Agilent

Trusted Answers

Leave Interferences Behind With MS/MS

Agilent 8900 Triple Quadrupole ICP-MS



Put Your ICP-MS Results Beyond Doubt

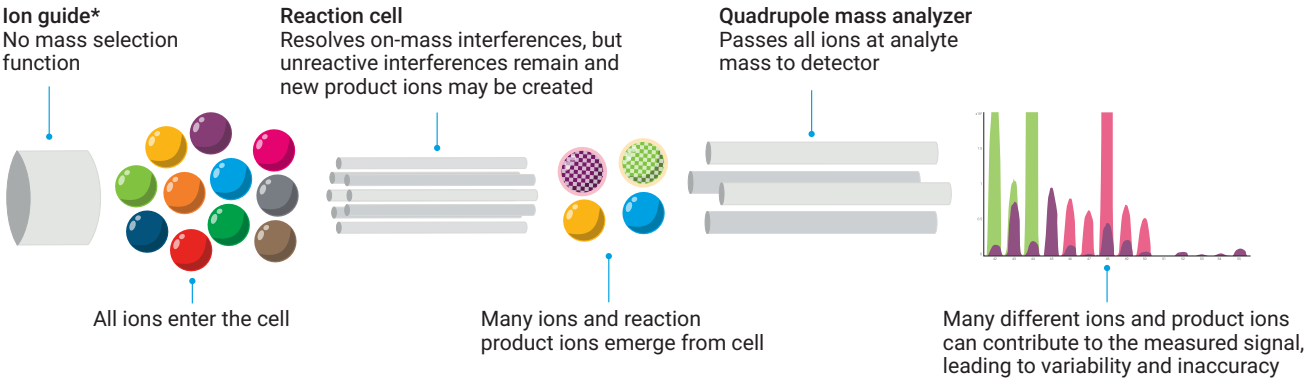
Reliable interference removal is easier to achieve with the second generation Agilent 8900 ICP-QQQ.

In 2012, Agilent released the Agilent 8800, the world's first triple quadrupole ICP-MS (ICP-QQQ) with MS/MS capability. This ground-breaking instrument created new analytical possibilities for analysts in hundreds of laboratories around the world.

The second generation 8900 ICP-QQQ suits a range of situations, from routine contract analysis to research, and materials analysis. The 8900 ICP-QQQ has the helium mode performance and productivity of Agilent's market-leading quadrupole ICP-MS systems. In addition, it has MS/MS mode for controlled and consistent interference removal in reaction mode. This capability makes it a powerful and flexible multi-element analyzer.

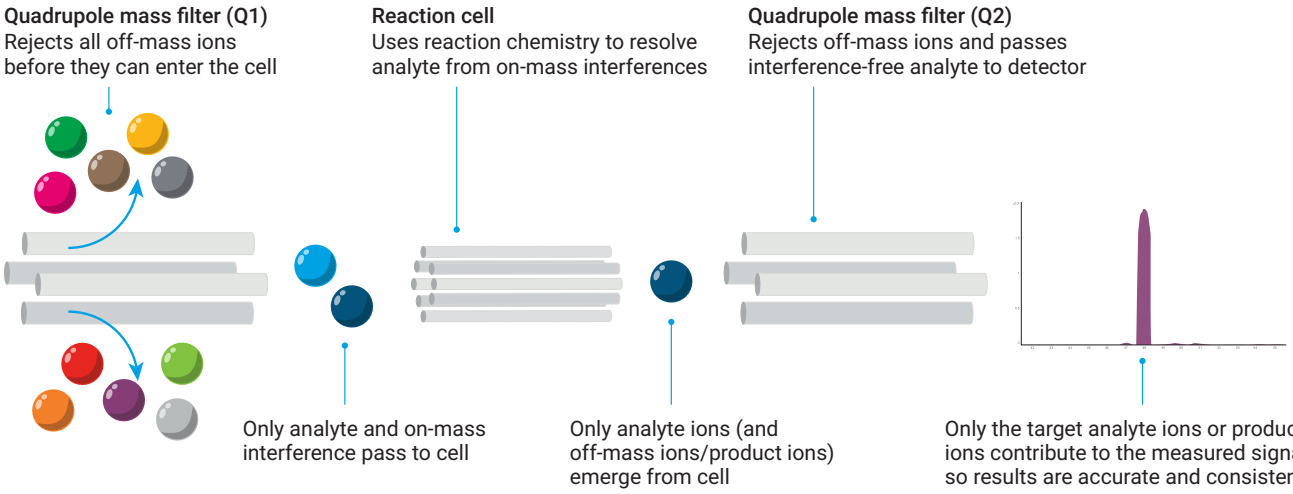
The MS/MS advantage for reaction gas methods

