

# A NEW ERA FOR ALKYLATION: IONIC LIQUID ALKYLATION ISOALKY™ PROCESS TECHNOLOGY



U O P

**DOMINIC WEBER**  
TECHNOLOGY MANAGER – ALKYLATION

26 September 2024, Becht HF Alkylation Summit



**Honeywell**  
UOP

# Presentation Outline

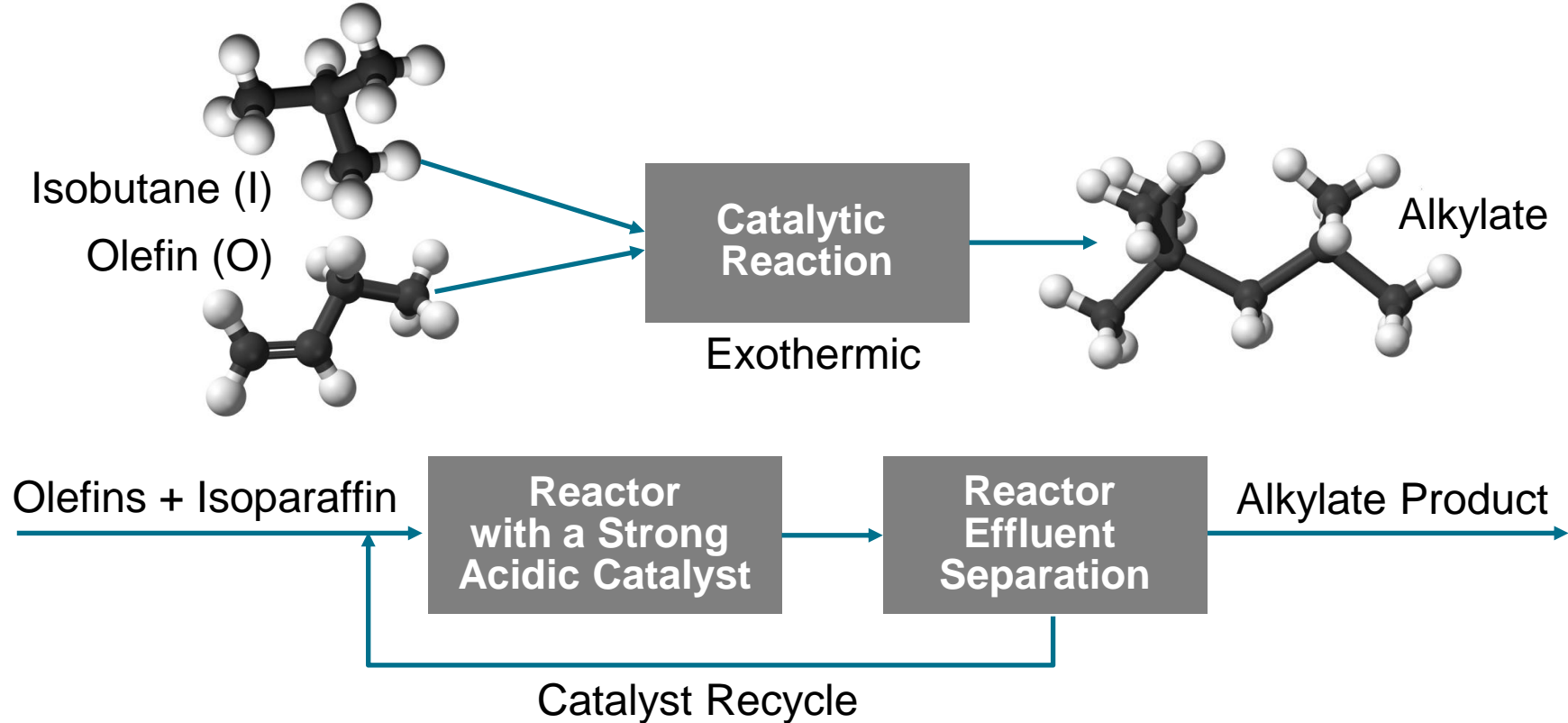
- ISOALKY™ Ionic Liquid Catalyst
- Process Flow & Technology Advantages
- Commercial Plant #1 at Chevron Salt Lake Refinery
- Summary

