Next Event

WHEC Conference, 26-30 July 2022, Istanbul, Turkey

CNR-ITAE presentation on *Chemically stabilised short side chain Aquivion® membranes for operation in water electrolysis*

Future Work

During the final 12 months of the project, the consortium will focus on the production of the large scale MEAs and build and testing of the stack and balance of plant for the demonstration unit. The technical advances made at the material and stack design level will be validated by demonstrating a robust and rapid-response electrolyser of 29 kW nominal capacity with a production rate of 13 kg H_2/day. An assessment of the system durability under steady state and duty cycles conditions and an evaluation of the improved dynamic behaviour for the PEM electrolysis system will be conducted.

The techno-economic assessment and life cycle analysis on the advanced PEM electrolyser will provide a strong basis for commercialisation of the advancements made within the project and will seek to prove that the Neptune solutions bring a game-changing advancement to PEM-electrolysis. The relevant applications for the new PEM electrolysis technology will be analysed as well as current and forecast market sizes with the aim to evaluate the specific market potential throughout Europe. The purpose is to position Neptune technology against its competitors for relevant market applications and to promote the large-scale deployment of energy storage technologies and favour hydrogen/water electrolysis penetration into the market.

ITM POWER Energy Storage | Clean Fuel

IRD IRD Fuel Cells

SOLVAY Progress beyond

Consiglio Nazionale delle Ricerche ITAE

ENGIE Lab

PR3TEXO

Project partners during the 18M progress meeting, IRD Fuel Cells, Odense, Denmark

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 779540, NEPTUNE. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Next Generation PEM Electrolysers under New Extremes

NEPTUNE

Newsletter #2
July 2020

EDITO

The FCH2 JU funded Neptune project, which aims to achieve a significant reduction in capital costs of PEM electrolysis, increase the production rate and output pressure of hydrogen while assuring high efficiency and safe operation, has just entered its third year. The NEPTUNE project is developing a set of breakthrough solutions at materials, stack and system levels to increase hydrogen pressure to 100 bar and current density to 4 A cm^{-2} for the base load, while keeping the nominal energy consumption <50 kWh/kg H_2.

In the last 12 months, the development, characterisation and scale-up of both membranes and catalysts has been completed and transferred from work packages 3 and 4 to work package 5 for MEA development and characterisation. Stack engineering and system development are on track to be able achieve upcoming project milestones.

A state-of-the-art electrolysis system with rated capacity of 29-69 kW and nominal hydrogen production capacity 13-26 kg H_2/ day at the operating current densities of 4-8 A cm^{-2}, respectively will be demonstrated in the next 12 months of the project.

PROJECT COORDINATOR
Rachel Backhouse
ITM Power plc
22 Atlas Way
S4 7QQ Sheffield
United Kingdom
www.neptune-pem.eu

Publications

Electrochimica Acta, Volume 344, 1 June 2020, 136-153

Enhanced performance of a PtCo recombination catalyst for reducing the H_2 concentration in the O_2 stream of a PEM electrolysis cell in the presence of a thin membrane and a high differential pressure

N. Briguglio, F. Pantò, S. Siracusano, A.S. Aricò

Conferences

9-11 December 2019, EFC19 Conference, Naples, Italy

CNR-ITAE presentations on *High pressure water electrolysis and corresponding safety issues: the role of platinum based recombination catalyst and Reduction of H_2 concentration in the anode stream of a pressurised water electrolyser based on a thin polymer electrolyte membrane*

Advanced membranes of Aquivion PFSA onto innovative Torlon PAI

In the frame of WP3 (Innovative Membranes) Solvay developed advanced membranes of Aquivion PFSA (PerFluoroSulfonic Acid) supported onto innovative Torlon PAI (PolyAmidoImide) reinforcement. Although electrochemical performances and mechanical toughness are below the state-of-the-art, this material seems to be promising and worth to be further investigated thanks its particular and unexpected morphology.
In collaboration with a subcontractor the manufacturing process of Torlon support via forcespinning has been upscaled producing rolls of several square meters (Figure 1).

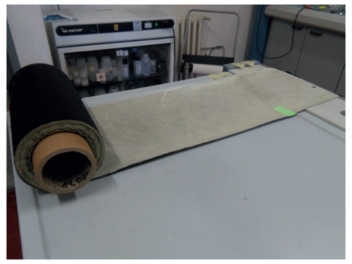


Figure 1: Roll of forcespun Torlon support

Following a deep physico-chemical and electrochemical characterization, Aquivion extruded E98-05S was selected, among four different grades developed and injected into the project, as the most suitable membrane to be used to prepare MEAs for the Neptune final stack. Solvay upscaled and improved the manufacturing process of this membrane providing a roll of several square meters (Figure 2).

Figure 2: Roll of Aquivion E98-05S extruded membrane

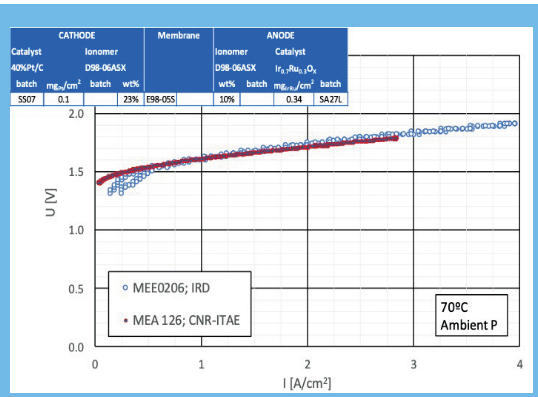
Catalyst ink and catalyst coating optimisation

Specific effort has been addressed to optimise catalyst ink composition and improve the procedure of catalyst coating on membranes for ultra-low catalyst loadings (IRD). The catalyst ink optimisation activity was addressed to tailor catalyst-ionomer composites as a function of ionomer equivalent weight and catalyst morphology to extend the reaction interface and favour a high degree of catalyst utilisation (CNR-ITAE). These were pre-requisite to achieve MEA performance of 4 A cm^{-2} at 1.75 V using an ultra-low PGM loading <0.4 mg cm^{-2} MEA (project target). The improvements were also addressed to minimise waste and improve stability. An iterative approach included optimisation of amount of solvent, additives and processing parameters used.

