Polymer Industry – Feedstock Revolution?

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Agenda

1. Borealis

2. Borealis Monomer Technologies

3. Ethylene and propylene products

4. Challenges for European PO Industry
Borealis – taking on the challenges of tomorrow for more than 50 years
Borealis – taking on the challenges of tomorrow for more than 50 years

- Around **6,200 employees** worldwide committed to Borealis values
- Customers located in over **120 countries**
- Unique **Borstar® technology** to develop polyolefin solutions that are tailored to customers’ needs
- Proprietary **Sirius catalyst technology** enabling products with high purity and wide property range
- Strong presence in the Middle East and Asia thanks to the joint venture with **ADNOC - Borouge**
Borealis & Borouge – A winning combination

Borouge is a joint-venture between Borealis and the Abu Dhabi National Oil Company (ADNOC).

40% ← Production Company → 60%
50% ← Marketing Company → 50%
Borealis provides pioneering solutions in three business areas

**Borealis Polyolefins**
Borealis works closely with its customers and industry partners to provide innovative and value-creating plastics solutions that increase end-product safety, reduce weight, lower costs and enable integration of parts.

**Borealis Base Chemicals**
Borealis continues to develop its profitable Base Chemicals business building on unique feedstock technology, logistics and integration strengths.

**Borealis Fertilizers**
By the end of 2014, Borealis will supply five million tonnes of fertilizers and technical nitrogen products per year via its Borealis L.A.T. distribution network.

Borealis is the leading fertilizer company in Central and South East Europe with strong ambitions for further growth.
From new technologies to services and solutions – everything we do is rooted in a clear strategy

- **Grow** our PO business in Infrastructure, Automotive and Advanced Packaging
- **Expand** Borouge to supply growth in the Middle East and Asia and leverage into Europe
- **Pursue** operational excellence, considering safety at all times
- **Exceed** in serving our customers with a focus on quality and reliable execution
- **Strengthen** our European Base and ensure cost competitiveness from feedstocks to customers
- **Drive** productivity in Base Chemicals with a focus on growth in fertilizers and strengthening the crackers asset base and business
- **Achieve** a step change in innovation
- **Continue** to develop our cross-cultural organisational capability and learning organisation
“Hardware & Software”: Borstar® Technology with Borealis Sirius Catalyst

Proprietary Catalyst + Proprietary Process → Functionalised Products

Control catalytic site specificity and particle morphology

Differentiated products through enhanced control of polymer structure
Borealis Monomer Plants - Europe

- Porvoo
  - Steam Cracker
  - Ethylene
  - Propylene

- Stenungsund
  - Steam Cracker
  - Ethylene
  - Propylene

- Kallo
  - Propane DeHy
  - Propylene

- OMV Burghausen
  - Steam Cracker
  - Metathesis

- OMV Schwechat
  - Steam Cracker
  - Ethylene
  - Propylene
Borouge Monomer Plants - UAE

Ruwais
Steam Cracker & OCU
Borouge 1: 600 kt/a ethylene
Borouge 2: 1500 kt/a ethylene
   OCU: 750 kt propylene
Borouge 3: under construction
   1500 kt/a ethylene (on stream)
Feedstock Composition and Consequences

**Required for Polyolefines:**

<table>
<thead>
<tr>
<th>Naphtha &amp; NGL’s</th>
<th>Heavies (Heavy Oil)</th>
<th>Methane (NG)</th>
<th>Coal (Anthracite)</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH$_2^{-}$&lt;2.5</td>
<td>CH$_{&lt;1.4}$</td>
<td>CH$_4$</td>
<td>CH$<em>{0.8}$O$</em>{0.1}$</td>
<td>CH$<em>{1.5-1.6}$O$</em>{0.6-0.7}$</td>
</tr>
<tr>
<td>Ideal Composition</td>
<td>Hydrogen deficient</td>
<td>Hydrogen surplus High stability</td>
<td>Hydrogen deficient</td>
<td>Hydrogen deficient Oxygen surplus</td>
</tr>
<tr>
<td>Liquids handling “Simple” Logistics</td>
<td>More complex logistics – up to 30% diluent!</td>
<td>Logistics well developed – LNG, Pipeline, (CNG)</td>
<td>Solids handling Logistics exist</td>
<td>Density &amp; collection radii pose challenge</td>
</tr>
</tbody>
</table>

