X. Small Business Innovative Research (SBIR) Hydrogen Program New Projects Awarded in FY 2006

The Small Business Innovation Research (SBIR) program provides small businesses with opportunities to participate in DOE research activities by exploring new and innovative approaches to achieve R&D objectives. The funds set aside for SBIR projects are used to support an annual competition for Phase I awards of up to $100,000 each for about nine months to explore the feasibility of innovative concepts. Phase II is the principal research or R&D effort, and these awards are up to $750,000 over a two-year period. Small Business Technology Transfer (STTR) projects include substantial (at least 30%) cooperative research collaboration between the small business and a non-profit research institution.

Table 1 lists the SBIR projects awarded in FY 2006 related to the Hydrogen Program. On the following pages are brief descriptions of each.

TABLE 1. FY 2006 SBIR Projects Related to the Hydrogen Program

Title		Company	City, State
X.1	Novel Approach to Microbial Hydrogen Production (Phase I Project)	Farasis Energy, Inc.	Hayward, CA
X.2	Novel Microbial Hydrogen Production from Biomass Containing Waste Water (Phase I Project)	Ion Power, Inc.	New Castle, DE
X.3	A New Method to Improve the Performance of Hydrogen Selective Silica Membranes (Phase I Project)	SVT Associates, Inc.	Eden Prairie, MN
X.4	Improved Membranes for Hydrogen Separation (STTR Phase I Project)	TDA Research, Inc.	Wheat Ridge, CO
X.5	Robust, Low-Cost Membranes for Hydrogen Production from Coal-Derived Syngas (Phase I Project)	Aspen Products Group, Inc.	Marlborough, MA
X.6	A New Compact Hydrogen Generation Device (Phase I Project)	Eltron Research Inc.	Boulder, CO
X.7	Manufacturing Improvements for Water Electrolyzers (Phase I Project)	Giner Electrochemical Systems, LLC	Newton, MA
X.8	High-Volume Fabrication of Hydrogen Sensor Using Direct-Write Inkjet Printing Technology (Phase I Project)	InnoSense, LLC	Torrance, CA
X.9	Low-Cost Manufacturing of Sheet Molding Compound Bipolar Plates for PEM Fuel Cells (Phase I Project)	Nanotek Instruments, Inc.	Dayton, OH
X.10	Low-Cost Automated Manufacturing of Hydrogen Production Components with Multi-Nozzle Abrasive-Waterjets (Phase I Project)	OMAX Corporation	Kent, WA
	X.11 Titanium Foam for Hydrogen Storage Container (Phase I Project)	Powdermet, Inc.	Euclid, OH
X.12	Fuel Cell Membrane Measurement System for Manufacturing (Phase I Project)	Scribner Associates Incorporated	Southern Pines, NC
X.13	Adsorption - and Membrane-Enhanced Reactor for Fuel Reforming Applications (Phase I Project)	Media and Process Technology, Inc.	Pittsburgh, PA
X.14	Planar Oxide Stabilized Metal Nanoparticle Catalysts (STTR Phase I Project)	ITN Energy Systems, Inc.	Littleton, CO
X.15	Effective and Practical Anode for MEMS Direct Methanol Fuel Cell (Phase I Project)	MER Corporation	Tucson, AZ
X.16	A Novel Mixed Metal Oxide Supported Catalyst System for Improved Fuel Cell Oxygen Reduction Reactions (Phase I Project)	Lynntech, Inc.	College Station, TX
X.17	Rational Design and Synthesis of Novel Microporous Materials for Hydrogen Storage (Phase I Project)	TechDrive, Inc.	Chicago, IL
X.18	Membrane Structures for Hydrogen Separation (Phase I Project)	Genesis Fueltech, Inc.	Spokane, WA
X.19	A High-Throughput Assay for Microbe-Based Hydrogen Production (Phase II Project)	GVD Corporation	Cambridge, MA
X.20	Advanced Coal Gasification System (Phase II Project)	Eltron Research Inc.	Boulder, CO
X.21	High Efficiency, Low-Cost Reforming to Produce Hydrogen (Phase II Project)	TDA Research, Inc.	Wheat Ridge, CO
X.22	Oil-Free Hydrogen Compressor (Phase II Project)	Mohawk Innovative Technology, Inc.	Albany, NY
X.23	Dimensionally Stable High Performance Membrane (Phase II Project)	Giner Electrochemical Systems, LLC	Newton, MA

