# Thermodynamic and Spectroscopic Analyses of Cyclopentane Hydrate with Guest Molecules for Potential Application in Gas Storage and Desalination

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The cyclopentane (CP) + water system forms structure II (sII) gas hydrate without any help gas by stabilizing structure under atmospheric pressure condition. However, the thermodynamic properties and guest inclusion behavior of the CP + water + guest gas systems were not clearly proved. In this study, four-phase (hydrate – liquid water – liquid CP – vapor) equilibria of the CP + water + guest gas ($CH_4$, $CO_2$, and $N_2$) systems were measured to determine hydrate stability regions. In addition, hydrate phase equilibria in the presence of NaCl were also measured to examine the equilibrium shift. The structure and guest distributions of CP hydrates with guest molecules were analyzed via $^{13}C$ NMR and Raman spectroscopy. The hydration number, onset temperature, and dissociation enthalpy of CP hydrate were measured using a differential scanning calorimeter. The experimental results show that the CP + guest gas systems form sII hydrates and CP molecules occupy large $5^{12}6^4$ cages whereas guest gas molecules mainly occupy small $5^{12}$ cages. The experimental results obtained in this study provide fundamental information for CP hydrate-based desalination and gas storage.