INHIBITION OF IRON(II) OXIDATION BY ARSENIC(III,V) IN THIOBACILLUS FERROOXIDANS: EFFECTS ON ARSENOPYRITE BIOLEACHING

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SUMMARY

The more complex inhibitory effect of As(III) than that of As(V) on Fe(II) oxidation in a non-growing Thiobacillus ferrooxidans suspension was demonstrated. The yield of arsenic bioextraction from a chalcopyrite concentrate was not affected by arsenic inhibition due to the low sensitivity of the strain to arsenic ions, supported by a spontaneous conversion of As(II1) to As(V).

INTRODUCTION

Iron-oxidizing activity of Thiobacillus ferrooxidans is important for arsenopyrite oxidation either in bacterial leaching of gold-bearing arsenopyrite concentrates (Lindström et al., 1992) or in removal of arsenopyrite from minerals (Špaldon et al., 1992) resulting in a production of arsenic ions. The inhibition of Fe(II) oxidation by arsenic affects the bioleaching process including the arsenic bioextraction yield.

During arsenopyrite biooxidation, As(III) is approximately three times more toxic to bacteria than As(V) (Barrett et al., 1993b). In addition to arsenic resistance in bacteria (Cervantes et al., 1994; Rosen et al., 1995), oxidation of As(III) by Fe(III) catalysed by pyrite or chalcopyrite and supported by mineral surface-oxidizing bacteria under acidic bioleaching conditions has been described (Barrett et al., 1993a). The kinetics of this anticipated detoxification process (Mandl and Vyškovský, 1994) indicates the following reaction: H3AsO3 + Fe3(SO4)3 + H2O = H3AsO4 + 2FeSO4 + H2SO4. The analogous reaction has been suggested by Monroy Fernandez et al. (1995) without considering the catalysis.
The purpose of this study was to demonstrate inhibitory effects of As(III,V) on Fe(II) oxidation in an ore isolate *T. ferrooxidans*, their changes after an incubation period and the effects on arsenopyrite bioleaching in the process of arsenic bioextraction.

**MATERIALS AND METHODS**

**Bacteria, culture conditions and inhibitory studies.** Culture conditions of *T. ferrooxidans* (CCM 4253) and treatment of the culture was described earlier (Mandl and Vyškovský, 1994). Inhibition of Fe(II) oxidation was investigated in the bacterial suspension (10^8 cells in 1 ml 10 mM H_2SO_4) supplemented with Na_2AsO_3 or Na_3AsO_4 simultaneously with FeSO_4, and in the suspension that had been incubated with arsenic ions at inhibitory concentrations before the addition of Fe(II) (all the solutions were adjusted to pH 1.7 by H_2SO_4). The rate of Fe(II) oxidation in the suspension was measured by the rate of oxygen consumption using a Clark-type oxygen electrode (Electrofact, The Netherlands). Regression analysis was used for evaluation of the inhibition.

**Bioextraction of arsenic.** Chalcopyrite concentrate contaminated by arsenopyrite (2.3 % [w/w] As), bioleaching conditions (at a volume of 100 ml), and analytical procedures were described earlier (Mandl et al., 1992).

**RESULTS AND DISCUSSION**

**Inhibition of Fe(II) oxidation by As(III,V)**

Fig. 1 and 2A,C show the inhibitory effects of both As(III) and As(V) on Fe(II) oxidation without preincubation. The significant difference (P<0.01) between zero and both the intercept values in Fig. 1 may theoretically include both non-competitive and mixed inhibition types (Webb, 1963). However, in Fig. 2A,C, the difference between the slope values of both lines is insignificant (P>0.05) excluding the mixed type of inhibition. The dependences in Fig. 2A,C corresponded to an equation for the non-competitive type of inhibition \( v/v_0 = 1 + i/K_i \) (\( v \) and \( v_0 \) are the rates of inhibited and inhibited Fe(II) oxidation, respectively, \( i \) is arsenic concentration, \( K_i \) is the inhibition constant). \( K_i \) were 45 ± 11 mM and 143 ± 19 mM for As(III) and As(V), respectively (Michaelis constant for Fe(II) was 0.57 ± 0.09 mM, all the values are expressed as 95% confidence intervals). An earlier study of inhibitory effect of As(V) in *T. ferrooxidans* used for bioleaching of an arsenopyrite concentrate reported a competitive type of inhibition of Fe(II) oxidation with \( K_i \) of 58 mM (Dorofeyev et al., 1990).