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BALANCE, KINETICS, ISOTHERM AND THERMODYNAMIC MODELING OF ADSORPTION OF REACTIVE ORANGE 7ON TO BALSAMODENDRONCAUDATUM WOOD SQUANDER ACTIVATED CARBON MATERIAL

KEYWORDS: BACM, Adsorption, Reactive Orange 7, kinetics, isotherm; low-priced sorbents; aqueous solution.

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ABSTRACT *Balsamodendron caudatum wood waste activated carbon (BACM) has the potential to take up the dyes from aqueous solution. The inappropriate discarding of dyes in waste water constitutes an environmental problem and can cause harm to the flora and fauna. Present examination deals with the exploitation of (BACM) waste as adsorbent for the elimination of Reactive Orange 7dye from its aqueous solutions. The treated (BACM) using sodium sulphate was evaluated through SEM and XRD.The analysis indicates that adsorption is inclined by initial dye concentration, contact time, dye solution pH.A Kinetic study of dye followed the pseudo-first-order, pseudo second-order and Elovich models correspondingly. Conclusions show that the pseudo first order kinetic model was found to compare the investigational data fit.*

INTRODUCTION

A dye is carcinogenic, affects reproductive organs and develops toxicity and neurotoxicity (Lakshmi 1987). Therefore, the dyes are to be necessarily removed from water and wastewater. Different processes for color removal typically include physical, chemical, and biological schemes. The lower generation of residues, easy metal recovery, and the possibility to reuse adsorbent are the greatest advantages of this method (Gurnani et al. 2003). One of the major challenges associated with adsorption by activated carbon is its cost effectiveness. Hence research of recent past mainly focused on utilizing waste materials as alternatives to activated carbon. Bamboo (Ahmad et al., 2009) , sugar cane bagasse ash (Kanawade et al., 2011), bone char (Alvin et al., 2010), fly ash(Sell et al., 1994), peat moss(Allen and McKay 2001; Chen et al.,2001), ipomoea carnia stem waste (Karthikeyan et al., 2007) , jujuba seeds (Somasekhara Reddy et al., 2012) and potatoes ,egg Husk (Hila et al., 2012) and solid coal (Katarzyna Czerw et al., 2016) are some of the waste materials which have been fruitfully tried for this purpose.

1 EXPERIMENTAL

1.1 Adsorbent

Balsamodendron caudatum wood waste was obtained from various regions of Erode & Tirupur Districts, Tamil Nadu, India. The study of *Balsamodendron caudatum* wood waste material is used as adsorbent is expected to be economical, environmentally safe and it has practical importance.To develop adsorbents, the material was first ground and washed with doubly distilled water and then dried. The dried material thus obtained was treated with hydrogen peroxide (30%W/V) at room temperature for about 24 hrs to oxidize the adhering organic matter. The resulting material was thoroughly washed with doubly distilled water and then subjected to the temperature of 120°C for the moisture removal.

One portion of the above material was soaked well with Na2SO4 solution for a period of 24 hours. At the end of 24 hrs the excess of Na_2SO_4solution were decanted off and air-dried. Then the materials were placed in the muffle furnace carbonized at 120-130°C. The dried materials were powdered and activated in a muffle furnace kept at 800°C for a period of 60 minutes. After activation, the carbon of obtained were washed sufficiently with large volume of water to remove free acid, Then the obtained material was washed with plenty of water to remove excess of acid, dried then to desired particle size and named as BACM.

1.2 Preparation of aqueous dye solution

The stock solutions of the dye (1000 mg/L) were prepared by dissolving 1 g of respective dye in one litre of water without any further treatment, which were kept in dark coloured glass bottles. For batch study, an aqueous solution of this dye was prepared from stock solutions in deionized water. NaOH and HCl solutions were used as buffers for pH studies.

1.3Amount of dye adsorbed

The formula used to find the Amount of dye adsorbed, Q_e , was as shown below:

$$Q_e = \frac{C_0 - C}{M} \times V \qquad (1)$$

Q_e (mg/g) is the amount of dye adsorbed at equilibrium, V (L), isthe volume of the solution dye, Co (mg/L) is the initial dye concentration, C (mg/L) is the dye concentration at any time and M (g) is the adsorbent dosage.

The percentage of removed anionic dye (R %) in solution was calculated using eqn.

$$\%\ \text{Removal} = \frac{C_0 - C_t}{C_0} \times 100 \qquad (2)$$

The initial concentration of Reactive Orange 7pH and temperature was investigated by varying any one parameters and keeping the other parameters constant

1.4 The pseudo first – order equation

The pseudo first - order equation (Lagergren 1898) is generally expressed as follows.

$$\frac{dq_t}{dt} = k_1(q_e - q_t) \qquad (3)$$

where,

q_e and q_t are the adsorption capacity at equilibrium and at time t., respectively (mg g^{-1}), k_1 is the rate constant of pseudo first –order adsorption (l min^{-1}).

