Hydrogen Detection Using "Smart Pigments & Paints"

N. Mohajeri, G. Bokerman, N. Muradov, & A. T-Raissi
Florida Solar Energy Center
University of Central Florida

Start Date: September 2004
Planned Completion Date: December 2006

Research Goals and Objectives

a) To modify existing and synthesize novel formulations for the visual detection of hydrogen leaks.

b) To develop a process for the application of irreversible smart paints.

c) To complete physicochemical characterization of prospective irreversible smart paint formulations.

d) To complete weathering tests of the prospective irreversible smart paint-substrate combinations.

e) To design and synthesize novel reversible smart paints based on tungsten & molybdenum polyoxometalate complexes.

Relevance to Current State-of-the-Art

- Point-of-use electronic sensors
  - They require time consuming & laborious process especially when very large areas must be monitored.
  - Unsatisfactory for continuous monitoring.
  - Loss of sensitivity in the field due to, for example wind effects, etc.
  - The leak can be detected only as it is occurring.

Relevance to NASA

- Detecting H_2 leakage at storage or usage sites is crucial for safe NASA operation.
- Considerable interest in the R&D of functional materials to locate hydrogen leaks when they occur.

Budget, Schedule and Deliverables

- Budget = $87,270.00

	Qtr 1			Qtr 2			Qtr 3			Qtr 4		
Project Steps:	Sep 04	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05	Aug 05
Process application of PGM oxides												
Synthesis of reversible pigments												
Physicochemical characterization of reversible												
Weathering												

Anticipated Technology End Use

- Any industry which produces or consumes hydrogen such as NASA.

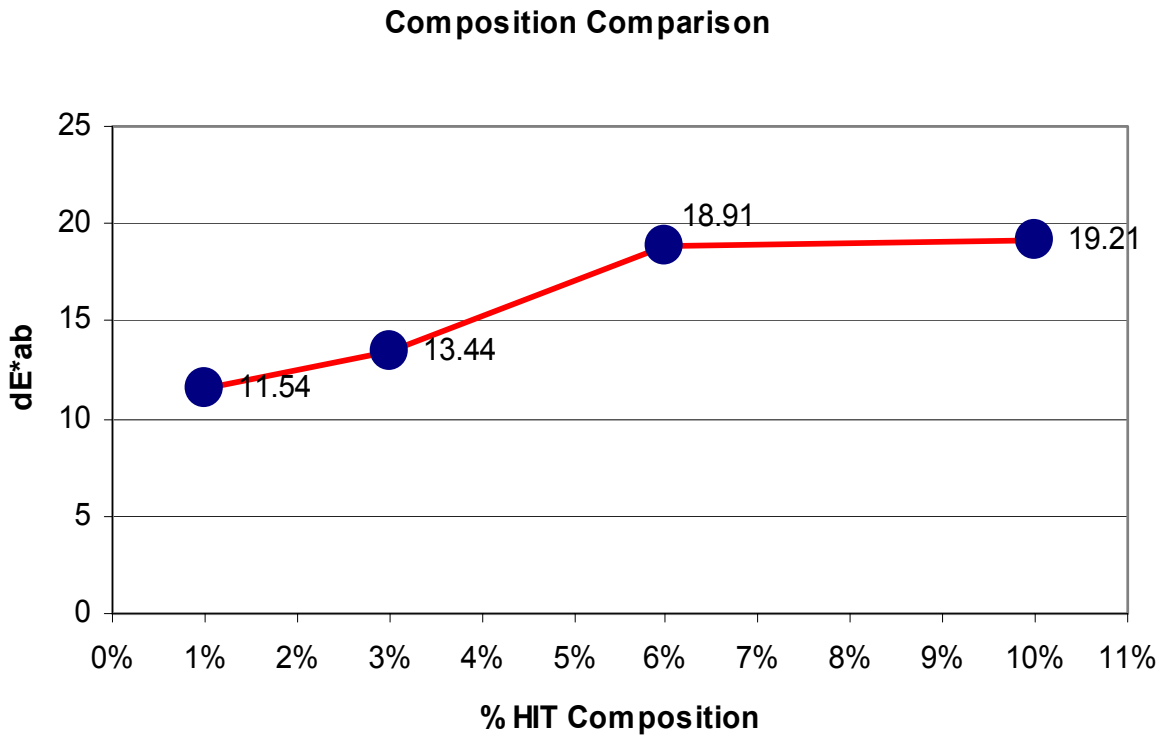
- Hydrogen Economy
  - Transportation
  - Storage
  - Fuel Cells

