High-temperature alkaline electrolysis – opportunities, challenges, and separators

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Alkaline electrolysis is a well-established technology and does not require scarce metal catalysts. However, the current density is currently too low in comparison to alternative technologies like polymer electrolyte membrane electrolysis. Most importantly, the ionic conductivity of the diaphragm and the performance of the electrodes need to be improved.

High operating temperature can improve both, ion conductivity and electrode performance, at the same time. On the other hand, corrosion and dissolution reactions are accelerated by increased temperature, which can lead to material stability issues. We found that a high operating temperature between 100 and 200 °C can increase the current density to competitive levels [1]. Moreover, this temperature range enables thermally balanced operation of an electrolyzer by selecting the appropriate operating pressure.

Developing and selecting suitable materials for such temperatures is not trivial. However, we found that proven materials are available up to at least 150 °C and further promising candidates have been reported up to 200 °C [1]. For diaphragms, the most promising approach is to use porous ceramics. Chatzichristodoulou et al. have shown successful operation with a tape-casted ceramic diaphragm at 200 °C [2]. We have employed thermal spray techniques to prepare ceramic diaphragms. These techniques allow precise control of the material structure by tuning the deposition parameters and do not require an additional sintering step. The prepared diaphragms, Figure 1, were tested under alkaline electrolysis conditions.
As one of the major drawbacks of ceramic diaphragms is their brittleness, we also developed a composite membrane based on layered double hydroxides. These are inherently ion conducting and also stable at increased temperature [3, 4]. We investigated the influence of the composition on the performance of the membrane and identified the major degradation routes.

Figure 1. Ceramic diaphragm prepared by thermal spray coating (left) and LDH-based membrane (right).

References
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