Electrolysis test of different composite membranes at elevated temperatures - DTU Orbit

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For both fuel cells and electrolyzers, perfluorinated sulfonic acid (PFSA) membranes, e.g. Nafion®, have been demonstrated to function with high performance and long term durability at temperatures below 100°C. However, the energy efficiency of electrolyzers could be improved significantly by elevating the temperature, due to decreased thermodynamic energy requirement, enhanced electrode kinetics, and the possible integration of heat recovery. Thus, efforts were made to modify the membranes in order to extend the operational temperatures to above 100°C. In order to improve Nafion® at elevated temperatures, phosphoric acid (H3PO4)[1] and zirconium phosphate (ZrP)[2] were introduced. These composite membranes were tested in an electrolysis setup. A typical electrolysis test was performed at 130°C with a galvanostatic load. Polarization curves were recorded under stationary conditions. Testing the durability of the membrane electrode assemblies (MEAs) were done by keeping the current constant for several hours and monitoring the potential and the flow rate of hydrogen. The electrolysis test was carried out on a 10cm² single MEA. MEAs were typical assembled directly in the cell. The electrodes were sprayed directly onto the gas diffusion layers (GDLs). For the anode side GDL a tantalum covered stainless steel felt was used, whereas on the cathode side, the GDLs were wet-proofed carbon cloth. The composite membranes were prepared from commercial available Nafion® membranes. They were treated over night at 150°C in a zirconium phosphate saturated 85wt% phosphoric acid solution. Different thicknesses of membranes were tested and as expected, the performance increased when the thickness of the membranes decreased. Furthermore composite membranes only treated with phosphoric acid or only treated with ZrP were tested to show the importance of H3PO4 and ZrP respectively. A typical value of current density for a MEA with a Nafion® 115 membrane only treated with ZrP was 43mA/cm² at a potential of 1.7V, whereas was 114mA/cm² at 1.7V for a Nafion® 115 treated with only H3PO4 and finally 177mA/cm² at 1.7V for a Nafion® 115 treated with both H3PO4 and ZrP. Variations of the GDL on the anode side were tested. Different kinds of stainless steel felts were examined to find the best candidate for the final electrolysis setup. The felts differed in both thread thickness and overall thickness. The felts were covered with tantalum to protect the stainless steel. The felts were covered either once or twice to obtain different thicknesses of the tantalum. Experiments with PTFE treated felt was also performed to examine if wet-proofing the anode GDL would improve the overall performance of the cell. References [1] R. Savinell, E. Yeager, D. Tryk, U. Landau, J. Wainright, D. Weng, K. Lux, M. Litt and C. Rogers, A polymer electrolyte for operation at temperatures up to 200°C, J. Electrochem. Soc., 141, 1994, L46-L48 [2] G. Alberti and M. Casciola, Composite membranes for medium-temperature PEM fuel cells, Annu. Rev. Mater. Res., 33, 2003, 129-154

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