Biogas upgrading-CO_2 removal by employing noble absorption and technology

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In the recent years, interest in the application of renewable energy sources, especially biomass and biogas has significantly increased. Methane (CH_4) 55-70% and carbon dioxide(CO_2) 15-40% are the main constituents, but biogas also contains significant quantities of undesirable compounds, such as hydrogen sulfide(H_2S), ammonia(NH_3) and siloxane. The acid gases can cause pipeline corrosion problems during transport. Their removal also reduces the gas volume to be transported and increases the value of gas stream.

Nowadays, there are several different technologies are available for biogas upgrading these are summarized in Table1 and Table2.

Operation	Technology	Acronym	Description of process
Absorption	High pressure water scrubbing	HPWS	Water absorbs CO under high pressure. Regenerated by depressurizing
	Chemical scrubbing	AS	Amine solution absorbs CO and regenerated by heating
	Organic physical scrubbing	OPS	Glycol absorbs CO regenerated by heating and depressurizing
Adsorption	Pressure swing adsorption	PSA	Highly pressurized gas is pass through a medium (e.g. activated carbon).Depresurise to recycle.
Membrane	Membrane separation	MS	Gas is contacted with a CO selective menbrane.
Cryogenic	Cryogenic sepataion	CRY	Cooled until the CO changes to a liquid and is then separated.

Table 1. current biogas upgrading technologies

operation	Methane recovery	Methane concentration in purified gas	Regenerate 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

Table 2. Contrast of different biogas upgrading technologies

One of the existing options for biogas upgrading technologies is based on chemical absorbents, in particular mono-, di- and trialkanolamine solutions. Such amine solutions have since long time been applied as highly efficient CO_2 capturing agents.

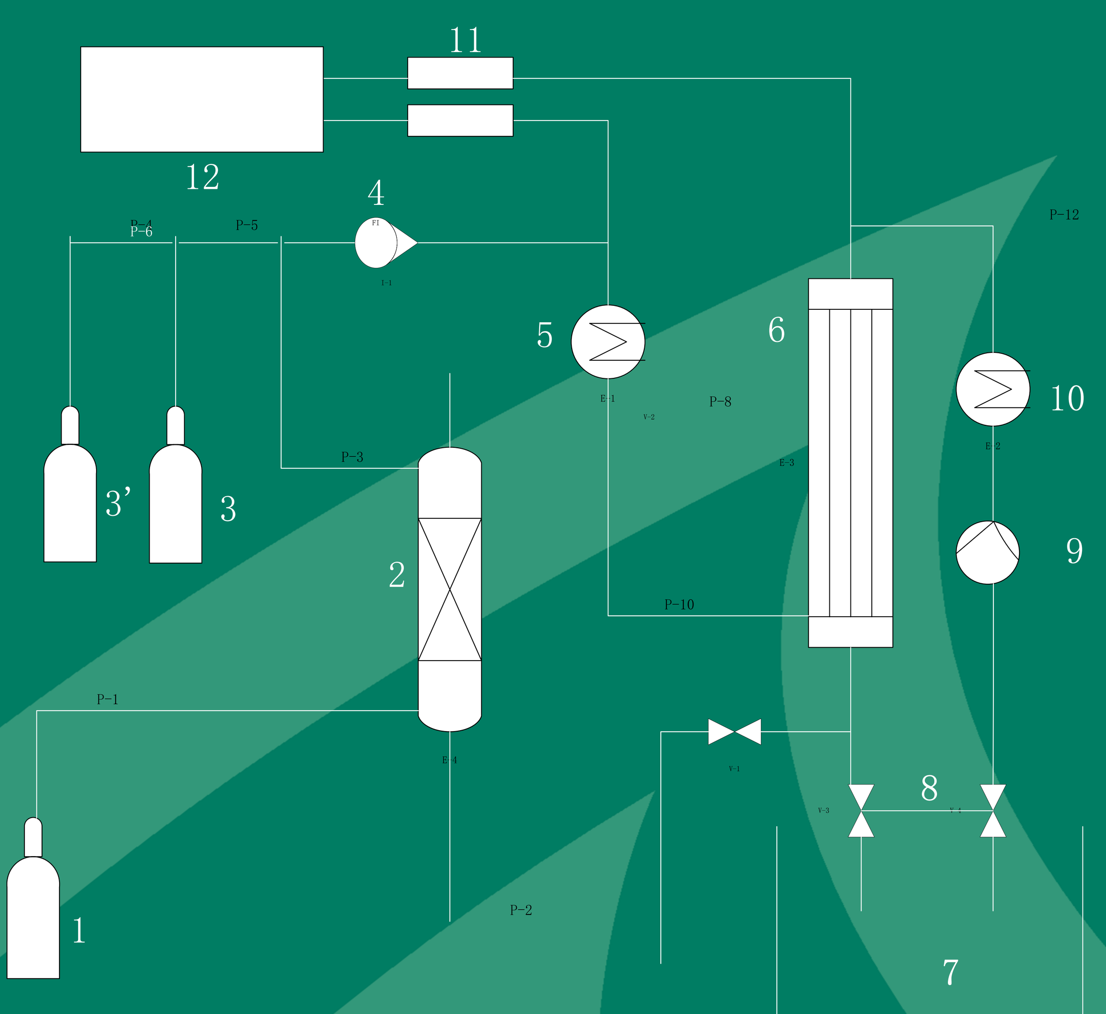
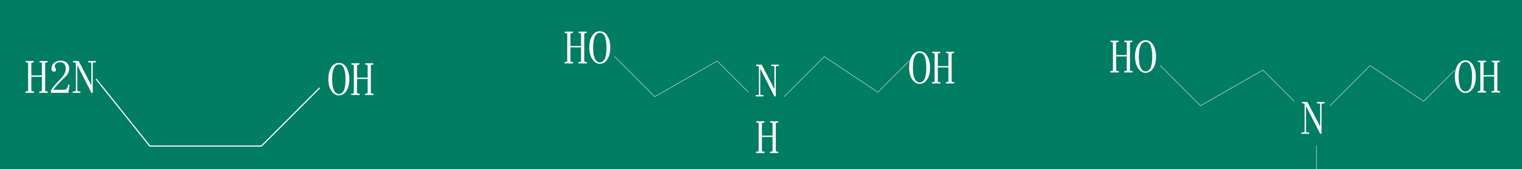


