INTERNATIONAL JOURNAL OF ECOSYSTEMS AND ECOLOGY SCIENCE-IJEES

Publisher: HEALTH & ENVIRONMENT ASSOC , HEALTH & ENVIRONMENT ASSOC, TIRANE, ALBANIA, 00000

ISSN / eISSN: 2224-4980

Web of Science Core Collection: Emerging Sources Citation Index

Share This Journal

View profile page

* Requires free login.

INVESTIGATION OF ISOTHERMAL PARAMETERS OF DYE ADSORPTION ONTO ACTIVE CARBON

Ahmet SELÇUK[2], Ali Ender KUYUCU[1], Ali Rıza KUL[1], Gülen ÖNAL[2]

[1]*Yuzuncu Yıl University Faculty of Sciences, Van, Turkey;*
[2]*Yuzuncu Yıl University, Faculty of Educational Van, Turkey;*

E-mail : aselcuk@yyu.edu.tr

Received May, 2015; Accepted June, 2015

ABSTRACT

The fact that active carbon adsorps colourants and heavy metals has been known for a long time and thus it is used as adsorbant in removal of such pollutants. In this study, the capacity of active carbon in removal of colourant was investigated. As active carbon, Zivzik pomegranate from Siirt district of TURKEY was used and removal of colourants of Methylene Blue and Crystal Violet was studied. Active carbon was prepared with ZnCl2 by chemical activation. BET surface area, total surface volume and surface area of active carbon were measured by hte istrument called BET. In our study, adsorptions Methylene Blue and Crystal Violet colourants to active carbon at 45°C were evaluated for four different initial colourant concentrations of 200, 400, 600 and 800 mg/L graphically.

Key words: Dye, Clay, Adsorption, Isotherm

INTRODUCTION

Equilibrium of adsorption is expressed by equations of adsorption isotherms. Adsorption isotherms is very important for design of adsorption systems. Adsorption isotherms, in general, explain how the adsorbant and adsorbat interact. Four different adsorption isotherm equations (Langmuir, Freundlich, Dubinin–Radushkevich and Temkin) were used for colourant adsorption.
Langmuir equation is given by;

$$q_e = \frac{q_{max} K_L C_e}{1 + K_L C_e}$$

where q_e (mg/g) is concentration of adsorbat which is adsorbed by adsorbant in eqüilibrium and C_e (mg/L)) is concentration of adsorbant for a solution in equilibrium. K_L (L/mg) and q_{max} (mg/g) are Langmuir constants. K_L expresses adsorpability of adsorbat q_{max} defines single layer capacity of adsorbant. Unitless seperation factor of R_L can be found by Langmuir isotherm data:

$$R_L = \frac{1}{1 + K_L C_0}$$

Here C_0 (mg/L) is maximum initial colourant concentration and K_L (L/mg) is defined as Langmuir isotherm constant.

Freundlich equation is in the form of $q_e = K_F C_e^{1/n}$ *where* K_F (L/g) and n (unitless) are Freundlich constants which are called as adsorbant capacity and heterogeneity factor, respectively (Kuyucu A.E. , 2013).

Temkin izoterm denklemi;

$$q_e = \frac{RT}{b} lnA + \frac{RT}{b} lnC_e$$

şeklindedir. Burada; R : Gaz sabiti (J $mol^{-1}K^{-1}$) ve T : Ortamın K cinsinden sıcaklığıdır (Temkin ve Pyzhev, 1940).
Temkin isotherm equation is

$$q_e = \frac{RT}{b} lnA + \frac{RT}{b} lnC_e$$

where R (J $mol^{-1}K^{-1}$) *is gas constant* and *T (K) istemperature of medium* (Temkin ve Pyzhev, 1940).

Dubinin-Radushkevich isotherm equation is in the form of $ln\ q_e = ln\ q_m - B_D\ \varepsilon^2$. Here q_m (mg/g) is Dubinin-Radushkevich single layer capacity, B_D (mg^2/J^2) is a constant about adsorption energy and ε is polony constant which is related to equilibrium concentration. B_D (mg^2/J^2) constant helps to find out adsorption energy (E). Adsorption energy provide information about whether adsorption mechanism is of physical or chemical character.

