

Determination of Multiple Elements in Lithium Salts using Autodilution with ICP-OES

Automated analysis of lithium-ion battery precursor chemicals by Agilent 5800 VDV ICP-OES and Agilent ADS 2 autodilutor



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Introduction

The transition to more sustainable practices and energy-efficient solutions is driving demand for high-quality lithium-ion batteries (LIBs). Many LIBs require the use of essential raw materials, including lithium salts like lithium hydroxide (LiOH) and lithium carbonate (Li_2CO_3). New methods of developing these chemicals are emerging, with increasing use of lithium chloride (LiCl) in the extraction process.^{1,2} To produce high-purity Li salts, refineries must ensure that the source salt (LiCl) is free from contaminants, as low-quality precursor chemicals can negatively impact the performance of the final battery.

Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) is an ideal technique for the fast, simultaneous measurement of trace elements in many types of samples, including LIB-related samples.³ Like many analytical techniques, ICP-OES methods require the preparation of calibration standards across a wide analytical range and samples must often be diluted before analysis. Both processes can be labor-intensive and time-consuming, potentially introducing contaminants and errors during preparation and dilution. The implementation of advanced autodilution technology for ICP-OES enhances sample turnaround time and minimizes the risk of human errors, while ensuring accurate results.

Developed and designed especially for Agilent ICP-OES (and ICP-MS) instruments, the Agilent Advanced Dilution System (ADS 2) facilitates fast, simultaneous measurements of multiple trace elements in lithium salts. Automating the calibration and dilution steps greatly reduces sample preparation time, freeing the analyst to concentrate on more productive tasks.

The Agilent 5800 Vertical Dual View (VDV) ICP-OES paired with the ADS 2 is ideal for labs dealing with high numbers of samples or aiming to make efficiency gains. Autodilution systems provide valuable support for less experienced operators in conducting routine analyses, while effectively minimizing the risk of errors during sample preparation. The ADS 2 is fully integrated into the Agilent ICP Expert Pro instrument control software and includes several features and tools that enhance method development, simplicity of use, and speed of analysis. Some features of the ADS 2 include:

- **Autocalibration:** fully automated in-line calibration from a single stock solution. Autocalibration reduces time spent on standard preparation, minimizes chemical waste, and mitigates the risk of errors being introduced.
- **Prescriptive dilution:** automatic dilution of solutions or samples by a known (prescribed) dilution factor before analysis.
- **Reactive dilutions:** automatic dilutions that occur if the measured concentration of a sample is above the calibration range (overrange), or if an internal standard recovery limit is exceeded.
- **Summary row:** a software feature that selects the best measurement result to display out of the available iterations, while retaining a record of all the data. Summary row allows for straightforward data viewing and reduces manual data processing/reporting times.

In this study, the 5800 VDV ICP-OES with an ADS 2 autodilutor and Agilent SPS 4 autosampler was used to determine 28 elements in technical grade LiCl. The elements included aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, gallium, germanium, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, sulfur, antimony, silicon, strontium, titanium, vanadium, and zinc.

Experimental

Instrumentation

The 5800 VDV ICP-OES was equipped with the integrated Advanced Switching Valve (AVS 7), ADS 2 autodilutor, and SPS 4 autosampler (Figure 1). The AVS and ADS 2 systems work seamlessly together to maximize sample throughput, increase sample turnaround time, and reduce cost-per-sample.⁴ The ADS 2 in-line autodilutor was used to facilitate automatic and accurate preparation of calibration standards and autodilution of samples, saving analyst time and reducing laboratory consumables. However, the integrated design of the ADS 2 and AVS avoids adding excess time when not performing a dilution, addressing a common drawback of other dilution systems. The SPS 4 autosampler was used for the automated delivery of samples to the instrument. The 5800 ICP-OES was fitted with a SeaSpray nebulizer, double-pass cyclonic spray chamber, and Agilent semi-demountable VDV torch with a 1.8 mm internal diameter (id) injector. All instrumentation was controlled using ICP Expert Pro software*.

The operating conditions of the integrated ICP-OES workflow automation system are listed in Tables 1 and 2, respectively.



