Measuring the enthaply of proton, lead, and cadmium adsorption onto *Bacillus subtilis*

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The adsorption of metals onto bacterial surfaces can control the mobility and speciation of metals in a wide range of environments. Metal adsorption studies have primarily relied on bulk adsorption data, thermodynamic modeling, and spectroscopic data to understand these interactions. Surface complexation modeling of bulk adsorption data has produced stability constants for metal-bacterial surface complexes, and spectroscopic data have provided constraints on the coordination environment. However, enthalpy and entropy measurements of proton and metal adsorption onto the bacterial surface have never been measured. In this study, we performed the first calorimetric experiments involving bacteria, measuring proton, Pb, and Cd adsorption onto a common Gram positive bacterium *Bacillus subtilis*. We combined our enthalpy measurements of adsorption with the results from previous potentiometric titrations of *Bacillus subtilis* (Fein et al., 2004) to calculate the enthalpy and entropy of proton, Pb, and Cd adsorption onto the specific surface sites responsible for metal adsorption. This innovative approach to studying metal adsorption provides new thermodynamic data that enable quantitative estimates of the temperature dependence of proton, Pb, and Cd adsorption. The calorimetric experimental techniques reported here can be applied to a wide range of metal ions, yielding thermodynamic data that may be integrated into geochemical models to determine the mobility of metals in bacteria-water-rock systems.

Reference

Fein J. B., Boily J. F., Yee N., Gorman-Lewis D., and Turner B. (2004) Potentiometric titrations of *Bacillus subtilis* cells and a comparison of modelling approaches. *Geochim. Cosmochim. Acta* In Press.

A link between bacterial surface adsorption and chemotactic response

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Bacterial chemotaxis is of medical, biological, and geological significance. Despite its importance, current chemotaxis measurements fail to account for the speciation of the chemical effector and the protonation state of the bacterial surface. Hence, extrapolation of chemotactic obsevations from laboratory systems to realistic settings is problematic. We hypothesize that adsorption onto the bacterial surface can determine the effective concentration of the chemical effector at the cell surface, and therefore influence the cellular response. We conduct experiments to test the chemotactic response of *E. coli* to the repellent, Ni^{2+} under different environmental conditions. The results demonstrate that adsorption of Ni^{2+} to the bacterial surface strongly influences the chemotactic response. Our data suggest that chemotactic responses in realistic settings depend on a number of environmental factors such as pH, the concentrations of competing binding agents (e.g., aqueous organic acids, natural organic matter, mineral surfaces, etc.), and ionic strength. We use potentiometric titration and Ni^{2+} adsorption experiments to develop and constrain a thermodynamic model capable of quantifying the concentration of Ni^{2+} at the bacterial surface. The concentration of Ni^{2+} at the bacterial surface directly correlates with the responses observed in the chemotaxis experiments, while the total Ni^{2+} concentration in bulk solution does not. This modeling approach can be coupled with the results from chemotaxis experiments to predict the responses of different bacterial species to a variety of effector chemicals. Moreover, these data suggest that specific changes in environmental conditions can be used to tune chemotactic responses in natural biological and geological settings.