g Gas Hydrate Problems in Q
Industry: Environmentally
vents for Gas Hydrate Inhibit

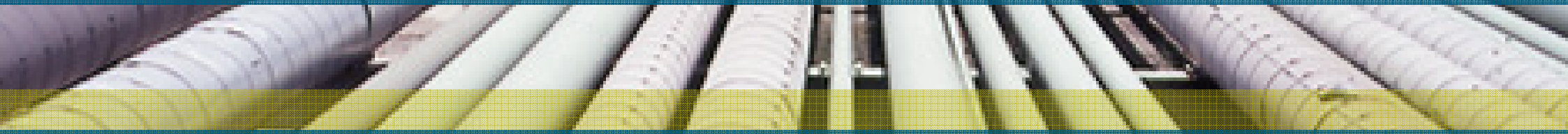
Nabila Adam Mohamed


nd: Offshore Operations
rance and challenges
te Definition, Structures, and Formation
sk Zones in Offshore Operatio
te Inhibition
tal Setup, Software, and Material used

nitial findings of investigating natural gas hydrate form

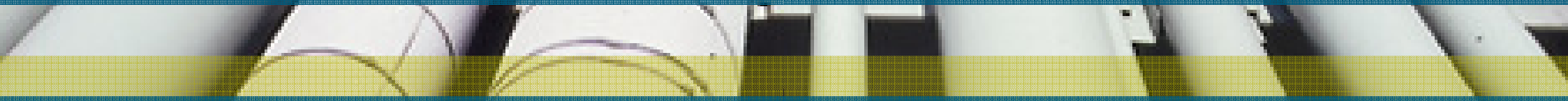
tics of Qatari type gas in both experimental (PVTx) an

simulation methods.



hydrates born conditions and equilibrium data for pu

atar natural gas mixture (QNG-S1).



for petroleum products
equirements to search for
the offshore regions of
s in the world.



pelines have become
echniques in transporti
gas.

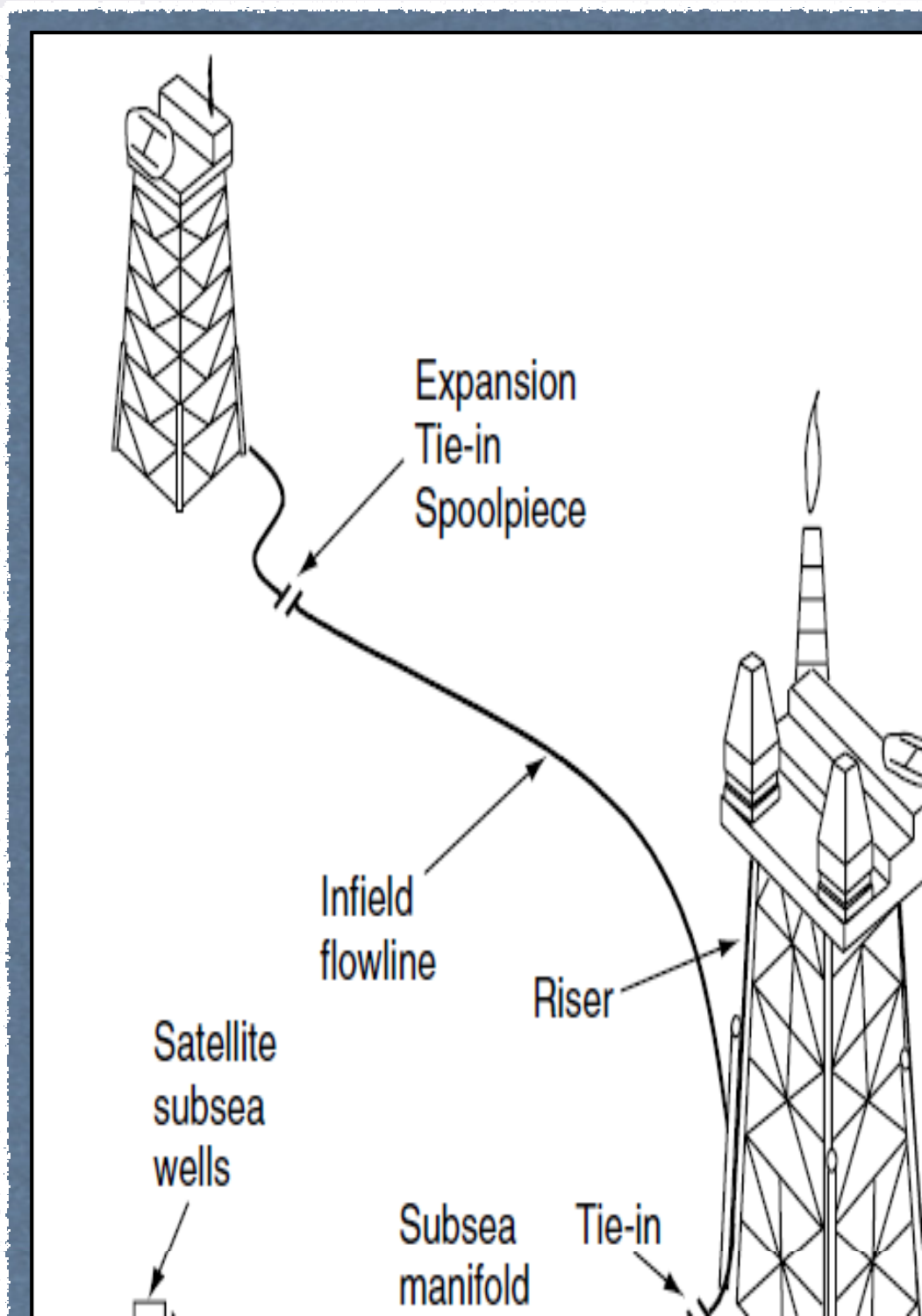
ines

atellite subsea wells to subsea

ubsea manifolds to production

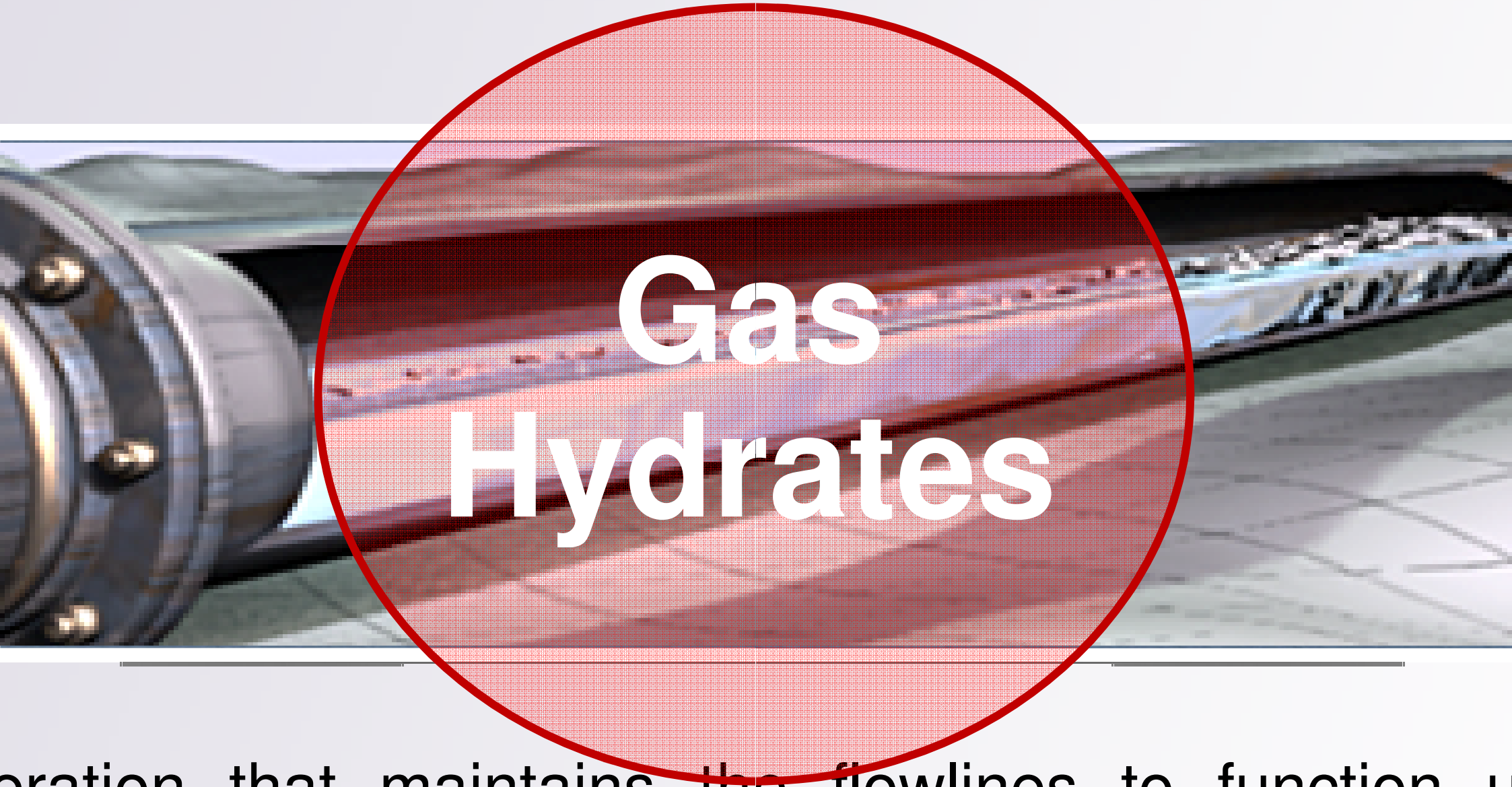
between production facilities

from production facility
e.



... and challenges”

