West Side Science Club – Event #10 – "Salt and Sugar"

Original Presentation (scheduled)

Date: 6 April 2013
Time: 10 am to 12 pm
Site: West Side Science Club

Brief Description

This lesson plan describes an activity where students explore the different properties of salt and sugar, two substances that are visually similar.

Big Questions

Words of the Day: Telling apart common compounds- Ionic, Polar, and Non-polar, Denisty

(1) Polarity is the separation of charge within a molecule, creating two charges, a positively charged portion and a separate negatively charged portion, like water and sugar. Ionic compounds could be considered ultra polar, because they actually break apart into their positive and negative components, NaCl (solid) + water = Na+ Cl- (in solution). Non-polar compounds, like oils and fat, share their charges equally across all the bonds and are sometimes symmetric, so there is very little or no positive and negative portions.

(2) Students will experiment with oil, sugar, salt and fresh water solutions and tell them apart using various physical properties, such as polarity, density, and conductivity.

Concepts

Concepts to cover from the "Work of CCI Solar" Mind Map:

Level one (concepts): ions, materials, conductivity, electrons, batteries, chemical properties (density)

Level two (skills): problem solving, wiring a circuit, using a multimeter

Motivation for this Activity

This activity was discussed at the ISE mini-retreat.

Relevant Feedback Provided at the Mini-Retreat and Its Effect on Design Elements for this Activity

- At the mini-retreat, the kids reported that they preferred using everyday materials rather than specialized chemicals brought from Caltech. Sam thought you had to be too careful with the research chemicals.

  This activity uses two very common kitchen chemicals: table salt (sodium chloride) and table sugar (sucrose).

- The WSSC kids said that they enjoyed activities where the activity directly related to edible materials.

  These materials are edible, though only specific food handled by the mentors (make caramel and apple slices, hand out Rock Candy) will be used for consumption, not the general table materials.

Lesson Plan

Student Objectives

- To differentiate between salt and sugar without tasting. Visually demonstrate the physical property of density of different salt, sugar, and oil solutions. Introduce "like dissolves like" and polar and non-polar compounds, including how they affect conductivity by lighting a light and measuring the current using a multimeter.

Schedule/Agenda

- Review: Event #9 – "Hydrogels" (10 min.)
- How to tell apart sugar and salt with warm up demo (10-20 min)
- Activity #1: Making Density Layers (20-30 min)
- Activity #2: Determining Conductivity (10 min intro + 30 min activity)
- Activity #3: Structure of crystals and heating (10 min)
- Wrap up: Share results of conductivity and enjoy sugary food stuffs (10 min)

Materials

General Items

- 1 bag of table sugar (Anna)
- 1 container of table salt (??)
- Karo Syrup ("Ultra Sugar" Water) (??)
- Vegetable Oil (Levi)
- food coloring (Anna)
- Rock Candy (Anna)
- Tap Water (--)
- Butter (caramel making) (??)
- Skillet (caramel making) (Levi)
- Apples to slice (caramel eating), and apple slicer (??)
- Spoon & Small plates for caramel/apple dip snack (??)

Items per Table (3 Tables)

- Duct tape (for securing alligator end to (-) battery terminal) (??)
- Set of 4 alligator clips (Ben)
    - 2 with both alligator ends
    - 2 with one alligator end and one wire end, for pin board
- Battery (AA or bigger is fine) (Anna)
- Set of 6 clear cups (??)
    - one for each liquid solution (oil, karo, salt water, fresh water)
    - 1 rinse water
    - 1 waste cup
- Set of 5 plastic pipettes for each solution and rinse water (Anna)
- Set of clear test tubes for each individual (~4 per table) (Anna)
- Plastic Test Tube Rack Holder (Anna)

- Multimeter (Levi)
- plastic table cloth cover (??)
- plastic multi-well spot tray (Anna)
- Red LED light "hacker board" (Anna)
    - Red LED light, capacitor, jumper, 8-hole pin circuit board with up-converter built in

Safety

- Students must wear their eye protection to practice good safety habits for experimental work, even though nothing in this activity is especially dangerous or toxic

Review of Previous Event: Hydrogels

- Recall the gooey solution we used last time (alginate). Why was it gooey? (Because it had long sugar-based molecules in it)

