Morphysorb® Syngas Treating Process

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Presentation Overview

- Morphysorb Introduction and Background
- Morphysorb Technical Advantages
- Morphysorb Process Applications
- Commercial Application
- Acid Gas Treating Pilot Plant Status
- Morphysorb Process Economics
- Syngas Application of Morphysorb
- Conclusion
- Q&A
Background

> Originally started in 1972 to treat coal gasifier effluents under A.G.A contract (1972-77)

> Screened 108 solvents

> Selected NFM as the best candidate

> Mid-1980s – 2005: Hiatus in coal gasification process developments for SNG

> Project restarted in 1990 under GRI sponsorship and later joined by USDOE for natural gas applications

> 1995 – 1998 Pilot Plant testing at Shell plant in south Texas

> Uhde GmbH and GTI sign joint development and commercialization agreement in 1996
Background (cont’d.)

> 1999 - Laboratory, pilot plant and scale-up studies completed

> Patents for natural gas and synthesis gas applications

> 2002 - First commercial plant (Kwoen, Canada)

> 2005 – Solvent distribution agreement with BASF

> 2007 - Expansion of first commercial plant

> The process is now commercially available as Morphysorb® through Uhde GmbH
Morphysorb Process

What is it?
- Proprietary solvent/process (GTI and Uhde own the technology)
- N-formyl morpholine/ N-acetyl morpholine mixtures

What is the application?
- Bulk or trace removal of acid gas components
- Subquality natural gas upgrading to either pipeline or LNG specification
- Selective removal of H₂S from natural/synthesis gas for generation of acid gas stream suitable for Claus plant feed
- Selective removal of H₂S, CO₂, COS, CS₂, mercaptans and other components from coal/oil gasification syngas at IGCC facilities
Morphysorb Process

> Advantages

- Higher solvent loading = lower circulation or higher throughput
- Lower co-absorption of hydrocarbons (less losses) - less recycle gas flow
- Lower CO and H₂ absorption
- In situ, partial COS Hydrolysis
- Low corrosion, low environmental hazard
- Low capital and operating costs
# Syngas Component Absorption

K values = \( \frac{y}{x} \)

<table>
<thead>
<tr>
<th>Component</th>
<th>DMEPEG</th>
<th>Morphysorb (100% NFM)</th>
</tr>
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<tbody>
<tr>
<td>CH(_4)</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>CO</td>
<td>25</td>
<td>&gt;220</td>
</tr>
<tr>
<td>H(_2)</td>
<td>50</td>
<td>124</td>
</tr>
</tbody>
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Ref: Zawacki et al., Hydrocarbon Processing, April 1981 “Process Optimized for high pressure gas cleanup
Natural Gas Commercial Application

- Plant started in late 2002
- Owned by Spectra EnergySM Transmission
- 300 MMscfd orig., 450 MMscfd expansion
- ~4500 gpm circulation
- ~2000 psia liquefied acid gas to injection
- Bulk removal of 25+% acid gas concentration stream
Morphysorb CO₂ Solubility
Kwoen “Upgrader” Scheme
Spectra Energy
BRITISH COLUMBIA

SALES GAS COMPRRESSOR STATION

GAS PLANT

SPECTRA ENERGY TRANSMISSION MIDSTREAMING AREAS, SOUR GAS GATHERING & PROCESSING
Kwoen Plant Process Flow Diagram

Sour Feed Gas

Filter/Separator

Absorbers (3)

2nd Stage Recycle Gas Compression

1st Stage Recycle Gas Compression

Recycle Flash Drums

Lean Morphysorb

Acid Gas Injection Well

2nd to 4th Stage Acid Gas Compression

1st Stage Acid Gas Compression

Acid Gas Flash Drums

Upgraded Sour Gas

Acid Gas

Sour Feed Gas

Lean Morphysorb

Acid Gas Flash Drums
First Commercial Application Brief
Highlights—
Spectra Energy’s Kwoen Gas Plant (as of April’06)

> The process is operating successfully without any solvent-related problems
> Average gas flow processed ~250 MMscfd
> Processed over 280 Bcf of sour gas
> ~28 Bcf of Acid Gas Injected
> Exceeded performance targets set forth in the demonstration agreement
> No corrosion related issues
> Recent process modifications for high CO₂ removal are successful
  – Acid Gas Stream Composition (Prior to the changes)
    > 85% H₂S, 14% CO₂ and 1% CH₄
  – Acid Gas Stream Composition (After process modifications)
    > 71% H₂S, 26% CO₂ and >2.5 % CH₄