Value of E can be calculated (Dubinin ve Radushkevich, 1947) as following: $E = \frac{1}{\sqrt{2B_D}}$

MATERIAL AND METHODS

Preparation of materials

Two dyes were used in the study. The dyes, Methylene Blue (MB) (Chemical Formula = $C_{16}H_{18}N_3SCl$, MW = 319.85 g/mol, λ_{max} = 660 nm) and Crystal Violet (CV) (Chemical Formula = $C_{25}N_3H_{30}Cl$, MW = 407.979 g/ mol, λ_{max} = 594 nm) were supplied by Merck. One thousand milligrams per liter of stock solution was prepared by dissolving the required amount of dye in double distilled water. Working solutions of the desired concentrations were obtained by successive dilutions. (Önal, 2006)

Preparation of activated carbon

Zivzik Pomegranate supplied by Siirt pomegranate plant were dried under labaratory conditions and then dried again at 100 ^{0}C. Zivzik Pomegranate was mixed with $ZnCl_2$ at the $ZnCl_2$ initial weight ratio of 1:1 and the mixture was kneaded with adding distilled water. The sample was placed on a quartz dish and heated at the rate of 10 ^{0}C min^{-1} up to activation temperature (500 ^{0}C) under N_2 flow and held at the activation temperature for 1 h. After activation, the sample was cooled down under N_2 flow and 0,5N HCl was added on to activated sample. Activated sample was washed sequentially several times with hot distilled water to remove residual chemicals until it did not anymore give chloride reaction with $AgNO_3$. The washed sample was dried at 110 ^{0}C to prepare activated carbon (Selçuk , 2014).

Characterization of the prepared activated carbon

Activated carbon surface measurements were made by BET device. Its total surface area, total surface volume and BET surface area were measured as 429,044 m^2/g, 0,59232 cm^3/g and 1513,05 m^2/g, respectively (Selçuk A.,2014).

Instrumentation

A Tri Star 3000 (Micromeritics, USA) surface analyzer was used to measure nitrogen adsorption isotherm at 77 K in the range of relative pressure 10^{-6} to 1. Before measurement, the sample was degassed at 300 ºC for 2 h. The BET surface area, total surface area and volume of the total surface were measured by the surface analyzer. The spectrophotometric determination of dyes was done on a Boeco UV – vis spectrophotometer (model UV – S22, Germany).

Adsorption experiments

To monitor the adsorption process at 45 ^{0}C batch techniques were employed. Four different initial dye concentrations (200,400,600 and 800 mg/L) were used in this process. This concentrations were prepared in 1000 mL conical flask containing 500 mL solution of each concentration. A known amount of 0.1 g activated carbon was then added into the solution and conical flask was stirred with thermostatic bath operating at 400 rpm. And then samples taken about 1, 3, 5, 7, 9, 13, 17, 23, 30, 40, 50, 60 and 70 minutes time period (Selçuk A., 2014) .

