**Alkaline water electrolysis stack utilizing polymer electrolyte membrane**

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**Highlights**

* Stable alkaline polymer electrolyte developed.
* Design of the laboratory electrolysis stack utilizing polymer electrolyte reported.
* Experimental stack results used to validate mathematical model of the stack.
* Simplified mathematical model of the stack validated.

**1. Introduction**

Water electrolysis represents a key component of the hydrogen economy concept allowing high capacity and long-term energy storage. It is based on decomposing water molecule into the gaseous hydrogen and oxygen by passing the direct current (DC). Alkaline water electrolysis (AWE) represents most technologically established route of this process. If suitable polymer electrolyte is available (membrane as well as the catalytic layer binder), AWE cell design and operational parameters resembling the PEM water electrolysis can be used. It concerns especially zero gap cell arrangement. At the same time, the advantage of the utilization of the non-PGM catalyst is preserved [1]. This makes alkaline polymer electrolyte water electrolysis (APEWE) highly attractive option. The topic of this study is to report on design of the laboratory APEWE cells stack based on novel alkaline polymer electrolyte developed in our laboratory.

**2. Methods**

*Materials used*

Both anodes and cathodes of the stack cells were of identical construction. They were made of nickel foam (INCO Advanced, Technology Materials, (Dalian) Co., Ltd, USA), size 5 × 5 cm2. Bare, non‑activated electrodes were used. Nickel foams served at the same time as a flow field.

Two different anion selective polymer electrolyte membranes were tested as an electrode compartments separator:

- commercial heterogeneous anion selective membrane Ralex® (Mega, Czech Republic)

- experimental polymer electrolyte membrane based on Polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene (PSEBS) activated by 1,4-diazabicyclo[2.2.2]octane (DABCO) serving as a functional group [2].

*Experimental procedures*

Stack load curves of the APEWE stack were recorded for the range of current densities up to 390 mA cm-2 for operational temperature of 28 °C. Purity of oxygen stream produced during different experiments was determined by means of gas chromatography. Current efficiency was determined in dependence on the concentration of the liquid electrolyte and number of the cells in the stack. It was based on the production of the gases determined using the bubble flow meter.

**3. Results and discussion**

*Distribution of the liquid electrolyte*

Sufficient supply of the liquid electrolyte into the electrode compartment represents vital aspect of the alkaline water electrolysis. It was proven, that the proposed geometry of the system ensures homogeneous liquid distribution along the electrodes. This is documented both by load curves, as well as by the flow visualization in the cell.

*Influence of the electrolyte feed arrangement*

APEWE arrangement allows significant freedom in arrangement of the liquid electrolyte feed into the cell. Both electrode compartments, or just one of them may be supplied by electrolyte [40]. This aspect was found to be of significant importance regarding both, produced gasses purity and cell lifetime. Supplied cathode compartment was found to be preferable regarding the produced gasses purity. But suitable measures have to be introduced to stabilize the electrolyte pH in the range ensuring electrodes stability.

*Influence of the electrolyte concentration*

Two effects have to be considered in this aspect: (i) due to the improved ionic contact between the electrodes and membrane with increasing KOH concentration current density at given stack voltage increases; (ii) at the same time parasitic current value increases. The second aspect is connected with decreasing resistance of the parasitic current pathways. For the given cell construction KOH concentration of 10 wt.% was chosen as the optimal one.

**4. Conclusions**

The results obtained within this study prove viability of the water electrolysis stack based on anion selective polymer electrolyte. They allowed to develop necessary cell and system components and to identify bottlenecks in the first version of the cell design. Know how gained allows to continue the development work and to propose new generation of the up scaled alkaline water electrolysis cells stack.

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