Optimal pre-treatment of sulfonated poly(ether ether ketone) membranes for decal processes

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Proton exchange membrane fuel cells (PEMFCs) are of importance for alternative power sources due to their high efficiencies and an ability to operate without greenhouse gas emissions. Recently, sulfonated poly(ether ether ketone) (sPEEK) have been synthesized and used widely in PEMFCs due to low-cost and easy fabrication. The sPEEK membranes also have good proton conductivity and thermal property [1-3]. When catalyst coated membranes (CCMs) are fabricated by decal transfer, decal transfer rate to membranes might be significantly dependent on the properties of membranes and the performance of membrane-electrode assemblies (MEAs). Prior to the decal process, proton exchange membranes used are necessary to be treated in acidic solutions to ion-exchange counter ions of the fixed charged groups into proton for better ionic conductivity. Then the membranes were dried and used for the fabrication of MEAs.

In this study, we investigated the effect of proton-exchanging conditions of the sPEEK membranes on decal transfer rate. Various pre-treatment conditions of proton-exchanging the sPEEK membranes were used in terms of acid concentration, temperature and time. SPEEK membranes were analyzed to examine the effects of acid concentration, temperature and immersion time. The proton conductivities of the membranes were evaluated. The water uptake and the swelling were also measured. Catalyst slurries were prepared by thoroughly mixing a carbon-supported catalyst (40 wt.% Hi-spec 4000 Johnson Matthey) as an electrocatalyst with Nafion^{TM} solution (EW1100, Dupont) as an ionomer binder and Milli-Q grade de-ionized water by a magnetic stirrer. The mixtures were then sonicated. Afterwards, the mixtures were applied on the surface of transfer films and dried at room temperature overnight. We calculated the decal transfer rates of CCMs using sPEEK membranes which were treated in different pre-treatment conditions. In addition, electrochemical characterization was done in terms of impedance spectroscopy, cyclic voltammetry and H_2 crossover of the MEAs and was evaluated. As a result, it was confirmed that the pre-treated sPEEK membranes showed the highest proton conductivity immersed in 0.5 M H_2SO_4 for 2 h, and it brought about the highest cell performance due to a decrease in Ohmic resistance. Among the conditions for pre-treatment, the concentration of pre-treatment acid solutions is the most significant to determine proton conductivity of the membranes.

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