Glass Microspheres for Hydrogen Storage

James Shelby and Matthew Hall

Alfred University

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STP47

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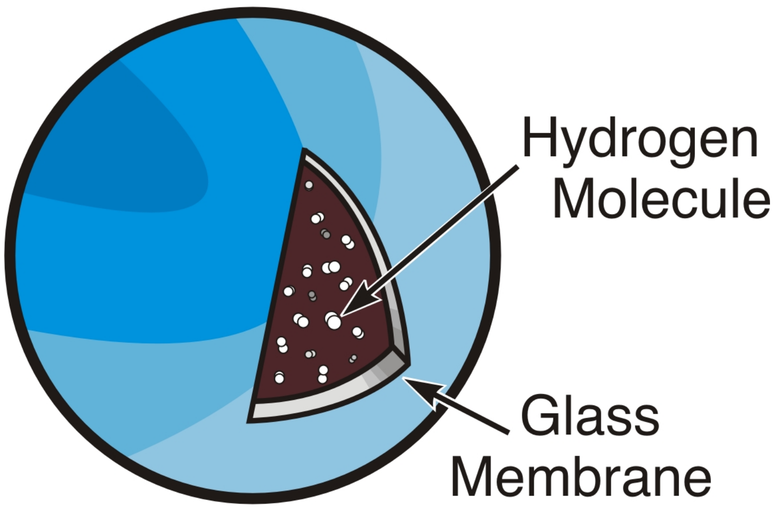
HOLLOW GLASS MICROSPHERES



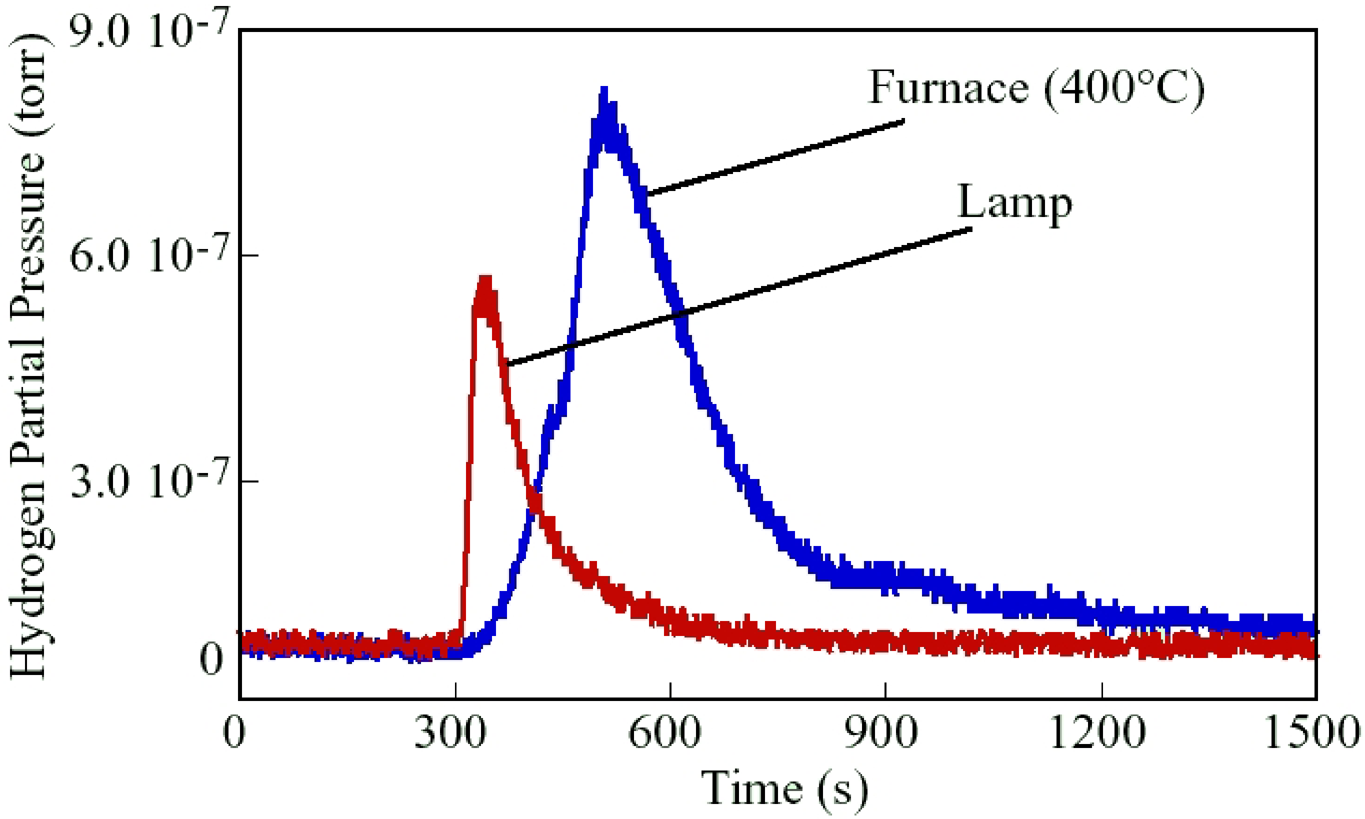
HYDROGEN-FILLED HOLLOW GLASS MICROSPHERE

The concept of using hollow glass microspheres (HGM) as a hydrogen storage medium has been known for some time. Hydrogen diffuses through the thin wall of the HGM at elevated temperatures and pressures. The gas is then trapped upon cooling to room temperature.

