



NIST's Advanced Technology Program

**DOE Workshop on
Hydrogen Separation and Purification Technologies
Arlington, VA, Sept. 8-9, 2004**

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ATP is part of NIST

NIST Mission:

Strengthen the U.S. economy and improve the quality of life by working with industry to develop and apply technology, measurements, and standards.



- **3,000 employees**
- **\$771 million annual budget**
- **2,000 field agents**
- **1,800 guest researchers**
- **\$2.2 billion co-funding of industry R&D**
- **National measurement standards**

Helping America Measure Up

NIST Assets Include:

Advanced Technology Program

Partnership with private industry to accelerate the development of high-risk, enabling technologies with broad benefits for the entire economy and society.

Manufacturing Extension Partnership

Network of centers offering technical assistance and best business practices to the 385,000 smaller manufacturers in all 50 states and Puerto Rico.

Measurements and Standards Laboratories

Nation's ultimate reference point for measurements, standards, and technology research to support industry, science, health, safety, and the environment.



Baldrige National Quality Program

Promotes business performance excellence and quality achievement by U.S. companies.

ATP Mission ...

*To accelerate the development of
innovative technologies for broad
national benefit through partnerships
with the private sector.*



Key Features of the ATP

- Emphasis on innovation for broad national economic benefit
- Industry leadership in planning and implementing projects
- Project selection based on technical and economic merit
- Demonstrated need for ATP funding
- Requirement that projects have well-defined goals/sunset provisions
- Project selection rigorously competitive, based on peer review
- Program evaluation from the outset

The Difference ATP Makes

With the ATP, R&D is:

- Higher risk
- Creating leap-frog technologies
- Leading to multiple applications
- Expanding company and national competencies
- Broadly diffused

