# Effects of Ionomer Loading on the Performance of Unsupported Catalyst in Direct Methanol Fuel Cell

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## INTRODUCTION

Due to use of liquid fuel and simplicity of the system, a direct methanol fuel cell (DMFC) is one of the promising power sources for a variety of application from portable electronics to vehicles. Despite the advantages, DMFC has several drawbacks to overcome including high catalyst loading, methanol crossover and low power density.

From the perspective of electrode performance, the cost problem can be tackled in two ways: reduction of the catalyst loading and improvement of the catalyst utilization and performance. Many researches [1, 2] have been reported a significant cost reduction by decreasing the catalyst loading. The fundamental concept of reducing catalyst loading is to increasing catalyst utilization in the gas diffusion region of the electrode. Previous report by Poltarzewski et al. [3, 4] on the influence of Nafion loading has demonstrated that in double layer electrode structure the Nafion loading mainly affects the ionic resistance of the catalyst layer. This report suggests that the initial Nafion loading fill up the pores of the catalyst layer, subsequent addition of the soluble Nafion results in formation of film on the surface of the electrode. Comparing with the supported catalyst, the proper amount of ionomer in the unsupported catalyst layer is somewhat different.

In this study, we investigated the effects of Nafion loading on DMFC electrodes. The objective is to resolve the effect of Nafion loading in its effect in the various polarization regions. From this purpose, the polarization measurements in single cells were correlated with results of impedance and morphological characterization. Cyclic voltammetry measurements were conducted to calculate electrochemically active surface area of the electrodes.

## EXPERIMENTAL

Catalyst coated membranes (CCMs) were prepared by a doctor-blade and hot pressing procedure using platinum black (Johnson Matthey), platinum ruthenium black (Johnson Matthey), Nafion 115 membrane, iso-propanol, n-butanol and 5wt% Nafion solution as an ionomer (Aldrich). Nafion loading was varied from 2 to 20 wt% of catalyst loading. After completing the CCM and carbon coated carbon paper, they were assembled and hot pressed at 125°C, 2 metric ton for 3 min.

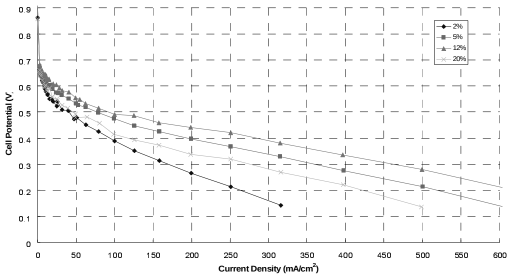

Fig. 1. Cell potential vs. current density plot at 40°C for 2M methanol (x3 stoich.)/oxygen (x3 stoich) as a function of Nafion loading.

A single cell, with a 10 $cm^2$ active area for the membrane/electrode assembly (MEA), was used in this study. This provided the opportunity for conducting simultaneous steady state polarization measurement as well as impedance spectroscopy for the same MEA. Polarization measurements were conducted using 2M methanol/air or oxygen, (x3 stoichiometric flow) at 40°C. Cyclic voltammetry measurements were conducted at 40°C on a single cell to determine the electrochemically active surface area. The measurements involved hydrogen and nitrogen at the counter electrode (anode) and working electrodes (cathode), respectively with a potential range of 0.05 to 1 V vs. RHE and a sweep rate of 20mV/s.

## RESULTS AND DISCUSSION

Figure 1 shows the single cell performance of 2M methanol/oxygen showing the effect of Nafion loading on the electrode polarization characteristics at 40°C. The optimum Nafion loading for the methanol/oxygen was 12wt % of loaded catalyst. In order to understand the significance of the effect of Nafion loading on the electrode performance its effect in all the three polarization regions corresponding to the activation, ohmic and mass transport was examined.

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