HEAVY METAL BIOSORPTION FROM AQUEOUS SOLUTIONS BY EPS-PRODUCING *Serratia plymuthica* STRAINS

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ABSTRACT

Background information

Many industrial activities have among their effects on the environment the release of heavy metals, which constitute a severe threat to ecosystems and human health. Wastewaters affected by heavy metal pollution are required to be adequately treated before release, but conventional methods (i.e., chemical-physical methods) still pose sustainability issues related to the economics and the efficiency of the processes. Valid alternatives are bacterial biosorption systems, which are based on biomass-metal interactions and allow for significant metal removal. In this study, the biosorption of copper (Cu^{2+}) and nickel (Ni^{2+}) on selected EPS-producing bacterial strains was examined under two different biosorption systems, providing information on the kinetics, equilibrium and effectiveness of the process.

Main results

Environmental bacterial strains were tested and selected for their ability to remove Cu^{2+} and Ni^{2+} from aqueous solutions. The concentrations of Cu^{2+} and Ni^{2+} were 200 and 50 mg L^{-1}, respectively, since these are typical concentrations in electroplating wastewater. Cell biomass was collected after 72 h of incubation and was either employed as deposited biofilm onto a 0.2 μm cellulose acetate filter (biofilm system) or directly re-suspended in metal-MilliQ water solution (planktonic-cell system). The metal bound to biomass and metal residue in water were quantified by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The planktonic-cell system was employed to assess the role of initial metal concentration, the effect of adsorbant biomass amount and to determine equilibrium parameters of Freunlich and Langmuir isothermal adsorption models. The maximum removal at given metal concentrations was reached by varying the adsorbant biomass, which was a compromise between the total adsorbant surface and binding sites overlapping phenomena. *Serratia plymuthica* strain As3-5a removed up to 48% and 91% of metal from a 200 mg L^{-1} Cu^{2+} solution in the biofilm system and in the planktonic-cell system, respectively, while *Serratia plymuthica* strain SC3I(2) removed 52% and 89% of metal from a 50 mg L^{-1} Ni^{2+} solution. Sorption equilibrium was always reached within 30 minutes, which is a reasonably short time. Both Cu^{2+} and Ni^{2+} removal were dependent on initial metal concentration. The highest removal percentages were measured at low initial metal concentration, where ionic competition for available sorption sites is lower. The efficiciency of biosorbants was expressed as the amount of metal per biomass unit (biosorption capacity, mg g^{-1}), wich allows comparison among biosorbants. *Serratia plymuthica* strain As3-5a and *Serratia plymuthica* strain SC3I(2) yielded up to 80.5 mg(Cu^{2+}) g^{-1}, and 33.5 mg(Ni^{2+}) g^{-1}, respectively. Fitting the experimental data with Freundlich and Langmuir adsorption models provided the empirical parameters that identify: (1) the type of surface (homogeneous *vs* heterogenous), (2) the bonding energy, (3) the adsorption linearity degree, (4) the prevalence of mono *vs* multi-layer structure of adsorbed ions and (5) the free energy variation (ΔG) of the process.

Conclusions

Serratia plymuthica strains As3-5a and SC3I(2) demonstrated concrete potential in the bioremediation of wastewater contaminated by copper and nickel. Their characterization as biosorbants provided

information on further possible enhancement of metal removal that might be transferred to a full-scale bioremediation system.

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