Supporting Information

X-ray attenuation and image contrast in the X-ray computed tomography

of clathrate hydrates depending on guest species

Satoshi Takeya,[*a] Sanehiro Muromachi,[b] Akihiro Hachikubo,[c] Ryo Ohmura,[d] Kazuyuki Hyodo,[e] and Akio Yoneyama [f]

[a] National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Central 5, 1-1-1 Higashi, Tsukuba 305-8565, Japan.

[b] Energy Process Research Institute (EPRI), National Institute of Advanced Industrial Science and Technology (AIST), 16-1 Onogawa, Tsukuba 305-8569, Japan

[c] Kitami Institute of Technology, 165 Koen-cho, Kitami 090-8507, Japan

[d] Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223-8522, Japan

[e] High Energy Accelerator Research Organization, Oho, Tsukuba 305-0801, Japan

[e] SAGA Light Source, 8-7 Yayoigaoka Tosu, Saga 841-0005, Japan
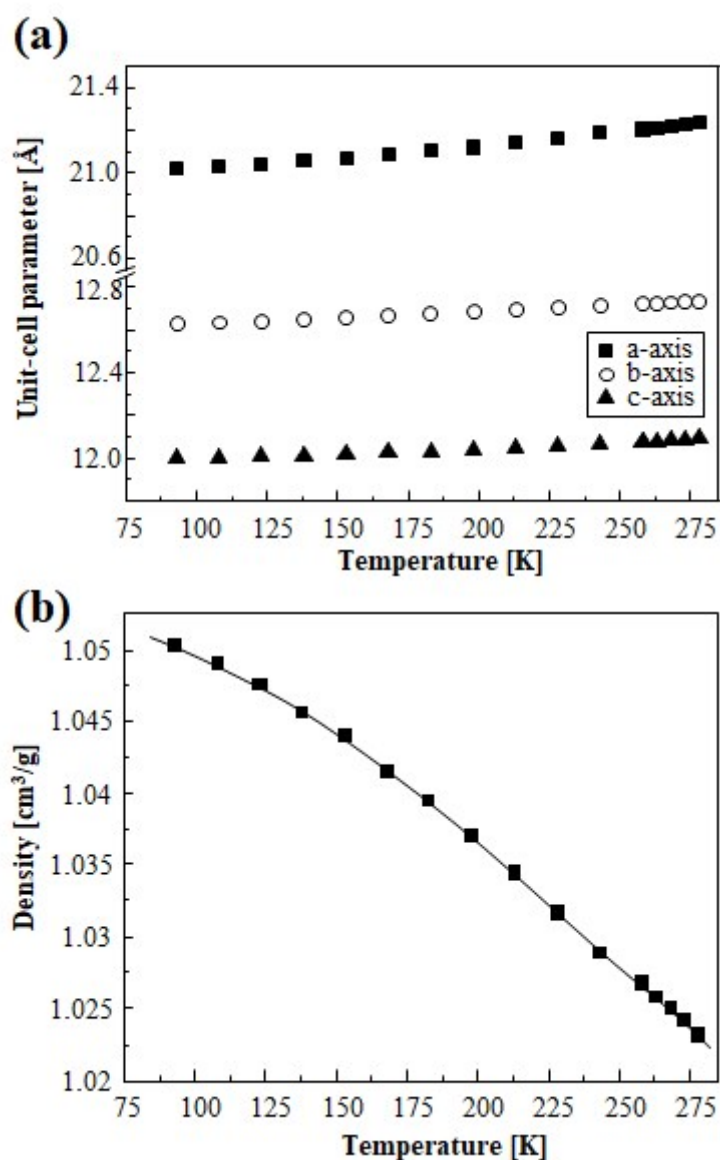
Figure S1 Crystallographic data of TBAB semi-clathrate hydrate obtained by powder X-ray diffraction measurement. (a) Lattice constants of TBAB semi-clathrate hydrate. (b) Temperature-dependent density values. Here, density $\rho(T)$ of TBAB semi-clathrate was fit to the following function of temperature T: $\rho(T) = 1.04889 + 1.11736 \times 10^{-4}\ T - 1.21158 \times 10^{-6}\ T^2 + 1.71944 \times 10^{-9}\ T^3$ (g/cm^3). The densities of the TBAB semi-clathrate are estimated to be 1.0275 g/cm^3 at 253 K and 1.0241 g/cm^3 at 273 K by the equation.