Oil and Ga



eration that maintains the flowlines to function u

or the fluids to flow from the reservoir to the required

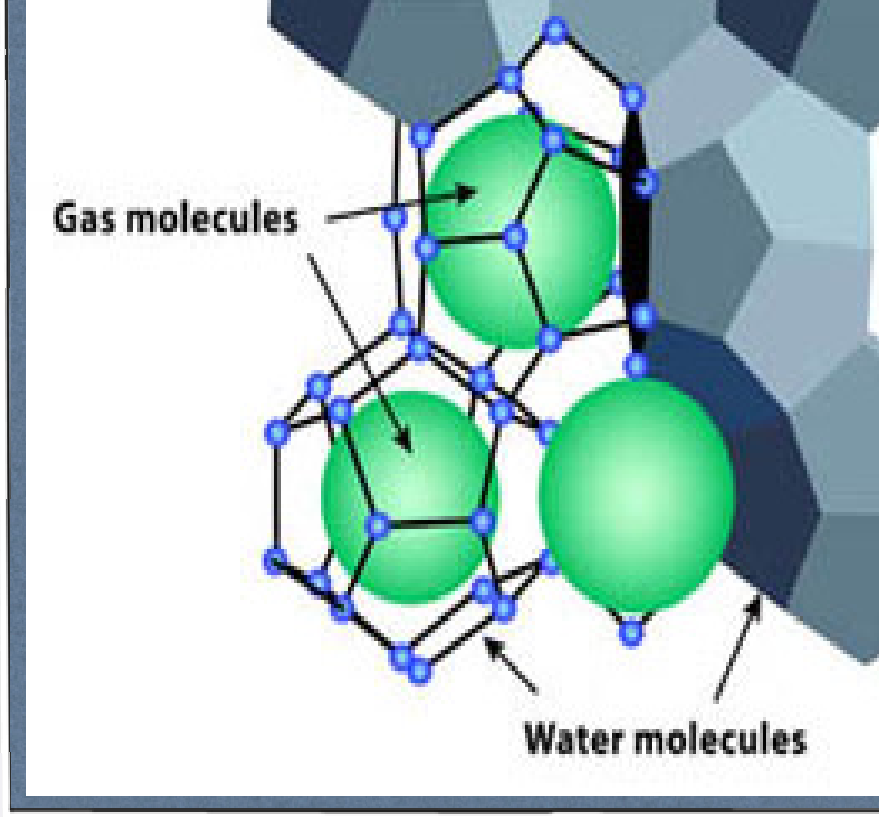
ns

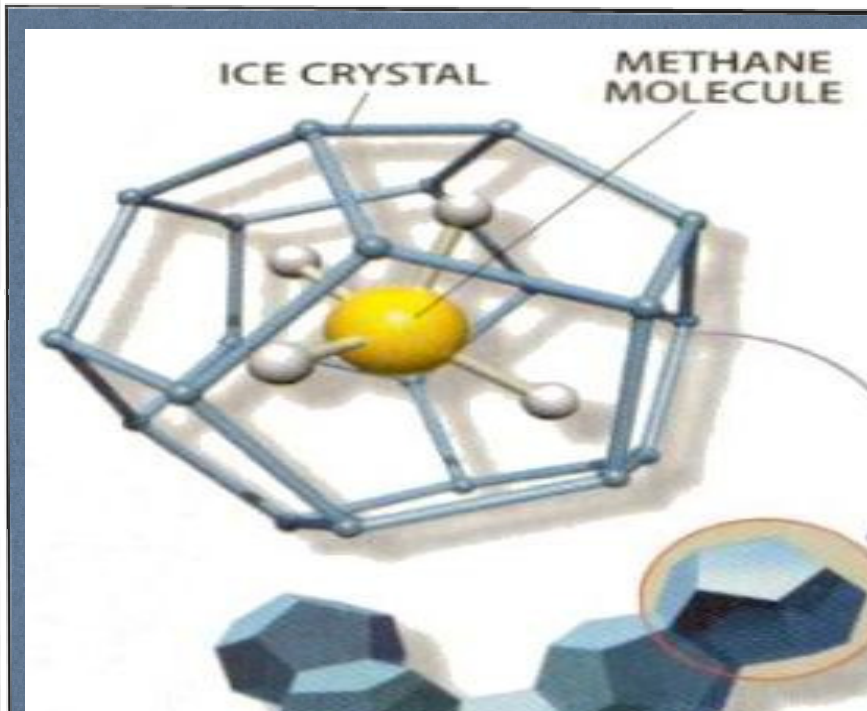
ydrate?

... Definition?"

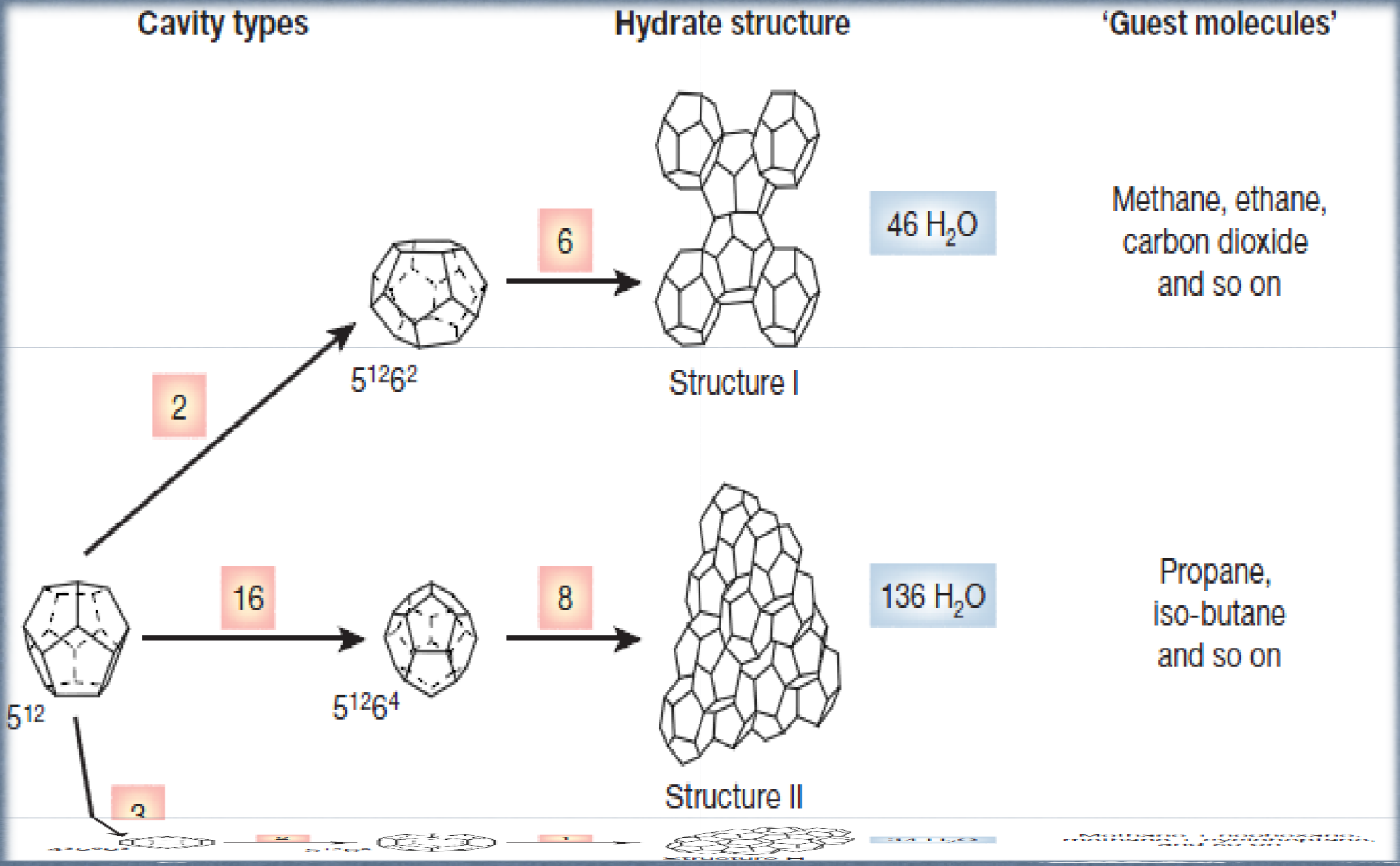
re crystalline solids consisting
s trapped and enclathered by
molecules.

ecules is the host which is
ugh hydrogen bonds forming
es and the gas molecules are

