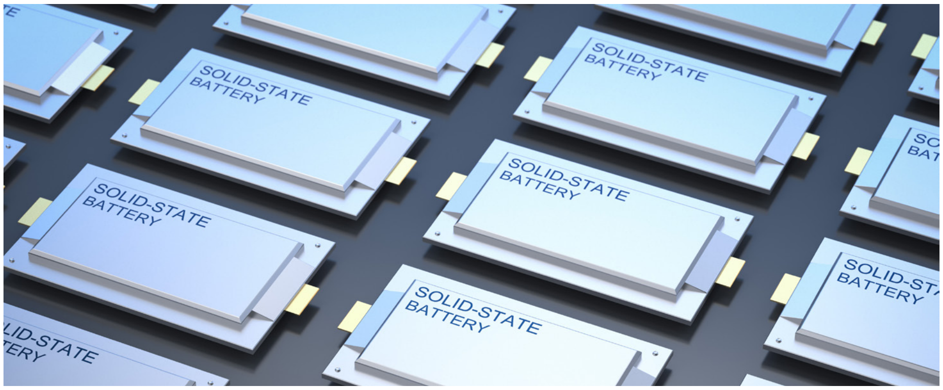
Application Note

Chemical and Energy

Determination of Elements in a Solid Sulfide Electrolyte using ICP-OES

Analysis of next generation solid-state lithium-ion battery electrolyte chemicals by Agilent 5800 VDV ICP-OES



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Introduction

The rapid expansion of renewable energy sources and electric mobility usage is driving interest in the next generation of energy storage technologies. Currently, lithium-ion batteries (LIBs) are the leading storage method that is used across a wide range of applications. However, LIBs are limited by raw material availability and high costs, as well as concerns around safety. Solid-state batteries are emerging as an alternative energy storage technology. These batteries use a solid superionic material as the electrolyte instead of traditional liquid-phase electrolytes. This material, which transmits ions through a solid crystalline lattice, has the potential for high energy density compared to conventional batteries, as well as increased safety and operating temperatures.[1] $Li_{10}GeP_2S_{12}$ (LGPS) is one such inorganic solid electrolyte that is currently being investigated due to its high ionic conductivity. As with traditional battery electrolytes, the quality and purity of the solid electrolyte must be high to effectively facilitate ion transport. The presence of elemental contaminants could potentially affect the regular lattice structures of the electrolyte and impact battery longevity, lifespan, and safety.[2,3]

Spectroscopic techniques like Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) are widely used to determine elemental contaminants in complex materials. The technique is especially useful for the simultaneous measurement of trace elements in samples such as battery electrolytes, due to its speed, sensitivity, and tolerance to high total dissolved solids (TDS).

Both the Agilent 5800 Vertical Dual View (VDV) and 5900 Synchronous Vertical Dual View (SVDV) ICP-OES instruments have been adopted across the LIB value chain to address the varied analytical needs of the industry.[4] Both instruments are ideal for labs dealing with novel materials, high numbers of samples, or aiming to make efficiency gains. In the absence of comparative methods for the analysis of LGPS, we focused on the development, optimization, and validation of the method to ensure the accuracy and reliability of the results. To support this process, we utilized the following hardware and software usability features to support the workflow throughout the study:

- IntelliQuant Screening: The fast scan software feature was used to initially screen LGPS samples for elemental content across the entire wavelength range. The semiquantitative data provided valuable information on the identity of elements in the sample, enabled selection of appropriate analyte wavelengths, and helped establish suitable calibration ranges.
- Early Maintenance Feedback (EMF): This software feature alerts the analyst when maintenance is required, based on a series of sensors, counters, and trackers. By maintaining optimum instrument operating conditions, unnecessary downtime is reduced, increasing the productivity of the instrument.
- Intelligent Rinse: A feature that adjusts washout times based on the actual time it takes to wash out each element in the sample. This intelligent rinsing routine ensures that there are no carryover issues for problematic or high concentration elements.

In this study, the 5800 VDV ICP-OES with an Agilent SPS 4 autosampler was used to determine 29 elements in battery grade LGPS electrolyte powder following microwave digestion. The elements included aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, gallium, germanium, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, sulfur, antimony, silicon, strontium, titanium, vanadium, and zinc.

Experimental

Instrumentation

Figure 1. Agilent 5800 VDV ICP-OES with Agilent SPS 4 autosampler and Agilent ICP Expert software.

