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Decantamination of Textile Wastewater by Powdered Activated Carbon

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Abstract: Dyes are usually present in the treated effluents of textile industry. The effectiveness of adsorption for dyes removal from wastewaters has made it an ideal alternative to other expensive treatment methods. For that, the adsorption of three textile dyes: Methylene blue, basic yellow and JK2R, on powdered activated carbon was studied in aqueous solution using the batch equilibration technique. The modeling of the adsorption equilibrium showed that the adsorption of this dyes fitted a Langmuir isotherm. Adsorption was influenced by the adsorbent concentration and solution characteristics such as pH and ionic strength.

Key words: Kinetic of adsorption, isotherms, ionic strength

INTRODUCTION

The textile industry is one of those industries that consume considerable amount of water in the manufacturing process. The water is primarily employed in the dyeing and finishing operations in which needs to be treated before final discharge^[1]. The primordial aim of industrials is to find a process of treatment that either technically and economically adapted to there means. Adsorption is one of the most useful techniques, much adsorbents have been studied for the uptake of dyes^[1-10]. The present study has been undertaken to evaluate the efficiency of powdered activated carbon in the textile wastewater treatment. The ability of this material to adsorb various cationic and anionic dyes such as methylene blue, basic yellow and JK2R under different experimental conditions was investigated

MATERIALS AND METHODS

Powdered activated carbon used is supplied by Merck (Lyon, France). The particle size was less then 80 μm . a specimen was characterized by N_2 adsorption at 77 K, from the data obtained, the specific area calculated by applying the Brunauer-Emmett-Teller (BET) equation^[11] is 831 $\text{m}^2 \text{g}^{-1}$. The pH of the point of zero charge was $\text{pH}_{\text{pzc}} = 1.80$ witch determined using the method described by Sontheimer *et al.*^[12] and Fero-Garcia *et al.*^[13]. Methylene bleu is supplied by Riedel-de Haën, basic yellow and JK2R are supplied by Heinkel. The aqueous solution concentration of the three dyes were determined using a CECEIL UV/Visible spectrophotometer. The wavelength of maximum absorption are 661, 440 and

395 nm, respectively for methylene blue, basic yellow and JK2R. The quantity adsorbed was calculated by measuring the concentration of the solutions before and after adsorption. Both adsorption experiments were carried out to investigate the factors that influence the dyes uptake by the adsorbent, such as the contact time under agitation, pH, absorbent dosage, ionic strength and dyes initial concentration.

RESULTS AND DISCUSSION

Kinetic of adsorption: Kinetic of retention describe speeds of reactions that permit to determine the contact time under agitation put to reach the equilibrium of adsorption. It's an important stage in the study of adsorption. For that, we followed in the Fig. 1 the kinetic of discoloration of methylene blue. Basic yellow and JK2R for an initial concentration of 20 mg L^{-1} , with 0.05 g L^{-1} of powdered activated carbon.

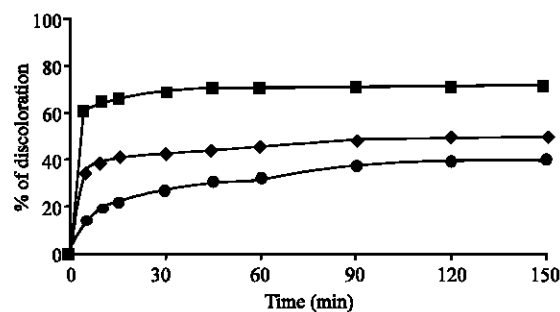


Fig. 1: Kinetic of adsorption of methylene blue (♦), basic yellow (■) and JK2R (●) on powdered activated carbon

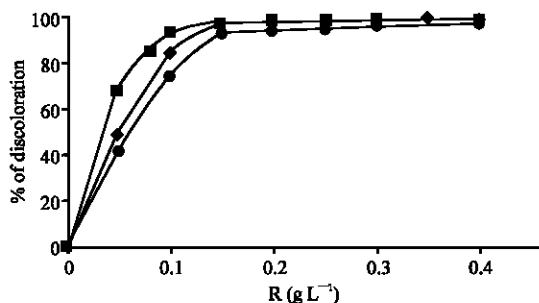


Fig. 2: Variation of fading percentages of methylene blue (♦), basic yellow (■) and JK2R (●) according to activated carbon mass

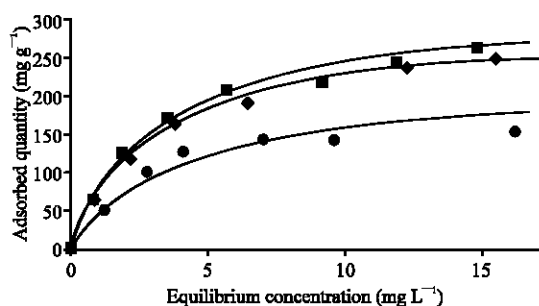


Fig. 3: Adsorption isotherms of methylene blue (♦), basic yellow (■) and JK2R (●) on powdered activated carbon

The equilibrium times of these three dyes are respectively 60, 90 and 120 min for methylene blue, basic yellow and JK2R. The curves indicate that speeds of reactions of adsorption of these dyes are faster in the beginning of contact. Nevertheless, we note that the kinetic of adsorption of JK2R is so slower.

Effect of adsorbent dosage: As shown in Fig. 2 the variation of the percentage of fading of the solutions according to the masses of powdered activated carbon with a contact time of 3 h and an initial concentration of dyes of 20 mg L⁻¹.