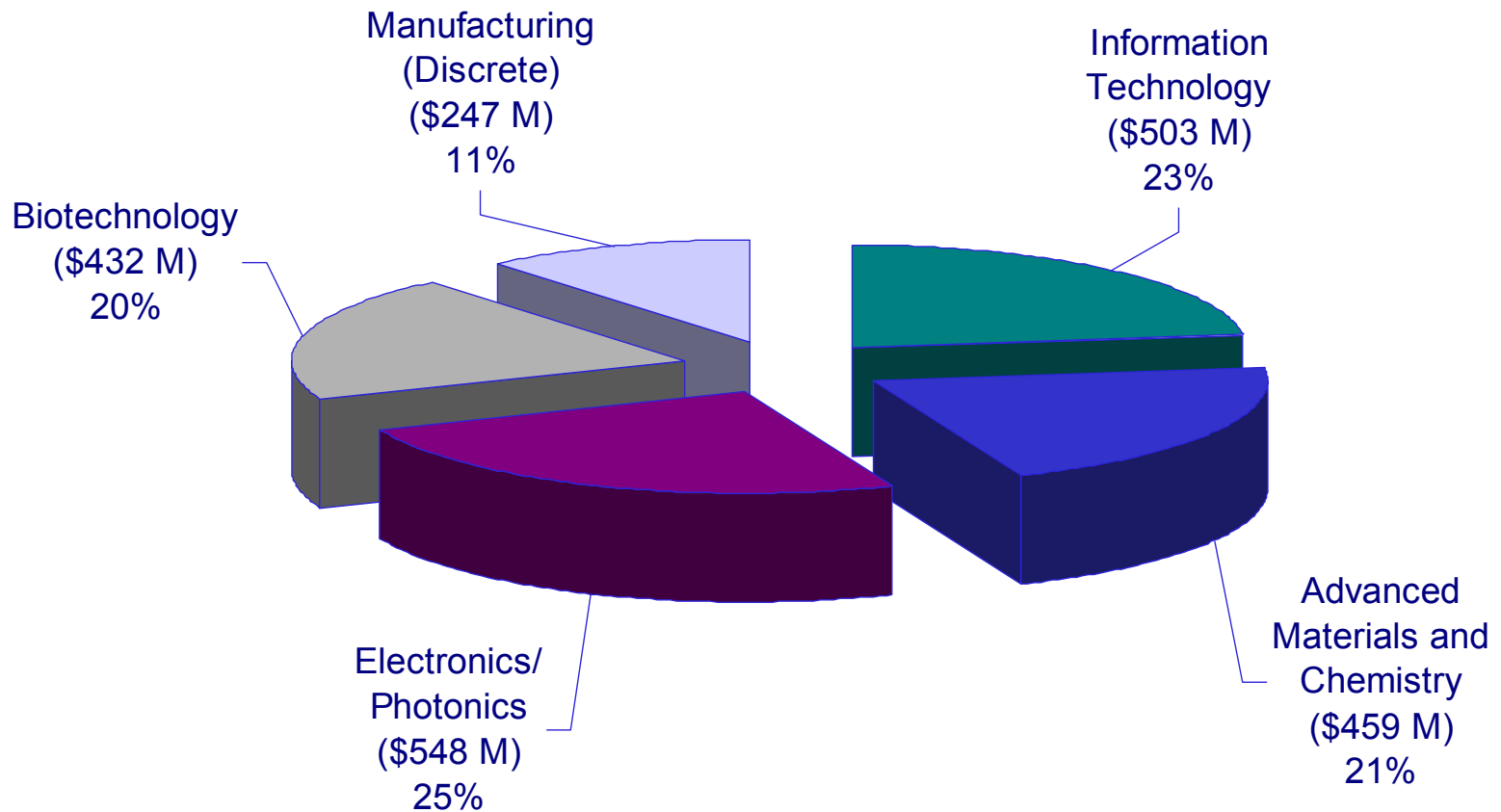


ATP

Fourteen Years of Innovation

- Since 1990, **6,054 proposals** submitted to **43 competitions**, requesting **\$13.0 B** from ATP
- **736 projects awarded** with **1,468 participants** and a roughly equal number of subcontractors
- **211 joint ventures** and **525 single companies**
- **\$4.2 billion of high-risk research** funded
 - *ATP share = \$2.2 billion*
 - *Industry share = \$2.0 billion*
- Small businesses are thriving
 - *66% of projects led by small businesses*
- Over **160 universities** participate
- Over **25 national laboratories** participate

736 ATP Awards by Technology Area (As a Percent of \$2,189 M Awarded)



Chemistry Research in ATP

Cost-effective design methods for environmentally benign routes to materials, chemical building blocks, industrial gases, drugs, food processing etc.

Science Impact Areas:

Reaction Design -- active site design tools and methods to speed development cycle of catalytic and biocatalytic chemistry innovations

Process Science – integration of advanced reaction design and product recovery technologies into cost-effective processes

New Materials -- New catalytic materials, polymers, coatings, membranes; control of material properties at nano-scales, nano-materials

Technology Application Examples

Catalysis & Biocatalysis

Membrane/ Separations

**Fuel Cells
Batteries**

ATP Technology Applications Cluster Selective Membrane Platforms

<u>Awardee:</u>	<u>Science Impact Areas / Technology Challenge</u>
Praxair/Hy9	Process Science, New Materials / Hydrogen-selective, composite Membranes for H ₂ production
GE Osmonics/ GSK	Process Science, New Materials / Solvent & Temp Stable Polymers: seed oils, pharmaceuticals
Engelhard	Process Science, New Materials / Controlled Pore Molecular Sieves – one-step purification of natural gas, oxygen enrichment of air streams
Plug Power/ PolyFuel, SRI	Process Science, New Materials / A highly simplified, CO tolerant PEM Fuel Cell System utilizing advanced components, high temperature membrane
Praxair	Process Science, New Materials / Develop a novel on-site electrolytic system to separate and compress oxygen from air

ATP Technology Applications Cluster

Selective Membrane Platforms, cont'd

Science Impact Areas / Technology Challenge

Microcell Corp.

Process Science, New Materials / Fabrication of Fuel Cells from Microcell Fibers

Cabot Superior
MicroPowders

Process Science, New Materials / Elevated Temperature Reformate-Tolerant Membrane Electrode Assemblies (MEAs) for PEM Fuel Cells

Baxter
International

Process Science, New Materials / Ultrafiltration Membranes for Biological Applications

Facilichem

Process Science, New Materials / Stable Liquid Membranes

Cabot Superior
MicroPowders

Process Science / Development of High Volume Digital Manufacturing of Membrane Electrode Assemblies for Fuel Cells

BP Chemicals

Process Science, New Materials / Dual Purpose Ceramic Membranes

High-Temperature Hydrogen Selective Membrane Platforms

A new membrane-based, hydrogen generation technology that can be integrated into a fuel cell system

Project Objectives:

- Develop an economical hydrogen-generation system and high temperature hydrogen separation membrane platform. The generation system combines a novel palladium-based, high temperature, hydrogen-selective membrane with a catalytic reactor.

Outstanding Technical Challenge:

- To produce a hydrogen separator with an extremely thin defect-free membrane capable of stable operation at high temperature

Recent Success:

- Commercial hydrogen purifiers for small-scale production of ultrapure hydrogen at high fluxes.

