A first step to better understands nanoparticle geochemistry: the direct-injection/spICPMS.

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The use of engineered nanoparticles (ENPs) is developing fast in many applications (cosmetics, medicine…) and their fate and behaviour once dispersed in the environment remain key issues. Their analytical characterization still suffers from drawbacks (*i.e.* matrix effects, time or sample consumption, high detection limits) that hampers a robust understanding of their geochemistry.

In the last decade, single-particle ICP-MS (spICPMS) emerged as a powerful method to characterize NPs (composition, number concentration and size distribution) (Tharaud et *al.*, 2017). In spICPMS, liquid samples are nebulized in a spray chamber, where only a few % of the injected volume are transferred into the plasma. This so-called "nebulization efficiency" is calculated using a reference material with known particle size and number. Then, the same nebulization efficiency is applied to natural samples assuming that NPs in all kind of matrices will behave in a similar way in the spray chamber. However, preliminary results show that depending on NPs size, composition or media in which NPs are dispersed, the nebulization efficiency changes, creating discrepancies in the results.

In order to increase the reliability of spICPMS analysis of complex matrices, the nebulization of NPs directly into the plasma (without spray chamber) is a promising strategy. Starting from an existing direct injection system, we developed an analytical setup allowing spICPMS micro-analysis at low micro-flow rates (down to 8 µL/min) for the introduction of NPs without a spray chamber. First, a dual-loop displacement pump fed by an Ar low mass-flow meter (ca. 15 to 200 µL/min) (Gas Displacement Pump) delivers a stable low velocity flow of carrier solution (*i.e.* HCl 2%) to a six port injection valve connected to an auto-sampler equipped with a micro-volume loop (*i.e.* 50 µL) (Flow-Injection Analysis). Secondly, a high efficiency demountable direct injection nebulizer (d-DIHEN) (Louvat et *al.*, 2014) plugged in the torch, instead of the regular injector, nebulizes the sample in the plasma.

This fully automatized system was tested on an HR-ICP-MS (Element II, ThermoScientic) for gold nanoparticle characterization down to 7 nm with very high efficiency.