Alternative Energy for Transportation: Hydrogen and Fuel Cells

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LAB-AIDS INCORPORATED EXPERIENCING SCIENCE™

SEPUP

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Publisher: LAB-AIDS, Inc.: lab-aids.com

Curriculum Website: sepuplhs.org/hydrogen

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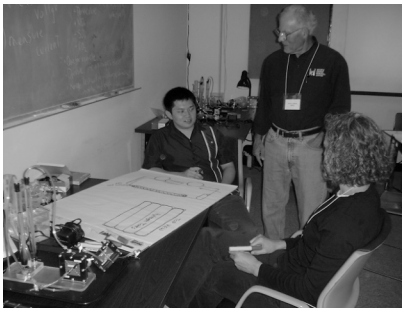
HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Dept of Energy
- "Introduction to Alternative Energy: Hydrogen Fuel Cells"
- Developed by a team of scientists, engineers, curriculum developers, teachers, and other educational leaders
- Development process includes extensive classroom testing and feedback
- High School Chemistry (or Physics & Envi. Sci.)



Partners

Lawrence Hall of Science

Schatz Energy Research Center

AC Transit

FilmSight Productions

LAB-AIDS, Inc.

Teachers and students from SF Bay Area, Washington, Ohio, California, Connecticut, Georgia, New York, and South Carolina

Issue-Oriented Science

- Engages students in learning science and applying it to make evidence-based decisions.
- In most cases, does not advocate a particular decision, but does advocate the use of scientific evidence and concepts in the decision-making process.
- Encourages students to look at various sides of an issue and evaluate the trade-offs involved in a complex decision.

Hydrogen and Fuel Cells in South Carolina

- South Carolina Hydrogen Fuel Cell Alliance includes 14 organizations: www. SCHydrogen.org
- South Carolina is one of the top 5 fuel cell states, according to Fuel Cells 2000 (along with California, Connecticut, New York, Ohio
- Stations in Columbia and Aiken
- Demonstration bus program in Columbia (Proterra)

Activity #1: Hydrogen for Transportation?

Hydrogen

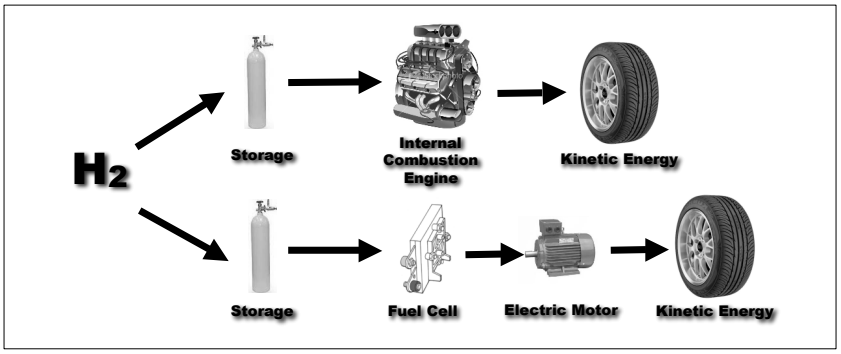
- Hydrogen is the most common element in the universe.
- The sun is composed mostly of hydrogen gas.
- Where is hydrogen found on Earth?
- Hydrogen occurs naturally as a component of water, air, and hydrocarbon fuels like coal and natural gas.

How do we get Hydrogen?

Hydrocarbon + Heat → **Reformer** → Hydrogen + CO_2

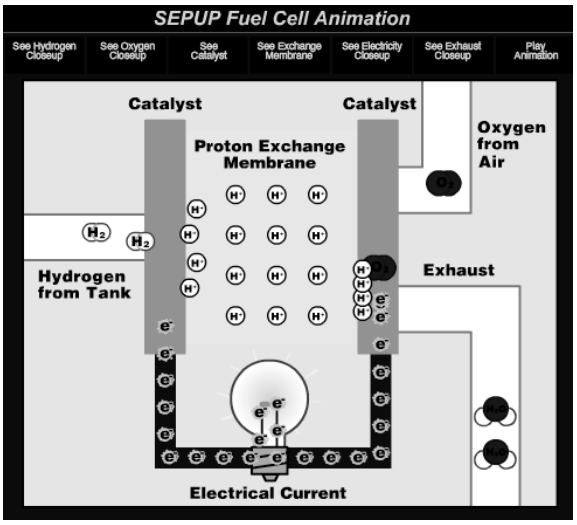
Water + Electricity → **Electrolyzer** → Hydrogen + Oxygen

What do we do with Hydrogen?

