INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACY AND CHEMISTRY

Available online at www.ijrpc.com

Research Article

ADSORPTION OF METHYLENE BLUE DYE USING ACTIVATED CARBON FROM THE NATURAL PLANT STEM

KA. Syed Abuthahir[1], C. Pragathiswaran[2], P. Govindhan[2], B. Mahin Abbubakkar[3] and VS. Sridevi[2]

[1]Department of chemistry, Dr. Zakir Hussain College, Ilyangudi-630 702, Tamil Nadu, India.
[2]Department of chemistry, Periyar E.V.R. College (Autonomous), Tiruchirappalli-620 023, Tamil Nadu, India.
[3]Department of Chemistry, Rani Anna College for Women, Thirunelvelli, Tamil Nadu, India.

ABSTRACT

The analysis of this work was to research the removal of methylene blue dyes from solution by using Acid Aloe Vera stem Carbon (AVS). Generally, dyes are organic compounds used as colouring products in chemical, textile, paper, printing, leather, plastics and varied food industries. The requirement for the treatment of dye contaminated waste water passed out from the trade. During this study, Aloe Vera stem Carbon (AVS) was studied for its potential use as associate degree adsorbent for removal of a cationic dye methylene blue. The equilibrium of surface assimilation was shapely by the Langmuir and Freundlich isotherm models. The scope of this work suggests the (AVS) is also utilized as a low cost adsorbent for methylene blue dye removal from aqueous solution.

Keywords: Acid Aloe Vera stems Carbon (AVS) Methylene blue, Adsorption isotherm.

1. INTRODUCTION

Separation of dissolved pollutants from aqueous solution, removal of impurities from targeted chemical substances, chemical recovery, and catalysis are examples of unit processes in industry that apply adsorption techniques. The adsorption technique has been successfully and extensively applied to industrial and domestic wastewater purification. Activated carbon is the most popular adsorbent for industrial use, having many advantages over most adsorbents applied in separation methods. In recent times, biosorbents from different sources including microbial[1] bacterial fungal or algal biomass[2] yeast[3] and lignocelluloses materials have been studied and applied for water purification.

In recent years it's been more and more used for the bar of environmental pollution and environmental condition laws have augmented the sales of affordable activated minerals for management the of air and pollution. Varied techniques like precipitation, natural process, chemical reaction and surface assimilation are used for the removal of venomous waste product from, wastewater. Methylene Blue (MB) is chosen as a model compound for evaluating the potential of (AVS) to get rid of dye from solution.

2. MATERIALS AND METHODS

2.1. Preparation of adsorbent materials

The poisonous plant Stem collected from agricultural space close Trichy district was with sulphuric acid and washed with water and activated around 1000 °C in a muffle furnace for 4 hrs then it had been taken out, ground well to fine powder and kept in a vacuum desiccators.

2.2. Preparation of adsorbate

Methylene blue was chosen during this work due to its robust surface assimilation onto solids and it recognized quality in characterizing adsorptive material stain is utilized to judge the surface assimilation characteristics of carbon. A famed weight of a 1000 mg of MB was dissolved in concerning one liter of water to urge the stock solution.

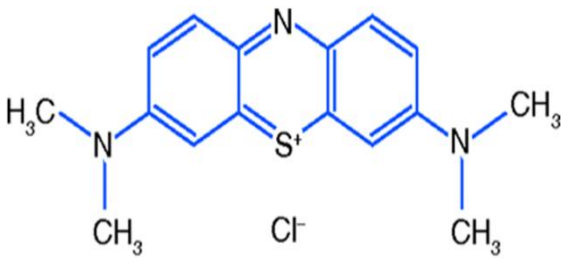


Fig. 1: Structure of Methylene Blue

2.3. Batch equilibrium method

The adsorption experiments were distributed during a batch method at 30, 40, 50 and 60˚C. A known weight of (AVS) was added to 50mLof the dye solutions with associate initial concentration of 50-250 mg/L that is ready from a 1000 mg/L of stock solution. The contents were agitated completely employing a mechanical shaker with a speed of 150 rpm. The solution was then filtered at present time intervals and also the residual dye concentration was measured.