Mar. 2016: Chevron & Honeywell UOP formed ISOALKY Alliance for further tech development & licensing  
UOP is the exclusive licensor of the ISOALKY Technology



# Alkylation Chemistry

**Basic chemistry is similar for HF or sulfuric acid or IL alkylation**

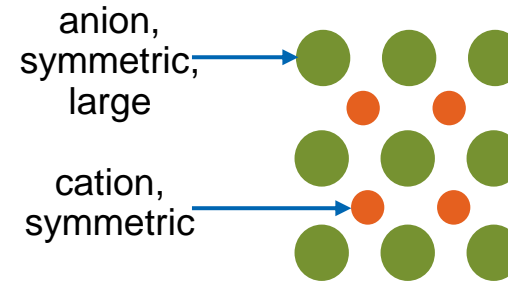


## Existing conventional alkylate gasoline manufacturing technologies:

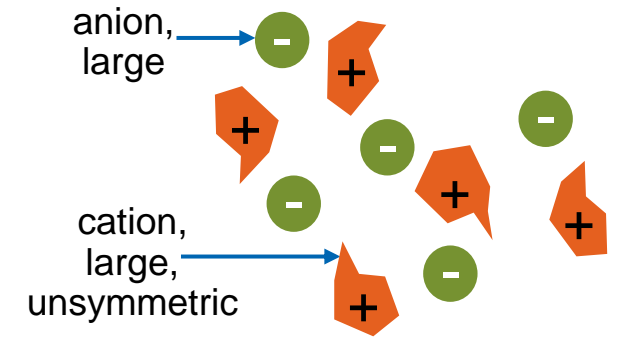
- Sulfuric Acid ( $\text{H}_2\text{SO}_4$ ) ~ 50 plants in US
- Hydrofluoric Acid (HF) ~ 50 plants in US
- Numerous attempts were made to develop an alternate process since 1980's – commercially not feasible until IL Alkylation processes emerged recently

