

Self-diffusion of hydrogen in high-pressure ices: Preliminarily results

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High-pressure ices are the primary constituents of mantles of the large icy bodies such as some of Galilean satellites and Edgeworth-Kuiper Belt Objects. Understanding self-diffusion of hydrogen in these high-pressure ices is essential to discuss about mantle dynamics of the large icy bodies because it controls rheology of these ices. In addition, diffusive properties of high-pressure ices are also an interesting topic in the field of high-pressure material science. Shortening of intermolecular distance with increasing pressure induces drastic changes of hydrogen-bonding property such as proton tunneling, proton symmetrization (Benoit et al. 1998), hydrogen sublattice melting (Cavazzoni et al. 1999), and proton hopping transition (Noguchi et al. 2014). Whether these changes of hydrogen bonding affect hydrogen diffusion or not is a major subject in the proton dynamics at high pressure. To elucidate these questions, we have carried out an experiment to determine hydrogen diffusion coefficients of the high-pressure ices using a diamond anvil cell (DAC) and Raman spectroscopy.

The diffusion couples have been prepared from polycrystalline H₂O and D₂O ices prepared within a sample chamber of DAC. The diffusion experiments of these couples were carried out using an electric furnace. Temperatures were set in a range between 400 K and 500 K. After keeping the DAC in the furnace for a few days, Raman mapping measurements of the diffusion couples were carried out at room temperature. Two-dimensional diffusion profiles of deuterium were determined using quantitative curves for deuterium concentration. The quantitative calibration curves were functions as the relative area of Raman band of OH stretching mode to that of OD stretching mode, or Raman shifts of OH and OD stretching modes. Preliminarily results will be reported in our presentation.

Keywords: high-pressure ices, self-diffusion, rheology, Raman spectroscopy