RESEARCH ARTICLE

Optimum Sorption Isotherm by Linear and Non-linear Methods for Methyl Violet onto Hydrogel Surface

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ABSTRACT

Adsorption experiments were carried out at temperature (25°C) to remove the methyl violet (MV) dye using the hydrogel as an inexpensive, more effective surface. We studied two kinds of adsorption isotherms i.e., Freundlich and Langmuir models depending upon the linear and non-linear methods. The results depending on the non-linear is the best way to obtain isothermal parameters compared to the linear method. Comparing the Freundlich model with the model Langmuir in the linear and non-linear method, the Freundlich model is the best. Where the value of the linear method (R^2 = 0.8796) or the non-linear method (R^2=0.9887).

Keyword: Adsorption, Dye, Hydrogel, Isotherm, Linear and non-linear, Methyl violet (MV).

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INTRODUCTION

Usually, the liquid pollutants emitted from the agricultural, dyestuff, textile, and paper dyeing industries and sources of hospital waste are among the most dangerous contaminants in the aquatic environment. They have a very dangerous and harmful effect on humans, animals and plants.[1-3] Among the most dangerous pollutants found in water are industrial dyes. These dyes have aromatic structures that are usually of high resistance to light and temperatures and are considered one of the most important features that make dyes difficult to decompose easily.[4-6] Therefore, it accumulates on living organisms, and leads to many diseases, and as a result of the large consumption of dyes in many industries in our daily lives, methods must be used to get rid of these pollutants in wastewater. One of the most basic and important methods for treating polluted water is to use the adsorption process, which is one of the easiest and cheapest ways to remove pollutants, which depends on the use of very high-efficiency and inexpensive surfaces to remove dangerous pollutants in water, even if they are with a very small concentration in the water.[3,7,8] The aim of this study was to use adsorption isotherms that are used to describe the equilibrium relationship between an adsorbent and an adsorbent and to determine the amount of a specific pollutant adsorbed, as well as a comparison between the linear and non-linear method for the isothermal analysis of the adsorption of methyl violet dye using a high-efficiency hydrogel surface.

EXPERIMENTAL PART

Preparation of Hydrogel

The process of preparing the hydrogel depends on taking (1.6 gm) of MCC and it is dissolved in distilled water in a volume of 20 mL for 20 minutes, continuously stirring with a capacity of (300 mL) Erlenmeyer flask equipped with a reflux condenser, passing nitrogen gas during the stirring process. After that, the solution is heated to 50°C,and the process of adding (0.3 gm) KPS drop -drop to solution with continuous stirring. To complete the polymerization process, the solution

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is placed in a water bath for three hours at a temp. of 60°C. To remove of some non-reaction, the sample is washed with distilled water several times. After that, the sample is dried at a temperature of 60°C, then the eye is ground to obtain the powder used in the study.

Adsorption Equilibrium Studies

One of the most important organic compounds is the methyl violet dye, which depends in its composition on the presence of a number of methyl groups associated with it. Through these groups, it changes the color of the dye, giving a purple color in fabrics and textiles, and a violet color in paint and ink, where the process of preparing the dye was taken (0.1 g) from the dye It was dissolved in (100 mL) of distilled water. This study is based on adsorption isotherms Dye solutions were prepared with concentration (5–250 mg/L) then added 0.05 g of hydrogel to a water bath shaker device for an hour. Then the solution was separated by Centrifuge to determine the equilibrium concentration(Ce) and absorbance at the wavelength of 575 nm in a UV-Vis spectrophotometer. The percentage removal (E%) of a dye MV is calculated by equation 1 where Co is the initial concentration. of the dye and Ce is the equilibrium concentration.

RESULT AND DISCUSSION

Linear and Nonlinear Freundlich and Langmuir isotherms

To determine the methyl violet dye in waters and to control its interactions and movement during the treatment process, it is necessary to study and understand the behavior and mechanism of adsorption and the action of these toxic pollutants present in water, where adsorption isotherms have a key role in determining this behavior. The results of adsorption isotherms analysis depend on two types of isotherms, the Freundlich model and the model Langmuir. Whereas the model Langmuir is based on single-layer models, while the Freundlich model is based on multi-layered heterogeneous surfaces.[9-11]