Accomplishments and Results
One time-use

- Pd oxide based pigments for “one time-use” have been synthesized & demonstrated.
- Pigments show a color change at a range of temperatures from ambient down to -40°C.
- Effective gas permeable matrices for the pigment encapsulation have been identified. These matrices show improved selectivity toward hydrogen detection.
- Various techniques for application of the pigments have been developed & tested.
- The irreversible “one time-use” system is being field tested at NASA-KSC.
- Sample kits have been sent to other NASA Centers for evaluation & feedback.

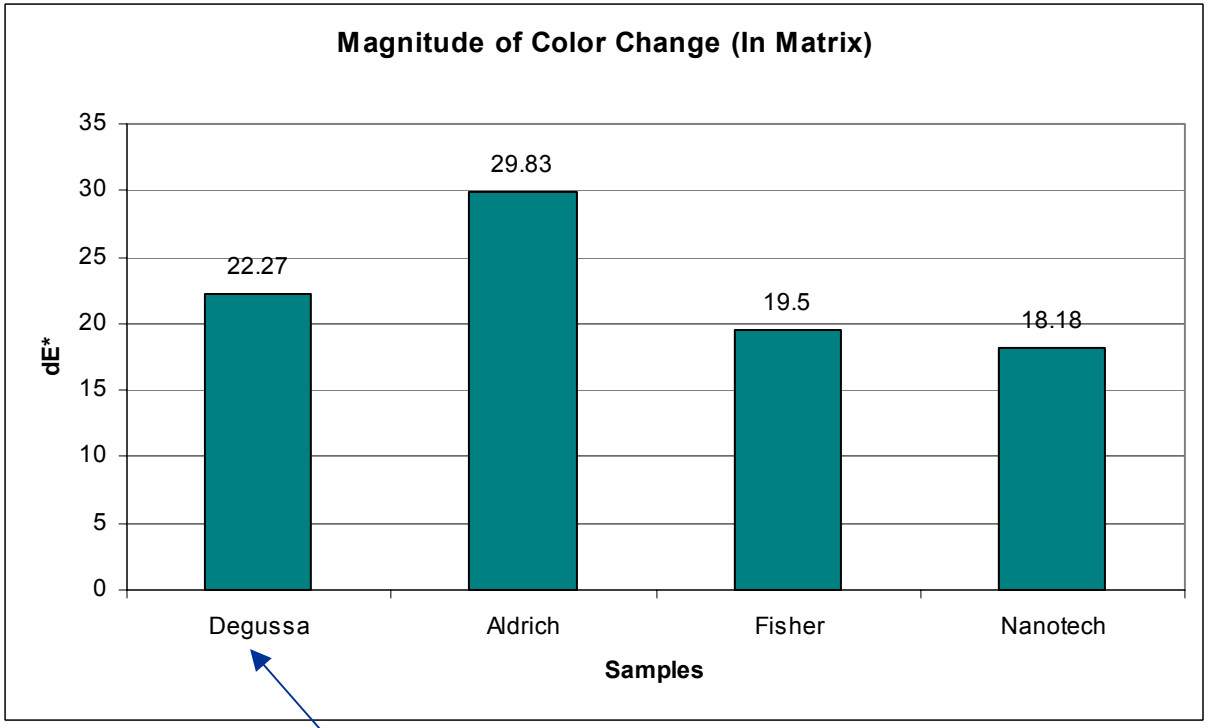
Accomplishments and Results

One time-use



Accomplishments and Results

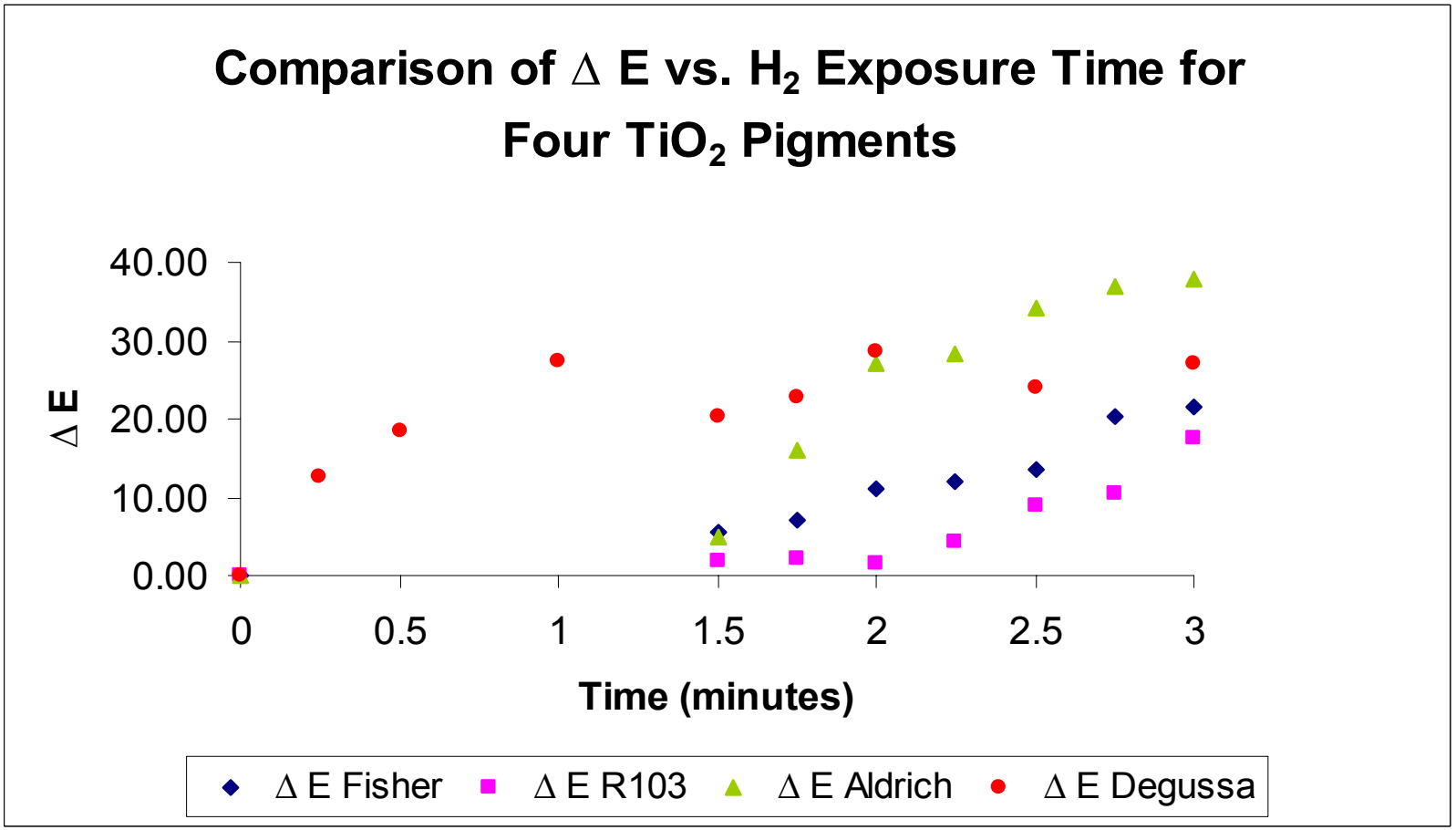
One time-use



Fastest color change

Accomplishments and Results

One time-use



Accomplishments and Results

One time-use

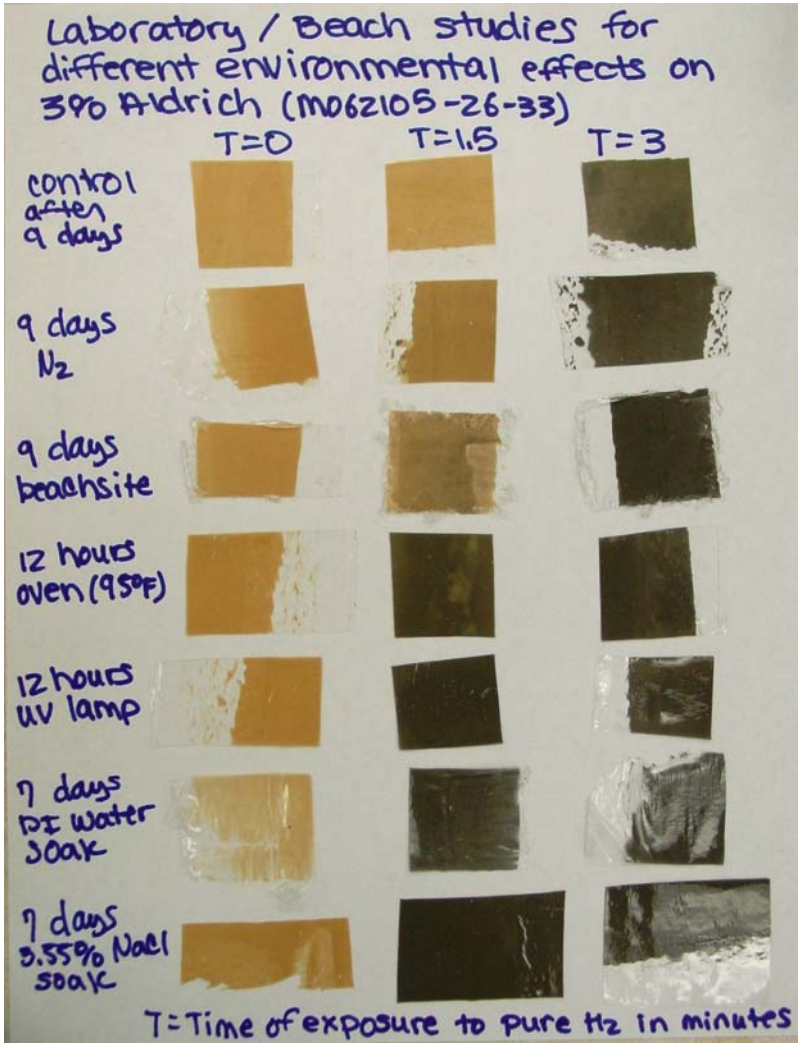
1% H_2 concentration study

