Catalytic Gasification of Poultry Manure and Eucalyptus Wood Mixture in Supercritical Water

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SYNOPSIS

In this study, supercritical water gasification (SCWG) of poultry manure mixture with eucalyptus wood was conducted in a continuous flow system for temperature range of 550–650 °C and pressure of 25 MPa at various ratio mixture of feedstock. The effect of Eucalyptus wood content towards the product gas compositions, carbon balance and carbon gasification efficiency (CGE) of the reaction has been obtained. Without catalyst, high gasification is limited by the concentration of the organic feedstock. Activated carbon is effective as catalyst and drastically improve CGE. In addition, the optimum amount of catalyst in the mixture is established in this study.

1. Introduction

Supercritical water gasification (SCWG) of organic compounds in poultry manure offers several advantages when compared to other biological conversion such as composting and anaerobic digestion. These advantages include that high conversion of organic content can be achieved in short reaction time due to the rapid reaction. Composting requires large land for utilization, while SCWG consists of reactors with controlled sizes and with the introduction of continuous process, and thus, a highly efficient compact system can be achieved. In addition, harmful gaseous products are not produced in the reaction to make the process more environmental friendly. Inorganic elements contained in the poultry manure are concentrated in the form of solid and some in the liquid compounds which in turn can be recovered and used in other applications.

Nakamura et al. [1] studied the gasification of poultry manure by SCWG with suspended activated carbon catalyst. The study indicated the feasibility of SCWG of poultry derived wastes. However, no study has been conducted before to determine the effect of wood content on the gasification of poultry manure. This investigations is vital especially for broiler derived wastes since it consists of manure and the bedding material itself such as wood sawdust. The complex compounds of wood sawdust due its various compounds (cellulose, hemicellulose, and lignin) are predicted to affect the overall decomposition pathway when mixed with poultry manure. The purpose of this study is to elucidate this effect. In addition, the utilization of suspended activated carbon catalyst for the SCWG of poultry manure and wood mixture is also investigated in this study.

2. Experimental

The schematic of the experimental apparatus is shown in Fig. 1. The preheater and reactor are made of SS316 steel tubing (ID: 2.18 mm, OD: 3.18 mm) of the length of 0.52 m and 12 m, respectively. Poultry manure (0.5 wt%) are gasified at reaction pressure of 25 MPa with varying mixture of eucalyptus wood (0.1–0.3 wt%) for non-catalytic gasification and addition of 0.2–0.8 wt% of coconut shell activated carbon for the study of catalyst effect on the reaction. The temperature ranges from 550 to 650 °C with residence time of 68–105 s. The gaseous products and liquid compounds are analyzed by gas chromatograph (GC) and by a total organic carbon (TOC) analyzer, respectively. The poultry manure is from the egg farm, Sera Farm, and contains no woody material.

Carbon gasification efficiency are calculated based on the carbon content in the feedstock.

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3. Results and discussions

3.1 Effect of temperature

Fig. 2 shows CGE and gas composition. CGE increases with temperature. However, the highest CGE achieved is considerably low (21.8%). The organic matter in the poultry manure is mainly converted into fuel gases such as H₂, CO₂, and CH₄.

![Fig. 2. Effect of temperature on the CGE and gas compositions for reaction condition: 0.5 wt% poultry manure and residence time of 86 – 105 s.](image)

(a) CGE
(b) gas composition

3.2 Effect of Eucalyptus wood addition

Fig. 3 shows the effect of wood powder addition on CGE. The increase in CGE for 0.1 wt% of Eucalyptus wood and the subsequent significant drop indicate the existence of inhibiting compounds in the Eucalyptus wood which decelerate the gas producing pathways in the overall reactions.

This phenomenon could be attributed to the effect of components in Eucalyptus wood, mainly lignin, on the decomposition of the organic matter. The intermediate compounds from lignin depolymerization can rapidly react with organic compounds from the poultry manure and intermediates from cellulose and hemicellulose, and undergo crosslinking with each other.

![Fig. 3. Effect of Eucalyptus wood addition on the CGE for reaction condition: 0.5 wt% poultry manure, and residence time of 86 – 105 s.](image)

3.3 Catalytic SCWG of poultry manure and Eucalyptus wood mixture.

Fig. 4 shows the effect of activated carbon catalyst. Large improvement of CGE is observed. The utilization of suspended fine activated carbon is found to be successful in this study. Furthermore, this observation indicates that gas producing pathways are enhanced and occurs at higher rate than the cross linkage reactions between the intermediate liquid compounds.

![Fig. 4. Effect of Eucalyptus wood addition on the gas compositions and carbon balance for reaction condition: 0.5 wt% poultry manure, temperature 650 °C and residence time of 86 s.](image)

4. Conclusion

For SCWG of poultry manure, eucalyptus wood causes significant decreasing effect on the gasification performance. This phenomenon can be attributed to the effect of components in wood, mainly lignin, on the decomposition of the organic matter during the reaction. Activated carbon is found to enhance the gas producing pathways.

Literature cited