We note, that the percentage of fading of the three solutions increase with increasing activated carbon mass, until the total fading at 0.15 g L⁻¹ with an order of fading going from the basic yellow, methylene blue to JK2R.

Adsorption isotherms: Isotherms of adsorption have been achieved with different initial concentrations of dyes with 0.05 g L⁻¹ of activated carbon at 25°C and a contact time 3 h. They are depicted in Fig. 3, these isotherms belong to type L of the Giles *et al.*^[14] classification, which indicates that, as more sites in the substrate are filled, it becomes increasingly difficult for the solute molecules to find

Table 1: Langmuir isotherm constants T[∞] and K_L for the three dyes on powdered activated carbon

	T [∞] (mg g ⁻¹)	K _L (L g ⁻¹)	R ²
Methylene blue	294.12	330.1	0.9961
Basic yellow	322.6	304	0.9956
JK2R	222.2	238.12	0.9716

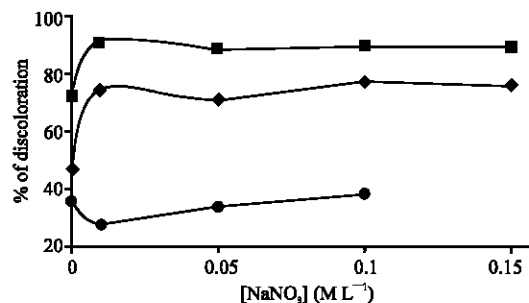


Fig. 4: Effect of ionic strength on the adsorption of methylene blue (♦), basic yellow (■) and JK2R (●) on activated carbon

an available vacant site. This could be either because the adsorbed molecules are more likely to be adsorbed on mono-layer on a surface containing a finite number of identical sites or because there is no strong competition from the solvent.

The description of adsorption isotherms has been achieved applying the linear form of Langmuir equation proposed by Stumm *et al.*^[15]:

$$\frac{1}{T} = \frac{1}{T^{\infty}} + \frac{1}{K_L \cdot T^{\infty}} \cdot \frac{1}{C_R}$$

T[∞]: Represents the mono-layer coverage of the adsorbent particle in terms of mg dye/g activated carbon.

K_L: Langmuir equilibrium constant.

$\frac{1}{C_R}$ vs $\frac{1}{T}$ A plot of yields T[∞] and K_L

Table 1 shows that the maximal adsorption capacities are in the following order basic yellow, methylene blue and JK2R. This order would be probably assigned to the molecular structure of this substrate.

Effect of ionic strength: Figure 4 shows the variation of the fading percentage according to the increasing concentrations of NaNO₃. Results showed that the addition of NaNO₃ increase distinctly the adsorption of cationic dyes: Methylene blue and basic yellow, whereas, the adsorption of anionic dye JK2R decrease.

The effect of the ionic strength on the adsorption of organic molecules is accorded to surface chemistry theory. Activated carbon particles and dyes molecules are both surrounded by an electric double layer, due to

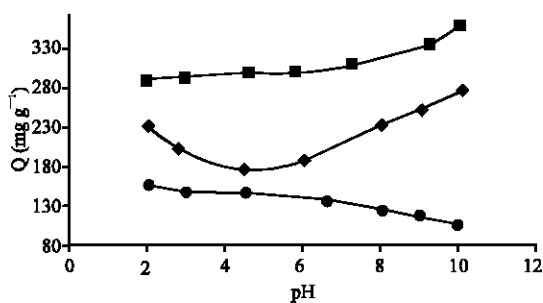


Fig. 5: Effect of pH on the adsorption of methylene blue (♦), basic yellow (■) and JK2R (●) on powdered activated carbon

electrostatic interaction. The thickness of this double layer were compressed by an increase in the ionic strength of the solution^[16], which increase the attraction forces with cationic dyes increasing therefore the adsorption and increase repulsive attractions with anionic dye decreasing his adsorption.

Effect of pH: The pH is an important factor in each study of adsorption, because both adsorbed and adsorbent may have functional groups which are affected by the concentration of hydrogen ions (H^+) in the solution and which are involved in the molecular adsorption process at the active sites of adsorbent. Figure 5 shows the effect of pH on the adsorption of the three dyes with an initial concentration of 20 mg L^{-1} and a mass of activated carbon of 0.05 g L^{-1} . The measures of concentrations are maked holding amount the effect of the pH on the calibration curves.

It was found that an increase in pH increase progressively the adsorption of cationic dyes methylene blue and basic yellow and decrease the adsorption of anionic due JK2R. These results can be interpreted on the following manner, the pH_{pzc} of the activated carbon is equal to 1.84, above this value, the surface charge negative become more significant with the increase of the pH increasing therefore the electrostatic attraction forces with cationic dyes and decreasing those of anionic dye^[17]. The increase of the adsorption of methylene blue in acidic surrounding can be probably owed to the fact that the molecule contains amin groups which are ionisable by quaternisation with H^+ , that driven an increase of the adsorption.

CONCLUSIONS

This study shows that the adsorption of this three dyes on powdered activated carbon are rapid and is greater for cationic dyes then the anionic one. The

adsorption in greatly pH dependent, with a high uptake of cationic dyes at high pH and high uptake of anionic dye at low pH. The uptake of cationic dyes increase with addition of $NaNO_3$, probably because of the compression of the diffuse double layer. These result show that the interactions between dyes molecules and carbon particles are essentially of an electrostatic nature. Finally, the use of powdered activated carbon shows a greater potential for the removal of textile dyes than an other process, as no costly equipment is required.

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