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Rapid Washout of Boron Using Glass Expansion's Peltier Cooled Cyclonic (PCC) Spray Chamber on Agilent® 7900 ICP-MS

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Abstract

This application note explores the efficient and rapid washout of boron (B) from the sample introduction system of Agilent's 7900 Inductively Coupled Plasma Mass Spectrometer (ICP-MS) instrument using Glass Expansion's Peltier Cooled Cyclonic (PCC) spray chamber. The combination of these technologies enhances analytical performance by minimizing memory effects and improving signal stability, particularly in the analysis of trace levels of boron in complex, real-world sample matrices.

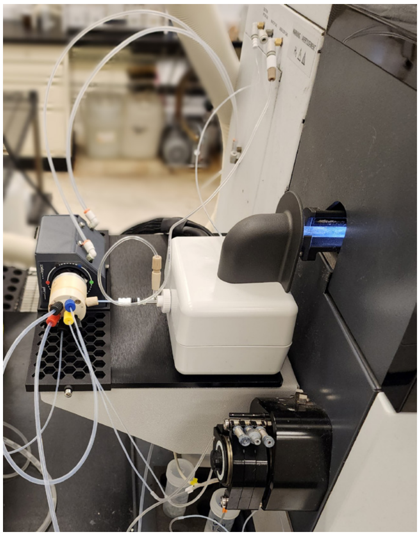
Introduction

Boron analysis poses challenges using ICP-MS due to its tendency to form memory effects and interfere with subsequent analyses. This occurs when residual boron from previous samples adheres to the spray chamber walls, leading to carryover and inaccurate measurements in following samples. Along with a few other elements, such as Hg, Pb and Sb, B is notorious for causing memory effects. Sometimes, even relatively advanced ICP-MS instrumentation can struggle to meet basic QC requirements when it comes to analyzing challenging elements like these in real-world samples. For example, when analyzing for boron using the standard Scott style spray chamber, washout times can be extensive. This is primarily attributed to the large surface area of the Scott-style spray chamber, where the time needed to sufficiently get boron levels to an acceptable level can take valuable analysis time. Whether analyzing difficult real-world samples with high boron content, or if low detection limits are hindering efficient rinse out times requiring repeated rinse blank analyses, Glass Expansion's Peltier Cooled Cyclonic Spray Chamber (PCC) Kit outfitted with a quartz spray chamber can quickly get boron down to acceptable levels in rinse blanks. Glass Expansion's Tracey™ cyclonic spray chamber design provides the best sensitivity, reproducibility and lowest memory effects. Additionally, the Helix Constant Torque (CT) locking screw and seal creates an optimal nebulizer interface that significantly reduces dead volume around the nebulizer, assisting the rapid washout.

PCC Spray Chamber Design

The PCC spray chamber by Glass Expansion is a high-performance accessory designed to replace standard Scott style spray chambers on ICP-MS instruments. It features a unique cyclonic design that creates a centrifugal force within the chamber. This force helps minimize the residence time of sample aerosols, reducing their interaction with the chamber walls and consequently, lowering memory effects. Furthermore, the PCC Kit incorporates Peltier cooling technology, which actively cools the spray chamber, further reducing aerosol dwell time and enhancing washout efficiency. It offers several advantages over the standard Scott-style spray chamber, particularly when analyzing troublesome elements like B.

Figure 1. PCC Kit (P/N KT-1212Q) Installed on Agilent® 7900 ICP-MS.



Key Advantages of the PCC Spray Chamber

1. **Improved Washout Efficiency:**
   - The distinctive design of the cyclonic spray chamber minimizes washout time, especially with highly concentrated samples containing challenging elements such as boron.
   - Compared to the standard Scott-style spray chamber, the PCC significantly reduces the time required to reach baseline levels after analyzing boron-rich samples.
2. **Helix CT Interface:**
   - All Glass Expansion cyclonic spray chambers feature the Helix CT locking screw and seal.
   - This interface ensures a consistent inert PTFE seal against the nebulizer, preventing overtightening and ensuring a gas-tight seal during nebulizer installation.
   - The Helix CT design provides unparalleled, reproducible day-to-day analytical performance, minimizing memory effects and improving sensitivity.
3. **Interchangeable Materials:**

