Valorization of Plants for Water Depollution

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Abstract

The present study concerns the elimination of Eriochrom Black T (EBT) dye, by adsorption onto calcinated potato peels (CPP). This dye is recognized as an organic pollutant because of its high toxicity and possible accumulation in the environment.

The experimentally determined adsorption equilibrium data for EBT was best fitted by the Langmuir isotherm mode and the adsorption rate followed a pseudo-second-order kinetics.

Keywords: *Adsorption; Eriochrom Black T; Calcinated potato peels; Langmuir isotherm; Pseudo-second order models.*

I. Introduction

Ever since the first synthetic dye, Mauveine, first appeared in the market, more and more dyes are being synthesized over the decades. Today there are about hundred thousands types of dyes available and more than seven hundred thousands tons of dyestuff are produced per year to satisfy the needs of industries such as textile, cosmetics, food, paper, etc. [1]. This has inevitably generated a great increase in the amount of dyes being disposed off into wastewater or natural ecosystem, thus resulting in serious pollution of the environment.

Several methods have been developed over the years to remove these toxic dyes from wastewater [2], among which Adsorption has known an important step forward in removing these pollutant species, particularly with the development of new adsorbents from natural, free cost and abundant materials which rae competing with granulated or powdered activated carbon [3] which has a major draw back of being highly costly, encouraging the use of low-cost biosorbents as viable alternatives [4].

Consequently the present work focused on the use of low-cost biosorbents, namely peel of potatos to remove the (EBT). Therefore the adsorption capacity of this biomaterial was tested as calcinated (Calcinated Potato Peels (CPP)) .

II. Materials and methods

A. Material

1. Calcinated Carbon

The preparation mode of the adsorbent was quite simple. It consisted of washing the solid support to remove the impurities and placing it in well-capped silica crucibles at 250°C in a furnace for 2h. The product was then powdered and stored in a desiccator ready for use, as shown in Figure 1[5].

Figure 1. Calcinated adsorbent

Table I. Properties of EBT dye

Type of dye	Anionic azo dye
Molecular formula	$C_{20}H_{12}N_3NaO_7S$
Molecular wt.	461.38 g/mol
Max. wavelength (λ_{max})	530 nm
Solubility in water (20 °C)	50 g/L
Solubility in ethanol (20 °C)	2 g/L
Color	Black

The characteristics of EBT dye are summarized in Table 1 and its chemical structure is shown in Figure 2 [6].

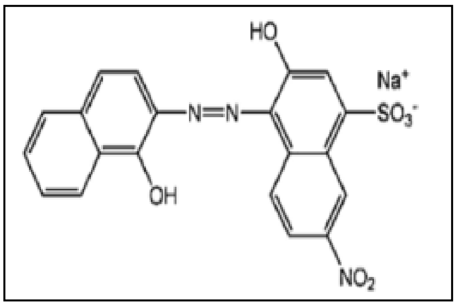

Figure 2. Molecular structure of EBT dye

B. Methods

Adsorption experiments were performed in a batch system, using an initial concentration of 25mg.l^{-1} at 20°*C, a* pH of solution of 6.4, an adsorbent dose of 6g.l^{-1} and an agitation speed of 500 rpm.

After adsorption, the treated solution was filtered and final dye concentration was analyzed using an UV–vis spectrophotometer where the absorbance characteristics were determined by means of a relationship between the absorbance A and the concentration C as follows:

$$A = 0.01736C - 0.00234 \quad (1)$$

The samples were collected at predetermined time intervals from 15 to 120 min. The adsorption capacity was calculated using this relation:

$$q = \frac{(C_0 - C)}{m} \times V \quad (2)$$

with q (mg /g) is the adsorption capacity, C_o is the initial concentrations of solution of (EBT) (mg.l^{-1}), *V* (l) is the volume of solution and *m* (g) is the weight of the adsorbent.

III. Results and discussion

A. Adsorption kinetic models

The kinetic study is helpful in the prediction of the adsorption rate and provides important information for designing and modeling the processes.

Adsorption kinetics was modeled by the pseudo first and second -orders rate equations. Linear plots of the two considered kinetic models and the adsorption kinetic rate constants are shown in Figures 3 and 4 and Table.2, respectively. Pseudo second-order model shows a good correlation values.

