Bacterial biogeochemistry revealed by submicron X-ray fluorescence spectroscopy

B. LAI*

X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, USA
(*correspondence: blai@aps.anl.gov)

The microenvironment around actively metabolizing bacteria can be significantly different from the bulk environment, with steep chemical gradients developed over very short distance. Submicron x-ray fluorescence (XRF) microprobes are ideally suited for studying the local chemistry and elemental distribution at or near the microbe-mineral interface. Investigations have ranged from the respiratory role of mixed-valence intracellular Fe granules formed in *Shewanella putrefaciens* [1], formation of extracellular UO_2 nanoparticles by *Shewanella oneidensis* [2], increased resistance of surface adhered *Pseudomonas fluorescens* to Cr (VI) [3], to mechanisms of gold biomineralization in *Cupriavidus metallidurans* [4]. These x-ray microprobe analyses, together with high resolution electron microscopy, have revealed the remarkable respiratory versatility and sophisticated metal regulation mechanisms developed by bacteria. These studies were made possible because XRF microprobes offer high elemental sensitivity (attogram), high resolution (150 nm), high penetration power (through whole cells and fluid layer), and spectroscopic capability (μ-XANES). Currently minimal sample preparartions are required, but as the spatial resolution improves, possibly approaching 20-30 nm in the near future, radiation damage will be the main limiting factor and strategies for cryogenic sample handling will need to be considered.

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XPS results pertaining to the applications of nanomodified vermiculite

T. LAIHO[1]*, O. EKLUND[2], A. SHEBANOV[3] AND V.N. RUDASHEVSKY[4]

[1]Lab. of Materials Science, Department of Physics and Astronomy, University of Turku, Finland (*correspondence: taina.laiho@utu.fi)
[2]Department of Geology, University of Turku, Finland
[3]GeoSmart, St. Petersburg, Russia
[4]CNT Mineral Consulting Inc., St. Petersburg, Russia

Background

A research group at the University of Turku has developed a new simple nanomineralogical method for removing ammonium ions from waste waters. This novel method is based on modified vermiculite mineral obtained in result of high-tech manipulations with the crystalline lattice.

Method

X-ray photoelectron spectroscopy (XPS) was used to perform a chemical characterisation of the chemically treated samples of nanomodified vermiculite. It is a method for analysing elemental composition and chemical states of atoms. Because of its applicability for chemical analysis, the method is also called ESCA (Electron Spectroscopy for Chemical Analysis).

Discussion of Results

We have studied absorption on nanomodified vermiculite in different chemical environments. We now report studies concerning ammonium ion sorption from ammonium acetate solution, urine and waste water.

XPS is our main analysis method. Elemental composition before and after chemical treatment is reported and detailed chemical analysis of samples is peformed based on the analysis of XPS spectra. The O 1s, Si 2p, Al 2p and Mg 2p photoemission lines are presented in detail and N 1s and other photoemission lines resulting from absorption products are analysed. Flow injection analysis (FIA) method is used to complete time-dependent quantitative analysis.

Time-dependence, effect of other than ammonium ions and tempereture-dependence are considered and results are presented.