BIOLEACHING OF LITHIUM-ION BATTERIES:

How microbes leach valuable metals from black mass

To reduce greenhouse gas emissions in the transport sector, the global demand for electric vehicles is booming. Due to the strong expansion of e-mobility, the need for lithium-ion batteries (LIBs) is on the rise. The increasing scarcity of resources demands recycling strategies of LIBs including the extraction of metals, such as lithium, nickel, cobalt, and manganese. The recycling of LIBs constitutes an essential part in establishing an efficient circular economy.

One potential recycling technique is called bioleaching, also referred as biological leaching. Bioleaching uses microbes to leach out metals that are bound in solid materials into solution, thus achieving an extraction of metals from the solid matrix. Bacteria, fungi, and archaea are able to produce acids or regenerate the oxidizing agent Fe^{3+}, allowing marginally soluble sulfidic and oxidic compounds to be transformed into water-soluble form.

So far, bioleaching has mainly been used in ore mining to extract metals such as copper. Weak ores, which cannot be economically processed using conventional methods are heaped up and biologically leached to extract the remaining copper. This form of bioleaching is also referred to as “heap-leaching”.

Over recent decades, the interest in bioleaching has increased and research is intensified to recover valuable metals from waste fractions such as active material of LIBs. The biological leaching of such secondary resources is usually carried out in stirred tank reactors (see Figure on page 2). By recovering metals from waste fractions, the raw material shortage of countries without natural resources can be compensated and recycling rates are increased. Compared to pyrometallurgy or other metal-extraction techniques, bioleaching offers ecological and economic benefits, such as a low energy demand, as well as more simple and cost-effective equipment. However, currently the industrialization of bioleaching processes is constrained by two major factors. On one hand, a slow reaction rate results in a leaching time of several days, and on the other hand, a high liquid to solid ratio impacts the plant size and the water footprint negatively.

Project 3 “Biohydrometallurgical treatment of LIBs” of the COMET Module FuLIBatteR attempts to overcome these weaknesses by implementing a sustainable biohydrometallurgical recycling process for LIBs. Therefore, microbes are cultivated in a growth medium and are brought either directly, or indirectly into contact with the active material. In the indirect approach, solely the produced acids and metabolites of microorganisms are used for metal leaching, whereas the direct method requires the microorganisms to directly interact with the active material. Currently, various mesophilic and thermophilic cultures of the genera Acidithiobacillus and Sulfobacillus are being investigated in terms of their leaching ability.

Experiments with pure and mixed cultures are carried out to examine the potential for leaching critical raw materials such as lithium, nickel, manganese, and cobalt. The aims of the project are to achieve leaching efficiencies of at least 80 %, increase the amount of used active material to 6 %, and reduce the leaching time to below five days. The results obtained so far are promising and have been presented at the Biomining conference 2023 in Falmouth (United Kingdom) in three talks.

Furthermore, to present FuLIBatteR the following dissemination activities are planned:

- ICBR 2023, Valencia, Spain, 6 – 8 September 2023; L. Wiszniewski (Project 2), “Pyrometallurgical recycling of lithium-ion battery cathode material: The impact of slag formers on meltability and lithium slagging potential”
- FuLIBatteR Workshop in Leoben, Austria, 19 September 2023
- ESTEP Annual Event 2023 – A Circular Economy driven by the European Steel, Barcelona, Spain, 3 – 5 October 2023, E. Cheremisina (Project 2 and 3), “Circular metallurgy: Valorizing valuable metals from Lithium-Ion Batteries in steel industrial symbiosis”
- 19th International Symposium on Waste Management and Sustainable Landfilling in Santa Margherita di Pula, Italy, 9 – 13 October 2023, B. Rutrecht (Project 1), “Zero waste – Chances and risks of (not) applying zero waste strategies and the importance of measuring sustainability in the recycling sector”

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