

Development of the pore-filling electrolyte membranes for PEMFC or DMFC application and their fuel cell performances

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Pore-filling electrolyte membranes have been prepared for use as electrolyte membranes for a PEMFC or DMFC. The concept is shown in Figure 1. The pores of a porous substrate were filled with a polymer electrolyte, and the membrane swelling was suppressed by the substrate matrix. Proton conductivity was achieved through the filling electrolyte polymer. Methanol permeation was controlled by the swelling of the electrolyte polymer, and the mechanical strength at high temperature was maintained by the substrate. From this concept, a high proton conductivity was shown to exist with reduced membrane methanol permeability.

Figure 2 shows comparison of the membrane performances. The ordinate axis shows the inverse of the methanol permeability values that were tested by pervaporation at 50 °C, and the abscissa shows the proton conductivity at 25 °C. A point located to the upper right-hand side implies a higher performance membrane. For the pore-filling membranes with AAVS copolymers, the vinyl sulfonic acid content, which is strongly acidic, was around 5 mol%. These membranes showed a higher proton conductivity than the AA pore-filling membrane, but the methanol permeability value did not differ so much. Pore-filling membranes with ATBS have high sulfonic acid content, and showed higher proton conductivity with low methanol permeability. The methanol permeability through the pore-filling membranes showed lower values compared with the Nafion membranes. The substrate matrix effectively suppressed membrane swelling, and resulted in lower methanol permeation. Those performances can be controlled by the substrate mechanical strength and the membrane swollen state. PEMFC and DMFC systems will need different type electrolyte membranes, and the concept can supply a suitable membrane for each application.

Figure 3 shows H₂/O₂ PEMFC performances at 60 °C with Nafion115 or CLPE-ATBS pore-filling membrane. The pore-filling membrane has around 40 μm in thickness, and higher proton conductivity. This results in lower Ohmic loss compared with the MEA using Nafion115. The MEA using CLPE-ATBS showed around 550 mW/cm² at 1500 mA/cm².

DMFC results using the pore-filling membranes will also be shown in the presentation.

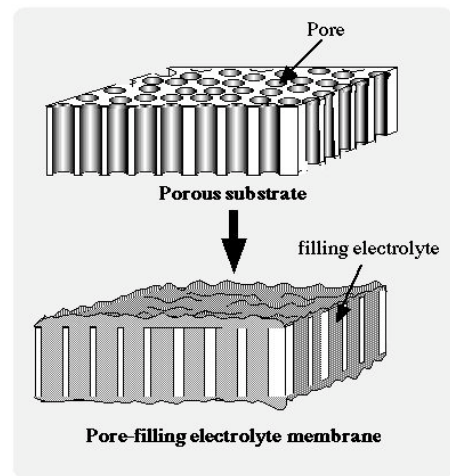


Figure 1. Concept of the pore-filling membrane.

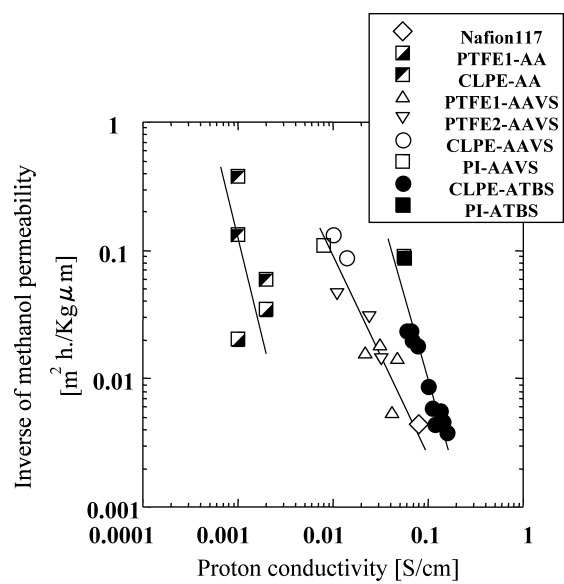


Figure 2. Relationship between proton conductivity and inverse of methanol permeability through Nafion117 and pore-filling membranes. (Porous substrate: PTFE: polytetrafluoroethylene, CLPE: crosslinked polyethylene substrate, PI: polyimide substrate, filling polymer electrolyte: AA: acrylic acid, AAVS: acrylic acid-co-vinyl sulfonic acid, ATBS: acrylamide tert-butyl sulfonic acid)

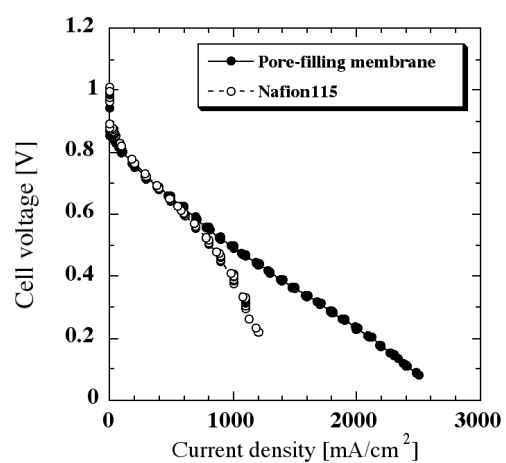


Figure 3. Comparison of H₂/O₂ PEMFC performances between MEAs using Nafion115 and the pore-filling membrane (CLPE-ATBS). (Cell temp.: 60 °C, Pt loading at anode and cathode: 0.33 mg/cm² and 0.36 mg/cm², atmospheric pressure.)