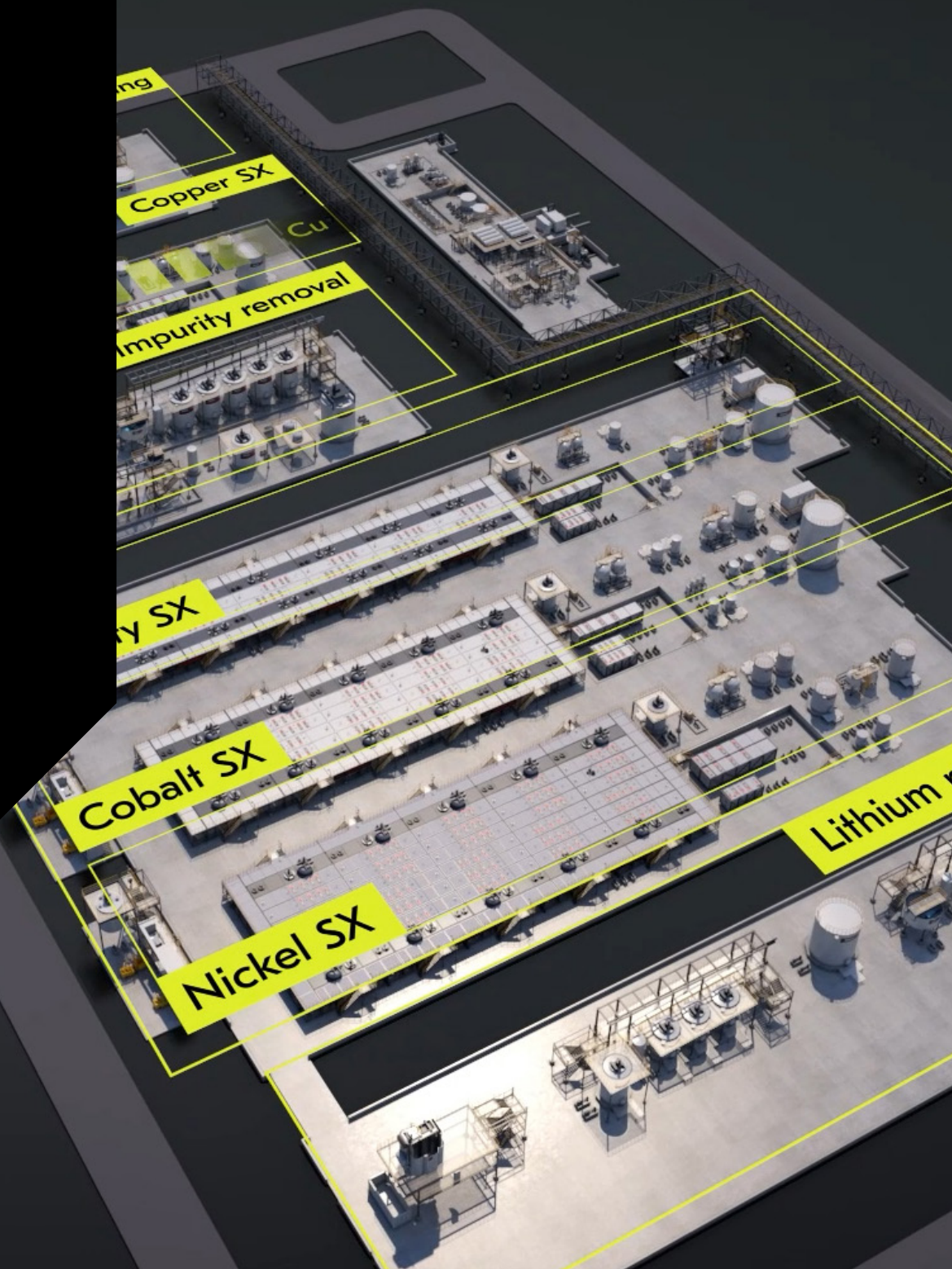
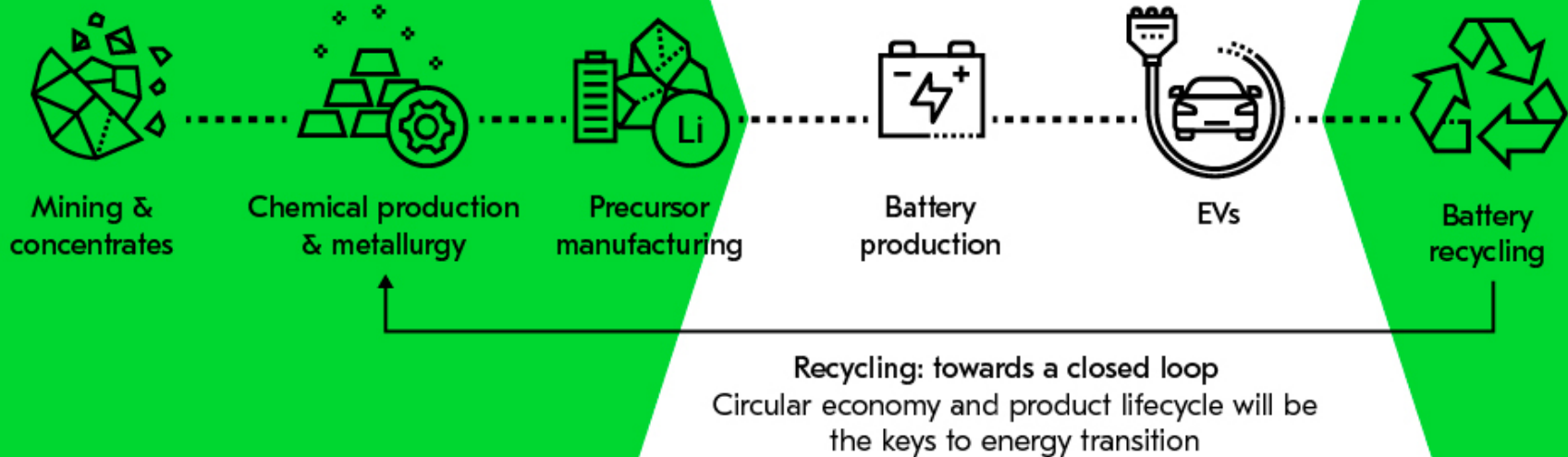