	1 minute exposure Pigment Side	2 minute exposure Pigment Side
TiO_2 Source	ΔE_{abs}	ΔE_{abs}
Fisher		7.00
Dupont R103		2.55
Aldrich		13.63
Degussa P25	7.24	14.75

- Color changes faster with Degussa support
- After 2 minutes exposure, the extent of color change is the same for Aldrich & Degussa supported pigments

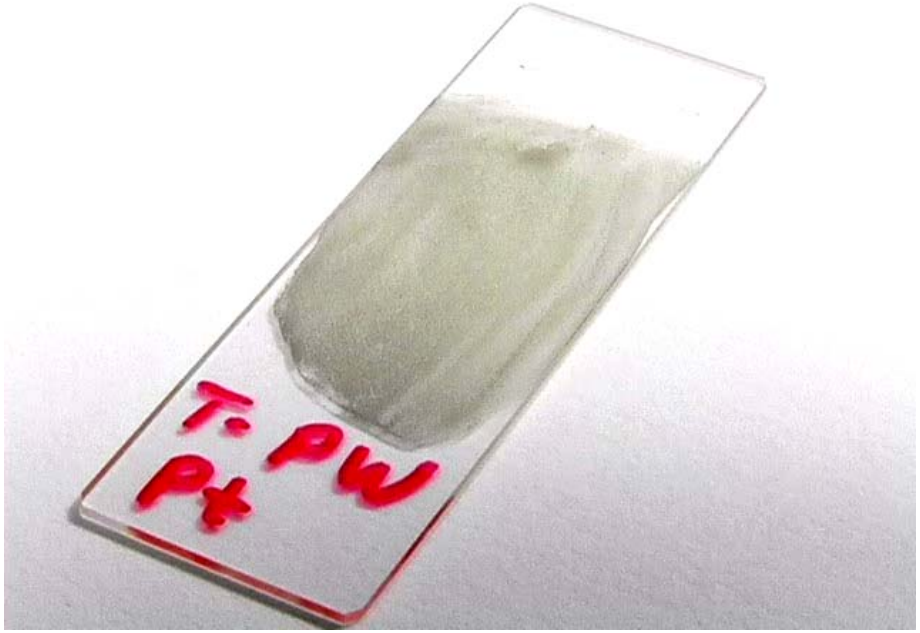
Accomplishments and Results
One time-use

Specimens placed on the beach react to H_2 faster than unexposed films, in a laboratory environment.