Single Quadrupole ICP-MS



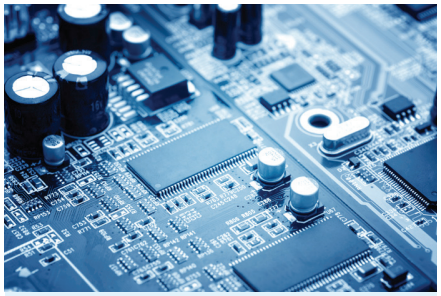
* A quadrupole ion guide may be operated as a low mass cutoff or bandpass filter, rejecting some – but not all – non-target ions

Agilent Triple Quadrupole ICP-MS with MS/MS



Proven ICP-QQQ Technology

Agilent's unique triple quadrupole ICP-MS uses MS/MS, enabling hundreds of labs around the world to do more than ever before.



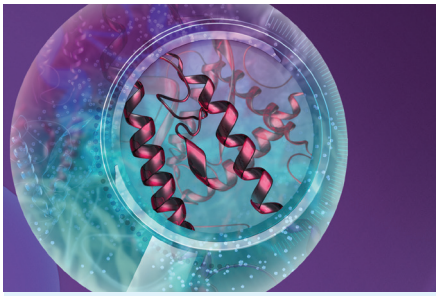
Semiconductor and materials

Dissolved metal and particulate contamination of **process chemicals and materials** is a major issue for semiconductor manufacturing. ICP-QQQ is used to monitor lower levels of ultratrace contaminants in raw materials, bulk chemicals, and wafer processing baths to ensure high product yield and minimize failure rates.



Nuclear research

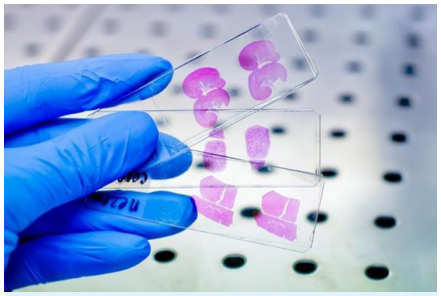
The 8900 ICP-QQQ uses MS/MS and reaction chemistry to resolve uranium-based interferences and measure radionuclides at ultratrace levels. Applications include trace ^{236}U isotope analysis, ^{237}Np in uranium matrices, and direct analysis of ^{93}Zr in nuclear decommissioning samples.



Life science and biopharma

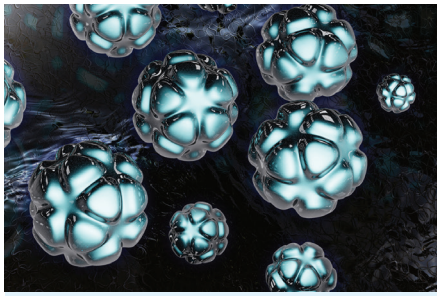
ICP-QQQ can be used to accurately quantify unknown **proteins and peptides.** This is done using MS/MS mode to measure the sulfur and phosphorus hetero elements accurately at low concentrations.

For Research Use only. Not for use in diagnostic procedures.



Bioimaging and single-cell analysis

ICP-QQQ supports advanced biological research from elemental analysis of individual cells to spatial mapping of metals in tissue. Fast time-resolved analysis measures elemental content in single cells, while LA-ICP-MS reveals the distribution of metals and metal-containing compounds across biological samples.



Nanoparticles

There's increasing interest in measuring **nanoparticles (NPs)** in the environment, food, and biological systems. But NPs based on silica and titanium are difficult to measure at small enough particle sizes using quadrupole ICP-MS. ICP-QQQ with MS/MS can characterize these NPs in complex samples, even at the sub-50 nanometer scale.



Geology

Reaction cell chemistry in Agilent's ICP-QQQ can separate direct isobaric overlaps. This includes mercury 204 on lead 204, rubidium and strontium 87, and ytterbium and lutetium 176 on hafnium 176, to give access to important isotopic clocks in **geochronology.** This is far beyond the resolution available on sector field high-resolution ICP-MS.

