MONDAY, AUGUST 22, 2005, P.M.

SESSION 2A: INTERNATIONAL SYMPOSIUM ON FUEL CELL AND HYDROGEN TECHNOLOGIES

PEMFC DIAGNOSTICS & EVALUATION
Sponsor(s): Materials Science and Engineering Section, The Metallurgical Society of CIM
Room: Walker
Chairmen: H. WANG and J. SHEN, NRC Institute for Fuel Cell Innovation, Canada

PAPER 2A.1 — 14:00
KINETIC DATA FOR METHANOL OXIDATION AT DIFFERENT TEMPERATURES USING A NEW AND IMPROVED ELECTROCHEMICAL CELL DESIGN.
R. BAKER, Z. XIE, J. ZHANG, NRC Institute for Fuel Cell Innovation, Canada, and
D.P. WILKINSON, University of British Columbia, Canada
A novel electrochemical half-cell and corresponding working electrode were designed to evaluate the electro-catalytic activities of catalysts in an environment close to that of an operating proton exchange or polymer electrolyte fuel cell (PEMFC). Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) techniques were employed using the novel cell to characterize various methanol electro-oxidation parameters that contribute to the overall reaction on a fuel cell anode. The effect of temperature on methanol oxidation kinetics was examined in the potential range of 0.31 to 0.65V (vs. NHE). The data was collected in the temperature range of 20 to 80^{o}C. Based on the experimental analysis and literature data, an equivalent circuit model (ECM) for methanol oxidation was proposed and was used to fit the EIS experimental data. The experimental data and ECM electrochemical data was used to extract electrochemical kinetic parameters for methanol oxidation such as the exchange current density, Tafel slope, and energy of activation for the reaction. Kinetic data, especially at different temperatures, is very limited in the literature.

PAPER 2A.2 — 14:20
CONTROL OF CROSSOVER IN DIRECT METHANOL FUEL CELLS THROUGH FUEL CELLS THROUGH FUEL MODIFICATION.
A. LAM and D.P. WILKINSON University of British Columbia, Canada
The use of a liquid fed direct methanol fuel cell (DMFC) as a power source for micro and small portable applications is attractive due to its system simplicity, low temperature, etc. The aqueous methanol is directly oxidized and does not require additional fuel processing steps as in reformate based PEM fuel cells. In addition, the use of a liquid fuel is advantageous with respect to humidification, stack cooling and system energy density. The DMFC however, has technological issues that must be addressed before it can be widely adopted, particularly in larger applications such as small utility and transportation. At present, the crossover of methanol from the anode to the cathode is a major limitation on DMFC performance and fuel utilization efficiency. In this paper we discuss the influence of fuel modification on the control of crossover. This involves the use of different fuel additives and concentrations to minimize crossover. This appears to be the first reported case of the use of fuel modification (additives) to reduce methanol crossover. The rate of methanol permeation under passive conditions is discussed with respect to the different conditions.

PAPER 2A.3 — 14:40
WATER TRANSFER FACTOR MEASUREMENT APPARATUS FOR PEM FUEL CELLS.
P. SAURIOL and T. BI, University of British Columbia, Canada
J. STUMPER, Ballard Power Systems, Canada
D. NOBES and D. KIEL, Coanda Research and Development Corporation, Canada
This paper addresses the design challenges and demonstrates the capabilities of a novel water transfer factor (ratio of water transferred to water produced) measurement apparatus. Several measurement concepts are screened on the basis of their water transfer factor accuracy using a Monte-Carlo approach. The most promising concept was assembled and tested to assess its actual measurement accuracy. For these tests, the fuel cell and water transfer factor are simulated by an equivalent liquid water injection into the anode and cathode streams. Combining anode and cathode measurements, the simulated water transfer factor accuracy was typically better than 0.01. Finally tests with a running fuel cell have been conducted to determine water transfer factor and compare it with model predictions.

PAPER 2A.4 — 15:20

DIAGNOSIS OF A HIGH TEMPERATURE PEM FUEL CELL BY ELECTROCHEMICAL AC IMPEDANCE SPECTROSCOPY.

Y. TANG, Z. XIE, T.VANDERHOEK, K. SHI, J. ZHANG, H. WANG, NRC International Fuel Cell Innovation, Canada,
S. HOLDCROFT, Simon Fraser University, Canada and
D.P. WILKINSON, University of British Columbia, Canada

In this paper, the use of electrochemical AC impedance spectroscopy (EIS) for in-situ diagnosis of high temperature PEM fuel cells is described. EIS was performed on single cell hardware, built in-house, using a fuel cell test station modified to operate up to 150^{o}C and 30 psig. Electrode kinetics, membrane resistance, porous-layer and mass transport impedance of MEAs, assembled in-house, were measured at various current densities for the purpose of validating the test station and cell hardware, and for optimizing MEA and flow-field designs. The effect of temperature and humidity on the various impedances was investigated. Impedances obtained at lower and higher temperatures were compared to obtain insight into the issue of water management in operating fuel cells.

PAPER 2A.5 — 15:40

METHANOL CONCENTRATION SENSOR FOR DIRECT METHANOL FUEL CELL SYSTEMS: A REVIEW.

H. ZHAO, J. SHEN, J. ZHANG, H. WANG, C. GU, NRC International Fuel Cell Innovation, Canada and
D.P. WILKINSON, University of British Columbia, Canada

Direct methanol fuel cells have been the subject of considerable research in the last decade. Performance levels realized in cells, stacks, and systems show that this technology is a promising power source for a wide range of portable applications. A direct methanol fuel cell (DMFC) operates directly on a methanol fuel stream typically supplied as a methanol/water vapour or as an aqueous methanol solution in liquid feed DMFCs. The fuel streams in DMFCs are usually recirculated in order to remove carbon dioxide and to re-use the diluent and any unreacted fuel in the depleted fuel stream exiting the DMFC. The concentration of methanol in the fuel circulation loop is an important operating parameter because it determines the electrical performance and efficiency of the direct methanol fuel cell system. The methanol concentration in the circulating fuel stream is usually measured continuously with a suitable sensor, and fresh methanol is admitted in accordance with the signal from the sensor. There are many factors to consider in developing a methanol sensor suitable for DMFCs. These factors include sensitivity, cost, size, simplicity, reliability, longevity, concentration range, and dynamic response. In particular, reliability and low cost should be addressed. Methanol concentration sensors measure methanol concentration by means of detecting the variations of physical/chemical properties of the solution. In this work, methanol concentration sensors based on electrochemistry, electric-capacitance measurement, infrared sensing, ultrasound sensing, and other techniques are reviewed to discuss their advantages and disadvantages.

COFFEE BREAK — 15:40 – 16:00