Jr. of Industrial Pollution Control 30(1)(2014) pp 163-167

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ADSORPTION OF REACTIVE DYE USING AGRICULTURAL WASTE - A KINETIC APPROACH

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(Received 10 February, 2014; accepted 15 March, 2014)

Key words : Commercial activated carbon, Coir pith activated carbon, Adsorption, Aqueous dye solution.

ABSTRACT

This study was designed to investigate the removal of reactive violet 48 from wastewater using Commercial activated carbon and Coir pith activated carbon. Its adsorption capacity has been tested for the decolourization of waste water containing reactive violet 48. The effect of system variables such as concentration, temperature, contact time and pH were studied. The adsorption data follow Langmuir model as well as Freundlich model.

INTRODUCTION

Waste water generated by the dye production industry and many other industries which use dyes and pigments is characteristically high in both color and organic content. About 10,000 different commercial dyes and pigments exist, and over 7 x 105 tons are produced annually world wide. It was estimated that about 10-15% of these dyes are released in effluents during dyeing processes (Papic *et al*. 2004).

The removal of dyes from industrial effluent is a major problem as Government legislation becomes more stringent. Discharge of dye bearing wastewater into natural streams from textile, paper, carpet and printing industries has created significant concern, as dyes impart toxicity and visibility (ICI Watercare, 1991).

Various techniques, such as chemical coagulation (Stephenson *et al.* 1996) (Niranjan and Karthikeyan, 1992) biosorption (Low *et al.* 1993) oxidation using ozone (Churchley, 1994), membrane separation (Grossley, 1994) and adsorption have been generally employed for colour removal. Adsorption is one of the most effective physical processes for the removal of dyes from wastewater. Most conventional adsorption systems use activated carbon which is expensive and necessitates regeneration (Mckay, 1982). Several researchers have investigated the alternative adsorbent materials that though less efficient involve lower costs. Among the studies alternative materials are lignite (Allen *et al*.1989), wood (Poots *et al*. 1978), flyash (Khare *et al.* 1988), coal (Gupta *et al.* 1990), boiler bottom ash (Mall and Upadhyay, 1995), rice husk (Lodha *et al.* 1997) and withered *Psidium guyava*

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Leaves (Singh and Srivastava, 1999)

Hence we undertook an attempt to prepare low cost carbon from the locally available natural material like coir pith. The characteristics of the carbons and applicabilities have been compared with that of Commercial activated carbon(CAC). The effect of various parameters such as initial dye concentration, temperature and pH has been investigated.

MATERIALS AND METHODS

Preparation of Coir pith Activated Carbon (CPAC)

Coir pith activated carbon (CPAC) was prepared by treating four parts with two parts of concentrated sulphuric acid and keeping it in an air oven at 140°C - 170°C for 24 hours. The carbonized material was filtered and washed with water to remove the excess acid and dried at 105 -110°C. The materials were grounded well and sieved to an average diameter of 0.5 mm (20- 50 ASTM) was used for further studies.

Preparation of dye solution

Accurately 100 mg of Reactive violet 48 was weighed and dissolved in 100 mL of water to get 1000 ppm dye solution.

Batch type experiments

Effect of time and initial dye concentration on the dye removal

Appropriate amount of stock solutions were diluted and were made up to 1000 mL to get 20, 40, 60, 80 and 100 ppm of dye solutions. Batch experiments were carried out by shaking 100 mL of dye solution with 0.1 g of the adsorbent in glass stopered conical flasks at a temperature of 20°C at the rate of 130 rpm. The effect of various parameters such as initial dye concentration, contact time and pH on the adsorption process was investigated. The progress of adsorption during the experiments was determined by removing flasks after desired contact time, centrifuging and analyzing the supernatant spectrophotometrically for dye concentration. The absorbance was measured at 408 nm against a blank.

Effect of pH on the dye removal

Effect of pH on the dye removal was found out by the following method. About 100 mL of aqueous dye solution containing 20 ppm of dye solution was taken in separate conical flasks. The pH of the solutions were maintained as 2,4,6,8, and 10 respectively using 0.1N NaOH and HCl solutions.

RESULTS AND DISCUSSION

The characteristics of the coir pith activated carbon (CPAC) obtained by agglomeration are presented in Table 1, Except for a decrease in the surface area, all characteristics of the coir pith was similar to that of the commercial activated carbon. The coir pith activated carbon (CPAC) with a density of 0.64 g/cm^3, can be suitably employed in a continuous treatment process.

Effect of initial dye concentration and contact time

The effect of initial dye concentration and contact time on the removal of reactive violet 48 is shown in Fig.1 and 2. From the Figure, it was evident that the removal of dye increased with decreasing dye concentration. Adsorption increased with an increase in contact time. It was found that equilibrium was attained at 40 min. Similar result was obtained in the removal of reactive dye using adsorbents CAC and CPAC were found to be 70% and 50% respectively, at 40 min equilibration time and at 20 ppm initial dye concentration.

