Toxicity of silver nanoparticles to environmental microbial consortia

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Nanomaterials, particularly silver nanoparticles (AgNPs), are present in a large number of consumer goods due to their strong antimicrobial properties. Their extensive use raises concerns as to their release to the environment and their potential toxicity to aquatic microbiota.

The mechanism of AgNPs toxicity remains elusive and may include direct inhibition by the nanoparticulate form and/or indirect toxicity via soluble silver released from AgNPs. Additionally, numerous studies have attempted to unravel the role of AgNP size and coating in bacterial toxicity response but there remains a large gap in our understanding of the impact of basic AgNP characteristics on their toxicity.

Here we report on a systematic study of AgNP toxicity towards two pure cultures -*Escherichia coli* and *Bacillus subtilis*- and a microbial community from lake Geneva. We studied the effect of size (5nm, 10nm, 20nm, 50nm and 100nm) and that of surface coating (polyvinylpyrrolidone, tannic acid, citric acid and carbonate) on toxicity.

The AgNPs were obtained commercially and extensively characterized by electron microscopy (EM), dynamic light sacttering, zeta potential and the release of silver ions quantified by inductively coupled plasma mass spectrometry. The impact of AgNPs (0 to 1mg/L) on growth was monitored by optical density at 600nm, by colony formation for pure cultures and by measuring protein concentration and monitoring the microbial diversity of the community for the consortia. Additionally, the spatial relationship of AgNPs and cells was assayed by EM imaging of resin-embedded cells. The environmental relevance of the experimental conditions was ensured by growing cultures in artificial lake water.

Results to date show little toxicity to laboratory strains with *E. coli* being more sensitive than *B. subtilis* and size being a less important factor than surface coating. The systematic approach of this study –where AgNP size distribution is narrow and the geochemical conditions and microorganisms environmentally relevant- may be helpful to policy makers aiming at regulating the use of AgNPs in consumer goods.

VESPERS XRF and Laue Diffraction mapping of Carlin-type auriferous arsenian pyrite

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Carlin-type gold deposits produce 8% of the world gold, and the main ore is auriferous pyrite commonly associated with various trace elements (Ag, As, Au, Cu, Hg, Ni, S, Sb, Se, Te, Tl and Zn). Their compositions have been investigated using electron-microprobe (EMP) and dynamic Secondary Ion Mass Spectrometry (SIMS), which indicates that gold and related trace elements occur in complex, micrometer-size irregular zones or overgrowths within single grains. The development of VESPERS (Very powerful Elemental and Structural Probe Employing Radiation from a Synchrotron) allows for non-destructive elemental mapping and crystal structure determination through XRF and Laue diffraction (LD). This methodology was applied in selected auriferous pyrite grains that were previously investigated using EMP and SIMS to advance our understanding of the relationship between the abundance of trace-elements and crystal structure.

The VESPERS elemental mapping results are consistent with those obtained by SIMS and EMP; however it offers the advantage of mapping a wide range of elements and the collection of LD patterns simultaneously and non-destructively. The elements that have adequate peak resolutions are Au (L series) and As, S, Fe, Ni, Cu (K series). Elements with peak overlap that have not yet been resolved include Ag, Sb, Te, Tl and Zn. Synchrotron LD data was collected along selected domains and the crystal structures are being interpreted.