**Energy Density decreases**

**Mass Efficiency decreases**

**Conversion technology complexity increases**

**CAPEX/OPEX increase**

**Sustainability (energy, CO$_2$) decreases*)**

*) Biomass represents an exception
Petrochemical feedstocks are generally produced from the refining of crude oil or the processing of natural gas. Alternative process routes utilizing coal, biological hydrocarbons and unconventional natural gas, particularly shale gas, have recently gained more attention as potential feedstock sources.
Borealis Monomer Technologies
Borealis Monomer Technologies

High temperatures ~1000°C
short residence time

Porvoo: naphtha steam cracker
Stenungsund: flexible set-up from steam naphtha and LPG cracker
Borouge: Ethane cracker, which makes only ethylene
**Propane Dehydrogenation: Catofin Technology in Kallo, Belgium**

\[
\begin{align*}
\text{C}_3\text{H}_8 & \xrightleftharpoons{\text{Cat.}} \text{C}_3\text{H}_6 + \text{H}_2 \quad \Delta H = 120 \text{ kJ/mol} \\
\text{Propane} & \quad \text{Propylene} \quad \text{Hydrogen}
\end{align*}
\]

- Endothermic reaction
- Propylene formation is limited by equilibrium
- Reaction is favored by low pressures and high temperatures
Propane dehydrogenation (PDH)
Olefin Conversion Unit (OCU)

Metathesis offers an attractive way to produce propylene:

2-Buten supply from two sources:
1. Naphtha steam cracking
2. OCU: Ethylene dimerisation and subsequent metathesis with ethylene
Olefin Conversion Unit (OCU)

Worlds biggest OCU unit at Borouge 2
750 kt/a propylene
Ethylene and Propylene Feedstock
Global ethylene consumption is forecast to grow at an average annual growth rate of 3.9% to 2020.
Global propylene consumption is forecast to grow at an average annual growth rate of 4.3% to 2020.

Polypropylene and PO dictate the global growth outlook.
Challenges for European PO Industry
Challenges for the European Petrochemical Industry

## Changes in the Petrochemical Industry

New projects may raise US ethylene capacity by 52%, PE by 47%

### US Planned Ethylene Expansions Based on Shale Gas

<table>
<thead>
<tr>
<th>Company</th>
<th>C2 capacity</th>
<th>Downstream</th>
<th>Location</th>
<th>Start-up</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW CRACKERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chevron Phillips Chemical</td>
<td>1.5m tonnes</td>
<td>HDPE, LLDPE</td>
<td>Cedar Bayou, Texas</td>
<td>mid-late 2017</td>
<td>Construction early 2014</td>
</tr>
<tr>
<td>ExxonMobil Chemical</td>
<td>1.5m tonnes</td>
<td>PE</td>
<td>Baytown, Texas</td>
<td>Late 2016</td>
<td>Permitting expected to be complete early 2014</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>1.5m tonnes</td>
<td>LDPE, other PE,</td>
<td></td>
<td>2017</td>
<td>EPC stage; permitting process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EPDM, elastomers,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Freeport, Texas</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>LAO (JV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LDPE, LLDPE, EO,</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sasol</td>
<td>1.5m tonnes</td>
<td>MEG, detergent</td>
<td>Lake Charles, Louisiana</td>
<td>2017</td>
<td>FEED, EPC stage; permitting, FID to come in 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>alcohols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formosa Plastics</td>
<td>1.0m tonnes</td>
<td>LDPE, MEG</td>
<td>Point Comfort, Texas</td>
<td>Q1 2017</td>
<td>Permitting process</td>
</tr>
<tr>
<td>Formosa Plastics</td>
<td>1.2m tonnes</td>
<td>NA</td>
<td>Louisiana</td>
<td>NA</td>
<td>Feasibility stage</td>
</tr>
<tr>
<td>Occidental Chemical/Mexichem</td>
<td>544,000 tonnes</td>
<td>EDC, VCM</td>
<td>Ingleside, Texas</td>
<td>2017</td>
<td>Construction mid-2014; permits complete</td>
</tr>
<tr>
<td>Axial/Partner</td>
<td>World-scale</td>
<td>NA</td>
<td>Louisiana</td>
<td>2018</td>
<td>FEED work, permitting</td>
</tr>
<tr>
<td>Shell</td>
<td>World-scale</td>
<td>PE, MEG</td>
<td>Monaca, Pennsylvania</td>
<td>2019-2020*</td>
<td>Feasibility stage</td>
</tr>
<tr>
<td>Odebrecht</td>
<td>World-scale</td>
<td>PE</td>
<td>Wood County, West Virginia</td>
<td>NA</td>
<td>Feasibility stage</td>
</tr>
</tbody>
</table>

