Proceedings of the 2000 Hydrogen Program Review
NREL/CP-570-28890

Separation Membrane Development

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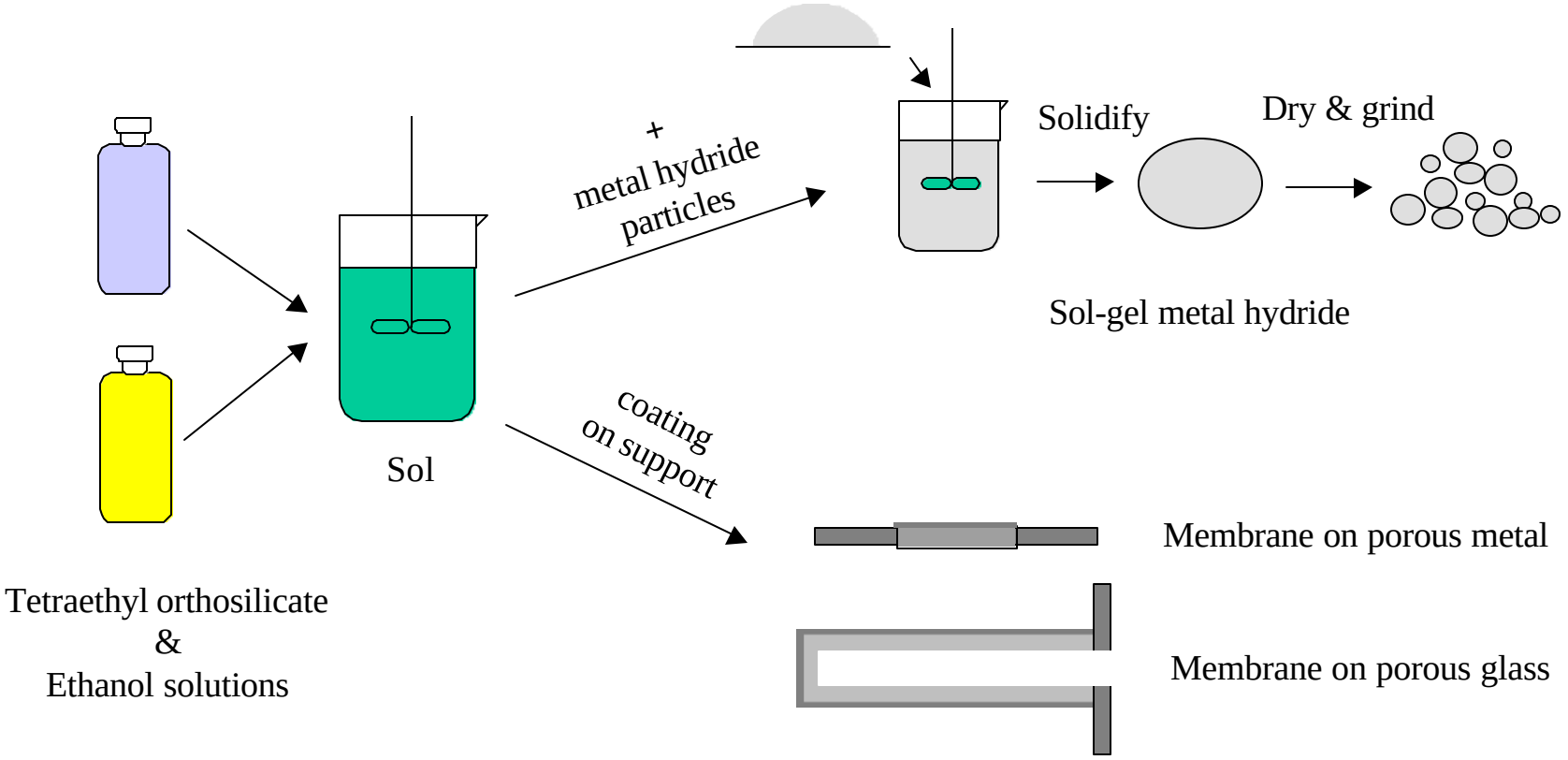
Long-Term Goals

