Interaction of nanoparticles with microorganisms

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Due to ubiquitous and abundant occurrence of nanoparticles (NPs) and microorganisms in the surface and subsurface environments, they encounter and interact in aqueous systems. Microorganisms can also form NPs on the cell surfaces by uptaking or releasing ions from/to solutions. Despite numerous studies reported biomineralization of NPs, knowledge on the interaction between micoorganisms and NPs is still limited. Here we report the response of microorganisms to NPs using *S. cerevisiae* (yeast) and CeO_2 NPs (CeNPs).

Yeast was harvested in a YPD media prior to the experiment or a YPD media containing 250 ppm CeNPs (7 nm). The yeast was then contacted with a 1 mM NaCl solution (P-free) for 0-120 h at four pHs: 2, 3, 5 and 7. A variety of analytical techniques have been employed to investigate substances released from the cells, including inductively coupled plasma mass spectrometry (ICP-MS), ion chromatography (IC), high performance liquid chromatography (HPLC) and total organic carbon analyzer (TOC). The cytotoxicity of CeNPs was determined by the classical methylene blue straining technique and the mutated proteins were identified by peptide mass fingerprinting (PMF) analysis.

The solution analysis revealed that yeast released ortho-phosphate, organic phosphorous compound and various organic matters (<3 kDa) in all solutions. Phosphate released from the cells adsorbed on CeNPs at greater extent than inorganic phosphate by a factor of two. Although dissolved organic carbon (DOC), in general, inhibits phosphate adsorption to mineral surfaces, the released organic substances enhanced anion adsorption in the present study and possibility changed surface property of CeNPs. No cytotoxicity of CeNPs was detected; however, CeNPs induced an excess expression of two proteins: Eno2p and Rps24bp. In addition, the abundance and type of released substances were modified by CeNPs. Because Eno2p is related to the glycolytic system, CeNPs can affect the yeast's metabolism. That is, stimulating glycolytic system, which is the fastest step in the energy production process, lead to the decrease of tricarboxylic acid cycle via the electron transport chain, resulting in the modification of the released substances. The phenomena elucidated in the present study provided new insights to the fundamental process in the interaction between microorganisms and NPs in the Earth surfaces.

Characterization of woody biomass ashes and their utilization potential

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Ash from biomass combustion is typically considered a waste product. Bottom ashes, however, are sometimes used as source of nutrients in fertilizer additives. Fly ashes may be enriched in hazardous constituents (e.g., heavy metals, dioxins, and chlorides). Therefore, they should not be distributed into the environment but rather be land-filled.

In this study, bottom and fly ashes from two different types of solid biomass fuel, wood chips and Miscanthus grass, were sampled on site at a district heating plant and a power plant, respectively. These ashes were investigated by using X-ray diffraction and subsequent pattern analysis by Rietveld refinement method to gain semi-quantitative results for crystalline phases. The results were compared with those from analogous ashes, which have been produced under controlled laboratory conditions from pellets of wood and Miscanthus. Furthermore, the samples were characterized by laser diffraction to determine their particulate size distribution.

The main focus was put on the calcium oxides (mainly lime), which are present in both types of ashes and could bear utilization potential as CO_2-neutral clinker substitution in cement production. Main sources of lime in the ashes of both fuel types are extraneous calcite (present as grains in the fuels and then decomposed during combustion) as well as biogenic Ca phosphates and oxalates, as indicated by SEM/EDX analysis and elemental maps. The Miscanthus fuel used in the power plant, however, was co-combusted with 2 wt% of limestone in order to minimize fouling and slagging and certainly contributed to the lime content of the Miscanthus ashes. Another component of the ashes is SiO_2, mainly under quartz specie. In the wood fuel, the silicon originates from extreaneous quartz grains, whereas in Miscanthus it is probably also of biogenic origin.

The second focus of this study was on alkali and alkaline earth metal species. They can help to classify the fuel type. Potassium contents were relatively low for both fuel types, indicating a diminished fouling and slagging potential on combustor walls and convection tubes.

Both ash types contain similar crystalline phases, and our data are close to literature. These results may be used to evaluate the potential of such ashes as secondary raw materials.

www.minersoc.org
DOI:10.1180/minmag.2013.077.5.13