



Science

KINETIC STUDY OF THE ADSORPTION OF THE REMOVAL OF BROMO CRESOL PURPLE FROM AQUEOUS SOLUTIONS

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Abstract

This study was carried out to estimate the kinetic behavior of adsorption of bromo cresol purple from aqueous solution by using low cost of natural materials (sea grasses). The calculations of adsorption system were evaluated according to Langmuir adsorption and Freundlich isotherms. Also, the removal percentage of the studied dye was calculated. The results recorded that the values of RL were found to be less than (1) and slightly high than (0) value ≈ 0.014 indicating the favorable adsorption of the selected dyes on the sea grasses. On the other side the study recorded that the adsorption isotherms are harmony with the Freundlich concept of adsorption. According to the values which obtained from the isotherms in this study of bromo cresol purple. The adsorption process follows the first order reaction.

Keywords: Kinetic Study; Bromo Cresol Purple; Adsorption; Aqueous Solution; Sea grasses.

Cite This Article: Enas A. Almadani, Hamad. M. Adress. Hasan, and Safwan. F. Kwakab. (2019). “KINETIC STUDY OF THE ADSORPTION OF THE REMOVAL OF BROMO CRESOL PURPLE FROM AQUEOUS SOLUTIONS.” *International Journal of Research - Granthaalayah*, 7(12), 144-149. <https://doi.org/10.5281/zenodo.3597637>.

1. Introduction

Adsorption became one of the most effective methods to remove color from aqueous solution (1). Despite the frequent use of adsorption in wastewater treatment systems, commercially available activated carbon remains an expensive material. Despite the frequent use of adsorption in wastewater treatment systems, commercially available activated carbon remains an expensive material. The two methods of processing adsorbents are physical and chemical methods. Physical method of treating adsorbent involves activation by heating in an oven (2). Chemical method of treating adsorbent involves activation by adding acid or adding some oxides. Since the addition of inorganic acids makes the method polluted and expensive, sometimes, combination of both methods may also be used (3). Cost is an important factor for comparing the feasibility of adsorbents in treating dyeing industry effluents. However, in any report, cost analysis is not stated and the expense of adsorbents varies depending on the method of processing and availability of source materials (4). In general, an adsorbent is said to be low cost if it requires little processing, abundant in nature with high adsorption capacity (5). For a compound to adsorb at a surface, a

driving force must exist so that the compound will leave the aqueous phase. Examples of these include hydrophobic forces, electrostatic forces chemical attractions or vander Waals forces (6). Electrostatic forces drive adsorption when an ionic compound encounters an oppositely charged ionic adsorbent. Although these forces are a result of the charge of the compounds and their chemical make-up, adsorption due to electrostatic forces is classified as chemical adsorption (6). In physical adsorption, the energy (enthalpy) of adsorption is low (7). An example of chemical adsorption is when a compound chemically bonds to the surface to which it is adsorbing. Activated carbons often have chemical functional groups at the edges of the graphitic planes; therefore compounds can adsorb strongly via chemical adsorption these active sites (8). The activated carbon of sea grasses as low cost material to removal of some dyes including bromo cresol purple indicator was used, The aims of this study are using the sea grasses for the removal of the industrial organic dye ; bromo cresol purple from aqueous solutions. Then Using of some mathematical relationships by calculated the Langmuir, Freundlich isotherms and kinetics of adsorption.

2. Materials and Methods

2.1. Preparation of Sea Grasses Carbon

Sea grasses collected from coastline of Al-Gabal Al- Akhdar region. The sea grass samples were washed several times by distilled water then dried at overnight place for many days, and burned in the oven at 500°C for two hours.

2.2. Preparation of Bromo Cresol Purple Solution

A stock solution of the studied dye of 100 ppm was prepared by dissolved the appropriate amount of dye in amount of water and made up to 100 ml mark with deionized water. Different concentrations ranged between 10- 50 mg L⁻¹ of the dye were prepared from the stock solution. Deionized water was used for prepare all of the solutions and the reagent.

2.3. Adsorption Studies

The concentration of absorbed dye was obtained by comparing the recorded absorbance from a standard curve of the dye, Figure (1).

