

## **New environmental-friendly technologies for the recovery of raw materials**

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In last years the production of lithium-ion batteries (LIBs) is constantly growing to meet the great demand. It is estimated that the global market of LIBs will reach about 92 billion of dollars in 2026. However, the supply of raw metals for batteries production is precarious due to their limited natural reserves and their local distribution. Therefore, technologies that can stably secure strategic metals must be developed, for example, urban mining, which allows the recovery of metals from secondary sources. Currently, the LIBs recovery processes are complicated and required high resources consumption in terms of energies (pyrometallurgy) and chemicals necessary for metals extraction (hydrometallurgy). This work introduces an innovative approach to recover strategic metals (Li, Ni, Co, and Mn) from exhausted batteries based on microwave (MW) heating. This new technology, recently patented, won the EIT RAW Materials competition in February 2022, due to the obtained promising results in terms of innovation in metals extraction.

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The dedicated MW device allows to increase the equipment thermal insulation, to recover the MW energy furnished to a carbon reduction reaction. The advantages of this method is that cathodic material Li(Ni-Co-Mn) oxide, having oxidation property and graphite, having reduction property, are both present in black mass. Li is separated by water, while Co, Mn and Ni by L-Malic acid. The choice of this organic acid relied on the sustainable management of this chemical after the treatment (recoverable) and for its neglecting secondary emissions (compared to the inorganic acids), making it suitable for future environmentally friendly applications.

The preliminary experiments allowed to recover >95% of Li, Co, and Mn with MW treatment.