X.1 Novel Approach to Microbial Hydrogen Production (Phase I Project)

Dr. Ranjini Chatterjee
Farasis Energy, Inc.
23575 Cabot Boulevard
Suite 205
Hayward, CA 94545
Phone: (510) 732-6600; E-mail: rchatt@farasis.com

DOE Grant No. DE-FG02-06ER84415

The use of fossil fuels as the primary source of energy has been one of the predominant causes of global climate change. Consequently, the need to explore and develop alternate energy sources that are both non-polluting and renewable is becoming increasingly critical. Hydrogen (H_2) offers significant potential as a clean energy source to replace non-renewable and polluting fossil fuels. This project will develop a microbial system that utilizes renewable resources, such as agriculture-derived biomass, for H_2 production. In Phase I, a microbial system will be engineered to demonstrate increased H_2 productivity, and a high-throughput screening system for H_2 detection in micro-scale fermentations will be constructed.

The technology should lead to a commercially viable microbial platform for the production of both H_2, a clean fuel, and value added chemicals from renewable feedstocks. The benefits of a bio-based H_2 production platform include the reduced dependence on fossil fuel feedstocks and imported fuels, the stabilization of CO_2 emissions resulting from fossil fuel consumption, the utilization of renewable feedstocks (agriculture-derived biomass) or organic waste matter for fuel production, and the creation of "greener" processes that utilize biomass and biocatalysts for energy generation.

X.2 Novel Microbial Hydrogen Production from Biomass Containing Waste Water (Phase I Project)

Dr. Stephen Grot
Ion Power, Inc.
720 Governor Lea Road
New Castle, DE 19720
Phone: (302) 832-9550; E-mail: s.grot@ion-power.com

DOE Grant No. DE-FG02-06ER84418

The treatment of waste water consumes a significant amount of energy, in order to reduce the organic matter to levels safe for environmental discharge. This project will develop a novel microbial-based approach to convert the organic matter in waste water into a valuable commodity, namely hydrogen. This approach would simultaneously clean the waste water and produce a fuel that can be sold to help recover the costs of treatment. Phase I will demonstrate the process on the lab bench scale, measure performance at different operating parameters, optimize the geometrical configuration, and reduce the scale of the laboratory demonstration by a factor of five (to a one cubic foot reactor). Finally, the data collected will be used to estimate the capital and operating costs of a full-scale plant.

X.3 A New Method to Improve the Performance of Hydrogen Selective Silica Membranes (Phase I Project)

Dr. Jianwei Dong
SVT Associates, Inc.
7620 Executive Drive
Eden Prairie, MN 55344-3677
Phone: (952) 934-2100; E-mail: dong@svta.com

DOE Grant No. DE-FG02-06ER84622

High-performance, molecular sieve membranes are sought by DOE to separate hydrogen from other gases (mainly carbon diode) in coal gasification processes. However, because of defects, the selectivity of crystalline, silicate-based, molecular sieve membranes can be compromised. This project will develop technology to fix defects in these membranes by reducing pore size and improving gas selectivity. This solution will be accomplished through the use of a low-temperature conformal-deposition process for depositing silicate films inside the defective pores. By using a special catalyst, the deposition will occur at temperatures as low as 60°C and will be self-limited. In Phase I, the low-temperature conformal-deposition process will be developed and then used to reduce pore size in a crystalline silicate membrane. Then, the gas selectivity between hydrogen and carbon dioxide will be measured and compared to the performance of untreated membranes. Lastly, the long-term stability of the processed membrane will be determined.

X.4 Improved Membranes for Hydrogen Separation (STTR Phase I Project)

Dr. Gokhan Alptekin
TDA Research, Inc.
2345 W. 52nd Avenue
Wheat Ridge, CO 80033-1916
Phone: (303) 940-2300; E-mail: galptekin@tda.com

DOE Grant No. DE-FG02-06ER86290

Research Institution: Colorado School of Mines, Golden, CO

Improved hydrogen separation membranes are needed for next generation power systems. Recent advances in metal membrane technology have identified a Pd alloy composite membrane that is not susceptible to embrittlement and poisoning problems, which have prevented widespread industrial use of Pd for high-temperature H_2 separation. However, there is still a need to prepare thin membranes on porous stainless steel substrates, in order to provide the robustness and ruggedness required in industrial processes. This project will develop a simple and effective technique to modify the surface of stainless steel supports, in order to allow preparation of very thin Pd alloy films. Phase I will develop a prototype water-gas-shift reactor for preparing the membranes, and its performance will be demonstrated in a simulated coal-derived syngas (H_2, H_2S, CO_2, NH_3 and HCl).

