

#### Methane Hydrate Formation, Storage and Dissociation Behavior in Unconsolidated Sediments in the Presence of Environment-friendly Promoters

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#### Methane Hydrate Formation, Storage and Dissociation Behavior in Unconsolidated Sediments in the Presence of Environment-friendly Promoters

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SPE-200532-MS, Methane Hydrate Formation, Storage and Dissociation Behavior in Unconsolidated Sediments in the Presence of Environment-friendly Promoters MS• Jyoti Shanker Pandey

### **Presentation Outline**

- Introduction
- Objective
- Experimental setup
- Experimental results
- Conclusion

# Introduction: Gas Hydrates & Applications

• What Are Gas Hydrates

.

Burning

hydrate

- Ice-like, crystalline structures
- Common hydrate formers: methane, ethane, propane, carbon dioxide, hydrogen sulfide, nitrogen, hydrogen



water cages

512



5<sup>12</sup>6<sup>2</sup> 5<sup>12</sup>6<sup>8</sup> Gas storage





#### Applications



## Introduction: Role of Chemicals in Gas Hydrates



Chemicals can influence

- Surface tension
- Solubility
- Gas diffusion

# Introduction Porous Media & Promoter



# Objective

- To study the methane hydrate formation kinetics
  - Change in particle size
  - Presence of chemicals (Amino acids & Surfactant)
- To study the dissociation kinetics

### **Experimental Setup**



Rocking Cell (PSL Germany)



- A- Bathtub
- **B-** High Pressure Cell
- C- Rocking Balls

- Rocking Rate, Rocking Angle
- Volume
- Temperature Ramping, Constant Temperature

# **Experimental Setup: Method and Materials**

Sand	Silica Sand (4 Particle Sizes) • 46.4-245 μm • 160-630 μm • 480-1800 μm • 1400-5000 μm
Amino acids (3000 ppm concentration)	<ul> <li>L-valine</li> <li>L-methionine</li> <li>L-histidine</li> </ul>
Sodium dodecyl Sulfate (SDS)	500-3000 ppm (500,1000,2000,3000 ppm)
Experimental conditions	100 bar, 1°C, Isothermal experiments
Parameter calculated	Induction time, gas uptake & dissociation rate below $0^{\circ}\mathrm{C}$

# **Experimental Results- Formation Kinetics**

- Hydrate morphology
  - Pore filling
  - Grain coating
- Formation kinetic (Gas-liquid contact interface)
  - Grain coating Particle surface area
  - Pore filling- Pore space
  - Large particle size: higher pore space- Large gas-liquid contact area
  - Small particle size : weak pore connectivity, barrier to mass transfer due to high capillary forces in smaller pore space
- $S_{wi} = 35\%$  change in grain coating to pore filling

# Formation-Induction time



- Pressure variation during Isothermal experiments at P= 100 bar and 1°C
- for given sand particle size
- Induction time is lower for SDS / Hydrophobic amino acids for any given particle size

# Formation-Induction time



- Induction time is lower for SDS / Hydrophobic amino acids for any given particle size.
- Increase in particle size lead to decrease in induction time
- L methionine and SDS have similar induction time.
- Histidine could only formed hydrate at higher sand particle size.
- Enhanced driving force due to large gas-liquid interface

# Gas Uptake



- Pressure variation during Isothermal experiments at P= 100 bar and 1°C
- For low concentration (500 ppm) , increase in particle size lead to decrease in gas uptake.
- At higher concentration, effect of sand particle size reduce and role of mass transfer increase
- For large particle size, change in concentration marginally affect gas uptake.
- For smaller particle size, change in concentration had dominating effect on gas uptake

# **Experimental Results-Dissociation**



- Dissociation under T = 266.7 K at starting pressure P = 1 bar.
- Self preservation of hydrates, Surrounded by ice sheet
- Dissociation rate is dependent on initial hydrate saturation.
- SDS/Hydrophobic amino acids dissociate faster
- SDS dissociate fastest for given sand particle while amino acids dissociated slower due to enhance hydrogen bonding

# Conclusions

- S<sub>wi</sub> controls formation kinetics.
- Low promoter concentration, particle size effect dominates the formation kinetics dominates
- Hydrophobic amino acids have similar kinetic behavior as SDS.
   Less deviation between amino acids and SDS at large particle size.
- Methane hydrate self preservation in the presence of hydrophobic amino acids enhanced.

# **Relevant Papers**

- Pandey, J. S., Daas, Y. J., & von Solms, N. (2020). Screening of Amino Acids and Surfactant as Hydrate Promoter for CO<sub>2</sub> Capture From Flue Gas. *Processes*, *8*, [124]. https://doi.org/10.3390/pr8010124
- Pandey, J. S., Jouljamal Daas, Y., & Solms, N. V. (2019). Insights into Kinetics of Methane Hydrate Formation in the Presence of Surfactants. Processes, 7(9), [598]. https://doi.org/10.3390/pr7090598
- Pandey, J. S., Daas, Y. J., Karcz, A. P., & Solms, N. V. (2020). Enhanced Hydrate-Based Geological CO2 Capture and Sequestration as a Mitigation Strategy to Address Climate Change. Energies, 13(21), https://doi.org/10.3390/en13215661



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For further discussion jyshp@kt.dtu.dk



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