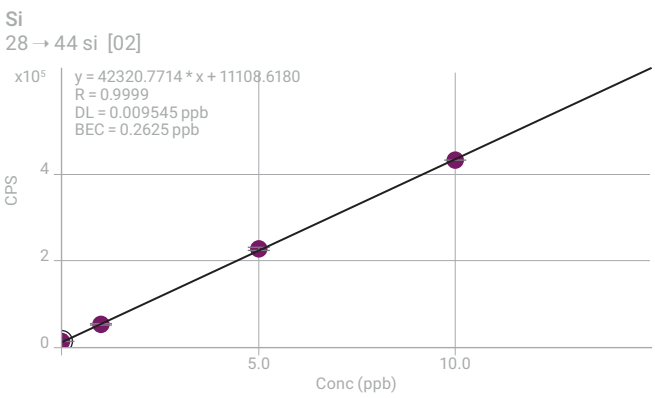
Be Sure With ICP-MS/MS

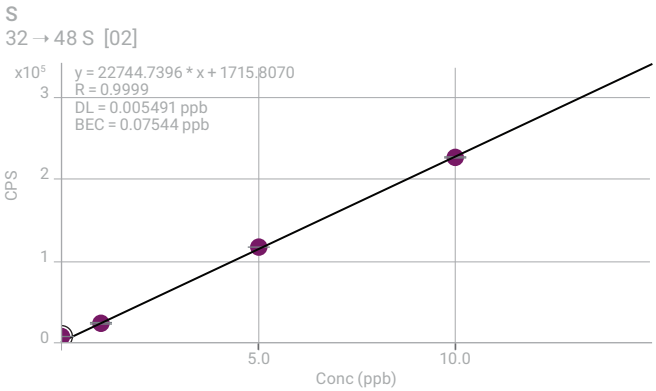
The Agilent 8900 ICP-QQQ provides outstanding performance for existing multi-element ICP-MS applications. The 8900 also introduces analytical capabilities not previously possible using ICP-MS. Low-level determination of previously difficult elements, separation of direct isobaric overlaps, and fast, trace analysis of emerging nano-scale materials extend the application of ICP-MS into new fields of analysis.

Ultratrace analysis of silicon and sulfur

Si and S suffer from intense polyatomic interferences and have not previously been possible to measure at ng/L (ppt) levels using quadrupole ICP-MS. ICP-QQQ offers the most reliable approach to resolving interferences using MS/MS and reactive cell gases. The 8900 ICP-QQQ Advanced Applications and Semiconductor configurations add unprecedented control of background signals for silicon and sulfur, using a new gas flow system to minimize Si and S contamination.

The calibrations, following, demonstrate detection limits (DLs) of <10 ng/L for Si (top) and S (bottom) using the 8900 ICP-QQQ in MS/MS mode with O_2 cell gas.



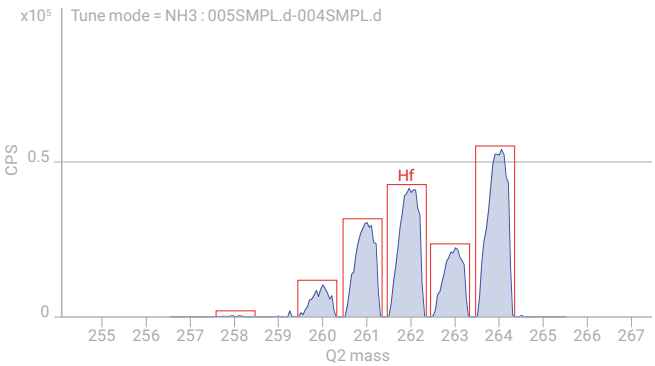


Resolve isobaric overlaps

How can ICP-QQQ, operating at a nominal resolution of 1 u, provide superior resolution to sector-field high-resolution (HR) ICP-MS? The answer lies in the selectivity of reaction chemistry with MS/MS. By choosing a cell gas that reacts with one element and not another, ICP-QQQ can use MS/MS to separate directly overlapping isobars. Isobars are isotopes of different elements that occur at the same mass, for example ^{204}Hg on ^{204}Pb. Separating such isobars would require mass resolution ($M/\Delta M$) far beyond the capability of commercial HR-ICP-MS.

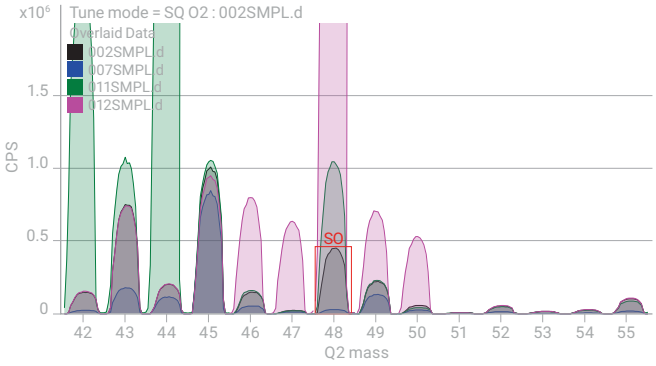
There are several applications in geochemistry, geochronology, and nuclear science where isobaric overlaps make accurate analysis difficult. Examples in geochronology include the accurate determination of ^{176}Hf/^{177}Hf ratios, Pb/Pb and Pb/U dating, and Rb-Sr ratio analysis. In nuclear science, radiogenic isotopes, such as ^{93}Zr, ^{151}Sm, and ^{129}I are often overlapped by a natural isotope of a different element. The isobars can be separated using ICP-MS/MS and a reactive cell gas.

