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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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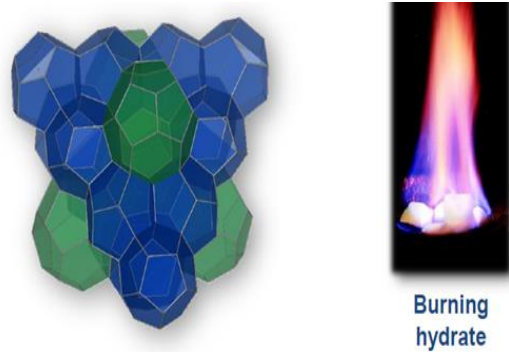
Presentation Outline

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

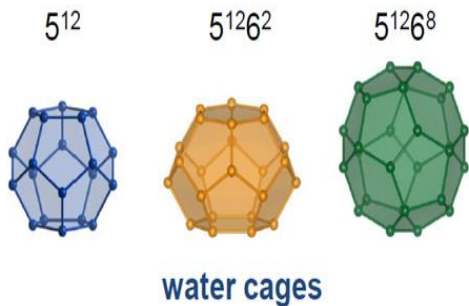
Introduction: Gas Hydrates & Applications

- What Are Gas Hydrates

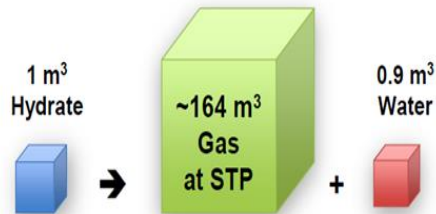
- Ice-like, crystalline structures
- Common hydrate formers: methane, ethane, propane, carbon dioxide, hydrogen sulfide, nitrogen, hydrogen



