

学 位 論 文 の 要 旨

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学位論文題目	Utilization of waste biomass resources for hydrogen-rich syngas production via steam co-gasification process （廃棄物系バイオマスの水蒸気共ガス化による水素製造に関する研究）		
<p>学位論文要旨</p> <p>Gasification of biomass in large-scale industrial applications is restricted due to several disadvantages such as tar production, low bulk density and energy density, wide and thin distribution, and unstable seasonal supply. As such, co-utilization of various kinds of biomass wastes as the mixture feedstock for the gasification process is more practical with relatively low cost. This dissertation, therefore, focuses on investigating the co-gasification reactivity and performances, especially for hydrogen production, of mixture feedstock and the potential synergy effect. Different carbon-based solid materials were selected as the gasification co-feedstock, i.e., biomass/biomass with different properties, biomass/biochar, and biomass/coal in order to utilize biomass resources more efficiently and explore the co-gasification behaviors and feasibility for the hydrogen-rich syngas production by the combination of biomass with different types of carbon-based materials.</p> <p>Firstly, steam co-gasification behaviors and H₂-rich gas production of biomass/biomass co-feedstock were studied. Banana peel (BP), rice husk (RH), Japanese cedarwood (CW) were selected as the steam gasification feedstock in a fixed-bed reactor. From the results of gasification of individual sample, the total gas yields of BP, RH and CW obtained at 750 °C were 52.5, 19.2, and 15.9 mmol/g-sample, respectively, indicating the high AAEM content in BP could provide the self-catalytic effect during the gasification process. Moreover, it was also found that the gasification reactivity of CW could be highly enhanced by mixing with BP. The experimental results showed that the total gas yield obtained from co-gasification of BP and CW was 45.3 mmol/g-sample at 750 °C with a mixing weight ratio of 1:1, which was obviously higher than the calculated result of 34.1 mmol/g-sample. On the other hand, the inhibiting effect was obtained from co-gasification of RH and BP due to the high content of silica species in the RH ash. The total gas yield from co-gasification of BP and RH was 31.2 mmol/g-sample at 750 °C with a mixing ratio of 1:1, which was lower than the calculated result of 35.8 mmol/g-sample. The calcined seashells as the CaO source were utilized as catalyst in co-gasification process, which showed a good catalytic effect on enhancing gas production, especially the hydrogen gas yield at a relatively low gasification temperature of 750 °C.</p>			

Secondly, steam gasification and co-gasification of CW and its commercial biochar (CBC) were performed to investigate the effect of the carbonization process on gasification reactivity and H₂-rich syngas production. Initially, the effects of gasification temperature and steam flow rate on gas production from the steam gasification of the individual samples were investigated, and the results showed that the total gas yields from raw biomass increased from 10.6 mmol/g-sample at 650 °C to 55.7 mmol/g sample at 850 °C, while that from the biochar was increased from 28.5 mmol/g-sample at 650 °C to 174.1 mmol/g-sample at 850 °C, indicating that the introduction of carbonization process could highly enhance gasification reactivity and decrease tar production. The co-gasification of raw CW and CBC with different mixing ratios was conducted at different reaction temperatures. The synergistic effect was obviously observed and the mixing ratios of two samples were found to be an important factor for the co-gasification process. It was found that the total gas yields obtained from co-gasification CW and CBC at 750 °C with a mixing ratio of 1:1 was 100.2 mmol/g-sample, which was higher than the predicted result of 87.7 mmol/g-sample. The commercial biochar with the highly porous structure and high content of AAEM species might provide the catalytic effect on cracking and reforming of tar derived from the raw cedarwood, resulting in a higher H₂ yield.

Lastly, steam co-gasification of BP with brown coal (BC) for H₂-rich syngas production was studied in a fixed-bed reactor. The results showed that the gasification rate of BC was highly enhanced after mixing it with BP, and the obvious synergistic effect was observed in all three mixing ratios (i.e., 1:1, 1:4, and 4:1), and the excess growth rates of total gas yields for blending ratios of 1:4, 4:1 and 1:1 were 28.8%, 16.3% and 37.3% respectively, resulting in a higher carbon conversion as well as H₂-rich gas production during the co-gasification. However, the extent of promotion by the synergistic effect was affected by the reaction temperature, mixing ratio, and steam amount. In addition, it was confirmed that the steam should be an important factor to promote the synergistic effect and H₂-rich gas production. The total syngas yields obtained from mixture sample at 750 °C were increased from 16.5 to 85.7 mmol/g-sample with increasing of the steam flow rate from 0 to 0.25 g/min, which was increased more than 5 times larger with introducing a sufficient amount of steam. The largest excess growth rate was obtained at the steam flow rate of 0.25 g/min, with 40.3% of more syngas generated from the experiment when compared with the calculated values.