

# **Your Home- It's All Built on Chemistry: A Hands-on Program**

**An Educational Demonstration Package**

**Prepared by the  
National Chemistry Week Committee  
of the  
Cleveland Section of the American Chemical Society  
for  
National Chemistry Week 2006**

## **Overview**

From floor to ceiling, wall to wall, chemistry really does it all!

Join us for an hour of hands-on experiments and demonstrations to celebrate National Chemistry Week and do tests to measure temperature with color-changing wonders, make home-building materials like concrete and special hard glues, and more.

Explore the building of your home through the eyes of a chemist.

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## **Acknowledgments**

The National Chemistry Week (NCW) programs of the Cleveland Section ACS began in 1994 with an idea to put together a scripted program that could be performed at any local school or library. This idea has expanded to become the centerpiece of Cleveland Section's NCW activities, which has received national recognition from the American Chemical Society. In 2006, the Cleveland Section volunteers will perform over sixty demonstrations at libraries, schools, and other public sites. Continuing our relationship that started in 2001, the Cleveland Section will also be providing hands-on training and (at least) 40 sets of materials for Cleveland-area teachers, at the Cleveland Regional Council of Science Teachers' Fall Conference, so that they can conduct additional programs in their own classrooms.

Our NCW efforts reach many children each year because of various sponsors who have donated money, materials, and/or services to the Cleveland Section specifically for National Chemistry Week. We are especially grateful for a second year in a row to the Martha Holden Jennings Foundation for a significant financial grant this year of \$3,000. We also thank NASA Glenn Research Center, John Carroll University, the Cuyahoga County Public Libraries, Hach Company (Loveland, CO), Pepsi Co. Americas (Twinsburg, OH), GE Consumer & Industrial Lighting (Cleveland), Chardon High School (Chardon, OH), Kenston High School (Brainbridge, OH), Solon High School (Solon, OH), BASF, McDonalds (Solon), McMahan DeGulis LLP, and other anonymous sponsors for their numerous contributions and support.

Last and most important, we thank all the volunteers who donate their time and expertise. This library/school program and other NCW events are the result of the hard work of many dedicated and talented volunteers. It all starts with our local section NCW Planning Committee. The Committee develops a theme for the program; recommends, tests, and reviews activities & experiments; writes a script; collects supplies and materials; prepares the kits; recruits sponsors and volunteers; contacts libraries and schools; and schedules shows. This Committee, as well as the rest of the Section's NCW activities, was overseen by the Cleveland Section's NCW coordinators for 2006 Lois Kuhns, Marcia Schiele, and Kat Wollyung. Committee members include Mark Waner, Dan Tyson, Don Boos, John Pendery, Shermila Singham, Rich Pachuta, Bob Fowler, Jesse Bernstein, and Betty Dabrowski (Jesse Bernstein, Barb Martin and Dave Miller joined us later.). Additional credit and thanks is given to all of the many GAK (Grand Assembly of Kits) Day volunteers who either donated their time before GAK day, including students at Kenston High School, Bainbridge, OH) or on GAK Day, including the John Carroll University ACS Student Affiliates, giving up a Saturday in September to help count, measure, and assemble all of the necessary materials for our demonstration kits. Without the dozens of dedicated chemical professionals to lead these activities, there would be no Cleveland Section NCW program.

## How Experiment Write-ups are Organized

The materials and set-up of the demonstrations are located in the introduction section of this packet. Then, each experiment write-up is presented as follows:

- Background Information for Demonstrators
- Demonstration Instructions
- Experiment Conclusions
- Additional Information If Needed – You obviously do not need to cover all of this material with your students. Some is only for your adult/parent audience. Pick out what you are comfortable explaining.

## Presentation Overview

This section describes the basic presentation technique used during the demonstrations. This is a guideline only as the technique may vary for some experiments. Make sure you follow the instructions given in each experiment.

1. Introduce experiment.

2. Do your demonstration piece.

*Note: Many experiments require you to perform the experiment to show the students what to do on their own.*

3. Have the students do their experiment.

*Note: For some experiments your demonstration and the student's hands-on work are nearly simultaneous. You lead them as they perform the experiment.*

4. Some experiments will be done by all students. For others, there will be one experiment that will be shared by all students at the table. In a few cases, only the demonstrator will perform the experiment. You are encouraged to get student helpers for the demonstrator-only experiments.

The NCW Committee offers a "Dress Rehearsal" to show the entire program to the demonstrators in advance of their own program performances; however attendance is not mandatory. This script provides enough detail for an adult to be able to perform the presentation. The Cleveland ACS and NCW Committee do not require background checks on its volunteers nor requires formal educational/teaching experience from all of its volunteers.

### **MAKE SURE TO FOLLOW ALL DIRECTIONS IN EXPERIMENTS**

Some experiments may have special safety concerns due to the materials being used. Any safety concerns are listed in the section for that experiment, including where to obtain an MSDS.

For information about the American Chemical Society's NCW safety guidelines, visit [www.acs.org/portal/Chemistry?PID=acsdisplay.html&DOC=ncw%5Csafetyguidelines.html](http://www.acs.org/portal/Chemistry?PID=acsdisplay.html&DOC=ncw%5Csafetyguidelines.html)

## Demonstration Check-Off List

The next few pages list necessary and suggested activities to complete for the program.

Activities To Do Well Before the Day of the Demonstration	Completed?
Read through this packet to familiarize yourself with the experiments and verify that you have all the items as listed in the kit contents	<input type="checkbox"/>
<i>Please check your kits upon receiving them.</i> Vials and bottles containing water solutions may have shifted during storage and transportation. Check for leakage and correct situations. Please store vials and bottles in an upright position as much as possible.	<input type="checkbox"/>
Please do not store kits in an overly warm area (such as in a car on a hot day). The kit contains many vials and bottles containing water solutions that may leak under pressure created by higher temperatures.	<input type="checkbox"/>
Contact us with any questions: Kat Wollyung at <a href="mailto:katkat@neo.rr.com">katkat@neo.rr.com</a> , Marcia Schiele @ <a href="mailto:MarSchiele@sbcglobal.net">MarSchiele@sbcglobal.net</a> or Lois Kuhns @ <a href="mailto:ch_kuhns@hotmail.com">ch_kuhns@hotmail.com</a>	<input type="checkbox"/>
Collect the materials you need to bring with you to the demonstration. The materials list is on page 7. The librarian may be able to provide some of the items, but you need to call to verify that – do not assume they have anything.	<input type="checkbox"/>
If you wish to add other experiments or demos into your program, please contact your librarian ahead of time to get their approval. Be careful and think “safety first”. Neither the NCW Committee nor the Cleveland ACS approves of any experiments added to your program, and you are responsible for your own actions.	<input type="checkbox"/>
<p>Contact the children's librarian:</p> <ul style="list-style-type: none"> <li>➤ Ask the room to be arranged with 6 tables around a front table</li> <li>➤ Ask to have 5 chairs around each of the 6 tables</li> <li>➤ Ask for all the tables to be covered with newspapers and for extra paper towels for each table. Otherwise take newspaper and do this during setup.</li> <li>➤ Ask about availability of demonstration materials from list of page 7 (ex. paper towels, newspaper, extension cord)</li> <li>➤ Ask if the librarian is available at the start of the program to greet the students and to help with the making of nametags and pinning them on student shirts.</li> <li>➤ Make sure that the room is available before and after the program for set up and clean up. <b>Set-up may take up to an hour</b> this year on your own. Ask the librarian if someone is available to help with set-up to cut this time.</li> <li>➤ Offer that a librarian is welcome and encouraged to stay for the entire program. (They might even offer to be an assistant if given the opportunity.)</li> </ul>	<input type="checkbox"/>

Activity To Do AT LEAST ONE DAY BEFORE the Demonstration	Completed?
Review the script in its entirety and become familiar with all the experiments.	<input type="checkbox"/>
Gather all the items needed for your presentation as provided in the materials list starting on page 7.	<input type="checkbox"/>
<p><b>EXPERIMENT 1:</b></p> <ul style="list-style-type: none"> <li>• <i>Please distribute the cement into the 31 plastic cups placing a piece of waxed paper between each cup to keep the powder off the bottom of the cup on top. Then place the stack into a plastic bag, remove most of the air and store it in your box in an upright position.</i></li> <li>• <i>Do the same for the gravel placing the 31 cups into its own baggie.</i></li> <li>• <i>Do the same for the sand placing the 31 cups into its own baggie.</i></li> </ul>	<input type="checkbox"/>
<p><b>EXPERIMENT 3:</b></p> <ul style="list-style-type: none"> <li>• <i>Measure out the meringue into the “glue” cups placing waxed paper between each and seal in a plastic bag.</i></li> <li>• <i>Measure out the borax into its cups in the same manner.</i></li> </ul>	<input type="checkbox"/>
<p><b>EXPERIMENT 6:</b></p> <ul style="list-style-type: none"> <li>• <i>Check over the cups for this experiment. We found that a number of the strips of thermochromic paper are not on tight. Take a glue stick and make a bold line on the cup and reattach any loose strips. Take along the glue stick in the event another falls off at the site.</i></li> </ul>	<input type="checkbox"/>

## Demonstrator's Guide

Activities To Do When You Get To The Library	Completed?
<p><b>NOTE: Arrive approximately 1 hour before demo time</b> to allow for set-up depending on how quickly you think you can perform the steps listed in the Experimental Setup section beginning on page 12. Do NOT assume that a librarian will be present to help you set up for the experiments.</p>	<input type="checkbox"/>
Introduce yourself to the children's librarian.	<input type="checkbox"/>
Ask the librarian how many students are pre-registered (designed for 30). Ask for a list of the children's first names (for making nametags in advance).	<input type="checkbox"/>
Confirm that the tables and chairs are set up properly.	<input type="checkbox"/>
Confirm that all tables are covered in newspaper and have paper towels.	<input type="checkbox"/>
Obtain those supplies from list on page 7 if provided by library.	<input type="checkbox"/>
Complete Demonstration Set-Up for all demonstrations: see Experimental Set-Up: "Activities to Do On-Site Prior to Demonstration" starting on page 12. <i>Note: This set-up is estimated to take 45-60 minutes.</i>	<input type="checkbox"/>
<b>Set-up warning!</b> If you follow the script as originally written, there are many cups and other items on the tables. Depending on the size of your tables, and the activity level of your students, you may wish to distribute fewer items originally, and distribute other items throughout the program	
<b>Set-up warning!</b> There is one bottle in a separate bag that has been filled with distilled water and labeled "D." The distilled water is used for Experiment 8 (the "S" vial of Soft water) and Experiment 9 (Chlorine) for the "D" or distilled water.	<input type="checkbox"/>
<b>Set-up warning!</b> Check the tap water to see if it contains chlorine using only ½ of a chlorine-test packet. If the water does not turn pink, use the water you brought from home.	
You may wish to set up an 'Exit' area table to allow space for end-of-program activities: goggle return and literature distribution.	<input type="checkbox"/>

Activities To Do At the Start of The Demonstration	Timing
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### Demonstrator's Guide

<p>Welcome the students and parents as they enter the room. Assist students/parents in writing the child's first name on one of our 'special name tags' and pin it on students' shirts (if allowable), otherwise have the child to put the nametag in front of them on the table. You may want to obtain assistance (friend/librarian) during the distribution of the nametags so that this part does not take time away from the program.</p>	4 min
<p>Hand out goggles and help adjust to the correct fit (if necessary).</p>	4 min
<p>Assess number of students per table and adjust to 3 - 5 per table. Record the number of students and adults on the provided Demo Feedback form. Do not allow any child to sit alone at a table as some experiments require two people to perform.</p>	-

Activities To Do During The Demonstration (Continued)	Timing
<b>Complete the Opening Session Introduction</b> - including nametag distribution	3-5 min.
<b>Perform demonstrations</b>	
➤ Experiment 1: Build Your Foundation – Making Concrete	7-10min.
➤ Experiment 2: Build Micro-Concrete Structures	4 min.
➤ Experiment 3: Everything Sticks with Glue	8-10 min.
➤ Experiment 4: Humidity in Your House	4 min.
➤ Experiment 5: Wrap Your House with Tyvek®	3 min.
➤ Experiment 6: Insulate Your Walls	6 min.
➤ Experiment 7: UV Protection on Your Windows	8 min.
➤ Experiment 8: Hard Water vs. Soft Water	4 min.
➤ Experiment 9: Is Your Water in the Pink? Safe (Chlorinated) Drinking Water	2 min.
➤ Experiment 10: Recycle!	2-3 min.
<b>Complete the Closing Session information.</b>	2 min.
<b>Collect goggles &amp; hand out literature.</b>	1 min.
<p><b>Note: Times are approximate. During your program, you may choose to omit an experiment so that your program does not run over time. Be familiar with the experiments before you arrive so you do not waste time 'reading' the script. Plan ahead to determine which Expt you might skip over or abbreviate; one suggestion is to do the Hard/Soft Water and/or Chlorine as a demonstration rather than hands-on, or drop them completely.</b></p>	<p><i>Total Time: ~ 60 min</i></p>

Activities To Do Immediately After The Demonstration	Completed?
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## Checklists

