Polybenzimidazole (PBI) based membranes offer advantages over traditional porous separators for use in alkaline water electrolysis. A better gas separation and the resulting decrease in required thickness promises lower ohmic resistance. The chemical stability of PBI has been tested at 88 °C in aqueous potassium hydroxide with concentrations ranging from 0 to 50 wt% for up to 6 months, showing excellent chemical stability for KOH concentrations up to about 10 wt%. The electrochemical stability is assessed by applying the membranes in an alkaline electrolysis cell using a zero gap configuration with nickel foam electrodes operating with 5-30 wt% KOH at 80 °C. Cell experiments ran for 2 days at a constant potential of 1.7 V or 2.0 V respectively.

Chemical Stability
The chemical stability of PBI has been investigated in KOH (aq) concentrations of 0-50 wt% for 200 days at 88 °C.

Motivation. Polyimide-based membranes are widely used for high temperatures proton exchange membranes (PEM) fuel cells, where ionic conductivity is retained in PEM fuel cells. However, for IT-PEM electrolyte applications, PBI has been found to degrade rapidly under electrolysis conditions. Alternatively, to phosphoric acid doping, PBI can be doped with aqueous KOH for alkaline applications, e.g. alkaline water electrolysis. This enables the use of nonaqueous electrolytes e.g. niobium oxides based on nickel, iron or cobalt.

Conductivity. Membranes doped with KOH at concentrations above 10 wt% show significant ionic conductivity. Aqueous KOH is dissolved in the PBI matrix, but the membrane composition depends very much on concentration. The ionic conductivity is seen to peak at lower concentrations than bulk solution KOH.

Chemical stability.
Membranes stored in KOH (aq) concentrations of 0-50 wt% for 200 days at 88 °C.

Conductivity of KOH doped m-PBI. The curve shows the ionic conductivity of m-PBI membranes at various concentrations. Measured data for membrane and solution versus ionic strength (101°C).

Electrochemical stability.
PBI membranes were evaluated in an operational alkaline water electrolysis cell at 80 °C. Electrolyte concentrations of 3.0 wt% KOH (aq) were used.

Test procedure. Membranes were cut from DMAA solution and doped for more than 16 hours in concentrated KOH (aq) prior to assembly. Membrane thickness after doping was <0.5 mm. The alkaline water electrolysis cell was assembled with pressed nickel foam electrodes, PBI membrane, and EPDM/PTFE gaskets. KOH (aq) of the same concentration as the doping was circulated continually in anode and cathode compartments. After 1 hr at 10 mA/cm² and a single polarization curve, the cell was operated at constant 1.7 V or 2.0 V. Polarization curves were recorded after 2, 25 and 48 hrs.

Polarization curves. Potential scan from 1.225 V to 2.5 V, scan rate 2.5 mV/s. Membrane thickness ~50-60 µm. KOH concentrations were washed, dried and dissolved in sulfuric acid. SEC reveals that for membranes stored at 10 wt% KOH (aq) a new peak appears at higher molecular weight. Cross-linking of the backbone occurs in KOH solutions and membranes stored in KOH (aq). This results in significant mechanical degradation.

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