ISOALKY™ TECHNOLOGY:

NEXT GENERATION ALKYLATE GASOLINE MANUFACTURING PROCESS TECHNOLOGY

PRESENTATION TO SCAQMD
PR 1410 WORKING GROUP MEETING #4

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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

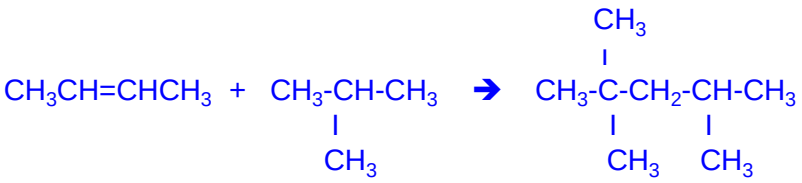
Alkylate is a premium gasoline blending component

- 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_2SO_4) ~ 50 plants in US
- Hydrofluoric Acid (HF) ~ 50 plants in US

Olefin + Isoparaffin ➔ "Alkylate"



2-Butene	Isobutane	Isooctane
$C_4^=$	iC_4	C_8

ISOALKY Technology:
A Commercially Viable Alternative

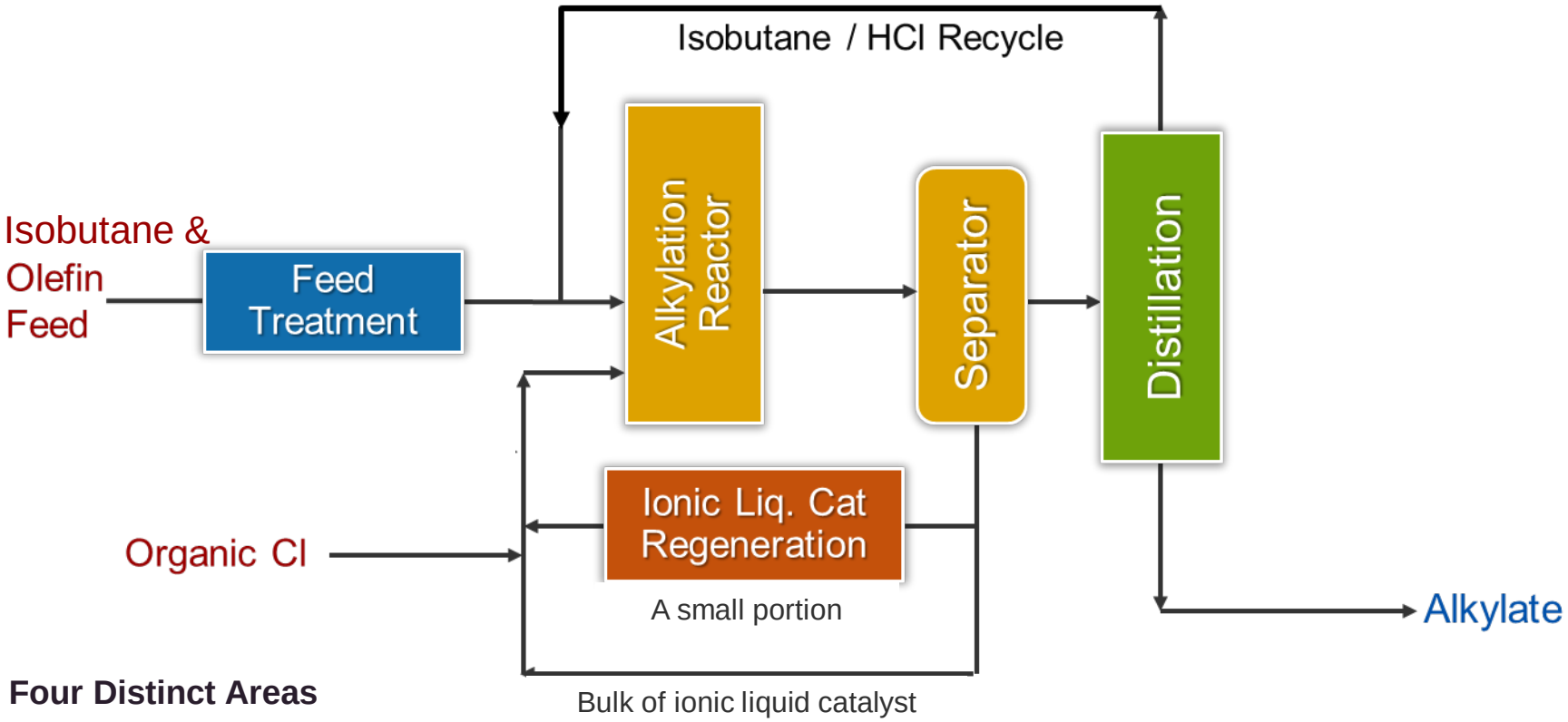
- Uses a non-volatile ionic liquid catalyst
- Advantages in process performance and handling requirements over existing conventional technologies
- Capital and operating costs are comparable
- Applicable for new plant construction or retrofit/ expansion of existing plant

