

INTRODUCTION

The proton exchange membrane fuel cells (PEMFCs) have been considered as a suitable alternative to internal combustion engines because of their high power density, high-energy efficiency and low emission level. However, one of the major issues limiting the introduction of PEMFCs for their applications is Nafion membrane (DuPont) that currently used for electrolyte of PEMFC show a significant loss in conductivity at these elevated temperature and low relative humidity due to dehydration of water from the membrane (Ramani et al. 2005).

In the direction of improving the proton conductivity of the Nafion membrane for medium temperature and low relative humidity, in the present work, we have prepared the composite Nafion-SiO₂-PWA membrane using solution phase sol-gel reaction to improve microstructure dispersion method where the sol gel method have been proven able to improve microstructure of the membrane from microcomposite become nanocomposite structure (Kukoveez et al. 2002). The nanocomposite structure can be achieved via hydrogen bonding of sulfonic acid from the side chain of the Nafion polymer and silanol (SiOH) resulting from hydrolysis of Tetra Ethoxy Ortho Silicate (TEOS). Molecular interaction also takes place between silanol and PWA ion via moment dipole interaction force. Interaction in the molecular level between those compounds (organic-inorganic) hope able obtain composite in the nanoscale dimension. The effect of the SiO₂ and PWA content in the Nafion polymer to the electrochemical properties of the composite membrane have been investigated using FCTS.

EXPERIMENT

MEMBRANE PREPARATION

Appropriately 5% wt Nafion solution was evaporated at room temperature to obtain solid Nafion. Solid Nafion was dissolved in DMF solvent to obtain 5% wt Nafion solution in DMF. PWA was also dissolved in deionized water and then mixed with TEOS at weight ratio of PWA:SiO₂ = 4:10. Subsequently, it was stirred in an ultrasonic bath for 30 min, and added to the Nafion-DMF solution and further stirred in an ultrasonic bath for 6 hours. The mixture was allowed to stand at room condition to release trapped air bubbles for another 24 hours without mixing. This solution was casted in a Petri dish and heated at 80°C for 2 hours to remove the solvent. In order to enhance the mechanical properties of the composite matrix, heating was continuously applied at 140°C at different periods of 2, 4, 6 and 10 hours until transparent membrane was obtained. Then, the recast composite membrane was made to detach from the Petri dish by boiling it in the de-ionized water. Finally, the membrane was cleaned by heating at 80°C in the solution of 3 wt. % H₂O₂, de-ionized water, 0.5M H₂SO₄ and again in de-ionized water until the pH of the washing water becomes almost neutral. These composite membranes are designated NS10W, NS15W and NS20W, whose specifications in ratio of Nafion/TEOS/PWA are 100:10:1.1538; 100:15:1.7303 and 100:20:2.3072 (wt./wt./wt.), respectively.

MEMBRANE ELECTRODE ASSEMBLIES

Gas diffusion electrodes were fabricated with 20 wt. % Pt on carbon and 0.4 mg Ptcm⁻². The membrane was sandwiched between the two electrodes and then hot pressed at 130°C and 70 atm for 90 s to obtain membrane electrode assembly (MEA).

CHARACTERIZATION OF ELECTROCHEMICAL PROPERTIES

The Fuel cell test (FCT) station (FCT-2000 ElectroChem, USA) was used for the cell polarization test and determination of the internal resistance of the membrane. The gas flow of H₂/O₂ was fixed at the stoichiometric (H₂ + ½ O₂ ↔ H₂O) mole ratio