Detection of externally mixed metal nanoparticles with Laser Vaporisation Aerosol MS

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Motivation

• The aim is to illustrate possibilities and challenges with the LV-AMS technique within nanotechnology, especially synthesis of nanoparticles via the aerosol route:
  – Synthesis of Engineered Metal NPs
    » Detection of refractory metal cores
    » Quantification of organic impurities/surface coatings
• Use silver particles with controlled properties combined with DOS coating to investigate quantification issues in the LV-AMS (SP-AMS).
Experimental Set-up

[Diagram showing a flowchart of experimental setup with labels such as Spark discharge generator (SDG), High Temperature Furnace (HTF), Sintering Furnace, DMA 1, DMA 2, DOS condenser, LV-AMS, CPC, SMPS, Electrometer, APM/CPMA-CPC, and PIXE.]
Detection of Engineered Metal Nanoparticles

PT Nilsson et al. Accepted for publication in *Nanoresearch* 2015
Selective Emissions of Metal NPs


Nano-objects emitted during maintenance of common particle generators: direct chemical characterization with aerosol mass spectrometry and implications for risk assessments
Impurities depend on synthesis method

Figure 5. a) Unit mass resolution spectrum of impurities on 100 nm Au aggregated particles generated with the HTF. b) Unit mass resolution spectrum of impurities for 100 nm Au aggregated particles generated with the SDG_P. Nilsson et al. 2015, Nanoresearch
AMS Quantification - Collection Efficiency

\[ C_s = \frac{1}{C_E \cdot R I E_s \cdot m I E_{NO_3} \cdot Q \sum_{i} I_{s, i}} \]

\[ CE = E_L \cdot E_B \cdot E_S \]

- **E_L**: The fraction penetrating lens+inlet
- **E_S**: The fraction hitting the vaporizer (W and/or L).
- **E_B**: The fraction of material that hits the vaporiser (W and or L) that becomes vaporized
  - Bounce off W vaporizer
  - Incomplete vaporisation due to insufficient absorption at 1064 nm
- The instrument was calibrated with monodisperse (300 nm) NH₄NO₃ (tungsten vaporiser) and Regal Black (laser vaporiser)
Relationship between dva and dme upon DOS coating of Ag NPs with different morphologies

\[
\rho_{\text{eff(III)}} = \rho_0 \frac{d_{va}}{d_m}
\]
Instrument Sensitivity to Ag NPs

![Graph showing instrument sensitivity to Ag NPs](image)

- X-axis: $R_{Ag}$ (mDOS/mAg)
- Y-axis: Ions per pg (norm. to bare)
- Data points indicate sensitivity changes with varying $R_{Ag}$.
Conclusions

• LV-AMS is a promising tool for highly time- and size resolved analysis of metal ENP agglomerates and their organic surface coatings and impurities

• Sensitivity to silver well correlated with BWP measurements

• In addition to chemical information, also particle physical properties can be extracted (when combined with mobility based techniques)