SFG measurements of water molecules at Nafion/water vapor interface under various relative humidity

K. Taneda¹, H. Noguchi¹, H. Minowa¹, H. Naohara², and K. Uosaki¹
¹Graduate School of Science, Hokkaido University, ²Toyota Motor Corporation

The performance of polymer electrolyte fuel cells (PEFCs) strongly depends on the humidification of Nafion, which is the polymer electrolyte of PEFC. The catalytic reactions on anode and cathode of PEFC, one of the key factors limiting the performance of PEFC, are affected by the adsorption of water at Nafion/water vapor interface. However, the influence of humidification on the degradation of catalysts is not clear because the lack of the fine picture of the adsorption of water molecule on the surface of Nafion. Thus, understanding of the hydration behavior of Nafion membrane is not only a subject of chemical interest but also of great importance for advanced applications of the membranes.

Many studies on water structure in the Nafion membrane have been carried out by using IR¹, NMR² neutron-scattering,³ thermo gravimetric analysis (TGA),⁴ and impedance measurements.⁵ However, all these experiments deal with the water “inside” the Nafion membranes. Molecular level understanding of water at Nafion membrane surface is also important particularly when we considered the reaction mechanism at anode and/or cathode reactions in the polymer electrolyte fuel cells (PEFCs), since electrochemical reactions take place at Nafion/electrode interfaces. Humidity control is also another important issue for operating PEFCs, while excess water will result in electrode flooding which may result in decrease of cell performance.

One needs to use surface specific techniques for this purpose because there is much larger number of molecules in bulk. Sum frequency generation (SFG) spectroscopy is an interface-selective probe and has been applied to determine the interfacial molecular structure in many systems.⁶-¹⁰

In this study, we examined the structure of water at Nafion thin film surface under various relative humidity (RH) by using SFG spectroscopy. SFG spectra in the OH stretching region of water molecules at Nafion thin film surface drastically changed with RH and suggest that two different types of water exist at Nafion thin film surface. We also found that the structure change was quite reversible against RH change. Effect of heat treatment and ion exchange reaction on water structure at Nafion surface are also investigated.

References
Name: Kento TANEDA

Position and Affiliation: Post Doctoral Researcher of the Graduate School of Science, Hokkaido University
Postal Address: North10, West 8, Kita-ku, Sapporo 060-0810, Japan
Phone/Facsimile: +81-11-706-2708/+81-11-706-3440
Email: taneda@pchem.sci.hokudai.ac.jp

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