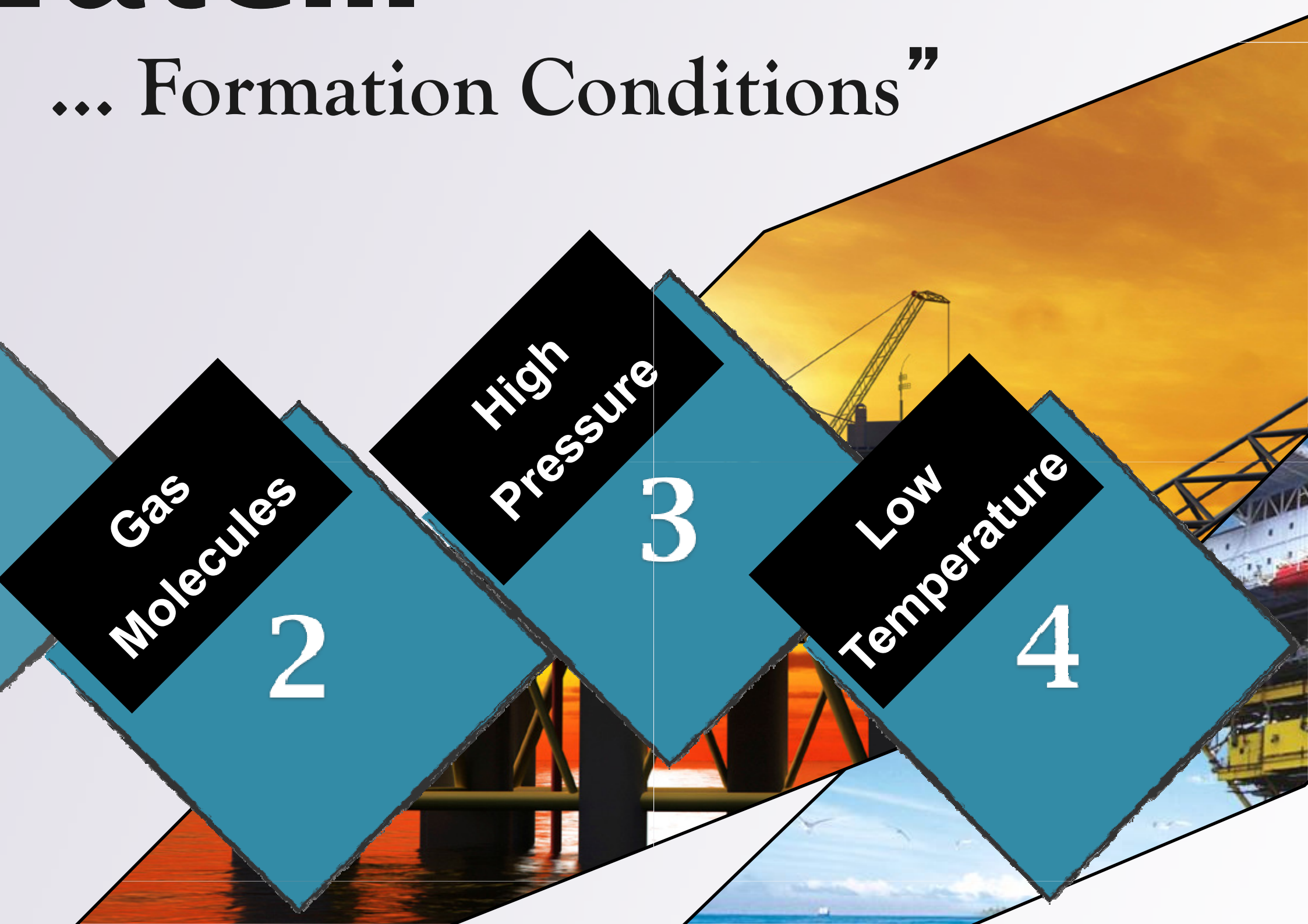


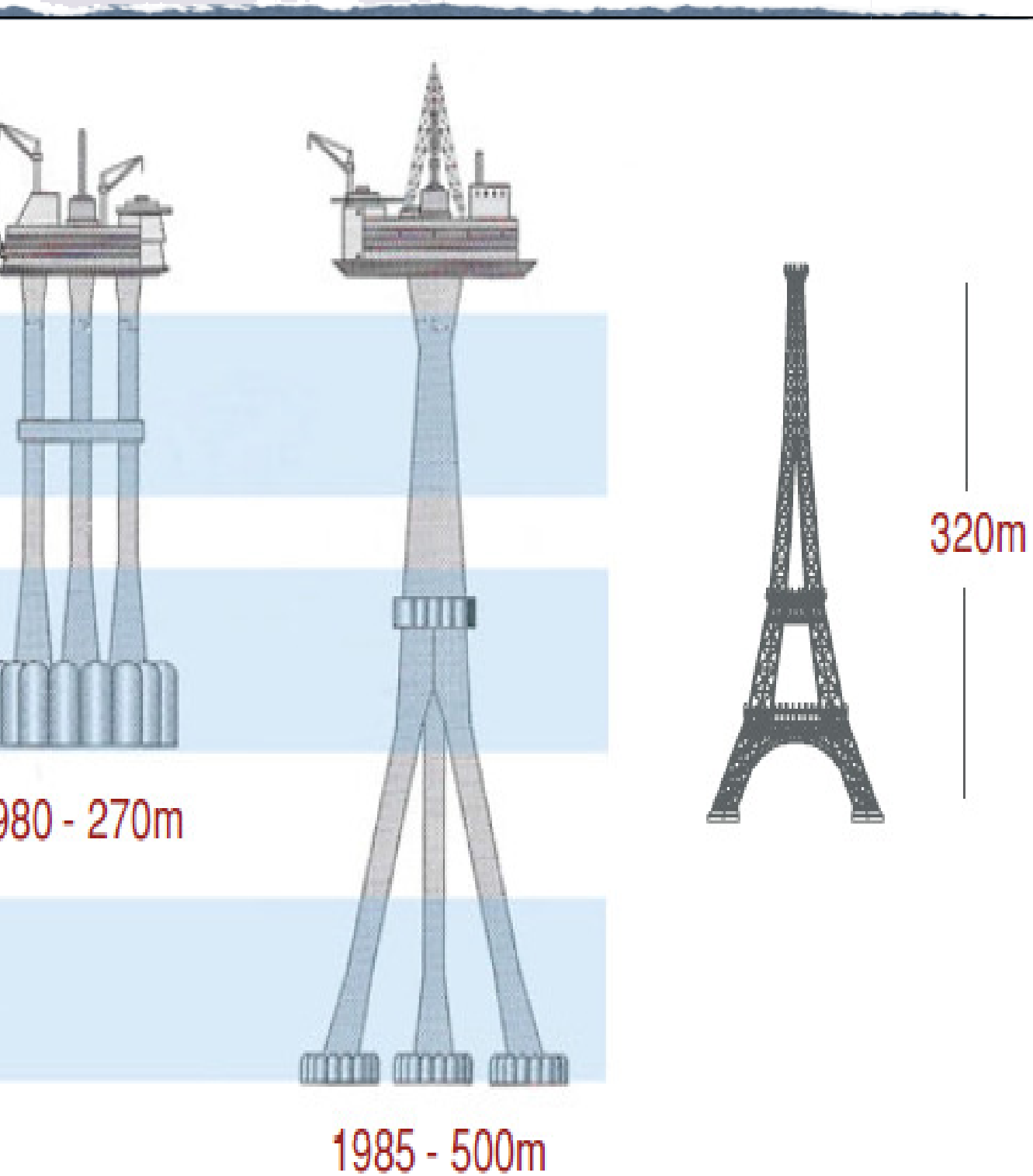


... Structure"


Cavity types
Hydrate structure
'Guest molecules'
6
46 H_2O
Methane, ethane, carbon dioxide and so on
$5^{12}6^2$
Structure I
2
16
8
136 H_2O
Propane, iso-butane and so on
5^{12}
$5^{12}6^4$
Structure II

... Formation Conditions”





Offshore Op

HIGH PRESSU

WATER

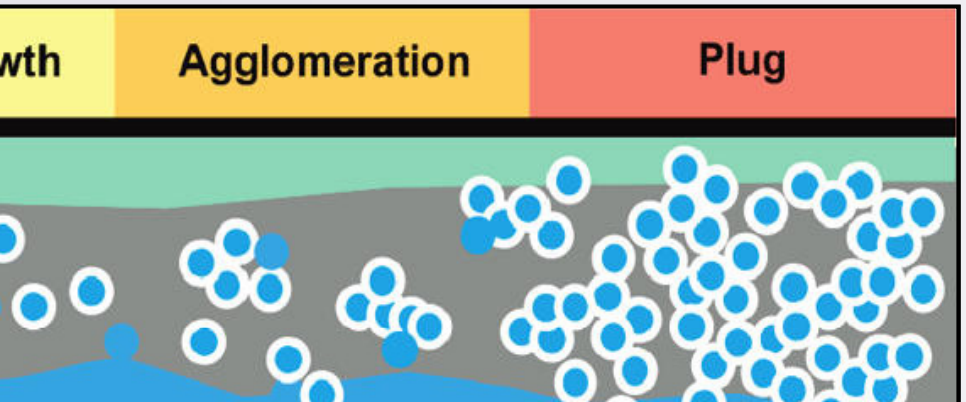
HYDRA

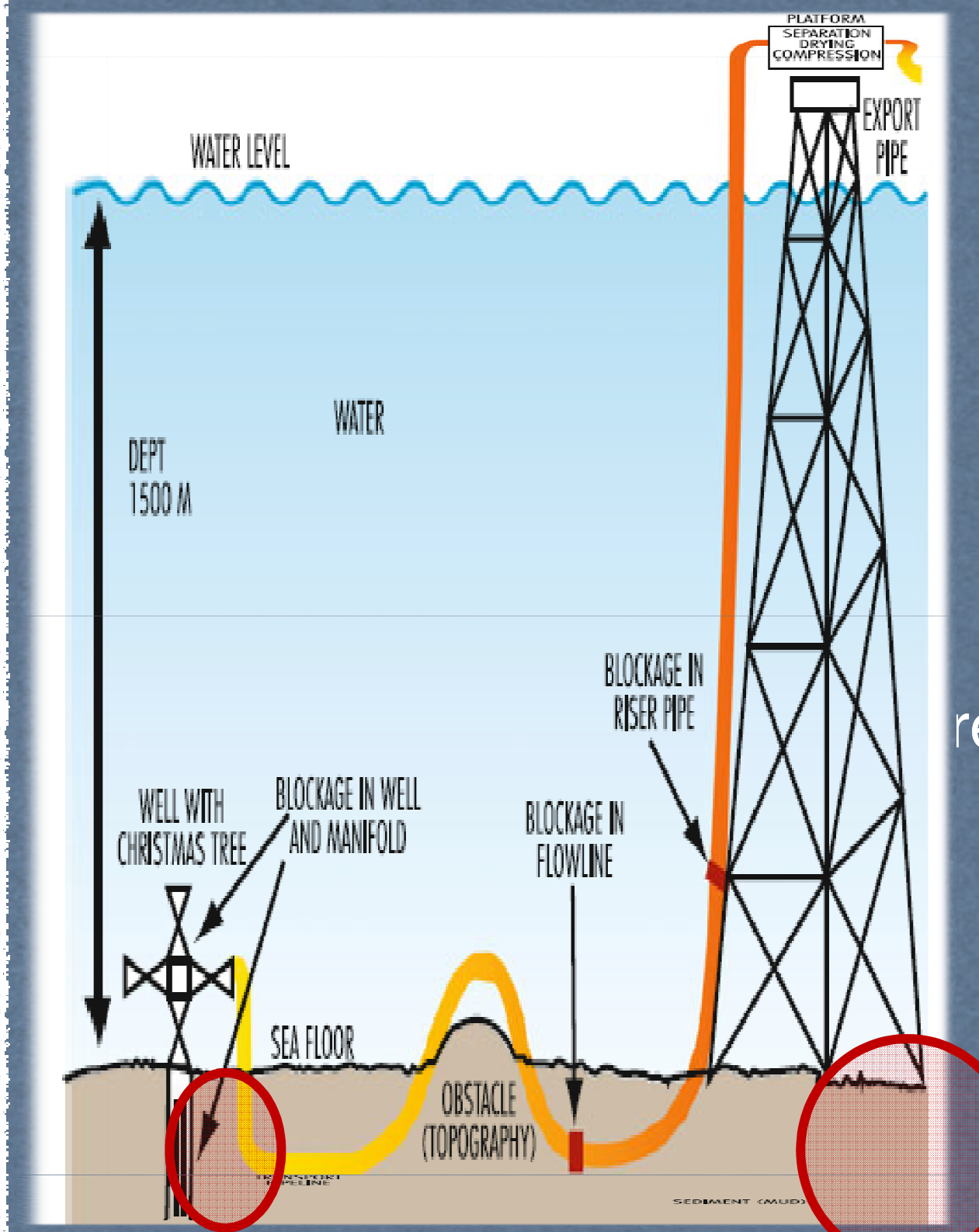
LOW TEMP

... Zones

ities, the incident of
the well is banned by
ure of the reservoir.

veen the well inlet and
typically threatened by







rnal
s
w.

* System upsets and reduce the operating efficiency.

* Requires intensive clean up and disposal problems

Maintenance



Safety



* Production shut downs and Hazardous conditions.

* F
c

Thermodynamic inhibitors

THIs

Shift the hydrate equilibrium curve to higher pressures and lower temperatures

Low dosage hydrate inhibitors

LDHIs

ibitors (KHIs)

Anti-agglomera

S

THIs

- Reliable and well understood inhibition mechanism.
- Effective for long distance gas-condensate tie-back systems.

KHIs

- Economically effective
- Operative at low dosage (<1 wt%)
- Less toxicity than THIs

- Ecc
- Ope (<1
- Wic (>15-2
- Les

es

THIs

- Cost considerations
- High injection rate (10-60 wt%) and large storage requirement
- Flammability and volatility
- Toxic and does not easily biodegraded.
- Some THIs are corrosive

KHIs

- Limited to small subcooling range (12 ℃) and residence time.
- Compatibility with some conditions in the field (temperature, pressure, and salinity)
- Lack of biodegradability features of some KHIs.
- Not effective during

