Jun Siang, Tan Shiuan Kai Jayden

Group ID: 01-03

Abstract

Activated carbon was prepared from mangosteen and orange peels and used for the removal of methylene blue from aqueous solutions. This study aims to find out whether the fibrosity would affect the effectiveness of the activated carbon's adsorption. It also aims to find out which of the 2 peels would be most effective in removing methylene blue. Activated carbon of both fruit peels was obtained by chemical activation through potassium hydroxide, by heating in an oven at 400°C for 40 minutes. The activated carbon was then soaked in methylene blue solution overnight. The centrifuge was then used to ensure a suitably low amount of activated carbon would be inside the cuvettes when testing for absorption in the UV spectrophotometer. The UV spectrophotometer was used to obtain the absorbance levels of each form of activated carbon. The activated carbon made from orange and mangosteen peels both had an adsorbance rate of 99.8%, proving it to be highly effective at the removal of methylene blue. The fibrosity does not significantly alter the results obtained by the individual activated carbon as orange peels had a higher fibre content than that of the mangosteen peels.

1. Introduction

Activated carbon, also called activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. Activated carbon sorption is highly effective for the removal of dyes and pigments as well as other organic and inorganic pollutants. (B. Acemioğlu, 2005.) Wastewater from textiles, cosmetics, printing, dying, food processing, and paper-making industries is polluted by dyes. Discharge of these colored effluents presents a major environmental problem for developing countries because of their toxic and carcinogenic effects on living beings. (B. Acemioğlu, 2004). There are two basic processes to activate carbon materials, physical and chemical. The temperatures used in chemical activation are lower than that used in the physical activation process. As a result the development of a porous structure is better in the case of chemical activation. Chemical activation can be accomplished in a single step by carrying out thermal decomposition of a raw material with chemical reagents. Mangosteen peels only consisted of 4.5% of fibre and orange peels had 61-69% fibre(JoséA, Pilar, 1998). Chemical activation was used using potassium hydroxide(KOH).

Methylene Blue is a synthetic basic dye, an organic chloride salt having 3,7-bis(dimethylamino)phenothiazin-5-ium as the counterion. A commonly used dye that also exhibits antioxidant, antimalarial, antidepressant and cardioprotective properties. We wanted to use coconut husk to see if the adsorption of methylene blue is better at adsorption of methylene blue. We sadly did not have enough time so we used commercial activated carbon which is said to have nearly 100% adsorption.

Not a lot of projects have been done about testing if the fibrosity affects the effectiveness of adsorption by the activated carbon. By doing this project, people would be able to gain knowledge about whether the fibrosity affects how much methylene blue is adsorbed by the activated carbon. There are not a lot of tests done on mangosteen peel made activated carbon to adsorb methylene blue, as found on the internet, so by doing this study, more people can find out about mangosteen peel made activated carbon's adsorbance. Even though orange peel activated carbon has been done many times, it has not really been compared to other fruits or materials, so by doing this study, people would know which kind of activated carbon is better for adsorbing substances.

2. Objectives and hypotheses

Independent variable	Orange and Mangosteen peels
Dependent variable	Percentage decrease in concentration of methylene blue due to adsorption by activated carbon made by the fruit peels.
Controlled variable	1. Volume of methylene blue solution (30ml) 2. Amount of time activated carbon is in the methylene blue solution (15.5 hours) 3. Amount of activated carbon placed in the methylene blue solution (0.2g)

	4. Speed at which the orbital shaker spins (150 rounds per minute)

The objective of this experiment is to find out which form of activated carbon, orange or mangosteen peel, fibrous or not as fibrous, is the most effective in the removal of methylene blue.

Hypothesis: Orange peels are more effective in removing methylene blue dye from water than mangosteen peels

3. Methods and Materials

3.1 Materials

Orange peels and mangosteen peels were purchased from a neighbourhood supermarket. Potassium hydroxide, with a concentration of 56.11 mg/litre was obtained from GCE. Methylene blue, with a concentration of 50 parts per million (ppm) / litre and commercial activated carbon were purchased from Unichem.

3.2 Obtaining potassium hydroxide solution

56.11 g of solid potassium hydroxide was placed in deionised water and immediately placed in a water bath for around 10 minutes to prevent too much heat from being liberated. The solution was then transferred to a 1 litre volumetric flask and topped up with deionised water until the solution hit the 1 litre mark. The 1 litre volumetric flask was mixed thoroughly before the solution was transferred into a 1 litre plastic bottle for storage.