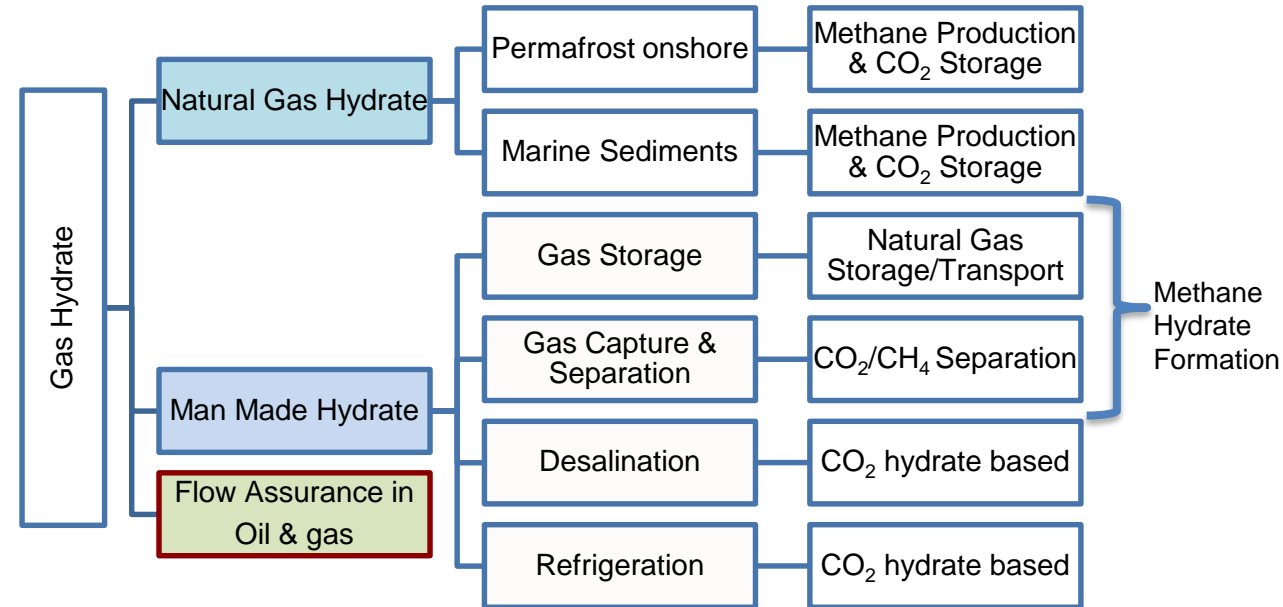
Burning hydrate



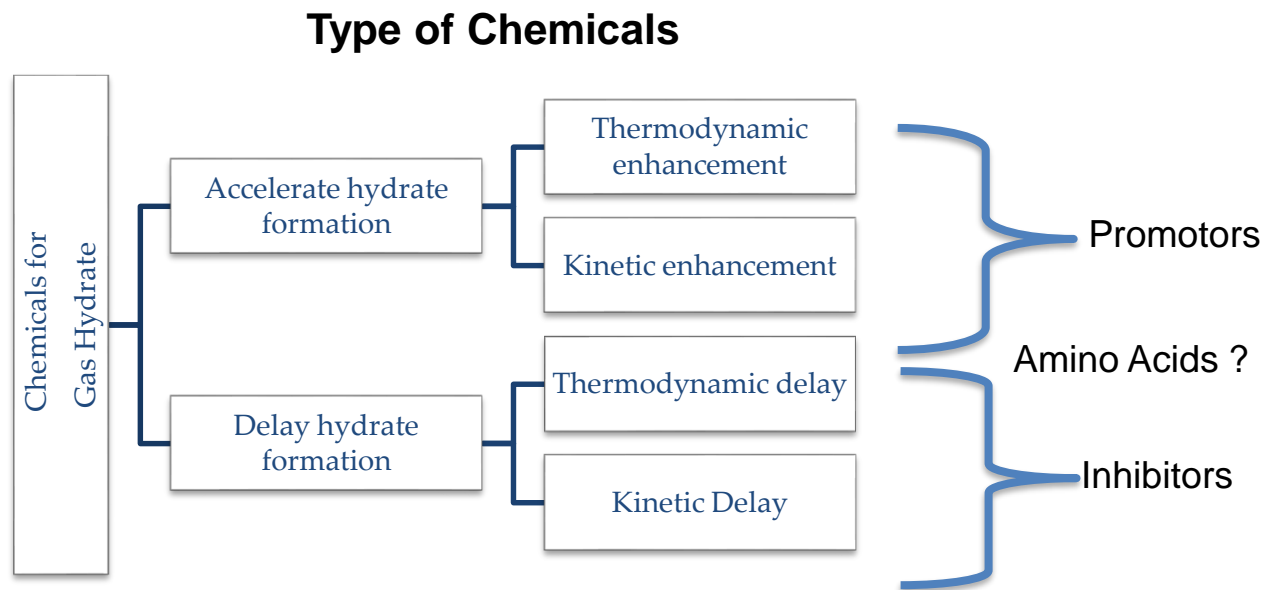
Gas storage capacity in hydrates



