AdapT®

Flexible gas sweetening solutions

Guidelines on how to select Eastman AdapT® solvents in ProTreat® simulation software

Simulations are the core of any new acid gas removal design or performance troubleshooting case. For grassroots system or solvent swap projects, it is crucial to select the most appropriate solvent as this may have a significant impact on both the capital expenditures (CAPEX) and operating expenditures (OPEX). Since 2015, Eastman AdapT® solvents are available as separate components in the ProTreat® simulation software developed by Optimized Gas Treating, Inc. Any holder of a basic ProTreat license can select and use the AdapT solvents.

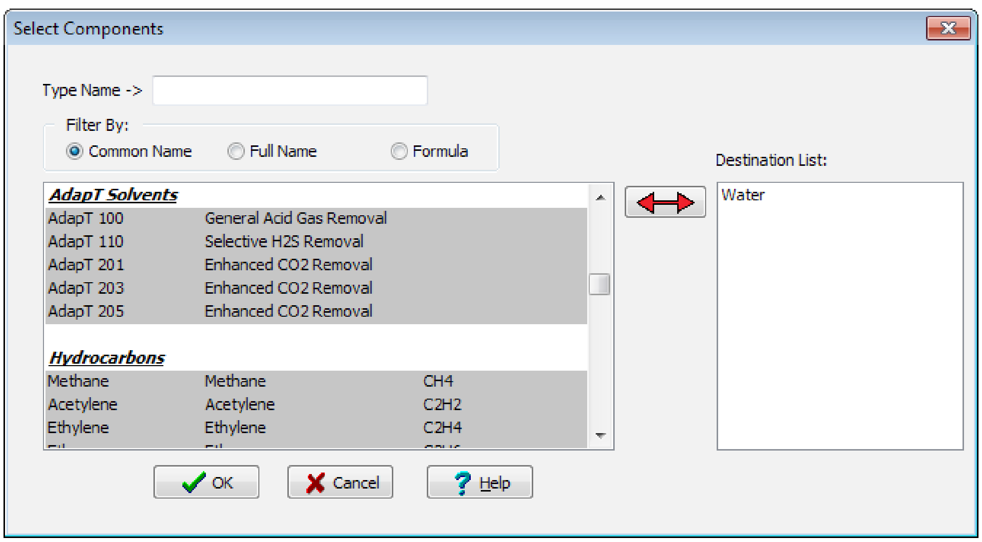

Figure 1: Overview AdapT Solvents in ProTreat Software

Note that the simulation does not allow a combination of AdapT solvents or a combination of an AdapT solvent with another amine. The formulations as defined in the software consist 100% of amines and additives and exclude any water. AdapT solvents are MDEA based and the maximum recommended concentration for an AdapT solvent is 50 wt%. Higher concentrations do not pose any risk, but the higher viscosity typically off-sets any advantage that a higher amine concentration may bring.

EASTMAN

Currently the following formulations are available for simulation:

AdapT Series	Function	Target Applications	Recommended Concentration
AdapT 100	Bulk acid gas removal	General acid gas removal	30 – 50 wt%
AdapT 110	Selective H_2S removal	TGTU, pipeline gas	30 – 50 wt%
AdapT 201	Deep CO_2 removal	LNG, syngas	35 – 50 wt%
AdapT 203	Bulk & deep CO_2 removal	Pipeline gas, NH3	35 – 50 wt%
AdapT 205	Deep CO_2 removal	LNG, NH3	35 – 50 wt%

Table 1: general guidelines for AdapT Solvents

Table 1 summarizes the main application areas for the most common AdapT solvents. These guidelines are however not set in stone and deviations are certainly possible and are a matter of optimization depending on the processing conditions. Below, we provide more guidance on solvent optimization:

- In cases where deep CO_2 removal is not needed, select an AdapT 100-series solvent
  - AdapT 110 generally has a higher performance for most cases where deep and/or selective H_2S removal is essential.
  - Increase the amine concentration to increase the selectivity of the solvent. Higher amine concentrations increase the viscosity and solvent strength, and generally favor H_2S over CO_2 removal because CO_2 absorption is kinetically limited.

