A Portrait of the SÜD-CHEMIE Group

SÜD-CHEMIE GROUP PRODUCTS DIVISIONS

- ADSORBENTS
- CATALYSTS

SÜD-CHEMIE GROUP

Comprises SÜD-CHEMIE AG the parent company and over 60 subsidiaries and joint ventures, in 25 countries.

- Annual Sales: 1.2 Billion EURO in 2008
- Employees: Approx. 5,000

SÜD-CHEMIE AG:

Shareholder company, founded 1857
Headquarters Munich, Germany

Creating Performance Technology
Süd-Chemie Group
Catalysts Division

Catalytic Technology
- Refinery
- Petrochemicals
- Chemicals
- Olefin Polymerization

Energy and Environment
- Air Purification
- Fuel-Cell Technology
- Energy Storage
Sud-Chemie Global Presence

Region 1
EMEA (+China)
- Novomoskovsk
- Severodonetsk
- Nanjing (2009)

Region 2
Americas
- Little Ferry
- Louisville (SP & WP)
- Heufeld
- Moosburg
- Novara
- Al-Masseid
- Sasolburg
- Richardsbay

Region 3
Asia Pacific
- Bitterfeld
- Panjin
- Toyama
- Shimonoseki
- Kujang
- Jinshan

Region 4
India
- Baroda

Region 3-1
SEA

Production Site (17+3)
Sales & Tech. Center (5)
R&D Center (9)
Sales Office (22)
Süd-Chemie Group
Worldwide Presence: Research and Development

- Catalysts
- Adsorbents
Why Catalysts?
What do they do?

- In general terms, a catalyst is described as a substance that **INCREASES** the rate of a reaction without being **CONSUMED** by the reaction.

- Most commercially important reactions are just not **FAST** enough to be viable without the use of a **CATALYST**.
Catalysts for Petrochemicals
Catalysts for Petrochemical Applications

**Olefins Conversion/Purification:**
- Selective Hydrogenation
  - OleMax® G83/G58 Series
- Poison Guards
  - Actisorb®
  - Monomer Purification
  - PolyMax®
- Iso-octene Hydrogenation
  - (KBR/Neste/FORTUM) – SF-800

**Aromatics Processing**
- Alkylation to EB
  - EBUF/EBEMAX
- EB to Stryene
  - Styromax®
- Toluene Disproportionation
  - TDP1
- Xylene Isomerization
  - Isoxyl

**Olefin Production:**
- Alkane Dehydrogenation Houdry® Process
  - Catofin® & Catadiene® catalyst
- Other custom catalysts
Olefins Purification – OleMax ®

- C2 Front end Hydrogenation
- C2-Tail end Hydrogenation
- C3-MAPD Hydrogenation
- C4-Stream Hydrogenation *(various process options)*
- PYGAS Hydrogenation
Styrene is produced by the dehydrogenation of ethylbenzene

\[ \text{C}_6\text{H}_5\text{-CH}_2\text{CH}_3 \leftrightarrow \text{C}_6\text{H}_5\text{-CHCH}_2 + \text{H}_2 \quad \Delta H = \sim 29 \text{ kcal/mol} \]
Propane Dehydrogenation

\[ \text{C}_3\text{H}_8 \rightarrow \text{C}_3\text{H}_6 + \text{H}_2 \]

Isobutane Dehydrogenation

\[ \text{i-C}_4\text{H}_{10} \rightarrow \text{i-C}_4\text{H}_8 + \text{H}_2 \]
Houdry Overview

- Manufacture Proprietary Cr$_2$O$_3$/Al$_2$O$_3$ Catalysts
- Own Commercial Processes
  - Dehydrogenation for production of olefins
    - CATADIENE® for 1,3-Butadiene
    - CATOFIN® for i-Butylene and Propylene
  - Hydrodealkylation to produce high purity benzene
    - PYROTOL® - pyrolysis gasoline
    - LITOL® - coke oven light oil
    - DETOL® - alkylaromatics
- Engineering and Licensing partner – CBI/Lummus
Catalysts for Chemicals
Typical Flowsheet for NH₃ Plant

Process Objective:
High purity H₂ and N₂ stream at ~3:1 ratio

Secondary Reformer to allow addition of N₂ required for the reaction

Synthesis Loop:
3H₂ + N₂ ↔ 2NH₃
Evolution of Reforming Catalysts

- More activity
- Less pressure drop
MegaMethanol Process / Coal based - MegaMax

COAL

Coal Gasification → Sour Gas Shift → Syngas Purification → Methanol Synthesis → Methanol Distillation

Air Separation

Oxygen → Air

Purge gas Recycle

Pure Methanol
<table>
<thead>
<tr>
<th>Chemical</th>
<th>Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde (FA) from Methanol</td>
<td><strong>FAMAX</strong>®</td>
</tr>
<tr>
<td>Ethylene Dichloride (EDC) by oxychlorination</td>
<td><strong>OXYMAX</strong>®</td>
</tr>
<tr>
<td>Maleic Anhydride (MA) from Butane (Scientific Design)</td>
<td><strong>SYNDANE</strong>®</td>
</tr>
<tr>
<td>Ethylene Oxide (EO) (Scientific Design)</td>
<td><strong>SYNDOX</strong>®</td>
</tr>
<tr>
<td>Phthalic Anhydride (PA) from o-Xylene</td>
<td><strong>PHTHALIMAX</strong>®</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td><strong>SULFOMAX</strong>®</td>
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Products & Applications
SC maintains a position of leadership or co-leadership in the supply of catalysts for oxychlorination, formaldehyde and terephthalic acid.

