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Research Article

ADSORPTION OF MALACHITE GREEN DYE ONTO ACTIVATED CARBON OBTAINED 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 present work deals with adsorption of Malachite Green (MG) dyes carried out in the presence of Activated Aloe Vera stems Carbon (AVS). Various parameters such like the effect of initial concentration, contact time, dose of adsorbent, temperature and pH have been studied. The result reveals when the amount of adsorbent increases, the percentage removal of dye also increases. The applicability of Langmuir adsorption isotherms has also been tested. The thermodynamics parameter such as ΔG^0, ΔH^0 and ΔS^0 is calculated. The adsorption capacities of Activated Aloe Vera stem Carbon (AVS) is being calculated by using batch process.

Keywords: Adsorption, Thermodynamics, Malachite Green (MG), Activated Aloe Vera stem Carbon.

1. INTRODUCTION
Dyes are commonly used in different industries like paper, textile, plastic, food, cosmetics and coloring industries. These industries commonly use synthetic dyestuff as a colorant, $7x10^5$ tones of dye stuff are being produced annually[1,2]. The discharge of dye containing waste water poured into the environment contaminated surface water and ground water. The present study tries to evaluate the efficiency of an activated Aloe Vera adsorbent in the removal of malachite green dyes from dye solution. Many countries have given prominence to the development of aquaculture as a long term strategy in providing sufficient source of protein to their ever growing population. The raising of large numbers of fish, prawns and others in confined space as in modern aquaculture practice necessitates the use of an extensive range of chemicals for the prevention and treatment of diseases, thus posing as a source of water pollution.

2. EXPERIMENTAL AND METHODS
2.1 Adsorbent
Aloe Vera stem is collected from the nearby Trichy district has carbonized with concentrated sulphuric acid and washed with water and activated around 1000 °C in a muffle furnace for 6 hrs then it has been taken out and stored in a vacuum desiccators.

2.2 Adsorbate
The stock solution of malachite green concentration 1000 mg/L is prepared by dissolving 1 g of malachite green in 1000 ml of double distilled water. Different concentration of dye solutions which begin from the range of (50 to 250 mg/L) have been prepared from the stock solution by appropriate dilution

3. RESULTS AND DISCUSSION

3.1 Effect of contact time and initial dye concentration

The experiment results of adsorption of various dye concentrations with contact time are shown in Fig.1. This Fig. 1 shows that the % removal initially increases and reaches the limiting value. So that the equilibrium has been constituted within 50 minutes, hence all the remaining experiments are also carried out at 50 minutes.

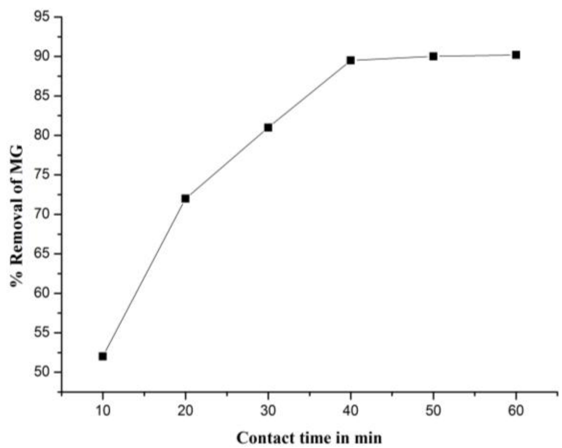

Fig. 1: Effect of contact time on the removal of MG dye [MG]=50mg/L; Temp:30^{0}C; Adsorbent dose=25mg/50ml.

3.2 Effect of adsorbent dosages

The effect of the AVS doses datas were given in table 3 and it was have studied at 30^{o}C by varying the amount of adsorbent dose 50-250 mg for the initial concentration of 50 mg/L. Fig.2 reveals that the increase in percentage removal of MG dye with increases in dose of adsorbent due to the increase in adsorbent surface area and the availability of more adsorption sites.

