

Abnormal structure transition induced by methane enclathration occurring in clathrate hydrates

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Two isomers of C_2H_7N , dimethylamine (DMA) and ethylamine (EA), are known as clathrate hydrate formers itself. Here, we introduced methane gas as a help gas into both dimethylamine and ethylamine clathrate hydrate system and identified the structure transition of amine clathrate hydrate through powdered X-ray diffraction (XRD) and solid-state nuclear magnetic resonance (NMR). Through X-ray diffraction and NMR studies, the structure transition of amine clathrate hydrate from structure I (cubic $Fd\bar{3}m$) to structure H (hexagonal $P6/mmm$) was confirmed. Raman spectroscopy was used to identify the abnormal structure transition occurring in amine clathrate hydrate systems. In addition, the hydrate equilibrium conditions for amine-water-methane hydrates were measured.