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Research Article

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Adsorption of Methylene blue dye on activated carbon from rice husk

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ABSTRACT

Adsorption of Methylene blue on activated carbon obtained from Rice husk has been investigated by batch adsorption method. The percentage removal of dye has been optimized by studying the initial concentration of the dye, adsorbent dosage, adsorption time and pH. The highly porous activated carbon removed about 66% of the dye. The experimental data were found to be well fitted to Langmuir isotherm. This indicated the monolayer adsorption of methylene blue on the adsorbent.

Key words: Methylene blue, Rice husk, Activated carbon, Langmuir adsorption isotherm

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INTRODUCTION

Dyes are used as colouring agents in many of the industries such as textiles, paper, rubber, cosmetics, plastics, carpet, printing, etc. Waste water discharged from these industries pollutes the environment especially the aquatic ecosystem. The toxic nature of the dyes affects the aquatic life when they are discharged into the rivers, streams, ponds, lakes, etc. The dyes even in very small concentration are visible to the naked eye and they affect the photosynthesis, food chain and food web [1]. Since the organic dyes are harmful to human beings, it is very important to remove them from the effluent coming from these industries. The conventional physiochemical, biological treatments etc are ineffective for the removal of organic dyes because of their complex structure.

Chemical oxidation [2], electro dialysis [3], adsorption [4], biodegradation [5], photo catalysis [6], coagulation [7] etc. are some of the techniques used for the removal of dyes from the effluent. In all these methods, adsorption onto activated carbon seemed to be effective for the removal of dye [8]. The commercial activated carbon is costly and there are problem with regeneration [9]. Agricultural by-products are found to be more economical sorbent. There are a large number of studies on the adsorption onto activated carbon prepared from agricultural wastes [10, 11] such as saw dust [12], nut shells [13], fruit stones [14], oil palm waste [15], sugarcane [16] etc. Activated carbon from these agricultural waste products on chemical modification has enhanced adsorption capacities. These can adsorb either anionic or cationic dyes.

In all the rice producing countries one of the important agricultural wastes is rice husk. For every 1000kg of rice, about 22% of husk is produced [17]. Rice husk has very high ash content which is light in weight, highly porous and has a large surface area. Hence, the activated carbon prepared from rice husk can be used as an adsorbent [18].

The present work is based on the adsorption capacity of the activated carbon from the rice husk. Methylene blue dye was chosen as adsorbent because of its known strong adsorption onto solids. The kinetic data and equilibrium data of adsorption were studied to understand the adsorption mechanism of the dye molecules into activated carbons.

EXPERIMENTAL SECTION

2.1. Materials and Methods

2.1.1 Preparation of activated carbon

Rice husk was collected and washed several times with water to remove the sand, ash and dust particles. Then it was dried overnight in an oven. The dried sample was activated by soaking in concentrated sulphuric acid and kept in a furnace at a temperature of about 600°C for two hours. The charred sample was then washed with sodium bicarbonate and with distilled water. This activated carbon was dried in an oven overnight. The activated carbon thus obtained is powdered and activated carbon in the particle size of 0.3 – 0.5mm was used for the study.

Methylene blue (Aldrich) was used as the adsorbate without any further purification. A stock solution of 100ppm was prepared and diluted for the desired concentrations. Double distilled water was used for preparing all the solutions and reagents.

2.2 Adsorption Experiment Methods

The experimental parameters for all the experiments were selected as initial concentration, adsorbent dosage, contact time and pH, Batch adsorption experiments were conducted in a mechanical shaker with 120rpm at room temperature.

2.2.1. Analysis of Methylene blue

The concentrations of methylene blue in the supernatant solution before and after adsorption were determined using a double beam UV spectrophotometer at 668nm.