- In cases where more CO_2 removal is needed, select an AdapT 200-series solvent. These products have a varying concentration of activator.
  - For very deep CO_2 removal, e.g. 50 ppmv for production of LNG, AdapT 201 is a very good starting point with a strong track record.
  - Compared to AdapT 201, AdapT 203 has a lower concentration of activator and AdapT 205 has a higher concentration of activator. More activator increases the reaction rate in absorption of CO_2, but also increases the amount of heat generated in the absorber.
  - If high temperatures are limiting the system performance, increase the water concentration to provide more cooling to the absorber.

Terminology

- Bulk acid gas removal: removal of H_2S and CO_2 to moderate concentrations in the treated gas
- Deep CO_2 removal: removal of CO_2 to low concentrations
- Selectivity: the ability of a solvent to preferentially absorb H_2S and reject CO_2
- TGTU: Tail gas treatment unit, located on the back end of a Claus-type sulfur recovery unit
- LNG: Liquefied natural gas
- NH3: production of ammonia from syngas

Case: Natural gas to LNG

An operator is looking to convert a stream of natural gas into LNG. The feed gas contains 5 mole% of CO_2 which needs to be reduced down to 50 parts per million to avoid CO_2 freezing in the downstream cold box. The gas also contains H_2S that needs to be removed completely. For simplicity, the remainder of the gas was assumed to be methane.

Feed gas	
Flow rate	40 MMSCFD
Pressure	60 bar
Temperature	40 °C

Composition		Target for removal
CH4	94 mole%	
CO_2	5 mole%	50 ppmv CO_2
H_2S	1 mole%	4 ppmv H_2S

To start the evaluation, AdapT 201 is selected as this solvent has a large reference base in LNG application. Using a concentration of 50 wt%, an absorber with 30 valve trays, and lean solvent temperature of 45°C, the simulation leads to a solvent circulation rate of 62 m3/h for adequate removal of CO_2 and H_2S. Table 2 contains the main material balance for this case.

Parameter	Unit	Feed gas	Treated gas	Acid gas	Flash gas
Temperature	°C	40	45	50	76
Pressure	Bar	60.0	59.7	2.0	5.8
Total flow	MMSCFD	40.2	37.7	2.6	0.0
Total flow	kmol/h	2,000	1,878	128	2
H_2O	Mole %	0.16	0.17	6.42	5.89
H_2S		1.00	0.0002	15.59	2.24
CO_2		4.99	0.0013	77.85	17.41
C1		93.85	99.83	0.14	74.45

Table 2: "Natural Gas to LNG" material balance

The simulation results show that the rich solvent loading is around 0.45 moles of CO_2 and H_2S per mole of amine, which is a conservative number. The temperature in the absorber reaches 92°C at the bulge, as can be seen in the temperature profile of figure 2.

