



## Adsorptive Removal of Rhodamine-B by Agricultural Waste

E. PORSELVI<sup>1</sup> and P. KRISHNAMOORTHY<sup>2</sup>

<sup>1</sup>Department of Chemistry, Bharathiar university .working at Department of Chemistry, Arignar Anna Govt Arts College, Cheyyar, India.

<sup>2</sup>Department of Chemistry, Dr.Ambedkar, Govt Arts College, Vyasarpadi, Chennai, India.

DOI: <http://dx.doi.org/10.13005/ojc/290248>

(Received: April 25, 2013; Accepted: May 26, 2013)

### ABSTRACT

Activated carbon prepared from *Asadiracta Indica* (neem) Seed Hull (AIH) was used for removal of Rhodamine-B (RDB) dye from aqueous solutions. The process was studied as a function of contact time, adsorbent dose and pH. Adsorption process was attained to the equilibrium within 90 min for initial dye concentrations of 80 mg/l. pH 5 was optimum condition for adsorption of dye at room temperature, and the maximum dye removal at that pH was 83.56 %. The isotherm data could be well described via Langmuir equation and Freundlich equations. Kinetic studies revealed that the experimental data correlated well with pseudo second-order model

**Key words:** Adsorption; Isotherm; Kinetic; Rhodamine-B, Activated Charcoal.

### INTRODUCTION

Colour removal from industrial effluents had been of significant concern due to the environmental problems<sup>1,2</sup>. The presence of very low concentrations of dyes in effluent was highly visible and undesirable. Wastewaters from the textile industry commonly contain moderate concentrations (10-200 mg/l) of dyestuffs, contributing significantly to the contamination of aquatic ecosystems<sup>3</sup>. Dyes were chronic and acute effects on living organisms affect the nature of water and inhibit sunlight penetration into the stream which avoids photosynthesis action<sup>4</sup>. Therefore, environmental legislation had imposed steady limits on the concentrations of contaminants, which might be discharged in aqueous effluents from manufacturing and textile industries. The removal

of colour from effluents was one of the major environmental problems. In this concern adsorption process had been found to be more effective method for the treatment of dye containing wastewater. The most efficient and commonly used adsorbent was commercially activated carbon which is expensive and has regeneration problems. Recent investigations focused on effectiveness of low cost adsorbents like pearl millet husk, neem leaf powder, coconut husk, wheat straw, sewage sludge, perlite, maize cobs, natural adsorbent, bio mass slurry, chitin, agricultural waste<sup>5-13</sup> in the removal of dyes from wastewater effluent.

In the present study the adsorption of RDB dye on AIH had been investigated. The effect of various parameters such as effect of time, pH, temperature, adsorbent dose, isotherm and kinetic

studies have been investigated in the batch experiments.

## MATERIALS AND METHODS

### Materials

Clean and dried neemseed hull was carbonized with concentrated sulphuric acid in the weight ratio of 1:1(W/V). The resulting carbon was washed with distilled water until a constant pH of the slurry was reached. Then the activation of carbon was done by heating the biomass for four hours at 100°C in a hot air oven. The dried material was ground well to a fine powder, sieved and stored in air tight glass bottles for further studies. All chemicals used were of high purity, commercially available AR grade. Stock solutions of 1g/l of dyes were prepared using doubly distilled water.

### Methods

Rhodamine-B (RDB) dye solution of known concentration were made. From that, 50 ml of 80 mg/l dye solutions were taken and loaded with the 75 mg of activated carbon adsorbent for various batch experiments. After that samples were withdrawn from the shaker and centrifuged. Then there were analyzed in UV-Visible spectrophotometer. (Elico Model No: SL150) Dye concentration in the supernatant solution was estimated by measuring absorbance at maximum wavelength 545 nm and computing from a calibration curve. Kinetics of adsorption was determined by analyzing adsorptive uptake of the dye colour from aqueous solution at different time intervals. The isothermal studies were performed by varying the

initial dye concentrations from 10 to 80 mg/l by shaking the reaction mixture at 180 rpm for the equilibrium time. Influence of the pH was studied by adjusting the reaction mixture to different initial pH (2 to 12) value using 0.1M Hydrochloric Acid or Sodium Hydroxide before addition of adsorbent (AIH). The amount of dye adsorbed onto seed hull, the adsorption capacity at steady-state  $Q_e$ (mg/g), was calculated by mass balance relationship equation.

$$Q_e = (C_o - C_e) \frac{V}{W} \quad \dots(1)$$

where,  $C_o$  and  $C_e$  are the initial and equilibrium liquid-phase concentrations of dye, respectively (mg/l),  $V$  is the volume of the solution (l) and  $W$  is the mass of the adsorbent used (g).