2.2.2 Effect of initial concentration

100ml volume of dye solution having initial concentrations of 2.5, 5.0, 7.5, 10.0, 12.5, 15.0 and 17.5ppm were taken. 0.1g of the activated carbon was added to each of the flask. This was shaked in a mechanical shaker for about one hour. Then the supernatant solution was centrifuged and the concentration of the methylene blue present in the solution was measured.

2.2.3 Effect of adsorbent dosage

The effect of adsorbent dosage was studied by varying the amount of activated carbon from 0.025g to 0.5g. Samples of adsorbent were added to each of 100ml dye solution containing 10ppm of dye at the room temperature and adsorption was studied at an adsorption time of 120min.

2.2.4 Effect of contact time

0.1g of the adsorbent was added to each of 100ml of the dye solution having a concentration of 10ppm and adsorption was studied at various times ranging from 30min to 150min.

2.2.5 Effect of pH

The effect of pH was studied at three different pH of 4.0, 7.0 and 10.0. Samples of 0.1g of adsorbent were added to each of 100ml dye solution containing 10ppm of dye at the room temperature and adsorption was studied at an adsorption time of one hour with constant shaking. The pH was adjusted by adding sulphuric acid and sodium hydroxide solution.

2.2.6 Adsorption Isotherms

The adsorption isotherms that have been tested are Freundlich isotherm and Langmuir isotherm.

RESULTS AND DISCUSSION

3.1 Effect of initial dye concentration

The relationship between initial dye concentration and the adsorbed percentage of dye is illustrated in figure 1 for an adsorbent dosage of 0.1g. It has been found that the amount of the dye adsorbed increases from 1.1ppm to 3.0ppm as the initial concentration increases. But it can be seen from the figure that the percentage of the adsorbed decreases. It can be concluded that the rate of dye binding is high initially and which gradually decreased and becomes almost constant after sometime.

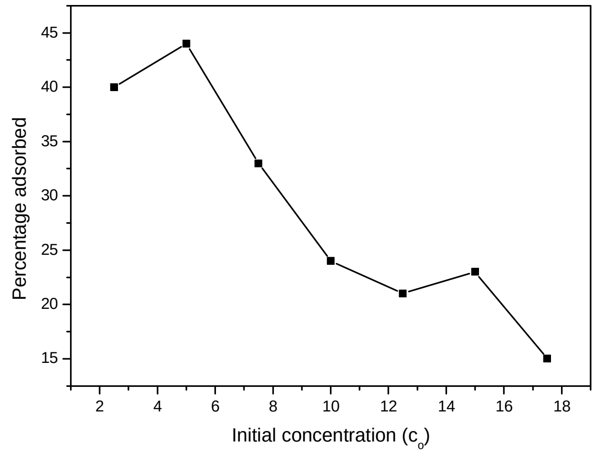

Fig. 1 Effect of Initial Dye Concentration

3.2 Effect of adsorbent dosage

The effect of adsorbent dosage is shown in the figure 2. The amount of the dye adsorbed increases from 2.0ppm to 6.4ppm as the dosage of the dye increases from 0.005 to 0.25g. Hence, it can be concluded that the increase in the adsorbent dosage increases the adsorption. This increase in adsorption may be due to the presence of large surface area which in turn provides more adsorption sites.