Metso

Analyzers for battery minerals



From battery minerals extraction to refinement and recycling



PSI® 300i, PSI® 500i, Courier® 8X SL, Courier® HX and PSI® 1000

Metso analyzers in battery minerals

Metso offers complete processes for the battery minerals production from minerals extraction to refined battery chemicals and end-of-life battery black mass recycling. In addition to actual processing equipment, Metso product portfolio includes solutions to measure, control and optimize these processes.

Enabling a responsible energy transition

The increasing electrification of society is fuelling a significant surge in the need for rechargeable batteries and the raw materials used in their production. These materials include lithium, cobalt, nickel, graphite, manganese, copper and aluminum.

From providing new exploration and greenfield sites with state-of-the-art equipment and practices, to helping improve the efficiency of existing brownfield mining and extraction sites, plants and processes, Metso has also developed efficient and sustainable processes for recycling minerals from decommissioned batteries.

Digital tools for optimized production

Metso provides process optimizers and Geminex™ digital twin to enable optimized use of resources, minimized carbon footprint and production reporting solutions for materials traceability. Metso's digital portfolio enables the

fulfillment of transparent production reporting, material mass balance management and traceability. Utilization of these digital tools require up to date information about operational state of the process. Metso online analyzers measure accurate real-time information about the process state, enabling process optimization both automatically and manually.

Analyzers throughout the value chain

Metso offers online analyzer products for battery minerals processing starting from minerals concentration, hydrometallurgical processing, cathode precursor production and metals recycling. By leveraging the capabilities of online analyzers, battery minerals processing can achieve greater sustainability by optimizing resource usage, improving energy efficiency, reducing emissions, maintaining product quality, and driving process enhancements.

