TECHNICAL BRIEF

ICP - Mass Spectrometry

NexION ICP-MS Series Universal Cell Technology – For the Next Generation of Analysis

Introduction

Interferences in plasma-based spectroscopy can be one of the most challenging aspects when developing methods for ICP-MS analysis. When combined with challenging matrices, the polyatomic and isobaric interferences can produce inaccurate and inconsistent results.

When evaluating the approaches that can minimize or eliminate interferences, several factors should be considered: type of interference(s), concentration of interference(s), sample volume, detection limits required.

PerkinElmer's NexION® series' third generation Universal Cell Technology (UCT) system, introduced on the NexION 1100/2200 instruments, is engineered to overcome the new analytical demands. The UCT system comprises three subsystems that come together to play a pivotal role in aiding everyday analysis:

- UCT gas delivery subsystem
- UCT power subsystem
- UCT cell

Together, these provide a versatile system to operate both in Collision/KED and Reaction/DRC modes of interference removal (Figure 1).

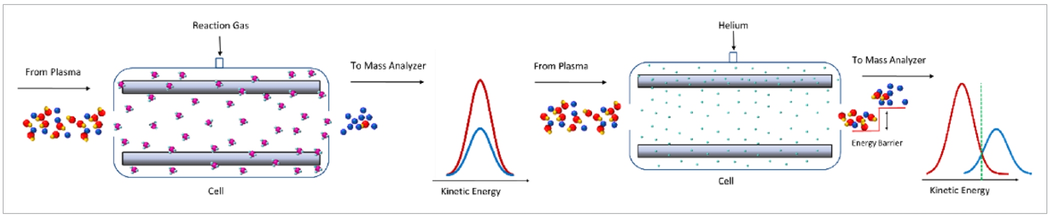

Figure 1. Illustrations on how the UCT modes of operation, DRC and KED, function.

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Science with Purpose

Reaction efficiency, and thus the removal of interferences, is governed by gas-phase kinetics – how quickly an interfering ion can be reduced, or an element of interest shifted away from the interference within a given period. The NexION series' quadrupole cell has been discussed in several academic papers to be the preferred choice of reaction and collision cell.[2]

The third generation UCT still has the features that made previous generations successful. The UCT is designed to: use 100% pure reaction gases; allow bandpass filtering for low mass cut off (RPq) and electronic dilution (RPa); and use Axial Field Technology (AFT) to control the speed of the reaction and on-line gas mixing. However, there have been improvements in all three subsystems to facilitate lower detection limits and improved analysis speeds.

UCT Gas Delivery Subsystem

The third generation UCT system also allows for increased gas flow for unprecedented analytical capability using ICP-MS. Figure 2 depicts a cell gas optimization using the extended flow capability of the NexION 1100 and 2200 systems using PerkinElmer's patented universal helium/hydrogen (He/H) gas mixture.[1] Ultralow background equivalent concentrations (BECs) of single-digit ppt ^{80}Se (Figure 3), can be attained using DRC mode while maintaining KED mode performance for other elements using a single He/H mixed gas.

Figure 3 illustrates the reduction of the $^{80}Ar_2^+$ species on mass 80 directly, resulting in the single-digit ppt background equivalent concentration (BEC). As the major $^{80}Ar_2^+$ species is reduced with increasing gas flows, there is a negligible scattering effect on the Se^{80+} ion at the higher cell gas flows. In addition, the dynamic bandpass tuning parameters of the quadrupole reaction cell (RPq) are adjusted to eliminate any unwanted secondary reaction products.

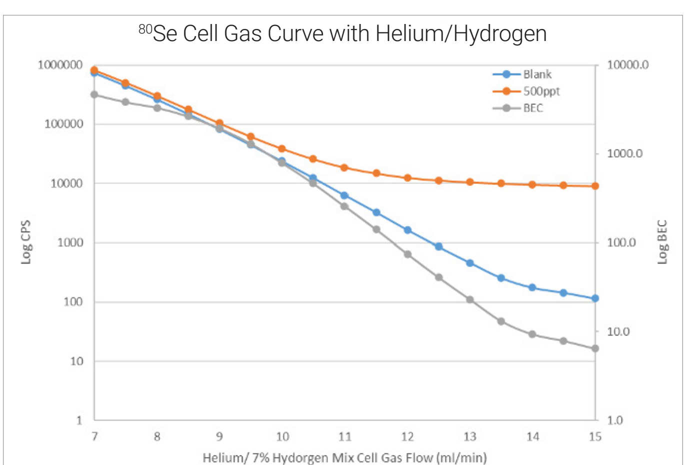

Figure 2. Cell gas optimization of ^{80}Se using He/H mix, showing calculated BECs from the 500 ppt and blank.

