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Removal of Lead from Waste Water Using Low Cost Adsorbent

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Abstract

The sorption of Lead (II) on chitosan has been found to be dependent on contact time, concentration, temperature, and pH of the solution. The process of removal follows first order kinetics and absorption of heat.

Keywords: chitosan, bioabsorbent, Lead (II), heavy metal adsorption, Chitin.

Introduction

The general methods of treating wastewater having cadmium follow precipitation and ion exchange[1]. Recently, much interest has been exhibited in the use of sorption technique for the removal of cadmium from wastewater using chitosan[2]. The present investigation aims at using chitosan, a low cost and highly effective sorbent for the removal of cadmium from waste water. Chitosan is a biopolymer, which is extracted from crustacean shells or from fungal biomass[3]. The structure of chitosan is presented schematically in figure 1.

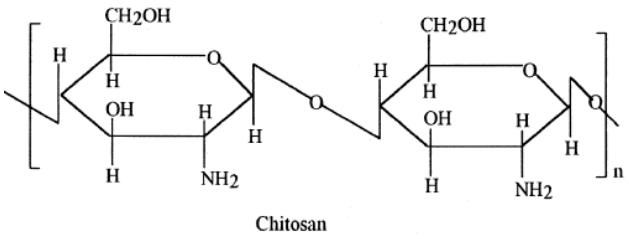

Figure-1
Structure of chitosan

Material and Methods

Chitosan was obtained from India sea foods, cochi (India)

Batch sorption experiments were carried out in temperature controlled shaking machine by agitating 25ml aqueous solutions of sorbates with 1.0 g sorbent in different glass bottles at different conditions of concentrations, temperatures and pH. The pH of different solutions were adjusted with 0.05 M NaOH or HCl by pH meter, systronic 335. The speed of agitation was maintained at 1000 rpm to ensure equal mixing. The progress of sorption was noted after each 20 min till saturation. At the end of predetermined time interval each 20 min, the sorbate and sorbent were separated by centrifugation at 16,000 rpm and the supernatant liquid analyzed by atomic absorption spectrophotometer[4].

Result and Discussion

Effect of Contact Time and Concentration: The removal of Pb (II) by sorption on chitosan from aqueous solution increase with time (figure 2) till equilibrium is attained in 140 min. The fig. shows that time of saturation is independent of concentration. It is further noted that the amount of Pb (II) sorbed increases from 1.899 mg.g-1 (79.60%) to 3.815 mg.g-1 (91.04%) by increasing Pb (II) concentration from 100 mg/l to 250 mg/l. the time-amount sorbed Curve is single, smooth and continuous indicating monolayer coverage of Pb (II) on the outer surface of chitosan.

Sorption Kinetics: The kinetics of sorption of Pb (II) on chitosan was studied using Lagergren equation[5],

$$\text{Log } (q_e - q) = \log q_e - kt / 2.3 \quad (1)$$

Where q_e and q are the amount sorbed ($mg.g^{-1}$) of Pb (II) at equilibrium and at time't' respectively and k is sorption constant. The straight lines obtained from the plots of log (q_e-q) against't' (figure 4) and different concentrations indicate that the sorption process follows first order kinetics[6].

Effect of temperature: The amount of Pb (II) sorbed on chitosan increases from 1.899 mg.g-1(79.60 %) to 2.458 mg.g-1 (98.32%) by increasing temperature from 30°c to 40°c indicating the process to be endothermic (figure 5).

Langmuir isotherm: The equilibrium data at the different temperatures follow Langmuir equation[7].

$$C_e/q_e = 1/\varphi.b + C_e/\varphi \quad (2)$$

Where Ce mg..L^{-1} is equilibrium concentration of Pb (II) and φ and b are Langmuir constants related to sorption capacity and sorption energy respectively. The value of φ and b (table 4) were determined from the slope and intercept of linear plots figure 6. The sorption capacity also increases with o temperature suggesting that the active centers available for sorption have increased with temperature[8].

