PROTON EXCHANGE MEMBRANE FUEL CELLS

Gauging membrane thinness

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In a typical proton exchange membrane fuel cell (PEMFC), the membrane (such as Nafion) allows the transport of protons from the anode to the cathode where oxygen is catalytically reduced to produce water. Proton conduction and oxygen diffusion in the membrane are therefore two important processes in the operation of PEMFCs. However, measuring these transport properties is difficult, especially for oxygen diffusion, because of complex electrode structures and large resistances to oxygen gas transport. Furthermore, the membrane thickness also influences the transport properties; using thinner membranes is often a way to reduce cost and there is therefore an open question as to how thin a membrane can be for optimal PEMFC performance. Now, Anusorn Kongkanand, Jacob Jorne and colleagues from University of Rochester and General Motors have designed a membrane-electrode assembly to characterize oxygen and proton transport in ultrathin Nafion films (100–1,000 nm).

The membrane-electrode assembly contains uniform thin films of Nafion spin-coated onto a silicon wafer where well-defined platinum microelectrodes with multiple sensing probes are also present. Such a design minimizes gas-phase resistances, and enables oxygen permeability and proton conduction to be determined at different temperature and humidity conditions. The researchers find that with decreasing membrane thickness, oxygen permeability increases but proton conductivity decreases. They consider that the oxygen permeability depends on both the oxygen diffusivity and solubility, and the thin Nafion film is anisotropic, meaning that the proton conductivity and oxygen diffusivity are not necessarily related. This, along with other factors from the silicon substrate, is used to explain the seemingly opposing trend of oxygen and proton transport. The researchers further suggest that the proton conduction places a limit on how thin the membrane can be in an actual PEMFC.

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