Int. J. Chem. Sci. : 2 (3), 2004, 331–336

ADSORPTION STUDIES OF Fe (II) ON *ACHYRANTHES ASPERA*

SAYYED HUSSAIN[1], M. J. JADHAV[a] and MAZHAR FAROOQUI[b]

[a]Sir Sayyed College, AURANGABAD (M.S.) INDIA
[b]Aurangabad College for Women, AURANGABAD (M.S.) INDIA

ABSTRACT

Achyranthes aspera has been used as adsorbate for the adsorption of metal ions. The forces operating between the molecules of an adsorbate and the adsorbent are mostly short range forces as suggested by Langmuir. These forces may be non specific like dispersion forces, orientation forces and induction forces or may be chemical bonds. Adsorption depends on the surface area of the adsorbate, pH, contact time etc. The surface charge of the adsorbate is an important criterion in adsorption. The adsorbing powers of many substances can be increased by temperature treatment. In the present study, the effect of contact time, temperature, pH, etc is reported. The paper also discuss the applicability of Friendlich and Langmuir adsorption isotherms.

Key words : Adsorption, Iron, *Achyranthes aspera*

INTRODUCTION

Pollution is the burning topic of the modern world. The most danerous type of pollution is water pollution. Various toxic metal ions presents in the industrial effluent is a major source of the pollution. Different methods are suggested for the removal of such toxic metal ions from aqueous solution such as ion–exchange, solvent extraction etc. The most useful and economic process is adsorption method. Researchers used different kinds of adsorbate material for the removal of metal ions. Some of them are tea leaves, cotton capsule shell, bajra hull, moong shell, bidi leaves, saw dust, paddy husk, etc.

Various researchers used plant materials as adsorbate. Plant materials are used as a cheap and low cost material for adsorption e.g. modified corn starch[1], modified onion skins[2] saw dust[3], phosphate treated saw dust[4], water lettuce[5] etc. Adsorption of different metal ions and organic compounds onto solid surfaces has immersed as a promising field of great value and has been extensively studied in the recent past.

In the present paper, the results of adsorption of Fe (II) ion on *Achyranthes aspera* from its aqueous solution are reported.

MATERIALS AND METHOD

Ferrous ammonium sulphate used as adsorbent was supplied by S.D. Fine Chemicals Ltd. and was used without any purification. The aqueous solution of Fe (II) was prepared by weighing appropriate quantity of F.A.S.

The plant material was collected from local field. It was dried and grinded to fine powder. Batch experiments were carried out, in which solution of Fe (II) ions treated with 1 gram of plant powder and kept for shaking at room temperature for a contact period of one hour. Finally, the solutions were filtered through Whatman filter paper No. 42.

The amount of Fe (II) was determined spectrophotometrically using 1, 10–phenanthrolein as a reagent[6]. Effect of contact time, temperature, pH and initial concentration was also determined.

RESULTS AND DISCUSSION

Effect of contact time : It was observed that *Achyranthes aspera* can be used as a low cost adsorbate effectively. The maximum time required for adsorption is 40 minutes for 60% adsorption, after which the amount adsorbed remains virtually constant. The removal curve was found to be smooth and continuous indicating the formation of monolayer coverage of adsorbent on the surface of adsorbate.

Effect of pH : The plant *Achyranthes aspera* powder proved to be effective adsorbate for the removal of Fe (II) from aqueous solution at pH 2. With increase in pH, adsorption decreases. This may be due to decrease in negative charge on the adsorbate as the pH of the solution increases.

Adsorption isotherm : To study the validity of Freundlich adsorption isotherm, the following equation was used

$$x/m = Kc^{1/n}$$

The linear plot of log x/m vs log C indicates the applicability of Freundlich adsorption isotherm.

This shows a system, which exists with a monolayer coverage of the adsorbent on the surface of adsorbate.