Pose Question and Warm-Up Demo: Making Density Layers

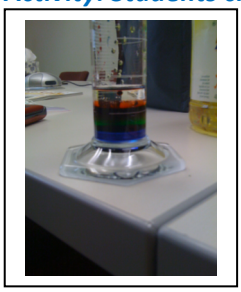
Procedure, with Facilitation Questions

1. How do you tell apart sugar and salt without tasting them?
    a. Have each in a clear plastic cup to walk around with and show students.
    b. Solicit answers from the group! Ask students what they think salt and sugar are made of, using the period table. Eventually determine that salt is Na and Cl and sugar is made of C, O, and H, mostly carbon though. Have them write out these elements and their symbols in their lab books.
2. Pose question, what if the compounds are dissolved in solution? How can you use the physical property density to tell apart the solutions?
    a. Be ready to test out some of their suggestions! Heating, dissolving, magnifying…
    b. Have ready:
        i. Very salty water (still in salt until hardly more dissolves or becomes saturated), color with 1 drop food coloring
        ii. same total volume of fresh water, color with 1 drop different coloring
    b. Pour salt water into an empty clear test tube and gently pipette the fresh water on top

Facilitation/Concept Questions

1. How would you describe density? (Density is where there is more stuff dissolved into the liquid, so the liquid can be heavier (salt water) than a different liquid that has less stuff dissolved in it (fresh water)

Activity: Students create their own 4-layer density column (exploratory)



PICTURE: These layers are blue Karo syrup, green salt water, purple fresh water, oil that had pink/red mixed with it, but the dye settled to the bottom of the oil and started mixing with the fresh water.

Procedure

1. Give each table a clear up with a different drop of food color and its own plastic pipette
    a. Karo syrup (remember from last time, syrups are SUPER sugary liquids!), color 1 drop Purple
    b. Very Salty Water, color 1 drop Green
    c. Fresh Water, color 1 drop Pink
    d. Vegetable Oil (cannot color, too non-polar!)
2. Also have Rinse Water Cup with pipette and Waste Cup at each table
3. Give each student their own test tube to make their density layer model, can empty contents into waste cup or down drain if student wishes to start again as they figure out which liquids are heavier or lighter than others

Facilitation/Concept Questions

1. The colors are suggestions, though should achieve pretty good contrast when layered correctly (heaviest- karo, salt water, fresh water, oil- lightest)
2. Which layers are the most dense, what's dissolved in them?
3. Do you think sugar is a polar or non-polar or ionic compound? (Polar, it dissolves in water because of the O atoms, though all the carbons in it are not very charged, so it's moderately polar)
4. What about salt? Ionic or polar? (Ionic-
5. What do you think oil is made out of? (Carbon, it's a very non-polar compound, meaning it's not charged very much or not at all)

Activity: Conductivity of different Liquids

1. Pass out 1 multi-well tray per table and have students fill 4 wells completely full with each of the 4 solutions from their cups, and label each well.
2. Recall basics of electron flow and using a multimeter like for the lemon batteries.
3. Make a sample table on the board for the students to copy in their lab books and fill in:

Liquid	Color Liquid	LED light up? Y/N	# sec between blinks	Current (μA)
Karo Syrup				
Oil				
Water				
Salt Water				

4. Observe the differences in the LED and conductivity between each solution
    a. Set up the battery circuit with the LED.

i. (+) battery end must lead to (+) circuit board connection, because a the current wants to run from the (+) end to the (-) end, and the Light Emitting Diode is like a one way door that pushes open, you can push it open from the (+) end but cannot push it open the other way.
ii. Alligator clip to (+) battery end and push the wire end into the (+) end of circuit board
iii. Push other wire end into (-) terminal on circuit board and leave the alligator clip free
iv. Attach a third wire with tape to the (-) battery terminal and leave its other alligator end free

b. Using the free ends, clip each end down into a side of one of the wells, so that the tip of the clip will be submerged without having to hold onto it
   i. Observe the LED for a few minutes in each solution and fill out the table in the notebook
   ii. Measure the current flowing with each solution in the circuit
      1. Turn on multimeter, and set to MICROAMPS (μA)
         a. Using same set up…
         b. Contact the RED multimeter probe to the (+) touch pad on the circuit board, must hold steadily in place
         c. Contact the BLACK multimeter probe to the (-) touch pad on the circuit board, must hold steadily in place

c. RINSE the liquid contacting alligator clip ends with the rinse water into the waste cup between each liquid so that you do not contaminate the other wells full of liquid
d. Repeat for each liquid, saving the salt water for the last measurement

