

Hydrogen Production and Storage

Topical Conference at the 2010 AIChE Annual Meeting

**Salt Lake City, Utah, USA
7-12 November 2010**

ISBN: 978-1-61782-139-4

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2010) by AIChE
All rights reserved.

Printed by Curran Associates, Inc. (2011)

For permission requests, please contact AIChE
at the address below.

AIChE
3 Park Avenue
New York, NY 10016-5991

Phone: (203) 702-7660
Fax: (203) 775-5177

www.aiche.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2634
Email: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

Compact Hydrogen Storage with Extended Dormancy In Cryogenic Pressure Vessels	1
<i>Salvador M. Aceves</i>	
Evaluation of Sorption System for Hydrogen Storage	2
<i>Richard Chahine</i>	
JHFC (Japan Hydrogen and Fuel Cell) Demonstration Project — Current Status Report	3
<i>Jinichi Tomuro</i>	
Development of Hydrogen Storage Technique for Fuel Cell Vehicle	4
<i>Kenji Komiya</i>	
Development of "Hybrid Hydrogen Tank" for Fuel Cell Vehicles	5
<i>Shigeru Tsunokake, Tatsuya Fuura, Kazuya Takahashi, Yoshiki Sakaguchi, Etsuo Akiba, Kohta Asano, Hiroyuki Mitsuishi, Masanori Monde, Yuichi Mitsutake</i>	
Testing of Hydrogen Storage Tank Based On 8 Kg NaAlH₄	9
<i>Oliver Metz, José Bellosta Von Colbe, Gustavo Lozano, Julian Jepsen, Martin Dornheim, Thomas Klassen</i>	
Adsorbents for Hydrogen Delivery	10
<i>Pascal Tessier, Frederic Barth, Sylvain Houle, Yudong Chen, Richard Chahine</i>	
Overview: Development and Safety Test of Low Pressure and Hybrid Metal Hydride Tanks Under Japanese National Projects	11
<i>Etsuo Akiba, Kohta Asano, Yoshinori Tsushio, Hiroyuki Mitsuishi, Kazuya Takahashi, Yoshiki Sakaguchi, Tatsuya Fuura, Shigeru Tsunokake</i>	
Mitigation Technologies for Hydrogen Storage Systems Based On Reactive Solids	12
<i>Daniel E. Dedrick, Michael P. Kanouff, Joseph G. Cordaro, Yehia F. Khalil</i>	
Potential Diffusion-Based Failure Modes of Hydrogen Storage Vessels for On-Board Vehicular Use	14
<i>Yehia F. Khalil, Norman L. Newhouse, Kevin L. Simmons, Daniel E. Dedrick</i>	
Fundamental Reactivity Analysis of Hydrogen Storage Materials	15
<i>David A. Tamburello, Charles W. James Jr., Jose A. Cortes-Concepcion, Donald Anton</i>	
Environmental Reactivity of Solid-State Hydrogen Storage Systems: Fundamental Testing and Evaluation	16
<i>Charles W. James Jr., Jose A. Cortes-Concepcion, David A. Tamburello, Kyle S. Brinkman, Joshua R. Gray, Donald Anton</i>	
A System Modeling Approach for Light-Duty Vehicles and On-Board Hydrogen Storage Systems	17
<i>Kristin L. Day, Matthew J. Thornton, Aaron D. Brooker</i>	
System Simulation Models for On-Board Hydrogen Storage Systems	18
<i>Sudarshan Kumar, Mandhapati Raju, V. Senthil Kumar</i>	
System Modeling Methodology and Analyses for Materials-Based Hydrogen Storage	19
<i>Daniel Mosher, Jose Miguel Pasini, Bart Van Hassel</i>	
On-Board and Off-Board Performance of Hydrogen Storage Options	20
<i>Rajesh K. Ahluwalia, Thanh Q. Hua, J.-K. Peng</i>	
Optimization of Metal Hydride Based Hydrogen Storage Bed Designs	23
<i>Mandhapati Raju, Sudarshan Kumar</i>	
Modeling of Self-Hydrolysis of Concentrated Sodium Borohydride Solution	24
<i>Rajasree Retnamma, Carmen Rangel, Augusto Novais, Lin Yu, Michael A. Matthews</i>	
Ammonia Borane Dehydrogenation Always Generates Ammonia, How Much and How to Remove It?	28
<i>Ahmad Al-Kukhun, Hyun Tae Hwang, Arvind Varma</i>	
Critical Loading Level for Low-Temperature, Simultaneous Release of Two Equivalents of Hydrogen From Ammonia Borane Nanocomposites	29
<i>Junsheng Zhang, Yu Zhao, Daniel L. Akins, Jae W. Lee</i>	
Dihydrogen Catalysis Assisted by Molecular Hydrogen Reactions: Storage Linked Processes and Possible N₂-Activation	30
<i>Joseph Bozzelli, Rubik Asatryan</i>	
Energetically Self-Sufficient Coproduction of Hydrogen and Formic Acid	33
<i>Jorge Pena Lopez, Vasilios I. Manousiouthakis</i>	
Research and Development of Hydrogen Storage Materials for Lightweight Tanks	34
<i>Yoshitsugu Kojima, Takayuki Ichikawa</i>	
High Capacity Metal Hydrides — Development towards Scaled up Tanks and Economical Evaluation	36
<i>José Bellosta Von Colbe, Julian Jepsen, Gustavo Lozano, Oliver Metz, Thomas Klassen, Martin Dornheim</i>	
Sorption Kinetics and Catalysis of 1:1 LiNH₂:MgH₂	37
<i>Donald Anton, Christine J. Erdy, Joshua Gray</i>	

