



CB&I's Advanced Alkylation
Technologies:
CDA/ky[®] and AlkyClean[®]

SCAQMD Working Group Meeting
Diamond Bar, California
August 2, 2017



A World of **Solutions**



This presentation contains forward-looking statements regarding CB&I and represents our expectations and beliefs concerning future events. These forward-looking statements are intended to be covered by the safe harbor for forward-looking statements provided by the Private Securities Litigation Reform Act of 1995. Forward-looking statements involve known and unknown risks and uncertainties. When considering any statements that are predictive in nature, depend upon or refer to future events or conditions, or use or contain words, terms, phrases, or expressions such as “achieve”, “forecast”, “plan”, “propose”, “strategy”, “envision”, “hope”, “will”, “continue”, “potential”, “expect”, “believe”, “anticipate”, “project”, “estimate”, “predict”, “intend”, “should”, “could”, “may”, “might”, or similar forward-looking statements, we refer you to the cautionary statements concerning risk factors and “Forward-Looking Statements” described under “Risk Factors” in Item 1A of our Annual Report filed on Form 10-K filed with the SEC for the year ended December 31, 2016, and any updates to those risk factors or “Forward-Looking Statements” included in our subsequent Quarterly Reports on Form 10-Q filed with the SEC, which cautionary statements are incorporated herein by reference.



- CB&I Overview Snapshot
- Introduction – Alkylation Technologies
- CB&I's Solid Catalyst Alkylation Technology - AlkyClean
- CB&I's Advanced Low Temperature Sulfuric Acid Alkylation Process - CDA/ky



- Leading provider of technology and infrastructure for the energy industry
- 125+ years of experience and expertise in reliable solutions
- \$18.5 billion backlog (Dec. 31, 2016)
- More than 40,000 employees worldwide
- Relentless focus on safety: 0.01 LTIR for 2016





▪ Solid Acid Catalyst Alkylation

- Inherently safer than liquid acid technologies, particularly HF
- CB&I and Albemarle successfully commercialized the first solid acid alkylation technology in China in 2015 using AlkyClean technology (capacity 2,700 BPD)
- AlkyClean technology is the first and only commercialized solid acid alkylation technology in the world



▪ Ionic Liquid Alkylation

- Ionic Liquid alkylation was commercialized in a 2,400 BPD unit in China (2013).
- Capital intensive: \$130 MMUSD for 2,400 BPD (complex IL/HC separation)
- High utility consumption: 50% more than sulfuric acid alkylation
- Chlorides in the alkylate product: Post-treatment unavoidable
- Reported alkylate quality falls short of a technology breakthrough

