Technology Licensing for the Petrochemical Industry

Budapest, 13/10/2015 | Dirk Burghardt | Sales Director Licensing and Technology, Downstream & Petrochemicals
The Air Liquide Group

Large Industries
- Air gases and hydrogen
- 15-year contracts
- Pipeline networks
- Industrial basins

Industrial Merchant
- Bulk and cylinder gases
- 80 countries
- Wide variety of sectors and customer sizes

Healthcare
- Hospitals
- Homecare
- Hygiene

Electronics
- Carrier gases
- Specialty gases
- Equipment and Installations

Other activities
- Welding & Cutting
- Diving
- Specialty chemicals

Cryogenics Lurgi
- Design, Engineering & Construction of leading-edge processing facilities
- Plants for AL Group and 3rd Party Clients

- Synthesis Gas Production
- Air Separation Plants
- Methanol & MTP
- Natural gas conditioning
- Petrochemicals
- Oleochemicals, Biodiesel
- Fischer-Tropsch GTL
Agenda

1. Petrochemistry – General
2. 1,3-Butadiene
3. Benzene (Distapex®)
4. Acrylic Acid
5. Melamine
Air Liquide E&C features special expertise in
- Oxidation
- Extraction
- Hydrogenation

Petrochemistry General – Technology Map

Air Liquide, world leader in gases, technologies and services for Industry and Health
Technology Portfolio – Business Model

Proprietary Technologies
Own Research & Development

Distapex®

Alliances
NIPPON KAYAKU
HEXION

Edgein
Acrylates
Melamine

Technology Portfolio

Acrylic Acid

Aquisition
BP

Butadiene

(Semi-) Exclusive Partnerships

Cryogenics Lurgi

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Global Butadiene Demand - Outlook

- Global Consumption 2013: 10.5 mio tons
- Expected Average Annual Growth Rate 2013 – 2020: 3.2 %
  driven by growth in demand for ABS, SBR, and Butadiene Rubber

**BD Consumption 2013**

-**Asia Pacific** 55%
-**North America** 17%
-**Western Europe** 16%
-**Central Europe** 3%
-**Middle East & Africa** 1%
-**South America** 3%
-**Eastern Europe** 5%

**BD Consumption Growth 2000 - 2013**

**BD Consumption Growth 2013 - 2020**

Source: Nexant, Mai 2014
Butadiene Experience and Partnership

Early 1960's

NMP Process invented by BASF

1958

Lurgi's First Butadiene Reference
Esso (CAA) Technology

1968

First BASF Plant built by Lurgi

Since 1990

Lurgi projects based on
Esso (CAA)
Shell (ACN)
Nippon Zeon (DMF)
BASF (NMP)

BASF
Technology Owner

Lurgi
Sublisensor for BASF NMP Process

Continuous Improvements
BASF NMP Technology Features

- Worldwide recognized technology
  - Safe
  - Eco-Efficient
  - Reliable
  - Low environmental impact

- 57 References in total
- 30 since Y2000
Butadiene Extraction Technology - Challenges

- Separation of Butadiene from a complex Mix of C4
- C4 Mix is different in each individual project
- Operational Difficulties
  - Popcorn Formation
  - Foaming
  - Fouling

![Diagram showing Butadiene Extraction Technology]

- C4 Feed → Extractive Distillation → Raffinate
- C4 Feed → Extractive Distillation → C4 Acetylenes
- Distillation → Propyne
- Distillation → C4 / C5
- Butadiene

Legend:
- C4 Acetylenes
- C4 Feed
- Raffinate
- Propyne
- Butadiene
- C4 / C5
AL E&C has long-term competence in Hydrocarbon Extraction
Besides standard process concepts we offer tailor-made solutions to meet the specific requirements of its clients
Active Contribution to continuous process improvements with regard to:
- Popcorn Formation
- Foaming
- Fouling

Source: Popcorn Issue Group (European Ethylene Producers Committee)
10 References since 2005, 4 in 2012, 36 in total

**OXENO**, Marl  
+ 36,000 tpa (2006)

**BASF**, Ludwigshafen  
+ 14,000 tpa (2008)

**Russian Federation**  
105,000 tpa (2012)

**EVONIK**, Antwerp, Belgium  
100,000 tpa (2012)

**OMV**, Schwechat, Austria  
+ 12,000 tpa (2012)

**Copesul**, Triunfo  
+ 103,500 tpa (2005)

**Petrobras**, Rio  
+ 165,000 tpa (2008)

**ONGC**, Gutjarat  
126,600 tpa (2009)

**HALDIA**, India  
+ 25,000 tpa (2007)

**MOL**, Tiszaujvaros, Hungary  
130,000 tpa (2012)
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Global Benzene Demand - Outlook