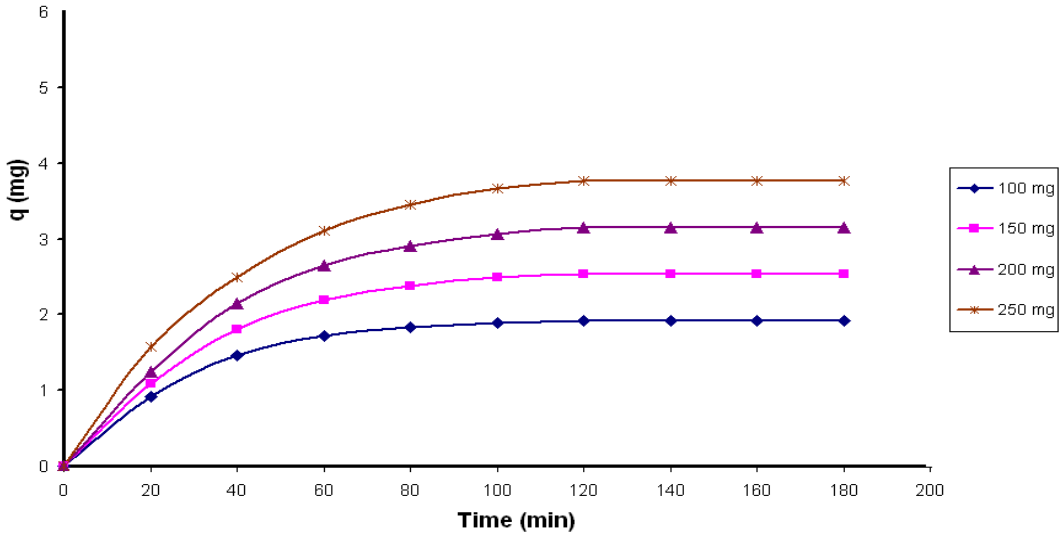

Figure-2

Effect of concentration for the sorption of Lead (II) on chitosan ●100 mg/L, ▪ 150 mg/ L, ◄ 200 mg/L, * 250 mg/L

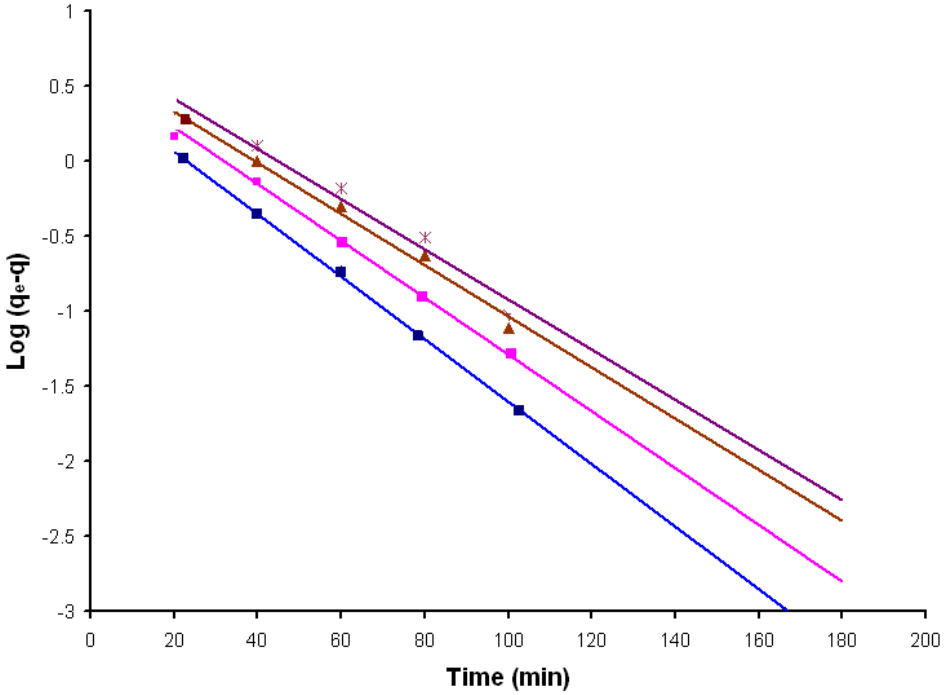

Figure-3

Langergren plot for the sorption of Pb (II) on chitosan;

