
Durability and Reliability of Low-Temperature Fuel Cells Systems

Editors:

T. D. Jarvi

UTC Fuel Cells
South Windsor, Connecticut, USA

H. A. Gasteiger

General Motors - Fuel Cell Activities
Honeoye Falls, New York, USA

S. Cleghorn

W L Gore & Associates
Elkton, Maryland, USA

Sponsoring Division:



Physical and Analytical Electrochemistry



Published by
The Electrochemical Society

65 South Main Street, Building D
Pennington, NJ 08534-2839, USA

tel 609 737 1902
fax 609 737 2743

www.electrochem.org

ecstransactions™

Vol. 1 No. 8

ISBN 1-56677-491-8

Copyright 2006 by The Electrochemical Society, Inc.
All rights reserved.

This book has been registered with Copyright Clearance Center, Inc.
For further information, please contact the Copyright Clearance Center,
Salem, Massachusetts.

Published by:

The Electrochemical Society, Inc.
65 South Main Street
Pennington, New Jersey 08534-2839, USA

Telephone 609.737.1902
Fax 609.737.2743
e-mail: ecs@electrochem.org
Web: www.electrochem.org

ISBN 1-56677-491-8

Printed in the United States of America

ECS Transactions, Volume 1, Issue 8
Durability and Reliability of Low-Temperature Fuel Cells Systems

Table of Contents

Preface iii

Section 1
Catalyst and Catalyst Support Durability in PEMFCs

*Durable PEM Fuel Cell Electrode Materials: Requirements and Benchmarking Methodologies <i>R. Makharia, S. Kocha, P. Yu, M. Sweikart, W. Gu, F. Wagner, and H. A. Gasteiger</i>	3
*Durability and Degradation in High-Temperature Polymer Electrolyte Fuel Cells <i>T. J. Schmidt</i>	19
Characterization of Support Corrosion in PEM Fuel Cell: Improved Durability of Carbon Nanotube Based Electrode <i>Y. Yan, X. Wang, W. Li, Z. Chen, and M. M. Waje</i>	33
Electrochemical Oxidation Resistance of Carbonaceous Materials <i>M. R. Dowlapalli, P. Atanassov, J. Xie, and G. Rice</i>	41
Durability Aspects of Nanostructured Thin Film Catalysts for PEM Fuel Cells <i>M. K. Debe, A. Schmoekkel, S. Hendricks, G. Vernstrom, G. Haugen, and R. Atanasoski</i>	51
Electrocatalyst Stability In PEMFCs And The Role Of Fuel Starvation And Cell Reversal Tolerant Anodes <i>T. R. Ralph, S. Hudson, and D. Wilkinson</i>	67
Consumption of Pt Catalyst under Electrolysis and Fuel Cell Operation <i>S. Kawahara, S. Mitsushima, K. Ota, and N. Kamiya</i>	85

Section 2
Impact of Contaminants on PEMFC Durability

Impact of Sulfur Dioxide on the Performance of PEMFC Cathodes <i>J. J. Pietron and K. Swider-Lyons</i>	103
Hydrogen Sulfide Kinetics on PEM Fuel Cell Electrodes <i>J. W. Weidner, V. A. Sethuraman, S. Balasubramanian, and L. Wise</i>	111
A Model for SO ₂ Impurity in Air Fed to a Proton Exchange Membrane Fuel Cell <i>W. Wang, W. Lee, and J. Van Zee</i>	131

Section 3
Pt and Pt-Alloy Degradation Mechanisms in PEMFCs

Enhanced Stability of PtCo catalysts for PEMFC <i>S. C. Ball, B. Theobald, D. Thompsett, and S. Hudson</i>	141
Fuel Cell Catalyst Particle Size Growth Characterized by X-Ray Scattering Methods <i>F. H. Garzon, J. Davey, and R. Borup</i>	153
Stability and Dissolution of the Platinum Single Crystal Surfaces in Perchloric Acid <i>V. Komanicky, K. Chang, A. Menzel, H. You, X. Wang, D. Myers, and N. Markovic</i>	167
*Coarsening of Pt Nanoparticles in Proton Exchange Membrane Fuel Cells upon Potential Cycling <i>Y. Shao-Horn, P. Ferreira, G. la O', D. Morgan, H. A. Gasteiger, and R. Makharia</i>	185

