Biobased technologies for selective metal recovery from liquids

A challenge of selectivity and specificity

Batteries play an increasingly important role for decarbonizing the transport sector by enabling the shift from fossil fuels towards renewable energies and their storage. Therefore, according to the report “A Vision for a Sustainable Battery Value Chain in 2030” of the World Economic Forum and the Global Battery Alliance from September 2019, the global battery demand is expected to grow by 25 % annually to reach 2,600 GWh in 2030. This growth goes hand in hand with a growing demand for critical raw materials such as lithium or cobalt, which are needed for battery production. Having in mind the EU’s battery regulation from 2023, recycling is the key word for promoting a circular economy.

The COMET Module FuLIBatteR (Future Lithium-Ion Battery Recycling for Recovery of Critical Raw Materials) addresses this challenge in three subprojects (Project 1, Project 2, and Project 3). Project 3 “Bio-hydrometallurgical treatment of LIB residues” focuses on a highly innovative and sustainable approach to recover critical raw materials and valuable metals from Lithium-Ion Batteries (LIBs). In the first recycling step, biological leaching, also referred as bioleaching, is applied to extract metals from the active material. Thereby, microorganisms play the lead, and the main product is a metal-enriched solution with high concentrations of cobalt, nickel, lithium, and manganese. To create an entire environmentally friendly process, two biobased technologies for selective metal recovery from those liquid streams are investigated in course of Project 3:

Bioelectrochemical systems are a sustainable and energy-efficient technology for removing and recovering metals from metal-containing solutions or wastewaters. The core components of those systems are electroactive microbes, which colonize the anode. These microbes can interact with the electrode and can deliver electrons to the electrode, while oxidizing organic substances, such as communal wastewater. The generated current can be used for driving entirely or partly the recovery of a specific metal at the cathode, depending on the redox potential. At the moment, the recovery of a cobalt-nickel alloy is investigated within this approach. Process parameters, such as the metal recovery efficiency are monitored. Challenges to deal with are mainly co-precipitation or co-deposition of other metals.

Metal-binding peptides have gained substantial scientific interest in resource recovery processes because of their selective binding properties to metals. The specificity of the metal-binding contributes to a more efficient and sustainable metal recovery process avoiding the application of harsh chemicals or the generation of toxic by-products. In Project 3, a plethora of different peptides has been screened with the biotechnological method "Phage Surface Display" and selected according to their specific binding to metals. The selected peptides consist of amino acids with diverse side chains, which are mainly responsible for the metal binding and can be exploited for targeted metal recovery (Figure 1). A bottleneck in the application of the peptides for resource recovery is the synthesis of the peptides which can be costly. Hence, the biotechnological production of the most promising peptide candidates will be evaluated to improve the scalability of peptide-functionalized filter materials for the selective metal recovery.

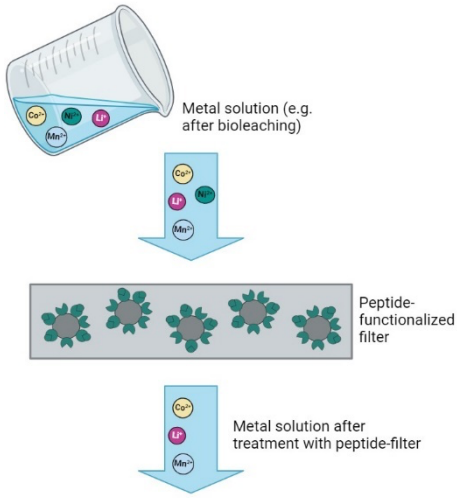

Figure 1: Nickel binding via peptide-functionalized filter. This figure was created with BioRender.com by acib GmbH.

Apart from our research efforts, the FuLIBatteR team actively contributes to various conferences to showcase the outputs of sustainable battery recycling (extract of recent and planned conference participations):

- 2nd International Conference on Metal-Binding Peptides: Methodologies and Applications, 10 – 12 July 2024, Toulouse, France (contribution from P3)
- 29th International Congress for Battery Recycling ICBR 2024 10 – 12 September 2024, Basel, Switzerland (contribution from P2)
- 17th Recy & DepoTech, 13 – 15 November 2024, Leoben, Austria (contribution from P1 and P2)

On a national level, voestalpine will present the module FuLIBatteR at its exhibition stand with K1-MET GmbH at the Recy & DepoTech 2024 from 13th to 15th November in Leoben.

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