The ability of HGM to safely store compressed hydrogen gas is a major advantage. However, a traditional limitation of HGM has been the poor thermal conductivity of a packed bed of HGM; poor conduction of heat translates to unsuitably low release rates of hydrogen gas.

HOLLOW GLASS MICROSPHERES

Previous work by Rapp and Shelby demonstrated that the release rate of hydrogen from a monolithic glass plate could be greatly accelerated by the radiation emitted from an infrared lamp.



In order to effect this "photo-enhanced" outgassing, the glass was doped with an optically active element; in this case, 0.5 wt% Fe_3O_4 was used

OVERVIEW

Timeline

- Estimated start date: May 2005

Budget

- Total project funding for FY 05
  - AU: $50k
  - SRNL: $50k

Partners

- Mo-Sci and Savannah River National Laboratory (SRNL)

Barriers

- Barriers addressed:
  - Cost: HGM are currently made in tonnage quantities from low-cost raw materials
  - Weight and volume: HGM are an ideal storage medium from the standpoint of weight
  - Durability: Provided that the glass membrane is not broken, HGM may be indefinitely used for hydrogen storage
  - Refueling time: Kinetics of hydrogen release is a major component of the project; optical radiation of the appropriate wavelength can greatly reduce the time needed to release hydrogen in comparison to conventional heating methods

Objectives

PRIMARY OBJECTIVE:

Demonstrate the feasibility of using HGM as a hydrogen storage and delivery medium in conjunction with the photo-enhanced outgassing effect

SECONDARY OBJECTIVE:

Further understand the basic mechanism(s) that lead to the photo-enhanced outgassing effect

APPROACH

- The three partners provide the following key capabilities which are critical to the completion of the project:
  - Alfred University → Kinetics of hydrogen storage and release, general glass characterization
  - Mo-Sci → Specialty glass production, Large scale HGM production
  - SRNL → High pressure hydrogen handling
- Initial work will focus on demonstrating optically-enhanced release from HGM filled at low pressures
- Subsequent work will investigate outgassing from HGM filled at significantly higher pressures
- A bench-top demonstration unit will then be constructed using results obtained from previous studies

Future Work

The work plan over the next 18 months includes:

1) Determination of the glass composition/dopant combination for initial proof-of-concept study

2) Production of HGM from chosen glass composition

3) Design, construct, and test apparatus for photo-enhanced diffusion measurements at Alfred

4) Conduct photo-enhanced outgassing measurements on HGM filled with low pressure hydrogen

5) Design and construct necessary facilities for filling HGM with high pressure hydrogen

6) Determine maximum HGM fill pressures that may be used without causing excessive failure

7) Conduct photo-enhanced outgassing measurements of HGM filled with high pressure hydrogen

Future Work

MILESTONES:

1) Produce several grams of appropriate HGM for testing within 1 year

2) Produce HGM filled with high pressure hydrogen within 1 year

3) Measure kinetics of photo-enhanced hydrogen outgassing from HGM within 18 months

4) Demonstrate ability to store 0.1 kilogram of hydrogen per kilogram of HGM within 18 months

GO/NO-GO POINT:

A go/no-go decision will be made at the end of 18 months based on the ability to demonstrate a gravimetric loading of 0.1 kilogram of hydrogen per kilogram of HGM

HDRYOGEN SAFETY

The most significant hydrogen hazard associated with this project is:

- Handling of high pressure hydrogen
  - HGM equilibrate to external applied pressure

    ⇒ HGM must be placed in ≈350 bar H_2 to achieve a fill pressure of 350 bar
- Subsequent testing of filled HGM is not a concern
  - Once the HGM are filled with high pressure hydrogen, the dangers associated with a single storage cylinder are not applicable
  - The total amount of gas contained within in a single HGM is miniscule

HDRYOGEN SAFETY

Our approach to deal with this hazard is:

- SRNL has developed safety protocols and has extensive expertise with the handling of high pressure hydrogen gas
  - Refer to WSRC-IM-97-00024, Revision 3.0
- Standard operating procedures for low pressure handling of hydrogen have been developed at Alfred University