Outline

- Introduction
- Project Objectives
- Technical Approach
- GTC Purification Process
- Project Impacts
- Future Plans
- Summary
Introduction

• US polyester production has grown from 2MM tons ➔ 5MM tons per year
• Polyester used for consumer goods
• PTA is polyester precursor
• Substantial energy savings
• Reduced environmental impact
# PTA Production Capacity vs. Consumer Demand

<table>
<thead>
<tr>
<th>Year</th>
<th>World PTA Production Capacity (Mt/y)</th>
<th>Consumer Demand (Mt/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>37,480</td>
<td>33,752</td>
</tr>
<tr>
<td>2008</td>
<td>46,283</td>
<td>39,494</td>
</tr>
<tr>
<td>2010</td>
<td>55,290</td>
<td>46,287</td>
</tr>
<tr>
<td>2014</td>
<td>68,875</td>
<td>59,962</td>
</tr>
</tbody>
</table>
# PTA Production Capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Producers/Sites</th>
<th>Production Capacity (Mt/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>~55/80</td>
<td>70 to 1740</td>
</tr>
<tr>
<td>2014</td>
<td>~55/90</td>
<td>70 to 3000</td>
</tr>
</tbody>
</table>
Project Objectives

- Commercialize a revolutionary new PTA process
- Reduce energy consumed
- Eliminate use of hazardous chemicals
- Accept lower-cost feedstocks
- Increase fundamental understanding
Technical Approach

• Low temperature, low pressure crystallization
• Highly selective solvent
• Simplified process
Typical Oxidation Products
Conventional PTA Process

- Conventional PTA Process
  - Oxidation Section
    - HAC and PX losses impact the economics of the process
  - Crude TA
    - Use expensive hydrogenation catalyst
    - High temperature and pressure process
    - Purification Section (hydrogenation)
      - Use of special metallurgy in purification process
      - Purification process limits 4-CBA content ~0.3% in the crude
      - Final product: 4-CBA <25ppm, p-toluic <170ppm, other acids <300ppm
  - PTA
    - p-X air catalysts
      - Use bromine as promoter

HAC and PX losses impact the economics of the process. Purification Section limits 4-CBA content ~0.3% in the crude. The final product contains 4-CBA <25ppm, p-toluic <170ppm, and other acids <300ppm.
GTC PTA Technology

- Relaxed oxidation conditions results in much lower pX and HAC losses
- Non-corrosive low pressure low temperature process
- Potential savings bring the possibility to upgrade current PTA plants
- Patented process
- Use of very selective solvent to remove impurities

**Oxidation Section**
- Crude TA
- GTC purification can process higher impurities content: 4-CBA up to 5%
- Final product: 4-CBA<20ppm p-toluic acid <20ppm other acids <100ppm

**Crude TA**
- Increased pX yields by full conversion/recycle of oxidation intermediates

**PTA**

- ~39% lower energy costs compared to conventional process
- ~16% lower capital investment
Simplified PTA Purification Process

Crude TA → 1st Stage → 2nd Stage → Solvent Recovery → Purge – Impurities Removal and Recycle → Dry → PTA
Solubility Curve

GRAMS/100 GRAMS OF SOLVENT

TEMPERATURE

BENZOIC ACID

MMT

P-TOLUIC ACID

4-CBA

TPA
Bar Type Crystals by Crystallization: Before and After

- Ham et. al. reported ‘salt complex’
- Selective solvent
- Washed to fines
Globular PTA

- Further understanding of crystallization
- Selective solvent
- Washed to crystals
### GTC PTA Typical Product Purity

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONVENTIONAL</th>
<th>GTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-CBA, ppm</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>p-Toluic Acid, ppm</td>
<td>&lt; 170</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>Other Acids, ppm</td>
<td>&lt; 300</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>Optical Density</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Particle Shape / Average Size, microns</td>
<td>Globular / 110</td>
<td>Globular / 130</td>
</tr>
</tbody>
</table>
Uniqueness & Flexibility of GTC’s Process

- **Oxidation**
  - HAC based conventional (relaxed)
  - DMT based
  - WATER based
  - HAC based bromine-free

- **Purification**
  - GTC Purification

- **PTA**
Operating Cost Comparison
(600 Mt/y - cost in $/Mt)

- GTC New
- Conventional

Raw Materials | Energy | Other
---|---|---

0 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800
Utility Consumption Comparison

GTC New Process vs. Conventional

 Millions of Dollars per Year

Power: Blue
CW: Pink
BFW: Red
Natural Gas: Cyan
Steam: Green
Inert Gas: Purple
Operating Cost Advantages of the GTC PTA Process

- Estimated ~39% reduction in utility consumption and ~10% operating costs.
- Improved raw materials consumption.
- Lower compression costs.
- Low temperature and pressure in crystallization and residual solvent removal sections mean lower energy consumption.
Capital Investment Cost (600 Mt/y)

- **GTC New**
- **Conventional**

$ x 10^6$
Capital Cost Advantages of the GTC PTA Process

• Estimated ~16% lower capital cost.
• Savings on reactor and compressor.
• No dissolver/hydrogenation reactor/catalyst required.
• Non-corrosive crystallization operates at atmospheric pressure and low temperatures and does not require special alloys.
Project Impacts

• 1.9E13 Btu/yr US energy savings
• 2.0E14 Btu/yr world energy savings
• 16% lower Capital Investment compared to conventional technology
• 39% reduced utility consumption compared to conventional technology
• Higher purity product and flexibility
• Adaptable to non-bromine oxidation systems
Future Plans

• Finalize industrial evaluation
• Continue optimization of technology for further energy savings
• Finalize process for commercialization
• Implement technology at commercial scale
GTC-PTA Purification Technology Summary

- Significant energy savings
- Low temperature/low pressure crystallization
- Selective solvent
- 16% lower Capital Investment
- 39% reduced utility consumption
- Higher purity product and flexibility
- Adaptable to non-bromine oxidation systems
Acknowledgements

• Department of Energy

• Team members:
  – George Ball
    • Manager of Technology Development
  – Costantino Braggiato
    • Sr. Design Engineer
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    • Research Engineer
  – Mircea Cretoiu
    • Project Manager
  – Randi Wytcherley
    • Principal Investigator
  – Qiao ZhiHui
    • Technology Manager PTA/Polyester