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Publication date:
2019

Document Version
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2019年11月18-20日 | 國立台北科技大學, 台北, 台灣

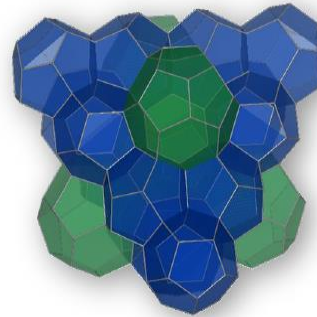
National Taipei University of Technology, Taipei, Taiwan | November 18-20, 2019

ICCSE 2019

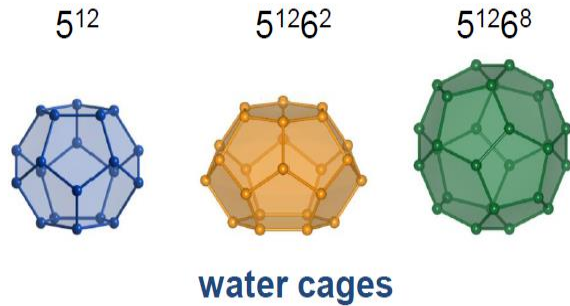
Introduction

What are Gas Hydrate ?

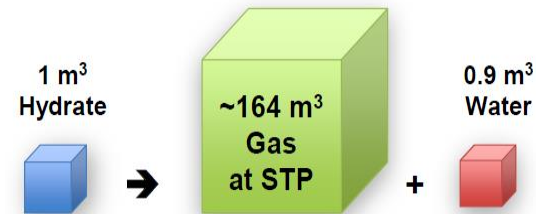
- Ice-like, crystalline structures
- Common hydrate formers: methane, ethane, propane, carbon dioxide, hydrogen sulfide, nitrogen, hydrogen