Absorber

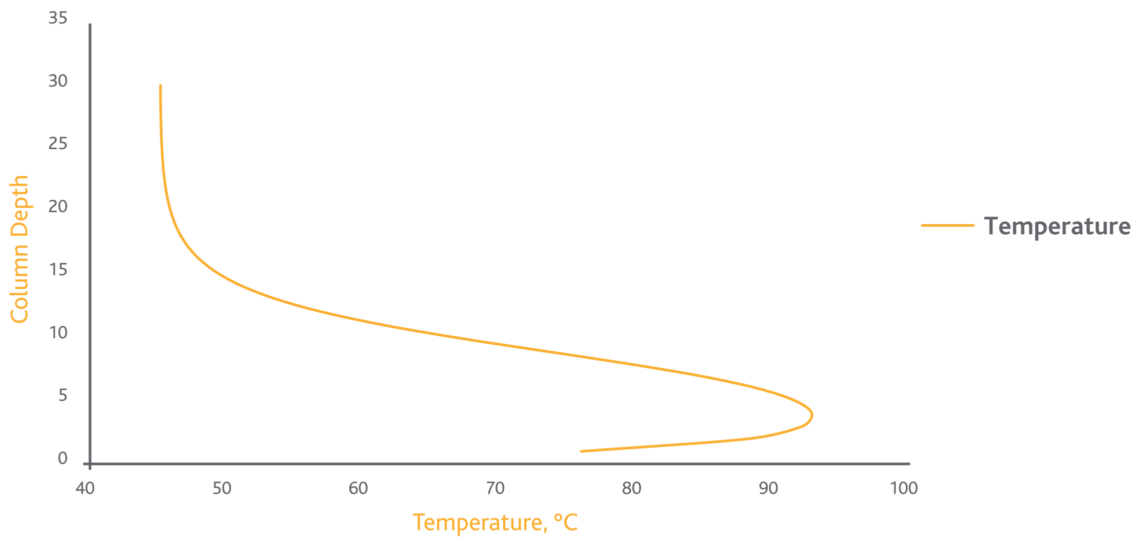

Figure 2: "Natural Gas to LNG" – Absorber temperature profile for 50 wt% AdapT 201.

In case this temperature is deemed too high, there are three obvious modifications possible to reduce the bulge:

1) increase the circulation rate,
2) reduce the solvent concentration or
3) switch to a grade with a lower concentration of activator.

A first attempt at optimization is based on maintaining AdapT 201, but modifying the solvent concentration and flow rate with the aim of bringing the rich solvent loading and absorber temperature within acceptable range. A reduced solvent concentration (more water in the solvent) cools down the absorber because water has a higher heat capacity, but it also increases the rich solvent loading because there are less moles of amine per kg of solvent.

The combination of a solvent concentration of 44 wt% and circulation rate of 64 m3/h brings the bulge temperature down to 85°C, while keeping a rich solvent loading below 0.5 moles of acid gas per mole of amine. Table 3 provides the summary of that optimization, with additional information on performance of DEA for comparison purposes. A generic amine such as DEA can also achieve LNG specifications but typically requires a higher circulation rate because of its lower capacity vs MDEA formulated solvents.

Parameter	Unit	AdapT 201	AdapT 201	DEA
Concentration	Wt%	50	44	30
Circulation rate	M3/h	62	64	90
Rich loading	Mole/mole	0.44	0.49	0.50
CO_2	ppmv	15	2	10
H_2S	ppmv	2	2	1

Table 3: "Natural Gas to LNG" optimization of AdapT 201

Absorber

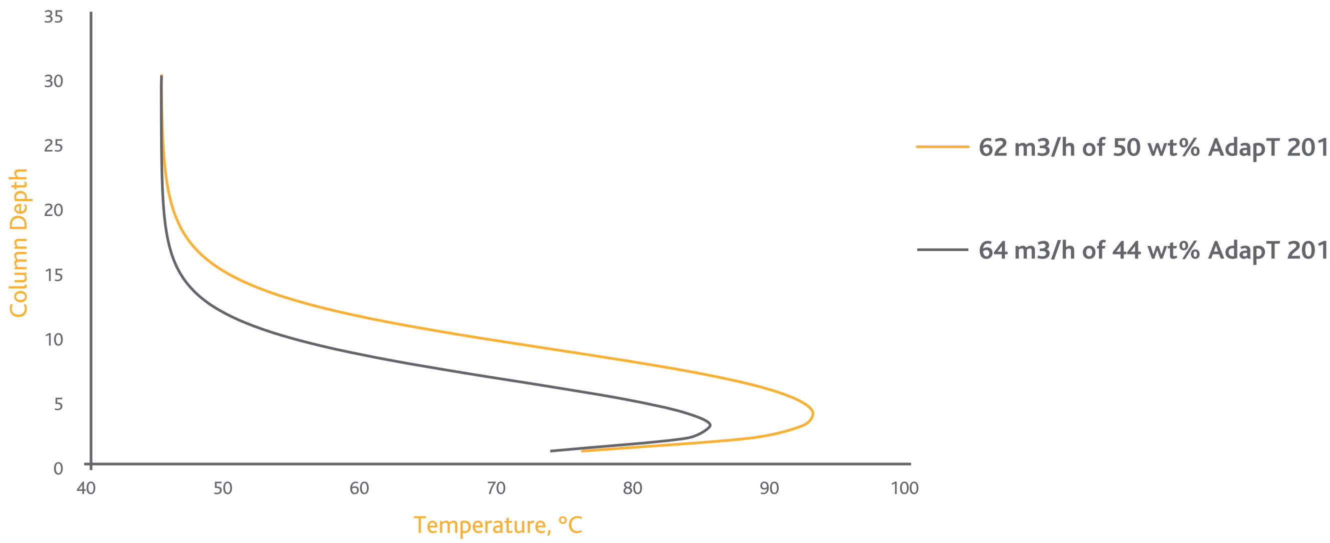

Figure 3: "Natural Gas to LNG" absorber temperature profiles for optimization of AdapT 201

