



# K-SAAT

Breakthrough Solid Acid Alkylation Technology

Proud history, bright future.





The worldwide gasoline market is changing.

# Gasoline Market Overview

## Demand

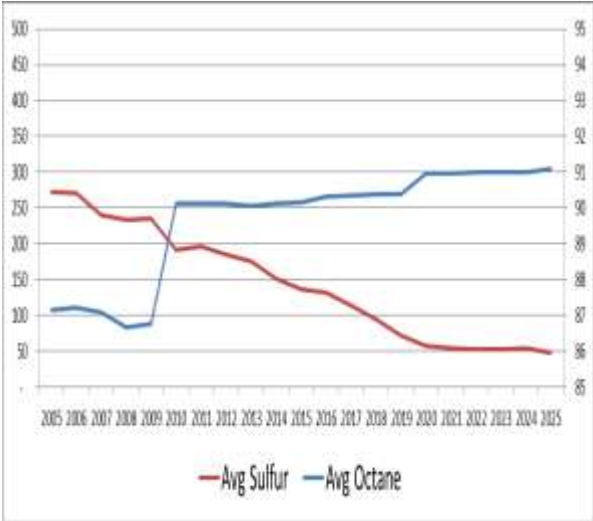
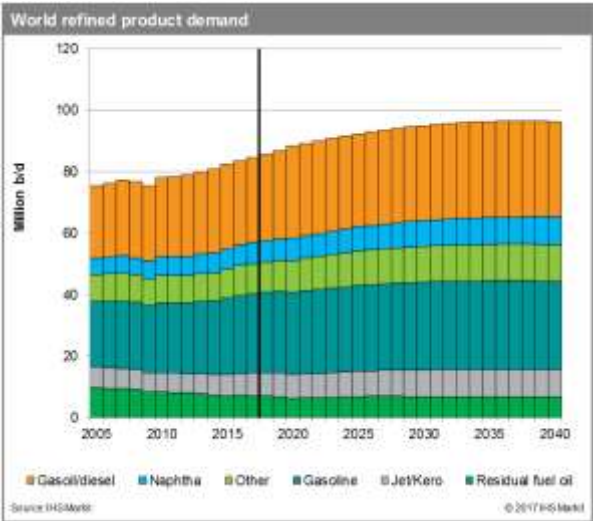
- Gasoline demand is steady or increasing across the globe
- More cars in emerging markets
- Stricter environmental standards
- Stringent blend requirements
- High premium on low RVP

## Sulfur

- Global environmental regulations require lower sulfur gasoline
- Hydrotreating lowers sulfur and octane
- Gasoline blending pool components to increase octane
  - Alkylate
  - Isomerizate
  - Ethanol
  - Reformate
  - Etc.

## Octane

- High-octane gasoline demand is rising
- North America and Western Europe are considering replacing legacy alkylate production units
- Availability of cheaper feedstock is driving new applications
- Developing countries are demanding higher octane



## Current Primary Market Octane Grade in Countries Expecting Fuel Economy Changes in 2020

Initial analysis suggests that octane levels may not be enough to meet automaker needs in coming years





An aerial photograph of a complex multi-level highway interchange, likely in a large city. The sun is low on the horizon, creating a warm, golden glow over the scene. The highway has multiple lanes and several overpasses. A semi-truck is visible on one of the upper levels. The surrounding area includes some greenery and urban development.

Alkylate is the preferred premium gasoline blendstock.

# Alkylate – Liquid Gold

- High octane
- Low RVP
- Low sulfur
- No aromatics
- No olefins





# Gasoline Blend Components

	C <sub>4</sub>	LSR	Isomerase	Poly Gasoline	FCC Light Naphtha	FCC Heavy Naphtha	Alkylate	Reformat	Ethers	Ethanol
RON	-	--	--	+	+	-	++	++	++	++
MON	+	--	--	-	-	--	++	++	++	++
RVP	--	--	--	++	--	++	++	++	++	--
E70	--	--	--	++	--	++	++	++	+	--
Olefins	+	++	++	--	--	-	++	++	++	++
Aromatics	++	++	++	++	++	+	++	--	++	++
Benzene	++	?	++	++	-	++	++	?	++	++
Oxygen	++	++	++	++	++	++	++	++	--	--

Alkylate is the preferred premium gasoline blendstock.



Current alkylate technologies have significant challenges.