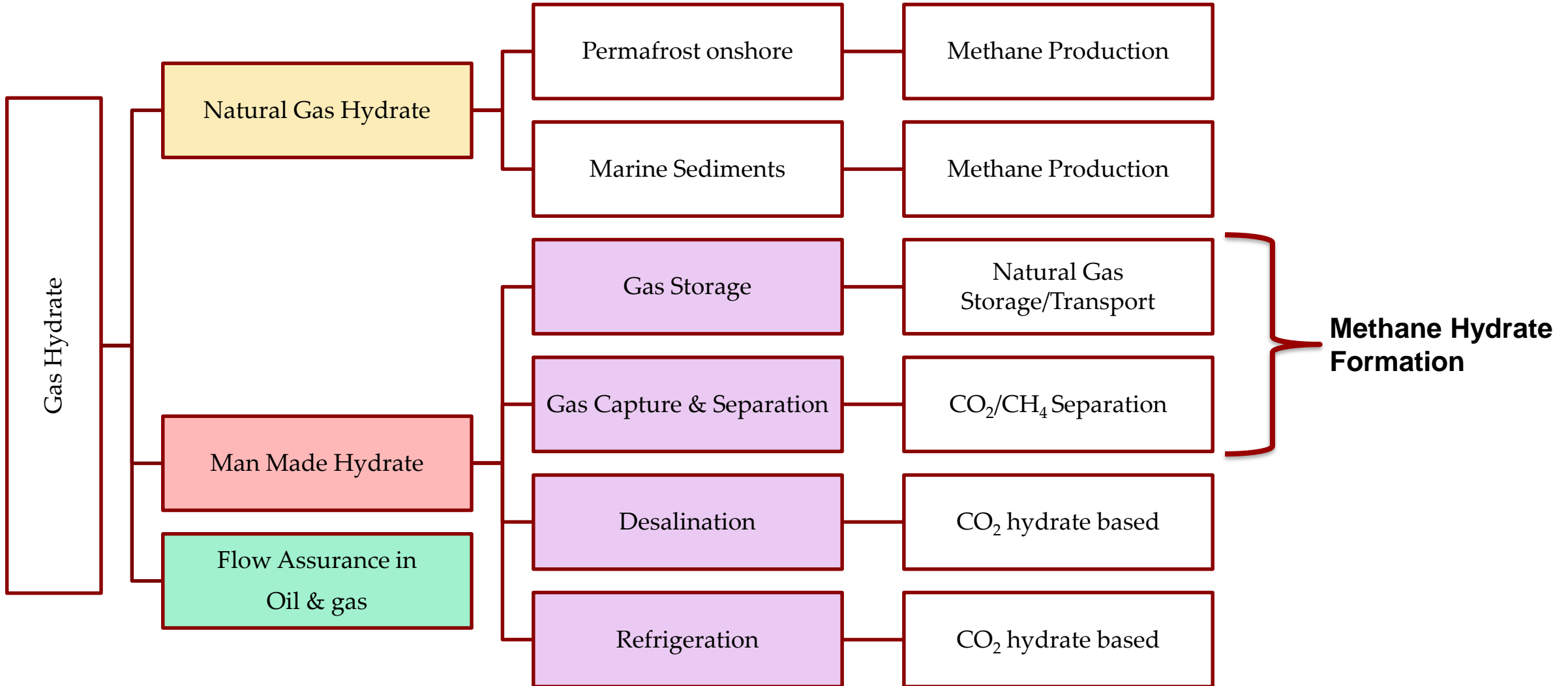
Burning hydrate



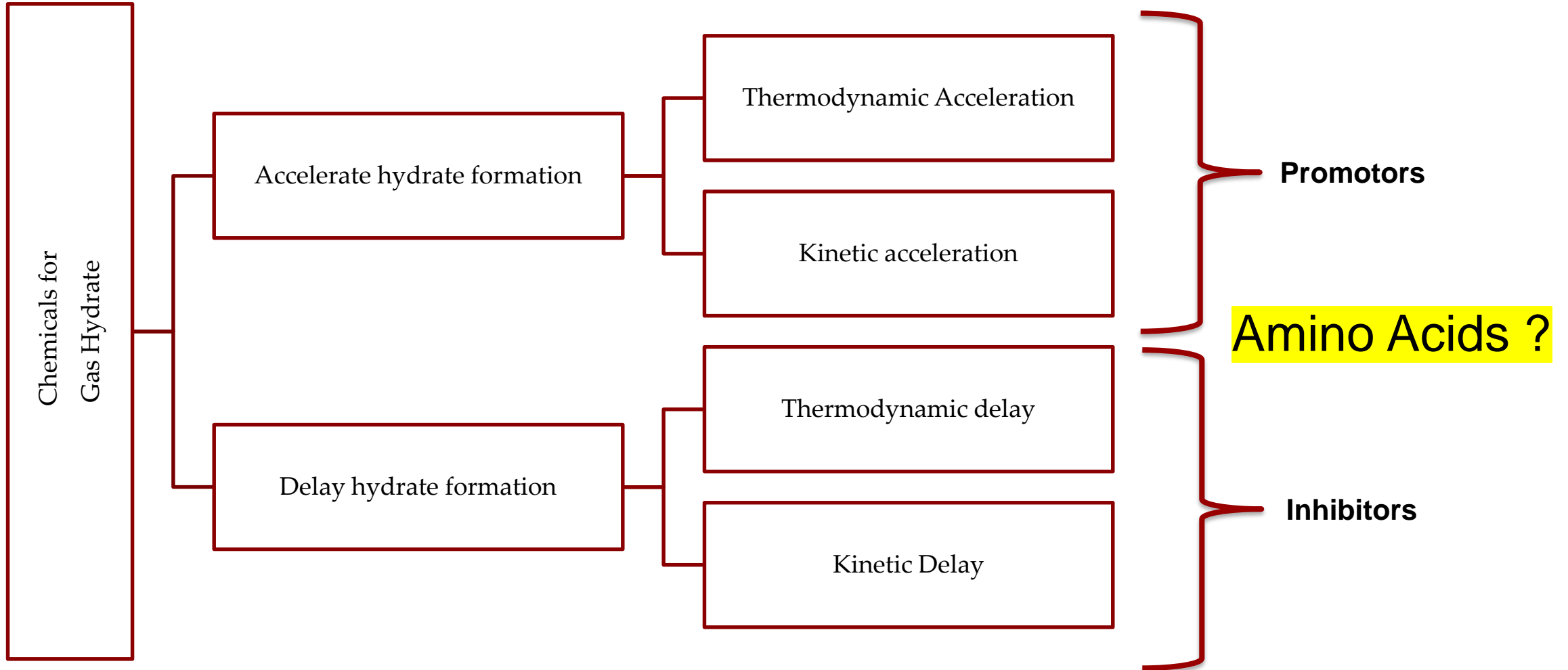
Gas storage capacity in hydrates



Application of Gas Hydrate



Chemicals For Gas Hydrates



Why Amino Acids ?

Available Chemicals

Amino Acids

Toxic

By
product of
petroleum

Create
foam

Expensive

Large
Quantity

Environment
Friendly

Non Toxic, Bio
degradable

Non Expensive

Objective

- Understand the kinetics of methane hydrate formation
 - In presence of Amino Acids

- Understand the role of Amino Acids
 - Promoter or Inhibitor

