Enhancement of PEMFC Performance with Polymer-Silica Composite Membranes

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Proton exchange membrane fuel cells (PEMFCs) are of particular interest energy conversion device for automobile and stationary applications because of their high efficiency and zero emission. Sulfonated poly(arylene ether ketone) (SPAEK) is considered as promising membrane because of its low cost, high thermal stability, low fuel crossover and high proton conductivity, which depend on the degree of sulfonation. However, sulfonated hydrocarbon membranes have fatal shortcomings in proton conductivity under low relative humidified condition compared to Nafion, which cause the significant performance drop during fuel cell operation. In order to overcome this problem, we prepared the asymmetric composite membrane in which surface modified silica nanoparticles were added to SPAEK mother polymer electrolyte membrane (PEM). An asymmetric structure, hydrophilic silica to the anode side and hydrophobic silica to the cathode side in the polymer matrix, enhanced the water back diffusion from the cathode to anode within a membrane which results in an increase of proton conductivity, particularly under low humidity condition. Moreover, PEM consisting of cross-linked SPAEK with silica nanoparticles (CL-SPAEK/silica) is developed for practical fuel cell applications under low relative humidity (RH) conditions. CL-SPAEK/silica is simply prepared by the reduction reaction of the synthesized SPAEK, followed by sulfonation reaction between benzophenone moieties of SPAEK and the hydroxyl groups of silica nanoparticles. The cross-linked structure of CL-SPAEK/silica enhanced a proton conductivity, which is attributed to a synergistic effect of well-connected hydrophilic proton channels and improved dispersion of silica nanoparticles in the polymer matrix.