Question 48: How does naphtha derived from tar sands and shale oil differ in respect to crude oil-based naphtha? What is the impact on reformer operation?

Praveen Gunaseelan (Vantage Point Consulting)

It is assumed that “shale oil” as mentioned in the question refers to oil produced from hydraulic fracturing of shale reservoirs, as opposed to oil produced from “oil shale” rock via retorting or other techniques. The composition of shale oils, let alone that of their naphtha cuts, is not reported in the public domain. Shale oils are known to be relatively light (40+ API) and sweet. Preliminary information for Bakken shale oil indicates that its properties are similar to conventional light oils, suggesting that its naphtha should have little to no impact on reformer operation.

Tar sands bitumen originally contains negligible amounts of naphtha. However, traded tar sands-based crudes such as DilBit do contain naphtha-range material. In the case of DilBit, condensate (light-naphtha range, saturated) is typically added as a diluent, but is more suitable as olefin cracker feedstock than reformer feed. The upgrading of tar sands-derived bitumen in a refinery, however, can produce naphtha that is suitable as reformer feed. For instance, coker naphtha produced from upgrading of bitumen via delayed coking is relatively low octane, and is suitable as reformer feed provided it can be adequately pre-treated. Tar sands-derived coker naphtha typically contains higher levels of contaminants such as sulfur, nitrogen, olefins, and silica, and, therefore, requires more elaborate pre-treatment compared to crude oil-derived naphthas. The higher contaminant load in coker naphthas tends to shorten the life of reformer catalyst compared to straight run crude oil-derived naphthas.

Brad Palmer (ConocoPhillips)

Naphthas from raw shale oil have high levels of olefins and paraffins, with variable concentrations of napthenes and aromatics, depending on the retorting process used. They are high in nitrogen and arsenic, but tend to be low in sulfur. Severe hydrotreating is required to produce a Reformer quality feed, such that many of the aromatics and all the olefins are saturated. In general, hydrotreated shale-derived naphtha to the Reformer has lower N+2A than hydrotreated crude-oil-derived naphtha.

Naphthas from tar sands are also low in naphthenes; however, the amount of paraffins and aromatics varies widely depending on the type and amount of diluent used. Bitumen diluted with condensate (dilbit) is highly paraffinic and has low aromatics. Bitumen diluted with syncrude (synbit) from an up-grader is highly aromatic. These crudes are also high in nitrogen and sulfur and must be severely hydrotreated with the subsequent aromatic saturation. The N+2A of the hydrotreated tar-sands-derived naphtha to the Reformer can vary widely depending on the diluent, but in general is lower than hydrotreated crude-oil-derived naphtha.

Since these naphthas require severe hydrotreating to remove nitrogen and sulfur, one potential negative side effect is nitrogen breakthrough, ammonium chloride formation and the subsequent reliability issues associated with equipment fouling, water washing and potential for increased corrosion. An increase in feed contaminants such as arsenic will poison the naphtha hydrotreater catalysts faster and could break through and poison the Reformer catalyst as well.

In general, a more paraffinic feed will require higher severity to make the same octane, increase coke make (shorten run length or increase catalyst circulation) and will reduce C5+ and hydrogen yields. As a rough rule of thumb, lowering the feed N+2A 1 lv% will decrease C5+ yields by 0.25 lv% and hydrogen yields by 10 scfb. These yield adjustments can vary depending on other operating parameters but are directionally correct with the right order of magnitude.

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