- Applications



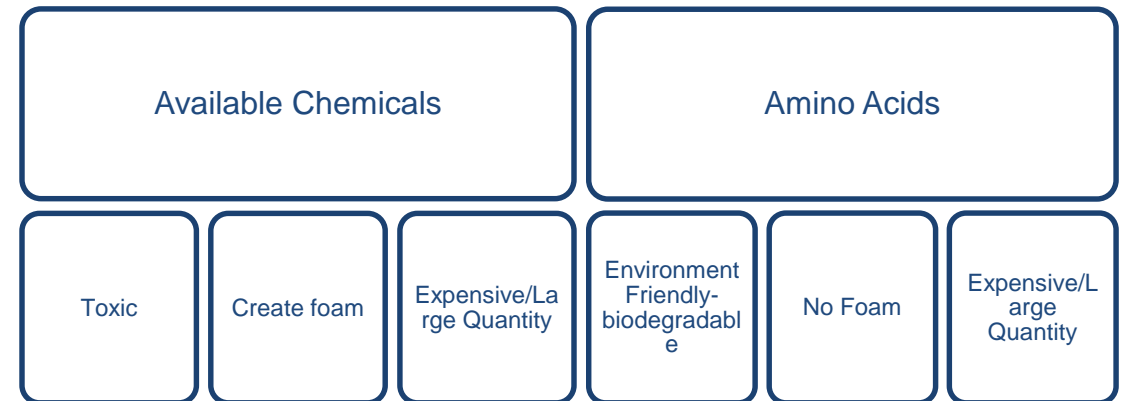
Introduction: Role of Chemicals in Gas Hydrates



