Polybenzimidazole membranes for zero gap alkaline electrolysis cells

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Publication date:
2016

Document Version
Publisher’s PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Polybenzimidazole membranes for zero gap alkaline electrolysis cells

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Membranes of m-PBI doped in KOH (aq), 15-35 wt%, show high ionic conductivity in the temperature range 20-80 °C. In electrolysis cells with nickel foam electrodes m-PBI membranes provide low internal resistance. With a 60 µm membrane thickness, resistance is achieved at 2.25 mS/cm for 20 wt% KOH at room temperature [1].

For membranes, this results in breaking of intermolecular hydrogen bonds, which decreases mechanical robustness and allows for significant swelling and electrolyte uptake. As a result, a ternary m-PBI-KOH-water system is formed which displays a high ion conductivity.

Cell polarization

For zero gap electrolysis cell measurements, m-PBI membranes were equilibrated in aqueous KOH at a given concentration overnight prior to cell assembly. Electrodes were pressed (thickness ~210 µm) nickel foam. Figure 4. Current-voltage-curves are presented in Figure 4. Data were recorded by scanning the potential from 1.2 to 2.5 V at 2.5 mV/s. The cells were operated at 80 °C.

The cell house and external setup is displayed in Figure 5, on the right. Aqueous KOH with concentration identical to the doping solution is circulated on both sides.

Novel electrode concepts

Hydrogen evolution

Increasing the active surface area of nickel catalysts is an efficient way to improve the hydrogen evolution activity. This is commonly done by using Flanigen catalysts, or by immobilizing nickel powder through the use of a binder, e.g. PTFE, or both [3].

We are using m-PBI polymer as a binder to make porous electrodes. The high ionic conductivity and hydrophilic properties makes this an interesting binder for alkaline electrolysis in particular.

So far, we have prepared electrodes by first dissolving ~5 wt% of m-PBI and bulk solution at different KOH concentrations. Electrodes of pressed nickel foam. Membrane thickness in the range 50-60 µm. Thickness of ZrO2 is about 900 µm.

Oxygen evolution

Increasing the active surface area of nickel does not seem to have the same effect on the OER compared to the HER, and stability issues are more severe for OER. However, recent research has shown that Fe-doped nickel hydroxide is a very active OER catalyst [4].

Electrodes can be made in various ways, here, Figure 7, an electrode prepared by a hydro thermal process using urea, and nickel and iron nitrates is presented. This demonstrates a huge potential for overall cell improvements.

References


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