The effect of the type of anion-exchange material, polymer binder and catalyst on the performance of alkaline water electrolyser

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Green hydrogen, produced via water electrolysis using energy from renewable sources, represents a possible key to achieve the goals of international climate agreements and decrease the dependence of the economy on fossil fuels. Two water electrolysis technologies, namely proton-exchange membrane water electrolysis (PEMWE) and alkaline water electrolysis (AWE) are used to produce green hydrogen. PEMWE is operating with pure water but requires noble catalysts, such as Pt and Ir, which are able to withstand the harsh working environment. AWE is, on the other hand, operating with strongly alkaline liquid electrolyte which is needed due to the nature of the separator of the electrode compartments. It is typically represented by non-conductive porous diaphragm which is transporting OH^- ions from one electrode to the other via liquid electrolyte filling its pores. The main advantage of AWE, compared to PEMWE, lies in the implementation of non-platinum catalysts as well as other cheap construction materials, like Ni, Fe, Co or Mo. The development of anion-exchange membranes (AEMs) and binders now offers the possibility of combining the advantages of both PEMWE and AWE technologies. With the introduction of the membrane the option of application of the catalyst directly on the membrane surface is possible forming thus so-called catalyst coated membrane (CCM). CCM approach offers some advantages over catalyst-coated electrode, such as closer contact between the membrane and the catalyst allowing the reduction of the catalyst loading. The aim of this work is to evaluate: 1) the influence of the structure of the membrane on the performance of AWE; 2) the influence of the binder of the catalyst layer on the performance as well as stability and compatibility of the layer; and 3) with the best combination of membrane and binder evaluate the activity of different catalysts together with its influence on the structure of the catalyst layer.
In this work we use two membrane and binder materials as well as two different non-platinum catalysts for preparation of the CCM. The first set of anion-selective materials is PSEBS-CM (chloromethylated poly (styrene-ethylene-butylene-styrene) block copolymer) polymer chain with DABCO (1,4-diazabicyclo [2.2.2] octane) functional groups. The same material is used as the binder of the catalyst layer. The second material set represents Fumasep FAA-3-50 membrane and Fumion binder. The catalysts we used are $NiCo_2O_4$ or $Ni_xFe_yO_z$ for anode and $NiFe_2O_4$ or Mo_2C for cathode. The CCMs were prepared by a computer-controlled ultrasonic dispersion of catalytic ink at 50 °C. The testing was done using the laboratory alkaline water electrolyser with circulating KOH (1 – 15 wt.%) as liquid electrolyte at temperature of 50 °C. Ni foam was used as electrodes with geometric area of 4 cm^2. Load curves in the range of the cell voltages 1.5 – 2.0 V were used to evaluate the differences between various materials. Electrochemical impedance spectroscopy was used to measure the resistances of the system. Long-term stability was also measured to test the durability of the prepared CCMs. Scanning electron microscopy was used for evaluation of the morphology of the prepared layers prior and after testing.
The obtained results show the possibility of performance enhancement with suitable AEM as well as the great influence of the type of the binder on the adhesion of the catalyst layer to the membrane. Also, the possibility of using non-platinum catalysts was verified.

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