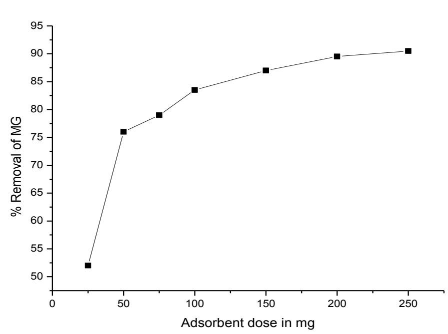

Fig. 2: Effect of adsorbent dose on the removal of MG dye [MG] = 50 mg/L; Temp: 30 $^{\circ}$C; Contact time = 50 min.

3.3 Effect of pH

The solution pH is one of the most important factors which control the adsorption of MG dye. To examine the effect of pH on the % removal of MG dye, the pH of initial solution is used that varied from 2.0 to 10.0 by the addition of sodium hydroxide or hydrochloric acid into them. When the % of removal increases, the pH also increases up to 6.5. There after the % of removal decreases. The optimum % of removal takes place at pH 6.5. So the remaining experiment has carried out at pH 6.5. The experiment's result is shown in Fig. 3.

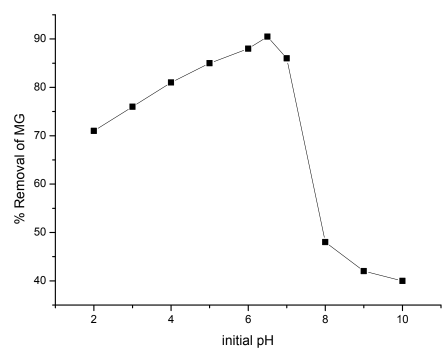

Fig. 3: Effect of pH on the removal of MG dye

3.4 Adsorption isotherm studies

The Langmuir isotherms are used in this study to quantify the sorption capacity of the absorbent in the removal of dyes.

3.4.1 Langmuir isotherm

The Langmuir isotherm model is based on the assumption that maximum adsorption corresponds to a saturated monolayer of solute molecules on the adsorbent surface. The linear form of the Langmuir isotherm equation can be described as

$$C_e/q_e = (1/Q_m b) + (C_e/Q_m) \quad .....(5)$$

Where C_e (mg/L) is the equilibrium concentration of the dye, q_e (mg/g) is the amount of dye per unit weight of adsorbent, Q_m and b are Langmuir constants related to adsorption capacity and rate of adsorption respectively.

Q_m is the amount of dye in a complete monolayer coverage (mg/g) which gives the maximum adsorption capacity of the adsorbent and b (L/mg) is the Langmuir isotherm constant that relates to the energy of adsorption or rate of adsorption. The linear plot of C_e/Q_e against the equilibrium concentration C_e shows the Langmuir model and the Fig.4. The Langmuir constant Q_m and b are determined from the slope and intercept of the Langmuir plot[3, 4] The feasibility of the Langmuir isotherm can also be expressed in terms of the dimensionless constant separation factor R_L by the equation

$$R_L = \frac{1}{1+bC_0} \quad \text{.................. (6)}$$

Where C_0 (mg/L) is an initial concentration of adsorbent and b (L/mg) is Langmuir isotherm constant. The parameter R_L indicates the nature of the isotherm.

$R_L > 1$ unfavorable
$R_L = 1$ Linear
$0<R_L< 1$ Favorable
$R_L= 0$ Irreversible

The R_L values lies between 0 and 1 indicate a favorable adsorption in all initial concentration study. The calculated R_L values are given in Table.1. The calculated R_L values appear within the range of 0.0458 to 0.1936. So the adsorption of MG follows the Langmuir isotherm.