## RESULTS AND DISCUSSIONS

### Effect of contact time

The percentage of dye adsorbed at different time is calculated by keeping the concentration as 80 mg/l and the mass of adsorbent 0.75g. The results are shown in Fig. 1. It was observed that the rate of removal of RDB increases with increase in contact time. After 60 minutes the solution attains equilibrium. This time was taken as equilibrium time for subsequent experiment<sup>14</sup>.

### Effect of carbon dose

The adsorption of the dyes on carbon is studied by varying the carbon dose (0.5 – 2.5 gm/ml) for RDB of concentration 80 mg/l

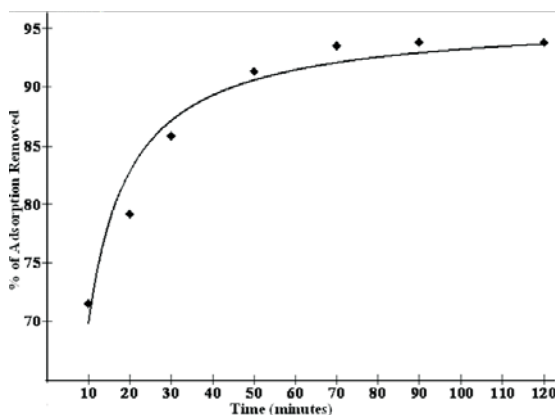


Fig. 1. Effect of Contact Time

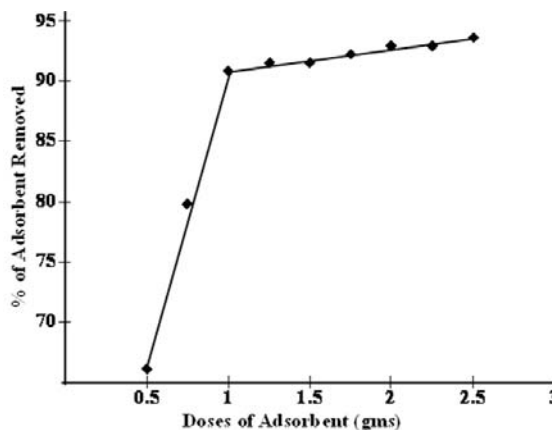


Fig. 2. Effect of Contact Dose

The percentage of adsorption increases with increase in the carbon concentration (Fig. 2). This is attributed to increase carbon surface area and availability of more adsorption sites. The adsorption of the dye increased from 71% to 83% with the increase in adsorbent dose. This observation is consistent with Langmuir hypothesis of an increasing competition among adsorbent particles for organic substances with increasing number of adsorbent particles per unit volume<sup>15-19</sup>.

**Effect of pH**

The experiments carried out at different pH show that there is a change in the percent removal of dyes over the entire pH range of 2 to 12 as shown in the Fig. 3. This indicates the strong force of interaction between the dyes and the activated carbon that, either H<sup>+</sup> or OH<sup>-</sup> ions could influence the adsorption capacity. Here the interaction is larger at pH 6 due to the competence of acidic H<sup>+</sup> ion with dye cation for the adsorption

sites. The percentage of adsorption increases above this pH value due to the presence of ionic COOH groups. The adsorption of dyes on the activated carbon does involve ion exchange mechanism. Due to this mechanism there should be an influence on the dye adsorption while varying the pH<sup>20</sup>.

**Adsorption isotherm**

The experimental data are analyzed according to the linear form of the Langmuir and Freundlich isotherms. The Langmuir isotherm is represented by the following equation (Langmuir and Amer, 1918).

$$\frac{C_e}{Q_e} = \frac{1}{Q_m b} + \frac{C_e}{Q_m} \quad \dots(2)$$

Here  $C_e$  is the equilibrium concentration (mg/l),  $Q_e$  is the amount adsorbed at equilibrium (mg /g) and  $Q_m$  and  $b$  are Langmuir constants