- Explain the mechanism

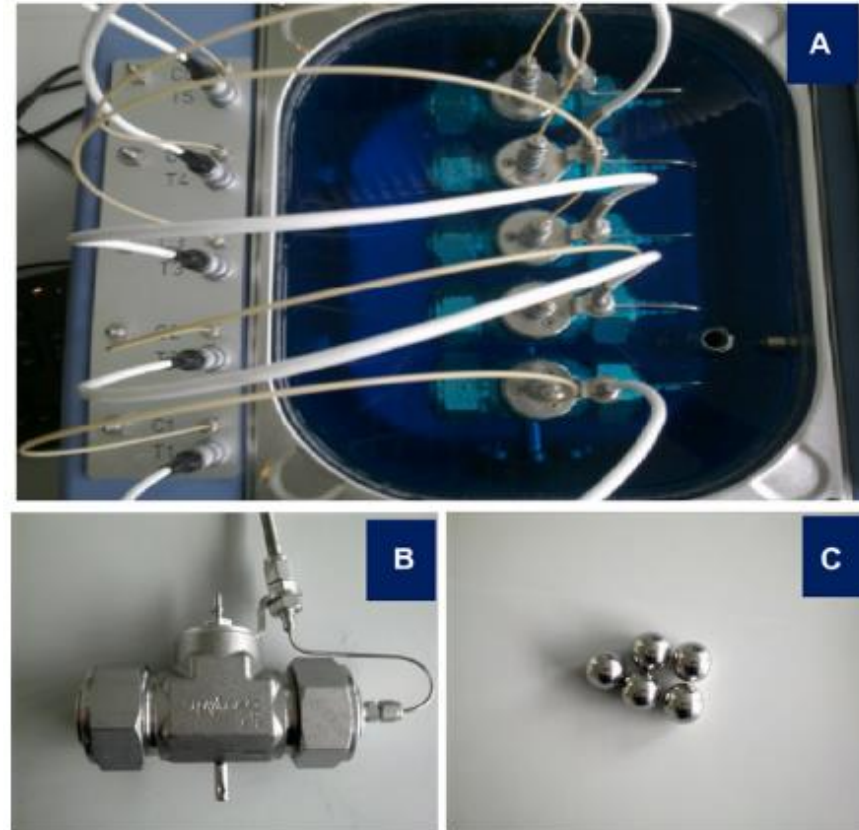
Selected Amino Acid in this study

#	Name	Side Chain polarity	Side Chain	Hydrophobicity/ Hydropathy Index (Kyte and Doolittle, 1982)
1.1	L –valine	Non polar	$-\text{CH}(\text{CH}_3)_2$	4.2
2.1	L –methionine	Non polar	$\text{CH}_3-\text{S}-(\text{CH}_2)_2$	1.9
3.1	L –histidine	Basic polar, aromatic side chain	$-\text{CH}_2\text{C}_3\text{H}_3\text{N}_2$	-3.2
4.1	L-arginine	Basic polar aliphatic side chain	$\text{HN}=\text{C}(\text{NH}_2)-$ $\text{NH}(-\text{CH}_2)_3$	-4.5