2.4. Adsorption studies

Methylene blue (MB) was used for the adsorbate within the adsorption experiments. Adsorption from the liquid section was administrated to verify the character the consistency and therefore the capacities of the samples. A solution with quantity 50-250 mg/L was ready by intermixture an approximate amount of MB with distilled water. Adsorption experiments were conducted by putting 0.025 g of the (AVS) samples and 50 mL of the aqueous solution in a exceedingly 250 ml of glass-stoppered flask. The flask was then place in an exceedingly constant-temperature shaker bath with a shaker speed of 150 rpm. The isothermal adsorption experiments were carried out at 30 ±2°C.

3. RESULT AND DISCUSSIONS

3.1. Characteristics of the adsorbent

Acid Aloe Vera stem Carbon is an efficient adsorbent for the abatement of the many waste material compounds (organic, inorganic, and biological) of concern in water and wastewater treatment. Most of the solid adsorbents possess small porous and fine structure, high surface assimilation capacity, high surface area and high degree of surface, which consists of pores of various sizes and shapes. The wide quality of (AVS) may be a result of their specific extent, high chemical and mechanical stability. The chemical nature and pore structure typically determines the adsorption activity.

3.2. Effect of contact time and initial dye concentration

The impact of contact time on the quantity of dye adsorbed was investigated at 1000 mg/L concentration of the dye. Therefore, the optimum contact time is taken into account to be forty five min. The experimental results of adsorptions at totally different concentrations (50 to 150 mg/L) determined that percent adsorption decreased with increase in initial dye concentration; however the particular quantity of dye absorbable per unit mass of (AVS) increased ends up in increase in dye concentration. This implies that the adsorption is highly depends by initial concentration of dye. At lower concentration, the quantitative relation of the initial number of dye molecules to the available surface area is low. Later, the fractional adsorption becomes independent of initial concentration.[6,7]

However, at high concentration the accessible sites of adsorption become less and therefore the removal percentage of dye is dependent upon initial concentration.

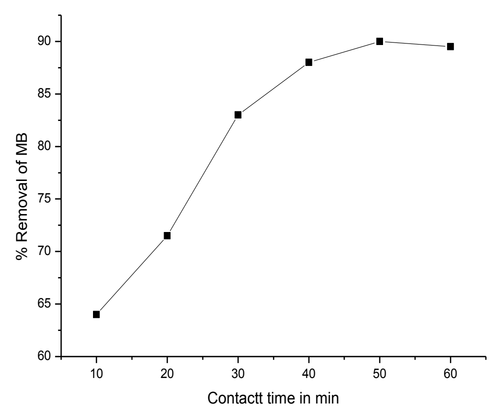


Fig. 2: Effect of contact time on the removal of MB dye [MB] = 50mg/L; Temp: 30 ˚C; Adsorbent dose = 25 mg/50 ml.

3.3 Effect of adsorbent dosage

The sorption of the MB dye on (AVS) was studied by variable the adsorbent dose (50 – 250 mg/50 ml) for fifty mg/L of dye concentration. The percentage of adsorption increased with increases in the (AVS) concentration that is attributed to increased carbon surface area and therefore the accessibility of additional sorption sites. Hence, all studies were administrated with 0.025 g of adsorbent/50 ml of the variable adsorbate solutions, 50,100, 150, 200 and 250. The Results obtained from this study are shown in Fig.3. The quantity of MB adsorbed per gram reduced with increase within the dose of (AVS). This reveals that the direct and equilibrium capacities of MB functions of the activated (AVS) dose.