- Develop efficient hydrogen separation process that will resists the adverse effects of reactive impurities (O2, CO….)
- Demonstrate hydrogen absorption material based on sol-gel membrane encapsulated metal hydrides
- Investigate the feasibility of using sol-gel method to fabricate effective hydrogen separation membrane

Background

- New class of composite material has been developed using a sol-gel process
- Material found to selectively absorb H_2 from gas mixtures and to resist poison impurities
- Commercially attractive in hydrogen recovery and removal from industrial gas streams
- Potential applications include chemical, refinery, transportation and consumer products

Schematic of Sol-gel Metal Hydride & Sol-gel Membrane Process



FY-00 Objective and Rationale

- Extend the sol-gel encapsulation method to hydrides beyond LaNiAl (to develop process parameters that can encapsulate high hydrogen content metal hydrides)
- Produce defect-free membrane for permeation evaluation (to define rate and selectivity potentials)

FY-00 Tasks

- Fabricate silica based membrane using porous glass as support
- Fabricate silica based membrane using sintered porous metal as support
- Test membrane samples for hydrogen and nitrogen permeation properties
- Develop procedure for making silica encapsulated metal hydride with improved H_2 capacity.
- Test and compare hydrogen absorption property of encapsulated, improved metal hydride with LaNiAl.

FY-00 Progress

- Tested porous glass as the support for sol-gel coating
- Tested sintered porous stainless steel as support for sol-gel coating
- Produced silica encapsulated ZrCo samples
- Tested oxygen (air) exposure effect on encapsulated ZrCo, in comparison with that of encapsulated LaNiAl
- Patent and publication:
  - Patent issued: “Composition for absorbing hydrogen from gas mixtures”, U.S. patent 5965482
  - Paper published: “Silica embedded metal hydrides”, J. of Alloys and Compounds, 293-295 (1999) 446-451
  - Patent pending:”Container and method for absorbing and reducing hydrogen concentration”.

Sample of Sol-Gel Encapsulated Metal Hydride

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Metal hydride as received

Metal hydride after H2 abs.& des,

Sol-gel encapsulated Metal hydride after H2 abs. & des.

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Encapsulated Metal Hydride Resists Poisons