Answers/Solutions

Liquid	Color Liquid	LED light up? Y/N	# sec between blinks	Current (μA)
Karo Syrup	Purple	N	--	8 to 12
Oil	No color, oil	N	--	0
Water	Pink	Y	4 to 5 seconds	60 to 80
Salt Water	Green	Y	2 to 3 seconds	170 to 180

Facilitation/Concept Questions

- Mentors should help set up the battery circuit and MAKE SURE the (-) battery negative end is ACTUALLY TOUCHING the clip, as this connection is not fool proof with the tape holding it.
- If anyone asks- How does this little circuit board work? (It organizes and holds the connections for you, and the power from the battery charges up the capacitor. Can relate capacitor to the capacity of the room, a room fills up with people until maximum capacity, and a capacitor fills up with power. Once the capacitor is fully charged, it lets all the energy go at once through the little LED, causes it to blink, rather than constantly be lit. The faster the LED blinks, the more power you have traveling through your circuit (P= V x I), so any increase in current and/or voltage will cause the power to increase and the LED to blink faster!)
- What do the numbers mean from the multimeter? (We are measuring current, and the higher the current number, the faster the electrons are able to flow through the circuit)
- How does the current correspond to the red light? Does it blink faster or slower when the current increases?

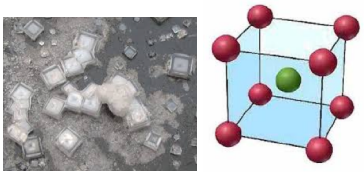
- Why doesn't the Led light up in the oil, and why is there no current? (This liquid is non-polar and doesn't allow the charges to pass through.)
- Why does the LED blink faster in the salt water than the fresh water? (There's more ionic salts dissolved in the salt water that transfer the charges quickly through the liquid and let the electrons pass through more easily, and there isn't as many dissolved ions in the fresh water so the electrons cannot flow as quickly as in salt water.)
- Why doesn't the LED light up in the Syrup? (There should be a small current, but it's probably not strong enough to push through the door to the LED and light it up. The sugar actually makes the water less polar (or more non-polar) than water is by itself, so the electrons cannot flow as freely through. So even though sugar dissolves in water because it's a polar compound, it makes the water more non-polar than it is by itself and less conductive.)

Activity #3: Magnify Crystal Structure and Apply Heat!

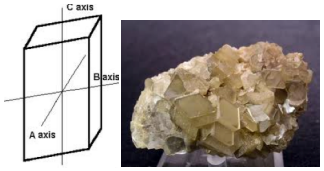
1. Look at solid crystals under magnifying glass. Make any notes in lab book. Compare to Rock Candy.
2. Heat some of each on a hot plate in a clear beaker (at least 200 C).

Facilitation/Concept Questions

- How do the crystals of the solid compounds look under the magnifying glass? How do they look compared to Rock Candy?



- Under magnification, salt has cubic crystals (pictured left)



- Under magnification, sugar has monoclinic crystals

- What will happen when we heat the two different compounds?
  - Heating sugar makes caramel (M.P 186°C), just add butter: http://www.youtube.com/watch?v=MGd138dlfKk
  - Heating salt does nothing (M.P 800°C!)
- Why do they have different melting points? (They are made of different elements and have different physical structures which both make them more or less stable under heat)

Wrap Up

- Students should share their results about which liquid had the best conductivity, which was the worst, and what currents they read from their multimeter measurements.
- Pass out Rock Candy for each student. Pass around apple slices and fresh caramel dip.

Check for Understanding

- What is one way we can tell the difference between sugar and salt?

- What makes one liquid denser than another? Ans- More stuff packed into it, such as salt or sugar!
- Why don't oils and fats mix with water? Ans- because they are non-polar and water is polar
- What makes the best conducting solution and why? Ans- ionic solutions (salt water!) because of all the charges that are free to move around and pass the electrons along.
- Does a more sense liquid always mean it will be a more conducting liquid? (NO!)

Survey from Kim?

References

(1) Salinity and Density http://www.msc.ucla.edu/oceanglobe/pdf/densitysalinity/densityentire.pdf
(2) Density column http://www.elmhurst.edu/~chm/vchembook/124Adensityliq.html
(3) 7 layer Density Column http://www.stevespanglerscience.com/experiment/seven-layer-density-column
(4) Lava Lamp: http://www.hometrainingtools.com/liquid-density-lava-lamp-newsletter/a/1738/
(5) Lava Lamp http://www.elmhurst.edu/~chm/demos/index.html