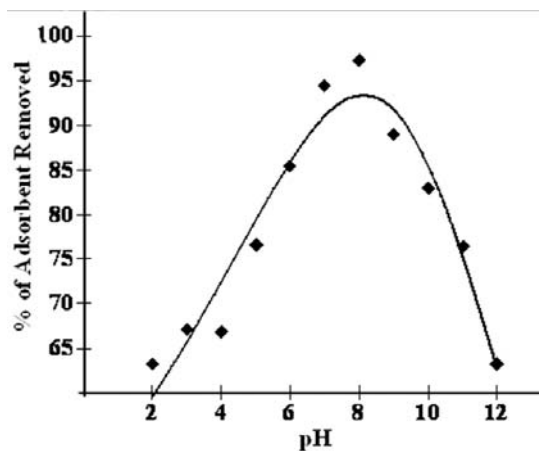


Fig. 3: Effect of pH

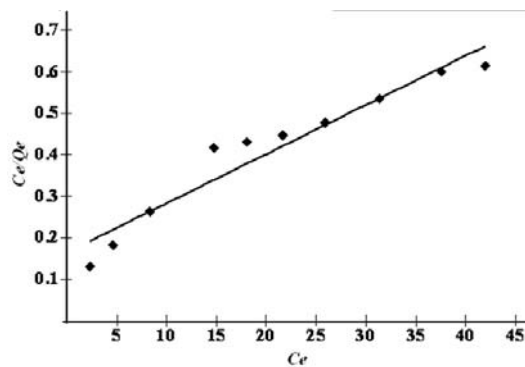


Fig. 4: Langmuir Isotherm

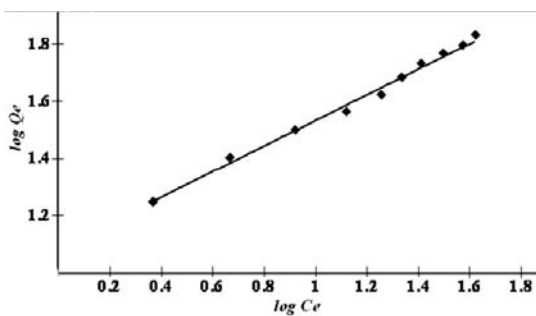


Fig. 5: Freundlich Isotherm

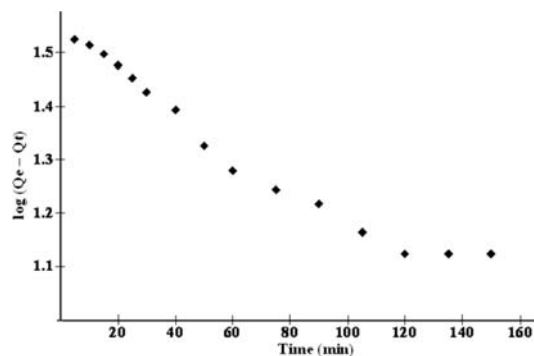


Fig. 6: Pseudo first order mechanism

related to the adsorption efficiency and energy of adsorption, respectively. The linear plots of  $C_e/Q_e$  versus  $C_e$  suggest the applicability of the Langmuir isotherms

The values of  $Q_m$  and  $b$  were determined from the slope and intercept of the plots as 90.91 and 0.0666 respectively. From the results, it was found that the adsorption efficiency  $Q_m$  and adsorption energy  $b$  of the carbon (Fig. 4). From the values we can conclude that the maximum adsorption corresponds to a saturated mono-layer of adsorbate molecules on an adsorbent surface with constant energy and no transmission of adsorbate in the plane of the adsorbent surface occurs. The trend shows that the adsorbent prefers to bind acidic ions and that special ion predominates on sorbent characteristics, when ion exchange is the predominant mechanism. To confirm the favourability of the adsorption process, the separation factor (RL) value was found to be 0.0982 and confirm that the ongoing adsorption process was favourable<sup>21</sup>.

The Freundlich equation was also employed for the adsorption of Rhodamine-B (RDB) dye on the adsorbent. The Freundlich isotherm (Freundlich, 1906) is represented as

$$\log Q_e = \log K_f + \frac{1}{n} \log C_e \quad \dots(3)$$

Here  $Q_e$  is the amount of Rhodamine-B (RDB) adsorbed (mg/g),  $C_e$  is the equilibrium concentration of dye in the solution (mg/l) and  $K_f$  and  $n$  are constants incorporating all factors affecting the adsorption capacity and intensity of adsorption, respectively. Linear plot of  $\log Q_e$  versus  $\log C_e$  shows that the adsorption of RDB

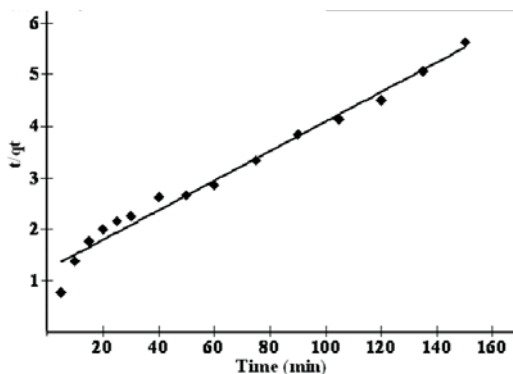


Fig. 7: Pseudo second order mechanism

dye follows also the Freundlich isotherm (Fig. 5). The values of  $K_f$  and  $n$  found to be 10.715 and 2.101 respectively showed the increase of negative charge on the surface that enhances the electrostatic force between the carbon surface and the dye ion, which increases in turn the adsorption of dyes. The values clearly show the dominance of adsorption capacity. The intensity of adsorption is an indication for the bond energies between dye and the adsorbent and the possibility of a slight chemisorption rather than physisorption. The possibility of multilayer adsorption of dyes through the percolation process could not be ruled out. However, the values of  $n$  is greater than one indicating that the adsorption is much more favourable<sup>22</sup>.

