

Battery solutions

Analytical technologies that help build better batteries



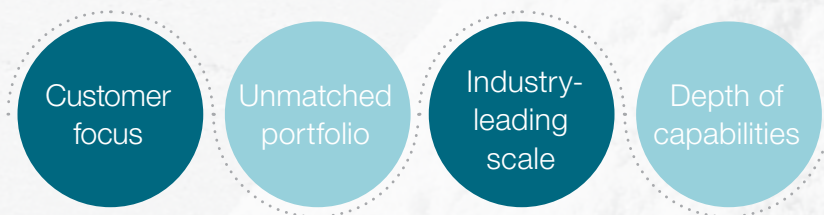
Driving the future of battery technology together

The race toward advanced battery solutions is on, and lab productivity is key

As lithium-ion batteries play an increasingly crucial role in everything from handheld electronics to electric vehicles, your lab needs to accelerate insights and answers to achieve technology advancements and meet essential sustainability goals. Thermo Fisher Scientific offers a broad range of instruments and tools to support you through the battery manufacturing continuum—from the extraction and processing of raw materials, through quality assurance in the production line, to material recovery in recycling, as well as assisting with the research and development of next-generation batteries. It's how we help scientists make big strides toward a sustainable, zero-carbon future.

Our commitment to scientific advancement

We offer products and solutions that enable customers to push the boundaries of innovation





We take pride in our Mission—we enable our customers to make the world healthier, cleaner and safer

Our shared vision: a cleaner, safer world

Our commitment is to help ensure a clean and safe environment, now and for the future. With deep experience across multiple technology areas, we can provide scientific guidance to ensure you find the right battery material analysis solutions to meet your business needs. As the world leader in serving science, we stay at the forefront of technology so that you can stay one step ahead.

Help meet global sustainability goals

Climate change and environmental degradation are existential threats to our world. Batteries that are more sustainable throughout their lifecycle are key aspects of various geographic sustainability investments focused on strengthening clean energy production. Global green initiatives are driving widespread changes across our world. To lead the way in a dynamic time, you need an ally that has the expertise, experience and a full lineup of solutions you need to advance your work.

Power to see the unseen: chromatography and mass spectrometry

Improving battery safety, charging speed, power output and longevity

When studying lithium-ion batteries, our range of state-of-the-art technologies help researchers gain new insights to improve safety and longevity, decrease charging time and boost power output:

- Superior stability for quantifying major elements, such as lithium, nickel, manganese, iron, phosphorus and cobalt
- Electrolyte composition and purity confirmation
- Analysis of electrolyte degradation products
- Characterization of battery aging and performance
- Fast, robust, accurate and precise detection of trace level impurity elements
- Enabling users of all skill levels to confidently obtain reproducible, high quality results



Comprehensive expertise and solutions across the entire battery continuum



Research

Work:

- Development of next-generation battery materials and improvements in existing lithium battery technologies

Processes:

- Novel cathode active materials (CAMs) research
- Electrolyte, cathode and anode material degradation product studies
- Exploration of new methods and improvement of existing techniques for battery material recycling
- Development of next generation batteries (solid state, sodium)

Analytical need:

- Material composition and purity characterization
- Failure analysis

Analytical techniques:

- ICP-OES
- ICP-MS
- IC/IC-MS
- LC/LC-MS
- GC/GC-MS
- HR-ICP-MS
- GD-MS
- EA



Raw materials

Work:

- Mining, processing and refining of raw materials such as lithium, manganese, graphite and silicon
- Ensure raw materials meet specifications and standards

Processes:

- Mined material processing
- Refined product purity analysis
- Quality assurance and control

Analytical need:

- Bulk process control and quality control (QC)
- Mineral, ore and brine analysis for lithium and impurity element content
- Confirmation of material quality

Analytical techniques:

- ICP-OES
- ICP-MS
- IC/IC-MS
- EA



Cell components and assembly

Work:

- Development of novel chemistries, anodes, cathodes, electrolytes and separators
- Mixing of materials, coating, drying, calendaring and stacking of rolls
- Packaging into pouches, prismatic or cylindrical forms
- Line inspection

Processes:

- Manufacturing of battery cells and/or cell arrays
- Electrolyte composition confirmation

Analytical need:

- Ensure quality of design
- Process control
- In-line inspection
- Failure analysis and material rejection
- Composition measurement
- Detection and quantification of elemental impurities
- Degradation studies
- Research and routine QA/QC measurement

Analytical techniques:

- ICP-OES
- ICP-MS
- GC/GC-MS
- IC/IC-MS

The surge in demand for advanced batteries is driving significant investments along every step of production. We help customers find solutions that work best for them across all aspects of the battery continuum. Whether your work takes you into raw materials, components, quality control or failure analysis, our comprehensive portfolio of analytical instruments, software and related tools and technologies can power your advancements, and enable a more sustainable future for us all.



