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NANOCOMPOSITE ELECTROLYTE MEMBRANE FOR MODERATE TEMPERATURE AND LOW RELATIVE HUMIDITY HYDROGEN PROTON EXCHANGE MEMBRANE FUEL CELL (HPEMFC) APPLICATION

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Nowadays PEMFC with hydrogen fuel has developed to commercialize to replace the conventional machine. Several limitations in PEMFC commercialization are its low efficiency, viability of hydrogen fuel supply and problem of controlling fuel and water as reaction products. Effective effort to increase efficiency and water management include elevating temperature of PEMFC operation near water boiling point to increase energy produced, prevent water flooding, enhanced cooling efficiency and also the possibility to use hydrogen and air under lower humidity in order to make simples PEMFC design. But at elevated temperature and low relative humidity, Nafion membrane that during the time still used as electrolyte will shrink and at high humidity and high temperature above 80°C membrane will swell and irreversibility decay occur. Membrane shrinking and swelling will reduce PEMFC performance. The objective of this study is to investigate the usage of Nafion-SiO_2-PWA nanocomposite membrane NS10W, NS15W and NS20W with the ratio of Nafion:SiO_2-PWA = (1:0.0288:0.0154), (1:0.0432:0.0173) and (1:0.05768:0.023) respectively as PEMFC electrolyte to improve PEMFC performance at moderate temperature and low relative humidity. 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 H_2/O_2 was fixed at the stoichiometric ($H_2 + ½\ O_2 \leftrightarrow H_2O$) mole ratio 0.5/0.38 while the hydrogen and oxygen pressures were fixed at 1 atm. The operating temperature of the cell was varied between 30–90°C. The relative humidity (RH) was controlled by using the water temperature of the H_2 and O_2 gas humidifiers. During the (V-I) measurement, the testing system was stabilized for about 1 h in order to obtain constant value for all the parameters of interest and the resistance of the membranes was measured by optimizing the (V-I) experiments. The electrochemical performance of the composite membrane with dry and humidified reactants are compared with those of the native Nafion membrane to identify the operating condition with low relative humidity condition. The results show that at temperature of 30-90°C and 100% RH humidity, the Nafion membrane performance is higher compare to composite membrane under same temperature value. But at 40% RH and same temperature, the composite membrane performance is higher compared to Nafion membrane. The result of data analysis and optimized polarization curve model shows that the mechanism of proton transfer in the Nafion membrane followed the vehicular model, which is as in the composite membrane is close to the proton hopping model. The performance of the Nafion-SiO_2-PWA composite membrane is stable at low relative humidity operating at 30-90°C temperature. Since the humidity is low and operating temperature are high, the PEMFC using the nanocomposite membrane can run with lower humidity and with higher power compared to a PEMFC using the pure Nafion membrane.

1.Introduction

Operation of proton exchange membrane fuel cells (PEMFC) at elevated temperatures can alleviate the anode electro catalyst poisoning and accelerate the oxygen reduction reaction (ORR) kinetics of the fuel cells. Common perfluorosulfonic acid (PFSA) membrane, such as Nafion, is widely used as