K-SAAT

Breakthrough Solid Acid Alkylation Technology

Proud history, bright future.


The worldwide gasoline market is changing.

Gasoline Market Overview

Demand

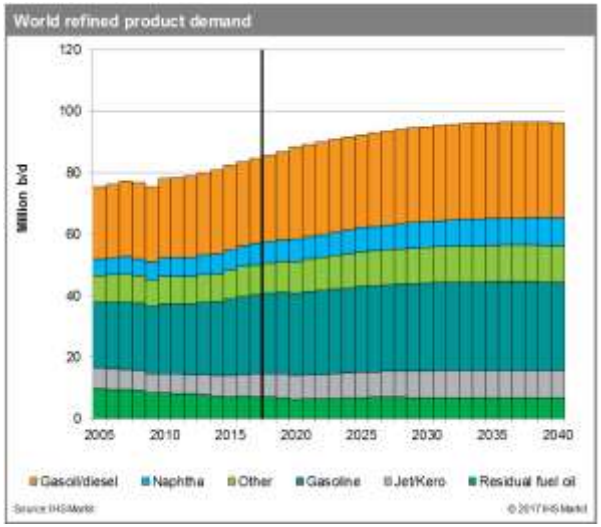
- Gasoline demand is steady or increasing across the globe
- More cars in emerging markets
- Stricter environmental standards
- Stringent blend requirements
- High premium on low RVP

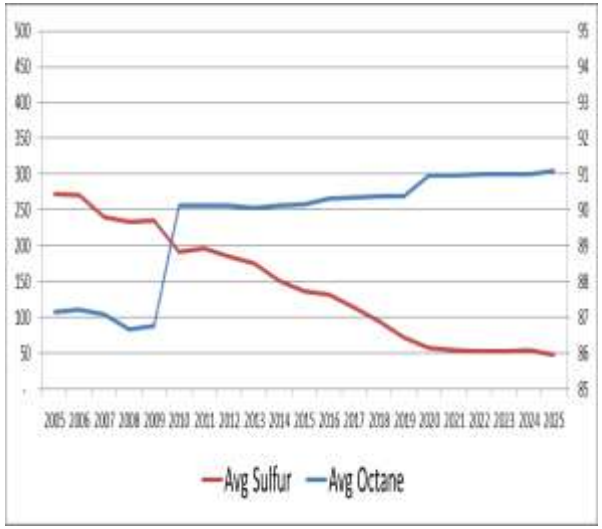
Sulfur

- 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





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Alkylate is the preferred premium gasoline blendstock.

Alkylate – Liquid Gold

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

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Gasoline Blend Components

	C_4	LSR	Isomerate	Poly Gasoline	FCC Light Naphtha	FCC Heavy Naphtha	Alkylate	Reformate	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

