

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

This research studied about cellulose conversion by gasification process. Freshly prepared metals which are Fe, Co and Co-Fe bimetallic are used as catalysts in gasification reaction. The effect of temperature, catalyst and gasifying agent were investigated in this study.

The use of catalyst transforms liquid products and tar into gas and modifies the final gas composition, increasing H<sub>2</sub> and CO yields and decreasing CH<sub>4</sub> and C<sub>2</sub> yields. Also, the use of catalyst leads to the decreasing in liquid yields and influences on the distribution of liquid components. An increase in temperature leads to an increase of gas fraction while solid and liquid fraction decrease. A significant influence of reaction atmosphere on gas product was observed when CO<sub>2</sub> gasification and steam gasification processes are compared. The participation of inverse water-gas shift reaction in CO<sub>2</sub> gasification and water-gas shift reaction in steam gasification influences the generation of higher CO yields in CO<sub>2</sub> gasification and higher H<sub>2</sub> yields in steam gasification. .

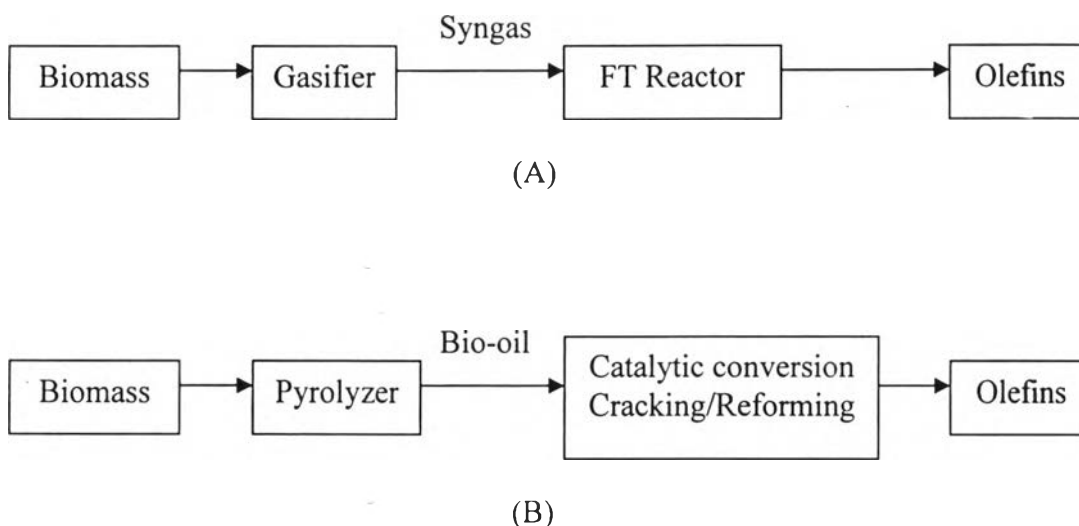
When consider ethylene as olefins representative, the olefins were found at low temperature gasification without catalyst. This indicates that the catalyst has no influence on olefins yields. Olefins maybe mainly produced from cellulose decomposition. However, under reactive atmosphere olefins will be converted into H<sub>2</sub> and CO by partial oxidation.

The liquid obtained from both of CO<sub>2</sub> gasification consists of many kind of products such as aliphatic and alicyclic compounds, oxygenated and nitrogenated compound, and alcohols.

Even though the amount of olefins from the gasification process in which one reactor is used is low, the amount of olefins can be boosted through the Fischer-Tropsch synthesis process in which the synthesis gas from the gasification process is converted into olefins.

In brief, there are two processes for conversion of biomass into olefins. The first one is olefins production from biomass gasification and Fischer-Tropsch

synthesis. Another one is olefins production from biomass pyrolysis and catalytic conversion. These two processes are shown in Figure 5.1.



**Figure 5.1** Possible routes of olefins production from biomass.

According to Process A, biomass needs to be converted into synthesis gas. Then, the synthesis gas will be fed to Fischer-Tropsch reactor and catalyst will be used to convert synthesis gas into olefins.

According to Process B, biomass needs to be converted into bio-oil. Then, the bio-oil will be fed to catalytic reactor in order to convert bio-oil to olefins.

Presently, Process A is in the interest of many concerned parties, and the feasibility study of this process has been conducted continually. The strength of this process is that there are a lot of researches done on the development of catalyst to increase the olefins selectivity. Additionally, the Fischer-Tropsch synthesis has been developed continually, and it now becomes a commercial process as evidenced by Sasol plant. Nevertheless, the existing hurdle of Process A is an emergence of tar in gasifier. Tar is condensable organic compounds, which is major problem in gasifier. Also, tar can erode and block any part of gasifier and pipe system. One way to solve this problem is to add catalyst in gasifier to accelerate tar reforming which will decrease tar amount, increase the amount of  $H_2$  and  $CO$ , and reduce gasifying temperature at the same time.

The strength of Process B is that bio-oil derived from pyrolyzer is easy for transportation. Also, the transportation cost of bio-oil is cheaper than the transportation cost of synthesis gas derived from gasifier. However, one weak point of this process is that the bio-oil to olefins conversion process is still at the very early stage and it needs a lot of development. This development requires a certain period of time for a preparation of suitable technology.

In general, these two processes share one common weak point, i.e. biomass. In fact, there is a variety of biomass that can be used in these processes, for example, plant, organic waste or sludge. A general characteristic of biomass is bulky material and has low density. This characteristic results in a limitation of the transportation of biomass per trip and accordingly increases the transportation cost. Therefore, it is advisable to be selective of biomass to be used in these processes. In this regard, the biomass consisting of low lignin is highly recommended in order to minimise tar amount arising in the gasifier or pyrolyzer given that lignin is the cause of tar. Also, it is advised to use biomass with high density. To follow this advice, perhaps the biomass may have to be sorted or downsized in order to increase its density and facilitate the transportation activity. As a result, it may be wise to establish an on-site plant at the place of biomass to save transportation cost.

Based on the above results, it seems that the olefins production from Process A is more feasible thanks to technology availability and continuous development. However, Process B is possible when it is developed and optimized with suitable process condition, catalyst, and reactor.