doi: 10.1017/S1431927609098493
Microsc Microanal 15(Suppl 2), 2009

Direct Methanol Fuel Cell Materials Characterization

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Direct methanol fuel cells (DMFC) utilize methanol as a fuel source. Since methanol has the same energy density as gasoline it has enormous potential as an alternative energy source. Methanol also has a low reforming temperature, and thus gives the system an improved efficiency, lower fuel processing costs, and a longer life for the fuel cell system. Methanol fuel cells have been proposed for use in military and aerospace applications as well as for powering portable consumer electronics. Two important parts of a DMFC are the anode and the cathode. At the anode is where methanol, combined with water, is oxidized into positive hydrogen ions, electrons, and carbon dioxide; $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$. [1] The main objective of this study was to characterize the anode and cathode materials found in a hydro-Genius^{TM} Methanol Fuel Cell (Heliocentris Energiesysteme GmbH, Berlin, Germany).

The DMFC anode and cathode chemical composition was determined using a Hitachi 5570 tungsten filament scanning electron microscope (SEM), operated at 20kV, equipped with an Oxford Instruments, Inc. Silicon Drift Detector (SDD) for X-ray analysis. A Hitachi S4000 field emission SEM (FESEM) operated at 20kV was used for high resolution imaging of the catalyst particles. Combined SEM/SDD multi-length scale analysis was first used to locate the catalyst particles and further characterization identified the materials used in constructing the anode and cathode.

Examination of the X-ray maps of the anode, shown in Figures 1 and 2, showed the presence of Carbon(C), Oxygen(O), Platinum(Pt), Ruthenium(Ru), and Nickel(Ni). At low magnifications the C and O corresponded to the thread like features which made up the bulk of the anode structure. The Ni, Pt, and Ru X-ray signals were present at the low magnification, but were not easily identifiable because of the small area fraction from which they originated. At higher magnification, Figure 2, it was clearly observed that the Pt, Ru and Ni X-ray signals originated from the same micro-scale region of the anode. This indicated that the catalyst particles were a ternary alloy of Pt-Ru-Ni metals. Tertiary catalysts are sometimes used it fuel cells because it cuts down on cost, helps to increase surface area of catalysts, as well as cuts down on the oxidation of the Pt.[2] Analysis of the FESEM images revealed slight differences in the structure of the anode and the cathode. The anode was comprised of crystal-like structures; with catalyst particles dispersed over interweaved fibers. The cathode however showed only the catalyst particles spread on fibers that were intertwined into a porous sponge-like support. From these initial findings we have gained a better understanding of the DMFC construction and have begun to study how changes to the materials can improve the fuel cell power output.

References

[1] O. Zerbanati, J. of Chem. Ed., 79 (2002) 829.
[2] C. Spiegel, Designing & Building Fuel Cells, McGraw-Hill, New York (2007).

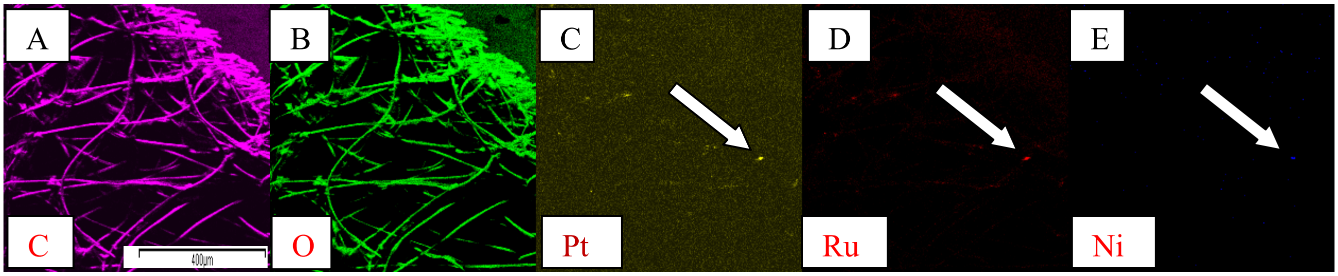

Fig. 1. Shown here are X-ray dot maps of the anode from a Direct Methanol Fuel Cell. A. Carbon is present in the fibers which interweave throughout the anode. B. Oxygen is also present in the fibersof the anode. C. Small Platinum rich regions were present throughout the anode. D. Small Ru rich regions were present in similar regions found in C. E. Nickel was also present in the anode.