X.5 Robust, Low-Cost Membranes for Hydrogen Production from Coal-Derived Syngas (Phase I Project)

Dr. Zhijiang Li
Aspen Products Group, Inc.
186 Cedar Hill Street
Marlborough, MA 01752
Phone: (508) 481-5058; E-mail: zli@aspensystems.com

DOE Grant No. DE-FG02-06ER84594

Hydrogen systems can provide viable, sustainable options for meeting the world's energy requirements. This project will develop a novel, low-cost, hydrogen membrane with improved durability for the production of high-purity hydrogen from coal-derived syngas. These membranes would be used in water-gas-shift membrane reactors to generate hydrogen from coal via gasification and would offer the following advantages (1) more hydrogen generation in a single shift reactor, (2) the simplification or complete elimination of downstream hydrogen separation and purification processes, and (3) the production of a high-pressure stream of predominantly CO_2, which could be sequestered to mitigate global warming effects. In Phase I, experiments will be conducted to prepare, characterize, and identify appropriate membranes with high hydrogen permeability and selectivity, improved mechanical and chemical properties, low material cost, and excellent scalability.

X.6 A New Compact Hydrogen Generation Device (Phase I Project)

Harold A. Wright
Eltron Research Inc.
4600 Nautilus Court South
Boulder, CO 80301-3241
Phone: (303) 530-0263; E-mail: eltron@eltronresearch.com

DOE Grant No. DE-FG02-06ER84601

The generation of hydrogen from fossil fuels appears to be the best bridge to the hydrogen economy. However, the efficiency of standard hydrogen-generation methods based on steam methane reforming needs to be improved. This project will develop a new compact hydrogen-generation reactor, which uses an oxygen transport membrane to separate oxygen from air. The new generator will combine the current multi-step generation of hydrogen from fossil fuels into a single reactor system, significantly reducing the size and cost of hydrogen generation. In Phase I, the following process steps will be studied (1) the reaction of oxygen with the hydrocarbon fuel to produce synthesis gas at about 1,000 degrees C, (2) direct water injection to reduce the temperature, (3) the reaction of the resulting cool syngas over a water-gas-shift catalyst to produce more hydrogen, and (4) the delivery of the resulting hydrogen and carbon dioxide rich stream to a hydrogen transport membrane. The resulting products will be pure hydrogen and a CO_2-rich stream suitable for sequestration.

X.7 Manufacturing Improvements for Water Electrolyzers (Phase I Project)

Mr. Timothy Norman
Giner Electrochemical Systems, LLC
89 Rumford Avenue
Newton, MA 02466-1311
Phone: (781) 529-0504; E-mail: tnorman@ginerinc.com

DOE Grant No. DE-FG02-06ER84537

Current electrolyzer systems, needed to produce hydrogen for the hydrogen economy, are too expensive to meet DOE target hydrogen production costs. Because current electrolyzer systems are not mass produced, significant savings could accrue from a disciplined design-for-manufacturing (DFM) approach and the application of modern manufacturing methods. This project will apply a number of cost-saving DFM solutions to the highest cost items within proton-exchange-membrane (PEM) electrolyzer systems. Phase I will develop and demonstrate low-temperature weld techniques for the PEM cell frame, thereby reducing its costs by 90%. The low-cost frame will be demonstrated in a working electrolyzer cell. The joining technology will be extended by integrating some seals with the fluid manifold of a thin-film PEM, thereby eliminating two sealing faces.

X.8 High-Volume Fabrication of Hydrogen Sensor Using Direct-Write Inkjet Printing Technology (Phase I Project)

Dr. Kisholoy Goswami
InnoSense, LLC
2531 West 237th Street
Suite 127
Torrance, CA 90505-5245
Phone: (310) 530-2011; E-mail: kisholoy.goswami@innosense.us

DOE Grant No. DE-FG02-06ER84541

The Department of Energy is committed to the development of technologies for the production, delivery, and storage of hydrogen for transportation, distributed stationary power, and portable power applications. Safety is an important concern related to hydrogen use. Because hydrogen can neither be seen nor smelled, a reliable hydrogen sensor will be needed in all aspects of the hydrogen economy. This project will develop an innovative manufacturing process, based on direct-write inkjet technology, for the high volume fabrication of hydrogen sensors. Feasibility will be demonstrated by comparing the performance of the new sensors with previously-characterized hydrogen sensors. In Phase I, an inkjet printer, which is compatible with ink formulations containing indicator precursors and a carrier vehicle, will be custom assembled. The ink will be evaluated to assure proper adhesion on a Pyrex substrate. Batch-to-batch and intra-batch consistency of the mass-produced sensors will be tested, and their performance characteristics will be compared with data previously obtained from manually-made sensors.