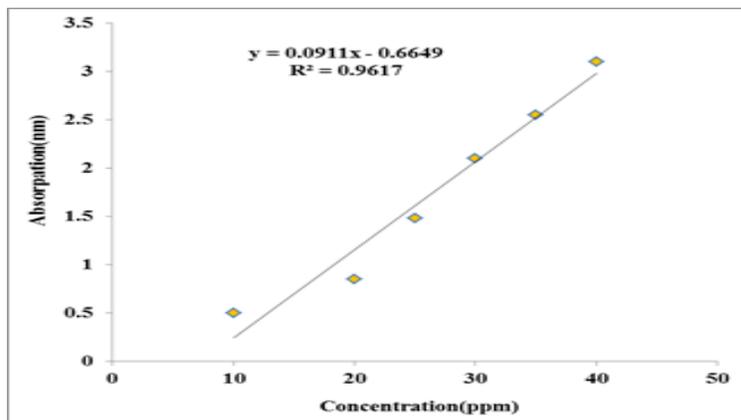


Figure 1: Calibration curve of bromo cresol purple after adsorption

2.3.1. Calculations of The Capacity of Adsorption.

The amount of dye adsorbed per gm (q_e) was calculated based on the following equation:

$$(q_e) = \frac{(c_o - c_e)}{m} \times v$$

C_o and C_e are the initial and equilibrium concentration of adsorbate (here, bromo cresol purple dye) ; V is the volume of dye solution (in liter); m is weight of adsorbent .The removal percentage of dye was calculated based on the following equation:

$$Removal \% = \frac{c_o - c_e}{c_o} \times 100$$

2.3.2. Adsorption Isotherms

Adsorption isotherms can be generated based on theoretical principles. Two isotherm equations have been tested in the present research, namely, Langmuir and Freundlich in order to describe the equilibrium characteristics of adsorption.

2.3.2.1. Langmuir Adsorption Isotherm

The most widely used isotherm equation for modeling the equilibrium is the Langmuir equation (9). The Langmuir linear equation is commonly expressed as followed:

$$\frac{C_e}{q_e} = \frac{1}{k_l} + \left(\frac{a_l}{k_l}\right)C_e$$

A plot of C_e versus C_e/q_e was linear showing the applicability of Langmuir adsorption isotherm for bromo cresol purple adsorption. K_L and a_L are the Langmuir constants related to adsorption capacity and rate of adsorption, respectively which are calculated from slope and intercept of the plot C_e versus C_e/q_e . The essential characteristics of Langmuir adsorption isotherm can be expressed in terms of a dimensionless constant, separation factor or equilibrium parameter 'RL' which is defined by:

$$R = \frac{1}{1 + a_l \cdot C_i}$$

Where, C_i = initial concentration of the dye and a_l =Langmuir constant. $RL > 1$ Unfavorable, $RL = 1$ Linear, $0 < RL < 1$ Favorable, $RL=0$ Irreversible.

2.3.2.2. Freundlich Adsorption Isotherm

The Freundlich isotherm model is the earliest known equation describing the adsorption process. It is an empirical equation and can be used for non-ideal sorption that involves heterogeneous adsorption. It also assumes that the adsorbent has a heterogeneous surface composed of adsorption

sites with different adsorption potentials. This equation assumes that each class of adsorption site adsorbs molecules, as in the Langmuir equation. It is given by the following nonlinear equation below:

$$q = KC$$

where KC is a constant for the system, related to the bonding energy. KC can be defined as the adsorption or distribution coefficient and represents the quantity of dye adsorbed onto adsorbent for unit equilibrium concentration. $1/n$ is indicating the adsorption intensity of dye onto the adsorbent or surface heterogeneity, becoming more heterogeneous as its value gets closer to zero. A value for $1/n$ below 1 indicates a normal Freundlich isotherm while $1/n$ above 1 is indicative of cooperative adsorption (10). The above equation can be linearized in the logarithmic form the following equation and the Freundlich constants can be determined:

$$\log q_e = \log K_F + \frac{1}{n} \log C_e$$

A plot of $\log C_e$ versus $\log q_e$ was linear, where K_F is measure of adsorption capacity (mg/g) and n is adsorption intensity. $1/n$ values indicate the type of isotherm to be irreversible ($1/n = 0$), favorable ($0 < 1/n < 1$), unfavorable ($1/n > 1$). The values of $1/n$ and K_F can be calculated from the slope and intercept respectively.

