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Adsorption Studies of Acetic Acid on the Surface of *Plectonema gracillimum* (ZOpf) Hansgirg

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The aim of present investigation is to study adsorption of acetic acid on *Plectonema gracillimum* (ZOpf) Hansgirg. The effect of certain parameters on adsorption has been studied. Applicability of Fruendlich adsorption isotherm, Langmuir adsorption isotherm has been tested. Various thermodynamic parameters such as ΔG°, ΔH° and ΔS° are reported. The adsorption power of *Plectonema gracillimum* (ZOpf) Hansgirg is calculated using batch adsorption process.

Key Words: Adsorption, Acetic acid, *Plectonema gracillimum*.

INTRODUCTION

Removal of undesired substances from the waste water is of prime environmental importance. The presence of excess amount of undesirable constituents causes water pollution. There are various adsorbent available for the removal of inorganic and organic substances from the polluted water. Various researchers are reporting low cost adsorbent for pollution control. Acetic acid is used in the manufacturing of vinegar, cellulose acetate, perfumes, dyes, plastic and pharmaceutical companies. It occurs in fruit juices which become sour as a result of fermentation. It is chief constituents of vinegar. It is corrosive liquid, the vapours are suffocative and causing a damage to lunges.

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

Plectonema gracillimum (ZOpf) Hansgirg is a common freshwater cyanophycean algae found in ponds, lakes and rivers. Thallus of this alga is thin membranous, pale blue, yellowish or grey green in colour. Filaments are 2-4 μ broad, cell 1-3 times longer than broad; false branches single or geminate[6].

EXPERIMENTAL

Acetic acid, NaOH, phenolphthalein were supplied by S.D. Fine Chemicals Ltd. and were used without any purification.

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Cultivation of alga and prepared of powder: Filaments of *Plectonema gracillimum* (zopf) Hansgirg were collected from Harsool reservoir of Aurangabad city. Bold's Basal medium was used for cultivation. Pure filaments were transferred to 200 mL liquid medium in 500 mL Borosil flask. This procedure was performed under aseptic conditions. The flasks were then incubated under static condition in culture chamber at 25 ± 1 ºC for 15-20 days. After sufficient growth pure algal sample was harvested and air dried on filter paper in shadow at room temperature. Fine powder of algal sample was prepared in grinder[6].

The amount of acetic acid was determined volumetrically using phenolphthalein as a reagent. Effect of contact time, temperature and effect of initial concentration was also determined.

RESULTS AND DISCUSSION

On the surface of substance there are free valancies. When adsorbate come in contact with the surface, each valancy satisfied by a weak bond formed. The adsorption of solute from solution takes place due to the decrease in the interfacial tension or clue to solid surface acquiring electrostatic charge in solvent. This charged surface of the adsorbent then attain oppositely charged ions from the solution. During the formation of solid such as zeolites gases are evolved and solid becomes porous. Such solids can be used as selective adsorbent and can be used for ion exchange. Same logic can be extended to the coal formation. During incomplete burning of algae material CO or CO_2 gets evolved and porosity may be formed. Hence charcoal obtain from the plant materials are more effective adsorbent. In the present paper we wish to study the adsorption behaviour of acetic acid on the charcoal obtained from algae *Plectonema gracillimum* (ZOpf) Hansgirg.

Effect of contact time: It was observed that *Plectonema gracillimum* (ZOpf) Hansgirg can be used as a low cost adsorbent effectively. The maximum time required for adsorption is that 20 min for 60 % adsorption, after that the amount adsorbed remains constant (Table-1).

TABLE-1
EFFECT OF CONTACT TIME

Time (min)	√t	C_e	$q = C_o - C_e$	$q_e - q$	$\log q_e - q$
5	2.2	4.11	6.09	4.20	0.6232
10	3.1	3.80	0.40	3.40	0.5314
15	3.8	3.92	0.78	2.64	0.4216
20	4.4	3.40	1.10	2.00	0.3010
25	5.0	2.80	1.40	1.40	0.1461

The removal curve was found to be smooth and continuous indicating the formation of monolayer coverage of adsorbent on the other surface of adsorbate.

