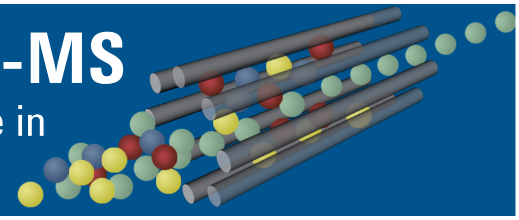
Collision/Reaction Cells in ICP-MS

Cell Design Considerations for Optimum Performance in Helium Mode with KED



Collision Reaction Cells in ICP-MS

Collision/Reaction Cells (CRCs) have been accepted as the preferred means of removing spectral interferences in quadrupole ICP-MS. However, there is still a debate about their routine use in many applications, because CRCs are operated in two distinctly different modes:

- **Reaction mode** uses specific reaction gases to remove known, reactive interferences from each analyte isotope.
- **Collision mode** uses a non-reactive gas and a process called kinetic energy discrimination (KED) to selectively attenuate all polyatomic interferences based on their size. KED exploits the fact that all polyatomic ions are larger than analyte ions of the same mass, so they collide with the cell gas more often as they pass through the cell, emerging with lower residual energy. These low energy ions are excluded from the ion beam by a bias voltage at the cell exit.

Reaction mode can remove some interferences very efficiently, as the reactions occur quickly (within the first few collisions). KED by contrast requires the ions to undergo many collisions before the difference in residual energy between analyte and polyatomic ions is large enough to allow them to be separated. Effective collision mode operation requires:

- A cell that operates with a light cell gas (helium) at high cell gas pressure to provide the large number of collisions necessary for effective KED.
- An ion guide that maintains effective ion focusing across the mass range, even at high cell gas pressure.
- Ions that enter the cell with a very narrow spread of ion energy.

The Importance of Ion Energy Distribution

Just as higher resolution (narrower peaks) allows better separation of overlapping spectra, so narrower ion energy spread allows better separation of overlapping ion energies, as illustrated in Figure 1.

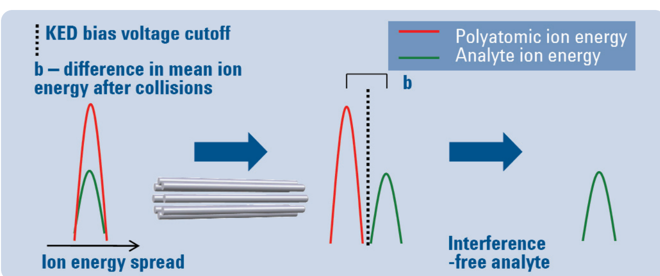


Figure 1. Narrow initial ion energy spread makes it much easier to separate the overlapping energies of analytes versus polyatomic ions

Ion energy control is therefore fundamental to the effective operation of a CRC in He mode with KED, and is integral to the design of the 3rd generation ORS^3 cell in the Agilent 7700 Series ICP-MS. Key enabling technologies are:

- The patented ShieldTorch System (STS). STS virtually eliminates the plasma offset potential (the difference between the plasma and interface voltages), so reducing mean ion energy and energy spread.
- The low voltage ion extraction. The extraction lens (first lens behind the skimmer cone) is set at zero volts, so ions are not accelerated into the vacuum system, which would broaden their energy spread.

Why an Octopole Works Best for Collision Mode and KED

Commercial ICP-MS instruments use a CRC containing a multipole ion guide, either a quadrupole (4 rods or poles), hexapole (6 rods) or octopole (8 rods). Quadrupoles permit mass-selective rejection of ions (e.g. reaction product ions or precursors to interfering polyatomics), using a user-selected bandpass window. But in order to select the appropriate reaction gases and cell bandpass, the user must know the matrix composition of each sample in advance, which is not possible for the unknown or variable samples analyzed in many laboratories.

In contrast, collision mode using He gas and KED is universal, as no analyte- or matrix-specific setup is required. For effective collision mode operation, an octopole ion guide offers several key advantages:

- An octopole transmits ions over the entire elemental mass range simultaneously, making it much more suitable for multi-element analysis under uniform conditions (no scanning bandpass needed)
- An octopole has a wide stability region (almost all ions between the rods pass through the cell), and scattering is minimized when the cell is pressurized. The wide stability region means that a narrower ion guide and therefore smaller volume cell can be used. The narrow ion guide is also better aligned to the ion beam diameter, meaning more consistent ion transmission with and without cell gas, compared to a lower order (quadrupole or hexapole) ion guide. This is illustrated schematically in Figure 2.

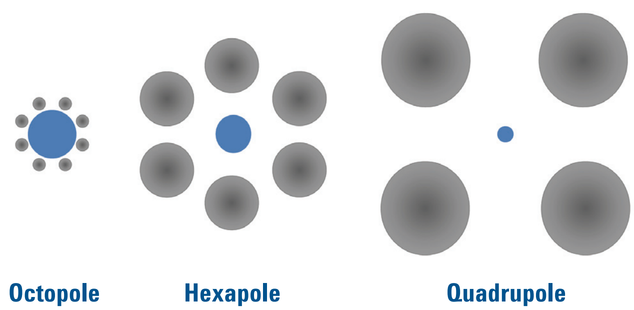


Figure 2. Relative size, internal diameter and ion stability regions (in blue) for multipole ion guides (octopole, hexapole and quadrupole)

Conclusions

For accurate multi-element analysis of unknown and variable sample matrices, the advantages of He collision mode using KED are indisputable. Effective KED requires an instrument with the technology to minimize initial ion energy spread, simultaneously and efficiently transmit all masses through the cell, and maximize the number of collisions while reducing losses due to scattering. This is achieved on the Agilent 7700 Series ICP-MS, using the ShieldTorch System, low voltage ion extraction and the unique octopole based ORS^3 collision cell.

Reference

J. Anal. At. Spectrom., 2004, 19, 561 - 570

For more information on the 7700 Series visit the Agilent Technologies web site at: **www.agilent.com/chem/icpms**

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