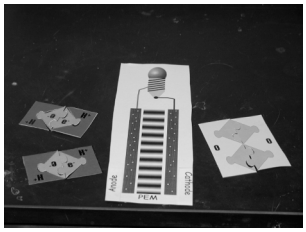


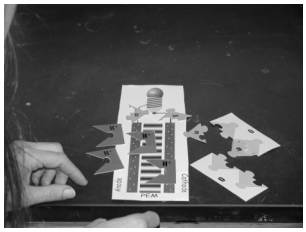
- A way to store energy (like a battery)
- A way to move energy (like electricity)
- NOT an energy source and NOT free

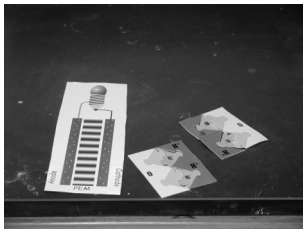
Activity #4: Modeling the Fuel Cell Reaction



Modeling the Fuel Cell Reaction







Student Activity
The Fuel Cell Half Reactions

The half-reactions:

- Oxidation: $H_2 \rightarrow 2H^+ + 2e^-$
- Reduction: $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

Adding the half-reactions:

- Oxidation: $\mathbf{2}H_2 \rightarrow \mathbf{4}H^+ + \mathbf{4}e^-$
- Reduction: $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

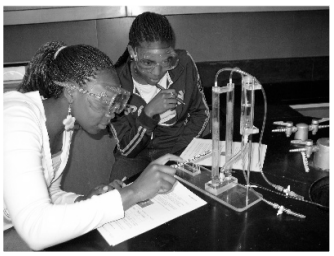
$$2H_2 + O_2 \rightarrow 2H_2O + \text{energy (electricity)}$$

The HyTEC Curriculum

Six activities take approximately two weeks of instructional time.

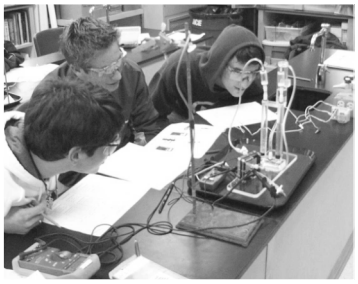
1. **Energy for Transportation** - Students examine trade-offs of various fuel/vehicle combinations.

2. **Obtaining Hydrogen through Electrolysis** - In this hands-on lab, students generate hydrogen and examine the required energy input, stoichiometry, and electrochemistry involved in the process.



The HyTEC Curriculum

3. **Putting a Hydrogen Fuel Cell to Work** - Students generate H_2 and O_2, and use a single cell fuel cell to perform work.



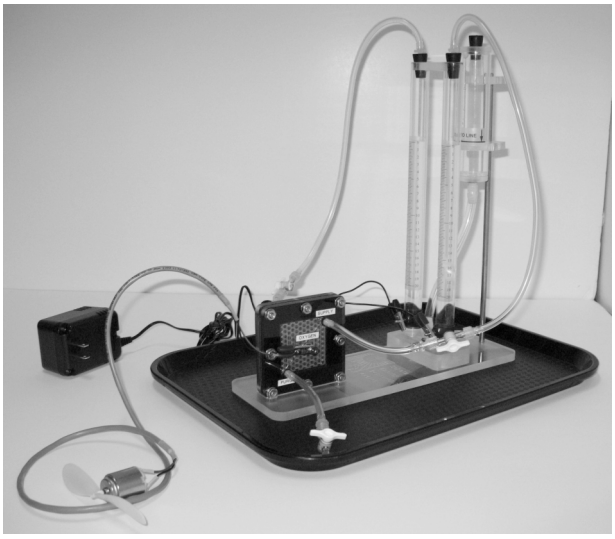
4. **Modeling a Fuel Cell Redox Reaction** - Students use model pieces and a fuel cell simulation to explore the fuel cell reaction.

The HyTEC Curriculum

5. **Fuel Cell Efficiency** - In a hands-on lab, students measure fuel cell efficiency.

6. **Hydrogen for Transportation** - Students conduct research and engage in a simulated City Council Meeting to present the advantages and challenges of using hydrogen and fuel cells for a city bus program.

