Molecular and Atomic Scale Characterization of Uranium Association with Marine Bacteria

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Abstract

The Alboran Sea located at the west side of the Mediterranean Sea is the only connection between the Mediterranean Sea and the Atlantic Ocean. The intense transportation of radioactive wastes and the traffic of nuclear submarines in this Sea resulted in its contamination with actinides, including uranium. The present work describes the molecular scale speciation of uranium associated with Idiomarina loihiensis MAH1, a bacterium isolated from Alboran Sea [2] using a multidisciplinary approach combining spectroscopic (X-ray Absorption Spectroscopy, XAS; Time-Resolve Laser-Induced Fluorescence Spectroscopy, TRLFS) and microscopic (High Resolution Electron Microscopy, HREM) techniques. These speciation studies were performed using two type of background electrolyte, $NaClO_4$ 0.1 M and seawater.

The results showed that the speciation of uranium associated with the cells of the strain MAH1 is highly dependent on type of background electrolyte used. In the $NaClO_4$ system, EXAFS spectroscopy indicated that U is coordinated to carboxyl groups in bidendate binding mode and to phosphate groups in a mondendate fashion mode. These results are supported by TRLFS studies which determined the fluorescence properties of the uranium complexes formed by the cells. The U accumulates were localized within the EPS and at the cell wall as was demonstrated by HRTEM analysis. However, in seawater and at uranium concentration of $5x10^{-4}$ M (environmentally relevant concentration), TRLFS analysis indicated that the marine bacterium precipitates this radionuclide as uranium carbonate mineral phases, and the implication of other uranium bacterial species including organic/inorganic phosphate uranium complexes is not excluded. HRTEM studies demonstrated that these U/bacterial species were located mainly at the cell wall.

The results obtained in this work give new insights in the implication of marine bacteria in the geomicrobial processes (e.g. biomineralization of uranium) in marine environments as well as on the role of these bacteria on the transport and mobility of radionuclides in these natural habitats.

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[2]Gonzalez-Mu?oz M.T., De Linares, C., Martínez-Ruiz, F., Morcillo, F., Martín-Ramos, D., Arias, J.M. Chemosphere 72, 465-472 (2008).