Experimental Setup



Rocking Cell (PSL Germany)



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

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

Temperature Scheme

Isothermal Experiment
(Fresh & Memory)

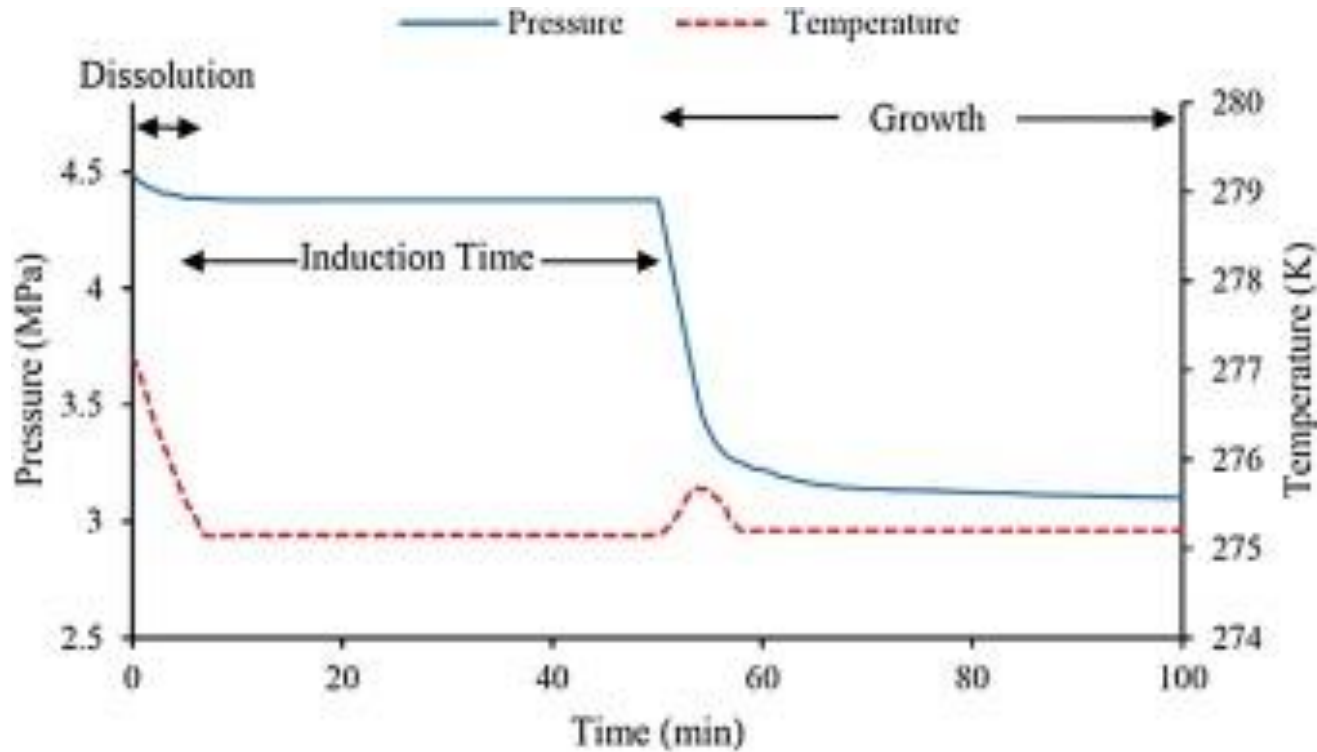
Induction Time (t_o)