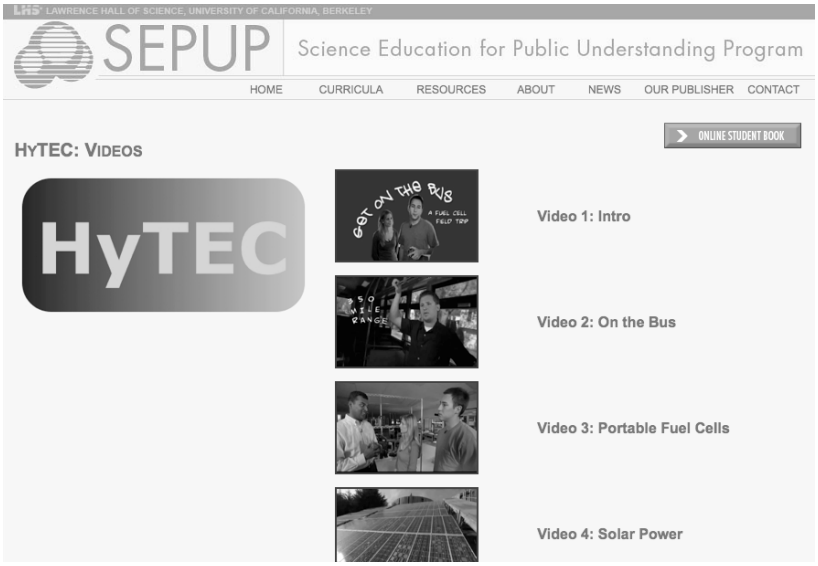
Prototype Kit



Website and Videos

Hydrogen Fuel Cell website:
sepuplhs.org/hydrogen

- Simulation of Fuel Cell
- Clips from video field trip
- Web Resources
- Info on fuel cells



Challenges to Hydrogen Economy

- Developing infrastructure and improving technology
- Reducing cost
- Addressing public concerns about safety
- Production of hydrogen from water using renewable energy sources

Get Involved!

Professional Development: Berkeley, Jan. 14-15, 2011

Contact SEPUP

- chris_k@berkeley.edu
- bnagle@berkeley.edu

Power point and handouts

- sepuplhs.org/news.html

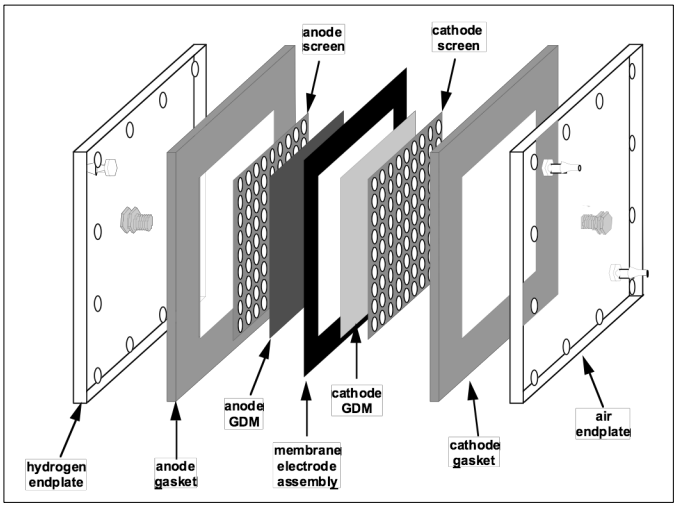
Curriculum Website

- sepuplhs.org/hydrogen

LAB-AIDS Booth

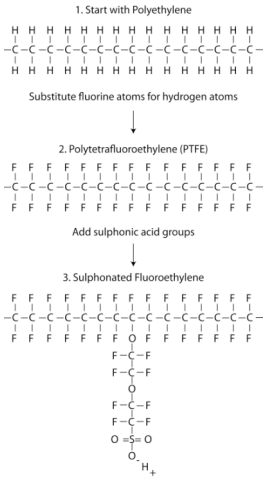
Additional Information

Fuel Cell Parts - Form and Function



The Proton Exchange Membrane (PEM)

- Modified polyethylene hydrocarbon chains
- Fluorine substitutions create polytetrafluorethylene (PTFE: teflon®)
- To make it electrolytic: side chains with hydrophilic sulphonate (-SO_3H) groups are added



NSES Addressed

Structure of Atoms:

•Matter is made of minute particles called atoms.

Structure and Properties of Matter:

•Atoms interact with one another by sharing or transferring electrons

Chemical Reactions:

•Chemical reactions occur all around us

•Chemical reactions may release or consume energy

•A large number of reactions involve transfer of electrons

•Catalysts lower activation energy necessary for reactions

South Carolina Standards

Chemistry

C-4 The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.

Balance equations for simple reactions

Analyze energy changes

Use concept of moles

Catalysts

Oxidation-reduction reactions