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論 文 要 旨
THESIS SUMMARY

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要旨（英文800語程度）
Thesis Summary (approx.800 English Words)

The aim of this research is to produce hydrochar from banana leaves (BL) for solid fuel applications employing hydrothermal treatment (HT). Like other biomass, BL have low heating value and high alkali content, that can be addressed by HT. The objective of this study is to upgrade the fuel properties of BL by HT and investigate its performance as solid fuel for combustion and co-gasification with coal. Among the specific areas dealt are the effect of the fuel properties on the combustion parameters and the influence of hydrochar blending on the reactivity and the synergy in CO_2 co-gasification with coal. Moreover, fundamental understanding on the formation and the secondary degradation of organic acids in the liquid by-product during HT is also included in this study. The contents of this thesis are as follows:

In chapter 1, the background of the hydrothermal treatment of banana leaves for solid fuel applications and organic acid production are introduced. The advantages of employing HT as a pretreatment technology are reviewed. Recent trends on applying hydrochar as solid fuel for combustion and gasification are also presented. In addition, some literatures on biomass conversion to organic acid are discussed, as well as the potential applications of organic acids. The general objective and significance of the study are stated. Specific objectives are given in the following chapters

For chapter 2, lab-scale production of hydrochar from banana leaves by HT for solid fuel combustion was investigated. HT was conducted at 180°C, 200°C and 220°C for 30 min. The fuel properties of BL were enhanced after HT, where the carbon content increased with increasing reaction temperature, while the oxygen and ash contents reduced. Consequently, the higher heating value (20.4-22.7 MJ/kg) of the solid products were comparable to sub-bituminous coal, with an energy yield of up to 94.0%. Changes in the fuel properties of hydrochars influenced its combustion behavior and reactivity in the thermogravimetric analysis. A second-order reaction mechanism by the Coats-Redfern approximation was adopted to describe the kinetics of the non-isothermal combustion.

As shown in the previous chapter, the alkali content in ash can be further reduced by increasing the reaction temperature. However, increasing the reaction temperature will decrease the solid yield and so the HT reaction temperature must be kept as low as possible. Moreover, the retained active alkali and alkaline earth metals (AAEM) after HT, may still have significant catalytic effect in the co-gasification reactivity with coal. In chapter 3, the reactivity in the isothermal CO_2-gasification of char from hydrochar (HT180) derived from banana leaves by HT was examined using the thermogravimetric analyzer at 800, 850 and 900°C. The AAEM concentration retained in the hydrochar after HT was analyzed. Washed hydrochar (WHT180) was also tested to examine the effect of AAEM concentration reduction. The results show that the gasification reactivity at 800°C in terms of the reactivity index, $R_{0.9}$ is in the order of BL>HT180>WHT180. The same trend was observed at 850°C and 950°C which is consistent for an endothermic reaction. The decreasing gasification reactivity correlates to the reduction of AAEM concentration in the hydrochars. Then the effect of blending of hydrochars (10, 30, 50%) with anthracite coal on the reactivity and the synergy in gasification at 1000°C was evaluated. The co-gasification reactivity of hydrochars and coal was enhanced and increased with

increasing the proportion of hydrochars, that was attributed to the synergistic effect brought by the catalytic effect of the retained alkali metals in hydrochars. The synergy factor was higher for HT180 than WHT180 blending with coal in all ratios. HT not only improved the fuel properties and reduced the ash content of banana leaves but also influenced the co-gasification reactivity with coal.

Chapter 4 covers the co-gasification of hydrochar and washed hydrochar with coal in a drop tube furnace under CO_2 atmosphere. The co-gasification in DTF was done at 1000°C in 5% CO_2 balanced by N_2 at 5L/min on a volume basis. A syringe pump was used to feed the fuels at 0.08 g/min. Different blending ratios of hydrochars (10%, 30% and 50%) with coal were tested to determine its effect on the syngas produced. The synergistic effect was determined and correlated with the alkali index (AI). The results show that the gas volume % of H_2 and CO produced increased with increasing blending proportion of hydrochars. There was a synergistic effect in the co-gasification of blended fuels and it was stronger at higher hydrochar proportion. At 50% blending ratio however, there was a decreased in the synergistic effect and consequently, a reduction in volume % of the producer gas. The synergistic effect positively correlated with AI and therefore it can be concluded that the synergy behavior arises from the catalytic effect of the retained AAEM in the hydrochars.

During hydrothermal treatment, organic acids in the liquid by-product are produced from the degradation of lignocellulosic composition of the sample. In chapter 5, the formation and decomposition of organic acids from a wide range of reaction temperature (120-240°C) were investigated. The concentration of formic, acetic, lactic and succinic acids tended to increase with increasing the reaction temperature, while oxalic, citric and malic acids decreased. The concentration of acetic and formic acids at 200°C and above, was much higher than that seen at lower temperatures. At a higher reaction temperature, oxalic, citric and succinic acids must have undergone a secondary degradation and, for citric acid, it may have caused the increase of the acetic acid concentration due to the thermal reaction pathways. Furthermore, a decrease in pH (5.35-4.60) of the liquid by-product was observed with the increase of the reaction temperature. This implies that the aqueous solution becomes more acidic at a higher reaction temperature as an effect of the formation and secondary degradation of organic acids.

It is recommended to conduct co-combustion studies of coal and hydrochar from banana leaves. The co-gasification reactivity and the synergy behaviour of hydrochar and coal can be further understood by performing TGA on a larger scale, to be able to collect more amount of semichar, for extensive analysis and validation of the catalytic effect of AAEM. The solid residues including the char, fly ash and soot from co-gasification of hydrochar and coal may be analysed to evaluate the effect of blending fuels and the catalytic activity of AAEM in co-gasification using DTF. Having known the nutrients and organic acids in the liquid by-product from HT of banana leaves, plant growth assays and animal feed tests must be conducted. Lastly, the other components of the banana residues such as the pseudostem, skin and stalk, should also be studied to thoroughly assess the potential of harnessing energy and chemicals from wastes of banana plantations.