In a second attempt at optimization, the solvent composition is modified to a version with a lower concentration of activator by switching to AdapT 203, which is used more for pipeline gas applications, but is also capable of removing CO_2 down to ppm level.

By keeping the parameters of concentration, circulation etc. identical to the original simulation, the CO_2 removal is inadequate. This can be explained by the slower kinetics in the absorber. As can be seen in figure 4, the temperature bulge is lower, but more "spread out" because absorption is slower.

Absorber

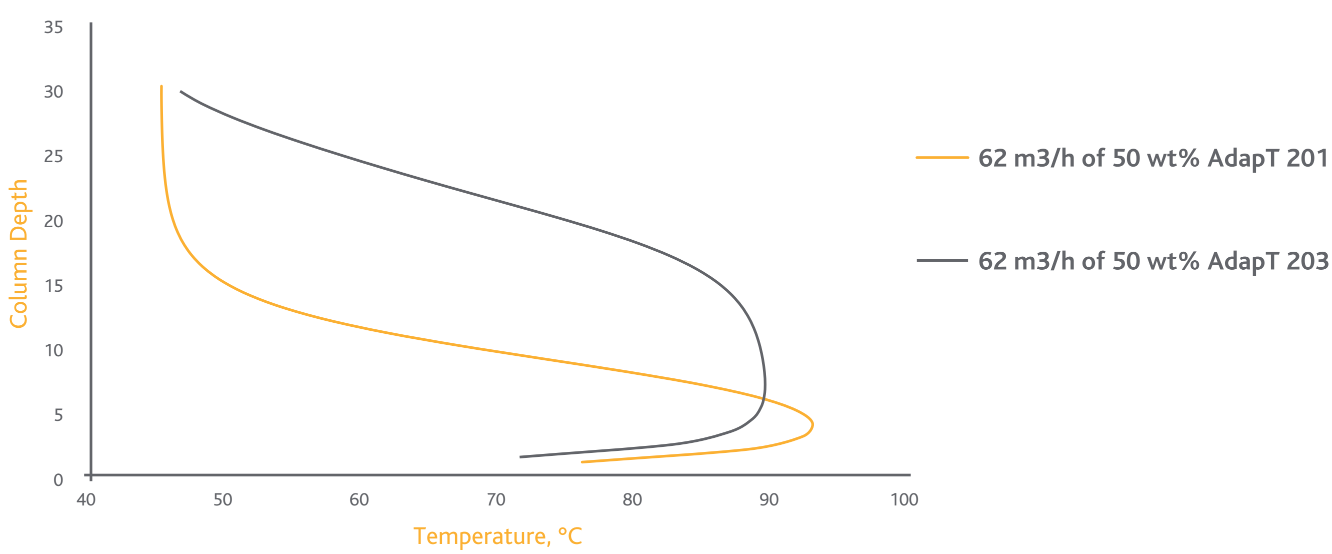

Figure 4: "Natural Gas to LNG" comparing temperature profiles of AdapT 201 and AdapT 203

In this particular case, the CO_2 removal is inadequate, and about 3000 ppmv of CO_2 is slipping through into the treated gas. The actual and equilibrium concentrations of CO_2 in the absorber (shown in figure 5) show that there is a pinch point near the top of the Absorber. The difference between the actual and equilibrium concentration is the driving force for CO_2 absorption. If the difference is small, there is little driving force and additional trays will have a limited effect on performance.