Effect of pH

The removal of dyes as a function of pH is shown in Fig. 3. the removal of dye by CAC and CPAC were found to be a maximum in the acidic pH range of 1-3. It was observed that CAC and CPAC have removed dye to a maximum of 89% and 82% at pH 2. The pH value of the solution plays an important role in the whole adsorption process and particularly on the adsorption capacity. Similar observations have been reported by other workers for adsorption of reactive dyes indicating that the carbon has a net positive charge on its surface (Bousher *et al*. 1997).

Adsorption Isotherms

The equilibrium data for the system undertaken has been observed and analyzed Langmuir isotherm equation.

$C_e / q_e = (1/Q^o b) + (C_e/Q^o)$ - - - - - (Gupta *et al*., 1988)

Where, Ce is the equilibrium concentration (mg/L), qe is the amount of the dye adsorbed (mg/g), Q^o and b are Langmuir constants related to adsorption capacity and energy of adsorption respectively. The linear plot of C_e/q_e vs C_e shows that the adsorption follows Fig. 4 and 5. The present investigation was confirmed by obtaining the value of Q^o and b using regression analysis of equilibrium data and found 44.643 & 21.978 mg/g for Q^o and 0.0692 & 1.001 (lmg-1) for b respectively (Table 2). A linear plot confirms the applicability of Langmuir isotherm.

Freundlich adsorption isotherms

The isotherm has been proposed by Freundlich for dilute and moderately dilute solutions. It is represented empirically by the expression.

$$\text{Log } q_e = \log k_f + 1/n \log C_e$$

The values of 1/n and kf are determined from the slope and intercept of the curves, which was obtained by plotting log q_e vs log C_e, where k f is the measure of sorption capacity (mg/g) and 1/n is the measure of sorption intensity (Vaishya and Prasad, 1991). The empirical constants k_f and 1/n determined from the intercept and the slope of the straight line are furnished in Table 2. The values of 1/n lie between 0.3 and 0.2 which represents good sorption potential of the sorbent (Fig. 6 and 7). The linear plot confirms the applicability of Freundlich isotherm.

CONCLUSION

The experimental results showed that activated carbon prepared from coir pith was a suitable adsorbent for removal of reactive dyes from both synthetic and textile effluent. In batch studies, the adsorption

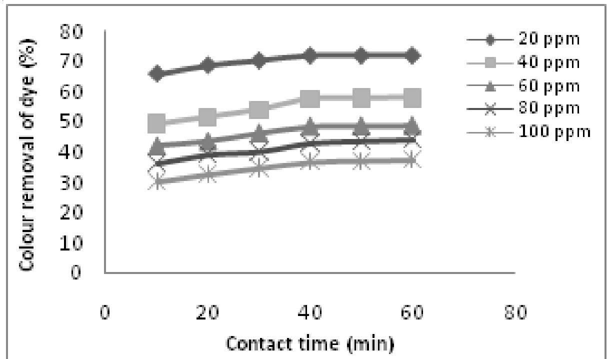

Fig:1 Removal of dye on CAC

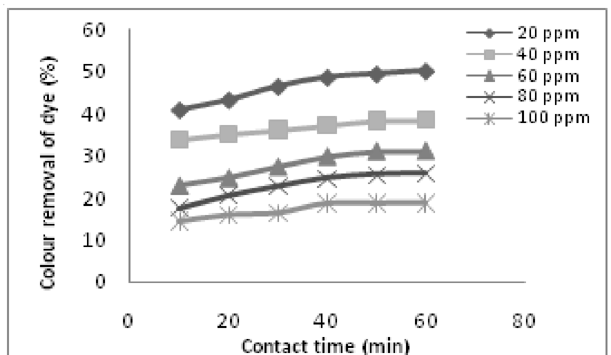

Fig:2 Removal of dye on CPAC

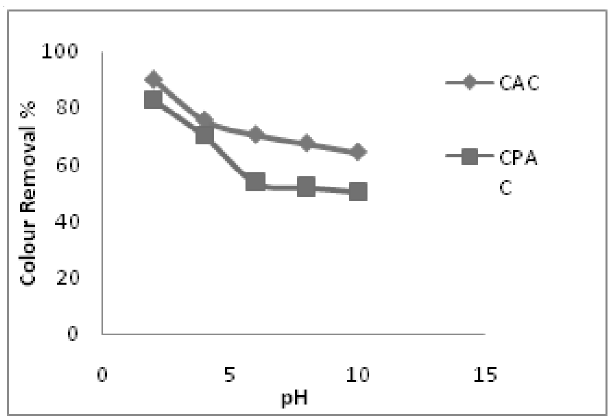

Fig. 3 Effect of pH on the Adsorption of dye using CAC and CPAC

Table 1. Physicochemical Characterization of CAC and CPAC

S.No.	Control Tests	CPAC	CAC
1.	Bulk density(g/cm3)	0.64	0.69
2.	Moisture (%)	7.11	6.4
3.	Ash content (%)	4.75	2.96
4.	Decolourising power (mg/g)	51.4	91
5.	pH	7.5	8.3
6.	Phenol number	55	39
7.	Surface Area (m2/g)	218	387
8.	Matter soluble in water (%)	0.85	1.8
9.	Matter soluble in acid (%)	0.96	1.4

