Catalytic Pyrolysis of Lignin using Fixed Bed Reactor and Rotary Kiln Type Reactor

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Highlights

- Catalytic pyrolysis of organosolv lignin was performed by bench-scale reactor
- Various additives were added with lignin to reduce coke yield
- Rotary-kiln type pyrolysis reactor were developed for stable continuous process of lignin pyrolysis without char foaming

1. Introduction

The increased concerns for climate change, air contamination, and energy shortages due to the intensive use of fossil fuels have made renewable energy more important than ever. Therefore, many researches has been performed to find alternative energy sources because of worldwide environmental and energy issues derived by the sharp increase use of fossil fuel. Among many other renewable source of alternative energy, lignocellulosic biomass is one of the important and abundant renewable energy sources that can replace fossil fuels. Lignocellulosic biomass is consisted with hemicellulose, cellulose, and lignin. Lignin is an amorphous polymer consisting of phenylpropane units, originating from three aromatic alcohol precursors (monolignols), p-coumaryl, coniferyl and sinapyl alcohol [1, 2]. Compared to hemicellulose and cellulose, pyrolysis and catalytic pyrolysis of lignin are difficult because quite larger amount of char is produced from lignin. Also, catalytic conversion of lignin pyrolysis products was more difficult than furans and levoglucosan which were main pyrolyzates of hemicellulose and cellulose. Also, continuous processes of lignin pyrolysis are undermined by problems such as char foaming phenomena [3].

In this study, thermal and catalytic pyrolysis of a lignin with various catalysts such as spent FCC, natural zeolite, olivine over HZSM-5(20) were investigated using bench-scale fixed bed reactor, and also, rotary-kiln type reactor were investigated to suppress char-foaming of lignin pyrolysis.

2. Methods

50 g of organosolv lignin, extracted from Korean miscanthus by Sugaren Company in Korea, was used for pyrolysis experiment using bench-scale fixed bed reactor. Fixed bed reactor consisted of 1st and 2nd reactor. Olivine, spent FCC, natural zeolite (NZ) were obtained from local company in Korea. These materials were mixed with lignin and pyrolyzed in the 1st reactor. HZSM-5(20) was obtained from Tianchang Company in China. HZSM-5 was located in the 2nd catalytic reactor. For rorary kiln reactor, alumina ball was filled in the reactor. Lignin was fed into rotary kiln reactor with feeding rate of 200g/h. The schematic diagram of rotary kiln was shown in Fig. 1. The gas and oil from both experiments were analyzed by GC/MS/TCD/FID

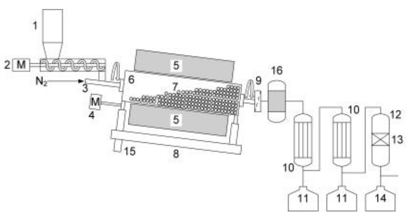

Figure 1. Schematic diagram of Rotary Kiln reactor

3. Results and discussion

Fig. 2 shows yield of each product from catalytic pyrolysis of organosolv lignin. For all the experiments, HZSM-5 was used in 2nd reactor. The highest yield of oil(24.73 wt%) was obtained from experiment with spent FCC, followed by with natural zeolite(24.64 wt%), with olivine (21.63 wt%), and without catalyst (21.11 wt%) in the 1st reactor. Also, coke yield was reduced when additives were added.

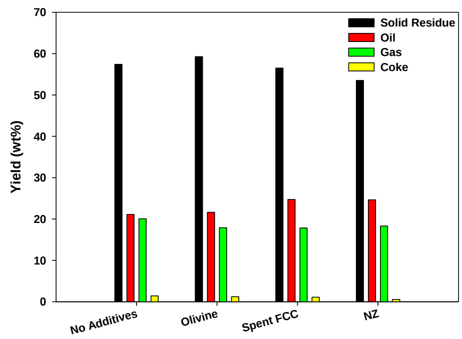

Figure 2. Yield of solid residue, oil, gas and coke obtained from the pyrolysis of organosolv lignin using different catalyst in the 1st reactor (2nd reactor: HZSM-5)

Generally, for lignin pyrolysis, char foaming and agglomeration of lignin was happened as shown in Fig. 3 (a). However, for rotary kiln reactor, char foaming was not occurred as shown in Fig. 3 (b). The yield of organic phase oil and heating value were also higher than those of fixed bed reactor.

(a) **(b)**

Figure 3. Char foaming and agglomerization of lignin with fluid bed reactor, and rotary kiln reactor

4. Conclusions

Pyrolysis of organosolv lignin over HZSM-5(20) with additives showed higher oil yield. Also additives lead to decrease of coke yield. And char-forming of lignin can be prevented by using rotary kiln type pyrolysis reactor.

Acknowledgement

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Keywords
Lignin; Catalytic pyrolysis; Rotary-Kiln type reactor; Char foaming.