Figure 1. Agilent 5800 VDV ICP-OES with integrated AVS switching valve (left), Agilent Advanced Dilution System ADS 2 (middle), and Agilent SPS 4 autosampler (right).

To provide the robustness and stability of the plasma over long analytical runs of high matrix LIB samples, the 5800 VDV ICP-OES uses a vertical plasma, a solid-state radio frequency (SSRF) generator operating at 27 MHz, and a Cooled Cone Interface (CCI). The CCI deflects the plasma's cooler tail, avoiding interferences that form in the cooler region. So, when reading the plasma in axial view mode, most elements at trace concentration levels can be measured with minimal interfering effects.

Table 1. Agilent 5800 VDV ICP-OES instrument and method parameters.

Parameter	Setting	
	Axial	Radial
Viewing Mode	Axial	Radial
Viewing Height (mm)	-	6
RF Power (kW)	1.3	1.1
Nebulizer Flow (L/min)	0.8	0.9
Plasma Flow (L/min)	13	
Aux Flow (L/min)	1.4	
Replicates	3	
Rinse Time (s)	0	
Read Time (s)	10	5
Stabilization Time (s)	10	4
Sample Pump Tubing	White-white	
Internal Standard Pump Tubing	Black-black	
Waste Pump Tubing	Blue-blue	

Table 2. Agilent AVS and ADS 2 operating parameters.

Parameter	Setting
Sample Loop Size (mL)	1.5
Pump Rate – Uptake (mL/min)	35
Pump Rate – Inject (mL/min)	5
Valve Uptake Delay (s)	13
Bubble Injection Time (s)	1
Pre-emptive Rinse Time (s)	1

Standard and sample preparation

A single stock standard was prepared at 1 mg/L for 27 elements and 10 mg/L for Li using Agilent 1000 and 10,000 mg/L single element calibration standard solutions in 10% HNO₃, respectively. To create calibration standards across the analytical working range, the stock solution was autodiluted by the ADS 2 at 100x, 20x, 10x, and 1x using 10% HNO₃. Final concentrations were 0, 0.010, 0.050, 0.100, and 1.000 mg/L for most elements and 0, 0.100, 0.500, 1.000, and 10.000 mg/L for Li. Automatic calibration by the ADS 2 avoided the need for time-consuming, and error-prone preparation of standards by the analyst.

For quality control (QC) and validation purposes, a blank 10% HNO₃ solution was used as a continuing calibration blank (CCB). A solution containing 5 mg/L of Li and 0.500 mg/L of all other elements was used as the continuing calibration verification (CCV). The CCV was prepared separately from the calibration standards using Agilent Quality Control Standard 27 plus separate spikes of Ga, Ge, Li, and S.

An internal standard solution comprising 5 mg/L yttrium (Y), 50 mg/L rubidium (Rb), 50 mg/L tellurium (Te), 20 mg/L bismuth (Bi), and 20 mg/L indium (In) was prepared in 10% HNO₃ using Agilent single element standard solutions. The ISs were used to account for any matrix effects or ionization interferences.

The sample preparation method closely followed the procedure outlined in China GB/T 11064.16-2013 national standard method.⁵ To prepare a 1% LiCl sample solution, 0.5 g of 99% LiCl was accurately weighed and slowly dissolved in 10% HNO₃. The solution was then made up to 50 mL giving a preparation dilution factor of 100x.

Spikes of the 1% LiCl sample were prepared at 0.100 and 0.250 mg/L.

Automatic preparation of calibration standards by ADS 2

All calibration curves were prepared from a single stock solution using the autocalibration feature of the ADS 2. With full control via the ICP Expert software, the ADS 2 diluted the stock solution at specific dilution factors (100, 20, 10, 1) to create all calibration curves. Autocalibration allowed for the preparation of standards and calibration curves in less than 20 minutes, compared to over an hour using conventional manual methods. This significant streamlining of the calibration process enhanced the overall efficiency of the analytical workflow. A representative linear calibration curve for Cr (R value of 1.0000) is shown in Figure 4.

In addition to saving significant amounts of analyst time, autocalibration reduces the use of lab consumables and minimizes waste. It also provides increased confidence in the results by lowering the risk of error and contamination that may occur during the manual preparation of samples.

