SINGLE AND BINARY ADSORPTION OF NICKEL AND ZINC IONS FROM AQUEOUS SOLUTIONS USING COIRPITH AS THE ADSORBENT

Eshana Niharika Ranasinghe

(178057H)

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Department of Chemical and Process Engineering

University of Moratuwa

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Eshana Niharika Ranasinghe

178057H

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Supervisor: Prof. (Mrs.) B.M.W.P.K. Amarasinghe

Department of Chemical and Process Engineering
University of Moratuwa
Sri Lanka

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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Abstract

This study analysed the competitive adsorption of multicomponent systems onto coir pith, readily available and environmentally friendly adsorbent chosen for the study. The efficacy of unmodified coir pith as an adsorbent as well as its physical and chemical characteristics were studied to analyse single and binary systems of nickel and zinc adsorption onto coir pith as well as the effects of temperature, concentration, adsorbent dose and pH to determine the optimal conditions for adsorption.

The equilibrium data for the single system adsorption of nickel and the single system adsorption of zinc at 30 °C was analysed using the Langmuir and Freundlich isotherm models while the multicomponent adsorption was analysed using the Langmuir, the Freundlich, the competitive Langmuir, the non-competitive Langmuir, the modified competitive Langmuir and the Langmuir Freundlich isotherm models. The single system adsorption data for both nickel and zinc fit the Freundlich model which showed the adsorption surface was heterogeneous. The multicomponent adsorption system data fit the Langmuir isotherm model the best which showed the adsorption surface formed a monolayer.

Most adsorption occurs at a higher pH value. To decrease costs and possibility of metal hydroxide precipitation the adsorption should be carried out at a neutral pH.

The kinetics of single system and binary system adsorption of nickel and zinc was studied using Lagergren pseudo first order model, pseudo second order model and the intraparticle diffusion model. The experimental data showed all of the systems could be described using pseudo second order model which shows adsorption occurs primarily through chemisorptions. In the single system the coir pith had a higher capacity for zinc than nickel. In the single system adsorption of nickel the adsorption increases with temperature which shows the adsorption of nickel is an endothermic process. In the zinc single systems the adsorption decreased when temperature increased which shows zinc adsorption is an exothermic process. In the adsorption capacity in the binary system is less than either of the single systems which prove in the presence of competitive species metal ion adsorption is hindered.

The data was analysed using the Intraparticle diffusion model which showed intraparticle diffusion in the nickel single system and in the zinc single system at 30 °C but little to no intraparticle diffusion at higher temperatures or in the multicomponent system

The FTIR analysis of the surface of coir pith before and after adsorption shows that adsorption decreases the presence of hydroxyl (-OH) bonds. This confirms the results of the kinetic analysis that the adsorption is a chemical process which breaks and forms bonds with the functional groups on the coir pith surface. The metal ion forms a complex with the polar surface functional groups during adsorption and the metal ion remains bonded to the surface even when the adsorbent is removed from the water and dried.

This confirms coir pith is an effective adsorbent for the removal of heavy metals from aqueous solution. To optimise multicomponent adsorption of nickel and zinc it should be carried out close to 30 °C in a solution of neutral pH and allowed to reach equilibrium.

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LIST OF ABBREVIATIONS

q_e	equilibrium adsorption capacity(mg g^{-1})
q_{max}	maximum adsorption capacity corresponding to complete coverage of available sites (mg g^{-1})
C_e	equilibrium concentration of metal ions in solution (mg L^{-1})
k_L	Langmuir isotherm constant (L/mg).
k_F	Freundlich constant which is the relative adsorption capacity of the adsorbent
n	Freundlich constant which indicates adsorption intensity
k_1	Lagergren pseudo first order adsorption rate constant
q_t	amount of solute adsorbed on the surface at time t (mg g^{-1})
k_2	Lagergren pseudo second order rate constant of adsorption (g mg^{-1} min^{-1})
h	Initial rate constant (mg g^{-1} min^{-1})
k_{id}	rate constant of the Intraparticle diffusion model
c	constant which is proportional to the boundary layer thickness
k_d	equilibrium dissociation constant
ΔG^o	change in free energy(J mol^{-1})
ΔH^o	standard enthalpy
ΔS^o	standard entropy
T	temperature (K)
R	gas constant (8.314 J mol^{-1} K^{-1})
IUPAC	International Union of Pure and Applied Chemistry
FTIR	Fourier transform infrared spectrometer
SEM	scanning electron microscopy
ICP-MS	inductively coupled plasma mass spectrometry

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