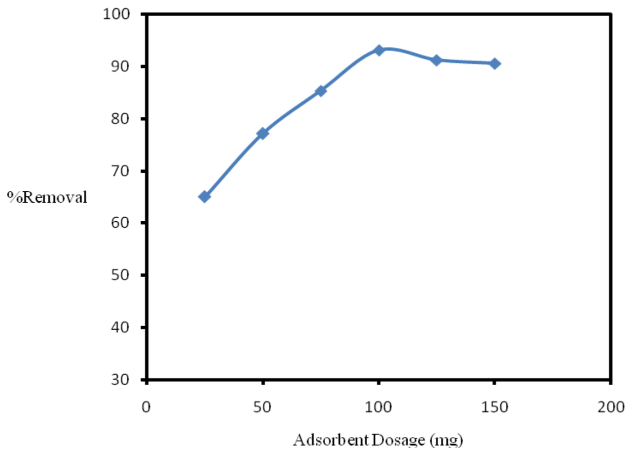


Fig. 3: Effect of adsorbent dose on the removal of MB dye [MB]=50mg/L

3.4 Effect of solution pH

The solution pH is one in all the foremost necessary factors that management the adsorption of dye on the material. The sorption capability is attributed to the chemical variety of dye within the resolution at specific pH. Additionally, owing to completely different purposeful teams on the adsorbent surface, that become active sites for the dye binding at a particular pH the result of adsorption will vary considerably. Therefore, a rise in pH could cause a rise or decrease within the adsorption, ensuing completely different optimum pH values obsessed with the kind of adsorbent. To look at the effect of pH on the sharp removal of MB dye, the solution pH were varied from 2.0 to 10.0 by adding acid and base to the stock resolution This will increase is also due to the presence of negative charge on the surface of the adsorbent. (AVS) which will be responds for the dye binding. From the experimental results, the optimum pH range varies for the adsorption of the MB dye is 2.0 to 6.5 shown in Fig.4.

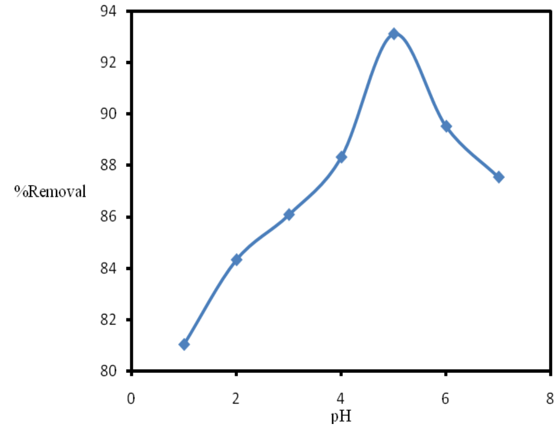


Fig. 4: Effect of solution pH of AVS

3.5. Adsorption isotherms

3.5.1 The Freundlich isotherm

The Freundlich isotherm model is that the earliest far-famed equation describing the adsorption method. It associate in nursing empirical equation and may be used for non-ideal natural process that involves heterogeneous surface assimilation. The Freundlich equation was used for the adsorption of MB dye on the adsorbent. The Freundlich isotherm was expressed by the following equation

$$\log Q_e = \log K_f + 1/n \log C_e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where Qe is that the quantity of MB dye adsorbed (mg/g), C_e is the equilibrium concentration of dye in solution (mg/L), and K_f and n area unit constants incorporating the factors affecting the adsorption capability and intensity of adsorption, respectively. Linear plots of log Q_e vs log C_e shows that the adsorption of MB dye obeys the linear plots of Freundlich adsorption isotherm. The graphs are shown from Fig.5. The relative molecular mass and size either limit or increase the chance of the adsorption of the dye onto adsorbent. However, the values clearly show the dominance in adsorption capability[4, 5]. The intensity of adsorption is a sign of the bond energies between dye and adsorbent, and therefore the risk of slight chemisorptions instead of physisorption However, the multilayer adsorption of MB through the percolation method is also attainable. The values of n are less than one, indicating the physisorption is way additional favorable.

