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## List of tables

Table 1. The volumes of 5% wt of Nafion solutions were added to catalyst inks, and the amount of 20 wt% Pt/C catalysts was kept constant at 34.5 mg (Pt loading of  $0.3 \text{ mg/cm}^2$ , and reactive area of  $23 \text{ cm}^2$ ). The density of 5%wt Nafion solution is  $0.85 \text{ g/cm}^3$ ; thus, the percentage of Nafion : Pt/C catalyst was calculated as weight ratio.

Table 2. Mass fraction analysis of C, F, and Pt from the EDX analysis shown in Figure 6.

Table 3. Summary of chemisorption data. No chemisorption activity observed for Nafion-coated Nafion membrane. For the 20 wt% Pt/C powdered catalyst, average Pt particle size is calculated to be 4.4 nm diameter to give a Pt dispersion of 25.8%. Dispersion is defined as the fraction of total Pt atoms in a particle that are present on the surface. Coated membrane was analyzed by chemisorption before (fresh) and after electrochemical surface area determined (used).

Table 4. Summary of Electrochemical Surface Area (ESA) for an MEA of 49.3 wt% of Nafion : Pt/C by cyclic voltammetry using a scanning rate of  $25 \text{ mV/sec}$ . The mass of Pt was approximately 6.9 mg ( $0.3 \text{ mg}_{\text{Pt}}/\text{cm}^2$  for  $23 \text{ cm}^2$  surface area for both anode and cathode); the Pt charge per surface area  $\text{Pt} = 2.1 \text{ C/m}^2$ .

## List of figures

Figure 1. Schematic of ultrasonic spraying system used to fabricate MEAs in this study.

Figure 2. Polarization curves of four MEAs with percentages of Nafion : Pt/C catalyst at 37.0% (+) , 49.3% ( $\square$ ), 61.6% ( $\circ$ ) , and 73.9% ( $\Delta$ ). The cell temperature was 75 °C, the humidity was 95%RH at both anode and cathode, the stoichiometric ratio of H<sub>2</sub>/air was set at 1.2/3.0, and back pressure was ambient pressure at both anode and cathode.

Figure 3. Current density versus Nafion : Pt/C catalyst ratio at cell potential of 0.50, 0.65, and 0.80 V (from Figure 2).

Figure 4. Cross sectional SEM images of MEA with 49.3% of Nafion : Pt/C; (a) CCL/electrolyte membrane/CCL at a magnification of 1,000 times, and (b) CCL/Electrolyte membrane interface at a magnification of 25,000 times.

Figure 5. The TEM image of MEA (49.3% of Nafion : Pt/C) at the interface between CCL and electrolyte membrane (a) at a magnification of 4,000 and (b) magnification of 20,000. Figure 5(c) shows the catalyst-coated layer of the MEA at a magnification of 100,000. The black Pt particles are clearly visible in (c).

Figure 6. Electron Diffraction X-Ray analysis (EDX) of a cross section of the MEA (49.3% of Nafion : Pt/C). Platinum, carbon, and fluorine (from Nafion) peaks from the highlighted portion of the SEM image are shown in the EDX spectrum.

Figure 7. Chemisorption spectra of (a) electrolyte membrane coated with 400  $\mu$ L of 5% Nafion, (b) powdered 20%wt Pt/C catalyst, (c) 49.3 wt% Nafion : Pt/C, fresh MEA , and (d) 49.3 wt% Nafion : Pt/C, used MEA.

Figure 8. Cyclic voltammetry of MEA (49.3% Nafion : Pt/C) with surface area of 23 cm<sup>2</sup> scanned from open circuit voltage (OCV) to 1.14 V with scanning rate of 25 mV/sec, cell temperature of 75 °C, H<sub>2</sub>/N<sub>2</sub> (A/C) at 300/300 sccm, ambient pressure, and 95% RH both anode and cathode.