ANIONE

ANION EXCHANGE MEMBRANE ELECTROLYSIS FOR RENEWABLE HYDROGEN PRODUCTION ON A WIDE-SCALE

Project ID	875024
PRR 2024	Pillar 1 – Renewable hydrogen production
Call topic	FCH-02-4-2019: New anion exchange membrane electrolysers
Project total costs	EUR 1 999 995.00
Clean H_2 JU max. contribution	EUR 1 999 995.00
Project period	1.1.2020–30.9.2023
Coordinator	Consiglio Nazionale delle Ricerche, Italy
Beneficiaries	Hydrolite Ltd, Université de Montpellier, TFP Hydrogen Products Ltd, Hydrogenics Europe NV, IRD Fuel Cells A/S, Uniresearch BV, Centre national de la recherche scientifique

https://anione.eu/

PROJECT AND GENERAL OBJECTIVES

The Anione project's primary goal was to create a high-performance, cost-effective and durable anion-exchange membrane water electrolysis (AEMWE) technology. This technology integrates anion-exchange membrane (AEM) and ionomer dispersion in catalytic layers for hydroxide ion conduction, combining the benefits of proton-exchange membrane and liquid electrolyte alkaline technologies. This approach facilitates the scalable production of low-cost hydrogen from renewable sources.

The project focused on developing hydrocarbon AEM membranes with either poly(arylene) or poly(olefin) backbones, incorporating quaternary ammonium hydroxide groups anchored to the polymer backbone. Concurrently, advanced short-side-chain Aquivion®-based AEMs with perfluorinated backbones and quaternary ammonium groups were developed. The goal was to match the conductivity and stability of these AEMs with their protonic counterparts and to improve mechanical stability and reduce gas crossover using novel nanofibre reinforcements.

NON-QUANTITATIVE OBJECTIVES

- **Enhanced oxygen evolution catalysts.** Development of an advanced, non-critical-raw-material, NiFe-based catalyst for the oxygen evolution reaction with reduced overpotential and enhanced stability.
- **Enhanced hydrogen evolution catalyst.** Development of an advanced, non-critical-raw-material, Ni-based catalyst for the hydrogen evolution reaction with reduced overpotential and enhanced stability
- **Advanced cost-effective membrane.** Development of cost-effective advanced AEMs with proper hydroxide ion conductivity and stability.
- **Process implementation.** Development of an AEM electrolysis operating mode with enhanced stability.
- **AEM electrolysis hardware components.** Implementation of advanced AEM electrolysis components in terms of diffusion layers and current collectors.
- **AEM electrolysis stack.** Development of an advanced, non-critical raw material AEM electrolysis stack.

PROGRESS AND MAIN ACHIEVEMENTS

The work addressed AEMWE technology development. The main results are summarised below.

- Fluorinated and hydrocarbon AEM ionomers with quaternary ammonium functional groups were developed and characterised in terms of ion-exchange capacity and anion conductivity.
- A nanosized NiFe-oxide, oxygen evolution anode electrocatalyst and a carbon-supported, Ni-based, hydrogen evolution cathode electrocatalyst for AEMWE were developed.
- Membrane electrode assemblies based on catalyst-coated electrodes including the nanosized, Ni-based anode and cathode electrocatalysts have shown electrolysis performance of about 1.8 V at 1 A/cm^2 and 50 °C. Stable performance were observed during 2 000-hour steady-state and 1 000-hour cycled (0.2–1 A/cm^2) operations.
- Large-area (> 100/cm^2) membrane electrode assemblies were integrated into a simplified stack design.
- The novel solutions developed in the project were validated in an AEM electrolysis stack of 2 kW capacity with a hydrogen production rate of about 0.4 Nm^3/h (technology readiness level 4) with 57 kWh/kg H_2 energy consumption at 1 A/cm^2. A second stack was assembled and showed improved durability, with continuous increase in its performance over time.
- A single-cell performance of 1 A/cm^2 at about 1.8 V/cell was achieved using non-critical raw materials and hydrocarbon membranes.
- A 2 kW AEM electrolyser, achieving a hydrogen production rate of about 0.4 Nm^3/h (technology readiness level 4), was validated as a proof of concept.

