



PERFORMANCE IMPROVEMENT OF PROTON EXCHANGE MEMBRANE FUEL CELL USING SOL-GEL CASTING TECHNIQUE

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Abstract

The sol-gel casting technique has been used for the fabrication of membrane electrode assemblies (MEA) as a means for better distribution of metal catalyst, such as Pt, residing on the membrane surface. This in itself will make the catalyst used to be more efficient. The precursor contained Tetra Ethoxy Ortho Silicate (TEOS) as the silica source and Phosphotungstic acid (PWA) as the proton conductive material. The electrolyte membrane, Nafion 112 was impregnated with the precursor solution containing PWA and TEOS before its coated with the catalyst ink to produce the electrodes. The electrodes were fused with the gas diffusion layers (GDL) by hot press at 120°C and pressure 30 atm for 4 minutes to produce the membrane electrode assembly (MEA). Catalyst loading on the membrane surface varies from 0.38 until 0.475 mg/cm². Characterization of the membrane Electrode Assemblies (MEA) conducted by fuel cell test system. Comparison sol-gel MEA to the commercial MEA at the same operation condition but lower catalyst loading in anode/cathode (0.4/1 mg/cm² for commercial MEA) and (0.43/0.43 mg/cm² for sol-gel MEA) show a better performance. The result of the experiment show sol-gel MEA produce more high current and voltage along test time during 12 hours, and show stability of current and voltage during 30 hours test time at ambient temperature. So that could be concluded that sol-gel process is applicable for membrane electrode assemblies, and have advantages improve performance of proton exchange membrane fuel cell (PEMFC).

Keyword: heteropolyacid, sol-gel, nafion, PEMFC

Introduction

At the moment Proton electrolyte membrane fuel cell (PEMFC) in process of development and not far from commercialization to be used as a power source in motor vehicle ⁽¹⁾. The solid electrolyte used in the PEMFC is Nafion membrane (Du Pont) is relevant to use allows for greater than 1 Acm⁻² of current out put. Nafion membrane is relevant to use of low temperature below 100°C ⁽²⁾. At high temperature and low humidity, membrane will shrink due to membrane dehydration cause the lack of the water molecule as proton carrier in the membrane, and at high current density or high humidity membrane will swell. Shrinking and swelling have an effect reduces proton conductivity of the membrane and degraded of the surface linking structure between membrane and catalyst surface. At temperature in the range of 50-90°C the catalyst is very sensitive to poison by CO. So that CO in fuel hydrogen must be limited below 10 ppm ⁽¹²⁾. This matter cause the liquid fuel like gasoline and methanol cannot directly be used as a fuel. Many works was have done to overcome the sensitivity of the CO catalyst by increase operating temperature of the fuel cell. But at high temperature above 100°C membrane is started to degrade and at 130°C structure of the membrane will change ⁽¹⁸⁾.

The aim of this work is to modified Membrane Electrolyte Assemblies (MEA) focused on Nafion membrane 112 with introduce the hygroscopic material (Si) and secondary proton conductive material using heteropolyacid (Phosphotungstic acid) (PWA) to produce a good performance of MEA. The role of silica in the membrane, to increases the stability of the membranes at low and high relative humidity while at the same time increasing the resistance to fuel crossover by creating more resistance in the flow channels ⁽⁴⁾.

The source of silicate is Tetra Ethoxy Ortho Silicate (TEOS). One of the problem arise on using silicate is has low conductivity. In order to increase conductivity of the layer, heteropolyacid (PWA) (H₃PW₁₂O₄₀nH₂O) is immobilized in the silicate matrix polymer, is used. Heteropolyacid in the composite membrane generally is introduced as second proton conducting species ⁽¹⁹⁾. The aim is to constrict the pore in the polymer matrix create greater resistance to molecular migration of the unwanted species. In addition