Mike Banach
Sr. Business Leader, Olefins & Detergents

Take the Profitable Path to Olefins using UOP Technologies

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Pathways to Maximize Profitability …

**Feedstocks**
- Methane
- Coal

**Processes**
- UOP Advanced MTO Process

**Products**
- Ethylene
- Propylene

**Feedstocks**
- Propane
- Butane

**Processes**
- UOP Oleflex™ Process

**Products**
- Propylene
- Isobutylene
Tremendous Opportunities in Light Olefins

- World demand for ethylene and propylene growing (about 4%/yr)
- More than 50 MMTA of additional capacity will be needed by 2020
- Driven primarily by growing middle class in developing regions

Source: IHS Chemical

Population growth continues to drive demand for products derived from light olefins
Refinery Shifts Balance Away from Light Olefins

**Refinery Objective**

- Refinery economics favor diesel production over gasoline
- Less severe catalytic cracking, more mild hydrocracking produce less gasoline and less light byproducts

**By Products**

- Ethylene
- Propylene

Shift towards heavier diesel reduces byproduct light olefins
Cracker Feed Slate Swings Past Propylene

**Cracker Feeds**
- Ethane
- E/P Mix
- LPG
- Light Naphtha
- FBR Naphtha
- Gas Oil

**Cracker Products**
- Ethylene
- Propylene
- Butadiene
- Other C4 By-products
- Pygas

Shift to lower cost, lighter feeds results in decrease in propylene and heavier olefins, including butadiene.
Tremendous Opportunities in Light Olefins

**Light Olefin Supply**

- Growing share from “other” sources other than steam cracking and refineries
- Propylene gap continuing to grow
- Options for on-purpose olefin production include MTO, OCP, and Oleflex

Source: IHS Chemical

UOP technologies to meet your light olefin market demands
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MTO: Value Chain from Gas or Coal

Gas to Olefins (GTO)
- Natural Gas
  - Synthesis Gas Production
  - Methanol Synthesis
  - MTO
  - Ethylene & Propylene

Coal to Olefins (CTO)
- Coal
  - Methanol Synthesis
  - MTO
  - Ethylene & Propylene

MTO Connects Natural Gas and Coal to the Largest Commodity Petrochemicals – Ethylene and Propylene
UOP Advanced MTO Technology

- Highest Olefin Yield
- High P/E Flexibility
- Maximum Single Train Capacity
- Opportunity to Produce Butadiene

MTO Process Integrated with Olefin Cracking Process (OCP)

- Ethylene
- Propylene
- n-Butenes (optional)

OCP

TPC/UOP OXO-D™ Process

Butadiene (optional)

All processes licensed by UOP
A little more ethylene, a lot more propylene, and a lot less C$_4^+$ by-product

OCP integration increases light olefin yields by >15%

Yield Benefits from OCP Integration

2.6 tons of Methanol consumed per ton of light olefin produced

Light Olefin Carbon Yields, Wt-%

Propylene/Ethylene (P/E) Product Ratio, Wt.
The following projects in China have selected the UOP/INOVYN MTO™ Process:

<table>
<thead>
<tr>
<th>#</th>
<th>Owner</th>
<th>Location</th>
<th>Scope</th>
<th>Status</th>
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<td>1</td>
<td>Wison (Nanjing) Clean Energy Company, Ltd.</td>
<td>Nanjing, Jiangsu</td>
<td>MTO / OCP</td>
<td>Onstream 2013</td>
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<td>2</td>
<td>Jiutai Energy (Zhungeer) Company, Ltd.</td>
<td>Ordos, Inner Mongolia</td>
<td>MTO</td>
<td>SU 2017</td>
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<td>Shandong Yangmei Hengtong Chemicals Company, Ltd.</td>
<td>Linyi, Shandong</td>
<td>MTO / OCP</td>
<td>Onstream June 2015</td>
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<td>4</td>
<td>Jiangsu-Sailboat</td>
<td>Lianyungang, Jiangsu</td>
<td>MTO / OCP</td>
<td>SU 2016</td>
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<td>Shandong Better Energy</td>
<td>Dongying, Shandong</td>
<td>MTO / OCP</td>
<td>SU 2017</td>
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<td>China</td>
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<td>8</td>
<td>LUXI Chemical Group Co. Ltd.</td>
<td>Liaocheng, Shandong</td>
<td>MTO / OCP</td>
<td>Design</td>
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</tbody>
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LPG to High Value Olefins with Oleflex Process

**Feedstocks**
- Propane
- Propane + Isobutane
- Isobutane

**Products**
- Propylene
- Propylene + Contained Isobutylene
- Contained Isobutylene

**Uses**
- Fiber
- Packaging
- High performance plastic
- Gasoline Blending Components
- MTBE
- ETBE
- Iso-Octane
- Synthetic Rubbers & Acrylics

**UOP Oleflex Process**

Dedicated and Mixed Unit Applications
• UOP Oleflex Process used in 16 of the 23 operating PDH Units operating in the world today
Leverage UOP CCR Experience in PDH/BDH

- Positive Pressure / Pt Catalyst
- Lower Energy Usage
- Fewest & Smallest Reactors
- Catalyst Change-Out without Shutdown

**Reactor Section**

**Regeneration Section**

**Catalyst Flow**

- \( \text{C}_3 \) Oleflex Unit = 4 Rxs
- \( \text{C}_4 \) Oleflex Unit = 3 Rxs
- \( \text{C}_3/\text{C}_4 \) Oleflex Unit = 3 Rxs

>250 UOP CCR’s in Operation Today

**Product Recovery Section**
UOP Leads the Way in Dehydrogenation

- UOP has been awarded 34 of the last 39 competitively bid dehydro projects worldwide since 2011
- World’s Largest PDH at 1,000 kmta and 2 PDH Projects at 750 kmta propylene capacity

Chosen EVERY engagement 2015 – 4 PDH and 1 BDH
Why Customers Choose UOP Oleflex - I

• Lowest Overall Cost of Production:
  – Low feed consumption design available <1.15
  – Lowest gross / net energy usage
  – Lowest coke → Flexible byproduct disposition

• Smaller Investment Required
  – Fewest reactors on most compact plot space
  – Efficient regeneration requires smaller equipment
  – Constant equipment count → Best economy of scale

You can have both!
Get lowest CAPEX and OPEX in one design
Why Customers Choose UOP Oleflex - II

• **High Reliability / On-Stream Availability**
  – Constant process conditions
  – CCR technology well proven across the industry

• **Smallest Environmental Footprint:**
  – Lowest energy leads to lowest CO₂
  – Low NOx & VOC emissions
  – Non-toxic catalyst system
Take the Profitable Path with UOP Technologies

• Fundamentals remain strong for on-purpose olefin investments
  – Traditional sources will not meet demand
  – Cost-advantaged feedstocks
  – Now is the right time to invest in on-purpose technologies

• UOP’s Advanced MTO Process
  – Highest Olefin Yields with Flexible P:E Ratio
  – Leverage cost advantaged coal or gas to produce high value light olefins

• UOP’s Oleflex Dehydrogenation Technology:
  – Lowest Capital Cost & Energy Usage results in Lowest Operating Cost (CCOP) and Highest Return on Investment (ROI)