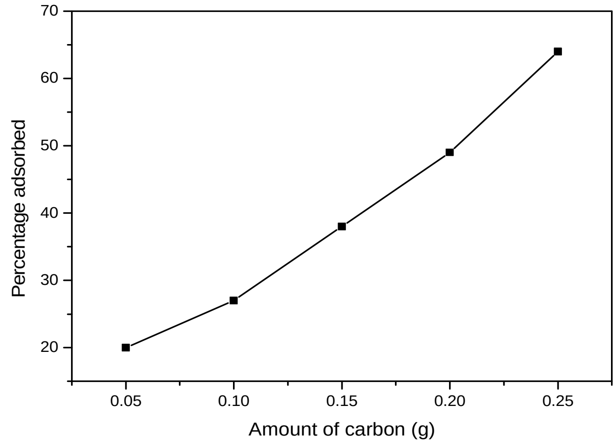

Fig. 2 Effect of Adsorbent Dosage

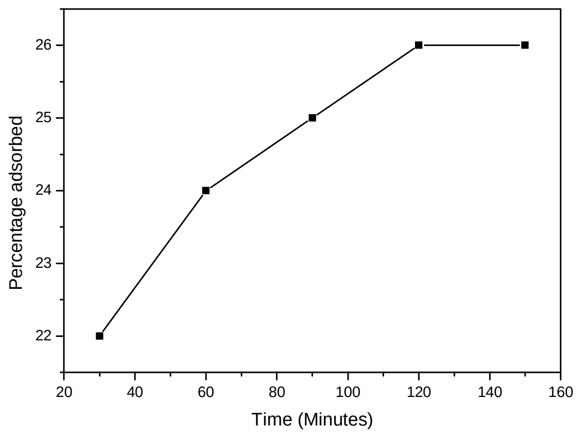

Fig. 3 Effect of Contact Time

3.3 Effect of contact time

The removal of dyes as a function of time is shown in the figure 3. It has been found that as the contact time increases from 30min to 150min the amount of the adsorbed dye increases from 2.2ppm to 2.6ppm. It has been also noted that the maximum adsorption occurs at 120min and after that it almost remains constant.

3.4 Effect of pH

The relationship between the pH and the percentage adsorbed is shown in the figure 4. The amount of the dye adsorbed increased from 3.2ppm at the acidic pH of 3.0 to 6.2ppm at the basic pH of 10.0. It can be noted that at higher pH the binding capacity the dye increased due to the cationic characteristics of the dye.

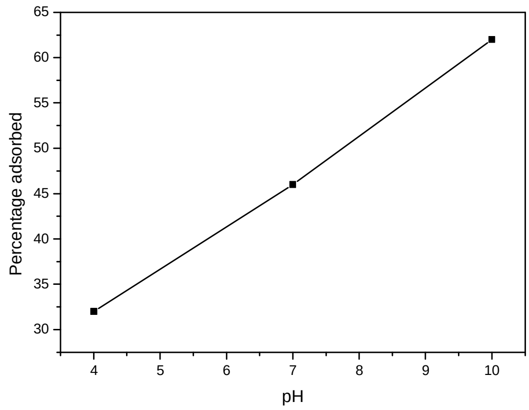

Fig. 4 Effect of pH

3.5 Adsorption Isotherms

Several models of adsorption isotherm are available in the literature. The most common among them are Freundlich and Langmuir isotherm. In the present study the data obtained were tested for these two isotherms to study the relationship between the amounts of dye adsorbed with the equilibrium concentration and to find out the possibility of monolayer or multilayer adsorption.

The linear logarithmic form of Freundlich isotherm is given by,

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n}\log C$$

where x/m is the amount of dye adsorbed, C the equilibrium concentration, k and n are the constants. When $\log\left(\frac{x}{m}\right)$ was plotted against $\log C$ a straight line was obtained with slope $\log k$ and y – intercept. The values of Freundlich constants 1/n and k are given in Table 1. The value of n is 2.49 which indicates the favourable adsorption between 1< n < 10 [19]. The value of n is favourable for adsorption but Freundlich isotherm is less fitted to the present adsorption study due to the less correlation coefficient value of 0.7388.

The linear form of Langmuir isotherm is given by,

$$\frac{C_e}{x/m} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

where Q_o is the equilibrium constant, b is monolayer capacity, C_e is the equilibrium concentration and $\frac{x}{m}$ is the amount adsorbed per unit mass of the adsorbent. A straight line was obtained when $\frac{C_e}{x/m}$ was plotted against C_e with a correlation coefficient of 0.9252 indicating that the present study of data follow Langmuir isotherm. The Langmuir constants are given in Table 1.

