Maximizing Profitability from Unconventional Oil and Gas using UOP Technologies

Mike Banach
Sr. Business Leader, Olefins & Detergents

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What is Honeywell

$40.3B
2014 sales

55%
sales outside U.S.

• 1,300 sites, 70 countries
• 132,000 employees
• Morristown, NJ headquarters
• Fortune 100

Aerospace
$15.6 billion sales

Automation and Control Solutions
$14.5 billion sales

Performance Materials and Technologies
$10.2 billion sales
PMT Business Overview

Balanced portfolio
geographically diverse

$10.2B
in sales

18%
segment margin

22,000 employees
serving 100 countries

UOP

- Refining and petrochemicals licenses & catalysts
- Gas & NGL processing
- Equipment & field services

EMEA 27%
Asia Pac 36%
Americas 37%

Honeywell Process Solutions

- Automation process control and field instrumentation
- Turnkey projects & services
- Productivity & cyber solutions

EMEA 43%
Asia Pac 26%
Americas 31%

Advanced Materials

- Energy efficient refrigerants, foams and solvents
- Additives, fibers and resins
- Metals & fine chemicals

Americas 72%
EMEA 13%
Asia Pac 16%

Data Using 2014 Estimates
UOP creates knowledge for the oil and gas industry

Better Economics
UOP technologies offer a high return on investment

Continuous Innovation
Continuous technology improvement allows customer operations to remain cutting edge

Reliability
UOP technologies are among the most widely proven in the world

Expertise
UOP has a century-long record leading technology development for the oil and gas industry

- Process Technology
- Catalysts
- Adsorbents
- Equipment
- Services

2,500
Engineers and scientists

3,000+
Active patents

800+
R&D employees

200
with PhDs

31 out of 36 refining technologies in use today were developed by UOP

Largest process licensing organization in the world
Shale Oil & Gas Reserves - Argentina

- Argentina has unconventional oil reserves equivalent to 27 B barrels and shale gas reserves of 802 TCF (recoverable).
- 15% of total gas production is coming from tight and shale exploration.
- Goal is to get 50% of gas production from these formations by 2020.
- Currently 50.6 thousand BOED considering oil & gas associated production.
- 424 shale wells in production and 173 wells drilled in 2015.
- 2\textsuperscript{nd} Largest Gas and 4\textsuperscript{th} Largest Oil Reserves Worldwide
UOP Technology Solutions for Shale Gas and Liquids

- C1 → Adv. MTO → C2= & C3=
- LPG → Oleflex → C3= & C4=
- LPG → Cyclar → Benzene & Xylenes
- Naphtha → RZ Platforming → Benzene

Honeywell UOP Solutions Allow You to Maximize the Opportunity
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

MTO Connects Natural Gas and Coal to 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)

All processes licensed by UOP
Yield Benefits from OCP Integration

A little more ethylene, a lot more propylene, and a lot less $\text{C}_4^+$ by-product
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 have selected the UOP/INOVYN MTO™ Process:

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<th>#</th>
<th>Owner</th>
<th>Location</th>
<th>Scope</th>
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<td>LUXI Chemical Group Co. Ltd.</td>
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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

Dedicated and Mixed Unit Applications
C₃ Oleflex Complex

- C₃ LPG
- Byproduct H₂
- Oleflex Unit
- Depropanizer
- C₂⁻
- Deethanizer
- SHP
- C₄+
- P-P Splitter
- Propylene
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

*The Lowest CAPEX and OPEX*
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

Safe and Environmentally Friendly Technology
UOP Cyclar™ Process

Cost advantaged LPG can be economically converted to a mixed aromatics product for:

- High octane gasoline blending
- Conversion to mixed xylenes and benzene
  - Further processing to benzene derivatives
- Conversion to para-xylene and benzene
  - Further processing to downstream petrochemicals
UOP Cyclar™ Process

• Originally developed by UOP and British Petroleum (BP)
• Conversion of cost-advantaged LPG to mixed aromatics
  – LPG from field, pipeline or refinery by-product
  – Flexible LPG Feeds: 100% C3 to 100% C4
  – High-purity hydrogen by-product via PSA
  – No aromatics extraction unit required
• Continuous Catalyst Regeneration (CCR™) system maintains steady state operation over catalyst life
  - Removes carbon deposition and re-conditions the catalyst continuously for constant activity

Economics improve as C3/C4 availability increases and cost declines
Cyclar Process Flow Diagram

- **Reactor Section**
  - Side-by-Side Reactors
  - **Heater Cells**

- **Regeneration Section**

- **Gas Recovery**
  - Hydrogen
  - Tail Gas

- Fresh LPG Feed → C<sub>6+</sub> Aromatics
- Fresh & Recycle Feed
- Light Ends

- **Stripper**
From LPG to Gasoline and Petrochemicals

- Cyclar Process for production for gasoline blending
  - May include benzene management technology – UOP BenSat™ Process (benzene saturation)

