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Removal of Maxilon Red GRL from aqueous solutions by adsorption onto silica

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ABSTRACT

The adsorption of basic dyes (maxilon red GRL) from an aqueous solutions by silica was investigated. Adsorption of maxilon red (GRL) onto silica samples was studied by batch adsorption techniques at 24±1 °C. The adsorption behavior of maxilon red (GRL) on silica samples was investigated using a Uv-vis spectrophotometric technique. In batch system, the effect of five different initial dye concentrations and using six different times on adsorption was evaluated. Values of the removal efficiency of the dye ranged from 47.7 to 96%. The equilibrium adsorption isotherms have been studied by Langmuir and Freundlich models. The experimental results have been fitted Langmuir and Freundlich models. Langmuir adsorption capacity, $q_{m,}$ was found to be 3.03 mg/ g silica at 24±1 ^{0}C. Also, initial concentrations and the equilibrium concentration of dye solutions were subjected to a comprehensive colorimetric appraisal using the CIE L*a*b* colour space system.

Key words: Adsorption; Silica; Basic dyes; Decolorization; colour space; Adsorption isotherms.

INTRODUCTION

Many Industries use dyes and pigments to color their products. The dye used this study is Maxilon Red GRL that are widely used in acrylic, nylon and wool dyeing. and their discharge waste waters from these industries into river water make the water inhibitory to aquatic life and causing visible pollution. Dyes have a tendency to sequester metals, so causing microtoxicity to fish and other aquatic organisms. Therefore the removal of dyes from waste streams before discharge to public water sources is of primary concern [Marungrueng and Pavasant, 2007].

Dyes have a tendency to sequester metals, so causing microtoxicity to fish and other aquatic organisms. Therefore the removal of dyes from waste streams before discharge to public water sources is of primary concern [Nassar and Magdy, 1997]. Many workers have investigated the fate of textile dyes in the activated sludge process and reported that adsorption is the main process fort he partial or decolorisation of wastewater containnig dyes [Basibuyük and Foster,2003].

Many techniques has been found for removal of dye-containing wastewater such as chemical oxidation, membrane filtration, biodegradability, separation and adsorption techniques [Choy et al.,1999]. Many workers have been made to find alternative sorbents particularly for the sorption of basic dyes,such as activated carbon, unburned carbon [Basibüyük and Foster, 2003], [Choy et al.,1999], silica [Shabin and Huiting, 2005] bentonite [G.McKay *et al.,* 1980] natural adsorbents such as orange peel [Cheng- Lain *et al.,* 2004] palm fruit bunch [Namasivayam-Muniasamy et al.,1996] teak wood bark, cotton waste, rice husk[Nassar and Magdy, 1997] sugar cane dust [Ho and Mckay, 1998], chitin[Mckay, Porter and Prasad, 1999], fly ash[Khattri and Singh, 1999], clay [Jesionowski, 2005], chitosan[Konica Minolta Sensing,1998] and others [G.McKay et al.,1938],[Grupta etal., 1990], Sethuraman and Raymahashay, 1975], Uzun, 2006], [Frei and Zeitlin, 1965], [Balkose and Baltacioglu, 1992] have been extensively used as adsorbents.

Silica synthesised by the sol- gel technique plays the role of selective adsorbent of organic dyes

[Macchi *et al.,* 1986], Marranon and Sastre, 1991]. The carrier formed in this way is highly uniform and first of all, contains spherical particles of low dimensions (100-500nm). Applying a high pressure technique[Roy et al., 1993] silicas formed by precipitation from aqueous solutions of alkali metal silicates provide an alternative to SiO_2 carriers obtanied by the sol- gel technique[Eren and Acar, 2006] The silica used in this study that owing to its high surface area, fast adsorption kinetics and chemical stability under acidic conditions

Experimental technique

Materials

Silica was purchased from sýlýkagel pro.Tenk.Chro. sklo union k.p. and the dye in this study is basic dye obtanined from a textile firm in Turkey. Other chemicals used were analytical reagent.