# ISOALKY™ Ionic Liquid Catalyst

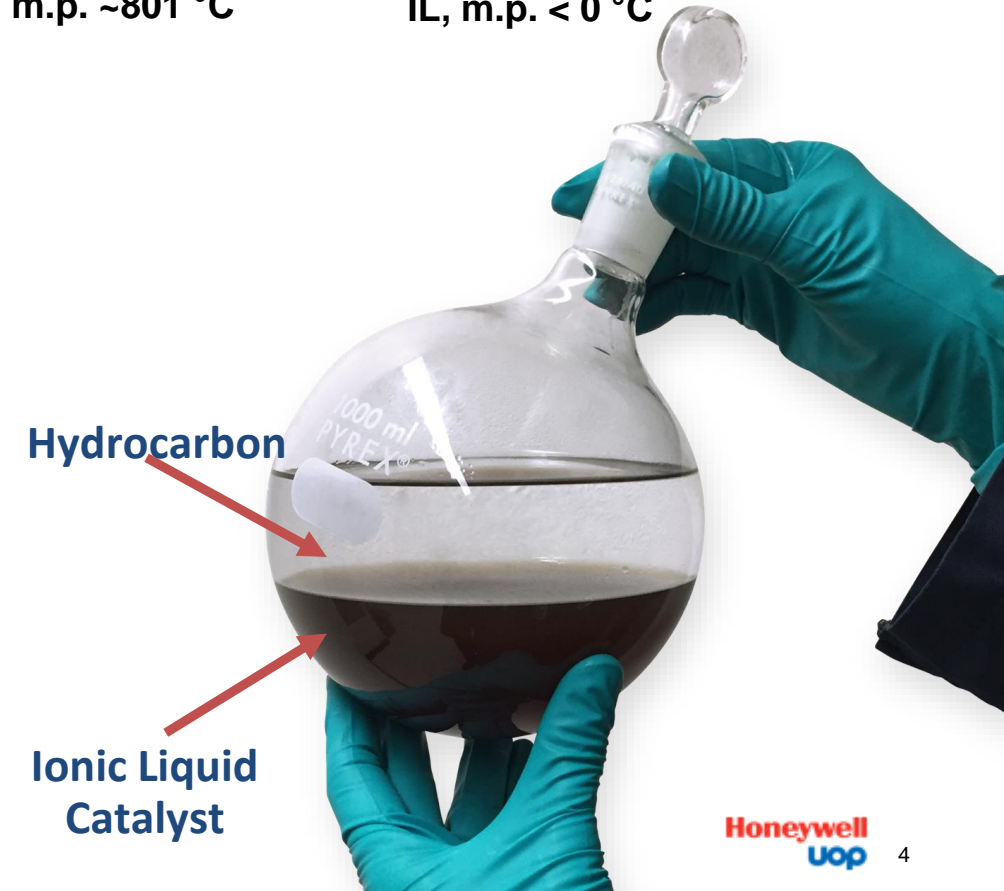
- **Ionic Liquids are salts that are liquid phase at low temperature**
  - Large anions and cations reduce the lattice energy of the crystalline form, lead to a low melting point
- **ISOALKY Catalyst** - proprietary ionic liquid catalyst
- **Acidic ionic liquids** - acid strength orders of magnitude higher than HF or H<sub>2</sub>SO<sub>4</sub>
- **In contrast to typical liquid acids, ionic liquids are easier to handle**
  - Vapor pressure near zero
  - Less volume required
  - Less corrosive to skin
- **ISOALKY Unit only requires standard refinery PPE**
- **Extremely low solubility in hydrocarbon** – easily separable



NaCl, m.p. ~801 °C



IL, m.p. < 0 °C



# ISOALKY™ Feedstock Flexibility – Process Advantages

## Advanced Regeneration

- Conjunct polymer converted to naphtha – small yield increase in final product

## C<sub>3</sub> and C<sub>4</sub> feeds

- Same as conventional alkylation; with subtle differences...
- Very little H transfer, e.g. limited C<sub>3</sub>= conversion to propane
- Low conjunct polymer formation with C<sub>3</sub>=, able to handle 100% C<sub>3</sub> feed

## C<sub>5</sub> olefin feeds

- Sulfuric acid technology can process C<sub>5</sub> olefins at the cost of high acid consumption
- HF technology – hydrogen transfer to iC<sub>5</sub> paraffin resulting in higher RVP alkylate
- ISOALKY technology – selective C<sub>5</sub> olefins conversion to alkylate

## Additional ISOALKY advantages

ISOALKY Technology can convert without hydrogen transfer, with good yields and octane

- C<sub>5</sub> olefins and iC<sub>5</sub> to alkylate
- Direct C<sub>2</sub>= alkylation with iC<sub>4</sub> to C<sub>6</sub> alkylate

