Testing engineered nanoparticles for their environmental behaviour

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The fate and behavior of engineered nanoparticles (ENPs) is mainly governed by their physico-chemical transformations and their dispersion stability in the aquatic environment. These processes are controlled by the surface chemistry of the particles, and the water chemistry i.e. pH, temperature, concentration of ions, natural organic matter (NOM) and the redox potential. In particular, the presence of NOM and Ca^{2+} can have significant effects on the aggregation of both natural colloids and ENPs in aquatic systems. Comprehensive tests are needed to address the special properties of ENPs, to enable direct comparison of the environmental behaviour of modified particles. However, the testing strategy must be feasible, reproducible and free of user bias. To accomplish this task we developed an automated scheme to evaluate nanoparticle dispersion stability as a function of water chemistry.

Degussa P25 and Hombikat UV100 were used to investigate and compare their behaviour under near natural conditions. A robotic autotitrator performs all the liquid handling, pH-setting, salt dosing and dilutions. We tested for sodium, calcium, sulphate, phosphate and NOM in a single-component and multi-component setting, pH range was between 4 and 8. Parameters as concentration in the supernatant, particle size and zeta potential are determined. A multi-dimensional result matrix is prepared showing the respective parameter as a function of water chemistry.

The advantages of the general concept of the test layout is demonstrated on two types of TiO_2 nanoparticles. The results of the presented methodology are in accordance with existing findings and show that both materials behave comparable regardless of differences in specific surface area and mineralogy. This comparable behaviour between similar core materials was not always found e.g. for bare TiO_2 nanoparticles which react differently with e.g. serum albumin. The results also reveal reactions formerly not recognized, as e.g. stabilization at elevated Ca^{2+} concentrations. We believe that that the presented approach is a suitable methodology to assess the behaviour of ENPs in a wide range of water chemical conditions and it enables the direct comparison of different materials and surface modifications thereby supporting a 'safety by design' procedure.

First static Os measurements using the new Discrete Dynode Multipliers and common SEM's

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The new mass spectrometer at ETH Zurich, Institute of Geochemistry and Petrology, TRITON PLUS, is equipped with ten Faraday cups and six multipliers. The six multipliers are built of three common SEM's and three Compact Discrete Dynodes. The set up of the six multipliers is made for static Os measurements of samples with small Os concentrations. One position in our cup alignment is equipped with one SEM (IC2) and one Faraday cup; this combination can be used for the yield determination. We will demonstrate the different procedures for the static Os measurements (Yield determination, dark noise, linearity).

Linearity measurements between 100'000 counts and 800'000 counts (^{192}Os) demonstrate the perfect behaviour of these types of multiplier in contrast to the setup of channeltrons. Individual single cup measurements of all multipliers (CDD's and SEM's) show that the $^{190}Os/^{188}Os$ and $^{189}Os/188Os$ ratios (normalized to $^{192}Os/^{188}Os$) have an external reproducibility of better than 0.015%.

For the static Os measurements we use an Os standard material. Preliminary static Os measurements show no linearitry problems of measurements between 100'000 and 800'000 counts (192Os). All Os ratios ($^{186}Os/^{188}Os$, $^{187}Os/^{188}Os$, $^{189}Os/^{188}Os$, $^{190}Os/^{188}Os$) are overlapping within the analytical errors with our single cup measurements. The errors of the individual ratios (static measurements) are 2-3 times smaller than the single cup measurements.

The new setup for static Os measurements offer the possibility e. g to select sample materials with very low Os concentration because the timing for counting is much shorter (4 times).