Batch experiments

Batch adsorption experiments were carried out at 24±1 °C in conical flaks (250ml) using shaken at 140rpm on a rotary shaker. The stock solution of maxilon red (100ml) was prepared and suitably diluted to the required initial concentrations (5-80mg/L). The silica (0.1g) was was added into 20ml dye solutions. The data for deriving the Langmuir constants were obtanied by using silica (0.1g) and dye concentrations of 5,10,20,40 and 80 mg/l. After the dye solution was separated from adsorpbent and centrifuged at 6000 rpm for 20min. The final equilibrium concentrations were measured spectrophotometrically at 537nm using a Specord 40 analytik jena AG. The percentage removal of dye and amount adsorbed (mg/g) were calculated using the following relationships

Percentage removal (%) = $(C_o - C_e)/C_o$ x 100 ...(1)

$$\text{Amount adsorbed } q_e \frac{C_o - C_e}{m} V \quad \text{...(2}$$

Where C_o and C_e are the initial and equilibrium concentration (mg/L), respectively, and m is the amount of adsorbent and V is the volume of solution.

The colorimetric data of the obtanied dye solutions were documented using an instrumented colorimeter using a spectrophotometer CM-3600d. Adsorbed dye concentrations were poured into the measurement cup. The instrument provided the colour in the terms of the CIE $L^* a^* b^*$ colour space system. In this colour space, L^*represented the lightness (or brightness), a^* and b^* were colour coordinates, where + a^* was the red direction, - a^* was the green direction + b^* was the yellow direction, and - b^* was the blue direction (Jesionowski, 2005), (Konica Minolta Sensing, 1998).

RESULTS AND DISCUSSION

Colorimetric properties

Colorimetric studies, performed in the CIE $L^* a^* b^*$ colour space system, permitted to obtaning data on changes input of individual colours following adsoption of maxilon Red GRL onto silica (Table 1-5),and clearly increased value of lightness (L^*) was reported. Increasing amounts of the adsorbed dye were paralleled also by an evident removal in colour of aqueous solution. Studies on adsorption of maxilon red was found by an evident change in participation of red (+a^*) and green (-a^*), and yellow (+ b^*) and blue (-b^*) colours. With increasing adsorption of maxilon red evidently increased parameter of lightness (L^*) and decreased parameter of $a^*$and b^* were reported. Indicating that adsoprtion process is favorable for silica adsorbents. Besides, the results of colorimetric studies indicate that the rate of color removal increased according to contact time and for dilute initial concentration, but the rate of color removal in aqueous solution is decreased according to strong initial concentration. The results are displays in Table. 1-5

Effect of initial dye concentrations

The adsorption of dye by silica was studied at several differrent initial concentrations and differrent time. Initial maxilon red concentrations ranging from 5 to 80 mg/L. The results are displayed in fig.1.

The results indicate that rate of color removal increased depending on the contact time and initial dye concentrations. For silica adsorbents, decolorization of dye is speedy in the first 20 min.

Then the rate of adsorption was became slowed. When the initial dye concentration was increased, adsorption efficiency decreased for same adsorbent dose. As can be seen in fig. 1 when the initial dye concentration was increased, adsorption efficiency decreased. Values of the removal efficiency of the dye ranged from 47.7 to 96 %.

The adsorption equilibrium data of Maxilon Red GRL onto silica were arranged to the Langmuir and Freundlich is isotherm forms. Langmuir and Freundlich models has written the form as follows (Marungrueng and Pavasant, 2007)

$$qe = \frac{q_m b C_e}{1 + b C_e} \quad ...(3)$$

Table 1: Colorimetric data for the initial (5ppm) and equilibrium concentration of dye solutions

	Concentration	Time	Colorimetric data		
			L^*	a^*	b^*
Initial concentration	5 ppm		20.79	20.08	-4.69
	5 ppm	20	45.35	2.13	-0.61
	5 ppm	40	47.21	1.58	-1,38
Equilibrium	5 ppm	60	47.10	2.02	-1.45
concentration of	5 ppm	80	40.68	1.56	-0.31
dye solutions	5 ppm	120	42.30	0.63	-2.29
	5 ppm	180	42,20	0.55	-2,31