**Wide Feedstock Range → Maximum Upgrade Value**

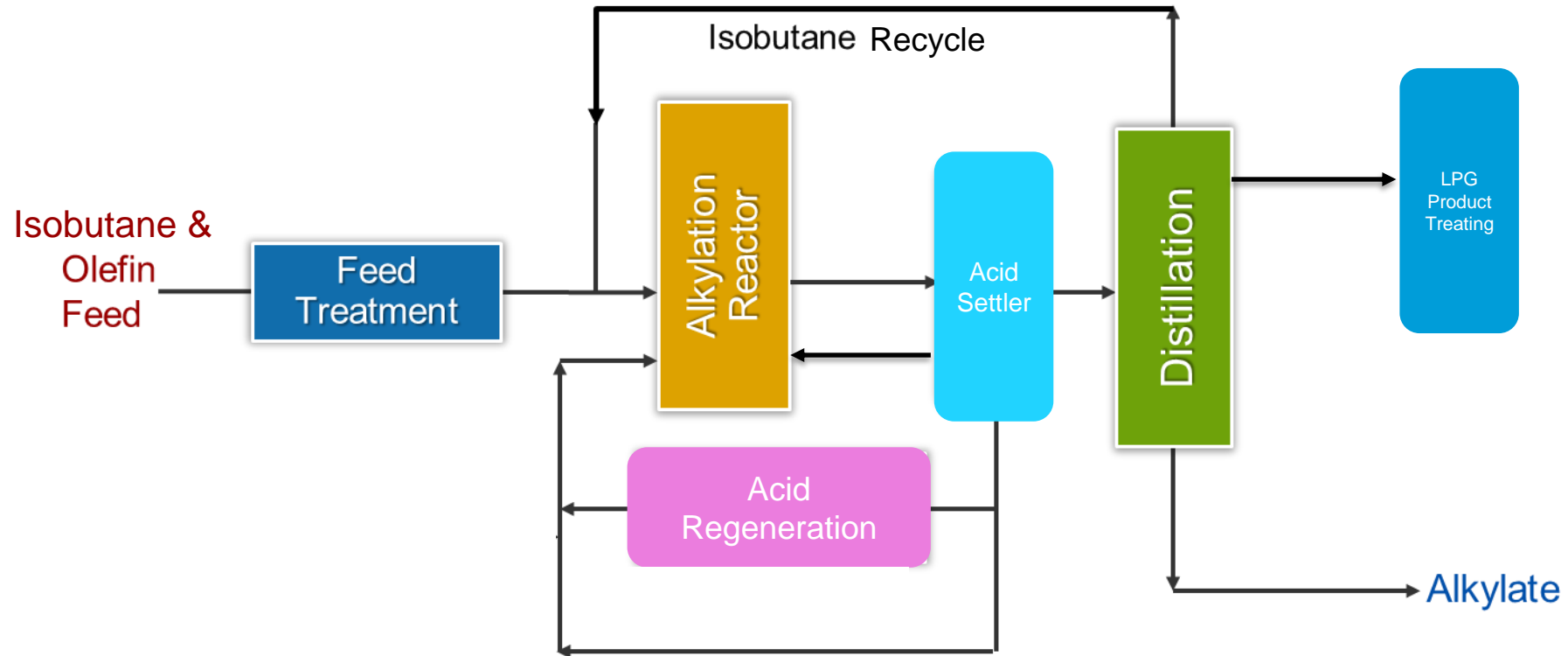
# ISOALKY™ Technology Comparison to Conventional Technologies

	<b>H<sub>2</sub>SO<sub>4</sub></b>	<b>HF</b>	<b>ISOALKY</b>
Temperature, °F	30 – 60	95	50 – 95
Pressure, psi	60	200	~200
Catalyst volume in reactor	50%	50 – 80%	3 – 6%
External Feed I/O, mol/mol	8 – 10	10 - 14	8 – 10
Feed moisture requirement	Not critical	<10 ppm	<1 ppm
Alkylate RON, mixed C <sub>4</sub> =, 10 I/O	95 RON	95 RON	94 - 98 RON
Alkylate yield per bbl of C <sub>4</sub> =	1.8 bbl/ bbl Base	1.8 bbl/bbl	1.8 bbl/bbl ~2 vol% yield advantage
Polymer formation, wt.% Olefin	1 – 1.5%	~0.5%	0.3 - 0.5%
Handling of conjunct polymer	Incineration	Incineration	Converted to naphtha & LPG
Catalyst make-up rate, lb of catalyst/ bbl alkylate	~400 x Base w/ Off-plot regen	~3 x Base w/ On-line regen	Base w/ On-line regen
Safety and Environmental Impact	<ul style="list-style-type: none"> <li>• Large acid inventory</li> <li>• Acid transport for off-plot regen facility</li> <li>• SO<sub>x</sub> emission during regen</li> <li>• High energy, CO<sub>2</sub> intensity</li> </ul>	<ul style="list-style-type: none"> <li>• Smaller acid inventory</li> <li>• High toxicity catalyst</li> <li>• Volatile HF requires engineering controls and special PPE</li> </ul>	<ul style="list-style-type: none"> <li>• Smallest catalyst inventory</li> <li>• Non-volatile catalyst</li> <li>• Integrated regeneration</li> <li>• Reduction of caustic soln. waste</li> </ul>