Figure 1. Experimental apparatus with the gas-liquid contactor 1. Carrier gas (N_2) cylinder, 2. humidification column, 3. solute(CO_2) cylinder, 3'. Solute (H_2S) cylinder, 4. flow indicator /control, 5. heat exchanger, 6. cables-bundle contactor, 7. solution tank, 8. switch for solution recycling, 9. liquid pump, 10. heat exchanger, 11. membrane dryers, 12. gas analysis: IR for CO_2 and UV for H_2S.



Monoethanolamine MEA — Diethanolamine DEA — N-methyldiethanolamine MDEA

The chemical nature of interactions between CO_2 and amines is based on the charge distribution and the theory of Lewis acids and bases.

Two models were developed to explain the solvent-CO_2 interactions

$$CO_2 + R_1R_2NH \longrightarrow R_1R_2NH^+COO^- \quad (1)$$

$$R_1R_2NH^+COO^- + B \longrightarrow R_1R_2NCOO^- + BH^+ \quad (2)$$

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 H_2O

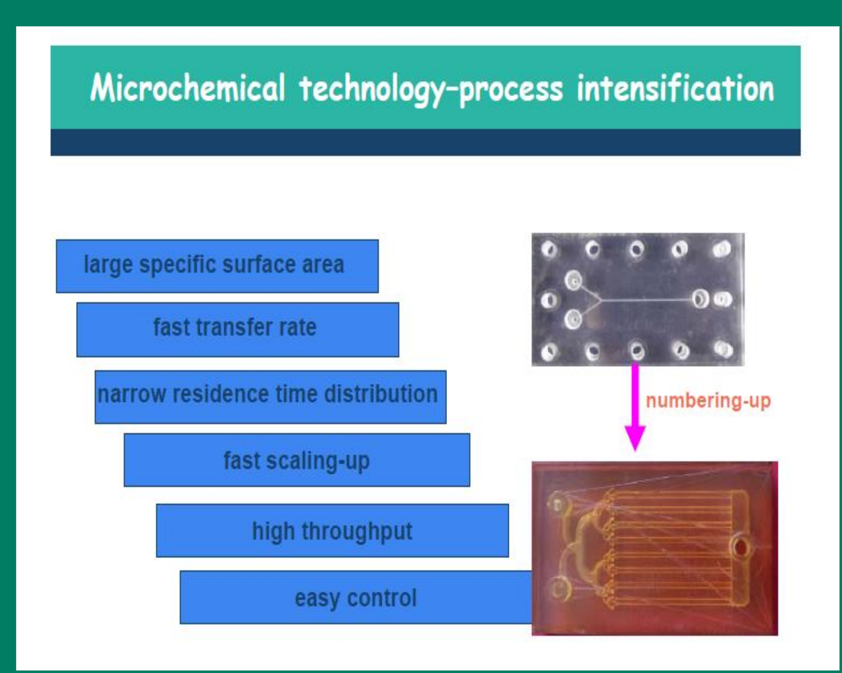
For tertiary alkanolamines, the mechanism is different, resulting in the formation of a bicarbonate:

$$CO_2 + H_2O \longrightarrow H^+ + HCO_3^- \quad (3)$$

$$R_1R_2R_3N + H^+ \longrightarrow R_1R_2R_3NH^+ \quad (4)$$

Contacting streams is important and membranes for CO_2/CH_4 separation are available. Other options include microchannel contactors. Examples produced by Dalian Institute of Chemical Physics(DICP) China are shown below which are smaller and have better regeneration characteristics.

Picture1. MBC is assembled and transported to harbor



Picture 2. Micro-chemical technology-process intensification

In this project we will also investigate these and other technologies including ionic liquids(ILs) as an alternative absorption media to traditional solvents. Suitable properties include thermal stability, potential high performance for CO_2 uptake and negligible vapor pressure. The low vapor pressure of ILs prevents the emission of volatile organic compounds. Additionally, an IL can be designed on a rational basis for a specific application. This versatility consequently opens a large group of potential alternative solvents.

References

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