# Alkylate Production Challenges

- Liquid-Acid Catalyst Processes
  - Handling
  - Corrosion
  - HSE
  - Permitting
  - Maintenance expense
- Conventional Solid-Acid Catalyst Processes
  - Poor stability
  - Expensive processes
  - Large inventories
- Limited feed stock flexibility







New technology overcomes these old challenges.

# K-SAAT™

Solid Acid Alkylation Technology

*Next generation* solid acid alkylation technology.

High Alkylate Yield + High Octane Numbers

High Feed Flexibility

Safer, Simpler, More Reliable

ExSact™ Solid Catalyst

Low CAPEX/OPEX





# High Alkylate Yield + High Octane Numbers

# Technology Comparison: Typical MTBE Raffinate Feed

	K-SAAT	Sulfuric Acid	HF Acid
Alkylate RON	99+	98	95 - 96
Alkylate Yield (vol/vol Olefin)	1.88	1.77	1.78
Eliminates Acid Soluble Oils?	Yes	No	No
Eliminates Liquid Effluents?	Yes	No	No
CAPEX	1.0	1.6	-
OPEX	1.0	1.6	-



# K-SAAT Product Quality

- Typically >1 point higher octane than liquid acids
- Typical values for potential olefinic feeds:

Feed	Ethylene*	Propylene ( 70% C <sub>3</sub> =)	MTBE Raffinate	Butenes (30% i-C <sub>4</sub> =)	Amylenes
RON	99	92	99	97	91
MON	94.5	90	95	93	89