- **OXYMAX**: for synthesis of 1,2-dichloroethane by oxychlorination.
  - 7 catalyst types available for standard processes

- **FAMAX**: for oxidative dehydrogenation of methanol to yield formaldehyde.
  - 6 catalyst types are currently available

- **H2MAX5/HAR**: for selective hydrogenation of ethylanthraquinone to ethylanthrahydroquinone to produce hydrogen peroxide.
  - 4 catalyst types available

- **H2MAX50/HD**: for the purification of terephthalic acid by hydrogenation.
  - 2 types of catalysts have been developed
Catalysts & Adsorbents for Refineries
Refinery – H₂ Production

PT CO Shift
ShiftMax 120 (C12-4)
ShiftMax 100

DMW

CH₃OH = VOC

Refinery – H₂ Production

Primary Reformer
ReforMax 250 (C11-NK)
ReforMax 210 (G91)
ReforMax 330 (G90)

Purification
HDMX 200 (C49)
HDMX 310 (20-7)

Actisorb S2 (G-72D)
Actisorb S3 (G-72E)

LT CO Shift
ShiftMax 240
ShiftMax 210 (C18-7)
ShiftMax 200

Methanation
METH 134 (C13-4)
Refinery – Naphtha Upgrading

**Operating Conditions:**
- Temperature: 250 °C
- Pressure: 25 barg
- LHSV: 1.5 h\(^{-1}\)
- \(\text{H}_2/\text{HC}\)-Ratio: 1.0

**HYSOPAR® - Zeolite Catalyst**
- Medium Operating Temperature
- High Catalyst Activity
- Low Investment & Operating Cost
- No Corrosion Risks
- Tolerates Water & Sulphur
- Feed Pretreatment optional
- Catalyst is regenerable
Refinery - Polygasoline

- Feed Pretreatment
- Feed Surge Drum
- \(C_3=C_4=\) Fresh Feed
- \(H_2O\) Drain
- \(LPG\) Recycle
- Quench
- Reactor
- Stabilizer
- Depropanizer
- Polygasoline
- Spent Propane
- Spent Butane
What is Solid Phosphoric Acid Catalyst?

- 25% free acid supported on a solid phase of primarily silicon phosphate(s)
- At least two forms of crystalline silicon phosphates can exist in the catalyst
  - silicon orthophosphate - \( \text{“Si}_4(\text{PO}_4)_6 \)"
  - silicon pyrophosphate - \( \text{SiP}_2\text{O}_7 \)
- the free acid is the active catalyst
Refinery - Gas To Liquids

SÜD-CHEMIE Perfectly Covers the Whole Portfolio of Catalysts Involved in GTL (Gas To Liquids) Synfuels Technology

- Market Leader in Syngas Catalysts
- Long-term Experience with Fischer-Tropsch Catalysts
- Leading Supplier of advanced Zeolite Catalysts for
  - Upgrading of light Hydrocarbons
  - Downstream Processing to High Value Special Products

SÜD-CHEMIE is the Partner for GTL Catalyst Technology
Refinery – Contaminant Removal

**ActiSorb ® Series of Adsorbents for various applications**

- Sulfur Guards based on Ni, Cu-Zn, ZnO, Zn-Mn
- Desulfurization upstream of semi-regenerative reformer to remove organic Sulfur and H2S
- Arsine and Sulfur Removal from Refinery Propylene (related to FCC units)
- Gas and Liquid phase Chloride Treaters in CCR Units as alternate to Aluminas
- Sulfur Impregnated carbon for Natural Gas purification – Hg Removal
- Silver on Alumina adsorbent for gas phase Hg removal
Catalysts for Polymerization
C-MAX® PP Catalyst Portfolio
Overview

Catalyst Type:
- Highly-optimized 4th Generation-MgCl₂-based Ziegler-Natta catalyst system

Product Range:
- Homopolymers
- Impact Copolymers
- Random Copolymers

Process Platforms served by C-MAX catalysts:
- Bulk loop process platform
- Stirred bulk processes
- Stirred-bed gas phase processes
- Fluidized-bed gas phase processes
Energy and Environment
Air Purification
BEE Air Purification: Market Segments

1. Semiconductor Industry
2. System Integrator (VOC, DeNOx, DeN₂O, etc.)
   - Chemical Industry
   - Coating and Printing Industry
   - Appliances, Airplanes
3. Power generation
   - Stationary Gas-/Diesel Engines, Turbines
   - Nuclear Industry
4. Mobile Engines
   - Motorcycles
   - Off-road
   - Retrofit
5. Zeolites
   - Cold start (DOC, TWC)
   - SCR, DeNOx
Markets & Applications

- Commercial Printing
- Flexible Packaging
- Wood Products
- Pulp & Paper
- Pharmaceuticals
- Metal Decorating
- Converting
- Coating
- Painting/Finishing
- Baking/Food Processes
- Chemical Processing
Chemical off-gas Treatment

- Acrylic Acid (AA)
- Polyethylene Terephthalate (PET)
- Phthalcic Anhydride (PA)
- Purified Terephthalic Acid (PTA)
- Acrylonitrile (AN)
- Phenol
- Maleic Anhydride (MA)
- Nitric Acid (DeN₂O)
- Methyl Methacrylate (MMA)
- Formaldehyde (FA)
- Urea Production (H₂ removal in CO₂)
**RECUPERATIVE CATALYTIC OXIDIZERS**

- Skid-Mounted Designs
- Handle air flows up to 85,000 Nm3/hr
- Cost-efficient way to Control
  - VOC’s
  - Air Toxics
  - Odor Emissions
- Low CO & NOx compared to Thermal Systems
- Meets destruction removal efficiency (DRE) of up to 99+%  
- Heat “Recuperated” up to 70% via Heat Exchanger
Catalytic incinerator - recuperative
Catalytic incinerator - recuperative
Catalyst Modules: Ceramic and Metallic Supports
Thank You Very Much
For Your Attention!

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