30 percent of global propylene supply will be from unconventional sources by 2025

- Overview
  - Propylene production from steam cracking is declining in some areas due to the preference for lighter feeds.
  - PDH has been through a phase of major expansion in the Middle East, but the focus is now moving to China and the United States.
  - Methanol-based developments are so far all in China, and mainly based on coal/methanol. Projects are now being developed in gas-advantaged regions such as Central Asia and the United States.
# Changes in the Petrochemical Industry

## Recent and Ongoing PDH Projects

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Country</th>
<th>Capacity (tpa)</th>
<th>Start-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujian Meide Petrochemical</td>
<td>Fujian</td>
<td>China</td>
<td>660,000</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Jiangsu Haixi Chemical</td>
<td>Dafeng City, Jiangsu</td>
<td>China</td>
<td>510,000</td>
<td>2014</td>
<td>UOP technology</td>
</tr>
<tr>
<td>Ningbo Haiyu New Material</td>
<td>Ningbo City, Zhejiang</td>
<td>China</td>
<td>600,000</td>
<td>2014</td>
<td>Lummus technology</td>
</tr>
<tr>
<td>Shaoxing Sanyuan Petrochemical</td>
<td>Nantong</td>
<td>China</td>
<td>450,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Shaoxing Sanyuan Petrochemical</td>
<td>Shaxing</td>
<td>China</td>
<td>450,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Tianjin Bohai Chemical Industry Group</td>
<td>Tianjin</td>
<td>China</td>
<td>600,000</td>
<td>2013</td>
<td>Lummus technology</td>
</tr>
<tr>
<td>Tianjin Bohai Chemical Industry Group</td>
<td>Tianjin</td>
<td>China</td>
<td>600,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Tianjin Bohua Petrochemical</td>
<td>Tianjin</td>
<td>China</td>
<td>600,000</td>
<td>2013-H1</td>
<td></td>
</tr>
<tr>
<td>Yantai Wanhua Polyurethanes</td>
<td>Yantai, Shandong</td>
<td>China</td>
<td>600,000</td>
<td>2014-H2</td>
<td></td>
</tr>
<tr>
<td>Zhangjiagang Yangzijiang Petrochemical</td>
<td>Zhangjiagang</td>
<td>China</td>
<td>600,000</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Zhangjiagang Yangzijiang Petrochemical</td>
<td>Zhangjiagang</td>
<td>China</td>
<td>600,000</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>Zhejiang Julong</td>
<td>Pinghu, Zhejiang</td>
<td>China</td>
<td>450,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Zhejiang Julong</td>
<td>Pinghu, Zhejiang</td>
<td>China</td>
<td>750,000</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Zhejiang Shaoxing Sanjin Petrochemical</td>
<td>Zhejiang</td>
<td>China</td>
<td>450,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Egyptian Propylene &amp; Polypropylene Co. (EPPC)</td>
<td>Port Said</td>
<td>Egypt</td>
<td>400,000</td>
<td>2010-Oct</td>
<td></td>
</tr>
<tr>
<td>OPC (Oriental Petrochemical Co.)</td>
<td>Gulf of Suez</td>
<td>Egypt</td>
<td>250,000</td>
<td>2015-H1</td>
<td>Ude technology</td>
</tr>
<tr>
<td>Mehr Petro Kimia</td>
<td>Pars Special Economic Energy Zone, Iran</td>
<td>Iran</td>
<td>450,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Kazakhstan Petrochemical Industries (KPI)</td>
<td>Atyrau</td>
<td>Kazakhstan</td>
<td>500,000</td>
<td>2013</td>
<td>Lummus technology</td>
</tr>
<tr>
<td>Sibur</td>
<td>Tobolak</td>
<td>Russia</td>
<td>510,000</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Al-Waha Petrochemical</td>
<td>Al Jubail</td>
<td>Saudi Arabia</td>
<td>450,000</td>
<td>2009-May</td>
<td></td>
</tr>
<tr>
<td>National Petrochemical Industrial Co (NatPet)</td>
<td>Yanbu</td>
<td>Saudi Arabia</td>
<td>400,000</td>
<td></td>
<td>UOP technology</td>
</tr>
<tr>
<td>National Petrochemical Industrial Co (NatPet)</td>
<td>Yanbu</td>
<td>Saudi Arabia</td>
<td>400,000</td>
<td>2008-Dec</td>
<td></td>
</tr>
<tr>
<td>HMC Polymers</td>
<td>Mah Ta Phut</td>
<td>Thailand</td>
<td>300,000</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>Abu Dhabi Oil Refining (Takreer)</td>
<td>Abu Dhabi</td>
<td>UAE</td>
<td>500,000</td>
<td>2013-H2</td>
<td>UOP technology</td>
</tr>
<tr>
<td>Dow</td>
<td>Freeport, Texas</td>
<td>US</td>
<td>750,000</td>
<td>2015</td>
<td>UOP technology</td>
</tr>
<tr>
<td>Dow</td>
<td>US</td>
<td>US</td>
<td>600,000</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>Formosa Plastics USA</td>
<td>Point Comfort, Texas</td>
<td>US</td>
<td>544,000</td>
<td>2010-Nov</td>
<td></td>
</tr>
</tbody>
</table>

