CHAPTER I
INTRODUCTION

High level development in human society is the cause of the increasing in energy consumption. Therefore, all scientists need to find new energy sources and to optimize the conventional energy. The new potential energy sources are nuclear energy, wind energy, solar energy and geothermal energy, while the conventional energy sources contain fossil fuels and nuclear energy. In the future, petroleum reservoirs seem to be insufficient. Natural gas can be utilized as a primary energy source (Basile *et al.*, 2001). Methane is the major component of natural gas and chemical utilization of methane for producing synthesis gas becomes very important (Rostrup-Nielsen, 1984 and Lee, 1997). Synthesis gas is the gas mixture containing hydrogen and carbon monoxide.

Recently, synthesis gas or hydrogen production has received much attention as a fuel for fuel cell applications, combustion engines, or gas turbines with the goal to achieve a more efficient utilization of energy sources. Hydrogen is considered as a clean energy which has small impact on the environment especially in terms of without carbon emissions and minimal other pollutant gases. Generally, hydrogen production can be used in chemical industries such as ammonia synthesis, methanol production. Hydrogen is used in various processes of petroleum refinery such as hydrodesulfurization, hydrogenation, hydrocracking, and heavy residue hydroconversion. In addition, hydrogen is used in steel industry for annealing of steel, in electronic industry for production of devices, and a large quantity in the food processing industry.

Hydrogen production can be produced from methane by other three possible processes beyond steam reforming of methane (SMR), which are carbon dioxide reforming, partial oxidation, and autothermal reforming.

Carbon dioxide reforming

An alternative technique for producing synthesis gas with the desired H_2/CO ratio is the carbon dioxide reforming of methane or dry reforming of methane. This reaction was first proposed by Fischer-Tropsch in 1928.

$$CH_4 + CO_2 \leftrightarrow 2CO + 2H_2 \qquad (\Delta H^\circ_{298} = +247 \text{ kJ/mol}) \qquad (1.1)$$

This process has also received attention from a viewpoint of environmental protection because the emission of CH_4 and CO_2 in the atmosphere brought about global warming by the greenhouse effect and these harmful gases can simultaneously be converted to useful synthesis gas (Hayakawa *et al.*, 1999). However, the catalyst for carbon dioxide reforming is not commercially available. The main reason is the formation of carbon, which rapidly deactivates catalysts.

Partial oxidation

Catalytic partial oxidation is another process for deriving hydrogen production.

$$CH_4 + 0.5O_2 \rightarrow CO + 2H_2 \qquad (\Delta H^\circ_{298} = -36 \text{ kJ/mol}) \qquad (1.2)$$

This reaction is a mildly exothermic reaction and hence, unlike the steam reforming of methane, it is not energy intensive process. In this process occurs the combustion of methane, which is highly exothermic, resulting in a large increase in reaction temperature. Because it is difficult to remove this heat from reactor causes the process becomes very difficult to control.

Autothermal reforming

An autothermal system is a combination of partial oxidation and steam reforming into one process.

Hydrogen can be also produced from pyrolysis, gasification, electrolysis of water, photoelectrolysis and biomass gasification. These methods are not widely used because they are more expensive than steam reforming of natural gas (Satterfield, 1991).

Nowadays, the dominant commercial process for producing hydrogen is the steam reforming. The feed stocks for steam reforming are low-boiling saturated hydrocarbons including natural gas, refinery gas, liquefied petroleum gas (LPG), and low-boiling naphtha. From these feed stocks, methane is commonly used as the feed stock for steam reforming. The background and literature surveys on steam reforming of methane and steam reforming catalyst will be described in Chapter 2.

The objective of this work is to develop on effective catalyst using Ni supported on KL zeolite catalyst for the steam reforming of methane. The catalysts were also characterized in order to understand the relationship between the structure of the catalyst and its performance.