Engineering Advances in NaAlH₄-Based Hydrogen Storage System	39
<i>Bart Van Hassel, Daniel Mosher, Jose Miguel Pasini, Mikhail B. Gorbounov, John E. Holowczak, Xia Tang, Ronald J. Brown</i>	
Storing Hydrogen Using (Ti,V)-Based Bcc Materials	40
<i>Michel Latroche, Blaise Massicot, Jean-Marc Joubert</i>	
Overview of Los Alamos National Laboratory's Engineering Research Efforts for On-Board Hydrogen Release From Chemical Hydrides	41
<i>Troy Semelsberger</i>	
Chemical Hydrogen Storage Center of Excellence	42
<i>Kevin C. Ott</i>	
Dehydrogenation Kinetics and Catalysis for Hydrogen Recovery From Organic Heteroaromatic Compounds for Hydrogen Storage	43
<i>Farnaz Sotoodeh, Benjamin Huber, Kevin J. Smith</i>	
Dynamic Modeling and Simulation of Ammonia Borane Hydrogen Storage Systems	51
<i>Ewa Ronnebro, Maruthi Devarakonda, Kriston Brooks, Scot Rassat, Darrell Herling</i>	
Hydrogen Generated From Hydrolysis of Ammonia Borane Using Cobalt and Ruthenium Based Catalysts	57
<i>Cheng-Hong Liu, Yi-Chun Wu, Bing-Hung Chen, Chan-Li Hsueh, Jie-Ren Ku, Fanghei Tsau</i>	
Hydrogen Liberated by Sodium Borohydride Hydrolysis: Kinetics and Material Properties in the Limited Water Regime	59
<i>Lin Yu, Amy M. Beaird, Ping Li, Karl Johnson, Rajasree Retnamma, Michael A. Matthews</i>	
Achieving Optimal Hydrogen Storage In MOF-5	62
<i>Andrea Sudik, Jun Yang, Justin Purewal, Donald J. Siegel, Emi Leung, Ulrich Mueller</i>	
Improving Comparability of Hydrogen Storage Capacities of Nanoporous Materials	63
<i>Valeska P. Ting, Nuno Bimbo, Anna Neczaj-Hruzewicz, Laura Fisher, Sean P. Rigby, Andrew D. Burrows, Timothy J. Mays</i>	
Thermal Stability of Nanopores in Palladium Alloys and Their Hydrides	64
<i>David B. Robinson, Markus D. Ong, Benjamin W. Jacobs, Mary E. Langham, Michael S. Kent, Ilke Arslan</i>	
Facilitating Dehydrogenation of Complex Hydride Hydrogen Storage Materials Using a CNTs-Based Catalytic Matrix	65
<i>Sean S.-Y. Lin, Jun Yang, Xin Zhao, Harold H. Kung</i>	
Carbon Nanostructures as Catalyst for Improving the Hydrogen Storage Behaviour of Complex Aluminium Hydride	66
<i>M. Sterlin Leo Hudson, Himanshu Raghubanshi, D Pukazhselvan, O. N. Srivastava</i>	
Hydrogen Storage and Effects of Cycling On Li-Based Hydrides	73
<i>Wen-Ming Chien, Joshua Lamb, Dhanesh Chandra</i>	
Hydrogen Absorption-Desorption Cycle Durability and CO Tolerance of Hydrogen Absorbing Alloys Developed in WE-NET Project	75
<i>Hideaki Tanaka, Kenji Aihara, Tomoyuki Miyata, Naoki Taoka, Kozo Mori, Teruo Kaneko, Nobuhiro Kuriyama</i>	
Hydrogen Storage System Using LiBH₄	76
<i>Hiroyuki T. Takeshita, Toyokazu Eguchi, Masanori Hayakawa, Makoto Ikeda</i>	
Hydrogen Purification and Storage System Using Metal Hydride	77
<i>Shinichi Miura, Akitoshi Fujisawa, Masayoshi Ishida</i>	
Optimization of Hydrogen Storage Tanks: The Case of Sodium Alanate	78
<i>Gustavo Lozano, Chakkrit Na Ranong, José Bellosta Von Colbe, Rüdiger Bormann, Jobst Hapke, Georg Fieg, Thomas Klassen, Martin Dornheim</i>	
Modeling of Adsorbent Based Hydrogen Storage Systems	79
<i>Bruce Hardy, Claudio Corgnale, Richard Chahine, Marc-André Richard, David A. Tamburello, Stephen Garrison, Donald Anton</i>	
Model Based Design of An Automotive-Scale, Metal Hydride Hydrogen Storage System	80
<i>Terry A. Johnson, Daniel E. Dedrick, Michael P. Kanouff, Gregory H. Evans, Scott W. Jorgensen</i>	
Scaled up LiBH₄ - MgH₂ Composite Storage System as New Promising Hydrogen Storage	81
<i>Julian Jepsen, José Bellosta Von Colbe, Ulrike Bösenberg, Gustavo Lozano, Thomas Klassen, Martin Dornheim</i>	
Evaluation of Acceptability Envelope for Materials-Based H₂ Storage Systems	82
<i>Claudio Corgnale, Bruce Hardy, David A. Tamburello, Stephen Garrison, Donald Anton</i>	
Automatic Optimization of Metal Hydride Storage Tanks and Novel Designs	83
<i>Stephen Garrison, Mikhail B. Gorbounov, David A. Tamburello, Bruce Hardy, Claudio Corgnale, Daniel Mosher, Donald Anton</i>	
Liquid Phase Reforming of Wood Flour to Hydrogen	84
<i>Timothy D. Davis, Sean C. Emerson, Tianli Zhu, Rhonda R. Willigan, Ying She, Thomas Henry Vanderspurt</i>	
Ni-Catalyzed Aqueous Phase Liquefaction of Biomass for Hydrogen Production	87
<i>Richa Tungal, Rajesh Shende, Kenneth Benjamin, Lew P. Christopher</i>	

