International Journal of Chemical, Materials and Biomolecular Sciences
ISSN: 2415-6620
Vol:7, No:6, 2013

Removal of Methylene Blue Dye Using Roselle Petals from Aqueous Solutions

Abdulali Ben Saleh and Mohamed Abudabbus

Abstract**—**The present study based on removal of natural dyes of Roselle petals, then used Roselle petals powder (RPP) as an adsorbent for the removal of methylene blue dye (as a typical cationic or basic dye) from aqueous solutions. The present study shows that used Roselle petals powder exhibit adsorption trend for the dye. The adsorption processes were carried out at various conditions of temperatures ranging from 278 to 338 K ± 2 K , concentrations, processing time and a wide range of pH between 2.5-11. Adsorption isotherm equations such as Freundlich, and Langmuir were applied to calculate the values of respective constants. Adsorption study was found that the currently introduced adsorbent can be used to remove cationic dyes such as methylene blue from aqueous solutions.

Keywords**—**Adsorption, methylene blue, removal of dyes, Roselle petals powder.

I. Introduction

THE natural water resources were often polluted by dyes discharge of a many industries like textile, printing, carpet and paper, ect that leading to increase in toxicity and COD (chemical oxygen demand) and interferes with the transmission of sunlight into the watercourse and therefore reduces photosynthetic process. Colors are the most apparent indicator of water pollution. The discharge of colored waste may be toxic to aquatic life [1]. It is found that adsorption process is a suitable and viable process to remove coloring matter from effluents, this process is became one of the effective and attractive processes for the treatment of this dye-bearing wastewaters [2]–[6]. The major advantages of an adsorption system for water pollution control are less investment in terms of initial cost, simple design and easy operation, less energy intensiveness, non-toxic, and superior removal of organic waste constituents as compared to the conventional biological treatment processes [7]. Activated carbon is the most effective choice as an adsorbent due to its high adsorption capacity but expensive. Hence it is desired to be replaced by low-cost, biodegradable or easily available adsorbents like psidium guava petals, tea petals ash, wood ash charcoal fly ash and polyaniline etc [1], [8]–[13]. Methylene blue (MB) is an important basic dye widely used for printing calico, coloring paper, temporary hair colorant, wools, coating for paper stock, dyeing, printing cotton and tannin, indicating oxidation-reduction, and dyeing leather, and in purified zinc-free form, it is used as an antiseptic and for other medicinal purposes, etc [14], [15] Adsorption of methylene blue from the aqueous phase is a useful for product control of adsorbents [16]-[18]. our study based on removal of natural dyes of Roselle petals, then used Roselle petals powder as an adsorbent for the removal of methylene blue dye (as a typical cationic or basic dye) from aqueous solutions.

Abdulali Ben Saleh, Department of chemistry, education faculty, Misurata university, Misurata city, Libya, abdu702002@yahoo.com.
Mohamed Abudabbus Department of chemistry, education faculty, Misurata university, Misurata city, Libya.

II. Procedures and Materials

A. Materials and Equipments

The basic dye used in present study was methylene blue (MW =319.65 g mol-1 termed as MB). The structure of methylene blue is shown in Fig. 1.

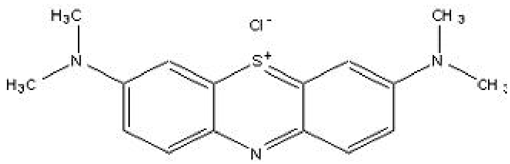

Fig. 1 Structure of methylene blue

Roselle petals were collected from shop, All chemicals used were analytical reagents grade and prepared in distilled water**.** A single beam UV spectrophotometer Jenway (UV- 6035), Japan with a 1cm cell was used for measuring all of absorption data. A Jenway pH meter (3505) Japan was used for pH measurements. Shaker, marine field / Germany was used in this study.

B. Preparation of Adsorbent

Dried Roselle petals were collected from the shop. Then washed to remove dirt and boiled with distilled water to completely removed the nature dye, then dried, powdered and sieved. The powdered petals were again heated and kept on an oven at 60-70 ^{o}C for complete drying.

C. Determination of Methylene Blue (MB)

Concentrations of methylene blue (MB) in the supernatant solutions were estimated by measuring absorbance at maximum wavelengths of the dye (λmax= 665 nm) using the calibration curve shown in Fig. 2. The calibration curve of absorbance against MB concentration was obtained by using standard MB solutions at PH≈ 7. The experimental data reported in Fig. 2 were fitted by a straight line with a high regression coefficient value (R^2 = 0.991).