●100 mg/L, ▪ 150 mg/ L, ◄ 200 mg/L, * 250 mg/L, pH 5, temp 30°c

The change in free energy (ΔG°), enthalpy (ΔH°), and entropy (ΔS^o) of sorption have been calculated using following equations.

$$\Delta G^\circ = -RT \ln K \quad (3)$$

$$\Delta H^\circ = RT_1T_2(T_1 - T_2) \ln k_2 / k_1 \quad (4)$$

$$\Delta S^o = \Delta H^\circ - \Delta G^\circ / T_1 \quad (5)$$

Where K_1 and K_2 are equilibrium constants at temperature T_1 and T_2 respectively.

The negative values of ΔG^o (table 2) indicate the spontaneous nature of the sorption process. The positive values of ΔH^o at different temperature support the endothermic nature of the process[9].

Table-1
Ø values at different temp and pH

Temperature (°C)	Ø mg.g-1	pH	Ø mg.g-1
30	0.2265	2	0.1998
40	0.5934	4	0.2119
50	0.9440	6.5	0.2265

Table-2
Thermodynamic parameters at different temperatures

Temperature (°C)	ΔG^o (kcal.mol$^{-1)}$	ΔH^o (kcal.mol$^{-1)}$	ΔS^o (kcal.mol$^{-1)}$
30	-6.21	13.58	22.71
40	-6.90	28.07	38.40
50	-7.43	-	-

Effect of pH: The amount of Pb (II) sorbed on chitosan increases from 1.440 mg.g-1 (57.60 %) to 1.899 mg.g-1 (79.60 %) by increasing pH of the solution from 2.0 to to 6.5 (figure 5). The Sorption capacity Φ, also increase with the increase of pH[10].

Conclusion

From the above discussion it is clear that due to chemical composition, structure, more adsorption sites, cheap, availability in plenty etc. this substance will provide to be efficient adsorbent.

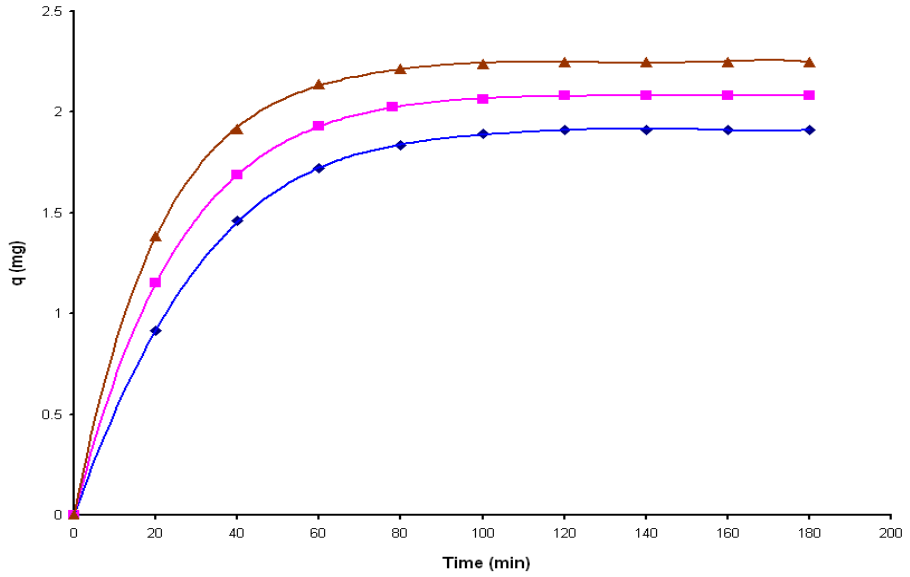

Figure-4
Effect of temperature on the sorption of Pb (II) on Chitosan ● 30°C, ▪ 40°C, ◄ 50°C

