

Synchrotron Spectroscopy and Imaging in unraveling bacterial surface metal interactions

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Bacteria are common and play an important role in controlling the speciation, biological toxicity and cycling of metals and contaminants in the environment. The species of microbes and their abundance vary significantly from one natural environment to the other and this modifies the role that the microorganisms may have on the metal chemistry in the environment. However, in all bacterial species, the cell surface chemistry is one key variable that influences the exposure of organism to metal, metal uptake and electronic state transformation by cells, which in turn influences the metal speciation. These bacterial cell-metal interactions have been studied using bulk wet chemistry or spectroscopy methods (e.g. infrared and UV-vis spectroscopy), or using ex-situ high resolution electron microscopy (e.g. SEM, TEM) methods. However, recent developments in synchrotron X-ray spectroscopy and imaging techniques and the development of 3rd generation synchrotron sources enabled the direct examination of reactions on cell membranes at spatial resolution closer to 10 nm. In this presentation, we will go over the application of X-ray imaging and spectromicroscopy methods in studying the cell membrane functional group composition (e.g. proteins, carboxyls) and their distribution in different bacterial cells, and how this information complements the infrared and other spectral information. In addition, we will present how X-ray scattering (XANES and EXAFS spectroscopy methods) and wet chemistry and fluorescence spectroscopy can be used to explore the bacterial cell interactions with aqueous contaminants such as Hg and Zn. These studies showed that metal interactions with cell membranes vary significantly with the metal concentration and bacterial species. A summary of these studies, and how the new developments of synchrotron methods can be applied to explore the bacterial cell surface interactions will be presented.

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