Pathways to Profit
UOP Dehydrogenation Technology
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16th INDIAN Petrochem Conference
Mumbai, India
October 30-31, 2014

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Agenda

• Light Olefin Demand Outlook
• Light Olefin Supply Routes and Market Shift
• On-Purpose Propylene Production Technology
• UOP Oleflex Process
• Why Customers Choose Oleflex Process?
• Conclusion
Tremendous Opportunities in Petrochemicals

Light Olefin Demand

- World demand for ethylene and propylene growing (about 4%/yr)
- More than 100 MMTA of additional capacity will be needed by 2025
- Consumption being driven by growing middle class in developing regions

The world market continues to drive demand for products derived from light olefins

Source: IHS Chemical
Cracker Feed Slate Swings Past Propylene

Shift to lower cost, lighter feeds results in decrease in propylene
Refinery objective: Shift towards heavier diesel reduces byproduct light olefins.

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

**Shift towards heavier diesel reduces byproduct light olefins.**
Tremendous Opportunities in Light Olefins

Light Olefin Supply

- Growing share from other sources besides steam cracking and refineries
- Propylene gap developing
- Several options for on-purpose propylene production

Source: IHS Chemical
Get into the Action with Oleflex Process

Feedstocks

- Propane
- Propane + Isobutane
- Isobutane

$\rightarrow H_2$

Products

- Propylene
- Propylene + Isobutylene
- Isobutylene

Uses

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

Selection of Process Technology

- Economic Feasibility: Low CoP, Low Investment, High IRR or NPV
- Simple Process and Easy to Operate
- Proven & Strong Technical Support
- Safe and Environment Friendly
PDH – P-P Spread is Main Economic Driver

PDH economics primarily driven by the price differentials between propylene and propane

PDH Project Economics Example

Profitability is attractive over wide range of price differentials

PG Propylene – Propane Price Spread, $/MT

Propylene to Propane differentials support investment in PDH

Data Source: IHS Chemical
C₃ Oleflex™ Complex – Simple Perfection

- Selective Hydrogenation Process converts methyl acetylene & propadiene to valuable propylene
- Elegant & simple solution!
- UOP Oleflex Process used in 12 of the 19 operating PDH Units today
Leverage UOP CCR Experience in PDH/BDH

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

°Catalyst Flow

°C3 Oleflex Unit = 4 Rxs
°C4 Oleflex Unit = 3 Rxs

>250 UOP CCR’s in Operation Today

Heater Cells

Reactor Section

Regeneration Section

Dryer

Rx Effluent Compressor

Cold Box

To Frac Section

H₂ Recycle

Fresh & Recycle Feed

Product Recovery Section

Net Hydrogen
Alternate End-Product processing options:
- ETBE from Ethanol, Tert-Butyl Alcohol from Water
- Alkylation (Indirect or Direct)
- High Purity Isobutylene (HPIB) via MTBE Decomposition
- Others (Methyl MethAcrylate, Isoprene, etc.)
C₃/C₄ Oleflex MTBE Complex

UOP has 20 years of experience for C₃/C₄ dehydrogenation
UOP Leads the Way in C₃ and iC₄ Dehydro

UOP has been awarded 28 of the last 33 dehydro projects world-wide since 2011

World’s Largest PDH at 1000 kmta and 2 PDH Projects at 750 kmta propylene capacity

Highest ROI and Highly Reliable Technology keeps Oleflex Process as the choice of the industry
Location of Operating UOP C3 Oleflex Units

Russia and China (x2) join the Oleflex Family
UOP Proven Track Record of Innovation

**1990-1992** - 1st Commercial Oleflex Units with DeH-6 Catalyst

**1992-1993** - DeH-8 and DeH-10 Catalysts (2\textsuperscript{nd} and 3\textsuperscript{rd} Generations)

**1995** - 250 kMTA propylene designed

**1996** - DeH-12 Catalyst (4\textsuperscript{th} Generation)

**1998** - 300 & 350 kMTA propylene designed

**1999** - 250 kMTA propylene designed

**2001** - DeH-14 Catalyst (5\textsuperscript{th} Generation)

**2003** - 400 kMTA propylene designed

**2004** - 460 kMTA propylene designed

**2007** - DeH-16 Catalyst (6\textsuperscript{th} Generation)

**2008** - 510 kMTA propylene designed

**2009** - 400 kMTA propylene designed

**2010** - 460 kMTA propylene designed

**2011** - 750 kMTA propylene designed

**2012** - UOP/HPS Oleflex Automation Package

**2012** - UOP/HPS Training Simulator

**2013** - 1000 kMTA propylene design

**2014** - DeH-18 (7\textsuperscript{th} Generation)

**2015** - 510 kMTA propylene designed

**2016** - 400 kMTA propylene designed

**2017** - 460 kMTA propylene designed

**2018** - 510 kMTA propylene designed

**2019** - 600 kMTA propylene designed

**2020** - 750 kMTA propylene designed

**2021** - 850 kMTA propylene designed

**2022** - 950 kMTA propylene designed

**2023** - 1000 kMTA propylene designed

Continuous Innovation Driven by Customer Needs
UOP’s Modular and Equipment Commitment

Advance your schedule and improve your bottom line with UOP Equipment & Modular Supply

**UOP Enhanced Tubes**
- MD™ / ECMD™ Trays
  - Smaller tower diameter
  - Close tray spacing
  - Lower column pressure drop

- High Flux™ / High Cond™ Tubes
  - Highest heat transfer performance
  - Closer Approach
  - Fewer / smaller bundles

**UOP Column Internals**

- Modular Supply
  - Highest quality
  - Delivered on time & on budget
Why Customers Choose UOP Oleflex

- **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 choose both! Get lowest CAPEX and OPEX in one design*
Why Customers Choose UOP Oleflex (Cont..)

- **High Reliability / On-Stream Availability**
  - Constant process conditions
  - Robust design incorporates largest operating base
  - CCR technology well proven across the industry

- **Smallest Environmental Footprint:**
  - Lowest energy leads to lowest CO$_2$
  - Low NOx & VOC emissions
  - Non-toxic catalyst system

*The safest & most environmentally friendly technology also leads in reliability*
In Conclusion

- **UOP’s Oleflex Process: Best dehydrogenation technology**
  - Lowest CAPEX + lowest CCOP = Best Bottom Line
  - Largest experience base & most reliable technology

- **UOP as Your Technology Provider: The best keeps getting better**
  - Continuous innovation for new & existing customers
  - Extensive capabilities with regional support

*Drive Your Profitability to new heights with UOP as your Technology Provider*
Thank You
Q&A