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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

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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 deloped 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 optimised 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 $Ir_{0.7}Ru_{0.3}O_x$ solid solution anode catalyst and a supported Pt/C cathode catalyst, in combination with the Aquivion® membrane, gave excellent electrolysis performances exceeding 3.2 $A\cdot cm^{-2}$ at 1.8 V terminal cell voltage (~80 % efficiency) at 90 °C in the presence of a total catalyst loading of 1.6 $mg\cdot cm^{-2}$. A very small loss of efficiency, corresponding to 30 mV voltage increase, was recorded at 3 $A\cdot cm^{-2}$ using a total noble metal catalyst loading of less than 0.5 $mg\cdot cm^{-2}$ (compared to the industry standard of 2 $mg\cdot cm^{-2}$). Steady-state durability tests, carried out for 1000 h at 1 $A\cdot cm^{-2}$, showed excellent stability for the MEA with total noble metal catalyst loading of 1.6 $mg\cdot cm^{-2}$ (cell voltage increase ~5 µV/h). Moderate degradation rate (cell voltage increase ~15 µV/h) was recorded for the low loading 0.5 $mg\cdot cm^{-2}$, MEA. Similar stability characteristics were observed in durability tests at 3 $A\cdot cm^{-2}$. 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.