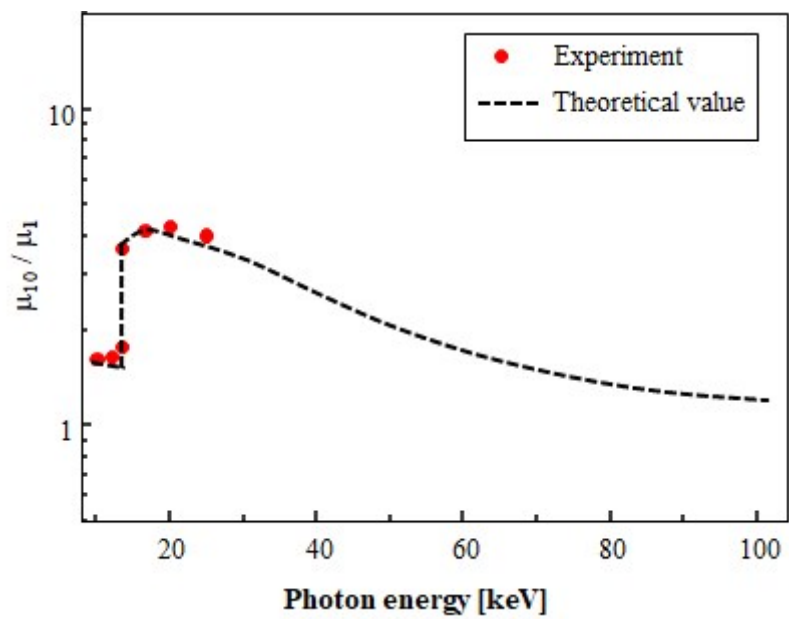
Figure S2 Ratio of linear attenuation coefficient of aqueous NaBr solution of 10 wt% (μ_{10}) to that of 1 wt% (μ_1).
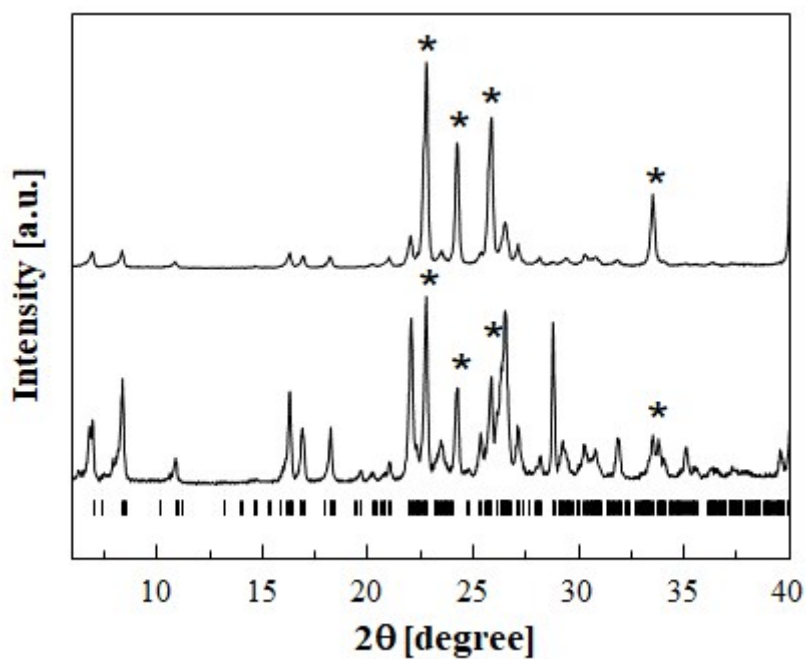
Figure S3 Powder X-ray diffraction patterns of the TBAB semi-clathrate hydrate sample at 123 K. The upper pattern represents the diffraction from the upper part of the sample, and the lower pattern represents the diffraction from the bottom part of the sample shown in Figure 5. Here, the bottom dashes represent the calculated peak positions for the TBAB semi-clathrate hydrate and the asterisk (*) represents the diffraction peak of the hexagonal ice.
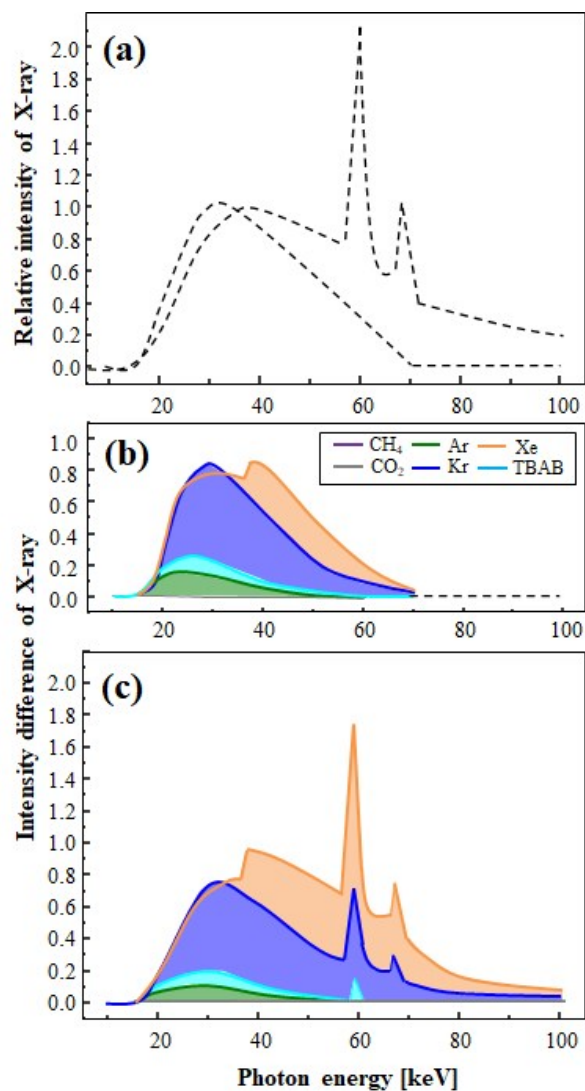
Figure S4 (a) X-ray profile of laboratory X-ray source using tungsten (W) tube by two different acceleration voltages (70 and 140 keV). Relative intensity of intensity difference of transmitted X-ray between ice and clathrate hydrate with thickness of 2 mm and X-ray spectra generated by the laboratory X-ray sources using acceleration voltages of (b) 70 kVp and (c) 140 kVp.