Alternative Feedstocks for the Production of Aromatics

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Aromatics - Feedstock & Product Diversity

- **Rearrange**
- **Separate**
- **Purify**

LPG

- High Octane Fuel Blend
- Benzene for Derivatives
- High Purity Para-Xylene

Naphtha

- Ring Maker

UOP 6510-2
DeHydroCycloDimerization (DHCD)

Light Paraffins → Olefins → Oligomers → Naphthenes → Aromatics

Feed: Propane/Butane

Intermediates /By-products

Products

Light Ends

Hydrogen
UOP Cyclar™ Process: Cost Effective Aromatics from LPG

- Originally developed by UOP and British Petroleum
- Conversion of LPG to mixed aromatics
  - LPG from field, pipeline or refinery by-product
  - Typical feed is from 25% - 75% Propane, balance Butane
  - Product - LPG spread between $500-700/MT
  - Significant amount of by-product Hydrogen can be recovered by PSA
- 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
UOP Cyclar Process

- **Pilot Plant development began in the 1980s**
- **Demonstration Unit commissioned in 1990**
  - 1,000 BPSD mixed LPG
- **First Commercial Unit – 1999 Start Up**
  - Saudi Arabia
  - Mixed C₃/C₄ Feed
  - ~1,300 kMTA feed
  - Mixed xylenes fed to a UOP Aromatics Complex to produce para-Xylene and Benzene
  - Operated until 2013

*Continuous process development over the 14 years of operation*
**Representative Cyclar Process Yield**

**C₃/C₄ Feed 75/25 Wt-%**

*Higher C₄ content in feed shifts yields slightly to more toluene and heavier aromatic products*
UOP Cyclar Process Flow Diagram

Over 250 CCR Units Operating
(Platforming™, Oleflex™, Cyclar Units)
Since 1971
Cyclar Process Based Aromatics Production

• 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
  – Tatoray™ Process: Toluene ➔ Benzene + Xylenes

• Cyclar Process for the production of benzene and p-Xylene
  – Tatoray Process: Toluene ➔ Benzene + Xylenes
  – Parex™ Process: para-xylene Separation/Purification
  – Isomar™ Process: o- and m-xylene ➔ para-xylene

Cyclar process based flow schemes enable many different product slates
Cyclar Configuration: Gasoline Blending

Effective management of benzene in the gasoline pool
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Cyclar process based flow schemes enable many different product slates
Maximize Benzene and Xylene Production

**Tatoray Process**

*Conversion of toluene & A₉’s to benzene and mixed xylenes by transalkylation and disproportionation*

**Major Tatoray Reactions**

**Disproportionation**

\[2 \text{Toluene} \rightleftharpoons \text{Benzene} + \text{Xylenes}\]

**Transalkylation**

\[\text{Toluene} + \text{C}_9 \text{ Aromatics} \rightleftharpoons 2 \text{Xylenes}\]
Increased Benzene + Mixed Xylenes

Extraction technology is not required for high purity benzene
Aromatics Cost of Production – LPG v Naphtha Benzene plus Mixed Xylenes

LPG at $600/MT is an economically competitive alternative feedstock

US price set: Benzene = $1,300/MT, Mixed Xylene = $1140/MT

Basis Assumed: @$967/T w/ H₂ export, no H₂ export, w/ H₂ export, no H₂ export
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Cyclar process based flow schemes enable many different product slates
Maximum para-Xylene and Benzene

Mixed Xylenes efficiently converted to higher value para-Xylene
Aromatics Cost of Production –
LPG v Naphtha Benzene plus p-Xylene

Basis Assumed: @ $967/T

US price set: Benzene = $1,300/MT, p-Xylene = $1,455/mT

LPG at $600/MT is an economically competitive alternative feedstock
Summary

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

• High octane gasoline blending with the benzene management as necessary

• Conversion to high-purity benzene and mixed xylenes
  – Further processing to benzene derivatives

• Conversion to benzene and para-xylene
  – Further processing to downstream petrochemicals
THANK YOU!