

The Agilent 7700x ICP-MS Advantage for Drinking Water Analysis

Application Note

Environmental

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Introduction

The Agilent 7700 Series ICP-MS brings 3rd generation Octopole Reaction System (ORS³) technology to routine environmental analysis of trace metals in drinking waters. Building on the cell technology used in the successful Agilent 7500 Series ICP-MS, the ORS³ has been completely redesigned to significantly improve the performance of helium (He) collision mode for the removal of polyatomic interferences. He mode is simple and universal, enabling the 7700x ICP-MS to remove all polyatomic interferences under a single set of conditions, without requiring any previous knowledge about the sample, and without the need for complex mathematical corrections. The result is easier set-up, lower detection limits, faster analysis, and improved interference removal, especially for the difficult plasma based interferences affecting iron and selenium. Selenium detection limits less than 20 parts per trillion (ppt) are now routinely achievable in He mode.



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Better Sensitivity, Better Accuracy, Better Dynamic Range

In addition to a more efficient Octopole Reaction System (the ORS³), the 7700x ICP-MS also includes a new ion lens and detector, which deliver higher sensitivity and lower background compared to the 7500cx ICP-MS it replaces. No special tuning or optimization is required for the routine analysis of water samples ranging from clean municipal tap waters to high total dissolved solids (TDS) mineral waters. Complete instrument optimization is fully automated, including the new One-click Plasma Setting function for fast, automated plasma setup, and a faster, more reproducible auto tune function (Expert AutoTune).

Figure 1 shows typical calibrations obtained with the 7700x ICP-MS. All calibration standards contained 1% HNO₃ and 0.5% HCl in order to stabilize Ag, Sb and Hg. While the use of HCl has traditionally been avoided in ICP-MS due to the formation of Cl based interferences on As, Se, Cr and V, the ORS³ is able to remove these interferences in He mode, eliminating the need for hydrogen or other reactive gases. The 3.7 ppt background equivalent concentration (BEC) for vanadium demonstrates the efficient removal of the ClO⁺ interference (mass 51) in He mode on the 7700x. This interference is difficult to remove by other means, typically requiring highly reactive cell gases such as NH₃ or NH₃/He, which are not suitable for multi-element analysis.

