Case study

Measuring the transformation of materials for lithium-ion battery recycling with Raman spectroscopy

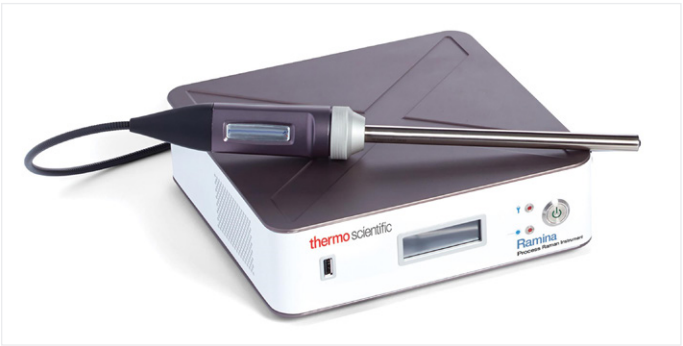
What is Raman spectroscopy

Raman spectroscopy is an optical analysis technique that measures the vibrational properties of molecules. Raman spectroscopy has improved process analysis with its high-resolution compositional data, linear response to concentration, non-destructive nature, ability to measure samples in real-time, without requiring a sampling system or carrier gasses.

Benefits of Raman Spectroscopy
Rich compositional information
Quantitative and linear response
Non-destructive
No sample preparation required
Measures all sample types: • Solid/powder/slurry • Liquid/Gas • Heteregenous samples
Fast measurement time Miliseconds to seconds - not minutes
Water has a weak signal

Application in lithium-ion battery recycling

By delving into the intricate chemical and physical alterations within battery components, Raman spectroscopy empowers researchers and industries to monitor and optimize the recycling process. With online analysis providing rapid results in seconds, Raman spectroscopy optimizes yield and offers real-time control over the hydrometallurgical conversions of essential battery elements such as lithium, manganese, cobalt, and more.



The Thermo Scientific™ Ramina™ Process Analyzer with a Performance BallProbe®, a robust sampling optic for samples

thermo scientific

Enhancing efficiency and yield in hydrometallurgical processes with Raman spectroscopy

A prominent battery recycling company based in the U.S. has harnessed the capabilities of multiple Raman spectroscopy systems for its hydrometallurgical platform. By focusing on the efficient recovery of essential elements such as cobalt (Co), lithium (Li), and manganese (Mn) from the cathode active materials (CAMs) of expired or used lithium-ion batteries, the company has realized significant advancements in their recycling processes.

Requirements

The company's battery recycling operations posed specific requirements that necessitated the implementation of Raman spectroscopy systems:

- Online system for process control: To enable real-time oversight and control of the recycling process, the company sought an online Raman spectroscopy system. This feature allowed them to closely monitor and adjust reactions as they occurred, enhancing overall efficiency.
- Continuous reaction monitoring for improved yield: A critical objective was to optimize the yield of the recycling process. Continuous monitoring of reactions using Raman spectroscopy played a crucial role in achieving higher recovery rates and minimizing waste.
- Precise reaction control to minimize waste and reagent usage: The company aimed to minimize both waste generation and the excessive use of reagents. Raman spectroscopy's ability to offer accurate and immediate insights into reaction progress empowered them to exercise better control over reactions, thereby reducing waste and reagent consumption.

Results

The incorporation of Raman spectroscopy systems yielded notable results for the battery recycling company:

Through the real-time monitoring and control facilitated by Raman spectroscopy, the company achieved a significant increase in yield and a corresponding reduction in costs. The precise adjustment of reactions in response to immediate spectroscopic insights enabled them to eliminate excess reagent usage, leading to enhanced overall efficiency and financial savings.

For the transformation analysis of various cathode active materials (CAMs), including lithium cobalt oxide (LCO), lithium nickel manganese cobalt oxide (NMC), lithium manganese oxide (LMO), lithium nickel cobalt aluminum oxide (NCA), lithium iron phosphate (LFP), and nickel metal hybrid (NiMH), the company utilized the Process BallProbe®. This rugged tool was selected for its ability to operate effectively in harsh conditions, offering an ideal solution for continuous monitoring. Multiple models within the same device were deployed to cater to different chemical species, simplifying the analysis process.

The incorporation of advanced chemometrics enabled the development and deployment of real-time analysis models. The systems were designed for seamless integration into the process setting, and the option of a field mount enclosure further ensured protection under challenging environmental conditions (Ingress Protection rated).

Applications extended beyond recycling, as the Raman spectroscopy systems provided rapid online metrology for both anode and cathode materials. Precise measurements of polymers, graphite, nickel, manganese and cobalt materials further highlighted the versatility of the technology across battery-related domains.

Additional applications

- Rapid online metrology for electrode materials for anode and cathode materials.
- Graphite, nickel, manganese, and cobalt measurement.

Learn more at **thermofisher.com/ramina**