RESULTS

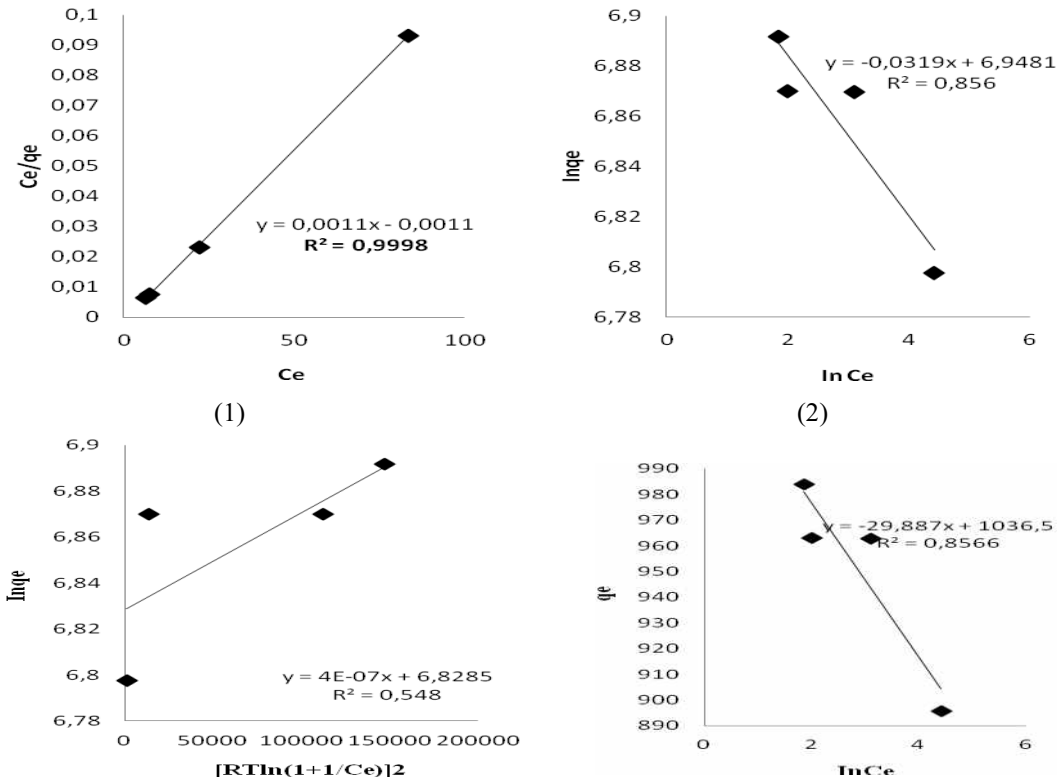
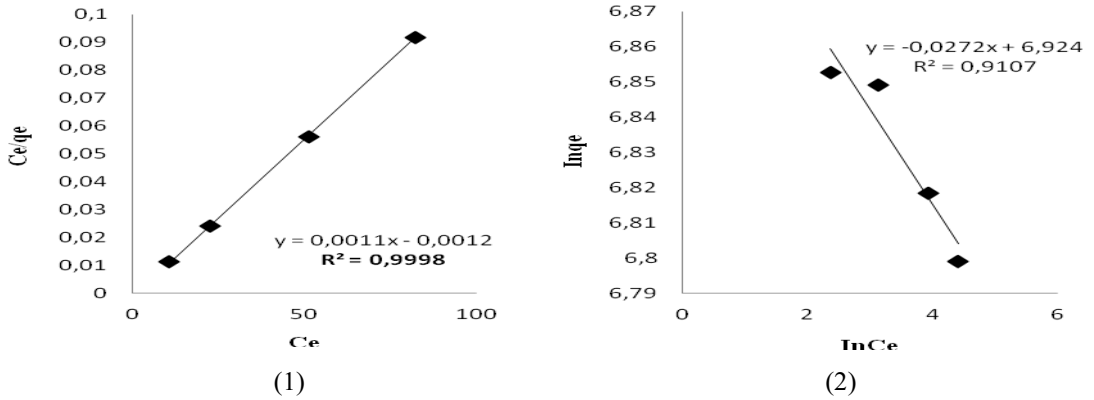
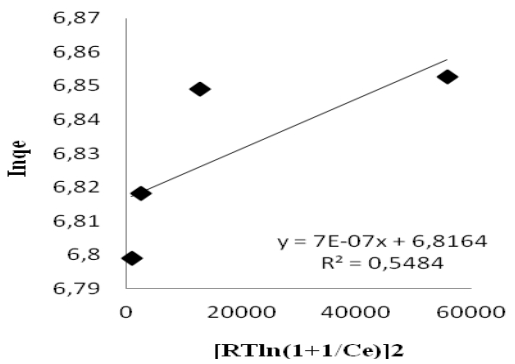


Figure 1:1-Langmuir, 2-Freundlich, 3-Dubinin-Radushkevich and 4-Temkin isotherm graphs of active carbon treated Methylene Blue

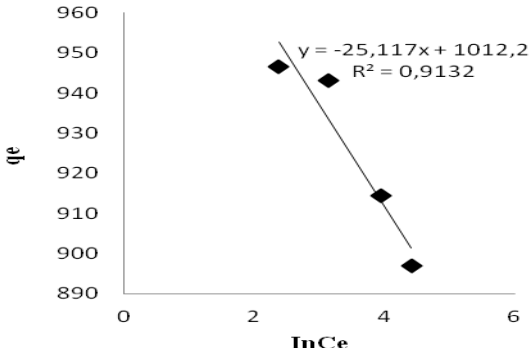
Table 1 : Isotherm contants of active carbon treated Methylene Blue