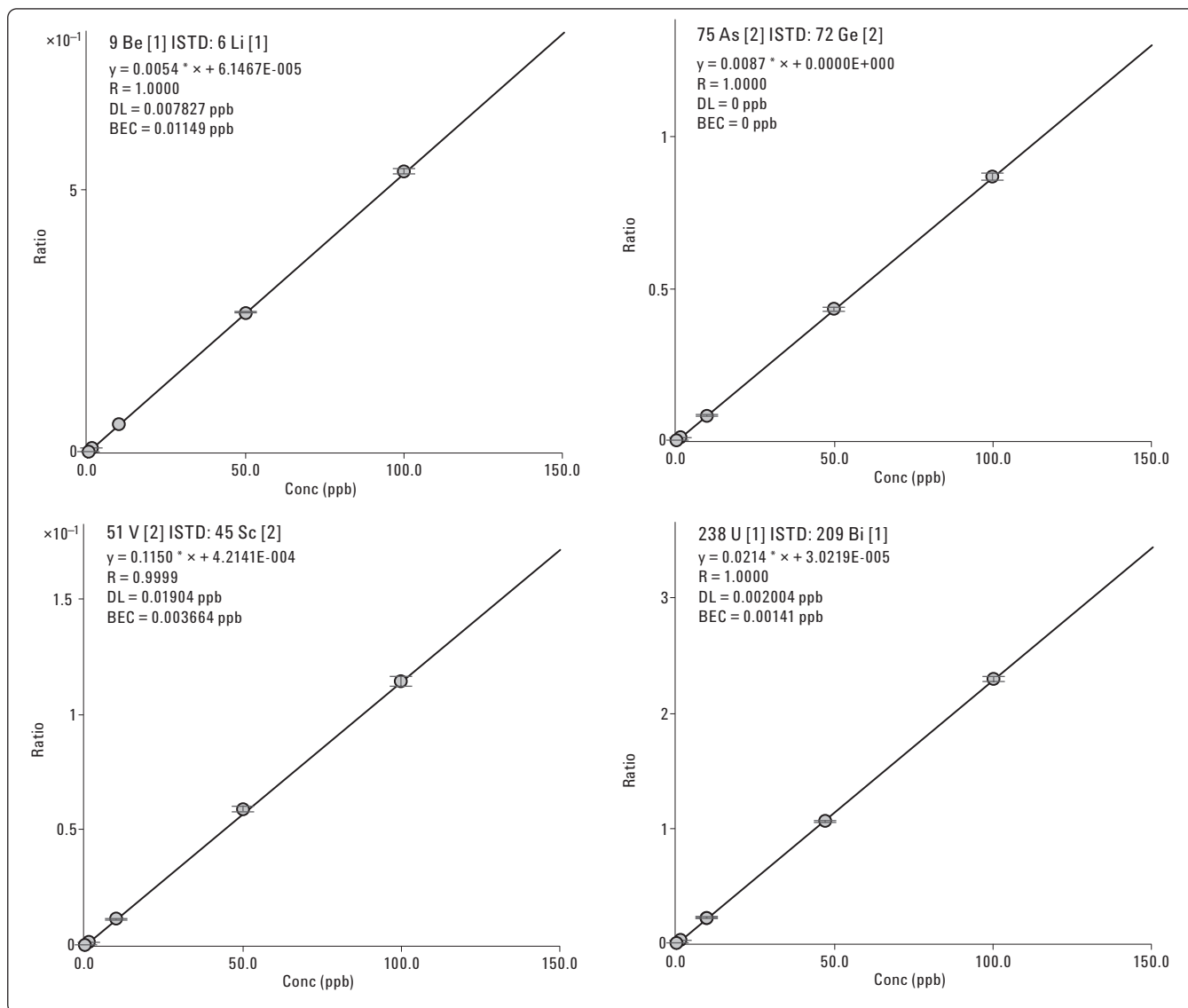


Figure 1. Representative calibration curves for drinking water method. Be and U were analyzed in no gas mode, while As and V were analyzed in He mode. All standards contain 1% HNO₃ and 0.5% HCl. BEC and DL for As calculated based on 0 cps +/- 0 as acquired. Actual BEC and DL would have required longer counting times than those used in this method.

Typical method detection limits (MDLs, 3 sigma of 10 replicates of the low calibration standard) in ppt are shown in Table 1. These MDLs were not generated under highly optimized conditions, but using the default robust plasma conditions obtained by the One-click Plasma Setting routine ($CeO^+/Ce^+ < 1\%$).

The high sensitivity of the 7700x ICP-MS means that accurate analysis of trace level contaminants in waters can be accomplished with ease, while the built-in High Matrix Introduction (HMI) system assures superior robustness and long term stability when running long sequences of high matrix samples. A sequence consisting of drinking waters, two high TDS mineral waters - samples "A" (TDS of 109 mg/L) and "B" (TDS of

309 mg/L), and NIST 1643e reference water (diluted 1/10) was analyzed continuously for 11 hours. The sequence included USEPA mandated continuous calibration validation and continuous calibration blank samples (CCVs and CCBs), giving a total of 190 analyses, performed with an average run time of less than 3.5 minutes per sample. CCV recoveries for all method analytes are plotted in Figure 2 for the entire sequence. No element in any CCV exceeded the USEPA limits of $\pm 10\%$ (shown in red). Table 2 lists the mean recoveries and relative standard deviations (%RSD) for the 28 repeat analyses of NIST 1643e (diluted 1/10 to test sensitivity and precision at low concentrations) which were included in the sequence.

Table 1. The 3 Sigma Method Detection Limits in Parts Per Trillion (ppt) for Trace Elements in Drinking Waters. Note Fe and Se Detection Limits are Less Than 20 ppt in He Mode. Note Excellent DL For Be and B at 5 ppt.

Mass	Element	MDL (ppt)	Cell mode
9	Be	5.2	No gas
11	B	5.0	No gas
23	Na	58.5	No gas
24	Mg	2.8	No gas
27	Al	7.9	No gas
39	K	76.9	He
42	Ca	57.8	He
51	V	14.3	He
52	Cr	4.3	He
55	Mn	8.5	He
56	Fe	14.8	He
59	Co	4.4	He
60	Ni	14.7	He
63	Cu	2.7	He

Mass	Element	MDL (ppt)	Cell mode
66	Zn	14.0	He
75	As	11.9	He
78	Se	17.6	He
88	Sr	2.1	He
95	Mo	6.9	He
107	Ag	2.3	He
111	Cd	2.9	He
121	Sb	6.1	He
137	Ba	5.7	He
202	Hg	1.2	He
205	Tl	2.4	He
208	Pb	1.3	He
232	Th	1.8	He
238	U	1.7	He