X.9 Low-Cost Manufacturing of Sheet Molding Compound Bipolar Plates for PEM Fuel Cells (Phase I Project)

Dr. Aruna Zhamu
Nanotek Instruments, Inc.
714 East Monument Avenue
Suite 119
Dayton, OH 45402-1382
Phone: (937) 775-5007; E-mail: arunazhamu@yahoo.com

DOE Grant No. DE-FG02-06ER84558

The fluid-flow field plate, or bipolar plate, is known to significantly impact the performance, durability, and cost of a fuel cell system. Conventional methods of fabricating bipolar plates require the engraving or milling of flow channels into the surface of metal plates. As a consequence, the bipolar plate is one of the most costly components of a proton-exchange-membrane (PEM) fuel cell, due to high machining costs. In addition, long-term corrosion is a major concern for metal plates. Composite bipolar plates are an option, but conventional composites are typically difficult to process, expensive, or not sufficiently conductive. This project will develop a low-cost, mass-production process for manufacturing flexible, graphite-based, sheet-molding-compound (SMC) bipolar plates. Compared to metal and other current composite bipolar plate technologies, flexible graphite SMC will have the advantages of high conductivity, low weight, small volume (thin plate), high resistance to gas permeability, high corrosion resistance, and mass production capability, resulting in lower fuel cell cost and improved system reliability. Phase I will demonstrate the feasibility of producing bipolar plates by using continuous in-line lamination and embossing of SMC. In particular, Phase I will design and construct a roll-to-roll sheet molding compound fabrication apparatus, fabricate the SMC bipolar plates, and characterize both the bipolar plates and PEM fuel cells using these plates.

X.10 Low-Cost Automated Manufacturing of Hydrogen Production Components with Multi-Nozzle Abrasive-Waterjets (Phase I Project)

Dr. Peter H. Liu
OMAX Corporation
21409 72nd Avenue South
Kent, WA 98032-1944
Phone: (253) 872-2300; E-mail: peterl@omax.com

DOE Grant No. DE-FG02-06ER84565

Stamping and photochemical machining have been two common methods for manufacturing multiple flow channels in hydrogen reformers, heat exchangers, and fuel-cell stacks. These methods are too costly to help meet DOE's targeted untaxed hydrogen price of $2.00-3.00/gge. This project will develop a multi-nozzle waterjet system for the automated machining of flow channels, on a stack of 30 or more thin shims, in one single run. In Phase I, a single-nozzle abrasive-waterjet system will be used to machine flow channels on a stack of 30 or more sheets of stainless steel shims. A cost reduction of at least 37% will be demonstrated. The ultimate goal will be the achievement of a cost reduction of at least one order of magnitude, along with significant productivity enhancement, using multiple abrasive slurry jets in Phase II.

X.11 Titanium Foam for Hydrogen Storage Container (Phase I Project)

Mr. Asit Biswas
Powdermet, Inc.
24112 Rockwell Drive
Euclid, OH 44117
Phone: (216) 404-0053; E-mail: asitruma@att.net

DOE Grant No. DE-FG02-06ER84572

To support the use of hydrogen in transportation applications, a light weight, robust hydrogen storage tank is necessary for use on board vehicles, at refueling stations, and on a hydrogen transport truck. The current fabrication process for hydrogen tanks – winding fibers on a mandrel, followed by epoxy infiltration and curing – is a time consuming, expensive process and is comprised of flaws. This project will develop a rapid hydrogen tank fabrication process, using low conductivity titanium foam in a hydrogen-comatible aluminum sandwich panel. The resulting titanium composite will provide lower conductivity and improved structural efficiency over current structural materials, without the limitations of alternate honeycomb-core sandwich structures. Phase I will demonstrate the fabrication of syntactic titanium foam using titanium-hydride-encapsulated ceramic micro-spheres. The sandwich panel will be constructed by using liquid interface diffusion to attach the hydrogen-compatible aluminum face sheet. The step-by-step rapid fabrication process for hydrogen tank construction will be demonstrated.

