THE BATTERY CHRONICLES

STREAMS
SUSTAINABLE TECHNOLOGIES FOR REDUCING EUROPE'S BATTERY RAW MATERIALS DEPENDANCE

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From mining by-products to battery materials: A circular approach for Europe's energy transition

The widespread adoption of lithium-ion (Li-ion) batteries, which are key to the global energy transition, is exponentially increasing the demand for critical cathode active metals such as lithium (Li), cobalt (Co), manganese (Mn), and nickel (Ni). Ensuring a reliable and sustainable supply of these minerals, particularly from secondary raw material sources (recycling), has become a strategic priority. However, innovative methods are needed to improve the economic and environmental efficiency of recycling processes. In this seeking, the large amounts of waste and by-products generated by traditional mining and industrial activities attract attention.

Pyrite often emerges as a waste or by-product in gold, copper, or nickel mining. Due to its abundance and low cost, this material has the potential to contribute directly and indirectly to the battery raw material supply chain. Utilizing secondary materials such as pyrite offers significant economic and environmental advantages.

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One of the main methods in battery recycling is hydrometallurgy, which uses chemical reagents such as sulfuric acid to dissolve valuable metals from spent batteries. Sulfuric acid (H_2SO_4), obtained by processing pyrite calcination, is a critical leaching reagent for hydrometallurgical plants. This reduces dependence on external sources for chemical reagents and makes the process more integrated and efficient. At the same time, utilizing pyrite helps reduce the massive sulfur-rich waste piles at mining sites, which pose significant environmental risks.

The laboratory is fully equipped with state-of-the-art instrumentation to conduct comprehensive material and interface physico-chemical characterizations. Our capabilities include X-ray diffractometer, thermal analysis (TGA/DSC), carbon analyzer, laser diffraction particle sizer, dynamic light scattering (DLS), BET specific surface area measurement, Zeta potential-meter, turbidimeter, liquid and powder rheometer, UV/Vis, FTIR and Raman spectrometers, ^{57}Fe Mossbauer spectrometer, scanning and transmission electron microscopy (SEM and TEM). Additionally, GREEnMat laboratory has a complete electrochemical characterization platform enabling in-depth investigation of the electrochemical properties of electrodes (cathode and anode) and solid electrolyte active materials.

Beyond being a source of sulfuric acid, pyrite can also contain metals such as cobalt, nickel, manganese, and copper. These elements are particularly critical for battery cathode materials. When processed appropriately, pyrite can recover these metals, becoming an important secondary raw material source for the battery industry. This approach maximizes value from existing mining sites and reduces pressure on primary ores.

The Bayer Process used in the aluminum industry also holds remarkable potential for the battery value chain. In this process, which treats bauxite ore, elements critical to the battery industry such as lithium may be present in process streams depending on the geological and mineralogical structure of the ore. Instead of treating these streams solely as waste, it is possible to recover valuable metals like lithium through suitable separation and purification technologies. This reduces waste and environmental impact while creating a new secondary supply channel for battery raw materials.

The main goal of the STREAMS Project is to strengthen Europe's battery material supply chain and reduce dependence on imported critical raw materials (CRMs) such as lithium and cobalt. To achieve the sustainability and recycled content targets set by the EU Battery Regulation, technological innovation and circular economy practices must be addressed together. The most direct way to reach these thresholds is to effectively utilize secondary sources and implement sustainable battery raw material production models that support circular economy principles.

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In this context, Eti Bakır A.Ş.'s Mazıdağı Plant stands out as a unique example on a global scale. Mazıdağı is the only facility in the world that produces cobalt from a by-product. Mazıdağı Plant recovers cobalt, zinc, nickel, iron, manganese and copper from pyrite concentrate using advanced hydrometallurgical and refining processes. In line with the STREAMS Project's goals of producing battery cathode active materials from secondary sources, Eti Bakır Mazıdağı R&D Department produces cobalt sulfate, manganese sulfate, nickel sulfate, and lithium carbonate. In this way, the EU's recycled content targets for lithium, cobalt, and nickel are supported within a technologically and economically feasible framework.

In conclusion, Pyrite, Bayer residue, and similar secondary sources are being redefined in the battery era not as waste, but as strategic raw material resources. The STREAMS Project strengthens Europe's battery supply chain to make it more resilient and sustainable, while Eti Bakır A.Ş.'s approach provides concrete examples of an industrial model that reduces environmental risks and aligns with circular economy goals. This approach plays a critical role in building a battery ecosystem based on clean energy and responsible resource management for future generations.

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