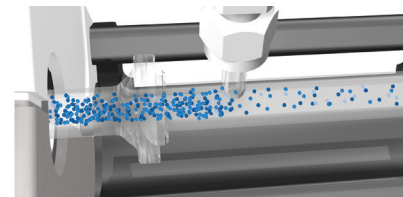


Plasma Robustness in ICP-MS: Benefits of a Low CeO/Ce Ratio



ICP-MS Plasma Robustness

Plasma robustness or effective plasma temperature is one of the most critical performance characteristics of an ICP-MS instrument, as it impacts many aspects of system operation and productivity, as well as directly affecting the quality of data generated.

ICP-MS plasma robustness is measured using the CeO/Ce ratio, with a lower CeO/Ce ratio indicating a more robust plasma. A more robust plasma is able to dissociate the strongly bound CeO molecule more efficiently, and also decomposes the sample matrix more completely. The CeO/Ce ratios of commercial ICP-MS instruments typically range from <1% to ~3%. This variation is due to several factors:

- Design and operating frequency of the ICP RF generator (solid state power generation and 27.12MHz contributes to a low CeO/Ce ratio)
- Internal diameter (ID) of the ICP torch injector (a larger ID normally increases plasma robustness).
- Operating conditions such as sample uptake rate, carrier gas flow and sampling depth

The Agilent 7700 Series ICP-MS typically operates at <1% CeO/Ce – the lowest ratio of any commercial ICP-MS – which provides:

- Better matrix tolerance and long-term stability – samples with higher total dissolved solids (TDS) levels can be measured directly, with less signal variation and with less reliance on internal standards to correct suppression and signal drift
- Reduced maintenance – less matrix deposition on the interface cones and ion lenses
- Better ionization, higher sensitivity and lower detection limits for critical toxic trace elements including Be, As, Cd, Hg (Table 1).

| IP range (eV) | Element |
|---------------|---|
| <6 | Li, Na, Al, K, Ga, Rb, Sr, In, Cs, Ba, some REE |
| 6 to 8 | Mg, most transition elements, Ge, Y, Zr, Nb, Mo, Ru, Rh, Ag, Sn, some REE, Hf, Ta, W, Re, Tl, Pb, Bi, Th, U |
| 8 to 11 | Be, B, Si, P, S, Zn, As, Se, Pd, Cd, Sb, Te, I, Os, Ir, Pt, Au, Hg |
| >11 | C, N, O, F, Cl, Br |

Table 1. Elements grouped by 1st Ionization Potential (IP)

Figure 1 shows the % ionization (and therefore sensitivity) of all elements at different plasma temperatures (i.e. plasma robustness). The vertical lines show how the % ionization of Cr, Cd and Hg is affected by plasma temperature. For example Cd is more than 80% ionized in the most robust plasma (plasma temperature 7800K), but only 5% ionized at a plasma temperature of 5800K.

HMI, Plasma Robustness and Matrix Suppression

Agilent's unique High Matrix Introduction (HMI) technology – standard on the 7700x, optional on other models – uses intelligent auto-optimization of aerosol dilution to further improve matrix tolerance, allowing the 7700 to measure % level TDS samples routinely. By reducing both aerosol density and water vapor loading on the plasma, HMI increases the already unmatched plasma robustness of the 7700. This further reduces the CeO/Ce ratio and improves matrix tolerance by approx. 5x compared to non-HMI operation.

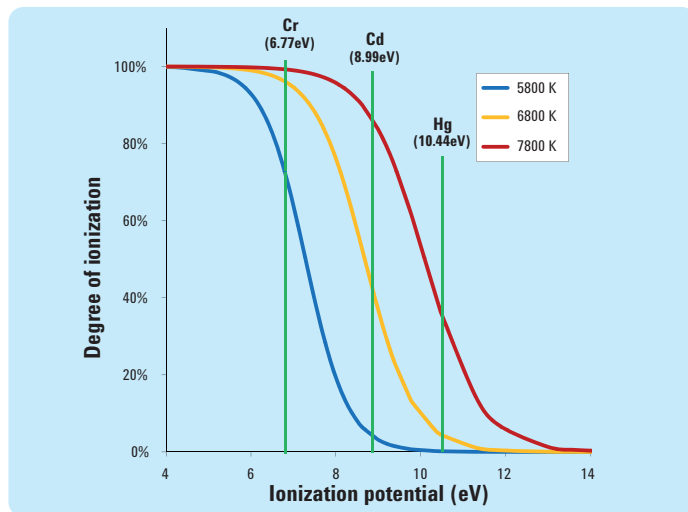


Figure 1. Degree of ionization at different plasma temperatures

A practical benefit of the improved matrix tolerance provided by HMI is the virtual elimination of matrix suppression. Matrix or ionization suppression in ICP-MS occurs when the plasma is overloaded by the matrix and has insufficient residual energy to fully ionize analytes. Signal loss due to suppression is greater for poorly ionized elements.

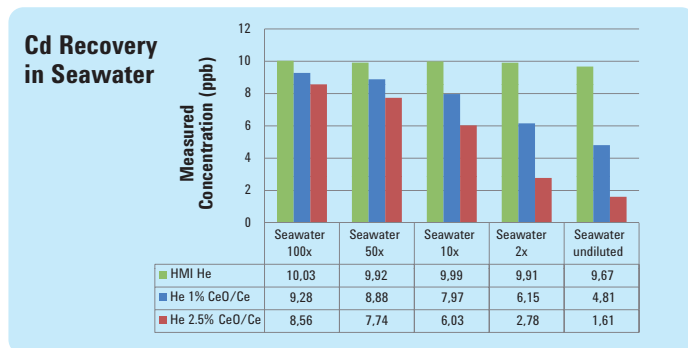


Figure 2. Effect of plasma robustness on 10 ppb Cd recovery in seawater

Figure 2 shows how HMI dramatically improves the recovery of a 10 ppb Cd spike in seawater. At a low plasma robustness level (2.5% CeO/Ce), Cd recovery is 86% in 100x diluted seawater, and only 16% in undiluted seawater. At the typical (non-HMI) 7700 plasma robustness level (1% CeO/Ce), suppression is much lower, but still apparent. In contrast, with HMI Cd recovery is close to 100% for all samples – even in undiluted seawater.

The Agilent 7700 ICP-MS with HMI is able to measure very high and variable matrix samples without the need to matrix-match the calibration, which significantly improves data quality, productivity and analytical workflow.

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

