PERFORMANCE OF AN ION TRAP INDUCTIVELY
COUPLED PLASMA MASS SPECTROMETER

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PERFORMANCE OF AN ION TRAP INDUCTIVELY COUPLED PLASMA MASS SPECTROMETER. David W. Koppenaal, Charles J. Barinaga, Monty R. Smith, Pacific Northwest Laboratory,* P.O. Box 999, MS P7-07, Richland, WA 99352

A prototype instrument comprising an inductively coupled plasma ion source and an ion trap mass spectrometer detector has been constructed, operated, and tested for improved elemental and isotopic analysis. The rationale for this work follows from recent achievements in the ion trap mass spectrometry (ITMS) field and the realization that coupling this mass spectrometer with the powerful ICP ion source may provide distinct analytical advantages. Potential benefits could include increased sensitivity (resulting from analyte ion isolation and subsequent detection against a dark background), atomic isobar resolution (extremely high ITMS resolution has been demonstrated), destruction of polyatomic interferences (via collisional dissociation or in-trap chemistry), and size reduction of instrumentation.

The ion trap inductively coupled plasma mass spectrometer (IT-ICP/MS) was assembled using commercially available ICP/MS and ITMS components. The instrument configuration is shown diagrammatically in Figure 1. The system uses a PlasmaQuad I ICP/MS instrument as a base, to which a six-way, 6-inch vacuum cross that houses a Finnigan ITMS trap/detector has been appended in place of the conventional detector. The linear quadrupole inherent to the conventional ICP/MS instrument was modified to function as either a resolving (RF/DC), non-resolving (RF only), or notch (RF/DC + RF_{aux}) mass filter to protect the ion trap from excessive non-analyte ion signals. The ion trap chamber was operated at 10^{-3} torr He pressure by bleeding He into this chamber while pumping through the analyzer region of the system. (cont)

Figure 1. IT-ICP/MS Schematic Diagram.

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To date, we have observed the following significant performance measures with the IT-ICP/MS system:

- initial, unoptimized detection limits better than 1 ppb for Pb and other high mass elements
- complete destruction of most matrix polyatomic ions, including ArH^+ , ArN^+ , ArO^+ , ArCl^+ , ClO^+ , and Ar_2^+ , probably via collisional dissociation
- near complete neutralization of Ar^+ through Auger neutralization and/or charge transfer processes.

The latter two observations are of particular interest and allow clean detection of classically interference-plagued isotopes (e.g., ^{51}V , ^{56}Fe , and ^{75}As ; see Figure 2) and clear observation of Ar^+ interfered analytes (e.g., ^{39}K , ^{40}Ca , ^{41}K ; see Figure 3).

The major disadvantages noted with the IT-ICP/MS system include the

- production of metal poly-oxide, -hydroxide, and $-\text{H}_2\text{O}$ ions with high oxide bond strength elements (e.g., REEs, U, Th)
- diminished mass response below m/z 50, probably due to in-trap scattering losses.

However, the former problem has recently been circumvented by using cryogenic cooling to remove water vapor from the ion trap chamber, allowing bare metal ion detection for even the high oxide bond strength elements (HOBSE).

Current system modifications include the incorporation of filtered noise field (FNF) techniques to provide real-time ion filtering into the trap and the adaption of slow scan technology for high mass resolution measurements. Such techniques should further enhance the IT-ICP/MS system capabilities.

Figure 2. IT-ICP/MS spectrum of V, Fe, and As peaks with no ClO^+ , ArO^+ , ArCl^+ , or Ar_2^+ interferences. Upper: 1 ppm V, Fe, As/2% HCl. Lower: 2% HCl blank. Vertically offset for clarity.

Figure 3. IT-ICP/MS spectrum of K, Ca, Sc peaks with no (little) Ar^+ interference. Upper: 10 ppm K, Ca, Sc/1% HNO_3 . Lower: 1% HNO_3 blank. Vertically offset for clarity.

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