STRATCO® ALKYLATION TECHNOLOGY

A FULL LINE GLOBAL LEADER FOR ALKYLATION TECHNOLOGY AND SERVICES

The STRATCO® Alkylation Technology is the world leader with over 90 units licensed with more than 800,000 BPSD (31,400 kmta) of installed capacity. DuPont is committed to alkylation research and is an expert in all aspects of the process, having extensive experience in assisting refiners through alkylation research, design, startups, test runs, troubleshooting, optimization, revamps, expansions, analytical testing, operator training, turnarounds, and HAZOP studies.

ALKYLATION FACTS

The alkylation process reacts light olefins (propylene, butylene, and amylene) with isobutane in the presence of a strong acid catalyst. The resulting alkylate product consists of branched paraffins with low Rvp, high octane, zero aromatics and olefins, and very low sulfur. These properties make alkylate an ideal blendstock for cleaner burning gasoline.

Due to heightened global environmental awareness, the importance of alkylate as a gasoline blend component is rapidly increasing worldwide. As a result, global alkylation capacity is approximately 2,000,000 BPSD (78,500 kmta).

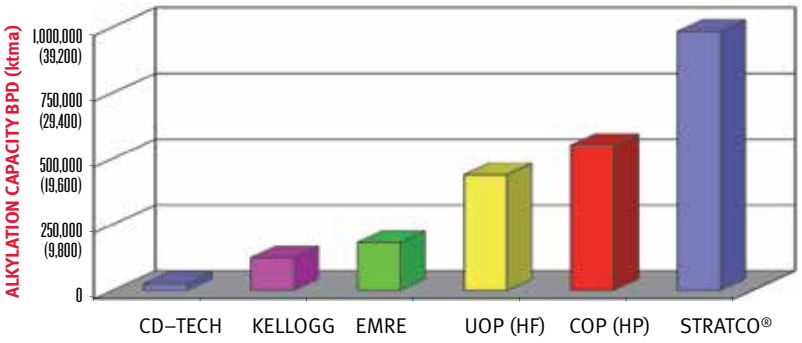
UNITED STATES TRENDS

The development of the STRATCO® Alkylation Technology in the 1930s was instrumental in the initial goal of fulfilling high octane aviation fuel. During the 1950s and 1960s, the U.S. automobile industry started producing higher compression engines, requiring higher octane gasoline, and refiners' interest in alkylation shifted from the production of aviation fuel to the use of alkylate as a blendstock in premium motor fuel.

FEATURES AND BENEFITS

- World leading alkylation technology with over 90 units licensed
- Over 800,000 BPSD (31,400 kmta) of installed capacity
- Single point contact for the entire alkylation complex:
  – Alkylation, SAR
  – SHP, Isomerization
- Nearly 90% of recent alkylation projects have been licensed and designed by DuPont
- Recognized expert in all aspects of the alkylation process
- Over 50 full time engineers and technicians dedicated to the STRATCO® Alkylation Technology
- Offices located in the USA, regional offices throughout Latin America, Asia, and the Middle East provide timely, local expertise
- Committed to continuous improvement through extensive R&D facilities

2014 WORLDWIDE ALKYLATION CAPACITY



DuPont Sustainable Solutions
CLEAN TECHNOLOGIES

www.cleantechnologies.dupont.com

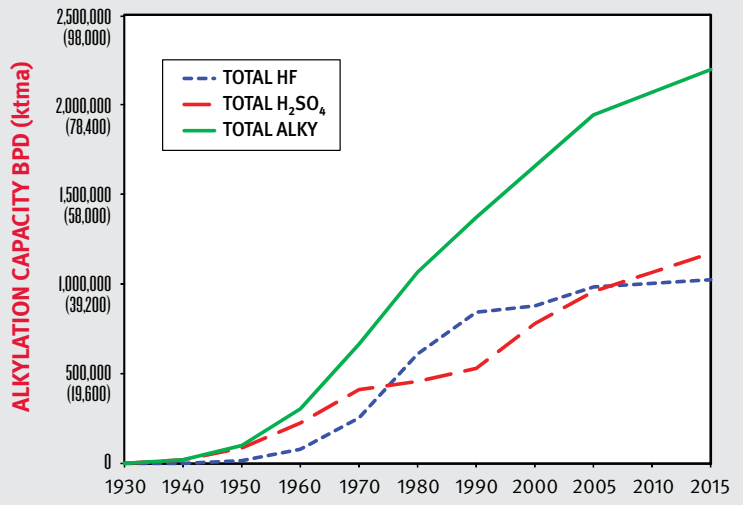
STRATCO® ALKYLATION TECHNOLOGY

Throughout the 1970s and 1980s, U.S. demand for alkylate continued to grow but at a slower rate. Alkylate was being used to help refiners cope with the phase-out of lead in gasoline by providing some of the lost octane. Furthermore, demand increased for higher octane premium gasoline, thus continuing the increase in demand for alkylation as a high octane blendstock.

