

Gasification characteristic of sewage sludge in sub and supercritical water

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Submission date: 25-May-2022 06:21AM (UTC-0400)

Submission ID: 1843858598

File name: Apip_Bid_B_c-9.pdf (326.53K)

Word count: 1042

Character count: 5507

3-6-3 亜臨界ならびに超臨界水中における下水汚泥のガス化特性

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Gasification characteristic of sewage sludge in sub- and supercritical water

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ABSTRACT

Gasification characteristics of sewage sludge under sub- and supercritical water in continuous flow reactor was investigated. Sewage sludge (0.1 wt%) was gasified at temperatures ranging from 300 to 550 °C and under constant pressure of 25 MPa with residence times ranging from 5-30 s. The gas component was identified and quantified by gas chromatography (GC), and the amount of total organic carbon (TOC) in the aqueous phase was also determined. The gasification characteristics were compared with our previous work. The gaseous products were mainly composed of H₂, CO₂, and CH₄. The influence of temperature and residence time under sub- and supercritical conditions were examined.

[1] Introduction

Renewable energy is a promising solution to the problem of global warming issue, depletion of fossil fuel, and increased energy consumption. Among various renewable energy resource, biomass is easy to use due to its chemical energy form. One promising source for biomass is sewage sludge. Sewage sludge is a by-product of wastewater treatment with the high moisture content, which leads to high drying costs when pyrolysis or combustion is employed. To convert sewage sludge into combustible gas production such as H₂ and CH₄, supercritical water gasification is effective because drying is not needed^{1,2}. Water under supercritical conditions (temperature above 374 °C and pressure above 22.1 MPa) dramatically changes its properties³. Under supercritical conditions, water has great potential as solvent for organic components and gases because all of the reactants can remain in a single phase⁴. The key to this technology is water, which plays various roles in the process. Water is at the same time a reagent (gasification agent) and solvent. To design the supercritical water gasification of sewage sludge, it is important to know its

gasification characteristics. However, thorough study on gasification characteristics of sewage sludge in supercritical water, covering both sub- and supercritical conditions has not been reported. Thus, the purpose of this study is to elucidate the gasification characteristics of sewage sludge under hot compressed water both under sub- and supercritical conditions.

[2] Experiment

All gasification runs were carried out using a continuous flow reactor. The reactor was made of SS316 steel tubing (i.d. 2.17 mm, o.d., 3.18 mm, and length 12 m). The reactor was placed inside an electric furnace. Initially, water was fed to the reactor. Subsequently, the pressure was increased to 25 MPa using the back-pressure regulator. After achieving a constant pressure of 25 MPa, the reactor temperature was set at the desired temperature. The feedstock was then fed using feeding system. The feedstock was fed into the system for 1 h prior to sample collection after steady state. Gas samples were collected in vials and their compositions were determined by gas chromatograph. Liquid samples were also

collected to determine the total organic carbon (TOC) content. The experiment was conducted for sewage sludge concentration of 0.1 wt% under various temperature (300–550 °C) and residence time (5–30 s). The CGE for all runs was calculated on basis of the carbon content in sewage sludge feedstock.

[3] Results and discussion

The effect of temperature and residence time on the carbon gasification efficiency (CGE) is shown in Fig.1. The CGE is largely affected by the reaction temperature, but effect of residence time was not observed for the range in this experiment. This is an interesting result because this fact suggests however long you may treat, gas generation is determined by the temperature, and that once sewage sludge is converted into gas and other product, the part that is not gas will never be converted into gas any more. It is also to be noted that this conversion into gas and other part is quite rapid reaction, and is terminated in less than 5 s even at 300 °C. This is quite characteristic to sewage sludge. Gasification of other feedstock so far studied followed first-order reaction, showing increase of CGE with residence time⁶.

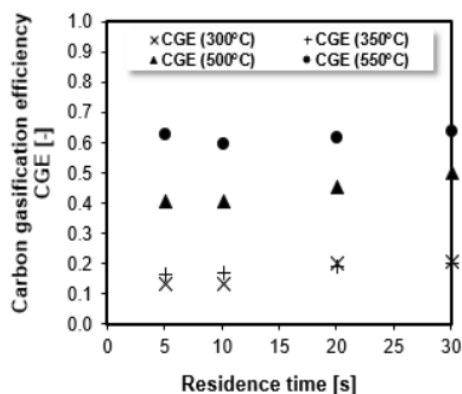


Fig.1. Effect of temperature on carbon gasification efficiency.

Gas composition was compared between the sub- and supercritical conditions. Under the subcritical condition, the gaseous product mainly contained H₂ and CO₂ with less amount of CH₄ and C₂H₄. No CO

was found. This a good agreement with previous results by Seift et al⁵. In contrast, under supercritical condition the temperature had more effect on product gas composition. The gaseous products were mainly composed of H₂, CO₂ and CH₄, and small quantities of C₂H₄ and C₂H₆. The level of CO was found either in traces or negligible amount.

[4] Conclusion

Gasification of sewage sludge was conducted using a continuous flow reactor. The effect of temperature and residence time on carbon gasification and gas composition were determined. Carbon gasification efficiency of sewage sludge increased with temperature but effect of residence time was negligible. The gaseous products were mainly composed of H₂, CO₂, and CH₄.

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[Acknowledgment] A is grateful for the financial support from Indonesia Endowment Fund for Education (LPDP) for PhD scholarship. The authors also thank the waste water treatment plant center in Higashi-Hiroshima, Japan. This study was partly supported by Tanigawa Fund.

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