Material and Chemical Processing (Concentrated Solar)

(Four Activities)

Grades: 5-8

Topic: Solar

Owner: National Renewable Energy Laboratory

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

Material and Chemical Processing

For the Teacher

Concentrated sunlight is a versatile and high-quality form of energy with several potential applications besides process heat and electricity. Today scientists are developing systems that use concentrated sunlight to detoxify hazardous wastes, to drive chemical reactions, and to treat materials for increased hardness and resistance to corrosion.

National Science Education Standards by the National Academy of Sciences

Science Content Standards: 5-8

Science As Inquiry

– Content Standard A:

"Abilities necessary to do scientific inquiry"

"Understandings about scientific inquiry"

Physical Science

– Content Standard B:

"Properties and change of Properties in matter"

"Transfer of energy"

Earth and Space Science

– Content Standard D:

"Earth in the solar system"

Science and Technology

– Content Standard E:

"Abilities of technological design"

"Understandings about science and technology"

Science in Personal and Social Perspectives

– Content Standard F:

"Science and technology in society"

Technology Description

Solar detoxification shows exciting promise for helping us clean up contaminated water, soil, and industrial wastes. It's the distinctive properties of photons—the tiny packets of energy that make up light—that make solar detoxification possible. The low energy photons in the infrared and visible parts of the solar spectrum provide thermal energy to heat the waste.

The very energetic photons in the near-ultraviolet range add the quantum energy necessary to break the bonds between molecules in chemical compounds.

Most of the systems being designed use a catalyst to speed up the sunlight-driven reaction. For example, scientists could add a semiconductor powder to the contaminated liquid and expose the mixture to sunlight. The catalyst powder absorbs the sunlight and produces a reactive chemical that attacks the pollutant.

Research on other applications has used sunlight concentrated to 60,000 times! Solar radiation this intense can be used to power lasers or treat the surface of metals. Scientists in Russia, Japan, Israel, France, Spain, and the United States are all studying ways of developing cost-effective systems that take advantage of the many possible uses of highly concentrated sunlight.

Resources:

United States Department of Energy
http://www.doe.gov/

National Renewable Energy Laboratory
http://www.nrel.gov/

MTU Institute of Materials Processing
http://www.imp.mtu.edu/

IEA Solar Paces
http://www.solarpaces.org/

SRI International
http://www.sri.com/

Institute of Energy Technology
http://www.pre.ethz.ch/cgi-bin/main.pl?home

Project Ideas

1 Can sunlight break down different kinds of plastics?

Learning Objective: Designing, constructing, and evaluating sunlight's effect on plastics.

Controls and Variables: Types and colors of plastics, time of exposure, sunlight intensity, direct exposure versus through glass, temperature

Materials and Equipment:
Thermometer, watch, radiometer (can be a photographic light meter and patch of light-colored material), box to regulate temperature.

Safety and Environmental Requirements: *Wear eye protection when working with ultraviolet-emitting lamps. Dispose of experiment materials in a responsible manner.*

Suggestions: Expose samples of plastic to direct sunlight and to sunlight that passed through a pane of ordinary window glass. How long does it take for the plastic to lose its color or show signs of degradation? What effect does the window glass have? What effects do

temperature and the presence of microorganisms, oxygen, and different chemicals have on the degradation rate? Determine the loss of strength quantitatively. Investigate glazing other than plain window glass. Determine degradation rates for exposure to different types of lamps (infrared, fluorescent, outdoor flood, black light, tanning).

2 Can hydrogen peroxide work with sunlight to break down dyes?

Learning Objective: Investigating the effects of sunlight on dyes and different types of plastics and measuring exposure time.

Controls and Variables: Intensity of light, different dilution of hydrogen peroxide, exposure time to sunlight and hydrogen peroxide.

Materials and Equipment:
Measuring cups or similar equipment, food coloring, or clothing dyes, tanning lamp or black light, hydrogen peroxide

Safety and Environmental Requirements: Wear safety goggles. Use caution when using high concentrations of hydrogen peroxide. Dispose of waste materials in a responsible manner.

Suggestions: Prepare equal amounts of water and food coloring. Expose your solutions to sunlight. Compare this to other solutions with hydrogen peroxide added. Conduct experiments on the hydrogen peroxide and the rate of breakdown.

3 Can sunlight be used to clean up water?

Learning Objective: Students will investigate how water can be cleaned by the use of sunlight.

Controls and Variables: Sunlight, types of commercial dyes, different catalyst.

Materials and Equipment:

Titanium dioxide (TiO_2), small (3-6mm) glass balls, hot plate to bake the titanium into a coating on the glass balls, pan to hold the slurry.

Equipment is available from chemical supply houses or hobby stores.

Safety and Environmental Requirements: Safety glasses are needed. Do not ingest any of the materials.

Suggestions: Make the titanium into slurry in the pan. Immerse the glass balls in the slurry and heat at 60 degrees centigrade until the water evaporates. Add the coated balls to the dye and water mixture. Place in sunlight. Note the time it takes to remove the color from the solution. Search for information on photo-catalytic oxidation. Determine what other contaminants might be candidates for cleanup using this method.

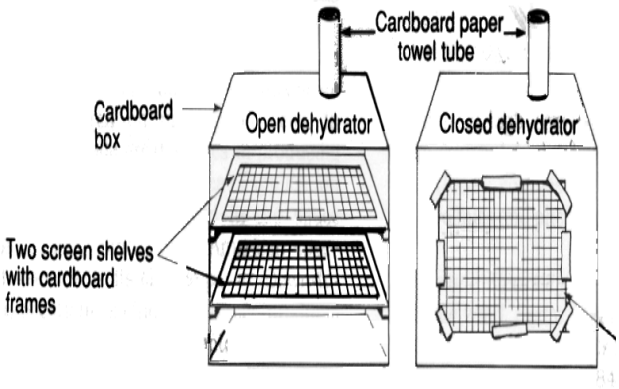
4 Make a solar dehydrator

Learning Objective: Investigating the effects of sunlight or heat on drying.

Controls and Variables: Intensity of light, exposure time, different types of dehydrators, and different types of food matter.

Materials and Equipment:
Different types of food, materials needed to construct the dehydrators.

Safety and Environmental Requirements: Keep hands clean when handling the food.



Suggestions: Compare the loss of water in the different types of food. Compare the drying time for different foodstuffs. What food can be dried in this manner and what food cannot? Compare the cost of food prepared this way to food purchased in a store.