II. Novel applications of hydrogen-filled hollow glass microspheres

James E. Shelby
Alfred University

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Novel Applications of Hollow Glass Microspheres

Matthew M. Hall and James E. Shelby

Alfred University
School of Engineering
2 Pine Street
Alfred, NY 14802

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Traditional Applications for HGMS
  Low density fillers for composites with polymers and concrete
  Thermally insulating paint
  Thermally insulating tapes
  Syntactic foams for submersibles
  Targets for laser fusion systems (D/T filled)

Modern Applications for Hydrogen-Filled HGMS
  Hydrogen storage
  Hydrogen separation and purification
  Radiation shielding for manned space flight
HYDROGEN-FILLED HOLLOW GLASS MICROSPHERE

ADVANTAGES:
• Cheap, plentiful raw materials
• Established technology
• Readily recycled
• Light-weight
• High strength
• Safety
• Flow properties

DISADVANTAGE:
• Slow hydrogen release rate
HOLLOW GLASS MICROSPHERE PRODUCTION

Flame spraying method for producing microspheres
HOLLOW GLASS MICROSPHERES
Photo-Enhanced Outgassing

Data shown are for 0.5 wt% Fe$_3$O$_4$ doped CGW 7070 glass
Photo-Enhanced Outgassing

Data shown are for 2.0 wt% Fe$_3$O$_4$ doped CGW 7070 glass
IDENTIFYING THE CRITICAL PARAMETERS

- Glass membrane composition
- Glass dopant identity
- Glass dopant concentration
- Illumination intensity
- Illumination wavelength
Data shown are for glasses doped with 2.0 wt% Fe₃O₄.
DOPANT IDENTITY

Data shown are for doped CGW 7070 glass
Comparison of Outgassing Rates from Glasses Doped with Nickel and Iron Oxides.
DOPANT CONCENTRATION

Data shown are for doped CGW 7070 glass.
Data shown are for 0.5 wt% Fe$_3$O$_4$ doped CGW 7070
Data shown are for 2.0 wt% Fe$_3$O$_4$ doped CGW 7070 glass
ACTIVE WAVELENGTH RANGE

EXTENDED HOT MIRROR

COLD MIRROR

HOT MIRROR

Dark bands are regions with optical transmission <40%
PVT Measurement System
Helium Outgassing Curves for Borosilicate HGMS
**ONGOING WORK**

- Produce hollow glass microspheres doped with transitional metal of choice
- Demonstrate optically-induced outgassing of hydrogen from hollow glass microspheres
- Evaluate designs for integrating hollow glass microspheres into a complete storage system
SUMMARY

• Hollow glass microspheres have many attractive features as a hydrogen storage medium

• Optically-induced outgassing of hydrogen from glass is significantly faster than conventional heating

• Current work seeks to demonstrate feasibility using hollow glass microspheres
HYDROGEN SEPARATION and PURIFICATION

Flow mixed gases through a bed of HGMS at elevated temperatures/pressures

Hydrogen will diffuse through glass, but CO, CO$_2$, H$_2$O, H$_2$S, etc. will not

When H$_2$ appears in exit stream, stop flow

Evacuate bed, capture hydrogen released at temperature, or

Cool, “freeze in” hydrogen, remove HGMS
Hydrogen will be retained and then released when surrounding atmosphere has lower partial pressure of hydrogen than is present in HGMS

Transport filled HGMS to use site

Reheat to release hydrogen, or

If doped, use photo-enhanced diffusion to release hydrogen

Return empty HGMS for reuse
Status of Separation/Purification Studies

Conceptual at present, but all known behavior of gas permeation in glasses indicates that this will work with existing technology and commercially available HGMS

Testing will use PVT system used for hydrogen storage studies, which is operational

Studies will be carried out during next 12 months

After that, just needs someone with money to commercialize!
RADIATION SHIELDING (NASA)

Outer space has “Galactic Radiation Spectrum”

High energy particles, neutrons, protons, alpha particles, gamma rays, x-rays, etc.

$^{56}$Fe is most favored of high energy nuclei and is very damaging to humans and spacecraft.

Other “high-energy, high-Z” radiation includes $^{16}$O, $^{28}$Si, and $^{12}$C.
Radiation Spectrum

Iron nuclei

Distribution of HZE particles produced by the sun
Shielding Criteria

Hydrogen is most effective shield against Fe nuclei

Currently use high density polyethelene (≈2 gm/cm$^3$)

Composite of PE/HGMS would be much lower density
≈0.5 to 0.7 gm/cm$^3$

HGMS filled with high pressure hydrogen will yield comparable hydrogen density, with lower bulk density

Glass can contain B, Li, Cd, Sm, and/or Gd for neutron absorption as well, i.e. multipurpose shielding
Status of Shielding Studies

Composites are being made using commercial HGMS, yield of good material is improving

Need stronger HGMS or lower stress process

Developing lithium aluminoborate glasses for producing HGMS

Radiation testing will occur during FY06

Posters presented at this conference covering several aspects of this work
Acknowledgments

Current Students

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