Spodumene minerals processing

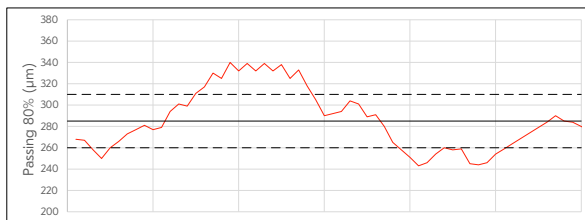
Spodumene is a lithium bearing mineral that is commonly used as a source of lithium for battery production. Generally, spodumene is concentrated by crushing/grinding followed by froth flotation. The main parameters in processing include particle size and elemental contents.

Particle size analysis

Spodumene minerals go through grinding to liberate the lithium bearing minerals from the surrounding rock, making it accessible for subsequent concentration. For this process, an optimal grind size is typically between 100 to 300 microns. The grinding step is often followed by desliming of the fine particles such as clay minerals before further concentration, as they will have several impacts on the follow up processing, including dilution of concentrate grade, hindering the attachment of air bubbles to spodumene particles.

Monitoring the particle size of the grinding step is often critical for further processing of the ore. Typical grind size is 100 to 300 microns, which balances the liberation of lithium bearing minerals and minimizes the generation of excessive fines.

P80 trend from a grinding circuit

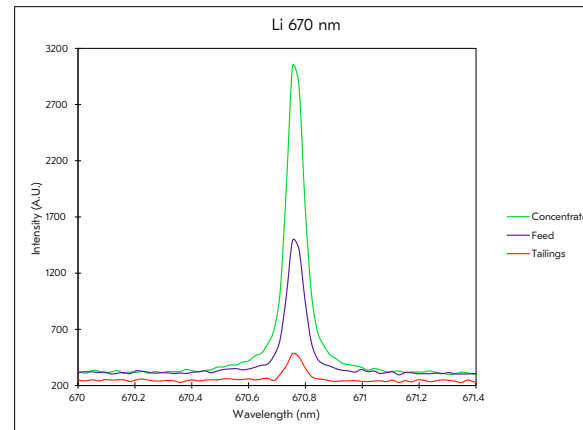


Metso offers two types of particle size analyzers for grinding applications. The PSI 300i for the coarse end of the particle size distribution is of interest and the PSI 500i is utilized when the whole particle size distribution is of interest.

Elemental analysis

Spodumene flotation final concentrate properties are essential for its suitability for further processing or sale. Key parameters for the flotation concentrate usually include the Li_2O grade, recovery, and impurity grades including iron, sodium, and potassium.

The laboratory analysis of spodumene can be time consuming and the results may take up to a day to complete. Up to date information on even minor ore body changes is essential for process control, to effectively react and avoid issues further downstream. On-line analysis of the flotation circuit can lead to improved process stability, increased recovery, and enhanced product quality. It allows for more precise and timely adjustments and increasing overall efficiency. Metso Courier 8X SL, based on Laser-Induced Breakdown Spectroscopy (LIBS), is capable of measuring lithium directly from all flotation process streams.



Lithium emission line at 670 nm from spodumene feed, concentrate and tailings samples measured using Courier 8X



Courier 8X SL

- Direct measurement of Li, Na, K, Fe, Mg based on laser-induced breakdown spectroscopy
- Typical analysis time two minutes per sample
- 1-12 assays
- 1-12 samples
- Typical accuracy 5-10%



Chemical processing of cobalt and nickel

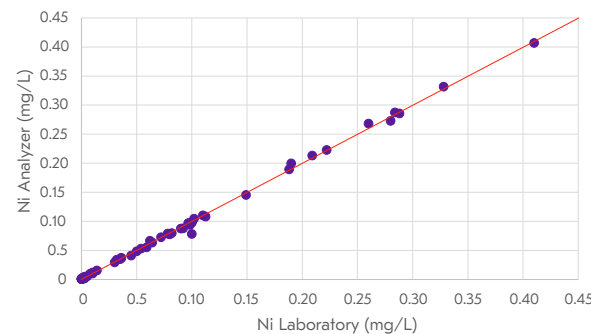
Courier HX

Nickel – cobalt leach, solvent extraction and reduction processes are complex and require real-time monitoring and control to maintain product quality and ensure profitable operation.

