Asymmetric Flow Field Flow Fractionation Online with Single Particle – Inductively Coupled Plasma Mass Spectrometry: Detection and Quantification of Silver Nanoparticles in Aqueous Samples

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Abstract

An advanced analytical method using asymmetric flow field flow fractionation (AsFlFFF) and inductively coupled plasma mass spectrometry operated in single particle mode (SP-ICPMS) is developed to detect and quantify silver nanoparticles (AgNPs) in water samples. Different from previous studies, the AsFlFFF and SP-ICPMS employed here are directly connected and able to perform real-time AsFlFFF-SP-ICPMS analyses. As a result, this system is expected to provide valuable information about size and hydrodynamic diameter of either AgNPs or AgNP-containing aggregates. Experimental results showed that the AsFlFFF-SP-ICPMS systems is able to distinguish 60 nm AgNPs from 110 nm Ag-SiO_2 core-shell nanoparticles (NPs) having Ag cores of 51 nm

Objectives

- Optimizing the performance of AsFlFFF in separating AgNPs less than 100 nm within 30 min: carrier, channel flow, cross flow, focusing time, particle concentrations, and cleaning procedures
- Optimizing SP-ICPMS measurements: dwell time and particle concentrations
- Examining the performance of AsFlFFF-SP-ICPMS systems by analyzing water samples containing different sizes and kinds of AgNPs

Background

- AgNPs are the most commonly used engineered nanomaterials in consumer products such as disinfectants AgNPs are likely to enter the environments and potentially cause adverse impacts on ecological system and human health
- To study the fate and transport, and assess the risk of AgNPs, it is essential to detect and quantify AgNPs water samples
- Currently, methods used to detect, quantify, and characterize of AgNPs are currently not well developed
- SP-ICPMS can be used to detect and quantify AgNPs (size and particle concentration) based on Ag mass. However, this technique is not suitable for analyzing samples containing AgNP heteroaggregates or core-shell NPs
- The coupling of AsFlFFF with SP-ICPMS is expected to detect and quantify AgNPs in any samples because AsFlFFF can separate nanoparticles or aggregates based on their hydrodynamic diameter

www.silverlon.com/adhesive_strip.html

store.sealshield.com/silver-seal-keyboard-p26.aspx

Coupling AsFlFFF with SP-ICPMS

www.speciation.net/Database/Instruments/Postnova-Analytics-GmbH/AF2000-FOCUS-Asymmetric-Flow-FieldFlow-Fractionation-;i2653

www.perkinelmer.com/catalog/category/id/nexion-consumables-and-supplies

The channel flow from the FFF directly entered the ICPMS

AF2000 Focus (Postnova Analytic)

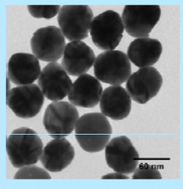
Carrier	0.02% FL-70
Membrane	10 kDa RC
Channel flow	1.5 mL/min
Cross flow	1.2 mL/min
Focusing time	3 min

NexION 300D (PerkinElmer) with Nano Application for Syngistix ICPMS Software

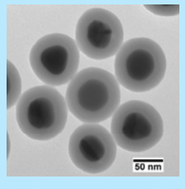
Flow rate	1.5 mL/min
Dwell time	5 ms
Sampling time	30 min
Data acquisition	after focusing

Nanoparticles

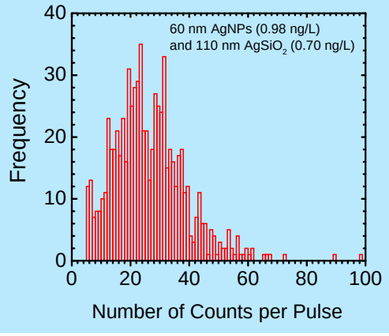
- 60 nm AuNPs (NIST 8013) - nebulizer efficiency determination
- 40, 60, 80, and 100 nm AgNPs (nanoComposix) – AgNP size determination and AgNP retention time vs. NP size determination
- Ag-SiO2 core-shell nanoparticles (nanoComposix, total diameter = 92.3 nm, Ag core diameter = 51.0 nm) – examining the performance of AsFlFFF-SP-ICPMS



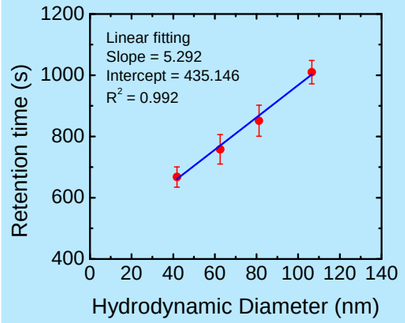
http://nanocomposix.com/collections/silverspheres/products/60-nm-silver-nanospheres

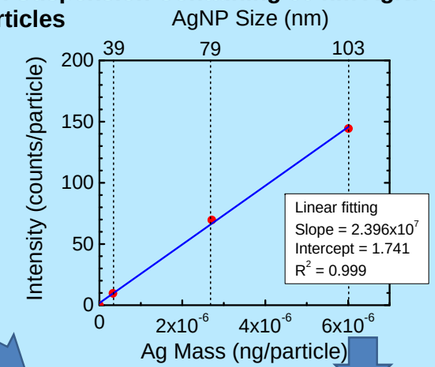


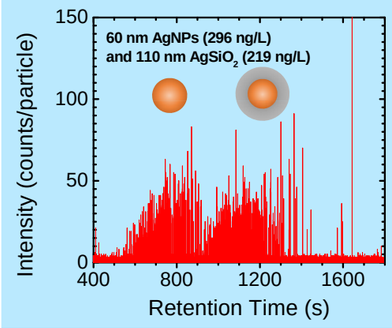
http://nanocomposix.com/collections/silverspheres/products/50-nm-silica-coated-silver-nanospheres

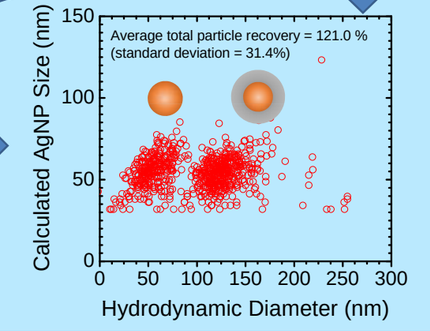


Detection and Quantification of AgNPs in Suspension Containing 60 nm AgNPs and 110 nm Ag-SiO_2 Core-Shell Nanoparticles









Conclusions

- AsFlFFF-SP-ICPMS successfully differentiates 60 nm AgNPs from 110 nm Ag-SiO2 core-shell NPs, which is a significant improvement on SP-ICPMS measurements
- However, AsFlFFF-SP-ICPMS technique requires more time and labor than SP-ICPMS

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