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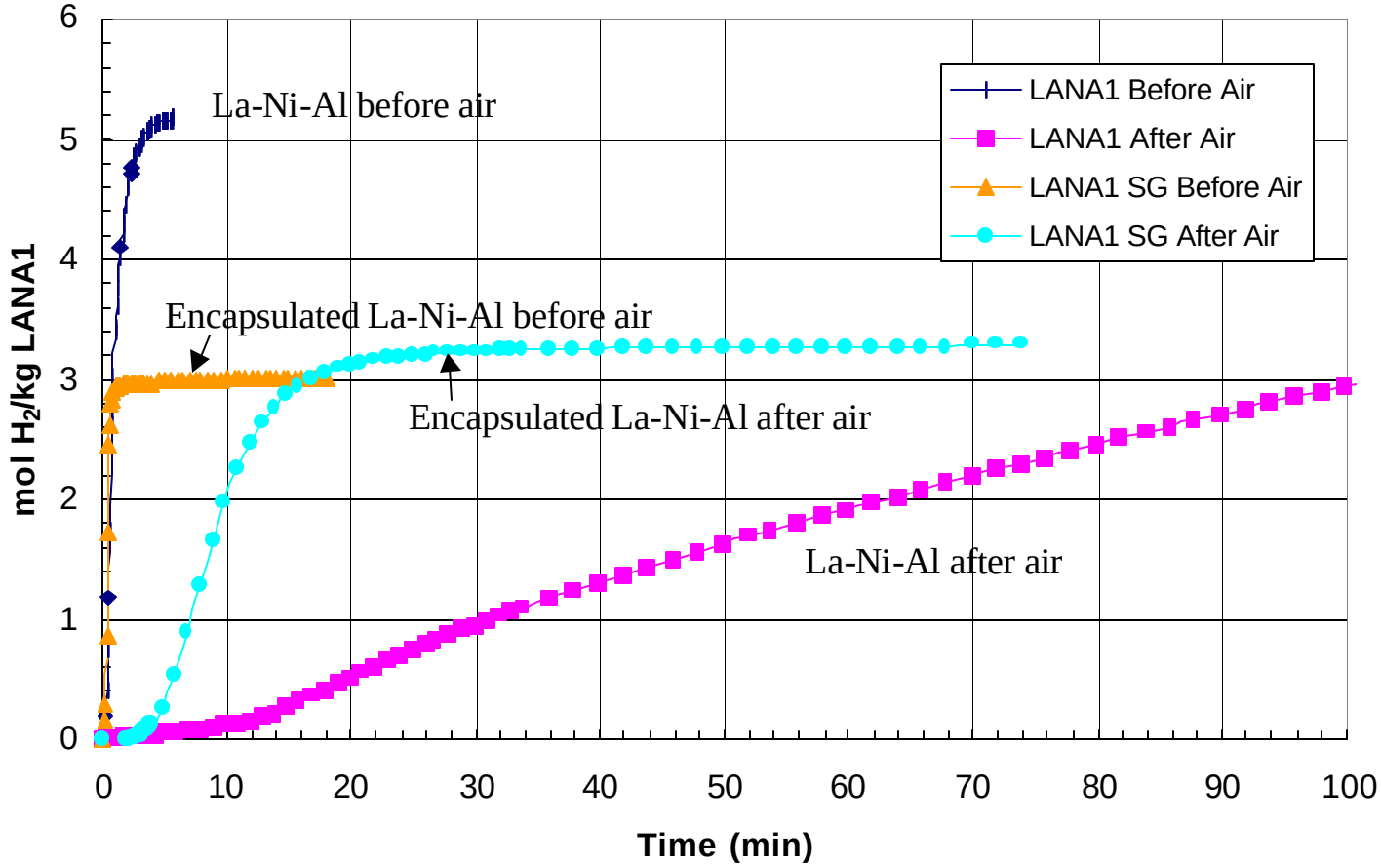
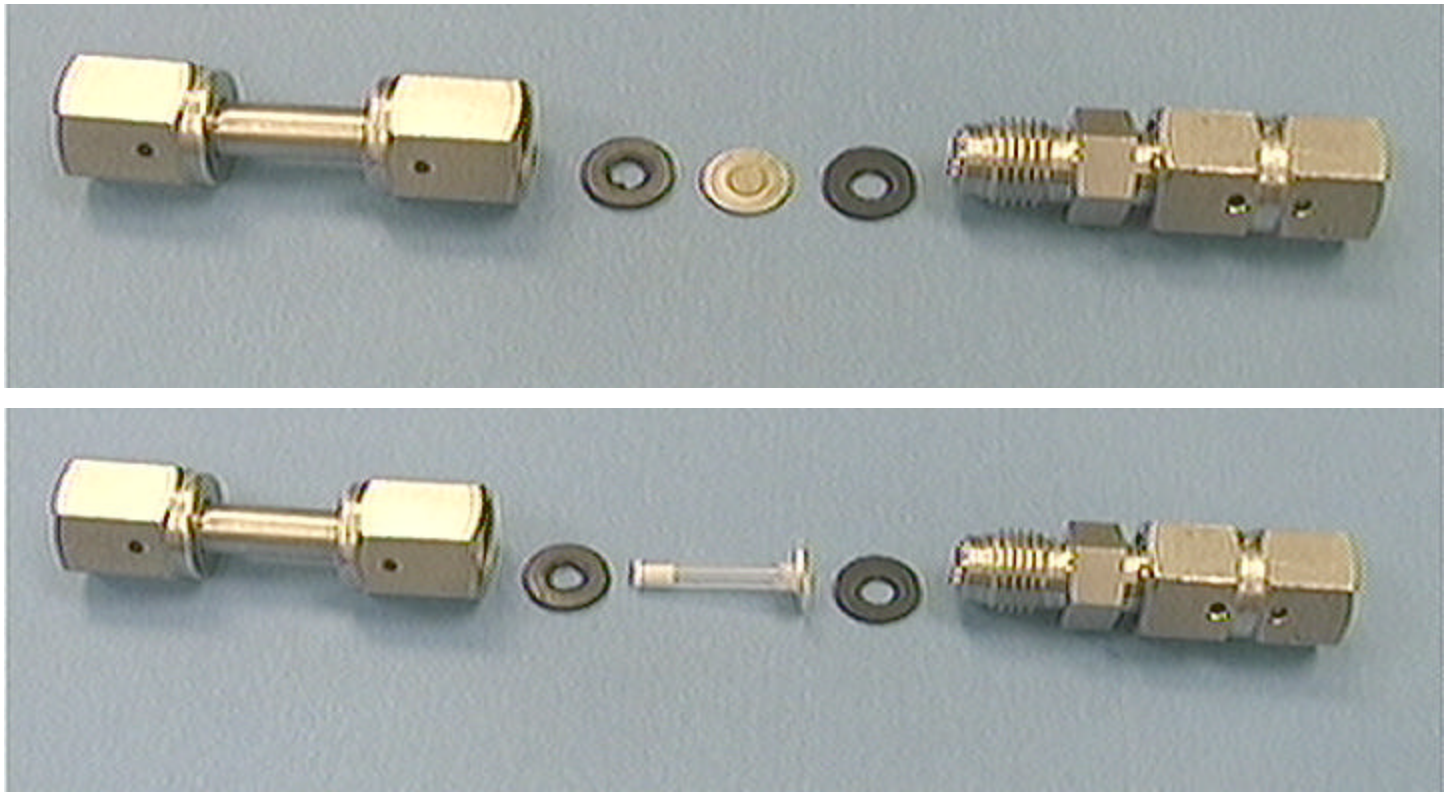
Feed gas	H_2 absorption capacity (H/M)	
	Pure La-Ni-Al	Encapsulated La-Ni-Al
Pure H_2 feed	0.7	0.5
10 mol% CO in H_2	0	0.5