▪ Sulfuric Acid Alkylation

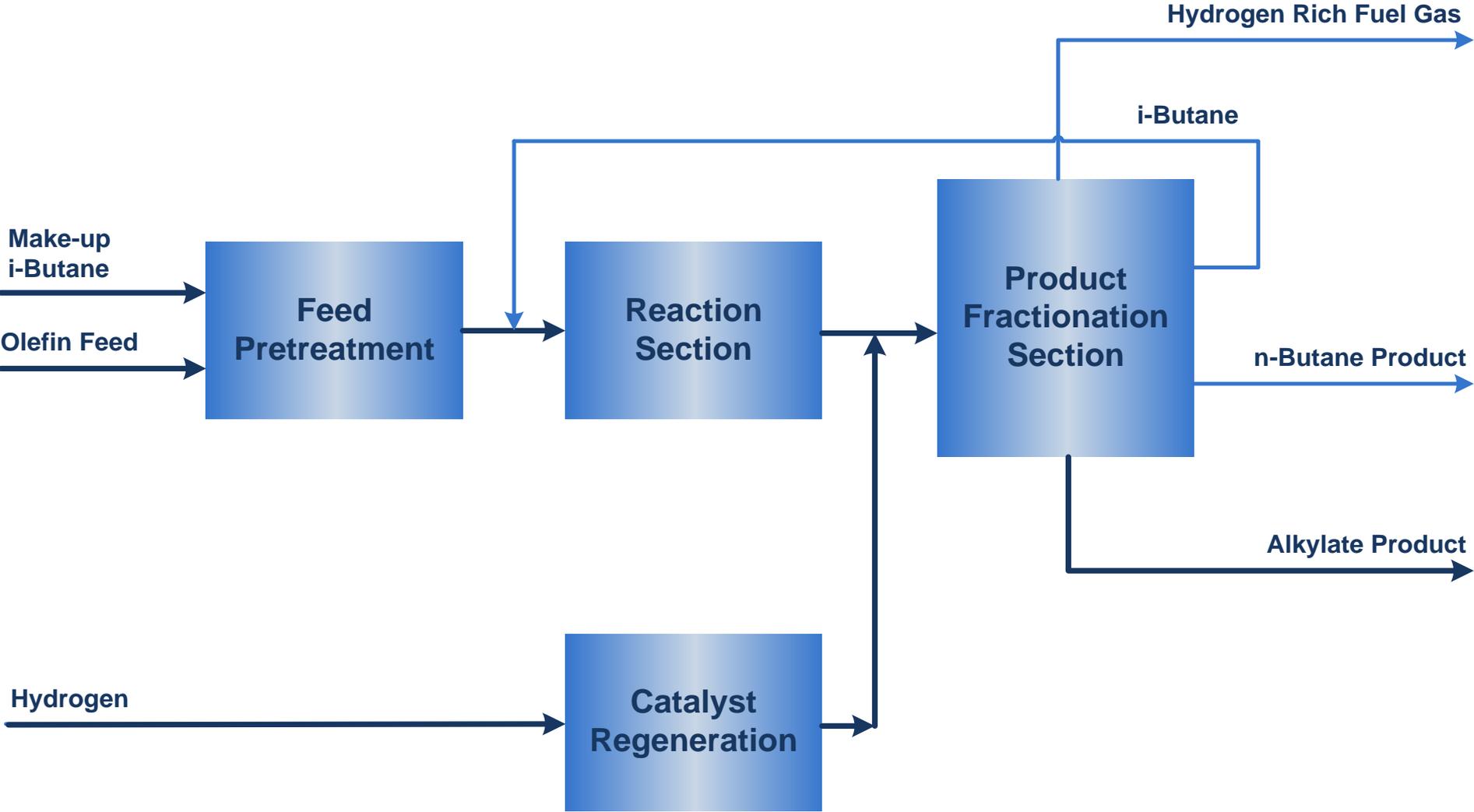
- CDA l ky has become the **technology of choice** for sulfuric acid alkylation due to its innovative design.
- Commercially proven since 2013
- 13 awards, 8 of which occurred during the past year, 1 in the US on C5 olefins





AlkyClean Technology

AlkyClean Process: Simplified Block Flow Diagram



AlkyClean technology ...

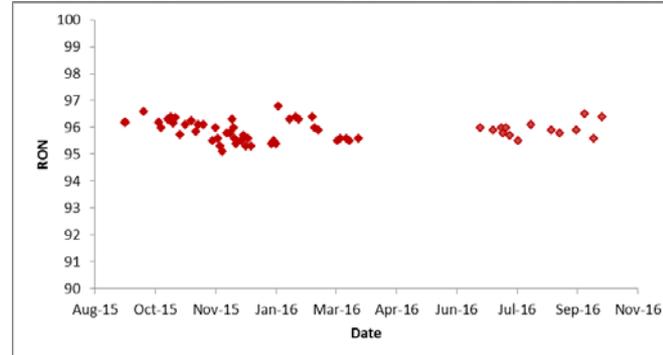
- Reduces the client's operational risk by eliminating safety and chemical process hazards associated with handling liquid acid.
- Is now commercially proven and is easy to operate thanks to an innovative solid catalyst and process combination.
- Employs a fixed-bed reactor system with a zeolite-based particulate catalyst.
- Regenerates the catalyst on a cyclical basis, fully restoring catalyst activity.
- Requires no post-treatment or product washing, further reducing its environmental footprint.
- Produces a high octane, low RVP alkylate on par with other technologies.
- Has been optimized for low to average capacities.



