Ionic Liquids Moving Into the Processing Industries

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Highlights

- New motor fuels alkylation technology using ionic liquid catalyst.
- Novel process technology highlights unique catalyst properties.
- Door now open for future ionic liquid applications in processing industries.

1. Introduction

Ionic liquids have been receiving exponentially increasing attention in academic research over the last decades, from only a few journal articles in 1996 to more than 5000 in 2016 [1]. Researchers have assumed ionic liquids would be useful in industrial applications because of their nonvolatile, nonflammable, stable, and designer properties; but there has been limited success so far harnessing their potential as catalysts on a commercial scale.

In late 2016, Honeywell UOP and Chevron introduced the refining industry's first new liquid alkylation technology in 75 years. The ISOALKY™ solution is successful on a commercial scale because Honeywell UOP and Chevron have engineered the process to take advantage of a wide range of unique chemical and physical properties of the ionic liquid catalyst. The catalyst, a chloroaluminate ionic liquid with a proprietary composition, has finely tuned acidity to avoid undesirable cracking, isomerization, and heavy by-product formation, as well as properties that allow low inventory, low consumption, efficient separation, feed flexibility, and easy on-site regeneration. The presented work details some of these catalyst properties and how they contribute to a process that offers refiners the ability to produce alkylate with lower handling risks and comparable process and economic performance to conventional hydrofluoric (HF) or sulfuric acid technologies

2. Methods

Experimentation was carried out by Honeywell UOP and Chevron as exploratory work in bench-scale autoclaves, 0.1 BPD pilot plants, and a 10 BPD demonstration plant operated at Chevron's Salt Lake City Refinery.

3. Results and discussion

ISOALKY technology uses a chloroaluminate catalyst with trace HCl co-catalyst which is generated in-situ from organic chloride. The tunable superacidity of the resulting ionic liquid catalyst system allows for higher alkylate octane at comparable reactor temperatures over sulfuric acid (Figure 1). In addition, superacid properties allow for significantly smaller amounts of acid to be used compared to conventional liquid acid technologies and integrated regeneration by conjunct polymer cracking. The high ionic liquid catalyst activity also provides advantages in feed flexibility. For example, propylene and butylene can be fed together to a single ISOALKY reactor with no change in catalyst consumption, operating cost, or capital cost. In contrast, because the rate of propylene alkylation is relatively slow compared to butylene alkylation, sulfuric acid alkylation requires feed separation with different reactor conditions and cascading acid strength, resulting in high acid consumption, difficult control, and higher operating and capital cost [2].

Along with the desirable strong acid characteristics of the catalyst, additional physical and chemical properties of the ionic liquid allow for an efficient and safe process. Low solubility in hydrocarbon and high density allow for efficient separation and recovery. No measurable vapor pressure and stability for long term storage provide handling advantages in a refinery over conventional liquid acid technologies. Some of these advantages are quantified in Figure 2.

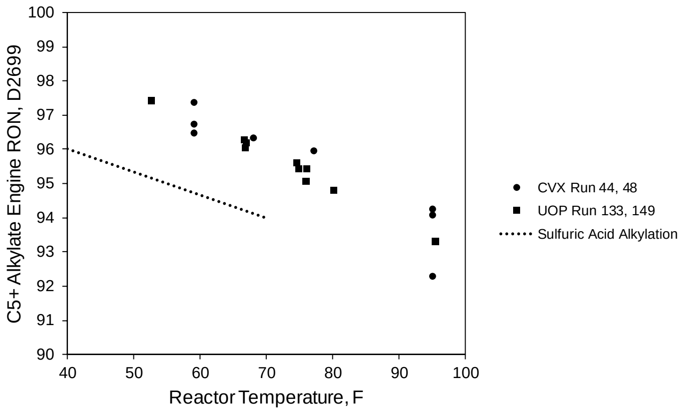

Figure 1. Comparison of ISOALKY Mixed C4 Olefin Feed Alkylate Research Octane Number with Sulfuric Acid.

	Sulfuric Acid Alkylation	HF Acid Alkylation	ISOALKY
Catalyst volume in alkylation reactor, vol%	50%	50 - 80%	3 - 6%
Conjunct polymer formation rate, wt% olefin	1 - 1.5%	0.5%	0.5%
Handling of conjunct polymer	Off-site incineration	On-site incineration	Integrated process to convert to naphtha and LPG
Typical catalyst consumption, lb/bbl alkylate	Base x 400-600	Base x 2	Base

Figure 2. Comparison of ISOALKY Process Features with Competing Conventional Technologies

4. Conclusions

ISOALKY technology has overcome many of the drawbacks of conventional liquid acid technologies related to catalyst properties: difficulty in regeneration and purification, concentration, corrosivity, volatility, and toxicity. Chevron is currently converting the existing HF acid alkylation unit at its Salt Lake City refinery into the first alkylation unit in the US based on ionic liquid technology. Ionic liquids have always been appealing because of their low volatilities and designer properties. The Salt Lake City refinery startup in early 2020 will take ionic liquids into the mainstream of commercial applications. In addition to motor fuels alkylation, Honeywell UOP is currently exploring other hydrocarbon conversions requiring strong acids and selective removal of contaminants with ionic liquids, as the door is now open for a wide range of applications in the fields of refining and petrochemicals. Enabled by this successful commercial demonstration of novel process technology to take full advantage of the unique properties of ionic liquids, new process applications will be common.

References

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Keywords

Ionic liquid; alkylation.