ISOALKY™ TECHNOLOGY:
NEXT GENERATION ALKYLATE GASOLINE MANUFACTURING
PROCESS TECHNOLOGY

PRESENTATION TO SCAQMD
PR 1410 WORKING GROUP MEETING #4
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Hye Kyung Timken
Chevron
Outline

Joint presentation by Chevron and UOP

Objective: Provide SCAQMD
- Basic information on ISOALKY™ Technology
- Status of ISOALKY Technology Commercialization

Presentation
- Alkylation Technology Today
- ISOALKY Technology Overview
- ISOALKY Technology Scale-Up and R&D History
- Chevron Salt Lake City Refinery ISOALKY Project Scope
- Honeywell UOP - Chevron ISOALKY Alliance
- Summary
Alkylation Technology Today
ISOALKY™ Technology Is Commercially Viable Alternative

Alkylate is a premium gasoline blending component

- Alkylation capacity steadily increased annually since 1980’s due to gasoline specifications
- High octane number (isooctane = 100)
- Low vapor pressure (less volatile)
- Clean burning (no aromatics or olefins, low S)

Two existing technologies for alkylate gasoline manufacturing:

- Sulfuric Acid (H\textsubscript{2}SO\textsubscript{4}) ~ 50 plants in US
- Hydrofluoric Acid (HF) ~ 50 plants in US

ISOALKY Technology: A Commercially Viable Alternative

- Uses a non-volatile ionic liquid catalyst
- Advantages in process performance and handling requirements over existing conventional technologies
- Capital and operating costs are comparable
- Applicable for new plant construction or retrofit/ expansion of existing plant
ISOALKY™ Catalyst - Chloroaluminate ionic liquid with a trace HCl co-catalyst, HCl is generated \textit{in-situ} by organic chloride promoter addition

- Ionic liquid is a liquid salt with no vapor pressure
- Stable for long term storage
- Non-volatile liquid - spills can be contained
- Extremely low solubility in hydrocarbon - easily separable
- Creates a biphasic reaction system, reaction at the interface
- Significantly higher catalytic activity – much smaller catalyst volume in alkylation reactor
- Corrosive to metals - alloys used in selected areas to ensure right metallurgy
- Refinery-standard personal protective equipment gives appropriate protection for operation
Four Distinct Areas

- Feed Treating
- Alkylation Reactor & Separation - Unique
- Product Distillation and Finishing
- Ionic Liquid Catalyst Regeneration - Unique
ISOALKY™ Technology
Advantages Compared to Conventional Technologies

<table>
<thead>
<tr>
<th>ISOALKY Technology</th>
<th>Feed Moisture Requirement</th>
<th>Reactor Pressure</th>
<th>External Feed Isoparaffin/Olefin Ratio</th>
<th>Catalyst Volume in Reactor</th>
<th>Alkylate Research Octane Number with Mixed C₄</th>
<th>Alkylate Yield Advantage</th>
<th>Health, Safety and Environmental Impact</th>
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<tbody>
<tr>
<td></td>
<td>&lt;1 ppm</td>
<td>~200 psi</td>
<td>10 mol/mol</td>
<td>3 – 6 vol%</td>
<td>95 - 97 RON</td>
<td>~1+ vol%</td>
<td>Uses non-volatile, ionic liquid catalyst</td>
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<td>Smallest catalyst inventory</td>
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<td>Integrated on-line regeneration of catalyst</td>
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<td>Eliminates polymer incineration</td>
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<td>Reduces caustic solution waste</td>
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Key Characteristics:
- Uses non-volatile ionic liquid catalyst
- Moderate process performance advantages
- Advantages in handling requirements
Chevron ISOALKY™ Technology

Project Evolution and Process Scale-Up

1999: Exploratory work in ionic liquids

2004: Identified alkylation as the key application for scale-up

2005 – Present: 0.1 barrels-per-day (BPD) Pilot Plant in a research site in CA

2010 – 2015: 10 BPD Demo Plant in a Chevron refinery
  - Process scaled-up by a factor of 100 from the Pilot Plant
  - Fully integrated with all sub-processes
  - Next to existing HF Alkylation Plant
  - Refinery feeds and operations staff
  - Generated process data needed for scale-up design

2013: Chevron initiated assessment of Salt Lake City HF Alkylation Plant Retrofit

Sep. 2016: Chevron made Final Investment Decision to retrofit ~5,000 BPD Salt Lake City HF Alkylation Plant
ISOALKY™ Technology Commercialization
Chevron Salt Lake Refinery ISOALKY Project Scope

- Build new alkylation and regeneration sections while utilizing the existing feed preparation and distillation sections.
- HF inventory to be removed/disposed during turn-around before the tie-in
- Commercial operation planned in 2020
- Demolition of HF equipment after successful start-up of ISOALKY Plant
ISOALKY™ Technology to be Licensed to the Industry by UOP

- Honeywell UOP and Chevron formed an alliance in March, 2016 to license ISOALKY Technology to the industry
  - **Strong Synergy to Produce a Better Technology** - Both companies have R&D capability in ionic liquids and are working together to create an even better process
  - UOP brings a long history of expertise in alkylation

- Complementary strengths
  - Both companies are key technology developers for our industry
  - Chevron contributes ISOALKY operation and commercial plant design experiences
  - UOP contributes new technology launch and process engineering experiences

- UOP is the exclusive licensor and sales channel for ISOALKY Technology
ISOALKY™ Technology Summary

- ISOALKY Technology has advantages over conventional technologies in performance and handling requirements
  - Commercially viable alternative to HF or H₂SO₄ process technology
  - Applicable to existing alkylation plant retrofit or to new plant construction

- Chevron is retrofitting the Salt Lake City HF Alkylation Plant with ISOALKY Technology
  - Construction started in 2017, commercial operation planned in 2020

- ISOALKY Technology is licensed to the industry through UOP

- Revolutionary new technology offers refiners an exciting new option
  - To upgrade low-value refinery butanes and olefins to high-value alkylate and to improve the quality of their gasoline pool
  - Expect to make significant impact on global production of clean fuels