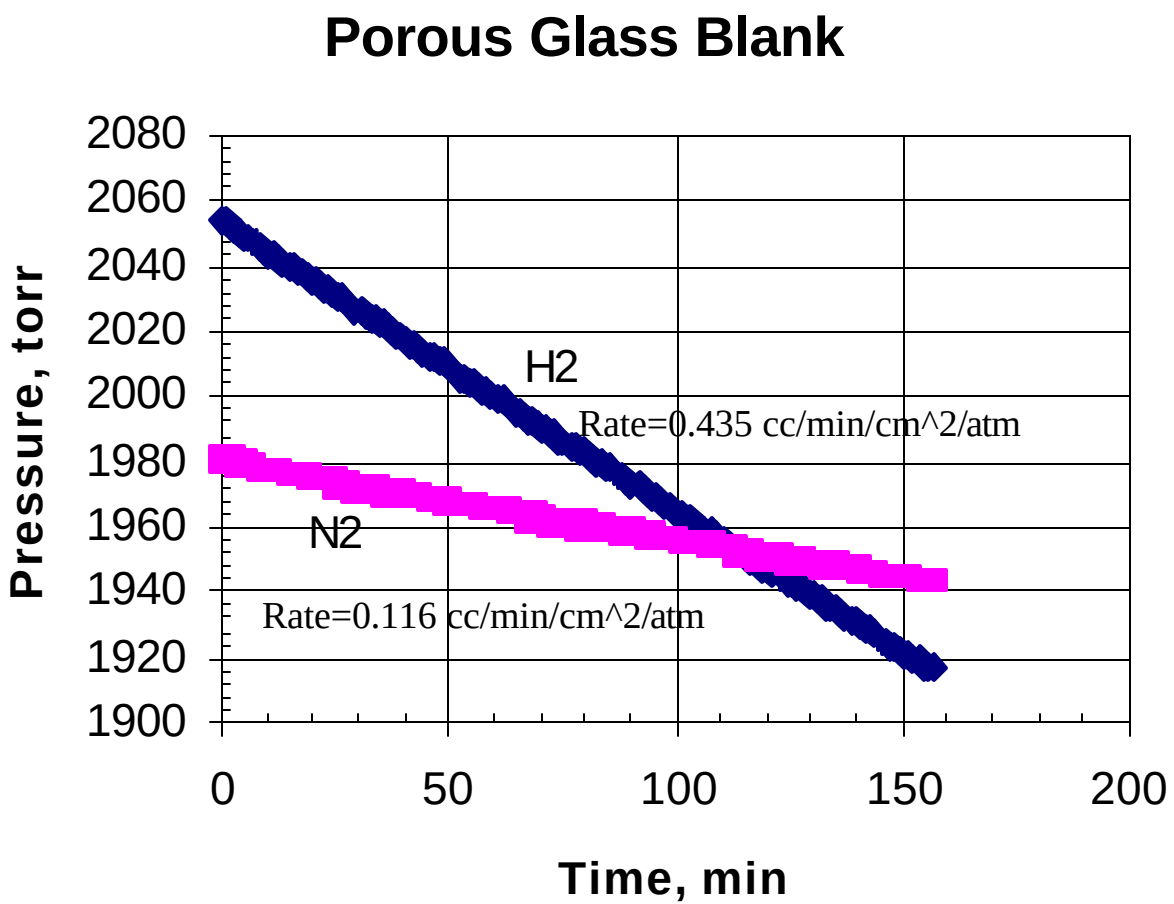
H_2 Absorption Of Encapsulated Metal Hydride Before & After Air Exposure



