CHAPTER I
INTRODUCTION

Global warming is a severe problem caused by human activities, particularly burning of fossil and petroleum fuels. The toxic byproducts generated from petroleum fuels, such as carbon dioxide (CO_2)., are released and stay as pollution in the environment. Currently, the amount of petroleum fuel is short whereas the consumption increases every day. Many researchers have searched for useful and less toxic alternative energy sources. Solar, water, wind, and biomass, etc., are used instead of the petroleum fuel and coal. Fuel cell is one of the efficient alternative energy sources. A fuel cell is an electrochemical device that continuously converts the chemical energy from a fuel into electricity and heat (Bozbag *et al.*, 2012). Moreover, fuel cell is clean and less toxic as an energy source, the byproduct from the reaction is only water vapor (Vielstich *et al.*, 2003).

Direct methanol fuel cell (DMFC) is a promising power source for mobile and portable device applications due to its high energy density, low pollutant emission, quick refueling time, simple system design, and rich fuel sources (Zhang *et al.*, 2011). To obtain a good membrane for the direct methanol fuel cell, the membrane should has the required properties, such as high proton conductivity which is the most important, good mechanical, and chemical stabililities under the operating temperature. The membrane should be able to resist swelling, have a good interface with the catalyst layer, have a low methanol crossover, and relatively low cost compared to the commercial membranes (Fu *et al.*, 2008).

Figure 1.1 shows the schematic drawing of direct methanol fuel cell (DMFC). Methanol is oxidized at anode on a catalyst layer usually containing platinum to form carbon dioxide and generates electrons which transport from the anode to the cathode through an external circuit to supply power to external devices, while the protons passes through the membrane. Water is actually consumed at the anode in the reaction with methanol that produces carbon dioxide and a set of positive hydrogen ions and electrons. At the cathode, oxygen from the air combines with the positive ions and electrons to form water molecules. The reaction of DMFC is shown according to the follow equation (Uctug *et al.*, 2011)

Oxidation: $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$

Reduction: $\frac{3}{2}O_2 + 6H^+ + 6e^- \rightarrow 3H_2O$

Overall reaction: $CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$

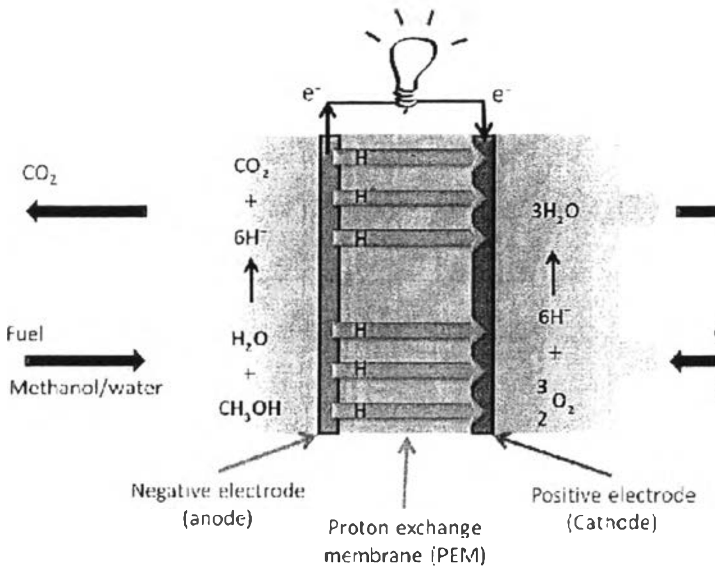

Figure 1.1 Schematic drawing of direct methanol fuel cell (DMFC) (From http://www.dti.dk/services/31150).

Nafion, produced by Dupont, is commonly used as the proton exchange membrane (PEM) in DMFC owing to its excellent chemical and mechanical stabilities, and high proton conductivity. However, the high cost, high methanol permeability, and low conductivity at low humidity or high temperature operating conditions have limited its commercialization in DMFC (Ko *et al.*, 2012).

Recently, nanocomposite proton exchange membranes based on Nafion and sulfonic acid functionalized zeolite beta (AFB) as an additive. Methanol permeability reductions and selectivity improvements were achieved by the addition of AFB nanocrystals in the composite membranes (Holmberg *et al.*, 2008).

Composite membranes can be made by using zeolites as fillers and a polymeric matrix as a host. If the zeolites are well dispersed in the matrix, they can serve as extra route for proton transport in the membrane in addition to the already existing water channels. This leads to increase of the membrane conductivity and at the same time, the tortuous pathway created by the zeolites can decrease the methanol crossover (Yildirim *et al.*, 2009).

In this work, sulfonated poly(2,6-dimethyl-1,4-phenylene oxide) (SPPO) membranes were prepared with various degrees of sulfonation. Afterward, the SPPO was prepared composite membrane via incorporation zeolite Y. The composite membranes were obtained by solvent casting. The properties of the pristine and composite membrane were characterized by Fourier transform infrared (FTIR), and Thermogravimetry analysis (TGA). Furthermore, the degree of sulfonation, ion exchange capacity, and zeolite Y concentration was systematically varied to tailor the proton exchange membrane (PEM) properties (proton conductivity, methanol permeability, membrane selectivity) and were compared to a Nafion 117 membrane.