- Global Production 2014: 45 mio tons
- Expected Average Annual Growth Rate 2015 – 2020: 3.5%
  driven by growth in demand Styrene, Phenol & Cyclohexane

Source: Platts
Distapex® Proprietary Technology - Challenges

- Separation of Benzene from a complex Mix of Pyrolysis Gasoline
- C6 Mix is different in each individual project
AL E&C Frankfurt - The Technology Partner of Choice

- AL E&C has long-term competence in Hydrocarbon Extraction
- Lurgi technology developed in 1960s and continuously improved
- Reference capacities ranging from 20,000 tpa up to 400,000 tpa

- Use of same solvent as in Butadiene Extraction (NMP)
  - Synergies for Cracker operators
  - Advanced competences available with AL E&C Frankfurt

- Outstanding solution for Benzene production
  - High purity and high Benzene yield
6 Aromatics References since 2003, 25 in total

**SABIC, The Netherlands**
280,000 tpa (2005)

**OMV, Burghausen**
+ 10,000 tpa (2003)

**Gexaro, France**
252,000 tpa (2005)

**Petrochimica Uniao, Brazil**
+ 123,000 tpa (2007)

**OPaL, India**
165,000 tpa (2009)

**HALDIA, India**
+ 77,000 tpa (2005)
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Global Acrylic Acid Demand - Outlook

- Global Consumption 2014: 5.2 mio tons
- Expected Average Annual Growth Rate 2014 – 2019: 3.8%
driven by growth in demand for SAP and Acrylic Esters

Source: Nexant
Acrylic Complex and Alliances

- Single Line Responsibility for EAA, GAA and Acrylates

- Licensing
- Engineering
- Marketing

- Proprietary Catalyst

- Proven Technologies
- 30 Years Experience
- Operational Excellence

Technologies licensed by AL E&C Frankfurt
Acrylic Acid Technology - Challenges

- Complex Reactor System
- Oxidation of Propylene: avoid flammable envelope
- Potential Polymerization of Acrylic Acid
Lurgi / NK Acrylic Acid – Features

- Reactor Design in Cooperation with a Reknown Manufacturer
- Single train capacity up to 160 ktpa
  - Lowest CAPEX
- Safety Standards for HC Oxidation fully mastered
- Highest performance catalyst on the Market
  - Lowest OPEX
  - Feedstock: Refinery Grade Propylene (> 80 wt.%)  

- Technological Features to prevent Polymerization
  - Internal Thermoplate Heat Exchangers
  - Use of Baffle Trays in Columns

- Minimum Health & Environmental Impact
  - Non-toxic Extraction Solvent
  - Minimized Waste Generation
3 References, 2 World-scale, July 2015: BPCL, India

- **Start-up: 2002**
  - **Hexion**, Sokolov, Czech Republic
  - **30,000 tpa**

- **Start-up: 2012**
  - **CNOOC**, Huizhou, Guangdong, China
  - **140,000 tpa**

- **BPCL**, Kochi, Kerala, India
  - **160,000 tpa**
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Global Melamine Demand - Outlook

- Global Consumption 2014: 1.6 mio tons
- Expected Average Annual Growth Rate 2013 – 2017: 4.6%
driven by growth in demand for Laminates and Adhesives

Source: National Energy Corporation
Melamine – Alliance

Edgein Technology Developer & Producer
- Technology Owner
- Vast Operation Experience
- Reference Plants
- Training at Site
- Site Visits
- Technical Assistance

ALLIANCE

Advanced Technology

Licensing and Know-How Package

Client

AL E&C Frankfurt Technology Licensor & Engineering
- Technology Licensing
- Value Engineering and Process Optimization
- Marketing
- Engineering
- Project Execution World Wide

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Melamine Technology – Challenges

- Complex Fluidized Bed Reactor
- Efficient Solids Handling
- Efficient Product Separation
- Avoid Corrosion Problems
- Gas Phase Crystallization
- Handling of Desublimation and Solid Product
- Prevention of Fouling
Melamine References

Start-up: 2012

NevAzot, Stavropol, Russia

50,000 tpa

Since 1993: 18 Plants

Golden Elephant, China

Total capacity: 400,000 tpa
Conclusion

- Air Liquide E&C cultivates Competences in:
  - Hydrocarbon Processing
  - Technology Research & Development
  - Management of Industrial Alliances
  - Acquisition of Technologies
  - Technological Challenges
  - Safety
  - Reliability
  - Conceptional Solutions
  - Effective Project Execution

Air Liquide E&C is the Technology Partner of Choice