Maximizing C3 and C4 Olefin Production from the FCC via Catalyst Technologies
Modesto Miranda, Technical Service Manager
Propylene supply

- Propylene is an important feedstock used to manufacture a wide-range of chemicals.

- Refinery/FCC supply 1/3rd of global Propylene.

  
  
  - On-purpose: 14%
  - Refinery/FCC: 36%
  - Steam crackers*: 50%

*Feedstock other than ethane, since ethane-based steam crackers yield only very limited propylene.
Propylene uses

1. Polypropylene largest consumer of Propylene

   - PP: 64%
   - Others: 14%
   - Acrylic Acid: 4%
   - Cumene: 5%
   - Acrylonitrile: 6%
   - Propylene Oxide: 7%

2. Grade and Purity (%)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Purity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refinery</td>
<td>55 - 75</td>
</tr>
<tr>
<td>Chemical</td>
<td>92 - 96</td>
</tr>
<tr>
<td>Polymers</td>
<td>99.5 - 99.95</td>
</tr>
</tbody>
</table>

3. Chemicals

   - Others: 96%
   - Chemical Manufacturing: 7%
Propylene global demand has grown steadily for 25yrs

Despite significant investment in production capacity, supply remains tight:

- Weaker Chinese economy
- United States
- Western Europe
- Southeast Asia

Graph shows Propylene prices ($/mt) from 1990 to 2018 with key events such as global recession and +10% increase.
BASF analyses Ecat and operating data from over 200 FCC units

These data are used to drive R&D and innovation programs
Propylene Yield vs Selectivity

- If the unit has enough capacity to process LPG, then the **Propylene yield** can usually be increased.

- For a “propylene producer”, propylene selectivity is the percentage of propylene you are able to produce based on total LPG production.
  - Academic definition is \( \frac{C3}{\text{Total C3}} \)

- When the capacity to process LPG is constrained, **Propylene selectivity** improvement is the way to produce more propylene.
Question? What is your FCC Riser Outlet Temperature (ROT)?

A  555-545°C
B  545-535°C
C  <535°C
Propylene production approaches

Old approach:
- Very clean VGO feed
- High activity catalyst + some additive (sometimes limited by dilution effect!)
- High ROT in the unit (>535°C)

Modern approach:
1. Any feed quality from hydrotreated- to Residue- to Hydrocracker bottoms
2. Improved catalyst + high amount of additive, avoiding dilution effect
3. Enables low-medium ROT in the unit (<535°C)
Feed quality effect (1)

- **GO / Light feedstocks**
  - Lower S.G. is better
  - UOP-K between 11.5 to 12.0 is best
  - Low metals are beneficial (low REO catalyst)

- **Residue / Heavy feedstocks**
  - Metals can influence the catalyst selection dramatically
  - High Concarbon can restrict operation in the unit (ROT, RegenT)

- **UCO (Hydrocracker bottoms)**
  - Low metals allows a lower REO catalyst (more propylene selectivity)
  - Low Concarbon & Coke allows higher ROT (higher propylene yield)
  - High paraffinicity, therefore, higher LPG yield, but less olefinic

- **Furfural Extracts**
  - Produce some propylene, increasing propylene selectivity
  - High Coke, Gas and Slurry/LCO (depending on the catalyst selection)
Maximum Propylene Solution

- High zeolite and matrix surface area (bottoms upgrading & olefins)
- Low Rare Earth to preserve olefins for high amount of ZSM-5
- Unique BASF technology / solution that delivers high activity, without activity dilution when using high amounts of ZSM-5
10°C increase in ROT will increase propylene production by ~0.5 wt%.

But… 10°C increase in ROT will decrease propylene selectivity by around ~0.5 wt%.

Net effect is more C3=, but with more total LPG to process.

By improving “Catalyst+Additive” (Maximum Propylene Solution) we can make more olefins, at lower ROT, with the benefit less gas & coke.
Base case (2013)

Initial conditions / base case (competitor catalyst):

- Feed quality:
  - 60% UCO
  - 30% VGO
  - 10% Furfural Extract

- Operating conditions:
  - ROT 535-545°C
  - Cat/Oil 6-8

- Catalyst:
  - REO 1.2 wt%?
  - TSA 340 m²/g?
  - ZSM-5 12-15%?

Propylene production 8.9 wt% ex. Reactor
BASF Maximum Propylene Solution (with ZIP Olefins Additive):

- **Feed quality:**
  - 60% UCO
  - 30% VGO
  - 10% Furfural Extract

- **Operating conditions:**
  - ROT 520-530°C
  - Cat/Oil 6-8

- **Catalyst:**
  - REO 0.9 wt%
  - TSA 300 m²/g
  - ZIP 17%

BASF catalyst solution produces propylene more selectively, at lower ROT. Enables refinery to use more ZIP Olefins Additive (ZSM-5).

Improved Propylene production 10.5 wt% ex. Reactor
Conclusions

- Propylene production is a very profitable product for the FCC
- It is better to produce Propylene catalytically and not thermally
- A large amount of ZSM-5 is required
- Thus, a maximum propylene solution catalyst is required to avoid dilution effect

BASF makes tailor-made catalysts for each FCC unit