\*Liquid acid catalyst will not alkylate ethylene



## High Feed Flexibility

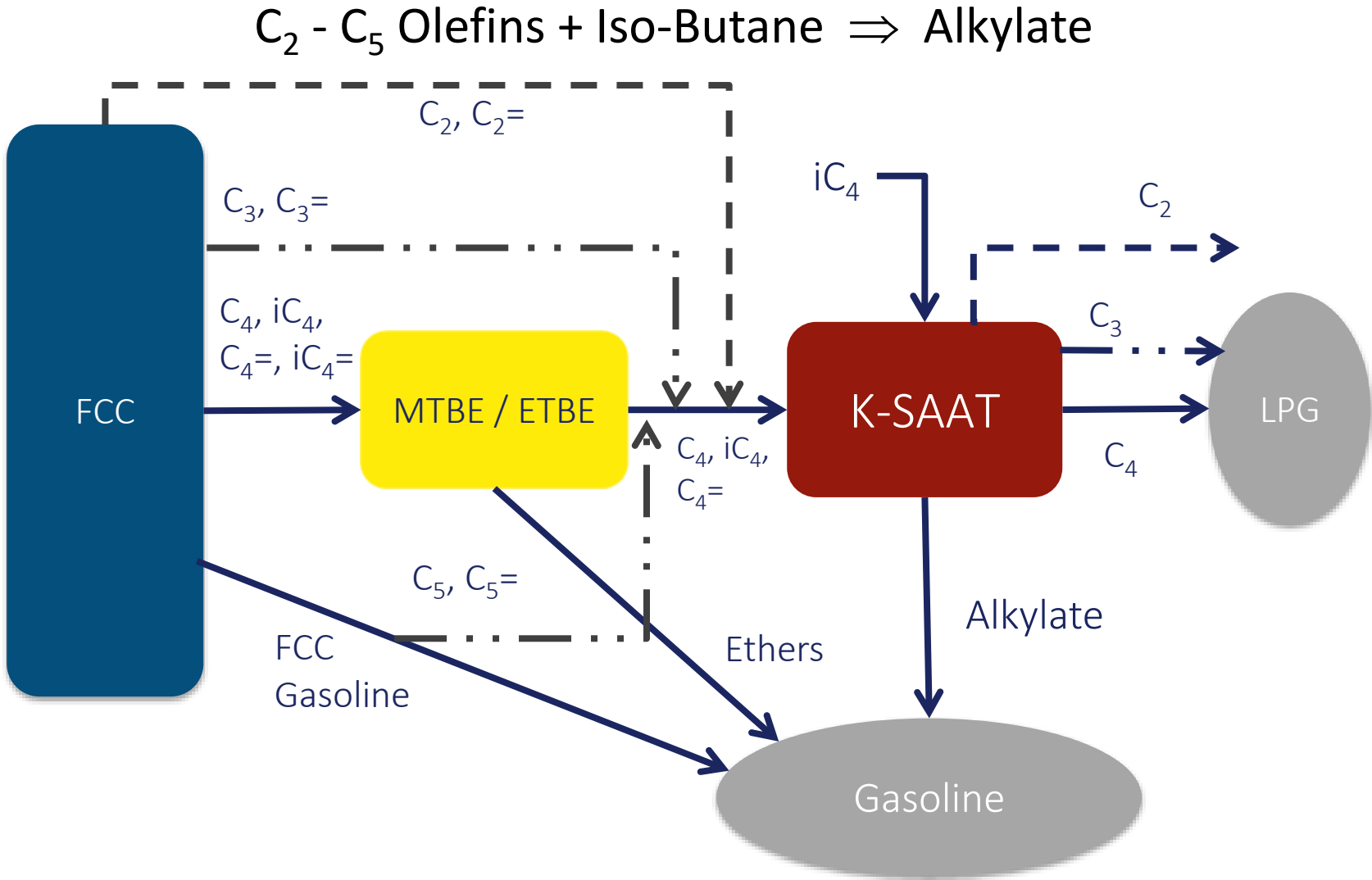


# Feed Flexibility

- Simpler reactor design
- No refrigeration or acid handling
- Lower power consumption
- Inexpensive regeneration
- High tolerance for impurities



