Tracing multi-isotopically labelled CdSe/ZnS quantum dots in the environment: an assessment of the method's strengths and limits

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Abstract

Manufactured nanoparticles (NPs) are highly susceptible to being released in the environment. However, studies on their fate and behavior presented in the literature are often carried out at concentrations far from those in real environmental media [1], because of the difficulty to detect NPs in complex and "noisy" matrices. Nevertheless, changes in NPs concentration are known to affect its physicochemical behavior.
In order to overcome analytical barriers while working at representative realistic concentration, innovative tools such as HR-ICP-MS and non-traditional stable isotopes (isotopically modified NPs [2] or "spiked") have been used. 7 nm sized isotopically labelled quantum dots (QDs), CdSe/ZnS core-shell structure were synthesized, enriched in 68Zn, 77Se and 111Cd. These multi-spiked QDs were disseminated at very low concentrations (from 0.1 ng/L to 5 μg/L) in aquatic media, and the isotopic compositions were determined by HR-ICP-MS. On this basis, the initial QDs concentrations were calculated [3], in order to assess the Lowest Quantifiable QDs Concentration (LQC) according to the medium and to the element isotopically labelled. Our results allow to assess the detection and quantification limits of spiked QDs in complex matrices such as river water, seawater and estuarine system. The feasibility of isotopic labeling at very low concentrations has been demonstrated: spiked Zn, Cd and Se issued from QDs were quantifiable at 1, 0.3 and 20 ng/L respectively in a media (HNO3 2%) not already containing the same natural elements. In contrast, these limits hardly reach 50 and 30 ng/L for spiked Zn and Cd respectively in seawater, and 50 and 0.3 ng/L respectively in Seine river water. The results obtained in this experimental work are applicable for studying QDs fate and behavior in most aquatic media.
Gottschalk F. et al. (2009). [2] Sivry Y. et al. (2011). [3] Dybowska et al. (2011).

Keywords: detection limits, metal stable isotopes, multi isotopically labelled, quantum dots, HRICPMS

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