Sustainable SoluTions FOR recycling of end-of-life Hydrogen technologies

BEST4Hy

TRAINING MODULE 2

Chapter_1

Introduction to the current existing recovery & recycling technologies

Document Details

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Input from	Literature and Consortium

Document Details

x PU - Public

CO - Confidential, only for members of the consortium (including the EC)

Clean Hydrogen Partnership

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1 Executive Summary

Within project BEST4Hy, a training kit is to be developed. This will be subdivided into 4 Modules with this content:

- Module 1: How to dismantle a fuel cell
- Module 2: Recycling technologies
- Module 3: Technical results and economical aspects
- Module 4: Measures towards to take up.

Module 2 is dedicated to the recycling technologies, providing knowledge on the adaptation and designing of existing and novel processes and an overview of the processes developed within the project.

Module 2 should be organized as follow:

- Chapter 1: Introduction to the current existing recovery & recycling technologies
- Chapter 2: Description and manual to perform the existing and optimized recovery & recycling technologies (PEMFC);
- Chapter 3&4: Description and manual to perform the novel recovery & recycling processes developed within the project (PEMFC/SOFC).

Video tutorials on how to perform the recovery and recycling processes above described are also available. For more information, users can consult the associated deliverables describing the activities performed in BEST4Hy:

- D1.2: Technical report on the adaptation of existing technology (hydrometallurgy process) for PEMFC material recovery: results and design
- D1.5: Pilot-scale plant (TRL5) based on 3 recycling technologies for PEMFCs
- D2.3: Report on the evaluation of MEA including recycled materials in a small single cell of PEMFC
- D2.6: Report on the evaluation of MEA including recycled materials in PEMFC stack_PU
- D3.3: Pilot-scale plant (TRL5) based on two integrated existing recycling technologies for SOFCs_PU
- D3.5: Technical report on open loop analysis of different scenarios
- D4.3: Technical report on developed recovery technologies for LSC cathode materials_PU

<u>The present document refers to Chapter 1: Introduction to the current existing recovery & recycling technologies.</u>

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2 Introduction

This chapter introduces Module 2 on the technologies for the recovery of critical raw materials, strategic materials, precious (platinum group) materials and rare earth elements from Proton Exchange Membrane Fuel Cells and Solid Oxide Fuel Cells.

Well-established low environmental impact technologies for recovery and recycling of end-of-life PEM and SO fuel cells still do not exist. In BEST4Hy, the Consortium focused on both optimization of existing technologies and exploration of novel technologies for the recovery of critical /precious (PGM)/ rare earth elements materials. These are explained in the following chapters, while this Chapter provides a quick overview on the state of the art with respect to existing technologies.

3 Overview of PGMs recovery technologies for EoL PEMFC

Recovery of PGMs from secondary sources such as catalytic converters is performed conventionally through pyrometallurgy [1]. The most common processes of pyrometallurgy are smelting, chlorination and sintering [2]. Since no large volumes of EoL fuel cells are currently available, tailored industrial technologies for recovery of PGMs from this specific waste stream do not exist just yet, but existing processes, well developed for other PGMs-containing waste, might be applied.

The smelting process is the mostly commonly employed (pyrometallurgical) approach for concentrating PGMs in many companies with advanced metallurgical and refining technologies, such as Umicore and Johnson Matthey. Spent catalyst is usually mixed with flux, collector, and reducing agent and then smelted in a high-temperature plasma furnace, electric arc furnace, or inductive furnace at a high temperature (usually above 1000°C). PGMs are enriched in the metal phase or converted into easily treated compounds, which can be refined later to recover PGMs. The process may involve initial pretreatment steps (e.g., dismantling/incineration of nonmetallic components, calcination, or reduction) before high-temperature smelting in which a suitable collector, in many cases, a high specific gravity base metal (lead, copper, nickel, etc.), collects the PGMs, forming a PGM-enriched alloy. Meanwhile, the catalyst carriers, such as alumina, mullite, or cordierite, are melted in the presence of suitable fluxes to obtain a low-viscosity liquid slag. After its separation from slag, the PGM-containing alloy is sent for PGM purification. In the choice of collector, the mutual solubility, melting points, and chemical properties of collector and PGMs are important. Generally, lead, copper, iron, matte, and other materials containing these metals (such as printed circuit boards, abbreviated as PCBs) are good collectors for smelting of spent catalysts [2].

This is also true for conventional pyrometallurgical route of PGM recovery from PEMFC electrodes through combustion of the spent membrane electrode assemblies (MEAs) to obtain PGM in metal form. However, the process produces toxic emissions owing to the presence of fluorinated carbon backbone of the polymer electrolyte membrane (PEM) [1].

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While it is clear that current pyrometallurgical technologies allow the extraction of PGMs also from EoL fuel cells, there is a considerable loss of potentially recyclable materials, from the ionomer to the carbon black/graphite, with subsequent loss of overall value.

It is for this reason that project BEST4Hy was tasked with the identification of low environmental impact recovery processes, and it identified approaches based on hydrometallurgy, alcohol dissolution and electroleaching/electrodeposition described in the following chapters.

4 Overview of recovery technologies for EoL SOFC

EoL SOFC are not currently recovered at an industrial level. Very few research groups are working on the issue despite the potential for increase in application of SOFCs in the future.

Research undertaken by project BEST4Hy has been at the forefront in the identification of possible recovery routes for the close loop and open loop recycling of critical raw materials and rare earths from SOFC.

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5 References

[1] Raghunandan Sharma, Shuang Ma Andersen, Circular use of Pt/C through Pt dissolution from spent PEMFC cathode and direct reproduction of new catalyst with microwave synthesis, Materials Chemistry and Physics, Volume 265, 2021, 124472, ISSN 0254-0584, https://doi.org/10.1016/j.matchemphys.2021.124472.

[2] Peng, Z., Li, Z., Lin, X. et al. Pyrometallurgical Recovery of Platinum Group Metals from Spent Catalysts. JOM 69, 1553–1562 (2017). https://doi.org/10.1007/s11837-017-2450-3

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