To verify Langmuir adsorption isotherm I/C_e is ploted against 1/q. The value of 'b' is calculated graphically, which is used to calculate the equilibrium parameter R_L.

$$R_L = \frac{1}{1 + bco}$$

The range $0 < R_L < 1$ reflects favorable adsorption.

Fig. 1

Langmiur adsorption isotherm

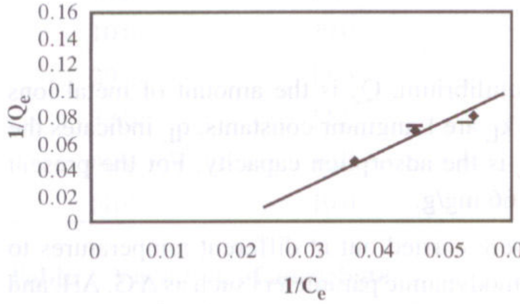


Fig. 2

Effect of temperature

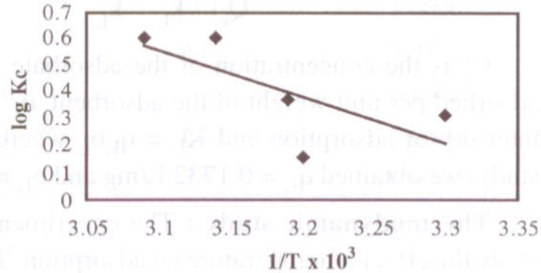


Fig. 3

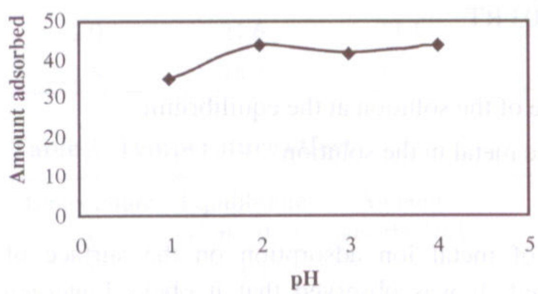


Fig. 4

Lagergen plot

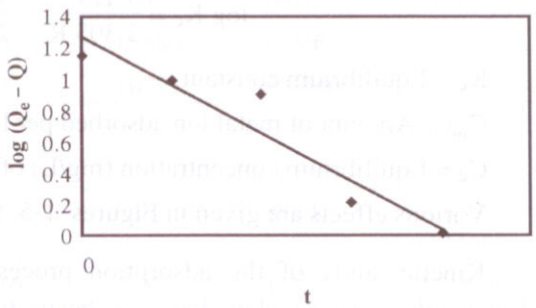
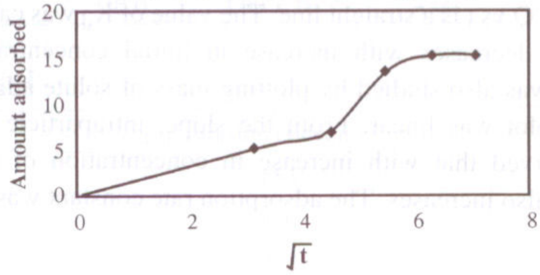


Fig. 5

Plot of amount adsorbed against $\sqrt{t}$



In the present study, the value of R_L was found to be less than 1 (one). The Langmuir adsorption parameters are very useful in predicting adsorption capacities and also for incorporating a mass transfer relationship. The isotherm can be written as

$$\frac{C_e}{Q_e} = \frac{1}{k_L} + \frac{q_L}{k_L} C_e$$

C_e is the concentration of the adsorbate at equilibrium, Q_e is the amount of metal ions adsorbed per unit weight of the adsorbent, q_L and k_L are Langmuir constants. q_L indicates the intensity of adsorption and $K_L = q_L b_L$ where B_L is the adsorption capacity. For the present study, we obtained $q_L = 0.1732$ L/mg and $b_L = 17.66$ mg/g.

