

Arsenic accumulation and transformation in thermoacidophilic Cyanidiales

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Abstract

The Cyanidiales, unicellular red microalgae, comprise a monophyletic clade of polyextremophilic. They usually thrive in acidic (pH 0.5-5), thermal (up to 63°C), and habitats worldwide containing heavy metals. Arsenic (As) is the most common toxic substance in the environment. It exists primarily as inorganic arsenite [As(III)] and arsenate [As(V)] in the ecosystem. Furthermore, arsenic can be methylated by microorganisms into mono-, di- or trimethylarsines. Considering such ranking first on the superfund list of hazardous substances, it is encouraged to remediate arsenic from the environment. In this study, the capacity and related mechanisms for As(III) sorption on three Cyanidiales genera [*Galdieria partita* (Gp), *Cyanidioschyzon merolae* (Cm), and *Cyanidium caldarium* (Cc)] was determined. Arsenic speciation and localization were analyzed using synchrotron-based high-resolution Fourier-transform infrared (FTIR), transmission X-ray microscope (TXM), X-ray absorption spectroscopy (XAS) analysis. The maximum sorption capacities of As were Cm (59.4 mg g⁻¹) > Gp (58.8 mg g⁻¹) > Cc (40.7 mg g⁻¹) at pH 7.0. According to TXM results, the sorbed arsenic presented as darker shadows scattered around the cell surface, suggesting the As was plausible on the surface of Gp. Compared with Gp, Cm and Cc sequestered As around the cell. In addition, the portion of As could get into the cell and complex with their proteins due to the changes of proteins secondary structure derived from FTIR results in Cc and Cm. However, Cyanidiales, specifically Cc, showed the unique mechanisms derived from XAS results to retain As. The noteworthy point 32.0% of As(III) was reduced and precipitated as arsenopyrite [FeAs(-1)S] on Cc exposure As. The reduction of As (III) to As (-1) on Cc might lead to the greatest defensive line for As stress. Collectively, different accumulation and transformation mechanisms were brought out including precipitated around the cell, complexed with proteins, and reduced the As(III) to As(-1).

Key words: Cyanidiales, Arsenic, speciation.