Acid Gas Treating Pilot Plant

Orig. 15 gpm unit

~1 MMscfd Capacity

Upgraded 40 gpm unit at GTI, Des Plaines, IL
AGTPP

> Can process full flow from GTI Flex Fuel 10-20 TPD gasifier ~ 1MMscfd (28,000 Nm³/hr)

> The absorber is 33.5 ft. (10.2 m) of packed height and is 14.7 inches (37 cm) internal diameter. It is packed with Koch Type 350Y Flexipac elements.

> The regenerator is 12 inches internal diameter (30.5 cm) and has 40.7 ft. (12.4 m) of Koch Type 350Y Flexipac packing

> Maximum operating pressure for the absorber is 1200 psi (~80 bar), and 50 psig (4.5 bara) for the regeneration still column.
AGTPP

> New gas cleanup equipment being added to Flex Fuel
  – Oxygen feed system, Quench vessel, SulfaTreat S recovery for high S feedstocks
  – Syngas testing in 2008 – 2009?

> Discussing natural gas-related testing on AGTPP for 2007-8 with multiple clients
Morphysorb Process Economics

> In natural gas applications, significant advantages come from lower methane absorption in the solvent which results in reduced recycle of HP and IP flash gas and higher solubility of acid gas
  - > 20% cost advantage

> For high methane levels in gasifier offgas similar benefits may accrue, proportional to the conc. of CH\(_4\) in syngas (e.g., GPE Bluegas process, Lurgi FBDB or Slagger)

> For low CH\(_4\) in syngas, benefits from lower solubility of CO and H\(_2\), higher CO\(_2\) solubility, and possibly higher COS hydrolysis (to be confirmed)
Morphysorb Process Economics (cont’d.)

> Zawacki et al. studied DMETEG and NFM (selective and non-selective cases) coal to SNG @250 MMscfd. They found a 40% advantage for non-selective NFM approach over DMETEG

Ref: Zawacki et al., Hydrocarbon Processing, April 1981 “Process Optimized for high pressure gas cleanup”

> Uhde study of syngas cleanup showed $0.6 million/yr advantage over conv. solvent and aMDEA cases.

Morphysorb Process Economics (cont’d.)

> These studies are dated and complete details are not available

> Energy and capital cost relationships are greatly changed today

> Newer studies geared to today’s pricing and plant approaches are needed for a variety of applications – IGCC, chemicals manufacture, hydrogen etc.
Morphysorb Syngas Cleanup Evaluation for IGCC

(EPRI/Worley Parsons Study)

> In Process – no results as of now

> Basis:
  - 600 MW plant
  - 5 ppm COS and ~0.5 vol% H₂S in syngas
  - With and w/o CO₂ removal cases
  - Without, the target is 15 ppmv S in gas to turbines
  - With, the target is 4% CO₂ in turbine gas and CO₂ with 0.1% S
  - Oxygen-fed (COPE) Claus unit
  - TGT with hydrogenation and recycle
Process Arrangements

> Numerous process configurations are possible involving multiple columns, multiple flashes, stripping gas, vacuum flash, heated regeneration, solvent chilling and so on

> Similar process configurations to competitive processes should also work for Morphysorb

> Product specs, gas composition, $\text{H}_2\text{S}/\text{CO}_2$ ratio, total sulfur capacity affect choices

> Example schemes follow
Syngas Evaluation Case – CO$_2$ Removal
Conclusions

- Morphysorb® has proven very reliable and efficient for natural gas bulk removal application
- May be viable and beneficial for syngas treating but at a minimum, pilot plant data are needed
- A solvent swap with an existing physical solvent application may be possible, as performed for natural gas application
- A competitor to existing physical solvent options would be of value to the budding gasification industry to keep prices competitive
- On the basis of Uhde’s vast gasification experience and GTI’s dedicated efforts in advancing gasification and gas treatment technologies, GTI/Uhde will continue to advance Morphysorb® for multiple applications throughout studies, pilot and demonstration applications