Light olefin production with high and flexible selectivity by plasma process

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Abstract: Main process for the production of light olefin is thermal cracking of hydrocarbons. However, there have been efforts to replace this highly energy consuming process to alternative process with less CO_2 emissions. Here, we demonstrated potential light olefin production process having high and flexible selectivity by plasma. Hydrocarbons having same carbon number and different molecular structure was used as reactants to study effects of relation with molecular structure and selectivity during this process.

Keywords: Light olefins, arc plasma, plasma chemical process

1. Introduction

Light olefins are significant raw materials in downstream chemical industry. Main process for light olefin production is thermal cracking of hydrocarbons such as light naphtha in the presence of steam. The thermal cracking process is the most energy intensive process in petrochemical industry and cause high amount of CO_2 emission [1,2]. However, this half of century used industrial process is being asked to change due to the recent climate change and strong demand for CO_2 emission suppression. Here, we demonstrated an environmentally benign way for the light olefin production by using plasma. The plasma process can provide enough thermal conditions for conversion of feedstock to light olefin from renewable electricity. Also, several kinds of different compound having same carbon number were compared as feedstock for olefin production in order to reveal the effects of molecular structure. In results, this work shows that electrified plasma process can produce highly selective light olefins having flexible range depending on operation conditions and molecular structures.

2. Experimental

The mixed gases for plasma discharge and the reaction are injected to the reactor having swirl flow. The feed for the olefin production is injected by syringe pump as a liquid phase. The feed and product gases are analysed by online GC-MS(5975C model, Agilent 19091P-K33 column, Agilent Technologies) and microGC(990 Micro GC, MS5A SS and PoraPLOT U FS columns, Agilent Technologies) using sample bag. In the GC-MS analysis method, the oven temperature started at 343.15 K and was raised to 463.15 K at a ramping rate of 293.15 K, followed by holding for 15 minutes. In the case of microGC, the analysis method was injector temperature 373.15 K, back flush time 11 s, column temperature 353.15 K, initial pressure 100 kPa for the first channel, and injector temperature 373.15 K, back flush time 7 s, column temperature 373.15 K, initial pressure 150 kPa for the second channel.

3. Result and Discussion

Fig.1 shows the selecitivty of C_1-C_4 products depends on flow rate of liquid hydrocarbons. The selectivity was calculated as following equations.

$$Selectivity_{C_xH_y}(\%) = \frac{x \times moles\ of\ C_xH_y\ produced}{z \times moles\ of\ C_z\ converted} \times 100$$

In this graph, the ethylene selectivity is range from 20 – 30% depending on the flow rate conditions. Especially, the selectivity of propylene is alomost 10%. In results, more than 30% selectivity of C_2-C_4 olefin are produced. Moreover, ethylene selectivity can be increased about 40% by simple hydrogenation process of acetylene. As considerd light olefin selecitivty (C_1-C_4) of conventional thermal cracking process and previous researches, this potential selectivity for light olefins is extraordinary.

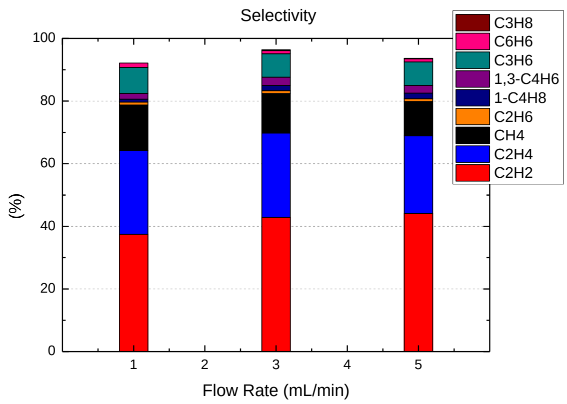

Fig. 1. Product selectivity of light olefins.

This study shows the feasibility of light olefin production process with high selectivity by electrified way using plasma.

4. References

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