Permeation Test Apparatus



Porous Glass Support Membrane Results



Selectivity H2/N2=3.747 vs 3.742 for Knudsen diffusion
Rate for 4 mil Pd/25Ag=18 cc/min/cm^2/atm (Rubin 1966)

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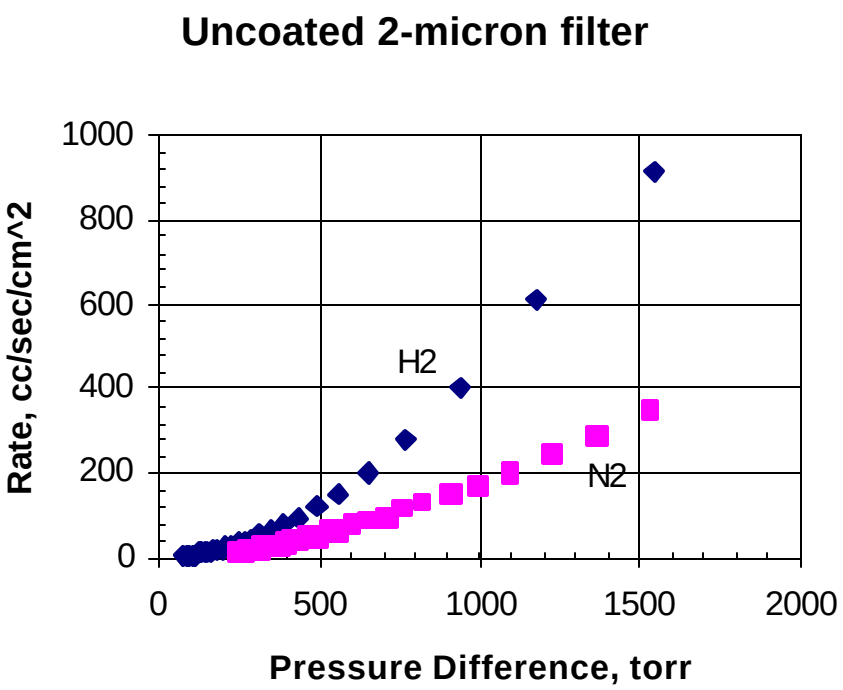
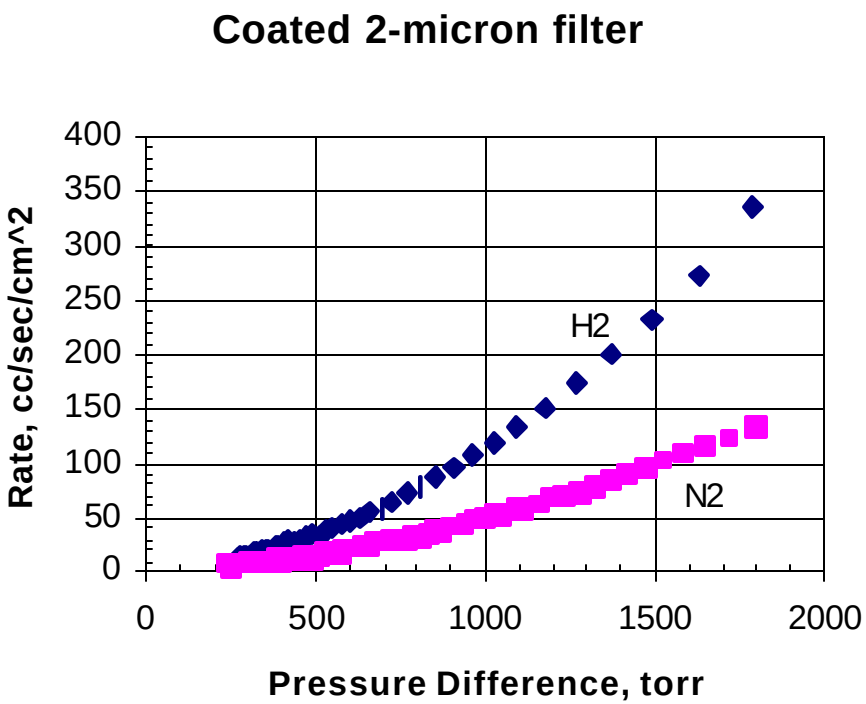
Porous Stainless Steel Support Membrane Results





Status of Economic and Systems Analysis

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- **Completed a Market Study and Commercialization Assessment**
  - Study by Foresight Science and Technology (separately funded)
  - Identified market applications and entry strategies
  - Concluded there is very significant market potential

- **Contacts with Potential Users and Development Partners**
  - Previous CRADA with major oil company
  - Discussions and conceptual design for major chemical company
  - Discussions and conceptual design for automotive company

- **Target Market Applications**
  - Hydrogen Gettering (with encapsulated metal hydrides)
    - Opportunity for early niche market
    - Automotive batteries: Total market = $3 Billion; Getter cost goal < $5 per battery
    - Nuclear waste containers: High value application
  - Stationary Hydrogen Separation
    - Refineries, chemical plants, H2 refueling stations, gas processing for fuel cell plants
    - H2 recovery cost with SGMH = approx. $0.75/lb, depending on gas conditions, waste heat cost, etc.
  - Onboard Fuel Processing Systems for FCVs
    - Gas purification in conjunction with POX
    - Goals for 50 kW system: 40 kg, 60 liters, $500 per vehicle

Plan For FY-01

- Continue development of sol-gel encapsulated metal hydrides for hydrogen separation and hydrogen gettering applications
- Demonstrate hydrogen separation process in laboratory scale with encapsulated metal hydrides
- Close-out development of sol-gel membrane
- Continue to identify commercial applications in conjunction with industrial partners.

Objectives For FY-01

- Make hundred-gram quantity of sol-gel encapsulated LaNiAl and new hydrides with higher hydrogen capacity
- Design & construct life-cycle test apparatus
- Modify laboratory scale equipment to permit continuous hydrogen separation test
- Perform life-cycle test of encapsulated hydrides
- Test material resistance to CO & other impurities
- Test hydrogen separation performance in a continuous process under simulated industrial conditions.