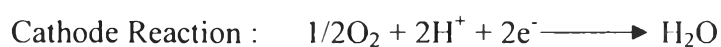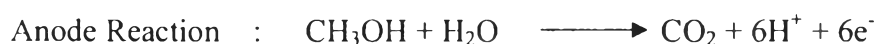# CHAPTER I
INTRODUCTION

Fuel cells are alternative energy sources which replace the traditional fossil energy of the future. The most important reasons are: fuel cells are environmental friendly, and they are available in a wide size range, from a portable electronic device to an electric vehicle. There are many types of fuel cell such as the solid oxide fuel cell (SOFC), the molten carbonate fuel cell (MCFC), the alkaline fuel cell (AFC), the polymer electrolyte membrane fuel cell (PEMFC), the microbial fuel cell (MFC), and etc. One of the most popular PEMFC is the direct methanol fuel cell (DMFC) because of its high energy efficiency and the operating system is of the simplest design. The polymer electrolyte membrane is required which has the following properties: high proton conductivity, chemical and thermal stabilities, mechanical property, and low cost.

DMFC consists of an anode where methanol is fed, which is catalyzed to proton and electron; and another one is a cathode in which oxygen (usually air) is fed, which combine with a proton that passes through the polymer membrane from the anode and an electron which passes through an external circuit that generate electric power to a connected device (Andújar *et al.*, 2009). The reactions are shown by the following reactions:

Anode Reaction : $CH_3OH + H_2O \longrightarrow CO_2 + 6H^+ + 6e^-$

Cathode Reaction : $1/2O_2 + 2H^+ + 2e^- \longrightarrow H_2O$

Cell Reaction : $2CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$

The main problems of DMFC are: 1) the crossover of methanol over the membrane from the anode to the cathode which leads to the poisoning of the catalyst (reduce electrical efficiency (Kirubakaran *et al.*, 2009) of fuel cell); and 2) the drying of the polymer electrolyte at high temperature, resulting in the loss of proton conductivity from the evaporation of water. Furthermore, an electrolyte membrane may degrade at a higher temperature if the polymer has a low degradation temperature. The degradation problem has been worked out by some researchers, however a new problem occurs in the film casting step as polymers cannot dissolve in common organic solvents.

Several techniques have been developed to solve these problems such as blending with other polymers, loading some particles into the membrane, and etc. Some of the most common methods for dealing with these problems are to modify the polymer structure which is used as the electrolyte membrane. Several monomers and polymers have been selected to be modified and synthesized with different functional groups containing in the main chains and/or existing at pendant groups. Aromatic polymers have already been well-known for high temperature stability. Polyimide has been commercially available possessing good mechanical, thermal, and oxidative stabilities (Sung *et al.*, 2010). A problem occurs in the processing, namely the insolubility (Kausar *et al.*, 2010) in common organic solvents due to the rigidity of backbone, the strong hydrogen bonding in aromatic polyimide, and the charge transfer complex formation in aromatic polyimide (Cheng *et al.*, 2004). One way to improve solubility of the polymer membrane is introduce a sulfonated group to the polymer structure; a sulfonated group not only improves solubility but also increases proton conductivity because increasing the number of sulfonated groups increases the proton hopping area (Peighambardoust *et al.*, 2010).

The objective of this research is synthesize and characterize a sulfonated poly(aromatic imide-*co*-aliphatic imide) (S-coPI) membrane which contains a flexible backbone structure, and to study proton conductivity, thermal, mechanical properties, and methanol permeability of S-coPI caste films.