A New Design of Ion Lens and Collision/Reaction Cell for ICP-MS

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Overview

A new collision reaction cell has been designed for ICP-MS

The new cell, called the ORS^3, provides much more efficient removal of interferences in collision mode, using an inert cell gas (helium)

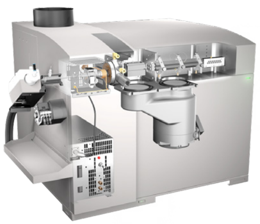
This improved efficiency is due to the use of a small internal diameter cell, with high cell gas pressure and a large energy discrimination step

Multiple interferences are removed from multiple analytes, even in unknown and variable sample types; a unique capability in quadrupole ICP-MS

Introduction

Collision/Reaction Cells (CRCs) are almost universally used in quadrupole ICP-MS, to remove spectral interferences that would otherwise bias results.

Most cell designs operate with reactive cell gases or mixtures, but the 7700 Series (shown below) incorporates a new, 3rd generation cell, the ORS^3, which provides effective interference removal in helium (He) collision mode.



The new cell operates effectively for multi-element analysis of complex and variable samples (as found in many analytical labs).

Multi-element analysis of complex samples requires a cell gas which:

1) Is effective against many interferences, even when multiple interferences overlap each analyte mass (e.g. see table below)
2) Does not create any new interferences
3) Does not react with any analytes.

Principal Interfering Species (mixed matrix containing N, Cl, S, C, Na, Ca and P)

Isotope	Possible Polyatomic Interferences	^{63}Cu	^{40}Ar^{23}Na, ^{12}C^{16}O^{35}Cl, ^{12}C^{14}N^{37}Cl, ^{31}P^{32}S, ^{31}P^{16}O$_2$
^{45}Sc	^{13}C^{16}O$_2$, ^{12}C^{16}O$_2$H, ^{44}CaH, ^{32}S^{12}CH, ^{32}S^{13}C, ^{33}S^{12}C	^{64}Zn	^{32}S^{16}O$_2$, ^{32}S$_2$, ^{36}Ar^{12}C^{16}O, ^{38}Ar^{12}C^{14}N, ^{48}Ca^{16}O
^{47}Ti	^{31}P^{16}O, ^{46}CaH, ^{35}Cl^{12}C, ^{32}S^{14}NH, ^{33}S^{14}N	^{65}Cu	^{32}S^{16}O$_2$H, ^{32}S$_2$H, ^{14}N^{16}O^{35}Cl, ^{48}Ca^{16}OH
^{49}Ti	^{31}P^{18}O, ^{48}CaH, ^{35}Cl^{14}N, ^{37}Cl^{12}C, ^{32}S^{16}OH, ^{33}S^{16}O	^{66}Zn	^{34}S^{16}O$_2$, ^{32}S^{34}S, ^{33}S$_2$, ^{48}Ca^{18}O
^{50}Ti	^{34}S^{16}O, ^{32}S^{18}O, ^{35}Cl^{14}NH, ^{37}Cl^{12}CH	^{67}Zn	^{32}S^{34}SH, ^{33}S$_2$H, ^{48}Ca^{18}OH, ^{14}N^{16}O^{37}Cl, ^{16}O$_2$^{35}Cl
^{51}V	^{35}Cl^{16}O, ^{37}Cl^{14}N, ^{34}S^{16}OH	^{68}Zn	^{32}S^{18}O$_2$, ^{34}S$_2$
^{52}Cr	^{36}Ar^{16}O, ^{40}Ar^{12}C, ^{35}Cl^{16}OH, ^{37}Cl^{14}NH, ^{34}S^{18}O	^{69}Ga	^{32}S^{18}O$_2$H, ^{34}S$_2$H, ^{16}O$_2$^{37}Cl
^{53}Cr	^{36}Ar^{16}OH, ^{40}Ar^{13}C, ^{37}Cl^{16}O, ^{35}Cl^{18}O, ^{40}Ar^{12}CH	^{70}Zn	^{34}S^{18}O$_2$, ^{35}Cl$_2$
^{54}Fe	^{40}Ar^{14}N, ^{40}Ca^{14}N, ^{23}Na^{31}P	^{71}Ga	^{34}S^{18}O$_2$H, ^{35}Cl$_2$H, ^{40}Ar^{31}P
^{55}Mn	^{37}Cl^{18}O, ^{23}Na^{32}S, ^{23}Na^{31}PH	^{72}Ge	^{40}Ar^{32}S, ^{35}Cl^{37}Cl, ^{40}Ar^{16}O$_2$
^{56}Fe	^{40}Ar^{16}O, ^{40}Ca^{16}O	^{73}Ge	^{40}Ar^{32}SH, ^{40}Ar^{33}S, ^{35}Cl^{37}ClH, ^{40}Ar^{16}O$_2$H
^{57}Fe	^{40}Ar^{16}OH, ^{40}Ca^{16}OH	^{74}Ge	^{40}Ar^{34}S, ^{37}Cl$_2$
^{58}Ni	^{40}Ar^{18}O, ^{40}Ca^{18}O, ^{23}Na^{35}Cl	^{75}As	^{40}Ar^{34}SH, ^{40}Ar ^{35}Cl, ^{40}Ca ^{35}Cl, ^{37}Cl$_2$H
^{59}Co	^{40}Ar^{18}OH, ^{43}Ca^{16}O, ^{23}Na^{35}ClH	^{77}Se	^{40}Ar ^{37}Cl, ^{40}Ca ^{37}Cl
^{60}Ni	^{44}Ca^{16}O, ^{23}Na^{37}Cl	^{78}Se	^{40}Ar ^{38}Ar
^{61}Ni	^{44}Ca^{16}OH, ^{38}Ar^{23}Na, ^{23}Na^{37}ClH	^{80}Se	^{40}Ar$_2$, ^{40}Ca$_2$, ^{40}Ar^{40}Ca, ^{32}S$_2$ ^{16}O, ^{32}S^{16}O$_3$