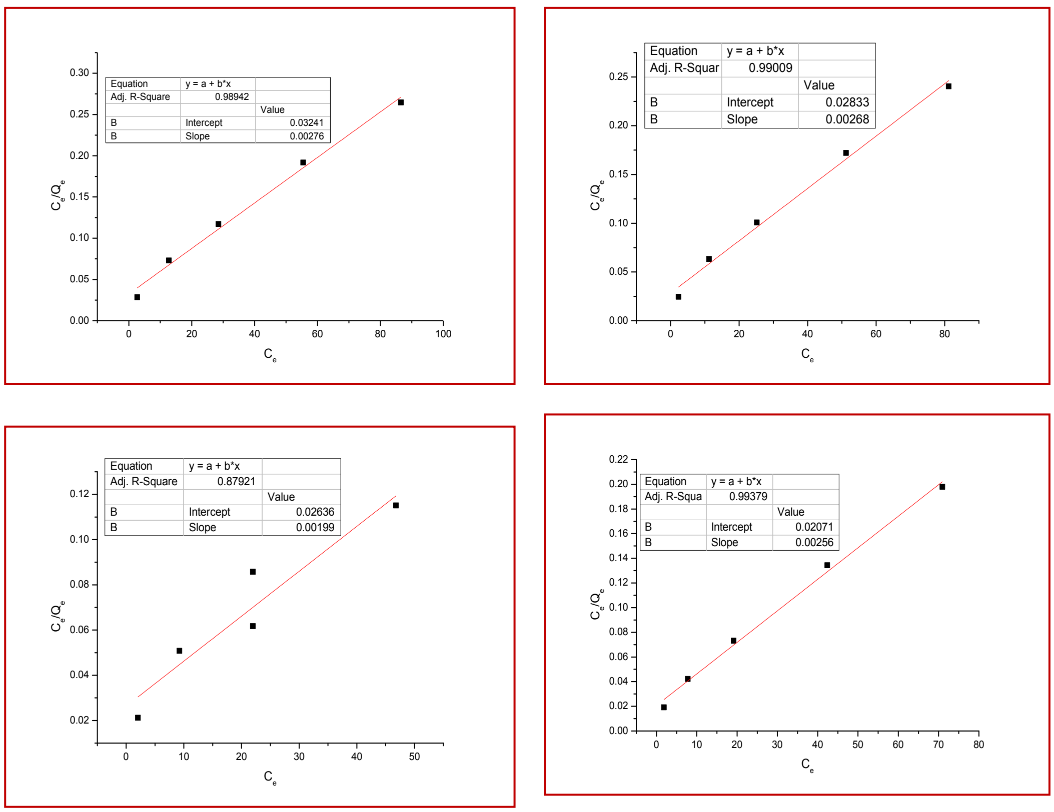

Fig. 4: Langmuir isotherm parameter for adsorption of MG dye onto AVS

Table 1: Langmuir isotherm parameter for adsorption of MG dye onto AVS

Temperature (°C)	Langmuir parameter		
	Q_m	b	R^2
30	375.3703	0.0733	0.9834
40	334.6153	0.0618	0.9930
50	426.3157	0.0522	0.9792
60	404	0.12056	0.9437

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

C_0 (mg/L)	Temperature (°C)			
	30	40	50	60
50	0.1226	0.1458	0.3169	0.1321
100	0.1023	0.0552	0.3216	0.0665
150	0.0641	0.0457	0.0645	0.0423
200	0.0336	0.0416	0.0747	0.0357
250	0.0448	0.0445	0.0424	0.0420

3.5 Thermodynamic study

Thermodynamic parameter such as change in free energy (ΔG^0) (KJ/mol), Enthalpy (ΔH^0) (KJ/mol) and entropy (ΔS^0) (JK/mol) has been calculated by using the following equation (7, 8) and (9)

$K_0 = C_{solid}/C_{liquid}$………………. (7)

$\Delta G^0 = -RT\ln K_0$……………….. (8)

$\log K_0 = \frac{\Delta S^0}{2.303R} - \frac{\Delta H^0}{2.303RT}$……….. (9)

Where K_o is the equilibrium constant, C_{Solid} is the solid phase concentration at equilibrium (mg/L). C_{liquid} is the liquid phase concentration at equilibrium (mg/L). T is temperature in Kelvin and R is the gas constant (8. 314 J $mol^{-1}K^{-1}$). A graph has drawn between $\ln K_0$ vs 1/T and shown the Fig.5 and table 3. The ΔH^0 and ΔS^0 values obtained from the slope and intercept of Van't Hoff plots. The negative ΔG^0 indicates the adsorption is spontaneous in nature and also the magnitude of ΔG^0 indicates the adsorption is physical adsorption (ie, less than 70 KJ/mol). The value of ΔH^0 is negative; this indicates the adsorption is exothermic process[5-9]. The positive ΔS^0 indicates an increased randomness during the adsorption. This also support the adsorption is a physical adsorption.