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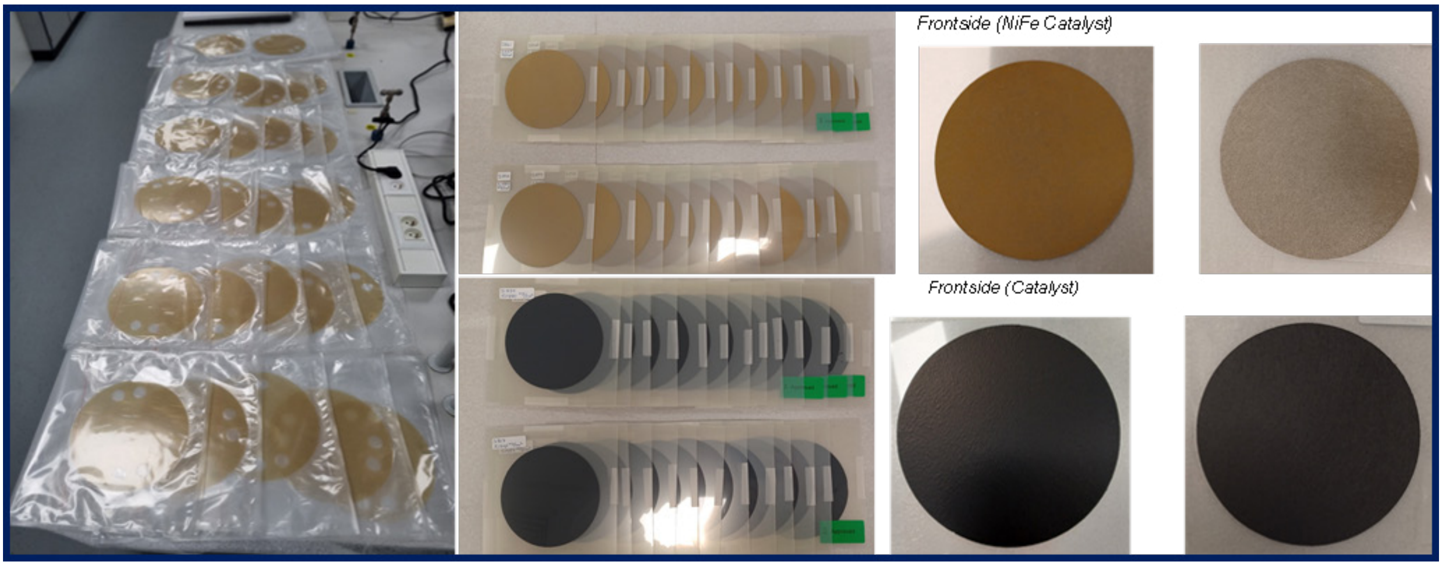
FUTURE STEPS AND PLANS

The project has finished

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SOA result achieved to date (by others)	Year for reported SOA result
AWP 2019	Maximum operating temperature	°C	90	90	✓	60	2022
	Series resistance	ohm cm^2	< 0.07	0.06	✓	0.1	2022
	Degradation rate: voltage increase at 1 A/cm^2	mV/h	< 0.005	< 0.005	✓	2	2020
	Electrolysis CAPEX @ the system level	M €/(t/day)	0.75	N/A	⚙	1.6	2020
	AEMWE stack efficiency	%	70	70	✓	N/A	N/A
	AEMWE stack power	kW	2	2.1	✓	N/A	N/A
	AEMWE stack capacity	kg/day	0.8	0.87	✓	N/A	N/A
	Membrane conductivity	mS/cm	50	105	✓	80	2022
	Cell voltage at 1 A/cm^2 (cell performance at 45 °C)	V	2	1.75	✓	1.67	2020



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