Investigation of coal-biomass catalytic co-pyrolysis and co-gasification

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SBI Science & Technology Review Winter Meeting
Tuesday January 29th, 2013. Utah State University, Logan, UT
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Abstract

The conversion of coal-biomass into energy and useful products via pyrolysis and gasification technology is a promising alternative to coal-biomass co-firing. However, one major issue with coal pyrolysis and gasification has to deal with high temperature processing. Therefore the focus of this study is to investigate the effect of biomass to coal ratio and catalyst influence on coal-biomass gasification at low temperature. Experiments were carried out in a bench-scale bubbling fluidizing bed reactor at 700°C, 800°C, and 900°C using subbituminous coal, hybrid poplar, cornstover, switchgrass, and coal-biomass blends. The percentage of biomass by weight in the mixtures studied was 0, 10, 15, 20, 25, 30, 40, and 50. Additionally, the experiment was conducted in two media: N_2 and CO_2. Currently, we are in the initial phase of the experiment. The results showed that char and liquid yields decreased with increasing temperature whereas gas yield increased with increasing temperature. Also, there appeared to be no synergistic effect of the two feedstocks on product distribution at 700°C and 800°C.

Introduction

- Currently fuels and chemicals are predominantly derived from petroleum and coal resources.
- Whereas petroleum sources are greatly depleted, coal reserves are sufficient to meet domestic demands for over 200 years at the current consumption rate.
- Combustion and co-firing of coal produce NO_x and SO_x that lead to global warming and acid rains respectively.
- However co-pyrolysis and co-gasification of coal and biomass has a potential of reducing harmful emissions (NO_x and SO_x). In addition, gaseous fuel (syngas: H_2 & CO) obtained can be synthesize into ultra-clean fuels such as liquid hydrocarbon, methanol, dimethyl ether, and ethanol.
- Biomass (renewable and widely distributed) utilization with coal is a key to sustainable natural resource management.

Objectives

The present study is aimed at investigating the influence of various biomass (poplar, cornstover, and switchgrass) blend ratio, gasification medium (N_2, CO_2, and steam), and catalyst influence on coal pyrolysis and gasification product distributions at low temperature using both a bench-scale and a pilot scale bubbling fluidizing bed unit.

Materials and Methods

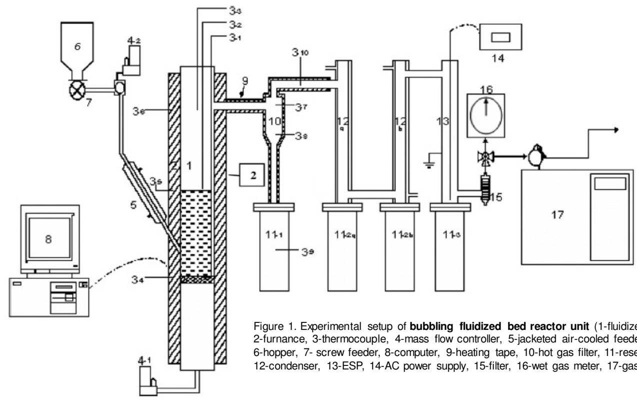

Figure 1. Experimental setup of **bubbling fluidized bed reactor unit** (1-fluidized bed, 2-furnance, 3-thermocouple, 4-mass flow controller, 5-jacketed air-cooled feeder tube, 6-hopper, 7- screw feeder, 8-computer, 9-heating tape, 10-hot gas filter, 11-reservoir, 12-condenser, 13-ESP, 14-AC power supply, 15-filter, 16-wet gas meter, 17-gas chromatography)

Results

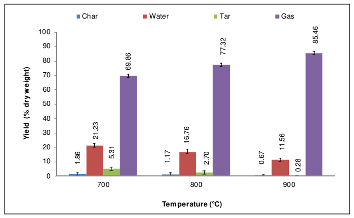

Figure 2. Product yield of poplar wood (wt%) as a function of pyrolysis temperature in N_2 atmosphere.

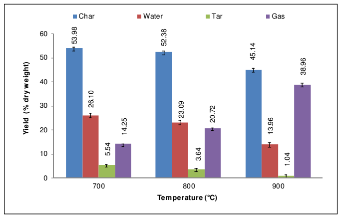

Figure 3. Product yield of coal as a function of pyrolysis temperature in N_2 atmosphere.

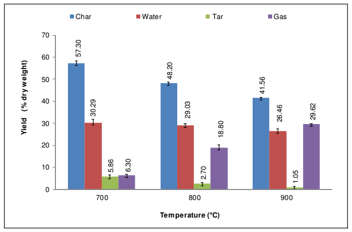

Figure 4. Product yield of coal as a function of pyrolysis temperature in CO_2 atmosphere.

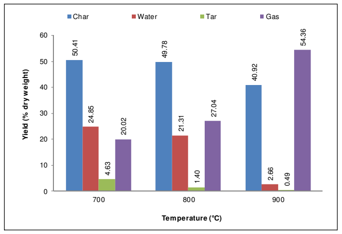

Figure 5. Product yield of coal-poplar (90-10 wt%) as a function of pyrolysis temperature in N_2 atmosphere.

Results cont'd

C- coal, P-poplar , CP- coal-poplar blend

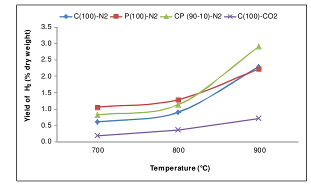

Figure 6. Yield of H_2 as a function of temperature, biomass, and gasification medium.

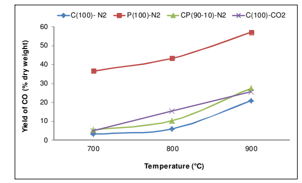

Figure 7. Yield of CO as a function of temperature, biomass, and gasification medium.

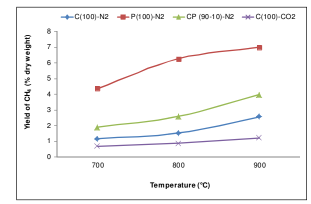

Figure 8. Yield of CH_4 as a function of temperature, biomass, and gasification medium.

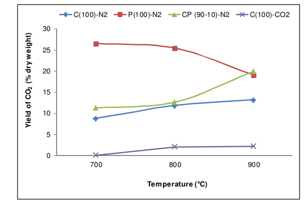

Figure 9. Yield of CO_2 as a function of temperature, biomass, and gasification medium.

Summary

- The results showed that solid and liquid yields decreased with increasing temperature and consequently the gas and its components (syngas) yield increased with increasing temperature.
- Coal showed moderate reactivity in both N_2 & CO_2 gasification medium.
- The anticipated synergistic effects of coal-biomass co-pyrolysis and co-gasification can potentially make coal utilization environmentally attractive and economically competitive as a domestic energy source.

Future work

Continuation of co-pyrolysis and co-gasification studies to demonstrate the influence of catalysts on the solid, liquid, and gas products distributions.

References

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Acknowledgement

United States Department of Energy (DOE)

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