DEVELOPMENT OF NOVEL ELECTROCATALYSTS FOR PROTON EXCHANGE MEMBRANE FUEL CELLS

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ABSTRACT

The present state-of-art Proton-Exchange Membrane Fuel Cell (PEMFC) technology is based on platinum (Pt) as a catalyst for both the fuel and the air electrodes. This catalyst is highly active but susceptible to poisoning by fuel impurities such as, S and CO, which may be present in the fuel used or may be introduced during the fuel processing such as, reforming. These impurities poison the anode irreversibly and decrease the performance of the PEMFCs. This irreversible poisoning of the anode can happen even in CO concentrations as low as few ppm, and therefore, require expensive scrubbing of the H_2-fuel to reduce the contaminant concentration to acceptable level. In order to commercialize this environmentally sound source of energy/power system, development of suitable CO-tolerant catalyst is needed. The cost and reliability of electro-catalyst in PEMFCs are major impediments in commercial application.

The major objective of this work was to develop low-cost CO-tolerant electro-catalysts for PEMFCs and demonstrate the feasibility of an H_2/air fuel cell based on these materials. Part of the work is focused on developing procedure for preparing metal catalysts loaded on carbon matrix. Novel catalysts are combined with the known high activity of the Pt and other noble/transition metals, such as Pt/Ru, Pt/Mo, Pt/Ru/Mo, and Pt/Ir.

In this work, we have synthesized several novel electrocatalysts (Pt/C, Pt/Ru/C Pt/Mo/C, Pt/Ir and Pt/Ru/Mo) for PEMFCs. These catalysts have been tested for CO tolerance in the H_2/air fuel cell. The concentration of CO in the H_2 fuel varied from 10 ppm to 100 ppm. The performance of the electrodes was evaluated by determining the cell potential against current density. The effect of temperature, catalyst compositions, and electrode film preparation methods on the performance of PEM fuel cell has also been studied. It was found that at 70 ^{0}C and 3.5 atm

pressure at the cathode, Pt-alloy catalysts (10 wt % Pt/Ru/C, 20 wt % Pt/Mo/C) were more CO-tolerant than 20 wt % Pt catalyst alone. From this preliminary study we conclude that to develop low cost CO-tolerant catalysts for use in PEMFC, one needs to include metals like Ru and Mo in combination with Pt in the catalyst formulation. The metal Ir in combination with Pt in the catalyst did not have any significant impact on cell performance. For optimum cell performance, fine-tuning of these metal compositions in the catalyst would be necessary. Work is in progress to fine-tune the compositions of Pt/Ru/C, Pt/Ru/Mo/C and Pt/Mo/C in the catalyst formulations.

List of Published Journal Articles, Completed Presentations and Students Receiving Supports from the Grant:

Journal Articles:

1. Sharmin, S., Schimmel, K.A., and Ilias, S., "Synthesis and Evaluation of CO-Tolerant Novel and Transition Metal-alloy Electro-catalysts for PEMC Electrodes," In Preparation for J. Electrochem. Soc., (2001).

Presentations:

1. Sharmin, S., Schimmel, K.A., and Ilias, S., "Synthesis and Evaluation of CO-Tolerant Novel and Transition Metal-alloy Electro-catalysts for PEMC Electrodes," 2000 AIChE Annual Meeting, Los Angles, California, November 12-17, 2000.
2. Sharmin, S., Schimmel, K.A., and Ilias, S., "Development of Novel Electrocatalysts for Proton Exchange Membrane Fuel Cells," US DOE HBCU/OMI Annual Symposium, Pittsburgh, Pennsylvania, June 8-9, 2000.
3. Sharmin, S., Schimmel, K.A., and Ilias, S., "Development of Novel Electrocatalysts for Proton Exchange Membrane Fuel Cells," 11th Annual Conference, North American Membrane Society (NAMS), Boulder, Colorado, May 23-27, 2000.

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