# Battery research

- Electrochemical characterization of batteries
- Determination of water content
- Determination of anions and cations by ion chromatography

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# Analytical instrumentation for battery research

Considerable resources are currently being channeled into battery research. The focus is on finding new materials enabling higher energy and power density as well as more efficient energy storage.

Progress in battery research requires sophisticated instrumentation for the production and characterization of materials and cells. Metrohm provides you with top-quality analytical instruments, know-how and first-class, on-the-spot service.

## Electrochemical characterization of batteries, electrode materials and electrolytes

The energy and power density of a battery depends on the properties of the electrolyte used and on the anode and cathode materials. Electrochemical methods are suitable for:

- determining voltage characteristics upon charge and discharge
- evaluating cycling performance and calculating coulombic efficiency
- evaluating the cycle life and calender life of the batteries
- measuring the battery capacity and power
- determining state of charge, depth of discharge, and state of health
- measuring internal resistance of the battery
- measuring the electrolyte resistance and charge transfer resistance

## Impedance spectroscopy station for batteries

Metrohm Autolab instruments are ideal for building automated impedance spectroscopy workstations. With an M204 multichannel potentiostat, up to six channels can be equipped with the FRA32M impedance module for concurrent impedance analysis. For a more compact workstation, the PGSTAT 204 is recommended. The power can be increased with a ten ampere booster that works in all four quadrants (positive and negative currents can be applied or drawn).
Alternatively, the highly versatile PGSTAT 302N can be equipped with a MUX multiplexer and FRA32M module for automated sequential impedance measurements on a batch of batteries.

## Metrohm Autolab instruments are ideal for the characterization and development of battery materials:

- anode and cathode materials
- electrolyte and electrolyte additives
- separators and current collectors

## Total solutions for battery research

Metrohm Autolab offers cells and accessories that facilitate battery research:

- DuoCoin Cell Holder: coin cell holder suitable for high precision impedance spectroscopy featuring 4-point gold-plated electrode contacts.
- Microcell HC: a variety of high end in-temperature cells designed for materials and electrolyte studies. Suitable for solid, liquid, and gel samples applicable to different battery technoloigies, e.g.solid state batteries.


**M204 multichannel instrument**
Simultaneous measurements on each channel. Flexible procedure programming with NOVA 2 electrochemical software.

Metrohm
Electrochemistry

## Determination of water content

Lithium-ion battery must be completely free of water (concentration of $H_2O$ < 20 ppm), because water reacts with the conducting salt, e.g. $LiPF_6$, to form hydrofluoric acid. In general, mixtures of anhydrous, aprotic solvents and lithium salts are chosen as electrolytes. The water content can be determined reliably and precisely in, for example, the samples listed below, using Karl-Fischer coulometry and the oven method:

- raw materials for the manufacture of lithium-ion batteries
- electrode coating preparations (slurry) for anode and cathode coating
- the coated anode and cathode foils as well as in separator foils and in packed foil layers
- electrolytes for lithium-ion batteries

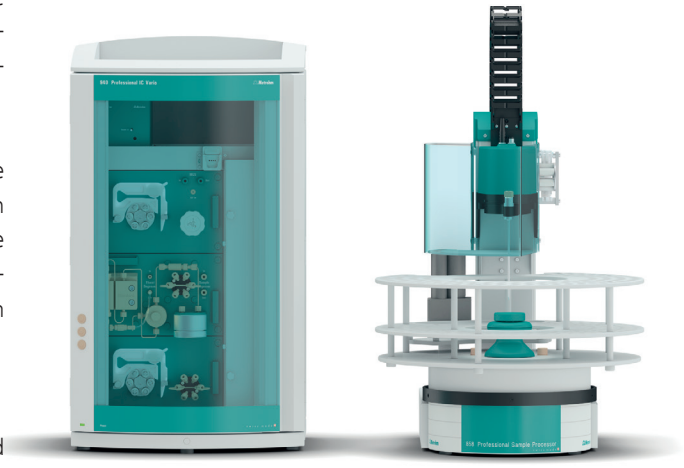
**Reliable water determination with the 851 Titrando coulometer and 874 USB Oven Sample Processor**
The oven method enables reliable determination of the water content of insoluble samples.

## Determination of anions and cations

In the development and optimization of lithium-ion batteries, one of the items of special interest is the content of ions such as lithium, fluoride and hexafluorophosphate in the electrolyte or in eluates of different components.

Using ion chromatography, it is possible to determine various inorganic and organic anions and cations in parallel over a wide concentration range. Any sample preparation steps that might be required (elution, dilution, filtration) can be automated with the Metrohm Inline Sample Preparation («MISP») techniques.
The following anions and cations can be determined:

- fluoride, hexafluorophosphate, tetrafluoroborate and lithium in eluates of individual components such as anodes, cathodes and separator foils
- fluoride, hexafluorophosphate and lithium in electrolyte liquids



**940 Professional IC Vario plus**
**858 Professional Sample Processor:**
Metrohm offers a unique range of completely automated sample preparation techniques for ion chromatography.

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