# Feed Flexibility

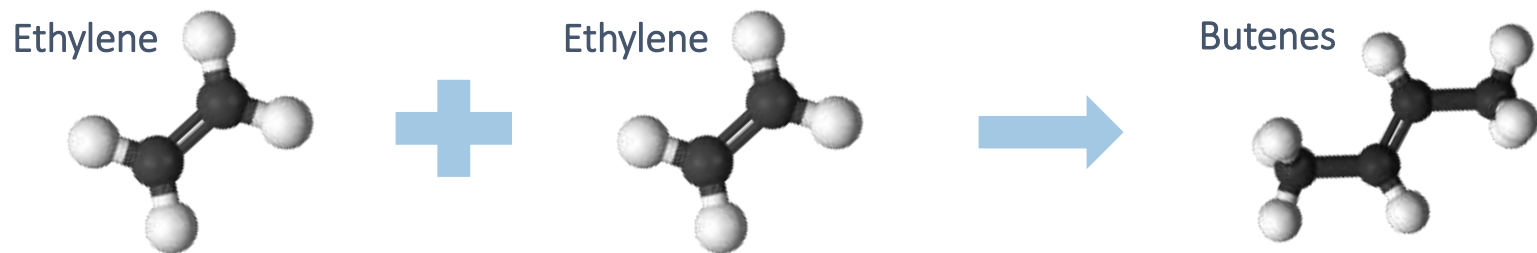




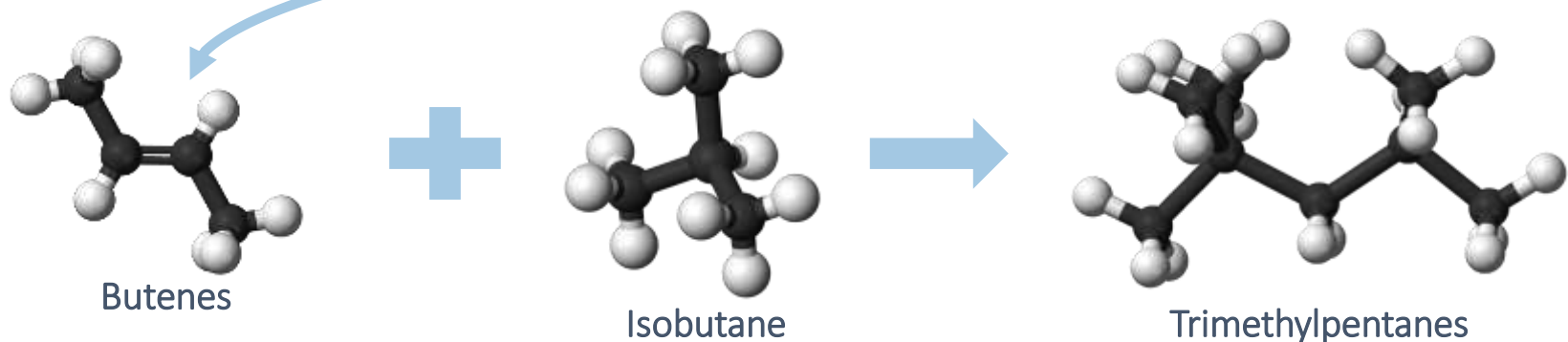
# K-SAAT Flexibility

- K-SAAT can alkylate ethylene up to 100% purity
  - Dimerization and alkylation steps in one reactor

## Dimerization



## Alkylation



The key is ExSact™ Solid Acid Catalyst.