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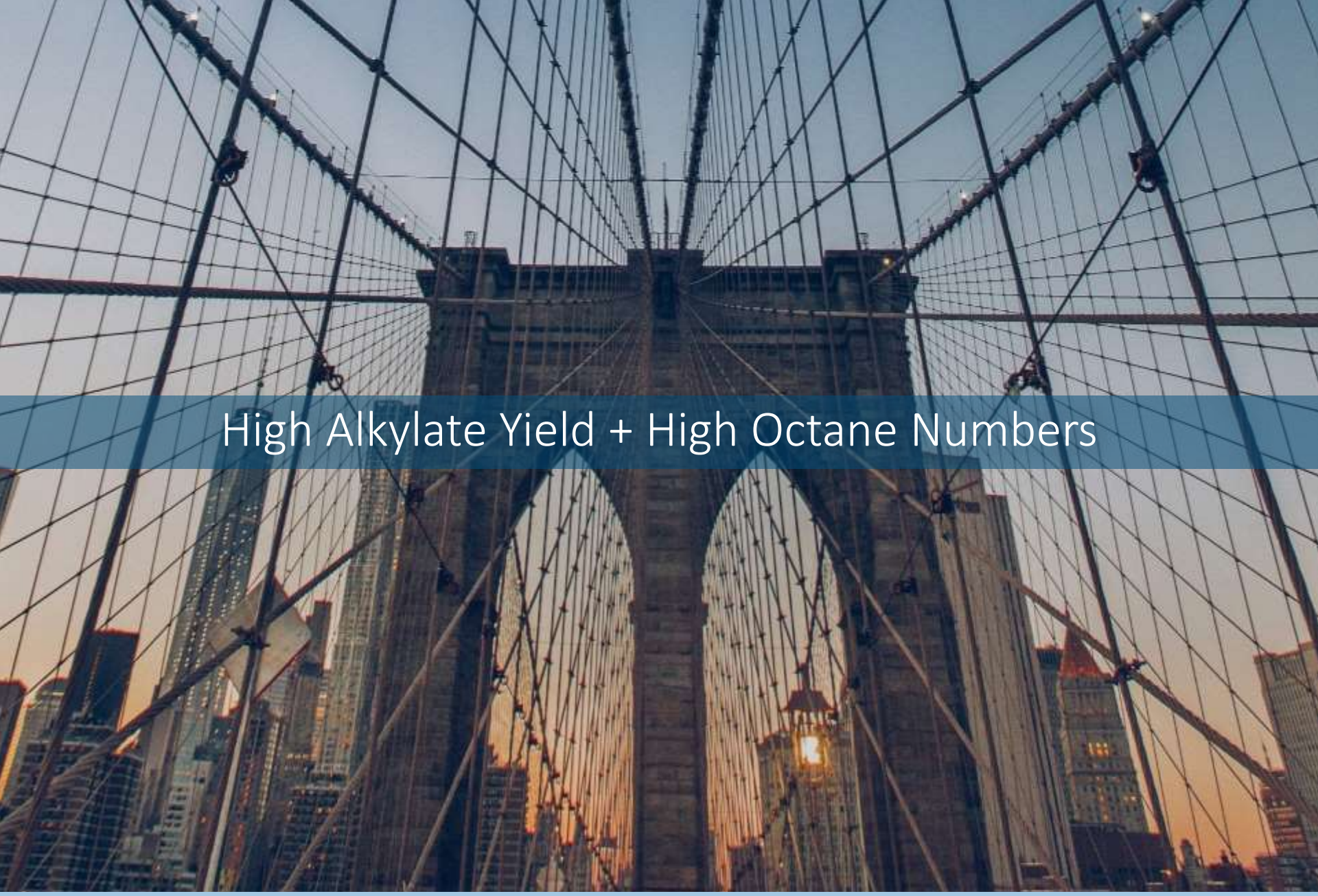
New technology overcomes these old challenges.

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_3=)	MTBE Raffinate	Butenes (30% i-C_4=)	Amylenes
RON	99	92	99	97	91
MON	94.5	90	95	93	89

