Investigation of the Effect of Different Thermodynamic Hydrate Inhibitors on the Formation of Carbon Dioxide Hydrate by Raman Spectroscopy

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Gas hydrates are crystalline solids composed of a three dimensional network of hydrogen bonded water molecules stabilized by the inclusion of gas molecules. The undesired formation of gas hydrates can cause pipeline blockage or even destruction. Substances that avoid or delay gas hydrates from forming, called inhibitors, can be classified into two groups: thermodynamic and kinetic hydrate inhibitors. Thermodynamic inhibitors shift the equilibrium to lower temperatures and higher pressure. One group representing thermodynamic inhibitors are salts. Their inhibition effect is based on the ion-dipol interactions between salt ions and water molecules, leading to a reduction of water-water and water-gas interactions. The reduction of water-water interactions results in a weakening of the hydrogen bonds in the water-rich phase, whereas the diminution of water-gas interactions causes the solubility of gas molecules in water to decrease.
We present an experimental Raman technique that is capable of quantifying the molar fraction of dissolved gas and analyze qualitatively the development of hydrogen bonds in the water-rich phase. Moreover, it is possible to calculate the amount of carbon dioxide gas hydrate crystals formed in the gas hydrate rich phase, in order analyze how the reduced amount of dissolved gas and the weakening of the hydrogen bonded network influence this property.
As the surface charge of the ions is crucial for strength of the Columbic forces, we investigate different thermodynamic inhibitors with different charges and sizes. By comparing these results for systems with different (water - carbon dioxide) – inhibitor compositions a better understanding of the mode of action of inhibitors is gained.

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