Preparation of Ion Exchange Polymer and Porous Ceramic Matrix Composite Membrane for Direct Methanol Fuel Cell

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A high temperature use of ion exchange membrane for Direct Methanol Fuel Cell (DMFC) is desired to obtain a high electrochemical activity for methanol oxidation at anode of DMFC. In this study, a composite membrane consisting of H^+ conductive gel-polymer and porous ceramics matrix was prepared by using a three-dimensional ordered micro pore (3DOM) assembly technology.

A solid polymer electrolyte membrane system has been utilized to DMFC. In order to improve several characteristics of DMFC, a higher operation temperature, such as 120 ~ 150 °C, is desired. However, mechanical properties for most of organic polymers are not enough high for such a high operation temperature. Moreover, methanol fuel goes through membrane from anode side to cathode. This leads to a lowering of an energy conversion efficiency of DMFC. This is also prevented with a high operation temperature. Therefore, several researches have been done to prepare new solid electrolyte membranes. In this study, composite membrane between 3DOM and organic gel polymer was prepared to improve mechanical properties of solid electrolyte membrane.

Fig. 1 shows a schematic illustration for the preparation of 3DOM-polymer composite electrolyte membrane. Styrene micro-beads with a uniform diameter was firstly arranged by using a slow filtration technique. Then a space between styrene beads was filled with a precursor material, such as sol or colloidal particles of silica. At last, the composite material consisting of styrene beads and precursor was heated at 450 ~ 900 °C. Through these steps, 3DOM ceramics membrane was prepared.

Fig. 2 shows the 3DOM membrane obtained by using silica sol. In this experiment, the silica sol was prepared from tetra-methoxy silane, NaOH, and hexadesile-trimethyl ammonium. The ordered pores were observed in this scanning electron micrograph. However, this membrane was very fragile. In fact, the membrane was destroyed during handling of this membrane. Of course, for DMFC application, much larger membrane was needed. Therefore, mechanical strength of the porous ceramic membrane film was improved. The thickness of the film is one of key factor. More thick membrane was prepared, but its mechanical strength was not enough to obtain a large-scale ceramic membrane.

Fig. 3 shows scanning electron micrographs of 3DOM membrane prepared by using colloidal silica and styrene micro-beads. Both particles were mixed before the filtration. The regular arrangement of pores in the obtained ceramic membrane was lower than that prepared from the silica sol. However, the mechanical strength of the porous ceramic membrane was enough high to prepare the ceramic membrane with 2 cm diameter. This high mechanical stability of the membrane may be due to its microstructure, as shown in the cross-sectional view of the membrane. The bottom layer of the ceramic membrane was different from its bulk structure. The bulk of the ceramic membrane was porous and had some regular arrangement. But, the bottom layer consisted of the tight film with a few pores. This skin layer may be strongly related to the mechanical strength, which is a very important key issue for the preparation of a large area ceramic membrane.

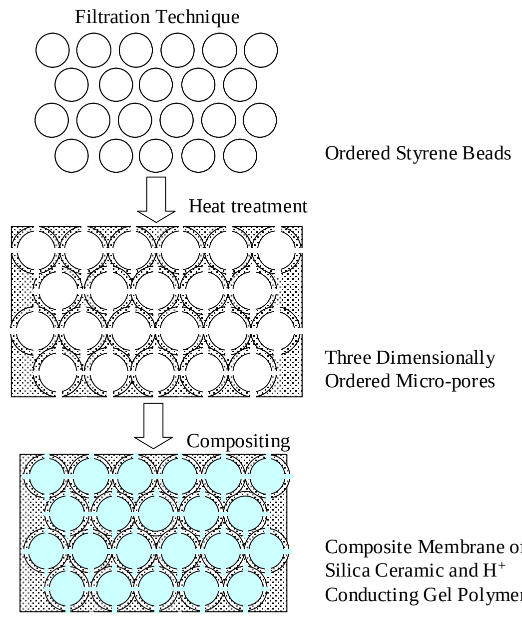

Fig. 1 Schematic illustration of preparation process for 3DOM ceramic membrane by using styrene beads technique with silica sol solution or colloidal silica.

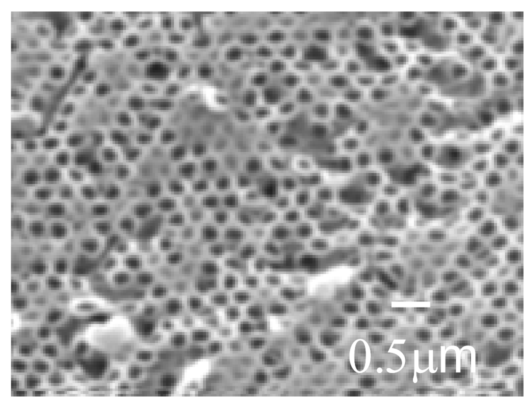

Fig. 2 SEM photograph of 3DOM ceramic membrane prepared from styrene beads and silica sol.

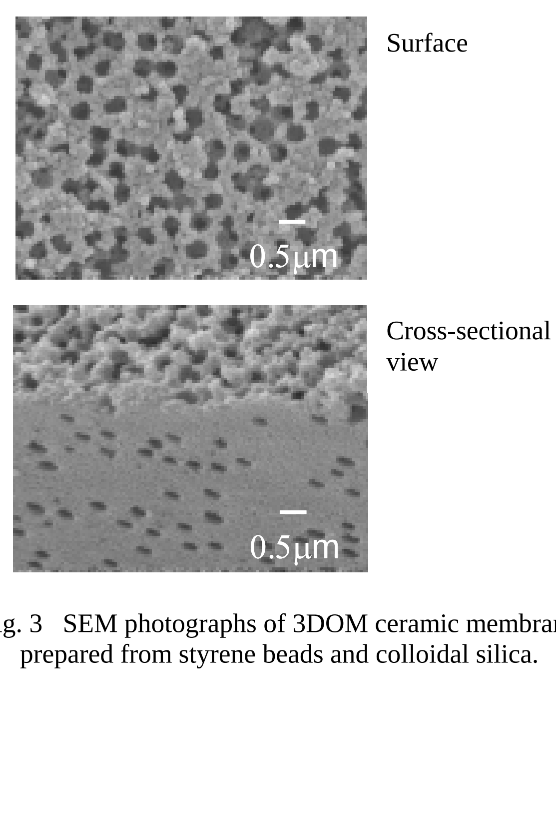

Fig. 3 SEM photographs of 3DOM ceramic membrane prepared from styrene beads and colloidal silica.