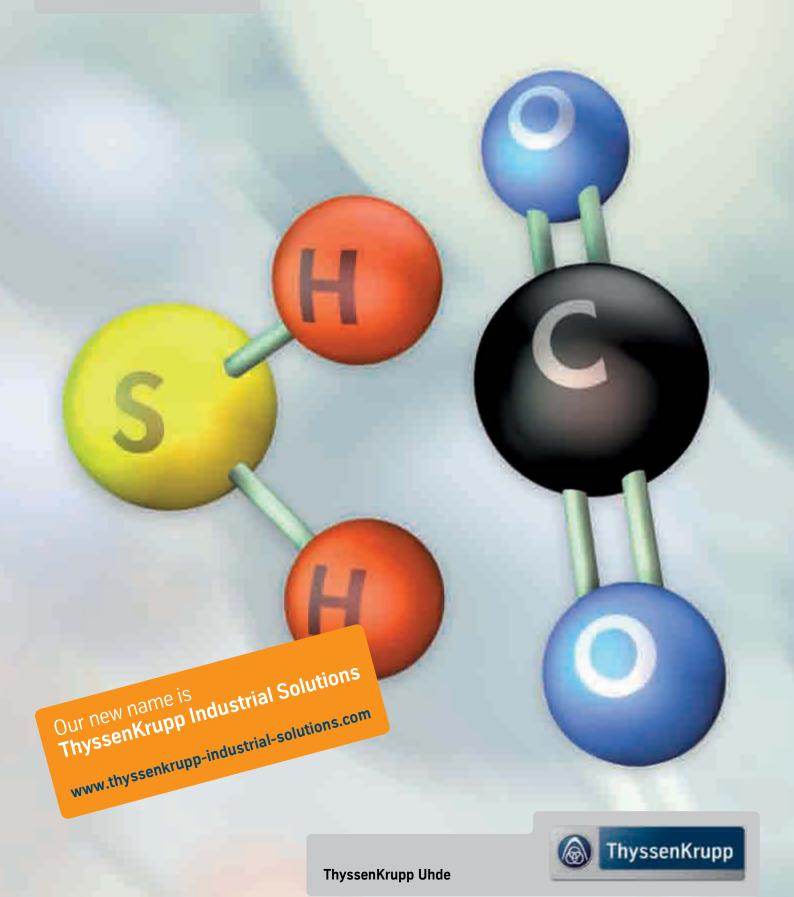
# Morphysorb®/Genosorb® Physical solvents for acid gas removal