# ExSact™ Catalyst

- Zeolite-based catalyst
- Selective to high-octane TMPs
- Eliminates acid-soluble oils
- Guaranteed 5-year life
- >24-hour cycle length



# Advantages of the ExSact™ Catalyst

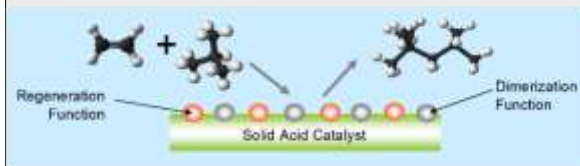
## Engineered Catalyst

- Optimized particle size and shape
- Optimized Pore Structure on a micro and macro scale
- Optimized Acid Site Strength & Distribution



## Optimized Reactions

- Improved mass transfer to prevent pore blockage
- Promotes alkylation over polymerization reactions
- Highly selective to 2,3,3- and 2,3,4-trimethylpentane\*
- Minimal isomerization of trimethylpentanes to dimethylhexanes



\* 2,3,3- and 2,3,4-trimethylpentane research octane >100

## Superior Yield & Octane

- Higher catalyst activity
- Longer cycle length (24 hr)
- Longer catalyst life (5 yr)
- Higher alkylate octane
- Simplified process design



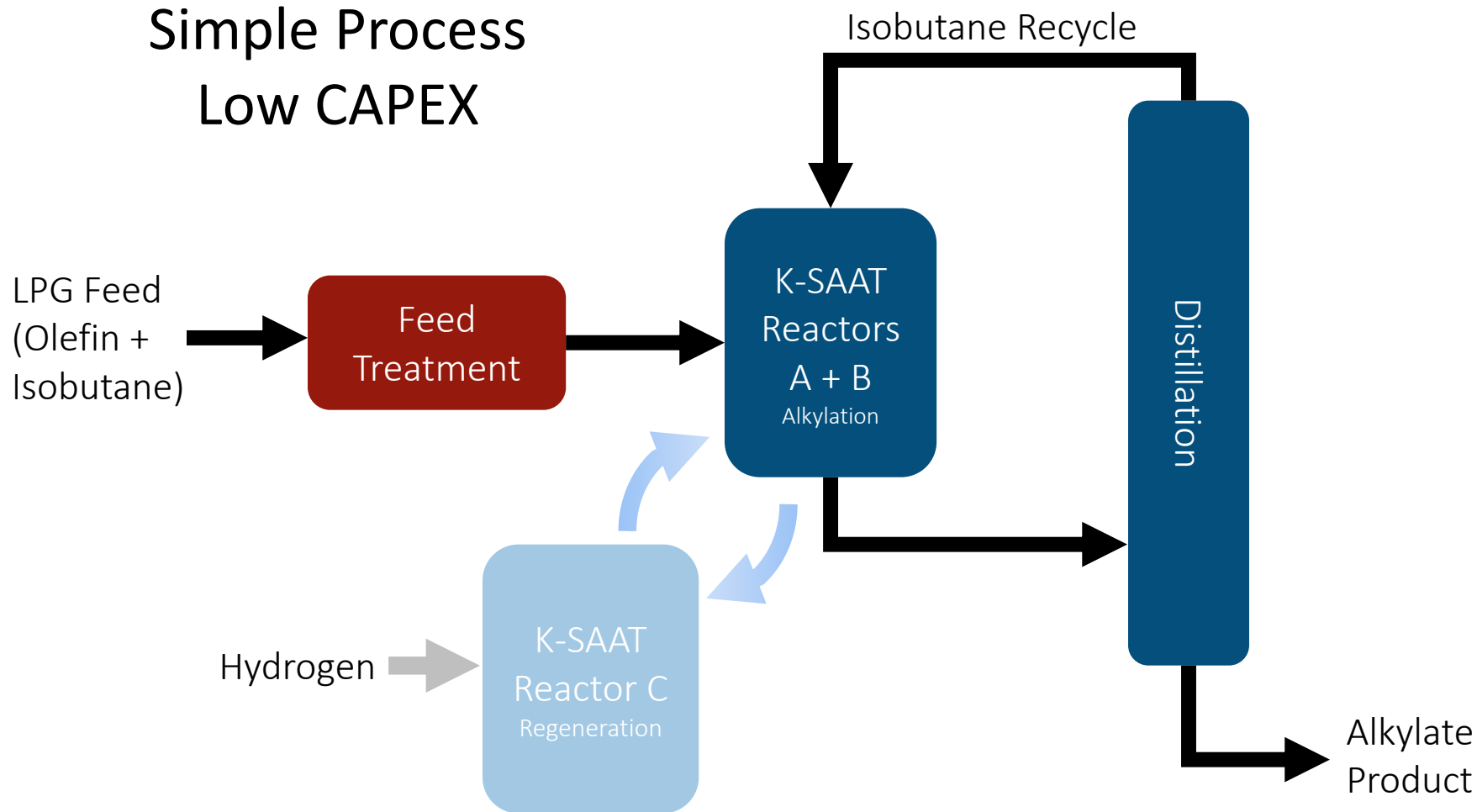


A detailed close-up photograph of industrial machinery, likely a compressor or pump. A black timing belt is visible, running across several pulleys. The pulleys are made of metal and have a ribbed design. The machinery is constructed from various metal components, including bolts and brackets. A blue semi-transparent banner is overlaid across the middle of the image, containing the text "K-SAAT Process – Safer, Simpler, More Reliable." in white.

K-SAAT Process – Safer, Simpler, More Reliable.

