Effect of natural zeolite on biomass pyrolysis

by Mokh Hairul Bahri

PAPER • OPEN ACCESS

Effect of natural zeolite on biomass pyrolysis

To cite this article: Mokh. Hairul Bahri 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1034** 012082

Effect of natural zeolite on biomass pyrolysis

Mokh. Hairul Bahri
Mechanical Engineering Department, *Universitas Muhammadiyah Jember*
Karimata 49, Jember 68121, Indonesia
Email: mhairulbahri@unmuhjember.ac.id

Abstract. Study the pyrolysis of biomass with the addition of natural zeolite to determine the enthalpy required to become gas, oil, and char. The materials used were *Sengon* (S) sawdust and natural zeolite type *Clipnotilolite* (Z). The pyrolysis process used STA *Iliensies* PTA 1600. The test samples S, S + Z1, S + Z2, and S + Z3 were heated at a heating rate of 20 ^{0}C min^{-1} and an air flowrate (Argon) of 0.5 liters min^{-1}. The result shows that the enthalpy of pyrolysis S decreases with the increase of Z. The greater the percentage of Z the decrease in enthalpy is getting sharper, while the decrease in mass is relatively small.

Keywords: *Sengon* sawdust, *Clipnotilolite*, pyrolisis, enthalpy

1. Introduction

The search for energy sources to replace fossil fuels was a world trend today. Energy sources that were easily available and abundant availability were priority searches. One of the alternative energy sources was biomass. Biomass energy sources were easily available and widely abundant in Indonesia, such as straw, wood chips, and sawdust. One way to obtain biomass energy was pyrolysis. The result of pyrolysis was in the form of bio-oil which becomes liquid fuel. One of the challenges in the pyrolysis process was the amount of activation energy [1]. Various methods were used to reduce activation energy. One of them was by adding a catalyst during the pyrolysis process. The addition of a catalyst has been shown to accelerate the thermal degradation process of biomass [2]. This research uses sawmill waste which is abundant in the province of East Java, Indonesia. Meanwhile, the catalyst used was natural zeolite obtained from traditional mining in the South Malang area. Several researchers have conducted biomass pyrolysis experiments by testing bioenergy potential using thermogravimetric analysis techniques, including [3] using camel grass (*Cymbopogon schoenanthus*) and [4] using Para Grass (*Urochloa mutica*). This experiment has studied the effect of adding natural zeolite (Z) as a catalyst to Sengon's sawdust (S) using thermogravimetric analysis techniques.

2. Methods

The biomass used in this experiment was wood sawdust waste from Sengon (*Albizia Falcataria*). The characterization of the catalyst used after XRD testing was the *Clipnotilolite* type. Both materials are ground until they pass 100 mesh size. Testing samples using an initial mass of 20mg. The variation of the addition of natural Zeolite (Z) with the addition of 5.10 and 15% of the initial mass (S) subsequently called Z1, Z2 and Z3. The test equipment used was STA Iliensis PT1600. The

IOP Conf. Series: Materials Science and Engineering 1034 (2021) 012082 doi:10.1088/1757-899X/1034/1/012082

test procedure is by operating the STA at an Argon flowrate of 0.5 liters min^{-1} and a heating rate of 20 ^{0}C $^{-1}$. The data recorded by the computer were time, temperature and relative mass decline. The results displayed are graphs of mass loss rate and heat flow to temperature. The composition and constituent elements of S are shown in Table 1.

Table 1. Characterization of *Albizia Falcataria*

Ultimate analysis	(dry basis, wt.%)	Proxymate analysis	(dry basis, wt%)
Carbon	45.53	Moisture	7.2
Hydrogen	6.49	Volatile matter	74.9
Nitrogen	0.31	Fixed Carbon	16.46
Sulfur	0.1	Ash	1.44
Oxygen	46.13	Gross Caloric Value (J/g)	18.229

3. Result and discussion

The results were shown in graphical form in Figure 1. In each image, there are 2 graphs. The first graph has shown mass loss relative to temperature (which was at the top) and the second graph has shown heat flow relative to temperature. The graph of mass loss relative to temperature has shown the percentage loss of relative mass due to an increase in temperature. In Figure 1, it can be seen that the percentage of mass loss was relatively greater than in Figure 2. The STA reactor has heated the exothermic S because there was no subzero value. So that the heating from the STA reactor was used to remove moisture and volatile matter from S (Sengon's sawdust).

