Evaluation of Field Portable X-ray Fluorescence in Detection of Engineered Nanoparticles

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Background

Electron microscopy (EM) is commonly used to assess the morphology, chemical composition, and concentration of nanoparticles deposited on a filter media. Inductively coupled plasma mass spectrometry (ICP-MS) can also determine the element composition and particulate matter concentration of filter samples. Both techniques, however, require processing of the collection media that restrict the analysis to laboratory settings.

Portable, real time instruments that provide in-situ chemical analysis of filter samples present an advantage over laboratory techniques. These portable instruments can help to rapidly assess air quality and safety of environments at risk of engineered nanoparticle contamination. Furthermore they can help determine whether more samples should be collected and in depth laboratory analysis should be performed.

Field Portable X-ray Fluorescence (FPXRF) can be used to provide a quick and cost effective response for elemental composition and concentration of engineered nanoparticles.

Objective

Evaluate effectiveness of FPXRF for field detection of chemical composition and concentration of engineered nanoparticles deposited on filter media.

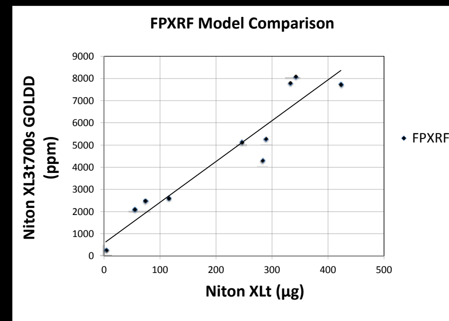
Methods

TiO_2 Aerosol Generation:
- Fluidized bed generator (FBG)
- Collison Nebulizer
- 3 samples were collected on mixed cellulose ester (MCE) filters for each generation method

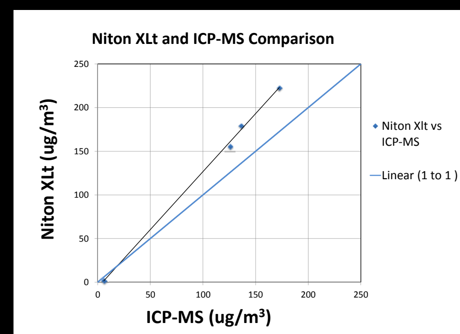
Collection Substrate	Filter Holder	Flowrate
• 1 MCE filter (37 mm)	Closed-face cassette	4 Lpm
• 2 MCE filters (47 mm)	Dry Filter Unit (DFU)	68 Lpm

Filter Analysis:
- Measure particle composition and concentration with two FPXRFs (Niton XLt and Niton XL3t700s GOLDD) following NIOSH standard 7702
- Measure particle composition and concentration by ICP-MS following NIOSH Method 7300
- Confirm particle composition by scanning electron microscopy (SEM) with energy-dispersive X-ray spectroscopy (EDS)

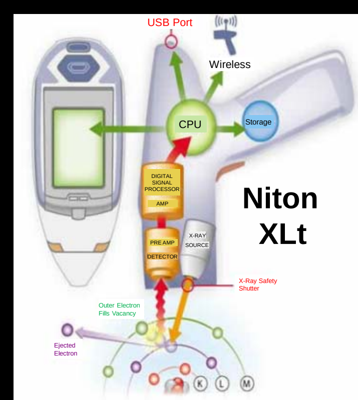
Results

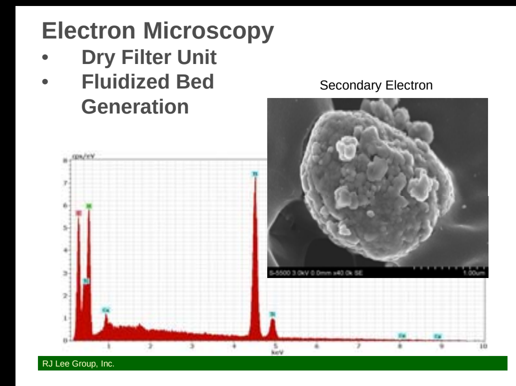


A strong correlation was observed between the two FPXRF models ($R^2 = 0.92$).



A strong correlation was observed between the Niton XLt FPXRF and ICP-MS ($R^2 = 0.99$).





Electron microscopy confirmed the presence of titanium on the filter samples.

Conclusions

- FPXRF can be an effective instrument in the detection of element composition and mass concentration of engineered nanoparticles. This is supported by a strong correlation with both ICP-MS and electron microscopy
- Variance of measurements between different FPXRF models could prove negligible as both FPXRF models in this study show a strong correlation

Future Research

- The ability of FPXRF to determine the presence and concentration of engineered nanoparticles should be expanded to particles of various composition (e.g., ZnO)
- The effect of different collection substrates on FPXRF nanoparticle characterization should be evaluated using other filter media

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