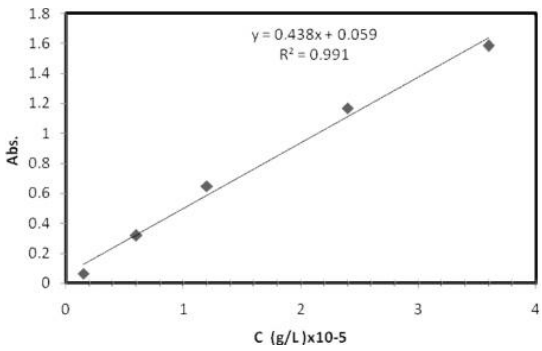

Fig. 2: The calibration curve of absorbance (Abs) against MB concentrations (C)

D. Adsorption Experiments

The studies were conducted 0.2g for isotherms study and 0.3 g for additional studies of adsorbents, taken separately, were shaken in 25ml and 35ml aqueous solution of MB dye of varying concentration ($1.2x10^{-5}$, $2.4x10^{-5}$ and $3.6x10^{-5}$ g L^{-1}) at room temperature for definite time periods. At the end of pre-determined time intervals, adsorbent was removed by simple filtration. The filtrates were analyzed for the residual (unadsorbed) concentration of methylene blue, spectrophotometerically at 665nm wavelength.

III. Results and Discussion

A. Effect of the Processing Time on Adsorption

The effect of processing time on the adsorption was studied for the system. The values of absorption were decreased with increase in time and attains a maximum value when adsorption equilibrium is reached then the values slightly decreases. Adsorption processes reaches equilibrium time at 25 min for $C=1.2x10^{-5}$ and at 15 min for both another concentrations. The results are shown in Fig. 3.

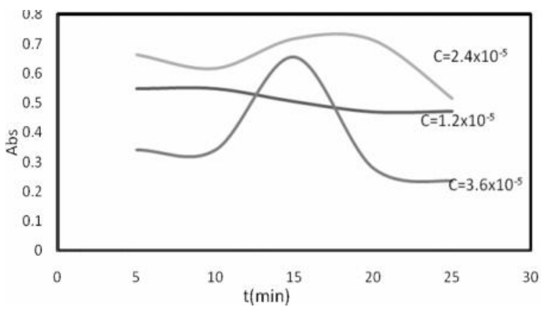

Fig. 3 The effect of processing time on the adsorption

B. Effect of Temperature on Adsorption

The temperature and adsorbed amounts of dye was also studied in the range of temperatures 298 to 338 K, using 0.3g of adsorbent, 35mL of MB solution ($C=1.2x10^{-5}$) for 30min. The inspection of adsorption study shows a decrease in the amount of adsorption of dye with the rise in temperature as shown in Fig. 4. It shows that adsorption of dye on RPP is exothermic in nature.

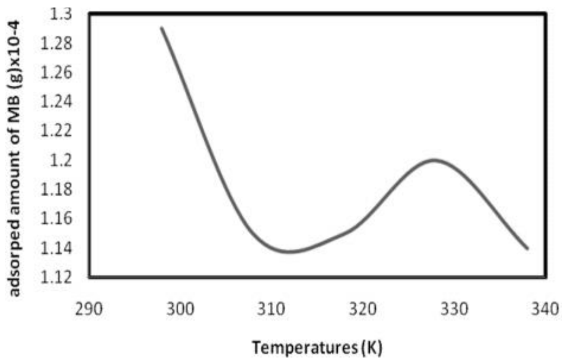

Fig. 4 Effect of temperature on adsorption of MB solution using RPP

C. Effect of pH on Adsorption

The effect of PH on the adsorption 35mL of MB solution ($C=1.2x10^{-5}$) for 30min using 0.3g of RPP was studied in a wide range of pH between 2.5-11 and the results are shown in Fig. 5. According to the absorption values, the removal of the dye was more favorable in neutral (pH= 7) medium as compared to that of acidic and basic mediums.

