# CHAPTER V
# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The conversion of bio-ethanol was carried out over the silicoalumino-phosphate zeolite (SAPO-34) in the isothermal fixed bed reactor at atmospheric pressure. Effects of reaction temperature, liquid hourly space velocity, and time on stream were studied in this work. The temperature of the catalyst bed was varied in the range of 350 °C to 500 °C, the liquid hourly space velocity (LHSV) was varied in the range of 0.2 $h^{-1}$ to 1.0 $h^{-1}$, and the time on stream of 45 minutes to 180 minutes. Moreover, the pre-feasibility study for the bio-ethanol to light olefins plant was studied as well. The economic evaluation was subjected to the process modified from the existing plant (Chematur).

The reaction temperature had the influence on catalytic activity. At a fixed LHSV, the ethanol conversion tended to increase with the increase in reaction temperature (350 °C to 500 °C). The ethanol conversion at 0.5 $h^{-1}$ LHSV varied from 88.5% to 98.3% in this range of temperatures. With the increase in reaction temperature, the ethanol reactant can be easily converted to form the product, leading to a higher ethanol conversion at higher reaction temperature. Apart from that, reaction temperature also affected the selectivity of the products. At the fixed LHSV (0.5 $h^{-1}$), the selectivity of ethylene was the highest among that of the other products in this range of temperature. At the low reaction temperature (350 °C), the amount of ethylene product was the highest. The temperature of 400 °C was found to be the suitable temperature for the high production of propylene due to the conversion of ethylene to propylene. At temperatures higher than 400 °C, the selectivity to propylene decreased whereas the selectivity to $C_4$ products increased due to the further conversion to form heavier molecules. Moreover, the reaction temperature also affected the coke formation on the catalyst. The amount of coke increased with the increase of reaction temperature.

The LHSV had the influence on catalytic activity as well. At a fixed reaction temperature, the ethanol conversion tended to increase with the decrease in

LHSV. The ethanol conversion at 400 $^{o}$C temperature varied from 91.8% to 97.7% in this range of LHSV. Apart from that, LHSV also affected the selectivity of the products. At a high space velocity, the ethylene selectivity was very high. When the LHSV was decreased, ethylene can be further converted to propylene, leading to the increase of selectivity to propylene. However, at a too low LHSV, the selectivity to propylene turned to decrease but the $C_{4+}$ products selectivity increased. Moreover, the LHSV also affected the coke formation on the catalyst. The amount of coke increased with the decrease of LHSV. For the effect of reaction time, the conversion of ethanol and the selectivity of ethylene and propylene decreased with the time on stream whereas that of the $C_4 - C_6$ products increased due to coke formation on the catalyst.

For the pre-feasibility study, the economic variables were determined. Raw material price (accounted for 78.2% of total operating cost) is the most seneitive and important factor affecting the total operating cost. The revenues of bio-ethanol to light olefins plant are ethylene, propylene, and natural gas which are 434, 288, and 563 millions baht per year, respectively. Since the operating costs (1,599 millions baht per year) are higher than revenues (1,284 million baht per year), the net cash flow after tax then has a minus sign, leading to no value of internal rate of return (IRR); thus, the bio-ethanol to light olefins plant was not commercially viable in this case. Moreover, the sensitivity analysis was also studied. Ethanol price and the product prices are the sensitive parameters mainly affecting to the feasibility of this project.

## 5.2 Recommendations

For the further study, the SAPO-34 catalyst shall be modified with a metal in order to maximize the propylene yield that may make this project commercially feasible. Moreover, the effect of ethanol concentration and feed dilution shall be studied in order to maximize catalytic activity at all aspects as well.