1.5 The pseudo second – order equation.

The pseudo second – order adsorption kinetic rate equation is expressed as (Ho et al. 2000)

$$\frac{dq_t}{dt} = k_2(q_e - q_t)^2 \qquad (4)$$

where, k_2 is the rate constant of pseudo second order adsorption (g. mg^{-1}. min^{-1}).

Which is the integrated rate law for pseudo second – order reaction. Equation (4) can be rearranged to obtain equation (5), which has a linear form.

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}(t) \qquad (5)$$

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If the initial adsorption rate h (mg g^{-1} min^{-1}) is

$$h = k_2 q_e^{\,2} \qquad (6)$$

The plot of (t/q_t) and t of equation (6) should give a linear relationship from which q_e and k_2 can be determined form the slope and intercept of the plot, respectively.

1.6 The Elovich equation

The Elovich model equation is generally expressed (Chien and Clayton 1980) as

$$\frac{dq_t}{d_t} = \alpha \exp(-\beta q_t) \qquad (7)$$

where, is the initial adsorption rate (mg.g^{-1} min^{-1}), is the adsorption constant (g. mg^{-1}) during any one experiment.

2 RESULTS AND DISCUSSIONS

2.1 Characterization of adsorbent

Physico-chemical characterizations of the adsorbents are presented in Table 1.

Table 1 Characteristics of the Activated Carbon BACM

Parameter	BACM
pH	6.5
Surface area (m^2/g)	339.64
pH zpc	4.5

The surface area of the BACM was measured through N_2 adsorption at 77K using a NOVA1000, Quanta chrome Corporation. The pH of BACM was measured by a PHS-3C pH meter. pH of zero charge (pHpzc) of the samples was determined using pH drift method (Fariaa et al., 2004). The surface area of the BACM obtained from the N_2 equilibrium adsorption isotherms was found to be 339.64 m^2/g. The results of "pH drift" experiment, from which the pHpzc of BACM studied in this test was found to be 4.5.

2.2 Effect of pH

From the set of experiments conducted to find the effect of pH on adsorption phenomenon, it was observed that pH influences BACM surface dye binding sites and the dye chemistry in water. Figure 1 shows the amount of dye adsorbed, q_e using acid activated absorbent at initial pH value. In this experiment, the initial dye concentration was fixed at 20 mg/L. From the shake flask experiments, better colour removal of the dye, Reactive Yellow 37, was observed at pH of 6.5 .The uptake of Reactive Yellow 37was found to be optimal at pH 6.5 with the maximum dye uptake of 81.6 mg/g .

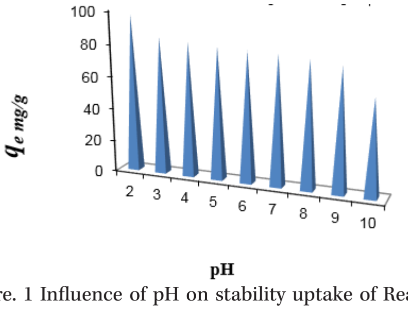

Figure. 1 Influence of pH on stability uptake of Reactive Orange 7 adsorption onto BACM. 100 mg; V, 50 ml; C_0 20 mg/L; temperature, 30°C).

It is evident that the adsorption of dye on the BACM waste activated carbon is best described by first order rate equation with regression coefficient value is greater than 0.98.

2.6. Morphology

The study by SEM of the adsorbent shown in the fig. 1 exposed that, it is highly permeable in nature. From the SEM results, it was found that there are uniform holes and cave type openings on the surface of the specimen that would definitely have increased the surface area (Khattri et al. 2000)

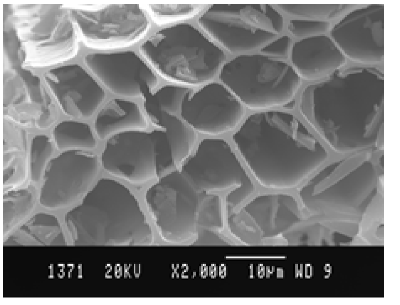

Figure.1 SEM analysis for BACM

3. CONCLUSIONS

The sorption of reactive dye on the BACM was originate to be reliant on the pH, (The most favorable pH of Reactive Orange 7was 6.5), temperature and concentration for adsorbent. Thermodynamic parameters obtained for the adsorbent accounts for feasibility of the process at each concentration. Adsorption equilibriums were reached within 105 min contact time for reactive dye used in this test. Thermodynamic parameters obtained for the adsorbent accounts for feasibility of the process at each concentration. The kinetics of Reactive Orange 7 sorption on adsorbent was found to follow a pseudo first -order rate equation. An equilibrium isotherm for the adsorption of Reactive Orange 7on BACM was analyzed by the Langmuir isotherm equations. Result showed that the Langmuir isotherm best-fit the Reactive Orange 7adsorption.

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