The World's First and Only Solid Catalyst Alkylation Unit



- The world's first and only commercial scale solid acid catalyst alkylation unit was successfully started up in August 2015 at Shandong Wonfull Petrochemical Group Co, Peoples Republic of China.
- Capacity: 2,700 BPD of Alkylate production.
- The startup of the unit, employing AlkyClean technology, went smoothly and safely.
- Performance test successfully completed within four (4) months. All guarantees met.
- The unit has been in operation for nearly two (2) years producing an excellent quality alkylate product.



AlkyClean Wins EPA's Presidential Green Chemistry Award



CB&I and Albemarle received the Presidential Green Chemistry Award from the U.S. Environmental Protection Agency on 6/13/16, in recognition of AlkyClean technology in the category of 'Providing Greener Synthetic Pathways.'



NEWS RELEASE
For Immediate Release:
June 14, 2016

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EPA Honors CB&I with Presidential Green Chemistry Challenge Award

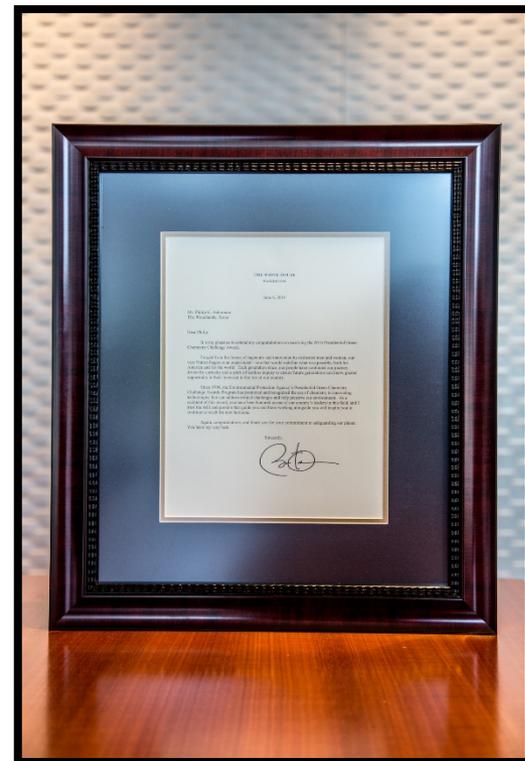
THE WOODLANDS, Texas – June 14, 2016 – [CB&I](http://www.cbii.com) (NYSE: CBI) today announced it has been awarded the 2016 Presidential Green Chemistry Challenge award from the U.S. Environmental Protection Agency for its AlkyClean® process technology, a solid acid catalyst alkylation technology jointly developed by CB&I, Albemarle and Neste Oil.

The EPA's Presidential Green Chemistry Challenge program promotes the environmental and economic benefits of developing and using novel green chemistry, while recognizing individuals and organizations on a national level for successfully researching, developing and implementing such technologies.

"CB&I is proud to be a recipient of this prestigious award from the Environmental Protection Agency. Our AlkyClean technology provides customers in the gasoline alkylation market a solution to produce higher octane alkylates—or premium gasoline—with less environmental impact," said Philip K. Asherman, CB&I's President and Chief Executive Officer. "CB&I is committed to the investment and implementation of industry technology and solutions that contribute to the positive health of the environment and help our customers meet government regulations."

CB&I's vast technology portfolio boasts additional green technologies such as its CDAlky® alkylation process technology, which similarly to AlkyClean offers an improved process to obtain high-octane, premium gasoline. Chevron Lummus Global, a joint venture between CB&I and Chevron, offers a Biofuels ISOCONVERSION process that converts renewable fat, oil and grease feedstock into high yields of pure hydrocarbon fuels. Additional proprietary technologies in the CB&I portfolio reduce sulfur in transportation fuels. These technologies offer a sustainable alternative for new projects and help revamp plants or refineries to meet U.S. and global energy regulation changes.