The 5800 VDV ICP-OES (Figure 1) was fitted with a SeaSpray nebulizer, double-pass cyclonic spray chamber, and Agilent Easy-fit fully demountable VDV torch with a 1.8 mm internal diameter (id) injector. The SPS 4 autosampler was used for the automated delivery of samples to the instrument. The instrument was controlled using the Agilent ICP Expert software (version 7.7) with the optional Pro-pack that includes extra smart software functions like IntelliQuant Screening and Intelligent Rinse. These features helped with method development and analysis times optimization. Instrument operating parameters are listed in Table 1.

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

Parameter	Setting	
Viewing Mode	Axial	Radial
Viewing Height (mm)	-	8
RF Power (kW)	1.2	
Nebulizer Flow (L/min)	0.7	
Plasma Flow (L/min)	12	
Aux Flow (L/min)	1.0	
Replicates	3	
Rinse Time (s)*	3 to 60	
Read Time (s)	5	
Stabilization Time (s)	15	5
Sample Pump Tubing	White/white	
Internal Standard Pump Tubing	Orange/white	
Waste Pump Tubing	Blue/blue	

**Minimum and maximum rinse times as determined by Intelligent Rinse*

Standard and sample preparation

Standards were prepared at 0.050, 0.100, and 0.500 mg/L using Agilent 1000 mg/L single element calibration standard solutions in 24% reverse aqua regia. This reverse aqua regia solution was prepared in batches by adding a volumetric 3:1 ratio of nitric acid (HNO_3, 45 mL) and hydrochloric acid (HCl, 15 mL) to 190 mL of deionized (DI) water, producing 250 mL of a 24% reverse aqua regia solution. This solution differs from the typical 1:3 molar ratio of HNO_3 to HCl of regular aqua regia. The reverse formulation has been found to help with the preparation of samples such as LGPS that have a high sulfide content.[5]

A commercially available 99.9% purity LGPS sample was bought from MSE Supplies LLC (Tucson, AZ, USA), see Figure 2. The samples were prepared in concentrated reverse aqua regia, then digested by microwave digestion using a MARS 6 Microwave Digestion System (CEM, Buckingham, UK).

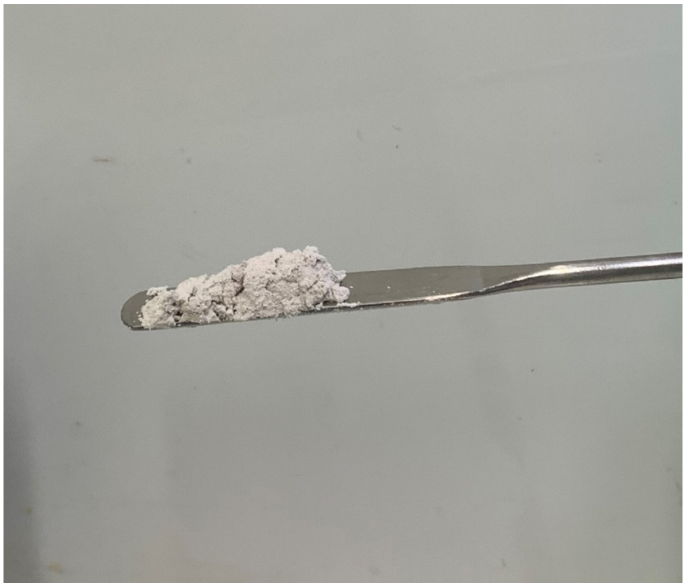


Figure 2. LGPS ($Li_{10}GeP_2S_{12}$) sample powder.

To prepare the samples for analysis, 0.100 g of the LGPS powder was accurately weighed into a 75 mL PFA MARS Xpress vessel in a fume hood while minimizing air exposure. Moisture in the air can react with the sample to generate odorous hydrogen sulfide gas. 1 mL of DI water was then added, alongside 9 mL concentrated HNO_3 and 3 mL concentrated HCl. The acids, particularly the HNO_3, were added dropwise to control the vigorous reaction and minimize gas formation.

The spiked samples were prepared by adding a spike volume of all analytes apart from Li, Ge, P, and S after the sample was weighed into the microwave digestion vessel. To prepare spikes at a concentration of 0.200 mg/L, 0.1 mL of Agilent Multi-element Quality Control Standard 27 was aliquoted accurately into the vessel. To ensure that all the analytes were included, an additional spike of Ga, also at 0.200 mg/L, was added separately using a single element standard.