*Liquid acid catalyst will not alkylate ethylene

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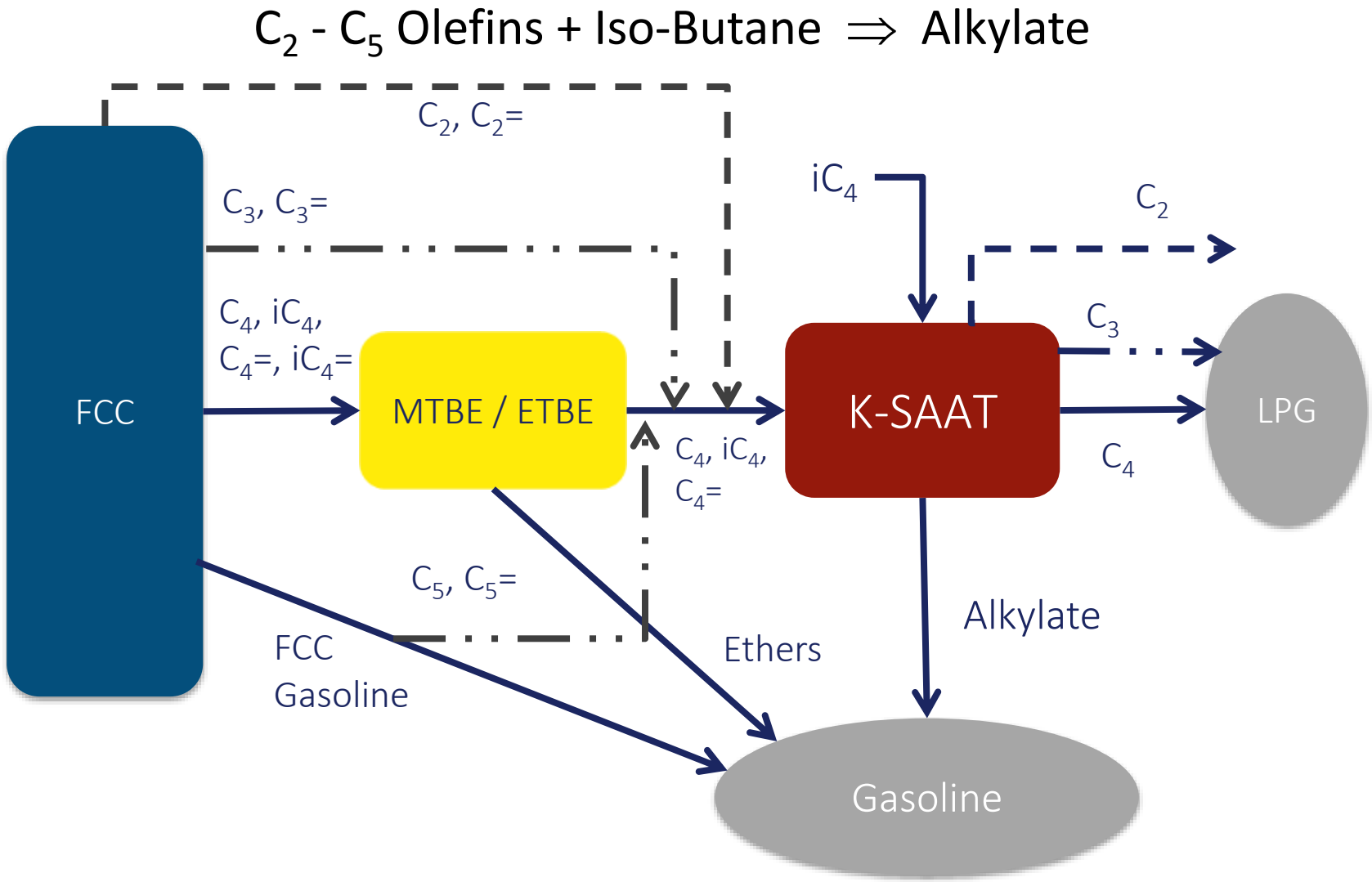
High Feed Flexibility

Feed Flexibility

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

Feed Flexibility



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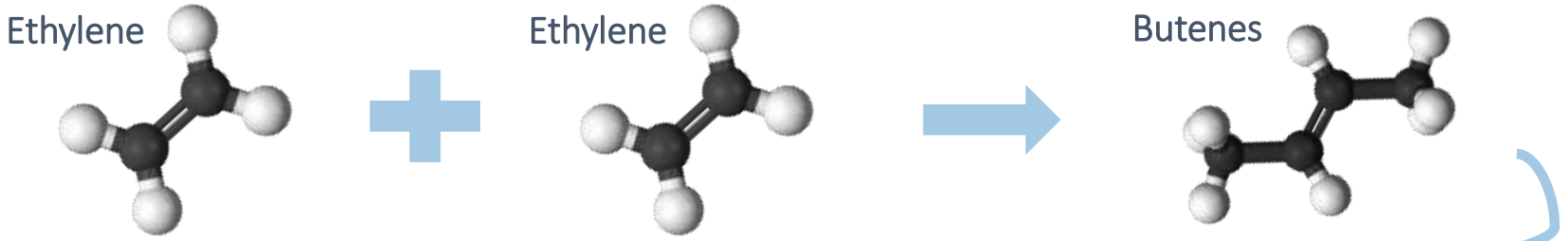
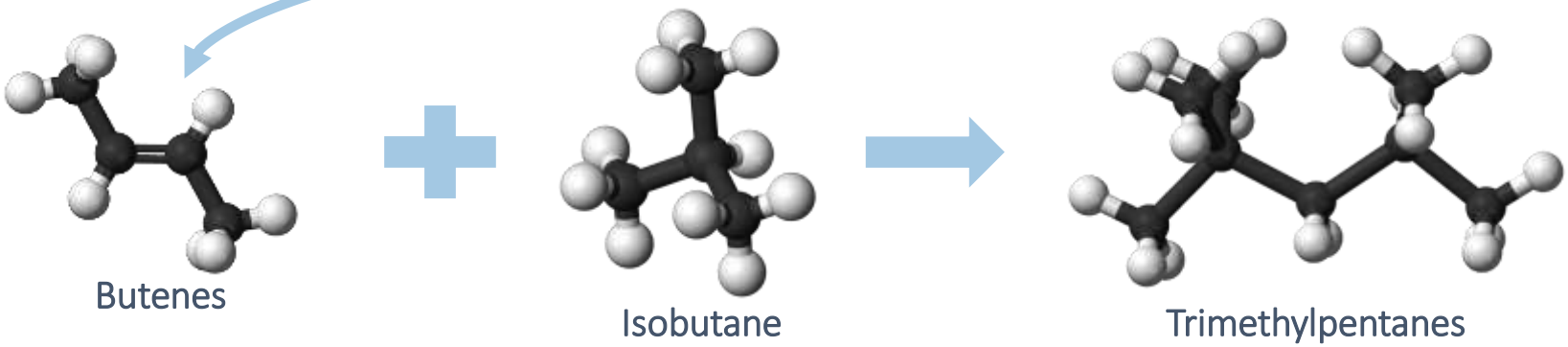
K-SAAT Flexibility