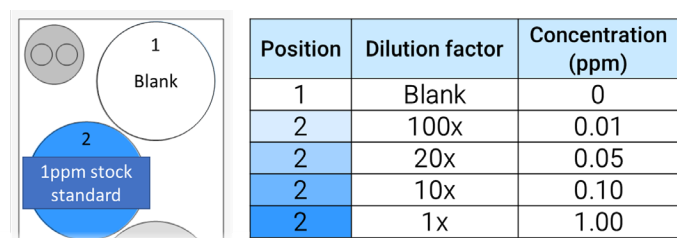


Figure 2. Autocalibration of a standard stock solution at different dilution factors using the Agilent ADS 2. The stock solution was loaded into the Agilent SPS 4 autosampler standard rack at position 2.

Reactive autodilution and result summaries

The ADS 2 can dilute solutions in response to the sample measurement using a process known as reactive dilution. Where a sample measurement exceeds the maximum calibration range or an internal standard (IS) exceeds the recovery range, the ICP Expert software automatically calculates the appropriate dilution factor needed to bring the out-of-range analytes within user-identified limits (Figure 3).

When measured without dilution, the presence of a high concentration of Li in 1% LiCl caused the signal of elements like sodium (Na) to be enhanced due to easily ionizable element (EIE) effects. This enhancement can be corrected by adding a high purity Cs buffer or using Rb as an IS (Figure 3, Solution Label "Original"). However, it is not generally accepted in ICP-OES to report results with an IS recovery beyond 2.0. So, by stipulating an IS recovery maximum of 2.0 in the software, the ADS 2 reactively diluted the original solution by 10x, bringing the ratio to under 2.0 (Figure 3, Solution Label "Dilution - 10"). The relevant sample was then reanalyzed. As this diluted measurement was not within the calibration range for Na, the ADS 2 performed a second reactive dilution to bring it within concentration range (Figure 3, Solution Label "Dilution - 100"). Both reactive dilution steps were conducted automatically, without any input from the analyst.

Best measurement selected		Na 1 589.592 nm ppm	Rb 1 780.026 nm Ratio	
Solution Label	Timestamp			Overrange concentration and IS ratio, requires dilution
LP 1% LiCl	1/23/2024 4:58:16 PM	1.27	--	
Summary	1/23/2024 4:58:16 PM	1.27	--	Reactive dilution to bring IS ratio within 2 (200%)
Original	1/23/2024 4:51:37 PM	####	2.94	
Dilution - 10	1/23/2024 4:53:42 PM	12.23 o	1.92	
Dilution - 100	1/23/2024 4:55:53 PM	1.27	1.27	Reactive dilution to bring measurement within calibration range

Figure 3. An example of the Agilent ADS 2 performing reactive dilution of 1% LiCl to meet both the internal standard ratio requirement of <2.0 and overrange concentration of Na 589.592 nm.

The ICP Expert summary row feature (Figure 3, Solution Label 'Summary') allowed for the remeasurement of solutions without overwriting any existing data or creating a new worksheet. The layout of the information facilitates a clear overview of the data, with the reactive dilution results displayed under the 'Summary' header. The summary row selects the best measurement for each element from the available iterations, providing confidence in the reported data set.

Prescriptive autodilution increases productivity of routine analyses

With the capability of diluting solutions up to 400x, the ADS 2 can perform precise, prescriptive dilutions by specifying a dilution factor in the software. This feature is useful in labs where routine dilutions occur, removing a time-consuming manual step from daily operations.

Traditionally, quantification of major and trace elements in high purity chemicals by ICP-OES required preparation of multiple sample vials of the same sample to measure across separate calibration ranges for each element to avoid interferences from EIEs. However, with the 5800 VDV ICP-OES and ADS 2, Li can be quantified in LiCl alongside trace elements in a single preparation of the sample.

To quantify Li in the 1% LiCl matrix, it was calculated that an additional 200x dilution was required to bring the measurement within the calibration range of 0 to 10 mg/L. This solution was prepared automatically with the ADS 2 via prescriptive dilution. It was then possible to quantify Li using a single method from a single vial, without the need to manually dilute any solutions or manually prepare a separate calibration. The ADS 2 saved the manual preparation of a second sample and reduced the use of additional lab consumables i.e., plastic sample vials, plastic pipette tips, and additional acid-based diluent.