### Demonstrator's Guide

Clean up as indicated in the <b>Clean Up</b> section (page 36).	<input type="checkbox"/>
Give the reusable items and the feedback form in the mailing envelope, the box of 32 goggles, and the GE Blacklight (in its protective case) to the librarian for return to Fairview Park Regional via interlibrary mail. <i>(Those outside of the CCPL network, please return items to your nearest CCPL branch for return to Fairview Park. Go to <a href="http://www.cuyahogalibrary.org">www.cuyahogalibrary.org</a> for branch listings.)</i>	<input type="checkbox"/>
Give any leftover literature to the librarian ( <i>CCPL library kits only</i> ).	<input type="checkbox"/>
<b>Activities To Do Once You Get Home</b>	<b>Completed?</b>
Leave a message for Kat Wollyung at <a href="mailto:katkat@neo.rr.com">katkat@neo.rr.com</a> with the following information: (1) attendance, (2) specific experiment comments/recommendations, (3) other comments.	<input type="checkbox"/>

## Supplies Required for Demonstration

### Items for Demonstrator to Provide (or to request in advance from the librarian)

*a few pens or markers (for writing on name tags)*

*scissors*

*1 large garbage bag for solid waste collection*

*1 bucket for liquid waste collection (optional if sink is within the demo room)*

*1 roll paper towels (if none at site)*

*half-gallon container (pitcher, etc) for holding water for the insulation experiment while you adjust its temperature and for pouring water into the cups*

*1 gallon of water, approximately (Note: It may be difficult to transport water from library restrooms with shallow sinks or fountains with low spigots, so do NOT plan to use this method to obtain water unless you have investigated the water availability at your site.)*

*newspaper for covering 7 long tables with a few layers of paper (if none at site)*

*extension cord –the length depends on the size of your room; it needs to reach between the outlet and the UV-light you will carry from table to table*

*1 measuring cup or other cup with spout for adding water to various cup/bottles in experiments*

*1/4 cup measuring cup*

*1 teaspoon measure if the meringue and borax were not previously distributed into the seven cups.*

*One glue stick*

*31 sandwich size baggies for students to take home their concrete and glued marbles as they will not be set-up completely until the next day.*

*One cup of tap water containing chlorine or 1 cup of water treated with 2 drops of bleach. This is for BACK-UP only if the library you are using does not have sufficient chlorine in its water (has been filtered).*

*Optional: 1/2 teaspoon measure*

*Optional: Thermos full of ice cubes.*

*Optional: Second thermos full of water slightly ABOVE 37°C or 98°F*

**Notice:** If you will be performing multiple demonstrations on the same day, you will need to sanitize the goggles between demonstrations. You will also need:

small quantity of household bleach

wash bin or bucket

rags, old towels, or cotton paper towels for drying (soft so as not to scratch the goggles)

### **From the site:**

Lukewarm tap water at 33-37°C or about 91.5-98.6°F is needed for the insulation experiment. Note that water obtained from the restroom during setup may cool during your presentation (due to air conditioning.). We recommend getting warmer-than-needed water from the library during set-up as well as a smaller amount of cool water and then adding the cooler water to the warm water as needed during the demo to obtain the correct temperature water. Or alternately:

Request that the librarian heat some water in a microwave (if available) or obtain warm water just before this demonstration.

#### Items Provided in Each Demonstration Kit:

*Note: Items needed for each demonstration that are to be provided by the demonstrator are listed in italics below the kit items for convenience/reference*

##### General:

- 1 box containing kit contents
- 30 copies *Celebrating Chemistry* newspapers (if available from ACS)
- 30 copies each of 'Book List/Take Home Experiment/House Picture' with a copy of a house diagram on the back
- 1 envelope for returning supplies (addressed to Fairview Park Library) (*library kits only*)
- 1 Program Feedback Form to be completed by demonstrator after the program
- 1 box of goggles (30 child & 2 adult size, addressed to be returned to Fairview Park Library) (*library kits only*)

*NOTE: The return envelope will contain much of the paperwork for the program. It was placed within the envelope to help prevent folding and wrinkling in storage/transport. Distribute it as instructed below.*

##### Opening Session

- 31 sheets of heat-sensitive paper
- 31 safety pins

*From home:*

*A few pens/markers to write names on the tags*

##### Entire Program

- 7 colored copies of our house with pictures for reference to each experiment in the program –one for each table and one for the demonstrator (found in the kit box in the envelope to be later used for returning items to Fairview Park library)

#### Experiment 1: Build Your Foundation – Making Concrete

- 31 3-oz. white plastic cups for cement marked "C"
- 31 3-oz paper cups for sand marked "S"
- 31 3-oz paper cups for gravel (aggregate of small stones) marked "G"
- 31 craft sticks
- 7 plastic teaspoons (also used in Tyvek and Glue expts)
- 7 clear plastic cocktail-style cup marked "water" (also used in Tyvek and Glue expts)
- 1 bag of sifted gravel
- 1 bag of sand
- 1 bag of cement
- 7 paper plates (to hold damp paper towels at each table)

*From home:*

- 31 wet paper towels, one for each student.*
- tap water*

### **Experiment 2: Build Micro-Concrete Structures**

- One bag of (more than) 160 Styrofoam packing peanuts - **Note:** Remove 31 of these Styrofoam peanuts and set aside for Expt 10 (Recycle)
- 750-1000 toothpicks (5- 6 per peanut)
- 1 cardboard box (form for the peanut/toothpick models) approximately a 6" cube.
- 1 piece (approx. 10 x 12 inches) of stiff pressboard, corrugated cardboard, or a stiff manila folder
- Remove the bag of cornstarch peanuts (they look like white Cheeto's®) stored in the cardboard box. This bag is for experiment 10.

### **Experiment 3: Everything Sticks with Glue**

- 1 baggie of meringue mix (38g)
- 1 baggie of borax (38g)
- 7 3-oz plastic cups
- 7 3-oz paper cups
- 31 craft sticks
- 1 bag of flattened glass marbles (62 in the bag, 2 per child)
- 7 disposable pipettes (will also be used in experiment 5 Tyvek)

*From previous experiments:*

- 7 plastic teaspoons (from Expt 1 (concrete); also used in Tyvek expt)*
- 7 clear plastic cocktail-style cup marked "water" (from expt 1; also for Tyvek expt)*
- 7 paper plates (to hold damp paper towels at each table)*
- 31 wet paper towels on a plate (can be same as in Expt 1.)*

*From home:*

- 1 teaspoon measure*
- ½ teaspoon measure (optional)*
- 31 wet paper towels on a plate (can be same as in Expt 1.)*

### **Experiment 4: Humidity in Your House**

- 6 screw cap vials containing a drying agent  $\text{CaCl}_2$
  - 6 screw cap vials containing a small amount of water (just enough to give high humidity in the bottle)
  - 6 screw cap vials, empty and dry, with cobalt chloride indicator strips attached to the inside of the cap – The indicator strips should be in dry and should thus be blue. This is guaranteed by shipping of these materials within another bag containing additional drying agent
  - 6 paper cups for holding the vials upright during the experiment
  - 1 bottle (clear, with cap) containing drying agent
  - 1 bottle (clear, with cap) (for with water)
  - 1 bottle (clear, with cap), empty and dry, with a cobalt indicator strip on the cap's inside
- NOTE:** do not open the vials for any significant amount of time or the moisture in the air will react with the drying agent and cobalt chloride indicator strips

### **Experiment 5: Wrap Your House with Tyvek®**

- 31 4" square pieces of Tyvek sheeting in a 1 quart-sized baggie
- From previous experiments:
- 7 disposable pipettes (from Expt 3 Glue)
  - 7 plastic teaspoons (from Expt 1 Concrete; also used in Expt 3 Glue)
  - 7 clear plastic cocktail-style cup marked "water" (from expt 1; also for Glue expt)

### **Experiment 6: Insulate Your Walls**

- 7 paper cups with a strip of thermochromic paper and liquid crystal
  - 7 sets of nested paper cups with a strip of thermochromic paper and liquid crystal on the outer cup and nothing on the inner cup
  - 7 plastic cups with a strip of thermochromic paper and liquid crystal
  - 7 Styrofoam cups with a strip of thermochromic paper and liquid crystal
  - 1 thermometer for demonstrators [teachers, please use one from your supplies]
- From home:*
- 1/4 cup measuring cup*
  - half-gallon container*
  - Optional: Thermos with at least 36 ice cubes.*
- At site:*
- Half-gallon of lukewarm water at 33-37°C or about 91.5-98.6°F as stated on page 8*

### **Experiment 7: UV Protection on Your Windows**

31 bracelets made with UV-sensitive and phosphorescent beads  
1 GE Blacklite Stik® for library demonstrators [Teachers should use sunlight outdoors]  
1 sheet of UV-protectant window film

*From home:*  
*extension cord*

### **Experiment 8: Hard Water vs. Soft Water**

7 vials of 35ml each hard water (containing Epsom salts) marked 'H' in a baggie with the next item (recycled, cleaned water/soda/Gatorade bottles may also be used)  
7 vials (empty) marked 'S' (recycled bottles may also be used)  
Over 285 mL of Distilled water in bottle marked "D" . (This experiment uses 35 mL per each of the 7 "S" vials in this experiment; the rest of the water (about 40 mL) is used in Expt 9 (Chlorine).  
7 zipper snack-size plastic bags containing 2 pea-sized pieces of Ivory soap  
7 salt packets

### **Experiment 9: Is Your Water in the Pink? Safe (Chlorinated) Drinking Water in Your Home**

4 2-oz. soufflé cups (or other small, clear plastic cups) marked "T"  
(for Tap Water); for each of 3 tables plus demonstrator  
4 2-oz soufflé cups marked "D" (for Distilled Water); for 3 tables + demonstrator  
8 chlorine-test packets (DPD Total Chlorine Reagent, Hach Co., Catalog No. 2105669)

*From previous experiment:*

Over 285 mL of Distilled water in bottle marked "D" . (This experiment uses ~40 total for the 4 cups in this experiment marked "D"; the rest of the water (about 245 mL) is used in Expt 8 (Hard/Soft Water).

*From home:*

*scissors*

*½ cup Tap Water containing chlorine - some program sites may filter their water to remove chlorine before consumption, so bring alternate tap water if needed or add 2 drops of bleach to one cup of water.*

### **Experiment 10: Recycling**

31 pieces of Styrofoam (removed from Exp. 2 bag before it is distributed)  
1 gallon bag full of cornstarch peanuts  
1 cup labeled "water" – used in previous experiment

**Closing:**

Set out the items for the students to take as they exit the program:

Celebrating Chemistry activity newspapers

Things-to-do at home and picture of house (take-home sheets)

**Items to be Returned through Inter-Library Mail (library kits only)**

Box of 30 children's and 2 adult pairs of goggles

GE Blacklite Stik® (or other brand) in its protective container

Vials from humidity (#4) and water experiment (#8), RINSED/CLEANED and bagged

Extra UV bracelets

Liquid crystal strips removed from the cups, stuck to a baggie, and placed inside another baggie.

Thermometers

Extra sheets of heat sensitive paper and safety pins

## Activities to Do On-site Prior to Demonstration

### General:

- Refer to pages 4 and 5 for items to verify room setup (6 student tables with 5 chairs each, one demonstrator table, all covered with newspaper, each with paper towels, etc.)
- Obtain any supplies requested from librarian

### Opening Session and General

- Place the name tags, safety pins, and pens/markers in a convenient place so that the students/parents can write their names as they arrive and pin the tags on their shirts. (You'll refer to this during Expt. 6).
- If you have a list of children's names from advanced registration, you may want to clearly write them on the name-tags yourself, saving time during the program.
- *An alternative: Give the librarian the heat-sensitive paper, the pins, and the pens and ask him or her to have the students make a name tag as they line up for the program.*
- Place one color copy of the house picture (on cardstock) on each table (found in the kit box in the return envelope) and put one on the demonstrator's table to refer to during the presentation.

### Experiment 1: Build Your Foundation – Making Concrete

- **The first three steps below may be done the day before at home to save considerable time. See page 4 of the script. You may wish to only do thirty cups each and actually demonstrate the measurement of each of the materials into the three cups at the start of the demonstration. This option will add additional time to your program.**
- Distribute the package of cement by putting 1 rounded spoonful into the 31 **plastic** cups marked "C." If the cement appears lumpy, just stir it before measuring. Discard any extra material.
- Distribute the package of sand by putting 2 level spoonfuls into the 31 **paper** cups marked "S." Discard any extra material.
- Distribute the package of gravel (aggregate) by putting 3 level spoonfuls into the 31 **paper** cups marked "G." Discard any extra material.
- Place 5 cups marked "C" (cement), 5 cups marked "S" (sand) and 5 cups marked "G" (gravel) on each student table.
- Place five craft sticks on each of the students' tables and one craft stick on the demonstrator's table.
- Fill the plastic cups marked "water" approximately 2/3 full with tap water. Place 1 cup on each of the students' tables and one on the demonstrator's table.