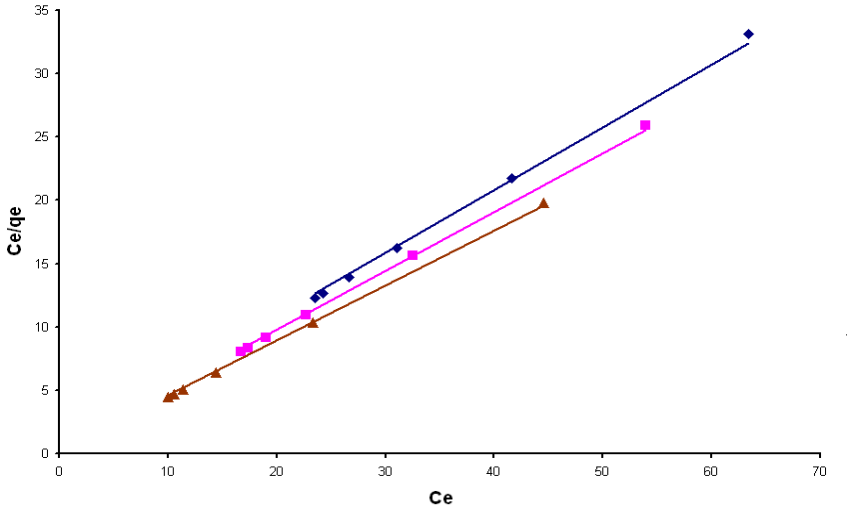

Figure-5
Langmuir isotherm for the sorption of Pb (II) on chitosan; ● 30°C, ▪ 40°C, ◄ 50°C.

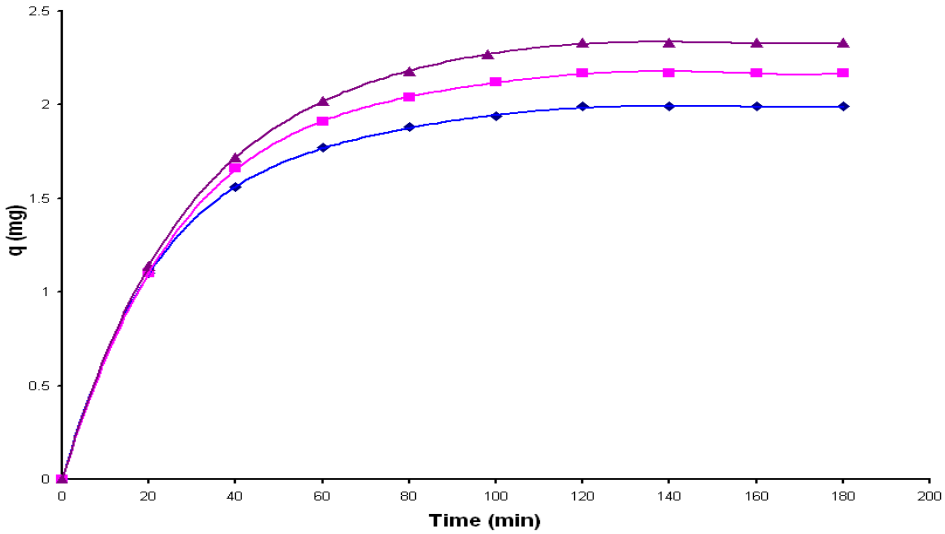

Figure-6

Effect of pH on the sorption of Pb (II) on chitosan; ● 2.0, ▪ 4.0, ◄ 6.5; temp: 30°C, conc. 100 mg/l.

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