As further evidence of the company's commitment to green technology, CB&I recently announced NET Power, LLC's groundbreaking of a first-of-a-kind power plant that will validate a new natural gas power system that produces low-cost electricity with zero atmospheric emissions, including carbon dioxide. NET Power is a collaboration between CB&I, Exelon





CDA/ky Technology

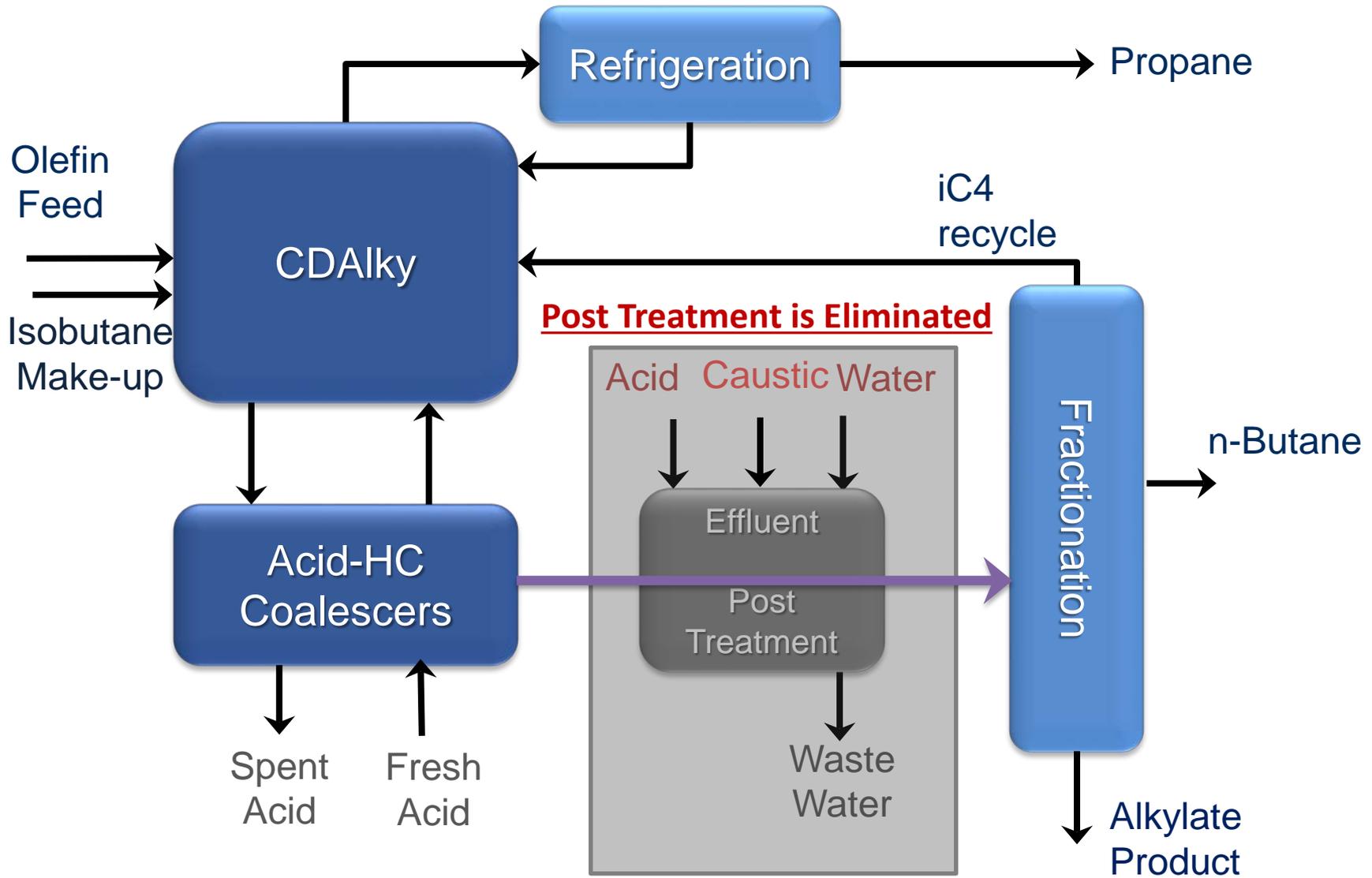
- CB&I's innovative and advanced sulfuric acid alkylation technology, 'CDAIky,' offers the refiner
 - Low operating costs
 - Low capital investment requirement
 - Ease of operation, and feed flexibility
 - Interval for major turn expected to be 6 years or more
 - Excellent alkylate product quality



