

## Fuel Cell Catalyst Screening by Using Powder Microelectrodes

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Anode and cathode catalyst activities have always been one of key issues in fuel cell development. Combinatorial electrochemistry using Borohydride reduction of mixed metal precursors has been advanced to explore efficient catalyst compositions for a direct methanol fuel cell (DMFC)<sup>1</sup>. It is known that catalyst properties are strongly dependent upon the synthesis procedures. The real fuel cell catalyst preparation method is generally different from the one used in combinatorial discovery. Presently many approaches have been developed to synthesize catalysts rapidly, and to generate many types of catalysts by changing experimental conditions. However, a better catalyst discovery is a trial and error process. It is known that the actual catalyst evaluation in a fuel cell is time-consuming. The whole process of catalyst-preparation, MEA fabrication, cell assembling and conditioning, I-E curve measurement with different conditions, etc. may take several days. Therefore a method to efficiently screen real fuel cell catalysts is of great interest.

The powder microelectrode technique was first advanced by Li and Cha<sup>2</sup>. It was then developed for fuel cell catalysis mechanism research<sup>3</sup>. We recently used powder microelectrode methods to demonstrate that the CO-stripping profile for different anode materials can serve to screen fuel cell catalysts. Lower CO-stripping peak and onset potentials indicate the better catalysts for CO-tolerant reformate-air and direct methanol fuel cell anodes. In addition, the oxygen reduction over-potential of powder microelectrodes packed with different cathode materials can provide direct information of fuel cell cathode properties. A number of catalysts can be screened in a short time, without requiring ink preparation and free of any binder effect.

Powder electrodes were prepared by etching a Pt microelectrode tip ( $\phi=110\mu\text{m}$ ) in aqua regia to form a micro-cavity. The cavity was then packed with powder material of interest by grinding its tip onto powder material that had been sprayed onto a flat glass.

Figure 1 shows CO-stripping profiles after adsorbing CO at 0 or 50 mV for 15 minutes and flushing CO in 0.5M H<sub>2</sub>SO<sub>4</sub> with purging N<sub>2</sub> for another 30 minutes. CO-stripping peak potentials are observed in the following order: PtRu(1:1)/C (45wt%) < PtRu(1:1)/W<sub>x</sub>C (23%) < PtRu(1:2)/C (16%) < Pt/C (20%). The above catalysts were evaluated separately (except Pt/C, since it was demonstrated not as good as PtRu by many other experiments) in a direct methanol fuel cell under the same conditions. Since methanol crossover effects may vary between catalysts, the anode polarization curves were used here to compare the activity to the methanol oxidation. The polarization curves were recorded by flowing humidified H<sub>2</sub> (as a dynamic hydrogen

reference) at the cathode side of a DMFC and driving the cell by a series-connected power supply. Interestingly, the same order of methanol oxidation activity for these materials was observed, as shown by current densities at 0.35V in figure 2, where the anode currents were normalized by mass loading assuming 100% catalyst utilization. These data illustrate that CO-stripping behavior is intimately related to fuel cell anode activity. This observation is consistent with CO being the main poisoning intermediate in the methanol oxidation.

### Acknowledgement

This work was supported by the National Science Foundation via the SBIR program.

### References

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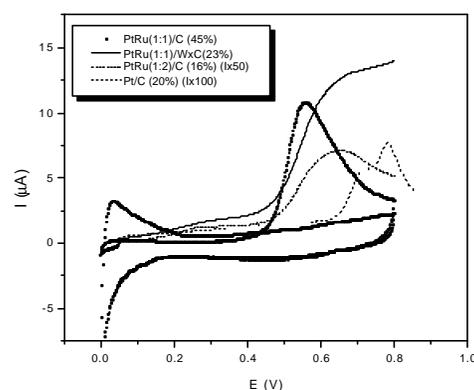


Figure 1. CO-stripping profiles at different powder microelectrodes in 0.5M H<sub>2</sub>SO<sub>4</sub>. Scan rate: 10mV/s.

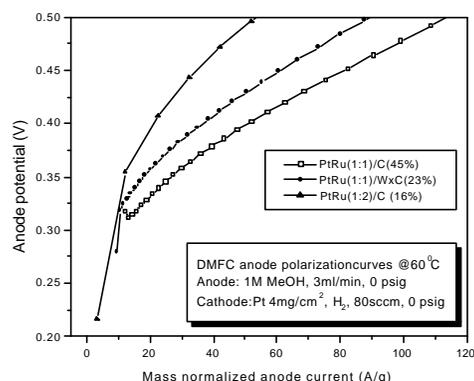


Figure 2. DMFC anode polarization curves with different materials at 60°C.