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

Dimerization



Alkylation



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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

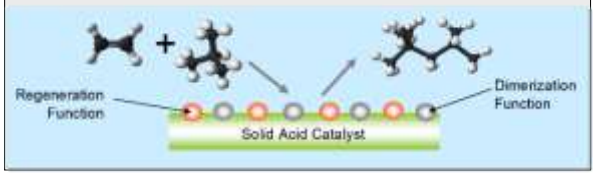
Advantages of the ExSact™ Catalyst

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



Superior Yield & Octane

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

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

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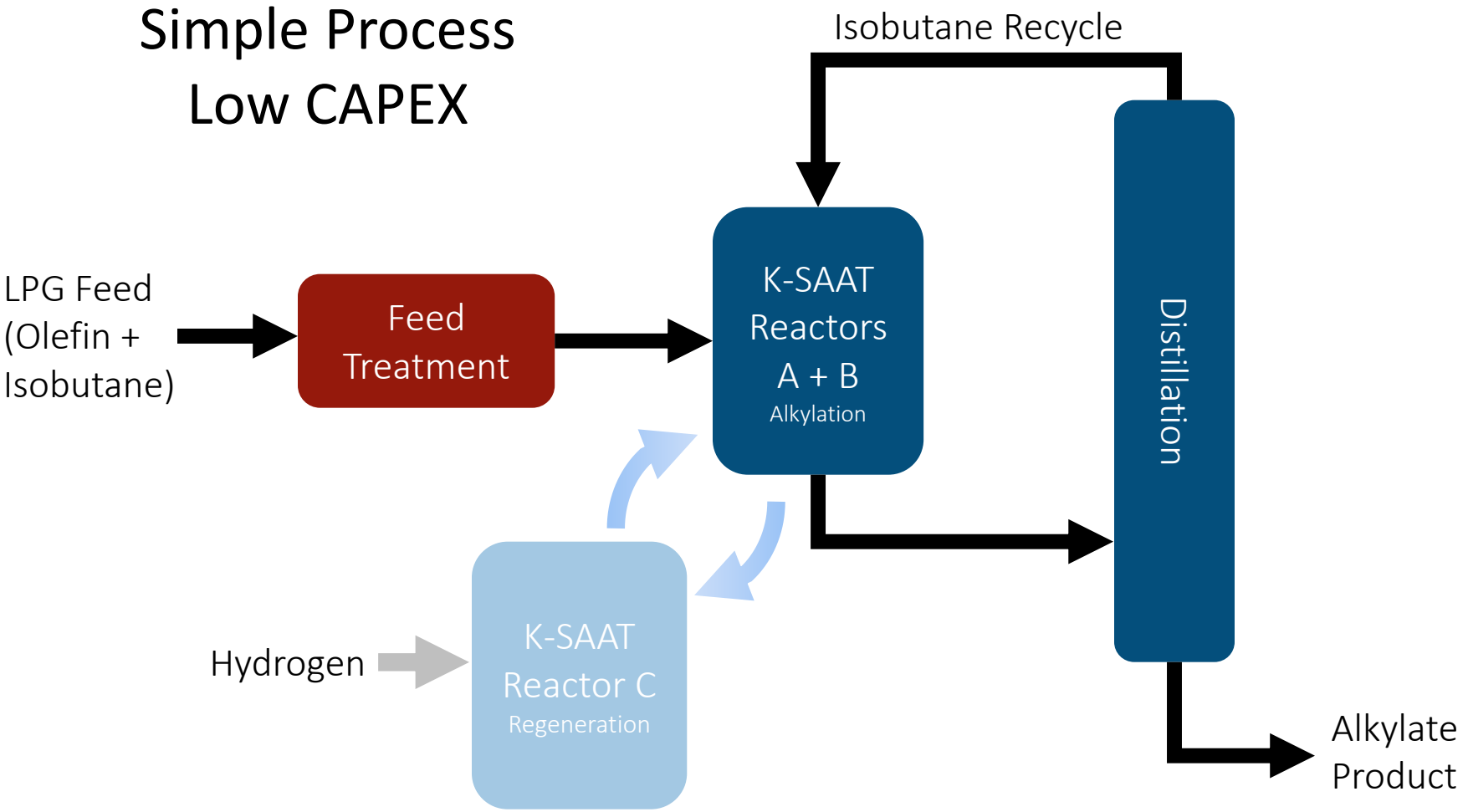
K-SAAT Process – Safer, Simpler, More Reliable.