The spectrum, following, shows Hf measured as the product ions $Hf(NH_2)(NH_3)_4^+$ using the 8900 ICP-QQQ. MS/MS allows accurate $^{176/177}$Hf isotope ratios to be measured in the presence of Lu, Yb, and other matrix elements that might overlap at *m/z* 176.

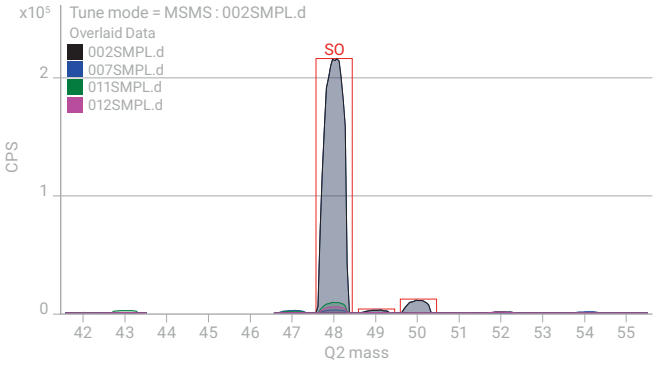


Accurate analysis of sulfur and sulfur isotope ratios using MS/MS

Using O_2 cell gas, S can be measured as the product ion SO^+ at *m/z* 48 (for the major ^{32}S isotope), 49, and 50. Measurement of multiple isotopes allows S isotope ratio analysis and accurate quantification using isotope dilution (ID). The 8900 ICP-QQQ with MS/MS is essential for this application, as carbon, calcium, and titanium can cause interference when the SO^+ product ions are measured without MS/MS, as illustrated, following.



Without MS/MS, Ca (in green), Ti (in pink), and C (in blue) cause severe overlaps on the SO^+ product ions.

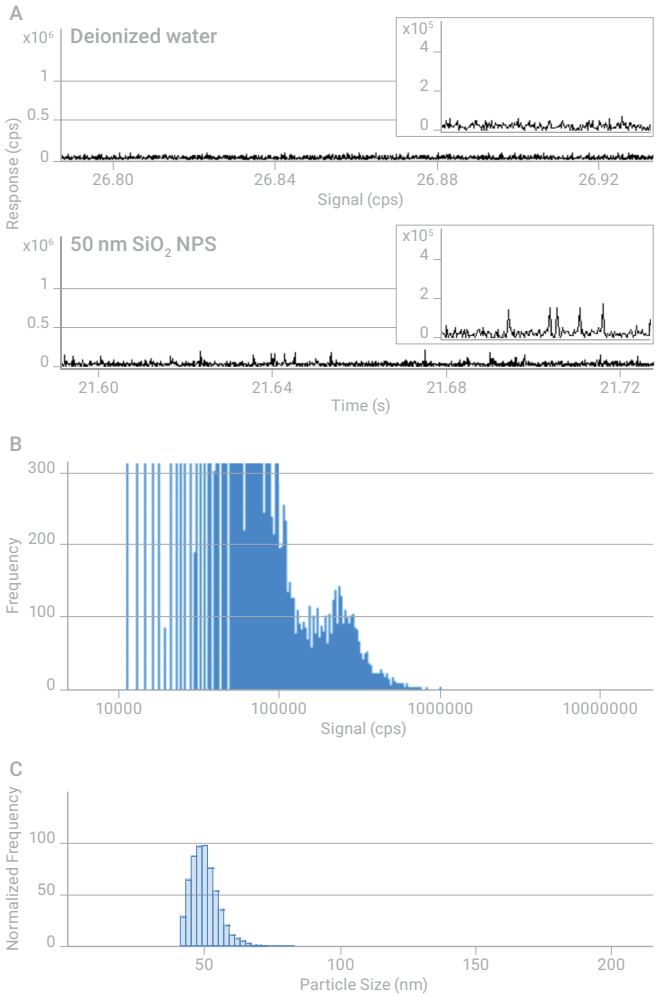


With MS/MS, Q1 rejects the Ca^+, Ti^+ and C^+ ions, so the SO^+ product ions are measured accurately and consistently, free from overlap.

