Alternative Energy for Transportation: Hydrogen and Fuel Cells

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HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Dept of Energy
- 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.)

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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

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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 the U.S.


• Top 5 fuel cell states, according to Fuel Cells 2000: South Carolina, California, Connecticut, New York, Ohio
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.

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How do we get Hydrogen?

Hydrocarbon + Heat → **Reformer** → Hydrogen + CO₂

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

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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: \( 2H_2 \rightarrow 4H^+ + 4e^- \)
  • 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.
3. **Putting a Hydrogen Fuel Cell to Work** - Students generate H₂ and O₂, 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.

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


• 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!

• 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
Fuel Cell Parts - Form and Function

- Modified polyethylene hydrocarbon chains
- Fluorine substitutions create polytetrafluoroethylene (PTFE: teflon®)
- To make it electrolytic: side chains with hydrophilic sulphonate (-SO₃H) groups are added

The Proton Exchange Membrane (PEM)
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

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