Oil Production from Waste Plastics & News Paper using Catalytic Dissociation on Noble Metal supported on Zeolite

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ABSTRACT

Catalytic dissociation reaction of waste plastics and news paper was studied for oil production. SEM analysis were performed to find out crystal structure of prepared catalysts. GC-MAS analysis was also performed to find out product distribution by various noble metal supported zeolite catalysts. Pt-zeolite catalyst had a highest yield of petroleum oil such as C_5 - C_{11} for waste plastics dissociation reaction over 370℃. Dissociation conversions of mixed waste plastics and newspaper were above 75 percentages over 370℃ on Pt-zeolite catalyst. Pt-zeolite catalyst had a lot of liquid product distribution over C_{23} components owing to low cracking activity at low temperature below 340℃.

Keywords : catalytic dissociation, waste plastics, zeolite, oil production, noble metal.

1 EXPERIMENT

Dissociation ratio was calculated by following equation. Dissociation ratio equals gaseous and liquid products divided input amount of waste plastics.

$$\text{Dissociation ratio}(\%) = \frac{1-Residue}{Input} \text{ X } 100 = \frac{Gaseous\ prouct + Liquid\ prouct}{Input\ amount\ of\ waste\ plastics} \text{ X } 100$$

In this study, the making method of Pt-zeolite catalyst is as follows; reactor with tefron have sodium silicate and sodiumaluminate mole ratio was 1:1 and chloroplatinic acid as a noble metal added 0.2wt% with respect to sodiumaluminate and also added sodiumhydroxide with two times of sodiumaluminate and last step water added 10 times of sodiumaluminate, and last step chloric acid added 1 wt% with respect to sodiumhydroxide. After then, stirred it over 1hr with over 500rpm at room temperature and reaction in the autoclave at 150℃ for 9hr. Dissociation catalyst has 3-dimension structure and involves alkali metal and water molecules and Si/Al ratio of it is above one. After previous process, it was centrifuged at 10,000rpm for 30 minutes and dried at 120℃ for 12hrs. and calcined at 500℃ for 3hrs.

Pd-Zeolite, Ru-Zeolite, and Ir-Zeolite were prepared same method.

GC-MAS analysis was performed to find out product distribution of oil by various noble metal supported zeolite catalysts and SEM(Field Emission-SEM) analysis was also performed to find out structure shape of ones.

2 RESULTS & DISSCUSIONS

2.1 Apparatus & SEM analysis

Schematic diagram of Lab. scale dissociation reactor was shown in Fig. 1. Fig. 2 represents SEM photograph of Pt-zeolite. Dissociation reaction was took place with increasing temperature in the reactor and exhausted gas was condensed for GC-MAS analysis.

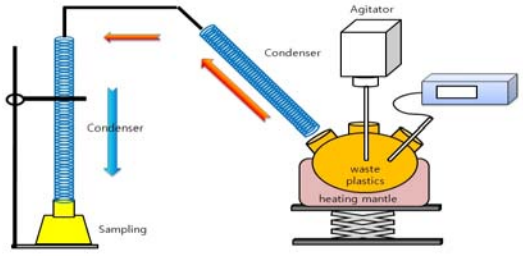

Fig. 1. Schematic diagram of experimental apparatus.

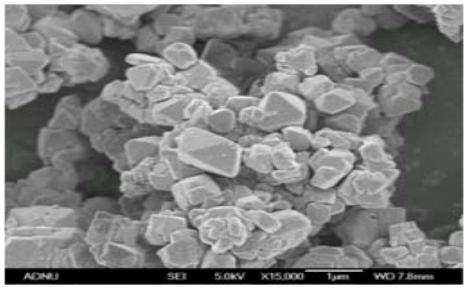

Fig. 2. SEM photograph of Pt-zeolite.