Langmuir		**Freundlich**		**Dubinin- Radushkevich**		**Temkin**	
q_{max} (mg/g)	909.091	n	-31.347	q_m (mg/g)	923.804	B_T	-29.887
K_L (L/mg)	-1	K_f	1041.16	B_D (mg^2/J^2)	-4.10^{-7}	A_T (L/mg)	$8.677.10^{-16}$
R_L	-0.0012			E (kj/mol)	1.118		
R^2	0.99	R^2	0.85	R^2	0.54	R^2	0.85





(3)



(4)

Figure 2 : 1-Langmuir, 2-Freundlich, 3-Dubinin-Radushkevich and 4-Temkin isotherm graphs of active carbon treated Crystal Violet

Table 2 : Isotherm contants of active carbon treated Crystal Violet

Langmuir		Freundlich		Dubinin- Radushkevich		Temkin	
q_{max} (mg/g)	909.091	n	-36.764	q_m (mg/g)	912.693	B_T	-25.117
K_L (L/mg)	-1.09	K_f	1016.37	B_D (mg^2/J^2)	-7.10^{-7}	A_T (L/mg)	$3.149.10^{-18}$
R_L	0.0011			E (kj/mol)	8.174		
R^2	0.99	R^2	0.91	R^2	0.54	R^2	0.91

CONCLUSIONS

When corelation constants(R^2) in the table were examined, it is seen that for the adsorption of both colourants Langmuir equation is in better agreement than the others. Value of unitless seperation constant of R_L, that is calculated by using a Langmuir parameter (K_L), was calculated as 0.001. This result shows that adsorption process is efficient. The value of corelation constant for Crystal Violet colourant was found as 0.91 in Freundlich and Temkin equations and it is a satisfying reslt too (Kuyucu , 2013). According to Dubinin-Radushkevich isotherm, if value of E is in the range of 8–16 kJ/mol, then adsorption mechanism is the exchange of chemical ions. For values smaller than 8 kJ/mol adsorption process is physical (Tunalı ve ark., 2006). Values of E calculated from Dubinin-Radushkevich isotherm equations are 1.118 kJ/mol for Methylene Blue and 8.474 kJ/mol for Crystal Violet colourants. Thus, it can be stated that both adsorption processes are physical.S_{BET} , V_t and S_t values were measured as 1513,05 m^2/g, 0,59 cm^3/g and 429,044 m^2/g, respectivly. This shows that active carbon contains moicropores and mesopores..Adsorption capacity of both colourants increased for increasing temperature. It was understood that the active carbon studied in this work can be used for removal of colourants from waste textile water.

REFERENCES

Ma, X., Li, L., Yang, L., Su, C., Wang, K., Yuan, S., Zhou, J., 2012. Adsorption of heavymetal ions using hierarchical $CaCO_3$–maltose meso/macroporous hybridmaterials: Adsorption isotherms and kinetic studies. Journal of Hazardous Materials, 209– 210: 467–477;

Kuyucu A.E. , 2013. Zivzik Narı (SİİRT)'ndan Elde Edilen Aktif Karbonun Karakterizasyonu ve Boyar Madde Adsorpsiyonu (Yüksek Lisans Tezi). Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, İlköğretim Anabilim Dalı, Van;

Temkin, M.J., Pyzhev, V., 1940. Acta Pysiochim. USSR Journal, 12: 217;

Dubinin, M.M., Radushkevich, L.V., 1947. Equation of the characteristic curve of activated charcoal. *Chemisches Zentralblatt* 1: 871;

Önal, Y., 2006. Kinetics of adsorption of dyes from aqueous solution using activated carbon prepared from waste apricot. Journal of Hazardous Materials B137, 1719-1728;

Selçuk A., Kuyucu A. E., Kul A.R. , Ocak S., 2014. Adsorption of Dye on to Activated Carbon obtained from Zivzik Pomagranate. International Environmental Sciences Symposium of Van;

Tunalı, S., Akar, T., Özcan, A.S., Kıran, İ., Özcan, A., 2006. Equilibrium and kinetics of biosorption of lead(II) from aqueous solutions by Cephalosporium aphidicola. Separation and Purification Technology, 47: 105-112;

Copyright of International Journal of Ecosystems & Ecology Sciences is the property of Health & Environment Association and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.