**Inductively Coupled Plasma Mass Spectrometry; The Ideal Tool for Trace Element Fingerprinting of Forensic Materials?**

Steve Shuttleworth

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**Forensic Analysis and Elemental Fingerprinting**

- Trace element fingerprinting allows the analyst to discriminate between samples.

- Analysis permits a determination of whether an association exists between a recovered fragment and a source of known origin.

- It’s key to understand the sources of elemental variation arising from the sample and also from the analysis technique.
Available Techniques

- AA
- ICP-OES
- ICP-MS

Characteristics of ICP-MS

Elemental Range

Dynamic Range
Consider an Olympic Swimming Pool
"An Olympic Pool must be 25 m wide with a depth of 2.0 m (min) at all parts of the course and must be 50 m in length."

Total Volume of Water 2,500,000 litres

1ppt is the equivalent of 2.5uL in a 2.5 million litre swimming pool

CARE IS NEEDED WITH BLANKS AND CONTAMINATION
Clean Practices for ICP-MS Sample Prep

- No Glassware
- Always wear gloves
- Wash All Vessels Prior To Use (5% nitric 24-48 hrs)
- Optima Grade Acid For Sample Prep
- Trace Metal Grade Acid For Cleaning
- 18 M Ohm DI Water For All Dilutions

Forensic Applications: Gunshot Residue Analysis

- GSR swabs taken from the hand and rifle.
- Samples were analyzed for antimony, barium and lead

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Gunshot Residue Analysis


Andrew M. Dobney, Wim Wiarda, Peter de Joode and Gerard J. Q. van der Peijl.

Netherlands Forensic Institute

- Pressure sensitive adhesive (PSA) tape may be associated with criminal activities.
  - Packaging of drugs
  - Violent assault
- Sample prep using closed vessel microwave digestion
- Trace element differences found in the adhesive.
- Different adhesives can be fingerprinted by looking at first row transition elements
- Interelement ratios allows tapes to be distinguished on basis of manufacturer and batch.
Forensic Analysis: Analysis of Glass

- Broken glass may be associated with criminal activities.
- Small fragments of glass are easily transported on clothing.
- Samples were crushed, then digested with a HF, HCl, HNO₃ mix on a hotplate.
- 45 Elements were identified as being useful differentiators.
- A limitation of ICP-MS noted as being a requirement for sequential dilutions – Varian has addressed this with its current design of ICP-MS.

Varian's Ion Optics Design – the 90 Degree Ion Mirror

Ions reflected & focused at 90° by parabolic electrostatic field produced by patented ion mirror.

**No scanning of applied voltages is required**

Focuses analyte ions into the mass analyzer at **unrivaled efficiency (> 80% from simulation studies)**

**Provides Highest Sensitivity coupled with low backgrounds**
Optimized Detector Design

All-digital extended range detector with patented electronic readout

- 9 orders of dynamic, linear range with no need for cross calibrations
- Simplifies analysis and results in less need to dilute over range samples
- All digital design extends detector lifetime.

Laser Ablation Sample Introduction
Laser Ablation For Solid Samples

- Minimal Sample Prep
- Spatially Resolved Analysis
- Laser Induced Fractionation Can Provide Additional Evidence of Whether Samples Come From The Same Source

Conclusions

- ICP-MS provides wide elemental coverage, wide dynamic range and high throughput.
- Different sample introduction techniques such as laser ablation permit direct analysis of solids
- ICP-MS now more robust and easy to use
- The Ideal Tool for Trace Element Fingerprinting of Forensic Materials