2.2 Dissociation reaction of waste plastics

Dissociation conversion showed in Fig. 3. - Fig. 6. according to temperature with respect to PE, PP, ABS, and mixed plastics and news paper. Noble metal supported zeolite catalysts had a little high conversion at low temperature(280℃ and 310℃). Especially Pt-zeolite catalyst had the highest conversion among noble metal supported zeolite catalyst. Fig. 6. represented the conversion of mixed plastics (PE:PP:ABS=1:1:1) and news paper 10 : 1 ratio according to temperature. As you can see from this figure, Pt-zeolite and Pd-zeolite had a little higher conversion at low temperature(280℃ and 310℃) and high temperature(370℃ and 400℃). News paper and waste plastics were prepared with under 2X2mm size for reaction. Among the plastics, catalytic dissociation of polyethylene(PE) is higher than that of other plastics. We thought that the high PE dissociation was that the glass transition temperature of PE is lower than that of others. Dissociation conversions of waste plastics were above 75 percentages over 370℃.

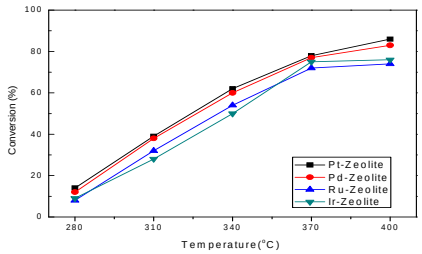

Fig. 3. PP dissociation conversion according to various catalysts.

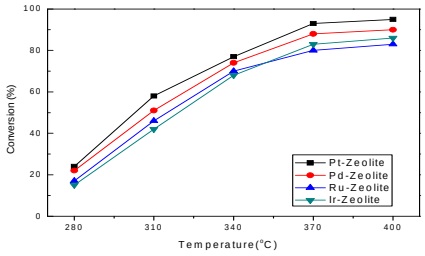

Fig. 4. PE dissociation conversion according to various catalysts.

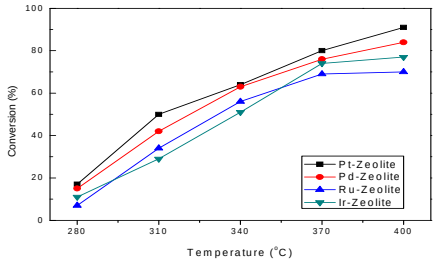

Fig. 5. ABS dissociation conversion according to various catalysts.

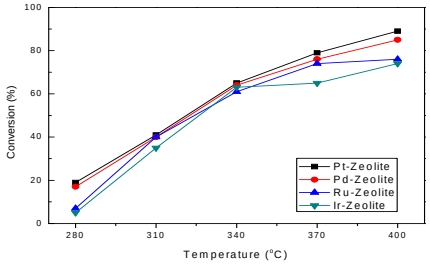

Fig. 6. Mixed plastics and newspaper conversion according to various catalysts.

Dissociation product and residue of gas and liquid phase for mixed plastics dissociation were shown in Fig. 7-9. At low temperature of 280℃, the residue was over 70% and almost product was residue and there was small amount of gas and liquid phase materials. However at 340℃, the ratio of gaseous and liquid product, and residue were almost same. Gaseous product increase with increasing temperature. Fig. 10 showed dissociation product distribution of mixed plastics and news paper at 400℃. Despite of increasing temperature up to 400℃, the percentage of residue was near 40 percentage. There were a lot of gas and liquid phases product at high temperature

(400℃), on the other hand, the amount of residue decreased drastically. Pt and Pd-zeolite had a lot of gas phase product since their good cracking performance. In the case of Pt-zeolite catalyst, there are a lot of gas product with low residue.

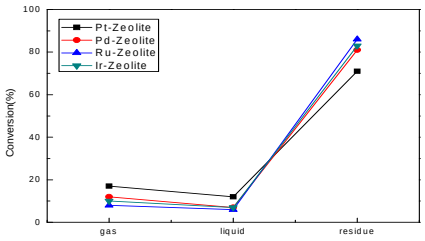

Fig. 7. Product distribution of mixed plastics and newspaper at 280℃ according to various catalysts.

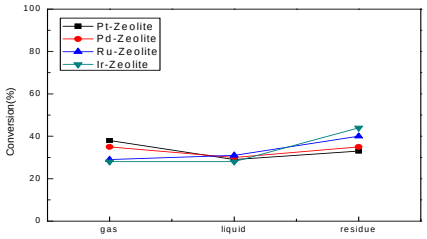

Fig. 8. Product distribution of mixed plastics at 340℃ according to various catalysts.

