Characterization of Fe-rich multi-element nanoparticles by icpTOF
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Overview
- Fe and Fe oxide nanoparticles (NPs) are used for water and soil remediation, drug delivery, medical treatment and imaging, as well as for surface coating and catalysis applications. [1,2]
- Monitoring the release of manufactured iron-containing nanomaterials into the environment is of special interest since iron is an ubiquitously occurring element with importance to living organisms and ecosystem. [3]
- Single particle ICP-MS (sp-ICP-MS) is more and more being used as analytical technique to measure number concentrations, mass and size of NPs due to its low detection limits and quantification capabilities. [4]
- Fe is a challenging element for detection using ICP-MS due to FeO+ plasma gas ions interfering on the most abundant 56ArO+ ions, resulting in high detection limits. Moreover, Fe is one of the abundant elements in the earth crust and is present in high concentrations in dissolved form.
- The TOFWERK icpTOF offers simultaneous multi-element single particle detection. This can be used to trace engineered NPs in the high background of natural particles and to study chemical transformation of NPs. The instrument is equipped with a Q-cell technology, which can suppress ArO+ interferences and improve the LOD for Fe. Its temporal resolution of 30 μs minimizes the contribution of dissolved Fe to the peak signal.

Methods and Instrumentation
- Sample: Fe2O3 nanoparticles of 80 nm and 100 nm (ZLS-determined size) were provided by Jian Nanotechnology (Department of Environmental Geoscience, University of York). Nanoplates were synthesized for the NanoDefine Project (http://www.nanodefine.eu/directory.php). Solution: Fe and Fe oxide nanoparticles (NPs) were used for transport efficiency and imaging, as well as for surface coating and catalysis applications. [1,2]
- Calibration: Element ratios in nanosteel were calibrated with multi-element standard solution and transport efficiency of the sample introduction system.
- Data evaluation: Total mass of FeO was calculated from 36 iron solutions measured in the same sample introduction system. The distribution of FeO was determined with 60 nm Au nanoparticles from NIST standard solution.
- Instrumentation: All measurements were carried out on an icpTOF icpTOF in combination with the standard liquid introduction system. For the measurement of nanosteel particles at 5 μm/h, the cell was introduced into the cell to remove ArO interference.

Results
- Suppression of ArO interference
- Simultaneous detection of multiple elements
- Determination of NP size distributions
- Determination of isotope ratios

Figure 4. Signal intensity distribution of 56Fe. Demonstrates high mass polydispersity of steel particles.

Polydispersity of nanoparticles

Summary
- A method for sensitive detection and quantification of size and element composition of Fe-rich nanoparticles was developed and validated with well-characterized synthetic nanoparticles.
- Fe detection limits could be significantly improved by using hydrogen as the reaction gas in the Q-cell.
- Size-based detection limits of 43 nm for Fe2O3 and 15 nm for metallic Au nanoparticles were achieved.
- Elemental composition of nanosteel determined on the particle-by-particle basis with the icpTOF was close to the expected composition. This demonstrates the power of the instrument for the analysis of multi-element particles.

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