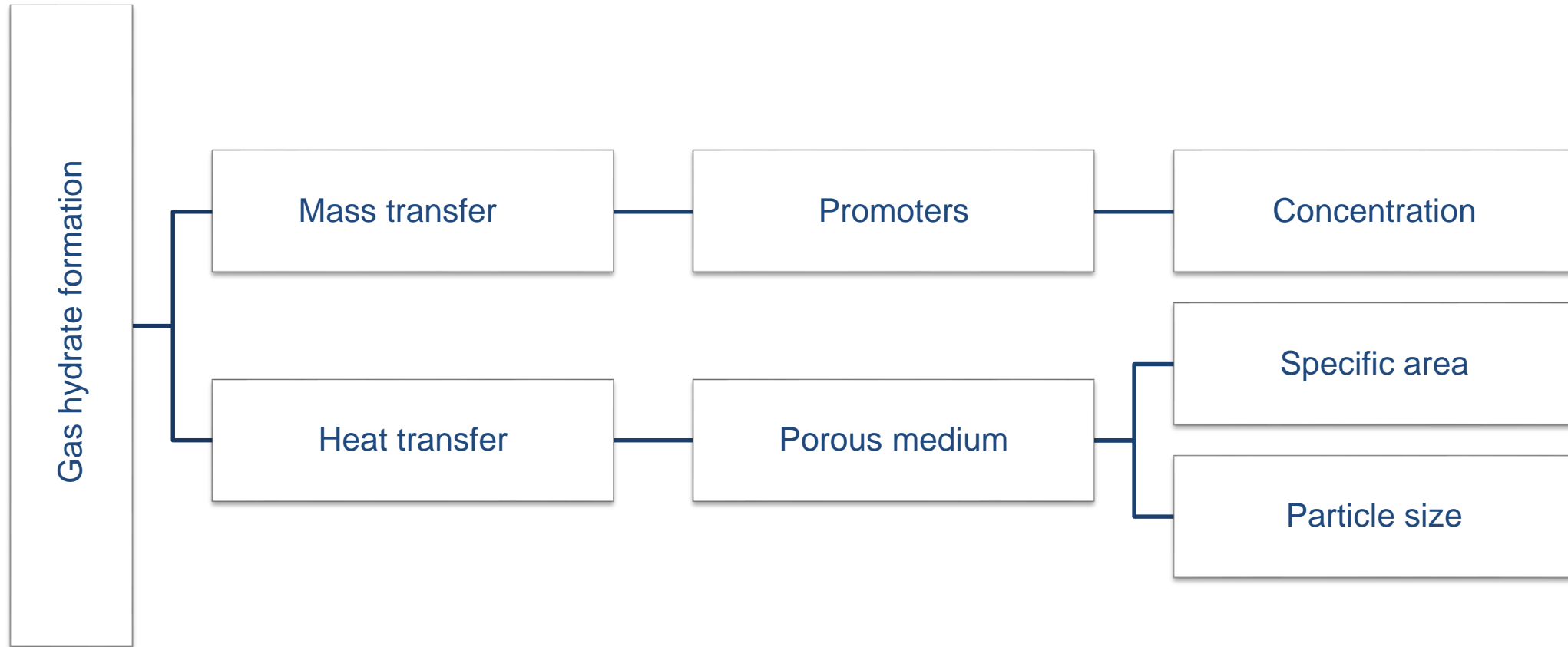
Chemicals can influence

- Surface tension
- Solubility
- Gas diffusion

Why Amino Acids ?



