



Novel technologies for integrated biogas separation and compression

Jing-Xiao Liang(Leanne)



The background of biogas separation

1. Methane (CH_4) and carbon dioxide (CO_2) are the main constituents, but biogases also contain significant quantities of undesirable compounds (contaminants), such as hydrogen sulfide (H_2S), ammonia (NH_3) and siloxanes.
2. The requirements for biogas depend on its further application
 - (i) CO_2 is sometimes considered to be a nuisance because it is present in large quantities (25-45%),
 - (ii) it is an inert gas in terms of combustion, decreasing the energetic content of the biogases.

The general method of biogas separation

Operation	Technology	Acronym	Description of process
Absorption	High pressure water scrubbing	HPWS	Water absorbs CO ₂ under high pressure. Regenerated by depressurizing
	Chemical scrubbing	AS	Amine solution absorbs CO ₂ . The amine solution is regenerated by heating
	Organic physical scrubbing	OPS	Polyethylene glycol absorbs CO ₂ regenerated by heating a depressurizing
Adsorption	Pressure swing adsorption	PSA	Highly pressurized gas is pass through a medium such as activated carbon. Once the pressure is reduced the CO ₂ is released from the carbon regenerating it.
Membrane	Membrane separation	MS	Pressurized biogas is passed through a membrane which selective for CO ₂
Cryogenic	Cryogenic separation	CRY	Biogas is cooled until the CO ₂ changes to a liquid while the methane remains a gas.

Contrast of different biogas separation technologies

operation	Methane recovery	Methane concentration in purified gas	Regenerat e gas purity	Energy consumption	Equipment investment	Technique maturity
Absorption	High	High	High	Medium	Medium	High
Adsorption	Medium	High	Comparely high	Low	Comparely high	High
Membrane	Low	Comparely high	Medium	Low	High	Low
Cryogenic	Comparely high	High	High	High	High	medium

Highly efficient CO₂ capture-amine solution

Amine solutions for biogas separation technologies is based on chemical absorbents, in particular MEA, DEA and MDEA.

Two models were developed to explain the solvent-CO₂ interactions

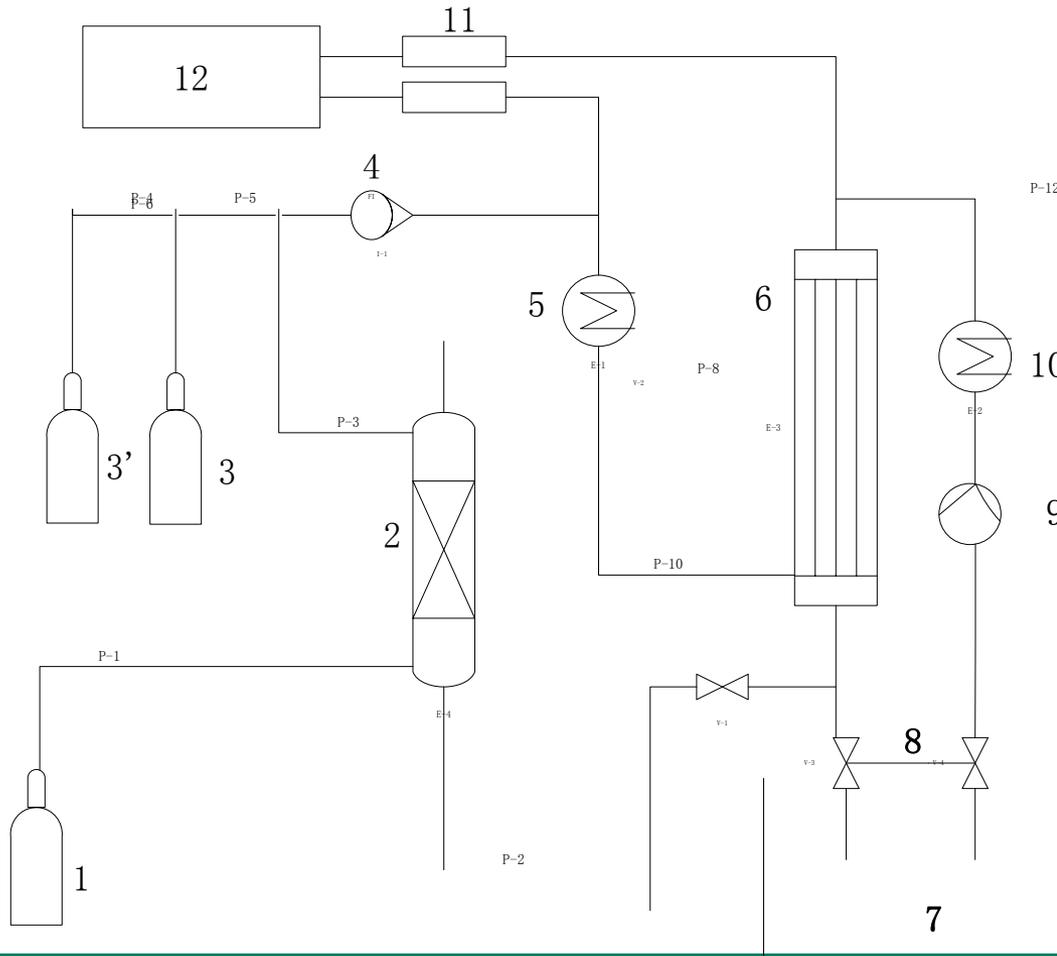


Where R₁ is an alkyl group, R₂ is H for primary amines and an alkyl group for secondary amines, and B is a base that can be an amine, OH⁻ or H₂O

For tertiary alkanolamines, the mechanism is different, resulting in the formation of a bicarbonate:



Experimental apparatus with the gas-liquid contactor



1. Carrier gas (N₂) cylinder
2. humidification column
3. solute(CO₂) cylinder
- 3'. Solute (H₂S) cylinder
4. flow indicator /control
5. heat exchanger
6. cables-bundle contactor
7. solution tank
8. switch for solution recycling
9. liquid pump
10. heat exchanger
11. membrane dryers
12. gas analysis: IR for CO₂ and UV for H₂S

Competitive CO₂/CH₄ separation- membrane-based technology

three major categories exist: polymeric membranes, inorganic membranes and mixed matrix membranes.

Polymeric membranes can be further classified into three types based on their transport mechanism, there are gas permeation membranes, facilitated transport membranes and asymmetric microporous membranes.

Microchemical technology—process intensification

large specific surface area

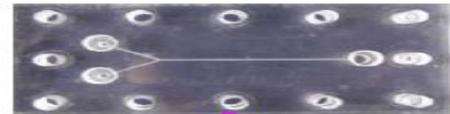
fast transfer rate

narrow residence time distribution

fast scaling-up

high throughput

easy control



numbering-up



Examples produced by Dalian Institute of Chemical Physics(DICP) China

Other options include microchannel contactors. It is smaller but with a better regeneration characteristics.



Other noble technology-ionic liquids (ILs)

Several characteristics have drawn significant attention to ionic liquids (ILs) as an alternative absorption media to traditional solvents. The feature of ionic liquid is thermal stability, potential high performance for CO₂ uptake and negligible vapor pressure. The low vapor pressure of the ILs prevents the emission of volatile organic compounds, offering a non-contaminated target gas. Additionally, an IL can be designed on a rational basis for a specific application.

In this project we will also investigate these and more technologies including ionic liquids(ILs) as an alternative absorption media to traditional solvents.



THANKS

