COMPARATIVE STUDY OF SORPTIVE PROPERTIES OF VARIOUS LOW-COST SORBENT MATERIALS FOR BEMACID BLUE (ACID DYE) REMOVAL FROM SYNTHETIC AQUEOUS SOLUTIONS.

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Abstract. This work explores the possibility of using three agricultural wastes namely: orange (Tomson and Clementine varieties) peel and grenada peel, as inexpensive sorbents for the removal of an acid dye: bemacid blue, as a model of acid dyes, from synthetic aqueous solutions. These materials are abundantly available in Algeria, hence cost effective sorbents. Dyes sorption equilibrium and kinetics tests were performed at acid pH of solutions (2.20) in batch conditions. The effect of some parameters such as: contact time and initial dye concentration on dye sorption kinetics, has been studied. For each sorbent, the quantity of dye sorbed at equilibrium depends on initial dye concentration: it increased with its increasing. Two simplified kinetic models including a first-order and pseudo second-order models were selected to analyse the dye sorption kinetics. The sorption kinetics of bemacid blue by each sorbent tested was well described by a pseudo-second order rate model. In order to describe the dye sorption isotherms mathematically and to obtain information about the maximum dye sorption capacity of each sorbent tested, the equilibrium data were analysed using only the Langmuir model which has shown an acceptable fitting in all the range of dye initial concentrations studied. Under the investigated experimental conditions, the maximum dye sorption capacities obtained by the sorbents followed the order: 31.39 mg/g (clementine peel) > 30.71 (Thomson peel) > 27.35 mg/g (grenade peel). As results, the present study shows these wastes tested can be acceptably used as sorbent materials for the removal of acid dyes from synthetic aqueous solutions but in acidic medium.

1. INTRODUCTION

Synthetic dyes are extensively used for dyeing and printing in industries. Their presence in watercourses is aesthetically unacceptable and may be visible at concentration as low as 1 ppm [1]. Moreover, they may also affect photosynthetic activity in aquatic systems by reducing light penetration [2]. Among the various types of dyes, various acidic dyes are used to color nylon, wool, sole in textile industries, paper and leather. This class of dyes is the most problematic, because they tend to pass through conventional treatment systems unaffected [3]. As a result, there is a

search for low-cost, naturally occurring, abundant sorbent materials that can serve as viable alternatives to activated carbon.

This work compares the sorption performances of three biological wastes namely: peel of two orange varieties (Tomson and Clementine) and Grenada peel as sorbent materials for the removal of bemacyd blue (acid dye), as a model of acid dyes, from synthetic aqueous solutions. These materials are abundantly available in Algeria, hence cost effective sorbents. Dye sorption equilibrium and kinetics tests at solution initial pH value of 2.20 were performed in batch conditions. The influence of some parameters such as: contact time and initial dye concentration on dye sorption kinetics, has been studied. Two simplified kinetic models including a pseudo first-order and pseudo second-order models were selected to analyse the dye sorption kinetics. In order to describe the dye sorption isotherms mathematically and to obtain information about the maximum dye sorption capacity of each sorbent tested, the experimental sorption equilibrium data were analysed using only the Langmuir model.

2. Materials and methods

2.1. Sorbents: In this work, three agricultural solid wastes: orange (Tomson and Clementine varieties) peel and grenade peel, were used as sorbent materials, because there are cheap and highly available lignocellulosic wastes in Algeria. These wastes were purchased from a local market in autumn-winter 2011 in the form of large flakes. Firstly, there were cut in small pieces, sun/air dried at ambient temperature during many days and oven-dried at 80 °C for 24 h. To be used as sorbent materials, these wastes were washed thoroughly with tap water to remove all the adhering dirt particles until no colour was observed, rinsed using a distilled water until the pH of solution was stabilized, filtered and then oven-dried at 80°C for 24 h. Then, there were crushed and sieved to keep only the size range 1.25-2 mm.

2.2. Dyes: Bemacid blue E-TL (Bezema Suisse) as a commercial salt with unknown structure, was kindly donated by SOITEX Company located in the City of Tlemcen-Algeria and used as received without further purification, in single component aqueous solutions. 2 000 mg/L stock solutions of dye were prepared in distilled water. All working solutions of the desired concentration were prepared by successive dilutions.

2.3. Sorption experiments

2.3.1 Uptake kinetics: In each sorption kinetics experiment, 2L volume of dye solution of known initial concentration in the range of 50-300 mg/L and solution initial pH adjusted to 2.20, was added to 2 g of each sorbent in a beaker agitated vigorously by a magnetic stirrer using a water bath maintained at a constant temperature of 25±1 °C. Samples from the clear supernatant, at appropriate time intervals, were pipeted from the reactor by the aid of the very thin point pipette, which prevented the transition to solution of sorbent samples. Their dye concentrations were determined using a UV-visible spectrophotometer (Lange Hach, model DR 5000, USA) by monitoring the absorbance changes at a wavelength of maximum absorbance: λ_{max} = 604 nm. The dye uptake q_t (mg dye/g sorbent) was determined by Eq. (1) as follows:

$$q_t = (C_o - C_t) \times V/m \qquad (1)$$

where C_o and C_t are the initial and time dye concentration (mg/L), respectively, V is the volume of solution (mL); and m is the sorbent weight (g) in dried form.

2.3.2. Uptake equilibrium: The dye equilibrium isotherms were determined by contacting a constant mass 0.200 g of each sorbent material with equal volumes of dye solution 200 ml of different initial dye concentrations in the range: 25-700 mg/L with an initial solution pH adjusted to 2.20 by adding small amounts of HCl 1N. The mixture obtained was agitated in a series of 250 ml conical flasks for a period of 24 h at room temperature (25 ± 1°C). The mixture pH was not controlled after the initiation of experiments. At equilibrium, the final pH was measured. The equilibrium concentration of unbound dye was determined with a UV-visible spectrophotometer as

previously described. The equilibrium dye uptake q_e (mg dye/g adsorbent) was determined by Eq. (2) as follows:

$$q_e = (C_o - C_e) \times V/m \qquad (2)$$

where: C_o and C_e are the initial and equilibrium dye concentration (mg/L), respectively, V is the volume of solution (mL), and m is the sorbent weight (g) in dry form.

3. RESULTS

The present study has shown that the three wastes tested in this work, can be acceptably used as sorbent materials for the removal of bemacid blue from synthetic aqueous solutions but in acidic medium. For each sorbent, the quantity of dye sorbed at equilibrium was initial dye concentration dependent. The sorption kinetics of bemacid blue by each sorbent was well described by a pseudo-second order rate model. An acceptable fitting of dye sorption equilibrium data was obtained with Langmuir model in all the range of concentrations studied. Under the investigated experimental conditions, the maximum dye sorption capacities obtained by these sorbents followed the order: clementine peel (31.29 mg/g) ≥ tomson peel (30.71 mg/g) > grenade peel (27.35 mg/g). These results are encouraging in spite there are still several very important aspects to clarify.

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