   The PCC Kit allows easy interchangeability between different spray chamber materials:
   - **Borosilicate Glass:** Cost-effective option for routine analyses not requiring low-level boron measurements.
   - **Quartz:** Required for precise low-level boron detection.
   - **PFA:** Ideal for applications with a hydrofluoric acid matrix and ultra-trace ICP-MS analyses (paired optimally with Glass Expansion's DuraMist DC Nebulizer).
   - The interior of the Tracey PFA spray chamber features the proprietary Stediflow surface treatment, improving wettability and efficient drainage.
4. **Fast and Simple Installation/Operation:**
   - The PCC Kit connects directly to the existing electronics and water-cooling system.
   - Use existing software and methods to operate.
   - A convenient mounting bracket ensures swift installation on the Agilent® 7900 and 8900 ICP-MS systems.
5. **Jet Vortex Interface (JVI™) – Aerosol Filtration:**
   - The JVI is illustrated in Figure 2, and is included in the PCC Kit to easily utilize your existing method settings for Make-Up or Dilution/Option Gas.

Experimental Setup

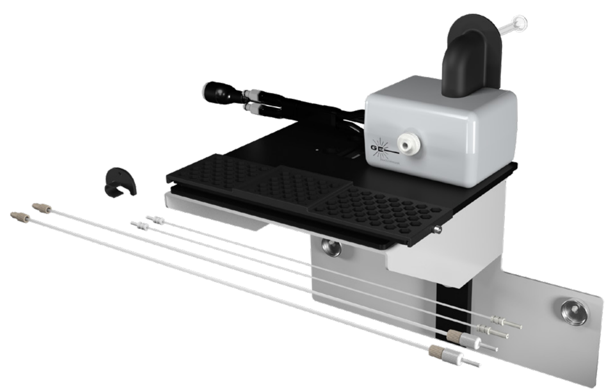
A high-throughput environmental laboratory analyzing particularly difficult samples with high boron concentrations was looking for a solution to their excessive rinse out times to ensure quality data and improve their sample throughput. The lab was using an Agilent 7900 ICP-MS with a standard Scott-style spray chamber, ISIS-3 switching valve, and SPS 4 Autosampler on two different instruments. Glass Expansion equipped both of the lab's 7900 ICP-MS instruments with the PCC Kit (KT-1212Q) to demonstrate the advantages (see Figure 1). The PCC Kit operates using the instrument's existing software, communication port and chiller cooling ports, so installation and operation were a breeze.

A challenging, real-world, aqueous sample from a remediation site, containing 4.3 mg/L of boron was used to collect washout analysis data, comparing the Scott and PCC Kit, by running 10 consecutive rinse blanks after the sample was analyzed. The rinse blanks and the autosampler rinse station were composed of 2% nitric acid and 1% hydrochloric acid. The sample and 10 consecutive blanks were first analyzed using their standard Scott-style setup. This same analysis was then repeated using the PCC Kit. The collected rinse blank data was compared using isotope 11 of B in H_2 mode. The details of the equipment and material used are summarized in Table 1 and Figure 2.

Table 1. Materials Summary

Materials Summary	
ICP-MS Instruments	Agilent 7900 with ISIS 3 Switching Valve & SPS 4 Autosampler
Spray Chamber	Glass Expansion Quartz PCC Kit (KT-1212Q)
Nebulizer	Glass Expansion MicroMist DC Nebulizer (A13-1-UM04)
Sampler Cone	Glass Expansion Ni Plated (AT7701-Ni/Ni)
Skimmer Cone	Glass Expansion Ni Skimmer Cone (AT7902X-Ni)

Figure 2. Materials Summary.



P/N KT-1212Q
PCC Quartz Spray Chamber

P/N A13-1-UM04
MicroMist DC Nebulizer 0.4mL/min

JVI™

P/N AT7701-Ni/Ni
Nickel Plated Sampler Cone

P/N AT7902X-Ni
Nickel Skimmer Cone

Standard Agilent Performance Reports were analyzed after instruments were warmed up for thermal stability of the interface. A total of 15 performance reports from two separate instruments operating the same PCC kit configuration were used to create averages of the key data summarized in Table 2. The performance reports span a time period of more than 3 months and include data immediately after changing cones.