- C
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Thermal stability

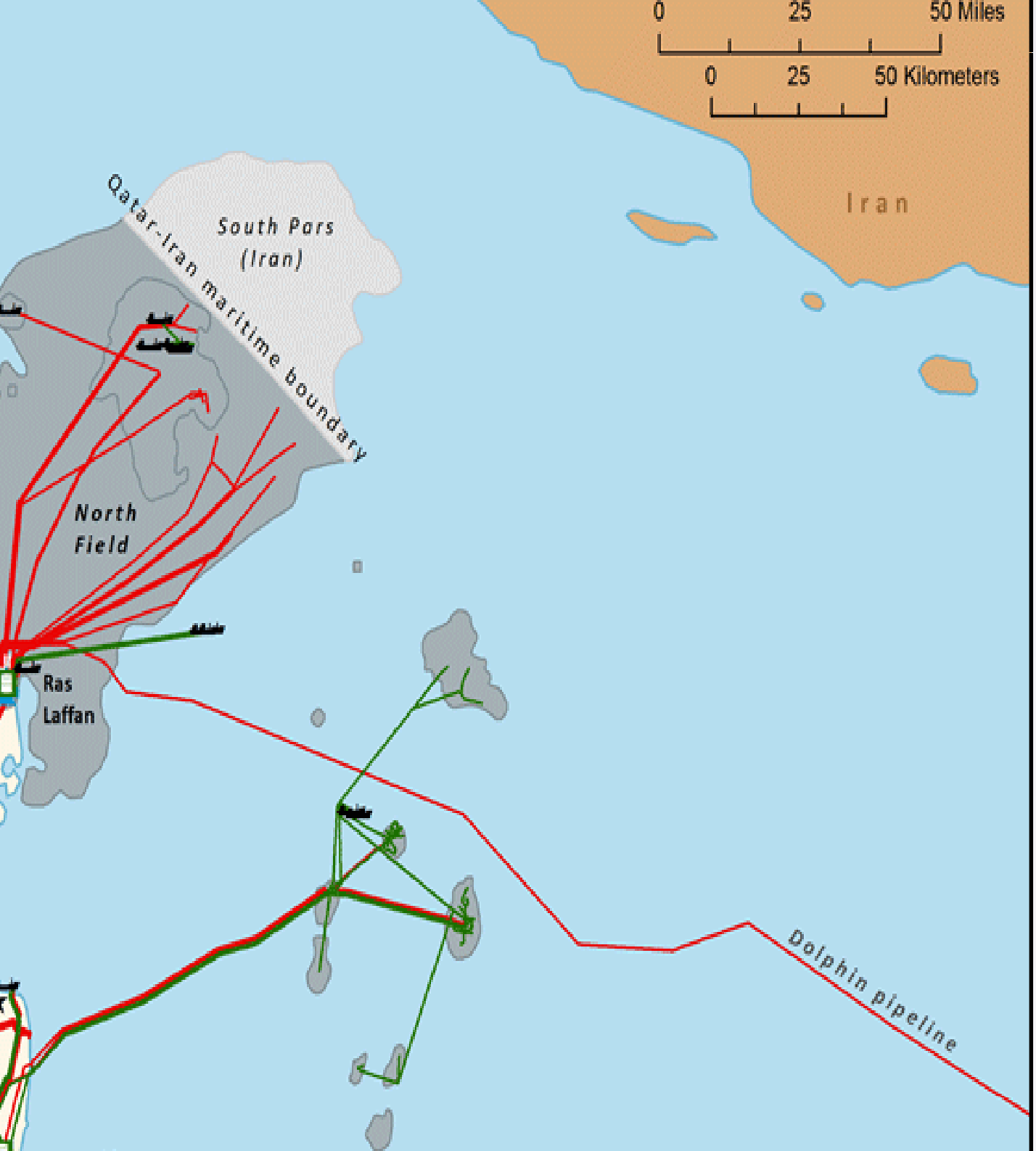
liquids (ILs) are organic salts with low melti
y consist of organic cations with alkyl chain

Green solvents

Motivation

Scope

ork



Exploration &

Qatar's economy cou
sector with more than
domestic product.

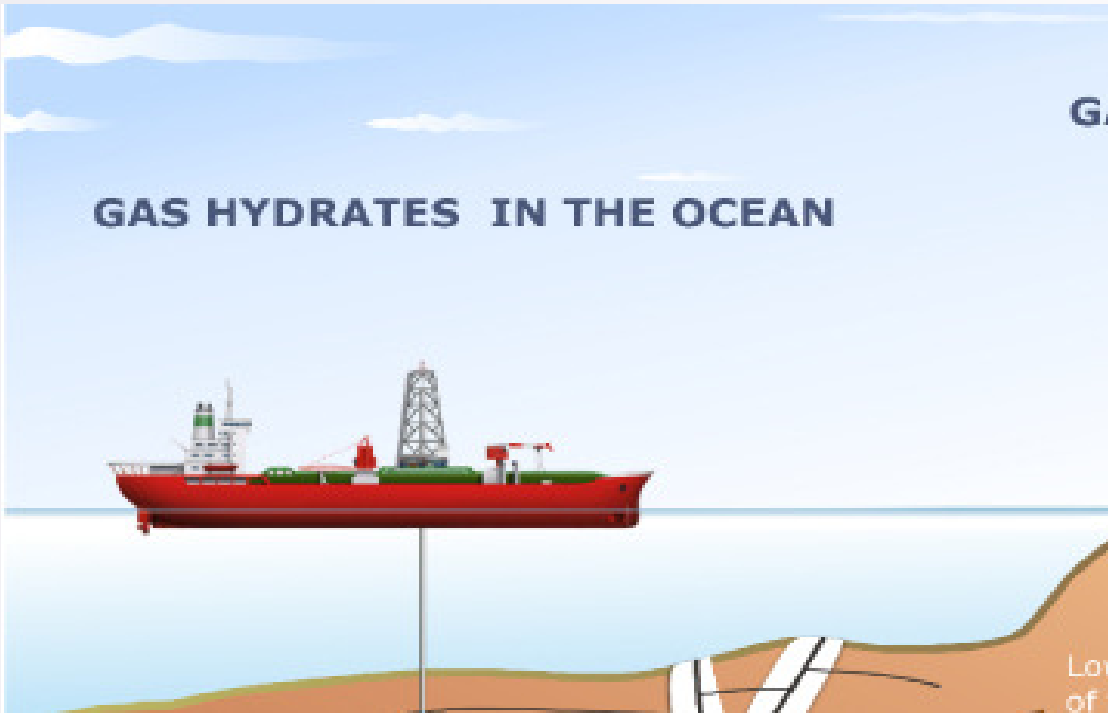
Qatar has the third
reserves of natural g
cubic feet.

The natural gas reso
developed to meet the
demand, mainly in the

ying the characteristics
al Gas under typical
nal conditions

- Establish a clear knowledge of conditions of Qatar natural gas
- Provides a new horizon for the using ionic liquid as hydrate in











Mert Atilhan

ate Professor at
ment of Chemical
neering, Qatar
University

Eng. Nabila Mohammed

Master Student in
Environmental Engineering

Dr. Mohamm

Postdoctoral Fe
Department of C
Engineering, C
University

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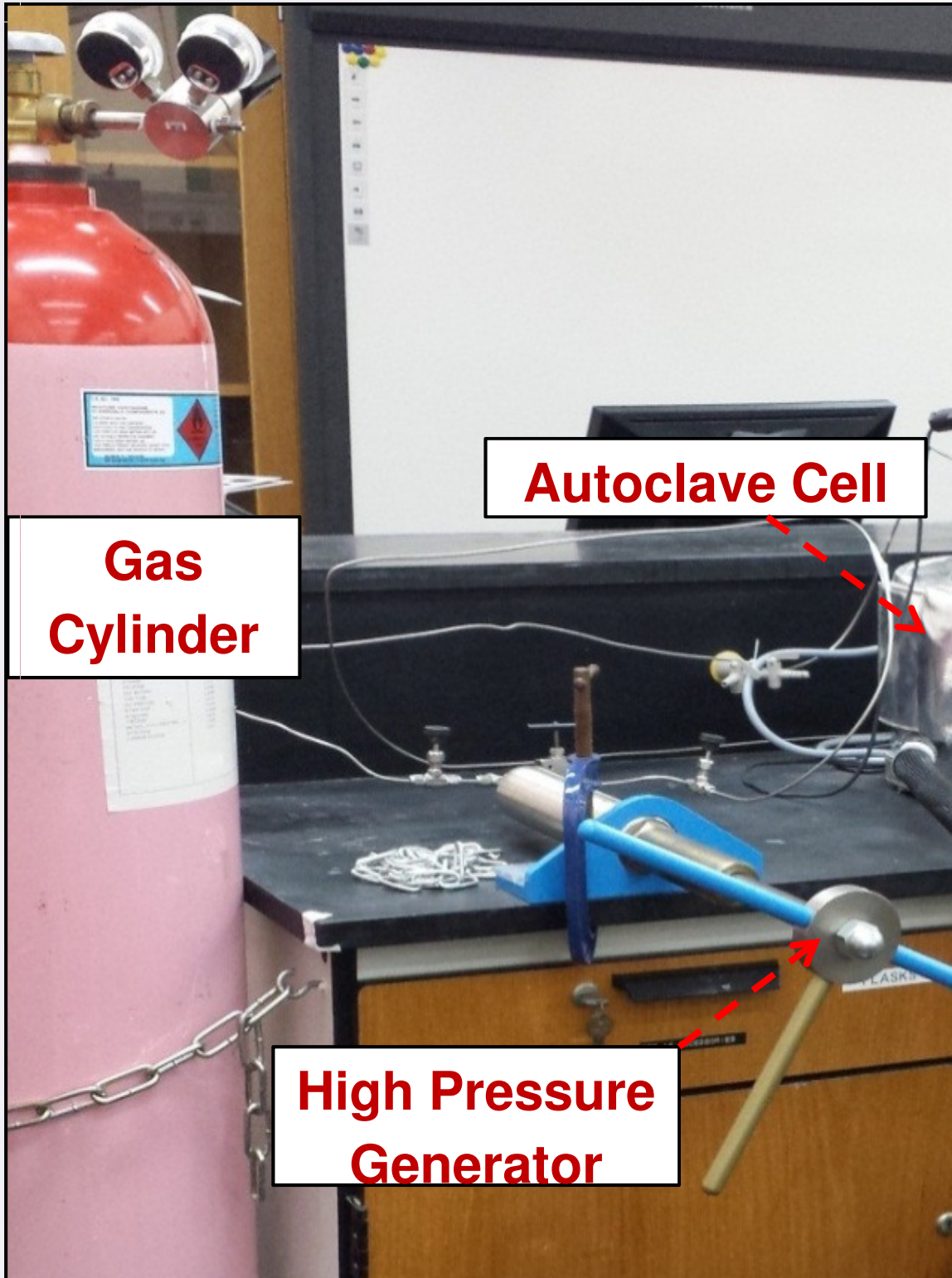
Setup

