CHAPTER I

INTRODUCTION

1.1 Introduction

Hydrogen, being a cleaning source of energy, is predicted to be the fuel of the future. The current hydrogen industry is not focused on the production or use of hydrogen as an energy carrier or a fuel for energy generation [1]. Rather, the nine million tons of hydrogen gas produced each year are used mainly for chemicals, petroleum refining, metals, and electronic. Although hydrogen gas is the most abundant element in the universe, it does not naturally exist in its elemental form on the earth. It must be produced from other compounds like water, biomass, or fossil fuels. Several researchers have been paid much attention on the utilization of fossil fuel reforming. Currently, the dominant method of hydrogen produce is the catalytic reforming of methane with steam. In industry, the reaction is carried out at high temperatures (800-830°C) and high pressures (20-40 bar) to obtain high yields of the production. The uses of hydrogen are numerous and varied. As a pure product, hydrogen has many uses, such as in refinery processes, ammonia synthesis, hydrogenation, and fuel cells. As a mixture with CO, hydrogen also has extensive uses, such as in methanol synthesis, hydroformylation, and long-chain hydrocarbon synthesis via Fischer-Tropsch reaction.

In recent years, the reforming of methane with carbon dioxide has attracted great attention as an alternative method for hydrogen production since this reaction utilizes an environmentally problematic greenhouse gas carbon dioxide [2].

$$CH_{4(g)} + CO_{2(g)} \rightleftharpoons 2H_{2(g)} + 2CO_{(g)} \qquad 1.1$$

$$\Delta H_f^0 = 247 kJ/mol$$

However, the methane reforming reactions are energy extensive, because they are endothermic in nature and must be carried out at high temperatures to obtain high conversions (high yield of hydrogen). Another way to achieve high hydrogen yield is to carry out the reactions in a separation membrane reactor. Membrane reactors are advanced chemical reactors in which reaction and separation can be carried out simultaneously. Concurrent and selective removal of the product hydrogen from the reforming reaction can enhance the yield of hydrogen by providing a continuous thermodynamic driving force for the reactions.

It has been known that palladium membrane is the most common material for hydrogen separation. Therefore, the palladium membrane reactor is possible to be used for improving the methane and carbon dioxide conversion of dry reforming reaction. However, the limitation of palladium membrane is the operation temperature. At temperature lower than 300°C, the palladium membrane was destroyed by hydrogen embrittlement. On the other hand at high operation temperature especially higher than 450°C, if the palladium is supported on the stainless steel, the hydrogen permeation flux will decline because of intermetallic diffusion. Therefore, it is necessary to have the barrier of metallic diffusion from stainless steel to the palladium layer. Most materials used as a barrier were metal oxides such as alumina, magnesia, zirconia or tungsten [3]. Unfortunately the method for preparing of metal oxide like aluminum, zirconia mostly is sol-gel technique. It is difficult for coating the metal oxide on the stainless steel surface. Therefore, the electroplating and electroless plating were interesting for this study.

1.2 Objective

The aim of this study is to improve the methane conversion of dry reforming by using the dense palladium membrane supported on porous stainless steel.

1.3 Scope of research

1 To study and prepare the palladium membrane by electroless plating technique.

2 To identify the proper material for using as an intermetallic diffusion barrier for palladium membrane.

3 To apply the palladium membrane tube reactor for improving the methane conversion in dry reforming reaction.