Ion-Exchange Nanocomposite Membrane Modified by Layered Double Hydroxide for Direct Methanol Fuel Cell

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Specially, Methanol crossover occurring in Direct Methanol Fuel Cell(DMFC) is still one of the major problems in fuel cell development. In this study, nano-sized layered double hydroxide particles are incorporated in the ion-exchange membrane (Nafion) in order to reduce the diffusion rate of methanol crossover. The LDH system used in this study is the Mg-Al-CO_3 hydrotalcite-like cationic clay mineral having different Mg^{2+} to Al^{3+} ratio and thus different anion exchange capacity. When the nano particles are homogeneously dispersed in the Nafion solution without agglomeration, the nano particles are desirably expected to provide significantly increased interface area, which often decreases the diffusion coefficients of gas or liquid molecules through solid media in various material systems [1,2].

According to Fig. 1, the LDH-Nafion nanocomposite membranes were prepared by the coprecipitation and solution casting methods. The prepared LDH nanocomposites were investigated by the wide angle x-ray diffraction experiments and the LDH particles were confirmed as being dispersed in Nafion matrix without any evidence of agglomeration in the nanometer scale.

Fig. 2 shows the accumulated methanol concentration across the LDH-Nafion nanocomposite membranes having different ion exchange capacity. As the ion exchange capacity of LDH is increased, it can be seen that the diffusion rate of methanol across the nanocomposite membrane is significantly decreased. We believe that the nano-sized LDH particles are homogeneously dispersed in the matrix and they physically prevent the methanol molecules from moving through the ion-exchange membrane. Using the Fick's law, appropriate approximations, and boundary conditions, the diffusion coefficients of methanol crossover can be obtained from the data in Fig. 2.

The diffusion coefficients of methanol across the nanocomposite membrane systems are compared in Fig. 3 demonstrating that the diffusion coefficients of the LDH nanocomposite are significantly decreased by the ion exchange capacity of LDH nanoparticles. As the anion exchange capacity is increased by increasing the relative quantity of Mg^{+2}, the nanoparticles are likely to interact more strongly with SO_3^- groups included in the Nafion matrix. The electrostatic force of the charged nano-sized particles seems to influence the diffusive transport of methanol through the matrix polymer. Overall, our work demonstrates that the diffusion rate of methanol crossover may be decreased by incorporating the nano-sized LDH particles and controlling their anion exchange capacity. Further study should be performed to identify the effects of nano particles on other fuel cell performance in terms of ionic conductivity, mechanical property, long-term durability, etc.

References

1. M. Alexandre and P. Dubios, Mat. Sci. Eng. 28, 1-63 (2000).
2. T.J. Pinnavaia and G.W. Beal, Polymer-Clay Nanocomposites, John Wiley & Sons, New York, 2000.

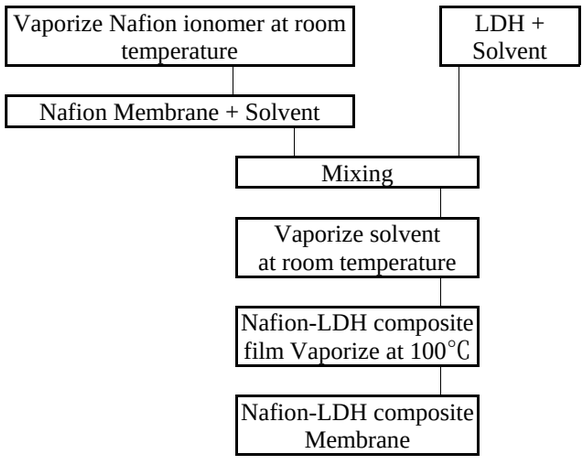

Fig 1. Preparation procedure of LDH-Nafion nanocomposite membrane

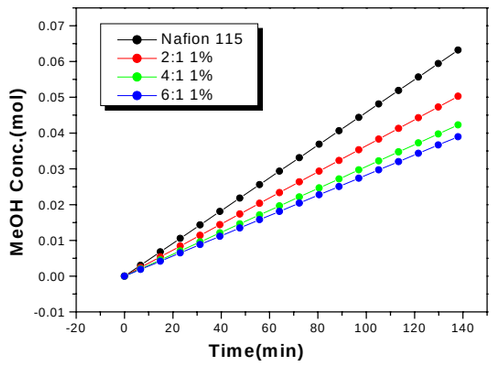

Fig 2. Accumulated methanol concentration across LDH-Nafion nanocomposite membrane for different Mg^{2+} to Al^{3+} ratio of LDH.

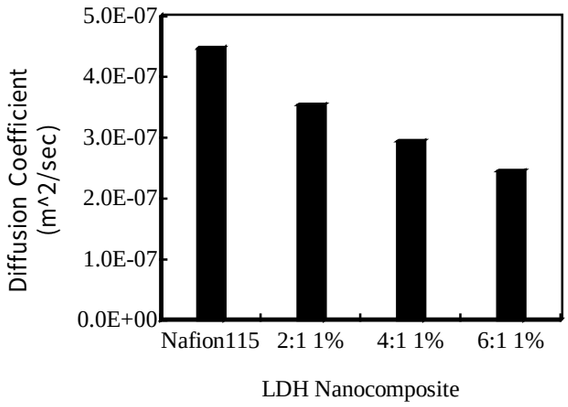

Fig 3. Diffusion coefficeint of Nafion-LDH Composite Membrane as content of clay