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

A. Imre-Lucaci, A-M. Cormos*, F. Imre-Lucaci**, S. Fogarasi* and M. Fogarasi****

**Department of Chemical Engineering, Faculty of Chemistry and Chemical Engineering, Babeş-Bolyai University, Cluj Napoca, RO-400028, Romania;*

***Interdisciplinary Research Institute on Bio Nano Sciences, Babeş-Bolyai University, Cluj Napoca, RO-400271, Romania*

****Department of Food Engineering, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, RO-400372, Romania*

Presenting author email: szabolcs.fogarasi@ubbcluj.ro

Introduction

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 [1], 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 [2-3]. 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. 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. 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. 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.

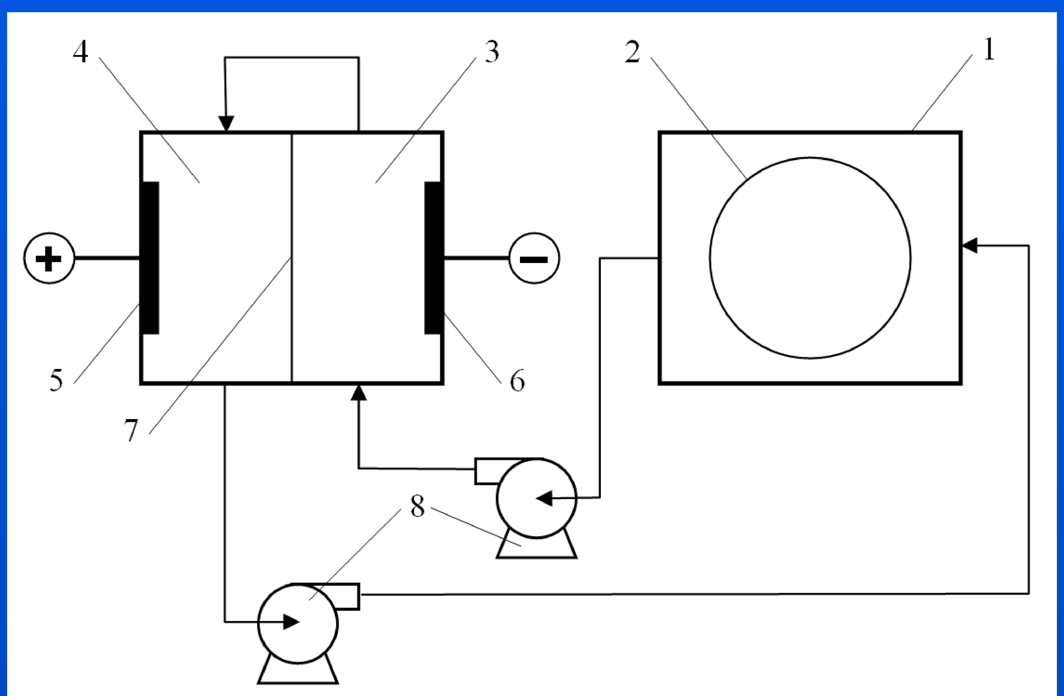


Figure 1. Experimental setup: leaching reactor (1), rotating perforated drum (2), cathodic (3) and anodic (4) chambers, graphite anode (5) and cathode (6), CS (7), pump (8).