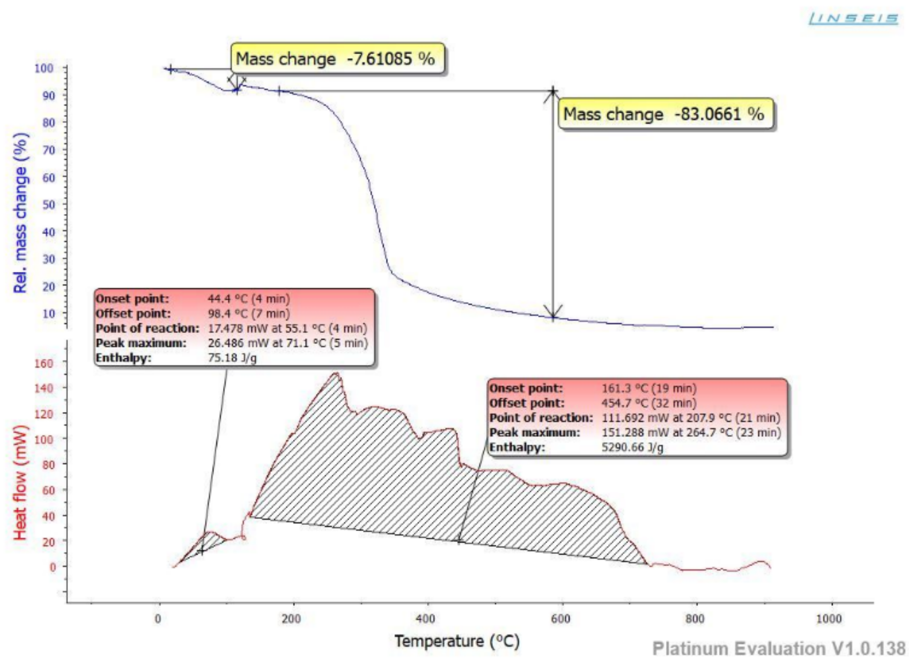

Figure 1. Graph of Sengon's sawdust pyrolysis

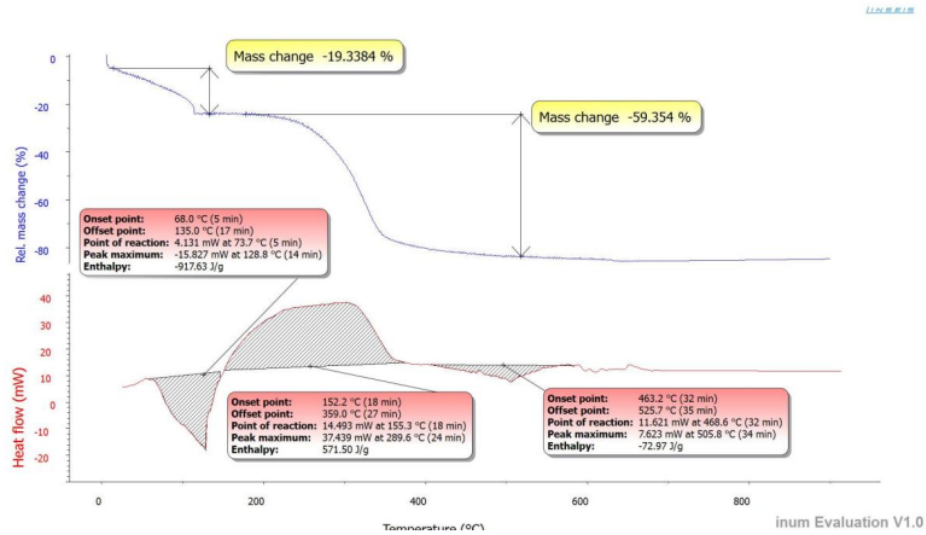

Figure 2. Graph of Sengon's sawdust + Z1 pyrolysis

Figure 2 shows the relative mass loss that occurs less than Figure 1. In this second test sample (S+Z1), endothermic and exothermic heating has occurred. Likewise, for the third and fourth samples, the results were shown in graphical form in Figure 3-4. The addition of Z (natural zeolite) affects the pyrolysis process at the beginning of heating. Z with dominant Si and Al content absorbs more heat than other elements. The more Z was added, the more heat will be absorbed during preheating. But not all of the heat on preheating was absorbed by Z. At an appropriate increase in the percentage of Z, there was a balance between heat absorbed and heat released.

The difference in heat absorption between S and S + Z may be due to the thermal conductivity of the material. Z as a mineral has a higher thermal conductivity than S so that at the beginning of heating it will first absorb heat from the STA reactor. When Z has met its heat absorption, Z will be released to S so that the percentage of mass loss is relatively less (shown in Figure 2-4). It also causes less heat to be used than the pyrolysis S in Figure 1.

The enthalpy shown in Figure 1-4 indicates the energy that has been consumed by S, S + Z1, S + Z2, and S + Z3 during the pyrolysis process, to turn into several products, including bio-oil, gas, and charcoal.[5].