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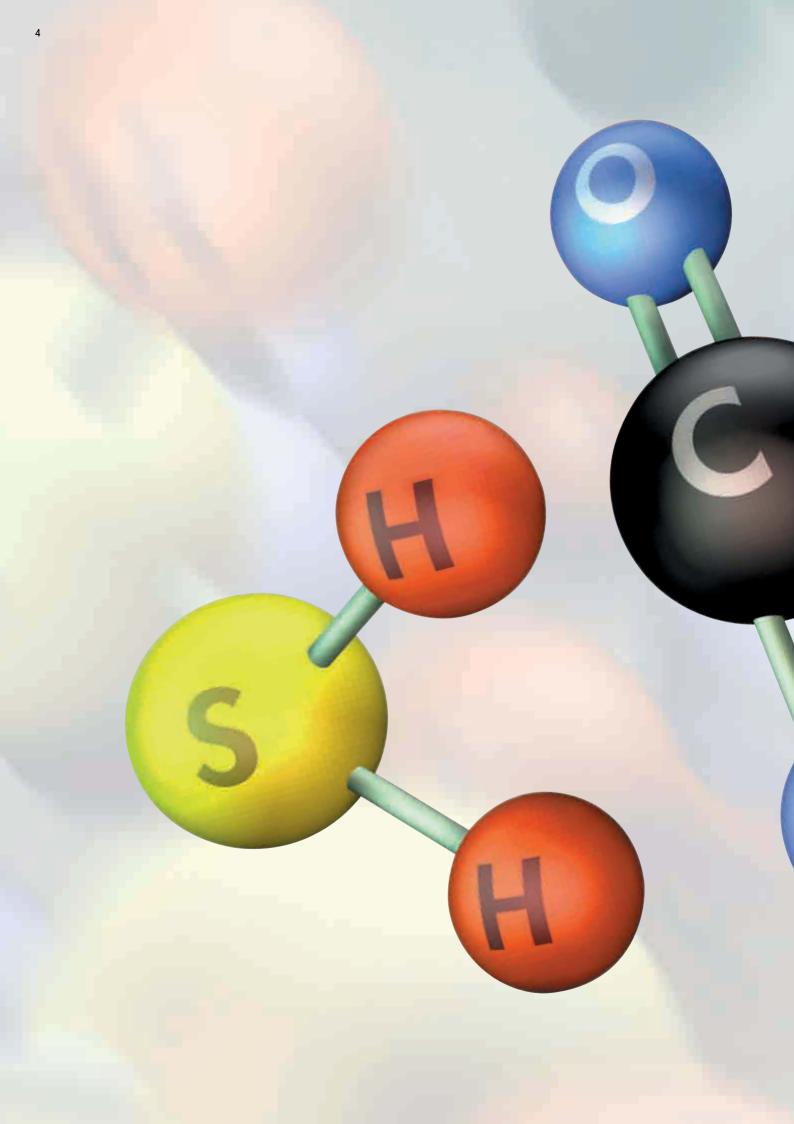
#### 1. Company profile

With its highly specialised workforce of more than 4,500 employees and its international network of subsidiaries and branch offices, Uhde, a Dortmund-based engineering contractor, has to date successfully completed over 2,000 projects throughout the world.

Uhde's international reputation has been built on the successful application of its motto Engineering with ideas to yield cost-effective high-tech solutions for its customers. The ever-increasing demands placed upon process and application technology in the fields of chemical processing, energy and environmental protection are met through a combination of specialist know-how, comprehensive service packages, top-quality engineering and impeccable punctuality.

**Uhde's head office**Dortmund, Germany





## 2. Morphysorb®/Genosorb® Physical solvents for acid gas removal

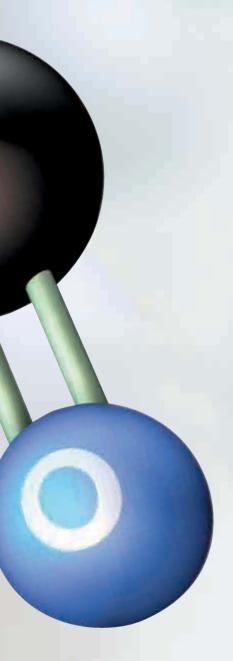
The upgrading of sub-quality natural or synthesis gas requires the removal of CO<sub>2</sub>, H<sub>2</sub>S and other trace constituents. The task to be performed by means of the acid gas removal process is extremely challenging because of the diversity of the feed gas composition:

| Feed          | CO <sub>2</sub> | H <sub>2</sub> S |
|---------------|-----------------|------------------|
| Natural Gas   | .up to 70%      | . up to 25%      |
| Synthesis gas | 20 - 40%        | up to 3%         |

The upgrading of natural or synthesis gas requires the removal of CO<sub>2</sub>, H<sub>2</sub>S and any undesired trace constituents present in natural gas such as carbonyl sulphide, carbon disulphide and mercaptans. The use of physical solvents for the removal of acid gas from pressurised gases with a high concentration of CO<sub>2</sub> or H<sub>2</sub>S offers considerable advantages regarding lower regeneration

energy requirements as the solvent is mainly regenerated through a simple pressure reduction.

The clean gas specification for natural gas is generally 2% or 50 ppmv for  $CO_2$  and less than 4 ppmv for  $H_2S$ . The synthesis gas specification depends on the type of synthesis and may vary from a total sulphur content of 0.1 to 10 ppmv.