Depending on the reaction type and the absorbent material's nature, we can distinguish between different types of adsorption isotherms. To obtain a suitable model that can be utilized for design purposes; Where in this study, the Langmuir isotherm was relied upon, which depends on the adsorption being at specific and homogeneous sites within the absorbent material and does not induce a side interaction between the adsorbed molecules.[12-15]

Also, the Freundlich model, which shows the occurrence of adsorption on heterogeneous absorbent surfaces, was used to determine the adsorption of dye MV on the hydrogel surface. Table 1 shows the linear and non-linear forms of adsorption isotherms in this study. Ce equilibrium conc. (mg/L) and qe is the quantity of adsorbent absorbed (mg/g). The maximum Langmuir MV dye adsorption per unit mass of the adsorbent b (mg/g) and the constant Langmuir related to the adsorption rate KL (L/mg) are obtained from the (Ce/qe) plot vs the Ce cutoff. While the Freundleich constants Kf and n can be obtained from the intercept and regression of the plots ln qe vs ln Ce, where n indicates how preferred the adsorption process is (n > 1) and the KF adsorption efficiency.[16,17]

To reach a good match of adsorption isotherms, a linear isotherm of Langmuir and Freundlich models was used, as shown in the equations shown in Table 1, and these equations were also used to determine the relationship between adsorption efficiency qe and equilibrium concentration as shown in Figure 1. Figure as appear the line plots for each of the Langmuir and Freundleich isothermal models selected via all studied adsorbents. Through the results representing the adsorption of methyl violet on the surface hydrogel well on the model Langmuir depending upon the coefficient of determination, the values of (R^2=0.8796) Comparison with

Table 1: Linear and non-linear forms of Isotherm Langmuir and Isotherm Freundleich.

Isotherm	*Nonlinear*	*Linear*	*Plot*
Type1 Langmuir		$\frac{Ce}{qe} = \frac{Ce}{qm} + \frac{1}{b * qm}$	Ce/qe vs Ce
Type2 Langmuir	$qe = \frac{qm\ b\ c}{1 + bCe}$	$\frac{1}{qe} = \frac{1}{b * qm\ Ce} + \frac{1}{qm}$	1/qe vs 1/Ce
Type3 Langmuir		$q_{e=qm-\frac{qe}{b*ce}}$	qe vs qe/Ce
Type4 Langmuir		$\frac{qe}{ce} = bqm - bqe$	qe/Ce vs qe
Freundlich	$q_{e=Kf\ c_e^{1/n}}$	Lnqe=ln Kf + 1/n * ln Ce	Lnqe vs lnCe

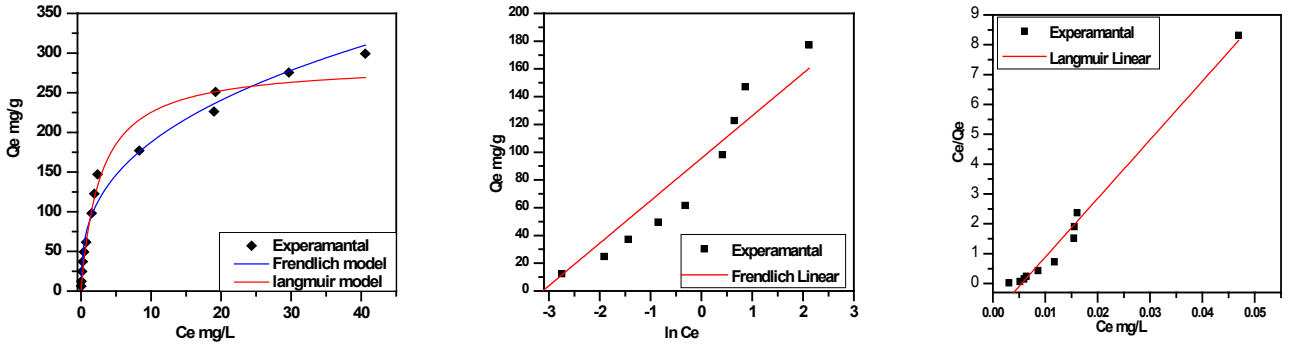

Figure 1: Adsorption Isotherm a) nonlinear model Langmuir and Freundlich Isotherms and b) linear Langmuir and Freundlich Isotherms.

Table 2: Parameters of the linear and non-linear forms of isotherm Langmuir and isotherm Freundlich.