Introduction Porous Media & Promoter



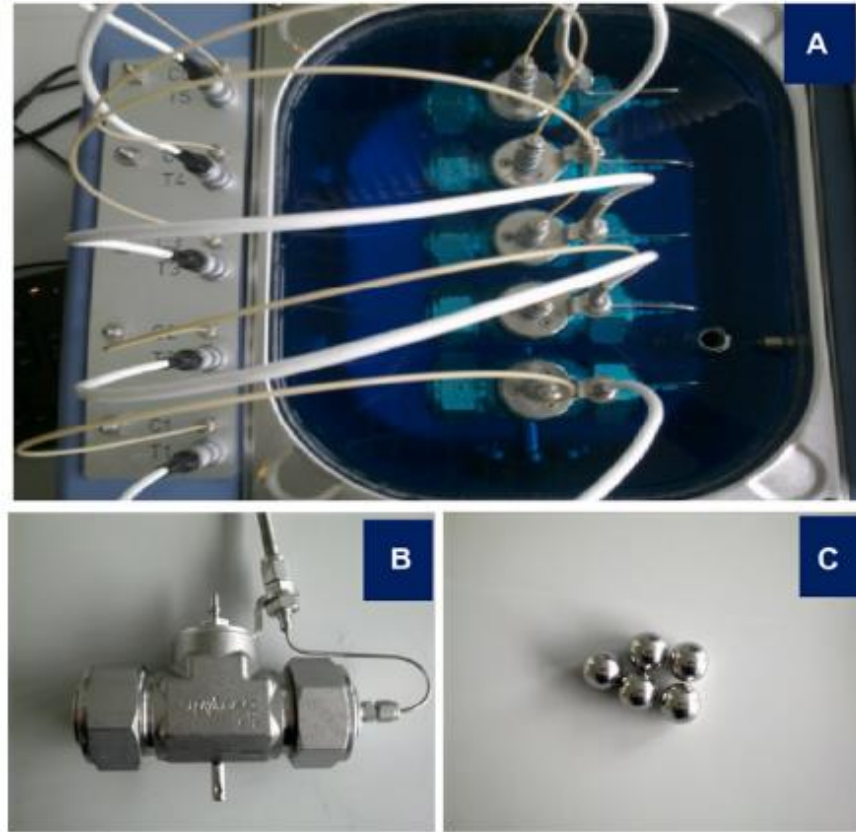
Objective

- 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

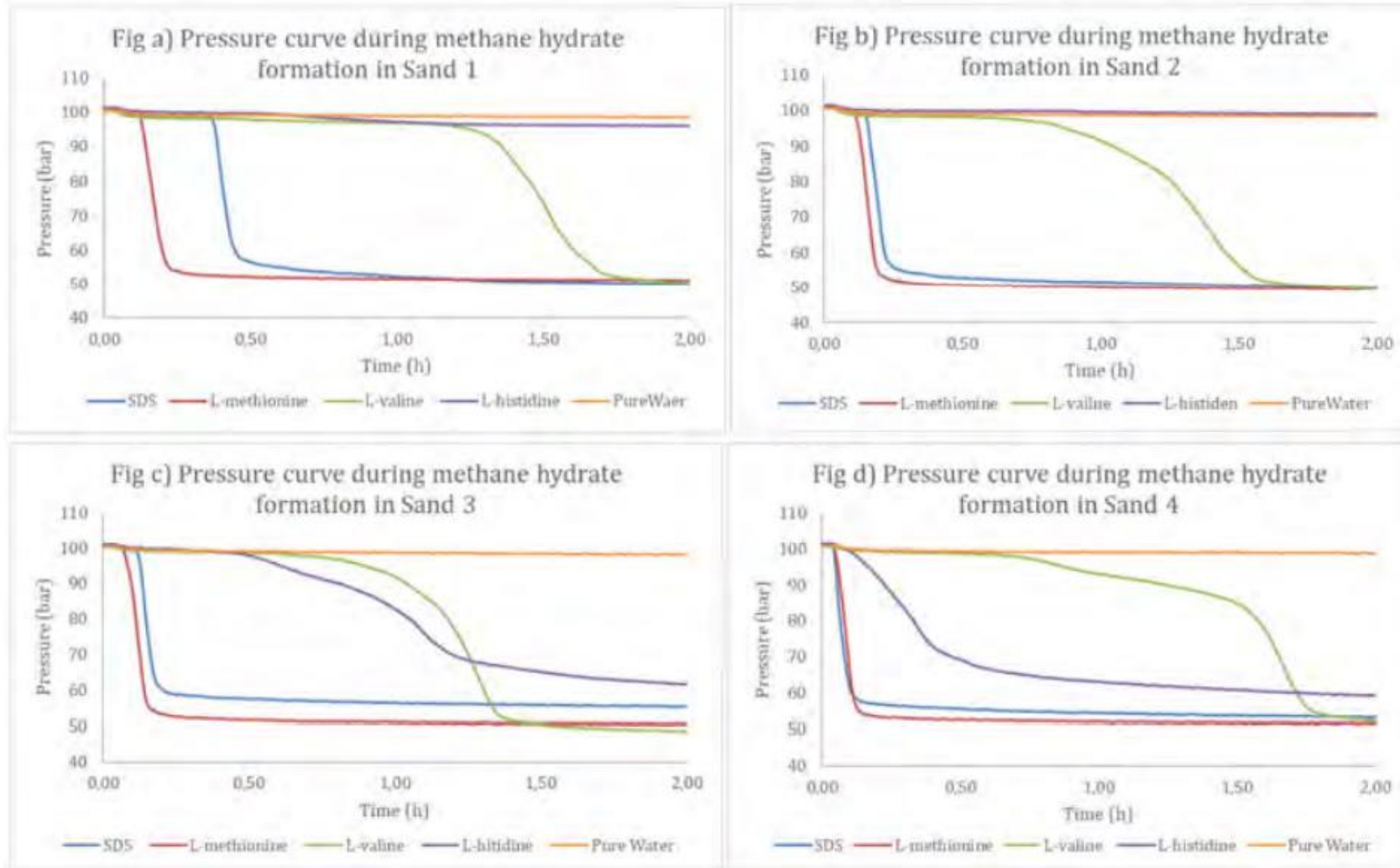
Experimental Setup: Method and Materials