K-SAAT Process Scheme



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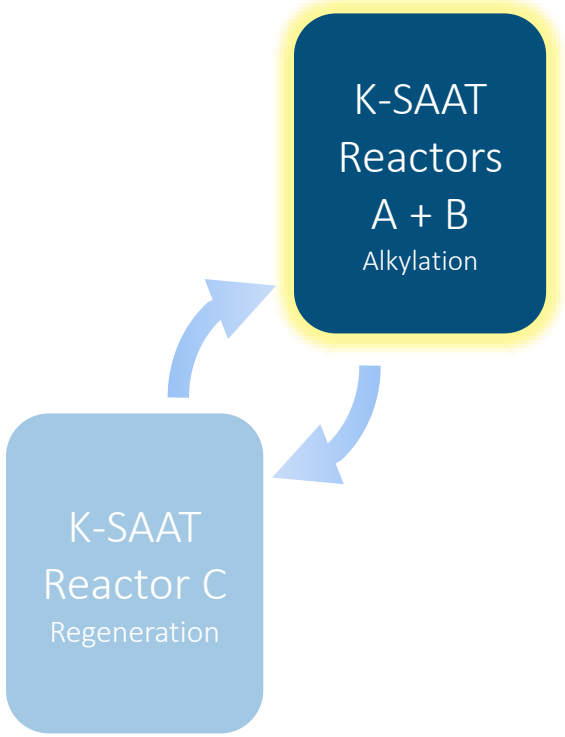
K-SAAT Reaction