# K-SAAT Process Scheme

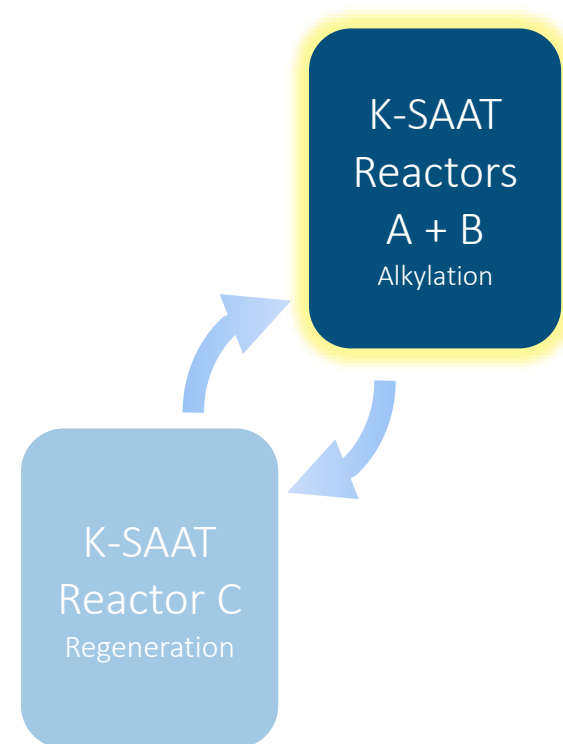
Simple Process  
Low CAPEX



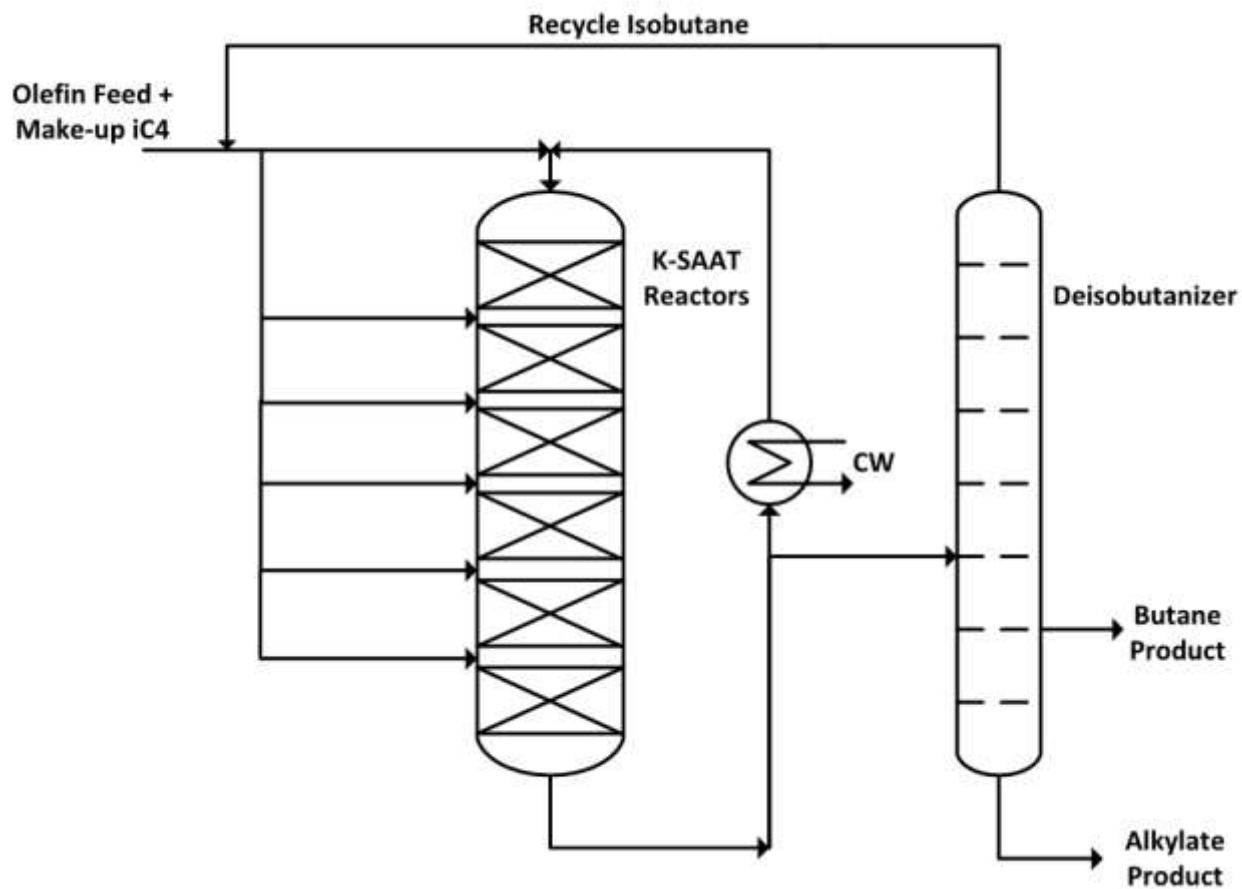


# K-SAAT Reaction

- Typically 3 fixed-bed reactors
- 24-hour cycle length
- Isobutane/olefin ratio ~10
- 20 barg & 50°C (290 psig & 120°F)
  - Moderate temperature favors alkylation over polymerization reactions
  - No refrigeration required
- No liquid effluents or ASOs
- Reactor material: low alloy steel