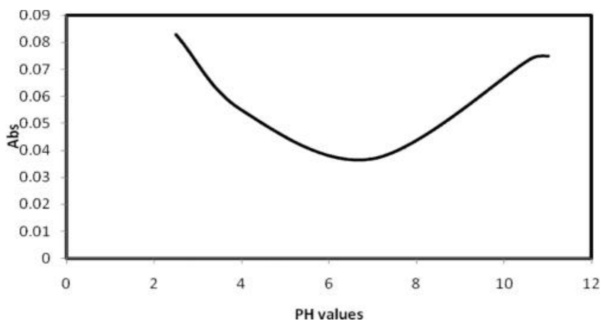

Fig. 5 The effect of pH on the adsorption of MB solution using RPP

D. Adsorption Isotherms

The equilibrium adsorption isotherms are of fundamental importance in the design of any adsorption system. In this study Langmuir and Freundlich isotherms were employed for treatments of the equilibrium adsorption data [19]. The linearized forms of Freundlich and Langmuir equations can be written as (1) and (2) respectively:

$$\log Qe = \log Kf + \log Ce \qquad (1)$$

$$\frac{m}{x} = \frac{1}{Xm} + \frac{1}{XmbCe} \qquad (2)$$

where Kf and n are Freundlich constants related to adsorption capacity and adsorption intensity of adsorbent respectively. Value of 1/n indicates the type of isotherm to be irreversible (1/n = 0), favorable (0 < 1/n < 1) and unfavorable (1/n>1)

[14], [19]-[20]. In Langmuir model, X is the amount adsorbed by adsorbent, X_m is the maximum amount adsorbed and b a Langmuir's constant signifying energy of adsorption, which calculated from the intercept and slope. Ce is the equilibrium concentrations of the dye in solution, Table I shows the experimental data of applied adsorption isotherms.

Fig. 6 shows a linear plot of log Qe vs. log Ce for MB dye adsorption on RPP at room temperature. As can be seen from Table II, the value of n is equal 0.53, indicating unfavourable adsorption phenomenon in this case.

TABLE I
EXPERIMENTAL DATA OF APPLIED ADSORPTION ISOTHERMS

Symbols	Values		
(C_0) x10^{-5}	1.2	2.4	3.6
(C e)x10^{-5}	0.57	0.59	1.2
C=$(C_0$-Ce)x10^{-5}	0.63	1.81	2.4
(X) mgx10^{-2}	5.03	4.71	19.18
m (g)	0.2	0.2	0.2
Qe = $(\frac{x}{m})$x10^{-2}	25.17	23.55	95.90
(1/Ce)x10^{4}	17.54	16.94	8.33
(m/X)x10^{3}	3.97	4.25	1.04
logCe	5.244	5.229	4.921
logQe	2.599	2.634	2.018

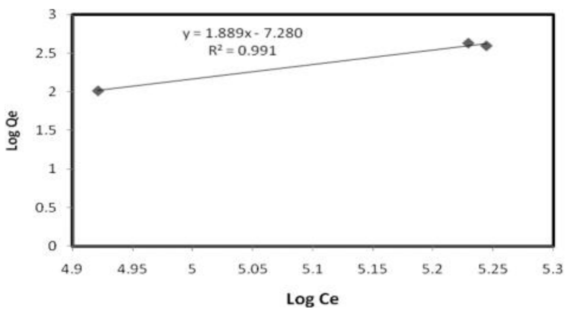

Fig. 6 Fruendlich isotherm obtained for adsorption of MB

The linear plots of m/x vs 1/C*e*, as shown in Fig. 7 confirmed the applicability of the Langmuir model for the system under investigation.

TABLE II
FREUNDLICH AND LONGMUIR PARAMETERS FOR THE REMOVAL OF MEHTYLENE BLUE DYE USING ROSELLE PETALS POWDER (RPP)

	Freundlich isotherm parameters		Langmuir isotherm parameters			
parameters	*n*	R^2	*Xm*	*b*	R^2	*K*
Values	*0.53*	*0.991*	*0.18*	*1.92*	*0.981*	*0.99*

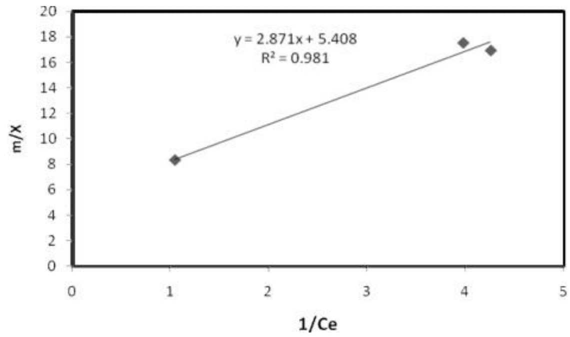

Fig. 7 Langmuir adsorption isotherm for the adsorption of MB

The values of K (dimensionless constant separation factor) indicate the type of isotherm as being irreversible (K=0), favourable (0< K< 1), linear (K=1) or unfavourable (K>1) [19]-[20]. K, using the following (3):

$$K = \frac{1}{1 + bC_0} \quad (3)$$

where b is the Langmuir constant and C_0 is the highest initial concentration of dye (mg/L).