Battery testing

Work:

- Ensure the finished product meets specifications
- Assembly of cells into battery packs

Processes:

- Failure analysis and rejection
- Battery aging, environmental and electrical studies

Analytical need:

- Analysis of degradation products:
 - Cathode material compounds
 - Electrolytes
 - Separator degradation products

Analytical techniques:

- ICP-OES
- GC/GC-MS
- ICP-MS
- IC/IC-MS
- LC/LC-MS



Battery recycling

Work:

- Bulk recycling and recovery of hazardous raw materials
- Address the ~30% scrap rate in production and reuse of spent batteries
- Development of second-life batteries
- Recycling of used end of life batteries to get the material back for building new batteries

Processes:

- Material recovery
- Inspection and reuse
- Battery recycling
- Testing

Analytical need:

- Inspection
- Characterization

Analytical techniques:

- ICP-OES
- IC/IC-MS
- ICP-MS
- GC/GC-MS
- HPLC
- LC/LC-MS



ICP-OES	Inductively coupled plasma optical emission spectrometry
ICP-MS	Inductively coupled plasma mass spectrometry
LC	High-performance liquid chromatography
LC-MS	Liquid chromatography mass spectrometry
IC	High-performance ion chromatography
GC	Gas chromatography
GC-MS	Gas chromatography mass spectrometry
IC-MS	Ion chromatography mass spectrometry
HR-ICP-MS	High resolution inductively coupled plasma emission spectrometry
GD-MS	Glow discharge mass spectrometry
EA	Elemental analyzer



One comprehensive portfolio, countless ways to drive new battery insights

Proudly offering the broadest instrument portfolio for advanced battery technologies, Thermo Fisher Scientific is your one-stop resource for solutions, innovation and collaboration—all from one trusted source. To help you address rapidly changing research, we're committed to providing the most robust solutions, tools and workflows to meet your dynamic needs. Our solutions can expand your battery knowledge where you need it most—helping you drive actionable business outcomes.

LITHIUM ION
BATTERY PACK
3.7V 6000mAh 2.4Wh

Ion chromatography

By using **ion chromatography**, researchers and scientists can gain insights into the fundamental processes and degradation mechanisms in Lithium-ion batteries to ensure product quality during manufacturing.



Thermo Scientific™ Dionex™ ICS-6000 Hybrid HPIC™ System, Dionex™ ICS-6000 Standard Bore and Microbore HPIC™ System

- Identifies non-volatile electrolyte degradation products
- Identifies and quantifies metal-based degradation species (when coupled with ICP-MS)
- Ideal for 2D-IC analyses—important when performing trace analysis in the presence of high concentrations of interfering matrix ions
- Truly modular, highly configurable, high-performance system
- Single- or dual-channel configuration to run simultaneous analyses

Mass spectrometry

When studying Lithium-ion battery components, **mass spectrometry** (MS) dramatically improves your ion and liquid chromatography (IC and HPLC) system capabilities and provides: higher sensitivity and accurate quantitation; peak confirmation and evaluation of chromatography peak purity; improved resolution of complex samples; and seamless integration of MS data into IC and HPLC workflows.



Thermo Scientific™ TSQ Fortis™ Plus Triple Quadrupole Mass Spectrometers

- Robust quantitative performance made simple
- Enhanced acquisition speed and sensitivity
- Proven robustness and reliability for high-throughput analysis
- Enables users of all skill levels to obtain reproducible, high-confidence results

Gas chromatography

Gas chromatography-mass spectrometry (GC-MS) systems can reach lower detection limits and obtain richer information with accurate detection of mass-fragments and molecular ions. By identifying and quantifying compounds formed during electrolyte aging, GC-MS systems can provide new insight into Li-ion battery degradation.



Thermo Scientific™ ISQ™ 7610 Single Quadrupole GC-MS System

- Provides qualitative and quantitative composition analysis of Li-battery electrolyte
- Reliability and accuracy for composition analysis and quality control
- Simplified operation, automated workflows and extended dynamic range for consistent results
- Thermo Scientific™ NeverVent™ technology, extended-life detector and intelligent software eliminate unnecessary downtime



Thermo Scientific™ TRACE™ 1600 Series Gas Chromatograph with TRACE™ 1600 Auxiliary Oven

- Analyzes composition of gases that produce li-battery swelling
- Characterizes aging and performance of batteries
- A multi-valve, multi-column system that enables full separation of gases in complex mixtures
- Maximized instrument productive time
- Simplified operations for quick adoption
- Lower cost of ownership

Elemental Analysis

Long before Lithium-ion batteries are developed or produced, laboratories use **elemental analysis** to determine the purity of lithium salts, which will eventually be processed into lithium-based materials and battery components. These materials also require elemental analysis to ensure their composition and purity before use, since the presence of impurities significantly degrades the charge-carrying capacity of the battery.