MEA characterisation was used to screen the different formulations and preparation procedures and served to assess the achievement of the project targets (CNR-ITAE). Electrochemical and physico-chemical characterisation addressed to provide insights into the optimal electrode structure (CNR-ITAE). The aim was to maximize electrochemically active surface area, minimize losses due to transport of charge carriers as well as reactants and products. Electrochemical testing included:

- Single cell testing in a wide range of temperatures (from ambient to 140°C) and pressures (from ambient to 20 bar) as well as in a wide range of current densities (up to 8 A cm^{-2})
- Determination of gas permeation using high sensitivity gas sensors and gas chromatographic analysis to evaluate the capability of the recombination catalysts inside the MEAs to manage gas permeation at high pressure.

Initial tests of both IRD- and CNR-manufactured CCMs showed that electrolysis cells containing CCMs with total PGM catalyst loadings of ≈0.44 mg/cm² had similar performance.



Catalyst achievements

A Pt-Co alloy unsupported catalyst was investigated as catalysts for recombining hydrogen and oxygen back into water. PtCo alloy catalyst was integrated in the membrane-electrode assembly, in particular between the membrane and the IrRuOx anode catalyst. This catalyst showed good capability to reduce the concentration of hydrogen in the oxygen stream under differential pressure operation (1-20 bar), in the presence of a thin Aquivion membrane. In this case, the mechanism mainly consisted in an electrochemical oxidation of the permeated H_2 to protons that were transported back to the cathode according to the electric field gradient effect. At the cathode, these ions were reduced again to molecular hydrogen. This parasitic current was not affecting much the faradaic efficiency of the system that remained larger than 99% in almost the overall range of operating current densities. The prevailing electrochemical oxidation mechanism for the permeated H_2 in the electrolysis cell is supported by the occurrence of relevant depolarisation phenomena in the presence of the PtCo catalyst.

The H_2 concentration in the oxygen stream of the PEM electrolyser decreased significantly in the presence of the PtCo catalyst. At 20 bar differential pressure, in the presence of PtCo, the hydrogen concentration in the anodic oxygen stream was well below the flammability limit (4% vol. of hydrogen in the oxygen Stream) also when the current density was as low as 0.15 A cm^{-2}. This corresponds to 5% partial load operation for the nominal current density of 3 A cm^{-2} for the present system compared to a minimum partial load of 20% for conventional electrolysis systems. This characteristic provides better flexibility to cope with the dynamic behaviour of renewable power sources. The observed H_2 concentration in the oxygen stream for the present electrolysis system is lower than that reported in the literature for PEM electrolysis cells operating at both similar pressures and current densities in the presence of much thicker membranes-based electrolytes.

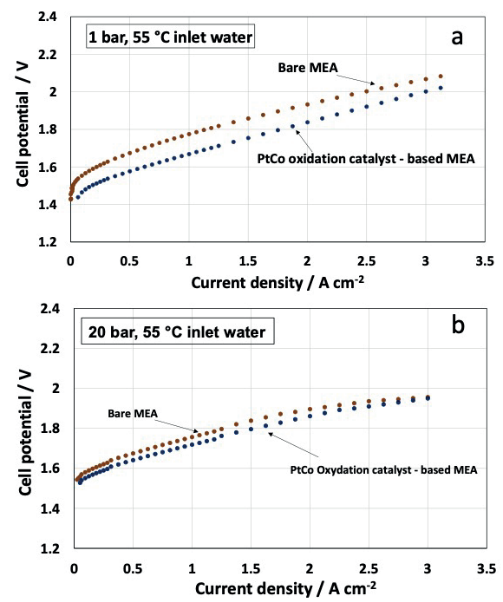
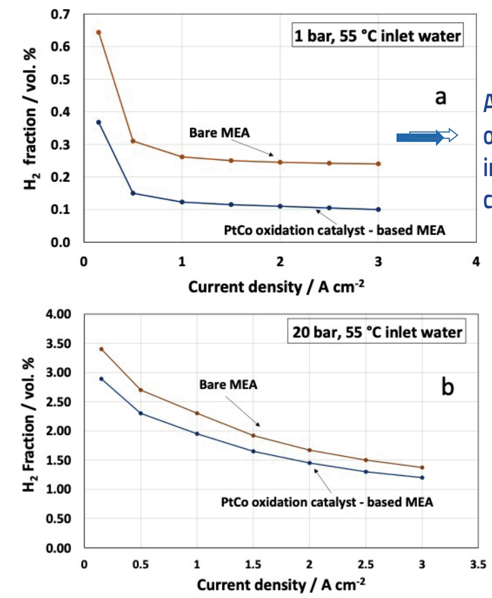


Figure 1: Electrolysis polarization curves for the bare MEA and the MEA containing the PtCo oxidation catalyst at ***(a)*** *1 bar and* ***(b)*** *20 bar differential pressure, at a constant water inlet temperature of 55 °C.*



Almost 50% reduction of the H_2 concentration in O_2 in a wide range of current densities

Figure 2: Hydrogen fraction in the outlet anode stream at various current densities for the bare MEA and the MEA containing the PtCo oxidation catalyst at ***(a)*** *1 bar and* ***(b)*** *20 bar differential pressure, at a constant water inlet temperature of 55 °C.*