Nanoparticle (NP) characterization using single particle/cell ICP-MS (sp/scICP-MS)

The 8900 ICP-QQQ provides both very high sensitivity and fast time resolved analysis (TRA) using a minimum dwell time of 0.1 ms. Sensitivity and high speed are combined with effective interference removal, extending existing nanoparticle analysis to include particles composed of elements such as Si, S, Fe, and Ti. These nanoparticles are difficult to measure using quadrupole ICP-MS.

The example, following, shows that 50 nm SiO_2 NPs can easily be distinguished from the signal in the blank DI water (A). This capability allows the frequency distribution to be plotted (B) and the particle size to be determined accurately (C).



Leave Interferences Behind With MS/MS

Ultra High Matrix Introduction (UHMI)

UHMI increases matrix tolerance up to 25% total dissolved solids (TDS). UHMI is standard on the 8900 Standard and Advanced Applications configurations, ensuring high matrix samples can be measured routinely, and eliminating matrix suppression.



Sample Introduction

Low-flow, Peltier-cooled sample introduction system provides stability and consistency. Optional Advanced Valve System (AVS MS) adds a piston pump and close-coupled 7-port valve for high-speed discrete sampling.



Gas Control

Four channel argon mass flow control for plasma gases. Advanced and Semiconductor configurations include 5th (option) gas controller and low Si/S argon flow path.

27 MHz Plasma RF Generator

The fast, frequency-matching RF generator offers the highest power transfer efficiency, tolerating changing sample matrices including volatile organic solvents.

Plasma and Shield Torch System (STS)

Provides high energy for effective matrix decomposition, and precise ion energy control for efficient interference removal in helium mode. Torch auto-aligns following routine maintenance.

Interface Cones

Ni or Pt-tipped cones deliver exceptional matrix tolerance and high sensitivity. Screw-threaded for easy removal during routine maintenance.



Ion Lens

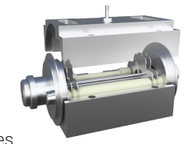
The dual extraction lens and off-axis omega lens provide high ion transmission and matrix tolerance in a single optimized interface. The ion lens is located outside the high vacuum region, making it easy to access for routine maintenance.

Some items shown are optional at additional cost.
Contact your Agilent Representative for further details.

First Quadrupole Mass Filter (Q1)

High frequency, hyperbolic quadrupole mass filter. In MS/MS, Q1 operates at 0.7 u resolution, rejecting all masses except the target analyte mass, and so controlling reaction chemistry in the cell.

4th-Generation Octopole Reaction System (ORS^4)



Temperature-controlled collision/reaction cell with a 4-channel gas controller for flexibility in cell gas methods. Operates in helium (He) mode and also provides effective, consistent control of interferences in reaction mode with MS/MS. Axial acceleration (Advanced Applications and Semiconductor configurations) enhances sensitivity and controls creation of high-order product ions.

Electron Multiplier Detector

Dual-mode, discrete dynode electron multiplier provides up to 11 orders dynamic range. Short (0.1 ms) minimum dwell time supports fast-transient signal analysis (optimal for single nanoparticles, single cells, and laser ablation).

Second Quadrupole Mass Filter (Q2)

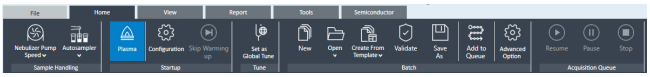
The second high-frequency hyperbolic quadrupole mass filter is also typically operated at 0.7 u resolution. Q2 selects the ions that emerge from the cell exit, passing only the target analyte ions/product ions to the detector.

Vacuum System

High-performance 4-stage pumping system with one split-flow turbo pump, a second turbo pump, and a single external foreline pump. The enhanced vacuum performance contributes to the very high sensitivity and low background of the 8900 ICP-QQQ, while ensuring that Q1 achieves the <1 u resolution capability needed for MS/MS.

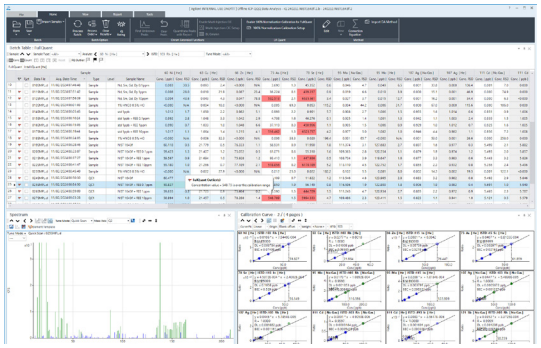
The term "triple quadrupole" (or QQQ) is defined by IUPAC as a *"Tandem mass spectrometer comprising* ***two transmission quadrupole mass spectrometers*** *in series, with a (nonselecting) RF-only quadrupole (or other multipole) between them to act as a collision cell."* IUPAC 2013 Recommendations, Term 538.

