

**RAW MATERIALS INPUTS**



**BATTERY COMPONENTS**



**CELL ASSEMBLY**



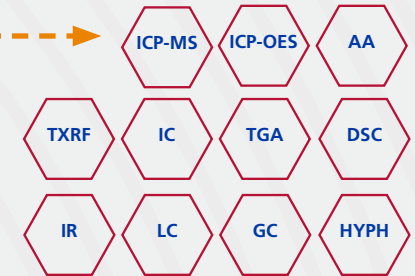
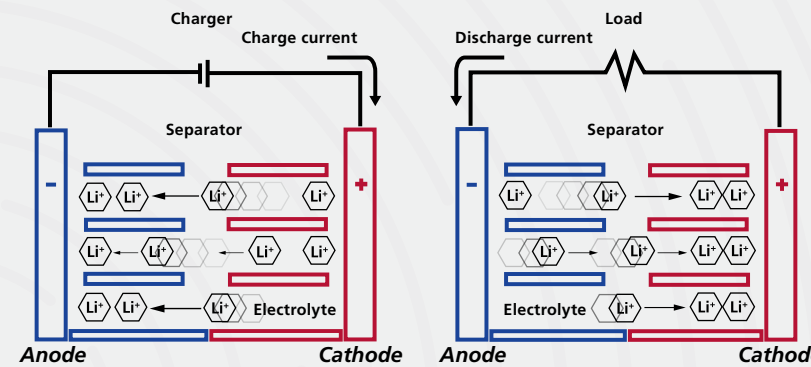
Unrecycled waste

Analysis in the

# BATTERY LIFECYCLE

**EXTRACTION/RECYCLING**

**CHARGING AND DISCHARGING PROCESS**



- **ICP-MS, ICP-OES:** determination of all elements of interest
- **AA, TXRF, EDX:** composition of recycled scrap materials
- **IC:** characterize anionic components of scrap metal
- **GC, GC-MS, LC, LC-MS:** identify originally used electrolyte components, information about additives
- **IR:** identification and advanced material characterization
- **TGA, DSC:** investigate mixture of anode and cathode materials (black mass)
- **Hyphenation:** greater insights by combining two or more technologies enables reverse engineering and a better understanding of evolved gases. Examples include; TG-MS, IR-MS, TG-GC/MS

**R&D AND QA/QC ANALYTICAL TESTING ----- THROUGH THE BATTERY VALUE CHAIN**

- ICP-OES**
- Quality of raw materials
  - Ratio compositions and impurities of lithium, nickel, manganese, cobalt and other elements
  - Characterize and develop optimal electrode materials

- ICP-MS**
- Analyze electrolyte for elemental and compound impurities (ppb and ppt range)
- ICP-OES**
- Analyze solvent composition
- GC-MS**
- Identify volatile, semivolatile, and chemical compound impurities
- LC**
- For compositional and purity/impurity analyses
- HYPH**
- Hyphenation: combine two or more technologies to answer what gases evolved and when

- ICP-MS**
- High sensitivity (ppb and ppt range) for quantifying impurities in anodic materials
- ICP-OES**
- Impurities analysis
  - Elemental analysis
  - Characterize/develop anodic materials

- IR**
- Separator performance (melting point, crystallinity, thickness, chemical composition, porosity)
  - Identify and characterize advanced materials used for separators, cell housings and pack enclosures
- TGA**
- Thermal characterization
- DSC**
- Identify and characterize binders
- HYPH**
- Hyphenation: combine two or more technologies to answer what gases evolved and when

- ICP-MS**
- Purity of raw materials
  - Battery failure analysis (cathode materials)
- ICP-OES**
- Battery failure analysis (cathode materials)
- GC-MS**
- Carbonate composition and content in electrolytic solution
- TMA**
- Measure thermal and mechanical properties
- TGA**
- Thermal stability and decomposition profile
  - Battery failure analysis (cathode materials)

**Key Analyses Benefits**

- Impact on manufacturing costs, safety, performance, longevity and the environment
- Precise and accurate results with high linearity and sensitivity

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