The spiked samples were matrix-matched to the unspiked sample by adjusting the DI water volume. For example, for a spike volume of 0.100 mL, 0.900 mL of DI water was added to make a total volume of 1 mL. The two acids (HNO_3 and HCl) were then added as normal.

All samples were digested using the microwave program outlined in Table 2. Duplicates of each sample type were digested in the same batch and the digested solutions were transferred to tubes and diluted with DI water to 50 mL once complete. The final matrix consisted of 0.2% LGPS in 24% reverse aqua regia.

An internal standard (IS) solution comprising 5 mg/L Y and 50 mg/L Rb in 5% HNO_3 was prepared using Agilent single element standard solutions. The IS solution, which was introduced to the ICP-OES online through a Y-piece connector, was used to account for any matrix effects or ionization interferences.

Table 2. MARS 6 microwave system parameters.

Parameter	Setting
Maximum Power (W)	1800
Temperature (°C)	200
Ramp Time (min)	25
Hold Time (min)	10

Method development: IntelliQuant Screening

The IntelliQuant Screening semiquantitative analysis tool acquires full-spectrum measurements for each sample within seconds and calculates semiquantitative data based on premeasured calibrations.[7,9] Before generating a calibration range for all analytes, the tool was used to screen the digested LGPS samples, confirming the presence of Li, Ge, P, and S, and identifying the presence of any potential impurities. The periodic table ‘heat map’ view of the results provided a helpful at-a-glance snapshot of the sample’s contents, including slightly elevated levels of Fe, Cu, and Si (Figure 3). This information was used to construct an appropriate calibration range for all analytes.

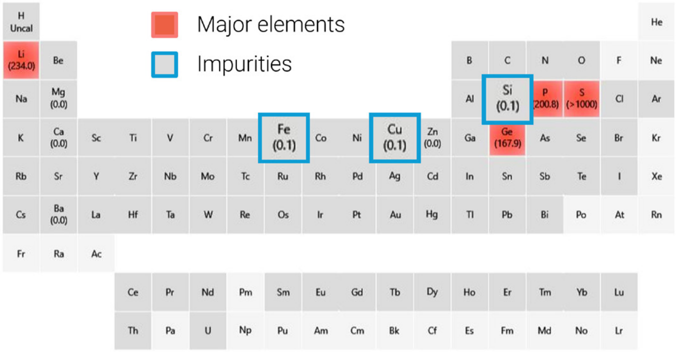
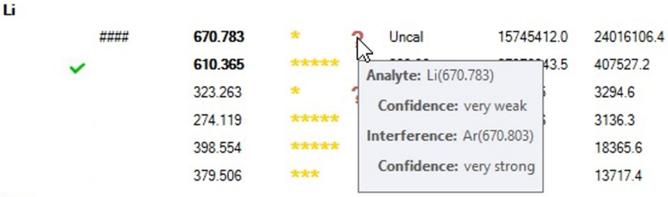


Figure 3. IntelliQuant Screening 'heat map' of 0.2% LGPS in 24% reverse aqua regia, showing semiquantitative analyte concentrations. Impurity elements have been highlighted in blue.

The IntelliQuant Screening also includes an effective wavelength star-rating system. The software can select the best analyte wavelengths to use for the quantitative method, as well as indicate poor quality wavelengths that may be subject to spectral overlaps and other suspected interferences. As shown in Figure 4 for Li, the wavelength star-rating system was used to select appropriate analyte wavelengths for the quantitative analysis of LGPS.



Li

	####	**670.783**	★	?	Uncal	15745412.0	24016106.4
✓		**610.365**	★★★★★			43.5	407527.2
		323.263	★	?			3294.6
		274.119	★★★★★				3136.3
		398.554	★★★★★				18365.6
		379.506	★★★				13717.4

Analyte: Li(670.783)
Confidence: very weak
Interference: Ar(670.803)
Confidence: very strong

Figure 4. IntelliQuant Screening wavelength rating system using Li as an example. The software recommends the Li 610.365 nm line due to an interference from Ar on the Li 670.783 line.

Optimized rinse times between samples

The Intelligent Rinse functionality proved highly useful in this application. In standard ICP-OES methods, analysts must specify a rinse time that accommodates the highest concentration samples. However, not all samples contain high analyte concentrations that require long rinse times. The Intelligent Rinse software monitors the intensities of the analytes during the rinse period and ends the rinse when the intensities reach a user-specified threshold. By removing excessive rinse periods, users save significant time during the analytical run.