- Place one teaspoon on each of the students' tables and one on the demonstrator's table.
- Place 5 damp paper towels onto each of the plastic or paper picnic plates you brought, and place one set of paper towels on each table to use for quick hand clean-up if needed.

### **Experiment 2: Build Micro-Concrete Structures**

- **IMPORTANT:** Remove 31 pieces of Styrofoam and set aside for use as a control for Expt 10 (Recycling, Styrofoam vs. cornstarch).
- Place the peanuts, toothpicks and empty box (concrete form) and piece of cardboard (or manila folder) on the demonstrator table. ...or... Alternately, you may wish to distribute 5 sets toothpicks (of ~25 each) to each of the 6 tables and leave a few on the demonstrator table.
- The last preparation step can be done at the end of this setup.

### **Experiment 3: Everything Sticks with Glue**

- Measure out exactly 2 teaspoons of meringue powder into the 7 **plastic** cups. Save the remainder if needed later.
- Measure out a slightly rounded ½ teaspoon of borax or a scant 1 teaspoon measure into 7 **paper** cups. You will want to save the extra in the event the student's mixtures are too wet.
- Place one cup of the meringue powder and one cup of the borax on each of the student tables and one at the demonstrator table.
- Place one beral pipet and 5 craft sticks on each of the student tables and one each at the demonstrators table.
- Place 10 flattened glass marbles on each of the student tables and two at the demonstrator table.
- If you didn't put out a plate of damp paper towels onto each table as suggested for experiment #1, put those out now.
- Each table needs only enough water to fill the Beral pipet to the bottom of the bulb where the angle begins or just above the top of the stem as shown with the arrow below. You may mark this point on the beral pipet if you wish with a permanent marker.



### **Experiment 4: Humidity in Your House**

- There are 3 bottles in the kit for the demonstrator to use and a bag of small vials for the student tables with cups to keep the vials vertical at all times.

- Remove the vials from the baggie. The indicator strips on the caps of the 6 empty vials and one bottle should be blue, indicating that they are dry, which is desired.
- There are also two other loose bottles in the kit—one with the drying agent and one dry bottle.
- ***For humid house: DO NOT add water to the 6 dry empty vials or bottle in advance of program!*** The neck of the vials may have droplets on it which will overly affect the indicator paper. Instead, during the program set-up, cover the bottom of the 6 empty vials with hot water about 1ml or so using the pipet to keep water off the sides of the vial. Place about an inch of hot water in the large dry bottle being sure to NOT wet the lip and neck of the bottle. RECAP the 6 vials and the bottle. These steps will insure you produce enough humidity in the vial by the time you perform this experiment.
- Into each of the six paper cups, place vertically, one dry tube with the indicator strip, one tube with the drying agent and one tube containing the water. Place the 6 student cups on the demonstrator's table until you do this experiment to keep the tubes from being accidentally knocked over.
- Place the three bottles on the demonstrator's table—one with the drying agent, one with the water and one empty and dry with the indicator strip on the inside of the cap.

#### Experiment 5: Wrap Your House with Tyvek®

- Place one sheet of Tyvek sheeting on the demonstrator table and 6 at each student table
- The Tyvek trademark printing should be facing up. It is the smoother side if there is no printing visible.
- Place one disposable pipette on each of the student tables and the demonstrator table. (Lois, this is already here, from exp 3, right?)
- The cups marked "water" were already distributed for Expt. 1

#### Experiment 6: Insulate Your Walls

- Place one Styrofoam cup with a strip of thermochromic paper and liquid crystal on each of the students' tables and one on the demonstrator's table.
- Place one plastic cup with a strip of thermochromic paper and liquid crystal on each of the students' tables and one on the demonstrator's table.
- Place one paper cup with a strip of thermochromic paper and liquid crystal on each of the students' tables and one on the demonstrator's table.
- Place one set of nested paper cups with a strip of thermochromic paper and liquid crystal on the outer cup and a plain inner cup on each of the students' tables and one on the demonstrator's table.
- Place the ¼ cup measure on the demonstrator's table
- Make arrangements for a helper or the librarian to run some lukewarm water into your half gallon container. Be sure the temperature of the water is about 33-37°C or about 92-99°F just before use; a thermometer was provided in the kits for this purpose (except teacher kits since it is assumed they have thermometers). If you are working alone, gather hot water in

the large container and cold water in a smaller container during setup, and then later test the temp just before use, adding cold water if necessary to be in the correct temperature range.

### **Experiment 7: UV Protection on Your Windows**

- Place all of the bracelets on the demonstrator's table.
- Open the baggie containing the large piece of film and keep it on the demonstrator's desk.
- Plug the GE Blacklite Stik® into the extension cord. If it is safe to do so, plug the cord into the wall during preparation. If not, note where the wall outlet is located for future reference.

### **Experiment 8: Hard Water vs. Soft Water**

- Into each of the vials/bottles marked "S" pour approximately 35 mL of distilled water from the bottle marked "D". Close the lids tightly. Do NOT use the extra water as approximately 40mL is needed for Expt. 9.
- Place one vial/bottle marked "S" on each student table and one on the demonstrator table.
- Place one vial/bottle marked "H" on each student table and one on the demonstrator table. If the vial has leaked (sorry), distribute the liquid in the vials as needed, and store in an upright position.
- Place 1 baggie of soap on each of the students' tables and one on the demonstrator's table.
- Place 1 packet of salt on each of the students' tables and one on the demonstrator's table.

### **Experiment 9: Is Your Water in the Pink? Safe (Chlorinated) Drinking Water in Your Home**

- Pour 10 ml (or more) of chlorinated tap water (on-site or brought from home) into the 4 cups marked "T". Place one on the demonstrator's table and one on each of 3 student's tables.
- Pour 10 ml (or more) distilled water into the 4 cups marked "D". Place one on the demonstrator's table and one on each of 3 student's tables.
- Set out the 8 chlorine-test packets on the demonstrator's table. You may wish to tap the contents to the bottom and cut off the tops, so you can easily pour them out later. If not, place your scissors on the table next to the packets.
- You may wish to test the library water with ½ packet of a chlorine-test packet. If no color is present, use the water you know is chlorinated that you brought from home as a back-up.
- Use the remaining ½ packet to test your cup marked "D" during the demonstration.

### **Experiment 10: Recycle!**

- Locate the 31 Styrofoam pieces set aside from Expt 2 – Concrete Microstructures.
- Place five pieces of Styrofoam on each student table and one on the demonstrator table.
- BE SURE TO NOT DISTRIBUTE the cornstarch peanuts until the experiment is being performed. If the students accidentally get them wet, they will be ruined.

**Closing Session -**

- You may wish to set up an 'Exit' area to allow space for end-of-program activities: goggle return, literature distribution.

**More for Expt 2: Concrete Microstructure**

- Ask your librarian the number of students you expect for your program. If you expect to have less than 20 students attend your program, make approximately 50 microstructures in advance (5 per child). You need to have enough microstructures to correctly fill the box or the experiment may not work.

## **Greet the Students (and Parents) Upon Their Arrival and Distribute Name-tags and Goggles**

*Do the following:*

- Ask each student (or their parent) to write their name on the heat-sensitive paper and pin it on.
- *An alternative: Give the librarian the heat-sensitive paper, the pins, and the pens and ask him or her to have the students make a name tag as they line up for the program.*
- Hand out and adjust students' goggles (alternately, do this at the start of the program; however doing this before the program saves time).
- Ask each student to take a seat at a table (no more than 5 students per table) and to PLEASE not touch any of the materials before the program begins. Some experiments may be ruined if they do.

## **Opening Discussion**

*Do the following:*

- Introduce yourself as a chemist or chemist/science teacher (or state your interests in chemistry), and introduce the American Chemical Society as the largest organization in the world devoted to a single profession.
- Introduce National Chemistry Week - what it is and why we do it. (*Hint: it is a nationwide event put on by volunteers like you to let non-scientists know about chemistry and how it has improved our everyday life.*)

## **What is Chemistry and Chemicals?**

*Do the following:*

- Explain that chemistry involves the study of everything around them.
- Ask volunteers to name some chemicals. Then ask more volunteers to name something that isn't a chemical.

***Remember: everything around us is a "chemical".***

*Be very careful in correcting the students. Encourage their participation while explaining that anything they name really is a chemical.*

## **What Do Chemists Do?**

- Ask the participants to tell you what a chemist does, what a chemist looks like.
- Tell them BRIEFLY and in simple terms what you do as a chemist.

- *Note: This should last no more than 1 minute. Remember to leave the physical chemistry lecture and the “big” chemistry words at home!*
- Tell them that chemists use their knowledge to answer questions about the world around them. This is very exciting, as they will soon see.

#### **Introduce the Items on the Tables and Distribute Goggles**

*Do the following:*

- Tell the students that various items have been gathered for them on their table.
- Tell them not to touch anything until instructed to do so.
- Most of the items can be found around the house. *Remind them never to taste or smell anything, as if they were in a laboratory!*
- Tell the students that even though most of our items are relatively harmless today, we will still be good chemists and take the safety precaution of protecting our eyes.
- Put on a pair of the adult-sized goggles. If you have an assistant, ask them to do the same.
- Distribute the goggles (if you haven't already done so) and help the students put them on. Adjust the straps as necessary. (Note: These goggles are sanitized each year and prior to each demonstration.)

#### **Introduce Today's Presentation:**

*Tell the students the following:*

- This year's theme for National Chemistry Week is “Your Home – It's All Built on Chemistry”.
- When we hear the word “chemical” in the news, it is often in a story about a ‘bad’ or ‘dangerous’ chemical spill, or how a chemical has been found to be harmful to our health. But this isn't always the case! Chemistry can be good for us and important to things around us too, including our homes!
- Throughout our experiments today, we will be discussing the building of a sound, environmentally friendly house which contains a good strong foundation, uses quality adhesives and waterproof/breathable materials, keeps us at a comfortable temperature and humidity, and provides good clean water.
- Tell the students that we will try to use the scientific method to guide us in our investigation of various items associated with chemistry in building our homes. We will make observations, form a hypothesis (a guess as to how or why something works), use experiments to test our hypothesis, and then evaluate the results of the experiment to accept or reject the hypothesis.
- Hold up a house picture and say to the students: Please take a look at the picture of our house on each of your tables. It will be used to help point out the experiments as we “Build our house from the ground up”. Let's get started with this construction project.

## Experiment 1: Build Your Foundation – Making Concrete

### Experiment Purpose & General Methodology

- The students will learn the materials and ratio necessary to make concrete, the foundation for homes and building. In the next experiment we expand upon the concept of the ‘bonding’ of the materials within the cured concrete.
- Each student will make a small amount of concrete.
- The experiment should take 8-10 minutes to complete.

### Introduce the Experiment

*Tell the students the following:*

- Explain that a house requires a stable base and that base must support the very heavy house. If you look at our picture of our house, you can see that a small amount of material holds up a very large and heavy structure. It does this by forming a special type of structure with strong bonds. We'll make some of the real material (NOTE TO DEMONSTRATOR: DO NOT use the word ‘concrete’ here.) and then we'll learn more about this special bonding.
- Ask the students: What material is used in the construction of the foundation of your home, sidewalks and some driveways? {answer: concrete} (Note that students may answer ‘cement’. Explain that cement is a common term used by many people but that cement is only one ingredient found in concrete.)
- Ask the students if they can think of any other uses for concrete. {Bridges, roads, skyscrapers}
- Ask the students if they know how concrete is made.
- Explain to the students that concrete is an important construction material composed of Portland cement and water and combined with sand and gravel.
- Portland cement was not even introduced into the United States until over 100 years ago in 1871.
- We will make some concrete that you can take home at the end of the demonstration

### Perform Experiment Simultaneously with the Students

*Do the following:*

- Make sure that all students and you have goggles on. Stress safety in this lab at all times.
- Let the students know that there is a simple three step process to make concrete using three ingredients in a 1-2-3 ratio plus water. A 1-2-3 ratio means we'll use 1 part of the first ingredient, 2 parts of the second ingredient (or twice as much as the first one), and 3 parts of the third ingredient.
- Tell the students you have already measured out these materials to prevent spilling them on the library carpet.
- Have each student select a plastic cup marked “C” for cement.

