Fate of silver nanoparticles at the bacterial biofilm/mineral/water interface

A. GELABERT[1]*, C. LEVARD[23], G. ONA-NGUEMA[4], M. DESMAU[1], M. AUFFAN[23], J. ROSE[23], J. LABILLE[23], Y. SIVRY[1], P. ENG[5], F. GUYOT[4] AND M. F. BENEDETTI[1]

[1]IPGP, Sorbonne Paris Cité, Université Paris Diderot, UMR 7154 CNRS, 75005 Paris, France (* gelabert@ipgp.fr)

[2]Université Aix-Marseille, CNRS, IRD, CEREGE UMR 7330, 13545 Aix en Provence, France

[3]iCEINT, Intern. Consortium for Environmental Implications in NanoTechnology, Aix en Provence, France

[4]IMPMC, Sorbonne Universités, Université P. et M. Curie, UMR 7590 CNRS, MNHN, 75005 Paris, France

[5]Consortium for Advanced Radiation Sources, University of Chicago, Chicago, IL 60637, USA

The production volume of manufactured nanoparticles (NPs) in 2010 was estimated around 285,000 metric tons. As highlighted in recent studies, a significant fraction of them is likely to be released in soils and waters, raising important concerns regarding their impact on ecosystems. In soils, their fate is expected to be partly controlled by their interaction with microbial biofilms. However, relatively few studies have explored reactions occurring in this key environmental compartment. Therefore, the main goal of this research is to understand how NPs size, structure, and composition control their diffusion at the biofilm/mineral/water interface.

Shewanella oneidensis MR1 biofilms grown on oriented single crystals (Fe_2O_3(0001), Al_2O_3(0001) and (1-102)) were exposed to Ag NPs. Their partitioning at this complex interface was measured *in situ* using X-ray Standing Waves spectroscopy. To determine the role of the NPs overall charge for their reactivity, 3 different coatings representative of manufactured NPs have been tested: one mineral negatively (SiO_2) and positively (SiO_2-NH_2) charged coatings, and one organic (PVP) negatively charged coating.

Experimental results show an important difference in partitioning as a function of single crystals used and the NPs coating types. While the negative SiO_2 coated NPs diffuse quickly (in less than 30 min) through the negatively charged biofilm to the positively charged mineral surface, the positive SiO_2-NH_2 coated NPs remain trapped in the biofilm matrix. The negative PVP NPs display an intermediate behaviour, demonstrating the importance of the coating type for NPs reactivity at this biofilm interface. Moreover, exposure kinetics is a key parameter, and significant differences in NPs profiles have been measured between 3 hours and 24 hours of exposure.