Topics

1. UOP MTO Technology
2. MTO Projects in China
3. MTO / GTO / CTO Analysis
Advanced MTO Technology

MTO Process Integrated with Olefin Cracking Process (OCP)

MTO

- Methanol
- Air
- Water
- DME Recovery

Light Olefin Recovery

- Ethylene
- Propylene
- C₄+

OCP

- By-products

INEOS

Total
A little more ethylene, a lot more propylene, and a lot less C_{4+} by-product
OCP integration increases light olefin yields by 20%
Scale-up Progression

- ~1 kg/day of MeOH feed
- Multiple grades/sources of feed
- Reactor and regenerator configuration

1988 UOP Pilot Plant – Operation

- ~1,000 kg/day (maximum) of MeOH feed
- Multiple grades/sources of feed
- Reactor and regenerator configuration

1995 INEOS Demo Unit

- ~10,000 kg/day (10t/d) of MeOH feed
- Fully integrated Advanced MTO Process configuration

2009 Total Process Demonstration Unit

- ~10,000 kg/day (10t/d) of MeOH feed
- Fully integrated Advanced MTO Process configuration

- Multiple grades/sources of feed
- Reactor and regenerator configuration
# Commercialization Status

The following projects in China have disclosed the selection of the UOP / HYDRO MTO™ Process:

<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Scope</th>
<th>LO Capacity MTA</th>
<th>On-Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wison (Nanjing) Clean Energy Company, Ltd.</td>
<td>Nanjing, Jiangsu</td>
<td>MTO / OCP</td>
<td>295,000</td>
<td>Sept 2013</td>
</tr>
<tr>
<td>Jiutai Energy (Zhungeer) Company, Ltd.</td>
<td>Ordos, Inner Mongolia</td>
<td>MTO</td>
<td>600,000</td>
<td>Exp 2014</td>
</tr>
<tr>
<td>Shandong Yangmei Hengtong Chemicals Company, Ltd.</td>
<td>Linyi, Shandong</td>
<td>MTO / OCP</td>
<td>295,000</td>
<td>Exp 2014</td>
</tr>
<tr>
<td>Jiangsu Sailboat Petrochemical Co. Ltd.</td>
<td>Lianyungang, Jiangsu</td>
<td>MTO / OCP</td>
<td>833,000</td>
<td>Exp 2015</td>
</tr>
</tbody>
</table>
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1) Domestic olefin capacity based on refinery FCC (DCC) and naphtha cracking. Oil price increased from $40/BBL in 2000 to more than $100/BBL in 2008.

2) Oil self-sufficiency ratio fell from 70% in 2000 to less than 40% by 2013.

3) Gas is relatively scarce but coal is abundant.

4) Government support for technology development, demonstration, and pilot projects for conversion of coal into materials that substitute for oil.

   - Coal gasification
   - Direct and indirect CTL
   - Methanol to chemicals (olefins, DME, MEG, etc.)
Approximately 20 methanol-based light olefin projects in China are in operation, under construction, or in detailed design and procurement as of 1Q 2014.

One MTP and 3 MTO technologies have been commercialized as of 1Q 2014.
Two Types of MTO Projects in China

Type 1 – MTO (CTO) Projects
- Inland Locations (near mines)
- Mega-sites / Often State Sector
- Raw Material Driven
- Large Capacity Projects
- Mostly PE / PP

Type 2 – MTO Projects
- Coastal Locations
- Often Private Sector
- LO Derivative Driven
- Wide Range in Capacities
- Wide Range of Derivatives
Status of MTO in China

**General**

Domestic and imported methanol, and more recently imported propane (for propane dehydrogenation projects), are displacing naphtha as the preferred feedstock for domestic light olefin capacity additions.

**Type-I MTO Projects**

1) Coal to chemicals (CTC) projects provide good financial returns to the owners, and significant industrial development and employment benefits to local and provincial governments when compared to electric power projects.

2) The CO$_2$ footprint for CTO is large. Coal-derived synthesis gas requires H$_2$/CO adjustment (more H$_2$) via water-gas shift reaction (additional CO$_2$ created).

3) China’s coal deposits are generally located where water is scarce and the environment is fragile. Every new project is closely scrutinized by all levels of government, and project approvals are difficult to achieve.
Coal Chemicals in China

Type-II Projects

1) MTO projects are a good way for private sector companies in China to secure light olefins, and thereby gain access to attractive olefin derivative markets.

2) MTO projects in China have proven to be viable for light olefin capacities as small as 300 KMTA.

3) Merchant methanol markets are volatile, which creates considerable risk for any project based solely on spot market or short-term contract pricing. Chinese companies are securing long-term access to methanol made from lower-cost gas located outside of China.
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$1,300/MT transfer price for light olefin products
MTO Project NPVs

$1,300/MT transfer price for light olefin products
Methanol Price History

Source: CMAI
Average quarterly prices
Adjusted to constant 2013 US $

N America  W Europe  N Asia  S Asia
GTO Project Returns

$1,300/MT transfer price for light olefin products
GTO Project NPVs

- **1.0 MM MTA**
- **600 KMTA**
- **300 KMTA**

$1,300/MT transfer price for light olefin products
North American Energy Prices

Gas and coal valuations have decoupled from oil in North America.

Source: CMAI
Average quarterly prices
Adjusted to constant 2013 US $
Coal energy content = 27.9 GJ/MT (26.4 MM Btu/MT)
CTO Project NPVs

$1,300/MT transfer price for light olefin products
Capital Cost and CCOP

1 Million MTA Light Olefin Capacity

- **MTO**
  - Capital Budget: $1.0 Billion
  - CCOP: $400/MT Methanol

- **GTO**
  - Capital Budget: $2.0 Billion
  - CCOP: $6 per MM Btu Gas

- **CTO**
  - Capital Budget: $3.0 Billion
  - CCOP: $60/MT Coal

LO Cash Cost of Production $
Does MTO Have Any Role in India?

1) Domestic oil, gas, and coal reserves / trade balances.

2) Suitability of Indian coal for methanol production.

3) Availability of petcoke as a feedstock.

4) CO$_2$ emissions / access to water near coal deposits.

5) Offshore gas discoveries / shale gas production.

6) JV projects to access lower-cost gas outside of India.