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Recoveryof rare-earth metal neodymium from aqueous solutions by poly-γ-glutamic acid and its sodium salt as biosorbents: Effects of solution pH on neodymium recovery mechanisms

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Abstract: For recovery of metals from low-concentration sources, biosorption is one of promising technologies and poly-γ-glutamic acid (γ-PGA) has been known as apotential biosorbent for recovery of heavy metals from aqueous solutions. Effects of solution pH on recovery of rare-earth metal Nd were systematically examined to clarify mechanisms of Nd recovery by γ-PGA and its sodium salt (γ-PGANa). The recovery efficiency of Nd by γ-PGA increases from 2.4% to 19.6 % as pH increases from 2 to 4. Subsequently the Nd recovery efficiencies for γ-PGA and γ-PGANa remain almost constant in the range of pH from 4 to 7. For pH>7 the increase in Nd recovery is significant and 100% recovery of Nd was achieved at pH 9. The pH dependency on Nd recovery by γ-PGANa was similar to that by γ-PGA. Contributions of adsorption and precipitation/coagulation to Nd recovery process were quantified. Whereas the adsorption dominates Nd recovery at lower pH (<~4), the precipitation/coagulation controlles Nd recovery process for pH>7. At higher pH, purple gel precipitates are observed. The maximum adsorption capacities for γ-PGA and γ-PGANa are 215 mg-Nd/(g-γ-PGA) at pH 4 and 305 mg-Nd/(g-γ-PGANa) at pH 3, respectively. From the spectra of FT-IR and XPS, the biosorption of Nd onto γ-PGA and γ-PGANavia electrostatic interaction with carboxylate anions at pH 3 is verified. The Nd complexation with amide and carboxylate anion groups onγ-PGA and γ-PGANa may also contribute to the Nd recovery. The biosorption isotherms for Nd recovery by γ-PGA and γ-PGANa can be satisfactoryilyfitted by the Langmuir model. The thermodynamic studies suggest that the biosorptions of Nd by γ-PGA and γ-PGANa are endothermic. The utilization of γ-PGA and γ-PGANa as potential and eco-friendly biosorbents for the highly effective recovery of Nd from aqueous solution is confirmed.

Keywords: rare-earth metal Nd recovery; poly-γ-glutamic acid; biosorption; precipitation; coexisting cations

Rare-earth metals have been utilized in diverse industrial applications due to their magnetic and conductive properties such as permanent magnets, lamp phosphors, catalysts and rechargeable batteries. Industrial wastewaters discharged to aquatic environments sometimes contain rare-earth metals [1-3]. Their presence in the aquatic environment is of great concern because of their toxicity even at lower concentrations. They are non-biodegradable and their removal from the environment is very difficult. They are not only highlytoxic but also significantly precious. Because of their low and localized reserves, recovery of valuable rare-earth metals from industrial wastewaters is very important as a secondary resource. Therefore, the recovery of rare-earth has recently