CHAPTER I
INTRODUCTION

As an environmentally friendlier and more efficient energy producing technology than up-to-date ones, fuel cells are expected for a practical power generation. Fuel cells are electrochemical devices that convert chemical energy directly to electrical energy and heat. One of the fuel cells, which receives much interest today, is based on polymer electrolyte membrane fuel cells (PEMFCs). The concept of PEMFCs has been well established since early 1960's (Larminie and Dicks, 2000), and reached to the level of commercialization for niche applications, such as electrical power sources in spacecrafts, submarines and vehicles from 1980.

PEMFCs operate at relatively low temperatures (60°C -100°C) with the highest power density than all other of fuel cell types (Thomas and Zalbowitz). The variable and quick response for the demand power output, make PEMFCs suitable for applications, especially for automobiles, where quick startup is required. Recent advances in designs, syntheses and preparations offer PEMFCs to be more attractive than any other type.

Polymer electrolyte membrane (PEM) is an essential part in PEMFCs functions as a separator for anode and cathode, solid electrolyte, and gas separator. As a result, the protons are facilitated from anode to cathode. Comparing to the traditional liquid electrolyte, the solid electrolyte provides the proton immobilization without problems of handling electrolyte solution and plumbing corrosion by acid and/or alkaline solutions. In addition, the solid electrolyte membranes are low weight and can be prepared by casting to various sizes and shapes offering flexibility in packaging. In their role as gas separators, the PEMs prevent mixing of fuel and oxidizer.

Perfluorinated polymer as PEM is developed to the level of commercialized product under the tradenames of Nafion®and Dow®, which, traditionally, are hydrated perfluorosulfonic polymer membranes. Although, the long-term stability of these polymer membranes have been proven to be more than 20,000 hours, the high cost (~900 $/m^2$) limits the practical uses. Fuel cell operating temperature is another point to be considered. Nafion®and Dow® show superior performance in fuel cells operating at moderate temperature (< 90°C), but the applicability, such as the water management in hydrated electrolyte, of these polymer membranes are insufficient at higher temperature and not suitable for pure hydrogen cells. Currently, the uses of hydrogen-rich gases produced by reforming methanol or even gasoline are proven to be attractive in terms of clean and cheap energy. Such gases contain traces of CO, which reduce the activity of the catalyst (Ianniello *et al.*, 1994). The CO tolerance, however, increases with increasing temperature, and, therefore, fuel cell operation at higher temperature becomes an indeed condition.

Imidazole molecules are known to involve in proton transport across biological membranes (Yoshikawa, 1999). The melting temperature of imidazole is higher than that of water at ambient pressure. This may be an advantage with respect to technical applications since polymer membranes containing imidazole phases may be exploited for fuel cells (Münch *et al.*, 2001). The high proton conductivity of hydrated polymers is related to the presence of water, however, the substitution of water by heterocyclic, such as imidazole, as proton transfering group also leads to high proton conductivity. It would be possible to significantly increase the operating temperature of the PEMFC. Kreuer *et al.* (1998) demonstrated the function of heterocyclic in membranes for fuel cells was from the replacement of imidazole for water in sulfonated polyetherketone membranes to result in high protonic conductivity at high temperatures. For practical application, however, the protonic conductivity still needs improvement and the imidazole molecules are expected to be immobilized (Kreuer, 1997), which is currently attempted by Schuster *et al.* (2001).

Although heterocyclic molecules such as imidazole group shows an important feature to contribute the proton connection route in PEM membrane without using water as a media, up to now, there is no report about functionalization of polymer chain with heterocyclic molecules for the objectives of PEM. Considering the up-to-date PEM, there are some requirements to produce membrane to overcome the problems at present stage, especially about the use in high temperature and the water required in the membrane. The present work (Part I Heterocyclic Derivatives of Polymeric Chain), thus, stands on the viewpoint about a controlled structure material from fundamental molecular design and practical synthesis pathway. The products designed is concentrated on a heterocyclic functional group where proton connection route is possible via imidazole unit. The achievement of this thesis work will be a guideline to develop a novel material for PEMFCs in the next area.