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High Performance Membrane Electrode Assembly Fabricated by Ultrasonic Spray Technique

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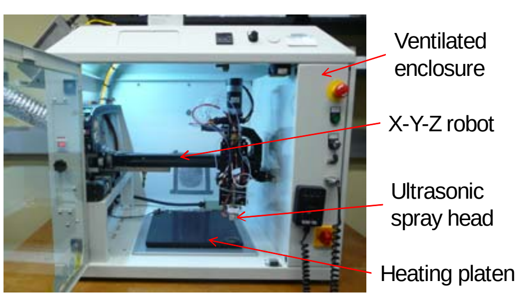
The core of a polymer electrolyte membrane fuel cell stacks are membrane electrode assemblies (MEAs). Manufacturing processes for MEA have significant impact on their performance and durability. The authors have attempted an ultrasonic spray technique for the fabrication of membrane electrode assemblies.

Ultrasonic vibration of a liquid surface attached to substrate causes the formation of surface capillary waves. As the amplitude increases, the rupture of capillary surface waves occur and liquid droplets are subsequently ejected from the surface. To realize the ultrasonic spray process, the atomized droplets using ultrasonic atomizer can be shaped and moved around with low velocity air or another carrier gas. Applications of ultrasonic spray technology range from ordinary liquids to molten metal for air conditioning, drug delivery, powder production, combustion, textile coating, solar cell manufacturing, and lately fuel cell manufacturing. The major advantages of ultrasonic spray include uniform spray with narrow distribution of droplet sizes, controllable mean droplet size diameter by ultrasonic forcing frequency, low droplet velocity (soft spray) that minimize splashing and material waste, silent, low energy consumption (for atomization and spray shaping), and scalable.

The authors applied an ultrasonic spray process to fabricate membrane electrode assemblies. A commercial ultrasonic spray robot from Sono-Tek® was used for this purpose. The spray parameters, such as generator frequency, ink feed rates, heater temperature, stand-off distance, etc., were investigated for the production of membrane electrode assembly with uniform and functional-gradient Pt/C catalyst layers.



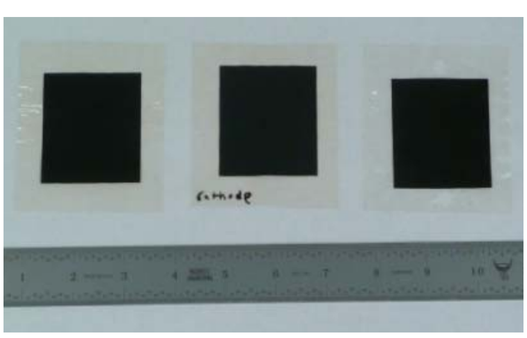
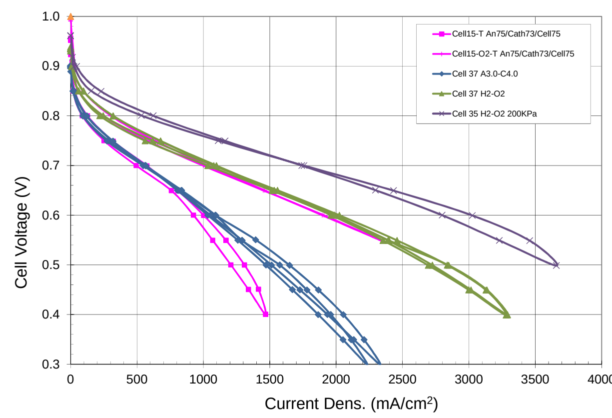


Figure 1 (Top) The ultrasonic spray system and (Bottom) the 25-cm^2 MEA.

The electrochemical performance of the ultrasonic sprayed MEAs was characterized by fuel cell testing. A wide range of catalyst loading can be realized, the MEAs tested so far contain approximately 0.3~0.4 mgPt/cm^2 on either side of the electrolyte. The representative performance of the ultrasonic sprayed MEA is shown in Figure 2. By optimizing the spray parameters, current density reached over 2 A/cm^2 at 0.6 V with hydrogen and oxygen (no back pressure). The ultrasonic spray technique was found to be a promising technique for producing membrane electrode assemblies with very high electrochemical performance.



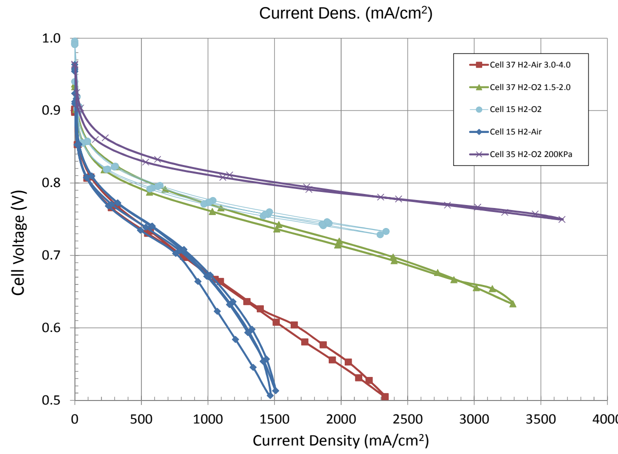


Figure 2. (Top) representative I-V performance of 25cm^2 MEAs tested at different conditions: H_2-Air, H_2-O_2, and H_2-O_2 with pressure; (Bottom) the corresponding IR-corrected I-V curves.