'Breaking the low temperature barrier'



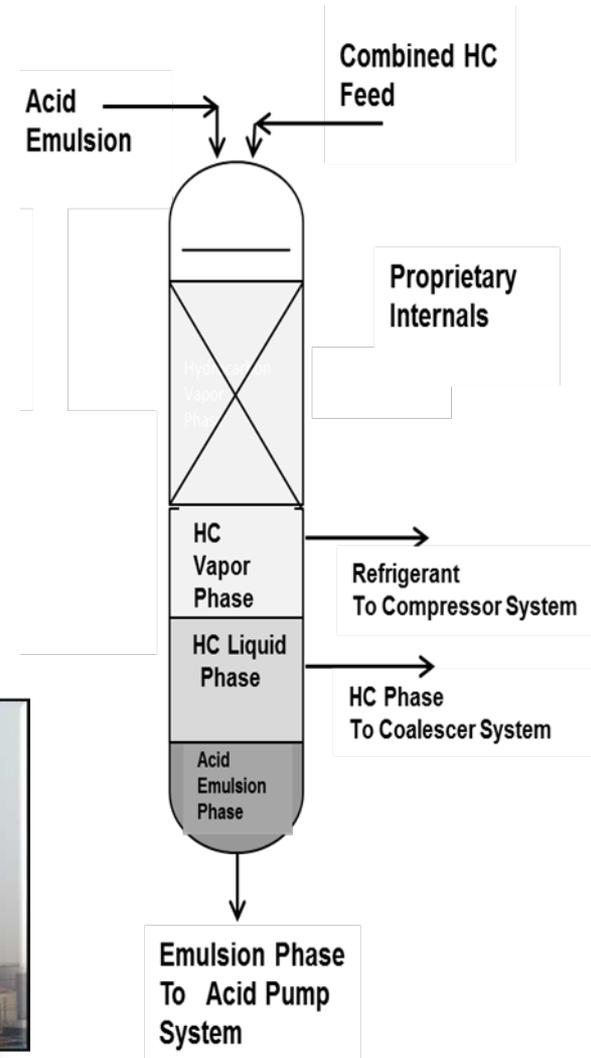
CDAlky Process: Simplified Block Flow Diagram



CDAlky Key Advantages vs 'Conventional' Sulfuric Acid Alkylation Technology: Process Simplification



- Innovative Reactor Design
 - Vertical down-flow packing easy to scale-up
 - No moving parts, minimal maintenance
 - Low temperature operation
 - Boiling point operation - direct cooling
 - Controlled acid/ olefin ratio with innovative distributor
 - Small foot print – single reactor up to 12,500 BPD
- Effective and Controlled Acid/ Hydrocarbon Separation
 - Controlled acid droplet size
 - Higher sulfuric acid utilization rate
 - Elimination of alkylate post treatment unit
 - Dry reactor effluent – lower corrosion
- Key to Success - Proprietary Design