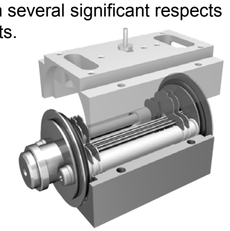
Cell Technology Development

The new collision/reaction cell of the 7700 Series is the 3rd generation of cells used in Agilent ICP-MS instruments. It differs in several significant respects from the cell used in the 7500 Series instruments.

The ORS^3 has:

1) 18% longer octopole rods
2) 15% smaller internal diameter
3) 16% higher cell gas pressure
4) 20% higher rf frequency

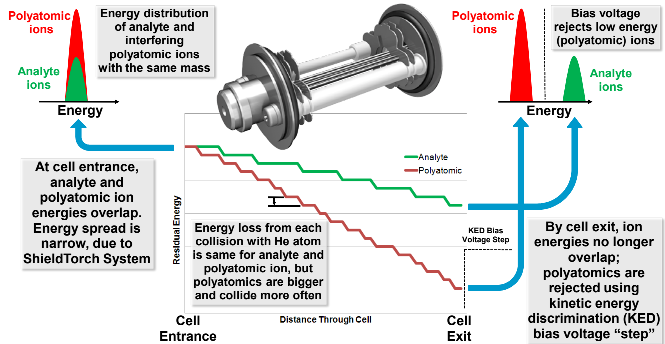
…than the cell used in the 7500



The ORS^3 is also able to operate with a bigger kinetic energy discrimination voltage step, giving more effective removal of low energy ions at the cell exit.

Polyatomic ion removal using He mode is illustrated below.

1) Ions enter the cell with a narrow energy distribution (due to the use of the ShieldTorch)
2) As they pass through the cell, polyatomic ions collide more frequently with the cell gas, as polyatomic (molecular) ions have a larger cross section than monatomic (analyte) ions.
3) By the cell exit, the residual energy of the polyatomics is too low to pass the KED bias voltage step, so the polyatomic ions are separated from the analyte ions, which pass into the quadrupole free from interference.



