Selective Hydroconversion of FCC Light Cycle Oil for High-value BTX Production

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Abstract: It is highly demanding to upgrade surplus polyaromatic hydrocarbons (PAHs) of diesel boiling range such as light cycle oil (LCO) from fluidized catalytic cracking (FCC) due to emission control worldwide. One feasible option for upgrading LCO is to produce high value BTX. In this study, we studied a two-step process consisting of hydrotreating(HDT)-hydrocracking(HDC) of LCO under a moderate reaction condition (total pressure = 40-60 bar) to obtain high per pass yield of BTX. In particular, the effect of HDT conditions on the BTX yield from subsequent HDC was analyzed by conducting a series tests of HDT-HDC of LCO. It was found that a selective hydrotreating of LCO giving high hydrogentrogenation (HDN) rate and high mono-ring aromatics selectivity is essential to obtain high per pass yield of BTX in the subsequent HDC.

Keywords: Light Cycle Oil (LCO), Hydrotreating, Hydrocracking, BTX.

1. Introduction

Catalytic solutions for upgrading surplus light cycle oil (LCO) from fluidized catalytic cracking (FCC) into high value products is highly demanding. A catalytic process to produce BTX from FCC LCO, known as LCO-X, was introduced by UOP [1]. Recently, much attention has been paid to upgrading LCO due to environmental issues [2-4]. However, there are no reports on the selective HDT of LCO accomplishing high HDN rate and high selectivity of mono-ring aromatics at the same time, which is essential for subsequent HDC for high per pass yield of BTX [4]. In this study, we have conducted HDT of LCO with different boiling range under various conditions to understand the effect of HDT conditions on the BTX yield from HDC.

2. Experimental

We used two different LCO, LCO-1 and LCO-2, which has different boiling range. The LCO-2 was obtained by temperature cutting of heavy fraction of LCO-1. The HDT and HDT-HDC series reaction tests of LCO were conducted in a fixed-bed down-flow reactor under a moderate total pressure(50-60 bar). As the HDT catalysts, typical sulfide metal catalysts such as NiMo (Cat1), CoMo (Cat2) and NiW (Cat3) were supported on γ-Al_2O_3 by wet impregnation method [4]. The HDT and HDT-HDC series tests were conducted by increasing the reaction temperature over the range of 325-425℃ at 50-60 bar. After reaction, the liquid product was collected from the bottom of the gas/liquid separator to analyze the nitrogen and sulfur compounds, aromatic content and detail composition (by GC-MS) of the liquid product.

3. Results and discussion

In a two-step HDT-HDC of LCO for BTX production in high yield, the HDT process has to be capable of achieving high selectivity of mono aromatics as well as high HDN rate at moderate reaction pressure.

Figure 1 shows the HDT results of LCO-1 and LCO-2 over various HDT catalysts. The HDN conversion was not high enough with LCO-1 over all the HDT catalysts due to high content of C2+-carbazoles which are resistant to HDN. Both the Di$^+$ aromatics conversion (Di and Tri$^+$ aromatics conversion into Mono aromatics) and mono aromatics selectivity in the HDT product were much higher with LCO-2 than those with LCO-1 over all the HDT catalysts. However, the NiW/γ-Al_2O_3 catalyst showed the lowest yield of mono aromatics due to too high hydrogenation activity. Mono aromatics content was the highest over NiMo/γ-Al_2O_3 catalyst. To obtain high HDN conversion with LCO-1, high reaction temperature was required which limit HDT catalyst life and Di$^+$ aromatics conversion due to thermodynamic equilibrium involved in the HDT reaction. The HDC tests were also conducted with HDT products from LOC-1 and LCO-2, which will be discussed in detail to understand the effect of HDT conditions on the final BTX yield in the two-step HDT-HDC process.

4. Conclusions

In the HDT of LCO, the Di and Tri$^+$ ring aromatic compounds were selectively converted into mono aromatic compounds. However, it was not easy to achieve high HDN rate and selective hydrogenation at the same time. The results from HDC of hydrotreated LCO showed that a selective hydrotreating is important to obtain high BTX yield and further optimization of HDC catalysts is required to improve BTX yield.

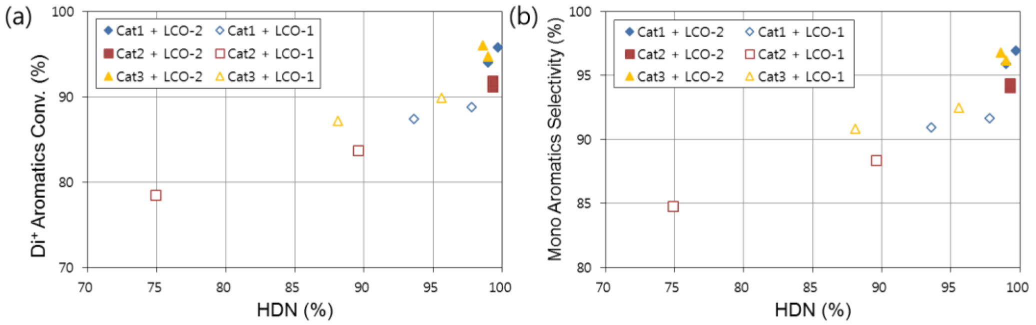

Figure 1. (a) Di$^+$ aromatics conversion and (b) mono aromatics selectivity as a function of HDN obtained from HDT of LCO over various catalysts.

References

1. J. A. Johnson, S. J. Frey, V. P. Thakkar, NPRA AM-07-40 (2007), 1–16.
2. Y. Choi, J. Lee, J. Shin, S. Lee, D. Kim, J. K. Lee, Appl. Catal. A 492 (2015) 140–150.
3. J. Lee, Y. Choi, J. Shin, J. K. Lee, Catal. Today 265 (2016) 144–153.
4. J. Shin, Y. Oh, Y. Choi, J. Lee, J. K. Lee, Appl. Catal. A 547 (2017) 12-21.