Table 2. Intercept and slope values of Langmuir and Freundlich isotherm for CAC & CPAC

Dye	Adsorbents	Langmuir Constant			Freundlich Constant			
		r	Q_o	b	R	1/n	n	K_f
Reactive	CAC	0.9885	44.643	0.0692	0.9875	0.3955	2.5284	7.3722
Violet	CPAC	0.9945	21.978	1.0001	0.9933	0.3381	2.9577	4.7022

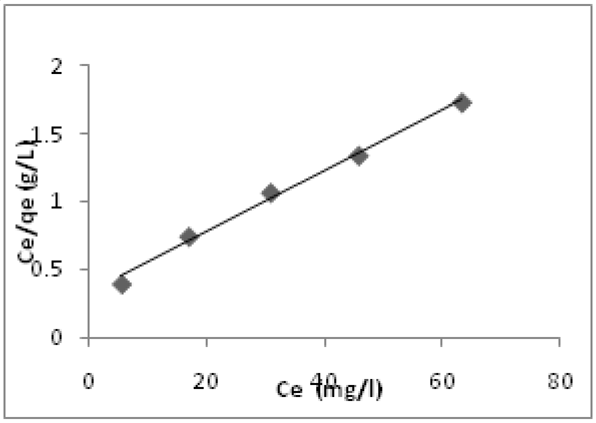

Fig. 4 Langmuir Plot for the adsorption of Reactive violet 48 on CAC

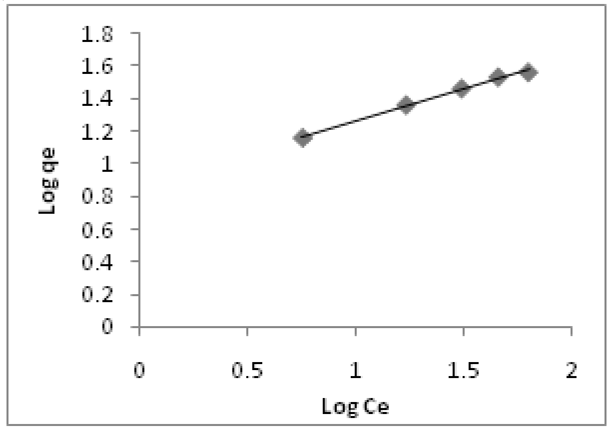

Fig: 6 Freundlich plot for the adsorption of Reactive violet 48 on CAC

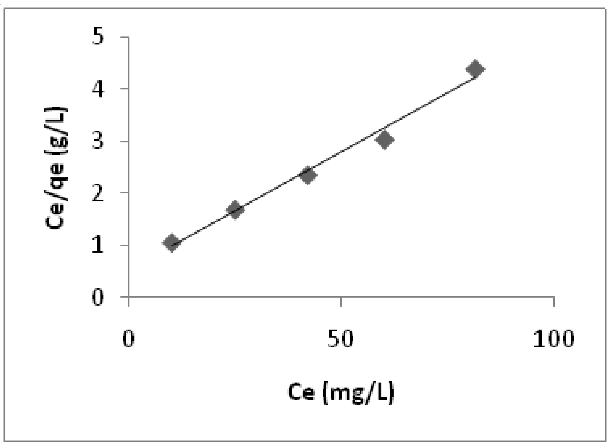

Fig.5 Langmuir Plot for the adsorption of Reactive violet 48 on CPAC

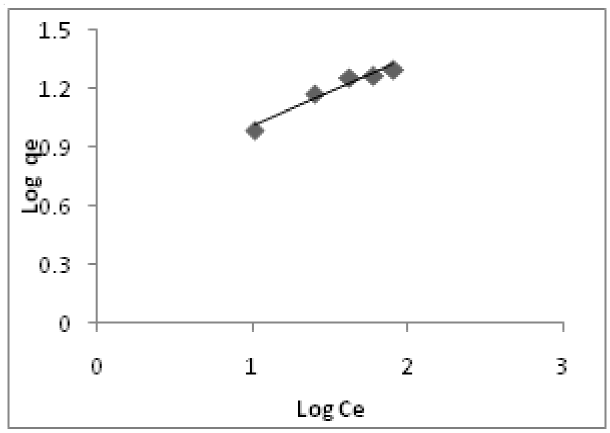

Fig. 7 Freundlich plot for the adsorption of Reactive violet 48 on CPAC

increased with an increase of contact time and decreased with an increase in solute concentration. Removal of dyes was higher at the acidic pH range. The results showed that the carbon affinity was higher for Reactive violet 48.

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