CHAPTER I
INTRODUCTION

Hydrogen is considered to be one of the most alternative energy due to it is a renewable energy, clean fuel, non-polluting (no green house gas effect), less fossil fuel consumption, and variety production sources such as splitting water, biomass, solar energy, and so on (Faungnawakij *et al.,* 2006). Moreover, hydrogen has the potential to run a fuel-cell engine with greater efficiency over an internal combustion engine that can be stored as a liquid state or gas state, which is distributed via pipelines, and has been described as a long term replacement for crude oil and natural gas (Shishido *et al.,* 2007).

In the on-board storage of hydrogen for fuel-cell engines in transportation applications, PEM fuel cell can be used for vehicles. However, the hydrogen storage has some problems associated with safety, and handling of hydrogen. Methanol has been identified as a highly suitable liquid fuel due to its self handling, low cost, high energy density liquid fuels, high hydrogen–carbon ratio, and no absence of carbon-carbon bond (less coke formation). In addition, it has good availability, low boiling point, no sulfur containing in the fuel, and easy to storage (Patel *et al.,* 2007).

Normally, a hydrogen-rich gas can be produced from methanol by several methods; steam reforming (SRM), partial oxidation (POM), and oxidative steam reforming (OSRM) or autothermal reforming (ATR) (Honga *et al.,* 2008). In this case, OSRM was chosen to be the promising way which combines two reactions: SRM and POM reactions. This operation closes to thermal neutrality or under slightly exothermic condition. This reaction requires lower temperature, resulting in energy saving, fast startup, and quick response of the overall reaction for operating under adiabatic condition (Turco *et al.,* 2007). However, OSRM process produces CO as a by-product in large amounts, which poisons the Pt anodes of PEM fuel cells, and also suppresses

the fuel cell performance (Pinzari *et al.*, 2006). To improve the performance of this reaction, the catalysts should be highly active in terms of high methanol conversion and high hydrogen selectivity (suppression of CO formation).

Gold (Au) catalysts are attractive catalysts because they are highly active and selective for a number of reactions (water-gas shift reaction, selective oxidation of CO in hydrogen-rich stream, and etc.). Compared with the existing commercial catalysts (Copper (Cu) and Palladium (Pd)), Au catalysts can operate at lower temperature (Haruta *et al.*, 2001). In addition, ceria (CeO_2) support is known to improve the stability of catalysts due to its ability to maintain a high dispersion and to change its oxidation state of the cation between Ce^{3+} and Ce^{4+} (redox condition) as an active site (Tabakova *et al.*, 2011). For another interesting support, iron oxide (Fe_2O_3) is also an attractive support because an interaction between Au and Fe_2O_3 could lead to the formation of an active phase at the interface of the catalyst (Makkee *et al.*, 2005). Nevertheless, the performance of Au catalysts is strongly affected not only from the type of support used, but also from the preparation method including pretreatment conditions (Haruta *et al.*, 2001).

The objective of this research is to study the OSRM over $Au/CeO_2-Fe_2O_3$ catalysts. The reaction parameters such as support composition (atomic ratio) of Ce/(Ce+Fe), calcination temperature, Au content, gas pretreatment, steam/methanol molar ratio, O_2/methanol molar ratio, and reaction temperature were studied. The catalysts were prepared by deposition-precipitation method and characterized by X-ray diffraction (XRD), Temperature-Programmed Reduction (TPR), Temperature-Programmed Oxidation (TPO), Transmission Electron Microscopy (TEM), Fourier Transform Infrared Spectroscopy (FT-IR), UV-Visible Spectrophotometer, X-ray fluorescence (XRF), and BET Surface Area Measurement.