Section 4
PEMFC Membrane Degradation Mechanisms

**Polymer Electrolyte Membrane Degradation Mechanisms in Fuel Cells - Findings Over the Past 30 Years and Comparison with Electrolyzers <i>A. Laconti, H. Liu, C. Mittelsteadt, and R. McDonald</i>	199
Development of Highly Durable MEA for PEMFC under High Temperature Operations (2) <i>E. Endoh, H. Kawazoe, and H. Nakagawa</i>	221
Accelerated Testing and Lifetime Modeling for the Development of Durable Fuel Cell MEAs <i>M. Hicks, D. Pierpont, P. Turner, and T. Watschke</i>	229
*Aspects of PEMFC Degradation <i>S. F. Burlatsky, V. Atrazhev, N. Cipollini, D. Condit, and N. Erikhman</i>	239

Section 5
Operating Conditions and Catalyst Impact on Membrane Degradation

*High Durability of Asahi Kasei Aciplex Membrane <i>N. Miyake, M. Wakizoe, E. Honda, and T. Ohta</i>	249
*Effect of Relative Humidity on Membrane Durability in PEM Fuel Cells <i>W. Liu and S. Cleghorn</i>	263
Outstanding Student/Post-doc Presentation Award Recipient: Factors Accelerating Membrane Degradation Rate and the Underlying Degradation Mechanism in PEMFC <i>V. Mittal, R. Kunz, and J. Fenton</i>	275
Factors Impacting Chemical Degradation Of Perfluorinated Sulfonic Acid Ionomers <i>H. Liu, H. A. Gasteiger, A. Laconti, and J. Zhang</i>	283

H ₂ O ₂ Formation Mechanism in PEMFC <i>V. Mittal, R. Kunz, and J. Fenton</i>	295
*Strategies for Mitigation of PFSA Polymer Degradation in PEM Fuel Cells <i>G. Escobedo, K. Raiford, G. S. Nagarajan, and K. E. Schwiebert</i>	303

Section 6
Materials Characterization with Respect to Membrane Degradation

*Hydrogen Peroxide Formation as a Degradation Factor of Polymer Electrolyte Fuel Cells <i>M. Inaba, H. Yamada, J. Tokunaga, K. Matsuzawa, A. Hatanaka, and A. Tasaka</i>	315
Methodology to Understand the Degradation Mechanism of Nafion Membrane in PEM Fuel Cells <i>J. Kim, L. Waller, G. Barbastathis, and Y. Shao-Horn</i>	323

Section 7
PEMFC Stack and System Membrane Degradation/Reliability

**Applying the Lessons Learned from PAFC to PEM Fuel Cells <i>T. Fuller, M. Perry, and C. Reiser</i>	337
Carbon Corrosion Induced by Partial Hydrogen Coverage <i>T. Fuller and G. Gray</i>	345
Flow Control in a Fuel Cell Flow Field for Improved Performance and Reliability <i>M. Blanco, D. Wilkinson, G. Yan, H. Wang, and H. Zhao</i>	355
New Approach for Detection of Different Critical Stack Operating Conditions for Large Volume Fuel Cell Applications <i>E. Ramschak, V. Peinecke, P. Prenninger, W. Baumgartner, T. Schaffer, and V. Hacker</i>	367
Accelerated Life Tests for Fuel Cells <i>M. J. Heneka and E. Ivers-Tiffée</i>	377
*PEMFC Stack Field Experiences <i>A. Maekawa and T. Aoki</i>	385

Section 8
PEMFC Freeze Degradation

Freeze/Thaw Effects in PEM Fuel Cells <i>R. Mukundan, Y. Kim, F. H. Garzon, and B. Pivovar</i>	403
---	-----

Outstanding Student/Post-doc Presentation Award Recipient: 1-D Transient Model of Shutdown to a Frozen State in a Polymer Electrolyte Fuel Cell <i>M. Mench and S. He</i>	415
--	-----

Section 9
DMFC Durability

Ruthenium Crossover in DMFCs Operating with Different Proton Conducting Membranes <i>P. Zelenay, Y. Kim, R. Bashyam, and J. Choi</i>	437
Performance of DMFC with TiN Coated Aluminum Bipolar/End Plates <i>B. R. Padhy, R. G. Reddy, and E. Ada</i>	447
Durability of Membrane-Electrode Interface under DMFC Operating Conditions <i>Y. Kim and B. Pivovar</i>	457
Durability Evaluation of Direct Methanol Fuel Cells <i>R. Jiang and D. Chu</i>	469
*Performance Durability of Direct Methanol Fuel Cells <i>P. Zelenay</i>	483
Author Index	497

* *Invited Papers*

** *Keynote Presentation*