STUDY ON HEAVY METAL ADSORPTION BY CHITOSAN BIOPOLYMER

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Declaration

I declare that this is my own work and this thesis with the title "**Study on Heavy metal Adsorption by Chitosan Biopolymer**" does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written or orally communicated by another person except where due reference is made in the text.

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Dr. S.U. Adikary

Abstract

Heavy metal pollution is a serious problem to aquatic ecosystems because some of these metals are potentially toxic even at very low concentrations. Chitosan, a biopolymer produced from crustacean shells, has applications in various areas, particularly in drinking water and wastewater treatment due to its ability to remove metallic ions from solutions. The purpose of this research work was to study the adsorption of cadmium and lead ions into chitosan, produced from shrimp shells at the laboratory level. Shrimp type "penaeus monodon" (giant tiger prawn) was used to synthesis the chitosan. The main characteristic properties such as degree of deacetylation (DD); the amount of amine groups in chitosan, viscosity, crystallinity and thermal analysis were done by using Fourier transform infrared spectroscopy, Brookfield viscometer, X-ray spectroscopy, thermo gravimetric analysis (TGA) and differential thermal analysis (DTA). Chitosan, with a degree of deacetylation between 80%- 95% was used in the experimental part and the flake sizes were smaller than 0.25mm. Experimental work involved the determination of the adsorption isotherms and kinetic studies for each metallic ion in a batch system.

Effect of Degree of deacetylation (DD) of the chitosan, effect of initial pH of the metal ion solution, effect of particle size, effect of initial heavy metal concentration, and effect of chitosan dosage were studied. The results showed that the adsorption capacity depends strongly on pH of the solution, DD of chitosan and slightly depends on the particle size. According to the results, pH values at 6.5 for cadmium and pH values at 4.5 for lead show higher adsorption capacity. High DD chitosan showed higher adsorption capacity mainly due to the higher number of active amino groups in high DD sample.

Simplified kinetic models such as pseudo-first-order, pseudo-second-order, Elovich model and intra-particle diffusion model were used to determine the rate limiting step. Both linear and non-linear According to the kinetic models pseudo second order model best described the adsorption process. Both linear and non-linear models and Elovich model best described the adsorption process. Multilinearity in the intraparticle diffusion model suggested that the adsorption of heavy metal consists of two major steps, due to the different pore sizes of chitosan.

Equilibrium experimental data were analyzed by using two different isotherm models namely, Langmuir and Freundlich. According to the results, adsorption process of cadmium and lead heavy metals is heterogeneous and multilayer adsorption as it best fit with the Freundlich isotherm model. According to the thermodynamic experiments, adsorption process is favorable and physical adsorption was predominant in the adsorption process. Desorption of the heavy metals was possible by using different regeneration solutions.

***Key words* :** Chitosan, Heavy metals, Isotherm, Kinetics, Adsorption

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J.M. Unagolla

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DA	Degree of acetylation
DD	Degree of deacetylation
DTA	Differential Thermal Analysis
FTIR	Fourier Transform Infrared Spectroscopy
NMR	Nuclear Magnetic Resonance
PFO	Pseudo first order
PSO	Pseudo second order
TGA	Thermogravimetry Analysis
C_e	liquid phase adsorbate concentration in equilibrium (mg/L)
C_0	Initial metal ion concentration of the solution (mg/L)
C_t	Metal ion concentration of the solution at time t (mg/L)
C_f	Final metal ion concentration of the solution (mg/L)
K_1	Pseudo first order rate constant (min^{-1})
K_2	Pseudo second order rate constant (g/mg.min)
K_d	Distribution ratio (L/g)
K_F	Freundlich constant
K_i	Intra-particle diffusion rate constant ($mg/gmin^{0.5}$)
K_L	Langmuir constant
m	Mass of the adsorbent (g)
q_e	Adsorption capacity at equilibrium (mg/g)

q_t Adsorption capacity at time t (mg/g)

q_m Monolayer adsorption capacity (mg/g)

R_L Langmuir separation factor

R Universal gas constant (8.314 J/mol.K)

T Absolute solution temperature (K)

V Volume of the aqueous metal ion solution (L)

ΔG^0 Standard state Gibbs free energy change

ΔH^0 Standard state Enthalpy change

ΔS^0 Standard state Entropy change

α, β Elovich constants

1/n heterogeneity factor