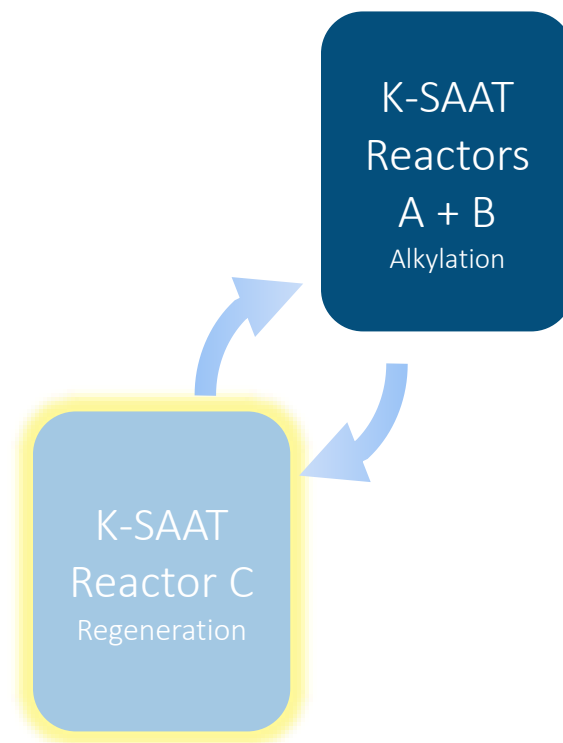
# Process Scheme





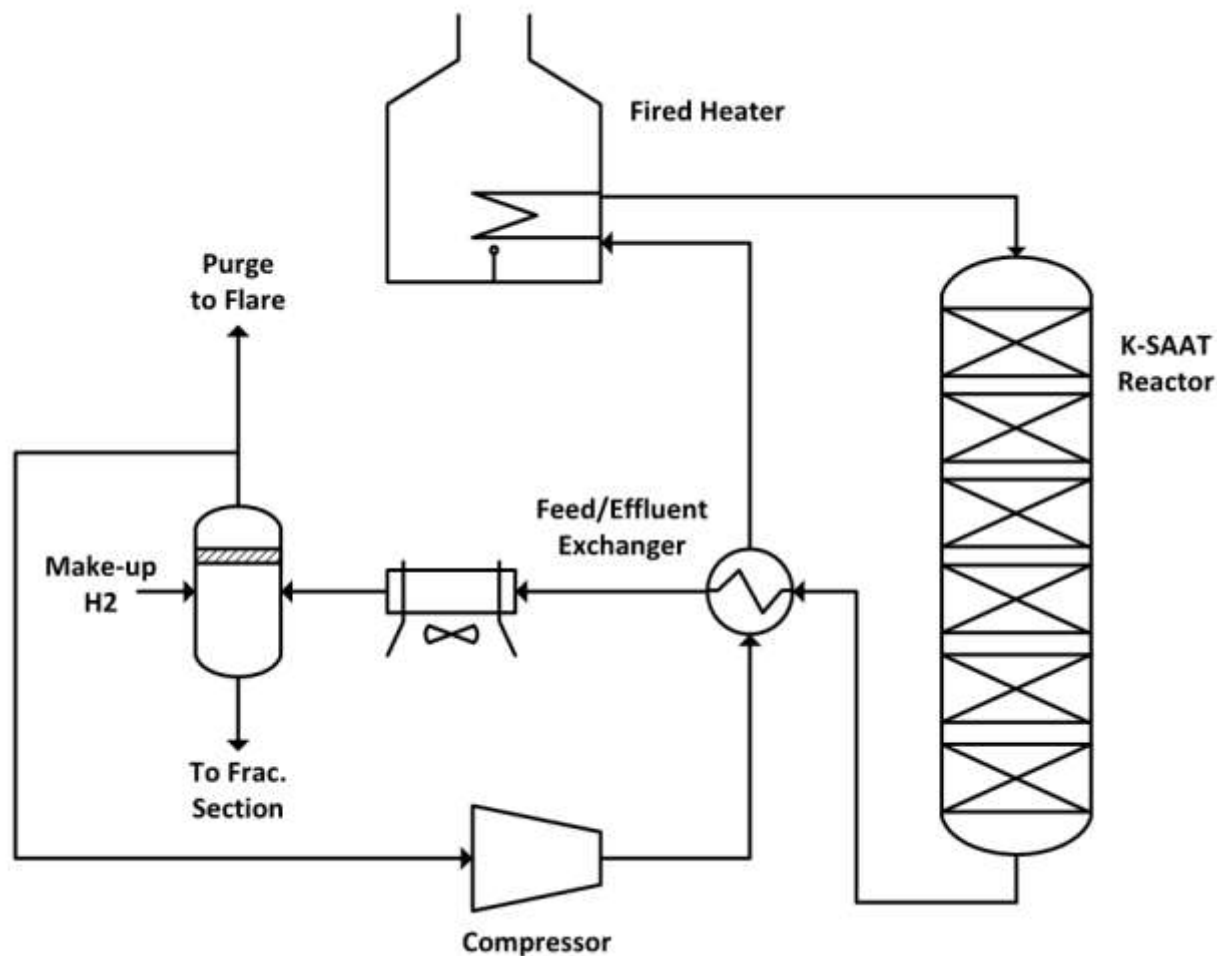
# K-SAAT Regeneration

- 12 hour regeneration cycle
- Hot hydrogen regeneration:
  - 20 barg & 275°C (290 psig & 525°F)
  - Hydrogen requirement: 0.87 kg/MT alkylate (0.2 lb/BBL alkylate)
- Reformer grade hydrogen (~80% purity)
- Fired or MV Electric Heater



