CHARACTERIZATION AND INVESTIGATION OF MECHANICAL STRENGTH PROPERTY OF POLYSULFONE-INORGANIC COMPOSITE MEMBRANES FOR FUEL CELL APPLICATION

INTRODUCTION

Current energy sources are being depleted at high rates due to the growth of the world's population and its desire to live at a high level of comfort. Petroleum is the world's most prevalent fuel. However, fossil fuels are becoming scarcer and their burning produces emissions that pollute the air. Furthermore, fossil fuel is not a renewable energy source. In contrast, a fuel cell is a viable, renewable, and environmentally friendly energy source.

There are essentially five fuel-cell systems, each with its distinct electrochemical reaction and operation requirements. The different fuel cells are generally classified by the electrolyte used. They are: phosphoric acid fuel cell (PAFC), molten carbonate fuel cells (MCFC), solid oxide fuel cells (SOFC), alkaline fuel cells (AFC), and proton exchange membrane fuel cells (PEMFC). PEMFC is an attractive energy conversion system in many industrial applications due to its high energy efficiency and the product is pure water. The PEMFC is a prime candidate for vehicle and other mobile applications of all sizes down to mobile phones.

A PEMFC consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat. Hydrogen fuel is fed into the anode of the fuel cell and oxygen into the cathode. Encouraged by a catalyst, one hydrogen atom splits into two protons and two electrons, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.

The most commonly used membrane is Nafion by DuPont, which relies on liquid water humidification of the membrane to transport protons. This implies that it is not feasible to use at temperatures above 80^{o}C, since the membrane would dry out. But, the higher-temperature operation can improve thermal management and increase reaction rates at both electrodes and activate catalyst layer. Others, more recent membrane types, are, for instance, polybenzimidazole (PBI), poly (ether ether ketone) and poly (arylene ether sulfone). However, these recent types are not as common, and thus most research labs and papers still use Nafion in their experiments relating to the fuel cell system.

In this current work, poly (arylene ether sulfone) was chosen due to its high glass-transition temperature (T_g) of 221^{o}C. In addition Wang (Wang *et al.*, 2002) supported the potential use of poly (arylene ether sulfone) in PEMFC due to its comparable proton conductivity to that of Nafion, besides low cost of membrane preparation. Still, at higher temperature, its proton conductivity decreases due to very low relative humidity. Hydrated inorganic added to the membrane may assist in relative humidity enhancement. However, the disadvantage of adding inorganic material is that the membrane may develop brittleness, unsuitable for the PEMFC application. (Shao *et al.*, 2004) Consequently, this thesis focuses on developing polymer electrolyte composite membranes by adding zeolite and heteropolyacid, and investigates their effect on mechanical strength property of the polymer at various temperatures and relative humidities according to the PEMFC operating conditions.

OBJECTIVES

To study effect of zeolite and heteropolyacid on the mechanical strength of composite polymer membranes at different temperatures and at 100% relative humidity.

SCOPE OF THESIS

1. Study effect of two inorganic materials on the proton conductivity at the room temperature only and on the mechanical strength of composite polymer membranes at different temperatures and at 100% relative humidity

2. ZSM-5 and phosphotungstic acid, representing zeolite and heteropolyacid, respectively, have been employed herein.