Thermo Scientific™ iCAP™ PRO ICP-OES System

Excellent precision and accuracy quantifying major elements, such as nickel, cobalt, manganese and lithium

- Well suited for detecting and quantifying elements in lithium salts and alloys
- Fast detection of major and trace elements in the ternary cathode material
- Robust analysis and quantification



Thermo Scientific™ FlashSmart™ Elemental Analyzer

- Quantitative CHNS elemental analysis in a single run
- Fast carbon and sulfur content determination for material purity assessment
- Excellent precision and reproducibility
- Cost-efficient and simple analytical workflow



Thermo Scientific™ iCAP™ RQ ICP-MS Spectrometer

- Ideal tool for detecting and quantifying the extent of chemical degradation caused by changes in trace elemental composition
- Helps identify metal-based degradation species and elucidate degradation pathways
- Higher sensitivity and additional analytical flexibility than the iCAP™ PRO Series ICP-OES



Liquid chromatography

Whether you're analyzing electrolyte solvents or working to achieve the next breakthrough in battery recycling, Thermo Fisher Scientific **liquid chromatography** solutions can improve your productivity, deliver a maximum return on your investment, and when coupled with Mass Spectrometry provide confident insights to drive business decisions.



Thermo Scientific™ Vanquish™ Core HPLC Systems

- Versatile, robust multiple wavelength detection
- Industry-leading flow and gradient precision
- SmartInject technology for unsurpassed precision with sample dosage and retention time
- Innovative air stream cooling for maximum sample integrity in both the sampler and the Charger module
- A full suite of method transfer tools makes adoption easy

Software

To meet an ever-growing demand for knowledge, battery researchers must be as efficient as possible. With market-specific **software** platforms to empower rapid data processing, interpretation, reporting and management, our software enables you to easily access and share valuable insights from your high-quality data sets. By bringing all your data together, our software can help uncover hidden value, provide the most comprehensive information, and help you fully characterize your samples to advance your research.

Smart solutions:

- Thermo Scientific™ Chromeleon™ Chromatography Data System (CDS) Software
- Thermo Scientific™ TraceFinder™ Software
- Thermo Scientific™ Compound Discoverer™ Software
- Thermo Scientific™ Qtegra™ ISDS Software



Forward-looking. Future-focused.

Together we can achieve a greener, cleaner world

Whatever your task, we've got the solution. Thermo Fisher Scientific is your one-stop source for the world's widest range of chromatography and mass spectrometry systems and support tools—plus the expert guidance to help you stay one step ahead. Our systems touch every part of battery manufacturing, from the

extraction and processing of raw materials, to quality assurance in the production line, to the research and development of the next generation of batteries.

Explore the categories below to see how Thermo Fisher Scientific is enabling the latest advances in battery technology.

Thermo Fisher product portfolios	Battery value chain					
	Research	Raw materials	Cell components	Cell assembly	Battery testing	Battery recycling
Black mass metallurgical processing (Process elemental analyzers – PGNAAXRF)						⚡
Bulk material handling (Belt scales and weigh feeders)	⚡	⚡				
Chromatography and Mass Spectrometry Software	⚡	⚡	⚡	⚡	⚡	⚡
Electrode and cell inspection (Microfocus Xray sources)				⚡	⚡	
Electrode coating and calendaring (Xray, Beta and laser gauging)			⚡	⚡		
Elemental Analyzer	⚡	⚡				
Fourier Transform Infrared Spectroscopy (FTIR)						
Gas Chromatography–Mass Spectrometry (GCMS)	⚡	⚡	⚡	⚡	⚡	⚡
Gas Chromatography (GC)	⚡		⚡		⚡	⚡
Gas Chromatography Autosampler	⚡		⚡		⚡	⚡
Glow Discharge Mass Spectrometry (GD-MS)	⚡					
High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS)	⚡					
Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	⚡	⚡				⚡
Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)	⚡	⚡	⚡		⚡	⚡
Ion Chromatography (IC/IC-MS)	⚡	⚡	⚡			
Liquid Chromatography Mass Spectrometry (LC/LC-MS)	⚡		⚡		⚡	⚡
Metallurgical minerals processing (Process elemental analyzers - XRF)	⚡	⚡				
Optical Emission Spectroscopy (OES)			⚡			
Ore grade analysis and sorting (Process elemental analyzers - PGNAAX)	⚡	⚡				
Particle size monitoring	⚡	⚡				
QC (hand-held spectroscopy)		⚡				
Raman	⚡		⚡	⚡	⚡	⚡
Scanning Electron Microscope (SEM)	⚡	⚡	⚡	⚡	⚡	⚡
Separator film manufacturing (IR, Xray, Beta gauging)		⚡				
Small Dual Beam (SDB)	⚡		⚡	⚡	⚡	⚡
Solid Phase (SP)				⚡	⚡	
Transmission Electron Microscope (TEM)	⚡					
X-Ray Photoelectron Spectroscopy (XPS)	⚡		⚡	⚡		



Keep getting results. We've got your back.

There's no time for downtime in your lab. You depend on your analytical instruments to support daily operations. Customers like you choose the Unity™ Lab Services Premier service plan to minimize disruption and stay focused on critical production and turnaround time.

 **See how the Premier Plan has your back**

Empower this relationship forward—let's get started

Contact a Thermo Fisher Scientific representative today

 Learn more at thermofisher.com/battery-solutions

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