Naphtha Catalytic Cracking for Propylene Production by FCCU

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CatCracking.com
More Production - Less Risk!

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Purpose (Objective)

• To present and discuss producing propylene (C3=) by catalytic cracking paraffinic naphtha utilizing Fluid Catalytic Cracking processes
Contents - Covering 3 Points

• Why Propylene from FCCU’s?
• Naphtha Feedstocks – Supply Balances
• Naphtha Catalytic Cracking Processes
  • FCC Catalytic Processes
  • Traditional Steam Cracking (Comparison)
REACTIVE SECTION
TYPICAL FCC

FLUE GAS

REGENERATOR

SPENT CAT.

REACTOR

PRODUCT VAPORS

REACTOR RISER

AIR

FEED

REGEN. CAT.

Paraffinic Naphtha
Benefits

- MOTOR GASOLINE
- PETROCHEMICAL FEEDSTOCKS
  - Propylene (C3=)

TODAY & FUTURE PLANNING

- Minimizing to no gasoline production from FCC
- Additional Focus
  - Light Olefins (Ethylene & Butylenes)
  - Aromatics
Why Propylene from FCCU's?

- Europe, North America (US) refineries are facing **profitability challenges**
  - Gasoline demand declining both areas
  - Middle Distillates (Diesel) markets increasing both areas
  - European surplus gasoline export markets are declining
  - US lighter shale crudes, “tight oil” use is increasing that produce more naphtha and less diesel

- Asia market is for distillates and petrochemical feedstocks

- Large Middle East, Asia, India and South America are building large integrated Refinery/ Petrochemical Complexes
Petrochemicals Opportunities

Main Building Blocks

- Olefins - Two Main Blocks
  - Ethylene
  - Propylene

- Aromatics
  - Benzene
  - Paraxylene (other xylenes too)

- High Olefins - FCC (HOFCC) produces C3= and byproducts of other light olefins and aromatics

Produced by Steam Cracking
Ethane & Liquid Feeds
Naphtha Reformers

Secondary Source Produced by FCC’s
Why Propylene ??

• C3= is the second important raw material after ethylene
• C3= by-product from steam cracking for ethylene with traditional FCC’s the other main source
• Ethylene demand is expanding proportionally faster than Propylene demand  (Propylene was exceeding ethylene growth up thru 2007-2008 Recession)
• To meet C2= demand new steam crackers are using Ethane as feedstock!
• With new SC, C3= shortages are expected; Existing FCC’s can’t meet the demand

On Purpose Propylene Processes (OPP) will be developed
Ethylene & Propylene Supply Sources

**Ethylene Supply Sources**
- Ethane: 12%
- Naphtha & Gasoil: 52%
- Propane & Butane: 34%
- Other: 2%

**Propylene Supply Sources**
- On Purpose: 30%
- Steam Crackers: 13%
- Refineries: 57%

127 Million Tons (US) 2011*
79 Million Tons (US) 2011*

Data Courtesy of IHS CMAI
Steam Cracking Yields

Propylene/Ethylene (P/E) Ratio indicates propylene selectivity

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Ethylene, wt%</th>
<th>Propylene, wt%</th>
<th>P/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>80</td>
<td>3</td>
<td>0.04 (0.0375)</td>
</tr>
<tr>
<td>Propane</td>
<td>44</td>
<td>15</td>
<td>0.34</td>
</tr>
<tr>
<td>Naphtha</td>
<td>30</td>
<td>16</td>
<td>0.53</td>
</tr>
<tr>
<td>Gas oil</td>
<td>23</td>
<td>15</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Table 1

Meet Future C3= Demand in Asia A P/E Ratio 0.85 is required
WHY NAPHTHA CATALYTIC CRACKING?

NAPHTHA SUPPLY
Naphtha Supply Balances

Supply is Increasing Globally

- Steam Cracking
  - Shifting to Ethane & Lighter Fuels from Naphtha & Gasoil
  - LNG/NGL
- Increased Byproduct Condensates from Gas Production
- Lighter Crude Slates for refiner feedstocks
  - Produce more naphtha
- Increasing demand for diesel not gasoline
- In North America: Fracking for Natural Gas and Shale Oil (Tight Oil)
- Aromatics supplies are being squeezed ???

“Somewhat decoupling” of naphtha pricing from crude”
Naphtha Cracking

Steam Cracking - Thermal

• Not Selective to Propylene makes Ethylene (P/E Ratio)
• P/E Ratio of 0.55-0.68 (Naphtha & Gasoil Cracking)
• Steam Cracker capacities are world class size > 1000 KTA

Naphtha Cracking - Catalytic

• Propylene Selective not Ethylene
• P/E Ratio of 1.0 to 2.4
• Naphtha FCC capacities 20 MBPD == 64 KTA of ethylene

SC 20 MBPD = 264 KTA
Naphtha Cracking Comparisons

Paraffinic Naphtha Feedstock Driven

Catalytic & Thermal Processes

• ACO (Advanced Catalytic Olefin)
  • KBR License
  • Riser Technology

• HS-FCC (High Severity FCC)
  • Axens/S&W License
  • Downer Reactor

• Steam Cracking
  • Generic
Advanced Catalytic Olefins (ACO) Process

ACO Process Key Features - Reactor

- Proprietary KBR FCC reactor features
- Propylene/ethylene (P/E) Product Ratio ~1/1
- Proprietary catalyst from SK Corporation
- All proven hardware and processes
- Robust and flexible, compared to other processes
HS-FCC Key Components

- Feed injection
- Downflow reactor
- Regenerator
- Catalyst / product separator
- Stripper using structured packing

Courtesy Axens/TechnipS&W
Features & Advantages of HS-FCC

Features

• Downflow Reactor (Downer)
• High Reactor Temperature
• High Catalyst to Oil Ratio
• Short Contact Time

Advantages

• High Propylene Yield
• High Butylene, iso-butylene Yields
• High Gasoline Octane (High Aromatics Content)
• Minimized Dry Gas
CATALYST FLOW

FCC

Regen.

Reactor

Low Conversion

Over Cracking

Downer

Feed Oil

Over Cracking

Reactor Residence Time

Back mixing

Riser

Feed Oil

Reactor

Regen.

HS-FCC
FEED INJECTOR

quick contact of feed & catalyst

Injector

US Patent 6186658
Quick separation Catalyst & Gas

SEPARATOR

US Patent 6146597

Product Gas + Cat

Product Gas

Guide Vane

Centrifugal force

Separator
HS-FCC Naphtha Process

- Retrofit Type to existing FCCU
- Standalone Unit
Full Range Naphtha Yields Olefins wt%
Naphtha Cracking Fluid Processes

ACO Commercial Demonstration Unit
Ulsan, South Korea

HS-FCC Semi-Commercial Unit
Mizushima, Japan
Conclusions
Petrochemical Opportunities

• Naphtha Fluid Catalytic Cracking is a viable “On Purpose Propylene Process”

• Naphtha Catalytic Cracking produces higher propylene selectivity than Steam Cracking

• Naphtha Catalytic Cracking will help meet future propylene demand

• Naphtha Catalytic Cracking byproducts of other light olefins and aromatics for petrochemicals

• Paraffinic Naphtha Catalytic Cracking processes are in the initial stages of commercialization
THANK YOU

The End

Questions ???