Separation of Dissolved and Nanoparticulate Metals with ICPMS Techniques

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Abstract
With the projected market volume for nanomaterial-based products, handling of these products and their waste will inevitably pose challenges to environmental health, particularly for metallic nanomaterials that may be toxic to aquatic organisms. High specific surface areas, high reactivities, abilities to pass through cell membranes, and unknown interactions with organisms has raised concerns over the environmental fate of these particles. Numerous studies have tried to characterize and explore the environmental fate of nanoparticles by using a variety of different techniques, including electron microscopy, dynamic light scattering, Fourier transform infrared spectroscopy, among others. Inductively coupled plasma mass spectrometry (ICP-MS) is a technique that has been widely used to detect and quantify dissolved metals and non-metals in concentration as low as part per trillion. Because ICPMS alone is not capable to differentiate between dissolved phase and nanoparticles, efforts have been done to modify sample introduction by using ICPMS in single particle mode (SP-ICP-MS) or couple it with particle separation techniques including field-flow fractionation and gel electrophoresis, which have their own limitations. In this study we use ICPMS coupled with chromatographic methods (LC-ICP-MS) to separate sub-20 nm diameter metallic particles from the dissolved phase, allowing direct and simultaneous quantification of multiple metals over both phases. Analytical operating conditions and performance evaluation is presented for mixed-metal nanoparticles. The results are expected to improve analytical chemistry methods for detection and quantification of nanoparticles in water.

1. Introduction:
1.1 ICPMS:
In an Inductively Coupled Plasma Mass Spectrometer instrument (ICPMS) a high-temperature Inductively Coupled Plasma source is coupled with a mass spectrometer, to detect and quantify metals and non-metals in concentrations as low as part per trillion (ppt).

1.2 SEC:
Size Exclusion Chromatography is a chromatographic method in which molecules in solution are separated by their size.

2. Method:
2.1 Samples:
Mixtures of CdSe/ZnS nanoparticles, with dissolved Cd, Zn and Se in different concentrations were prepared and ran through set-up.

2.2 Set-up:
Figure (2) shows SEC-ICPMS set-up. Table (1) shows used chromatography eluent composition.

3. Results:
3.1 Chromatogram:
Following chromatograms show concentration vs time for Cd, Zn and Se for 100 ppb nanoparticle phase and 100 ppb dissolved phase concentrations. It also shows that separation of dissolved phase from nanoparticulate metals using SEC-ICPMS is possible.

3.2 Standard curve:
Following diagrams show linear range of machine response (counts) vs concentration for both dissolved and nanoparticulate phase.

4. Conclusion:
SEC-ICPMS method can be used to separate dissolved phase from nanoparticulate metals in a mixture, and can replace current cumbersome techniques.