

## CHAPTER I

### INTRODUCTION

In present, hydrogen ( $H_2$ ) becomes the majority role in the future alternative fuel, which is known as an environmental friendly with less impact of greenhouse emission. When compared to fossil fuels, hydrogen can be produced from different feed stock fuels. It can be used as the fuel for direct combustion in an internal combustion engine or as the fuel for a fuel cell. In addition, this clean processing has high efficiency of energy transformation compared to other conventional combustion processes. Nonetheless, the efficiency level of fuel cell strongly depends on the types of fuel cell selection.

Fuel cell–device that use hydrogen (or hydrogen-rich fuel) and oxygen to generate an electricity–is widely used as the green technology which emits only heat and water without pollutants concerning. Among the types of fuel cell selection, the proton exchange membrane fuel cells (PEMFCs) is considered to be beneficial for transportation and mobile applications. However, being still the topic of hydrogen, its storage and handling under high-pressure or cryogenic conditions must be solved. As mentioned above, methanol ( $CH_3OH$ ) seems to be the suitable candidate fuel for hydrogen production due to its abundant advantages, such as easily storing, being in a liquid phase at room temperature during transportation, low cost, high energy density liquid fuels, no sulfur containing, high H/C ratio, and no carbon-carbon bond which can reduce the soot formation.

Hydrogen production via methanol can be produced through various pathways; Methanol Decomposition (DCM), Water Gas Shift (WGS), Steam Reforming (SRM), Partial Oxidation (POM), and Oxidative Steam Reforming of Methanol (OSRM). In this work, OSRM was chosen to be an alternative reaction which combines the SRM and POM together. SRM is an endothermic reaction so the transient operation is difficult due to the required energy input. POM is highly exothermic (high difficulty to control the temperature) and higher reaction rate but the reaction has half the hydrogen selectivity compared with steam reforming. The OSRM can be operated under slightly exothermic condition-with lower operating temperature where its advantages of energy saving, fast startup (can control reactor

temperature), quick response of the overall reaction when operated under adiabatic condition, and protect the catalyst deactivation better than SRM and POM. However, OSRM produces appreciable amounts of CO as by-product in addition to lower suitable value hydrogen content in product stream. It was also noted that the OSRM activity in the low temperature range strongly depends on the types of catalyst selection.

In this case, gold (Au) catalysts was chosen because of its performance in various reactions. It shows interesting performance in selective reaction when compared with other noble metals. Gold has been regarded as a potentially useful catalyst when it is highly dispersed on a suitable support for various industrial and environmental applications. The major factors influence the gold catalytic activity: the size of gold nanoparticle, preparation methods, pretreatment condition, and choice of support. For ceria ( $\text{CeO}_2$ ) support, it was reported that it can increase Au dispersion and the thermal stability of the catalysts and even to reduce CO concentration. Another interesting support, Zirconia ( $\text{ZrO}_2$ ) was also reported that it can increase Au dispersion and prevent the sintering of Au due to its amorphous phase in catalyst. Moreover,  $\text{ZrO}_2$  could increase the amount of  $\text{Au}^+$ , resulting in improving the activity and stability of the catalysts (Grau-Crespo *et al.*, 2007).

The objective of this research is to study the OSRM activity over  $\text{Au/CeO}_2\text{-ZrO}_2$  catalysts. The main parameters considered were the support composition (atomic ratio of  $\text{Ce}/(\text{Ce}+\text{Zr})$ ), calcination temperature, gas pretreatment,  $\text{O}_2/\text{CH}_3\text{OH}$  molar ratio,  $\text{H}_2\text{O}/\text{CH}_3\text{OH}$  molar ratio as the function of reaction temperature. The catalysts were prepared by deposition-precipitation and characterized by X-ray Fluorescence Spectroscopy (XRF), X-ray Diffraction (XRD), Temperature-Programmed Reduction (TPR), Temperature-Programmed Oxidation (TPO), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), UV-Visible Spectrophotometer, BET Surface Area Measurement, and Fourier Transform Infrared Spectroscopy (FT-IR).