He mode provides several advantages compared to a reactive cell gas:

- He mode effectively removes all polyatomics, not just reactive ones
- He is inert, so no new interferences are produced, regardless of matrix
- Unlike a reactive cell gas, He does not react with any analytes, so consistent and predictable sensitivity is maintained

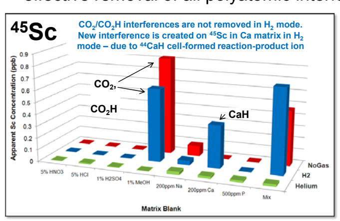
Results

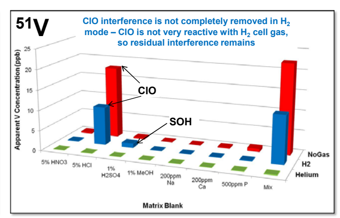
Seven different sample matrices (plus a mix) were measured in no gas, H_2 and He mode. The apparent concentration of 14 analytes was determined in each blank matrix, to quantify the level of interference on each analyte.

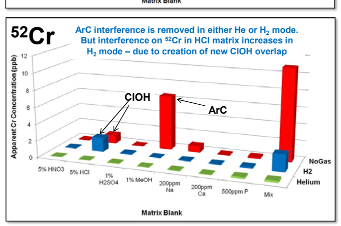
- Many interferences were present in no gas mode

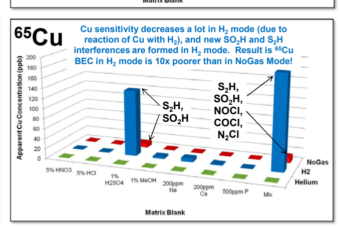
- Many interferences remained and some new ones were created in H_2 mode

- Consistent low blanks were obtained for all elements in He mode, indicating effective removal of all polyatomic interferences in all matrices.





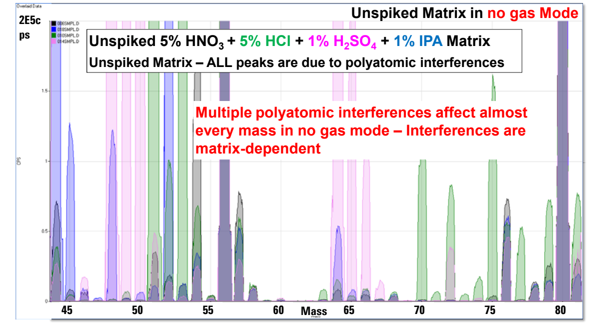


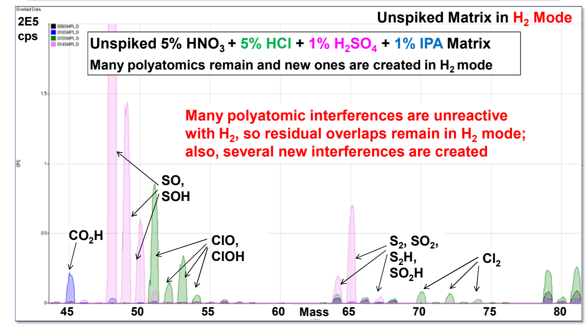


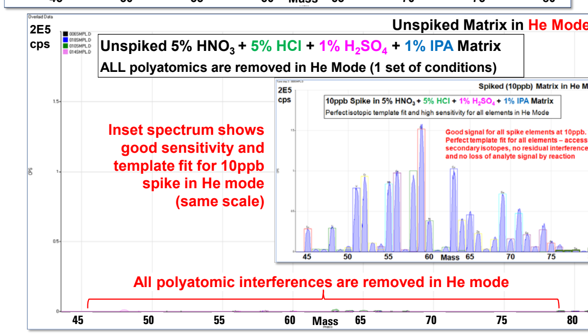
Multi-Element Analysis

Effective removal of multiple interferences is illustrated below, for the same matrix (on the same scale) in no gas, H_2 and He modes. This complex matrix (HNO_3, HCl, H_2SO_4 and IPA) gave many interferences in no gas mode.

Many interferences remained in H_2 mode, but all were removed in He mode.







Conclusions

The newly-developed 3rd generation collision/reaction cell (ORS^3) of the 7700 Series ICP-MS provides effective removal of interferences in He mode (using an inert collision cell gas).

This is due to the narrow ion energy spread, high cell gas pressure, well-focused ion beam and large KED voltage step of the new ORS^3.

The result is a high level of data integrity, due to the reduction of multiple interferences on multiple analytes, even in complex, unknown and variable sample matrices.