Gas Uptake

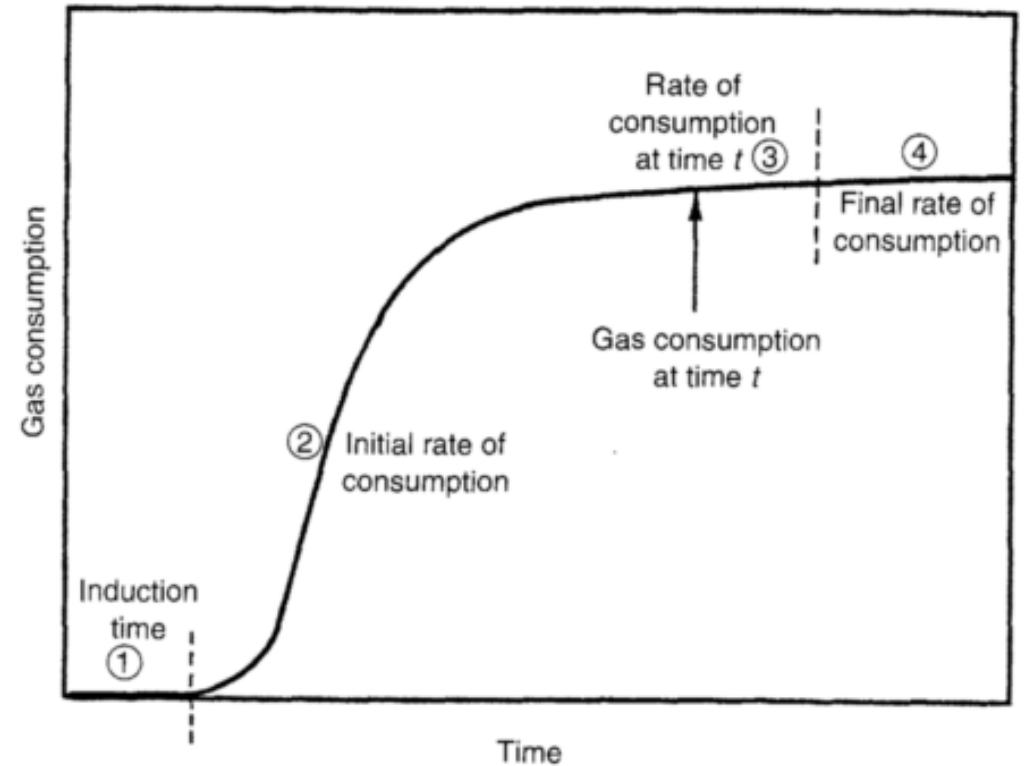
$$uptake = \frac{\Delta n_H^{methane\ gas}}{n_{Sol}}$$