# Process Scheme – Regeneration

Reformer Grade Hydrogen (~80% purity)

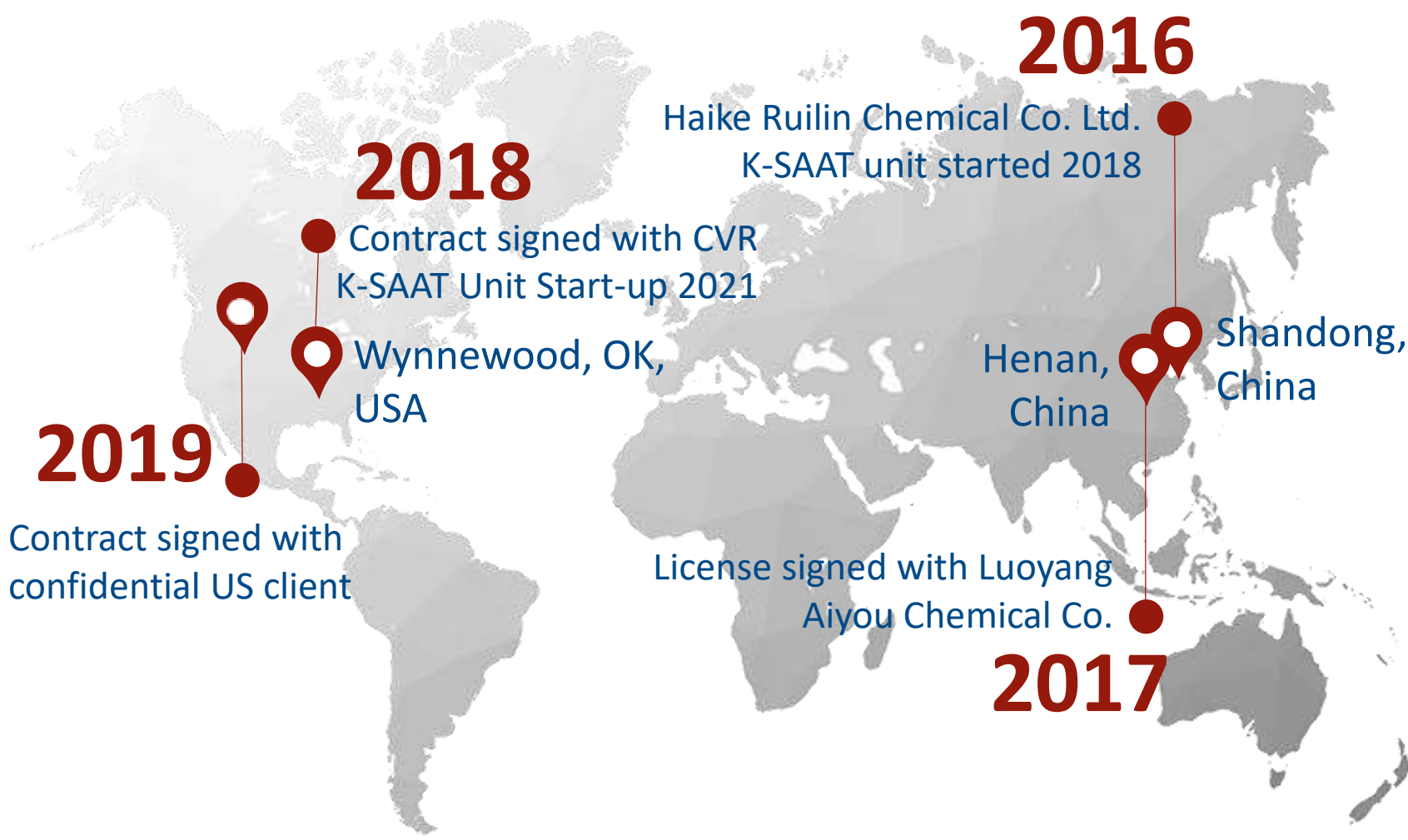


A close-up, low-angle shot of a silver car's front end. The image focuses on the sleek, curved lines of the hood and the modern, angular design of the headlight. A side-view mirror is visible in the upper right corner, reflecting some blurred lights. The lighting is dramatic, with strong highlights and shadows that emphasize the car's metallic texture and aerodynamic shape.

## Commercial References



# References



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Breakthrough Solid-Catalyst Alkylation Technology