Table 2. Performance Report Averages [n=15]

Instrument Performance Report		
Average Nebulizer Gas Flow (L/min) = 1.038		
JVI Dilution Gas Flow (L/min) = 0.00		
H_2 & He Gas Flows (mL/min) = 0.00		
Mass	**Sensitivity (cps)**	**RSD%**
^{7}Li	6385	2.481
^{89}Y	30735	2.223
^{205}Tl	21436	2.447
Oxide 156CeO/Ce140 (<1.8%)	1.301	
Doubly Charged (<2.5%)	1.297	

This lab was operating under EPA Methods 200.8 and 6020, so each day after the instrument performance reports were analyzed they also analyzed an EPA Tune Check Report for H_2 and He modes to ensure the operating conditions of the nebulizer and JVI gas flows met these method criteria, which are different from the instrument performance reports in Table 2. Tables 3 and 4 illustrate the average of 16 EPA Tune Check Reports from 2 different instruments for the H_2 and He modes, respectively.

Table 3. H_2 Mode US EPA 200.8/6020 Tune Check Report Average [n-16]

US EPA 200.8/6020 Tune Check Report [H_2]		
Nebulizer Gas Flow (L/min) = 0.85		
JVI Dilution Gas Flow (L/min) = 0.15		
H_2 Gas Flow (mL/min) = 3.5		
Mass	**Sensitivity (cps)**	**RSD%**
^{9}Be	972	1.497
^{24}Mg	11245	2.083
^{25}Mg	1609	2.207
^{26}Mg	1982	1.974
^{59}Co	25236	0.899
^{115}In	84931	0.735
^{206}Pb	17030	0.871
^{207}Pb	14342	0.898
^{208}Pb	35324	0.868

Table 4. He Mode US EPA 200.8/6020 Tune Check Report Average [n-16]

US EPA 200.8/6020 Tune Check Report [He]		
Nebulizer Gas Flow (L/min) = 0.85		
JVI Dilution Gas Flow (L/min) = 0.15		
He Gas Flow (mL/min) = 4.5		
Mass	**Sensitivity (cps)**	**RSD%**
^{9}Be	87	2.615
^{24}Mg	1266	1.486
^{25}Mg	184	2.021
^{26}Mg	232	1.962
^{59}Co	20333	1.333
^{115}In	24991	1.464
^{206}Pb	11164	1.370
^{207}Pb	9399	1.357
^{208}Pb	23286	1.361

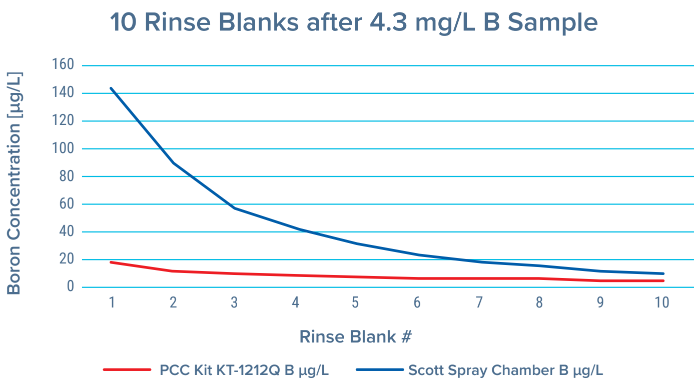
Results and Discussion

This lab's reporting limit for B was 10 µg/L, and it frequently encountered samples with boron levels on the order of 4.3 mg/L, making it difficult to rapidly rinse out these relatively high concentration samples. After analyzing a 4 mg/L B sample, it would normally take the Scott-Style spray chamber 10 rinse blanks, taking a total of 31 minutes to analyze the sample and then washout out the sample introduction system to get the background level below the reporting limit. In comparison, the PCC Kit was able to analyze the same sample and washout to <10 µg/L in 12 minutes. Table 5 contains this comparative data set to illustrate the washout efficiency of the PCC Kit. And Figure 3 graphs this data showing the <10 µg/L reporting limit was achieved on the 4th rinse blank using the PCC Kit, as opposed to the 10th rinse blank after the Scott-style spray chamber. This decreased the number of necessary rinse blanks from 10 to 4, saving 6 rinse blanks. In this example, this is a **61% improvement** in B washout time, resulting in a much higher throughput and much lower potential for any carryover.