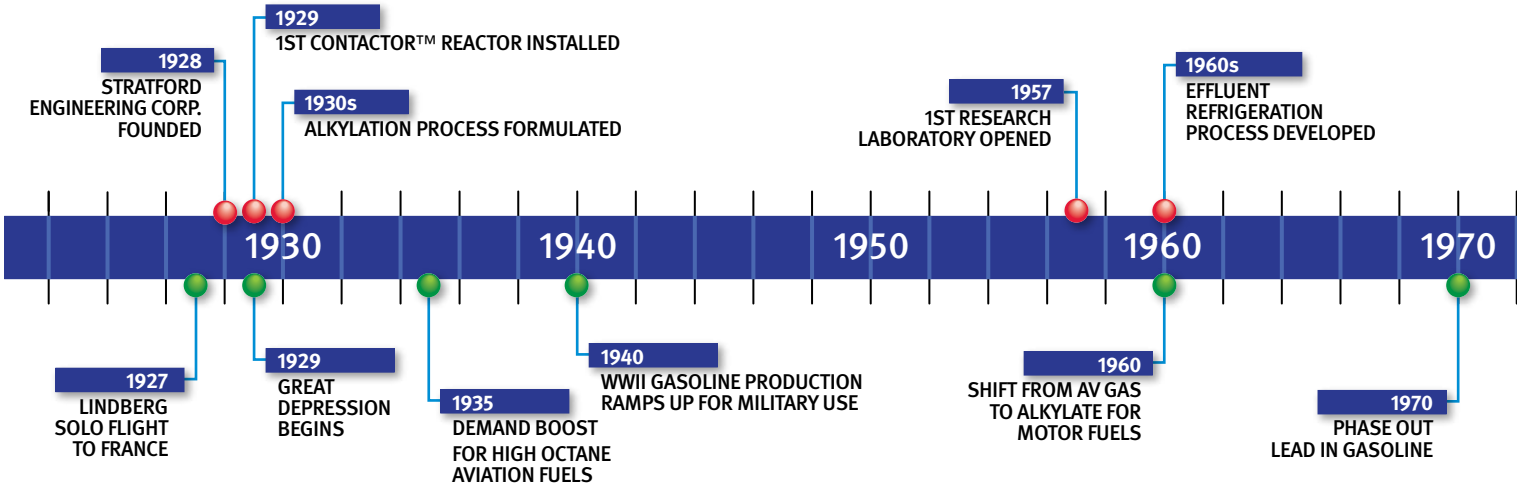
In the U.S., current and future demand increases are primarily the result of the 1990 Clean Air Act Amendments and subsequent legislation which, beginning in 1995, required "reformulated", cleaner burning gasoline for the most highly polluted areas of the U.S.

Through the 1990s, methyl tertiarybutyl ether (MTBE), which has a blending octane in the range of 106–110, was the preferred oxygenate of petroleum refiners, with nearly 90 percent of the nation's cleaner burning gasoline using MTBE as the prime pollution-fighting oxygenate. Due to leaks from underground fuel tanks and the fact that MTBE is soluble in water, MTBE turned up in Orange County, California's ground water in 1995. Soon after, MTBE began appearing in groundwater, lakes, and reservoirs throughout the state.

As a result of the groundwater contamination issues in California as well as the concern that MTBE is a possible carcinogen, MTBE has effectively been phased-out of the gasoline pool in the U.S. While there are other oxygenates available to meet the requirements of reformulated gasoline (the Environmental Protection Agency [EPA] has approved TAME, ETBE and TBA for blending), there is still a concern over the toxicology of these oxygenates. These components are also soluble in water and are likely to contaminate groundwater. Nominal quantities of these ethers are currently produced but not nearly enough to be a solution for the phase-out of MTBE.