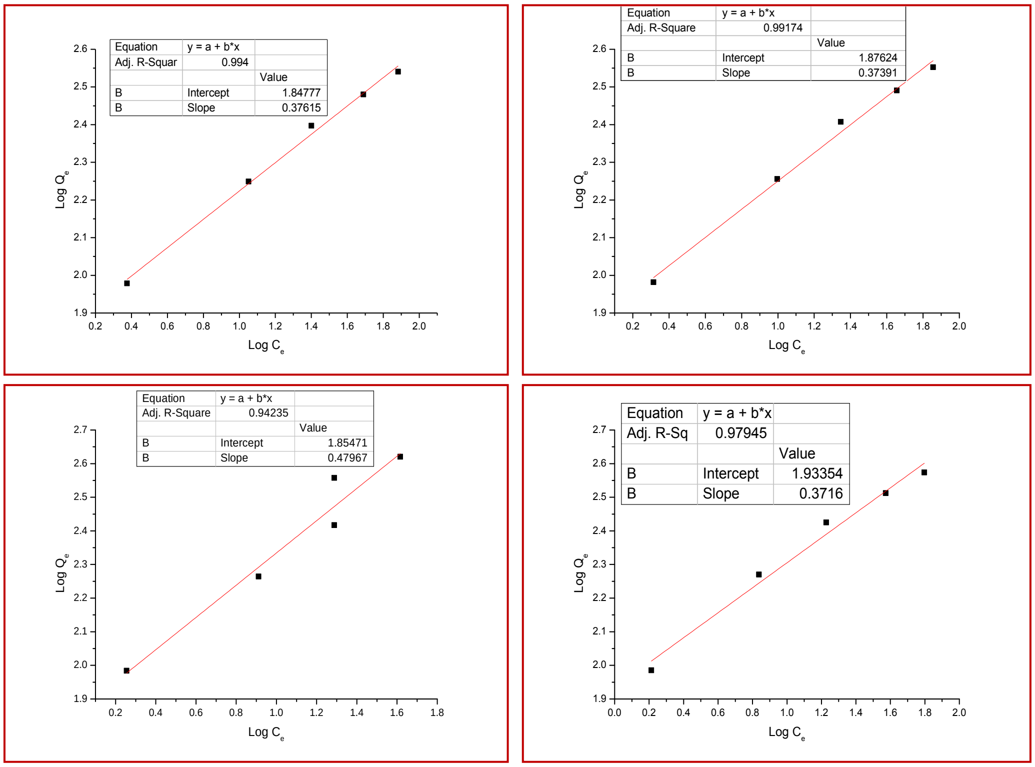


Fig. 5: Freundlich isotherm parameter for adsorption of MB dye onto (AVS) (30°c, 40, 50, 60)

Table 1: Freundlich isotherm parameter for adsorption of MB dye onto (AVS) (30 °C, 40, 50, 60)

C_0 (mg/L)	Temperature (°C)			
	30	40	50	60
50	0.1772	0.1710	0.1885	0.1320
100	0.1033	0.0923	0.1062	0.0720
150	0.0813	0.0739	0.0848	0.0590
200	0.0644	0.0887	0.0472	0.0472
250	0.0430	0.0383	0.0452	0.0409

Table 2: Dimensionless separation factor (R_L) for adsorption of MB dye onto (AVS)

Temperature		Freundlich parameter		
(°C)	R^2	K_f	n	R^2
30	0.9826	71.4206	2.6258	0.9910
40	0.9818	75.1969	2.6545	0.9929
50	0.9765	72.5648	2.0840	0.9433
60	0.9975	80.8025	2.6310	0.9782

