Metal Hydrides for Hydrogen and Helium Recovery and Purification

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Start Date = June, 2002
Planned Completion = December, 2006
Research Goals and Objectives

- Develop chemical system(s) capable of separating hydrogen from helium and capturing hydrogen boil-off
  - Determine the effects of aluminum addition
  - Determine effect of cycling
Relevance to Current State-of-the-Art

- Metals and alloys are currently under intense investigation as hydrogen storage media. The work here extends the application of these materials to hydrogen and helium separation and purification.

Relevance to NASA

- The materials developed will provide for conservation of resources and funds at KSC by allowing the recovery and re-use of hydrogen and helium.
Budget, Schedule and Deliverables

- June 2002: Initial cmpds selected
- Jan. 2003: Activation achieved via ball milling
- June 2003: Initial cmpds selected
- July 2003: Absorption ability of LaNi5 confirmed
- Aug. 2003: Gas phase absorption identified
- Aug. 2004: Gas phase absorption chemistry determined
- March 2005: Effect of Al quantified
- April 2005: Effect of Membranes Determined
- Sept. 2004: Gas phase rxn characterized
- Aug. 2005: Effect of He on H2 uptake determined
- March 2005: Effect of Al quantified
- July 2005: Recommendations to NASA
- Aug. 2005: Gas phase rxn characterized
- Dec. 2005: Recommendations to NASA
Anticipated Technology End Use

- Conservation and re-use of hydrogen and helium at KSC
- Recovery of boil off or vented hydrogen at hydrogen refueling stations and storage facilities
- Safety systems for facilities in case of hydrogen leaks
- Hydrogen getters
Accomplishments and Results

Technical

• Determination that LaNi₅ can be used to purify He to NASA specifications
• Determination that LaNi₅ can be used to capture hydrogen from boil-off
• Determination that Al improves kinetics of hydrogen uptake by LaNi₅ with little reduction in capacity
• Lanthanum nickel loses little capacity with extended cycling
• Lanthanum nickel with aluminum added shows similar results but with greater loss in capacity
• Development of a gas phase system that allows for rapid capture of hydrogen
Publications and Collaborations

- “Hydrogen Uptake Characteristics of Mechanically Alloyed Ti-V-Ni”
  J. Alloys Comp. 2005, in press.
- Manoj K. Ram, Fractal Systems, Inc., Safety Harbor, FL
- Danesh Chandra, University of Nevada, Reno
- Fereshteh Ebrahimi, University of Florida

Personnel

- Muzaffer Tonguc Oztek, MS Degree, Industrial Chemistry
Chromatogram for hydrogen absorption in the U-tube reactor

Effluent gas composition as percent hydrogen
Percent hydrogen uptake curves for different amounts of Al in LaNi₅
Cycling Comparison With and Without Al

![Graph showing cycling comparison with and without Al](image-url)
Lifetime Study for LaNi$_5$ with 11.4 Atomic% Al

- Uptake 10
- Uptake 20
- Uptake 30
- Uptake 40
- Uptake 50
- Uptake 60
- Uptake 70
- Uptake 80
- Uptake 90
- Uptake 100

Y-axis: Wt% H$_2$ Absorbed
X-axis: Time (sec)
Gas Phase Reaction

\[ \mathrm{H}_2(g) \rightarrow \mathrm{MX}(g) \rightarrow \mathrm{MH}_2(s) \rightarrow X(g) \rightarrow \mathrm{H}_2(g) \]

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Gas Phase Results
Future Plans

Current Project Continuation

• Study effects of inclusion of other light elements, eg. Mg, into LaNi$_5$
• Develop forms of material that are efficient and easy to handle for hydrogen and helium separation and purification
• Work out reversibility of gas phase reaction
• Develop methods for reactivation of LaNi$_5$ after extended cycling

New Direction

• Develop new materials
  – Materials similar to MOF’s but with real-time, externally controllable pore sizes
  – Will provide for efficient storage of hydrogen
  – Will allow non-thermal control of hydrogen uptake and release

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