Inductively Coupled Plasma Time-of-Flight Mass Spectrometry (ICP-TOFMS) as a New Monitoring Tool for Nanoparticles and Trace Metals in the Environment

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The detection of engineered nanoparticles and trace metals, present at low concentrations in the environment, constitutes a major challenge for environmental monitoring and risk assessment. The method of inductively coupled plasma time-of-flight mass spectrometry (ICP-TOFMS) has recently led to significant breakthroughs in this field, owing to its capability of simultaneous multi-element analysis.

The recently commercialized icpTOF instrument (TOFWERK AG, Thun, Switzerland) extracts full mass spectra at every 30 µs and can thus record transient signals originating from very small samples, such as individual nanoparticles. In a study on single-particle multi-elemental fingerprinting, a prototype of the icpTOF was used for the distinction of engineered nanoparticles from natural nanoparticles, based on distinct elemental signatures[1]. Using machine learning algorithms, the engineered particles could be reliably quantified within representative soil extracts.

Moreover, when coupled to advanced laser ablation systems equipped with fast wash-out cells, the icpTOF can be employed for rapid high-resolution imaging of trace element and nanoparticle distribution within biological specimens. In a recent study on bioavailability and toxicity of metals, the three-dimensional distribution of the elements Cu, Ni, and Zn within a water flea (Ceriodaphnia dubia) could be reconstructed using this technique of LA-ICP-TOFMS[2].

We highlight on several new application examples the importance of ICP-TOFMS as a powerful tool in studying the behaviour of engineered particles and potentially toxic metals in the environment.

[1] Praetorius, A., et al. (2017). Single-particle multi-element fingerprinting (spMEF) using inductively coupled plasma time of flight mass spectrometry (ICP-TOFMS) to identify engineered nanoparticles against the elevated natural background in soils. Environmental Science: Nano. [2] Van Malderen, S. J., et al. (2017). Three-dimensional reconstruction of the tissue-specific multi-elemental distribution within Ceriodaphnia dubia via multimodal registration using laser ablation ICP-mass spectrometry and X-ray spectroscopic techniques. Analytical Chemistry.