Material

oftware

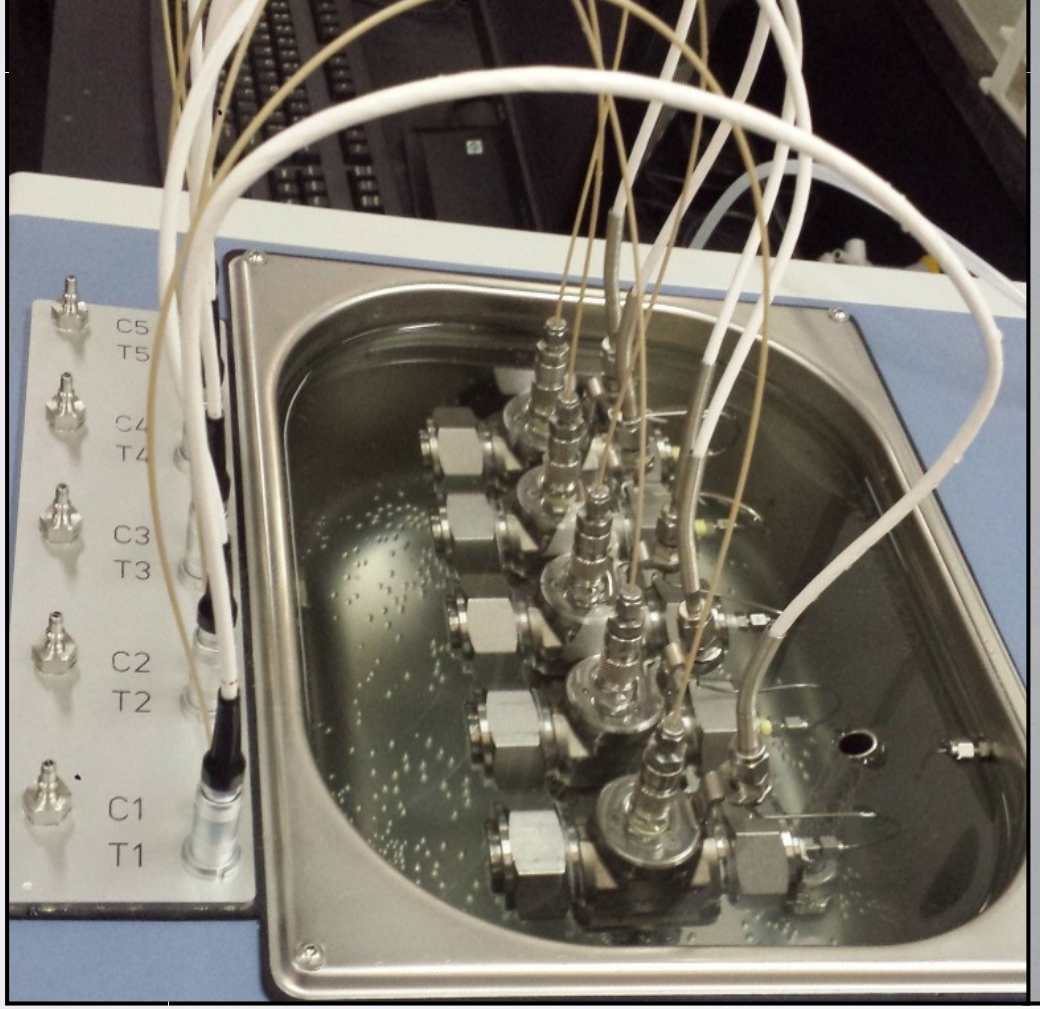
te Autoclave

	PSL Systemtechnik GmbH, Germany
s	Stainless steel
	450ml
	200 bar

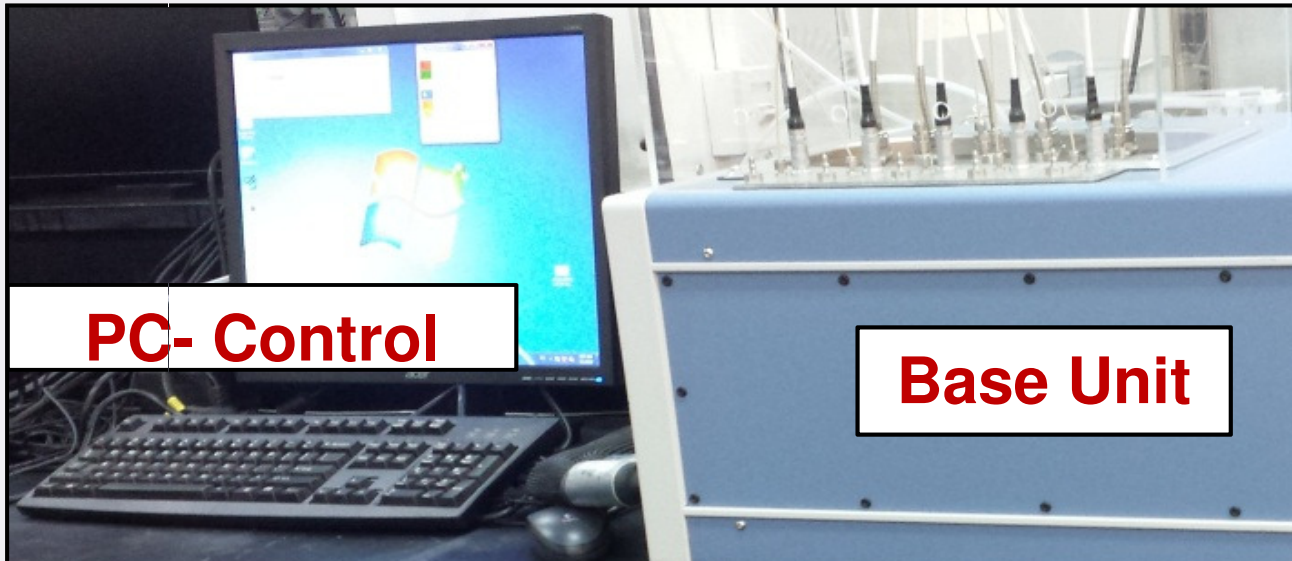


Cell (RC5)

	PSL Systemtechnik GmbH, Germany
s and	Stainless steel
	40 ml
alls	10 mm
orking	200 bar







se

rmation conditions for

ate formers

Temperature

Natural Gas

NG-S1)

HydraFLASH

File View Options Fluid properties Pseudo-fractions Porous Media Parameters Database He

HydraFLASH™

Hydrate line: Calculates the hydrate dissociation pressure over a range of temperatures.

Hydrate line (T->P)

Run Calculation

Stop Calculation

Calculate P / T Guess

Temperature parameters

5 Temperature | 20 Upper limit | 1 Step | °C Unit

Liquid hydrocarb

Use guess

Pressure parameters

50 Pressure | 10 Guess | bara Unit

Hydrate structure

II

Water

100

Hydrate forming and hydrocarbon components

Methane
Ethane
Propane
i-Butane
n-Butane
i-Pentane
Carbon dioxide
Nitrogen
Hydrogen sulfide
Oxygen

Toluene
Ethylbenzene
o-Xylene
m-Xylene
p-Xylene
n-Pentane
n-Hexane
n-Heptane
n-Octane
n-Nonane

component
Methan
Ethane
Propane
i-Butane
n-Butan

Add hydrate former

Add non-hydrate former

Stre

Aqueous fraction

Aqueous mole fraction 0.3

Inhibitors and electrolytes

Methanol
Ethanol
Ethylene Glycol
DEG

component
Water

e gas

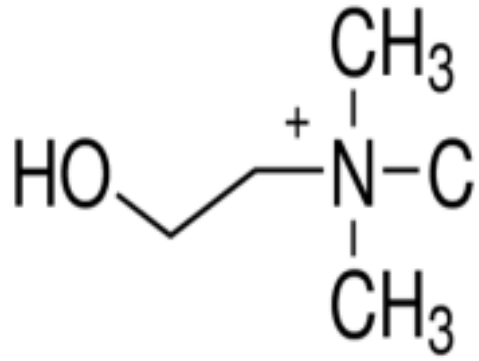
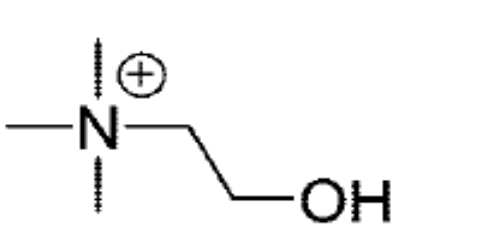
y of 99.99%

Synthetic multi-compo
that resemble Qatari t



Component	
Methane	
Ethane	
Propane	
Iso Butane	
N Butane	
Ison Pentane	
N Pentane	

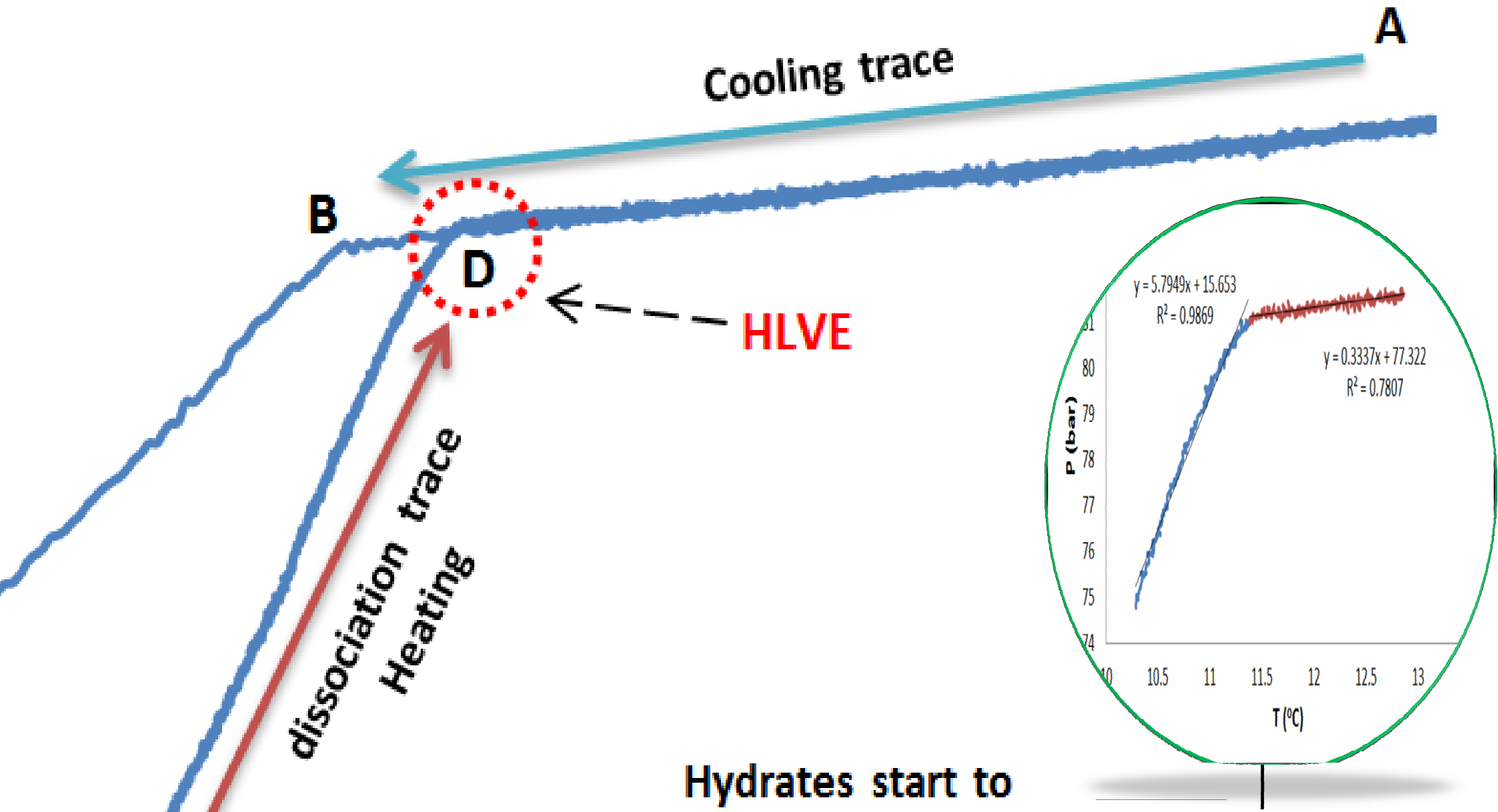
Choline based ionic liquids used as hydrate inhibitors

