Indium and silver recovery from perovskite thin film solar cell waste by means of nanofiltration

Sebastian Hedwig[1], Meret Amrein[1,2], Karina Rohrer[1], Dirk Hengevoss[1], Heon Jin[3] Henry J. Snaith[3], Michael Thomann[1], Frank Nüesch[2,4], Markus Lenz[1,5]

[1] *Institute for Ecopreneurship, School of Life Sciences, University of Applied Sciences and Arts North-western Switzerland, Hofackerstrasse 30, 4132 Muttenz, Switzerland*
[2] *EPFL, Institute of Materials Science and Engineering, Ecole Polytechnique Fédérale de Lausanne, Station 12, Lausanne, 1015, Switzerland*
[3] *Department of Physics, University of Oxford, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK*
[4] *Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Functional Polymers, Dübendorf, 8600, Switzerland*
[5] *Department of Environmental Technology, Wageningen University, 6708 PB, Wageningen, the Netherlands*
sebastian.hedwig@fhnw.ch

The rapid deployment of perovskite solar cells (PSCs) poses challenges for sustainable raw material supply and waste management of the future, particularly due to their use of precious raw materials such as indium (In) and silver (Ag) [1]. This study presents a novel and environmentally benign process for the recovery of PbI_2, In and Ag from end-of-life PSCs, integrating hydrometallurgical extraction and advanced nanofiltration (NF) technologies.
Following mechanical dismantling and aqueous PbI_2 recovery [2], In and Ag were extracted using nitric acid, achieving recovery efficiencies of 87 ± 7% for both metals [3]. To separate and concentrate these elements from the acidic leachate, we employed a custom-built layer-by-layer (LbL) NF membrane. The LbL membrane demonstrated near-complete In retention (96.9 ± 0.4%) and negligible Ag retention, resulting in a concentrated In stream and a dilute Ag permeate. Compared to a commercial acid-resistant NF membrane, the LbL membrane achieved similar separation performance with significantly lower pressure (5 bar vs. 25 bar) and higher flux (30 L/m^2h vs. 6 L/m^2h), reducing energy consumption by over 85%. By modifying their composition, the LbL membranes gained stability towards a number of highly concentrated inorganic acids, expanding their range of applications beyond In / Ag recovery from PSC [4].
Life cycle assessment confirmed the environmental benefits of the processes in comparison to primary raw material extraction, especially when acid reuse strategies were considered. Hence, the hydrometallurgical recovery of Pb, In and Ag offers a scalable and environmentally benign solution for material recycling from next-generation photovoltaics [3,4].

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