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Adsorption behaviour of Fe(II) and Fe(III) ions in aqueous solution on chitosan and cross-linked chitosan beads

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Abstract

A batch adsorption system was applied to study the adsorption of Fe(II) and Fe(III) ions from aqueous solution by chitosan and cross-linked chitosan beads. The adsorption capacities and rates of Fe(II) and Fe(III) ions onto chitosan and cross-linked chitosan beads were evaluated. Chitosan beads were cross-linked with glutaraldehyde (GLA), epichlorohydrin (ECH) and ethylene glycol diglycidyl ether (EGDE) in order to enhance the chemical resistance and mechanical strength of chitosan beads. Experiments were carried out as function of pH, agitation period, agitation rate and concentration of Fe(II) and Fe(III) ions. Langmuir and Freundlich adsorption models were applied to describe the isotherms and isotherm constants. Equilibrium data agreed very well with the Langmuir model. The kinetic experimental data correlated well with the second-order kinetic model, indicating that the chemical sorption was the rate-limiting step. Results also showed that chitosan and cross-linked chitosan beads were favourable adsorbers.

Keywords: Chitosan beads; Cross-linked chitosan beads; Adsorption capacities; Adsorption rates; Adsorption isotherm

1. Introduction

Water pollution by toxic metals remains a serious environmental problem and can be detrimental to living systems. Metals can be toxic pollutants that are non-biodegradable, undergo transformations, and have great environmental, public health, and economic impacts (Gupta and Sharma, 2002). In the environment, one element can be present in different chemical forms, which differ in their chemical behaviour, bioavailability and toxicity. Some elements such as iron (Mulaudzi et al., 2002), arsenic (Balaji and Matsunaga, 2002), manganese (Xue et al., 2001) and chromium (Xue et al., 2000) are mainly present in natural water as two oxidation states. For instance Cr(VI), As(III) and As(V) are known carcinogens, while Fe(II), Fe(III), Mn(II), Mn(VII) and Cr(III) are essential micronutrients for organisms and plants. However, they become toxic at higher levels.

Iron is the fourth most abundant element in the earth's crust, it is present in a variety of rock and soil minerals both as Fe(II) and Fe(III). Fe(II) is required for proper transport and storage of oxygen by means of hemoglobin and myoglobin while its oxidized forms, methemoglobin and metmyoglobin, which contain Fe(III), will not bind oxygen (Safavi and Abdollahi, 1999). Iron plays an essential role in photosynthesis and is the limiting growth nutrient for phytoplanktons in some parts of the ocean (Kieber et al., 2001). Both Fe(II) and Fe(III) are important in the biosphere, serving as an active centre of a wide range of proteins such as oxidases, reductases and dehydrases. Waste effluents from steel tempering, coal coking and mining industries, for example, contain significant quantities of iron, nickel, copper and zinc (Aksu et al., 1999).

Among the many methods available for the removal of trace metals from water namely: chemical precipitation, ion exchange, coagulation, solvent extraction and membrane processes, adsorption has been shown to be an economically feasible alternative. Activated carbon has undoubtedly been one of the most popular adsorbents for the removal of metal ions from aqueous solution and is widely used in wastewater treatment applications throughout the world (El-Shafey et al., 2002). In spite of its profilic use, activated carbon

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