Assessment of acids as desorbents of metal ions bound to sludge surfaces

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Abstract

Waste activated sludge has shown potential for the removal of heavy metals from solution. In order to render bioremediation of metal-contaminated effluents a suitable alternative to costly chemical treatment methods, reusability of the biomass may form an integral part of the process. Four sludges which were pre-exposed to six metai species at varying concentrations were subsequently challenged with three desorbing agents, viz. acetic acid, hydrochloric acid (HC1) and deionised water. Results showed that sludges which presented superior biosorption of metafs in solution also showed superior desorption characteristics. Desorption was acid-dependent rather than sludge-dependent. Acetic acid was the most efficient desorbent for Cu and Ni and HC1 was most efficient for trivalent Cr, Cd and Zi. Comparatively, the efficiency of deionised water as a desorbing agent, could be regarded as negligible.

Introduction

The economical and ecological implication of a successful biotechnological process for the remediation of metal-contaminated effluent would depend on optimum biosorption by way of superior biosorbents and moreover the ease of metal recovery for subsequeni reclamation and most important, the ability to regenerate biomass for reuse in multiple adsorption-desorption cycles. From an economic standpoint, regeneration of biosorbent lowers waste treatment costs for users and can enhance profitability for biosorbent producers. Adsorption and desorption are usually coupled processes. Desorption is also known as elution, particularly in processes involving adsorbents in column configurations.

Studies have been conducted previously on assessing the feasibility of a variety of desorbing agents (Huang and Morehart, 1990). Strandberg et al. (1981), investigated uranium recovery by *Saccharotnyces cerevisiae* and *Pseudomonas aeruginosa*. They employed several desorbing agents to recover metals from these ceils after biosorption. *S. cerevisiae* cells were exposed to 0.l M nitric acid, 0.1 M disodium ethylenediamine tetra-acetic acid (EDTA) and 0.1 M ammonium carbonate for 16 h and obtained only 59,*12* and 84% removal, respectively. They also attempted desorption with two other agents, viz. sodium citrate 0.1 M and potassium oxalate 1.0 M and obtained 57 and 14% removal, respectively. They did, however, report increased adsorption by biomass desorbed with ammonium carbonate, sodium citrate and potassium oxalate. Although nitric acid and EDTA decreased final adsorption of uranium, initial uptake rates were enhanced. Swalaha (1993) showed EDTA to be not as efficient and economically feasible when compared to other desorbents.

During comparison of 0.0l MEDTA with 0.l MHCl.Mathackal et al. (1991), found HC1 to be the most efficient desorbent since a small amount of Cu still remained bound to the biomass after treatment with EDTA. They postulated that the high concentrations of protons made available by the HCI may dislodge Cu from active sites thereby making the bond between Cu and the biosorbent labile. EDTA desorption was attributable to direct competition between ligands and EDTA for Cu ions since EDTA forms astrong complex with Cu with a strong stability constant. Therefore, for present application the use of HCI was favoured when compared with EDTA. Previous research had investigated a range of desorbents. Hydrochloric and acetic acids presented superior desorption for the removal of metals investigated at concentrations of 2.5% acetic acid and0.2 N HCI respectively (Bux et al., 1994).

The present communication forms part of a larger ongoing study focused on the development of a biotechnological process for the remediation of metal-contaminated industrial effluents. This process seeks to exploit the ability of waste sludge biomass to act as a metal biosorbent. However, metal ions bound to sludge biomass need to be desorbed in order to facilitate reuse of the biomass and either disposed of or further treated to promote complete recovery of metals. Therefore, the objective of the present study was to investigate the efficiency of desorption of the following desorbing agents, viz. deionised water, acetic acid and HCI for sludge-bound metal ions, viz. Cu^{2+}, Cr^{3+}, Cd6+, Cd^{2+} Ni^{2+} and Zn^{2+}

Materials and methods

Pretreatment of materials

Polypropylene centrifuge tubes, vials and all glassware were soaked for 24h at ambient temperature in 5 % (v/v) Extran MA-01 alkaline (Lasec, South Africa) before use to remove any resident metal. Vials and centrifuge lubes were then rinsed three times in deionised water and dried. Glassware, including pipettes were subjected to stringent acid wash procedure, i.e. rinsing in 50% (v/v) nitric acid (HNO_3) (Unilab, South Africa), followed by 50% (v/v) HCI (Unilab, South Africa) and finally rinsing in triple deionised water.

Preparation of solutions

Aqueous metal stock solutions of 1 000 *mg-l-1* were prepared in 1 *t* volumes for immediate use as required for the initial phase of

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