Hydrogen Production From Liquefied Switchgrass in Supercritical Water Over Ru, Ni, and Co Catalysts	96
<i>Adam J. Byrd, Sandeep Kumar, Ram B. Gupta</i>	
Modeling of Biohydrogen Production Using BioWin	97
<i>Hisham Hafez, Elsayed Elbeshbishy, Hesham El Nagggar, George Nakhla</i>	
Nanocomposite Ni-ZrO₂ Catalysts for Ethanol Steam Reforming: Effect of Support Size On the Catalytic Behavior	115
<i>Xinbin Ma, Shuirong Li, Maoshuai Li, Shengping Wang, Jun Wang, Yongli Sun</i>	
Hydrogen Production From Ammonia Using a Micro-Reformer System Integrated with a Heat-Recirculating Micro-Combustor	117
<i>Jung Ho Kim, Sang Ik Lee, Jae Moon Joo, Oh-Chae Kwon</i>	
Effect of Ultrasonication On Pulp Waste Solubilization and Enhancement of Hydrogen Production in Batch Study	118
<i>Elsayed Elbeshbishy, Hisham Hafez, George Nakhla</i>	
Modeling and Operation of a Photo-Electrochemical Reactor for H₂ Production	128
<i>Chris Carver, Zack Ulissi, Klaus Hellgardt, Chin Kin Ong, Stephen Dennison, Geoffrey Kelsall</i>	
Non-Thermal Plasma Reforming of Refractory Tars and Oils Generated by Biomass Gasification	130
<i>Joseph Hartvigsen, Lyman Frost, S. Elangovan, Michele Hollist, Piotr Czernichowski</i>	
Synthesis of Functional Nanostructured TiO₂ Photo Active Membranes for Room Temperature Water Splitting	131
<i>Alok Vats, Anurag Y. Kawde, Rajesh Shende, Jan A. Puszynski</i>	
Oxygen Inactivation of An [FeFe] Hydrogenase From Clostridium Pasteurianum and Evolution of a Mutant Hydrogenase with Decreased Oxygen Sensitivity	132
<i>Alyssa S. Bingham, James R. Swartz</i>	
Performance Evaluation of Sulfur Trioxide Decomposer in a Scale-Down Test Loop at KAERI	133
<i>Jong-Ho Kim, Sung-Deok Hong, Ki-Young Lee, Yong-Wan Kim</i>	
Hybrid Sulfur Cycle Options for the Next Generation Nuclear Plant	139
<i>Maximilian B. Gorenssek, William A. Summers</i>	
Characterization of HBr PEM Electrolyzer for Hydrogen Production	140
<i>Rui Zhang, John Weidner</i>	
Hydrogen Production Via Two - Step High Temperature Thermochemical Process Using Porous MnFe₂O₄ Material	145
<i>Michael K. Opoku, Rajesh Shende, Jan A. Puszynski</i>	
H₂ Generation From Thermochemical Water-Splitting Using Sol-Gel Synthesized Ferrites (M_xFe_yO_z, M = Ni, Zn, Sn, Co, Mn, Ce)	147