Sand	Silica Sand (4 Particle Sizes) <ul style="list-style-type: none">• 46.4-245 μm• 160-630 μm• 480-1800 μm• 1400-5000 μm
Amino acids (3000 ppm concentration)	<ul style="list-style-type: none">• L-valine• L-methionine• L-histidine
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°C

Experimental Results- Formation Kinetics

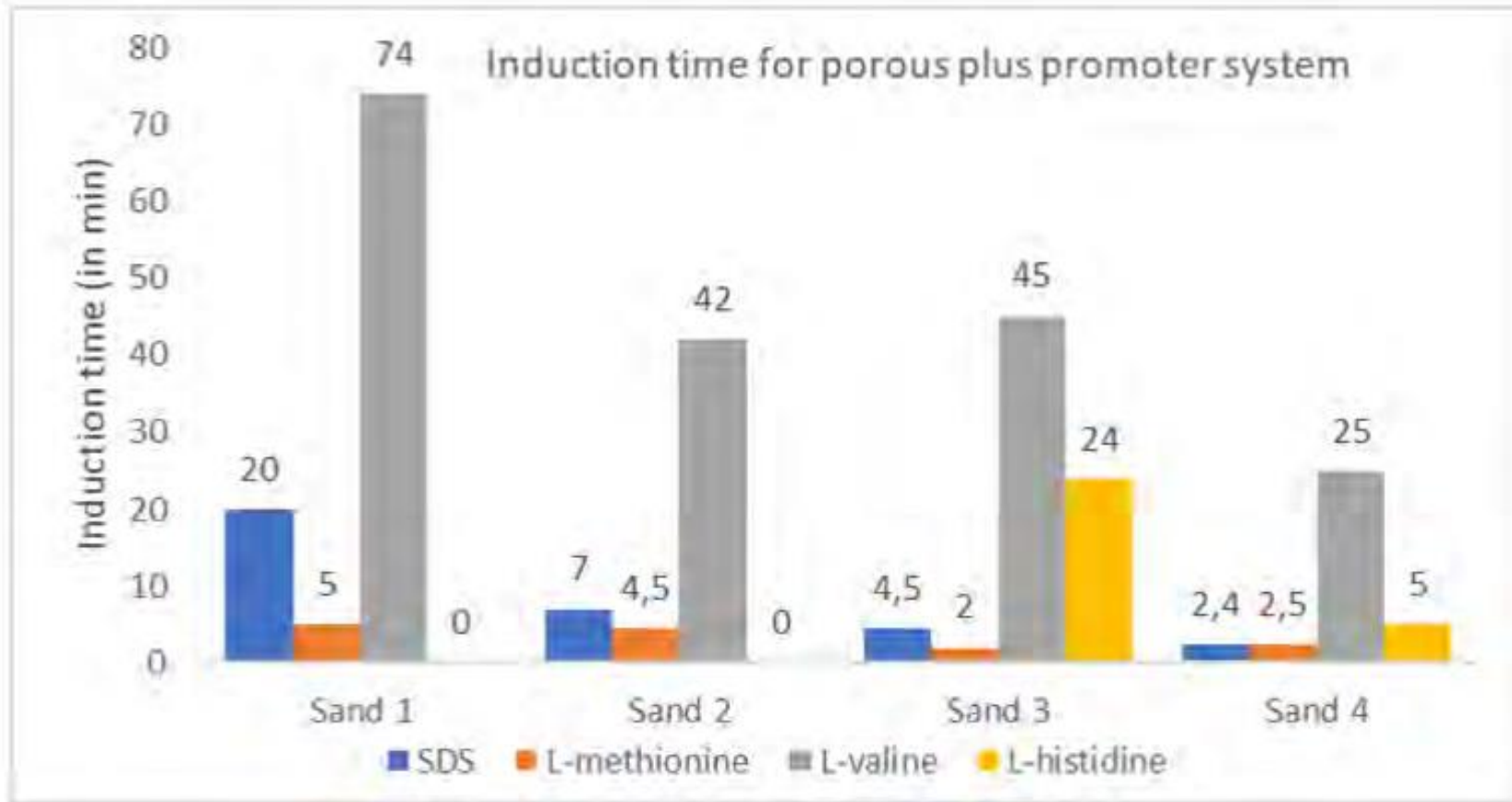
- Hydrate morphology
 - Pore filling
 - Grain coating
- Formation kinetic (Gas-liquid contact interface)
 - Grain coating – Particle surface area
 - Pore filling- Pore space
 - Large particle size: higher pore space- Large gas-liquid contact area
 - Small particle size : weak pore connectivity, barrier 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