X.12 Fuel Cell Membrane Measurement System for Manufacturing (Phase I Project)

Dr. Kevin R. Cooper
Scribner Associates Incorporated
150 E. Connecticut Avenue
Southern Pines, NC 28387-5528
Phone: (910) 692-5966; E-mail: kevin@scribner.com

DOE Grant No. DE-FG02-06ER84574

Before fuel cells will be adopted by the automotive market, the cost of proton exchange membrane (PEM) materials must be reduced through improved manufacturing quality control and quality assurance. In particular, tools and standard protocols are needed to measure keystone membrane properties: conductivity and fuel permeability. This project will develop a robust, simple membrane measurement system and test protocol to support fuel cell membrane manufacturing operations. Analytical instrumentation and electrical/electrochemical diagnostic techniques will be developed to produce a membrane measurement tool that will provide reliable, accurate, and rapid assessment of the conductivity and fuel permeability of membrane materials in a high-volume production environment. In Phase I, technical feasbility of the membrane manufacturing measurement technology will be demonstrated by (1) establishing the functional requirements (specifications) of the measurement tool, (2) developing and evaluating a prototype test system, including the electrode design and membrane property measurement techniques, and (3) developing a preliminary test protocol by evaluating the principle factors that influence measurement of these keystone membrane properties.

X.13 Adsorption - and Membrane-Enhanced Reactor for Fuel Reforming Applications (Phase I Project)

Dr. Paul K. T. Liu
Media and Process Technology, Inc.
1155 William Pitt Way
Pittsburgh, PA 15238-1368
Phone: (412) 826-3711; E-mail: pliu@mediaandprocess.com

DOE Grant No. DE-FG02-06ER84551

Small-scale hydrogen production, for both mobile and stationary applications, is a technology critical to the future implementation of fuel cell technology. Existing fuel reforming processes are extremely complicated, as well as capital- and energy-intensive, primarily due to their high temperature (600 to >800ºC) requirements. These disadvantages handicap the scale-down of existing reforming processes. Furthermore, the high-purity-hydrogen requirement (e.g., for PEM-type fuel cells) dictates a series of separation and purification steps as a post-treatment. This project will develop a hybrid reactor that integrates an adsorption reactor (AR) and a membrane reactor (MR) into a single integrated unit, allowing hydrogen production at 350 to 450ºC. The hybrid system will be simple to operate and compact in size. More importantly, the hydrogen will be produced with extremely low CO contamination and could potentially achieve a total conversion of hydrocarbon fuel. In Phase I, an experimental study will be performed to determine the hydrogen production efficiency and CO contaminant levels, in order to demonstrate technical feasibility. An existing mathematical model will be validated with experimental results, and then simulations for estimating H_2 production rates, capital costs, and operating economics will be performed. In Phase II, a prototype unit will be fabricated for in-house testing and field demonstration.

X.14 Planar Oxide Stabilized Metal Nanoparticle Catalysts (STTR Phase I Project)

Dr. Bruce Lanning
ITN Energy Systems, Inc.
8130 Shaffer Parkway
Littleton, CO 80127-4107
Phone: (303) 285-5111; E-mail: blanning@itnes.com

DOE Grant No. DE-FG02-06ER86279

Research Institution: Southwest Research Institute, San Antonio, TX

Carbon monoxide is produced as a result of incomplete combustion of fossil fuels and has been identified in the Chemical Industry Vision 2020 Catalysis Report as one of the highlighted areas of development with an emphasis on lowering energy requirements via higher selectivity, more moderate temperature or pressure, and higher productive per unit area. A specific area under development is CO oxidation for low-temperature fuel cells that use platinum catalysts to extract electricity from hydrogen gas since CO can poison the catalysts. Not only is there a need therefore, for improvements in types and efficiency of catalysts, but approaches that enhance material utilization. ITN Energy Systems, Inc., in collaboration with SwRI, propose to develop a new paradigm of manufacturable planar oxide stabilized Au, Pt, or Pt bimetallic nanoparticles with the following innovations 1) conductive oxides supports via dry vacuum processing, 2) oxide stabilized Au/Pt nanoclusters with enhanced activity at the nanoscale (<5 nm), and 3) reduced cost by maximizing Au/Pt surface area (monolayer coverage). Upon completion of a 9-month, Phase I effort, ITN will not only demonstrate the feasibility of producing metal oxide supported, Au or Pt nanoparticle catalysts using established manufacturable processes (vacuum web coating) but satisfy performance metrics, through systematic characterization and test methodologies, that clearly delineate catalyst performance enhancements related to nano-size features of the catalyst and not just increases in surface-to-volume ratio alone. In a Phase II effort, ITN along with its Phase I team, SwRI and Dr. Goodman (Texas A&M), will focus on utilizing ITN's proven capability to transition research results into large-scale manufacturing processes. Similarly, in both Phase I and II, ITN will engage existing as well as potentially new strategic partners to ensure product performance specifications are in line with end user performance, stability, and cost specifications.

