

CHAPTER I

INTRODUCTION

Fuel cell is a clean electronic device for electricity production by the electrochemical reactions of fuel and oxidant. Among various types of fuel cells, polymer electrolyte membrane fuel cell (PEMFC) is considered to be a promising candidate system not only because of the high efficiency, the rapid start-up and the variety of fuel types but also the practical design with high output. Therefore, PEMFC is the most appropriate fuel cell for the use in automobiles and mobile electronic devices.

Polymer electrolyte membrane (PEM) is one of the key parts in PEMFC to function as a proton conductor, gas separator and electrical insulator. At present, perfluorosulfonic acid based membrane i.e., Nafion[®] is considered to be a standard polymer electrolyte used in PEMFC because it shows an excellent proton conductivity and good chemical and mechanical stability. However, the main drawbacks of Nafion[®] which are high cost and limited working temperature (lower than 100 °C) lead to expectation of alternative material for practical use at the temperature range of 100-150 °C. The utilization of PEMFC at high temperature offers several advantages i.e., accelerating kinetic reaction of cathode, reducing CO poisoning on catalyst surface and improving heat management.

Since the operating temperature above 100 °C is always required to maximize the cell performance, heterocyclic membranes are proposed due to their high thermal stability and amphoteric structures that allow proton transfer under hydrogen bond network. Up to present, various heterocyclic based membranes have been reported and the proton conductivity of these materials is still the point to be improved.

We believe that an understanding of the molecular structure as well as the factors related to the proton conductivity is a key guideline to develop the conductive material with effectiveness. In the case of heterocycles, i.e., imidazoles, benzimidazoles, etc., the hydrogen bond among the molecules is known as a key factor related to the proton conductivity. The point is how the heterocycles developed their hydrogen bond network. In order to answer this question, it is necessary to focus

on the heterocycles in systematic manner. The present work, therefore, raises benzimidazoles as a case study and the molecules are systematically developed from monofunctional, difunctional, and trifunctional benzimidazoles to declare the formation of hydrogen bond network. The changes of hydrogen bond network related to the temperature and the consequent proton conductivity are investigated to clarify how the pattern of hydrogen bond network and molecular packing structure play the role on proton transfer.

Considering the proton transfer through hydrogen bond network of heterocycles in polymer matrices, another factor involved with this is about the mobility of the heterocycle molecules. The fact that the hydrogen bond network results in fixing the molecular framework whereas the chain mobility enhances the movement of the molecules, it comes to our question whether we can declare the balancing of chain mobility and hydrogen bond at a level that both factor can synergistically function in proton transfer. In order to answer this question, branching benzimidazole polymer chains are designed and synthesized and the structural changing related to the temperature and the consequent proton conductivity are investigated.

It is also another breakthrough to design and synthesis a regular structure of polymer containing multi-functional benzimidazoles. When we consider a linear polymer containing tri-benzimidazole, the question is how to prepare the tri-benzimidazole in a simple way. In this work, the synthesis approach based on trifunctional acid chloride and difunctional amines is focused.

In overall, the present dissertation aims to show how we can develop benzimidazole in a systematic way and study on the molecular packing structure related to the proton conductivity. The information obtained from this work will be a guideline in developing an effective and efficient proton conductive polymer for PEMFC in the future.