Table 1: Freundlich and Langmuir isotherm constants

Isotherm	Parameters
Freundlich Isotherm	k = 11.08 n = 2.49 R^2 = 0.7388
Langmuir Isotherm	Q_0 = 33.78 b = 0.421 R^2 = 0.9252

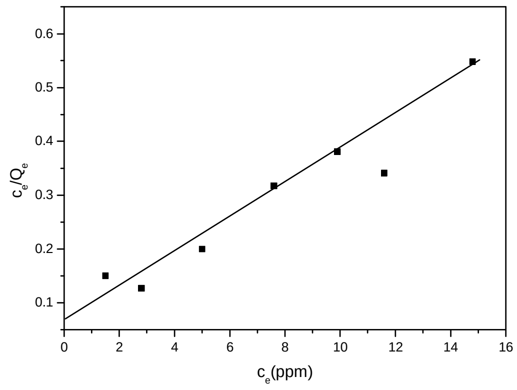

Fig. 5 Langmuir Adsorption Isotherm

Confirmation Langmuir isotherm indicates the homogeneous surface of rice husk activated carbon and monolayer adsorption.

CONCLUSION

The present study indicates that activated carbon obtained from rice husk is an effective adsorbent of Methylene blue dye. The extent of adsorption decreases with increase in initial dye concentration, increases with increase in adsorbent dosage, adsorption time and pH. The adsorption of Methylene blue dye on activated carbon obeys Langmuir adsorption isotherm indicating the homogeneous surface of the adsorbent and monolayer adsorption.

REFERENCES

[1] G McKay; A Sweeney. *Water, Air, Soil Pollut.*, **1980**, 14, 3-11.
[2] SM Mc Clung; AT Lemley. *Text. Chem. Color*, **1994**, 26, 17-22.
[3] J Oakes; P Gratton. *J.Chem. Soc., Perkin Trans.*, **1998**, 2 (10), 2201-2206.
[4] S Papic; N Koprivanac; A Loncaric Bozic. *J.Soc. Dyers Color*, **2000**, 116, 352-358.
[5] K Kadir Velu; C Karthika; N Vennilamani; S Pattabi. *Chemosphere*, **2005**, 60, 1009-1017.
[6] SH Lin; CC Lo. *Environ. Technol.*, **1996**, 17, 841-849.
[7] D Pak; W Chang. *Water Sci. Technol.*, **1999,** 40, 115.
[8] PK Malik. *Dyes pigments*, **2002**, 56, 239-249.
[9] P Janos; M Buchtova. *Water Res.*, **2003,** 37, 4938-4944.
[10] K Kadirvelu; C Namasivayam. *Adv. Environ. Res.*, **2003**, 7, 471.
[11] A Nag; N. Gupta; MN Biswaas. *Indian J. Environ. Prrot.*, **1999**, 19, 19.
[12] F Marquez – Monterinos; T Cordero; J Rodriguez-Mirasol; J J Rodriguez. *Sep. Sci. Tecnol.*, **2001**, 36, 3191.
[13] K Mohanty; M Jha; BC Meikap; M N Biswas. *Chem. Eng.Sci.*, **2005**, 60, 30.
[14] MG Lessier; JC Shull; DJ Miller. *Carbon*, **1994**, 32, 1493.
[15] CA Lua; J Guo. *Carbon*, **1998**, 36, 1663.
[16] JB Castor; PR Bonelli; EG Cerella; AL Cukierman. *Ind. Eng. Chem. Res.*, **2000**, 39, 4166.
[17] D Koteswara Rao; Pranav. *Int. J. Engg. Sci. Tech.* **2011**, 3(11), 8076-8085.
[18] Cristina Dolly Grandos; Rosa Venturini. *Eng. Chem. Res.*, **2008**, 47, 4754 -4757.
[19] R. Sivaraj; C Namasivayam; K Kadirvelu. *Waste Manange.*, 2001, 21, 105-110.