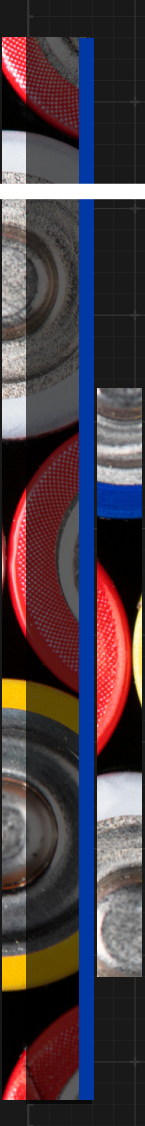
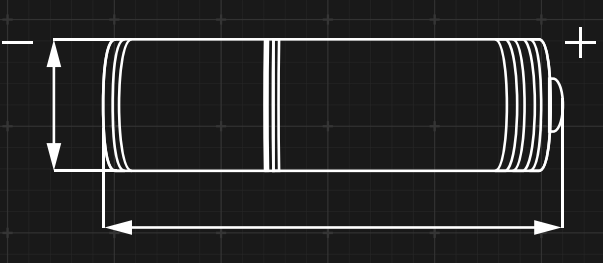
PerkinElmer
For the Better

ANALYSIS in the BATTERY SUPPLY CHAIN



Analytical testing solutions for the battery supply chain



Batteries underpin the ongoing advancement of renewable energy generation. Our world will need a diversity of battery types - for different applications - depending on the trade-offs that occur when combining power capacity, charge-holding and weight.

High purity components are required to produce safe, high quality batteries with superior performance and lifespan. Accurate analytical testing solutions are needed for evaluating materials and chemicals throughout all stages of the battery lifecycle.

ICP-OES	Inductively coupled plasma optical emission spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
AA	Atomic absorption spectrometry
TXRF	Total reflection X-ray fluorescence spectrometry
EDX	Energy-dispersive X-ray spectroscopy
IC	Ion Chromatography
GC-MS	Gas chromatography–mass spectrometry
LC-MS	Liquid chromatography–mass spectrometry
HR-MS	High resolution mass spectrometry
IR	Infrared
FT-IR	Fourier-transform infrared spectroscopy
TGA	Thermogravimetric analysis
DSC	Differential Scanning Calorimetry
TMA	Thermomechanical analysis

RAW ELEMENT INPUTS

MORE TO EXPLORE

Mining companies and chemical producers use inductively coupled plasma mass spectrometry or optical emission spectroscopy (ICP-MS, ICP-OES) to analyze elemental impurities as well as the impacts on manufacturing costs, safety and the environment.

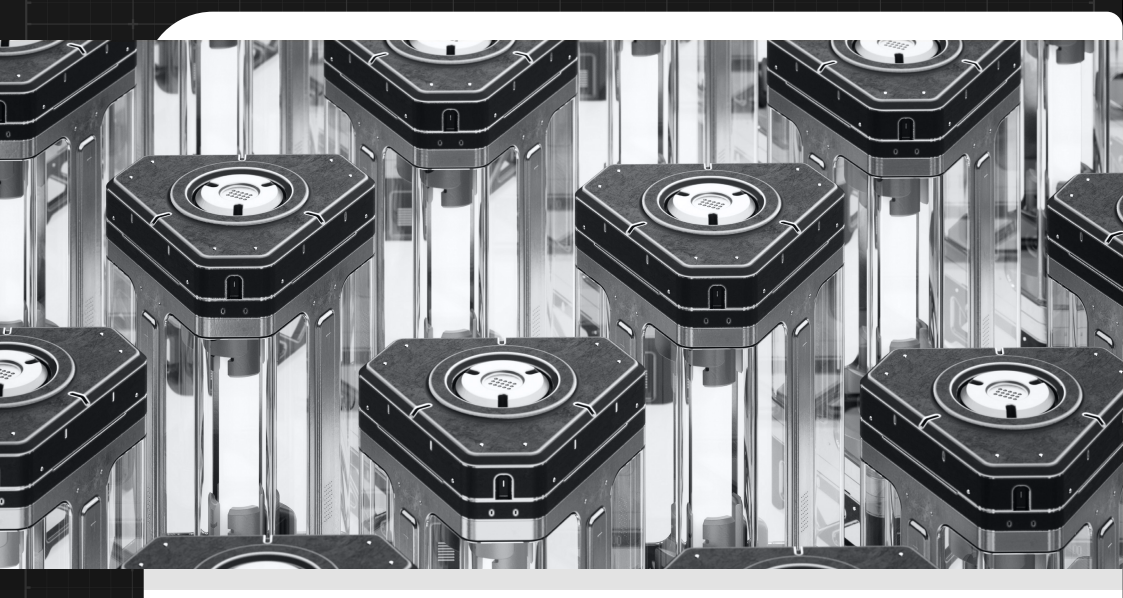
ICP-OES

- Determine the quality of raw materials.
- Measure ratio compositions and impurities of lithium, nickel, manganese, cobalt and other materials.
- Characterize and develop optimal electrode materials.