### Kinetics of adsorption

The kinetics of sorption described the solute uptake rate, which in turn governs the residence time of adsorption reaction. It was one of the important characteristics in defining the efficiency of adsorption. In the present study, the kinetics of dyes removal was carried out to understand the behaviour of this low cost carbon adsorbent.

From the values of correlation coefficient (0.970 and 0.984) it was found to be that pseudo second order was better than the other one (Fig. 6 & 7). Similar results have been reported for adsorption of reactive dyes<sup>23-25</sup>.

### CONCLUSIONS

The results of the present work indicate that the activated carbon prepared from *Asadiracta Indica* seed hull is a promising adsorbent for the removal of Rhodamine-B from aqueous solutions. Maximum adsorption of dyes takes place when the pH of solution is at 6, the mass of adsorbent used is 0.75 mg and the equilibrium time is 60 minutes. The experimental data correlated reasonably well with the Langmuir and Freundlich adsorption isotherms and the respective isotherm parameters show that both the isomers are followed and the kinetic study reveals that the reaction order fits with pseudo second order.

Thus the present study proves that the adsorbent has potential to remove the dye and also more efficient and economical.

## REFERENCES

1. R. Sanghi and B.Hatiachrya, *Color Techno.*, **118**: 256-269 (2002).
2. S. Wang, Y. Boyjoo, A. Choueib and H. Zhu, *Water Res.*, **39**: 129-138 (2005).
3. C. O'Neill, F.R. Hawkes, N.D. Lourenco, H.M. Pinheiro, and W.J. Delee, *J. Chem. Technol. Biot.*, **74**: 1009-1018 (1999).
4. Y.M. Slokar, and M. Le Marechal, *Dyes Pigments*, **37**: 335-356 (1998).
5. K.Selverani, Ph.DThesis, REC, Tiruchirapalli, India (2000).
6. G.M.Walker and L.R.Weatherly, *Environ. Pollution*, **99**: p.133-136 (1998).
7. K.S.Low and C.K. Lee, *J. Pertanika*, **13**: 221-226 (1990).
8. T.Robinson. B, Chandaran and P.Nigam. *Water Research*, **36**: 2830-2842 (2002).
9. V.K.Verma and A.K. Mishra, *Ecol. Environ. & Conservation*, **12**(4): 755-757 (2005).
10. M.Otero.M. Rozada.L.F. Calvo., Garcia A.I. and Moran A., (2003),
11. G.MaKay , HS Blair and JR Gardner , *J. Appl. Sci.* **27**: 3042 (1982).
12. G.McKay, *J. Chem. Tech. Biotechnol.* **32**: 759 (1982).
13. G.McKay, and VJP.Poots, *J. Chem. Tech.Biotechnol.*, **30**: 279 (1980).
14. Sumanjit, Tenjinder Pal singhWalia andIshuKansal,*J. Surface Sci. Technol.*, **24**: p.179-193, (2008).
15. M.N.V. Ravi Kumar, *React.Funct. Polym.*, **46** ,p.1-27, (2000).
16. H. Yoshida, S. Fukuda, A. Okamoto, and T. Kataoka,,*Water Sci. Technol.* **23**: p.1667-1676, (1991).
17. Richa Tiwari, M.K. Sharma and S.C. Ameta., *Orient J. Chem.*, **27**(2): (2011).
18. S.A. Paul and S.K. Chavan, *Orient J. Chem.*, **28**(1): (2012)
19. Milind Ubale, Ratna Shelke, Jagdish Bharad and Balaji, Madje., *Orient J. Chem.*, **27**(1): (2011)
20. R.Sivaraj,C, Namasivayam, and K. Kadirvelu., *Waste Manag.*, **21**: p.105, (2001).
21. V.Vadivelan and K.Vasanthkumar., *J. Colloid. Interface Sci.*, **286**: p.91, (2005).
22. E.J.Weber and VC.Stickney, *Water Res.*, **27**: 63 (1993).
23. Y.S. Ho and G. McKay, *Chem. Eng. J.*, **70**: 115-124 (1998).
24. S. Senthikumaar, P. Kalaamani, K.P.R. Varadarajan, and C.V. Subburaam, *Bioresource Technol.*, **97**: 1618-1625 (1998).
25. M.Abassi.andN.R.Asl.,*J. Iran. Chem. Res.*, **2**: 221-230 (2009).