The primary replacement oxygenate to meet the requirements of reformulated gasoline (RFG) is ethanol; however, the use of ethanol requires additional handling and blending investments. Ethanol, similar to MTBE, provides an octane boost to the gasoline pool having a blending octane of 110+. Ethanol's oxygen content is approximately 35% compared to MTBE's oxygen content of 18%. Therefore, much less ethanol is required in RFG in order to meet the oxygen requirements. Because the volume requirement is less, there is an overall octane loss to the RFG pool. The two most likely candidates for providing the additional octane are reformate and alkylate. Alkylate is the more desirable choice due to the lack of aromatics.



Ethanol is currently blended in over 95% of the nation's gasoline. Nationwide ethanol makes up 9.8 vol% of the gasoline pool which leaves the U.S. at the blend wall as E10 (composed of 10% ethanol and 90% gasoline) is currently the fuel of choice. The addition of ethanol to the gasoline pool raises the Reid vapor pressure (Rvp) by approximately 1 psi, even at very low concentrations. The use of ethanol also contributes to an increase in the NOx emissions from vehicles. These two factors force the refiner to adjust the base gasoline components to meet regulatory vehicle emissions and gasoline evaporative emissions specifications.

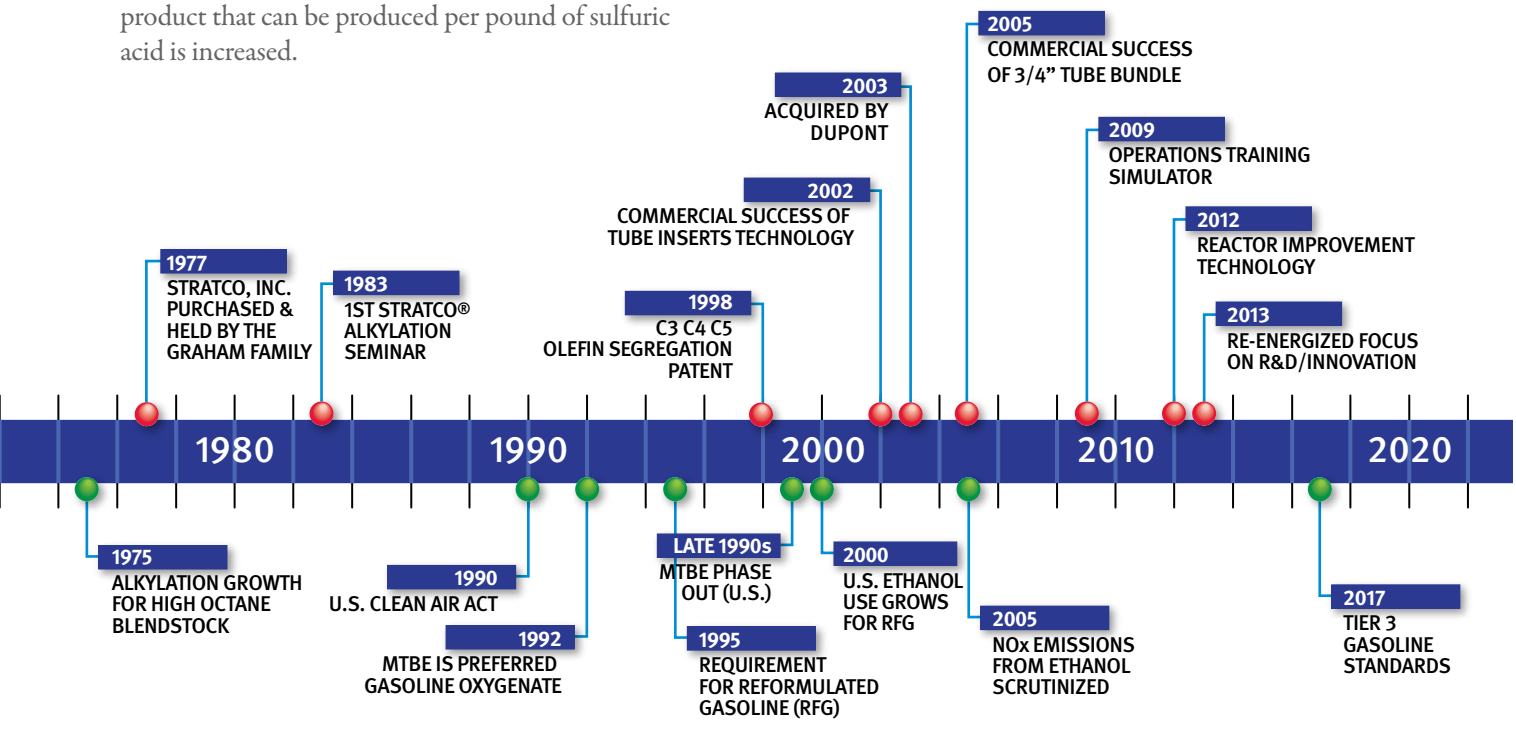
Recently, many U.S. refiners are looking at the alkylation of amylenes as an option for reduction of gasoline pool Rvp and olefin content. Although there is a volume loss experienced when alkylating amylene olefins vs. blending them directly into gasoline, the positive impact to the gasoline pool Rvp typically outweighs the negative impact of the volume reduction. Amylene alkylation becomes especially economical as the value of the feedstocks (amylenes and isobutane) continues to decline.