# HF Alky

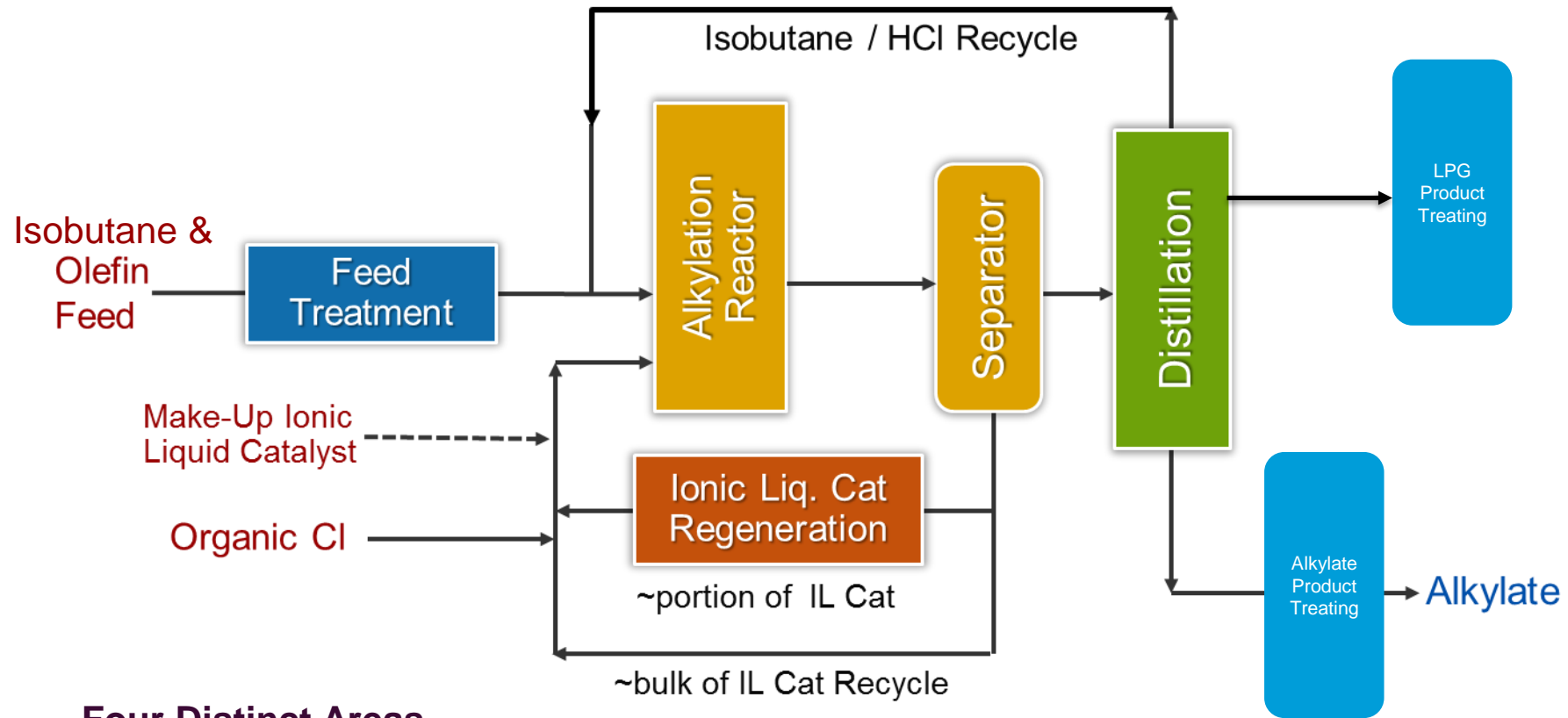
## Simplified Process Scheme



### Four Distinct Areas

-  Feed Treating
-  Alkylation Reactor & Separation – Rxtr Cooler and Settler
-  Product Distillation and Finishing
-  HF Acid Regeneration - Distillation