### 3. Morphysorb®

The Morphysorb® technology is a new acid gas removal process based on the use of a physical solvent consisting of morpholine derivatives, i.e. N-formyl-morpholine (NFM) and N-acetyl-morpholine (NAM). It is the result of thorough laboratory research and a series of field tests by the Gas Technology Institute (GTI) and Uhde's R&D centre. The pilot plant for the Morphysorb® process is located at GTI's Flex-Fuel Test Facility in Des Plaines, Illinois, USA. The process has been commercially applied the first time at the Kwoen Gas Plant in Canada. This plant for the bulk removal of acid gas was originally designed for a different physical solvent. However, during the construction phase a

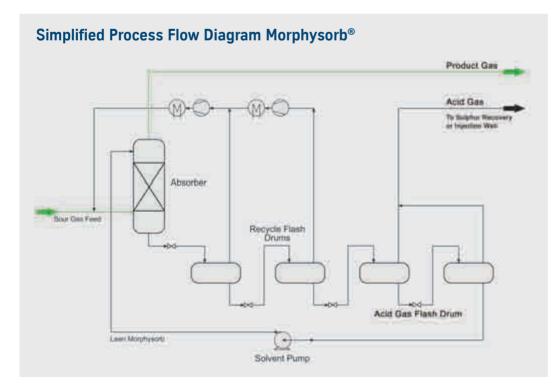
decision was taken at short notice to install the Morphysorb® process in the then almost completed plant as this process promised to meet the meanwhile increased requirements for the amount of acid gas to be removed. This change enabled the owner to cut operating costs and boost the plant's acid gas capacity by more than 15%.

The key advantage of the Morphysorb® technology is the high acid gas capacity together with the low solubility of  $\mathbf{C}_1$  to  $\mathbf{C}_3$  hydrocarbons, resulting in a higher product yield and a lower recycle flash stream. Moreover, the Morphysorb® solvent is capable of removing mercaptans from the feed gas at the

same time. The Morphysorb® technology is not only the process of choice for feed gases containing mainly methane and lower contents of C<sub>4</sub>+ hydrocarbons, it is also well suited for the removal of benzene, toluene and ethylbenzene (BTEX components). Due to the high selectivity of the solvent, the Morphysorb® process is capable of generating an acid gas stream that is suitable for Claus-plants even in unfavourable applications with high CO2 and low H<sub>2</sub>S contents in the feed gas. The process feature of possible partial or total regeneration of the solvent under higher pressure offers additional benefits in cases where the acid gas is disposed into high-pressure reinjection wells.

The Morphysorb® pilot plant at the Flex-Fuel Test Facility at GTI, Des Plaines, Illinois, USA

Capacity: 1100 Nm³/h Pressure: 70 bar (max.)







#### 3.1 Morphysorb® application

Morphysorb® technology in the simplest form requires only flash regeneration of the solvent as the acid gas compounds are merely physically dissolved. For removal of H<sub>2</sub>S down to pipeline specification (4 ppmv H<sub>2</sub>S, 2% CO<sub>2</sub>) or removal of CO<sub>2</sub> to LNG specification (50 ppmv CO<sub>2</sub>, 4 ppmv H<sub>2</sub>S) thermal regeneration is applied. The simplified process flow diagram depicted on the left shows an example of a Morphysorb® application for a bulk acid gas removal unit. The feed gas enters the bottom of the absorber, flows upward through a packed bed, where it is treated with the regenerated Morphysorb® solvent, and leaves the absorber at the top.

The enriched solvent exits the absorber at the bottom and is flashed consecutively into the recycle flash drums. The off-gas from these drums is recycled to the absorber feed by a two-stage compressor in order to minimise methane losses. The solvent is further flashed into the acid gas flash drums for regeneration. The acid gas is produced at two pressure levels for further processing in a sulphur recovery unit or for high-pressure downhole reinjection. The regenerated Morphysorb® solvent is pumped back to the absorber. For spec removal of acid gas components additional thermal regeneration is required.