In this application, Intelligent Rinse identified that samples with low analyte concentrations, such as blank solutions, did not require the regular 60 s rinse time. The software automatically shortened the rinse times for low concentration solutions significantly, while maintaining the robust rinse needed for more concentrated samples, saving a significant amount of time. When analyzing 100 samples with Intelligent Rinse compared to a normal 60-second rinse, over an hour was saved (Figure 5). The non-linearity of the Intelligent Rinse data in Figure 5 highlights periods of shorter rinse times during the analysis of QC blocks and longer rinse times for the analytical blocks of solutions containing higher analyte concentrations.

Silicon took significantly longer to wash out compared to the other elements. This was particularly evident in solutions containing high levels of silicon, such as the final calibration standard. By indicating that a 'thorough' washout was required for silicon in the software, extra time was taken to ensure that all silicon was rinsed out before the next sample measurement. Using this approach, analysts can be confident that there are no carryover issues between samples.

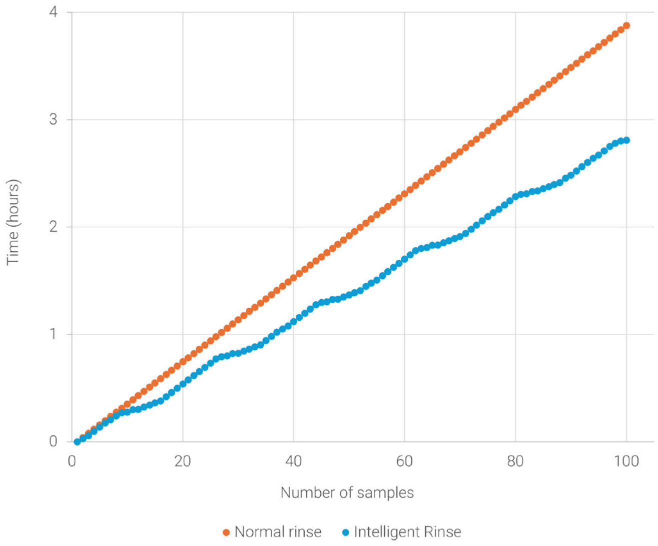
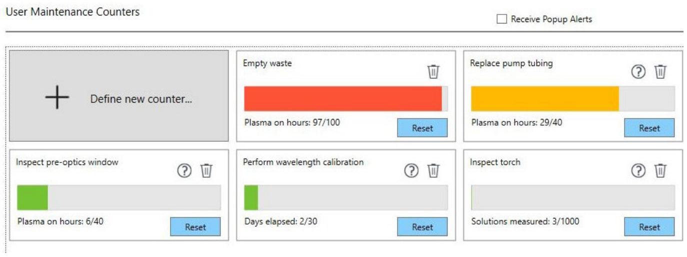


Figure 5. Time taken to analyze 100 samples using Intelligent Rinse (blue) compared to a normal rinse time of 60 s (orange).

Automatic instrument maintenance tracking

The 5800 instrument's EMF function uses a series of sensors and counters to alert the user when maintenance is required without the need for manual tracking. These alerts are especially useful in cases where multiple users are operating the same instrument. Keeping the instrument in the best condition reduces the need for remeasurements and maintains optimal-levels of instrument performance.

Since there are no established or reference methods for the analysis of the novel matrix analyzed in this study, a high volume of testing was required. To maintain optimum instrument performance over long analytical days, we set the EMF software alert to inspect and replace the pump tubing after 40 'plasma on' hours (Figure 6). Worn or blocked pump tubing affects the quality of the results, so replacing it at regular intervals avoids time-consuming and expensive re-runs.



