Events

WHTC Conference, Tokyo on June 2-7, 2019

CNR-ITAE presentation on *Pt-alloy Catalyst Used as Recombination Catalyst in a Thin Polymer Electrolyte Membrane Electrolyser*

Future Work

By the mid-point of the project, MEAs will have been assembled and tested at high temperature and high pressure to see if the positive results seen in the catalysts, and early membranes can be replicated. Improvements in catalyst coating will be trialed, and catalyst ink process optimized.

The new stack architecture design will be trialed with some of the first project results to see how the catalyst and membranes components function when used in MEAS and tested.

These novel solutions will be validated by demonstrating a robust and rapid-response electrolyser of 48 kW nominal capacity with a production rate of 23 kg H_2/day. The design for this is underway and a prototype testing rig is in production.

The techno-economic analysis of the system will be undertaken mainly in the second half of the project, to prove that the Neptune solutions bring a game-changing advancement to PEM-electrolysis.

Project partners during the 6M progress meeting, CNR-ITAE, Messina, Italy

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 #1
July 2019

EDITO

Now approaching its halfway point, the Neptune project is working towards a goal of reduction of capital costs and increase in production rate and output pressure of hydrogen in PEM electrolysis.

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. Dramatic improvements in the stack efficiency will be realised using novel thin reinforced membranes, able to withstand high differential pressures. An efficient recombination catalyst will solve any gas crossover safety issues. Newly developed electro-catalysts with increased surface area will promote high reaction rates. The project has already had some good progress developing membranes, with catalysts already achieving some of the first project goals. The MEAs are starting to be produced in the next couple of months, and project partners look forward to some more positive results.

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Publications

Journal of Membrane Science, Volume 578, 15 May 2019, Pages 136-148

Chemically stabilised extruded and recast short side chain Aquivion® proton exchange membranes for high current density operation in water electrolysis

S. Siracusano, C. Oldani, M.A. Assunta Navarra, S. Tonella, L. Mazzapioda, N. Briguglio, A. S. Aricò

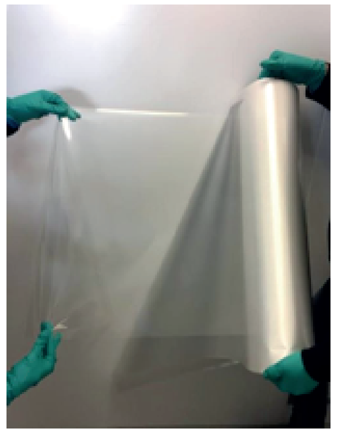
Applied Catalysis B: Environmental, Volume 246, 5 June 2019, Pages 254-265

Flammability reduction in a pressurised water electrolyser based on a thin polymer electrolyte membrane through a Pt-alloy catalytic approach

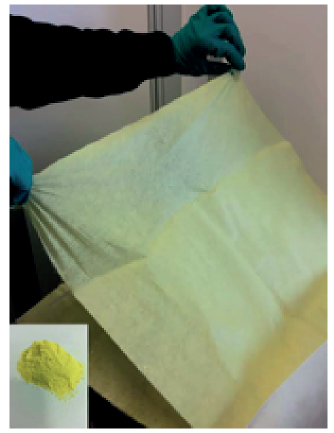
N. Briguglio, S. Siracusano, G. Bonura, D. Sebastián, A. S. Aricò

New supports based on Torlon PAI

In the frame of search for innovative materials for electrolysis, WP3 in the first 12 months of the project started development of new supports based on Torlon PAI to be used in reinforced membranes manufacturing, studied an improved stabilization process improving durability of membranes and started upscaling of Aquivion-based extruded membranes heading to TRL5.



Aquivion® PFSA E98-05S extruded membrane roll produced at larger scale



Torlon PAI force-spun mat ready to be used as support for innovative Aquivion-based membranes. Inset: Torlon PAI powder (commercial grade).