Source: ICIS

IN EOS confirms Ente supply deal

07 May 2014 12:15  Source: ICIS News
(updates with INEOS comment in paragraphs 1-5)

LONDON (ICIS)--INEOS confirmed on Wednesday that it has reached an agreement to deal with US producer Enterprise Products Partners to supply ethane to its planned ethane mega terminal under developmen.

Additional ethane from the planned 240,000 bbl/day (b/d) facility in Houston, Texas, will be shipped to the company’s operations in the US.

Commentary: Borealis grabs US ethane

15 August 2014 10:38  Source: ICIS Chemical Business

Borealis has become the second European player to take advantage of the US shale gas revolution as it revealed plans in August to import US ethane to its Stenungsund cracker in Sweden.

It signed a 10-year agreement with US-based Antero Resources, starting in 2016 to supply 240,000 tonnes/year of ethane from the Marcellus and Utica shale formations in the northeastern US. For transport, Borealis has struck another deal for fractionation, pipeline and terminal services with Sunoco Logistics. The material will be transported by Navigator Holdings, which will build a 35,000 cubic metre ethane vessel equipped with dual fuel engines.

The company is also upgrading its flexible cracker at the site to enable more ethane cracking and is investing a total of €120m in the Stenungsund location for the logistics and cracker upgrade work. Borealis CEO, Mark Garrett told ICIS that the cracker upgrade will enable Stenungsund to produce more than
Summary

- Shale gas and shale oil based feedstock will drive more and more olefin industry towards LPG cracking and on-purpose monomer technologies.

- European monomer and polyolefin producers have to tackle the challenge of cost-disadvantaged feedstock and high manufacturing costs.


- Borealis reacts to this challenge by driving the business by excellence in safety, customer interaction, innovation and operations.

- Polymer Industry – Feedstock Revolution?
Thank you

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