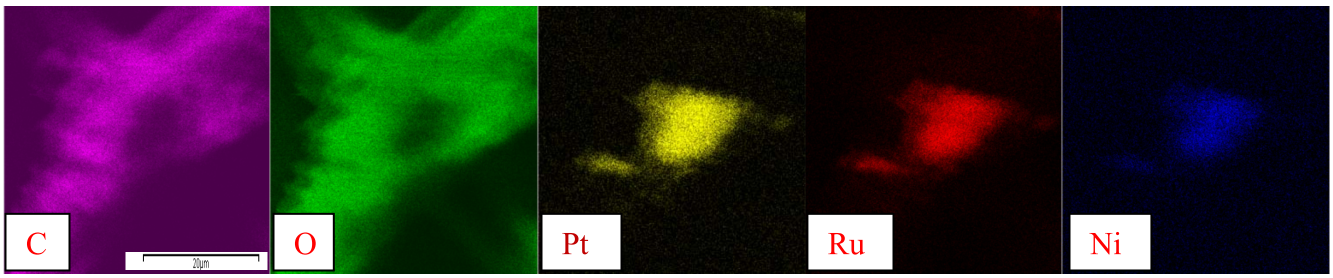

Fig. 2. Higher magnification X-ray dot maps from the region indicated by the white arrows in Fig. 1 revealed the catalyst particles contained in the DMFC anode was a ternary Pt/Ru/Ni alloy.

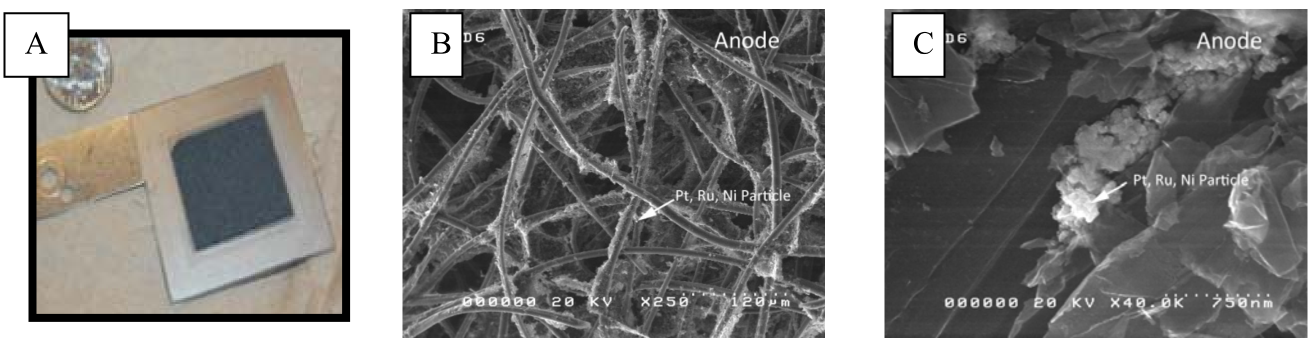

Fig. 3. A. Photograph of the DMFC anode. B. SEM secondary electron (SE) micrograph of fibers that make up the DMFC anode. The arrow points to a catalyst particle. C. Higher magnification SE micrograph of catalyst particles on the fibers of the anode.

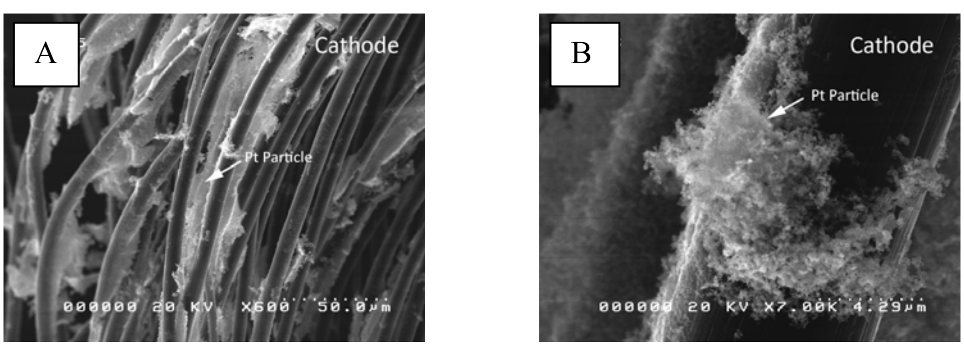

Fig. 4. A. Fibers contained in the DMFC are pictured in the SE micrograph. B. Shown in this SE micrograph are large agglomerates of catalyst particles found dispersed on fibers of the cathode.

https://doi.org/10.1017/S1431927609098493 Published online by Cambridge University Press