Courier HX is a high-performance solution analysis system which can measure up to 24 process samples automatically. Samples can be analyzed from aqueous and organic solutions without cross contamination of samples. The analyzer system can be equipped with various elemental/chemical analyzers, including X-ray fluorescence, titration, ion chromatography, and optical emission spectroscopy, depending on the measurement needs. Solid containing samples can automatically be filtered to enable analysis in the liquid phase.

The analyzer offers high dynamic range of measurement. 1-10 mg/L and 100 g/L samples can be analyzed with the same analyzer. Measurement results from one sample are delivered in 2 minutes.

Calibration curve for Courier HX nickel measurement at a Ni/Co solvent extraction plant



Benefits

- Rapid measurements and results up to 24 sample streams
- Sampling and analysis are fully automated and always consistent
- Monitor extraction and stripping efficiencies and maximize the lifetime of lixiviants
- Minimize impurity transfer
- Monitor the separation of cobalt and nickel products

Leach

Elemental analysis of the leach solution in nickel leaching is a critical step in monitoring and controlling the process, while assessing the efficiency of nickel extraction. Free acid can be measured from the leach solution to monitor the optimal dosing of acid, to reduce operational costs and environmental impact.

Solvent extraction

In solvent extraction the pregnant leach solution is concentrated and purified, and pure aqueous nickel and/or cobalt sulfate solutions are produced in the next processing steps. The number of impurity metals may also be treated in the same solvent extraction plant as nickel and cobalt.

Courier HX is used in challenging separation processes to monitor the process effectiveness in real-time to monitor the effectiveness of the separation. The analyzer can also monitor the effectiveness of the organic wash of aqueous overflow to minimize the transfer of impurities.

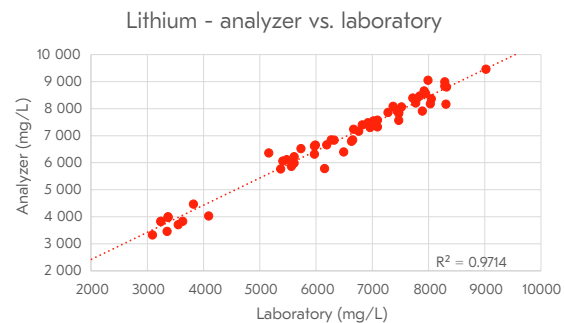
Metso OKTOP Autoclave is the key equipment in the LiOH process



LiOH and Li_2CO_3 processing

Lithium has become the preferred choice for many battery applications due to its properties and is usually produced as either carbonate (Li_2CO_3) or hydroxide (LiOH) depending on the requirements on the battery product. In the hydroxide process the carbonate is usually produced as an intermediate step. In both cases dissolved lithium is precipitated by addition of soda ash (Na_2CO_3). By analyzing the lithium and impurity content of the feed to carbonation, optimum chemical dosage to the reaction can be maintained. Solution purification can be optimized by measuring the feed and output from solution purification.

