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Application of spirobiindane-based microporous poly(ether sulfone)s as polymeric binder on solid alkaline exchange membrane fuel cells

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ABSTRACT

In this report, we introduced spirobiindane group to poly(arylene ether sulfone) (PES) to build the structure of polymers with intrinsic microporosity (PIMs). A novel PESs (QOH-SBIs), which have spirobiindane and tetra (quaternary ammonium) hydroxide pendant moieties, were synthesized for anion-conducting binder material in membrane electrode assembly (MEA) of solid alkaline exchange membrane fuel cell (SAEMFC). The time-lag method was used to check the high gas permeability of the polymers. The high permeability is due to the micropores at the molecular level that is formed by the difference in chain thicknesses between two alternating units, thick spirobiindane group and thin arylene ether sulfone group. QOH-SBIs shows a semi-rigid chain conformation in a solution. The inter-chain spacing and chain conformation were measured with wide angle X-ray diffraction (WAXD) and small angle neutron scattering (SANS), respectively. High gas permeability directly affected the performance of SAEMFC. The MEA with spirobiindane-modified PES shows much higher maximum power density than that of spirobiindane-free PESs.

1. Introduction

The membrane electrode assembly (MEA) in polymer electrolyte membrane fuel cells (PEMFC) is the most important component that determines the whole cell performance [1]. Polymer electrolytes are used as both a membrane and catalyst binder for ion transfer in the MEA. However, the required properties of the membrane and the catalyst binder are quite different. The electrolyte membrane should have high gas barrier property to prevent hydrogen and air cross-over [2], while the electrolyte binder should be gas-permeable to enhance the electro-catalyst activity in the electrode of the MEA [3]. A highly gas-permeable binder can enhance a reaction at the three-phase boundary among reactant gases, the catalyst, and electrolytes in the electrode.

Poly(arylene ether sulfone)s (PESs) are one of the promising hydrocarbon-based polymer electrolytes for PEMFCs owing to their good chemical resistance, mechanical properties, and thermal stabilities [4–6] and especially low gas permeabilities. Therefore, PES-based electrolytes are excellent materials for a membrane. However, they show very low cell performance as binders [7].

Polymer materials have also been investigated for their gas separation applications. The polymer structure influences its permeability and selectivity for different gas pairs [8]. To obtain high gas permeability, many researchers have studied the influence of distorted groups on the polymer backbone and bulky pendant groups to increase the fractional free volume (FFV) between polymer chains [9–11]. Representative cases of the approach to improve the gas permeation behavior were about the application of spirobiindane [12], hexafluoro [13], and cardo moieties [14].

Very few studies have focused on improving cell performance by increasing the gas permeability of the binder [15–17]. Previously, we also synthesized sulfonated PES binders containing spirobiindane groups for proton-exchange membrane fuel cell electrodes. The highly gas-permeable polymer electrolyte binder with spirobiindane moiety showed higher cell performance than those without the moiety [18].

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