A Novel Sol-Gel Based Approach to Synthesize High-Surface-Area Pt-Ru Catalysts as Anodes for Direct Methanol Fuel Cells

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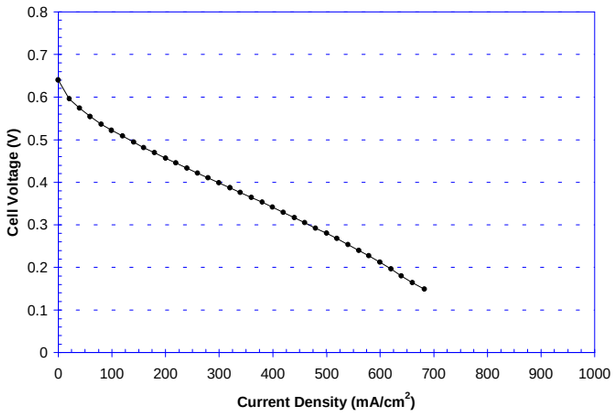
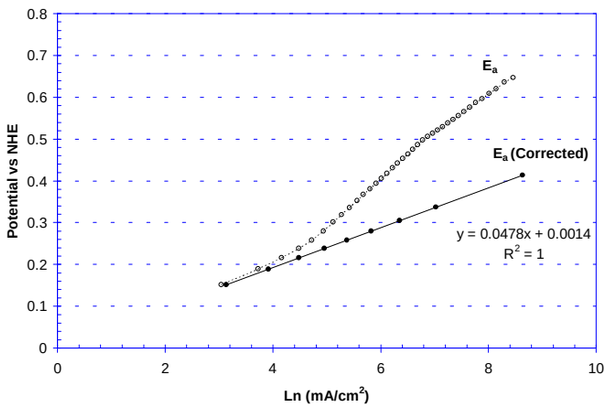
A novel sol-gel based chemical process was developed to synthesize Pt-Ru catalysts possessing high specific surface area and good catalytic activity. In this process, tetramethylammonium hydroxide was used to hydrolyze platinum (II) acetylacetonate and ruthenium (III) acetylacetonate to form a homogeneous gel. Phase-pure powders possessing a high specific surface area as high as 136.9 m^2/g were successfully produced using controlled oxidizing atmospheres such as 1% O_2 balanced with N_2. The resultant powder consists of nanocrystalline Pt-Ru particles (less than 10 nm) and also reveals an excellent catalytic activity, demonstrating the potential of the sol-gel based processes for synthesizing high-performance catalysts for direct methanol fuel cells. The key factor in obtaining phase pure powders with high specific surface area is the controlled removal of carbon species in the as-prepared precursors. The rapid kinetics of carbon removal in air causes the growth of particles as well as the formation of Ru oxide, thus leading to a low specific surface area powder, combined with the segregation of Ru oxide from the homogeneous Pt-Ru precursors. A limited oxidizing ability of the heat treatment atmospheres such as 0.1% O_2 also yields a low specific surface area powder due to the insufficient removal of carbon.

The catalyst powders exhibiting optimum specific surface area of 136.9 m^2/g were tested for their electrocatalytic ability by fabricating a membrane electrode assembly (MEA) and testing in a prototype DMFC test configuration. The loading for both the anode and the cathode was in the range of 7 to 11 mg/cm^2. Figure (a) below shows the performance of the catalyst when tested in a MEA. A peak power density of 140 mW/cm^2 was obtained at a cell voltage of 0.305 V at an applied current density of 460 mA/cm^2. Plot (b) below also shows the anode performance of the MEA as a function of the applied current density. The Tafel slope, calculated in the current range of 20 to 180 mA/cm^2, of this MEA is on the order of 110 mV/decade. Results of the synthesis and characterization of these sol-gel derived catalyst will be presented and discussed. A comparison of these test results with other commercial catalysts tested under similar conditions will also be made.



(a)



(b)

Fig. Results of electrochemical testing conducted on MEAs fabricated from the sol-gel derived catalyst; (a) Voltage-Current Characterization (b) Anode Polarization. (90 ^oC, 1**M** methanol)