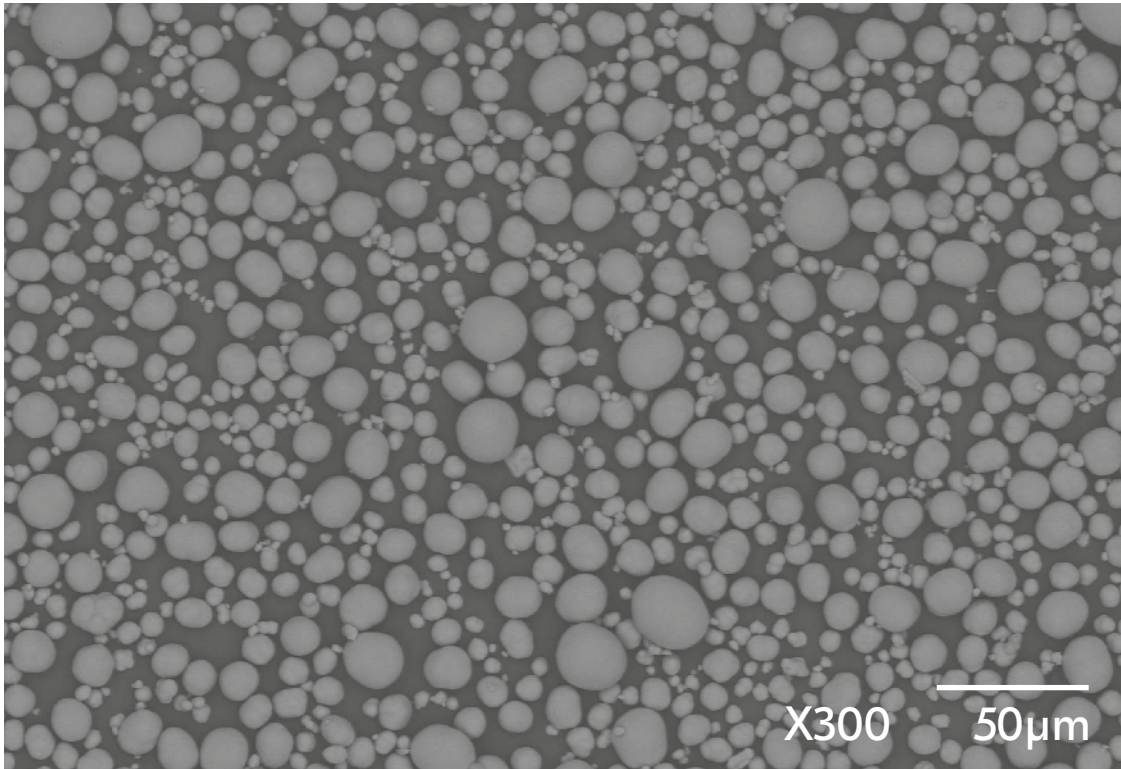
Courier HX analyzer system can be utilized in the measurement of Li content and impurities including sodium and calcium in real-time from liquid samples in the lithium chemical processing.



Process samples collected from alkali leach LiOH pilot plant measured with Courier HX and ICP-OES

Benefits

- Optimize the chemical dosages
- Maintain the solution purity
- Monitor lithium extraction and yield
- Monitor effluent quality



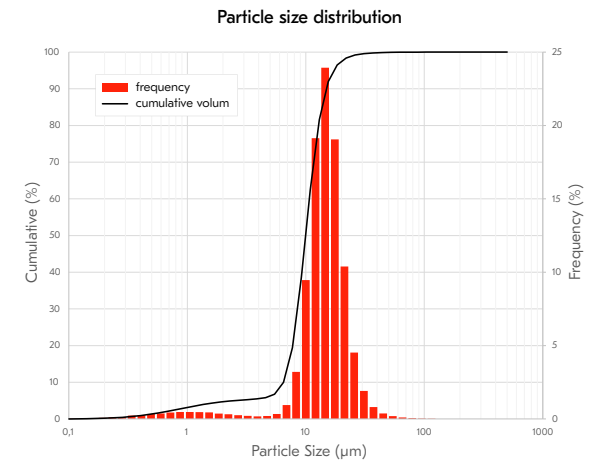
Battery cathode precursor production

Battery precursor production is a critical step in the production of lithium-ion batteries. Precursors are the initial materials which are used to create the active materials within the battery electrodes. For cathode precursors, metal hydroxides are synthesized through a process of co-precipitation.

The process involves the simultaneous precipitation of metal ions from a solution to form a solid compound mixture that serves as a precursor for cathode materials.

Here, the critical parameters for the precursor material is the particle size and distribution, particle roundness and the tap density. Optimal particle size depends on the specific battery chemistry, desired performance characteristics and intended application.

Metso PSI 1000 analyzer can measure the particle size evolution in real-time, inside the precipitation reactor. Allowing better control for the intended particle size distribution and span while minimizing off-spec product.