Results and discussion

Autocalibration and linearity

As shown in Table 3, 27 elements were calibrated between 0.010 and 1.000 mg/L using autocalibration, while Li was auto calibrated between 0.100 and 10.00 mg/L. Each calibration point was created by autodilution of a single stock standard at multiple factors using the ADS 2. The stock solution was prepared at 10 mg/L of Li and 1 mg/L of all other elements. From this stock solution, automatic dilutions of 100x, 20x, 10x, and 1x provided a four-point calibration across the calibration range.

All calibration curves were linear over the range, as indicated by correlation coefficients between 0.99986 and 1.0000. A representative spectrum and calibration curve for Co is shown in Figure 4.

Table 3. Analyte, background correction, internal standard, and calibration information.

Element and Wavelength (nm)	Viewing Mode	Background Correction	Calibration Range (mg/L)	Correlation Coefficient	IS and Wavelength (nm)
Al 237.312	Axial	Fitted	0.010 – 1.000	1.00000	Te 214.282
As 188.980	Axial	Fitted	0.010 – 1.000	0.99999	Te 214.282
B 182.577	Axial	Fitted	0.010 – 1.000	1.00000	Te 214.282
Ba 455.403	Axial	Fitted	0.010 – 1.000	0.99999	Y 371.029
Be 313.042	Axial	Fitted	0.010 – 1.000	0.99999	Y 371.029
Ca 396.847	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Cd 226.502	Axial	Fitted	0.010 – 1.000	0.99999	Y 371.029
Co 238.892	Axial	Fitted	0.010 – 1.000	1.00000	In 230.606
Cr 267.716	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Cu 213.598	Axial	Fitted	0.010 – 1.000	0.99999	Y 371.029
Fe 238.204	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Ga 294.363	Axial	Fitted	0.010 – 1.000	1.00000	In 325.609
Ge 209.426	Axial	Fitted	0.010 – 1.000	1.00000	Te 214.282
K 766.491	Axial	Fitted	0.010 – 1.000	1.00000	Rb 780.026
Li 670.783	Axial	Fitted	0.100 – 10.00	1.00000	Y 371.029
Mg 279.553	Axial	Fitted	0.010 – 1.000	0.99999	In 230.606
Mn 257.610	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Mo 202.032	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Na 589.592	Radial	Fitted	0.010 – 1.000	0.99986	Rb 780.026
Ni 216.555	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Pb 220.353	Axial	Fitted	0.010 – 1.000	1.00000	In 230.606
S 180.669	Axial	Fitted	0.010 – 1.000	0.99999	In 325.609
Sb 217.582	Axial	Fitted	0.010 – 1.000	1.00000	Te 214.282
Si 251.611	Axial	Fitted	0.010 – 1.000	0.99999	Te 214.282
Sr 407.771	Axial	Fitted	0.010 – 1.000	0.99999	Y 371.029
Ti 336.122	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
V 292.401	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029
Zn 202.548	Axial	Fitted	0.010 – 1.000	1.00000	Y 371.029

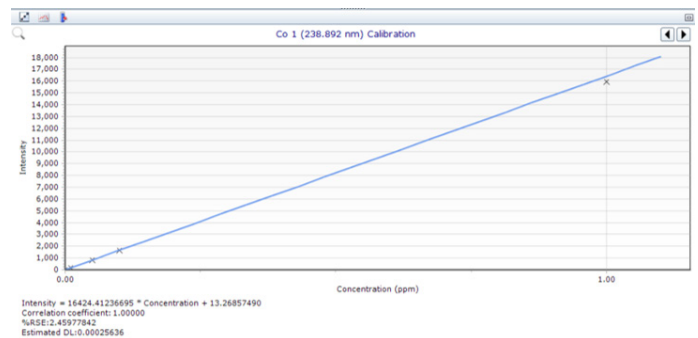
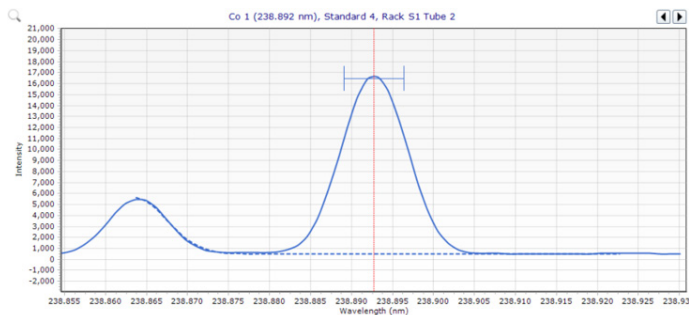