## Experiment 1

### Demonstrator's Guide

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- Ask each student to select one of the cups marked “S” for sand.
- Before the next step tell students to be careful not to stir too hard to avoid getting and breathing the dust from the ingredients in concrete.
- Demonstrate this technique to the students by carefully pouring the sand from the “S” cup into the cup with the cement marked “C”. Mix gently using the stirring stick. Avoid creating a dust cloud.
- Students should dump in the container marked “S” for sand into the cup with the cement and stir gently as you demonstrated.
- Demonstrate that now each student should add 2 teaspoons full of water (from the cocktail cup marked “water”) to their cup and pass the spoon to the next person.
- Have the students take turns adding two plastic teaspoons-full of water from the cup marked “water” to their cups containing the concrete mix.
- It is very important to stir slowly but thoroughly. Heat will be released and the cup warms.
- Tell the students that when cement is mixed with water, complex chemistry, not fully understood occurs. Even though we have used this material for over 100 years chemists are still studying its properties and reactions.
- The cement and sand reacts slowly with water in a process called hydration which releases energy. This is a chemical reaction. At this point you have made mortar (used for “gluing bricks together). To make concrete you need to add STONES (or small stones like gravel.)
- DO NOT TOUCH THE WET MATERIAL. If students contact this material there should be a wet paper towel with which to wipe the material from their hands.
- Show the students the next step by adding the contents of the cup marked “G” for gravel to the cup with the cement and sand. Mix gently with the stirring stick.
- Have the students add the cup marked “G” for gravel to their cup with the wet cement and sand and mix gently.
- Using the craft stick as the stirrer, have each student mix the contents of their cup until it is smooth and all the stones are coated with the cement. Then they should push any stones down until the concrete is smooth on the surface.
- *Note: The mixture should have the consistency of thick pudding. If the mixture is too dry, have the student add more water, **one-half** teaspoonful at a time, and mix thoroughly. If the mixture is too runny, there is no need to take any action (it may just take longer for the ~~chalk~~ concrete to begin to harden).*
- Remove the Stirring stick
- Tap the cup gently on the table to remove air bubbles.
- Place the mixture aside to harden while doing the other demonstrations (Allow a minimum of 30 minutes.)
- The demonstrator should collect the craft sticks and empty cups in the waste bag to prevent them from getting on other materials during the remainder of the presentation.
- The demonstrator may also want to collect the water cups and spoons if there is a concern about accidental spillage but you will need the water later in the program.

#### Conclusions

Tell the students the following:

- Tell them that concrete hardens by a chemical reaction called hydration. This is chemically bonding water molecules to the cement. This is an exothermic (energy releasing) reaction.
- When a very large amount of concrete is being poured as in the construction of Hoover dam, special measures must be used to prevent overheating.
- As the water bonds to the cement, it forms spiky molecules that hold the whole mixture together. We'll investigate this even more in our next demonstration.
- Tell them that although the concrete will get hard in a few hours it continues to get stronger for years but most of the hardening occurs in the first 28 days.
- The ultimate strength of concrete depends on many factors. The amount of cement and water are the main factors. If the concrete dries out or freezes before hydration is complete the concrete is weakened. Sometimes small amounts of other chemicals are added for special purposes. In winter calcium chloride is added to prevent freezing.
- When concrete is pumped to where it is needed a surfactant is added to help it flow through the pipes. Coloring agents are sometimes added to imitate stone. For patches an acrylic bonding agent is added to bond the new concrete to the old concrete.
- While you wait the cement is setting and will begin to harden. It may not be completely hard until tomorrow at this time. Please do not touch the material until then.
- Tell them you will provide a baggie at the end of the program for them to take home their concrete. They should remove it from the bag at home exposing it to air to harden in one or two days (possibly up to one week).

#### Additional Information If Needed: Technical Background

- The dry portion of Portland cement is a complex mixture of about 63% Calcium oxide (CaO), 20% silica (SiO<sub>2</sub>), 6% alumina (Al<sub>2</sub>O<sub>3</sub>), 3% iron (Fe<sub>2</sub>O<sub>3</sub>) and small quantities of other materials.
- Portland cement was patented in England in 1824 by Joseph Aspdin and named "Portland" because when it hardened it reminded him of stone from the Isle of Portland.
- One of the amazing concepts is that chemical reactions are still taking place at a significant rate more than 100 days after the addition of water to cement.
- Research to improve concrete is ongoing and important. One serious problem is cement corrosion, which can be accelerated in steel-reinforced concrete, and by the action of water. The corrosion can be physically based, especially from the freeze-thaw cycle of water in the porous material, or chemical in nature, such as from the action of acid converting calcium hydroxide to calcium carbonate.
- Cement corrosion costs North Americans nearly a billion dollars a year.
- For more information on this and other topics relating to this National Chemistry Week see the October, 2006 edition of *Journal of Chemical Education*, devoted to National Chemistry Week's theme "Your Home—It's All Built on Chemistry" and *Chemical & Engineering*

*News* for information on porous concrete used in Mexico so the rainfall can replenish the water table.

## Experiment 2: Build Micro-Concrete Structures

### Experiment Purpose & General Methodology

- This experiment is to be done by each student and will run about 4 minutes.
- Each student will use Styrofoam packaging peanuts and toothpicks to construct models of the hydrates formed during concrete curing. The hydrates form spikes that interlock to give concrete its structure and strength. The models will also interlock when assembled in the box, or “concrete form” to demonstrate the effect of the spikes in giving the peanuts form and strength.

### Introduce the Experiment

*Tell the students the following:*

- How does a fluid, or liquid mixture, like we just made in Experiment 1, become hard and strong and hold its shape? Concrete is a mixture of cement, sand, gravel and water (which they have just done). The cement is the reactive part of the mix that binds the sand and gravel together and keeps them from falling apart.
- In this experiment, we'll look at the micro-structure, or a very, very close up view, of dried cement. We'll use Styrofoam peanuts as the grains of cement and toothpicks to represent the bonds that form to hold them together as the ‘cement’ dries. The bonds in cement are called ‘hydrates’.

### Perform Experiment Simultaneously with the Students

*Do the following:*

- Look at the house picture – doesn't the micro-structure picture of concrete look like a peanut with sticks coming out of it? We're going to build something that looks like that picture!!
- Remind the students that we are pretending our peanuts are the tiny particles of concrete.
- As you slowly pour the peanuts onto the table and form a pile, allowing them to ‘flow’ and spread apart, state to the students: These peanuts represents our liquid concrete. See that the pile of peanuts do not hold any shape and flow over each other as I pour them. This alone shows they are very mobile and act somewhat as a fluid.
- State: Let's see what happens if I try to stack them up.
- Form them into a cone-shaped pile and then place the box on top. The pile will flatten out and not support the weight of the box.
- Ask the students: why couldn't the taller pile of peanuts hold up the box? {They're not strong enough. They can't hold onto each other.} State: This shows the peanuts themselves have no strength.
- Ask the students to remember the volume/size of the pile.
- Distribute 5 peanuts to each student or divide the peanuts evenly among the participants. If there are not enough students, then get some parents to help.
- Distribute approximately 30 toothpicks per student (or about 6 toothpicks per Styrofoam peanut).

- Demonstrate the making of a microstructure as you explain to the students how to make theirs: Have the students stick the toothpicks into the peanuts. They should stick out in all **three dimensions** (e.g. ball-shaped rather than only 2-dimensions like a pancake). They should also be stuck in **at least to the opposite side of the peanut** so they are firmly in place. It is also desirable if **some of the students stick the toothpick completely through the peanut** so that both ends show. This gives a shorter “hydrate” or bond and doubles the number of “hydrates” that helps with the packing. **Warn the students** that if they are too rough with their models the peanut will break apart.
- **NOTE TO DEMONSTRATOR:** If you have fewer than 25 students, either make additional microstructures on your own as the students make theirs, and or have an assistant or the students assist in making more. You need most of the structures completed for the experiment to work.
- When the students are finished, collect all of the peanut models in the box. Gently shake the box as the student put the models in. This allows the models to settle. Use your hand to arrange them to get some of the shorter toothpick ends near the sides of the box. (You will get a better shape out of the formed “concrete” below.) (If the students say you cheating here and arranging the structures, tell them that as a chemist/scientist you know that the water dries differently at the edges and forms shorter bonds there, so you are just making the ‘correct’ model.)
- Tell the students it’s time to look at our dried cement model. Place the piece of pressboard over the top of the box. (Note: a piece of corrugated cardboard, or a stiff manila folder could also be used.) Pick up the covered box and invert the box so the pressboard is on the bottom. Place the piece of pressboard with the box still on top back on the table. Finally, gently agitate the box while lifting it off to leave the peanut models on the table. The result is a block of formed “concrete.” This shows that it now has shape.
- Place the box on top of your “block of concrete” to show that it now has enough strength to hold the box. (It will actually hold a bit more weight if you want to try it.)
- Set aside using the piece of pressboard, corrugated cardboard, or the manila folder as a tray since it will hold this shape for at least the remainder of the demonstration session.
- Refer to the house picture on your tables to see an SEM picture of real concrete structure. Tell the students that this is what it really looks like magnified x times (refer to the photo). Don’t you think the interlocking structure looks similar to our interlocked structure?

### Conclusions

- Our original pile of peanuts flattened out when we poured them onto the table. Ask the students why this structure can stand up tall. {Answers below}
- Our original pile of peanuts flattened out when we set the box upon it. Ask the students why this structure can hold weight. {Answers below}
- The peanuts and the toothpicks alone act more like a liquid/fluid much like the cement powder and water. Together they form a definite solid shape that has strength. This is a model of the way concrete forms and shows its ability to be made into any shape and have strength.
- Aren’t you glad your house is built on a hard, strong foundation!

- You can also point out that there is now space between the peanuts. This allows water and air to flow through concrete. You can point out that concrete will appear to dry much faster than other materials after a rain. It is also why it is difficult to clean concrete since stains like motor oil gets into these holes and can be wiped off the surface.

#### **Additional Information if Needed: Technical Information.**

The cement powder reacts with the water to form a hydrate (either a calcium silicate hydrate or calcium alumino hydrate). This hydrate forms as long needle-like crystals (chemically and geologically called ettringite crystals) that grow from the surface of the grains of the cement. These ettringite crystals are shown in the picture below (Source: the Concrete Technology website of the Portland Cement Association [http://www.cement.org/tech/faq\\_DEF.asp](http://www.cement.org/tech/faq_DEF.asp) )



As these hard needles grow they begin to interact physically and chemically with their surroundings. The reaction begins immediately upon mixing the cement with water. In the few hours or so the hydrate crystals have only grown long enough to cause loose interactions with the remaining water, the sand and the gravel giving the mixture less mobility. This makes it harder to pour the concrete out of the truck because it feels thicker and starts to leave air pockets when it is poured into forms. This is why it is critical for the contractor to get the timing right on the delivery and placement of the concrete. As the hydration reactions continue over the next hour or so the crystals become long enough to start forming long-range interactions. These long-range interactions cause the particles of cement-hydrate to start physically and chemically bonding to the sand and gravel. This is the point that the concrete begins to hold shape, is no longer mobile, and can support weight. If it is not out of the cement mixer truck before this they have to remove it with a jackhammer. The hydration reaction continues for quite a long time (some say months and other years) while it develops more strength. It takes about one month for concrete to develop enough strength to support a large tractor-trailer. This is why they keep traffic off new concrete highways even though they look like they could be used.

Interesting and useful information for the demonstrator are found in some links to several Wikipedia articles on cement and concrete history, production, reactions, and uses.

on cement: <http://en.wikipedia.org/wiki/Cement>

on Portland cement: [http://en.wikipedia.org/wiki/Portland\\_cement](http://en.wikipedia.org/wiki/Portland_cement)

on concrete: <http://en.wikipedia.org/wiki/Concrete>

the Concrete Technology website [http://www.cement.org/tech/faq\\_DEF.asp](http://www.cement.org/tech/faq_DEF.asp) )

## Experiment 3: Everything Sticks with Glue

### Experiment Purpose & General Methodology

- Cements, pastes, glues, and adhesives are used in building houses. Each table will make a type of glue and will get to glue two glass marbles together to take home.
- Students will be informed about denaturation of proteins and how this works to make our glue.
- The experiment will take about 8-10 minutes and then require the glue to set during the rest of the program to dry enough to take home.

### Introduce the Experiment

*Tell the students the following:*

- Complete the saying:” **“I am rubber.... You are glue. Everything you say bounces off me and sticks to you.”** Then ask if the students have heard this saying before.
- Glues are certainly important when we build a house because we need things to stick together.
- Ask the students: Where might you find glue in your home? Look at the picture for some clues. (answers: flooring, liquid nails, wallpaper paste and ceramic tile cement)
- Ask the students: Does anyone have an idea of what glue is made from? (answers will vary from flour and paste to commercial products)
- Today one of you at each table will make glue that we will all use to hold two objects together.
- Our glue is made from egg white, which is a protein. In our case the protein has been dried into a powder and a few other things added to create a substance cooks/chefs use to make meringue pies.
- The “white” of a fresh egg is about 10% protein. The egg protein has several other names as well: **Egg white** or **albumen** or **glair** is the clear liquid contained in a raw egg.
- We will make the glue, glue some flattened marbles together, and then let our glue harden so you may take them home at the end of this program.

### Perform Experiment as a Demonstration, then Simultaneously with the Students

*Do the following, leading the students:*

- Have one student at each table locate the plastic cup that contains the meringue powder.
- Ask that student to add the contents of the paper cup containing the borax to the meringue powder and to stir it GENTLY with their craft stick to mix the powders. Demonstrate this technique to keep powder from blowing into the air.

- **SAFETY NOTE:** If the students get borax on their hands, they should use one of the wet paper towels provided to wipe it off. If they get a significant amount on their hands, they should wash in a rest-room sink.
- Ask that same students to hold the cup steady (wrap/cup your hand around it) (Note to demonstrators: This is so that the student can feel the heat given off by the reaction.). They should prepare to **CAREFULLY AND GENTLY** mix in some water with the craft stick.
- Ask one of the other students at each table to take a beral pipet, squeeze the bulb to remove the air and then let the water fill up the beral pipet bulb to the bottom of the bulb where the angle begins or just above the top of the stem “Y” as shown with the arrow or previously marked on the pipet.



