Bridging academia and industry: Successful up-scaling of bioleaching of spent lithium-ion batteries

The recycling of lithium ion batteries (LIBs) constitutes an essential part in establishing an efficient circular economy. One potential recycling technique is biohydrometallurgy. Bioleaching, also referred as biological leaching, uses microbes to leach out metals such as cobalt (Co), nickel (Ni), lithium (Li) or Manganese (Mn) that are bound in solid materials into solution, thus achieving a metal extraction from the solid matrix.

Although bioleaching is considered to have environmental as well as economic advantages, it has its limiting factors, such as being a slow process and requirement of optimal conditions for the microorganisms. Additionally, most of the studies related to bioleaching have been on laboratory scale, particularly in flasks experiments. In contrast, in a stirred tank reactor, optimal conditions for the microorganism and in turn for the bioleaching process, such as pH, temperature, mixing, air supply, etc. can be maintained and monitored. Therefore, using such a reactor for the bioleaching process can help in mitigating the limitations.

Previously, the feasibility of bioleaching for biorecovery of critical metals from different black mass types was investigated using different microorganisms in flask experiments. The next step was to up-scale the selected experimental conditions, microorganisms and black mass type from small scale (flasks experiments) to larger scale (a stirred tank reactor). For this purpose, an Outgoing Research Stay was planned by the PhD researcher L. Lalropuia (K1-MET) at the FuLIBatteR project partner BRAIN Biotech AG in Zwingenberg, Germany. This stay offered a valuable opportunity due to their extensive experience and having expertise in the field of biobased technologies. During the research stay, bioleaching of black mass, derived from lithium iron phosphate (LFP) batteries, was performed in a one litre stirred tank reactor. For the bioleaching microorganism, a mixed culture, which was enriched from an acidic mine lake was used. A high recovery rate (up to 100%) of critical metals such as lithium was achieved with these experiments, highlighting the potential of bioleaching as a sustainable method for battery recycling. Following the experiment, the changes in the microbial community were also investigated using a metagenomic analysis, which could potentially offer a deeper insight into the microbial-black mass interaction and the mechanism behind the metal solubilization.

This outgoing research stay has made a significant stride in both personal and professional development of the author, strengthening technical and analytical skills. The insights and experiences during this stay also demonstrate a strong synergy between academic research and industry collaboration.

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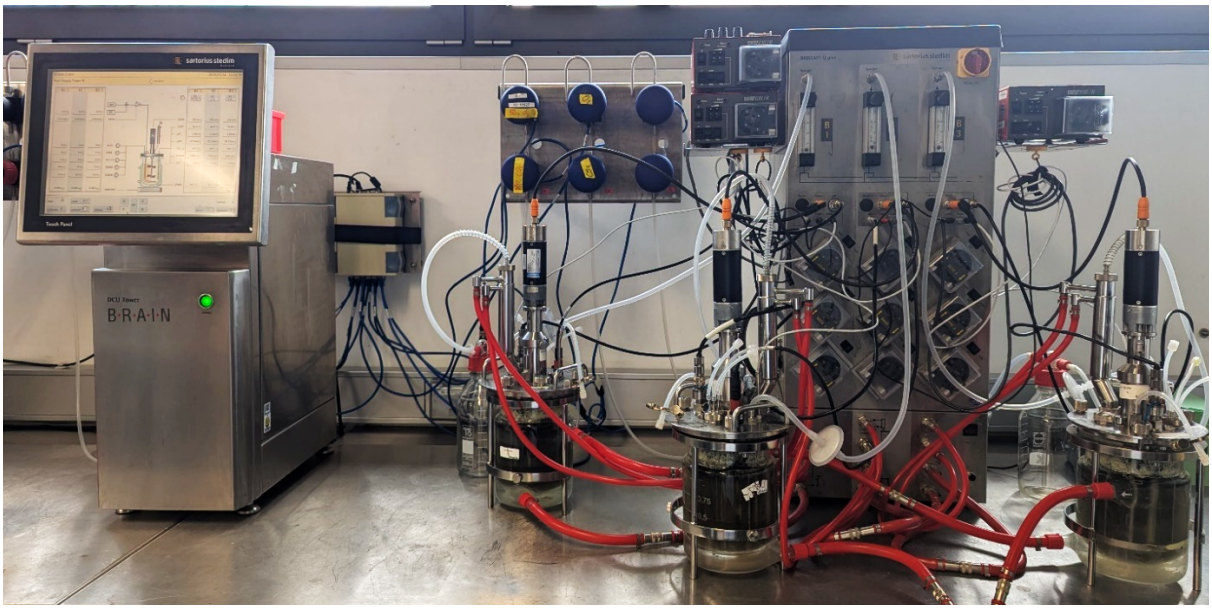

Figure 1: Bioleaching of black mass performed by L. Lalropuia (K1-MET) in a stirred tank reactor at BRAIN Biotech AG during his outgoing research stay.

Further selected dissemination activities in the FuLIBatteR module (Project 1, 2 and 3) were published or are planned in the upcoming months:

- Rieger, J., Stuhr, S., Rutrecht, B., Morgenbesser, S., Nigl, T., Arnberger, A., Kunanz, H., Lesiak, S. Graphite Separation from Lithium-Ion Battery Black Mass Using Froth Flotation and Quality Evaluation for Reuse as a Secondary Raw Material Including Non-Battery Applications. Recycling 2025, 10, 75.
- Wiszniewski, L., Lalropuia, L., Spiess, S., Presoly, P., Kremser, K., Doschek-Held, K., Guebitz, G. M., Raonic, Z. (2025). Integrating Pyro- and Biohydrometallurgy in a Green Closed-Loop Lithium-Ion Battery Recycling Approach. Journal of Environmental Chemical Engineering, 116811.
- 19th Minisymposium Chemical and Process Engineering and 10th Austrian Particle Forum, Innsbruck, Austria, 1-2 July 2025, Emerson Barros de Souza (Project 2) “Numerical development of thermal pre-treatment for Li-ion batteries recycling”
- 12th International Flotation Conference, Cape Town, South Africa, 17 November 2025; S. Stuhr (Project 1) “Graphite Recovery from Spent Lithium-Ion Batteries via Froth Flotation and Assessment as a Secondary Raw Material for Non-Battery Applications”

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For more information about the FuLIBatteR project and its progress, please visit LinkedIn and the K1-MET-Website.

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