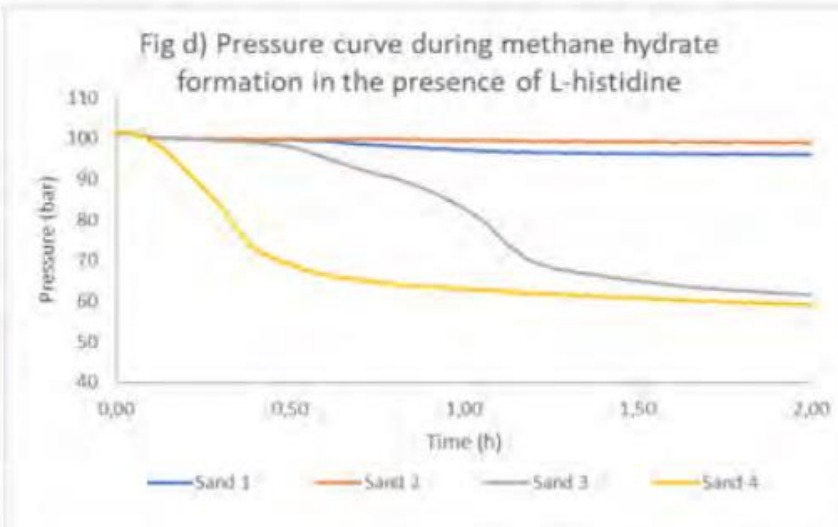
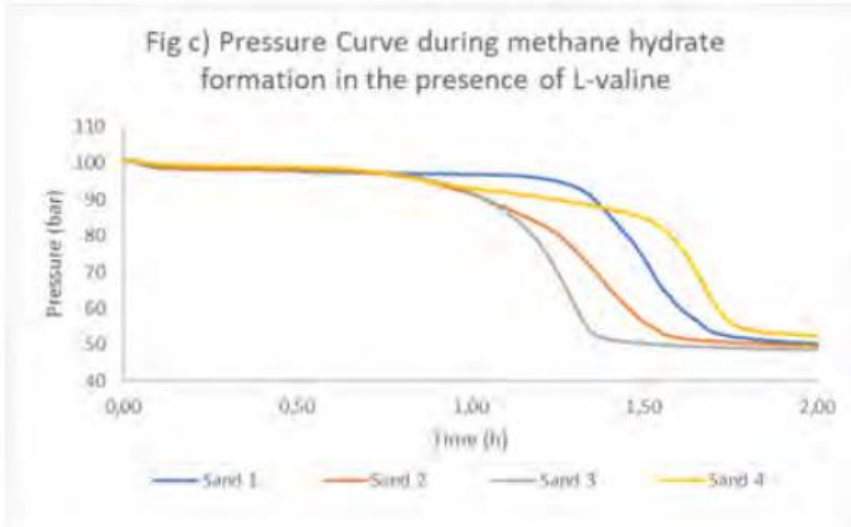
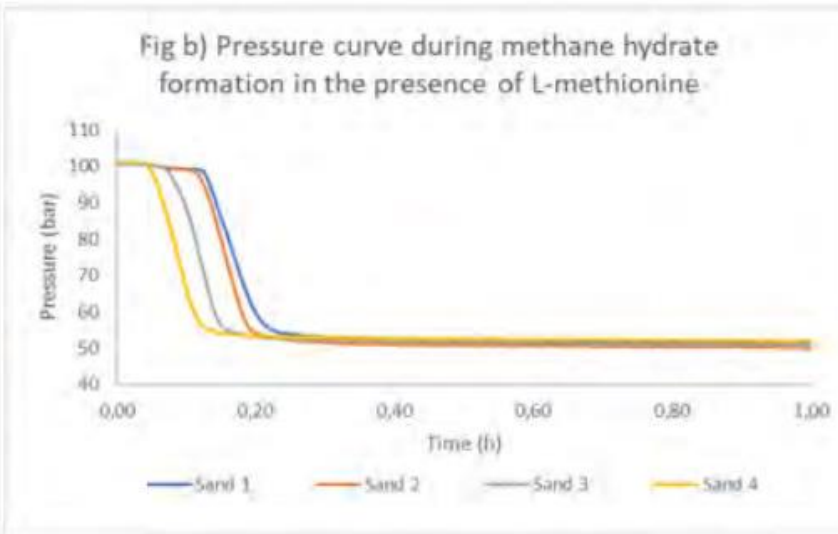
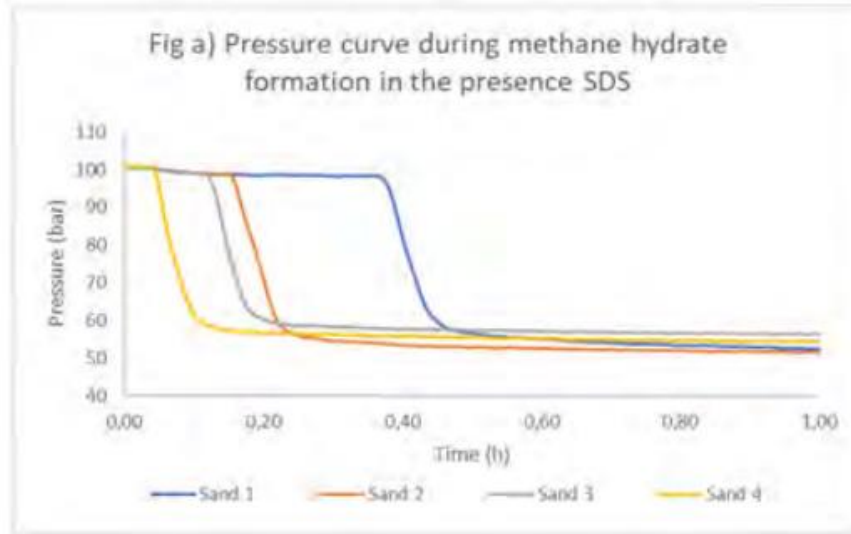
- Pressure variation during Isothermal experiments at $P=100$ bar and 1°C
- for given sand particle size
- Induction time is lower for SDS / Hydrophobic amino acids for any given particle size