- Then add all the water in the beral pipet to the mixture in the cup
- Have the student gently stir thoroughly for about 30 seconds. Ask if they notice anything. A small amount of heat will be generated by the reaction. Other students may want to feel the warm cup.
- **SAFETY NOTE:** If the students get glue on their hands, they should use one of the wet paper towels provided to wipe it off. If they get a significant amount on their hands, they should wash in a rest-room sink.
- Tell the students that some of the borax reacts with the water and forms a very weak base. The borax-base denatures the egg white and makes it glue. Denaturation is the unfolding and rearrangement of the protein in an irreversible process in this experiment. (See the note under Additional Information for more about this process). The unreacted borax acts as filler for the glue.
- The mixture should be the consistency of stiff cookie dough. Ask the students if any of their mixtures appear too thin or too thick. If it is too thin, you the demonstrator should add a little bit of borax to the needed cups (if you run out of borax, then use the excess meringue if necessary). Alternately, if the mixture is too dry after stirring, add one or two drops of water.
- Each student should then use their craft stick to obtain a pea-sized amount of glue, quickly brushing the glue on the flat sides of one marble then place the second marble on top, gently pressing the two marbles together.
- Walk around with the garbage bag and collect the cups of glue and craft sticks so that we do not accidentally get glue on ourselves.
- Tell the students to put their glued marbles off to the side so that they have time to dry during the rest of the program.

- Tell the students, if they get glue on their hands, they should use one of the wet paper towels provided to wipe it off. If they get a significant amount on their hands, they should wash in a rest-room sink.

#### Conclusions

*Tell the students the following:*

- The glue will completely set thoroughly in 24 to 48 hours.
- The chemical reactions that take place when glues are created allow bonds to be formed between the different substances being glued together. The stronger the bonds the better it holds. Not all glues are good at holding the same two types of materials together. That is why there are so many varieties of glue at your hardware stores such as those to bond metals, plastics, ceramics and wood.

#### Additional Information If Needed: Technical Background

- **Borax** is hydrated Sodium Borate ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot \text{H}_2\text{O}$ ). Borax dissolved in water has a pH of 9.5 and is thus basic. It is often found as a whitener in laundry detergents.
- Proteins are made of long chains of amino acids, which can be represented as beads on a string. In raw egg white, these strings are raveled up in a tangled compact mass. As the egg white reacts with the borax, the bonds within the proteins break. Each ball of protein unfolds and tangles up with other protein balls. Bonds form between the amino acids on different proteins causing the albumen to form a rubbery gel. This rubbery gel is the glue. The longer it dries the harder it gets.
- Any base may be used for this experiment, sodium carbonate or washing soda ( $\text{Na}_2\text{CO}_3$ ), sodium bicarbonate ( $\text{NaHCO}_3$ ), or lime ( $\text{CaO}$ ). The base is simply used to denature the protein.

## **Experiment 4: Humidity in Your House**

### **Experiment Purpose & General Methodology**

- The importance and controlling of humidity levels in the house are discussed.
- Students will see how to qualitatively measure humidity using color-change indicator strips.
- This experiment will be done at each table and should take <4 minutes to complete.

### **Introduce the Experiment**

*Tell the students the following:*

- Do any of you have a dehumidifier in your home (which removes moisture from the air)? How about a humidifier (the opposite which puts moisture into the air in your home)? Where are they located? Look at the picture of our house for hints. {Answers: Dehumidifiers typically in bathrooms and basements. Humidifiers in living rooms and bedrooms.}
- Why do we need to control the amount of moisture in the air? What happens if the air in our home is too moist? {Answer: Papers and books absorb too much water from the air and curl and become damaged. We might grow mold in our basements and bathrooms where wet areas won't properly dry.} What happens if the air in our home is too dry? {Answer: We are more susceptible to colds since our noses filter the air better if there is moisture available. We are also less likely to have dry, sore throats.}
- Since it is so important to know if the air in our homes is dry or moist, we will see a way to measure the moisture in the air.

### **Perform the Experiment Simultaneously with the Students**

*Do the following, leading the students:*

- Place one cup containing the three vials on each student table. Ask 3 students at each table to carefully pick up the 3 vials on their table. They need to hold them straight up-and-down and not lean them on their sides or the experiment may not work properly. When they put them down, they should put them in the cup so they do not fall over.
- Tell the students: These vials represent three homes. In one home lives Mr. Indicator, Secret Agent Indicator actually. He is an indicator strip, or color-changing strip of paper. It/He changes between two different colors depending on if it/he is in a high-humidity (wetter) environment or a low-humidity (drier) environment
- The three vials-homes have either low humidity of a 'dry' house or high humidity of a 'wet' house. Agent Indicator would like to know if his home has low or high humidity.
- Ask the student to locate the vial-home with the "high humidity". They might be able to see some moisture within the vial or a drop of water on the bottom of the vial. This represents our "overly humid house".

- Have the students locate the vial-home of Agent Indicator. What color is the indicator strip inside of it? {Agent Indicator is Blue.} Tell them they'll have to remember this for later.
- Ask them if Agent Indicator lives in a "high humidity" or "low humidity" home. {Answer: We see no water droplets, so we think it's dry. But we know that it can be a hot and humid day outside even though we cannot see the moisture in the air, so let's prove our theory.}
- Show and have the students exchange the caps of the two vials, thus moving Agent Indicator from his original home to the home with the high-humidity, containing a small quantity of water. Be sure the caps, or roofs, are placed tightly onto each of the **two** vial-homes.
- Indicator strips often need time to react to the moisture in the air, and Agent Indicator has to visit a while to gather clues about this second home. So let's discuss more on humidity in another experiment while we all wait.
- 
- NOTE TO DEMONSTRATOR ONLY: After about 5 minutes the strip should change to a purple and/or pink color indicating the presence of significant water vapor.

### ➤ Perform Expt. 5 (Tyvek) then return to finish this experiment

### ➤ Continuation of Humidity Experiment

- Ask the students: So what happened to our indicator strip in the bottle? What does Agent Indicator look like? {Answer: It changed from blue to purple or pink.}
- So what does this tell us about the humidity in the original vial-home where the indicator strip was originally stored/living? {Lead them to each answer: Remind them that indicator strips such as Agent Indicator only change between **two** different colors depending on their environment. We already stated that the air in this new vial-home has a significantly high relative humidity as seen by the water droplets in the vial. The color changed to pink/purple in the "high humidity" vial-home, thus we expect the blue color to represent the "low humidity" indicator color. This **helps** prove our theory that Agent Indicator's original vial-home was at "low humidity".}
- Tell the students: Now we have **experimental evidence** that Agent Indicator's original vial-home had low humidity and made the strip a blue color, and the second vial-home had a high humidity and made the strip a pink/purple color. But all good secret agents **and good Scientists** like to collect more data to prove their theories whenever they can.
- Tell the students that our third vial-home contains a powder, calcium chloride  $\text{CaCl}_2$ , that is a drying agent. Drying agents pull water/moisture out of the air. This house should be very dry.
- Exchange the two vial caps, moving Agent Indicator from his second (and wet) home to the third vial-home containing the powder drying agent.

- Again we need to wait for the test to complete. So let's go discuss what we're learning about further while we wait to see what happens to Agent Indicator.
- Have you ever left a glass of water out overnight? What happens? {Answer: There is less water in it the next day. If they need prompting, ask "What happens to the dishes in the rack next to the sink after we wash them?"} What happened to the water? {Answer: it evaporated.} We all have seen the result of water evaporating into the air. Some of the liquid water has become water vapor in the air. When water is plentiful (as in a glass of water) and the relative humidity of the surrounding air is low (it's dry), evaporation readily/easily occurs.
- What happens to us when the humidity is very high, such as on a hot humid summer day? {Answer: We feel hot and uncomfortable and get all sweaty.} Why does it feel so different when there is a day which is just as hot, but has low humidity? {Answer: When humidity gets higher water evaporates less readily/easily. That's why we are more uncomfortable on a humid day in the summer. On that humid day sweat does not evaporate easily from our skin. Evaporation of sweat removes excess heat from our body, keeping us cool and comfortable. There is a measurement called the heat index to measure this. For example, on an 85°F day that's 85% relative humidity it will feel like 102°F! }
- Say: But I know something about Agent Indicator. Our indicator strip is made with a type of salt called cobalt chloride. At low humidity the cobalt chloride test strip will appear to be blue. At moderate humidity it will appear its transitional color of purple, and at high humidity the strip will turn pink. As the salt crystals within the paper combine with water their shape changes and thus it reflects light differently, which we see as a color change.
- So, let's take a look at Agent Indicator. What color is he in this third vial-home? {Answer: The indicator strip is blue.}
- Explain to the students that this vial will have dry air (essentially 0% relative humidity). The powder inside is a drying agent that absorbs moisture. As the indicator strip gives moisture to the dry air by evaporation, the drying agent absorbs the moisture thus keeping the air in the vial dry. The indicator strip will turn back to blue after a few minutes. If the strip was fully pink and thus very wet, it may only get to a purple (intermediate) color after 5 minutes, the blue color may take longer to achieve.
- Say: So do you remember what color he was in his original home? {Blue} ...and in the 'humid home'? {Pink} ...and in the 'dry' home? {Blue}. So what is the humidity like in his original home? {Dry – since he was blue there too.} So these **two sets of evidence**, blue when dry and pink when wet, support our **theory** that his original home was dry.
- When finished replace the indicator cap back on the empty tube (Agent Indicator's original home).

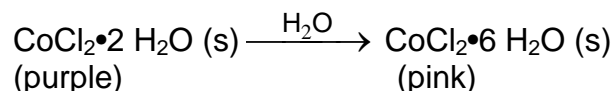
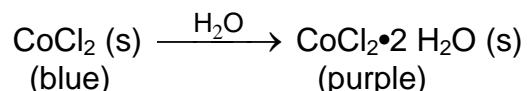
**Conclusions**

Tell the students the following:

- These were already discussed during the experiment.

**Additional Information If Needed: Technical Background**

- The chemistry:



- Humidity is typically measured as percent relative humidity, which compares the amount of water vapor present in the air to the maximum amount of water that the air could contain. At low humidity the cobalt chloride test strip will appear to be blue.
- At moderate humidity it will appear purple (as it forms the dihydrate) and at high humidity the strip will turn pink (as it forms the hexhydrate).
- It's common to install exhaust fans in bathrooms. These are useful when taking showers or baths. Running the fan during a hot shower helps to remove some of the very humid air that forms as a result of having lots of hot water around. That's what causes your mirror to fog up - it condenses on the cooler surface of the mirror

## **Experiment 5: Wrap Your House with Tyvek®**

### **Experiment Purpose & General Methodology**

- The students will be shown that Tyvek resists water and thus prevents moisture from entering homes.
- In a hand-out for a take-home experiment, the students will also be shown that Tyvek allows water vapor to pass from inside the house to the atmosphere.
- The experiment should take 3 minutes to complete and is done per student, with each student receiving a piece of Tyvek to take home for their water vapor experiment.
- If you do not have a Thermos of warm water, please ask the librarian or a parent to obtain some while you do this experiment. Provide them with the thermometer and ask them to obtain water at 33-37°C or about 92-99°F.

### **Introduce the Experiment**

*Tell the students the following:*

- Chemistry has produced materials that keep their homes dry.
- Please look at #5 on your home picture. What do you see that may help keep your home dry?
- Tyvek is a material that builders “wrap” homes in to prevent liquid water and air from entering their homes. At the same time it permits water vapor to leave their homes. As the house picture shows, we want to keep rain out, and let humidity out too. The experiment today will demonstrate how Tyvek keeps their homes dry by preventing the invasion of liquid water into the house.

### **Perform Experiment as a Simultaneously with the Students**

*Do the following:*

- Have each student place the Tyvek sheet (lettering up) on the newspaper next to a corner of newspaper which they can partially turn over and see the other side. If no printing in visible tell them to use the smoothest side on top.
- Have the student take the disposable pipet and obtain some water from the cup marked “Water”.
- Place one drop of water on the surface of the Tyvek. Place another drop of water on the edge of the piece of newspaper . (This could be any edge of the paper so that the drops are close in proximity to one another.)
- After waiting about 10 seconds, carefully pick up the Tyvek and move it away from the water-drop on the newspaper. Observe how much water has passed through the Tyvek and

onto the newspaper. Also carefully lift the newspaper and observe how the water has penetrated through the newspaper.

#### Conclusions

*Tell the students the following:*

- The newspaper is like the walls of your home. Unprotected, rainwater could easily pass through the walls and into your home. But with the protection afforded by the Tyvek, the walls of your home are kept waterproof.
- You may try a take home experiment to further investigate the properties of Tyvek. As you leave today you will receive a handout with details for this experiment.