The pseudo-first-order kinetic model was given by Langeren and Svenska (Langeren and Svenska, (1898)) and has been widely used to predict the adsorption kinetics **[7].** It can be expressed in a linear form as follows:

$$\frac{dq_t}{dt} = K_1.(q_e - q_t) \quad (3)$$

Where q_e and q_t(mg/g) are the amounts of adsorbate adsorbed at equilibrium and at any time, *t*(min), respectively, and k_1 (min-^{1}) is the adsorption rate constant. Integration of (3) for the boundary conditions *t*=0 to *t* and q_t =0 to q_t [10], gives:

$$\ln(q_e - q_t) = \ln q_e - K_1 t \quad (4)$$

The following plot of ln(q_e-q_t) versus *t* will give the slope k_1 and the intercept ln q_e.

To investigate the mechanism of adsorption kinetics data is tested by using pseudo second order model [8]. Its linear form is expressed as follows:

$$\frac{t}{q_t} = \frac{1}{K_2.q_{e2}^2} + \frac{1}{q_{e2}} t \quad (5)$$

The following linear plot of t/q_t versus *t* will give $1/q_{e2}$ as slope and $1/K_2q_{e2}^2$ as the intercept.

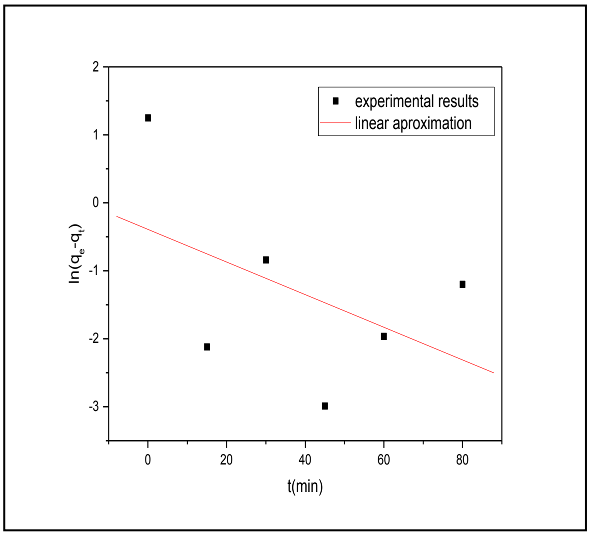

Figure 3.Pseudo-first order

In this manner the value of the second order rate constant can be determined.

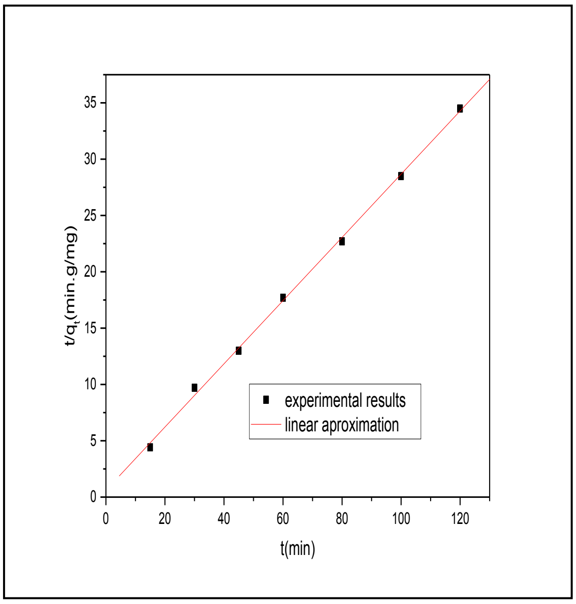

Figure4.Pseudo-second order

Table 2. Kinetic parameters

C_0 (mg.l^{-1})	R^2	K_1 (min^{-1})	R^2	K_2 (g.mg^{-1}.min^{-1})
25	0.48299	0.024	0.9993	0.12

B. Adsorption isotherms

Several models have been published in the literature to describe the equilibrium adsorption systems.

The Langmuir and Freundlich equations were used to study the adsorption isotherms of EBT. The linear form of the Langmuir equation [9] is as follows:

$$\frac{1}{q_e} = \frac{1}{q_0} + \frac{1}{q_0 b} \cdot \frac{1}{C_e} \qquad (6)$$

C_e(mg.l^{-1}) is the concentration of the dye solution at equilibrium, q_e(mg/g) is the amount of EBT sorbed at equilibrium, q_0 is the maximum adsorption capacity and represents a practical limiting adsorption capacity when the adsorbent surface is fully covered with monolayer adsorbent molecule and b is Langmuir constant. The q_0 and b values are calculated from the slopes (1/b q_0) and intercepts (1/ q_0) of the following linear plot of 1/q_e versus 1/C_e

The linear form of the Freundlich equation [10] is as follows:

$$\ln q_e = \ln K_F + \frac{1}{n} . \ln C_e \qquad (7)$$

Where q_e is the amount of EBT adsorbed at equilibrium, C_e is the concentration of EBT in solution at equilibrium k_F and *1/n* are empirical constant which indicate the adsorption capacity and intensity, respectively. Their values were obtained from the intercepts (ln k_F) and slope (*1/n*) of the following linear plots of ln q_e versus lnC_e. It can be seen that the Langmuir isotherm is a good correlation values, linear plots of the two considered isotherms and the constants are shown in Figures 5 and 6 as well as in Table.3.

