INVESTIGATING GAS CLATHRATE HYDRATE STRUCTURE, FORMATION AND DECOMPOSITION.

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Introduction: Gas clathrate hydrates are crystalline inclusion compounds composed of a lattice of hydrogen-bonded water cages which can encage small guest molecules, such as methane, carbon dioxide, and hydrogen [1]. Applications of hydrate technologies include the assessment of hydrates as a potential future energy source, in energy storage, and industrial flow assurance. New insight into controlling hydrate formation and decomposition in these technological applications requires fundamental understanding of clathrate hydrate structural and physical properties, and crystal growth and decomposition processes.

Clathrate Hydrates in Solar System Ices: Gas clathrate hydrates have been also suggested to exist in association with the icy environments of outer planetary bodies in the solar system, including Enceladus, Titan, Saturn's icy moons, and even in comets [2-4]. Discussion will be given to how the knowledge-base and methods applied to the technological applications of clathrate hydrates could impact studies of extraterrestrial clathrate hydrates.

Structural Studies of Natural Hydrated Deposits versus Synthetic Hydrates: The structural properties of natural hydrated deposits and synthetic hydrates have been measured and compared using Raman and NMR spectroscopy and X-ray and neutron diffraction. The natural samples were recovered from Barkley Canyon, off Vancouver Island (sea-floor hydrates), the KG Basin, India (oceanic hydrates), and the Northern Cascadia Margin (IODP 311; oceanic hydrates). Discussion will be given to how structural and physical property measurements of hydrates can contribute to the paradigm shift from hydrate exploration to hydrate production.

Clathrate Hydrate Formation and Decomposition Studies: The kinetics of gas hydrate formation and decomposition have been investigated using a combination of microscopic and macroscopic techniques. Molecular-scale studies on the formation and decomposition of single and binary gas hydrates have been performed using Raman and NMR spectroscopy. These studies have revealed the presence of long-lived metastable hydrate phases. The transformation of these metastable phases is dependent on gas composition, and can be significantly affected by the addition of polymer molecules (kinetic hydrate inhibitors). A new high pressure differential scanning calorimetric method has been developed to assess the effects of kinetic hydrate inhibitors on the nucleation and growth processes of gas hydrates.

Hydrogen Clathrates: Synthesis and Characterization studies have been performed on clathrate structures encapsulating molecular hydrogen (Figure 1). Storage of molecular hydrogen in clathrate hydrates has been achieved, with reversible release of hydrogen at ambient conditions. Hydrogen enclathration in different clathrate molecular compounds has been measured using Raman spectroscopy coupled with neutron diffraction.

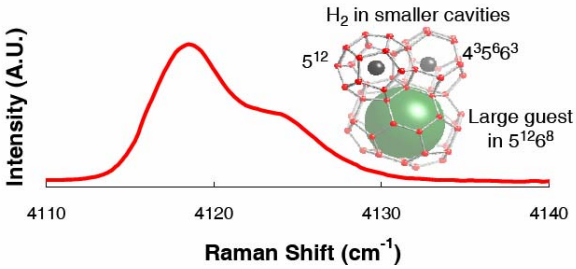

Figure 1: Molecular hydrogen encapsulated in the small cavities of sH clathrate hydrate, large guest molecules occupy the large eicosahedral cavities of sH [5]. The vibron region in the Raman spectrum reveals the environment of the hydrogen molecules.

References:

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