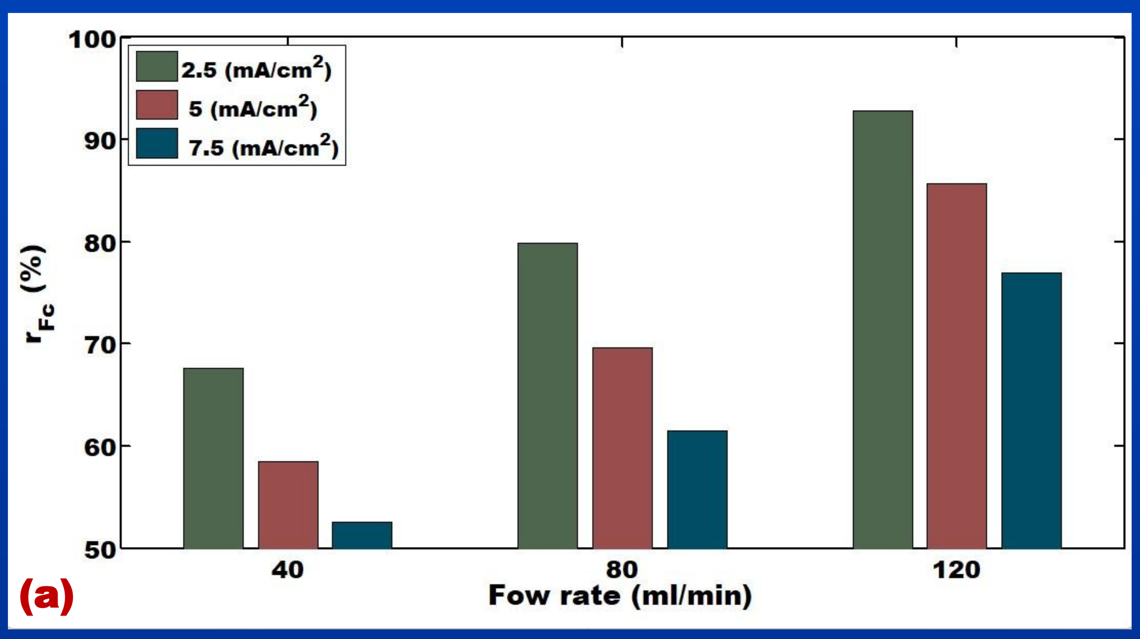
EXPERIMENTAL CONDITIONS

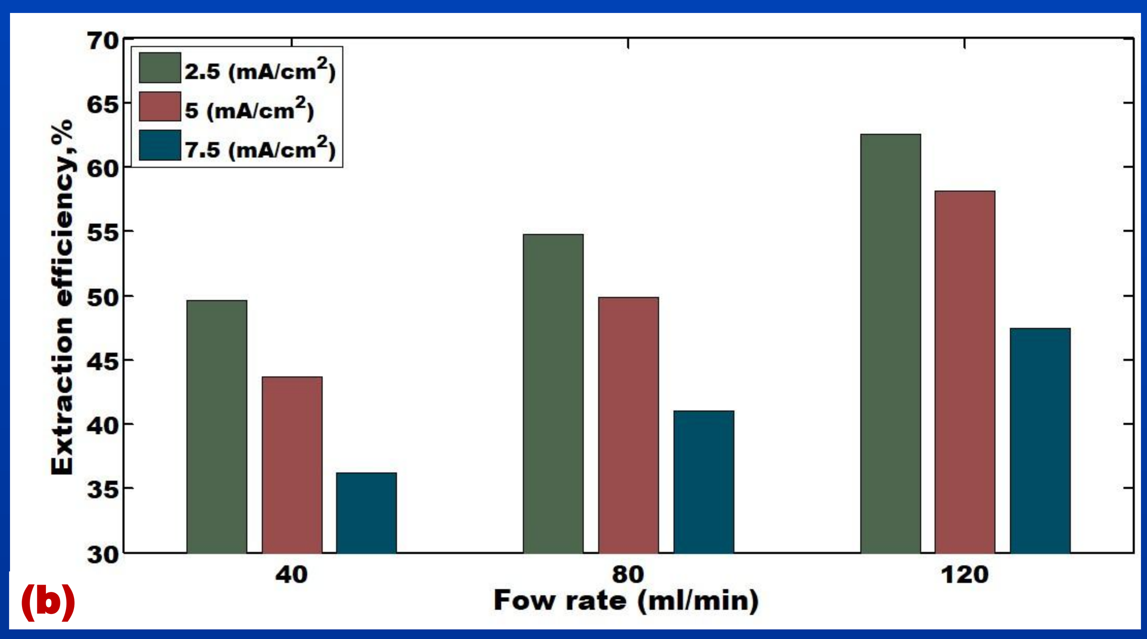
- **Electrolyte composition: 0.3 M $FeCl_3$ and 0.5 M HCl**
- **Leaching reactor volume: 150 mL**
- **Compartmented electrochemical reactor: 150 mL**
- **Galvanostatic mode: 2.5-5-7.5 mA/ cm^2**
- **Processing time: 3 h**
- **Reference electrode: Ag/AgCl/$KCl_{(sat)}$**
- **Flow rate: 40- 80 – 120 ml/min**
- **Drum rotation speed (30 rpm)**
- **Solid/liquid ratio(1/8)**
- **Computer equipped system**
- **Potentiostat / galvanostat: DXC236 (5 A, ± 20 V)**