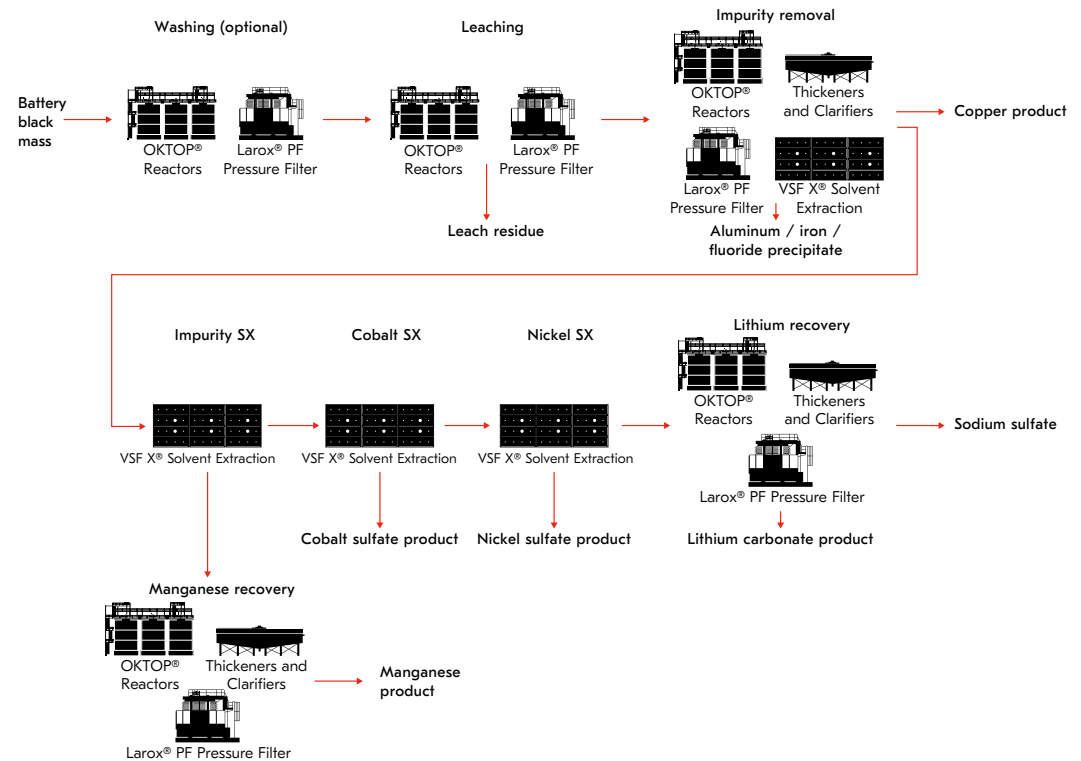


Black mass recycling

The battery black mass recycling process treats batteries after mechanical separation for the recovery of nickel, cobalt, and lithium, as well as optionally manganese and copper. Metso utilizes proprietary hydrometallurgical technology to recover high-value battery raw materials through advanced battery black mass recycling.

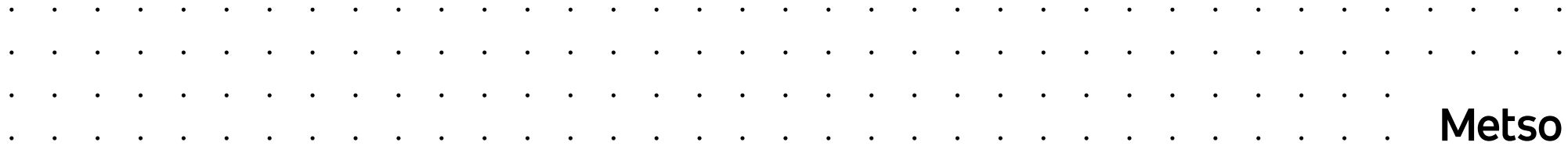
After leaching the valuable metals from recycled batteries the solution goes through various purification and separation steps. These steps may include selective precipitation, solvent extraction and ion exchange. The choice of processing route depends on the specific application and economics of the recycling process.

Courier HX analyzer system can be utilized in the recycling process to monitor the recovery of the valuable metals and to minimise transfer of impurities. Minimizing impurities is not only crucial for the quality of the end products but also for the overall efficiency and sustainability of the recycling process.



Metso is a frontrunner in providing sustainable technologies, end-to-end solutions and services for the aggregates, minerals processing and metals refining industries globally. By helping our customers increase their productivity, improve their energy and water efficiency and environmental performance with our process and product expertise, we are the **partner for positive change**.

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