3.3 Obtaining Methylene Blue solution

50 ppm of methylene blue was added to a 50 ml beaker and mixed with deionised water. The solution was then added to a 1 litre volumetric flask. Deionised water was then added until the solution reached the 1 litre mark. The mixture was then mixed 5 times then transferred into a 1 litre plastic container for storage.

3.4 Obtaining methylene blue maximum wavelength and absorbance calibration curve

The wavelength was determined by placing the 50 ppm solution in a cuvette and placing it in the UV spectrophotometer. To obtain the calibration curve, the methylene blue was split 1, 2, 3, 4, 5 ppm concentrations. This was done using a micropipette and setting them to 0.2, 0.4, 0.6, 0.8 and 1 ml to obtain 1, 2, 3, 4 and 5 ppm solutions respectively, with triplicates. The individual solutions were then poured into individual 10ml volumetric flasks. 15 volumetric flasks, each of 10 ml were used. The solutions were diluted with deionised water until the 10 ml mark was reached. The solutions were then mixed well. The solutions were then transferred into individual cuvettes and placed into the UV spectrophotometer to test for absorbance and the average of the 3 were taken.

3.5 Obtaining activated carbon

Orange and mangosteen peels were cut into pieces of 1.7 cm by 1.7 cm. The pieces were then placed in a furnace to be dried at 70 °C overnight so that most of the moisture would be removed. 200 g of the dried pieces were placed in a 500 ml beaker and potassium hydroxide solution was added until the total volume reached 500 ml. The dried peels were then activated in a furnace at 400 °C for 40 minutes. The activated carbon was then rinsed continuously, with deionised water, until it had a pH of 7. The mixture was then left to dry. The dried activated carbon was then grinded with a mortar until it was in powdered form.

3.6 Mixture of activated carbon and Methylene Blue

0.2 g of activated carbon was placed into 30 ml of Methylene Blue solution. This process was repeated so that there will be 3 sets of orange activated carbon, 3 sets of mangosteen peel activated carbon and 3 sets of commercial activated carbon. 40 ml of methylene blue solution with no activated carbon was also added as the control. The 10 mixtures were placed on a shaker for 18 hours at 150 rounds per minute.

3.7 Obtaining filtered solutions and results

The shaker was turned off and the mixtures were left to settle for 10 minutes. The mixtures were then poured into centrifuge tubes. The mixtures were poured into individual centrifuge tubes until the 12 ml mark was reached. The centrifuge tubes were then placed in the centrifuge and spun for 10 minutes at a speed of 13000 rounds per minute. The mixtures were then taken out of the centrifuge and transferred into a 1 cm by 1 cm cuvette, using a dropper. The cuvettes were then placed into the UV spectrophotometer, which was set to the wavelength of 664nm to collect the final readings. The Beer–Lambert equation, $C = A/\varepsilon L$, where C is the concentration of methylene blue left after adsorption, A is the absorbance of light at 664 nm and εL is the gradient derived from the calibration curve, where ε is the constant and L is the path length of the cuvette, is used to obtain the concentration of methylene blue left, in terms of ppm. The equation, $(50 - C) / 50 \times 100\%$ was used, where 50, in terms of ppm, is the starting concentration of methylene blue before the experiment and C is the concentration of methylene blue left after adsorption, to obtain percentage of methylene blue adsorbed by activated carbon.

Figure 1.

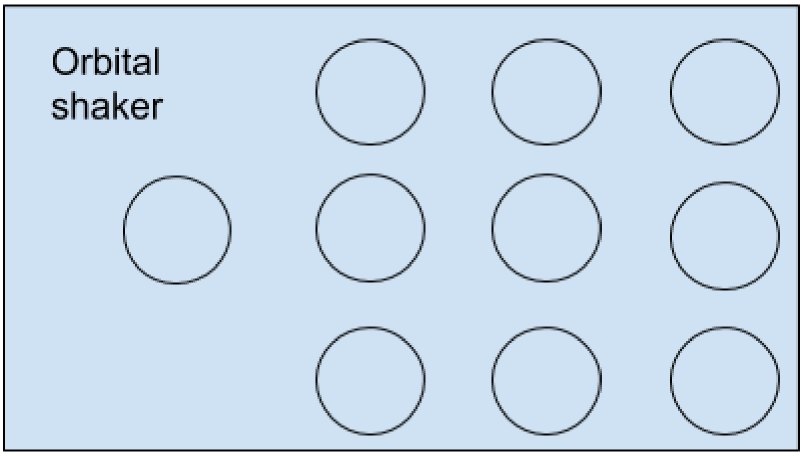


Figure 1. Arrangement of methylene blue and activated carbon mixture on orbital shaker. The 1st row is commercial activated carbon. The 2nd row is the orange peel activated carbon with the normal methylene blue solution (50ppm) as the control on the extreme left. The 3rd row is the mangosteen peel made activated carbon.