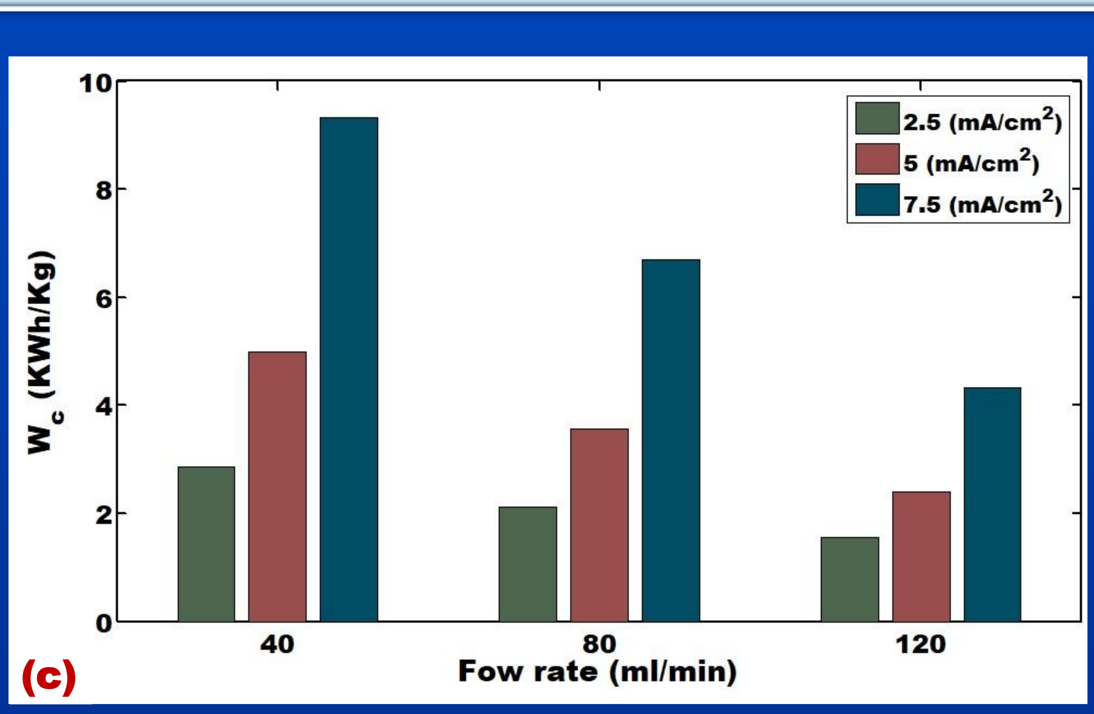
Key technical performance indicators

Extraction efficiency (%): the ratio between the amount of electrodeposited Cu and total dissolved Cu.
Current efficiency (%): the ratio between the amount of electricity used for the formation of the cathodic deposit and the total amount of electricity consumed in the process.
Dissolution degree (%): the ratio between the amount of dissolved Cu and the total amount of Cu in the initial sample.
Specific cathodic energy consumption (KWh/Kg): the amount of energy used for the formation of 1 Kg of cathodic deposit.
Specific energy consumption for the dissolution process (KWh/Kg): the amount of energy for the dissolution 1 Kg of Cu.