System Design and Prototyping

The aim of WP6 is the development of an advanced, cost-effective, rapid response PEM water electrolyser system that is able to operate at very high current densities (4 – 8 A/cm^2), while sustaining the associated increase in operating temperature. In addition to this, the design will look to reduce the energy consumption necessary for external gas compression, by operating at pressures of up to 100 bar. In order to meet these challenging goals, a review of current ITM Power system designs has been carried out, which has led the creation of a new design for a small-scale prototype balance of plant, that will facilitate the testing of new MEA developments, under a range of operating conditions. Knowledge gained through development of the small-scale system will inform the design of the larger demonstration unit planned later in the project. Early on the focus was on engineering calculations and computer simulations to enable the correct materials of construction to be selected. Now attention has turned towards the manufacture of first generation prototype test cell components and the procurement of balance of plant.

Stati Generali e Celle a Combustibile IdroGeno, 28 Novembre 2018, Milano, Italy

The project has been presented at "Stati Generali e Celle a Combustibile IdroGeno", held at politecnico di Milano.

Catalyst achievements

High electro-catalytic activity has been achieved in the first phase of the Neptune project corresponding to operating current densities of 4-8 A/cm^{-2} at high voltage efficiency 1.85 and 2.0 V/cell. This was obtained through he development of advanced catalysts and by increasing the operating temperature as this improves reaction kinetics and enables faster mass transport.

Intrinsic activity of the catalysts was enhanced by modulating the surface chemistry and through optimisation of electronic effects to improve electron transfer. Operating the electrolysis cells at high current density such as 4-8 A/cm^{-2} has also required the management of the mass-transport within the catalytic layer. Promising results have been achieved by forming macroporous structures that effectively speed up mass transport.

Specific stresses on the catalysts caused by increased current density increase of the degradation rate were managed by formulating advanced catalyst structures and catalyst-ionomer interfaces.

Reduction of noble metal loadings was also addressed to reduce the impact of precious metal catalysts on the stack cost. Anode and cathode catalyst morphology was improved by using optimised complexation routes for the catalyst precursors and tailoring the thermal treatments. Nanostructured morphology with high dispersion provided an effective route to decrease noble metal loading.

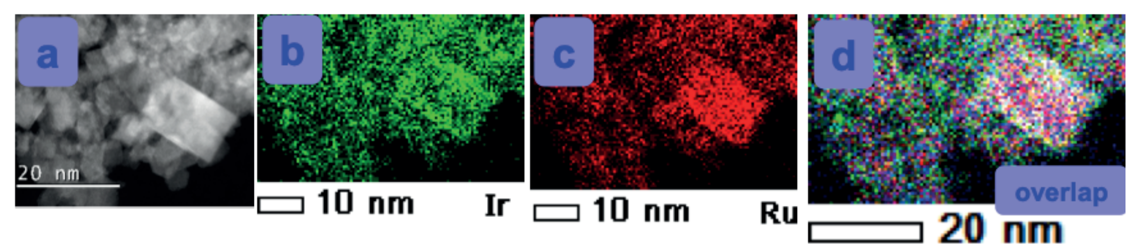


Figure 1: Morphology (a) and spatial distribution of Ir and Ru (b-d) in anode catalysts; light blue colour in d) is related to oxygen

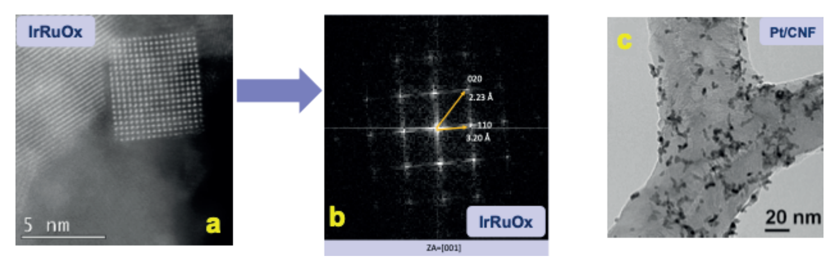


Figure 2: IrRu-oxide nanostructure with faceted crystals (3-5 nm) and [110] preferred orientation for the anode catalyst (a, b) and Pt dispersed on carbon nanofibers for the cathode catalyst (c).