Opportunities and Developments in para-Xylene Production

Guangdong Qu
Aromatics Technology Innovation

- BTX market update and regional trends
- Latest UOP technologies enable the lowest cost of production of aromatics
Polyester chain drivers continue to be strong

Key demand factors:
- Global economy
- Regional Middle Class Growth
- Substitution (container applications)
- Recycle & Renewable Raws

Fundamentals remain good
Global \( pX \) demand will increase by 75% in 10 years

New \( pX \) capacity needed to match demand growth

Source: UOP (SBA-CCI & PCI)
China’s growing economy drives global pX demand

Para-Xylene Demand Growth

CAGR = ~7%

Almost 20 million tons of p-X demand growth in China alone
China will not be able to meet its para-Xylene demand alone. Deficit in China met via imports from Middle East and Asia Pacific regions.
Para-Xylene margins have been at attractive levels

- PX – naphtha margins have begun to decline & expected to continue in 2014 – 2015

- 2011-2013 spreads have exceeded most every prior year average

- 2013 was a good year for naphtha based producers; mixed xylenes based producers have been squeezed by MX suppliers
**p-Xylene Cost of Production impacted by regional utility costs**

**Basis Assumed:**
- **Energy Values, /mm btu:**
  - AP = $5.50
  - USGC = $3.9
  - China = $6.00
  - India = $4.20
  - ME = $1.25
- **Location Factors:**
  - AP = 1.02
  - USGC = 1.00
  - China = 0.80
  - India = 0.77
  - ME = 1.08

**Reducing COP drives profitability**
Latest technology advances drive COP reduction

<table>
<thead>
<tr>
<th>COP Contributors</th>
<th>Advanced Catalysts and Adsorbents</th>
<th>Efficient Designs, World Class Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock</td>
<td>Reduced byproduct formation, enhanced recoveries</td>
<td>Maximizing product recoveries drives feedstock utilization</td>
</tr>
<tr>
<td>Utilities</td>
<td>High activity for reduced energy input; High recoveries and maximum yields for reduced recycles</td>
<td>Advanced process integration maximizes energy efficiency</td>
</tr>
<tr>
<td>Capital</td>
<td>High activities and capacity for smaller equipment</td>
<td>Designs optimized for minimal capital overall</td>
</tr>
<tr>
<td>Reliability/Operations (Contributes to Fixed Costs)</td>
<td>High activity and capacity extend intervals between turnarounds</td>
<td>Designs reduce maintenance needs; high on-stream availability</td>
</tr>
</tbody>
</table>

**UOP technology minimizes COP**
UOP’s innovation delivers new products for key processes!
Continuous innovation at UOP drives technical leadership in aromatics

**UOP I-500 Isomar™ EB Dealk Catalyst**
- Low xylenes losses
- 3 operating units

**UOP Tatoray PTD Process**
- Low xylenes losses
- First unit s/u in 2014

**UOP R-284 Platforming™ Catalyst**
- Improved aromatics yields
- First unit s/u in 2014

**UOP ADS-47 Parex™ Adsorbent**
- Over 25% extra throughput
- 7 operating units

**Energy Efficient Aromatics Complex**
- First unit s/u in 2014

**UOP TA-30 Tatoray™ Catalyst**
- Max conversion of heavy aromatics
- 3 operating units

**Upcoming Product Launches**
- Next Gen Aromatics Complex Design
- ImpX Rx System for Platforming™ Unit
- UOP I-600 Isomar™ EB Isom Catalyst

**Recently Commercialized**
- UOP R-334 Platforming™ Catalyst
  - Maximizes aromatics yields
- UOP TA-32 Tatoray™ Catalyst
  - Improved activity & yields

**Substantial CAPEX/OPEX reductions over last 4 years**
ADS-47 Adsorbent Development and Commercialization

**ADS-47 Adsorbent Benefits**

- Drop-in replacement for existing adsorbent resulting in low capital costs for capacity additions
- Up to 50% capacity increase in existing units
- 5-20% improved energy efficiency (~ $2-5 / ton of pX benefit over ADS-37)
- Significantly lower capital per ton of pX (less adsorbent, smaller chambers)
- Fast revamp execution; implement across a standard turnaround
- Seven commercial units successfully loaded with ADS-47 Adsorbent since 2011
- Five new unit designs have been based on ADS-47 Adsorbent

**UOP’s Parex technology leads innovation and value**

**ADS-47 Adsorbent is the result of improving mass transfer and capacity properties applied to the same proven chemistry**

- 2011 – ADS-47
- 2004 – ADS-37
- 1990 – ADS-27
- 1980 – ADS-7
- 1971 – ADS-3
UOP TA-32 Tatoray catalyst sets new standard for activity & stability