#### Additional Information If Needed: Technical Background

Tyvek is a white polyethylene sheet of ultra-fine fibers made from spinning extremely fine, high density polyethylene into a uniform web. Tyvek is engineered to create millions of extremely small pores that resist bulk, liquid water and air penetration while allowing water vapor to pass through. It is intended for use as an air infiltration barrier or moisture protection barrier. It is typically installed over the studs or on the exterior of building sheathing boards.

## **Experiment 6: Insulate Your Walls**

### **Experiment Purpose & General Methodology**

- The concept of insulation and heat transfer will be studied. Color-change heat-sensitive papers and liquid crystals will show the rate at which heat escapes through plastic, paper, nested paper, and Styrofoam cups.
- The experiment is done per table and should take less than 5 minutes to complete..

### **Introduce the Experiment**

*Tell the students the following:*

- Your home is a really large container with many things inside of it, including air.
  - In the winter you want to warm the air and keep your home cozy and in the summer you might wish to cool it or at least keep the hot air out of the house.
  - When you turn on the furnace and heat the house you do not want to lose all that heat. It is costly to heat a home and you want to keep as much of the heat in as possible. What does a home have that helps us to keep our house warm in winter and cool in summer? Answer: insulation (they may also answer “furnace and air conditioners”)
  - Where is insulation found in your home? Look at the picture for at least one clue. Answer: Walls, roofs. Note that insulation is also around all your doors and windows and even behind your electrical outlets to prevent even small amounts of heat from escaping your home.
  - Look at the house picture again, at the wall on the right. It’s thick, but not solid. There are air pockets in it. Keep this in mind as we do this experiment.
  - Let us take a look at insulation and the concept of heat being transferred. Heat is a form of energy. Heat energy always moves from an area that is hotter to an area that is less hot.
- A warm house cools down during a cold night because heat energy moves out of the house and warms the colder air outside around the house.

### **Perform Experiment Simultaneously with the Students**

***PART 1: Do the following:***

- Ask the students to put their hands on the name tag and observe what happens. Ask what they observe. Answers: The paper changes color if their hands are warm. Different colored papers changed to different colors.
- Tell the students when they arrived today they made a name tag using special paper that is sensitive to heat. The name tag color changes due to a chemical reaction that requires heat. The heat from a hand is enough for the reaction to occur.
- Tell them that their hands transferred heat to the paper and the paper absorbed that heat. The special dyes in the paper change color in very specific temperature ranges just below body temperature. This type of transfer of heat is called conduction, heat that is transferred between objects in contact.
- Tell the students they will now investigate how different materials can stop the loss of heat.

- PART II: Do the following
- Have the students at the table locate the 4 sets of cups with the thermochromic paper but DO NOT TOUCH THE PAPERS ATTACHED OR THEY RUIN THE EXPERIMENT.
- Make sure the temperature of the water the librarian has obtained for you or that you collected earlier is 33-37°C or about 92-99°F. If it is too hot the color change is too quick for comparison. Add cold water if necessary to fall into this range. (Thermometers were provided in library kits.)
- Have the students look at the color-changing paper and the liquid crystal strips on the cups. Tell them that you will pour warm water into each of the cups and they are to try to count out (in their heads) the number of seconds until the color changes in each cup. If this is difficult, try to simply notice which cups make the papers and liquid crystals change color more slowly.
- Use your ¼ cup measure and pour the warm water into each of the cups on the table in front of the students. DO BUT DO NOT DISCUSS YET: Do in this order: single paper cup (about 1 second); plastic cup (about 1 second); doubled paper cups (about 5 seconds) and the Styrofoam cup (long time). Thus with the paper, the changes are quick for the individual cups, maybe noticeably slower for the double cup, and a little longer for the Styrofoam. The colors for the liquid crystals change instantly, except Styrofoam. Do this for each table.
- Have the students continue to observe the two strips while you move around to the rest of the room.
- Ask the students if they saw a difference between the paper and liquid crystal? (the liquid crystal has a transition range of 25°-30°C or 77-86 °F and the paper from 31° -37° C or 88- 99 °F)
- Compare results for the single paper cup and the plastic cup.
- Ask the students if they think there was much difference? (very little)
- Ask the students why the two cups together took longer for the water to transfer the heat to the thermochromic paper and liquid crystal? Answer: there is a very narrow layer of air between the two cups that acts as an insulator. Many storm windows in your homes have two panes of glass separated by a layer of gas, often Argon. Fortunately it's more efficient than our two layers of cups!
- Ask the students why the Styrofoam container was such a good insulator? Clues: Think about the structure of the cup: is it smooth? or heavy? Answer: there is lots of air incorporated into the polymer structure which acts as a very efficient insulator.
- Ask students if now that they have investigated insulation they would rather hold hot chocolate in a plastic cup or a Styrofoam cup.
- Ask the students if any of them noticed any color changes in the strips nearer the top of the cup? (Answer: the liquid crystal may go through some color changes.)
  
- Let the students know that convection of heat was occurring above the surface of the liquid. Convection occurs when heat is transferred through the air. Conduction then occurred between the sides of the container to the liquid crystal strip in the area near the top of the cup causing the color change.

- **OPTIONAL:** You may place an ice cube in each of the cups of water to see the paper strips return to their original color below the water line and the liquid crystal to go through its transition again. This will add several minutes to the program.

#### ***Part II – Heat-Sensitive Paper***

*Do the following:*

- Ask the students to put their hands on the name tag and observe what happens.

#### ***Part II Conclusions - Heat-Sensitive Paper***

*Do the following:*

- Tell the students that their name tags are made with heat-sensitive paper.
- The name tag color changes due to a chemical reaction that requires heat. The heat from a hand is enough for the reaction to occur. The paper is thermochromic; “thermo” meaning heat, and “chromic” meaning color.

#### **Conclusions**

*Tell the students the following:*

- We see that to insulate your home is a very good idea to keep in the warmth in the winter and keep out the heat in the summer.
- All substances, including air spaces and building materials (such as wood, glass, plaster and insulation), obey the same laws of nature and TRANSFER heat. They differ only in the rate of heat transfer, which is mainly affected by differences in density, weight, shape, permeability and molecular structure. Materials which transfer heat slowly can be said to RESIST heat flow.
- Molecules are the very, very small particles something is made of. Solid materials transfer heat better than liquids and much better than gases because their molecules are closer together and bump into each other a lot and transfer heat energy. Thus, as the opposite, gases have molecules that do not transfer heat well since they are far apart from each other and don't bump into one another as much. This is why double-paned windows are filled with gas.

#### **Additional Information If Needed: Technical Background**

- The thermographic film looks black at room temperature because the cholesteric liquid crystal is sandwiched between two plastic films, one clear and one with a black background. If the reflected wavelength is not in the visible region (below the required temperature) the black background absorbs the visible light and the film appears black. Once the temperature is increased the reflected color is in the visible region and you will see the reflected color. When

the temperature is increased above the cholesteric-isotropic temperature, the liquid crystal becomes isotropic like an ordinary liquid and you see the black background.

- The laminated sheets of liquid crystal are temperature sensitive. The Plastic sheets remain black except for a five-degree temperature range in which they display a series of colors that reflect the actual temperature of the crystal. These crystals are cholesteric.
- These liquid crystal sheets have a transition temperature of 20-25°C or 68-77°F.
- The liquid crystals we were using are called “cholesteric” and are thermotropic, changing phase as a function of temperature. The liquid crystal phase is formed when the material is heated above the temperature where the solid phase just melts.
- The heat-sensitive paper works at temperatures above 75°F.
- The heat-sensitive paper contains color-changing microcapsules. The microcapsules are composed of melamine formaldehyde (the same material as Formica®). The microcapsules are filled with a lipid (fat) such as methyl stearate and a dye that is barely visible when the lipid is liquid, but is bright when the methyl stearate solidifies. The paper actually contains two dyes, one a permanent ink and other a color-changing pigment. For example, if a red permanent ink is mixed with a blue color-changing pigment, it will appear purple when cool. When heated, the blue color melts away, turning the purple to red.
- Insulation products are manufactured and sold by their R-values. An R-value is a measure of insulation's resistance to heat flow. With today's continually rising energy costs, a well-insulated and sealed energy efficient home provides a long term return on investment through lower energy costs. Also, the reduced use of fossil fuels helps to reduce overall green house gas emissions and slow climate change.
- There are many types of insulation for example: Cellulose fiber or loose fill, glass fiber (batt) and extruded polystyrene boardstock (rigid)
- **Heat is transferred in distinct ways:**
- 1) **Conduction** - the transfer of heat through a solid object. When an object is heated, the molecules within it begin to move faster. These molecules then hit other molecules within the object, causing heat to be transferred through the entire object. Because heat can be transferred through solid objects, most insulation usually contains tiny "pockets" of still air.
- 2) **Convection** - the transfer of heat through the air. In an un-insulated wall cavity, air removes heat from the interior wall then circulates to the colder exterior wall where it loses the heat. In large air spaces such as wall cavities, large amounts of heat can be lost through convection. As long as the insulation is carefully installed to completely fill the cavity, there should be no air spaces in which convective heat loss can occur.
- 3) **Radiant Energy** - . Radiated heat is usually termed infra-red. When infra-red strikes an absorptive object such as concrete, wood, water, paint, skin or clothing it is converted into heat at the surface. Surrounding air is then warmed by conduction and convection. The best example of this transfer of heat is from the sun to the earth without loss of heat to outer space. Warm objects, including people inside a heated building lose or radiate heat to the cooler inside surfaces of the walls. The walls conduct heat to the outside surface and then lose heat by radiation, conduction and convection to the outside.

- Additional info at [http://www.radiantbarrier.com/physics\\_of\\_foil.htm](http://www.radiantbarrier.com/physics_of_foil.htm)

## **Experiment 7: UV Protection on Your Windows**

### **Experiment Purpose & General Methodology**

- The concept that UV rays can cause physical and chemical changes in materials is presented, and also that they can be blocked by certain types of protectant films.
- Students will receive UV-changing bead bracelets and see how UV light (from a black light can be blocked by a UV-resistant film made for windows.
- The experiment should take about 8 minutes to complete.

### **Introduce the Experiment**

*Tell the students the following:*

- Our house has many objects in it that might fade if exposed to direct sunlight.
- Has anyone seen this happen at their home? [They may have a picture hanging over a part of the wall that has a slightly different color behind it or an area of their rug where its color is different from the rest.?)
- Why do you think this happens?
- Let's experiment with it and find out!

### **Perform Experiment Simultaneously with the Students**

*Do the following:*

- Distribute one bracelet to each student. Have them twist it around a wrist.
- Ask for one student from each table to come to the front of the room and stand on your left. Indicate this by showing where to stand.
- Ask for another student from each table to come to the front of the room (delete here?: with the piece of UV film) and stand on your right, showing them where you want them to stand.
- Turn on the GE Blacklite Stik®
- To the first group of the students you called to the front, ask them to put their arms with the beaded bracelet together and hold the UV light over the bracelets for a few seconds or until the beads change color.
- Ask the students what is happening? (The UV beads will change color to red, orange, yellow and violet.
  
- Tell the students that these beads are able to absorb Ultraviolet (UV) light which is one of the invisible frequencies of light given off by the sun. Light is a form of energy, and UV light has

energy that can make certain chemical reactions occur. Overexposure to it can be harmful to many things, including humans. Its effects can be seen in faded paper, sunburned skin, and a cracked rubber garden hose that has been left out in the sun.

- The UV-sensitive beads contain a pigment that changes color when exposed to UV light from the sun or the GE Blacklite Stik®. The beads are not, however, affected by visible light and so will remain white indoors or when shielded from UV light.
- Windows that have been treated with a UV protective film should block out the harmful rays. Let's see if that is true!
- Have the second group of students (Delete: peel off the backing) put their arms together and place the UV film directly over their bracelets and again turn on the GE Blacklite Stik® passing it over each student's bracelet.
- Ask the students if they see a difference with the UV-protectant film or not? {Answer: no, the beads protected from UV light will not change color.}
- To prove that you didn't give the second group of students different, non-color-changing beads, have them remove the UV-protectant film and expose them to the GE Blacklite until they change color.
- Let the students know that you will have the GE Blacklite Stik® out at the end of the program so that each one of them can see the color change before they leave. If they wear their bracelets outside tomorrow they will see the color change as well.
- Optional – If you have allowed yourself additional time for your program, you can go to each table and ask
- Ask the students: "What do these experiments tell us?" (Answer: That Windows treated with a UV protective film will reflect the UV light keeping it out of the house and it will help keep fabrics and other materials in their homes from fading and being damaged over time.)

### Conclusions

*Tell the students the following:*

- UV rays cause slow physical and/or chemical reactions to occur on wood, carpeting or other surfaces. We can protect our home's interior from UV light which can cause fading and discoloring of our furnishings with UV-protectant film similarly to the way we protect our skin from UV rays by using suntan lotion or hat or a beach umbrella.