Methodology

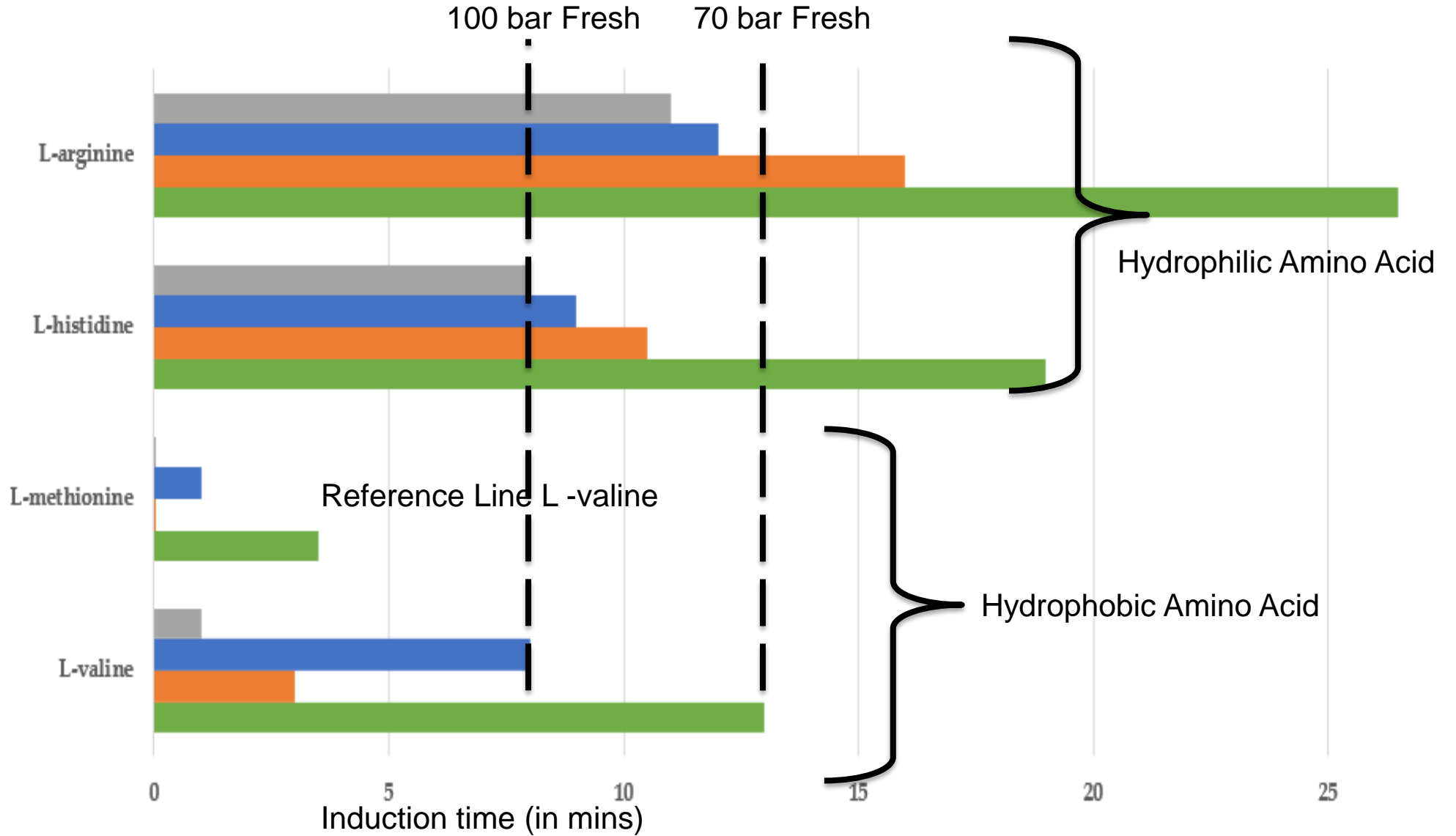
P-T Curve at Constant Volume in Batch system