#### 3.2 Solvent features

The Morphysorb® solvent has outstanding features for cost-effective gas sweetening applications for treating natural, synthesis, or landfill gases:

- high CO<sub>2</sub> and H<sub>2</sub>S loadings which are further increased at low absorption temperatures such as -10°C.
- H<sub>2</sub>S selectivity facilitating acid gas processing in a sulphur recovery unit
- ability to remove organic sulphur compounds (mercaptans, CS<sub>2</sub>, COS)
- suitable for removal of BTEX components
- low hydrocarbon co-absorption
- low vapour pressure, minimising solvent loss

- low capital investment, mainly carbon steel equipment
- ecologically compatible, biodegradable, nonhazardous and non-toxic solvent
- chemical and thermal stability

The Morphysorb solvent is obtained in the quality required for the process from BASF, a well-known supplier with many years of experience in the production of solvents for gas treating processes.

Uhde has more than 25 years' experience in the application of morpholine derivatives for high-purity aromatics recovery.

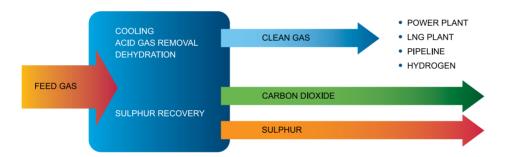
#### Genosorb® 4.

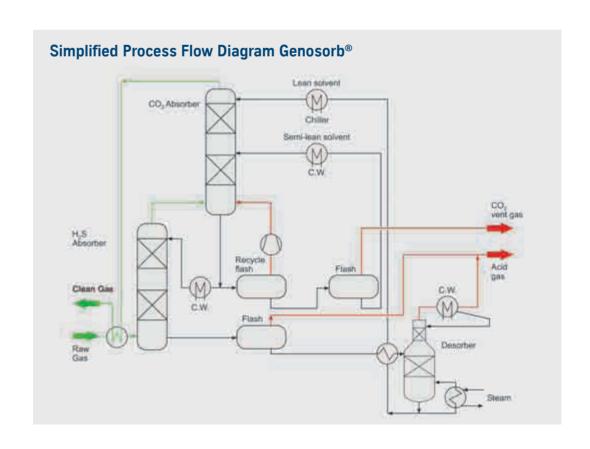
Trademark of Clariant GmbH

Clariant and Uhde have investigated the application of polyethylene glycol dimethyl ethers as physical solvents. This technology, known as the Genosorb® process, has been substantiated by detailed laboratory evaluations and extensive field tests involving the treatment of synthesis gas from a high-temperature Winkler gasification unit. The solvent has a very low vapour pressure, thus minimising solvent loss. Genosorb® is well suited for the removal of H<sub>2</sub>S and CO<sub>2</sub> in synthesis gas applications and it can also be used for the removal of naphthalene or benzene.