# ISOALKY Technology Simplified Process Scheme



## Four Distinct Areas

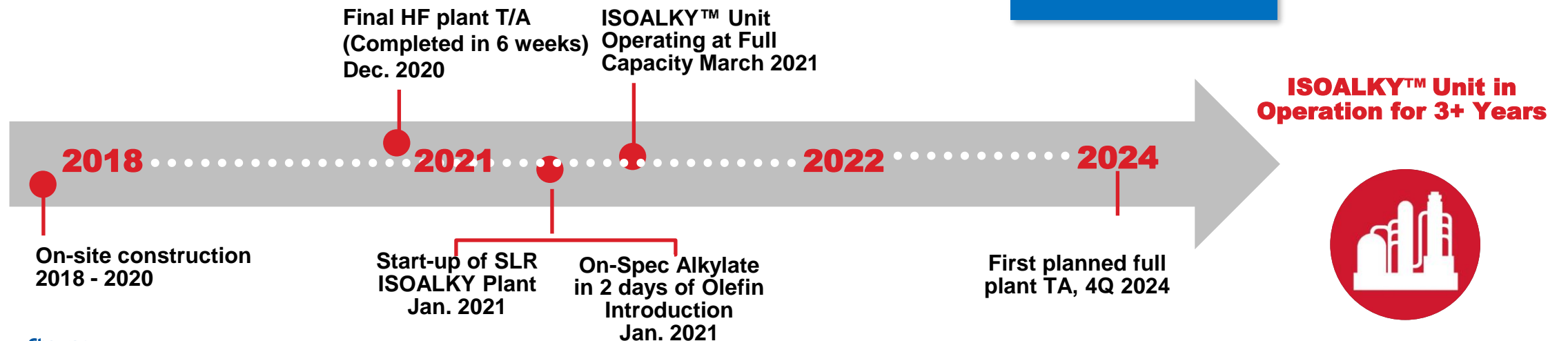
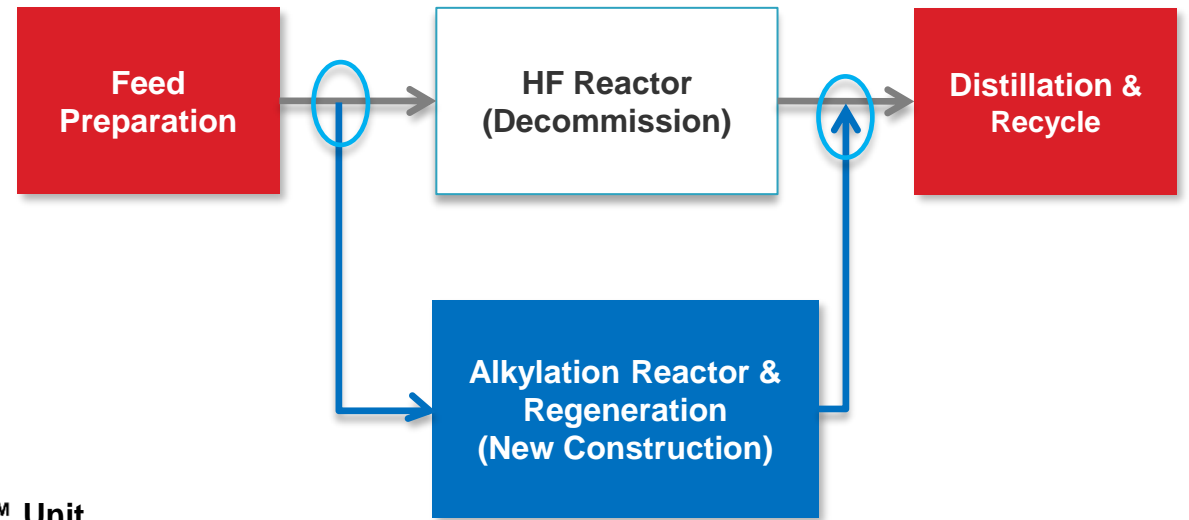
- Feed Treating
- Alkylation Reactor & Separation - Unique
- Product Distillation and Finishing
- Ionic Liquid Catalyst Regeneration - Unique



