

EUROPEAN COMMISSION

HORIZON 2020 PROGRAMME
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING (FCH 2 JU)
TOPIC H2020-JTI-FCH-2015-1
Improved electrolysis for distributed hydrogen production

GA No. 700008

High Performance PEM Electrolyser for Cost-effective Grid Balancing Applications



HPEM2GAS - Deliverable report

D 3.1 Progress report on membrane and catalyst development and preparation of first batches of large area membranes and catalyst components for MEA development

Deliverable No.	HPEM2GAS D3.1	
Related WP	WP3- PEM electrolysis components, optimization and scaling-up	
Deliverable Title	Progress report on membrane and catalyst development and preparation of first batches of large area membranes and catalyst components for MEA development	
Deliverable Date	2017-03-31	
Deliverable Type	REPORT	
Dissemination level	Confidential (CO)	
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This project has received funding from the FCH JU and European Union's Horizon 2020 research and innovation programme under grant agreement No 700008. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY

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Summary

Advanced catalysts and membranes were developed in the first phase of the HPEM2GAS project. Short-side chain (SSC) perfluorosulfonic acid (PFSA) Aquivion® membranes and ionomers were developed and scaled up for this application. The developed electrocatalysts consisted of Ir-Ru oxide catalysts for the anode and carbon supported Pt catalysts for the cathode. These were optimized and scaled-up for utilisation in PEM electrolysis cells and stacks. Membrane-electrode assemblies (MEAs) designed for polymer electrolyte membrane (PEM) water electrolysis, based on the novel short-side chain (SSC) perfluorosulfonic acid (PFSA) membrane, Aquivion®, with various cathode and anode noble metal loadings, were investigated in terms of both performance and durability. Utilizing a nanosized $\text{Ir}_{0.7}\text{Ru}_{0.3}\text{O}_x$ solid solution anode catalyst and a supported Pt/C cathode catalyst, in combination with the Aquivion® membrane, gave excellent electrolysis performances exceeding $3.2 \text{ A}\cdot\text{cm}^{-2}$ at 1.8 V terminal cell voltage ($\sim 80\%$ efficiency) at 90°C in the presence of a total catalyst loading of $1.6 \text{ mg}\cdot\text{cm}^{-2}$. A very small loss of efficiency, corresponding to 30 mV voltage increase, was recorded at $3 \text{ A}\cdot\text{cm}^{-2}$ using a total noble metal catalyst loading of less than $0.5 \text{ mg}\cdot\text{cm}^{-2}$ (compared to the industry standard of $2 \text{ mg}\cdot\text{cm}^{-2}$). Steady-state durability tests, carried out for 1000 h at $1 \text{ A}\cdot\text{cm}^{-2}$, showed excellent stability for the MEA with total noble metal catalyst loading of $1.6 \text{ mg}\cdot\text{cm}^{-2}$ (cell voltage increase $\sim 5 \mu\text{V}/\text{h}$). Moderate degradation rate (cell voltage increase $\sim 15 \mu\text{V}/\text{h}$) was recorded for the low loading $0.5 \text{ mg}\cdot\text{cm}^{-2}$, MEA. Similar stability characteristics were observed in durability tests at $3 \text{ A}\cdot\text{cm}^{-2}$. These performance and stability characteristics were attributed to the enhanced proton conductivity and good stability of the novel membrane, the optimized structural properties of the Ir and Ru oxide solid solution and the enrichment of Ir species on the surface for the anodic catalyst.