TA-32 Benefits

• **Twice the catalyst life**
  - Higher activity by 30°C
  - Lower heater firing: $1/MT pX
  - IRR Improvement by +1 to 3%

• **Higher xylenes yield**
  - More than 1% higher xylene selectivity
  - Value improved by > $3/MT pX

• **Lower feed requirement**
  - Up to 50% lower ring loss

• **Broad range of operating parameters**
  - Designs optimized to maximize value

• **Commercially Proven**
  - Nearing two year of stable performance

Improved profitability through selectivity and catalyst life
UOP I-500 Isomar catalyst sets new standard for isomerization

- **Improved Xylene Selectivity** (~0.5 % better Xylene Retention)
- **High Paraxylene Selectivity** (~24% pX/X at high WHSV)
- **Higher EB Conversion Activity** (8 – 10°C better than I-300)
- **High Benzene Selectivity** (> 98% compared to 90% Bz Sel)
- **High Benzene Purity** (> 99.8% Benzene Purity)

I-500 catalyst improves COP by ~ $3-9 / ton pX
Latest products improve yields and capital investment effectiveness

For new aromatics complex designed with the latest products:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Base Product</th>
<th>Latest Product</th>
<th>COP Reduction Excluding Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCR Platforming</td>
<td>R-264</td>
<td>R-284</td>
<td>$3+ /MT pX</td>
</tr>
<tr>
<td>Isomar</td>
<td>I-300/350</td>
<td>I-500</td>
<td>$1-8* / MT pX</td>
</tr>
<tr>
<td>Tatoray</td>
<td>TA-20HP</td>
<td>TA-32</td>
<td>$3+ / MT pX</td>
</tr>
<tr>
<td>Parex</td>
<td>ADS-37</td>
<td>ADS-47</td>
<td>$3 / MT pX</td>
</tr>
<tr>
<td><strong>Total COP Reduction</strong></td>
<td></td>
<td></td>
<td><strong>Over $10 / MT pX</strong></td>
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* For complexes without transalkylation

Latest products substantially reduce production costs
Integrated process design reduces energy costs by over 53%

<table>
<thead>
<tr>
<th></th>
<th>Total Energy Requirement (MMBtu/hr)</th>
<th>Energy Savings (MMBtu/hr)</th>
<th>Energy Savings @ $6 / mm Btu (MM$/year)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>UOP Design – 2009</td>
<td>1150</td>
<td>Base</td>
<td>Base</td>
</tr>
<tr>
<td>UOP Design – 2011</td>
<td></td>
<td>455 (40%)</td>
<td>$22.9</td>
</tr>
<tr>
<td><strong>Energy Benefit / MT pX</strong></td>
<td>4.2 MMBtu / MT pX</td>
<td></td>
<td><strong>$26/ MT pX</strong></td>
</tr>
<tr>
<td>ADS-47 Energy Benefit / MT pX</td>
<td></td>
<td></td>
<td><strong>$5 / MT pX</strong></td>
</tr>
<tr>
<td>TA-32 Energy Benefit / MT pX</td>
<td></td>
<td></td>
<td><strong>$1 / MT pX</strong></td>
</tr>
<tr>
<td>I-500 Energy Benefit / MT pX</td>
<td></td>
<td></td>
<td><strong>$3 / MT pX</strong></td>
</tr>
<tr>
<td><strong>Additional Energy Benefit from Upgraded Products</strong></td>
<td>1.2+ MMBtu / MT pX</td>
<td></td>
<td><strong>$9 / MT pX</strong></td>
</tr>
<tr>
<td><strong>Total Energy Benefit / MT pX</strong></td>
<td>5.6+ MMBTU / MT pX</td>
<td></td>
<td><strong>$35 / MT pX</strong></td>
</tr>
</tbody>
</table>

*Aromatics Complex pX Capacity = 900,000 tonne pX / year

Latest products and integrated design substantially improve energy efficiency
UOP technology advances enable larger scale plants

Parex Adsorbent Train Size Increases Over Time

UOP continues to lead the market in all size pX complexes

Source: UOP licensed unit data
Summary

- Since 2009, UOP has achieved $45+ per ton reduction in COP of pX
- Catalyst and adsorbent advancements have improved yields and selectivities, but also improve energy efficiency
- Latest technology developments have enabled single train complex designs in excess of 1.5 MM TPA pX
- Our development pipeline is loaded with projects that leverage recent improvements to gain additional value
- UOP’s Parex/Isomar/Tatoray portfolio is the clear leader in highest margin pX in the market

Track record of innovation to address diverse challenges