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A study on the fast pyrolysis characteristics of biomass in fluidized bed pyrolyzers

Jae Gyu Hwang[1)] *Hang Seok Choi[2)] Hoon Chae Park[1)]
and Myung Kyu Choi[1)]

[1), 2)] *Department of Environmental Engineering, Yonsei University, Wonju 26493, Korea*
[2)] hs.choi@yonsei.ac.kr

ABSTRACT

In this study, the fast pyrolysis characteristics of wood larch using two different fluidized bed pyrolyzers were investigated. Fast pyrolysis was performed in a lab-scale bubbling and circulating fluidized bed reactor. In order to study biocrude-oil yield and physicochemical characteristics, wood larch was applied to the fluidized bed reactor for one hour with reaction temperatures ranging from 450 ℃ to 550 ℃. The quality of biocrude-oil as an alternative fuel was examined using various analytical methods such as higher heating value (HHV), water content, ash content and homogeneity. In the case of bubbling fluidized bed pyrolyzer (BFBP), the highest yield of biocrude-oil was 45.1 wt. % at 500 ℃. And in the case of circulating fluidized bed pyrlyzer (CFBP), the highest biocrude-oil yield was 49.9 wt. % at 550 ℃. Compare with other biocrude-oils, wood larch biocrude-oil shown high HHV higher than other biocrude-oils. From the analysis results, wood larch has potential as an alternative energy source.

1. INTRODUCTION

Because of the depletion of fossil fuels, the instability of fossil fuels price and the problems of greenhouse gas, the necessity of alternative energy came to the fore. Therefore, many researchers have studied various alternative and renewable energies. Bioenergy is one of the most promising energy among alternative and renewable energies. Bioenergy is the sustainable and carbon neutral energy. Biomass is one of bioenergy sources. Through thermal conversion processes such as combustion, gasification and pyrolysis, biomass source is decomposed into gas, liquid and solid products. Especially, fast pyrolysis process is the best way in order to obtain the liquid fuel called a biocrude-oil. Fast pyrolysis process is performed about 500 ℃ without oxygen. And it needs very short vapor residence time less than two seconds. (Grace 2012, Bridgwater 1999, Geldart 1992 and Kunii 2013)

[1)] Professor
[2)] Graduate Student

2. EXPERIMENTAL

2.1 Experimental apparatus

Fig.1 shows the experimental apparatus. BFBP consist of biomass silo, screw feeder, rectangular reactor, cyclone, condenser and electrostatic precipitator. And CFBP consist of biomass silo, screw feeder, riser, cyclone, condenser, electrostatic precipitator and loop seal.

1. Biomass silo
2. Screw feeder
3. Reactor
4. Cyclone
5. Condensers
6. Electrostatic precipitator
7. Blower

1. Biomass silo
2. Screw feeder
3. Riser
4. Cyclone
5. Condensers
6. Electrostatic precipitator
7. Loop-seal

Fig. 1 Experimental apparatuses
(left: bubbling fluidized bed reactor, right: circulating fluidized bed reactor)

Table 1 shows the experimental conditions of two fast pyrolyzers. Reactor was made of SUS316 material. Fast pyrolysis was performed in bubbling and fast fluidization regimes, respectively. Reaction temperature was changed from 400 ℃ to 550 ℃.

Table 1 Experimental conditions

Reactor type	Bubbling fluidized bed	Circulating fluidized bed
Shape	Rectangular	Cylindrical
Reactor dimension [m]	0.3(L) × 0.075(W) × 0.3(H)	Ø 0.04 × 1.2
Reactor capacity [kg/h]	1	1
Superficial gas velocity [m/s]	0.147	3.5
Reaction temperature [℃]	400-550	400-550
Initial solid loading [kg] (Riser / Loop-seal)	5.4	0.295 / 0.335

2.2 Materials

For the fast pyrolysis experiment in this study, wood larch was crushed using a grinder and 1-2 mm size particles were collected by ASTM sieves. The sample was

dried in a drying oven at 105 ℃ for 24 hours. Standard silica sand (mean diameter 600 ㎛) was used for the fluidizing material. Fig.2 shows the materials of present study.

Fig. 2 Standard silica sand (left) and sawdust of wood larch (right)

3. RESULT AND DISCUSSION

The weight of biocrude-oil produced by the fast pyrolysis process was measured using a 1/100 accuracy digital balance. The unit of product yield is expressed as wt. %, and the product yields were calculated using the following equation:

Product yield (wt. %) = (weight of each product) / (weight of input biomass) × 100 (1)

Figs. 3 shows the biocrude-oil yield with reaction temperature. In the case of BFBP, the yield of biocrude-oil increased from 400 ℃ to 500 ℃ and decreased at 550 ℃. The highest biocrude-oil yield was 45.1 wt. % at 500 ℃. On the other hand, CFBP biocrude-oil is shown 49.9 wt. % of highest biocrude-oil yield at 550 ℃. The trend of biocrude-oil yield increased from 400 ℃ to 550 ℃. Fig.4 shows the HHV of biocrude-oil. The range of higher heating value of BFBP and CFBP is from 16.9 to 19.3 MJ/kg and 18.5 to 19.7 MJ/kg, respectively. Fig. 5 shows the moisture content of biocrude-oil. CFBP biocrude-oil is shown the lower moisture content than BFBP. In Fig. 6, the ash content of biocrude-oil is lower than 0.5 wt. % in both cases. Fig. 7 shows the homogeneity of biocrude-oil. CFBP biocrude-oil is shown the higher homogeneity than BFBP.

