



UOP HF Alkylation with Forced Circulation

Refining

Background

As the 21st century begins, significant changes to the gasoline pool requirements increase the importance of alkylate as a key blending component. UOP continues to improve the HF Alkylation technology in response to market needs. This helps maximize profits for our customers.

Benefits

UOP is the leading licensor of HF alkylation technology, with over 140 units licensed around the world. Adding an alkylation unit to a refinery scheme offers several benefits:

- Improves gasoline quality by adding clean-burning, mid-boiling-range isoparaffins
- Reduces gasoline pool vapor pressure and olefin content by converting C₃-C₅ olefin components to alkylate
- Converts surplus normal butanes to alkylate. Our Butamer™ process isomerizes normal butanes to isobutane. These are reacted with olefins in the HF Alkylation unit to form alkylate.
- Consumes excess olefins to create alkylate

Feed treating and product properties

Alkylation feedstocks are typically treated to remove sulfur and water. In cases where MTBE and TAME raffinates are being processed, an oxygenate removal unit (ORU) may be desirable. Selective hydrogenation of butylene feedstock is an option to reduce acid regeneration requirements, catalyst (acid) consumption, and increase alkylate octane by isomerizing 1-butene to 2-butene.

Feed treating is particularly important when processing C₅ olefins. The C₅ stream is typically first treated in an extractive Merox™ process unit to reduce the sulfur content to 50 ppm or less, and then in a Hüls Selective Hydrogenation process (SHP) to remove cyclopentadienes and linear diolefins. The treated stream can then be alkylated with conventional C₃-C₄ olefin feedstocks.

Typical yields and alkylate properties for planning are shown in Table 1. Actual yields and product properties depend on the specific feedstock composition, as well as on process design and operating conditions.

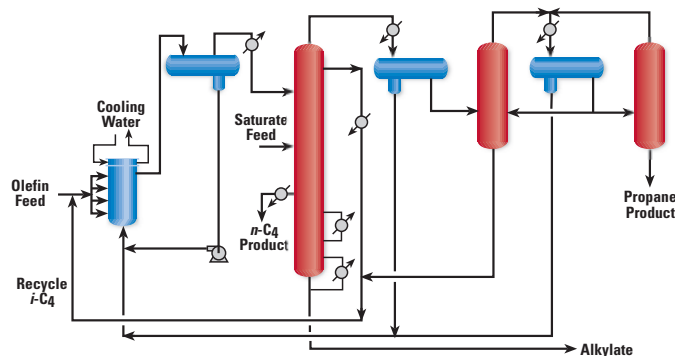
Table 1 ■ HF Alkylation Yields and Properties

Feedstock	Olefin Feed Component		
	C ₃ =	C ₄ =	C ₅ =
Yield vol. per vol. Olefin:			
Isobutane consumed	1.4	1.2	1.3
C ₅ ⁺ alkylate produced	1.8	1.8	2.0
C₅⁺ Alkylate properties:			
API	70.7	69.9	69.9
RONC	91.0	96.0	90.0
MONC	89.5	94.0	89.0
RVP, psia	3.0	2.7	0.45
(kPa)	(20.7)	(18.6)	(3.10)

Process description

The alkylation reaction catalytically combines C₃-C₅ olefins with isobutane to produce motor fuel alkylate. Alkylation takes place in the presence of HF catalyst under conditions selected to maximize alkylate yield and quality. A general process flow diagram for the production of motor fuel alkylate is shown in Figure 1. Actual designs are tailored to individual refinery needs. Design improvements have reduced unit acid inventory to as low as 7-10 lb of HF acid per barrel of alkylate.

Figure 1 ■ HF Alkylation Yields and Properties



The reactor system is carefully designed to ensure efficient contacting and mixing of hydrocarbon feed with the acid catalyst. Continuous removal of the heat of reaction in the reaction zone reduces peak reaction temperatures and enhances product selectivity. Efficient heat transfer makes effective use of the available

cooling water supply. Acid inventory in the reactor system is minimized by the combination of high heat-transfer rates and lower overall acid circulation. UOP also offers a split-feed, series-recycle reactor system that maximize the internal isobutane-to-olefin ratio in multi-reactor systems. The split-feed, series-recycle configuration benefits the refiner by maximizing throughput and product quality when the isobutane recycle quantity is fixed.

Acid regeneration takes place in the acid regenerator or via a patented internal acid regeneration method. Internal regeneration allows the refiner to shut down the acid regenerator, thereby realizing a utility savings as well as reducing acid consumption and eliminating the task of polymer disposal.

Economics

HF Alkylation remains the most economically viable method for the production of alkylate. The acid consumption rate for HF Alkylation is less than 1/100th the rate for sulfuric alkylation units. And unlike sulfuric alkylation units, HF Alkylation does not require refrigeration equipment to maintain a low reactor temperature.

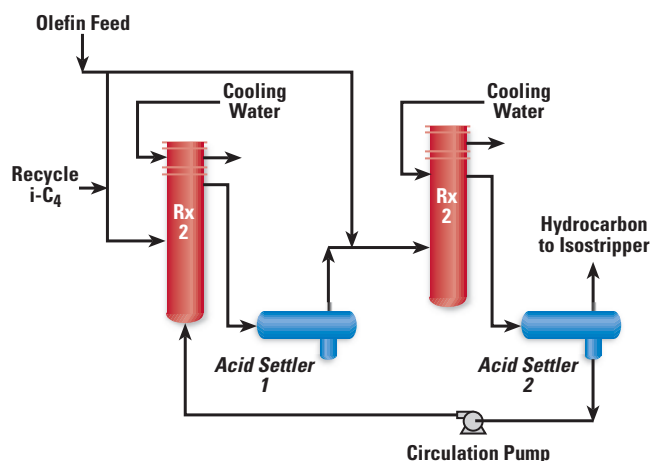
Revamp opportunities

Unit revamps may be undertaken to process incremental olefin feedstock or specifically to process FCC C₅ olefins. Many possible options are available to expand the capacity and enhance performance of existing units or reduce potential hazards associated with HF alkylation.

Options for increasing capacity and performance

- Additional reactors
- Split-feed, series-recycle reactor scheme - In terms of octane, acid inventory, operating costs, and capital costs the SFSR design is a very attractive option for adding alkylate production to either a gravity flow system or a single stage pumped system. With either system, the revamp can produce additional alkylate at about 30% the cost of a new unit.
- New feed nozzles - specially designed nozzles produce droplets of an optimal size, increasing alkylate octane and reducing acid consumption

Figure 2 ■ HF Alkylation Yields and Properties



- Fractionation upgrades
- SHP unit for improved feed treating - Reducing the diene content of the feed results in lower acid consumption in an HF alkylation unit and increased alkylate yield. Butene isomerization also occurs over the SHP catalyst that will increase the ratio of butene-2 to butene-1. The increased 2-butene content will increase alkylate octane.
- Expanded regeneration capacity
- Neutralization section upgrades - Disposal costs are reduced while operability and safety is enhanced.

Options for reducing process risk

- Adding aerosol reduction technology (the Alkad™ process)
- Acid inventory reduction - Strategies include modified settler designs.
- Rapid acid transfer designs

UOP can assist refiners in a revamp analysis to determine the most effective modifications to achieve the desired objectives.

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