- Cyclar Process for the production of benzene and mixed xylenes
  - TatorayTM Process: Toluene $\rightarrow$ Benzene + Xylenes

- Cyclar Process for the production of benzene and p-Xylene
  - Tatoray Process: Toluene $\rightarrow$ Benzene + Xylenes
  - ParexTM Process: para-xylene Separation/Purification
  - IsomarTM Process: o- and m-xylene $\rightarrow$ para-xylene
Feedstock Versatility

- Can be designed for any mix of C3/C4 feedstock.
- Use of C4 generate higher aromatics than C3 and lower light byproducts.
- C4 is easier to convert than C3, resulting in less amount of catalyst.
- Overall conversion per pass will remain at about 60%.
- Byproduct C3 is recycled back to the reactor for maximum overall yields.
- C4-only leads to longer catalyst life due to slower RIT increase over cycle.
Light Naphtha – What is it?

- Typically boils between 50°F to 160°F (C₅s/C₇s)
- High RVP, low octane numbers
- Demand growing at ~2 %/yr average
- Supply surplus over next 10 years
- Sources:
  - Crude Distillation & Natural Gasoline – 53%
  - Lightest naphtha from natural gas – 10%
  - Coking, Hydrocracker, hydrotreating – 16%
  - Raffinate and heavy naphtha blending – 21%
- Uses:
  - Steam crackers (Europe and Asia) – 60%
  - Direct use or Isomerized for gasoline blending – 30%
  - Diluent (cutter) for heavy oil – 4%
  - Paraffinic solvents – 1.5%
  - Other (heating, gasification, etc.) – 4.5%

Highly Traded Commodity (378 million MTA)
US Light Naphtha Supply / Price

US Tight Oil Production - Forecast

- US’ condensate from Light Tight Oil (LTO) will continue to play a role in the mid-term – current productions: 35,000 kMTA
- Light Naphtha (LN) continues to trade at a discount versus crude oil
- High LN yields from LTO/Shale-gas keeps price of LN at discount
- LN discount vs. Brent ranging 13% to 20% since 2011

Light Naphtha FOB, Mont Belvieu vs. Eur Brent FOB
(12-month M/A)

Mid/Long Term LN Surplus
Continued LN Discount at Low Oil Prices

Source: www.eia.gov / IHSConnect - Feb 10, 2016
RZ Platforming™ Process for Benzene Production

• **On-purpose Benzene Production**
  - Higher aromatic yields than conventional Platforming™ technology
  - Higher selectivity from C₆/C₇ paraffin to aromatics than conventional Platforming™ technology

• **Upgrade paraffinic [light] feeds**
  - Shale-based naphtha
  - Low-value raffinate

• **High H₂ Yields for**:
  - New fuel specifications
  - Higher distillates/gasoline yields
  - Potential for BoB conversion
RZ Platforming™ Process: Main Reactions

1. n-Hexane
2. c-Hexane $\rightleftharpoons$ Benzene + 3H₂
3. Methyl Cyclo-Pentane

Lighter Molecules $C_5^-$

- 2,2 DMB
- 2,3 DMB
- 2 MP
- 3 MP
- Methyl Cyclo-Pentane
- n-Hexane
- Benzene

Methyl Cyclo-Pentane

+ 3H₂
RZ Platforming™ Process: Configuration and Applications

- **Stand-alone processing**
  - C₆/C₇ (Buy LN / Sell Aromatics)

- **Parallel LN and HN for max aromatics**
  - w/ Fixed-Bed or CCR Platforming

- **Debottleneck Refinery Naphtha Section**
  - *Unconventional Light Crudes*
  - *Shale Oil*

- **First unit on-stream (1998)**
  - Forward-integrated
  - Production of aromatic derivatives
  - Self-sufficient in hydrogen
**UOP RZ Platforming™ Process Overview**

- **Fixed-bed process**
  - Low pressure
  - 5 reactors
  - H₂ recycle
  - 482-543°C
  - EOR 520°C – typical
  - CapEx and OpEx similar to CCR Platforming Unit

- **Feedstock**
  - Best application C₆/C₇
  - Ideal highly paraffinic
  - Raffinates for recycle back to RZ Platforming Unit (after aromatics extraction)

- Ex-Situ regeneration
- One load in operation
- One load regenerated and stored
Summary – RZ Platforming™ Process

• Addresses the product-lift needs for excess of C₆-C₇s
• Technology offers high benzene selectivity and yields
• High H₂ byproduct can also be very beneficial
Summary - Shale Development Creates Opportunity

- **UOP’s Advanced MTO Technology**
  - Highest Olefin Yields with Flexible P:E Ratio

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

- **UOP’s Cyclar Technology**
  - Upgrade LPG to Benzene and Aromatics

- **UOP’s RZ Platforming Technology**
  - Upgrade C6-C7’s to Benzene

*Honeywell UOP Solutions Allow You to Maximize the Opportunity*