Electrospinning Pt/C Catalysts into a Nanofiber Fuel Cell Cathode

by Wenjing Zhang

There has been considerable research over the past 20 years on new catalysts for proton exchange membrane (PEM) fuel cells. The motivation has been to increase catalytic activity, particularly for the cathode in a hydrogen/air fuel cell. Most fuel cell electrodes are fabricated by a decal method or by air-brushing catalyst-ink onto a carbon paper gas diffusion layer. The Pt catalyst utilization efficiency in such structures, however, is low (~30%). Surprisingly, there has been little research done on new electrode structures and new methods of fabricating fuel cell membrane-electrode-assembly (MEA) with improved catalyst utilization.

In this project, a novel three-dimensional nanofiber fuel cell catalyst morphology has been created by electrospinning. Electrospun nanofiber mats were prepared from an ink of solution of Pt/C powder, Nafion® ionomer, and carrier polymer. Electrospun nanofibers were deposited on a carbon paper GDL substrate that was fixed to a rotating drum collector. From a top-down SEM of the resulting electrospun catalyst mat in Fig. 1a, a uniform distribution of Pt-C catalyst nanoparticles on the surface of the nanofibers can be seen, where the average nanofiber radius is ~400 nm.

To evaluate the performance of the nanofiber catalyst construct, MEAs were fabricated using a Nafion 212 membrane, a decal-processed anode (with a Pt laoding of 0.4 mg/cm^2) and an electrospun nanofiber cathode, where the Pt cathode loading was either 0.4 mg/cm^2 (designated as ES04 in subsequent figures) or 0.2 mg/cm^2 (ES02). For comparison, a third MEA was tested, where both the anode and cathode were prepared by the decal method with a Pt loading for each electrode at 0.4 mg/cm^2 (designated as Decal04). All three MEAs were evaluated in a hydrogen/air fuel cell (5 cm^2 MEA) at 80°C and 100 RH% (without backpressure).

As shown in Table I, ES04 delivers 1080 mA/cm^2 at 0.6 V, with a maximum power density of 705 mW/cm^2. These results represent a 28% improvement in fuel cell performance, as compared to the MEA with a decal cathode and anode. When the Pt-loading of the nanofiber cathode was reduced to 0.2 mg/cm^2, the power output performance was still better than that of Decal04. These preliminary results are very encouraging and show that an electrospun nanofiber electrode morphology can generate more power in a PEM fuel cell than traditional decal-processed electrodes. This innovative approach is being further studied at Vanderbilt University, with a focus on different electrode compositions and morphologies.

Table I: Hydrogen/air fuel cell performance for decal and electrospun (ES) cathode catalyst constructs. Cell temperature was 80°C with 125 sccm H_2 and 500 sccm air (0 psi backpressure). For all tests a decal anode (0.4 mg/cm^2 Pt) was employed.

Cathode	Cathode Pt-loading (mg Pt/cm^2)	Current Density@0.6V (mA/cm^2)	Maximum Power Density (mW/cm^2)
Decal04	0.4	866	550
ES02	0.2	932	610
ES04	0.4	1080	705

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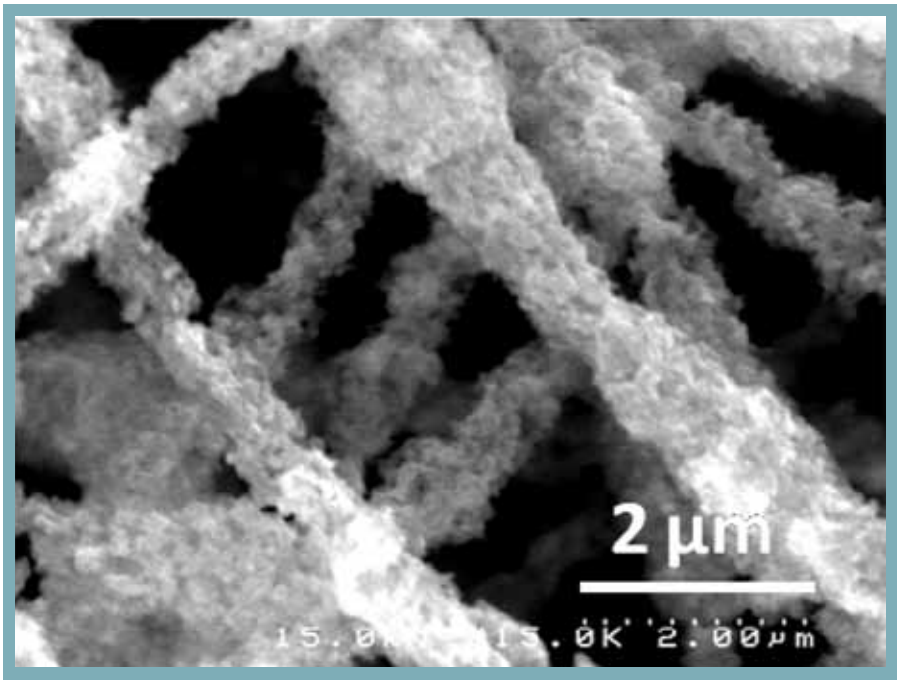

Fig. 1. *SEM images of electrospun nanofibers containing Pt-C and Nafion®.*