SUMMARY: For the synthesis of DME from woody biomass via gasification, we have developed and promoted the biomass-to-liquid (BTL) process. This process consisted of oxygen-enrichment gasification of woody biomass by a bench-scale fixed-bed gasifier, gas cleaning system, gas compression, desulfurization, removal of CO₂, catalytic DME synthesis reaction by a fixed-bed reactor. We succeeded in the continuous synthesis of DME from biomass derived gasification gas (CO+H₂) over 200 h and recovery of approximately 100 g of BioDME.


doi:10.1016/j.jorgchem.2021.05.016

INTRODUCTION
DME which synthesized from woody biomass(BioDME) can be regard as carbon-neutral fuel. So, the synthesis of DME from woody biomass via gasification is a promising method. We have been developed and promoted the bench-scale biomass-to-liquid (BTL) plant process for FT diesel synthesis. In this paper, we have adopted this BTL plant for producing BioDME.

EXPERIMENTAL
Our process consisted of oxygen enrichment gasification of woody biomass by a bench-scale fixed-bed gasifier, gas cleaning system, gas compression, desulfurization, removal of CO₂, DME synthesis reaction by a fixed-bed reactor. Eucalyptus wood chips (size: 20-30 mm) were used as the biomass feedstock.

In the gasification step, syngas must be effectively produced from woody biomass. In the present study, oxygen-enriched air gasification was carried out using a downdraft fixed-bed gasifier. Feeding rate of wood was 9 kg, and oxygen concentration in the oxygen-enriched air was 28vol% in this study. During the run, the temperatures of the combustion zone and reduction zone were 900-1000 ℃ and 800-850 ℃, respectively, and the product gas flow rate was approximately 18 Nm³/h[1].

In the DME synthesis step, DME was synthesized via methanol synthesis and following dehydration reaction in a fixed-bed reactor using the Cu-Zn catalyst for methanol synthesis and γ-Al₂O₃ catalyst for dehydration. Weight ratio of two catalysts was adjusted as (Cu/Zn)/γ-Al₂O₃ =1. Total amount of 500g catalyst was introduced in the reactor and reduced by H₂ diluted with N₂ (H₂/N₂=1, flow rate=250 ml/min) at 250 ℃ for 2h. DME synthesis reaction was carried out under following conditions. Reaction pressure: 0.98MPa, Reaction temperature: 210-250 ℃. The gas sample obtained at each sampling port was analyzed by GC-TCD and GC-FID. The H₂ and CO conversion and DME yield were calculated based on these results.

RESULTS & DISCUSSION
The analytical results of the feedstock are as below. C: 51.0 wt%, H: 6.0 wt%, N: 0.2 wt%, S: 0.015 wt%, O(diff.): 42.8 wt%. From the Proximate analysis, moisture content is 10.5%,volatile matter is 73.1%, and fixed carbon is 15.8% respectively. The composition obtained at gasification step was as follows: 25.6 vol% of H₂, 31.2 vol% of CO, 2.7 vol% of CH₄, 0.4 vol% of CO₂, 40.1 vol% of N₂, <5 ppb of H₂S, and <5 ppb of COS. DME synthesis reaction has been carried out using this gasification gas[2].

The results of DME production for long time is shown in Fig.1. DME concentration 6.2 vol% in the product gas was obtained under the following conditions: 0.98 MPa, 230℃, W/F=75.8 cat.-kg h/m³. It was possible to recover the almost all DME in the gas phase by using the activated carbon trap with dry ice. Finally, we succeeded in the continuous synthesis of DME over 200 h and recovery of approximately 100 g of liquefied BioDME.

Fig.1 Results of DME production for long time.

REFERENCES