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In-situ Observation of Polymer Electrolyte Fuel Cell Using Deuterium Gas

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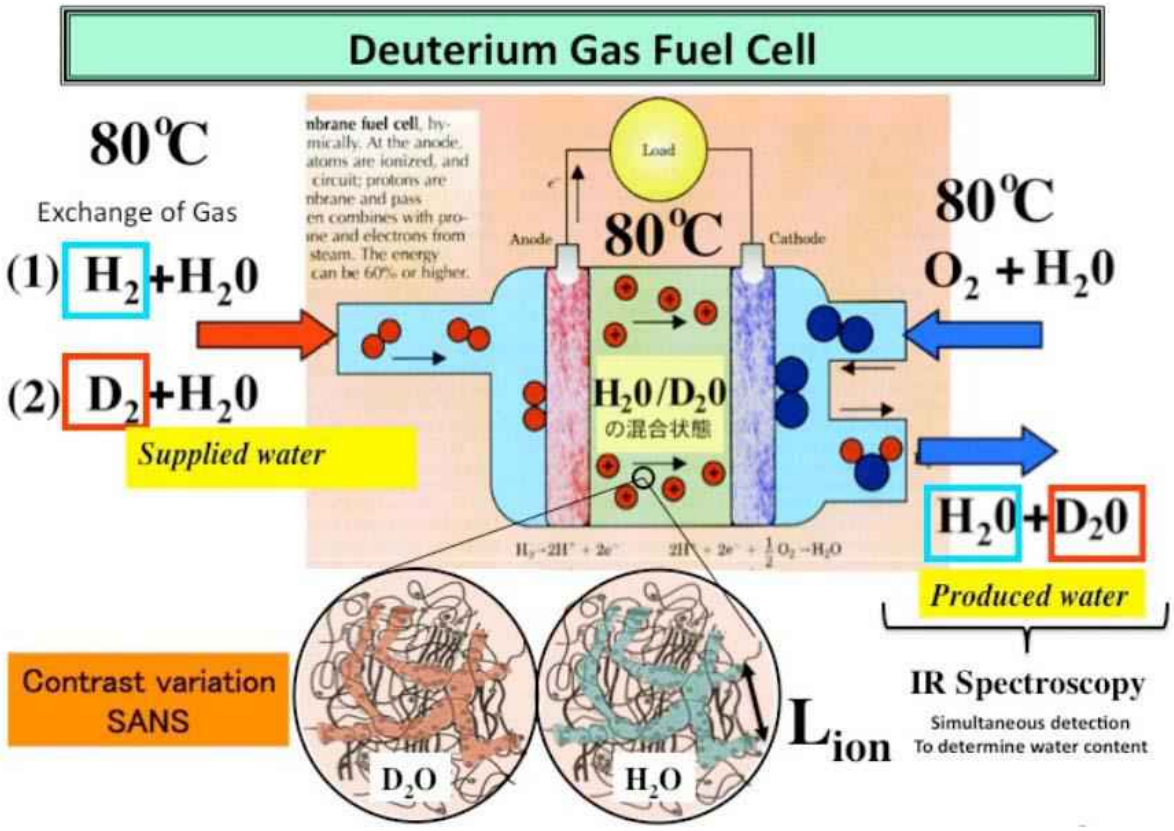
In order to visualize water distribution in an operating fuel cell, we combined two different methods using neutron as a probe, i.e., a combined method of small-angle & ultra-small-angle scattering (SANS) and radiography imaging. SANS observes water distribution in a membrane electrolyte assembly (MEA), whereas radiography observes bulk water appeared in a gas flow channel (so called "flooding"). The polymer electrolyte fuel cell (PEFC) was specially designed suitable for small-angle neutron scattering by replacing materials with aluminum in order to decrease background scattering. We employed hydrogen gas (H2) and deuterated gas (D2) as a fuel for operation. With exchange of H2 and D2, we aim to perform a contrast variation as for polyelectrolyte film (Nafion). When D gas is used as a fuel, D2O is produced at the cathode and diffuses back to the film. Then the film, originally swollen by H2O, exhibits change of coherent scattering contrast. By changing a fuel gas from H2 to D2, SANS quantitatively detected decrease of scattering intensity at scattering maximum originating from the ion-channel in the electrolyte. After quantitative analyses on scattering intensity, which is related to water ratio (H2O/D2O) in the ion channel, we found that 30 wt% of the total water is replaced by D2O by changing the gas from H2 to D2. In a stationary state of fuel cell operation using D2, the scattering intensity rhythmically oscillates (respiration of fuel cell). The rhythmic oscillation found for the peak intensity is a non-equilibrium and non-linear phenomenon, in which "flooding" in a flow field is a feedback mechanism to slow down chemical reaction or water production by affecting mass transportation of air at the cathode. A valance between two diffusions, (i) back diffusion of D2O from the cathode to the electrolyte and (ii) diffusion of H2O supplied as humidity, determines a time interval of the respiration.

[1] *H. Iwase et al. Nucl. Instrum. Methods Phys. Res., A 605, 95-98 (2009).*



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