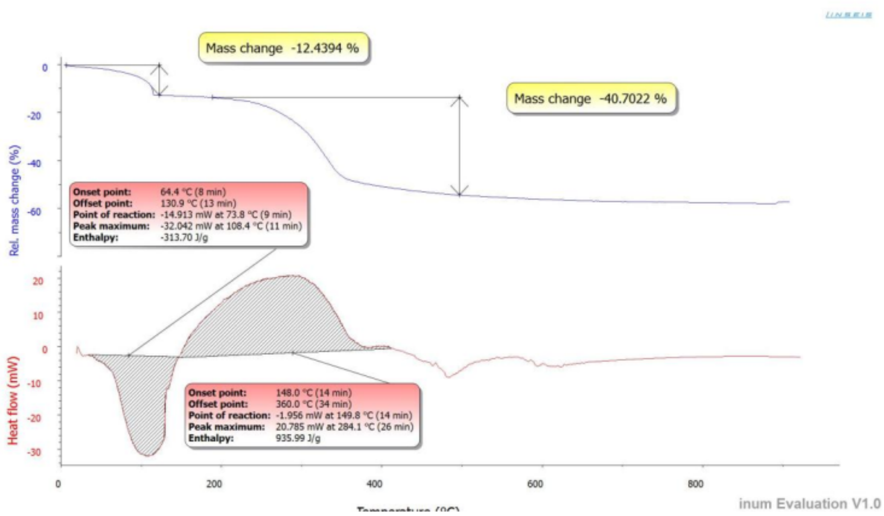

Figure 3. Graph of Sengon's sawdust + Z2 pyrolysis

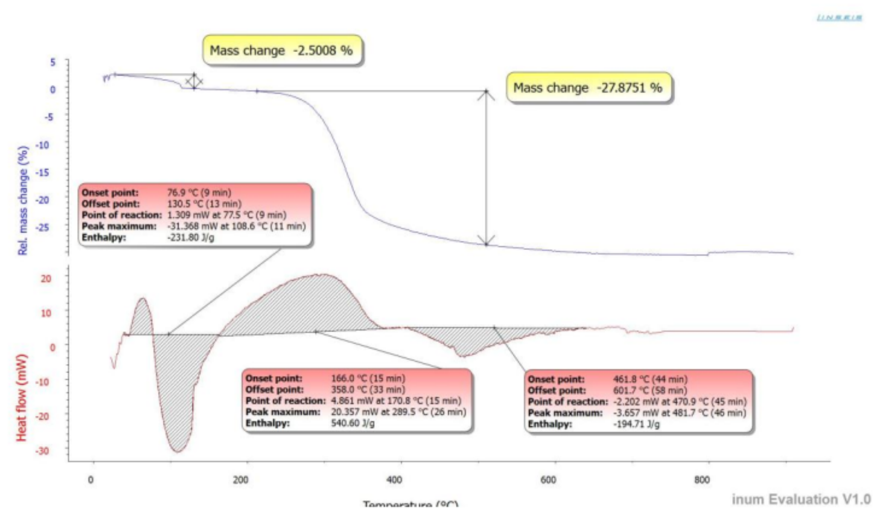

Figure 4. Graph of Sengon's sawdust + Z3 pyrolysis

4. Conclusion

This study has obtained data on the effect of natural zeolites on the pyrolysis of S biomass. It has been shown that the greater the percentage of Z, the lower the energy required to convert S into product yield. Furthermore, it is necessary to optimize the right mixture of S and Z so that the product yield becomes maximum and high quality.

5. Acknowledgement

The author would say thank a lot to Dean of Engineering Faculty and Head of Mechanical Engineering, *Universitas Muhammadiyah Jember* for financial supporting in this manuscript.

6. References

[1] M. S. Ahmad *et al.*, "Thermogravimetric analyses revealed the bioenergy potential of Eulaliopsis binata," *J. Therm. Anal. Calorim.*, vol. 130, no. 3, pp. 1237–1247, 2017, doi: 10.1007/s10973-017-6398-x.

[2] M. Hairul Bahri, W. Wijayanti, N. Hamidi, and I. N. G. Wardana, "The role of alkali metal and alkaline metal earth in natural zeolite on combustion of Albizia Falcataria sawdust," *Int. J. Energy Environ. Eng.*, vol. 11, no. 2, 2020, doi: 10.1007/s40095-019-00323-2.

[3] M. A. Mehmood *et al.*, "Pyrolysis and kinetic analyses of Camel grass (Cymbopogon schoenanthus) for bioenergy," *Bioresour. Technol.*, vol. 228, no. March, pp. 18–24, 2017, doi: 10.1016/j.biortech.2016.12.096.

[4] M. S. Ahmad *et al.*, "Kinetic analyses and pyrolytic behavior of Para grass (Urochloa mutica) for its bioenergy potential," *Bioresour. Technol.*, vol. 224, no. November 2019, pp. 708–713, 2017, doi: 10.1016/j.biortech.2016.10.090.

[5] D. E. Daugaard and R. C. Brown, "Enthalpy for pyrolysis for several types of biomass," *Energy and Fuels*, vol. 17, no. 4, pp. 934–939, 2003, doi: 10.1021/ef020260x.

Effect of natural zeolite on biomass pyrolysis

ORIGINALITY REPORT

18%	15%	17%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCHED SOURCE

3	Mokh. Hairul Bahri, Widya Wijayanti, Nurkholis Hamidi, I. N. G. Wardana. "The role of alkali metal and alkaline metal earth in natural zeolite on combustion of Albizia Falcataria sawdust", International Journal of Energy and Environmental Engineering, 2020 Publication	3%

3%

★ Mokh. Hairul Bahri, Widya Wijayanti, Nurkholis Hamidi, I. N. G. Wardana. "The role of alkali metal and alkaline metal earth in natural zeolite on combustion of Albizia Falcataria sawdust", International Journal of Energy and Environmental Engineering, 2020

Publication

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		