Development of the most cost-efficient hydrogen production unit based on anion exchange membrane electrolysis

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Project Overview

- Call year: 2019
- Call topic: FCH-02-4-2019: New Anion Exchange Membrane Electrolyzers
- Project dates: 01.2020 - 30.2023
- Total project budget: 1 999 906,25 €
- Clean Hydrogen Partnership max. contribution: 1 999 906,25 €
- Partners: SINTEF; NTNU; FZJ; SHELL; EVONIK; ENAPTER
Project Objectives

**Concepts developed within CHANNEL**

- Optimisation of cQA-PAEK based polymers structural parameters, e.g. MW, block-co-polymer ratios, thickness.
- Optimisation of Ni-based catalysts, NiMo, NiFe by surface stabilisation, shape control and study of catalyst ionomer interactions.
- Electrode optimisation (ionomer and catalyst type and loadings), different coating methods and different MEA approaches guided by electrochemical AEM modelling.
- New AEM advanced pressurised electrolyser design, low-cost PTLs, assisted by CFD flow simulations in porosu media.

**Outcome**

- Beyond SoA 30 bar 2kW AEM electrolyser with performance of 1.85 V @ 1 A cm⁻² in diluted electrolyte
- 2000 h operation < 50 mV degradation
- <600 EUR/kW
To Take Away:

1. AEM is good enough in terms of their KPIs, however, the question is related to their durability.

2. A better understanding of the in-operando membrane degradation mechanics is needed.

3. Thinner AEM can be manufactured, but questions concerning gas crossover, mechanical strength, and durability should be addressed properly.
To Take Away:

1. A better understanding of the ionomer role and optimal ratio AEI-catalyst is needed as a function of the hydroxide concentration.

2. For PGM/CRM-free catalysts, the catalyst utilization would be more relevant than mass activity (cost-related), however high catalyst loading (thick electrodes) to compensate for lower mass activity (low-cost catalyst) needs to be carefully tuned to minimize mass transport constraints.

3. The development of in-situ methods for a better understanding of the catalyst activity and stability is recommended.

CHANNEL Catalysts Target at 10 mA cm⁻²:
- **HER**: <150 mV overpotential and **OER**: <300 mV overpotential
- Both catalysts achieved performance and stability targets at 1M KOH besides to be scalable
Project results - Single Cell Performance

CHANNEL Target: 1.85 V at 1 A/cm², 60°C, 1M KOH
Components long-term stability demonstrated over 1000 h

To Take Away:

1. The electrode performance is quite sensitive to the ionomer content in the catalyst layer.
2. Crucial to understand the role of the AEI within the catalytic layer.
3. The electrodes to be used must be also optimized for the chosen KOH concentration since the optimal ratio AEI to catalyst may vary as a function of the hydroxide concentration.
4. The binding properties of the AEI must be considered as well.

- Developing a AEMWE model to predict local effects (e.g. pH change, water concentration gradients, etc.), degradation (cat's dissolution)
To Take Away:

1. CHANNEL stack demonstrator was validated over 260 h at atmospheric pressure, 0.25 A/cm² and 55 °C resulting in a degradation rate of 38 µV/h.

2. Unfortunately, the performances expected for the stack were not fully reached at the end of the project.

3. Components dimensioning and manufacturing, methodology transferring from lab scale to stack level, and design/engineering of the final prototype is not a simple task to commit.

Project results - 2 kW Stack

16 cells with active area of 64 cm²
BoP for stack testing was also designed and optimized
The results have been presented in 10 conferences.
A patent application has been submitted.
Creation of the AEM Hub for promoting the AEM technology in cooperation with the other EU granted AEMWE projects (NEWELY and ANIONE).

Two more manuscripts are under revision.
✓ CHANNEL successfully developed alternative low-cost non-PGM catalysts exhibiting excellent performance and durability. *A patent application on cathode catalyst was submitted by NTNU.*

✓ The project achieved a good generation of anion exchange membranes and ionomers with excellent chemical and mechanical properties.

✓ The optimized membrane and electrodes allowed to reach a full non-PGM single-cell performance target of <1.85 V at 1 A/cm² with a good stability after 1000 h (@1A/cm²) long-term test.

✓ Due to the low TRL of the stack prototype, manufacturing strategies, and cost forecast for a 500kW system were calculated based on estimations of the stack manufacturer.
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Thank you for your attention