CHAPTER I
INTRODUCTION

Since the beginning of the 20th century, the fossil fuels, especially oil, have been used to generate electricity and to drive vehicles. It is not an over speaking to say that the human civilization has been driven by the oil. By now, the beginning of the 21st century, the results of an intensive usage of oil start to show up in environmental problems, such as, global warming, air pollution, acid rain etc. In addition to those environmental problems, the energy crises still reflect the dependences of the world on the fossil fuels. Moreover, it will certainly deplete sometime in the near future. Based on current annual consumption rate, the worldwide petroleum reservoir will run out in 39 years (Song, 2002). Therefore, the development of sustainable energy becomes an important issue. Fuel cell is a good candidate for solving those problems. It may help the world to decrease dependency on the fossil fuels. Moreover, because of the fuel cell's relatively low emission, the fuel cell may result in improvement of the air quality (Table 1.1).

Table 1.1 Energy consumption and emissions of carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO) and volatile organic compounds (VOC) from passenger cars with different propulsion systems; energy and emission per 100 km driving distance (Pettersson and Westerholm, 2001)

Propulsion system	Energy	CO_2 (kg)	NO_2 (g)	SO_2 (g)	CO (g)	VOC (g)
Gasoline engine	79	20	52	8	180	130
Diesel engine	64	17	89	19	83	21
Electric motor PEMFC using methanol	34	7	3	1	1	2

Fuel cell is an electrochemical base energy converter, to directly convert fuel into electricity. Fuel cells can be roughly divided into 5 types according to the electrolyte or electrode employed, except the direct methanol fuel cell (Carrette *et* *al.*, 2001). Fuel cell has been used in different applications, such as, propulsion of vehicles, stationary power station, portable electric device, due to their different characteristics. For the propulsion system of vehicles, the proton exchange membrane fuel cell (PEMFC) was found to be ideally suitable due to its high power density, compactness, light weight, relatively low emission, extreme quietness, transient respond, quick start up and low operating temperatures (Bernay *et al.*, 2002, Song, 2002). Actually, there are a number of displayed prototype of the fuel cell cars from almost every car maker company (McNicol *et al.*, 2001). However, the fuel cell car is still not commercially available because of many obstacles.

The PEMFC requires pure H_2 as fuel, and it is not practical to store efficient amount of H_2 on-board. Moreover, storing H_2 not only needs a lot of safety constraint but also have refilling problems. Therefore, the on-board H_2 generator from liquid hydrocarbon or alcohol, reformer, was used to produce H_2-rich stream (H_2 and CO mixture), and syngas. Unfortunately, the PEMFC is very sensitive to CO, only trace amounts of CO can severely depress the performance of the PEMFC, as shown in Figure 1.1.

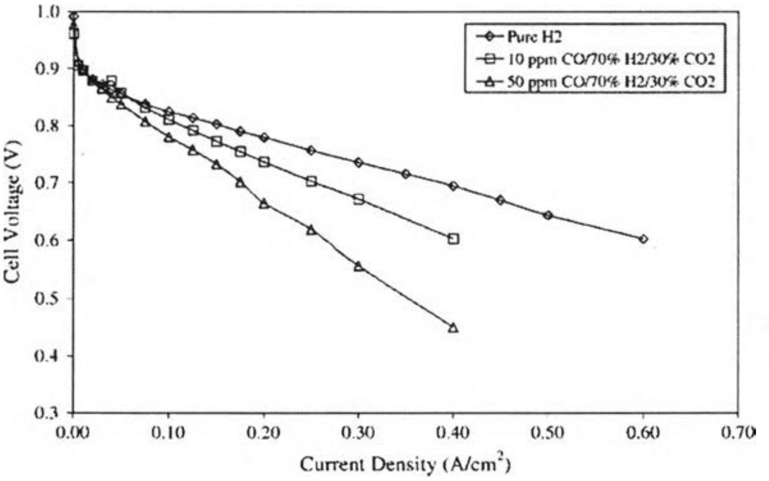

Figure 1.1 The performance of an MEA when the anode fuel was H_2, 10 ppm CO/70% H_2/30% CO_2 and 50 ppm CO/70% H_2/30% CO_2, respectively: Anode, Pt-Ru = 0.6 mg/cm^2; cathode, Pt = 1.7 mg/cm^2; Nafion 1136 membrane (Qi, He, and Kaufman, 2002).

Thus, CO in the reformate stream needs to be removed before entering the PEMFC. In order to remove CO, the water gas shift and preferential oxidation of CO (PROX) or selective CO oxidation were used in series. In the shift unit, the water gas shift reaction (WGSR) was used to reduce CO content to about 1%. Then, the selective oxidation reaction was used for deep CO cleaning in the PROX; the coming out stream should have CO less than 20 ppm. (Dudfield *et al.*, 2001)

The catalyst for PROX needs to be active and highly selective. The catalysts are supposed to oxidize 0.5-1.0% CO to less than 20 ppm without a large consumption of H_2. Several catalysts have been studied, including Pt or promoted Pt, Ru, Pd, alloys of Pt-Sn or Pt-Ru, or Rh on alumina or on molecular sieves, or more recently, Au catalyst (Ghenciu, 2002). Among these catalysts, the Pt catalyst seems to offer the most appropriate catalytic activity for this reaction. However, there are still rooms for an improvement; the Pt catalyst requires multi-stage reactor to achieve the desired CO concentration. Therefore, the state-of-art formula of catalyst needs further improvement to maximize the CO conversion as well as to minimize the H_2 loss.