Zeolite-Nafion Composite Membranes as Proton Conducting Materials for High Temperature Direct Methanol Fuel Cells

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Introduction

Direct methanol fuel cells have good potentialities for application in transportation, portable power sources and distributed generation of clean energy due to their low environmental impact. The main problems that have hindered the market penetration of these systems are the cost of the polymer electrolyte membrane presently used in these devices, the membrane dehydration at temperatures higher than 100-120°C and the methanol cross-over.

A direct methanol fuel cell based on a high temperature proton conducting membrane with suitable conductivity and stability up to 130°-150 °C, with proper thermal and water management would become a viable system for mobile applications. Thus, of particular interest are composite membranes with the filler exhibiting strong affinity towards water molecules [1, 2]. In the present work, composite membranes with Nafion as the ion conducting matrix and Chabazite, Clinoptilolite and Mordenite as zeolite fillers have been prepared. These are natural zeolites of fairly low cost and are stable in aqueous solutions within the pH range from 3 to 12 approximately.

Experimental

The zeolites were received from GSA Resources Inc, Tucson AZ. The zeolites were converted from Na+ to H+ form by treatment in a 0.01 M H2SO4 aqueous solution. Afterwards, the zeolite powders were mixed with a Nafion solution (Aldrich) to obtain membranes with zeolite content of 3 and 6 vol.%. The thickness of the membranes was about 70 μm. Fuel cell experiments were carried out in a 5 cm2 single cell (GlobeTech, Inc.). 2M aqueous solution of methanol and oxygen were preheated at 85°C and fed to the cell. The catalyst employed for methanol oxidation was 60% PtRu (1:1)/Vulcan (E-TEK), whereas a 30% Pt/Vulcan (E-TEK) was used for oxygen reduction. The platinum loading for all the electrodes was about 2 mg cm².

Results

All the MEAs equipped with the composite membranes were capable of operation at 140°C. Fig. 1 shows the polarization curves at 140°C obtained for the DMFCs equipped with the 3 vol.% zeolite-Nafion composite membranes. A maximum power density of 390 mW cm² was reached for the MEA including the mordenite composite membrane (Fig. 2). Similar performances were obtained for the DMFCs equipped with 6 vol.% zeolite-Nafion membranes.

These preliminary experiments appear to be sufficiently encouraging to prompt us to carry out more in depth investigations on different zeolites, finalized to achieve a proper tailoring of the physico-chemical characteristics of such composite membranes.

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References: