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Metallic glass separators for fuel cells at intermediate temperatures

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ABSTRACT

Inorganic-organic hybrid membranes comprising an aliphatic backbone polymer and a trisiloxane bond were synthesized from a trisiloxane derivative, phosphonic acid acrylate, and vinylbenzotriazole, and used to prepare membrane electrode assembly (MEA) sandwiched between metallic glass separators (MGSs). The prepared MEA exhibited a higher cell voltage than that comprising carbon separators at 140 °C and 30% relative humidity for 50 h.

1. Introduction

Perfluorosulfonic polymer membranes show the optimum performance at 100% relative humidity (RH) at around 80 °C when the CO concentration in the H_2 gas is maintained below 20 ppm to prevent CO poisoning on the Pt catalyst [1–3]. If the operating temperature increases to the intermediate temperature values between 100 and 150 °C, CO poisoning decreases and the cell efficiency increases with the simplified system [4]. Therefore, membrane electrolytes exhibiting high proton conductivities ranging from 100 to 150 °C are required. As inorganic-organic hybrids have both the flexibility of an organic material and the chemical, thermal, and mechanical stabilities of an inorganic material, the hybrid membranes are among the best candidates for preparing membrane electrolytes at the intermediate temperatures [5].

A MEA comprises an electrolyte membrane with catalyst layers on both sides, sandwiched with a pair of separators. Separators such as metal and carbon with paths for fuel and oxygen gases should have high electron and heat conductivities [6]. MGSs of Ni-Cr-P-B are characterized by their high corrosion resistance, which improves the demerit of MS [7]. The effect of the surface roughness of separators on the cell properties has not been reported yet, particularly at intermediate temperatures and low humidities: however, the properties of MGSs at 80 °C and 100% RH have been reported [7].

This research describes the cell performance of MEA using MGSs and carbon separators (CSc) at intermediate temperatures and low humidities. The inorganic-organic hybrid membranes were synthesized from 1,5-divinyl-3-phenylpentamethyltrisiloxane (DPPMTS), 2-hydroxyethyl methacrylate acid phosphate (HEMAP), and *N*-vinylbenzotriazole (VBT) via copolymerization.

2. Experimental procedures

2.1. Materials

The molecular structures of DPPMTS (Gelest Inc.), VBT, and HEMAP (2-hydroxyethyl methacrylate acid phosphate ($[CH_2{=}C(CH_3)CO(O)(CH_2)_2O]_nP(O)(OH)_{3-n}$, HEMAP, Johoku Chemical: monoester (n = 1) to diester (n = 2) ratio = 1.35:1.0) are shown in Fig. S1.

2.2. Preparation of membranes

VBT/HEMAP/DPPMTS copolymer was prepared at a molar ratios of VBT/HEMAP/DPPMTS = 1:9:5. VBT (58.1 mg, 0.4 mmol), HEMAP (927.2 mg, 3.6 mmol), and DPPMTS (645.2 mg, 2.0 mmol) were dissolved in 20 ml of DMF with azobis(isobutyronitrile) (7.9 mg, 0.8 mol%). After polymerization in a sealed vessel at 90 °C for 10 h, solid precipitates were obtained upon addition of diethyl ether. The precipitates were redissolved in DMF and were casted onto a polyethylene diphthalate film, which was dried at room temperature for 24 h and then heated from 60 °C to 140 °C, affording hybrid membranes.

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