

EXAFS analysis of biogenic iron oxide nanoparticles obtained from a water purification tank

Tatsuo FUJII*, Hideki HASHIMOTO, Yoshifumi WATANABE, Mitsuaki FURUTANI,
Jun TAKADA
Okayama Univ., Tsushima-naka, Okayama 700-8530, Japan

Introduction

Leptothrix ochracea is one of the most common iron oxidizing bacteria producing low crystalline iron oxides extracellularly [1, 2]. Hollow-shaped iron oxides produced by *L. ochracea* have uniform sheath diameter and length of about 1 μm and several hundred μm , respectively. The biogenic iron oxide sheaths have very unique shapes in respect of materials chemistry. But there are little studies on the biogenic iron oxides by means of materials chemistry because of large difficulties obtaining high purity biogenic iron oxide samples.

In the present study, we tried to reveal structural characterizations of high purity biogenic iron oxide sheaths produced by *L. ochracea*. The biogenic iron oxide sheaths have interesting morphology and microstructure which can't be produced artificially at ordinary temperature under normal pressure. Structural properties of the biogenic iron oxide sheaths gradually changed from amorphous structure to crystalline one under the heat treatment. The local structure around Fe ions was examined by Fe K-edge EXAFS spectra. These results could give useful information when the biogenic iron oxide sheaths will be applied as functional materials in near future.

Experimental

The Fe K-edge EXAFS spectra of biogenic iron oxides produced by *L. ochracea* were measured at beamline BL12C. The biogenic iron oxides obtained from water purification pools were purified several times by water elutriation to remove the impurity sand particles. After that, the particles were dried in vacuum at room temperature and subsequently heat-treated in air at 100°C ~ 800°C. All samples were finely ground and mixed with BN powder, and then were pelletized. The EXAFS spectra were obtained by using a conventional transmission setup at room temperature. The data analysis was performed by using commercial software REX2000 (Rigaku). The values of back scattering amplitude and phase shift were calculated by FEFF program using the crystal structural data of $\alpha\text{-Fe}_2\text{O}_3$.

Results and discussion

According to the EXAFS analysis, radial distribution functions (RDF) of the biogenic oxide sheaths are very similar to those of 2-line ferrihydrite [3]. The biogenic oxides are poorly crystalline material as well as the 2-line ferrihydrite. Fe ions in sheaths have octahedral oxygen

coordination. The first peak in RDF is assigned to the Fe-O bond while the second peak corresponds to the Fe-Fe bond. The RDF profiles of unheated sample and heat-treated samples below 500°C did not show long or middle range order. The second peak intensity was very small. If the heat-treated temperature increased above 600°C, the second Fe-Fe bond intensity was gradually increased to develop the middle range order. The Fe-O bond length was calculated from the first Fe-O peak profile in RDF assuming the fixed oxygen coordination number of 6. Figure 1 shows the Fe-O bond length as a function of the heat-treated temperature. The Fe-O bond length gradually decreased with increasing of heat treatment temperature up to 500°C. But, above 600°C, the Fe-O bond length increase with increasing of the temperature. This suggests that the crystallization process of biogenic oxides locally started at 500°C.

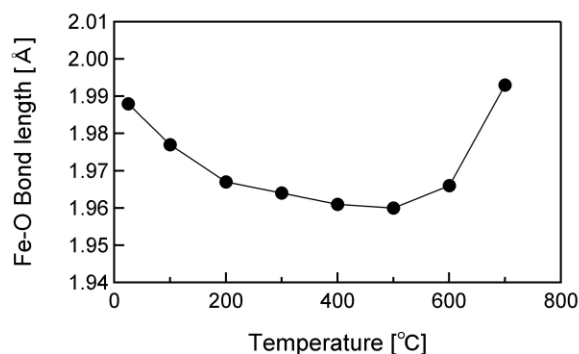


Fig. 1, Fe-O bond length of biogenic iron oxides as a function of the heat-treated temperature.

Acknowledgements

Authors gratefully acknowledge the technical support of Dr. Masashi Tanaka and Prof. Yasushige Kuroda of Okayama University for EXAFS measurements.

References

- [1] W. L. van Veen, E. G. Mulder and M. H. Deinema, *Microbiol. Rev.* 42, 329 (1978).
- [2] H. Hashimoto, S. Yokoyama, H. Asaoka, Y. Kusano, Y. Ikeda, M. Seno, J. Takada, T. Fujii, M. Nakanishi and R. Murakami, *J. Mag. Mat.* 310, 2405 (2007).
- [3] A. Manceau and V.A. Drits, *Clay Mineral.* 28, 165 (1993).

* tfujii@cc.okayama-u.ac.jp