High purity copper production from spent Li-ion batteries anode current collector

Arpad Imre-Lucaci[1], Ana-Maria Cormos[1], Florica Imre-Lucaci[2], Szabolcs Fogarasi[1], Melinda Fogarasi[3]

[1]Department of Chemical Engineering, Faculty of Chemistry and Chemical Engineering, Babeş-Bolyai University, Cluj Napoca, RO-400028, Romania;
[2]Interdisciplinary Research Institute on Bio Nano Sciences, Babeş-Bolyai University, Cluj Napoca, RO-400271, Romania
[3]Department of Food Engineering, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, RO-400372, Romania
Keywords: spent Li-ion batteries, copper recovery, recycling, electroextraction.
Presenting author email: szabolcs.fogarasi@ubbcluj.ro

Lithium-ion batteries (LiBs) are one of the most important energy storage technologies for the future, and they are increasingly applied in different industrial sectors as well as for the state-of-the art renewable energy storage facilities. According to the literature LiBs cell similarly to other electronic devices have a short life span around 1–3 years (Zhang et al., 2017), leading to the accumulation of massive amounts of spent LiBs. There are predictions for the generation of about 11 million metric tonnes of spent LiBs until 2030 (Gaines, 2019; Liu et al., 2019). To deal with such high amounts of spent LiBs the European Union is enforcing legislations that call for increased recovery rates from waste batteries, especially for Li, Co, Ni and Cu (Makuza et al., 2021). While copper is already an integral part of current energy system, based on the predictions made by several studies, the transition to a low-carbon future will significantly increase copper demand by 2050 with an estimate of 200-300 % compared to today's level (Harmsen et al., 2013). The evolution of renewable technologies over the next decades will boost copper consumption considering that solar panels require 3000 kg Cu / MW, wind turbines would demand 3500 kg Cu / MW, and efficient grids, interconnectors, subsea grid would need + 400 kt Cu. Also, by 2027, more than 100,000 tonnes of copper will be needed to build 40 million charging points for electric vehicles coming on the market (Tomas and Gauri, 2020).

All this data prove that copper is expected to be a cornerstone of a low-carbon future but requires ground-breaking technological solutions that can be applied at industrial level with low carbon footprint for its recovery from spent LiBs. With this aim the present study proposes an innovative technological solution for the recovery of high purity copper from anode current collectors of spent LiBs by applying a combined chemical-electrochemical process. The main process steps are defined in Figure 1.

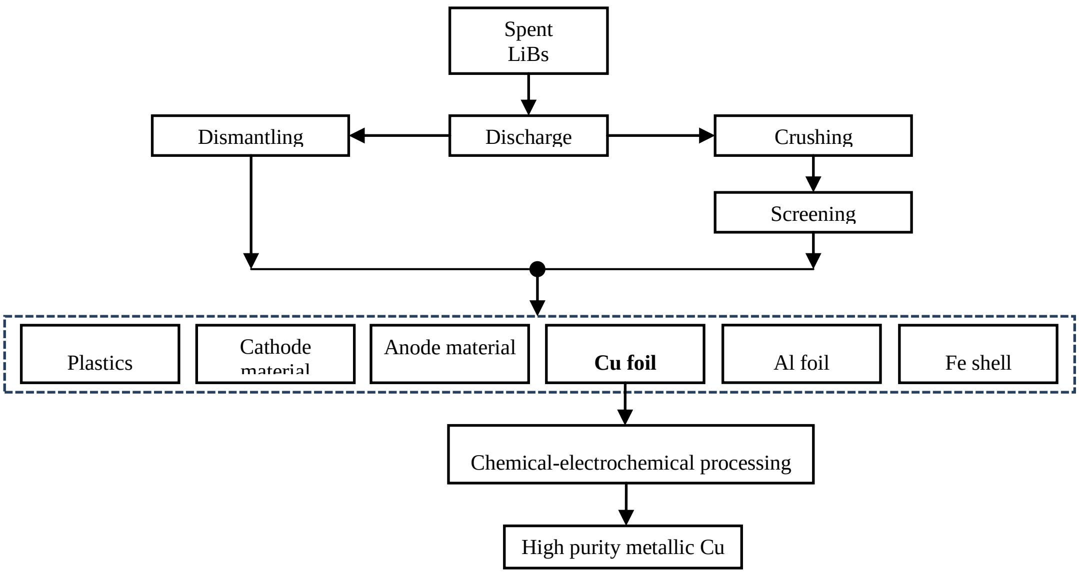

Figure 1. Schematic representation of high purity copper recovery process from spent Li-ion.

The recovery step of copper was preceded by a mechanical pre-treatment of the spent Li-ion batteries which led to the separation of the material fractions presented in Table 1.

Table 1. Content of the main material fractions separated from the spent Li-ion batteries.

Component	Quantity (wt.%)
Anode (graphite)	22
Active cathode material (lithium cobalt oxide, …)	31
Copper foil	17
Aluminum foil	8
Electrolyte solution	15
Separator plastics	3
Carbon black and binder	4

The performance of the process was evaluated in different operating conditions based on the dissolution efficiency, current efficiency and specific energy consumptions. It was found that in the best operating conditions the purity of the obtained copper deposit was more than 99 wt.% which makes it suitable for many industrial applications.

Acknowledgements
This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI - UEFISCDI, project number COFUND-LEAP-RE-RESTART, within PNCDI III.

References

1. Gaines, L., 2019. Profitable Recycling of Low-Cobalt Lithium-Ion Batteries Will Depend on New Process Developments. One Earth 1(4), 413-415.
2. Harmsen, J.H.M., Roes, A.L., Patel, M.K., 2013. The impact of copper scarcity on the efficiency of 2050 global renewable energy scenarios. Energy 50, 62-73.
3. Liu, P., Xiao, L., Tang, Y., Chen, Y., Ye, L., Zhu, Y., 2019. Study on the reduction roasting of spent LiNixCoyMnzO2 lithium-ion battery cathode materials. Journal of Thermal Analysis and Calorimetry 136(3), 1323-1332.
4. Makuza, B., Tian, Q., Guo, X., Chattopadhyay, K., Yu, D., 2021. Pyrometallurgical options for recycling spent lithium-ion batteries: A comprehensive review. Journal of Power Sources 491, 229622.
5. Tomas, W., Gauri, K., 2020. Metals for a Climate Neutral Europe A 2050 Blueprint. Institute for European Studies.
6. Zhang, W., Xu, C., He, W., Li, G., Huang, J., 2017. A review on management of spent lithium ion batteries and strategy for resource recycling of all components from them. Waste Management & Research 36(2), 99-112.