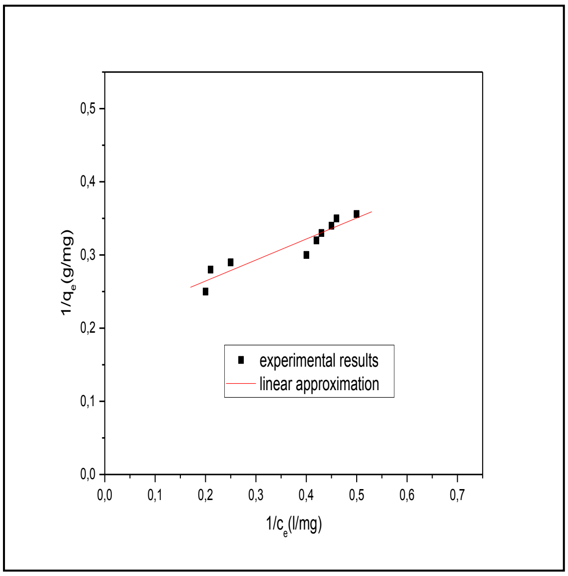

Figure 5.Langmuir isotherms of the adsorption of EBT onto CPP

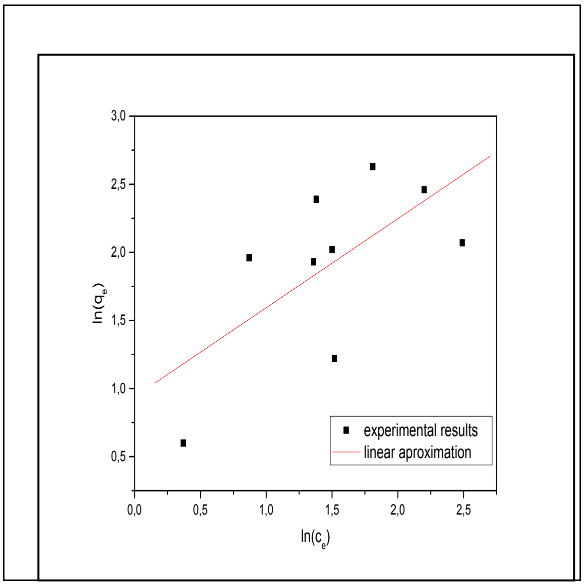

Figure6.Freundlich isotherms of the adsorption of EBT onto CPP

Table3.Langumir and Freundlich parameters

Modèles	R^2	Parameter
Langumir	0.93867	q_0 = 4.83 (mg. g^{-1}) b = 0.72 (l. mg^{-1})
Freundlich	0.65304	K_f = 2.55((mg/g).(l/mg)$^{1/n}$), $1/n$ = 0.65392

IV. Conclusion

The results did show the retention of the Eriochrom Black T (EBT) dye by the calcinated potatoes peels CPP followed a pseudo second order kinetic model and the Langmuir adsorption model expressed quite well the sorption phenomena.

List of symbols

A	the absorbance	
b	Langmuir constant.	
C	the concentration of the dye solution at time (t)	[mg .l^{-1}]
C_0	the initial concentration of the dye solution	[mg .l^{-1}]
C_e	the concentration of the dye solution at equilibrium	[mg .l^{-1}]
K_1	the adsorption rate constant for Adsorption kinetics first-order	[min^{-1}]
K_2	the adsorption rate constant for Adsorption kinetics second-order .	[g. mg^{-1} .min^{-1}]
K_f	Constant of Freundlich isotherms	[(mg/g). (l/mg)$^{1/n}$]
m	the weight of the adsorbent	[g]
n	Second constant of Freundlich isotherms	
q_e	the amount of dye adsorbed at equilibrium	[mg .g^{-1}]
q	The adsorption capacity at time (t).	[mg .g^{-1}]
q_0	the maximum adsorption capacity	[mg .g^{-1}]
R	The correlation factor	
t	The time of adsorption.	[min]
V	the volume of solution	[l]

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