Formation-Induction time



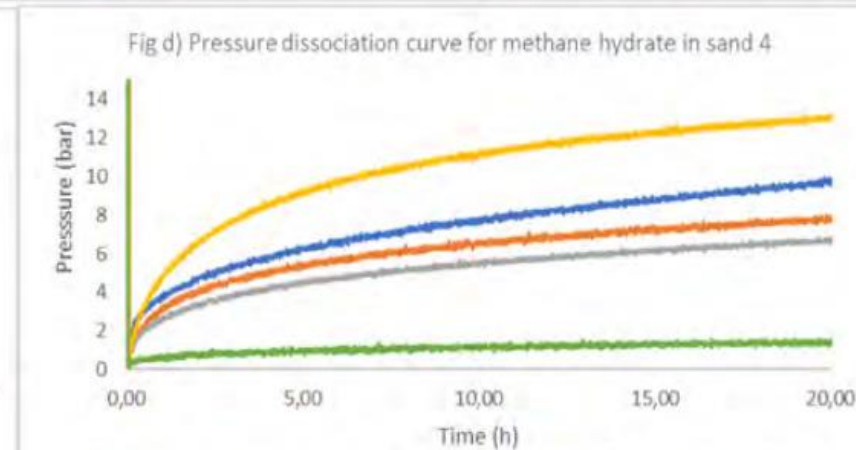
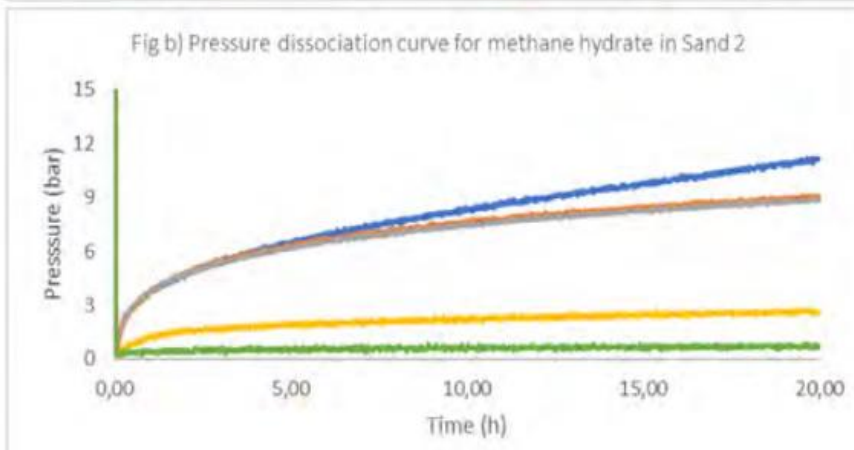
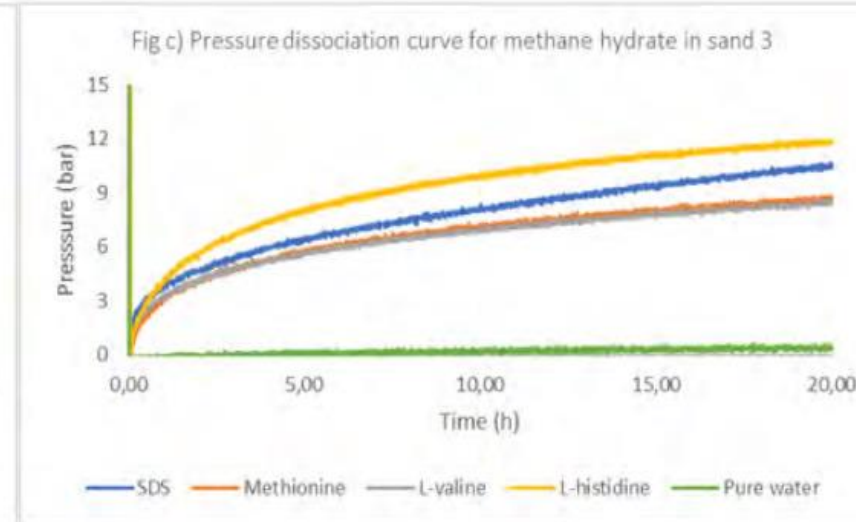
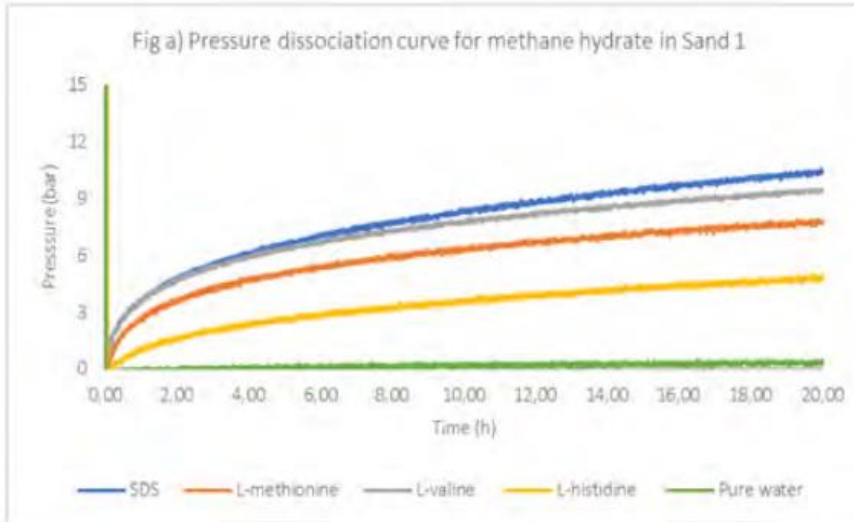
- Induction time is lower for SDS / Hydrophobic amino acids for any given particle size.
- Increase in particle size lead to decrease in induction time
- L methionine and SDS have similar induction time.
- Histidine could only formed hydrate at higher sand particle size.
- Enhanced driving force due 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_{wi} 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 CO₂ 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
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