- 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



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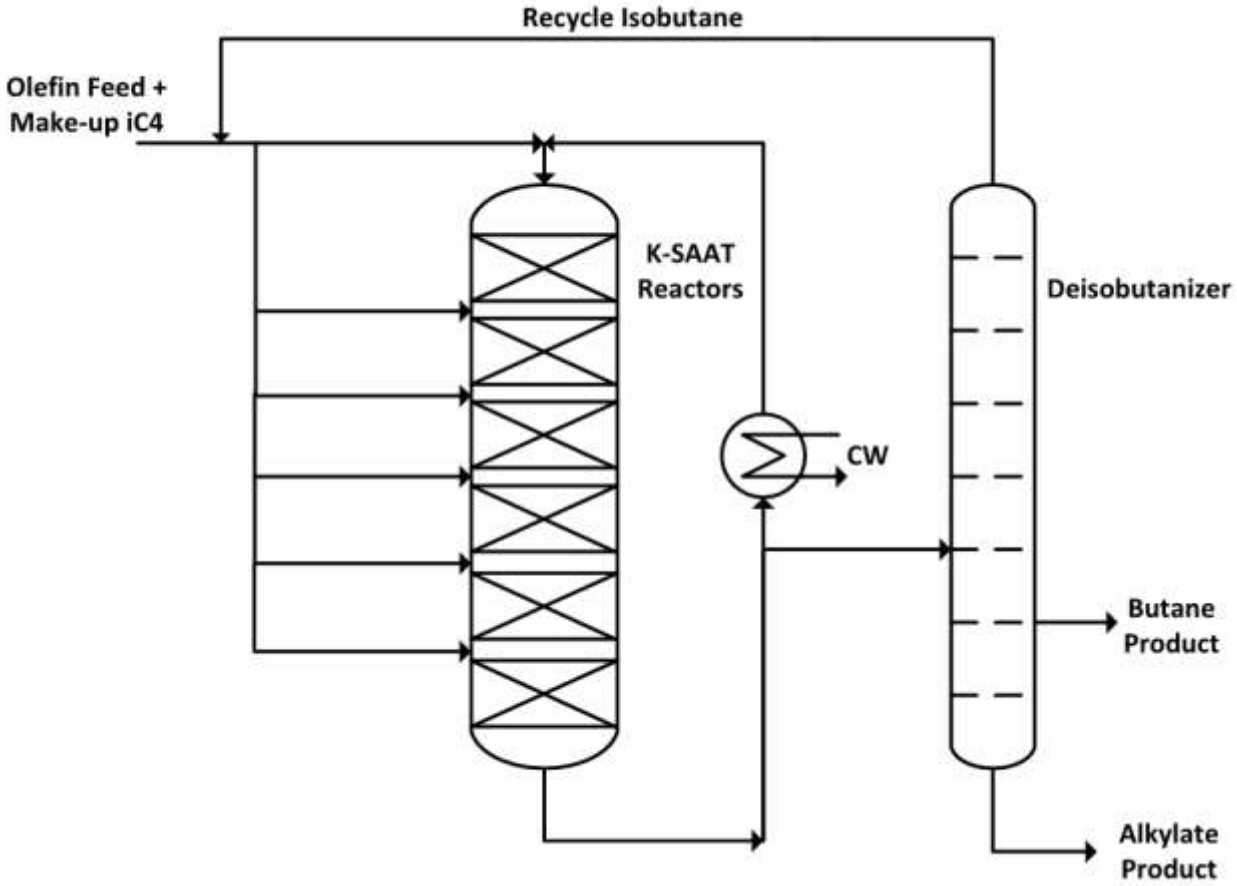
Process Scheme



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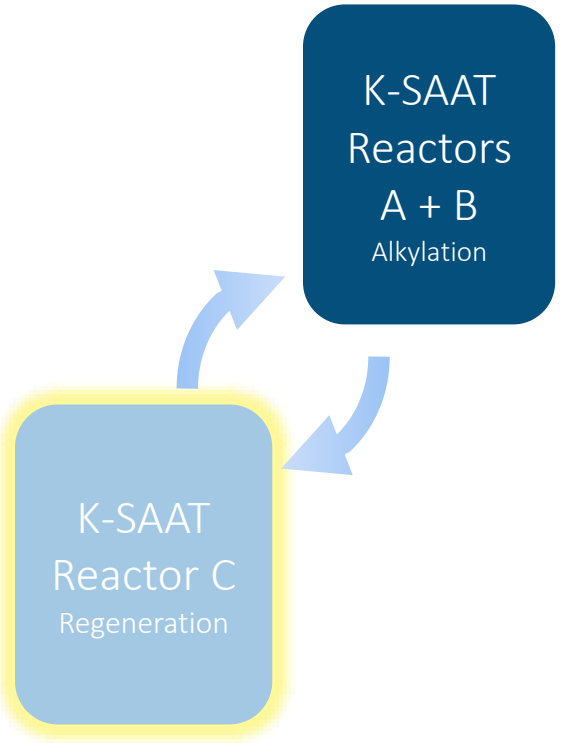
K-SAAT Regeneration