Isotherm	*Equation*	R^2	*b(L/mg)*	*qm(mg/g)*
Linear Langmuir Type1	$\frac{Ce}{qe} = \frac{Ce}{qm} + \frac{1}{b * qm}$	0.9777	1.0821	196.556
Nonlinear Langmuir	$qe = \frac{qm\ b\ c}{1 + bCe}$	0.9491	0.3581	287.358
Isotherm	*Equation*	R^2	*n*	*Kf(mg/g)*
Freundlich nonlinear	$q_{e=Kf\ c_e^{1/n}}$	0.9887	0.363	282.174
Freundlich linear	Lnqe=ln Kf + 1/n * ln Ce	0.8796	95.634	30.581

the linear model of Freundlich depending on the value of (R^2 =0.9777) is shown in the Table 2.[17-19]

The use of a non-linear model depends on avoiding the errors caused by the use of linear model of my isotherm (Langmuir and Freundlich), which mainly depends on the value of (R2). Adsorption isotherms Freundlich and isotherm Langmuir of MV dye via hydrogel adsorbents utilizing non-linear analysis as appear in Figure 1; and their corresponding isotherm factor, coefficients of estimation (R2) as shown in Table 2.[19-21] Values higher of R2 obtained in this study via fitting experimental result into the isotherm Freundlich model of hydrogel. The isotherm Langmuir model top fits the result for hydrogel (Table 2 and Figure 1). Table 2 shows maximum adsorption efficiency values found utilizing the non-linear Freundlich isotherm model, were 282.22 mg/g for hydrogel.[22-24]

CONCLUSIONS

The adsorption of dye MV onto hydrogel from an aqueous medium was studied on the fundamental of equilibrium studies. The models' isotherm were carried out at several premier concentrations of MV dye non-linear and linear isotherm Langmuir and isotherm Freundlich was utilized to model the experimental result. Where through the results it was found that it obeys the non-linear model compared to the linear model. Depending on the value of (R2), it is found that it obeys the non-linear Frendlich model.

REFERENCE

1. Temel F, Turkyilmaz M, Kucukcongar S. Removal of methylene blue from aqueous solutions by silica gel supported calix [4] arene cage: Investigation of adsorption properties. European Polymer Journal. 2020 Feb 15;125:109540.
2. Jasim LS, Aljeboree AM. Removal of Heavy Metals by Using Chitosan/Poly (Acryl Amide-Acrylic Acid) Hydrogels: Characterization and Kinetic Study. NeuroQuantology. 2021 Feb 1;19(2):31-38.
3. Aljeboree AM, Abd Alrazzak N, Alqaraguly MB, Mahdi MA, Jasim LS, Alkaim AF. Adsorption of pollutants by using low-cost (Environment-Friendly): Equilibrium, kinetics and thermodynamic studies: A review. Systematic Reviews in Pharmacy. 2020 Dec 1;11(12):1988-1997.
4. Jafari K, Heidari M, Rahmanian O. Wastewater treatment for Amoxicillin removal using magnetic adsorbent synthesized by ultrasound process. Ultrasonics Sonochemistry. 2018 Jul 1;45:248-256.
5. Aljeboree AM, Alkaim AF. Role of plant wastes as an ecofriendly for pollutants (Crystal Violet dye) removal from Aqueous Solutions. Plant Archives. 2019;19(2):902-905.
6. Kamil AM, Mohammed HT, Alkaim AF, Hussein FH. Adsorption of Congo red on multiwall carbon nanotubes: Effect of operational parameters. Journal of Chemical and Pharmaceutical Sciences. 2016;9(3):1128-1133.
7. Maleki A, Mohammad M, Emdadi Z, Asim N, Azizi M, Safaei J. Adsorbent materials based on a geopolymer paste for dye removal from aqueous solutions. Arabian Journal of Chemistry. 2020 Jan 1;13(1):3017-25.
8. Al-Gubury HY, Fairooz NY, Aljeboree AM, Alqaraguly MB, Alkaim AF. Photcatalytic degradation n-undecane using coupled ZnO-Co2O3. International Journal of Chemical Sciences. 2015; 13(2):863-874.
9. Yan LG, Qin LL, Yu HQ, Li S, Shan RR, Du B. Adsorption of acid dyes from aqueous solution by CTMAB modified bentonite: kinetic and isotherm modeling. Journal of Molecular Liquids. 2015 Nov 1;211:1074-1081.
10. del Mar Orta M, Martín J, Medina-Carrasco S, Santos JL, Aparicio I, Alonso E. Adsorption of propranolol onto montmorillonite: Kinetic, isotherm and pH studies. Applied Clay Science. 2019 Jun 1;173:107-114.
11. Liqaa H, Aseel RA, Aljeboree M, Firas H, Falah H, Ayad HA. Role of Semiconductors (Zinc Oxide as a Model) for Removal of Pharmaceutical Tetracycline (TCs) from Aqueous Solutions in the Presence of Selective Light. International Journal of Recent Technology and Engineering (IJRTE). 2019;8:138-143. DOI : 10.35940/ijrte.B1270.0782S319.
12. Yan LG, Qin LL, Yu HQ, Li S, Shan RR, Du B. Adsorption of acid dyes from aqueous solution by CTMAB modified bentonite: kinetic and isotherm modeling. Journal of Molecular Liquids. 2015 Nov 1;211:1074-1081.
13. Alzayd AA, Atyaa AI, Radhy ND, Al-Hayder LS. A new adsorption material based GO/PVP/AAc composite hydrogel characterization, study kinetic and thermodynamic to removal Atenolol drug from wast water. InIOP Conference Series: Materials Science and Engineering 2020 Nov 1 (Vol. 928, No. 6, p. 062023). IOP Publishing.
14. Aljeboree AM, Abbas AS. Removal of pharmaceutical (paracetamol) by using CNT/TiO2 Nanoparticles. Journal of Global Pharma Technology. 2019;11(01):199-205.
15. Ghaedi M, Ansari A, Habibi MH, Asghari AR. Removal of malachite green from aqueous solution by zinc oxide nanoparticle loaded on activated carbon: kinetics and isotherm study. Journal of Industrial and Engineering Chemistry. 2014 Jan 25;20(1): 17-28.

