学 位 論 文 概 要

題目　Supercritical water gasification of palm oil mill effluent
（パーム油工場廃液の超臨界水ガス化）

D174923
RAHMAT IMAN MAINIL

The fossil fuel utilization (conventional sources of energy) contributes to carbon dioxide emissions. Such emissions directly lead to potentially catastrophic changes in the atmosphere. Moreover, the high consumption of fossil fuels affects the depletion of this energy source and will run out in the near future. Biomass, one of the potential renewable energy sources, has ability as zero carbon dioxide emissions. Palm oil is the foremost industry in Indonesia with severe waste byproducts that are harmful to the environment; however, it has excellent potential as biomass resources. Palm oil mill effluent (POME) is the most problematic waste generated from palm oil production process. The use of POME as a source of secondary energy also has advantages. It would be helpful in overcoming environmental problems, and in supplying alternative energy. Among various technologies which have been being used to convert biomass to obtain energy, supercritical water gasification (SCWG) is the most promising, innovative and effective process for the treatment of organic compound. This process does not require drying, uses a small compact reactor, and only requires short reaction times.

No study has been carried out on gas production from POME in the supercritical water gasification. Additionally, the recovery of valuable nutrients in parallel with energy production could make this process becomes more economically beneficial. In this study, POME was treated in supercritical water at 500−600 °C under a pressure of 25 MPa, with a residence time of 5−50 s in a laboratory-scale continuous reactor. The effects of temperature and residence time on the carbon yields, gas composition, and behavior of phosphorus during supercritical water gasification were examined. A reaction model was developed, and reaction rate constants for first-order kinetics were determined. The calculation was based on the model agreed well with the experimental results.

The study on the effects of the heating rate on the simultaneous production of gas and phosphorus from POME in supercritical water (600 °C, 25 MPa) has elucidated. The heating rate was controlled by modulating the preheater lengths (1, 2, and 4 m) and flow rates (2 and 3 g/min). Faster heating rates were obtained using shorter-length preheaters. Although the increased heating rate resulted in a higher carbon gasification efficiency and lower hydrogen content, it also reduced the amount of precipitated IP (inorganic phosphorus). As the effect of flow rate, which determined the residence time in the reactor, was much smaller than that of the heating rate, it can be concluded that the primary reactions of this process are completed in the preheater. This finding can help to guide the optimization of the POME recycling process.

The classification of retro-aldol reaction types was also studied because the real mechanism has not known yet. In this work, glyceraldehyde is used to clearly demonstrate that the retro-aldol reaction of glyceraldehyde under hydrothermal conditions is a radical reaction. Glyceraldehyde was dissolved in deionized water and then heated to 350–450 °C at a fixed pressure of 25 MPa in a continuous reactor. The reaction rate of glyceraldehyde followed Arrhenius's Law, irrespective of subcritical or supercritical temperatures. The reaction network of glyceraldehyde was also developed and each reaction rate was determined.