CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The catalytic conversion of bio-ethanol over 0.5 wt% $MgHPO_4/\gamma$-Al_2O catalyst was conducted in an isothermal fixed bed reactor at the atmospheric pressure. The effects of reaction temperature and bio-ethanol concentration on the ethanol conversion and ethylene selectivity were studied. The reaction temperature was varied from 370 °C to 460 °C with different bio-ethanol concentration (40-50%, 95%, and 99.5% ethanol), whereas the liquid hourly space velocity (LHSV) was fixed at 1.0 h^{-1}. Furthermore, the pre-feasibility of the two commercial processes (Chematur and Petrobras) for ethylene production from bio-ethanol was studied.

The reaction temperatures significantly affected to the ethanol conversion and ethylene selectivity. Using 99.5% ethanol as a feed, the increase of reaction temperature (370 °C to 460 °C) tended to increase both the ethanol conversion and ethylene selectivity. Moreover, other by-products (methane, ethane, propylene, and carbon dioxide) significantly increased with increasing reaction temperature due to ethylene cracking ability and side reactions of ethanol dehydration that are promoted at a high temperature. Especially, the temperature of 460 °C gave a higher amount of by-product, leading to a decrease in ethylene selectivity. In addition, the increasing reaction temperature significantly increases the coke formation on the catalyst. The ethanol conversion was nearly 99% at the temperature of 460°C, and ethylene selectivity was as high as 93.5% at the temperature of 430 °C. However, the highest yield of ethylene (97.1% conversion and 93.5% ethylene selectivity) is obtained at temperature of 430 °C. The bio-ethanol concentration in the feed also affected to the ethanol conversion and ethylene selectivity. The ethanol conversion decreased with decreasing ethanol concentration. Especially, when the reaction temperatures were lower than 400 °C. This may be due to the competitive adsorption of water and ethanol on the active site of catalyst surface and the cooling of catalytic bed, leading to a lower ethanol conversion. However, the effect of water in the feed was

insignificant when the reaction temperatures were higher than 400 °C. The ethylene selectivity significantly increased with decreasing ethanol concentration in the temperature above 400 °C. At the reaction temperature of 460 °C, the ethylene selectivity was as high as 94.8%, when 40-50% ethanol was used as the feed. Moreover, other by-products (methane, ethane, propylene, and C_4-C_5) significantly decreased with decreasing ethanol concentration in the feed. Therefore, the operating conditions giving the highest yield of ethylene (97.6% ethanol conversion and 93.3% ethylene selectivity) were at the temperature of 460 °C, using 95% ethanol in the feed.

For the pre-feasibility study, the two commercial processes were investigated in terms of economic viability. Chematur process does not provide economic return on investment (no IRR value), which means that the Chematur process was not economically feasible, whereas Petrobras process gives 3.3% of internal rate of return. With the aim for 15% internal rate of return, the Petrobras process was therefore not economically feasible as well. Moreover, the sensitivity analysis was also performed to study the sensitive parameters to this project. Ethanol and ethylene prices are the sensitive parameters that affected to the economic feasibility of two commercial processes. However, both plants can be commercially feasible, provided that the ethanol and ethylene prices are 46.5% lower and 38% higher than the current price for Chematur, and 14.5% lower and 12% higher than the current price for Petrobras, respectively.

5.2 Recommendations

The catalyst shall further be studied with various liquid hourly space velocity (LHSV) in order to maximize the ethylene selectivity. Moreover, the catalytic stability shall be studied as well. For the pre-feasibility study, the integration of ethanol plant with ethylene plant shall be further studied in order to maximize the rate of return.