X.15 Effective and Practical Anode for MEMS Direct Methanol Fuel Cell (Phase I Project)

Dr. Perumal Pugazhendhi
MER Corporation (Materials and Electrochemical Research)
7960 South Kolb Road
Tucson, AZ 85706-9237
Phone: (520) 574-1980; E-mail: mercorp@mercorp.com

DOE Grant No. DE-FG02-06ER84553

As a fuel, methanol could provide high efficiency, low emissions, and convenient refueling. Methanol fuel cells, based on MEMS (micro-electro-mechanical systems) technology, have the potential to realize better heat and mass transport because of their extremely small size. In order to build an effective MEMS fuel cell, it is necessary to optimize the electro-kinetic performance of the catalyst layer. Therefore, this project will develop a novel and practical microelectrode that utilizes carbon nanotubes in a flexible, catalytically-active polymer film. This will be accomplished by producing ultra-thin, flexible, and catalytically active nanotube-polymer composite films as a novel and practical way to fabricate fuel cell electrodes. With this microelectrode, a MEMS fuel cell could be rapidly assembled, and its properties and performance could be assessed. In Phase I, an ultra-thin microelectrode will be developed by reacting selective chemical species with well aligned carbon nanotubes. The interaction of the electrode with the surrounding media, particularly with the proton conducting membranes and metal catalysts, will be improved, and the novel electrode will be durable and flexible.

X.16 A Novel Mixed Metal Oxide Supported Catalyst System for Improved Fuel Cell Oxygen Reduction Reactions (Phase I Project)

Dr. Wayne Gellett
Lynntech, Inc.
7607 Eastmark Drive
Suite 102
College Station, TX 77840-4027
Phone: (979) 693-0017; E-mail: wayne.gellett@lynntech.com

DOE Grant No. DE-FG02-06ER84548

Polymer electrolyte membrane electrochemical systems, such as fuel cells, offer many advantages over competing energy conversion technologies in terms of energy density and lifetimes. However, for this technology to become commercially viable, several technological breakthroughs are required with respect to cathodic reaction kinetics. The kinetic limitation of the oxygen reduction reaction (ORR) is a problem in proton exchange membrane (PEM) fuel cells operating at low temperature ($<100°C$) and often limits the overall effectiveness of the energy conversion device. This project will utilize a stabilizing, conductive oxide layer as a catalyst support that will effectively maintain the ORR catalyst in a highly dispersed state. This approach would optimize catalytic activity, as well as resistance to sintering and agglomeration, leading to improved oxygen activity and catalyst lifetime. In Phase I, planar metal and mixed metal-oxide supports will be fabricated, using rolled vacuum techniques, as support materials for oxygen reduction catalysts. A nanometer-sized ORR catalyst will be deposited onto this support. The cathode catalyst then will be subjected to mechanical, electrochemical, and stability tests for characterization. Phase II will address issues of optimization and manufacturing analysis, in order to promote the commercial viability of this product and to advance the DOE goals for hydrogen fuel cells.

X.17 Rational Design and Synthesis of Novel Microporous Materials for Hydrogen Storage (Phase I Project)

Dr. Robert Filler
TechDrive, Inc.
3255 S. Dearborn Street
Suite 320
Chicago, IL 60616-3793
Phone: (312) 567-3910; E-mail: rfiller@techdrive.com

DOE Grant No. DE-FG02-06ER84579

The availability of an efficient fuel-cell-based automobile, running on renewable hydrogen, would improve the environment by dramatically reducing air pollutants, while also diminishing the U.S. dependence on imported petroleum. However, there is a critical need to develop a safe hydrogen storage technology before fuel-cell-based automobiles can compete effectively with gasoline-powered vehicles. This problem will be addressed by introducing, via syntheses, a series of novel specifically-designed hydrogen sorption materials, which exhibit enhanced physisorption. These materials will be evaluated with respect to hydrogen uptake and release over explicit ranges of temperature and pressure. In Phase I, two classes of materials – both with high surface area, pore diameter ranging from 1 to 15 nm, thermal and dimensional stability, and strong sorption sites – will be prepared. The effectiveness of these new substances as hydrogen sorption materials will be carefully evaluated.