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

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

The linear plot of log x/m *versus* log C indicates the applicability of Fruendlich adsorption isotherm (Table-2). This shows system which exist a monolayer coverage of the adsorbent on the other surface of adsorbate. To verify Langmuer adsorption isotherm I/C_e is plotted against 1/q the value of 'b' is calculated graphically which is used to calculate the equilibrium parameter R_L

TABLE-2
ADSORPTION CAPACITIES (INITIAL CONCENTRATION Co = 4.20 g/L)

Mass of adsorbent (mg)	Equilibrium concentration C_e (g/L)	log C_e	$X = C_0 - C_e$	$y = \frac{(C_0 - C)V}{M}$	$fr = \frac{C_0 - C}{C_0}$	X/M	log X/M	C_e/X/M
250	4.11	0.6138	0.09	18.00	0.021	0.36	-0.4436	11.410
300	3.80	0.5797	0.40	66.66	0.090	1.33	0.1238	2.857
400	3.42	0.5340	0.78	97.50	0.185	1.95	0.2900	1.750
500	3.10	0.4913	1.10	110.00	0.260	2.20	0.3424	1.400
600	2.80	0.4471	1.40	116.60	0.333	2.33	0.3673	1.200

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

The range $0 < R_L < 1$ reflect favourable adsorption.

In the present study the value of R_L was found to be less than 1. The Langmuir adsorption parameters are very useful for predicting adsorption capacities and also for incorporating into 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/unit weight of the adsorbent, a_L and K_L are Langmuir constants, q_i, indicate the intensity of adsorption and $K_L = q_L b_L$, where b_l is the adsorption capacity for the present study we obtained $a_L = 2.025$ L/mg, $b_L = 0.041$ mg/g.

The rate of acid adsorption (removal) falls off to give a smooth curve, this part of plot is due to intra particle diffusion the initial portion of the plot can be interpreted by supposing a three step model as follows: Mass transfer of acid from the bulk solution to the particle surface. (2) Intraparticle diffusion. (3) Adsorption at an interior side. It is assumed that step three. (3) is rapid with respect to first two steps[7].

The mathematical theory of diffusion is based on Pick's first law, mainly molecular adsorption processes involve diffusive mass transport and the interpretation of over all behaviour in terms of two diffusivity and intrinsic equilibrium sorption properties is difficult.

Intra particle diffusion is an important rate controlling step during adsorption process. Following equations were used to find out adsorption capacity of plant *Plectonema gracillimum.*

$$y = \frac{(C_0 - C)V}{M}$$

$$fr = \frac{(C_0 - C)}{C_0}$$

Thermodynamic study: The experiments were performed at different temperature to study the effect of temperature on adsorption, thermodynamic parameter such as ΔG°, ΔH° and ΔS° were determined using following equations (Table-3)

TABLE-3
THERMODYNAMIC PARAMETERS

Temp. (K)	$1/T \times 10^{-3}$	K_c	log K_c	ΔG° (J/mol)
303	3.30×10^{-3}	0.2042	-0.6899	-4002.48
308	3.24×10^{-3}	0.1692	-0.7715	-4556.79
313	3.19×10^{-3}	0.1176	-0.9295	-5570.50
318	3.04×10^{-3}	0.2063	-0.6855	-4173.83
323	3.09×10^{-3}	0.0857	-1.0670	-414.36
328	3.04×10^{-3}	0.0857	-1.0670	-414.36

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

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

$$\log K_c = \frac{\Delta S^\circ}{2 - 303R} \frac{\Delta H^\circ}{2 - 303RT}$$

K_c = Equilibrium constant, C_{ad} = Amount of metal ion adsorbed/L of the solution at the equilibrium, C_e = equilibrium concentration (mg/L) of the metal in the solution.

The kinetic study of the adsorption process of acetic acid has been studied and it was observed that it obeys Lagergen equation.

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

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

Intraparticle diffusion was also studied by plotting mass of solute adsorbed *versus* square root of contact time the plot was linear. From the slope intraparticle diffusion constant was determined.

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