<i>Rahul Bhosale, Rajesh Shende, Jan A. Puszynski</i>	
Canada's Experimental Program on Nuclear Hydrogen Production with the Cu-Cl Cycle	155
<i>Greg F. Naterer</i>	
Reaction Engineering of a Novel Sulfur-Sulfur Thermochemical Water-Splitting Cycle	160
<i>Alex Yokochi, Nicholas Auyeung</i>	
Simultaneous Solubilities of Oxygen and Sulphur Dioxide in Water: Thermodynamic Data for the Sulphur Family of Thermochemical Cycles	162
<i>Rachael H. Elder, Moises Romero, Andrew C. Shaw, Ray W. K. Allen</i>	
Storage and Separation of Hydrogen by the Metal Steam Process	163
<i>Markus Thaler, Viktor Hacker, Matthaeus Siebenhofer</i>	
The Kinetics of H₂-D₂ Exchange Over PdCu Surfaces	164
<i>Casey O'Brien, James Miller, Bryan Morreale, Andrew Gellman, Petro Kondratyuk</i>	
Thermo Catalytic Decomposition of Methane Into Hydrogen and Carbon Nanofibers On Ni and Fe/SiO₂ Catalyst	165
<i>Sushil Saraswat, Kamal Pant</i>	
Degradation Studies of Solid Oxide Electrolysis Cells	166
<i>Greg G. Tao, Bruce Butler, Niladri Dasgupta, Anil V. Virkar, Manohar S. Sohal</i>	
Renewable Energy Storage by CO₂ Recycling Using High Temperature Electrolysis	167
<i>Joseph Hartvigsen, Lyman Frost, S. Elangovan, Carl M. Stoots, James E. O'Brien, Stephen Herring</i>	
Electrolysis and Regenerative Operation of the NASA Symmetrical SOFC	168
<i>Thomas Cable, John A. Setlock, Serene C. Farmer</i>	
Development of a Hydrogen Home Fueling System	169
<i>Greg G. Tao, Bruce Butler, Anil V. Virkar</i>	
High Temperature Solid-Oxide Electrolyzers: The Role of Materials in Long-Term Performance Stability	170
<i>S. Elangovan, Joseph Hartvigsen, Dennis Larsen, Insoo Bay</i>	

Studies On Solid Oxide Electrolysis Cells	171
<i>Xiufu Sun, Søren Højgaard Jensen, Sune Dalgaard Ebbesen, Mogens Mogensen</i>	
Testing of the NASA Bi-Supported Cell Concept	175
<i>Carl M. Stoots, Robert O'Brien, Thomas Cable</i>	
Experimental Evaluation of Electrode-Supported Solid-Oxide Cells for High-Temperature Electrolysis	176
<i>James E. O'Brien, Robert O'Brien</i>	
3D CFD Model of Electrode-Supported Solid-Oxide Cells for High-Temperature Electrolysis	177
<i>Grant L. Hawkes, James E. O'Brien</i>	
Author Index	