4. Results and Discussion

4.1 Methylene blue chemical structure

Figure 1.

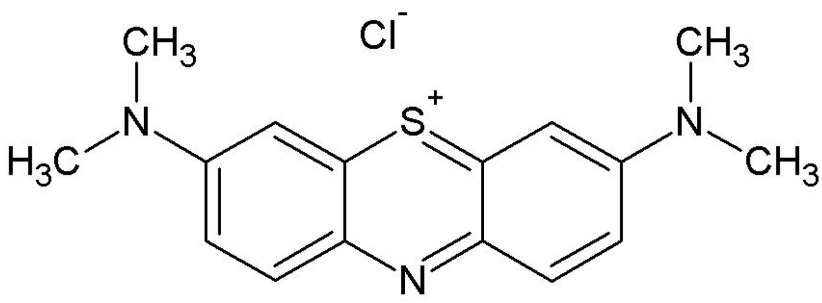


Figure 1. shows the chemical structure of methylene blue, with a chemical formula of C16H18ClN3S.

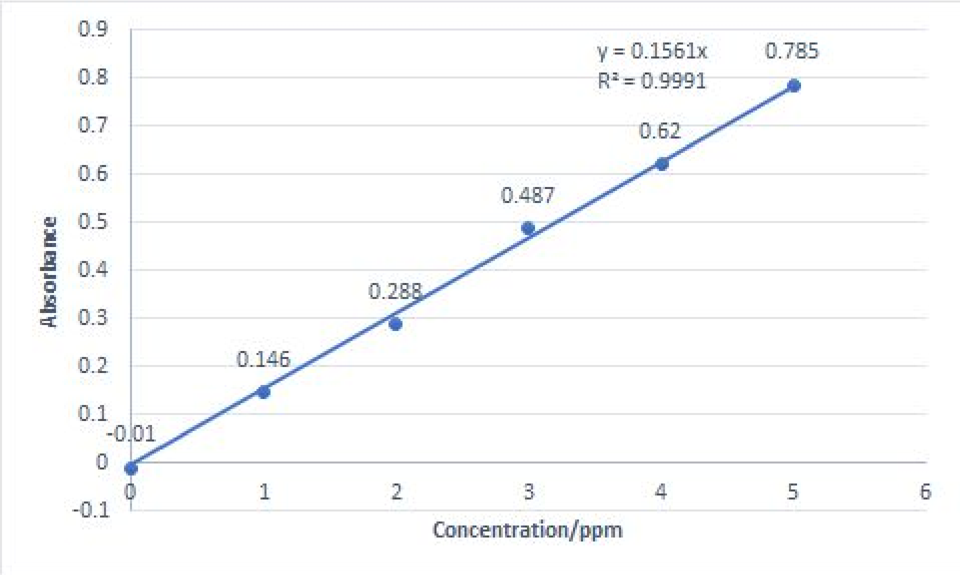
4.2 Calibration curve and wavelength

The use of the calibration curve is to find out the εL value of our methylene blue solution so that we can substitute it into the Beer–Lambert equation to find out the percentage of the methylene blue adsorbed by activated carbon.

Table 1.

	Absorbance at 664 nm by methylene blue at different concentrations				
Reading	1 ppm	2 ppm	3 ppm	4 ppm	5 ppm
1	0.148	0.292	0.471	0.601	0.770
2	0.152	0.263	0.495	0.621	0.809
3	0.137	0.310	0.496	0.637	0.777
Average	0.146	0.288	0.487	0.620	0.785

Table 1. Absorbance of methylene blue at different concentrations at 664 nm



Graph 1. Calibration curve of methylene blue with a concentration of 50ppm using the UV-spectrophotometer.

4.3 Raw Readings of Activated Carbon

Table 2.

	Absorbance by Methylene Blue at 664 nm		
Readings	Commercial activated carbon	Mangosteen peel	Orange peel
1	0.001	0.001	0.002
2	0.002	0.015	0.026
3	0.005	0.014	0.016

4	0.015	0.013	0.002
5	0.006	0.011	0.002
6	0.003	0.004	0.01
Average	0.005333 ± 0.005086	0.00966667 ± 0.00578504	0.00966667 ± 0.00983192

Table 2. Raw readings of absorption in the UV spectrophotometer

4.4 Results

Table 3.

Type of activated carbon	**Absorbance at 664 nm**	**Concentration of methylene blue / ppm**	**Percentage of methylene blue adsorbed by each activated carbon**
Commercial	0.005±0.005	0.0320	99.9%
Mangosteen peel	0.009±0.009	0.0576	99.8%
Orange peel	0.009±0.005	0.0576	99.8%

Table 3. Results after calculation of the percentage of methylene blue adsorbed by the different activated carbon.