# Chevron's ISOALKY™ Technology Commercialization at Salt Lake Refinery

## Project Scope

- Retrofit of HF Alky Plant
- Built new alkylation and regeneration sections while utilizing the existing feed preparation and distillation sections



# Salt Lake Refinery Retrofit Project – October 2018

- Early Civil Work 2018
- Demolition of underground obstructions
- Installation of Foundations



# Chevron Salt Lake Refinery ISOALKY™ Plant

## Construction complete in fall, 2020



# Efficient Transition of HF Plant to ISOALKY™ Plant

## Commissioning of Green Field (10/1/20 – 1/17/21)

- Commissioning of green field equipment
- Activation of dryerants
- Drying out green field equipment
- Activation of catalyst

## HF Plant Final T/A (12/1/20 – 1/17/21)

- Neutralization of entire HF inventory
- Acid wash of entire plant – free of HF
- Final connection of Green Field and Brown Field plant

## Start-Up of ISOALKY Plant (1/17 – 1/30/2021)

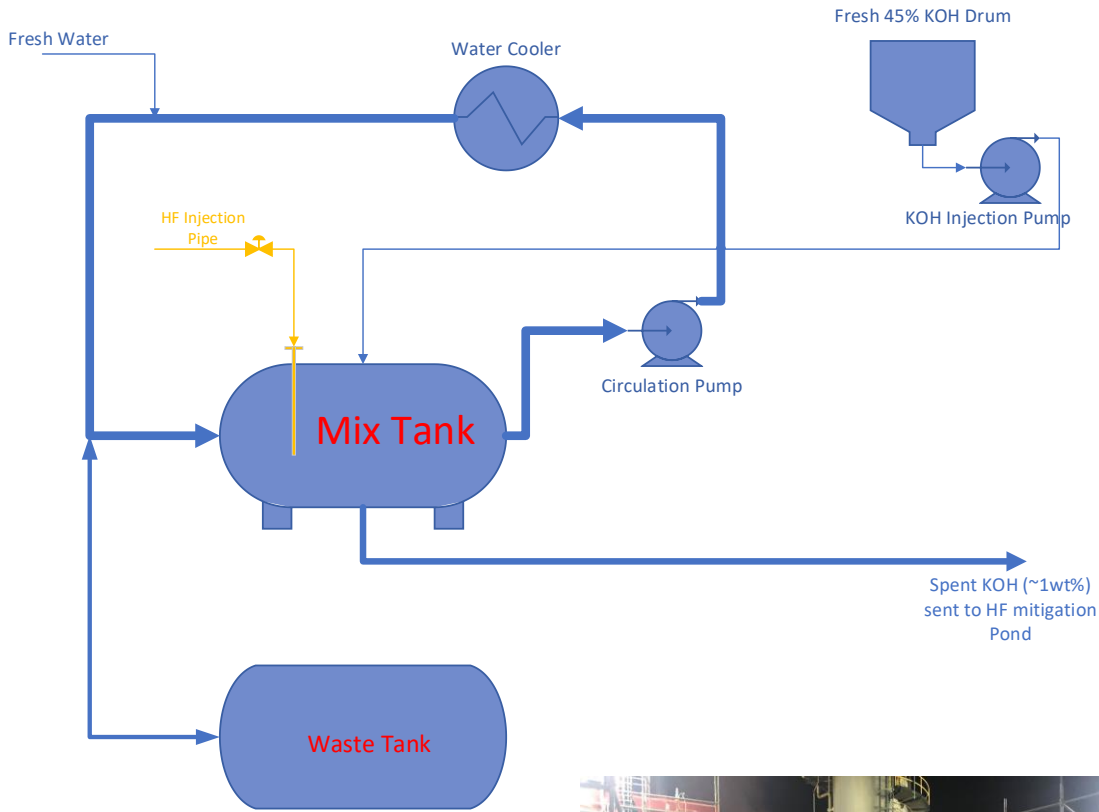
- Dryout of the entire plant with isobutane
- Circulation of ionic liquid catalyst
- Olefin feed introduction (1/28/2021)
- On-Spec alkylate production (1/30/2021)
- Increased throughput to full capacity in Feb. 2021