Figure 4. A representative spectrum of Co 238.892 nm using automatic Fitted Background Correction (left) and linear calibration curve (right) with a correlation coefficient of 1.0000 and Relative Standard Error <3%.

Method Detection Limits

Method detection limits (MDLs) were determined using the 5800 VDV ICP-OES operating conditions specified in Table 1. To determine the MDLs, 10 solutions of the representative 1% LiCl in 10% HNO₃ matrix were analyzed three times across three non-consecutive days using the 5800 VDV ICP-OES with ADS 2 autodilution system. The MDL for Li was calculated separately by analyzing a 10% HNO₃ solution. The MDLs were calculated as three times the standard deviation of the measurements of the 10 solutions. The three runs were then averaged and are shown both before and after the dilution factor has been applied.

The quantitative results for all 28 elements in the 1% LiCl sample are also given in Table 4, which shows the quantification of some trace elements at concentrations of < 0.001 mg/L and the matrix element Li at > 1000 mg/L from only one prepared sample vial.

Spike recovery test

Table 4 shows results from the analysis of spiked samples using the 5800 VDV ICP-OES with ADS 2. The 1% LiCl solutions were spiked at 0.100 and 0.250 mg/L. All spike recoveries were within ±10% of the expected concentration, demonstrating the accuracy of the method for the analysis of LiCl solutions. All spike information is displayed before the dilution factor has been applied and is representative of the spike present in the 1% LiCl solution.

Table 4. MDLs (calculated in sample and as 0.500 g sample in 50 mL solution respectively), quantitative results, and spike recovery data for elements measured in LiCl using the Agilent 5800 VDV ICP-OES, n=3.

Element and Wavelength (nm)	1% LiCl			1% LiCl spiked at 0.100 mg/L		1% LiCl spiked at 0.250 mg/L	
	MDL in Sample (mg/kg)	MDL in Solution (mg/L)	Measured Concentration (mg/L)	Measured Concentration (mg/L)	Spike Recovery (%)	Measured Concentration (mg/L)	Spike Recovery (%)
Al 237.312	0.46	0.0046	0.0076	0.102	102	0.260	104
As 188.980	0.34	0.0034	<MDL	0.106	106	0.272	109
B 182.577	0.17	0.0018	<MDL	0.103	103	0.265	106
Ba 455.403	0.013	0.00013	0.0031	0.094	94	0.238	95
Be 313.042	0.058	0.00058	<MDL	0.098	98	0.250	100
Ca 396.847	1.0	0.010	0.38	0.091	91	0.237	95
Cd 226.502	0.033	0.00033	<MDL	0.093	93	0.237	95
Co 238.892	0.058	0.00058	<MDL	0.104	104	0.264	106
Cr 267.716	0.051	0.00051	0.00070	0.097	97	0.246	98
Cu 213.598	0.16	0.0016	<MDL	0.090	90	0.233	93
Fe 238.204	0.030	0.00030	0.00159	0.092	92	0.235	94
Ga 294.363	0.13	0.0013	<MDL	0.095	95	0.243	97
Ge 209.426	0.60	0.0060	<MDL	0.098	98	0.253	101
K 766.491	5.0	0.050	0.054	0.104	104	0.265	106
Mg 279.553	0.012	0.00012	0.0011	0.108	108	0.273	109
Mn 257.610	0.014	0.00014	0.00015	0.094	94	0.238	95
Mo 202.032	0.069	0.00069	0.00095	0.099	99	0.252	101
Na 589.592	0.45	0.0045	<MDL	0.098	98	0.247	99
Ni 216.555	0.098	0.00098	0.00116	0.093	93	0.239	95
Pb 220.353	0.37	0.0037	<MDL	0.101	101	0.259	103
S 180.669	0.77	0.0077	0.10	0.097	97	0.254	102
Sb 217.582	0.35	0.0035	<MDL	0.107	107	0.270	108
Si 288.158	0.37	0.0037	0.048	0.105	105	0.263	105
Sr 407.771	0.017	0.00017	0.0050	0.095	95	0.241	96
Ti 336.122	0.014	0.00014	<MDL	0.101	101	0.254	101
V 292.401	0.079	0.00079	<MDL	0.100	100	0.253	101
Zn 202.548	0.15	0.0015	0.045	0.097	97	0.247	99
Li 670.783	0.094*	0.00094**	1632	NA			