ICP-MS

- Quantifying impurities in metal concentrates.
- Characterizing the content of rare earth elements (REEs) such as cerium, yttrium, lanthanum, neodymium, and others used in rechargeable batteries.

ELECTROLYTES



MORE TO EXPLORE

Electrolytes act as the medium for making batteries conductive by promoting movement of ions from cathode to anode on charge, and in reverse on discharge. Research on electrolytes focuses on functional electrolyte additives, flame-resistance and new electrolyte salts including new solid state materials.

ICP-MS **ICP-OES** **GC-MS** **LC** **HYPH**

- Analyze the electrolyte for elemental and compound impurities (ppb and ppt range) for quantifying impurities in anodic materials.
- ICP-MS is ideal for high sensitivity detection (ppb and ppt range) for quantifying impurities in anodic materials.

- GC-MS is the standard choice to identify possible volatile chemical compounds.
- LC methods can be further used for compositional and purity/impurity analyses.
- HYPH (Hyphenation) combines two or more analytical systems to answer what gases evolved and when.

BATTERY COMPONENTS PRODUCTION

MORE TO EXPLORE

The ratios of (NMC) nickel, manganese, and cobalt dictate how the cathode—and ultimately the battery—will perform. Other elements are also being investigated. The ratio of the metals used in the cathode must be precisely defined to ensure battery quality. Anode materials such as graphite need to achieve a high levels of purity in order to maximise performance.

ICP-OES

- Method of choice for impurities analysis and elemental analysis.
- Characterize and develop optimal anodic materials such as graphite.

ICP-MS

- Offers a high degree of sensitivity (ppb and ppt range) for quantifying impurities in anodic materials such as copper.

MORE TO EXPLORE

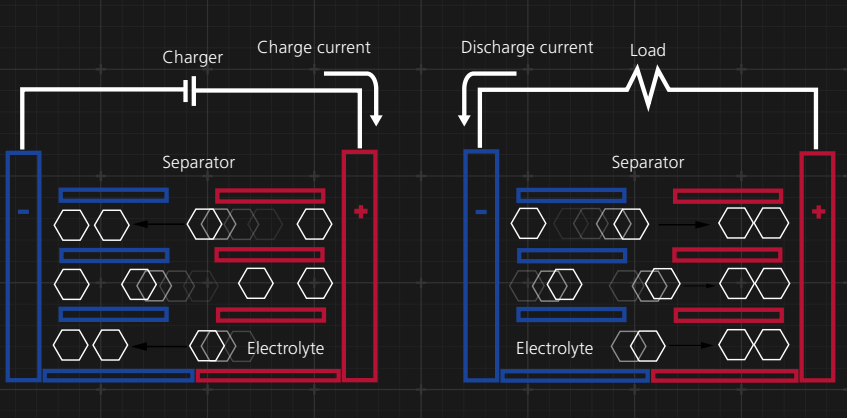
Material testing for separators and binders:

Video on Characterzation of Separators & Electrodes

IR **TGA** **DSC** **HYPH** **DMA**

- **Separators** provide a permeable barrier between the anode and cathode. Parameters such as melting point, crystallinity, thickness, chemical composition, and porosity are all important indicators of separator performance.
- IR and Thermal analysis (such as DSC, TGA and DMA) can be used to identify and characterize advanced materials used for separators, cell housings and pack enclosures

- **Binders** are used to improve adhesion of the anode slurry to the current collector and improve dispersion of active material.
- IR, TGA, and DSC all provide important information about binders—such as identification and thermal properties.
- Hyphenation combines two or more technologies for greater analytical depth - know what gases evolved and when.



CELL ASSEMBLY

MORE TO EXPLORE

The producers of the final cells use a variety of techniques including ICP-MS, gas chromatography and thermal analysis to ensure the performance of battery components destined for the automotive, energy storage, electronics and medical device industries.

ICP-OES **ICP-MS** **GC-MS** **TGA** **TMA**

- Ensure the raw materials are of sufficient purity before assembling the cell.
- Cathode materials testing as part of battery failure analysis.

- Study the composition and content of carbonates in the electrolytic solution for optimal **energy density, cycle life, and safety.**
- Offers precise results with **precision, accuracy,** and detection limits required by industry.

- TGA and TMA can be used to determine the **thermal stability** and **decomposition profile** under controlled heating conditions.