Results & Discussion







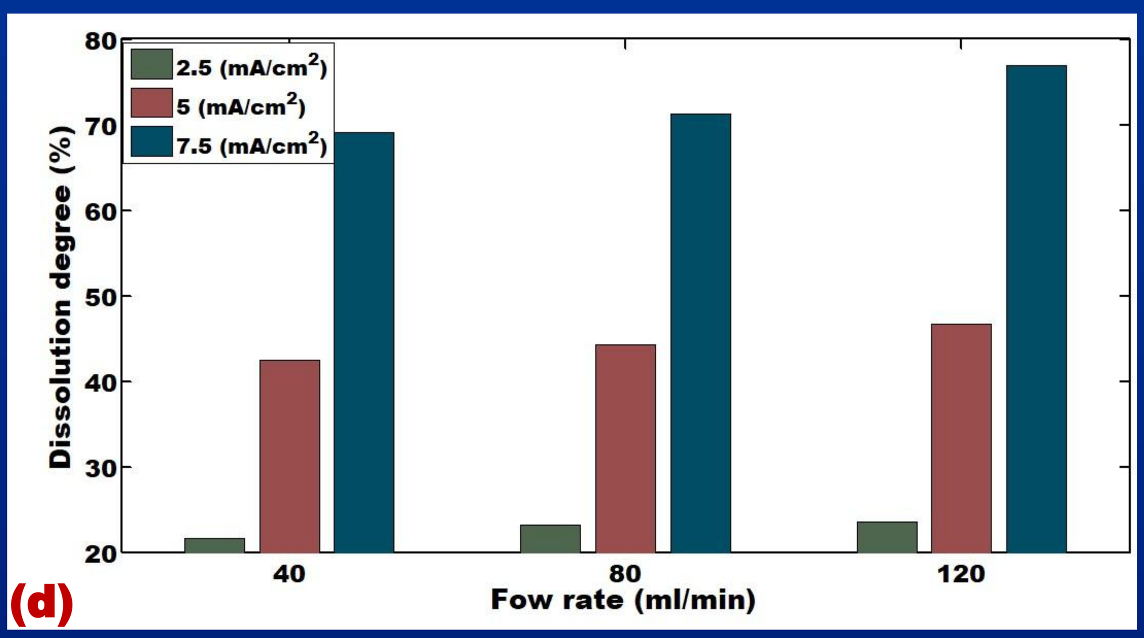
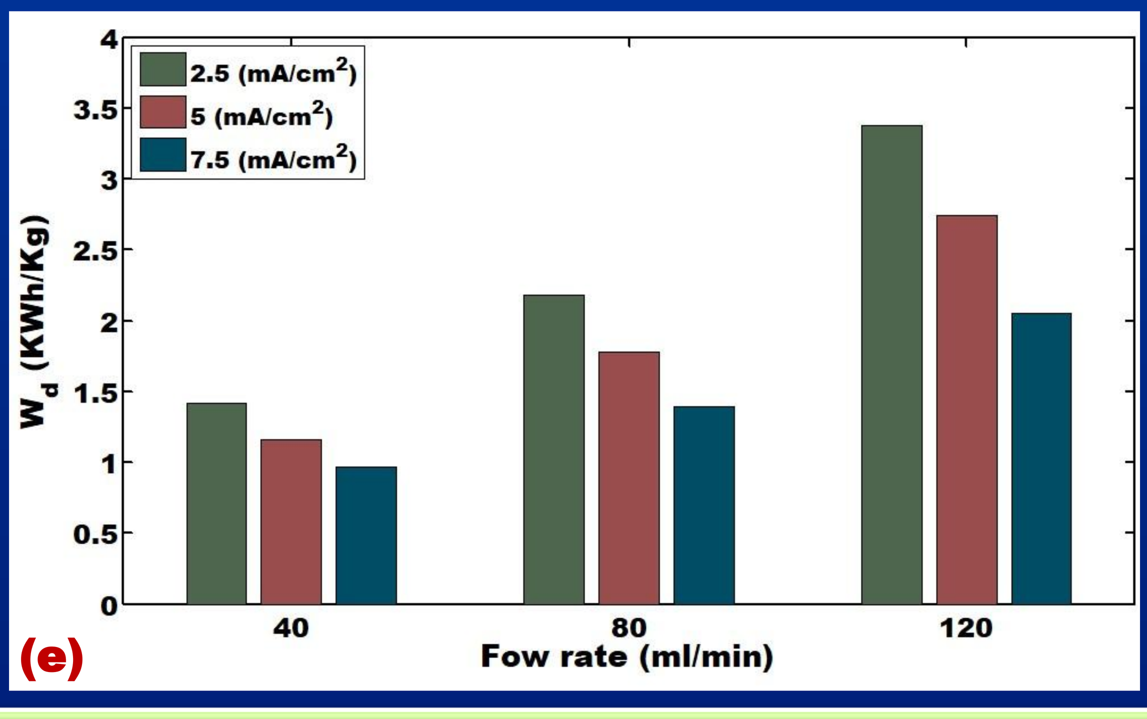


Figure 2. (a) current efficiency, **(b)** extraction efficiency, **(c)** specific cathodic energy consumption, **(d)** dissolution degree, and **(e)** specific energy consumption for the dissolution process at different current densities and flow rates.



Conclusions

- ► **The current study proved that $FeCl_3$ is a regenerable and efficient oxidant for the dissolution of Cu and can be applied efficiently for the recovery of copper from spent Li-ion batteries anode current collector using a combined chemical-electrochemical process.**
- ► **Based on the experimental results it can be stated that highest amount of Cu can be recovered the most efficiently at the lowest current density and the highest flow rate.**
- ► **It was found that in the best operating conditions the purity of the obtained Cu deposit was more than 99 wt.% which makes it suitable for many industrial applications.**

References

[1] Gaines, L., 2019. One Earth 1(4), 413-415.
[2] Harmsen, J.H.M., Roes, A.L., Patel, M.K., 2013. Energy 50, 62-73.
[3] Makuza, B., Tian, Q., Guo, X., Chattopadhyay, K., Yu, D., 2021. Journal of Power Sources 491, 229622.

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.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.