Thin Membranes Using PFSA-Vinylon Intermediate Layer for PEM Fuel Cells

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Abstract Text:
Fuel cells are attracting attention as one of the key energy devices for achieving carbon neutrality in 2050. Currently, fuel cells are being improved for versatile mobile applications. Among the components of fuel cell devices, polymer electrolyte membranes for proton exchange, in particular, are required to have high proton conductivity at high temperature, high and low humidification, and thin membranes. Proton-exchange fuel cells utilize perfluorosulfonic acid (PFSA) ionomers and membranes from Chemours and 3M and Solvay [1]. Nafion membranes with a thickness of 178-25 μm and Gore select membranes (with reinforcement) with a thickness of 20-5 μm have been commercialized [2,3]. On the other hand, thinner polymer electrolyte membranes can reduce the ohmic voltage drop in fuel cells to improve performance and lower costs. However, it is difficult to obtain thin membranes of less than 20 μm without reinforcement using PFSA ionomers.

In this report, a thin PFSA electrolyte membrane (10 μm) without reinforcement was successfully developed by introducing a PFSA-vinilon composite layer as an intermediate layer of the PFSA membrane. The fuel cell evaluation revealed that it has a high current density.

The ionomers used were 5% Nafion solution (DE520 CS type, EW=1100) and 6% Aquivion solution (D83-06A, EW=830). PVA (polyvinyl alcohol) was synthesized from polyvinyl acetate (PVAc, Mw=100,000). The laminated membranes (10 μm thickness) was obtained by preparing a 2 μm PFSA layer, followed by a 6 μm PFSA-PVA composite layer, then a 2 μm PFSA layer was coated. Finally, laminated membranes with PFSA-Vinylon composite layers were obtained by Formalization reaction the PFSA-PVA composite layers.

FTIR evaluation of the PFSA/ PFSA-Viynylon/ PFSA multilayers confirmed the presence of an intermediate layer by observing Vinylon-derived peaks. Conductivities of about 4.5 mS/cm and 2.5 mS/cm in the thickness direction were obtained at 80°C, 90%RH and 20%RH, respectively. On the other hand, I-V evaluation was performed at 80°C, 100%RH and 35%RH using hydrogen, oxygen and air. Nafion 212 was used as a comparison membrane. The I-V characteristics of the laminated membranes showed higher current density than that of the Nafion membrane. Maximum current densities of 3 A/cm2 at 0.6 V and 3 A/cm2 at 0.4 V were obtained at 80°C, 100% RH and 35% RH with hydrogen and oxygen, respectively. Regarding the comparison of PFSA ionomers, Aquivion showed higher performance at higher current densities than Nafion [4].

References

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