*Generated from a 10% HNO₃ blank solution.

Long-term stability

To assess the stability of the 5800 VDV ICP-OES and ADS 2, 375 solution measurements were taken over 10 hours without recalibration. The solutions consisted of a 0.5% LiCl solution and a QC block, which comprised the CCB and CCV solution at 5 mg/L for all elements except Li, which was present at 50 mg/L. The ADS 2 performed a 10x dilution on each QC, bringing the final concentration to 0.500 and 5.000 mg/L, respectively.

The plot of the CCV recoveries in Figure 6 shows the stability of all elements to be within $100 \pm 10\%$ over the entire analytical run, which included autodilution before every measurement. The recovery data and precision (%RSDs of less than 3%) of the measurements demonstrates the excellent robustness of the 5800 VDV ICP-OES and ADS 2 method for the routine analysis of LiCl over 10 hours.

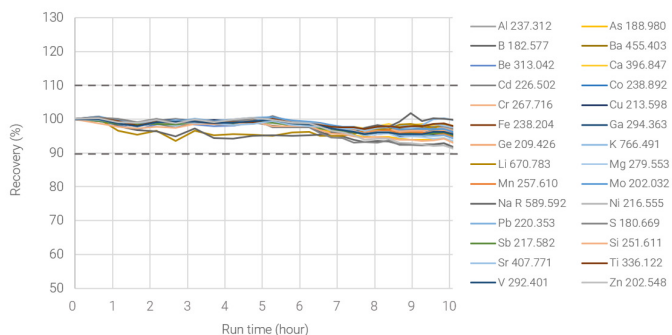


Figure 5. Normalized recovery of QC solutions over 10 hours.

Conclusion

The Agilent 5800 VDV ICP-OES integrated with the Agilent ADS 2 was used to quantify 27 trace elemental impurity elements plus lithium in a 99% LiCl solid. LiCl is increasingly used in the production of lithium precursor chemicals for use in the lithium-ion battery (LIB) sector. The use of the ADS 2 and dedicated software provided automation benefits that improved productivity, reduced the manual preparation of samples, reduced waste, and avoided human-induced errors. Benefits of the 5800 ICP-OES with ADS 2 automated method included:

- Automatic calibration: completely automated calibration from a stock solution removed the need to manually prepare standards to cover the wide concentration range of analytes.
- Prescriptive dilution: the ADS 2 was used to automatically dilute the 1% LiCl sample 200 times to bring Li within the upper calibration range of 10 mg/L. It was then possible to quantify Li using a single method, without the need to manually dilute any additional solutions.
- Reactive dilutions: the ADS 2 automatically diluted a sample in response to the internal standard ratio exceeding 2.0 and the concentration of sodium exceeding the calibration range.
- Summary row: the software feature selected the best measurement results to display from the available reactive dilution remeasurement results. It allowed for straightforward data viewing and reduced the amount of time required for manual data processing.

The 5800 VDV ICP-OES method produced high-quality results. MDLs were below 1 mg/kg for most elements in the sample. Recoveries of all 27 elements, spiked at both 0.100 and 0.250 mg/L, were between 90 and 110%, indicating great accuracy. The instrument displayed excellent stability and robustness over 10 hours, with QC measurement recoveries between 90 and 110% and average %RSDs below 3%.