3.6. Effect of temperature

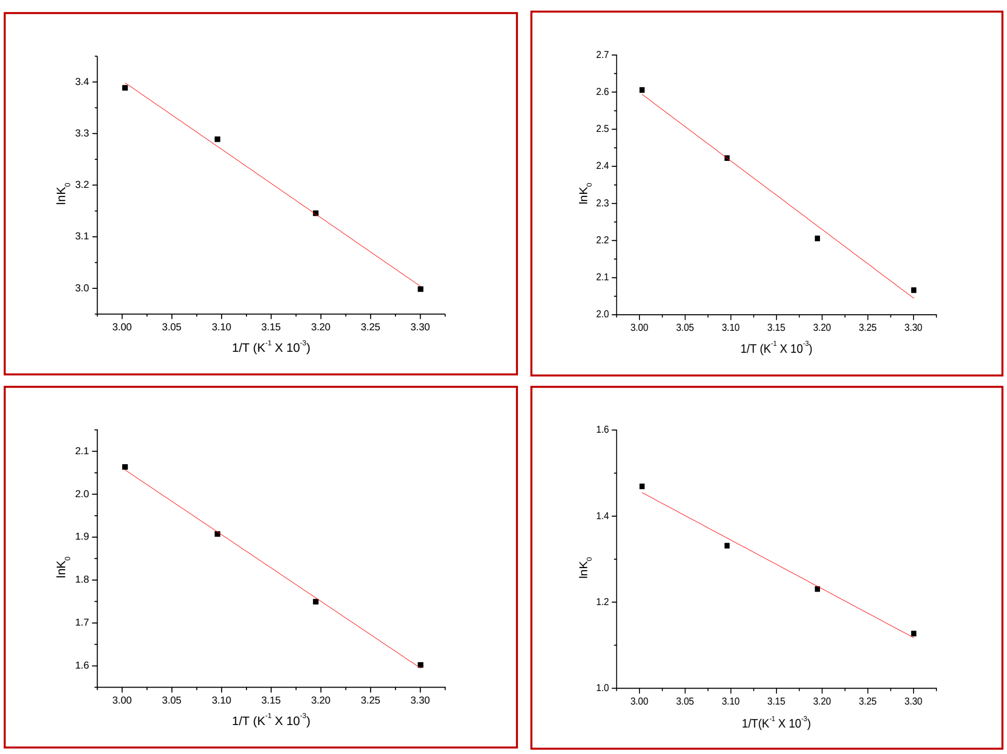
To study the result of temperature on the adsorption of dye adsorption by (AVS), the experiments were performed at temperatures of 30, 40, 50, 60°C. As it was determined that, the equilibrium adsorption capability of MB onto (AVS) was found to extend with increasing temperature, particularly in higher equilibrium concentration, or lower adsorbent dose owing to high driving force of adsorption. This reality indicates that the mobility of dye molecules increased with the temperature. The adsorbent shows the exothermic nature of adsorption. The adsorption capability of the (AVS) increased with increase of the temperature in the system from 30° to 60°C. Thermodynamic parameters like change in free energy ($\Delta G°$) (kJ/mol), enthalpy ($\Delta H°$) (kJ/mol) and entropy($\Delta S°$) (J/K/mol) were determined using the subsequent equations.

$$K_0 = C_{solid}/C_{liquid} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\Delta G° = -RT\ lnK_0 \ldots\ldots\ldots\ldots\ldots (4)$$

$$\log K_0 = \Delta S°/(2.303R) - \Delta H°/(2.303RT) \ldots\ldots\ldots (5)$$

Where K_0 is the equilibrium constant, C_{solid} is that the solid phase concentration at equilibrium (mg/L), C_{liquid} is that the liquid phase concentration at equilibrium (mg/L), T is that the temperature in Kelvin, and R is that the universal gas constant(8.314 J/K/mol). A graph has drawn between lnK_0 vs 1/T and shown the following Fig. 6. The $\Delta H°$ and $\Delta S°$ values obtained from the slope and intercept of Van't Hoff plots area given in Table 3. The values of $\Delta H°$ is that the vary of 11 to 17 kJ/mol, indicate the physisorption. The results show that physisorption is far possible for the adsorption of MB dye. The negative values of $\Delta H°$ shows the exothermic nature of adsorption that governs the chance of physical adsorption[8, 9]. As a result of within the case of physical adsorption, whereas increasing the temperature of the system, the extent of dye adsorption will increase, there's no chance of chemisorptions. The negative values of $\Delta G°$ (Table-3) shows that the adsorption is extremely favorable and spontaneous. The positive values of $\Delta S°$ (Table 3) show the increased disorder and randomness at the solid solution interface of MB dye with (AVS) adsorbent. The increasing of adsorption capability of the activated (AVS) at higher temperatures was ascribed to the enlargement of pore size and activation of the adsorbent surface.