Powerful, Flexible, Intuitive ICP-MS Software



OpenLab ICP-MS software uses an intuitive Task Navigator and toolbar layout, making it easy to learn and use:

- The home tab provides easy access to common setup and operation functions, such as Startup, Batch, and Acquisition Queue.
- The acquisition pane brings together tune settings, element selection, and acquisition parameters. IntelliQuant Assistant preselects preferred cell modes for each analyte, providing even simpler method setup.
- The sequence pane contains the sample list, and the queue pane displays current and scheduled tasks, current batch progress, and a real-time acquisition monitor for the current sample.
- The data analysis pane provides real-time updates of the data batch table during sequencing. The data table is interactive, displaying the sample spectrum or chromatogram for the currently selected, internal standard and QC recoveries, and calibration plots.
- Customizable outlier flags are included, together with LabQC charts, functionality for spike recoveries, and method-specific performance reports.



OpenLab ICP-MS Data Analysis pane, showing interactive batch table, outlier flags, current sample spectrum, and calibration summary.

Preset methods and automation

Many common applications can be setup with a few mouse-clicks, using OpenLab ICP-MS predefined preset methods and report templates. For new methods, the Method Wizard builds an optimized method based on your sample type and application. Routine batch analysis is easier than ever using the optional ICP Go simplified user interface.

OpenLab ICP-MS software handles automated startup checks following plasma ignition, through method setup and sequencing, to integrated data processing and final report generation. OpenLab ICP-MS includes system checks to ensure that your Agilent 8900 ICP-QQQ performs superbly, whatever the analytical needs.

OpenLab ICP-MS software compatibility

For regulated industries such as pharmaceutical manufacturing, OpenLab ICP-MS software can be integrated with Agilent compliance solutions. This combination provides data security, integrity, and traceability solutions from single workstation to global enterprise level.

OpenLab ICP-MS is also compatible with Agilent's Mass Profiler Professional (MPP), which provides tools for detailed statistical evaluation of ICP-MS data sets.

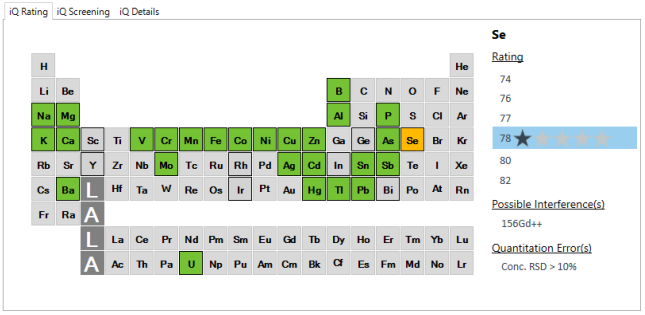
OpenLab ICP-MS software is used across Agilent MS platforms, simplifying cross training for Agilent quadrupole ICP-MS, ICP-QQQ, LC/MS, and GC/MS products.

IntelliQuant and Star Rating

IntelliQuant uses a rapid full-spectrum scan to semi-quantitatively analyze every sample even for elements not calibrated. It uses this and other data to highlight result quality issues using a simple five-star rating. This gives confidence in the data while giving quick access to any problems. The star rating uses multivariate data analysis, reducing analyst stress and time needed to assess data quality. The star rating considers:

- Interferences from unknown elements and matrix components
- Measurement quality
- Detection limits

This happens for every measured isotope in every sample throughout the run; it's like having a QC on every sample.



Extend Your Nanoparticle or Single Cell Analysis

Preset methods for nanoparticle and single cell analysis

The optional Single Nanoparticle (NP) Application Module in OpenLab ICP-MS software includes preset methods for both single particle analysis (spICP-MS) and nanoparticle analysis using field-flow fractionation (FFF-ICP-MS). Measurement of the metal content of single cells (scICP-MS) is also supported.

The spICP-MS Method Wizard uses predefined and user-entered values to calculate essential method variables. Calibration of particle size and number is performed automatically using the analysis of specific spICP-MS reference samples.

The method includes an integrated tool to calculate the nebulization efficiency. This value is required to calculate the particle number and to convert the measured signals to particle sizes.

