

Oxidation states change of Ce in the mixtures of manganese oxides and *Pseudomonas fluorescens*

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1 Introduction

Many heavy elements (HEs) containing lanthanides and actinides exist in several oxidation states in the environments. Various physical-, chemical-, and biological-processes alter the speciation of HEs. Hence, the presence of multiple species and their complex chemistry make it difficult to predict their migration behavior in the environment.

HEs are sorbed by inorganic and organic materials in the environments during the migration. Manganese oxides are ubiquitous, and are known to oxidize redox sensitive HEs; i.e. Ce(III) [1, 2]. Several microorganisms are known to exhibit a high capacity to sorb HEs. Such binding to bacterial surfaces might well affect the movement of HEs in the environment. Unfortunately, we have limited knowledge of the role of microorganisms in the migration.

In this study, we have investigated the association of Ce(III) with the mixture of a common soil bacterium, *Pseudomonas fluorescens*, and manganese oxides. This microorganism is widespread in the terrestrial environment.

2 Experiment

The cells of *P. fluorescens* (ATCC 55241) were grown in the nutrient solution until log phase. Manganese oxides of MnO₂ and Mn₂O₃ were abiotically formed. The sorption experiments of a 0.1 or 0.01 mM Ce(III)(NO₃)₃ solution by the mixtures of *P. fluorescens* and manganese oxides were performed under atmospheric condition. The mixtures containing 1, 5, or 10 mg cells and 5 mg manganese oxides were immersed with a 0.01 mM Ce(NO₃)₃ solution at pH between 3 and 8.

The concentration of Ce in solution was measured by ICP-AES. The K_d, the ratio of Ce in solution and on the mixture was obtained by the concentration of Ce in the solution. The spatial distributions of elements in the mixtures were measured after the exposure to the Ce solution using micro beam at BL15U1 of SSRF. Ce L_{III}-edge (5723 eV) XANES spectra and Mn K-edge (6539 eV: δ-MnO₂) were measured at BL15U1 of SSRF and at BL-9A, BL-12C, and BL-27B of PF.

3 Results and Discussion

The K_d of Ce increased with increasing pH of the solution. The lower K_d was obtained at higher Ce concentration. The XANES spectra of Ce sorbed by the mixture at 0.1 mM Ce solution (Fig. 1) showed that most

of Ce was present as Ce(IV) at pH 5.72 and some fraction of Ce was present Ce(III) at pH 4.06 and 3.28. Ohta et al. showed oxidation of Ce(III) to Ce(IV) at pH between 3 and 7 [3]. Our results indicate that microorganism inhibits the oxidation of Ce(III) in acidic solution.

The spatial distribution of Ce and Mn (Fig. 2) showed that high intensity of Ce was detected at the position of Mn, indicating that most of Ce was present with manganese oxides.

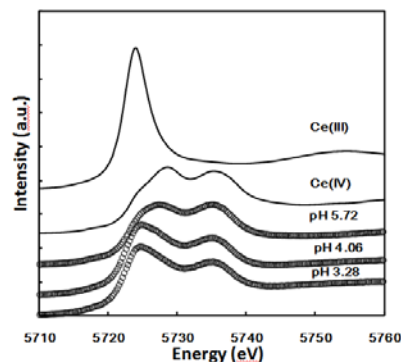


Fig. 1 XANES spectra of Ce sorbed at different pH by the mixtures of manganese oxides and *P. fluorescens*.

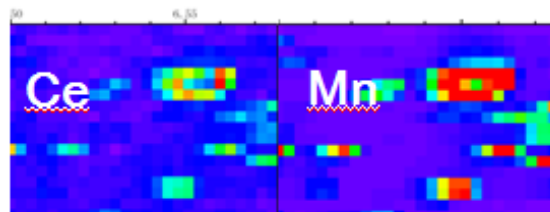


Fig. 2 Spatial distribution of Ce and Mn in the mixture.

Acknowledgement

The μ -XANES and spatial distributions of elements were measured at Shanghai Synchrotron Radiation Facility (SSRF) as alternative use of PF damaged by earthquake. We thank all staff of SSRF for their cooperation and hospitality.

References

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