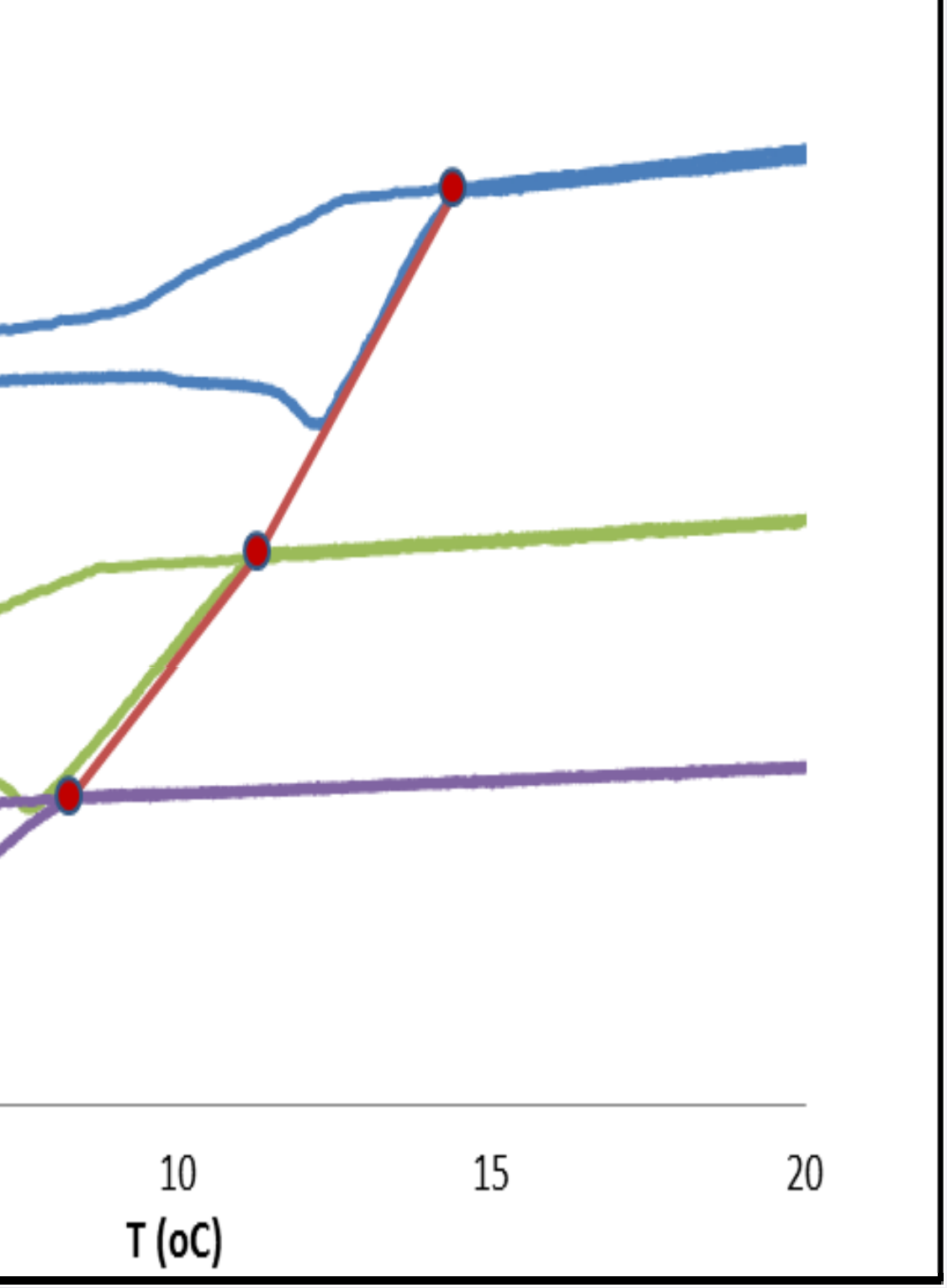
ic liquid	Empirical Formula	Molecular Weight (g/mol)	Chemical Str
ne Chloride	$C_5H_{14}ClNO$	139.62	
line][NTf_2]	$C_7H_{14}F_6N_2O_5S_2$	384.34	

