

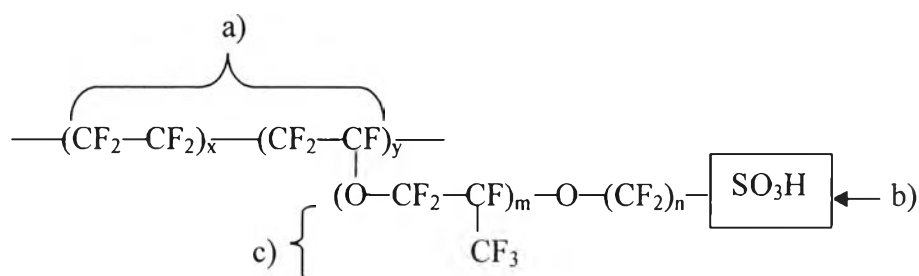


## CHAPTER I INTRODUCTION

Over the past decade, the tendency to find alternative of electricity and energy resources to satisfy the world's demand have led to the various aspects of researches and technology development. Fuel cells are expected for a practical power generation and may help to reduce our dependence on fossil fuels. Using pure hydrogen, fuel cells are electrochemical devices to convert the chemical energy of a reaction directly into electrical, heat energy and water, thus diminishing poisonous emissions into the atmosphere. Automobiles, powered by internal combustion engines, are significant producers of harmful gaseous emissions. If fuel cells are to replace the internal combustion engine, fuel cells that will drive vehicles must be able to reach operating temperature rapidly, provide competitive fuel economy and give a responsive performance. Fuel cells offer efficiency of up to 60% compared to the 25% achieved by internal combustion engines (Honda FCX 2004, *press information*). Fuel cells are classified primarily by the kind of electrolyte they employ which are alkaline (AFC), polymer electrolyte membrane (PEMFC), direct methanol (DMFC), solid acid (SAFC), phosphoric acid (PAFC), Molten carbonate (MCFC), and solid oxide (SOFC); however, PEM fuel cells are best placed to meet those requirements. With low operating temperature  $< 80\text{ }^{\circ}\text{C}$ , PEM fuel cells reach operating temperature quickly. PEM fuel cells also have the highest power density from the current fuel cell range; a crucial factor when space maximization is such an important consideration in vehicle designs.

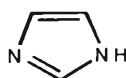
PEMFC consists of two electrodes and a solid polymer membrane that acts as an electrolyte. In general, PEMFCs require humidified gases, hydrogen and oxygen (or air) as a fuel for their operation. Hydrogen-powered fuel cells have a high power density and are relatively efficient in their conversion of chemical energy to electrical one. Thus, transportation uses in spacecrafts, submarines and fuel cell electric vehicles (FCEV), are on attractive and effective application because of high-energy efficiencies with compact size and effective solution to the coming petroleum shortage (Carrette *et al*, 2001).

The major problems for the commercial use of FCEV are expensive materials and low performance at high temperature (over 100 °C) as well as the difficulty in controlling humidity. The performance of fuel cell is also affected by the membrane. In previous, to solve these problems, a polystyrene sulfonate (PSS) was demonstrated as a membrane for low-temperature fuel cells using in space shuttle (operating temperature; 85-105 °C) (Wright, 1998).



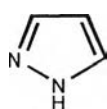
**Figure 1.1** Nafion<sup>®</sup> with three different functional polymers, a) hydrophobic PTFE backbone, b) hydrophilic ionic zone, and c) intermediate region.

Nafion<sup>®</sup> (see Figure 1.1) is another successful PEM fuel cell membrane which is a poly-tetrafluoroethylene (PTFE) based structure with high stability to the reduction and oxidation in most environments. Although, the conductivity of Nafion<sup>®</sup> reaches as high as  $10^{-2} \text{ scm}^{-1}$  in its fully hydrated state, the conductivity decreases at temperature above the boiling temperature of water according to the loss of absorbed water in the membranes (Wakizoe *et al.*, 1995). Consequently, the development of new solid polymer electrolytes, which are good proton transport properties and water uptake above 100 °C, has become one of the most important areas for research in PEMFC.



**Figure 1.2** Imidazole molecule.

Heterocyclic aromatic compounds such as imidazole (see Figure 1.2) have been known as strong proton acceptors forming protonic charge carriers. Their protonated and unprotonated nitrogen sides may act as donors and acceptors in proton transfer process. For examples, Kreuer *et al.* (1998) introduced imidazole or pyrazole as a proton carrier and showed that conductivity was remarkably changed with a change in composition in the systems of imidazole or pyrazole and H<sub>2</sub>SO<sub>4</sub> (see Figure 1.3).



**Figure 1.3** Pyrazole molecule.

The approach is to accelerate proton conduction under an anhydrous condition using protic amphoteric materials with large self-dissociation ability as a proton conductor (Kreuer, 1997; Kreuer *et al.*, 1998). The work hinted a novel approach and attracted significant attention among the scientists. Proton conducting polymer electrolytes based on P-4vinylimidazole (P-4VI) and H<sub>3</sub>PO<sub>4</sub> have been reported by Bozkurt *et al.* (2001). Pu *et al.* (2001) indicated that the conductivity of H<sub>3</sub>PO<sub>4</sub> blended P4VI was lower than that of H<sub>2</sub>SO<sub>4</sub> blended P4VI at the acid concentrations they studied. Furthermore, Bozkurt *et al.* (2003) have prepared anhydrous proton conducting polymer electrolytes by entrapping imidazole in polyacrylic acid. The transparent films obtained are thermally stable up to 200 °C. With increasing imidazole content the glass transition temperature decreases while their conductivity increase, reaching 10<sup>-3</sup> s/cm at 120 °C. Although imidazole group shows an important feature to contribute the proton connection route in PEM membrane without using water as a media, considering the up-to-date PEM, there are some requirements to produce membrane to overcome the present stage, especially the use in high temperature and the water required in the membrane. On this viewpoint, the present project considers a state-of-the art PEM by designing the polymer which has imidazole group as a proton transferring part covalently bonded to the polymer backbone. The key of the success should also relate to a well-defined

structure to let the proton transfer in a regular manner. The achievement of this work will be a guideline to develop a novel polymer material for PEMFC in the next step.