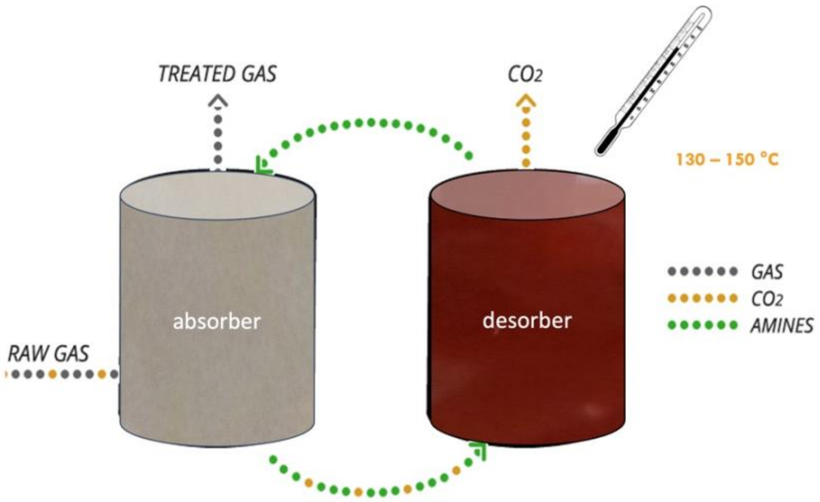
CarbonOrO

Carbon Capture Solutions for Industrial Flue Gasses

Carbon Capture Technology

Capturing CO_2 from flue gasses with sizable installations relies upon a chemical process. In this process, amines (distinct molecules) are used to bond and release CO_2 with temperature.

Figure 1: Basic configuration of an installation to capture CO2 with amines



The installation consists of an absorber and a desorber (or regenerator). Both vertical columns containing packing material, where amine solvent circulates in between. The process involves the following steps:

1. Flue gas (cooled to 30-40 ˚C) containing CO_2 enters at the bottom of the absorber.
2. It then rises through the absorber where CO_2 is bond by the amine solvent that moves down in counterflow with the gas stream.
3. The treated (cleaned) gas leaves the absorber at the top of the absorber.
4. From the bottom of the absorber, the 'rich' amine solvent (now containing CO2) is pumped to the desorber where CO2 is released by heating. Typical regeneration temperatures are 130-150 ˚C.
5. With CO_2 released, the 'lean' solvent is pumped back to the top of the absorber to be re-used in a continuous process.

Developments in Technology

Throughout the last 15 years, CO_2 capture technologies have been extensively researched. These studies have focused on the search for amine mixtures allowing:

- A decrease in the regeneration temperature, reducing the energy consumption of the CO_2 capture process.
- An increase in the CO_2 loading of the amine solvent, slowing for the discrepancy of 'lean' and 'rich' CO_2 concentration in solvents.
- An increase in the lifetime of solvents. Amines tend to degrade (decreasing effectiveness) from contact with oxygen and high temperatures. The oxidative degradation is triggered by the presence of metal oxides; thermal degradation typically kicks in above 130 ˚C.

The introduction of amine mixtures (second-generation solvents with piparizine) has allowed considerable development, however most industrial installations still run on a 30% MEA (monoethanolamine) solvent, considered the industry benchmark.

CarbonOrO's Bi-phasic Solvent

CarbonOrO uses a proprietary third-generation solvent. This is a so-called bi-phasic solvent, a mixture of two amines in water. At room temperature, the solvent splits in two layers (fractions). When loaded with CO_2, the solvent turns into a single homogeneous phase. CO_2 is released by heating, however with a mechanism completely different from traditional amine solvents.

Traditional solvents will release more CO_2 if temperature is raised in a straightforward (almost linear) chemical process. The CarbonOrO mixture encompasses a unique effect seen only in bi-phasic solvents: CO_2 is released in bulk above a certain threshold temperature, triggering the phase shift in the solvent.

Figure 2. CarbonOrO bi-phasic solvent.

After CO_2 capture the liquid is homogeneous (left). Heating will release the CO_2 and produce a bi-phasic solvent in two layers.

Bi-phasic Solvent Properties

The unique properties of the bi-phasic solvent translate into some clear advantages over first- and second-generation amine solvents:

↓ **Reduction of regeneration energy**
A result of the phase shift temperature of the solvent at approximately 70 ˚C. This may even allow for the use of residual heat to drive the process in small size applications.

↑ **Higher solvent loading**
Allowing for more compact installations and saving on solvent volume costs.

↓ **Less solvent degradation**
Lab results show that the CarbonOrO solvent is less prone to oxidative degradation compared to MEA. Thermal degradation is avoided by low regeneration temperatures.

Operation at Scale

To prepare for full-scale operation, CarbonOrO has teamed up with CCS experts at TNO[1] to develop a robust industrial CO_2 capture process, using CarbonOrO's proprietary solvent, allowing for scale and low costs. Initial lab results from TNO (e.g. on loading, VLE, solvent stability) and basic models have been created including Process Flow Diagram, Heat & Mass Balance, basic equipment sizing etc.

CarbonOrO's industrial process is characterized by:

- Regeneration at 105-120 ˚C: significantly lower than temperatures in first- and second-generation solvents.
- Release of CO_2 at 4-6 bar: above prevailing solvents which produce CO_2 at 1-2 bar.

These unique characteristics preserve the energy effectiveness of the CarbonOrO process; temperature rise for regeneration translates into elevated CO_2 pressure, saving on downstream costs for compression/liquefaction. In addition, the benefits from using the bi-phasic solvent including higher loading and reduced degradation are maintained.

Feasibility studies executed by independent third parties for TotalEnergies (hydrogen plant) and the Global Cement and Concrete Association (cement plants) arrive at over 40% costs savings per ton of CO_2 captured vs. the MEA benchmark. Both studies were carried out for installations with capture capacities in the range of 800 kt/yr.

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[1] *TNO (https://www.tno.nl/en/sustainable/co2-neutral-industry/industrial-carbon-capture/) is an independent research and development institute, funded by the Dutch government. TNO is a world leader in CCS knowledge and experience. In the last decade, it has been involved in every sizable CCS-project in Europe.*