Behavior of Silver nanoparticles in a waste water treatment plant

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Metallic silver nanoparticles (Ag-NP) are increasingly used as biocides in a wide range of products. Because Ag-NP will mainly be released into sewer systems, retention of Ag-NP in wastewater treatment plants (WWTP) will control the extent to which Ag-NP are released into the aquatic environment. Physical and chemical processes during aerobic and anaerobic stages of wastewater treatment may change the speciation of Ag and the colloidal stability of the Ag-NP and thereby the degree of Ag-NP retention in the WWTP.

We investigated the fate of the Ag-NP during wastewater treatment in a pilot scale WWTP consisting of a non-aerated tank ($7m^3$), an aerated tank ($7m^3$) and a secondary clarifier ($11m^3$). Real municipal wastewater ($24m^3$/day) was spiked with Ag-NP to reach an Ag concentration of 130 μg/l in the influent. The experiment consisted of an initial dosage (1day, 2.4 g/l Ag at a flow rate of 1 l/h, i.e. 57.6 g/d Ag) followed by 24 days (twice the sludge age) of continuous Ag-NP dosage (3.1 g/day) and 24 days of normal operation without Ag-NP addition. Samples from the sludge and from the effluent were collected for analysis. Inductively coupled plasma mass spectroscopy (ICP-MS), X-ray absorption spectroscopy (XAS) and electron microscopy (SEM, TEM), were used i) to establish the mass balance of the total Ag, ii) to determine bulk Ag speciation in the sludge and iii) to determine the agglomeration state of the Ag-NP and their transformation products.

XAS and TEM analysis of the starting material confirmed that the Ag-NP were metallic and <15nm in diameter. The mass balance derived from the ICP-MS analyses demonstrated that about 5% of the Ag-NP passed the WWTP. TEM analyses of the effluent revealed that the Ag-NP passing the WWTP were mostly attached to or incorporated into micron-sized flocs. Further XAS analyses will be performed to determine the speciation of Ag in the sewage sludge and TEM analyses on resin-embedded thin-sections will provide additional insight into the interaction of Ag-NP with bacteria and decomposing organic material in the sludge. This study provides a robust mechanistic and quantitative basis for future studies on Ag-NP emissions and exposure in aquatic systems and will be very important for future risk exposure studies of Ag-NP.

Pushing the limits of neutron tomography

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Neutron tomography of dynamic processes requires special care and planning of the experiment. This is a challenge due to the long scan times which are in the same order as the time constant of the studied process. Too fast processes will result in motion artifacts.

There are several points of the experiment that can be modified to decrease the scan times of a sample. In general, increased temporal resolution comes at the price of lower spatial resolution. Here, an overview of the efforts to increase the temporal resolution made at the neutron imaging beamlines ICON and NEUTRA (Paul Scherrer Institut, Switzerland) is reported.

A basic method to decrease the exposure times is to increase the neutron flux. If this is possible at all, it usually comes at the cost of reduced beam collimation. On our beamlines we are working on increasing scintillator efficiency and shortening the readout times from the acquisition devices. A method to shorten the scan and readout times is to use binning and cropping, i.e. reducing the spatial resolution of the projection data. This has the side-effect that less projections are required to fullfill the sampling theorem [1].

Currently, filtered back-projection is the main reconstruction method. However, to reduce the number of projections other reconstruction methods are required. E.g. [2] used a penalized likelihood method to reconstruct image using 46 projections. A different approach is to use tomosynthesis, i.e. only reconstructing a vertical slab using few projections and short scan range. This method is advantageous for samples with complex tubing.

By continuous development of the beamlines we are mostly able to meet the requirements of the user community.

[1] Kak & Slaney (2001) *Principles of computerized tomographic imaging*, SIAM. [2] P. Trtik *et al*. (2010) *Int. Conf. on Material Sci. & 64th RILEM* September 6–10, Aachen, Germany, (submitted)