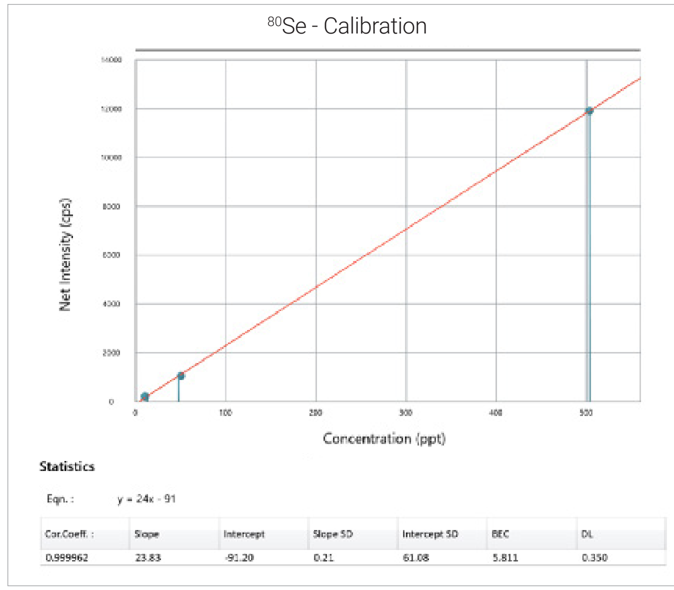

Figure 3. Calibration of ^{80}Se using He/H mix in DRC mode of operation.

UCT Power Subsystem

The creation of quadrupolar fields, extending the dynamic range and switching between modes of operations, takes a uniquely designed power supply. With exceptional stability, the third generation UCT system allows the fastest ICP-MS to become even faster, with 10 times reduction to settling times in UCT modes operation.

Applications that require short dwell times and high accuracy, such as laser ablation, can benefit from the NexION series third generation UCT power supply.[3] Figure 4 depicts an example laser ablation method where four masses are analyzed at various dwell times. The third generation UCT power supply provides a 10x reduction in settling times between masses. This allows two different options, whether to improve precision by increasing dwell times for the same given duty cycle, or to use the shorter delays and reduce the duty cycle. For applications where throughput is a necessity, the third generation UCT system can enable reduced sample analysis times.

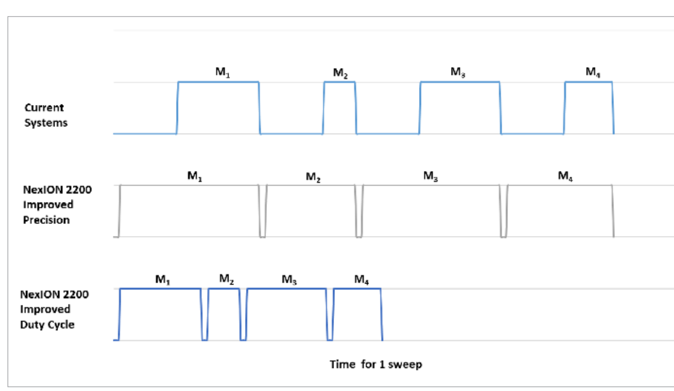

Figure 4. Depiction of the reduced settling delays and how they can be operated to improve precision or speed up analysis.

UCT Cell Subsystem

When reduced sample volumes and increased throughputs are required, the UCT gas delivery system has unparallel performance when utilizing multiple gases to the UCT. Figure 5 shows how the NexION's Syngistix™ for ICP-MS software and hardware combine to reduce switching times during UCT modes of operation.

Syngistix for ICP-MS provides a "look ahead" function when running a batch, ensuring that the gas mode for the first group of analytes to be measured in the method is pressurized and ready for analysis during the rinse phase. Figure 5 depicts the transition times from KED-STD-DRC-O_2 to DRC-NH_3 analysis modes, using indium (In) for illustrative purposes. The properties of helium make it an ideal gas for rapid cell evacuation, to exit the cell, allowing STD mode analysis to follow in under 3 seconds. Taking advantage of Syngistix software's Mode Ordering functionality, heavier gases such as oxygen and ammonia can be run last, where a longer venting period can be reserved for the rinse operation, and the Syngistix "look ahead" function begins the transition back to KED mode.

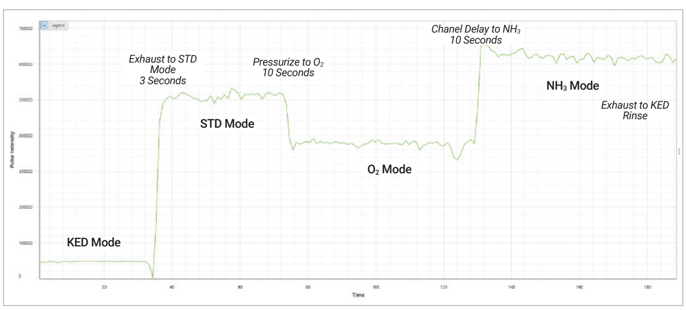

Figure 5. Analysis of ^{115}In in KED/STD-He, DRC-O_2 and DRC-NH_3 modes of operation, switching between the modes and acquiring stable data.

Conclusion

The NexION ICP-MS series third generation UCT system offers advances in all three subsystems to solve the challenges faced by polyatomic and isobaric interferences. The unique features allow the user full flexibility of gas flow, gas mode ordering and gas switching times, as well as allowing for the fastest duty cycles for advanced techniques such as laser ablation.

References

1. "Systems and methods using a gas mixture to select ions", CA3074351A1 P. Patel, F. Abou Shakra, C. Stephan. PerkinElmer, 2018.
2. "Reaction cells and collision cells for ICP-MS: a tutorial review", S. Tanner, V. Baranov, D. Bandura. Spectrochimica Acta Part B 57 (2002).
3. "Advantages of Short Settling Times for Quadrupole-Based ICP-MS Laser Ablation Imaging", PerkinElmer Technical Note (2020).

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