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Alkali-doped polyvinyl alcohol – polybenzimidazole membranes for alkaline water electrolysis

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Abstract

We developed an innovative polymer blend system composed of polyvinyl alcohol (PVA) and polybenzimidazole as an anionic membrane for application to zero gap alkaline electrolysers. The challenge was to combine PVA with either poly[2-2'-(m-phenylene)-5-5'-bibenzimidazole] (PBI) or poly (2,5-benzimidazole) (ABPBI) to complement these neutral polymers, which must be doped to conduct, with hydroxyl groups that benefit the OH^- transport mechanism. We studied PVA-PBI and PVA-ABPBI membranes with compositions varying between 2:1 and 8:1, with 4:1 being best ratio. PVA is crosslinked inside PVA-PBI 4:1 and PVA-ABPBI 4:1 membranes with glutaraldehyde (GA) by immersion in a reaction solution with different GA contents ranging from 0.5 vol. % to 50 vol. % to enhance the stability of the membranes. The chemical stability in a KOH environment, thermal and mechanical properties, surface morphology, swelling, water / KOH sorption, and conductivity of the linear alkali-doped (L-PVA-PBI, L-PVA-ABPBI) and crosslinked (C-PVA-PBI, C-PVA-ABPBI) membranes were analysed. The best results were observed for the C-PVA-ABPBI 4:1 membrane crosslinked in 0.5 vol. % GA, which exhibited specific conductivities at 90 °C of 50 $mS \cdot cm^{-1}$ and 90 $mS \cdot cm^{-1}$ when doped using 15 wt. % and 30 wt. % KOH, respectively. In short-term electrolysis tests performed with circulated 15 wt. % KOH at 50 °C, this membrane exhibited a current density that was twice that of the commercial porous Zirfon® diaphragm (i.e., 300 $mA \cdot cm^{-2}$ and 140 $mA \cdot cm^{-2}$, respectively) at a cell voltage of 2.0 V. The performance achieved with the C-PVA-ABPBI membrane in a 15 wt. % KOH electrolyte at 70 °C was good (i.e., 360 $mA \cdot cm^{-2}$ at a cell voltage of 1.9 V).

Keywords: Anion exchange membranes; PVA; PBI; ABPBI; water electrolysis.