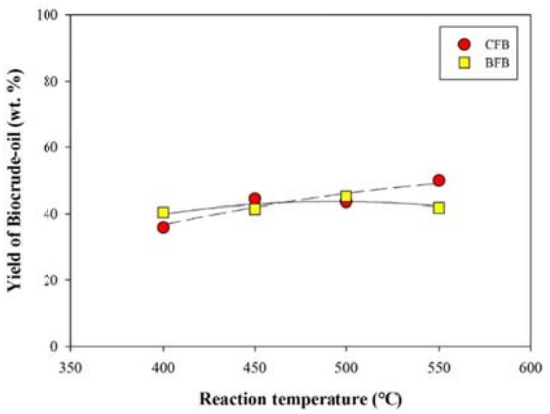

Fig.3 Yield of biocrude-oil with reaction temperature

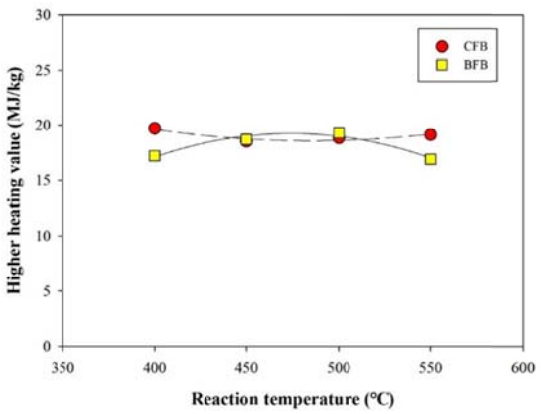

Fig.4 HHV of biocrude-oil with reaction temperature

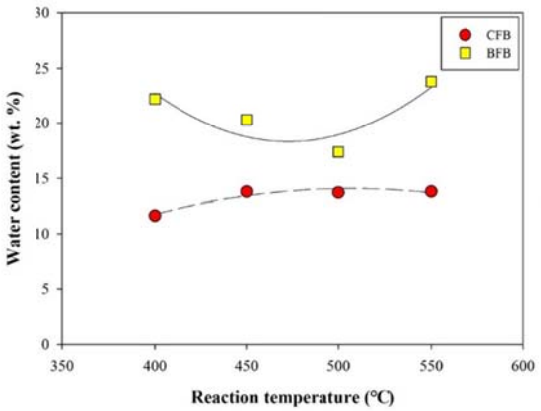

Fig.5 Water content of biocrude-oil

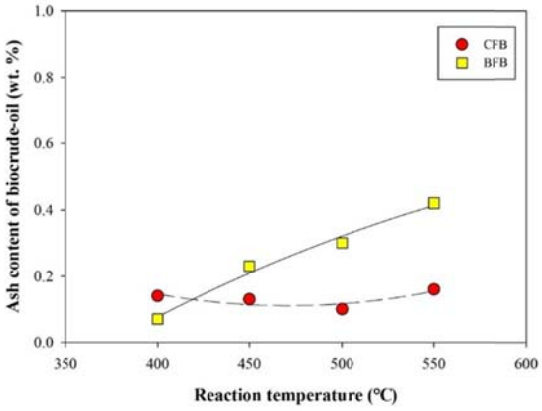

Fig.6 Ash of biocrude-oil

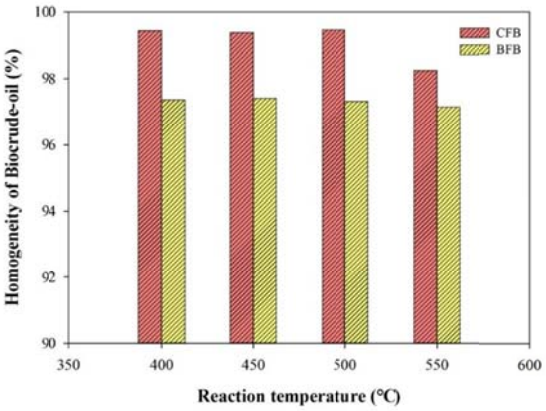

Fig.7 Homogeneity of biocrude-oil

4. CONCLUSIONS

In the present study, the fast pyrolysis of wood larch was performed in a lab-scale bubbling and circulating fluidized bed pyrolyzers and the characteristics of biocrude-oil was analyzed. The following conclusions were based on the observed results.

1. In the case of BFBP, The highest yield of biocrude-oil is 45.1 wt. % at 500 ℃. The range of higher heating value is from 16.9 to 19.3 MJ/kg. And moisture content of biocrude-oil is shown around 20 wt. %.
2. In the case of CFBP, The highest yield of biocrude-oil is 49.9 wt. % at 550 ℃. The range of higher heating value is from 18.5 to 19.7 MJ/kg. And moisture content of biocrude-oil is shown around 13 wt. %.
3. Ash content of biocrude-oil from CFBP is lower than BFBP.
4. From the results of this study, biocrude-oil from CFBP is shown high biocrude-oil yield and quality. Hence, CFBP biocrude-oil is more suitable for alternative energy than biocrude-oil from BFBP.

REFERENCES

Grace, J. R., Knowlton, T. M. and Avidan A. A. (2012), *Circulating Fluidized Beds*, Springer Science & Business Media, NY.

Bridgwater, A. V., Meier, D. and Radiein, D. (1999), “An overview of fast pyrolysis of biomass.” *Org. Geochem.,* Vol. **30**, 1479-1493.

Geldart, D. and Rhodes, M. J. (1992), “Survey of Current World-Wide Research in Gas Fluidization.” *Powder Technol.*, Vol. **71**, 1-46.

Kunii, D. and Levenspiel, O. (2013), *Fluidization Engineering*, Elsevier, AM.