Silver nanoparticles interactions with solution/biofilm/mineral interfaces

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The recent increase in silver nanoparticles (Ag-NPs) use raises important concerns regarding their environmental release and their potential impact to ecosystems. Ag-NPs are likely to accumulate in landfills, soils and sediments, where they are expected to interact with bacterial biofilm/mineral interfaces. This complex interface exhibits a high reactivity that could strongly impact the NPs environmental fate. However, the controls imposed by this key environmental compartment on Ag-NPs are not well known. The main goal of this research is thus to determine the impacts of the NPs structure and coating type on their transport properties and stability at the biofilm/mineral interface. To do so, *Shewanella oneidensis* MR1 biofilms grown on oriented single crystals Al_2O_3 (1-102) were exposed to three types of Ag-NPs exhibiting different coatings - one inorganic negative (SiO_2), one inorganic positive (SiO_2-NH_2), and one organic negative (PVP). The Ag partitioning and the Ag-NPs transformations at the interface were determined using in-situ Long Period X-ray Standing Waves Fluorescence Yield and X-Ray Absorption Spectroscopy at the Ag K-edge.

The investigated mineral/biofilm interface constituted a sink for the NPs investigated. However, the NPs partitioning and stability were found to strongly depend on the coating type. The negative SiO_2 coated Ag-NPs were transported through the negatively charged biofilm to the positively charged mineral surface, while the positive SiO_2-NH_2 coated Ag-NPs remained trapped in the biofilm, suggesting a strong electrostatic control during NPs interactions. In addition, both SiO_2 and SiO_2-NH_2 coated Ag-NPs remained stable after 24 hours of exposure, with no dissolution observed. The negative PVP Ag-NPs, however, were transported slowly through the biofilm, with Ag_2S, Ag-thiol and free Ag^+ being rapidly observed, likely the result of dissolution/reprecipitation processes. Thus, biofilm/mineral interfaces are likely to strongly impact the nanoparticles environmental fate, with a major control imposed by their coating type.