CHAPTER I
INTRODUCTION

Currently, the earth has been rapidly expanded in the industry section including extremely high rates of the population growth resulting in the limited energy resources will eventually run out. In addition, green house gas emissions (CH_4, CO_2, etc.) have been widely interested to protect and control which affect to the average global temperature issue on the rise. Consequently, the novel alternative energy resources become the most popular technology to investigate and develop. Hydrogen is the most promising fuel for a clean alternative process. Hydrogen cannot be used for the vehicle applications without the fuel cells. The fuel cell is an electrochemical device that directly converts a fuel's energy (H_2) to electrical energy without harmful emissions since water is the only by-product from the fuel cell stack reaction. There are many fuel cell types, however, the proton exchange membrane fuel cell (PEMFC) is now considered as the most suitable process for the automotive applications, which offers high efficiency, high power density; operated at relatively low temperatures (60°-120°C) and potentially in power electric vehicles. However, the hydrogen can be generated from various raw materials, such as methane or natural gas, methanol, ethanol and liquid hydrocarbon by using the H_2 production processes called the fuel processor. Many types of fuel processing systems were developed by several researchers to produce pure hydrogen fast enough to supply to PEMFC operation by passing through auxiliary units. The auxiliary units were integrated into the H_2 production unit (Reformer) to effectively remove CO from the H_2 fuel and to minimize H_2 loss in the H_2-rich stream. The preferential CO oxidation reaction seems to be the most practical process for automotive applications. The majority of researchers have mainly focused on the improvement of a high performance catalyst for this process. From our previous results (Naknam *et al.*, 2007), the presence of Au in a Pt/A zeolite catalyst can slightly improve the catalytic activities. Moreover, the addition of a multi-staged PROX system offers better CO conversion and CO selectivity. The method is considered as an alternative one to improve the performance of the preferential CO oxidation process (Ahluwalia *et al.*, 2005; Srinivas and Gulari, 2006; Seo *et al.*, 2006).

In this present work, we have attempted to optimize the overall operating conditions in the double-stage process for the preferential CO oxidation unit to effectively remove CO from the H_2 fuel and to minimize H_2 loss in the simulated reformate stream by using a AuPt/A zeolite as a catalyst. The purpose of this section is to present the results of the double-stage reactor in the PROX unit for applying directly to on-board fuel processor applications.

Consequently, the catalysts for the preferential catalytic oxidation of CO in the presence of H_2 by using the Au supported on ZnO have been developed. The catalytic activities are presented in the terms of CO conversion, CO selectivity and O_2 conversion as a function of temperature, to find a catalyst able to completely convert CO to CO_2 at a relatively low temperature range, which is suitable directly connected to the on-board fuel processor. The deposition-precipitation method was used to prepare the catalysts. The results of the characterization by X-ray diffraction (XRD), and transmission electron microscopy (TEM) are presented. Otherwise, the photodeposition precipitation technique was applied to prepare Au/ZnO and Au/ZnO-Fe_2O_3 catalysts in order to find a new route to deposit nano-sized Au particles onto the catalyst support. The advantages of the photodeposition over the deposition-precipitation, for examples, the higher amount of Au is loaded and the heat treatment is not necessary because $Au(OH)^-_4$ is reduced by UV irradiation (Chang *et al.*, 2008). As well known, the catalytic activities of Au catalysts depend on the particle size of Au, the preparation method, and the type of support, etc. Many parameters were considered for the photodeposition-precipitation technique such as power of light source, irradiation time, and precipitation agent.

As a final point, the integrated fuel processing system was conducted to observe the catalytic activities in the real reformate. The most excellent prepared catalyst and operating condition in the double-stage reactor were applied to the fuel processor. This system consists of the hydrogen production unit and the CO removal unit which are the methanol steam reformer and the double-stage PROX reactor, respectively. Not only the process performance was monitored but also the optimization of the hydrogen production rate and the CO removal behaviors were investigated.