Thermodynamic study : The experiments were carried out at different temperatures to study the effect of temperature on adsorption. Thermodynamic parameters such as ΔG, ΔH, and ΔS were determined using following equations :

$$Kc = \frac{C_{ad}}{C_e}$$

$$\Delta G = - RT \ln K_c$$

$$\log K_c = \frac{\Delta S}{2.303\ R} - \frac{\Delta H}{2.303\ RT}$$

K_c = Equilibrium constant

C_{ad} = Amount of metal ion adsorbed per litre of the solution at the equilibrium

C_e = Equilibrium concentration (mg/L) of the metal in the solution

Various effects are given in Figures. 1-5.

Kinetic study of the adsorption process of metal ion adsorption on the surface of *Achyranthes aspera* plant has also been studied. It was observed that it obeys Lagergen equation.

$$\log (Q_e - Q) = \log Q_e - (K_d/2.303)\ t$$

Where Q_e and Q are the metal ion adsorbed (mg/g) at equilibrium and at time t.

The plot of log Q_e – Q vs t is a straight line. The value of K_d was calculated from the graph. It was found that K_d decreases with increase in initial concentration of the metal ion. Intraparticle diffusion was also studied by plotting mass of solute adsorbed vs square root of contact time and the plot was linear. From the slope, intraparticle diffusion constant was determined. It is observed that with increase in concentration of metal ion, intraparticle diffusion rate constant also increases. The adsorption rate constant was found to be 7.25×10^{-2} min.

Table 1. Effect of contact time

Time (min)	Equilibrium concentration (Q_e)	Amount Adsorbed (Q)	$\sqrt{t}$	log (Q_e – Q)
0.0	25.0	0.0	0.0	1.1760
10.0	20.0	5.0	3.1	1.0000
20.0	13.3	6.7	4.47	0.9190
30.0	11.6	13.4	5.47	0.2041
40.0	10.0	15.0	6.32	0.0000
50.0	10.0	15.0	7.07	0.0000

Table 2. Variation of adsorbate

Amount of Powder	Equilibrium Conc. (C_e)	Amount adsorbed	Q_e	$1/Q_e$	$1/C_e$	log (C_e – C)
0.5	53.3	0.0	0.0	0.0	0.0186	1.72267
1.0	43.3	6.7	6.7	0.1492	0.0230	1.5634
1.5	26.6	23.4	21.6	0.0462	0.0375	0.5054
2.0	21.6	29.4	14.7	0.0680	0.0462	–
2.5	18.3	31.7	12.6	0.0793	0.0546	–

Table 3. Temperature effect

Temperature K	Equilibrium Conc. (C_e)	Amount adsorbed (c)	1/T	K_c	log K_c	Δ G (J/Mole)
298	13.3	26.7	3.3×10^{-3}	2.007	0.3025	1726.01
308	16.6	23.4	3.2×10^{-3}	1.409	0.1489	878.11
313	15.0	35.0	3.19×10^{-3}	2.33	0.3673	2201.2
318	10.0	40.0	3.14×10^{-3}	4.00	0.6020	3665.45
323	10.0	40.0	3.09×10^{-3}	4.00	0.6020	3723.00

Table 4. Variation of pH

pH	Equilibrium concentration	Amount adsorbed
1	15.0	35.0
2	6.6	43.4
3	8.3	41.7
4	11.6	43.4

REFERENCES

1. S. P. Dani and S. S. Dara, J. IPHE, 54 (1983).
2. D. B. Bankar and S. S. Dara, Chem. Era., XVIII, **10**, 251, (1982).
3. D. S. Day and J. K. Basu, Ind. J. Env. Prot., **19**, 416, (1999).
4. B. A. Siddiqui, P. P. Sharma and Mohd. Sultan, Ind. J. Env. Prot., **9**, 846 (1999).
5. Selvapati, J. J. Jesline and S. Prabha. J. Env. Prot., **18**, 1 (1998).
6. Day and Underwood, Quantitative Analysis, VI Ed, Prentice Hall, India (1993).
7. C. P. Huang and W. Stumm., J. Colloid Interface. Sci., **43**, 409 (1973).

Accepted : 20.7.04