- 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



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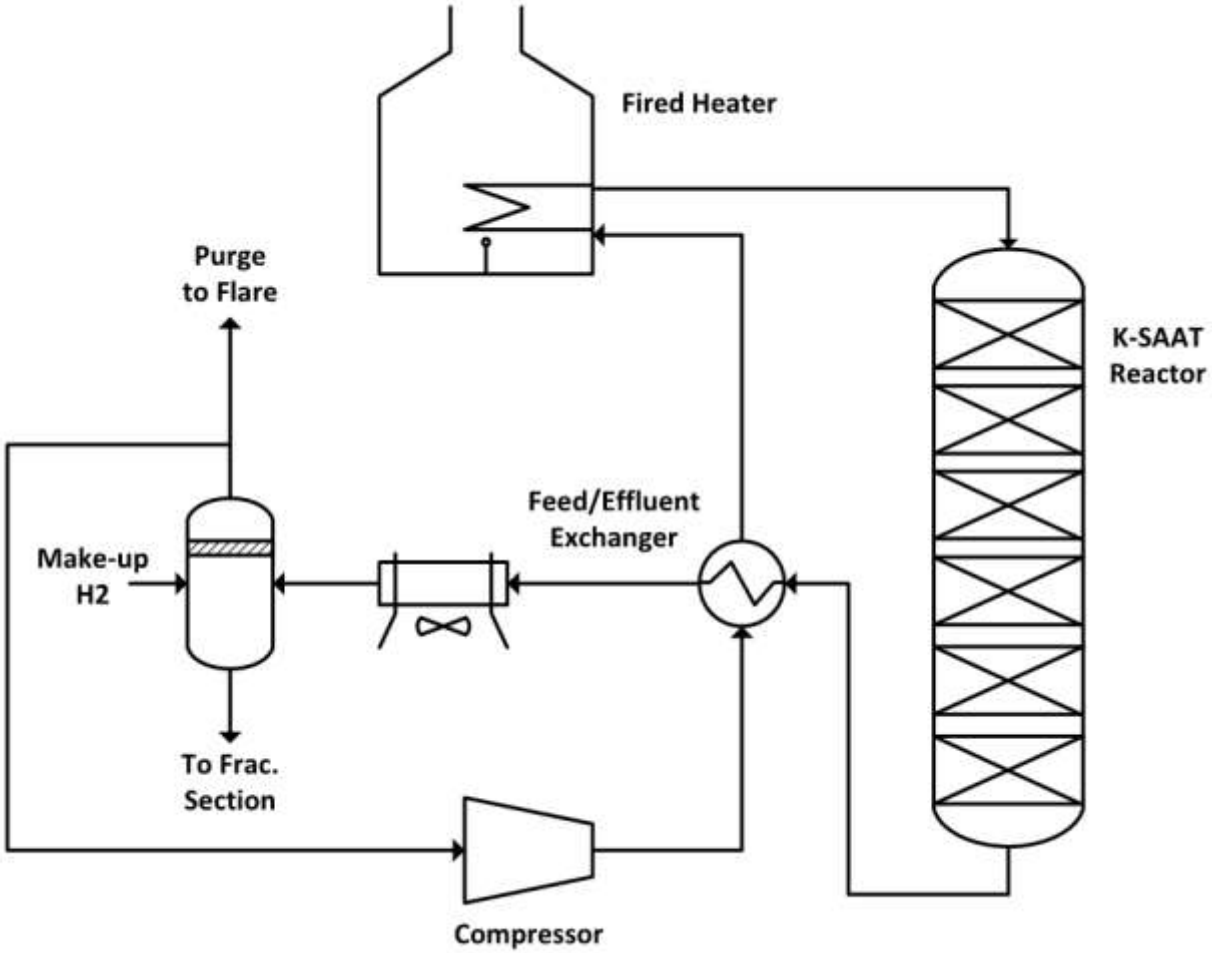
Process Scheme – Regeneration

Reformer Grade Hydrogen (~80% purity)



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Commercial References

References

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