Table 5. Boron washout data for Scott-Style Spray Chamber vs PCC Kit

	PCC Kit (KT-1212Q)		**Scott Style Spray Chamber**	
	11 B [H2]		**11 B [H2]**	
Time Stamp	**Conc. [ppb]**	Type	**Conc. [ppb]**	Time Stamp
7:35 PM	4294.897	Sample	4376.533	2:49 PM
7:38 PM	18.655	Blank 1	141.146	2:52 PM
7:41 PM	12.491	Blank 2	89.449	2:55 PM
7:44 PM	10.483	Blank 3	57.566	2:58 PM
7:47 PM	**9.49**	Blank 4	42.028	3:01 PM
7:50 PM	8.183	Blank 5	31.679	3:04 PM
7:53 PM	7.505	Blank 6	24.263	3:08 PM
7:57 PM	7.083	Blank 7	19.126	3:11 PM
8:00 PM	6.706	Blank 8	15.771	3:14 PM
8:03 PM	5.366	Blank 9	11.902	3:17 PM
8:06 PM	5.026	Blank 10	**9.851**	3:20 PM

Figure 3. Comparison of B washout after 4.3 mg/L sample using 10 consecutive rinse blanks.



When only considering the combined sample uptake and washout times for routine sample analysis, this particular lab noted that it was able to save about 40 to 60 seconds per sample, depending on the analysis type. Saving these 40 to 60 seconds was accomplished by reducing unnecessary capillary length from the autosampler probe capillary to the nebulizer and utilizing the faster washout times of the PCC kit. Additionally, by reducing the number of rinse blanks from 10 to only 4 following high concentration B samples, the lab was able to regain up to 24 minutes of billable analysis time for each highly concentrated B sample. With the faster washout of the PCC Kit and shortened sample path, the sample analysis time range was reduced from 3.66—4.0 minutes down to a range of 3.0—3.25 minutes. Gaining these 18 to 24 minutes from one highly concentrated boron sample enables the analysis of about 6 to 8 more samples just from eliminating excessive rinses.

Summary of Key Benefits of Using a PCC Kit for Boron Analysis

1. **Faster Washout Times:**
   - Compared to traditional Scott-style spray chambers, the PCC significantly reduces boron washout times, and in this case nearly 10x faster.

2. **More Efficient Workflow:**
   - Less reruns from unanticipated carryover or poor RSDs.

3. **Improved Signal Stability:**
   - Reduced memory effects lead to more consistent and reliable boron measurements, and longer analysis times with less analytical drift.

4. **Higher Quality Data:**
   - Less data flags on instrument blanks, method blanks, duplicates, dilutions, and other QA/QC samples.

5. **Increased Sample Throughput:**
   - Faster uptake and washout times enable shorter total sample acquisition times, thereby increasing sample throughput.

Conclusion

The Glass Expansion PCC Spray Chamber provides a significant advantage for ICP-MS users performing boron analysis. This application note demonstrated Glass Expansion's Quartz PCC Kit's effectiveness in reducing boron washout times when using a standard Scott style spray chamber on Agilent's 7900 ICP-MS. This environmental laboratory saw immediate results and was able to recapture profitable analysis time by eliminating unnecessary consecutive rinse blanks to more rapidly bring boron to baseline levels after highly concentrated samples. Moreover, sample uptake and rinse out times were reduced by shortening capillary lengths and taking advantage of the PCC Kit's fast stabilization times. Compared to the standard Scott-style spray chamber, Glass Expansion's uniquely designed cyclonic spray chamber minimizes washout time with elements known to cause memory effects, such as B, Hg, Pb, and Sb. The benefits of investing in the PCC Kit are many, making it a wise choice for labs analyzing elements that cause memory effects. For more information on Glass Expansion's PCC Kit, please visit our webpage: Glass Expansion's Peltier Cooled Cyclonic Spray Chamber for Agilent® ICP-MS.

Customer Feedback

"For our particular application, this PCC kit was a great improvement. On specific cases that required four or more blank runs to bring the boron level to baseline now we can do it with one or two blank runs. This allowed us to increase sample throughput by about 50%." — Specialty Chemicals Manufacturer – USA