ta

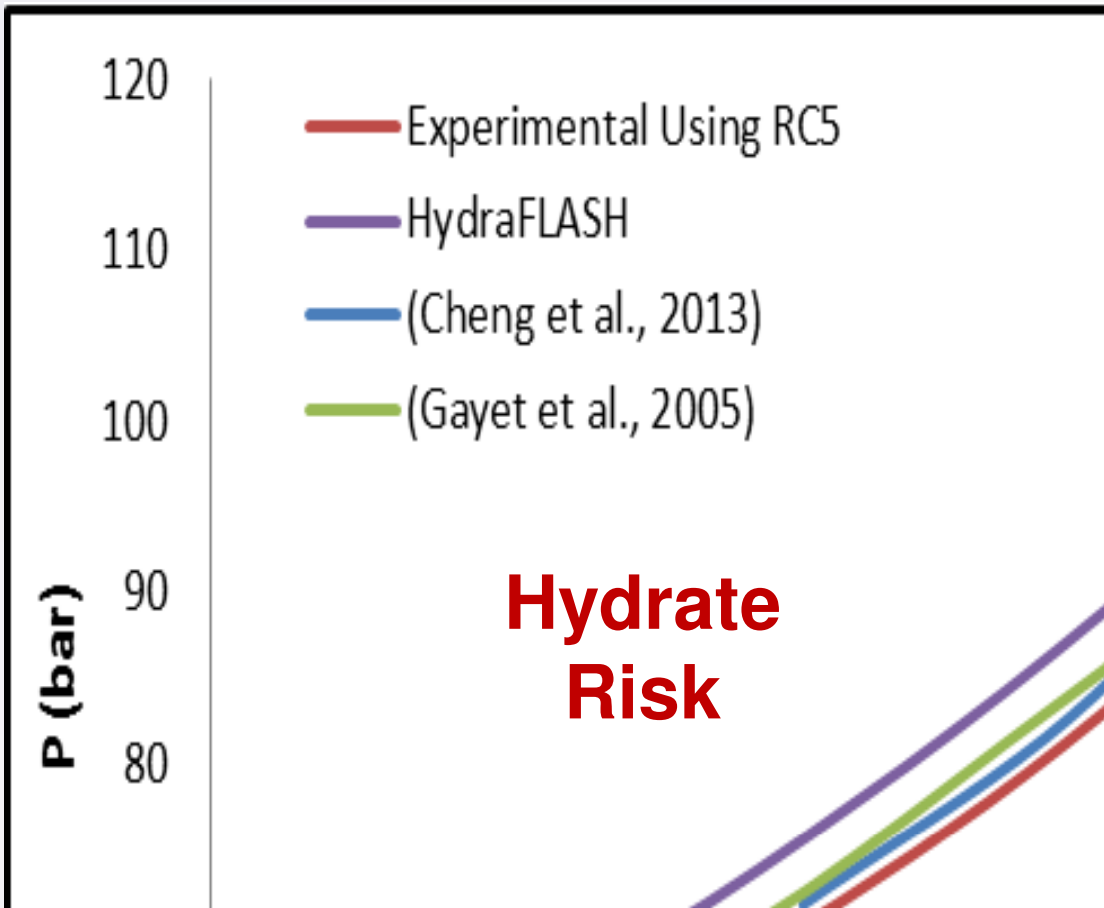
nalysis

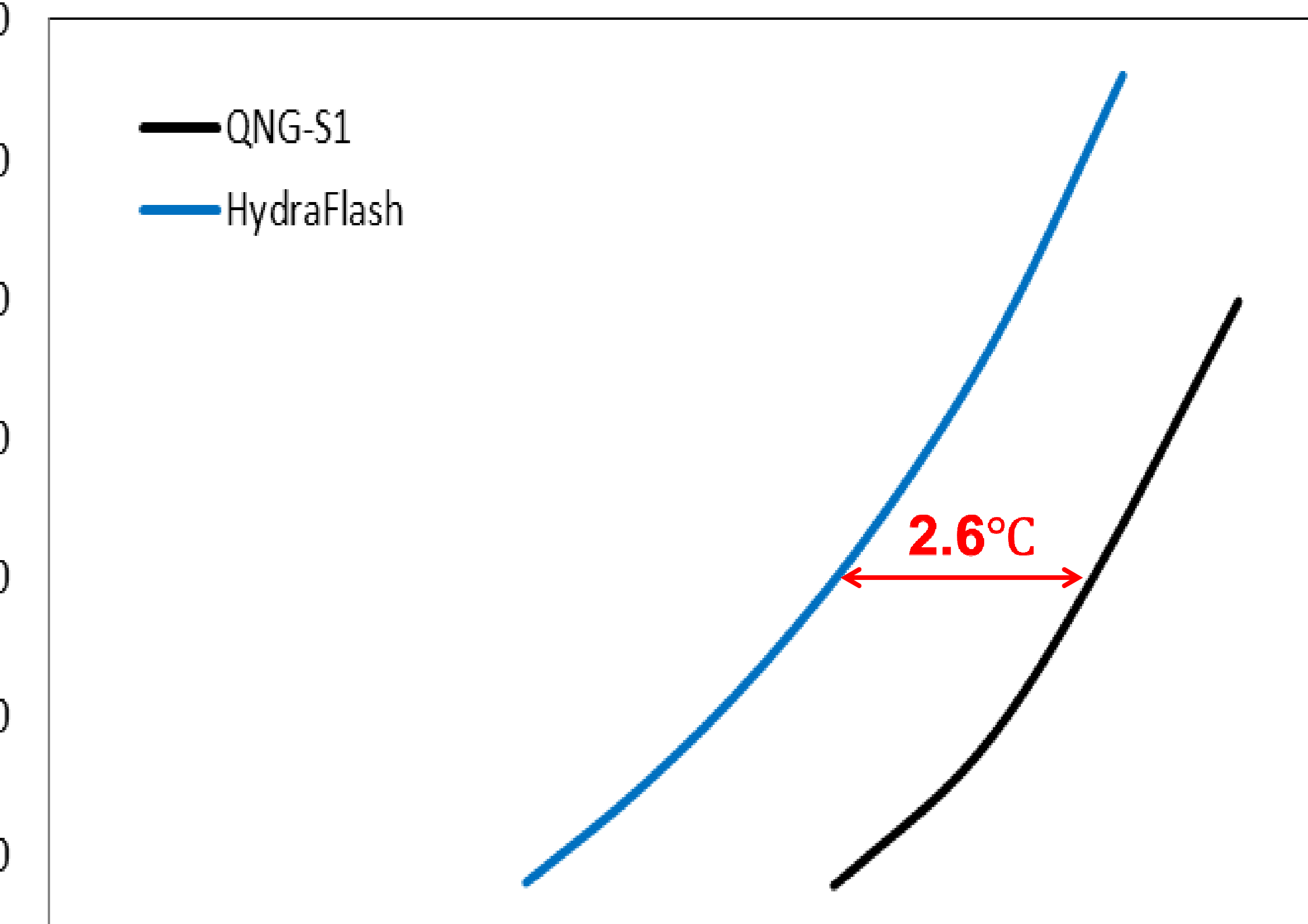
on/ Dissociation Loop





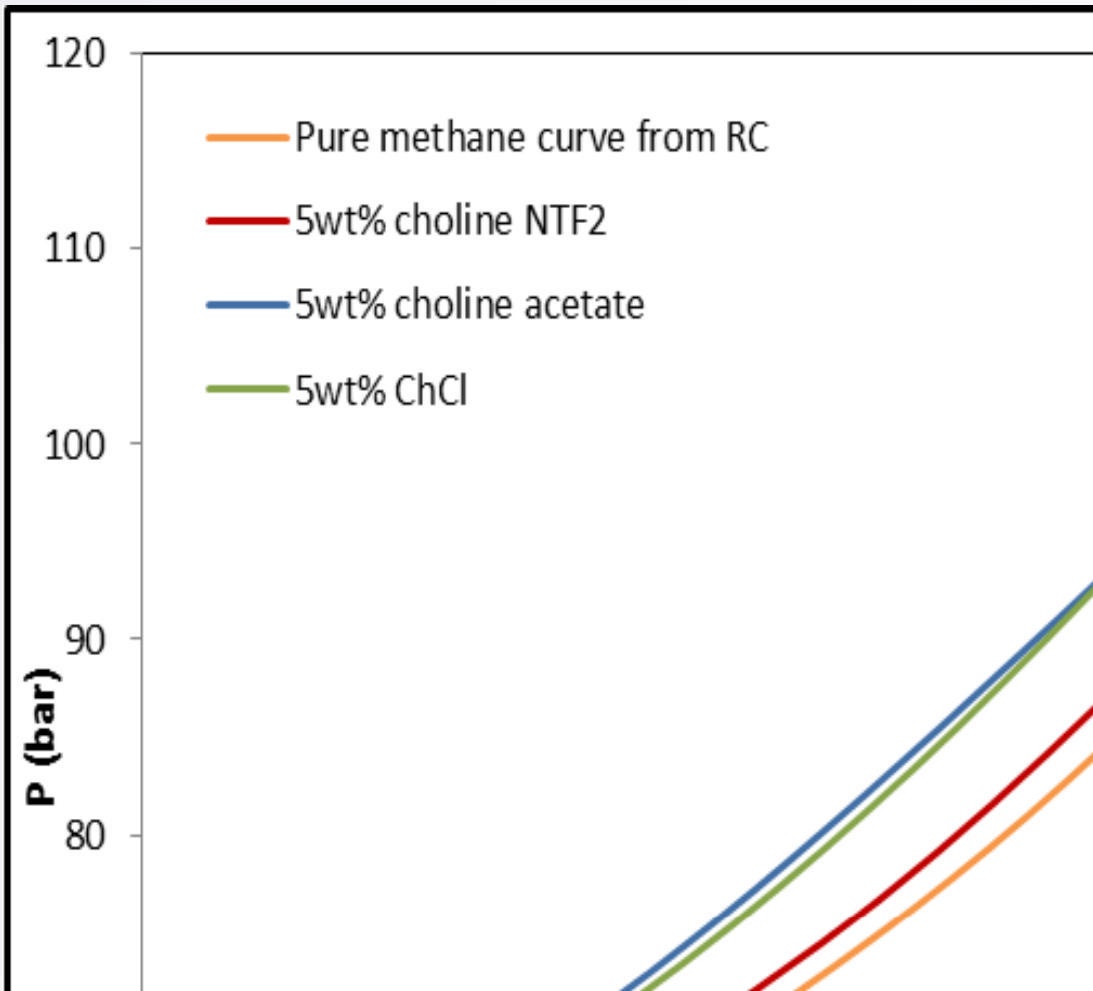
Data validat



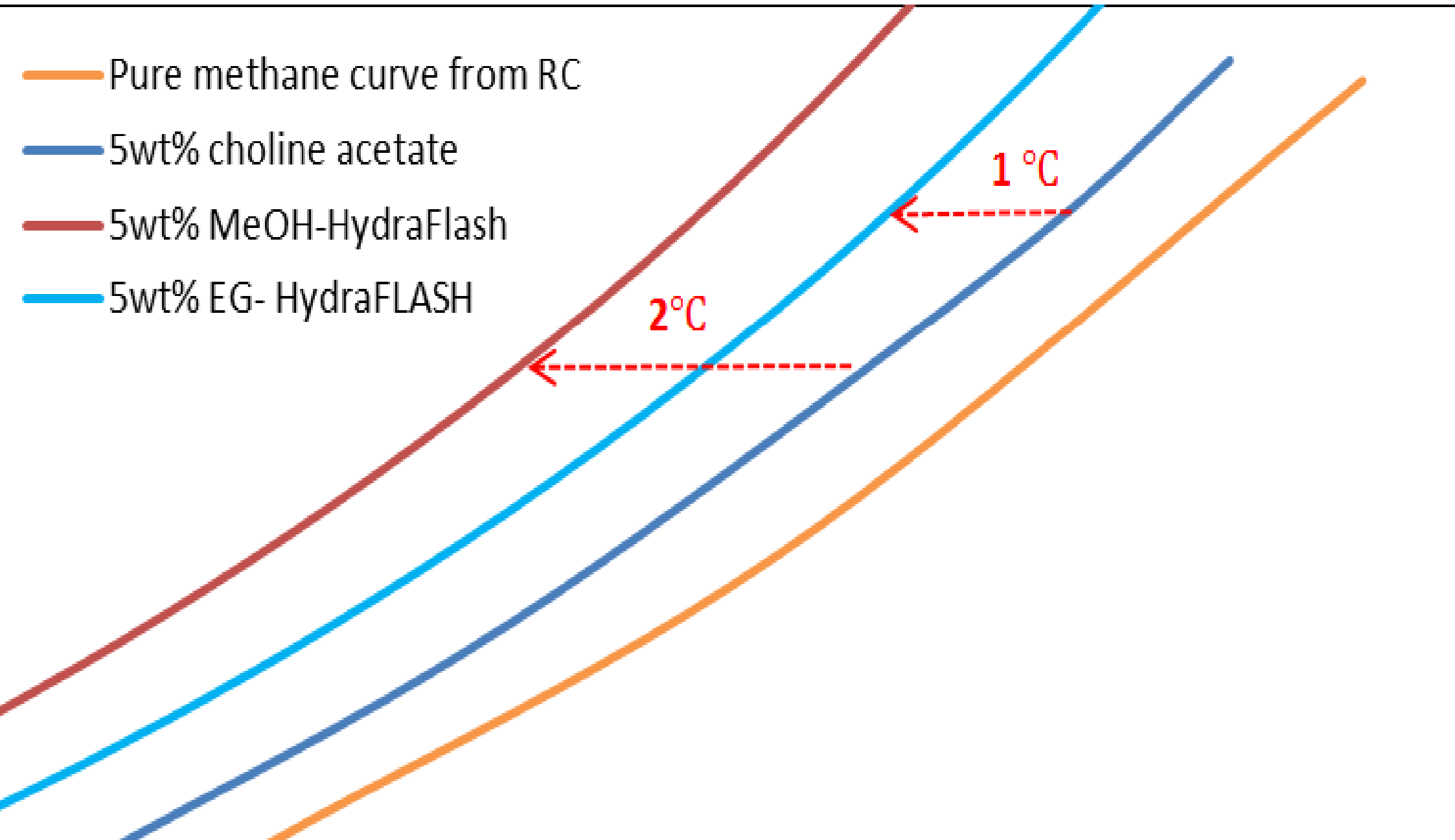

QNG-S1
HydraFlash
2.6°C

Ionic liquids

5wt% Ionic li

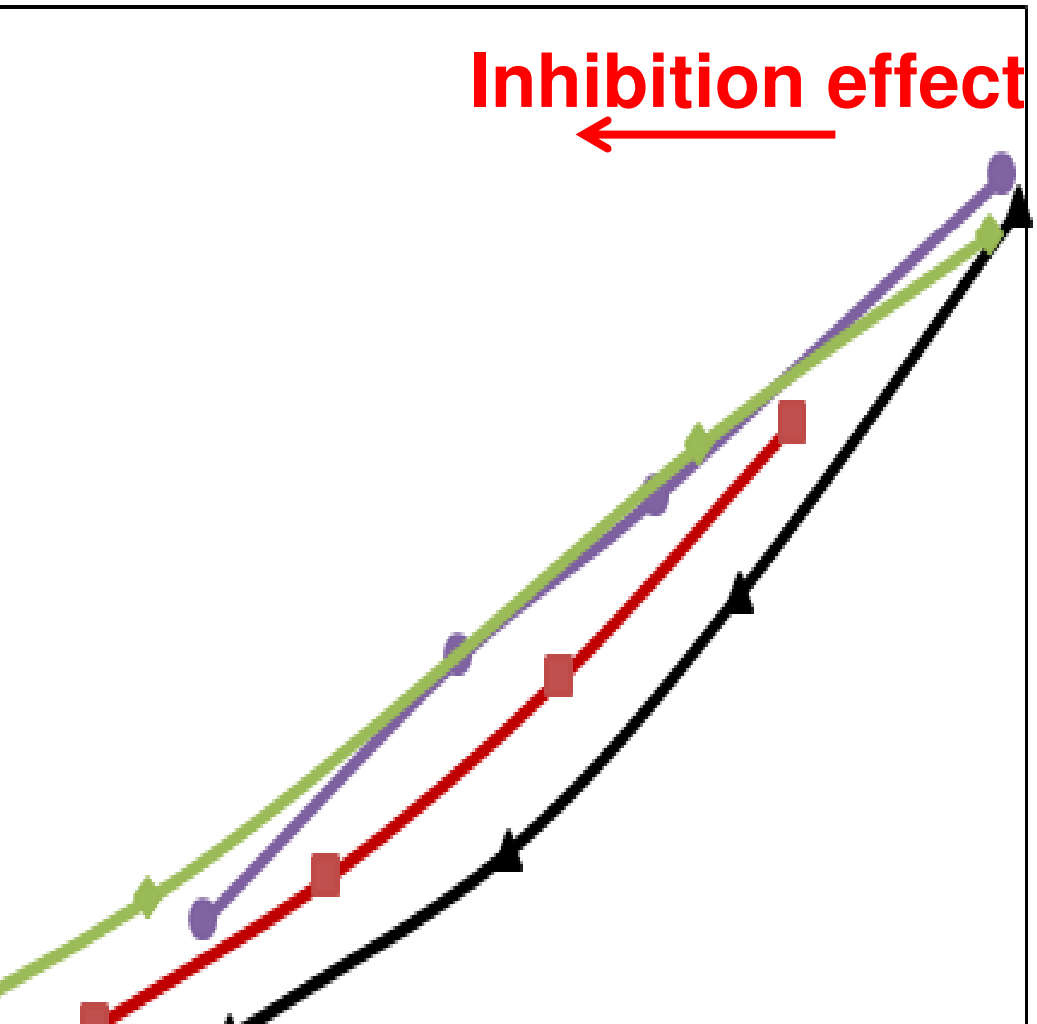


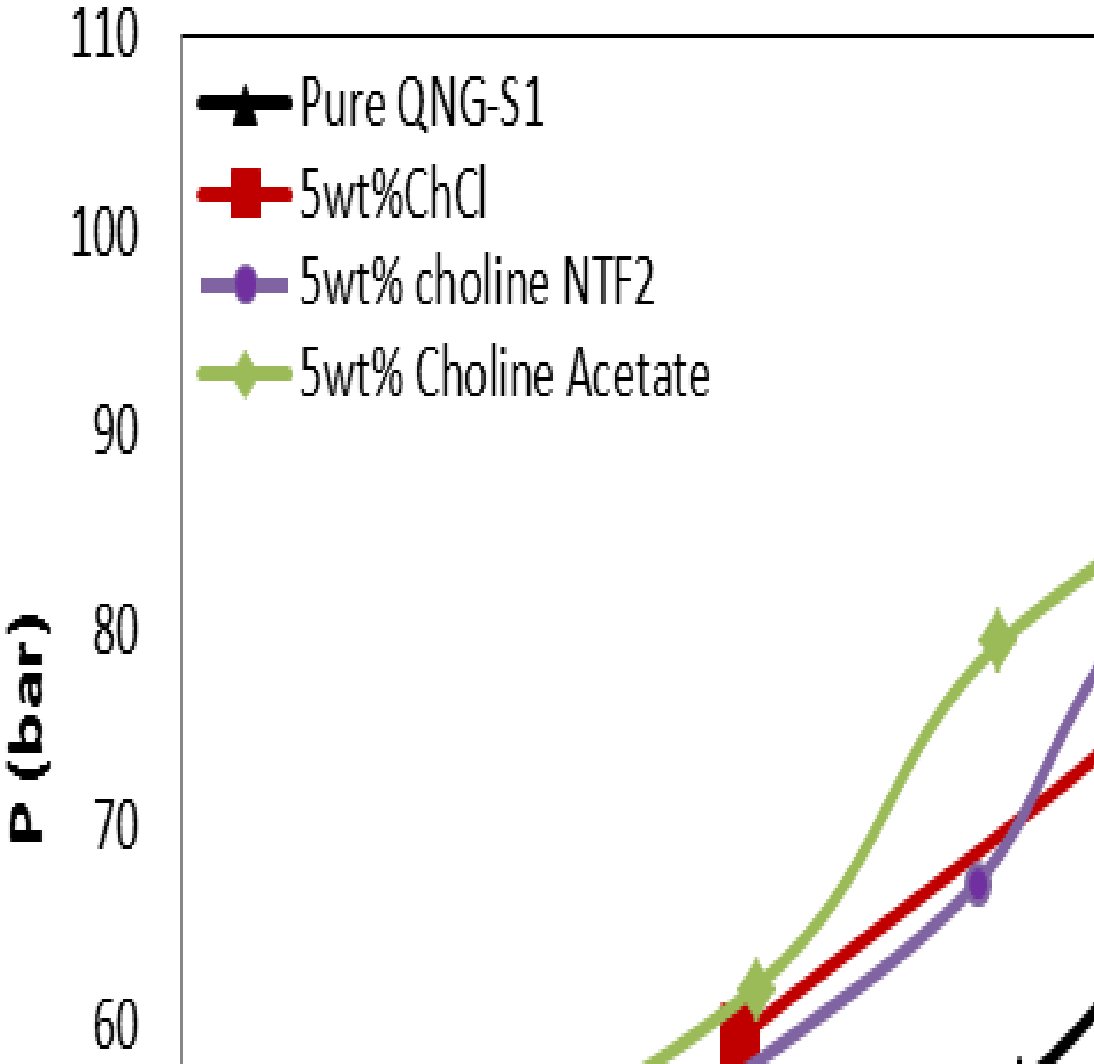
Comparison between



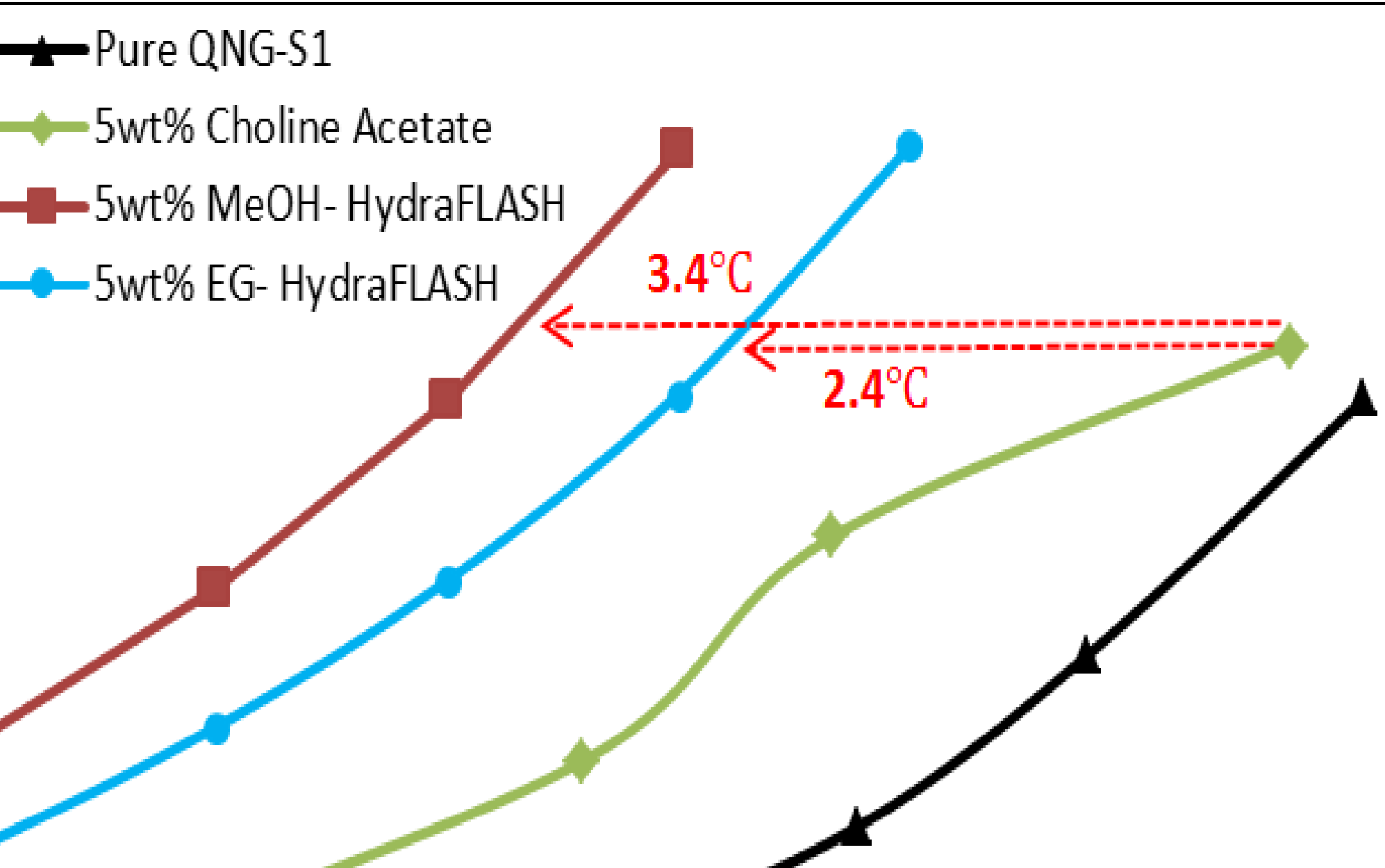
Ionic liquids

5wt% Ionic l

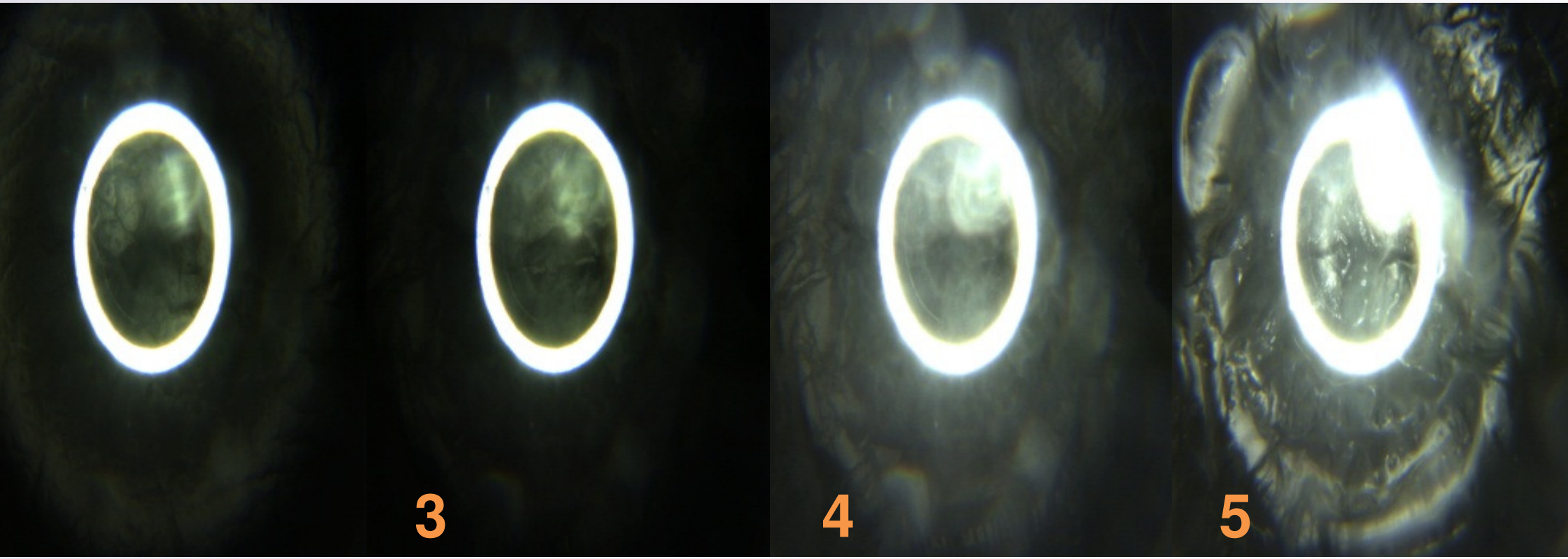




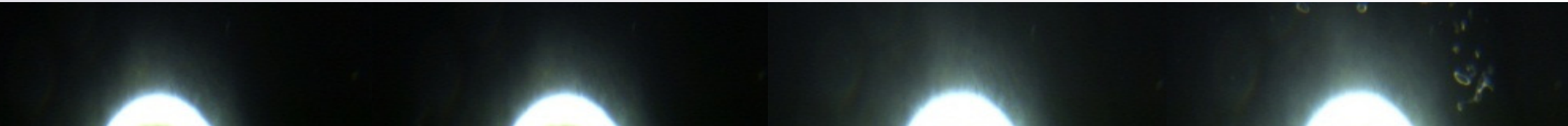
Comparison between