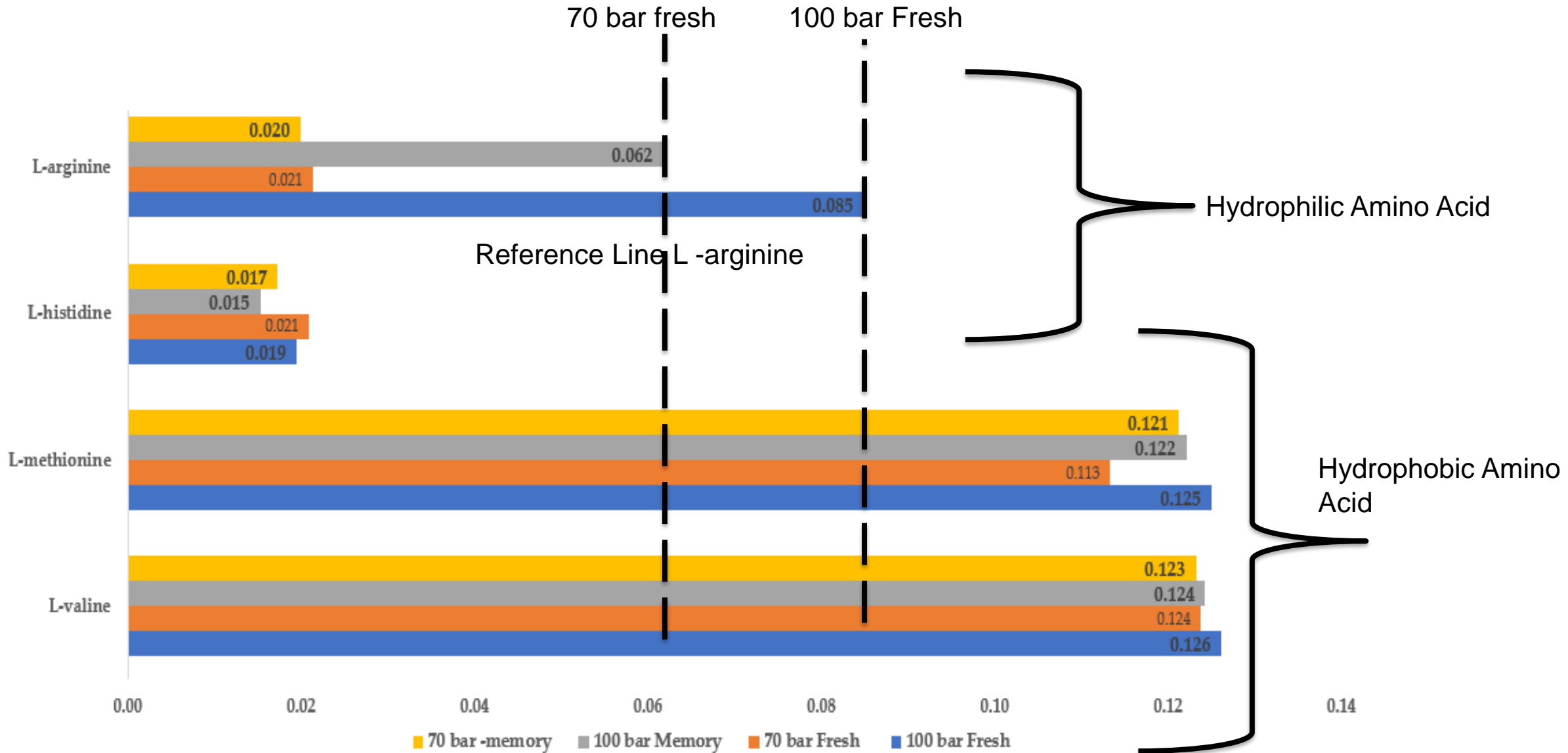
Gas consumption (Gas uptake) curve



Induction time (in mins) for given Amino acids at 1 ° C

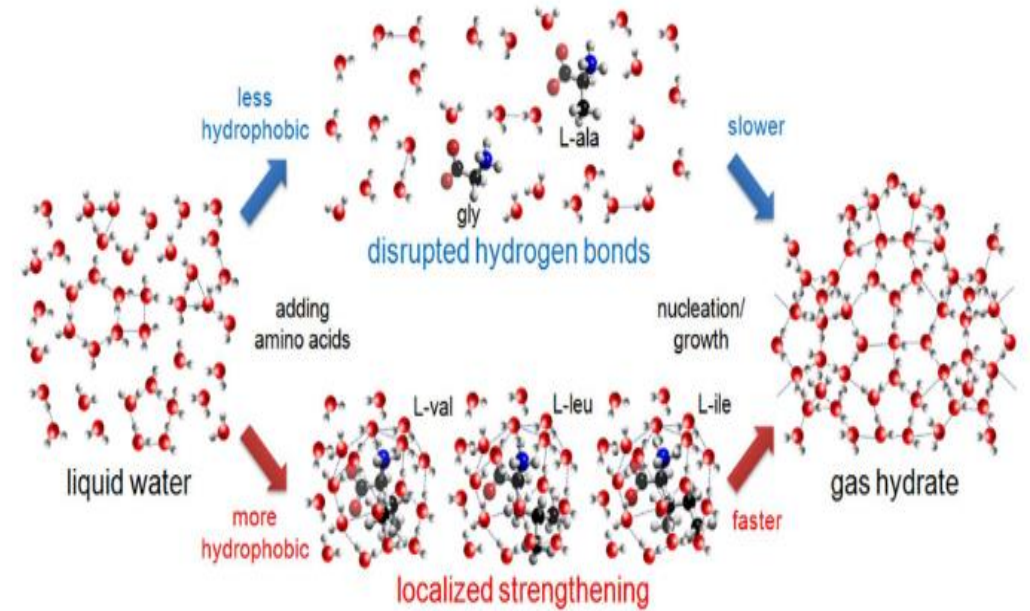
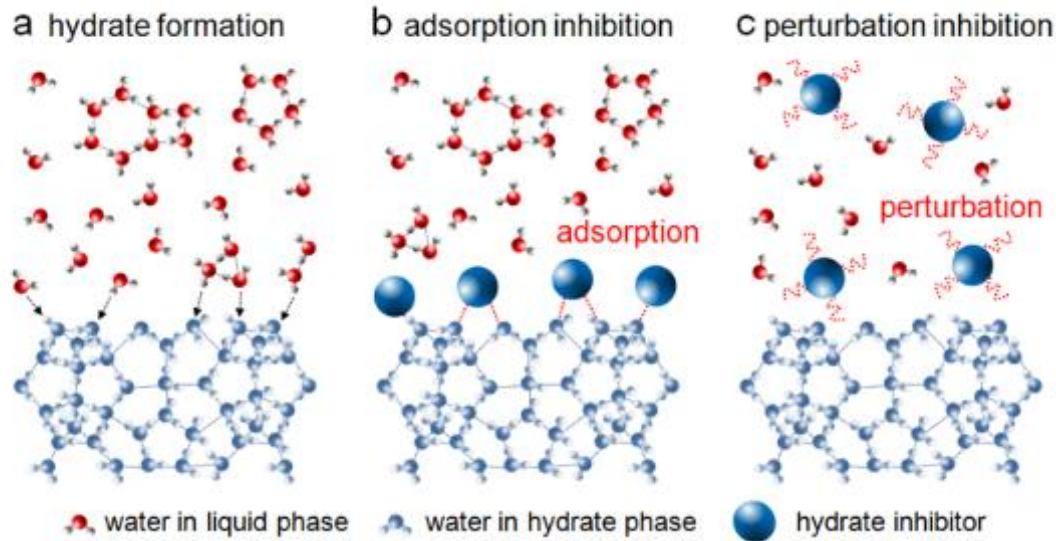


Normalized Gas Uptake (m-mol/m-mmol) for given Amino acids at 1 ° C



Summary

- Hydrophobic amino acids, as promoter while hydrophilic amino acid as inhibitor
- Hydrophobic amino acids in gas hydrate promotion such as gas storage, capture etc
- Hydrophilic amino acids in flow assurance in Oil & Gas pipeline
- Amino acid shows memory effect in Induction time, kills memory effect in gas uptake.
- Increase in pressure create higher driving force, thus lower induction time and higher gas uptake
- L-methionine is best promoter while L histidine is best inhibitor.



Water molecules in liquid phase are connected through a hydrogen bond network (a) In the system without inhibitor, liquid water molecules close to the hydrate surfaces (e.g. nuclei and bulk surfaces) or solid substrates (e.g. reactor walls, foreign impurities) participate in hydrate formation. (b) The adsorption inhibition hypothesis involves adsorption of the inhibitors on the hydrate surface or any nucleating sites, inhibiting hydrate formation. (c) The perturbation inhibition hypothesis involves perturbation of the organization of local water molecules, preventing hydrate formation.

Less hydrophobic amino acids disrupt hydrogen bonds between water molecules to inhibit hydrate formation while more hydrophobic amino acids strengthen the local organization of the water structure.

that



AT CERE

- Applied Thermodynamics
- Transport Processes and Properties
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- Material science
- Petroleum Technology
- Enhanced Oil Recovery
- CO₂ capture and gas hydrates
- Energy resources
- Biorefinery Conversions



**Professor Georgios
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Gas Hydrate Research