A new approach to the remediation of heavy metal liquid wastes via off-gases produced by *Klebsiella pneumoniae* M426

A.M.M. Essa, N.J. Creamer[†], N.L. Brown[‡], L.E. Macaskie

Biotechnol Bioeng. 95(4):574-83.

When the off-gas from an aerobic culture of *Klebsiella pneumoniae* M426 grown in the absence of added heavy metals was passed through a solution of Hg^{2+}, Cd^{2+}, Pb^{2+}, or Cu^{2+} a yellow-white (Hg), white (Cd, Pb), or blue (Cu) precipitate was formed. Metal removal from solution was >97% within 2 h at initial concentrations of (as metal): Hg, 8.5; Cd, 12.6; Pb, 7.8; Cu, 9.5 mg/mL. Mercury was removed from solution at pH 2 and in up to 1 M NaCl. Energy dispersive X-ray microanalysis (EDX) of the precipitates showed them to comprise metal, sulfur and carbon in the case of Hg, Cd, and Pb, and, in the case of Cd and Pb, also oxygen. The pH of the solution increased by 1–2 units at an initial pH of 7 and by 4–5 units at an initial pH of 2. In the case of cadmium and lead, the presence of crystalline metal carbonates and hydroxides was confirmed by X-ray powder diffraction (XRD) analysis and additional peaks were seen which could not be assigned to known compounds in the diffraction file database. In the case of copper, hydroxides, and a form of copper sulfate, were found. In the case of mercury the XRD patterns could not be assigned to any known compound, except for HgCl in the solution at the acidic initial pH. The absence of sharp peaks in the pattern for the Hg-precipitate was indicative of poorly crystalline, nanocrystalline or amorphous material. The unknown mercury compound, since it contained non-carbonate carbon, was suggested to be derived from a volatile organothiol in the gases evolved from the culture. Analysis of the culture head gas by GC-MS showed the presence of dimethyldisulfide as a likely precipitant. No sulfur compound was found using XRD analysis in the case of cadmium and lead, although EDX analysis suggested this as a major component and the lack of XRD pattern is evidence for a non-crystalline metal-organothiol. The exact chemistry of the new materials remains to be elucidated but metal precipitation via a biogenic organothiol is a potentially effective approach to the remediation of aggressive metal wastes.