+ 5wt% choline NTF_2



-S1 + 5wt% MeOH



erature.

LVE curve for QNG-S1 deviates by 2.6℃ from the estimated

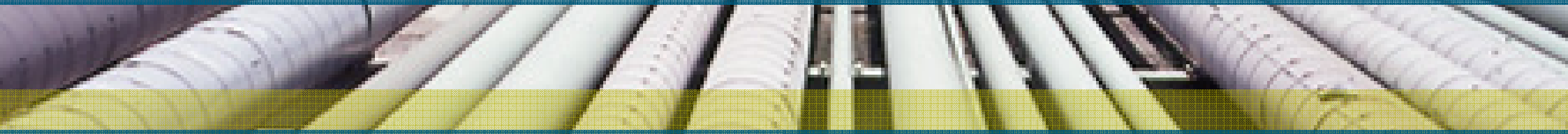
Data

ect of the tested ILs with 1wt% was almost negligible.

owed a moderate inhibition effect where the maximum inhib

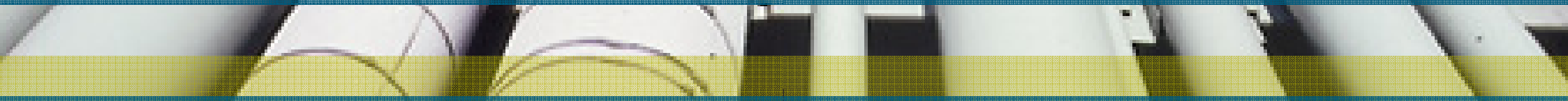
at higher pressures with 1℃ shift.

rent groups of ionic liquids with same anion to investig
tions on hydrate formation especially for QNG-S1 mix



mprehensive molecular simulation study and optim

mixture such as QNG-S1.



Scientific Discovery

