

Development of a Novel CO Tolerant Anode

Andrew T. Haug, Ralph E. White and John W. Weidner

Center for Electrochemical Engineering, Department of
Chemical Engineering
University of South Carolina, SC 29208
Columbia, South Carolina

and Wayne Huang
Plug Power, Inc.
968 Albany-Shaker Road
Latham, NY 12110

Proton-exchange membrane fuel cells (PEMFCs) are gaining popularity due to their benefits such as environmental friendliness and increased fuel efficiency. Because of the difficulties inherent to storing hydrogen, liquid fuels are reformed into hydrogen rich gas. This reformat also contains carbon monoxide that has been shown to poison the platinum catalyst used in PEMFC systems at concentrations as low as 10 ppm (1-4).

Attempts to find catalysts both tolerant to CO and equivalent in performance to Pt have led to the alloying of Pt with Ru, Mo, W, Co, Ir, Ni and Sn (4-9). Most attempts at developing CO tolerant catalysts involve alloying metals such as Ru, Sn and Mo with Pt to combine the high performance of Pt with the CO tolerance provided by the second species.

The hypothesis of this paper is that by placing a layer of carbon-supported Ruthenium between the Pt catalyst and the anode flow field to form a filter, tolerance to CO will be increased relative to a Pt:Ru alloy when oxygen is added to the anode fuel stream. A schematic of this is shown in Figure 1. The slow H₂ kinetics of Ru in this filter would become an advantage compared to Pt and Pt:Ru alloy anodes, allowing a greater percentage of O₂ to oxidize adsorbed CO to CO₂ rather than reacting with adsorbed hydrogen to form water.

50 cm² MEAs, containing Pt, Pt:Ru alloy, and Pt + Ru filter anodes were tested at 70 °C and a stoichiometric ratio ([actual flow]/[stoichiometric flow]) required for a 1.0 A/cm² current) of 1.5 at the anode and 2.0 at the cathode.

Figure 2 shows that for an anode feed stream consisting of reformat (containing 50 ppm CO) and 1 vol. % oxygen, the Pt + Ru filter electrode shows increased CO tolerance compared to a Pt:Ru alloy containing similar amounts of Pt and Ru. For CO concentrations up to 100 ppm and 2 vol. % O₂, the Pt + Ru filter anode also shows superior performance. This is because the decreased hydrogen kinetics of the Ru allow for more oxygen to be used to oxidize adsorbed CO to CO₂, rather than react with H⁺ to form water.

The oxygen in the anode feed stream was found to form a hydroxyl species within the filter. The reaction of these hydroxyl groups with adsorbed CO was the primary means of CO oxidation within the filter, forming a proton in the process. Because of this proton formation, Nafion must be present in the filter to provide the necessary aqueous phase for the proton transport. Thus, the Ruthenium filter must be placed in front of and adjacent to the Pt electrode to provide the necessary path for the protons to conduct to the membrane, and hence achieve the maximum benefit from the filter.

However, with insufficient oxygen (< 1 vol. %) or too much CO (>100 ppm), not all CO is oxidized in the Ru filter. The remaining CO reaches and then poisons the

Pt region of the Pt + Ru filter anode. As a result, cell performance under those conditions is worse than the Pt:Ru alloy anode.

Because benefits of the Ru filter occur at high levels air bleed (2% O₂) and the Pt:Ru alloy provides CO tolerance even without air bleed, it is suggested that the anode configuration that would provide optimal CO tolerance would consist of a Ru filter placed in front of and adjacent to a Pt:Ru alloy.

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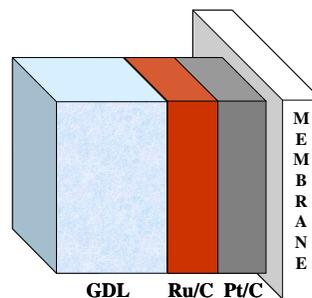


Figure 1. Diagram of the Ru Filtered Anode. The feed gases pass through the GDL and comes in contact with the Ru filter before reaching the Pt anode. The Ru Filter acts as a chemical barrier on which O₂ oxidizes the CO present in the feed stream to CO₂, preventing a loss in the Pt anode performance due to CO poisoning.

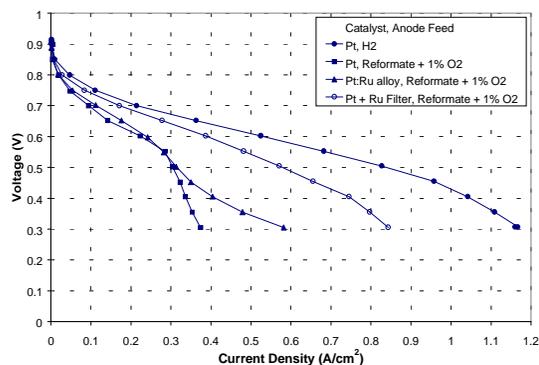


Figure 2. Single cell performance comparison of Pt, Pt:Ru and Pt + Ru filter for an anode feed of reformat + 1 % O₂ bleed. P = 1 atm, T = 70°C.