X.18 Membrane Structures for Hydrogen Separation (Phase I Project)

Mr. Peter David DeVries
Genesis Fueltech, Inc.
528 South Cannon Street
Spokane, WA 99204
Phone: (509) 534-5787; E-mail: david@genesisfueltech.com

DOE Grant No. DE-FG02-06ER84535

Hydrogen can be produced from coal, natural gas, biomass, and biomass derivatives through the use of gasification, pyrolysis, reforming, and shift technologies. In all of these processes, the initial product is a hydrogen-rich producer gas or syngas, from which the hydrogen must be separated and purified. This project will develop a low-cost hydrogen-permeable membrane, which produces permeated hydrogen with purity high enough for PEM fuel cell usage. The work will focus on achieving thin palladium-alloy membranes, for which the alloy film is free of porosity or defects. Phase I will produce palladium-alloy membranes of varying thicknesses on a permeable metallic support. The membranes will be tested for structural integrity in a membrane module, in order to also measure the flux.

X.19 A High-Throughput Assay for Microbe-Based Hydrogen Production (Phase II Project)

Dr. Hilton Gavin Pryce Lewis
GVD Corporation
19 Blackstone Street, Suite 1
Cambridge, MA 02139
Phone: (617) 661-0060; E-mail: hilton@gvdcorp.com; Website: http://www.gvdcorp.com

DOE Grant No. DE-FG02-05ER84281

Microbe-based hydrogen production is a potentially cost-effective, non-polluting approach to the production of hydrogen, and research efforts are underway to identify, isolate, and enhance microbial strains which facilitate the process. However, these efforts are hampered by a lack of adequate instruments to detect and pinpoint hydrogen producers, and no assays currently provide the characteristics needed – in terms of sensitivity, short response times, scalability, and compatibility with high-throughput methodologies – for the rapid screening of colonies. This project will develop a commercial assay that provides high-throughput screening capabilities, safety in the presence of hydrogen, spatial determination, high sensitivity, reusability, and long lifetimes. The assay will consist of a flat, transparent array that, when placed in close proximity to the microbes under investigation, will identify the location and intensity of hydrogen producers. Phase I created successful prototypes of a high-throughput assay by combining a chemochromic sensor technology with a protective coating. The characteristics of the protective coating were optimized to achieve maximum sensitivity, short response times, and long lifetimes. The assay was field-tested by a photobiological hydrogen researcher, survived the warm wet conditions of testing, and pinpointed the hydrogen-producing organisms exactly as intended. In Phase II, the assay will be scaled-up to produce a greater volume of prototypes for testing by researchers, with whom collaborations will establish common formats and configurations. The manufacturability of the assay will be demonstrated by designing and building a prototype production tool.

X.20 Advanced Coal Gasification System (Phase II Project)

Dr. James H. White
Eltron Research Inc.
4600 Nautilus Court South
Boulder, CO 80301-3241
Phone: (303) 530-0263; E-mail: eltron@eltronresearch.com; Website: http://www.eltronresearch.com

DOE Grant No. DE-FG02-05ER84200

The efficient, clean, and cost effective conversion of coal is a principal goal of the U.S. energy industry and the DOE. Although still costly, coal gasification remains the most effective method for converting the raw feedstock into syngas for liquid fuel production, for hydrogen production (for fuel cell use), or for combustion in a gas turbine generator. In order to reduce capital costs, this project will develop technology for integrating fluidized bed gasification with chemical looping to allow gasification under less severe conditions. In particular, the technology eliminates cryogenic air separation and enables CO_2 sequestration. Phase I identified oxygen carrier materials and demonstrated the integration of air separation and coal gasification in chemical looping. Preferred catalyst materials not only were extremely inexpensive, but also exhibited an oxygen storage capacity as high as 30 wt% and proved to be rugged even with minimal processing. When incorporated into a fluidized bed reactor, the gasification system exhibited carbon conversion greater than 98% and cold gas efficiency greater than 70%, at a bed temperature less than 850°C. These results easily exceeded the performance of other fluidized bed gasification processes while enabling CO_2 sequestration. Phase II will consist of the final selection and development of catalyst materials; design, fabrication, and testing of a pilot scale chemical looping system; and employment of the system in chemical looping coal gasification and other potential applications.