### Additional Information If Needed: Technical Background

- The electromagnetic radiation needed to affect change is between 360nm and 300nm in wavelength. This includes the high-energy part of the UV type A (400-320nm) and the low energy part of UV Type B (320-280nm). Long fluorescent type black lights work well. Incandescent black lights, the type used to make fluorescent paints glow, will not change the color of the beads nor will UV Type C (280-1nm)
- The dye molecules consist of two large, planar, conjugated systems that are orthogonal (at right angles) to one another. No resonance occurs between two orthogonal parts of a molecule. Imagine two planes (surfaces) at right angles to one another, connected by a carbon atom. When high energy UV light excites the central carbon atom, the two smaller planar

conjugated parts form one large conjugated planar molecule. Initially neither of the two planar conjugated parts of the molecule is large enough to absorb visible light and the dye remains colorless. When excited with UV radiation, the resulting larger planar conjugated molecule absorbs certain wavelength of visible light resulting in a color. The longer the conjugated chain, the longer the wavelength of light that is absorbed by the molecule. By changing the size of the two conjugated sections of the molecule, different dye colors can be produced. Heat from the surroundings provides the activation energy needed to return the planar form of the molecule back to its lower energy orthogonal colorless structure.

- These beads will cycle back and forth thousands of times upon exposure to or protection from UV light.
- **Students might try a few experiments at home:**
- Take your beads outside at the same time of the day, but under different weather conditions. Does cloud cover change the amount of UV light you are exposed to?
- Place different transparent filters between the sun or a UV light source and your beads. Try sunglasses or a dab of sunscreen rubbed onto a piece of clear plastic wrap.
- You will find that the front windshield of most automobiles absorbs UV radiation. Often the side windows do not have this built-in protection.

## **Experiment 8: Hard Water vs. Soft Water**

### **Experiment Purpose & General Methodology**

- The students will learn the difference between “soft” and “hard” water.
- The students will learn why it is so difficult to clean-up using hard water.
- This experiment will be done per table, and will take 5 minutes.

### **Introduce the Experiment**

*Tell the students the following:*

- Ask students if they have ever heard of hard or soft water.
- Ask students to look at the picture of the house. Where does the water come from? (pipes, of course) (from the city's water treatment plant or a well)
- Does hard water really feel hard and soft water feel soft? (Answer: No. They don't look or feel different from one another, but they are different chemically.)
- Depending on the hardness of the water, washing and cleaning up can be easy or more difficult. Ask the students if they know which (hard water or soft water) is easier to use for washing up.
- Our experiment will help us understand the meaning of “hard” and “soft” water and will help us determine which is better to use in your home.

### **Perform Experiment Simultaneously with the Students**

*Do the following, leading the students:*

- Add one small piece of soap (about the size of a pea) to the vial/bottle marked “H” and another piece of soap to the vial/bottle marked “S.” The “H” water will become our example for hard water, while the “S” water will become our example of soft water as we continue the experiment. Shake both vials to partially dissolve the soap and see if you can make a head of bubbles in each container.
- Ask the students, “What did you observe?” (hard water had few soap bubbles and lots of clumped material) (soft water has lots of the soap bubbles but no clumps) ...
- Ask the students: Why do you think hard water and soft water act so differently? What do you think the clumped material is in the hard water? ...
- Answer and discuss: Tell the students that they didn't know something about this experiment. While both the ‘hard’ and ‘soft’ vials/bottles of water originally contained distilled water, Epsom salt was added to the vial/bottle marked “H” to represent hard water. Hard water contains chemical salts similar to those in Epsom salt which interact and combine with the soap. This creates a sticky soap scum film inside the vial. Since the Epsom salt combined with the soap, there is less soap available in the water which makes foaming difficult. Remember, hard water = hard to make a lather.

### Demonstrator's Guide

- Have a student at each table find their table-salt packet, open it, and add a few crystals of table salt to the vial/bottle marked "S". Shake the vial/bottle. What happens? [Answer: The soap head should be unaffected.] ...
- Answer: The table salt added to the "soft" test tube represents the salt on your body or on your clothes, such as when you sweat. Your body salt and table salt is composed of the elements sodium and chloride which do not interact with the soap and do not interfere with the foaming action of the soap, so it is easily washed away with "soft" water.

### Conclusions

*Tell the students the following:*

- Many homes and businesses have water that is hard and will use a device called a water softener to reduce these ions in their water. We made our own hard water today because some libraries use softeners and we wanted everyone to see the effect.

### Additional Information If Needed: Technical Background

- The soap used must be Ivory; other brands tested did not work as well.
- Water hardness results from calcium, magnesium, and iron in water. In nature, water becomes hard by picking up calcium or magnesium when it flows over or through rocks that contain limestone and other minerals.
- Calcium, magnesium, and iron form stearate salts when mixed with soap (which is mainly sodium stearate and other sodium salts of fatty acids). These calcium, magnesium, and iron stearates are much less soluble in water than the sodium salt and precipitate upon mixing. The solid precipitate correspond to "soap scum" or bathtub ring.
- Most detergents and shampoos have been formulated so as not to lose their effectiveness when used with hard water. Detergents often contain sodium lauryl sulfate which does not form precipitates in the presence of calcium or magnesium ions.
- Many homes have water-softening devices that remove the dissolved metal ions. The most common type of water softener utilizes an ion-exchange resin that replaces any  $\text{Mg}^{+2}$ ,  $\text{Ca}^{+2}$ , and  $\text{Fe}^{+2}$  ions in the water with  $\text{Na}^{+}$  ions which form soluble stearate salts. Laundry aid agents, such as Calgon, borax, and washing soda, are marketed to remove hard water cations by causing them to become part of larger soluble anions, or by precipitating them as carbonates, which can be washed away with rinse water.
- The chemical formula for Epsom salt is  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$

## **Experiment 9: Is Your Water in the Pink? Safe (Chlorinated) Drinking Water in Your Home**

### **Experiment Purpose & General Methodology**

- The students will be informed that the Cleveland (and most) city water that comes into their homes is chlorinated, and will be told that chlorine kills germs (specifically “microbes” like viruses and bacteria) and makes the water safe to drink.
- Each table will get some water and they can decide, after a test packet is added, if they have tap water from the faucet or distilled water.
- The experiment should take 2 minutes to complete.

### **Introduce the Experiment**

*Tell the students the following:*

- Tell the students to look at the house picture, at the sink in the upstairs window (Experiment #9).
- Ask: Would you drink the water in your house? [Answer: Yes! Because it's safe to drink!] Would you drink the water from a stream? [No!] Can we drink water directly from Lake Erie (or other known nearby body of water)? [No! It can have germs (“microbes” like viruses and bacteria) in it; especially after rain, when rainwater has washed all kinds of things into it, like from farm lands. Microbes also come from waste from people and animals in nature.]
- Explain that living in a house requires clean water to drink and cook with. Some homes in other parts of the world do not have plumbing/running water inside; water has to be brought in from wells or streams. Some streams, even mountain streams that look clear and clean, may have germs that can make you sick. We're lucky because our water has the chemical called chlorine added to it to kill germs (microbes) and make it safe to drink.
- **Enter your own local information here:** Explain that our water comes from Lake Erie (exceptions include Berea and others who may have well water) and is piped to a water treatment plant in Cleveland to get cleaned up. This includes addition of chlorine gas which provides protection to the water all the way from the treatment plant through all the pipes to our individual homes and businesses.
- The average home in the U.S. uses **100,000 gallons** of water every year! And every day people drink up to 2 ½ quarts of water. Clean water is very important to us!

### **Perform the Experiment Simultaneously with the Students**

*Do the following, leading the students:*

- Make sure that all students and you have goggles on.
- Show the students the 2 soufflé cups of water that you have. Ask, “Do they look different?” [No]. However, one is distilled water (which has nothing but water; no minerals or salts or chlorine); and the other is tap water (city water; Lake Erie (or other source of) water that has been treated with chlorine; water taken right from the tap at the library or your site).
- Tell the students: We can add a chemical to each of these to show which has been treated with chlorine. This chemical is called DPD Total Chlorine Reagent and is actually a mixture of several different compounds.
- Add a packet to each cup and show that tap water turns pink. If you tested the water on site, add the ½ packet remaining from the set-up to the “D” cup.
- Ask the students if they can tell if their water is tap or distilled by looking at it. [No.]
- Empty a DPD packet into each of the cups on the tables (there is one per table).

### Conclusions

*Tell the students the following:*

- Ask, “Is your water ‘in the pink’?” Do you know that phrase? That phrase means “in good health and ready to go”; remember the rosy color in your cheeks when you’re healthy versus a pale face when you are sick. So if your water is ‘in the pink’ then it’s chlorinated tap water and will keep you healthy.
- Where else do we find chlorinated water? {Swimming pools (so we don’t share germs or grow algae).}
- Note that we don’t want too much chlorine in our water – just enough to kill germs. Can you think of a place where we might not want too much chlorine in the water? Hint: Do you have a wet pet? {A fish-tank. There is little chlorine in natural water so we have to be careful not to harm our scaly friends with too many chemicals. There can be too much of a good thing.}
- Some locations have filters to remove the remaining chlorine or products of chlorination.
- Also note that when there’s a water main break there may not be much detectable chlorine. When this happens we may be asked to boil our water to kill germs (microbes).

### Additional Information If Needed: Technical Background

- The chlorine test packets were obtained from Hach Company in Loveland, Co. The product name is DPD Total Chlorine Reagent and it contains Potassium Iodide (20-30%), Salt of N,N-Diethyl-p-Phenylenediamine (1-5%), Sodium Phosphate, Dibasic (20-30%), Carboxylate Salt (40-50%), and a small amount of other components. It is a white or light pink powder.
- The city of Cleveland’s Division of Water has a great website for information on the source of our drinking water, source of contaminants, and the treatment system. Go to [www.clevelandwater.com](http://www.clevelandwater.com) for the water quality report, or search using “city of Cleveland
- Division of Water”.

#### **Safety Information:**

- For the demonstrator: The toxicological information in the MSDS sheet for this material, as provided by the supplier, Hach Company, states that there is no reported data on skin and eye irritation, etc. However under Hazards Identification it states that this material may cause eye, skin and respiratory tract irritation and may cause allergic reaction and lists a HMIS Health ranking of 2. Consequently we have only the demonstrators handling the packets. Per MSDS sheet, please be sure to “maintain general industrial hygiene practices” like washing hands after handling. Only small amounts of material are used in the packets in this experiment, and they have been safely used in previous demos, as per a Hach employee on our 2007 NCW Planning committee, and she has no hesitation to use these with children.
- An MSDS is available through the material supplier, Hach Company, at:

[http://www.pollardwater.com/EMarket/PDFs/pdf\\_web\\_manuals/hach\\_dpd\\_free\\_chl\\_reagent\\_msds.pdf](http://www.pollardwater.com/EMarket/PDFs/pdf_web_manuals/hach_dpd_free_chl_reagent_msds.pdf)

## **Experiment 10: Recycle!**

### **Experiment Purpose & General Methodology**

- The students will compare the properties of Styrofoam and cornstarch packaging peanuts, which “stick around forever” and decompose in water.
- The experiment will encourage students to recycle in their homes.
- This experiment should take 2-3 minutes.

### **Introduce the Experiment**

*Tell the students the following:*

- The second experiment we did today showed you the structure of concrete.
- Ask the students what is the name of the material that they stuck the toothpicks into? (Styrofoam)
- Ask the students to raise their hands if they recycle at home. Ask what they recycle and why they do it.
- Ask the students to look at the picture to show that even though the idea is not part of the house, recycling is important enough to include it in our picture.

### **Perform the Experiment Simultaneously with the Students**

*Do the following:*

*Pass out 6 Styrofoam and 6 cornstarch (Cheetos®-looking) peanuts to each table.*

- Have students compare the Styrofoam and the cornstarch materials. Water cups need to be about one-half full—refill if necessary at this point)
- Ask the students if they know what they are used for? (packaging/shipping)
- Let them know you are going to explore their differences.
- Demonstrate the experiment by having each student put their forefinger and thumb into the cup of water to wet it and then pick up a piece of Styrofoam. Ask them for their observations.(they should not notice anything happening)
- Wet your finger and thumb again and pick up the cornstarch piece and ask for observations. (the material becomes sticky)
- Ask what do you think will happen if you put one piece in the cup marked “water” on the table in front of them?

### Demonstrator's Guide

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- Have just one student put a piece in the water, stir it. Observe. Have another student put a cornstarch piece into the warmer water in the Styrofoam cup used in Exp. 6. (If the water is still warm it should dissolve the cornstarch piece faster.)
- Have each of the other students put one piece into the water, stir and observe.
- Ask the students which material would be better and easier to recycle?
- Tell the students that today's experiment has a lot of materials that are being reused and then recycled: the cardboard box that contained the supplies for the program, the plastic water bottles, and the Styrofoam and the cornstarch packing materials.
- Tell students to remember the 3 "R's"—Reduce, Reuse and Recycle.
- Ask the students what materials might be recycled and reused in building their homes? (Plastic bottles are recycled into carpeting and poly-lumber. Newspapers are recycled into grocery bags and new paper for printing or writing.)