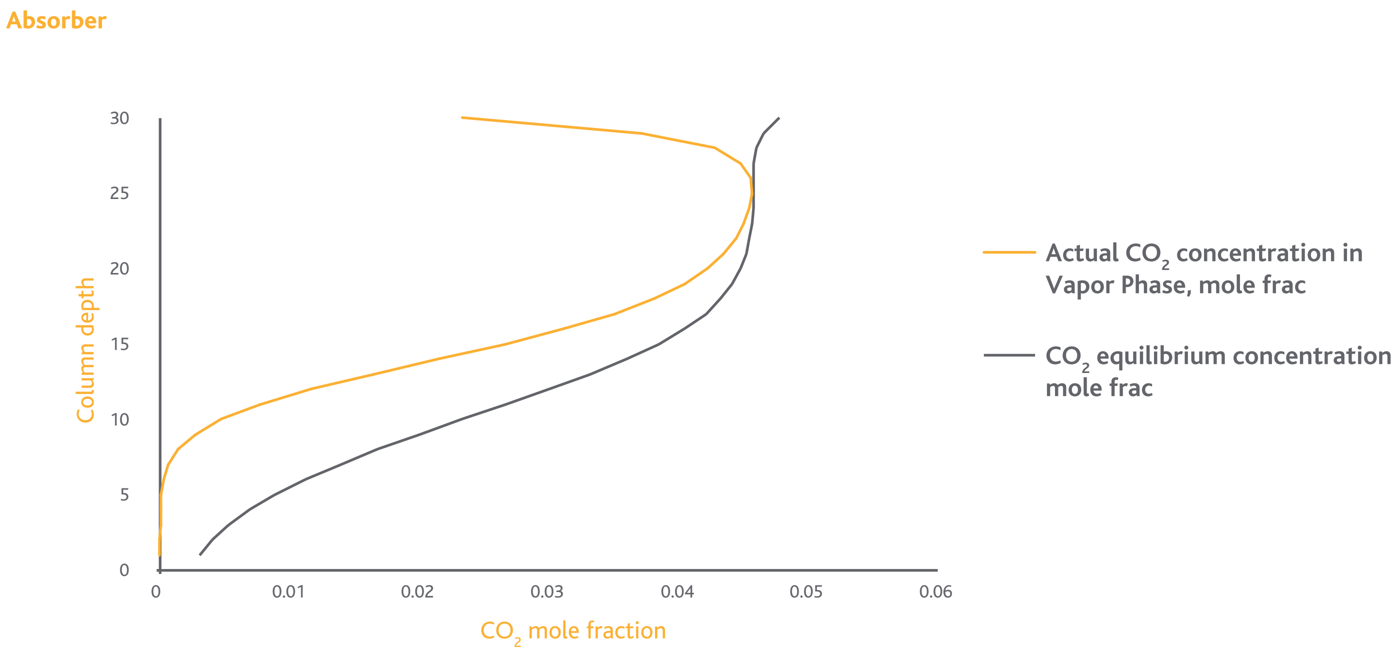

Figure 5: "Natural Gas to LNG": actual and equilibrium CO2 concentrations, using 62 m3/h of AdapT 203 solvent

As an alternative, we studied the impact of increasing the circulation rate. A higher circulation rate reduces the CO_2 concentration of the solvent and allows more CO_2 to be absorbed. The circulation rate is increased until sufficient CO_2 is removed. The performance for these cases is summarized in table 4.

Parameter	Unit	AdapT 201	AdapT 203	AdapT 203
Concentration	Wt%	50	50	50
Circulation rate	M3/h	62	62	80
Rich loading	Mole/mole	0.44	0.43	0.35
CO_2	ppmv	15	3000	46
H_2S	ppmv	2	4	1

Table 4: "Natural Gas to LNG" performance comparison of AdapT 201 and AdapT 203

A significant increase (+30%) in circulation rate is needed to overcome the slower kinetics in the absorber.

Conclusion

When optimizing an acid gas removal case, many parameters need to be taken into consideration including solvent type, concentration, circulation rate, tower internals, regeneration energy etc.

Compared to generic amines, formulations can yield significant improvements in the performance of the acid gas removal unit. By selecting an AdapT Solvent, you can fast track the optimization process, knowing you are working with a solvent with a solid track record that is globally available.

For more information about our Eastman AdapT range of flexible gas sweetening solutions:
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