# Salt Lake Refinery Retrofit Project – December 2020



# Acid Neutralization



## GEM Mobile Neutralization

- Supplied pumps, neutralization vessel, instrumentation and control panel
- Circulate KOH through a closed loop from neutralization vessel through cooler to remove heat and back to neutralization vessel
- Inject acid at controlled flow rate limited by temperature
- Neutralized all HF in roughly two days
- Requires purchasing KOH for neutralization and having storage capability for spent KOH
- Other options are to truck off-site (Honeywell can help – but restrictions apply)
- Can also self neutralize – longer down time



# Overall Plant Performance, Post Start-Up

## Alkylate Property and Yield – on target

Feed and Product Properties	
Olefin Feed	56% C3=, 44% C4=
RON	89 – 91*
MON	88 – 90*
Alkylate End Point	380 – 440 F
RVP	6 - 7
Throughput	
Alkylate Production, BPD (demonstrated)	Per Design
Olefin flow, BPD	Per Design

\* High C3= in feed, CW for reactor temp control.  
 - Lower reactor temp improves octane.

## Catalyst Usage

IL Catalyst and Co-catalyst Consumption	
IL Catalyst Target Consumption, lb/bbl alkylate	Met Target
Co-catalyst Target consumption, lb/bbl alky alkylate	> Target**
HRR Performance (IL Catalyst Regeneration)	
CP (Conjunct Polymer) Formation	< Design (Better than Target)
CP Conversion in HRR	> Design

\*\* Expected to improve with modifications post 2024 TA



# UOP Changes from Original Salt Lake Design

## Added Refrigeration Section

- Reactor temperature ~50 °F compared to SLR at ~90 °F
- Can increase alkylate octane 2-4 RON
- Lower grade metallurgy requirement (carbon steel) in reactor section

## Leverages Learnings from Salt Lake Operation

- Significant equipment count reduction (~30% lower) achieved through value engineering analysis and operating data
- Improved feed drying technology similar to Butamer™ (Isomerization) dryers
- Includes design modifications to reduce co-catalyst consumption
- Metallurgy improvements in regeneration section

**Continuous improvement through regular collaboration with Chevron**



# ISOALKY™ Technology – A Better Way to Alkylate

**ISOALKY** Technology proved a new step-out commercially viable alkylation technology using ionic liquid catalyst is possible

**ISOALKY** Process Technology utilizes a specialized ionic liquid catalyst for production of high quality alkylate from Olefinic LPG

- Utilizes strong acidic function of IL for alkylation reaction
- Process design similar to existing alkylation technology
- Small, in-situ catalyst regeneration

**ISOALKY™** unit is operating successfully at Chevron Salt Lake Refinery and meets design specifications

- 2024 Q4 TA scheduled. Will incorporate operational process improvement efforts.

**Chevron and UOP work as partners in all aspects of monitoring and improving ISOALKY**

- Regular communications, data sharing, collaboration on improvements
- Incorporation of learning in next generation of ISOALKY Plant design by UOP