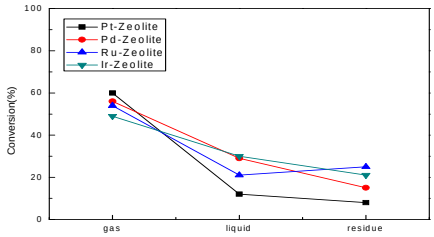

Fig. 9. Product distribution of mixed plastics at 400℃ according to various catalysts.

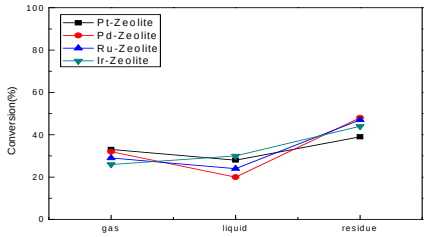

Fig. 10. Product distribution of mixed plastics and newspaper at 400℃ according to various catalysts.

Fig. 11-14 represented liquid product distribution of mixed waste plastics according to temperature on Pt-zeolite catalyst by using GC-MS analysis. Pt-zeolite catalyst as well as noble metal based zeolite ones had high yield of C_5-C_{11} as petroleum.

The light liquid composition increase with increasing temperature. Pt-zeolite catalyst had high yield of C_{12} - C_{22} as diesel oil at low temperature below 340℃, however the magnitude of diesel yield was a little. Meanwhile, Pt-zeolite catalyst had high yield of under C_{11} as petroleum oil thus it was able to produce petroleum oil.

Fig. 11-12 showed a lot of liquid product distribution over C_{23} components owing to low cracking activity at low temperature.

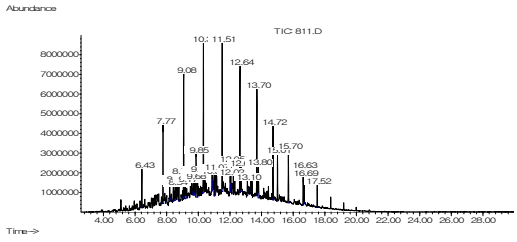

Fig. 11. GC/MS peaks of product distribution for mixed plastics catalytic dissociation at 310℃.

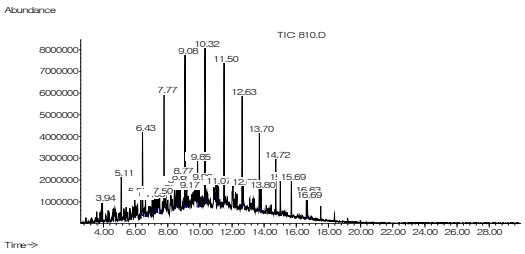

Fig. 12. GC/MS peaks of product distribution for mixed plastics catalytic dissociation at 340℃.

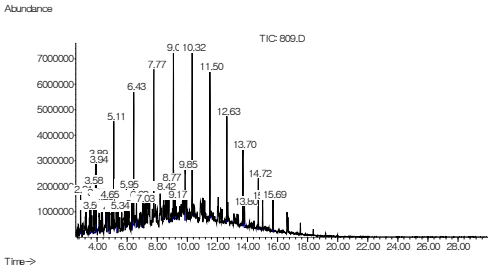

Fig. 13. GC/MS peaks of product distribution for mixed plastics catalytic dissociation at 370℃.

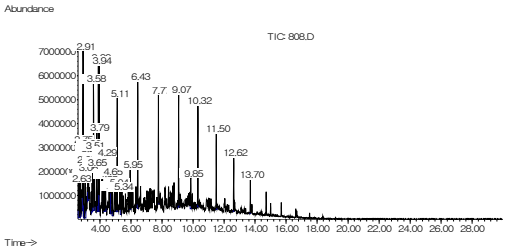

Fig. 14. GC/MS peaks of product distribution for mixed plastics catalytic dissociation at 400℃.

3 CONCLUSIONS

(1) Pt-zeolite catalyst had a highest yield of petroleum oil such as C_5 - C_{11} for waste plastics dissociation reaction over 370℃.

(2) Dissociation conversions of mixed waste plastics and news paper were above 75 percentages over 370℃ on Pt-zeolite catalyst.

(3) Pt-zeolite catalyst had a lot of liquid product distribution over C_{23} components owing to low cracking activity at low temperature below 340℃.

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