4.5 Discussion of results

From Table 3, the results of our raw readings are obtained from the UV-spectrophotometer at absorbance level of 664 nm. From the table, both fruit peels performed very well, with an effectiveness of 99%, as the amount of light absorbed by the UV spectrophotometer was very low. Furthermore, the average absorbance of both the orange and mangosteen peel activated carbon were equal.

The percentage of methylene blue adsorbed by each form of activated carbon was further found out by using the calibration curve, instead of using just raw readings as results. Hence, we can see that the percentage of methylene blue absorbed, for both types of activated carbon, is 99.8 %, close to 100 %, showing that the activated carbon from the peels are highly effective and as good as commercial activated carbon, all of which have an adsorbance rate of nearly 100 %. The readings of orange and mangosteen peel activated carbon are equal, showing that the fibrosity of the activated carbon does not clearly affect how it adsorbs methylene blue. This means that it would be equally as good to use non-fibrous materials to remove dyes like methylene blue. Our hypothesis cannot be 100% correct as the mangosteen peel made activated carbon performed as well as the orange peel made activated carbon.

A study was done using mangosteen peels to remove Rhodamine B dye. The Rhodamine B dye had a wavelength of 554nm. The mangosteen peels were also activated with KOH. The results were not as similar to this study as their aims were different but the amount of activated carbon the study used were the same as this study. In another study for orange peel activated carbon, the same amount of activated carbon was used but the results were not very favourable. Most studies were unusable as it only shows the abstract and not a lot of the results, so not a lot of information could be collected, but the most were made out of the resources. Even though the results were not favourable, this study should still be successful as all the variables and conditions were kept constant.

4.6 Explanation of results

Orange peels can be converted into high quality mesoporous activated carbon. Mesopores exhibit extremely narrow pore size distributions in the range of 0.5 – 2 nm. The developed pore structure of activated carbon is very useful for attachment of substances. As liquid or air comes into contact with activated carbon, intermolecular forces draw molecules into the millions of pores and pockets on the surface of activated carbon. Some of the forces are van der waals forces and hydrogen bonding. The elemental force causing physical adsorption on activated carbon is the London dispersion force, a form of Van der Waals force, resulting from intermolecular attraction. In the case of adsorption, carbon and the adsorbate are thus chemically unchanged. Given that there are so many pores, resulting in the large surface area, a small amount of activated carbon can absorb a lot of impurities. The 2 types of activated carbon have very similar Brunauer–Emmett–Teller (BET) surface area, mostly above 1000 m^2/g. With about the same surface area and such a large surface area, the activated carbon would be able to adsorb a large amount of methylene blue, resulting in similar results.

5. Conclusion and Recommendations for future work

Two types of activated carbons, one made from orange peel and the other from mangosteen peel, were prepared from fruit-biomass wastes by chemical activation with KOH. These activated carbons were characterized in terms of fibrosity. 0.2 g of activated carbon was placed in a solution of methylene blue (30 ml) to sit on an orbital shaker for 18 hours, shaking at 150 rounds per minute. The solution were then transferred to the centrifuge to remove the activated carbon. It was then transferred to cuvettes to be tested for absorption using the UV spectrophotometer. The results obtained were then calculated using the Beer–Lambert equation. The final results showed that the fibrosity of the activated carbon does not affect how much methylene blue it adsorbs as the final results are the same, with both at 99.8 % adsorbance. The hypothesis was not 100% accurate as the final readings were the same.

The activated carbon could be further used for removing other dyes and oil spills in the lakes. Given that there are dye spills in the world, like the recent red dye spill in Stony Creek, Melbourne, Australia and Plum Island Wastewater Treatment Plant, across the Ashley River from downtown Charleston. The readily available activated carbon can be used to effectively remove the dye from the lake or sea. However, one problem with this is that the activated carbon may not be effectively removed as activated carbon is very small and may settle to the bottom of the lake. Activated carbon may be able to remove impurities in the air, given how polluted our planet is. This way, the air will not be as polluted, slowing down climate change.

As banana peels are common, the peels can be easily used to make activated carbon. Banana peels were going to be included in the experiment but there was a lack of time, so it will be placed under further studies. Purifying air could also be an option as activated carbon is usually used for purifying water and results could be compared to find out effectiveness of activated carbon in different medias. Air pollutants include carbon dioxide, sulfur dioxide from burning fossil fuels. Different types of dyes like methyl orange and congo red could be used to show the versatility of activated carbon.

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