Table 2: Colorimetric data for the initial (10ppm) and equilibrium concentration of dye solutions

Initial	Concentration	Time	Colorimetric data		
			L^*	a^*	b^*
	10 ppm		17.57	29.27	-3.77
	10 ppm	20	45.35	2.13	-0.61
	10 ppm	40	42.64	4.49	-1,35
Equilibrium	10 ppm	60	43.38	0.78	-2.08
concentration of	10 ppm	80	42.69	4.44	-2.07
dye solutions	10 ppm	120	43.43	4.13	-2.29
	10 ppm	180	44.16	1.07	0.68

Table 3: Colorimetric data for the initial (20ppm) and equilibrium concentration of dye solutions

Initial	Concentration	Time	Colorimetric data		
			L^*	a^*	b^*
	20 ppm	20	39.23	14.81	-2.90
	20 ppm	40	45.02	5.47	-0,89
Equilibrium	20 ppm	60	42.75	8.81	-2.41
concentration of	20 ppm	80	40.14	12.08	-2.39
dye solutions	20 ppm	120	40.63	11.45	-2.23
	20 ppm	180	44.57	1.84	1.32

qe = Kf Ce1/n ...(4)

where q_m, b, C_e, K_f and n representing the maximum amount of dye uptaken per unit mass of the sorbent, Langmuir constant and equilibrium concentration of the in the solution, K_f and n Freundlich constants, respectively.

Where Eqs.(3) and (4) were linearized, which has the form as follows

$$\frac{1}{q_e} = \frac{1}{q_m} + \left(\frac{1}{bq_m}\right)\left(\frac{1}{C_e}\right) \quad ...(7)$$

$$\text{Log } q_e = \log K + 1/n \log C_e \quad ...(6)$$

Table 4: Colorimetric data for the initial (40ppm) and equilibrium concentration of dye solutions

Initial	Concentration	Time	Colorimetric data		
			L^*	a^*	b^*
	20 ppm		17.92	34.02	8.05
	40 ppm	20	44.03	5.78	-2.27
	40 ppm	40	33.39	1.55	-1.89
Equilibrium	40 ppm	60	34.76.	22.91	-0.49
concentration of	40 ppm	80	37.80	15.60	-1.36
dye solutions	40 ppm	120	34.98	19.34	-1.05
	40 ppm	180	42.36	4.13	0.94

Table 5: Colorimetric data for the initial (80ppm) and equilibrium concentration of dye solutions

Initial	Concentration	Time	Colorimetric data		
			L^*	a^*	b^*
	20 ppm		23.39	41.31	25.9
	80 ppm	20	38.04	20.71	2.26
	80 ppm	40	37.04	19.67	1.32
Equilibrium	80 ppm	60	31.81	23.67	2.86
concentration of	80 ppm	80	33.83	23.94	1.61
dye solutions	80 ppm	120	37.80	16.27	-0.83
	80 ppm	180	39.00	9.50	2.19

Table 6: Langmuir and Freundlich constants for Maxilon Red dye

				Langmuir model		Freundlich model		
	qm mg/g	$b_{,L/mg}$	R^2	R_L	$C_{o,\,mg/L}$	*n*	K_f, *L/g*	R^2
Maxilon	3.03	0.068	0.92	0.746	5	1.563	0.486	0.92
Red				0.595	10			
				0.423	20			
				0.268	40			
				0.155	80			

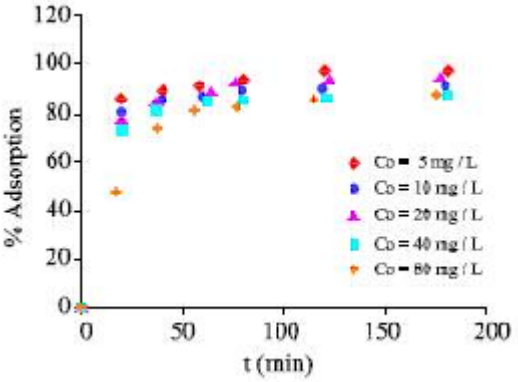

Fig. 1: Effect of contact time and initial dye concentration on dye removal. Silica dose 0.1 mg natural initial P^{H,} at 24±1 °C agitation speed 140 rpm

