



Prospects to Storage and Transport Natural Gas While Using Natural Seawater: Clathrate Hydrates

Dr. Asheesh Kumar

Upstream and Wax Rheology Division, CSIR-Indian Institute of petroleum, Dehradun, India [Email: asheesh.kumar@iip.res.in](mailto:asheesh.kumar@iip.res.in)



Introduction to Gas Hydrates

□ Molecular cages of water that trap small guest molecules at suitable pressure and temperature conditions



Molecular view

□ Similar to ice – ice that burns or combustible ice



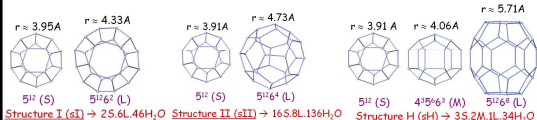
Naked eye view

(1 m³ of hydrate contains 170 m³ CH₄ at STP)!

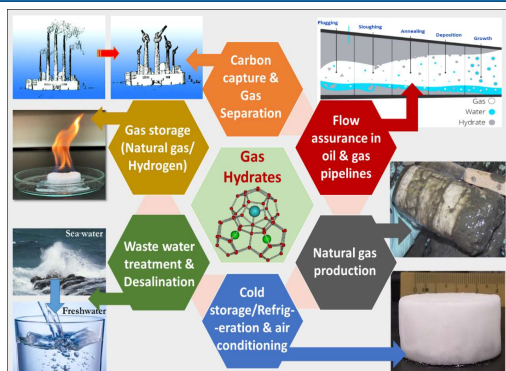
□ Major natural gas components (CH₄, C₂H₆, C₃H₈...) form gas hydrates

□ Flow assurance, found in nature & many innovative applications

Different Guest Size Results in Different Hydrate Structure

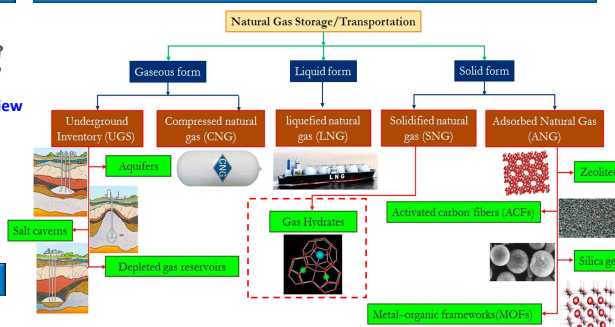


Applications of Clathrate Hydrate Process



A. Kumar et al. Book Chapter, in Clean Energy Production Technologies, Springer nature 2021

Pathways for Natural Gas Storage and Transportation



Limitations of conventional methods for large scale NG storage

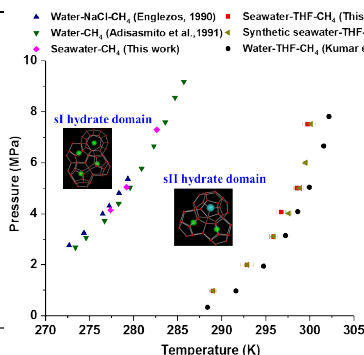
- CNG: Huge safety risk (explosive!); High cost due to high pressure requirement
- LNG: Not an option for long term storage due to continuous boil off and extreme low temperature requirement

Thermodynamic Hydrate Phase Equilibrium and Challenges

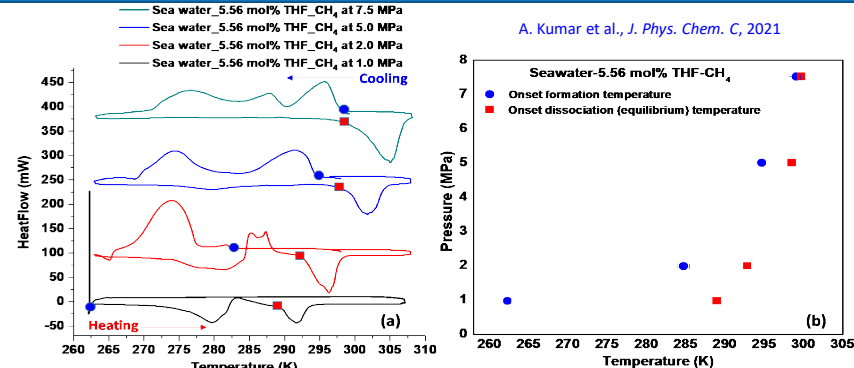
Challenges to Overcome:

- Formation step**
- High pressure requirement in the range of 8-15 MPa
 - Low temperature (~1 °C) required in formation step
 - Slow kinetics of hydrate formation
- Storage step**
- -20 °C is an energy intensive requirement for a large scale deployment

A. Kumar et al., J. Phys. Chem. C, 125, 30, 16435–16443, 2021.



Hydrate Formation-dissociation Cycles in Seawater along with Onset Formation Temperature



Methane Uptake (volume of methane stored/volume of hydrates) and Stability of hydrate pellet

