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**Question 7: Given challenges in gasoline Reid vapor pressure (RVP), benzene, low-carbon fuels, and other requirements, are refiners considering expansion or other changes to make more alkylate? Has increased catalytic polymerization become a consideration?**

**BULLEN** (UOP LLC, A Honeywell Company)

UOP has not observed a big uptake in project activity related to this issue. However, we have observed more interest in revamping existing alkylation units rather than new projects. Compared for the catalytic condensation process, or another process called InAlk™, we observed activity in the area where the refiners are not able to use HF for sulfuric acid. So that is an option. Also, some of the refiners are processing more C5 olefins in their alkylation units to help reduce the RVP in the pool, but this does not always work as well as you think it would on paper. Some of the C5 olefins react via hydrogen transfer and then crack to higher RVP compounds, so they reduce some of that benefit that you get in lower RVP.

**ADAMS** (HollyFrontier Corporation)

I just think about where we have come with alkylation and polymerization. Historically where octane was the goal in the pool, alkylation won. You could take a certain amount of olefin that you had in your plant and match it up with isobutane, and you could get one and three-quarter times the volume of gasoline component versus how much olefin you started with before it was alkylated. Whereas with the polymerization, you are not really matching up with any other intermediate stream; so, you get the volume shrink and just get about half as much gasoline blending component.

Also, the motor and the research octanes are much closer than the poly gas motor and research octanes. The poly gas is somewhere more in the 90s on the research and then somewhere in the 80s on the motor. If you are motor-limited, then you are looking for alkylation process, which is a better process. If you are limited by gasoline blend olefin content and gasoline, you also want to alkylate. Poly gas does not have any olefins in it, but it is still olefinic.

As far as the environment that we are in today, because all of these light LPGs (liquefied petroleum gases) and condensates, a lot of the ethylene-producing capacity is turning to ethane, propane, and lighter materials. You are not getting the byproducts from the naphtha cracking that you used to get; nor are you getting the benzene, butadiene, butylene, or propylene. So, there are projects that people are building for the Gulf Coast for propane dehydrogenation. If someone is going to make propylene on purpose, you can imagine that it will set a floor for the price of propylene that will either get bid into or out of your alkylation unit. So that is a challenge for expanding alkylation units as well.

As much as I just talked a little about how lousy the poly gas can be in the current circumstances,

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HollyFrontier bought an old cat poly unit from Western, and we are moving it from a Bloomfield, New Mexico refinery to Woods Cross. This project is a consequence of the capital costs being really low for the relocation compared to the costs associated with the obstacles encountered when expanding an HF alkylation unit. We just looked at that whole map and said that we will just put in the cat poly.

As far as alkylation unit expansions, depending on what you have, which bottlenecks you have to take out (whether is in fractionation or in the reaction section), and if you need a new compressor or not, it is a matter of cost and benefit and those regulatory obstacles. So, we do not have any on the books, but others may.

**PATRICK BULLEN** (UOP LLC, A Honeywell Company)

Revamp options to increase production in an existing alkylation unit are a major driver for making more alkylate. The handling and safety aspect of using HF and sulfuric acid are already well established, thus making greater use of liquid acid technology more manageable from an environmental and safety perspective.

Some refiners are processing more C5 olefins in their alkylation units to reduce RVP in the pool. However, a fraction of the C5 olefins converts to isopentane via hydrogen transfer and cracking reactions, thus reducing some of the RVP benefit.

For new unit projects, liquid acid alkylation is typically the most cost-effective investment. Alternate technologies, such as UOP Catalytic Condensation Process and UOP Indirect Alkylation (InAlk™) Process, are considered when availability of acid and environment restrictions of using acid are a concern. The UOP InAlk™ process does not use liquid phase acid.

**MARK ADAMS** (HollyFrontier Corporation)

Alkylate is a high octane (90+), low RVP (5 to 6), low olefin gasoline blendstock that can be a sink for light naphtha blending into the gasoline pool. Expansions of alkylation units would depend on the cost and the economics for additional olefin feed. One of the dynamics of the shale revolution is the abundance of LPGs and the shift in ethylene cracking from naphtha to lighter feeds, such as ethane-propane mix. One of the implications of the shift in ethylene cracker feedstocks is that byproducts of naphtha cracking (such as propylene, butylene, butadiene, and benzene) are not produced and will be shorter in the marketplace. Refiners with access to these markets may find incremental alky feed bid away into a stronger petrochemicals market.

More alkylate is not necessarily the answer to all blending problems. Reformate may be more desirable than alkylate in ethanol blended fuels if distillation is a constraint. Ethanol blended fuels must have a T-50 of 150°F after the addition of ethanol. You might have to start with a T-50 as high as 220°F in the neat gasoline to make the spec after ethanol blending. The T-0 of alkylate and reformate are typically 200°F and 250°F, respectively.

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With regard to catalytic polymerization versus alkylation, an advantage of alkylation over polymerization is that you get more barrels of high octane blendstock per barrel of olefin feed because you can match it up with reasonably available isobutane. Additionally, poly gas from catalytic polymerization is less desirable for the gasoline pool than alkylation products from the same feedstocks. The RVP and RON of alkylate and poly gas are comparable, but the MON of the poly gas can be 12 numbers lower than the RON, while the MON-RON difference for alkylate is 2 to 3 numbers. The poly gas product is still an olefin and could be less desirable in certain regions.

HollyFrontier is relocating a catalytic polymerization unit from Bloomfield, New Mexico to Woods Cross, Utah as part of a refinery expansion. The driver for installing the cat poly gas is low capital cost and a lower hurdle for permitting versus an HF alkylation unit expansion.

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