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Mr. Michael Krause
South Coast AQMD
21865 Copley Dr.
Diamond Bar, CA 91765

RE: Proposed Rule 1410 Hydrogen Fluoride Storage and Use at Petroleum Refineries

Dear Mr. Krause,

Thank you for your recent inquiry regarding the Honeywell UOP Indirect Alkylation (InAlk™) Process. We take this opportunity to respond to your questions and provide additional information to assist the South Coast Air Quality Management District's (SCAQMD) evaluation of alkylation technologies.

The importance of alkylate to a refiner's gasoline pool is increasing as regulatory specifications for gasoline quality continue to tighten globally -- particularly targeting vapor pressure, and the content of sulfur, aromatic compounds and olefins to achieve compliance with lower emission levels. Alkylate is a critical blending component because of its inherent physical properties:

- Ultra-low sulfur
- Zero aromatics and benzene
- Zero olefins
- Low vapor pressure
- High octane

The InAlk Process

The InAlk process consists of two process steps: oligomerization of light olefins (butylenes), followed by hydrogenation to form an iso-paraffinic material. The resulting product stream has essentially the same properties as alkylate derived from the traditional liquid acid alkylation

processes, also known as direct alkylation. Thus, the InAlk process delivers certain advantages over liquid alkylation processes:

- Long-life solid bed catalyst, resulting in reduced catalyst handling requirements
- Reduced emissions (No SOx emissions generated, unlike sulfuric acid regeneration)
- Reduced capital expenditure
- No requirement for mitigation systems

However, there also are some significant drawbacks of this technology as a potential replacement for HF alkylation that make this process much less attractive:

- A greater than 50-percent reduction in alkylate yield for a comparable refinery FCC C4 stream (only olefins are reacted)
- Limited feed flexibility (only C4 olefins)
- Requires a hydrogen source for hydrogenation

Conversion of Torrance refinery to InAlk would present significant challenges and impact on the local gasoline market. In the case of the Torrance refinery, replacement of the existing alkylation process with InAlk would result in a greater than 75-percent reduction in alkylate make, and likely a similar reduction in the refinery's overall gasoline production -- because of the existing blending specifications required for the local market. Currently, nearly half of the olefin feed at the Torrance refinery consists of propylene, which cannot be processed in the InAlk unit. UOP has designed and licensed approximately 24 units since 1995, of which about 10 currently are in operation.

ISOALKY Is a Viable Alternative

A potential technology replacement that should be considered as a viable alternative is the ISOALKY™ ionic liquid alkylation process, co-developed by Chevron and Honeywell UOP. The ISOALKY process produces high quality alkylate and has unique advantages over other alkylation processes, especially with regard to catalyst consumption and health, safety and environmental benefits.

- **Easy to Handle Catalyst**: The specialized ionic liquid catalyst employed in the ISOALKY process has negligible vapor pressure and is less acutely toxic compared to alternative liquid alkylation catalysts. Indeed, the ISOALKY catalyst can be handled with standard refinery personal protective equipment (PPE). Unlike traditional liquid acid catalysts, the ionic liquid catalyst does not form a vapor cloud or a harmful mist, thus eliminating the need for catalyst-specific mitigation systems that are necessary for other technologies.

- **Minimum Catalyst Consumption**: At reaction conditions, the ISOALKY catalyst has orders-of-magnitude stronger acidity than traditional liquid acid catalysts, which fundamentally changes the volume of catalyst required for the reaction. The catalyst-to-hydrocarbon ratio in the reactor is less than 5 percent, compared to greater than 50 percent for traditional liquid alkylation technologies. The higher activity and ease of catalyst separation results in catalyst consumption that is 400 to 600 times lower than sulfuric alkylation. This eliminates the need

for an expensive on-site acid regeneration plant or extensive acid storage and transportation requirements.

- **Integrated Catalyst Regeneration Without Emissions**: ISOALKY includes a small, zero-emission, fully integrated catalyst regeneration process. The regeneration is a mild hydroprocessing process that efficiently regenerates the catalyst without environmental emissions or liquid byproducts. Conjunct polymer that is produced in the process is converted to valuable LPG and naphtha-range material, unlike traditional liquid alkylation processes that must incinerate or lose heavy polymer to waste. With the ISOALKY process, product yield is improved and the inconvenience, maintenance, environmental emissions, and costs associated with a separate catalyst regeneration plant are eliminated.

- **Better Economic Performance**: The ISOALKY process offers equivalent or better process and economic performance relative to alternative alkylation technologies. The process produces the same high quality, high octane alkylate that is readily blendable into a refinery gasoline pool. The unique qualities of the liquid catalyst eliminate high inventories of precious metals, solid catalyst stability issues, and product quality degradation issues associated with solid bed alkylation. In addition, the ISOALKY process operates at mild process temperatures, low isobutane-to-olefin (I:O) ratios, and with straightforward non-cycling refining operations which greatly reduces process complexity and operating costs when compared to solid alkylation technologies.

- **Demonstrated Commercial Performance**: The ISOALKY process has been commercially demonstrated for more than five years at the Chevron refinery in Salt Lake City, Utah. In 2016, Chevron decided to replace the existing HF alkylation unit at that refinery with an ISOALKY unit. The alliance between UOP and Chevron provides nearly 30 years of combined ionic liquid process development and leverages Chevron's operating experience with UOP's unmatched technology transfer and engineering capabilities. This ensures a confident, low risk startup with guaranteed process performance.

  The first commercial-sized unit for ISOALKY is scheduled to be completed and started up in 2020. In order to gain widespread acceptance by the refining industry as an acceptable alternative, the process will need to be operated through at least one Turnaround cycle (typically 5-6 years for most refiners) to ensure there are no significant design, maintenance/corrosion and operating issues.

It also should be noted that for approximately 80 years, HF alkylation units have been operated safely by the industry. Even with alternate technology introductions, HF alkylation technology remains the most economically attractive means of producing alkylate. Roughly half of all licensed alkylation units currently in operation -- worldwide and in the United States -- safely utilize HF as a catalyst.

Recognizing the need to establish a benchmark for safe operations, the refining industry and American Petroleum Institute have taken measures to establish a rigorous set of best practices to set the standard within the industry in the form of API-751, which covers:

- Hazards management
- Operating procedures
- Maintenance and inspection
- Metallurgy, design and construction
- Transportation and inventory
- Relief and utility systems
- Mitigation systems (detection, water sprays, additives, etc.)

UOP and, prior to 2007, ConocoPhillips continued to develop and improve their existing process designs (UOP acquired the ConocoPhillips alkylation technology portfolio in 2007). Notable developments and improvements to further reduce the risk profile of the technology include:

- Overall reduction in acid inventory
- Minimization of sources of leaks
- Additive to reduce catalyst volatility (ReVAP™ technology/modified HF)
- Rapid deinventory systems (such as IMP™)

The history and experience involving HF alkylation units shows that, when well maintained and operated in adherence with API-751, such units can be operated safely with minimal impact to the surrounding communities.

Refineries consider a variety of factors when selecting a technology to meet their product demands. Safety, environmental and community impact, technical viability and economics all figure into the technology decision making process. We're confident the Southern California Air Quality Management District will consider a balanced approach to evaluating the viability of different alkylation technologies.

Sincerely,

Michael J. Cleveland
Business Director
UOP LLC