ISOALKY™ Technology - Catalyst Properties

ISOALKY™ Catalyst - Chloroaluminate ionic liquid with a trace HCl co-catalyst, HCl is generated *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

ISOALKY™ Technology
Simplified Process Scheme



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

	ISOALKY Technology
Feed Moisture Requirement	<1 ppm
Reactor Pressure	~200 psi
External Feed Isoparaffin/ Olefin Ratio	10 mol/ mol
Catalyst Volume in Reactor	3 – 6 vol%
Alkylate Research Octane Number with Mixed $C_4^=$	95 - 97 RON
Alkylate Yield Advantage	~1+ vol%
Health, Safety and Environmental Impact	• Uses non-volatile, ionic liquid catalyst • Smallest catalyst inventory • Integrated on-line regeneration of catalyst • Eliminates polymer incineration • Reduces caustic solution waste

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

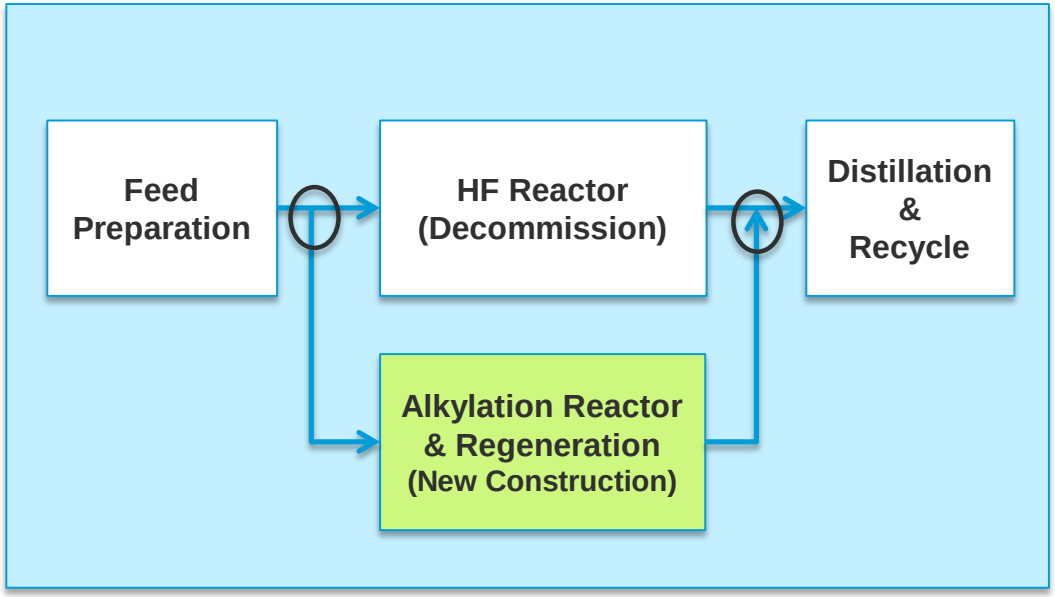
- Process scaled-up by a factor of 100 from the Pilot Plant
- Fully integrated with all sub-processes
- Next to existing HF Alkylation Plant
- Refinery feeds and operations staff
- Generated process data needed for scale-up design

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 H_2SO_4 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