Effects of maghemite (γ-Fe_2O_3) nanoparticles on the toxicity of arsenic within cultured human fibroblasts

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Arsenic is a toxic metalloid largely studied these last years. Its toxicity is known to be related to its oxidation state and speciation. In cellular media, arsenic shows a strong affinity with thiol functions, which play an important role on arsenic biocellular transformations and cancerogenic effects. Serious health problems due to high rates of arsenic in drinking water, amplified the interest in minerals such as iron oxide which can immobilize arsenic species on their surfaces and so decrease their toxicity. Recently, Nano-Maghemites (iron oxide nanoparticles with a diameter <10nm), are studied for biomedical purposes (MRI contrast agents, drug delivery or cell engineering). These nanoparticles are very attractive because around 50% of their atoms are near the surface, that increases significantly their surface energy, reactivity and affinity with adsorbates. The aim of this work is to assess if Nano-Maghemites could be used, in cellular media, as an effective tool of As immobilisation and detoxification.

Interactions between Nano-Maghemites and As(III) in cultured human fibroblasts were studied by X-ray Absorption Spectroscopy (XAS) at the As K-edge on the XAS CRG french beamline "FAME". Preliminary experiments led in deionised water indicate that the adsorption capacity of Nano-Maghemites is high (4.7 As atoms per nm^2). Arsenic is sorbed through double corner sharing between two Fe surface atoms, with a mean distance As-Fe of 3.38Å±0.2Å. However, in cultured human fibroblasts, As adsorption is reduced due to competition effects, at nanoparticles surface, between As species and other organic or inorganic compounds.

Another XAS results indicate that Nano-Maghemites cause a 40% reduce of the total number of thiolated arsenic species, in the extracellular medium. Arsenic is then more available to interact with cells. Thus Nano-Maghemites seems to modify the As biocellular transformations and to increase its toxicological effects.

Rapid ectomycorrhizal channel development on biotite in liquid culture experiments

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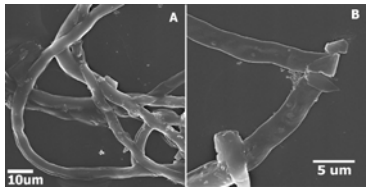
Liquid culture experiments were carried out to investigate the alteration of biotite by an ectomycorrhizal fungus, *Suillus tomentosus*. 1cm by 1cm biotite flakes were incubated on a shaker table at room temperature in 8% glucose solution inoculated with the fungus. The pH of the glucose solution was lowered from 6 to 4 over the course of the experiment by the fungus, whereas the control pH increased to 6.5.

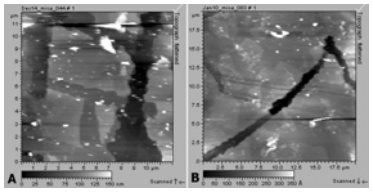
After 12 weeks the flakes were examined by Scanning Electron Microscopy (SEM). Fungal hyphal development was documented growing from the edges inward, but no significant surface changes were detectable by SEM (Fig.1).

Figure 1: SEM images of the hyphal development on a biotite



The flakes were examined by Atomic Force Microscopy (AFM) using contact mode in air. When compared to freshly cleaved material, the samples incubated with fungi exhibited rougher surfaces with well defined dissolution channels (Fig. 2). The AFM observed dissolution channel network is similar to the hyphal network documented by SEM.

Figure.2: AFM images of dissolution channels on a cleaved biotite surface



Our results suggest that ectomycorrhizal fungus is responsible for producing dissolution channels in a short time interval. Such fungi can therefore play an important role in biogeochemical cycling of nutrients in biotite.