THE BATTERY CHRONICLES

STREAMS
SUSTAINABLE TECHNOLOGIES FOR REDUCING EUROPE'S BATTERY RAW MATERIALS DEPENDANCE

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Advancing STREAMS through Selective Electrowinning while recycling NMC

Hello, my name is Borys Haliuk, and I am a PhD student and a junior researcher at the Institute for Sorption and Problems of Endoecology (ISPE) of the National Academy of Sciences of Ukraine.

In 2024, I joined a large international team working on the Horizon Europe's project "Sustainable Technologies for Reducing Europe's Battery Raw Material Dependence" (STREAMS). My work within this project focuses on developing and refining electrochemical methods for extracting valuable metals from spent cathodes which were extracted from the end-of-life lithium-ion battery cells (LIBs).
In today's world, the issue of LIBs recycling is extremely pressing. As the electric vehicle market grows, the number of spent batteries is increasing exponentially, creating significant environmental risks — ranging from spontaneous fires to environmental pollution, to include contamination of ground waters caused by heavy metals.

Traditional industrial recycling methods, such as pyrometallurgy, are energy-intensive and costly. Their implementation results in significant CO emissions. Hydrometallurgical approaches require the use of large quantities of chemical reagents and produce toxic waste. The latter approach typically requires 20x wash water by volume, which makes classic hydrometallurgical recycling ill-efficient and non-sustainable. This is precisely why we have chosen the method of electrolysis of an aqueous solution as a promising and a lot more environmentally friendly alternative.

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My research focuses on the recycling of NMC (nickel-manganese-cobalt) cathode materials, which are among the most common in modern lithium-ion batteries.

The main aim is to create a closed-loop cycle in which recovered metals are returned to the production of new batteries, thereby upholding the principles of the circular economy. The process I am working on begins with the preparation of raw materials, carried out in close collaboration with ISPE partners from American Energy Technologies Co. (AETC, Chicago, Illinois, USA), who, in the first stage of their Direct Recycling process, carry out the mechanical separation of electrode materials, after which the cathode strips undergo heat treatment. This allows the cathode mass to be effectively separated from the aluminum foil without the use of additional chemical reagents or large amounts of water.

The next stage, which we are already doing at ISPE, is the dissolution of the resulting "cathode mass" in sulfuric acid with the addition of hydrogen peroxide as a reducing agent. The resulting solution of transition metal sulfates serves as “ready-to-use” electrolyte for the subsequent extraction of individual metals comprising the NMC cathode. In the course of experiments, we use specially designed large volume electrochemical cells with moving electrodes and agitation, where a nickel-cobalt alloy of precisely engineered composition is deposited on the titanium cathode, and the formation of electrolytic manganese dioxide (EMD) occurs on the specialty alloy anode. The simultaneous precipitation of useable products on both the cathode and the anode requires careful control of the electrolysis parameters: current density, temperature and pH of the solution.

The results of our tests are very encouraging, in that we managed to achieve a cobalt recovery rate of 98.2wt% and a manganese recovery rate of 98.6wt% of the input received from AETC’s Direct Recycling process. Although nickel extraction is currently slightly lower (about 57wt%) due to the competitive release reaction of hydrogen in the electrowinning cell, we are already working on optimizing electrolyte composition and electrode placement to increase the efficiency of this process. An important aspect of my participation in the STREAMS project is scaling up the developed method. We are working on transferring the laboratory results to a pilot plant with multiple cells operating at volume of 10 liters. This allows us to evaluate the performance of the process in conditions close to industrial setting. To this end, we are very proud to be collaborating with another partner of STREAMS project, UkrNIIElectrotherm (UNE) of Zaporizhzhia, Ukraine. They are brining to the project a unique expertise of an engineering company and they are helping us, at ISPE, to develop a scaled up manufacturing plant around our electrowinning technology.

For me personally, working as part of the STREAMS project is not only a motivational scientific challenge, but also a sense of involvement in solving global problems. The products we have obtained, such as Ni-Co alloys and manganese dioxide, can be used not only in the production of new batteries, but also in the chemical industry, as well as for the creation of magnetic materials. There is also this sense of personal involvement into global scale supply chains which bring us, in Ukraine, closer to our industrial partners in the USA and in the European Union. This means a lot to me, personally.

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We believe that our developments can be used by STREAMS project partners to extract above-mentioned valuable metals from spent cathode mass of LIBs on a commercial scale and we are open to collaborating with people from other industries on technologies which could benefit from selective electrowinning and sustainable recycling.

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