学 位 論 文 概 要

題目　Supercritical water gasification of microalgae
（微細藻類の超臨界水ガス化）

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The decline in the primary fuel source is currently attracting attention to develop other energy sources that are more sustainable and renewable. Biomass is expected to replace the energy source from fossil fuel in the future. Due to its readiness to obtain, the amount is considerable, and the higher heating value in biomass promises to replace fossil fuel. Furthermore, biomass is also known for its carbon neutrality. The combustion process still produces carbon dioxide pollutants, but this carbon dioxide will be re-consumed to generate energy through the photosynthesis process. Microalgae is a form of biomass that has the potential to produce oil suitable for biodiesel. But after the oil is extracted, a thermal conversion helps to separate the nutrients of the biomass simultaneously generating synthetic gas. This conversion process can be achieved through the supercritical water gasification (SCWG). By obtaining these two types of product, the SCWG can effectively and efficiently carry out the energy recovery from microalgae without a drying process.

Research on microalgae gasification under supercritical water conditions includes the study on yield of hydrogen, methane, and carbon dioxide gases—however, few report on recovered nutrients from microalgae biomass that can be reused for microalgae cultivation process. Microalgae fed in the SCWG reactor at a temperature of 600 ^{o}C and a pressure of 25 MPa in residence time of 7 – 60 s produce several products, including gas, liquid and solid. The gas generated is a mixture of combustible gases. At the same time, the liquid product contains a nutrient element of microalgae cells removed throughout the reaction process and dissolveed in water. In this study, we report the effect of residence time on the decomposition process of microalgae at a temperature of 600 ^{o}C and a pressure of 25 MPa. There are differences in the gas composition produced from microalgae gasification without oil and whole microalgae cells. Oil provides a more significant contribution to hydrogen supply because of glycerol compounds. The study on the kinetics of decomposition reaction was carried out based on the product yield. The model of decomposition reaction was developed, and the reaction rate constants were determined using the least square error (LSE) methods.

The nutrients that have been recovered during the gasification process are reutilized as nutrients in another microalgae cultivation process. The nutrient composition are nitrogen, phosphorus, and potassium similar to fertilizer. When 10% by volume of the SCWG effluents at a temperature of 400 ^{o}C and 600 ^{o}C were added, the microalgae growth with the medium with effluent of 600 ^{o}C was faster than that with the effluent of 400 ^{o}C. This finding can help to guide the optimization of the microalgae recycling process.