### Conclusions

*Tell the students the following:*

- Recycling is encouraged to reduce waste in our valuable landscapes. If they can they should try to recycle aluminum cans, plastics with recycling codes # 1 and #2 (PET-polyethylene terephthalate and HDPE-high density polyethylene, respectively), newspapers, magazines, phone books, and cardboard as these are collected in most communities. They can go on the internet with their family and also find special drop-off locations for other items. They should think before they throw away.
- There are many ways to recycle including creating compost heaps in your yard which can take vegetable and fruit table scraps, dead leaves and grass cuttings and produce high quality soil for your garden..
- Demonstrator Note: At the end of the program students may take a few more cornstarch pieces to show their family and/or teachers what they have learned.
- Even our program kit contains many items that have been or can be recycled. These boxes have been used before to make deliveries to a local high school and were then donated to the American Chemical Society National Chemistry Week committee for our use. The large vials have been used in many previous demonstration programs, and both the large and small vials will be rinsed and used for future programs. The bottles are from water, soda, Gatorade and other drinks.

### Additional Information If Needed: Technical Background

- The cornstarch packing materials are made from cornstarch, a natural organic polymer, and are soluble in large amounts of water. Styrofoam is insoluble in water and hence will occupy large volumes in landfills.

- Encourage students to recycle plastics with codes of #1 (PET-polyethylene terephthalate) and #2 High Density polyethylene. These are used to make new fibers for rugs, clothing and even plastic lumber.

#### Websites on recycling and proper waste disposal of household items (Cleveland area):

Recycling paper, metal cans, and car batteries, in Cleveland:

[http://deq.state.ms.us/mdeq.nsf/pdf/Recycling\\_ClevelandRecycling/\\$File/Cleveland.pdf?OpenElement#search=%22batteries%20cleveland%20recycle%22](http://deq.state.ms.us/mdeq.nsf/pdf/Recycling_ClevelandRecycling/$File/Cleveland.pdf?OpenElement#search=%22batteries%20cleveland%20recycle%22)

Recycling paper, cell phones, ink jet and toner cartridges, phone books, and more in Cleveland through the Cleveland Metroparks Zoo:

<http://www.clemetzoo.com/conservation/environment.asp>

Recycling in Cleveland of glass bottles and jars, metal cans, 1-7 plastic containers, non-waxed cardboard, plastic grocery bags, and mixed paper:

<http://cleveland.about.com/od/livingincleveland/a/clevrecycle.htm>

Cleveland Heights recycles techno-trash - old CDs, DVDs, diskettes, audio and video tapes, cell phones, PDAs, digital cameras, rechargeable batteries, and inkjet and laser cartridges. Complete security.

<http://www.clevelandheights.com/whatsnew.asp?id=327>

Clevelanders: For proper disposal of other hazardous waste (paints, lawn care chemicals, motor oil, mercury, batteries, florescent bulbs, and much more.

<http://www.city.cleveland.oh.us/government/departments/pubservice/pubserwastecol/recycle/recyclespecialhaz.htm>

## Closing Session

### Close Demonstration

- Remind the students that **they can take home** their concrete, a few pieces from our micro-concrete structure, glued glass beads, the Tyvek piece, the bracelet with UV sensitive beads and a few cornstarch peanuts to share our experiments with their family and friends. Give each student one sandwich sized baggie to store **ONLY** their concrete and glued beads. Do not put the other items in this bag. Once home they should remove the cup and beads to let them dry in the air for a day. The concrete can take up to a week to fully harden.
- Remind the students to check our website for information on how to participate in our Chemistry and Poster Contests where each student receives a small token for entering and can win prizes. Our website address is [http://www.csuohio.edu/cleveland\\_acs/ncw.htm](http://www.csuohio.edu/cleveland_acs/ncw.htm) but they should also be able to find us by searching for the Cleveland NCW or Cleveland ACS.
- Thank the students and parents for coming to this year's demonstration and learning about the chemistry of building their home.
- Have students come up to the closing area to turn in their goggles, and pick up their take-home sheets & *Celebrating Chemistry* newspapers.

## Clean up

### After the students leave, clean up the room

- Return items borrowed from the library. Give any leftover literature to the librarian.
- The liquid crystal sheets were quite expensive and the NCW committee would like to have them returned. Please remove them from the cups and put them into (and stuck to) a PLASTIC bag for return with other items, as discussed below.
- **NOTE SPECIAL TREATMENT: CHLORINE TEST** experiment soufflé cups: If you have a sink in your demo area, pour the contents of the pink cups down the drain with plenty of cold water (flush for 5 minutes), rinse the cups 3 times, and then dispose in normal trash. Alternately, if no sink is available in your demo room, pour the contents into the liquid-waste jug or bucket you brought, rinse each pink cup 3 times using the water from the soft water experiment or other 'clean' water, then dispose of the cups in the normal trash.
- Combine water and other liquid-waste in a gallon jug or bucket. **BE CAREFUL TO TRY TO GET THE PIECES OF SOAP OUT OF THE VIALS AS YOU POUR THEM.** This liquid waste can be put down the sink safely with running water – but, do not clog the sink with the soap pieces.
- Empty the vials, rinse them well with water, shake off as much water as possible, then place them on paper towels to start to dry while you clean up the rest of the room.
- Repackage the GE Blacklite Stick into its container using the padding/papers at each end to secure it for preventing damage in the mail.

- Complete the Feedback Form.
- **Collect items into the mailing envelope marked “Fairview Park” to be returned to the NCW Committee for future programs via CCPL interlibrary mail. These include:**
  - Completed Feedback Form
  - Extra nametags and safety pins
  - thermometers
  - liquid crystal strips (they are expensive) – please first remove them from the cups and place them into a plastic bag (not mixed in or they may stick to other items such as paper)
  - extra UV bracelets
  - save all the capped vials at the end of the program
  - place the dry (or damp) vials into a zip lock bag and zip the bag
  - DO NOT COLLECT AND SAVE the UV-resistant films. Once the backing is off they roll and become sticky when exposed to moisture. Throw them in the trash.
  - Do not save paper and plastic cups. They are crushed in interlibrary mail.
- All solid waste can be collected in the large garbage bag and thrown into the regular trash. **BUT PLEASE RECYCLE** any of the **CLEAN** soda/water bottles.
- If you are performing another demonstration for this year's National Chemistry Week, sanitize the goggles between demonstrations with a dilute bleach solution as instructed in the written directions found on the inside cover of the goggle container. Be sure to dry them with soft cloth or soft paper towels to prevent scratching. Please stack them into their box without twisting or crushing!
- If you are finished performing your demonstration(s) for this year, place the used goggles into their box. Please stack them without twisting or crushing! (There is no need to clean them when you are through; our committee will clean them for the next year and/or for other programs.)
- Give the mailing envelope (containing saved supplies and feedback form) as well as the GE Blacklite Stick and box of goggles to the children's librarian with instructions to put it them in the interlibrary mail to Fairview Park Library. (Or take to your nearest CCPL library, as instructed at the start of this script).

#### **At home:**

E-mail Kat at [Katkat@neo.rr.com](mailto:Katkat@neo.rr.com) with:

1. The number of students and adults at your program
2. Any comments you have to improve our programs in the future. She needs this information to write the reports required by ACS National and industrial donators of supplies.

**Finally:**

Smile! You may have expanded or even sparked scientific interest in a child today!

THANK YOU for your participation in our program this year. We hope you will join us next year too. Planning of experiments and contests starts in late **April**. You don't have to be a teacher or scientist to join our committee; all you need is a desire to share science with children. Development of ideas and refinement of experiments goes on throughout the summer, shopping is in late summer, and kit assembly (over 100 of them!) (needing a lot of volunteer hands) is on a Saturday in late September. It takes many, many volunteers to develop and put on all our programs. Even a little bit of help goes a long way. Contact us this year or next year if you (or a friend of yours) want to join in on the preparations!

## Appendix

### A. Material Safety Data Sheets

- Chlorine testing reagent in Expt 9: DPD Total Chlorine Reagent
- Manufacturer/Donor: Hach Company, Loveland, Colorado (with branch in Cleveland, OH)
- For Hach's "Safety Guidelines for Teachers", see <http://www.h2ou.com/h2safety.htm>
- For Hach's "How to Read an MSDS Sheet", see <http://www.h2ou.com/h2msds.htm>
- An MSDS is available through the material supplier, Hach Company, at:  
[http://www.pollardwater.com/EMarket/PDFs/pdf\\_web\\_manuals/hach\\_dpd\\_free\\_chl\\_reagent\\_msdms.pdf](http://www.pollardwater.com/EMarket/PDFs/pdf_web_manuals/hach_dpd_free_chl_reagent_msdms.pdf)
- You can obtain an MSDS from the Cleveland section ACS's National Chemistry Week Committee by going to our website and clicking on the link for the MSDS sheet, or contacting Kat Wollyung at [katkat@neo.rr.com](mailto:katk@neo.rr.com) or 330-686-0056 or 330-279-4280 to request one via email or postal mail.
- The toxicological information in the MSDS sheet for this material, as provided by the supplier, Hach Company, states that there is no reported data on skin and eye irritation, etc. However under Hazards Identification it states that this material may cause eye, skin and respiratory tract irritation and may cause allergic reaction and lists a HMIS Health ranking of 2. Consequently we have only the demonstrators handling the packets. Per MSDS sheet, please be sure to "maintain general industrial hygiene practices" like washing hands after handling. Only small amounts of material are used in the packets in this experiment, and they have been safely used in previous demos, as per a Hach employee on our 2007 NCW Planning committee, and she has no hesitation to use these with children.

### B. Supply list for recreating these demos including item substitutions

- Items required for each demonstration are listed in the "Required Supplies" section of this script, starting on Page 8. "Special" harder to find items are listed below.
- Most of the materials in our script can be purchased from local General/Grocery, Craft (Pat Catans, Michaels), Outdoor/Building Supplies (Lowe's, Home Depot), and Hardware stores.
- Often the type and size of cups can be varied, but pay attention to if the cup needs to be clear (see-through not opaque) or needs to be sturdy (plastic not paper).
- If you plan to scale-up or scale-down the experiment you may need to test the new procedure.
- The few special items and their suppliers are listed here. For some experiments, alternative items are listed for some of the supplies. Using alternate items for acids and bases, or other changes to experiments, should also be tested for obtaining the desired result and for safety.

## Experiment 1 –

- Home building supply stores.

## Experiment 2 –

- Note on Styrofoam packing peanuts: use a denser/harder/more firm type of peanut as the ones that are lighter/softer/more compressible will break apart when the toothpicks are inserted.
- The size of the box used as a form for the peanut/toothpick models is very important. Try using different sized boxes if you scale-up this experiment.

## Experiment 3 –

- Meringue mix (or egg white powder) may be purchased at cake and candy supply shops.
- The flattened marbles may be found at Pat Catan's and other craft stores.
- Borax is found in the laundry products section of your grocery store. 38g/kit is more than what is needed, but it's good to have a little extra for if the students add too much water to their cement cups.
- Beral pipets (also known as disposable polyethylene transfer pipets) are available from most science supply houses.
- The experiment also works with casein which produces a water-proof glue. Casein is a phosphoprotein consisting of approximately 15 amino acids. Cow's milk contains about 3% casein. The two products produced in the curdling cow's milk are curds and whey. Casein is another name for curds.
- Casein can be extracted from milk directly (see: [http://www.accessexcellence.org:8080/AE/AEPC/IFT/unit\\_three.html#31](http://www.accessexcellence.org:8080/AE/AEPC/IFT/unit_three.html#31)) or may be purchased from chemical supply houses.
- The recipe for this is: 1/4 TSP (1.25 ml) casein added to 1 TSP (5.0 ml) saturated water solution of Borax and stirred for two minutes.
- You might want to use this rhyme if you work with casein:

Little Miss Muffet  
Sat on a tuffet,  
Eating her CURDS and whey.  
Along came a spider,  
Who sat down beside her  
And Frightened Miss Muffet away!

## Experiment 4 –

- Teachers should obtain CaCl<sub>2</sub> and CoCl<sub>2</sub> strips from Flinn Scientific or other sources. We are sorry that we did not find a source for these materials in common local stores by the time of the writing of this script – cooking store?

Experiment 5 –

- Tyvek may be purchased at Carter Lumber but is most easily obtained from local builders when they “wrap” a house and must cut out areas for doors and windows. Tyvek may also be more easily purchased as envelopes in the local office supply stores.

Experiment 6 –

- Papers and sheets may be available in craft stores; other sources are:
- Thermochromic paper from Educational Innovations, [www.teachersource.com](http://www.teachersource.com)
- Liquid crystal sheets from Educational Innovations, [www.teachersource.com](http://www.teachersource.com)

Experiment 7 –

- Typically tinted UV-protective films can be purchased in home supply stores (Lowe's, Home Depot), but some do not carry the clear UV-protective films. One source is GILA® Film Products (pronounced heela) at <http://www.gilafilms.com/>

Experiment 8 –

- You may be able to use your own tap water or you can spike it with Epson salts to verify it is indeed “hard”.

Experiment 9-

- Chlorine packets may be available for demonstrations from Hach, Co. You may obtain test packets at pet supply stores to test for chlorine in fish-tank water, but the color change is to yellow and is not as dramatic.

Experiment 10—

- Styrofoam and cornstarch packing peanuts should be collected from workplaces, friends and neighbors. It is possible to purchase them from mailing and postal services, such as PostNet.