Take the Profitable Path to Olefins using UOP Technologies

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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
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 has the technologies to meet your light olefin demands
Pathways to Maximize Profitability …

**Feedstocks**

- Methane
- Coal

**Processes**

- UOP Advanced MTO Process

**Products**

- Ethylene
- Propylene

**Feedstocks**

- Propane
- Butane

**Processes**

- UOP Oleflex™ Process

**Products**

- Propylene
- Butylene
MTO: Value Chain from Gas or Coal

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

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

MTO Process Integrated with Olefin Cracking Process (OCP)

- Ethylene
- Propylene
- n-Butenes (optional)

MTO inovyn

Regen Gas

Air

Methanol

Water

DME Recovery

Light Olefin Recovery

Sep Section

C₄+

OCP

TPC/UOP OXO-D™ Process

Butadiene (optional)

Butylenes (optional)

TPC Group

UOP 7267-5

All processes licensed by UOP
Yield Benefits from OCP Integration

OCP integration increases light olefin yields by >15%

2.6 tons of Methanol consumed per ton of light olefin produced
## Commercialization Status

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>kmta LO Capacity</th>
<th>Status</th>
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<tbody>
<tr>
<td>1</td>
<td>Wison (Nanjing) Clean Energy Company, Ltd.</td>
<td>Nanjing, Jiangsu</td>
<td>MTO / OCP</td>
<td>300</td>
<td>On stream 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>600</td>
<td>SU 2018</td>
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<tr>
<td>3</td>
<td>Shandong Yangmei Hengtong Chemicals Company, Ltd.</td>
<td>Linyi, Shandong</td>
<td>MTO / OCP</td>
<td>300</td>
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<tr>
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<td>Shandong Better Energy</td>
<td>Dongying, Shandong</td>
<td>MTO / OCP</td>
<td>300</td>
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<tr>
<td>6</td>
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<td>China</td>
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<td>7</td>
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<td>SU 2019</td>
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<tr>
<td>8</td>
<td>LUXI Chemical Group Co. Ltd.</td>
<td>Liaocheng, Shandong</td>
<td>MTO / OCP</td>
<td>300</td>
<td>SU 2018</td>
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<tr>
<td>9</td>
<td>Connell Chemical Industrial Co. Ltd.</td>
<td>Jilin City, Jilin</td>
<td>MTO / OCP</td>
<td>300</td>
<td>SU 2017</td>
</tr>
</tbody>
</table>

Strong global interest continues – On stream unit operating successes
MTO Summary

• Strong demand growth for ethylene and propylene
• MTO opens a new path to ethylene and propylene starting from cost advantaged gas and coal
  – Low cost of production
  – High yield of ethylene and propylene (> 89%)
  – Flexible product ratio (P/E range 0.9 to 1.8, depending on configuration)
  – Byproduct C₄ olefins available for B1, B2, and BD production
• Single train capacity up to 1.8 million MTA of light olefin
• Commercialized in 2013 by Wison Clean Energy, 3 units on stream in 2016, 3 more by 2018
• Best technology available – UOP will help you evaluate MTO for your situation
Pathways to Maximize Profitability …

**Feedstocks**

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**Products**

- Ethylene
- Propylene

**Feedstocks**

- Propane
- Butane

**Processes**

- UOP Oleflex™ Process

**Products**

- Propylene
- Butylene
LPG to High Value Olefins with Oleflex Process

**Feedstocks**
- Propane
- Propane + Butane
- Butane

**Products**
- Propylene
- Propylene + Contained Butylene
- Contained Butylene

**Uses**
- Fiber
- Packaging
- Gasoline Blending Components
  - MTBE
  - Ethyl Tert-Butyl Ether (ETBE)
  - Iso-Octane
- Synthetic Rubbers & Acrylics

**Dedicated and Mixed Unit Applications**
C₃ Oleflex Complex

- UOP Oleflex Process used in 18 of the 28 operating PDH Units operating in the world today
  (Two C3 Oleflex at 750 KMTA – world’s largest PDH Units)
UOP Leads the Way in Dehydrogenation

UOP has been awarded 40 of the last 47 competitively bid dehydro projects worldwide since 2011.

Since first commercialized, 6 repeat customers and 5 takeaways from competition

Chosen in every engagement in 2015
6 wins out of 7 in 2016
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 CO$_2$
  – Low NOx & VOC emissions
  – Proven non-toxic compliant catalyst system
Take the Profitable Path with UOP Technologies

• Fundamentals remain strong for on-purpose olefin investments
  – Traditional sources will not meet demand
  – Low-cost coal or methane and propane
  – **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)
  – Selected in 35 of last 41 projects since 2011
  – **Process your LPG into profitable propylene or butenes**