Karlsruhe Institute of Technology

Division III – Mechanical and Electrical Engineering

wbk Institute of Production Science

Machines, Equipment and Process Automation

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Data sheet

Direct Recycling of Battery Electrodes

Function-preserving Recovery of Active Material

Climate change and the growing awareness of the need for sustainability have driven the development of renewable energies and energy storage systems. However, high quality requirements and rapid technological progress are leading to significant scrap rates in production, which impairs resource efficiency. This is particularly problematic in view of the scarcity of metals such as lithium, cobalt, and nickel, which are used in lithium-ion batteries (LIB) and represent a challenge for the European industry for geopolitical reasons. The concept presented in the DiRecFM project enables the direct recycling of battery electrodes.

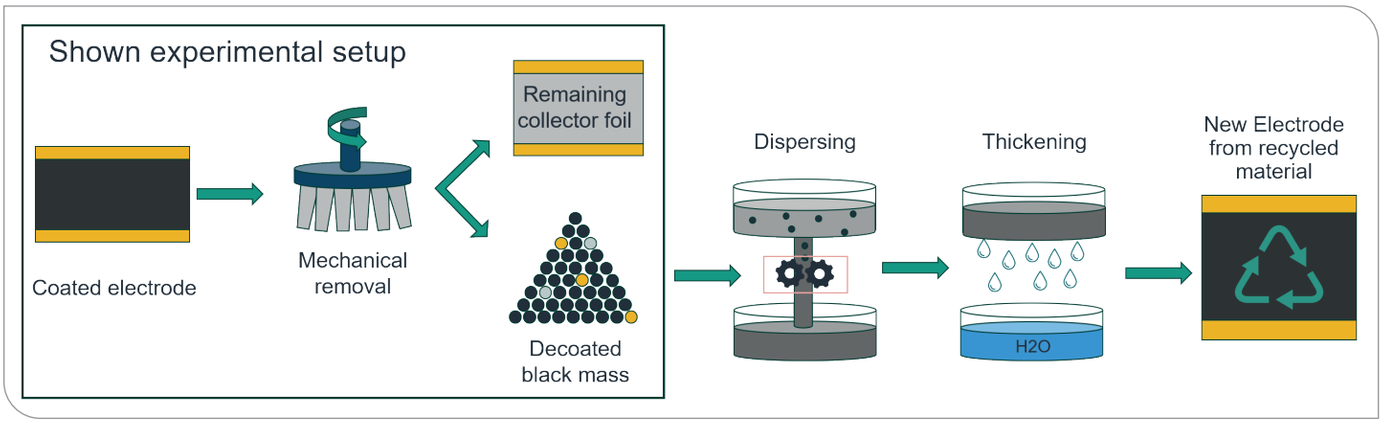
Established recycling methods that break down active materials into their raw materials are resource- and emission-intensive. In contrast, direct recycling is considered more sustainable, as active materials can be recovered through gentle and function-preserving processes and returned directly to battery production. The prerequisite is the residue-free separation of the active materials from other cell components.

A mechatronic concept is presented in which the anode active material is mechanically removed from the copper foil by brushing. The experimental setup shown here illustrates the possible implementation of continuous processing of roll material through utilization of a sword brush.

Process Chain for Direct Recycling

The technological concept, namely a process chain for the direct recycling of active materials (LFP and graphite), was developed as part of the DiRecFM research project (FKZ: WM34-42-57/28). This project aims to fundamentally improve the battery ecosystem. Coated and dried electrode foils form the starting point of the process chain and are delaminated in a first step. The active material is then prepared for return to production by dispersing and centrifuging.

Experimental setup for the direct recycling of battery electrodes through utilization of a sword brush.



Schematic process flow for direct recycling according to [2].

Anode material was treated for the proof of concept. Before processing with a sword brush, water was added. This facilitates the removal of the active material and prevents the formation of dust, which occurs with dry brushing. As a result, the targeted material removal rate of 95 percent is even exceeded. As experiments have confirmed, the penetration depth of the brush and the feed rate of the electrode sheet are the most important influencing parameters. Damage to the substrate was not observed.

Conclusion and Outlook

The experiments successfully demonstrate the feasibility of direct recycling through utilization of mechanical brushes for continuous processing. Despite the need for pre-treatment processes and complex material handling, direct recycling offers advantages compared to other recycling methods, including low levels of solvent consumption.

Optimizations regarding, for example, the penetration depth of the brushes and the liquid feed, as well as the processing of damaged electrodes will be the subject of further investigations. In the future, this concept can make an important contribution to the resource-saving production of LIBs by returning materials to the production cycle.

Recent Publications

Circularity Days 2024 [1]

ICSM 2024 (Pre-Print) [2]

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