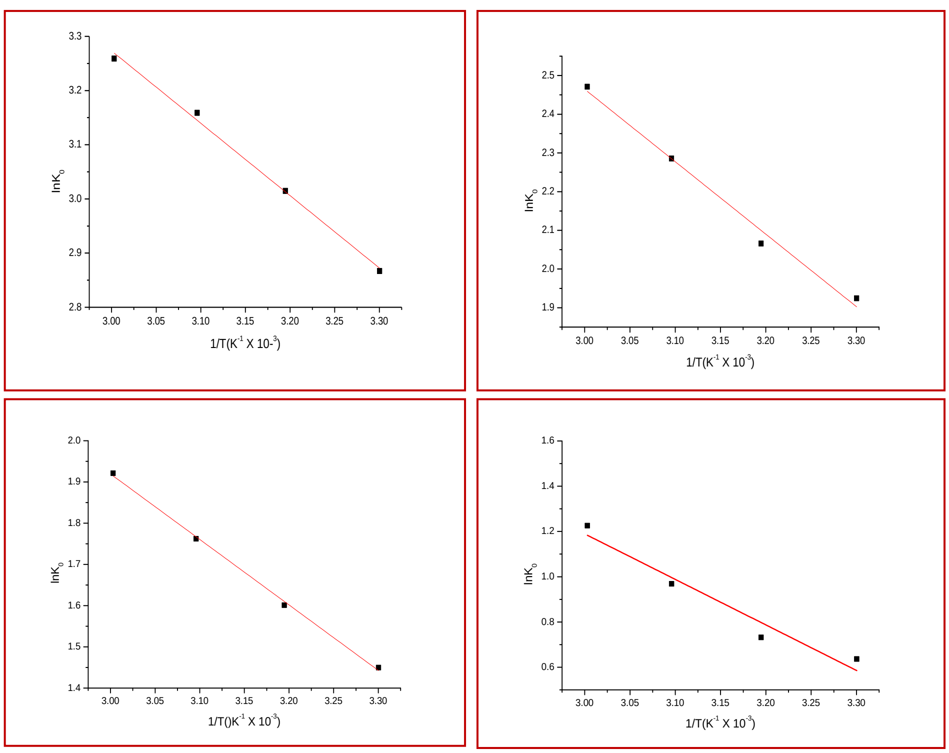

Fig. 5: Thermodynamic parameter for the adsorption of MG dye onto AVS

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

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	16.5797	19.3830	22.459	25.0255	-6.2217	-68451	-74831	-8.0229	-10.1016	62.5184
100	6.592	6.8920	8.8298	12.8346	-4.7471	-6.3759	-71373	-7.8411	-14.5729	662120
150	4.124	3.9582	6.8250	7.8304	-3.6523	-4.1663	- 3.7321	-6.3194	-14.2059	53.5765
200	3.6069	3.9040	7.1000	4.7176	-2.3137	-1.7742	-4.6175	-3.6345	-16.9865	66.9137
250	1.7893	30794	3.3425	2.5240	-1.5026	-1.9150	-3.9434	-1.5632	-12.7887	53.2350

4. CONCLUSION

The adsorption characteristics of MG dye onto Activated Aloe Vera are strongly affected by the initial dye concentration, initial pH and the adsorbent dose. The pH 6.5 was favorable for the optimum adsorption of MG dye by AVS. The R_L values and other adsorption parameters indicate Langmuir isotherms favorable for AVS adsorption. The thermodynamics parameter ΔG^0, ΔH^0 values are negative so the reaction is spontaneous and exothermic and ΔS^0 values indicate the adsorption is physical adsorption.

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