3. Results and Discussions

3.1. Adsorption Isotherms (Langmuir and Frindulich):

3.1.1. Langmuir Isotherms

The effect of different times of adsorbent on the adsorption of the studied dyes was monitored. A linearized of C_e versus C_e/q_e was obtained as shown in Table (1) and Figure (2).

Table 1: The values of langmuir adsorption isotherms for bromo cresol purple.

C_e/q_e	q_e (mg/g)	Final concentration C_e (ppm)	Time (min)
16.4893	0.5264	8.68	10
16.5905	0.5256	8.72	20
5.7857	0.6274	3.63	30
3.1591	0.6584	2.08	40
1.8090	0.6744	1.22	50

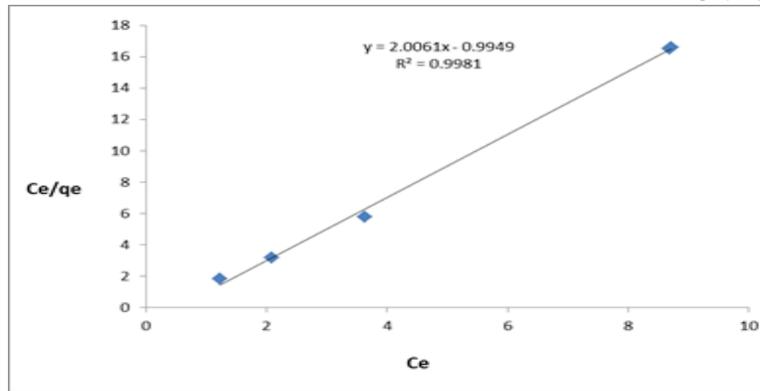


Figure 2: Langmuir adsorption isotherm for bromo cresol purple.

The fits are quite for the sorbent to suggest the application of the Langmuir model for the investigated system. The values of Langmuir parameter with correlation were computed from the intercept and the slop of the fitted Langmuir equation, Table (2).

Table 2: The Langmuir parameters for the adsorption bromo cresol purple using sea grasses.

dye	q_{max}	aL	KI	r^2
Bromo cresol purple	0.5	2.018	1.006	0.998

It seems the both values of r^2 of the studied dyes are high to assign the successful application to adsorbent the dye on the sea grasses. In the present study the values of RL were found to be less than (1) and slightly high than (0) value ≈ 0.014 indicating the favorable adsorption of the selected dyes on the sea grasses.

3.1.2. Freundlich Adsorption Isotherm

The values of $1/n$ and K_F can be calculated from the slope and intercept respectively as shown in Table (3).

Table 3: Freundlich isotherms for the adsorption of bromo cresol purple.

dye	$1/n$	KF	r^2
Bromo cresol purple	0.138	0.71	0.99

The results of Freundlich of the present study were illustrated in Table (4) and represented in Figure of (3).

Table 4: The values of Freundlich adsorption isotherms for bromo cresol purple adsorption.

Time (min)	Final Concentration C_e	Log C_e	q_e (mg/g)	Log q_e
10	8.68	0.9385	0.5264	-0.2786
20	8.72	0.9405	0.5256	- 0.2793
30	3.63	0.560	0.6274	- 0.2024
40	2.08	0.320	0.6584	- 0.1815
50	1.28	0.110	0.6744	- 0.1710

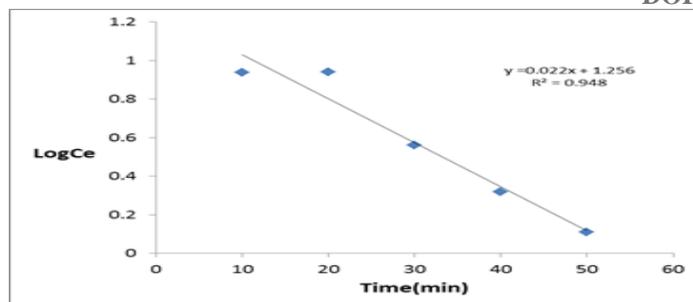


Figure 5: The relation between Time (min) and Log C_e of the bromo cresol purple.

4. Conclusions and Recommendations

According to the results which recorded in this manuscript the activated carbon which prepared from low cost material (sea grasses) showed high capacity to removal the studied dye, also the adsorption behavior gave very interesting isotherms of Langmuir and frendlish parameters.

Acknowledgements

The authors gratefully thank to Faculty of Science and Technology, Omar Al-Mukhtar University, Al Bayda (OMU) for providing the facilities for the research work.

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