Since amylene olefins can be alkylated at a lower acid strength than butylene olefins, DuPont recommends spending at approximately 90 wt% for butylenes vs. approximately 87 wt% for amylenes. Therefore, it is relatively simple for DuPont to revamp an existing alkylation unit adding a segregated stage of amylenes into a butylene alkylation unit. Because of the larger spending range of sulfuric acid, the amount of alkylate product that can be produced per pound of sulfuric acid is increased.

The U.S. will be moving to Tier 3 gasoline standards starting in 2017 which reduces the sulfur content in gasoline from its current level of 30 ppm to 10 ppm. Increasing the amount of alkylate in the gasoline pool is an attractive option for meeting these new regulations as the sulfur content of the alkylation product is less than 10 ppm with most refiners reporting less than 2 ppm or non-detectable levels. Current alkylation capacity in the U.S. exceeds 1,200,000 BPSD, (47,000 kmta) with alkylate constituting over 11% of the total U.S. gasoline pool, and the use is growing. Regions in the U.S. with Clean Air Act constraints blend even more alkylate. California's gasoline pool, for example, has contained upwards of 25% alkylate at times. Therefore, alkylate will continue to play a major role in the U.S. gasoline blending strategy for the foreseeable future.

INTERNATIONAL TRENDS

Historically, the international demand for alkylate has lagged behind that of the U.S. due to economic and environmental factors. Many countries outside the U.S. have imposed substantially higher taxes on finished gasoline products which reduces the mileage driven per year per person. But as populations and income continue to increase in many developing countries, more gasoline will be consumed. When growing concerns about pollution are factored in, the status quo of using highly aromatic and olefinic blendstocks is no longer acceptable.



STRATCO® ALKYLATION TECHNOLOGY

Recently there has been a significant shift in the international refining industry as emphasis is placed on high conversion refineries. This is due, in large part, to worldwide environmental awareness and legislation directed at the international refining industry to clean up the finished gasoline product. Companies are being pushed to revamp existing refineries or to construct grassroots refineries to meet an increasing local demand for cleaner burning and environmentally friendly gasoline. Alkylate serves as a viable solution for meeting the stricter gasoline regulations and, therefore, will likely makeup a larger portion of the future gasoline pool in countries outside of the U.S.

DUPONT OFFERING

DuPont provides a holistic solution for the alkylation complex with the STRATCO® Alkylation Technology and MECS® Spent Sulfuric Acid Regeneration Technologies. In addition, DuPont can act as a single point coordinator for adjacent technologies within the alkylation complex such as the Selective Hydrogenation Process (SHP) for removal of 1,3 butadiene and the Butane Isomerization Technology which isomerizes normal butane to isobutane for use in the alkylation unit. For grassroots customers, the DuPont offering includes technology licensing, basic engineering package, proprietary equipment, and on-site technical services. DuPont maintains a close working relationship with our customers long after the initial unit start-up. DuPont has a comprehensive list of products, services and solutions for existing alkylation units, whether you're considering an alkylation unit revamp or expansion, seek to improve unit reliability or want to optimize existing unit operation.

COMPANY	LOCATION	STARTUP	CONTACTOR™ REACTOR
TBA	Africa	2018	12
TBA	Middle East	2018	8
TBA	Middle East	2018	7
TBA	Middle East	2018	6
TBA	China	2017	6
TBA	China	2017	5
TBA	China	2017	3
TBA	North America	2017	4
TBA	South America	2017	3
TBA	South America	2017	3
TBA	Russia	2016	3
TBA	Russia	2016	2
TBA	Middle East	2016	3
TBA	Middle East	2015	14
SATORP	Middle East	2014	5
PETROTRIN	South America	2013	6
CPC	Taiwan	2013	6
BASHNEFT	South America	2013	4

WORLDWIDE SALES AND SUPPORT

For more information, please contact the following DuPont representative:

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CLEAN TECHNOLOGIES

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