16. Aljeboree AM, Alkaim AF. Removal of Antibiotic Tetracycline (TCs) from aqueous solutions by using Titanium dioxide (TiO2) nanoparticles as an alternative material. InJournal of Physics: Conference Series 2019 Sep 1 (Vol. 1294, No. 5, p. 052059). IOP Publishing.
17. Choy KK, Porter JF, McKay G. Langmuir isotherm models applied to the multicomponent sorption of acid dyes from effluent onto activated carbon. Journal of Chemical & Engineering Data. 2000 Jul 13;45(4):575-584.
18. Jan SU, Ahmad A, Khan AA, Melhi S, Ahmad I, Sun G, Chen CM, Ahmad R. Removal of azo dye from aqueous solution by a low-cost activated carbon prepared from coal: adsorption kinetics, isotherms study, and DFT simulation. Environmental Science and Pollution Research. 2021 Feb;28(8):10234-10247. https://doi.org/10.1007/s11356-020-11344-4.
19. Chatterjee J, Rai N, Sar SK. Kinetic isotherm of amoxicillin antibiotic through adsorption and its removal by electrocoagulation. Oriental Journal of Chemistry. 2014;30(2):775-784.
20. Aljeboree AM. Adsorption and removal of pharmaceutical riboflavin (RF) by rice husks activated carbon. International Journal of Pharmaceutical Research. 2019;11(2):255-261.
21. Mousa M, Evans ND, Oreffo RO, Dawson JI. Clay nanoparticles for regenerative medicine and biomaterial design: A review of clay bioactivity. Biomaterials. 2018 Mar 1;159:204-214.
22. Kim YS, Kim JH. Isotherm, kinetic and thermodynamic studies on the adsorption of paclitaxel onto Sylopute. The Journal of Chemical Thermodynamics. 2019 Jan 1;130:104-113.
23. ALjeboree AM, ALshirfi AN, ALkaim AF. Removal of pharmaceutical amoxicillin drug by using (Cnt) decorated clay/fe2 o3 micro/nanocomposite as effective adsorbent: Process optimization for ultrasound-assisted adsorption. International Journal of Pharmaceutical Research. 2019;11(4):80-86.
24. Zaheer Z, Aisha AA, Aazam ES. Adsorption of methyl red on biogenic Ag@ Fe nanocomposite adsorbent: Isotherms, kinetics and mechanisms. Journal of Molecular Liquids. 2019 Jun 1;283:287-298.