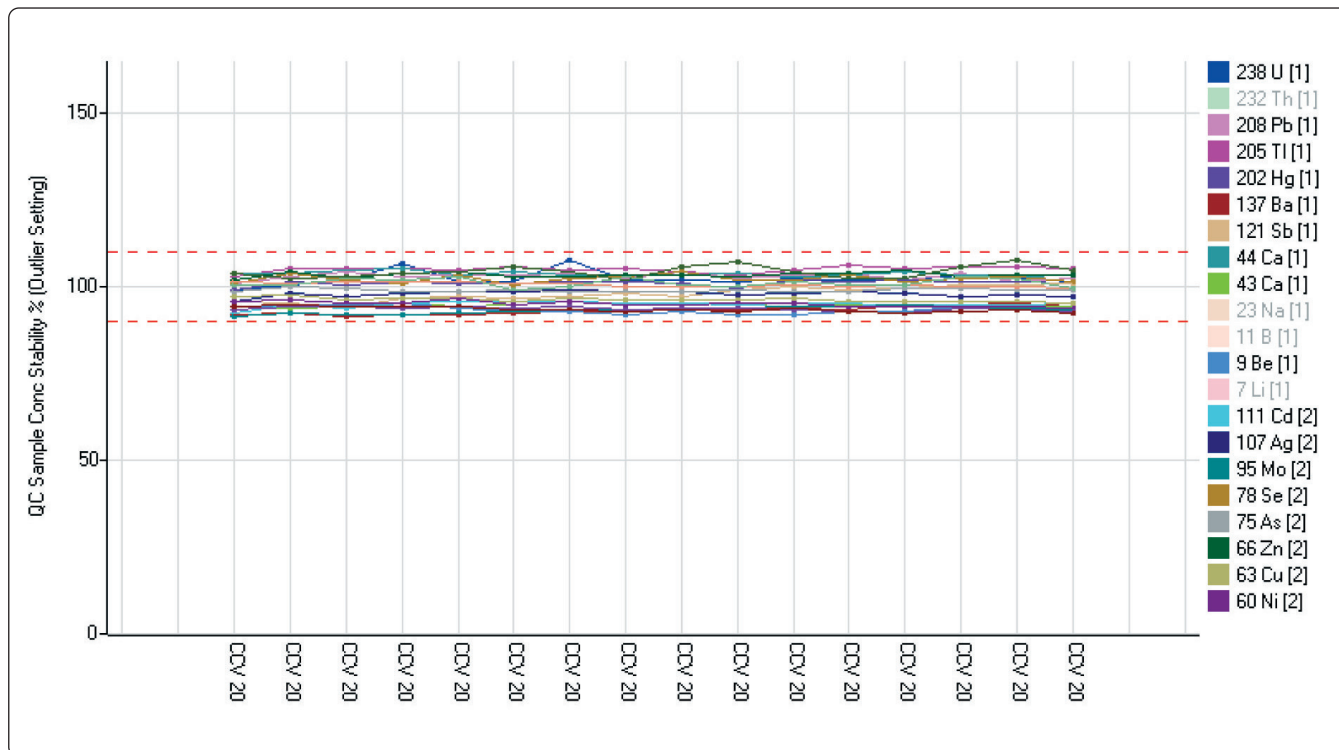


Figure 2. CCV recoveries (20 ppb) for all method analytes for the entire 190 sample sequence. No CCV failures occurred. Mode [1] = no gas, Mode [2] = He mode

Table 2. Mean Values, Relative Standard Deviation and % Recoveries of Certified Values for NIST 1643e (1/10 Dilution) Standard Reference Water.

Element/mode	Measured (ppb)	RSD (%)	Recovery (%)	Element/mode	Measured (ppb)	RSD (%)	Recovery (%)
9 Be [no gas]	14.4	2.0	103.3	60 Ni [He]	58.2	0.7	93.4
11 B [no gas]	156.3	1.6	99.0	63 Cu [He]	21.1	0.8	92.8
23 Na [no gas]	19581	2.7	94.4	66 Zn [He]	73.2	0.5	93.3
24 Mg [no gas]	7376.6	2.9	91.8	75 As [He]	59.9	2.2	99.2
27 Al [no gas]	137.5	2.8	97.0	78 Se [He]	10.9	2.8	91.2
39 K [He]	2043.5	0.9	100.5	88 Sr [He]	301.5	4.5	93.3
44 Ca [He]	34251	2.6	106.0	95 Mo [He]	114.9	0.6	94.7
51 V [He]	36.6	0.7	96.9	107 Ag [He]	0.94	1.4	88.1
52 Cr [He]	19.8	1.0	97.2	111 Cd [He]	6.32	1.0	96.2
53 Cr [He]	19.7	0.7	96.6	121 Sb [He]	56.2	0.5	96.3
55 Mn [He]	38.5	0.6	98.9	137 Ba [He]	617.1	1.0	113.4
56 Fe [He]	100.9	1.2	102.9	205 Tl [He]	6.00	0.7	99.2
57 Fe [He]	100.2	1.4	102.2	208 Pb [He]	18.9	0.2	96.1
59 Co [He]	25.8	0.6	95.5				

Conclusions

The new Octopole Reaction System (ORS³), ion optics and detector of the Agilent 7700x ICP-MS have produced an instrument that is fully capable of measuring all required elements at ppt levels in drinking waters without the need for either reactive cell gases or complex interference equations. The result is absolute confidence in data quality with significantly improved productivity. The 7700x has the largest operating dynamic range of any quadrupole ICP-MS, and the integrated HMI system provides ultimate tolerance to high matrix samples. Furthermore, the simple optimization conditions used for drinking water analysis are identical to those used for more complex environmental samples such as soils and sludges, eliminating the need for the sample specific optimizations which are required on instruments that can only use reactive cell gases.

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Printed in the USA
October 23, 2009
5990-4315EN



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