RECYCLING

MORE TO EXPLORE

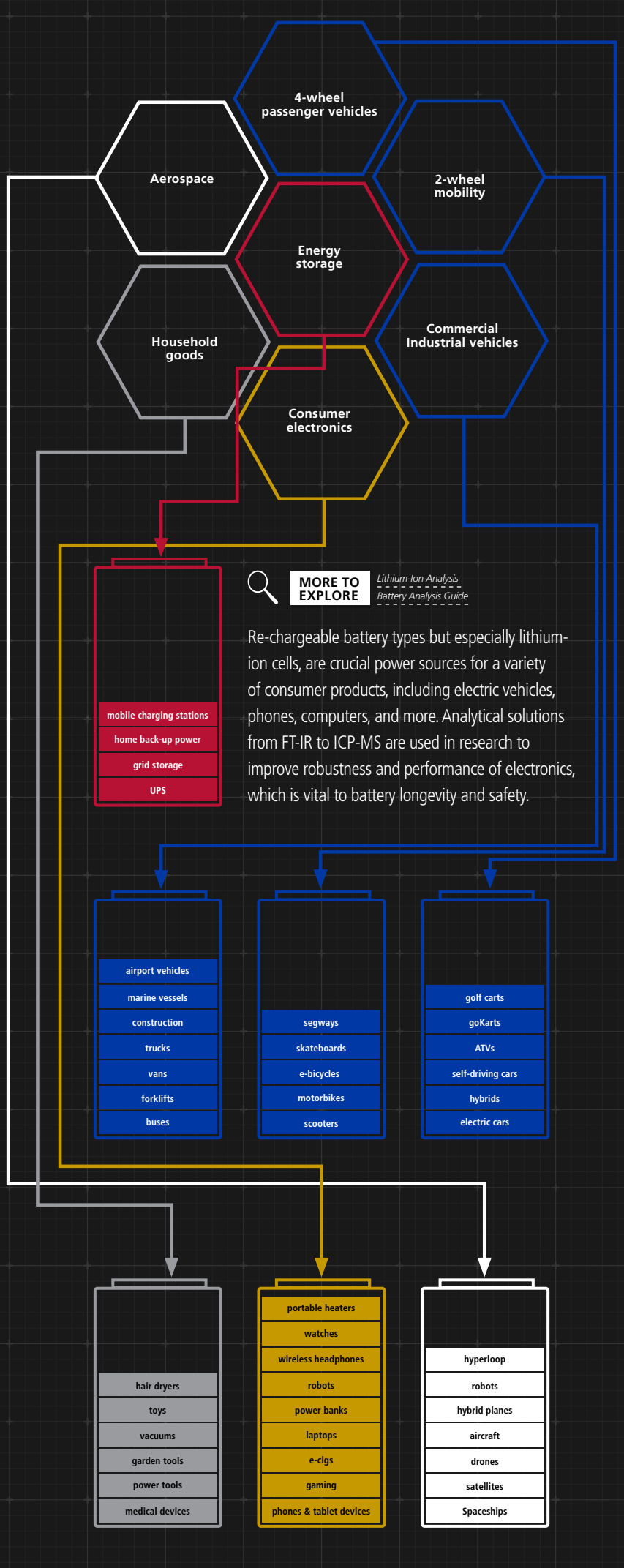
The battery industry is working to improve recycling capabilities as the volume of decommissioned batteries (those that have reached the end of their reusable life) is expected to rise exponentially in the next several decades. It is difficult to effectively break down batteries—especially electric vehicle (EV) batteries, designed to last many years and thousands of miles.

Characterizing end-of-life batteries / analytical methods during recycling

ICP-MS **ICP-OES** **AA/TXRF/EDX** **IC** **GC-MS** **LC-MS** **HYPH** **IR** **TGA/DSC**

- ICP-based methods provide the best parameters for the determination of all elements of interest (nickel, cobalt, manganese, and more).
- AA, TXRF or EDX provide information about thecomposition of recycled scrap materials.
- IC can be used to characterize anionic components of scrap metal, such as fluoride, which can hamper downstream recycling processes.
- GC and LC methods combined with HR-MS can be used to identify the originally used electrolyte components and provide information about additives.
- IR can identify and characterize advanced materials, and often used for the polymers present in cell housings and pack enclosures.
- TGA and DSC can be applied to investigate the mixture of anode and cathode materials (black mass).
- Hyphenated solutions (HYPH) combine multiple technologies, enabling reverse engineering and a better understanding of evolved gases. Common examples include TG-MS, IR-MS, TG-GC/MS

APPLICATIONS



MORE TO EXPLORE

Lithium-Ion Analysis

Battery Analysis Guide

Re-chargeable battery types but especially lithium-ion cells, are crucial power sources for a variety of consumer products, including electric vehicles, phones, computers, and more. Analytical solutions from FT-IR to ICP-MS are used in research to improve robustness and performance of electronics, which is vital to battery longevity and safety.

To learn more about PerkinElmer analytical testing solutions for the battery production chain, visit: **www.perkinelmer.com/battery**

PerkinElmer
For the Better