Biosorption of Ni(ii) and Pb(ii) by *Phanerochaete chrysosporium* from a binary metal system - Kinetics

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Abstract

The biosorption kinetics of Ni(II) and Pb(II) by the resting cells of a lignolytic white-rot fungus, *Phanerochaete chrysosporium*, from a binary metal system were investigated. Kinetic studies revealed that biosorption takes place in two stages: a rapid surface adsorption, within the first 30 min, and a slow intracellular diffusion till the end of the 3 h contact time. In the first minutes of contact solution pH decreased sharply, parallel to the fast metal uptake, probably because of the protons released by the biosorbent. As sorption equilibrium was reached, solution pH also reached an equilibrium level. Metal biosorption capacities increased as the initial metal concentrations (C_i) increased, independent of initial pH (pH_i) and generally the metal with higher C_i had a higher uptake capacity. The results also show that some portion of the metal ions sorbed by *P. chrysosporium* was readily released to solution with a decrease in pH. At equilibrium, the maximum total metal uptake of *P. chrysosporium* was 109.5 mg/g and was reached at pH_i 5. Under these circumstances Ni(II) and Pb(II) uptake capacities were 55.9 mg Ni/g and 53.6 mg Pb/g, respectively.

Introduction

Heavy metal releases to the environment have been increasing continuously as a result of industrial activities and technological development, posing a significant threat to the environment and public health because of their toxicity, accumulation in the food chain and persistence in nature. It is therefore important to develop new methods for metal removal and recovery from dilute solutions (1 to 100 mg/l) and for the reduction of heavy metal ions to very low concentrations. The use of conventional technologies, such as ion exchange, chemical precipitation, reverse osmosis and evaporative recovery, for this purpose is often inefficient and/or very expensive (Chong and Volesky, 1995; Leusch et al., 1995; Spinti et al., 1995; Wilde and Benemann, 1993; Yu and Kaewsarn, 1999; Zhao et al., 1999).

In recent years, the biosorption process has been studied extensively using microbial biomass as biosorbents for heavy metal removal. In these studies, metal removal abilities of various species of bacteria, algae, fungi and yeasts were investigated (Chen and Yiacaumi, 1997; Guibal et al., 1992; Veglio and Beolchini, 1997; Yetis et al., 2000). Biosorption consists of several mechanisms, mainly ion exchange, chelation, adsorption, and diffusion through cell walls and membranes (Churchill et al., 1995; Kuyucak and Volesky, 1988), which differ depending on the species used, the origin and processing of the biomass and solution chemistry.

The exact mechanism by which micro-organisms take up metals is relatively unclear, but it has been demonstrated that both living and non-living fungal biomass may be utilised in biosorptive processes, as they often exhibit marked tolerance towards metals and other adverse conditions such as low pH (Gadd, 1990; Standberg et al., 1981; Volesky et al., 1993). Although metal removal from industrial effluents by means of biosorption has been studied extensively (Gadd, 1990; Volesky and Holan, 1995), very few studies have been carried out that examine the biosorbent characteristics of the white-rot fungi.

The purpose of this study is to investigate the use of *Phanerochaete chrysosporium* type white-rot fungus as the biosorbent, which is also employed for the treatment of industrial effluents containing chlorinated organics, such as the pulp and paper industry (Barr and Aust, 1994; Kirby et al., 1995; Mittar et al., 1992), for heavy metal removal from wastewaters having more than one metal in their constituents. A biological process of wastewater treatment by white-rot fungi, such as *P. chrysosporium*, continuously produces waste sludge of fungal mass, which needs to be appropriately disposed of. Thus, the main objective of selecting this type of fungus for studying biosorption is assessing the possibility of utilising the waste sludge for removal of heavy metals from industrial effluents, before disposal.

Multimetal biosorption systems would more closely represent the composition of industrial effluents, since these effluents generally include more than one metal. However, relatively few studies on multimetal systems have been reported, though multimetal competitive interactions in solution with the sorbent material are amongst the basic factors affecting the degree of metal removal by biosorption. With the help of multi-metal biosorption studies, these complex systems and their behaviour will be better understood. Accordingly, this study examines the biosorption of Pb(II) and Ni(II) from a binary metal system. Lead and Ni(II) are known environmental pollutants and are frequently encountered together in industrial wastewaters, such as from mine drainage, metal plating, paint and ink formulation and porcelain enamelling.

There is more than one variable affecting the biosorption process, such as temperature, pH, agitation rate and metal concentration (Chen and Yiacaumi, 1997; Gadd, 1990; Veglio and Beolchini, 1997). Some of these factors (e.g. pH and metal concentration) have greater influence on metal removal by this process (Veglio and Beolchini, 1997; Volesky and Holan 1995; Yetis et al., 2000). In this study the effects of initial Pb(II) and Ni(II) concentrations (C_i(Pb) and C_i(Ni)) and pH (pH_i)on metal removal and sorptive capacity of microbial biomass have been investigated using the resting cells of the *P. chrysosporium* that are in the middle

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