Outlook:

- To develop a pilot scale membrane reactor for the production of hydrogen that can be used to power fuel cells

Praxair/ Hy9

Universities: Tufts U

Start / End: 2/1/99 - 1/31/04

ATP Funds: \$1.515 M

Total Project: \$3.082 M

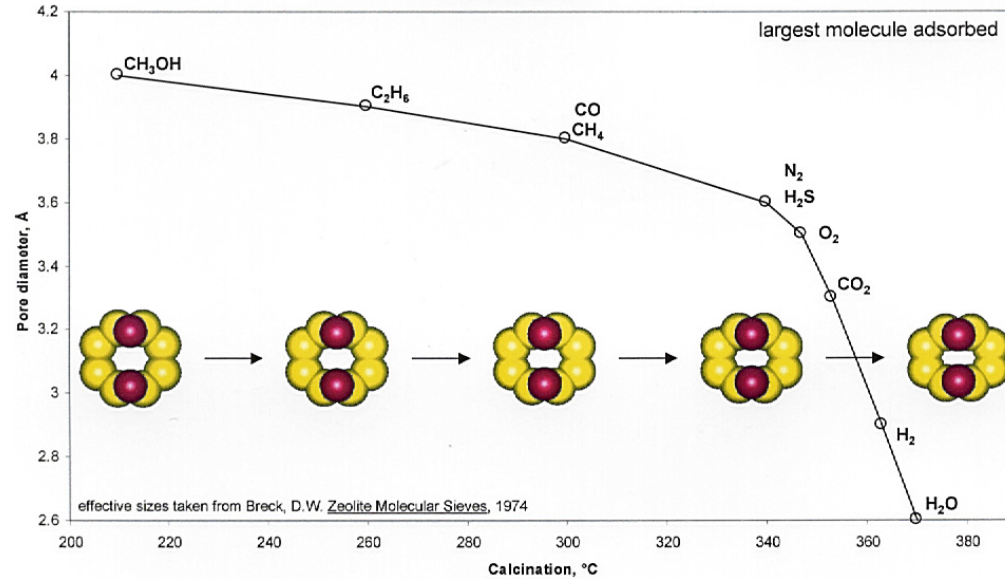
Application of Molecular Gate^R Technology To Oxygen Enrichment of Air and Simplified Purification of Natural Gas

One Step Purification of Natural Gas:

- One-third of U.S. natural gas reserves cannot be used on account of excessive contamination by nitrogen and/or carbon dioxide (N₂ and CO₂).
- A new purification technology called Molecular Gate^R developed by Engelhard removes contaminant N₂ and CO₂ from natural gas at the well head in a simplified one-step process.
- **The initial target for this new technology is in the recovery of coal bed methane. Engelhard announced its first sale of a commercial Coal Mine Methane Recovery Unit in 2003.**
- Recent *Nature* publication, **412**, 720 (2001), showing that the Molecular Gate^R adsorbent (titanium silicate molecular sieve) has the unique ability to adjust pore size openings, has generated many suggestions on new applications from around the world.

Molecular Gates

Systematic Contraction of Zeolite Pores
in Sr/Na CTS-1



Company: **Engelhard Corp.**

Universities: Cleveland State,
U of Massachusetts/Amherst

Start / End: 12/01/99 - 11/30/02

NIST/ATP Funds: \$1,800,000

Total Project Cost: \$4,500,000

Integration of Membrane Technology and Power Systems

New opportunities for substantial advantages in power density, CO tolerance and water management in **fuel cell power systems** are driving this important recent trend, as evidenced by:

- ✓ New fuel cell technologies incorporating innovative new membrane systems
- ✓ New membrane-based, hydrogen generation technologies that can be integrated into a fuel cell power system

ATP Technology Cluster Fuel Cell Power Systems

Awardee:

Technology Challenges

Avista Labs

Modular 2KVA Fuel Cell Power Plant with Live Replaceable, Self-Hydrating PEM Smart Cartridges

MesoFuel, Inc

Compact Pure Hydrogen Generation Systems for PEM Fuel Cell Applications.

**MTI MicroFuel/
DuPont**

Integrated Hybrid Direct Methanol Fuel Cell Electrochemical Capacitor Powerpack

Plug Power

Development of a Highly Reliable and Low Cost Fuel Processing System for Stationary PEM Fuel Cell Applications

T/J Technologies

Hybrid Ultracapacitor/Methanol Fuel Cell Power Paks for Portable Electronics

ATP Technology Cluster Fuel Cell Power Systems

Awardee:

Technology Challenges

Microcell

Fabrication of Fuel Cells from Microcell Fibers

**Virent Energy
Systems**

**Small Scale Hydrogen Generation via Aqueous-
Phase Carbohydrate Reforming**

**Technology
Management**

Small, Ultra Efficient Fuel Cell Systems

**Lilliputian
Systems**

**Micro Solid Oxide Fuel Cell (SOFC) Based Power
Supplies for Handheld Electronics**

**NexTech
Materials, Ltd.**

Direct Fuel Power Module