User Maintenance Counters

☐ Receive Popup Alerts

Empty waste
Plasma on hours: 97/100

Replace pump tubing
Plasma on hours: 29/40

Inspect pre-optics window
Plasma on hours: 6/40

Perform wavelength calibration
Days elapsed: 2/30

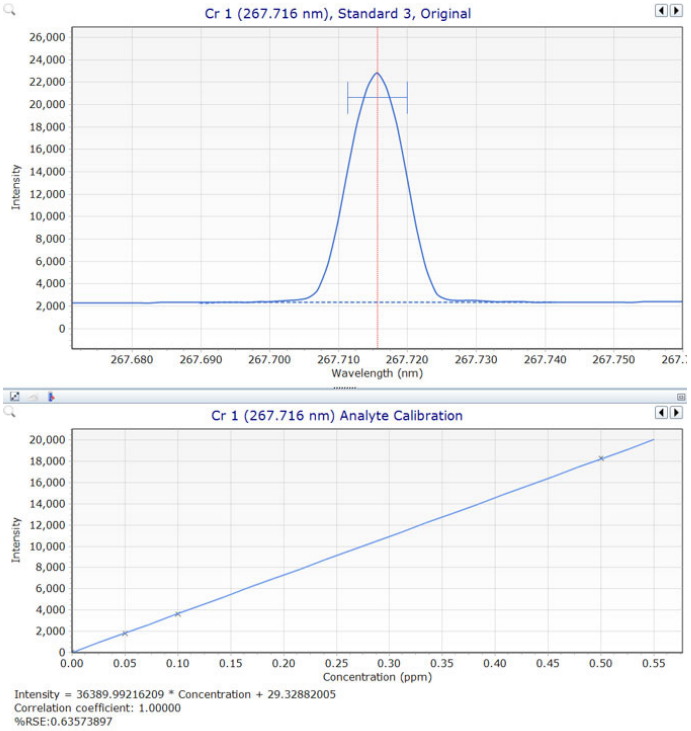
Inspect torch
Solutions measured: 3/1000

Figure 6. Early Maintenance Feedback counters indicating the status of various maintenance tasks based on user-defined time intervals.

Results and discussion

Calibration and linearity

All 29 analytes were quantified using an external standard calibration method, with background correction performed by the instrument's default and automatic Fitted Background Correction (FBC) routine. The FBC software corrects simple and complex background peaks automatically, requiring no input from the analyst. The results of the linear regression analysis of each analyte show excellent linearity across the calibration range with correlation coefficients ranging from 0.99900 to 1.00000 (Table 3). A representative spectrum and calibration curve for Cr 267.716 nm are shown in Figure 7.



```
Intensity = 36389.99216209 * Concentration + 29.32882005
Correlation coefficient: 1.00000
%RSE:0.63573897
```

Figure 7. Top: A representative spectral view of Cr 267.716 nm obtained using automatic Fitted Background Correction. Bottom: A linear calibration curve for Cr 267.716 nm with a correlation coefficient of 1.00000 and % Relative Standard Error (%RSE) of <1%.

Table 3. Analyte, background correction, internal standard, and calibration information. Major elements, Li, Ge, P, and S, are highlighted in bold.

Element and Wavelength (nm)	Viewing Mode	Background Correction	Calibration Range (mg/L)	Correlation Coefficient	IS and Wavelength (nm)
Al 396.152	Axial	Fitted	0.050 – 0.500	0.99988	Y 371.029
As 188.980	Axial	Fitted	0.050 – 0.500	0.99996	Y 371.029
B 249.772	Axial	Fitted	0.050 – 0.500	0.99998	Y 371.029
Ba 455.403	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Be 313.042	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Ca 396.847	Axial	Fitted	0.050 – 0.500	0.99998	Y 371.029
Cd 214.439	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Co 238.892	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Cr 267.716	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Cu 327.395	Axial	Fitted	0.050 – 0.500	0.99997	Y 371.029
Fe 238.204	Axial	Fitted	0.050 – 0.500	0.99931	Y 371.029
Ga 294.363	Axial	Fitted	0.050 – 0.500	0.99995	Y 371.029
K 766.491	Axial	Fitted	0.050 – 0.500	0.99995	Rb 780.026
Mg 279.553	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Mn 257.610	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Mo 202.032	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Na 589.592	Radial	Fitted	0.050 – 0.500	0.99998	Y 371.029
Ni 231.604	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Pb 220.353	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Sb 217.582	Axial	Fitted	0.050 – 0.500	0.99998	Y 371.029
Si 251.611	Axial	Fitted	0.050 – 0.500	0.99994	Y 371.029
Sr 407.771	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Ti 336.122	Axial	Fitted	0.050 – 0.500	0.99999	Y 371.029
V 292.401	Axial	Fitted	0.050 – 0.500	1.00000	Y 371.029
Zn 213.857	Axial	Fitted	0.050 – 0.500	0.99992	Y 371.029
Li 610.365	**Radial**	**Fitted**	**50 – 500**	**0.99999**	**Y 371.029**
Ge 209.426	**Radial**	**Fitted**	**50 – 500**	**1.00000**	**Y 371.029**
P 213.618	**Radial**	**Fitted**	**50 – 500**	**0.99999**	**Y 371.029**
S 182.562	**Radial**	**Fitted**	**50 – 500**	**0.99999**	**Y 371.029**