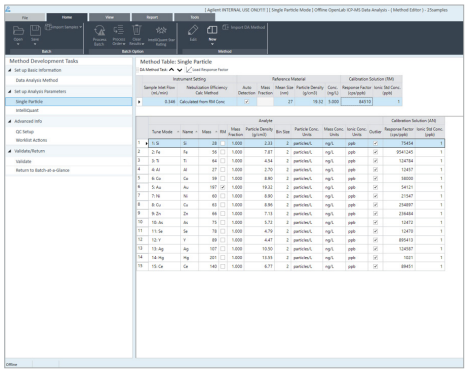
Integrated NP data analysis

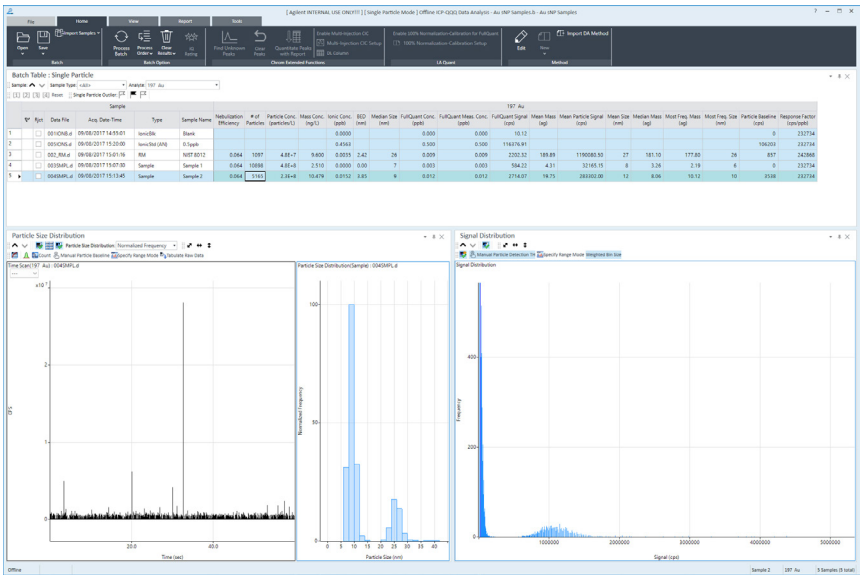
The optional Single Nanoparticle Application Module provides comprehensive data analysis tools for processing NP or single cell signals.

Calculations are included for both peak integration mode (where short integration times are used and multiple measurements are made across each particle signal “plume”), and single scan mode (where the integration time is longer than the duration of the particle signal).

A proprietary algorithm ensures that small particles can be reliably discriminated from the background signal. Calculation of the Background Equivalent Diameter is performed automatically, giving an estimate of the minimum detectable particle size capability of the method.

The module includes a Rapid Multi-Element NP Analysis mode, allowing multiple analytes to be determined in a population of NPs from a single sample acquisition.





Agilent’s optional Single Nanoparticle Application Module for OpenLab ICP-MS includes a Method Wizard to automate setup for single particle (above) or field-flow fractionation (FFF) mode. Integrated data analysis uses the OpenLab ICP-MS batch table (right), taking you from raw signals to quantitative NP characterization.

Proven Speciation Capability



Integrated speciation with ICP-QQQ

Environmental, food safety, pharmaceutical, and consumer product regulations increasingly require the identification and quantification of elemental species as well as total concentrations. Agilent offers the most comprehensive range of integrated speciation systems and methods for ICP-QQQ, including LC, CE, IC, FFF, and more.

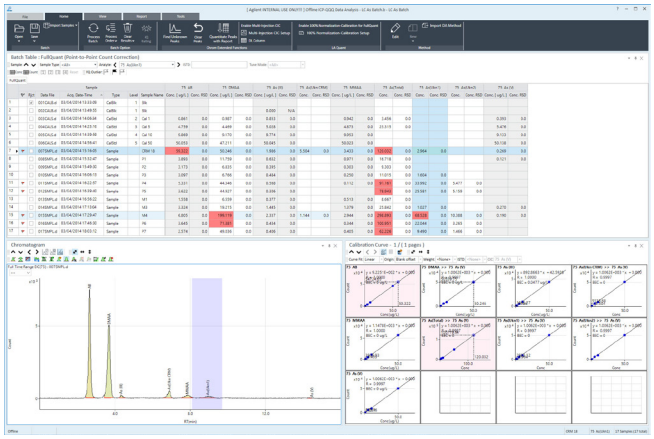
Petrochemical applications require the superior sensitivity and interference control of the Agilent 8900 ICP-QQQ to meet ever lower detection limit requirements for a wider range of analytes. Life science bio-analysis benefits from accurate quantitative analysis of elements such as S, P, and Cl, which are difficult to measure using conventional quadrupole ICP-MS.

