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High Performance Platinum Black Cathodes by Ultrasonic Spray Deposition

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The cathode of the membrane electrode assembly (MEA) is the most important part of design in high performance polymer electrolyte fuel cells. A process was developed to prepare MEAs using a direct ultrasonic spray deposition of platinum black catalyst suspensions on to the polymer. The ultrasonic sprayer is utilized for coating a uniform dispersion of catalyst in the cathode layer delicately on to the substrate. These electrodes are designed to run at high efficiency conditions, when operated under hydrogen and oxygen in pressurized systems. Platinum black has an unrivaled combination of performance and durability [1, 2]. For its spray deposition, catalysts were suspended in a mixture of water and isopropanol solvents. An ultrasonic horn or high speed shear mixer was used to aid in the ink dispersion. Critical solvent addition was key to optimizing the ink formulation. Maximizing interfacial contacts in the composite layer and utilizing the greatest electrochemically available surface of the catalyst is evidence of progress correlated to performance.

The ink composition is comprised of solvents containing the catalyst in addition to the ionomer in a suspension. The ionomer is a perflurosulfonic acid known commercially as Nafion®. The concentration of this material is an important variable, but it can also act as a surfactant by aiding the suspension of the heavy noble metals. The electrokinetic potential or zeta potential can be used as an indicator of the colloidal suspension quality. Other materials including functionalized carbon nanotubes were also considered as surfactants and for their hydrophobic and structural effects [3]. If the ideal amount of ionomer is used, the most available surface of the catalyst can be used in the oxygen reduction reaction. This is the rate limiting step of the fuel cell reaction and small changes to the electrode structure have a drastic effect on performance.

Ultrasonic spray deposition also involves many parameters. The liquid flow rate, spray head velocity, solvent evaporation, and amplitude of generator are all important, for example. The ultrasonic frequency determines the droplet size and can change the void structure in the electrode. Several ultrasonic frequencies from 48 to 180 kHz were tested which provide varying polarization results. The solution density and surface tension also have an effect on droplet size. These parameters were adjusted first (see Table 1) and the results for these are made available in Figures 1 and 2.

MEA	H2O : IPA	Mixing	Nafion : Pt
1	10:90	speed mixer	2:1
2	50:50	speed mixer	2:1
3	50:50	ultrasonic horn	2:1
4	50:50	ultrasonic horn	1:1

Table 1. Ink preparation matrix used to spray MEAs

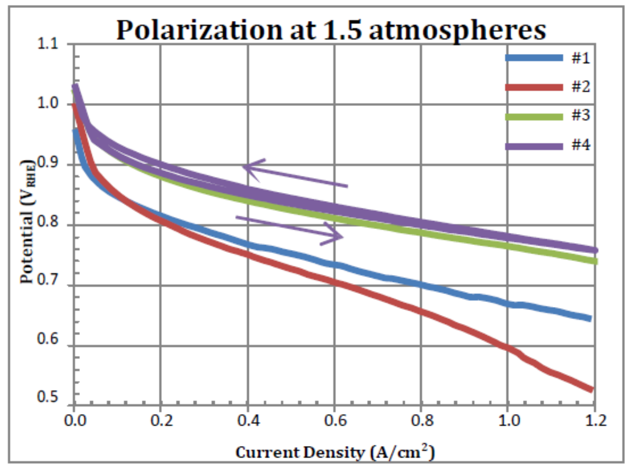

Figure 1. Polarization at 80 °C, 3/3 stoich, H_2/O_2, 1.5 atm

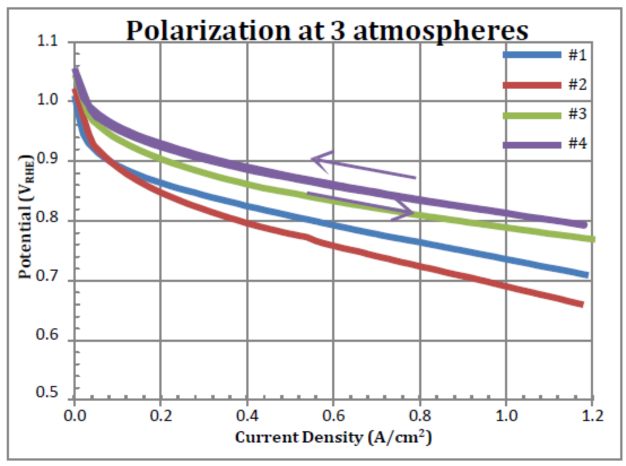

Figure 2. Polarization at 80 °C, 3/3 stoich, H_2/O_2, 3 atm

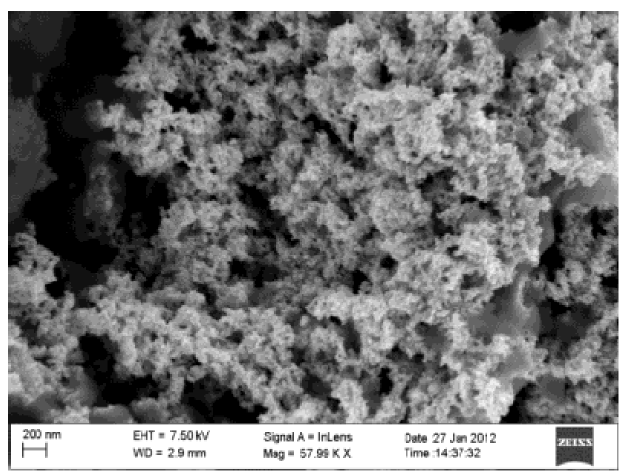

Figure 3. High resolution FESEM of electrode structure

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References

[1] M-K Min, J. Cho, K. Cho, and H. Kim, *Electrochimica Acta*, **45**, 4211, (2000).
[2] N. M. Marković, T. J. Schmidt,V. Stamenković, P. N. Ross, *Fuel Cells*, **1** (2), 105 (2001).
[3] X. Huang, W.A. Rigdon, K. Billings, and T.I. Valdez, *ECS Transactions*, **50** (2), 753-763, (2012).