Method detection limits

Method detection Limits (MDLs) were determined by preparing a 'method blank' solution using the same digestion procedure as the samples. The method blank was prepared as follows: 9 mL of concentrated HNO_3 and 3 mL concentrated HCl were added to 1 mL of DI water and digested according to the digestion method outlined in Table 2. The solution was then transferred to a tube and diluted to 50 mL, resulting in 24% reverse aqua regia.

Three separate sets of 10 measurements were taken of the method blank solution over non-consecutive days. The MDLs were calculated as three times the standard deviation of the 10 method blank measurements. The three MDLs were then averaged and are reported both before and after the dilution factor (500x) has been applied (Table 4).

Spike recovery test

The 0.2% LGPS solutions were spiked at 0.200 mg/L for all analytes excluding Li, Ge, P and S. All spiked recoveries were within 100 ± 10% of the expected concentration, as shown in Table 4. These excellent recoveries demonstrate the accuracy of the 5800 ICP-OES method for the analysis of LGPS.

All spike information is displayed without the dilution factor applied and is representative of the spike present in the 0.2% LGPS solution.

Table 4. MDLs (calculated in sample and as 0.100 g sample in 50 mL solution, respectively), quantitative results, and spike recovery data for elements measured in LGPS using the Agilent 5800 VDV ICP-OES, n=3.

	LGPS	0.2% LGPS		0.2% LGPS + 0.200 mg/L spike	
Element and Wavelength (nm)	**MDL in Sample (mg/kg)**	**MDL in Solution (µg/L)**	**Measured Concentration (mg/L)**	**Measured Concentration (mg/L)**	**Spike Recovery (%)**
Al 396.152	0.573	1.15	0.0138	0.203	95
As 188.980	2.23	4.45	0.0154	0.206	95
B 249.772	0.362	0.724	<MDL	0.187	94
Ba 455.403	0.0373	0.0745	0.000392	0.192	96
Be 313.042	0.00750	0.0150	<MDL	0.197	99
Ca 396.847	1.18	2.36	0.0239	0.215	95
Cd 214.439	0.175	0.350	<MDL	0.193	97
Co 238.892	0.278	0.556	<MDL	0.196	98
Cr 267.716	0.277	0.554	0.00971	0.197	94
Cu 327.395	0.244	0.487	0.0617	0.249	94
Fe 238.204	0.236	0.472	0.0312	0.228	98
Ga 294.363	1.82	3.64	<MDL	0.191	94
K 766.491	1.62	3.23	<MDL	0.198	98
Mg 279.553	0.0703	0.141	0.00651	0.199	96
Mn 257.610	0.0554	0.111	0.000756	0.196	97
Mo 202.032	0.464	0.929	<MDL	0.196	98
Na 589.592	1.24	2.48	0.00988	0.204	97
Ni 231.604	0.615	1.23	0.00332	0.200	98
Pb 220.353	1.59	3.18	<MDL	0.190	95
Sb 217.582	1.60	3.20	<MDL	0.189	94
Si 251.611	2.42	4.84	0.0240	0.213	94
Sr 407.771	0.00837	0.0167	0.000179	0.195	97
Ti 336.122	0.115	0.230	0.00186	0.197	97
V 292.401	0.529	1.06	<MDL	0.194	97
Zn 213.857	0.213	0.427	0.000827	0.202	100
Li 610.365	4.62	9.25	212		
Ge 209.426	30.1	60.1	208		
P 213.618	7.31	14.6	190		
S 182.562	61.9	124	1115		

The quantitative data of the major elements (Li, Ge, P and S) aligned with the semiquantitative data to an accuracy of 100 ± 20%, showing the value of IntelliQuant Screening as a method development tool.

