Comparison of Various Anion Selective Materials and Catalysts Used as Components in Membrane-electrode Assembly for Alkaline Water Electrolysis

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Producing green hydrogen using alkaline membrane water electrolysis (AMWE) is a promising approach to partially solve the serious energy crisis the human society is currently facing. AMWE can be powered by renewable and sustainable energy sources, utilize low-cost electrocatalysts and other inexpensive components. But improvement of AMWE technology, including power efficiency, safety and flexibility is needed.

Efficiency of the system can be considered low as AMWE operates at a cell voltage of 1.8–2.0 V, much higher than the thermoneutral voltage of water splitting (1.48 V). This is due to two factors: i) ohmic loss on the separator of the electrode compartments, but mainly ii) overpotential at the electrodes. The overpotential is decreased by utilization of catalysts, preferably non-platinum. In order to utilize the catalyst efficiently, it is necessary to ensure "three-phase" contact. It means, that the catalyst particle has to have contact with electron and ion conductor and reactant. To further improve the ion contact of the catalytic layer and the membrane as ion conductor and thus improve the catalysts utilization, the catalyst can be applied directly onto the membrane surface (CCM – catalyst coated membrane). The CCM approach thus allows to reduce the catalyst loading and consequently reduce the capital expenditures of the technology. CCM approach is already being used in proton-exchange membrane water electrolysis (PEMWE) but in an alkaline environment, generally accepted polymeric material able to withstand the operation conditions is not available.

The aim of this work is to compare different anion-selective materials and catalysts in order to identify the best setup, which will increase the efficiency of AMWE. In this work, chloromethylated block copolymer polystyrene-ethylene-butylene-styrene (PSEBS- CM) functionalized with 1,4-diazabicyclo[2.2.2]octane (DABCO) groups is used as an anion selective material. For comparison reason, commercially available Fumapem® FAA-3-50 membrane is tested. $NiCo_2O_4$ or $Ni_xFe_yO_z$ and $NiFe_2O_4$ or Mo_2C are used as anode and cathode catalysts, respectively. Computer controlled ultrasonic dispersion of catalyst ink is used as a CCM preparation method.

Performance of the prepared CCMs is tested by mean of the load curves under the AMWE conditions with different concentrations of KOH at 50 °C. Electrochemical impedance spectroscopy (EIS) is used to evaluate the resistances of the system and SEM is used to observe the morphology of the layers. The obtained results show the possibility of PSEBS-CM-DABCO membrane outperforming the Fumapem® membrane. Moreover, also non-platinum catalysts have proven their potential in AMWE. All the samples showed sufficient stability in the stability tests.

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