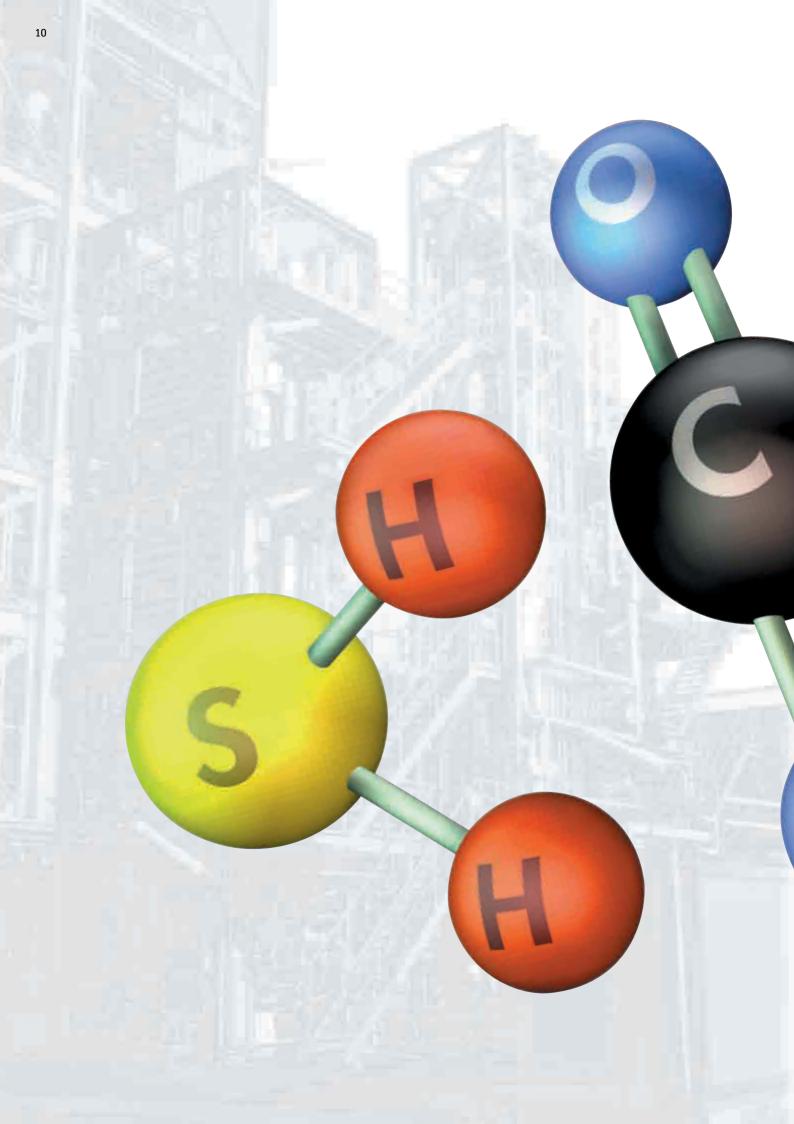
4.1 Genosorb® application

The figure below shows a typical synthesis gas application involving selective H<sub>2</sub>S removal. The H<sub>2</sub>S-rich off-gas is sent to a sulphur recovery unit and the CO<sub>2</sub>-rich and sulphur-free off-gas is vented. The raw gas is first cooled in a heat exchanger by means of cold raw hydrogen gas. The gas enters the H<sub>2</sub>S absorber to remove H<sub>2</sub>S by counter-current contact with a side stream of the CO<sub>2</sub>-rich solvent leaving the CO, absorber. The gas leaving the H<sub>2</sub>S absorber is contacted with semi-lean and lean solvent in the CO<sub>2</sub> absorber and leaves the CO<sub>2</sub> absorber top as clean gas. The H<sub>2</sub>S and CO<sub>2</sub>-rich solvent discharged from the H<sub>2</sub>S absorber is first regenerated in a



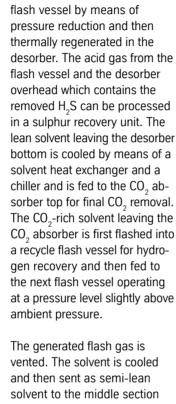






#### 4. Genosorb®

Trademark of Clariant GmbH



of the CO<sub>2</sub> absorber.

#### 4.2 Solvent features

The Genosorb® solvent has outstanding features for cost-effective gas sweetening applications for treating synthesis or landfill gas:

- high CO<sub>2</sub> and H<sub>2</sub>S loadings which are further increased at low absorption temperatures such as -10°C.
- H<sub>2</sub>S selectivity facilitating acid gas processing in a sulphur recovery unit
- ability to remove organic sulphur compounds (mercaptans, CS<sub>2</sub>, COS)
- applicable for removal of benzene and naphthalene
- low vapour pressure, minimising solvent loss
- low capital investment, mainly carbon steel equipment
- ecologically compatible, biodegradable, non-hazardous and non-toxic solvent
- chemical and thermal stability

#### ThyssenKrupp Uhde

We supply customer-tailored gas treatment processes based not only on proprietary but also licensed technolgies.

