

Microstructure and performance of catalyst layer based on highly graphitized carbon support

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For automotive application, cost reduction and durability enhancement of membrane electrode assembly (MEA) are of primary concerns toward commercialization of fuel cell electric vehicle. It has been generally understood that the design of catalyst support is highly important in improving MEA durability under load cycling and start-stop operation, and reported that a highly graphitized carbon possesses a high durability because of the intrinsic resistance on carbon corrosion [1]. The graphitization decreased the defect sites on carbon structure where carbon oxidation initiates [2]. However, the influence of the highly graphitized carbon on microscopic morphology and power performance of MEA has not been intensively studied. In this work, we examined the electrodes based on highly graphitized carbon (gc-MEA) and high surfaced amorphous carbon support (hc-MEA) with an eye to gaining information on how carbon support impacts on microstructure and power performances of catalyst layer.

The major drawback of the highly graphitized carbon found in this work is a relatively low power performance at low RH condition. As shown in Fig. 1, the IV performance of gc-MEA is quite comparable to that of hc-MEA at 100% RH, however, the cell voltage of gc-MEA is lower over whole all current densities compared to hc-MEAs at 50% RH. The power performance is more sensitive to RH change for the gc-MEA. It is interesting that the performance at 100% RH is nearly the same for the two MEAs in spite of the large difference in electrochemical active area (55m²/g for hc-MEA and 36m²/g for gc-MEA).

To understand the reason for the lower power performance for gc-MEA at low RH than for hc-MEA, we investigated the hygroscopic property of the catalysts, the ionomer coverage, and the distribution of hydrophilic and hydrophobic pores for gc- and hc-MEA. The ionomer coverage was determined from the change in the electrochemical double layer capacitance of the catalyst layer as suggested by Nissan [3]. The double layer capacitance comes from the interface of catalyst/ionomer and catalyst/water. The contribution from the catalyst/ionomer is not significantly varied with relative humidity, however, that from the catalyst/water should be reduced with lowering humidity to a greater extent. Therefore, the % ratio of $C_{dl,dry}$ and $C_{dl,wet}$ ($C_{dl,dry}/C_{dl,wet}$) qualitatively indicates ionomer coverage. The smaller the ratio is, the smaller the ionomer coverage is. Fig. 2 shows the results of the ionomer coverage for gc-MEA and hc-MEA at various humidity conditions. The % ratio was found to be 55~65% at 30% RH for gc-MEA and beyond 80% for hc-MEAs at 30% RH for hc-MEA, which means the smaller ionomer coverage for gc-MEA. The result strongly indicates the high RH sensitivity for gc-MEA attributes to an imperfect ionomer coverage.

The influence of carbon support on ionomer coverage is expected to be related with the surface interaction between ionomer and carbon. More detailed analysis on microstructure of the catalyst layer will be

presented.

References

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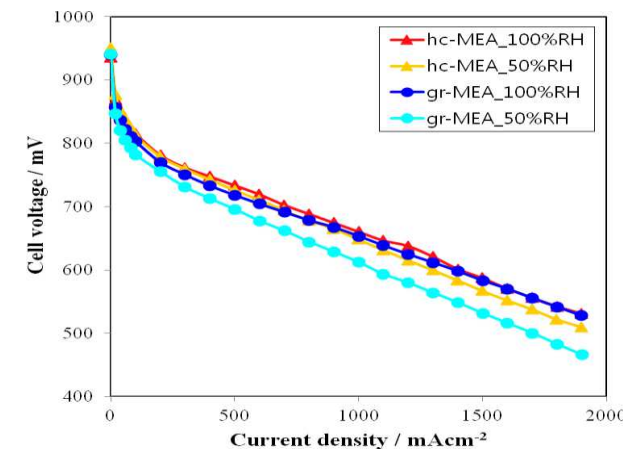


Figure 1. IV performance of gc-MEA and hc-MEA; 80°C, H₂/air, atmospheric pressure.

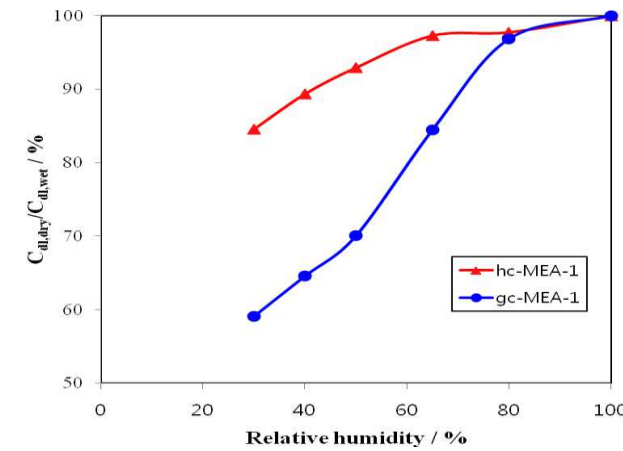


Figure 2. Ionomer coverage ($C_{dl,dry}/C_{dl,wet}$) of gc-MEA and hc-MEA with relative humidity