Long-term stability

To assess the stability of the 5800 VDV ICP-OES, 241 solutions were measured over eight hours without recalibration. The solutions consisted of 10 LGPS solutions and a QC block, which contained a rinse, Continuing Calibration Blank (CCB), and Continuing Calibration Verification (CCV) solutions. The CCV solution contained 0.250 mg/L of all analytes except Li, Ge, P and S, which were present at 250 mg/L. The recovery of the CCV was then plotted, as shown in Figure 8. The stability of all elements were within 100 ± 5%, with no QC failures over the entire analytical run. The precision of all elements, displayed as % Relative Standard Error (%RSD) was ≤2.5%, except As, which was ≤5%. The recovery data demonstrates the robustness of the 5800 VDV ICP-OES for the analysis of solid-state electrolyte material for over eight hours.

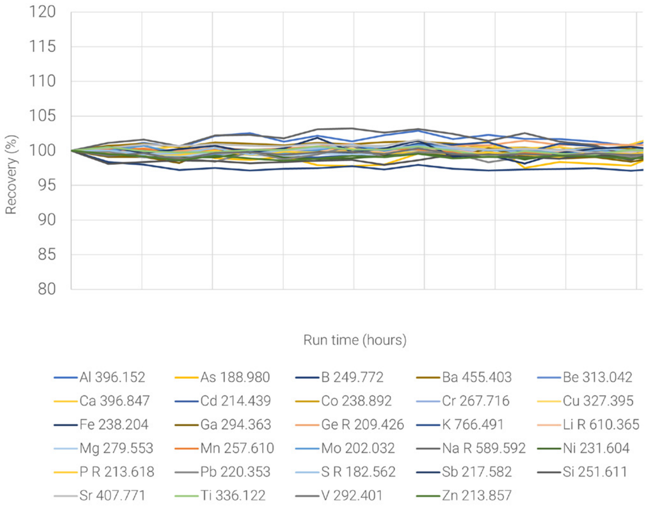


Figure 8. Normalized recovery of QC solutions over eight hours, with no analyte exceeding 100 ± 5%.

Conclusion

The Agilent 5800 VDV ICP-OES with the Agilent SPS 4 autosampler was used to quantify 29 elements in 99.9% LGPS—a solid superionic material used as an electrolyte in solid-state LIBs. The samples were prepared using microwave digestion in reverse aqua regia and then analyzed by ICP-OES. With no previous methods available for reference, the following smart tools were used during the study to simplify method development and optimize the analytical workflow, ensuring consistent high-quality results throughout the analysis:

- The IntelliQuant Screening method development tool was used to set an appropriate calibration range and to select the best wavelengths to use for the quantitative method.
- Intelligent Rinse greatly reduced the analysis time by monitoring analyte intensities and rinsing for the minimum required time, while maintaining data accuracy. More than 60 minutes were saved for every 100 solutions using the intuitive rinse routine, compared to the standard 60-second rinse time per solution.
- Early Maintenance Feedback alerted the analyst when maintenance was required based on real usage, maintaining optimum instrument performance and uptime.

The accuracy of the method was evaluated by conducting spike recovery tests of the LGPS sample. Recoveries were within 100 ± 10% in all cases, with precision (%RSD) of most elements below 2.5%. The instrument also displayed excellent stability over the eight-hour run without failing a single QC measurement. This study demonstrates that manufacturers of solid-state battery electrolytes can reliably and accurately measure impurity elements using the 5800 VDV ICP-OES.

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9. Agilent IntelliQuant Software: For greater sample insight and simplified method development, Agilent publication, 5994-1516EN

Note: The Agilent 5800 VDV ICP-OES requires ICP Expert Pro pack software to access IntelliQuant Screening and Intelligent Rinse. ICP Expert Pro pack software is standard with the Agilent 5900 SVDV system.

Agilent part numbers

Description	Part Number
Easy-fit 1.8 mm semi-demountable torch for 5000 series VDV/SVDV ICP-OES	G8020-68005
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
Peristaltic pump tubing, white/white, 12/pk	3710034400
Peristaltic pump tubing, orange/white, 12/pk	3710046900
Peristaltic pump tubing, blue/blue, 12/pk	3710034600
Diluent/carrier bottle kit for ADS 2 and Autosampler (6L HDPE)	5005-0435
Waste container kit, 10L 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 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	5190-8457
Agilent 10,000 ppm single element stock solution for Ge, 100 mL	5190-8390
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 10,000 ppm single element stock solution for P, 500 mL	5190-8429
Agilent 1000 ppm single element stock solution for Pb, 500 mL	5190-8476
Agilent 1000 ppm single element stock solution for Rb, 500 mL	5190-8440
Agilent 10,000 ppm single element stock solution for S, 500 mL	5190-8210
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 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

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