A study on pyrolysis characteristics of torrefied biomass

○ Ho Seong Yoo, Hang Seok Choi*, Hoon Chae Park, Jae Gyu Hwang, Byeong Kyu Lee
Department of Environmental Engineering, Yonsei University

1. Introduction

These days, fossil fuels have become an essential part of human’s life. Fossil fuels are heavily relied upon as it delivers heat, energy, fuels and chemicals that are indispensable for the mankind. Due to this over reliance and limited existence of fossil fuels, fossil fuels have turned out to be very expensive. Further, fossil fuels when utilized emits load of emission. Hence, the world is on the lookout for an alternate source of energy. Biomass is one such alternate energy source which can effectively substitute fossil fuels. Biomass is copious 1), 3), renewable and clean fuel. As the potential of biomass is huge, it has been in the spotlight recently.

On the contrary, biomass is low energy density fuel. Hence, the biomass needs to be upgraded. Pyrolysis and gasification are the two most widely used thermochemical processes of biomass conversion into energy. The efficiency and performance of pyrolysis and gasification processes can be improved by utilizing pretreated biomass feedstock. Torrefaction is one such pretreatment process which can be used to upgrade the quality of biomass. Torrefaction is similar to pyrolysis. However, it has to be operated at a lower temperature between 200-300°C2). Not only torrefaction improves the heating value of feedstock, it also improves grindability, reactivity and hydrophobicity of the feedstock.

Though many works on torrefaction of biomass are available only few concerns about using torrefaction for pretreatment of pyrolysis. In this study, the effect of torrefied biomass on pyrolysis is investigated.

2. Material and experimental methods

In this study, Larix the main tree species of Korea sawdust was selected as the biomass of study. Sawdust of size 1 to 2 mm was taken up for the study. The samples were torrified in an auger type reactor at various torrefaction temperatures of 220, 240, 260, 280 and 300°C. Then, the torrified biomass was pyrolysed using spouted bed reactor. Pyrolysis was conducted at 500°C. Pyrolysis experiments were carried out with torrified samples fed at 1 kg/hr. The effect of temperature on yield, HHV and moisture content of bio-oil was studied in the pyrolysis condition. Each experimental run was conducted thrice to check for consistency of results. The bio-oil was collected using three condensers and an electric precipitator. Also, the bio-oil yield of the pyrolysis experiments of torrified biomass was compared with bio-oil yield of raw biomass (untorrified biomass).

3. Results and discussion

Figure 1 displays the effect of torrefaction temperature on bio-oil yield. It can be seen from the figure that the yield of bio-oil decreases as the torrefaction temperature increases. This decrease in bio-oil yield with respect to temperature is could be due to the decomposition of cellulose and hemicellulose. It is known that, hemicellulose and cellulose upon decomposition favours for bio-oil while lignin supports for gas and char yields. At low temperatures, the contribution of cellulose and hemicellulose towards bio-oil is predominant. Hence high bio-oil yield is obtained. However, at higher temperatures influence of lignin is predominant. Hence, low bio-oil yield is obtained at high temperatures2). Highest yield (54.6 wt. %) of bio-oil was obtained for raw biomass while lowest yield (42.17 wt. %) was found for torrefied biomass at 300°C.

Figure 2 shows the effect of pyrolysis temperature on HHV and moisture content of bio-oil. From the figure, it can be noticed that with increasing temperature the heating value of bio-oil increases. It was also found that the HHV of bio-oil was greater for torrefied biomass

Hang Seok Choi, Associate Professor, Department of Environmental Engineering, Yonsei University

1 Yonseidae-gil, Wonju, Gangwon-do, Republic of Korea, 220-710
Tel: +82-33-760-2485  FAX: +82-33-760-2571  E-mail: hs.choi@yonsei.ac.kr
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than for raw biomass. The highest HHV of 4,724 kcal/kg was obtained at 300°C for torrefied biomass. It is interesting to note that this heating value is greater than that of peat and lignite. It can be evidenced from the figure that the moisture content of bio-oil decreases with respect to temperature. This could be due to the liberation of water molecules at higher temperatures. Lowest moisture content was found to be 19.86 wt.% at 300°C. It was noticed the moisture content of bio-oil generated from torrefied biomass was lower than the water content of bio-oil of raw biomass. This could be due to improved hydrophobicity of biomass achieved through torrefaction.

![Graph showing the effect of torrefaction temperature on bio-oil yield.](image1)

**Fig. 1** Effect of torrefaction temperature on bio-oil yield

![Graph showing the effects of torrefaction temperature on HHV and moisture contents of bio-oil.](image2)

**Fig. 2** Effects of torrefaction temperature on HHV and moisture contents of bio-oil.

### 4. Conclusions

In this study, pyrolysis experiments on torrefied sawdust was conducted. It was found that the increasing torrefaction temperature decreased the yield and moisture content of bio-oil; however, it improved HHV significantly. It was also found that the torrefaction improved the quality of bio-oil. Hence, it can be concluded that the torrefaction can be used as a pretreatment process for pyrolysis to amend the quality of bio-oil.

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### References