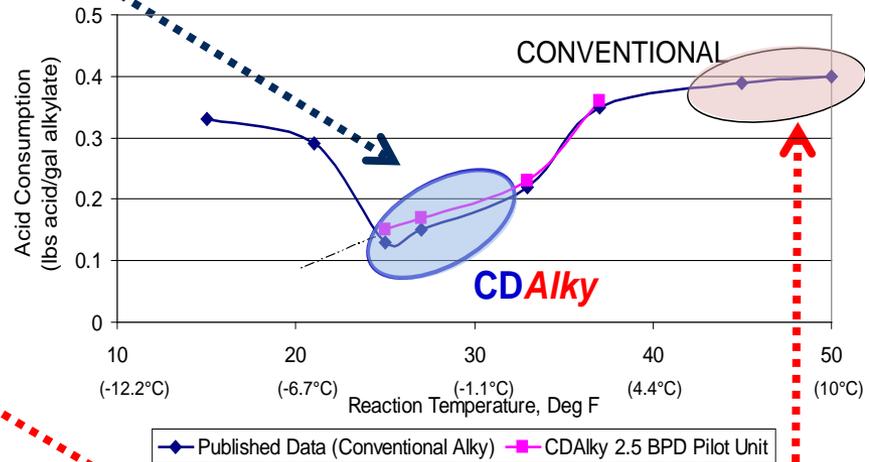
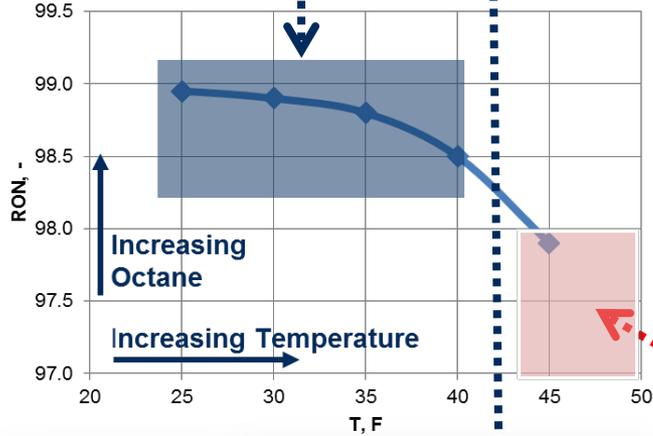


CDAlky Key Advantages vs 'Conventional' Sulfuric Acid Alkylation Technology: Low Temperature

CDAlky Breaks the Low-Temperature Barrier Through Innovative Reactor Design:

- Maximizes selectivity, octane value, and yield (1,2)
- 30-50% lower acid consumption! (1,2)
- Lower corrosion rate

Low Temperature Alkylation



No signs of corrosion, damage, pitting or H2 grooving during the 4Q2014 inspection of 1st CDAlky unit and 3Q2017 inspection of 2nd unit

Mechanically Agitated Reactors

1. Herron, C. and Cole, P. "Reducing Reactor Temperatures In Sulfuric Acid Alkylation Units" NPRA Conf. Paper, 2003.
2. US Patent 5,095,168 Stratco 1992.

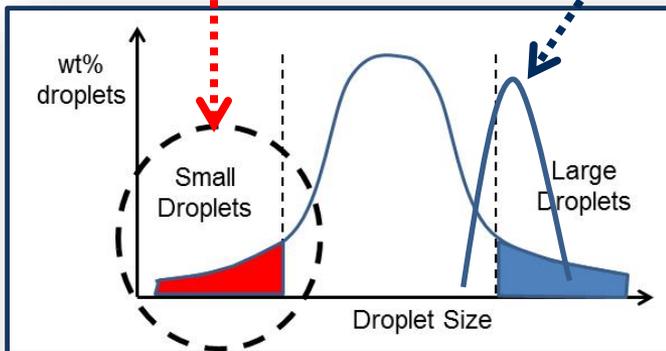
CDAIky Key Advantages vs 'Conventional' Sulfuric Acid Alkylation Technology: Acid/ HC Separation



Innovative CDAIky Design for Improved Acid/Hydrocarbon Separation:

- Droplet Size & Distribution Controlled with CDAIky

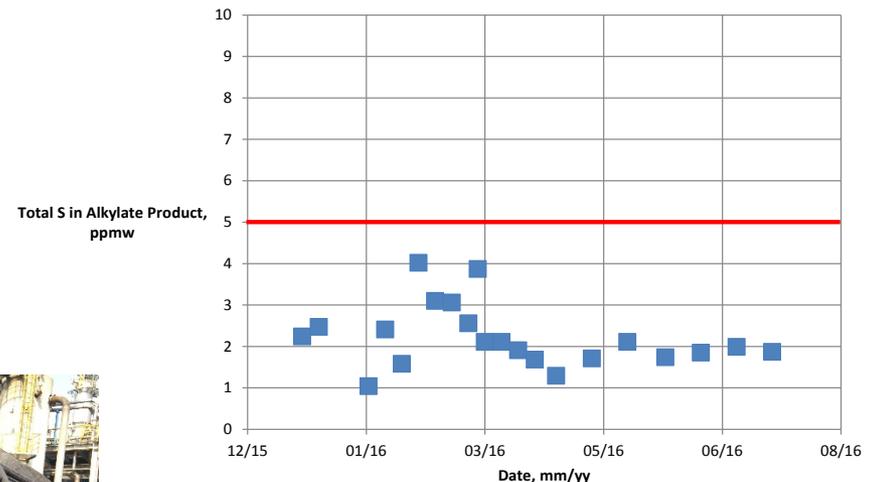
Mechanically Agitated Reactors



No visible fouling of the DIB reboiler after 3 years of operation at the 2nd CDAIky unit



Sulfur Content of Alkylate Product: 5,000 BPD CDAIky Unit



- 2 ppmw sulfur in alkylate on average
- More than 110% of design capacity achieved with S < 5ppmw

CDAIky Improvements:

- Increased Acid Utilization
- Dry Effluent to Fractionation
- Elimination of Post-Treatment Steps and Associated Process Equipment
- Elimination of Downstream Fouling



CDAlky Commercial Experience List

- CDAlky has become the sulfuric acid alkylation Technology of Choice
- Approximately 130 kBPD alkylate capacity to be commissioned by 2020

Licensee	Capacity		Start-up	Awarded	Feedstock
	BPD	KTA			
Sincier, PRC (1)	5,000	200	2013	2012	C4 Raffinate
Haiyue, PRC (1)	15,000	600	2014	2011	C4 Raffinate
Tianheng, PRC (1)	5,000	200	2014	2012	C4 Raffinate
YuTianHua, PRC	6,800	265	2017	2014	C4 Raffinate
S-Oil, Korea (2)	16,000	624	2018	2014	C4s
Pertamina, Indonesia (2)	7,400	290	2019	2016	FCC C4s
Undisclosed, USA (2)	23,000	900	2020	2016	FCC C5s
Zhejiang Pet. Co. (ZPC), PRC	14,000	555	2018	2016	C4 Raffinate
Yanchang, PRC	5,000	200	2019	2016	C4 Raffinate
Undisclosed, PRC	12,000	420	2018	2017	C4 Raffinate
Undisclosed, PRC	5,000	200	2018	2017	C4 Raffinate
Undisclosed, PRC	6,500	250	2018	2017	C4 Raffinate
Undisclosed, PRC	9,000	350	2018	2017	C4 Raffinate

Footnotes:

- (1) Licensed CDAlky Unit exceeded all process performance guarantees
- (2) Client operates competitor's conventional sulfuric acid alkylation technology – CDAlky technology selected over incumbent technology. Projects now in engineering phase.



CDAlky was one of the top 5 technology finalists for the 2015 Kirkpatrick Chemical Engineering Achievement Award

CDAlky Technology:



- Consumes 30-50% less acid compared to ‘conventional’ sulfuric acid alkylation technologies.
 - Less acid to transport, handle, store, or regenerate.
- Requires no post-treatment or product washing, further reducing its environmental footprint.
- Requires conventional and less frequent maintenance, thereby reducing operator and maintenance craft exposure to acid, relative to ‘conventional’ sulfuric acid technology.
- Is ideal for sites with limited plot space.
 - Single vertical reactor scalable to 12,500 BPD.
- Is commercially proven.