X.21 High Efficiency, Low-Cost Reforming to Produce Hydrogen (Phase II Project)

Dr. Jeannine E. Elliott
TDA Research, Inc.
12345 W. 52nd Avenue
Wheat Ridge, CO 80033-1916
Phone: (303) 940-2300; E-mail: jelliott@tda.com; Website: http://www.tda.com

DOE Grant No. DE-FG02-05ER84215

Current natural gas reforming plants that produce hydrogen are expensive because of the large capital cost associated with the reformers. The heat required to drive the reforming reaction is transferred in a fired-furnace through heat exchanger tubes. These tubes are extraordinarily expensive because they are high nickel alloys, which cost ten times as much as carbon steel, and have thick walls to run at high temperatures (up to 900°C) and high pressures (400-500 psi). In addition, the efficiency of current reformers is limited by the temperature at which they operate, which is in turn limits the operating temperature of the reformer tubes. This project will develop a steam reforming system for the production of hydrogen, which uses direct combustion to generate heat reforming, instead of using combustion in a fired-furnace reformer. In Phase I, experimental research, system design, and cost analysis studies were used to show that the new hydrogen-generation approach can reduce capital cost, increase methane conversion efficiency, and reduce the cost of hydrogen. In Phase II, a new test apparatus will be built to demonstrate the performance of the entire system. Also, a full system design and an economic analysis for a large-scale plant operation will be conducted.

X.22 Oil-Free Hydrogen Compressor (Phase II Project)

Dr. Hooshang Heshmat
Mohawk Innovative Technology, Inc.
1037 Watervliet-Shaker Road
Albany, NY 12205-2033
Phone: (518) 862-4290; E-mail: hheshmat@miti.cc.com; Website: http://www.miti.cc

DOE Grant No. DE-FG02-05ER84245

The DOE is developing delivery technologies that will enable the introduction and long-term viability of hydrogen as an energy carrier for transportation and stationary power. To be successful, approaches must address hydrogen's relatively low volumetric energy density and its difficulties with respect to transportation, storage, and final delivery to the point of use. In particular, existing hydrogen compressor designs cannot meet the need for a reliable, efficient and cost competitive transportation infrastructure. Therefore, this project will develop an oil-free bearing technology that will enable oil-free centrifugal hydrogen gas compressors to boost in-line pressures by approximately 700 psig and deliver 300 kg/min of hydrogen gas. In Phase I, a number of oil-free centrifugal compressor configurations were identified that could meet the stated boost pressure and flow requirements. However, the high operating speeds and sealing requirements indicated that very low power loss bearings and low leakage seals would be needed to make the compressor system viable. Therefore, Phase II will involve the design and fabrication of full-scale, oil-free compliant foil bearings. The bearings will be tested at design speeds of 50,000 to 60,000 rpm, while realistic loads are to be applied to the bearings. (The development of very low leakage seals and has been proposed under a separate program.)

X.23 Dimensionally Stable High Performance Membrane (Phase II Project)

Dr. Han Liu
Giner Electrochemical Systems, LLC
89 Rumford Avenue
Newton, MA 02466-1311
Phone: (781) 529-0504; E-mail: hliu@ginerinc.com; Website: http://www.ginerinc.com

DOE Grant No. DE-FG02-05ER84322

Devices that employ fuel cell technology (such as vehicles, portable devices, and remote installations) require frequent startup/shutdown cycles. Surviving these cycles, particularly at freezing temperatures, will require the development of cost-effective, high-performance, proton-exchange membrane (PEM) materials. This project will develop a high performance membrane with excellent dimensional stability over a wide range of temperature and relative humidity. The new membrane will alleviate the water/ice expansion problem during the freeze/thaw process while simultaneously facilitating operation at low humidity and high temperature. This improved operability under suboptimal conditions will retard shorting and enhance the durability of the membrane. Phase I developed a dimensionally stable membrane that showed stellar mechanical stability compared to Nafion®, with a creep rate at least one order-of-magnitude lower. The feasibility of the concept was demonstrated in membrane formation, membrane-electrode assembly fabrication, fuel cell performance, and freeze/thaw stability. Phase II will develop alternative membrane fabrication processes to lower cost and increase performance, and demonstrate freeze/thaw stability and scalability with both 50 cm^2 fuel cells and short stacks (three to five cells, 100-200 cm^2, 250-500 W).