This study confirms the suitability of the 5800 with ADS 2 for the QC analysis of high matrix samples like LiCl. These types of complex samples are found at most stages of the LIB manufacturing process. The method was enhanced by the ADS 2 autodilutor, which increased productivity by reducing manual handling of standards and samples.

References

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Agilent part numbers

Description	Part Number
Easy-fit 1.8 mm semi-demountable torch for 5000 series VDV/SVDV ICP-OES	G8010-60228
Double-pass spray chamber, glass cyclonic design with ball joint socket and UniFit drain outlet, for Agilent 5000 series ICP-OES	G8010-60256
SeaSpray concentric glass nebulizer for 5000 series ICP-OES	G8010-60255
Syringe, 5 mL, ADS diluter (for ICP-OES and ICP-MS carrier)	5299-0037
Syringe, 10 mL, ADS diluter (for ICP-OES diluent)	5299-0038
Sample loop ADS/AVS 1.50 mL 1.00 mm ID 1/pk	5005-0425
Peristaltic pump tubing, white/white, 12/pk	3710034400
Peristaltic pump tubing, black/black, 12/pk	3710027200
Peristaltic pump tubing, blue/blue, 12/pk	3710034600

Diluent/carrier bottle kit for ADS 2 and autosampler (6 L, HDPE)	5005-0435
Waste container kit, 10 L with Stay Safe cap and filter	5005-0437
Agilent Multi-element Quality Control Standard 27	5190-9418
Agilent 1000 ppm single element stock solution for Al, 500 mL	5190-8243
Agilent 1000 ppm single element stock solution for As, 500 mL	5190-8247
Agilent 1000 ppm single element stock solution for B, 500 mL	5190-8255
Agilent 1000 ppm single element stock solution for Ba, 500 mL	5190-8249
Agilent 1000 ppm single element stock solution for Be, 500 mL	5190-8251
Agilent 1000 ppm single element stock solution for Bi, 500 mL	5190-8253
Agilent 1000 ppm single element stock solution for Ca, 500 mL	5190-8330
Agilent 1000 ppm single element stock solution for Cd, 500 mL	5190-8328
Agilent 1000 ppm single element stock solution for Co, 500 mL	5190-8347
Agilent 1000 ppm single element stock solution for Cr, 500 mL	5190-8345
Agilent 1000 ppm single element stock solution for Cu, 500 mL	5190-8349
Agilent 1000 ppm single element stock solution for Fe, 500 mL	5190-8472
Agilent 1000 ppm single element stock solution for Ga, 500 mL	5190-8458
Agilent 1000 ppm single element stock solution for Ge, 500 mL	5190-8460
Agilent 1000 ppm single element stock solution for In, 500 mL	5190-8468
Agilent 1000 ppm single element stock solution for K, 500 mL	5190-8504
Agilent 10,000 ppm single element stock solution for Li, 500 mL	5190-8409
Agilent 1000 ppm single element stock solution for Mg, 500 mL	5190-8482
Agilent 1000 ppm single element stock solution for Mn, 500 mL	5190-8484
Agilent 1000 ppm single element stock solution for Mo, 500 mL	5190-8488
Agilent 1000 ppm single element stock solution for Na, 500 mL	5190-8526
Agilent 1000 ppm single element stock solution for Ni, 500 mL	5190-8492
Agilent 1000 ppm single element stock solution for Pb, 500 mL	5190-8476
Agilent 1000 ppm single element stock solution for Rb, 500 mL	5190-8512
Agilent 1000 ppm single element stock solution for S, 500 mL	5190-8530
Agilent 1000 ppm single element stock solution for Sb, 500 mL	5190-8245
Agilent 1000 ppm single element stock solution for Si, 500 mL	5190-8522
Agilent 1000 ppm single element stock solution for Te, 500 mL	5190-8534
Agilent 1000 ppm single element stock solution for Sr, 500 mL	5190-8528
Agilent 1000 ppm single element stock solution for Ti, 500 mL	5190-8546
Agilent 1000 ppm single element stock solution for V, 500 mL	5190-8552
Agilent 1000 ppm single element stock solution for Y, 500 mL	5190-8556
Agilent 1000 ppm single element stock solution for Zn, 500 mL	5190-8558

www.agilent.com/chem/5800icp-oes

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