PEMFC Reconfigured Anodes for Enhancing CO Tolerance with Air Bleed

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Practical PEM fuel cells based on perfluorinated ionomer membranes (e.g. Nafion) most probably will use reformed fuel as the primary source for the anode feed. Besides hydrogen, the reformate may contain trace amounts of carbon monoxide (CO, from a few to hundreds ppm) which is detrimental to the cell performance. CO strongly adsorbs on the Pt catalyst surface, causing a decrease of the available catalytically active Pt surface area for H_2 electro-oxidation and consequently losses in electrical current that are unacceptable for a practical device.

A technical approach to achieving CO tolerance is to bleed a small amount of air into the anode along with the fuel stream [1]. Oxygen from the air is able to oxidize the CO adsorbed on the catalyst layer to CO_2. The air cleans enough Pt sites, making them available for H_2 electro-oxidation at a sufficient rate.

We present here a variation on this approach, that makes the presence of the air (oxygen) considerably more efficient in keeping the anode catalyst activity. In a conventional PEM fuel cell, all the anode catalyst content is placed directly onto the ionomer membrane. Our modification consists of adding a thin chemical catalyst layer onto the anode gas distribution carbon cloth. In this way, the CO contaminated H_2 , which also contains a small amount of O_2 (from air bleed), will first encounter an outer catalyst layer. This layer will promote the direct chemical oxidation of the CO with O_2, before the fuel stream reaches the internal catalyst layer where the electrochemical oxidation of H_2 takes place.

Fig. 1 shows performances of a FC with a "standard" anode configuration FC. Operation with 100 ppm CO impurity is considerably improved with 2 % air bleed, but the tolerance is only partial. Note also that the Pt loading in the catalyst layer is higher in this case than in subsequent cases. Figure 2 shows the performance of a reconfigured anode (RCA) with equivalent total Pt loading. Part of the Pt in this cell is in the MEA and the rest on the backing. Clearly with this anode configuration, the same amount of air bleed is able achieve full tolerance to 100 ppm CO.

Next, we present results with a RCA whose chemical catalyst layer contains no precious metals. Figure 3 shows performances of a FC with a RCA containing Fe_2O_3 on the carbon cloth backing and a typical anode Pt loading of 0.2 mg Pt cm^{-2}. In this case we achieved almost full tolerance to 100 ppm CO with 4% air bleed.

Other compounds, mostly non-precious transition metal oxides, can also be used as catalysts for the chemical oxidation of CO. The advantages of this method are apparent. First, no major part is added to the system, just a thin composite layer. Second, it works at 80 ^{0}C, the operating cell temperature. And third, the cost of these materials is orders of magnitude lower than Pt. Thus we provide a potential method for achieving CO tolerance while also lowering Pt loading.

References

1. S. Gottesfeld and J. Pafford, *J. Electrochem. Soc.* **135**,2651(1988)

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Figure 1. Polarization curves of a 5 cm^2 cell with a **standard anode**, fed with various fuel compositions at 80 °C Loadings/cm^2 : Anode membrane 0.46 mg **Pt**. Anode backing: no catalyst. Cathode 0.20 mg Pt.
Figure 2. Polarization curves of a H_2/air fuel cell with a **reconfigured anode**, fed with various fuel compositions at 80 °C. Loadings/cm^2 : Anode membrane: 0.18 mg Pt. Anode backing: 0.29 mg Pt. Cathode: 0.20 mg Pt. Cell size: 5 cm^2.
Figure 3. Polarization curves of a H_2/air fuel cell with a **reconfigured anode** at 80 ºC. Loadings/cm^2: Anode membrane: 0.20 mg Pt. Anode backing 0.32 mg $\mathbf{Fe_2O_3}$. Cathode: 0.21 mg Pt. Cell size: 5 cm^2.