Preconfigured LC-ICP-MS kits

LC/IC is by far the most common separation technique coupled to ICP-MS, and Agilent can offer a range of preconfigured kits for Capillary and nanoflow LC-ICP-MS as well as conventional HPLC/IC-ICP-MS. With high sensitivity and reliable control of interferences, the 8900 ICP-QQQ is the ideal solution for advanced LC/IC-ICP-MS applications.

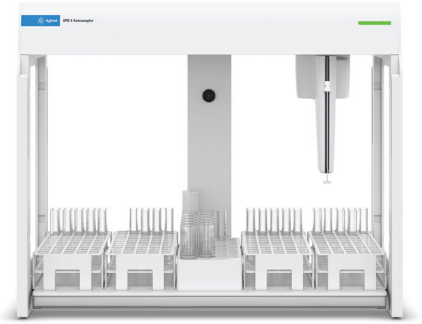
Chromatographic data analysis

Agilent ICP-MS Chromatographic software seamlessly handles chromatographic data on the 8900 ICP-QQQ. Developed by Agilent, this optional software enables powerful integration, calibration, including Compound Independent Calibration (CIC), and quantification capabilities. It also includes the Agile2 integrator that provides parameter-less integration for accurate and consistent LC peak detection, without requiring the operator to manually enter integration parameters.



LC-ICP-MS chromatogram for arsenic speciation using calibrants: arsenobetaine (AB), dimethylarsinic acid (DMAA), arsenite (As(III)), monomethylarsonic acid (MMAA), and arsenate (As(V)). Unknown arsenic species and total arsenic were quantified using CIC, based on the inorganic As(V) response.

Options and Accessories



SPS 4 and SPS 6 Autosamplers

High-performance autosamplers designed for both everyday high-throughput and higher-capacity laboratories. The SPS 4 holds up to 360 samples, while the SPS 6 holds up to 540 samples, for longer unattended runs. Robust, easy to use, and ideal for automated elemental analysis.



Advanced Dilution System (ADS)

Designed and manufactured by Agilent, the ADS automates standard preparation and pre-run sample dilutions. It also automates post-run sample dilutions for over-range samples using real-time reactive dilutions during the analysis. Automating dilutions removes common sources of human error, contamination, and wasted time.



I-AS Autosampler with pumped rinse station

Ideal for ultratrace analysis in high purity semiconductor chemicals, and for analysis of small sample volumes (0.5 mL). Flexible rack configurations offer a maximum capacity of 89 vials, plus 3 rinse vials.



Advanced Valve System (AVS MS)

High-speed uptake pump and close-coupled 7-port switching valve provide fast analysis of less than 1 minute per sample with discrete sampling.

SEMI S2 Compliance Kit

Includes an Emergency Off button for the 8900 Semiconductor ICP-QQQ. Together with customer-provided lab safety measures, this kit ensures compliance with SEMI S2 guidelines.

Integrated software for setup and control of third-party accessories

Agilent's software developer's kit (SDK) for OpenLab ICP-MS allows third-party accessory suppliers to embed their product drivers into OpenLab ICP-MS workflows. This integration delivers a method setup and run control interface that works seamlessly from the OpenLab ICP-MS workstation PC.

SDK plug-ins extend the scope of the ICP-MS operation by adding the capabilities of a third-party accessory.

Optional accessories support a range of configurations and applications

Nebulizer options include low-flow, concentric, inert (HF resistant), and parallel path; a range of alternatives to suit your unique sample types and volumes.

Inert sample introduction kit is O-ring free, and manufactured from PFA for low contamination levels. HF resistant and suitable for high-purity reagents.

Organics kit contains the sample introduction parts you need to run most organic solvents.

Laser ablation (LA-ICP-MS) Integrated software control enables direct solid sample analysis for bulk and time resolved applications, including imaging applications requiring extended acquisition times (more than 24 hours).

Field Flow Fractionation (FFF)
When coupled to the Agilent 8900 ICP-QQQ, Asymmetric Flow FFF (AF4) offers an ideal separation and detection approach for characterizing the nanoparticle content of a sample.

Agilent parts and supplies

Manufactured to stringent specifications to ensure top quality, and rigorously tested to maximize instrument performance.

For more information, see:
www.agilent.com/chem/icp-ms-supplies

Agilent CrossLab: Real insight, real outcomes

CrossLab goes beyond instrumentation to bring you services, consumables, and lab-wide resource management. So your lab can improve efficiency, optimize operations, increase instrument uptime, develop user skill, and more.

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