Application Note # CA-270107

Typical Detection Limits for the Bruker 820-MS

Introduction

Bruker's patented 90 degree ion mirror [1, 2] provides unsurpassed efficiency for the transfer of ions from the interface to the mass analyzer. This enables the new Bruker 810/820-MS to achieve a sensitivity of more than 1000 million c/s per mg/L of analyte, while maintaining oxide ratios (CeO^+/Ce^+) below 3%. In addition, the Bruker 820-MS is equipped with Bruker's unique and patented interference management system [3], the Collision Reaction Interface (CRI). The CRI reduces common polyatomic interferences on elements such as As, Se, Cr, V and Fe, thus achieving lower detection limits in hot plasma. In this application note, typical detection limits for some elements commonly regarded as 'difficult-to-analyze' by conventional ICP-MS are determined using the Bruker 820-MS in its normal sensitivity mode.

Instrumentation

All the detection limit measurements were performed on a Bruker 820-MS instrument, equipped with the standard sample introduction system and SPS3 autosampler fitted with a cover to prevent contamination of the samples from laboratory dust. In addition to the high sensitivity provided by the patented 90 degree ion optics, the new Bruker 820-MS includes Bruker's unique collision reaction interface system. Unlike other interference management systems, the Bruker CRI does not use a pressurized multipole in front of the mass analyzer. Instead, reaction and collision gases are injected directly into the plasma through the tips of the interface cones. This innovative approach removes interfering ions before any ions are extracted into the ion optics. Due to highly efficient pumping of the interface region, switching between gases is very rapid, allowing a single solution to be measured using several different sets of operating conditions.

Samples and reagents

A blank solution, 1% v/v HNO_3, was made using high-purity nitric acid (Ultrapur®, 60%, Merck, Kilsyth, Victoria, Australia) and pure deionized water (18 MΩ cm, Millipore Milli-Q, Billerica, MA, USA). Two standard solutions, at 1 µg/L and 10 µg/L levels, were prepared by diluting multi-element stocks (Var-Cal-1, Var-Cal-2 and Var-Major-1, Inorganic Ventures, Inc., Lakewood, NJ, USA) with the blank. Before use, all laboratory ware was thoroughly cleaned (i.e., by acid washing and deionized water rinsing). The clean containers were left filled with 1% v/v HNO_3 until use.

Conditions

Analysis conditions are summarized in Table 1.

Table 1: Typical ICP-MS analysis conditions.

	Parameters	Settings
Gas flow (L/min)	Plasma flow Auxiliary flow Nebulizer flow Sheath flow	16.5 1.65 1.00 0.25
CRI gases (mL/min)	Skimmer (with H_2)	80
RF	RF power (kW)	1.35
Sample introduction	Sampling depth (mm) Pump rate (rpm) Stabilization time (s) Spray chamber (°C)	6.5 5 50 3
Ion optics (volts)	1st Extraction lens 2nd Extraction lens 3rd Extraction lens	-1 -38 -155
	Corner lens Mirror lens left Mirror lens right Mirror lens bottom	-155 25 22 25
	Entrance lens Entrance plate Fringe bias Pole bias	2 -37 -3.8 0
Quadrupole scan	Scan mode Dwell time (ms) Points per peak Scans/replicate Replicates/sample	Peak hopping 1000 1 10 10

Results and discussion

Table 2 shows the typical detection limits (DLs) and background equivalent concentrations (BECs) for a range of elements, including those that are commonly regarded as 'difficult-to-analyze' by conventional ICP-MS. Each DL was determined as the concentration giving a signal equal to 3 times the standard deviation of 10 replicates of the blank (1% v/v HNO_3). All the measurements were made in a routine analytical laboratory, not under 'clean-room', conditions. This work indicates typical DL values that can be achieved outside a 'clean-room' in a routine analytical laboratory.

Table 2:
Typical Detection limits (DL) with and without CRI gas.

	Non CRI*	with CRI, H_2 at skimmer	
Isotopes	DL (ng/L)	DL (ng/L)	BEC (ng/L)
^{9}Be	3	0.5	1.1
^{23}Na	200	13	252
^{24}Mg	2	0.5	4.7
^{25}Mg	5	1	5.3
^{27}Al	2.0	0.8	7.9
^{39}K	500	43	328
^{40}Ca	-	3	23
^{44}Ca	500	7	81
^{49}Ti	3	1	3.2
^{51}V	3	0.2	1.7
^{52}Cr	8	0.6	13
^{53}Cr	3	1.5	23
^{55}Mn	2	0.4	10
^{56}Fe	4000	2	167
^{57}Fe	300	44	2146
^{59}Co	0.2	0.2	0.8
^{60}Ni	2	10	68
^{63}Cu	0.3	1	5.3
^{65}Cu	2	1	7.0
^{66}Zn	5	2	15
^{68}Zn	20	1	17
^{75}As	20	0.6	2.2
^{78}Se	400	2	26
^{80}Se	-	9	193
^{98}Mo	0.4	0.7	2.7
^{107}Ag	0.6	0.2	1.2
^{111}Cd	0.2	0.2	0.2
$^{206, 7, 8}$Pb	0.3	0.1	1.9
^{232}Th	0.04	0.08	0.9
^{238}U	0.06	0.01	0.07

* DL values for non-CRI were obtained from the Bruker ICP-MS Application Note #CA-270689

As shown in Table 2, compared to the values measured in non-CRI mode, the DL values measured using the Bruker 820-MS in CRI mode are much lower for those elements considered to be 'difficult to analyze'. For example, in CRI mode, a minimum 10-fold improvement in the DL values was obtained for elements such as Na, K, Ca, V, Cr, Fe, Zn, and As, etc. The DL values for those elements having less spectral interferences, such as Mo, Ag, Pb, Th and U, etc. show no significant difference between the CRI and non-CRI mode. More DL values for the Bruker ICP-MS running under non-CRI mode can be found in Bruker ICP-MS Application Note #CA-270689 (from www.bruker.com, literature room section).

Achieving lowest possible DLs

Detection limits are influenced by a number of factors, including the sensitivity of a given isotope, and the presence of background interferences or contamination. For the DLs and BECs measured in this work, the instrument was initially tuned to normal sensitivity mode under hot plasma conditions, before injecting the CRI gas and re-tuning the ion optics to achieve a high sensitivity and best signal-to-noise (or interference) level for selected isotopes. Note that tuning the ICP-MS to its highest sensitivity does not necessarily provide the lowest detection limit for all elements.

It is vitally important to control contamination in the laboratory. To achieve the lowest possible detection limits and accurate analytical results, strict precautions must be taken to eliminate or minimize any potential contamination when preparing the sample solutions. For example, all laboratory ware (new or used) should be thoroughly cleaned prior to use. A typical cleaning procedure includes acid washing for at least 24 hours to remove contamination, thoroughly rinsing with high-purity deionized water, and then leaving the clean containers filled with 1% HNO_3 until use. Lower contamination levels mean better detection limits.

Conclusion

This application note has shown that the CRI in the Bruker 820-MS provides a very simple, but effective, approach to remove common plasma-based interferences, thus achieving lower detection limits for 'difficult-to-analyze' elements such as As, Se, Cr, V and Fe.

References

[1] I. Kalinitchenko, Ion Optical System for a Mass Spectrometer, US Patent 6,614,021 B1, 2 September 2003

[2] S. Elliott, M. Knowles and I. Kalinitchenko, A New Direction in ICP-MS, Spectroscopy, 19(1), 30 (2004)

[3] I. Kalinitchenko, Mass spectrometry apparatus and method, US Patent 7,329,863,132 B2, 12 February 2008

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