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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 at 80 °C in 20 wt% KOH, 1000 mA/cm² is achieved at 2.25 mS/cm.

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. Current-voltage curves are presented in Figure 3. 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.

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 [6].

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

Hydrogen evolution

Increasing the active surface area of nickel catalyst is an efficient way to improve the hydrogen evolution activity. This is commonly done by using Raney 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 good alkaline stability and hydrophilic properties makes this an interesting binder for alkaline electrolysis in particular.

So far, we have prepared electrodes by first dissolving ~5 wt% m-PBI in alkaline ethanol (~5 wt% KOH in ethanol), and adding nickel powder to form a viscous mixture. The mixture was applied by a dip-coating procedure, in which nickel foam pieces were briefly submerged and otherwise left to dry in air.

A polarization curve for such an electrode is presented in Figure 6, compared to a non-coated nickel foam electrode.

Figure 6. Hydrogen evolution polarization curves. Conditions: 20 wt% KOH and room temperature. Scan rate 2 mV/s.

Figure 7. Oxygen evolution polarization curves. Conditions: 20 wt% KOH and room temperature. Scan rate 2 mV/s.

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References


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