CHAPTER 6

CONCLUSION

6.1 CONCLUSION

Fuel properties of biomass were investigated. It was found that mimosa and bamboo have carbon content of 43.9% and 45.6%, and oxygen content of 48.7% and 49.7%, with fixed carbon of 23.6% and 14%, and low content of ash 3.7 and 5.6%, respectively. High heat value of mimosa and bamboo were 17.5 and 17.8 MJ/kg, which are similar to other biomass material. Mimosa and bamboo are useful as solid biofuels and may be utilized through gasification at relatively moderate conditions.

Thermogravimetric analysis of mimosa was investigated. It was found that it started to decompose at around 200^{o}C under N_2, air and O_2 atmosphere. Under N_2 and air atmospheres, there were two main weight losses. The first stage ranged from 200-400^{o}C was holocellulose, the second was lignin from 200-550^{o}C. Thermal degradation exhibited two major mass loss stages due to devolatilsation and char combustion. At 600 ^{o}C with weight loss 70% and 95%, it was left for 20% and 5% toward 1000 ^{o}C under N_2 and air, respectively. Thermal decomposition curves of mimosa showed similar peak decomposition temperatures to woods, but at higher temperatures than energy plants, agro-residues and biomass materials.

Increased oxygen concentration resulted in higher decomposition rate and conversion profile shift to lower temperature. Increasing heating rate (10, 30 and 50^{o}C/min) was found to increase mass loss rates but delay thermal decomposition to higher temperatures. The activation energy of these decomposition was approximately 334 kJ/mol.

Effects of temperature, reactor types and catalyst to biomass ratio on the product distribution of mimosa and bamboo gasification were investigated.

Air gasification of bamboo and mimosa in fixed bed reactor for temperature from 600 to 900^{o}C was conducted. It was found that increased temperature resulted in increased of gas yields from 66 to 69 w/w, 56.8 to 63 w/w and 81.1 to 84.8 w/w while tar and char yield decreased from 11.6 to 10.0 w/w, 21.2 to 19.0 w/w and 11.9 to 8 w/w. for bamboo, mimosa at slow and fast heating rates, respectively.

H_2 content increased from 0.4 to 0.8 mol% and 0.5 to 1.2 mol% and 4.6 to 10.8 mol% for bamboo, mimosa at slow and fast heating rates, respectively. CO content increased from 3.4 to 4.6 mol% and 10.5 to 17.9 mol% for mimosa at slow and fast heating rates, respectively. While bamboo unchanged. At 900^{o}C, the highest contents of H_2 and CO of mimosa were 10.8 and 17.9 mol% for mimosa at fast heating rates.

LHV, carbon conversion efficiency increased with increased temperature. At 900^{o}C, gas heating value, carbon conversion efficiency and gas yield of bamboo, and mimosa were 1, 1.1 and 5.2 MJ/Nm^3, 36, 49 and 98.7% and1.3, 1.3 and 1.6 Nm^3/kg for bamboo, mimosa at slow and fast heating rates, respectively.

The collection time appeared to have positive effect on H_2 and CO yields during devolatilization and char oxidation process. From 0 to 20 min, the content of H_2 and CO increased and at 20 min was maximum of 28 and 14 mol%, respectively. After that H_2 and CO yield decreased while CO_2 yield increased with collection time.

Presence of catalyst in gasification process improved the product yields and compositions. Increased catalyst to biomass ratio from 0 to 2, it was found that catalyst to biomass ratio of 1 was the optimum condition. Increased catalyst resulted in increased of gas yield from 66.2 to 69 w/w, 56.8 to 63.4 w/w and 81.1 to 84.8 w/w, while slightly decreased of tar yields from 11.6 to 10.0 w/w, 21.2 to 19 w/w and 11.9 to 8.0 w/w for bamboo and mimosa at slow and fast heating rates, respectively.

H_2 yields increased from 0.8 to 1.9 mol%, 1.2 to 3.2 mol% and 10.8 to 13.3 mol%, respectively. CO increased from 4.8 to 7.7 mol%, 4.6 to 8.2 mol% and 17.9 to 23.0 mol% for bamboo and mimosa at slow and fast heating rates, respectively. Product gas heating value and gas yield increased but carbon conversion efficiency decreased with increased catalyst. At catalyst to biomass ratio of 1, gas heating value, carbon conversion efficiency and gas yield of bamboo and mimosa were 1.5, 1.8, 5.3 MJ/Nm^3, 48.8, 45.5 and 86.2% and 1.5, 1.5 and 1.7 Nm^3/kg, for bamboo and mimosa at slow and fast heating rates, respectively.

For air gasification in fluidized bed when temperature increased from 400 to 700^{o}C, it was found that the content of char and gas decreased from 14.5 to 11.2 w/w and 53.7 to 46.10 w/w for bamboo, and 13.5 to 11.8 w/w and 54.9 to 45.7 w/w for mimosa, respectively. But tar yield increased from 31.8 to 42.7 w/w and 31.6 to 42.5 w/w for bamboo and mimosa, respectively.

H_2 content decreased from 2.33 to 0.77 mol% and 3.13 to 0.77 mol%, and content of CO decreased from 8.7 to 6.9 mol% and 9.8 to 6.9 mol%, for bamboo and mimosa, respectively. But content of CO_2 increased from 16.1 to 19.4 mol% and 13.2 to 19.4 mol% for bamboo and mimosa, respectively. The content of CH_4 was found to slightly decrease. Gas heating value product gas, carbon conversion efficiency and gas yield decreased with increasing temperature.

Presence of catalyst with bamboo and mimosa was found to increase content of gas from 46.1 to 62.9 w/w and 45.7 to 64.5 w/w, respectively. While char and tar yield decreased from 11.2 to 9.6 w/w and 42.7 to 27.5 w/w for bamboo, and 11.8 to 9.5 w/w and 42.5 to 26.0 w/w for mimosa, respectively.

H_2 content increased from 0.7 to 2.8 mol% and 0.7 to 5 mol% and CO from 5.9 to 10.0 mol% and 6.9 to 10.0 mol% in gas product as catalyst to biomass ratio increased from 0 to 1. Trends were opposite for CO_2 which decreased from 19.4 to 16 mol% and 19.4 to 12 mol% for bamboo and mimosa, respectively. Gas heating value of bamboo and mimosa increased with increased catalyst to biomass ratio from 1.3to 1.9 MJ/Nm^3 and 1.4 to 2.2 MJ/Nm^3, and gas yield increased from 1.8 to 2.0 Nm^3/kg and 2.2 to 2.4 Nm^3/kg, respectively.

Calculated product gas from thermoequilibrium model was compared with those from literature. RMSE was less than 5. To compare between air gasification of bamboo and mimosa, RSME was also less than 5.

6.2 SUGGESTIONS FOR FUTURE STUDY

Based on the results, analyses and reviews of literature, the following are my suggestions for advancing the research on biomass gasification.

- Characterization of biomass is essential to the development of effective mathematical models which can predict product composition and properties.
- Using activation energy of devolatization for mimosa in model will strengthen the gasification model for calculating gas composition during biomass decomposition. Volatile decomposition can also be prediction gas production during these stages.
- Calculation of tar in gas product with tar equation can be used to correct the gasification model.
- Using char balance to correct for carbon balance and gas production in model.
- Moisture in air should be corrected for water in chemical balance.