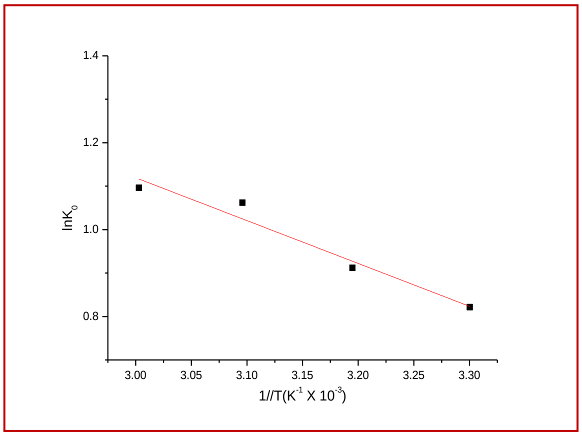


Fig. 6: Effect of temperature of MB dye onto (AVS)

Table 3: Thermodynamic parameter for the adsorption of MG dye onto AGSC

MG (mg/ L)	Ko				ΔG^0				ΔH^0	ΔS^0
	30°C	40°C	50°C	60°C	30°C	40°C	50°C	60°C		
50	17.5797	20.3830	23.5459	26.0255	-7.2217	-7.8451	-8.4831	-9.0229	-11.1016	60.5184
100	6.8492	7.8920	9.8298	11.8346	-4.8471	-5.3759	-6.1373	-6.8411	-15.5729	67.2120
150	4.2624	4.9582	5.8250	6.8304	-3.6523	-4.1663	-4.7321	-5.3194	-13.2059	55.5765
200	2.6069	2.9040	8.1000	3.7176	-2.4137	-2.7742	-5.6175	-3.6353	-17.9865	67.9137
250	1.8893	2.0794	4.3425	2.5240	-1.6026	-1.9050	-3.9434	-2.5632	-13.7887	51.2350

5. CONCLUSION

The present study has shown the effectiveness of using (AVS) is the removal of MB dye from aqueous solutions. Acid Aloe Vera Carbon stem in numerous forms contains a great role in trendy life to clean surroundings. Aloe Vera stem Carbon is often sensible precursors for manufacturing extremely porous Acid Aloe Vera stem Carbon by easy preceding strategies. An adsorption check has been administrated for industrial pollutants (MB dye) below different experimental conditions in batch mode. The adsorption of MB dye was dependent on adsorbent surface characteristics, adsorbent dose, MB dye concentration, time of contact and temperature. From the ΔG^0, ΔH^0 and ΔS^0 values reveal the process is a spontaneous, exothermic and physical adsorption.

REFERENCES

1. Z. Aksu, S. Tezer, Equilibrium and kinetic modelling of biosorption of Remazol Black B by Rhizopus arrhizus in a batch system: effect of temperature. Proc. Biochem. 2000, 36, 431.
2. S. Tunali, I. Kiran, T. Akar, Chromium (VI) biosorption characteristics of Neurospora crassa fungal biomass. Miner. Eng. 2005, 18, 681.
3. V. Padmavathy, S. Vasudevan, C. Dhingra, Biosorption of nickel (II) ions on Baker's yeast. Proc. Biochem. 2003, 38, 1389.
4. H. Freundlich "Adsorption in Solutions", Phys. Chemie, 57, 1906, 384.
5. C. Pragathiswaran, S. Sibi P. Sivanesan, Low cost adsorbent for heavy metals uptake from aqueous metal ion solution: A review International Journal of Research in Pharmacy and Chemistry 2013, 3(4).
6. S.S. Barton The adsorption of methylene blue by active carbon. Carbon 25, 1987, 343-350.
7. C. Pragathiswaran S. Sibi, P. Sivanesan, Low cost adsorbent for heavy metals uptake from aqueous metal ion solution: A review International Journal of Research in Pharmacy and Chemistry 2013, 3(4).
8. C. Namasivayam N. Muniasamy, K. Gayathri, M, Rani, K. Renganathan, Removal of Dyes from Aqueous Solution by Cellulosic Waste Orange Peel, Biores Technol**,** 57, 1996, 37.
9. C. Pragathiswaran, S. Sibi, P. Sivanesan, Removal Cr (VI) from aqueous solution using Eihharnea crassipies: characteristic and equilibrium study International Journal of Research in Pharmacy and Chemistry 2013, 3(4).