The calculated value of K (0.99) obtained for highest concentration (3.6x10^{-5} g L^{-1}) for system indication (Table II) of RPP being suitable adsorbent for removal of MB from aqueous solutions with favorable isotherms.

IV. CONCLUSION

The adsorbent used in this paper was effective in removing methylene blue from aqueous solution. The effect of processing time on the adsorption was studied for the system. The temperature and adsorbed amounts of dye was also studied and it is showing that adsorption of dye on RPP is exothermic in nature. According to the absorption values, the removal of the dye was more favorable in neutral (pH 7) medium as compared to that of acidic and basic mediums. The regression coefficients in this case were found in 0.981 and 0.991 for Langmuir model and Freundlich model respectively. It could be concluded that the adsorption isotherms of MB using RPP followed the Langmuir model and Freundlich model. The dimensionless factor *K* revealed that the adsorption process for adsorbent is very favorable. The Freundlich constant *n* related to adsorption intensity of adsorbent MB/RPP isotherms revealed that the adsorption process for adsorbent is unfavorable.

ACKNOWLEDGMENT

The authors are grateful to the Final year student's project for years 2011 and 2012. Many thanks to these students and I hope they have learned a lot from the different projects they did.

REFERENCES

[1] W. G. Ravindra and A. M. K. Sunil, Studies on auramine dye adsorption on psidium guava petals Korean J. Chem. Eng., 26(1), 2009, 102-107.CATION
[2] P. K. Malik, Journal of Hazardous Materials, 2004, B113: 81-88.
[3] Y. S. Ho, G. Can McKay, J Chem Eng, 1998, 76: 822–826.
[4] G. M. Walker, L. Hansen, J. A. Hanna, S. J. Allen, Water Res, 2003, 37: 2081–2089.
[5] M. N. Mona, M. El Abd . Yehia, Separation & Purification Reviews, 2002, 31(1) : 171-228.
[6] S. K. Khare, K. K. Panday, R. M. Srivastava, V. N. Singh, J Chem Technol Biotechnol, 1987, 38: 99–104.
[7] C. Namasivayam, R. T. Yamuna, J. Chem Technol Biotechnol, 1992, 53:153–7.
[8] A. s. A. Raza and M. Ali, application of polyaniline for removal of acid green 25 from aqueous solutions, J. of scientific & industrial research 2011, Vol. 70.
[9] G.J. Parish, Rev. Prog. Colouration, 1976, Vol. 55 p. 7.
[10] S. N. Patnaik and P.C. Baisakh, Indian Journal of Environmental Protection, 1995, Vol. 16 (2), , p. 135.
[11] S. J. Allen, G. Makay and K.Y. H. Khader, J. Chem. Technol. Biotechnol, 1989,45, 291.
[12] V. J. P. Poots, G. Mckay and J. J. Healy, J. Water Poll. Control Fed. 1978,50, 926.
[13] A. Lodha, K. Bohra, S.V. Singh and A. B. Gupta, Ind. J. of Env. Protec., 1997, 17, 675.
[14] A. Reza, M. Zahra, B. k. Mohammad, and M. Ali, Adsorption of Cationic Dyes from Aqueous Solutions using Polyaniline Conducting Polymer as a Novel Adsorbent, J.Adv.Sci.Res, 2(2): 2011, 27-34.
[15] V.K. Gupta, I. A. Suhas and V.K. Saini, Ind Eng Chem Res, 43: ,2004 1740-1747.
[16] V.K. Garg, R. Gupta, A. B. Yadav and R. Kumar, Bioresour Technol, 89: , 2003, 121–124.
[17] V. K. Garg, M. Amita, R. Kumar and R. Gupta, Dyes and Pigments, 63: 2004, 243–250,.
[18] Y. Fawzi, Thermodynamic Study of the Adsorption of industrial Pollution Dyes in Al-Hilla Textile factory on Sawdust Wood Surface Master Degree thesis, Kufa University 2008, 25-30.
[19] E. R. Alley, Water Quality Control Handbook, McGraw Hill, 8: 2000, 125–141.
[20] B. Soria Noroozi, H. GAl Bahrami and M. Aram,I, J. Hazardous Materials, 139: ,2007, 167-174).