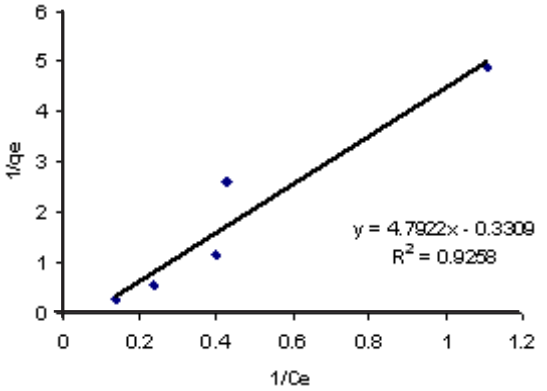

Fig. 2: Langmuir plots corresponding to the adsorption of maxilon red dye onto silica

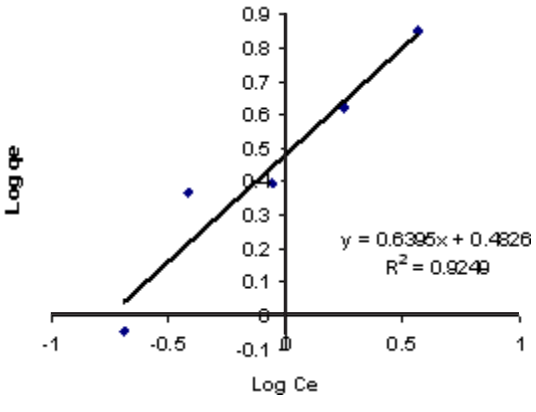

Fig. 3: Freundlich plots corresponding to the adsorption of maxilon red dye onto silica

Plot $1/q_e$ vs. $1/C_e$ for Maxilon blue GRL, from the slope of line, q_m and from the y- incercept of the line b isotherms values have been calculated. Fig.2-3 clearly shows that the Langmuir and freundlich model can describe the experimental data. The finding suggested that the sorption of Maxilon red onto silica was monolayer coverage. The essential characteristics of the Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor or equilibrium parameter R_L, which is defined by Nassar and Magdy (Nassar and Magdy, 1997), (Eren and Acar, 2006) as

$$R_L = 1/ (1+ b C_o) \quad ...(7)$$

The R_L values (Eq. (7)) dictate favorable adsorption for $0< R_L<1$(Nassar and Magdy, 1997), (Eren and Acar, 2006). The data in table 6 show that the R_L values ranged between 0.746 and 0.155 indicating that silica is favorable for Maxilon Red dye. Similarly, from the of linear correlation between the values log q_e and log C_e, Freundlich constants (K_f and n) have been calculated. The parameters K_f and n for listed in table. 6. Parameters of Langmuir and Freundlich model constants are shown in table 6. The results display that the Langmuir and Freundlich isotherms are fit for adsorption of Maxilon red onto silica.

As shown in table 6 Where q_m is a parameter related to the Langmuir adsorption capacity and parameter b Langmuir constant and R^2 Correlation coefficient, similarly, K_f is a parameter related to the Freundlich adsorption capacity and n Freundlich constant. This shows that the adsorption isotherm and models fit by Freundlich and Langmuir equation are depicted.

CONCLUSIONS

This study shows that the silica is a potential adsorbent for Maxilon Red removal in aqueous solutions. In addition, it is a locally available low-cost adsorbent in Turkey. Colorimetric studies, performed in the CIE $L^* a^* b$ system, evidently increased parameter of lightness (L^*) was indicated.

For the adsorption equilibrium, it was found that Langmuir and Freundlich models were fitted. The monolayer adsorption capacity of silica was found to be 3.03mg/g

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