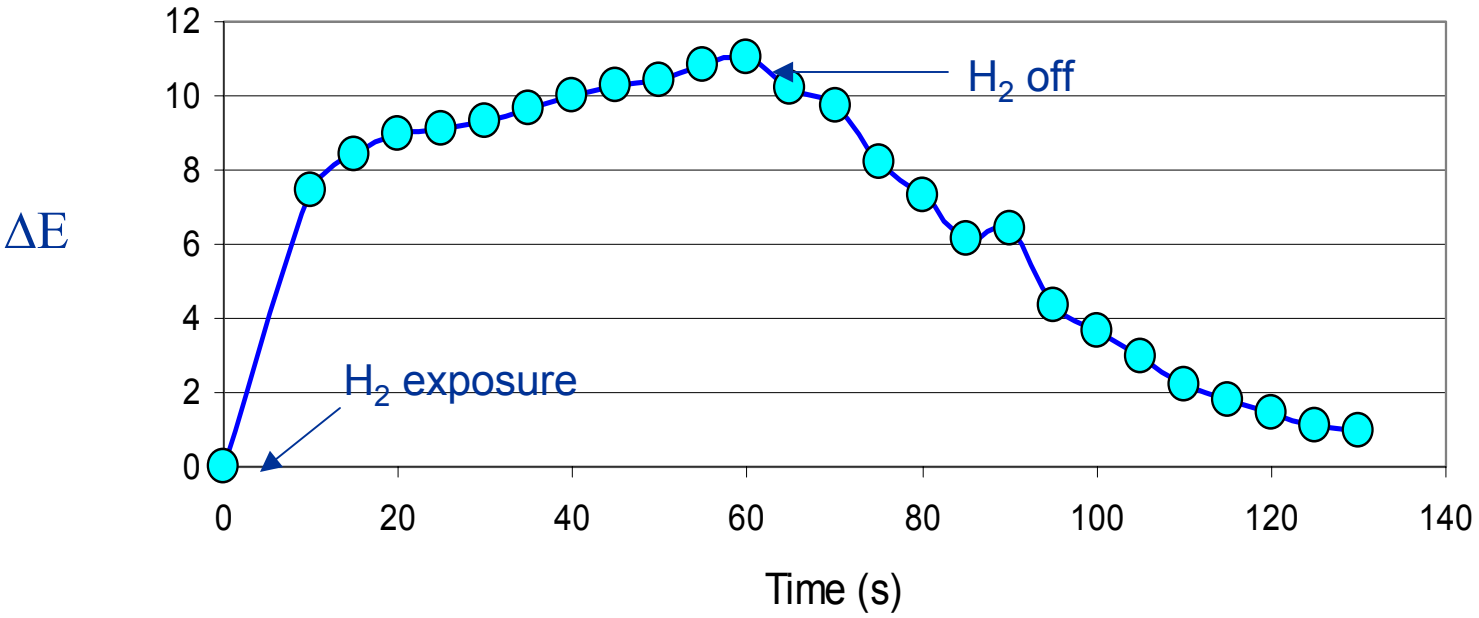
Accomplishments and Results
Repeated use

- Special reversible pigments based on tungsten and molybdenum polyoxometales for “repeated use” application has been prepared & tested at FSEC laboratories.



Accomplishments and Results

Repeated use



Kinetics of Coloration and Bleaching of Reversible H_2 Chemochromic Indicator

Material Costs for Manufacturing 1” Wide Chemochromic Tape

	Reagents & Chemicals ($/Yd)	Matrix ($/Yd)	Total ($/Yd)
One Time-Use	0.05	0.87	0.92
Repeated-Use	0.20	0.26	0.46

Accomplishments and Results

- A provisional patent entitled "Gas Permeable Matrix for Encapsulating Chemochromic Compounds with Enhanced Hydrogen Sensing Performance," Application No. 60/676,352 has been filed with the USPTO.

Future Plans

- **Research**
  - Field testing & weathering evaluation of “repeated use” articles.
  - Development of “repeated use” & “one time-use” articles suitable for temperature service down to –359 °F.
  - Lowering the overall manufacturing costs of the chemochromic articles.

- **Future Funding & Commercialization**
  - Florida Hydrogen Initiative LOI pending.
  - Will seek additional NASA funding.
  - Planning full-scale commercialization via UCF's Venture Lab. & SBIR funding conduit.

Acknowledgment

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