学 位 論 文 概 要

題目　Gasification of lignocellulosic biomass under sub- and super critical water condition: Interaction between model compounds and process evaluation
（亜臨界及び超臨界水中におけるリグノセルロース系バイオマスのガス化：モデル物質間の相互作用およびプロセスの評価）

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Supercritical water gasification (SCWG) is promising method to convert biomass into gaseous products. At supercritical state of water, biomass could be homogeneously dissolved in supercritical water and consequently obtain high conversion. However, biomass consists of various compounds that make difficulty to optimize the process. Thereby, reaction scheme and model compound of biomass are keys to achieve the goal. For lignocellulosic biomass, it contains mostly cellulose, hemicellulose and merged by lignin.

According to that only few studies have been investigated in behavior of hemicellulose in supercritical water, this study firstly attempts to elucidate the decomposition of xylose as a model compound of hemicellulose in supercritical water aiming for comprehending the whole behavior of lignocellulosic biomass. Solutions of xylose in water were heated under sub- and supercritical conditions. The intermediates found in the liquid phase were xylulose, furfural, retro-aldol products (glyceraldehyde, glycolaldehyde, dihydroxyacetone, and formaldehyde), and organic acids (acetic acid and formic acid). The reaction network scheme of the decomposition of xylose includes the intermediates and the final products. The kinetic reaction rates were determined by the least square of error (LSE) method that gave the best fitting of the empirical data and the calculated values. The reaction types involved were classified according to Arrhenius behavior: the ionic reaction (not showing Arrhenius behavior in the supercritical region) and the free-radical reaction (showing Arrhenius behavior in the supercritical region).

Consequently, the interaction between model compounds of lignocellulosic biomass, which are glucose, xylose and guaiacol as a model compounds of cellulose, hemicellulose and lignin respectively, is studied. Gaseous, liquid and solid products were collected and quantitatively determined. Liquid product is dominant in the range of this work. Intermediates that are of focus were glucose, fructose, 5-HMF, furfural, xylose, xylulose, retro-aldol products, acids, guaiacol, and phenolic compounds. Interaction of these intermediates had an effect on kinetics of reactions and distribution of the final products. The reaction pathway of three model compounds is developed and proposed in this study.

The decomposition of glucose was employed for the consequent study because both most of the intermediate reactions in the reaction network are ionic reactions except gasification, which is radical reaction.　As such, phenol was expected to inhibit gasification as a result of the radical scavenging effect.　The kinetic analysis was conducted in order to investigate any changes in reaction kinetics. The results indicated that char formation was enhanced in subcritical condition, whereas no significant difference in supercritical condition in a presence of phenol.　Because char formation from glucose was found as ionic reaction, it can be implied from this result that phenol could also act as acidic catalyst in subcritical condition.　Gasification, which is a radical reaction, was suppressed in both sub- and supercritical condition, which indicated that phenol may also contribute to the radical scavenging effect.

At last, process evaluation of supercritical water gasification of biomass in Kita-Hiroshima town, as an outcome of the on-site team project conducted under the requirement of Taoyaka program is presented. As biomass resources, tomato residue produced has a good possibility because tomato is easy to develop and can be sold as value added product. To convert tomato residue into useful secondary energy, SCWG is considered as a proper technology. The tomato residue potential for the gas production was evaluated in terms of energy, economics and environmental aspect.

In conclusion, this research includes fundamental studies, which elucidates mechanisms of model compounds of lignocellulosic biomass in terms of kinetic analysis. A detailed kinetics study allow ones to predict the outcome of the reactions. Furthermore, practical utilization of SCWG system was evaluated to reveal its feasibility in terms of energy, economic and environmental viewpoints.