Soda Density Demo

Adapted by Michael Fox

It turns out that there is just enough mass of sugar in regular coke and sprite to cause the unopened 12 ounce can to sink in water. In the diet version of each, since the sugar is replaced by a much less massive amount of phenylalanine (nutrasweet), the CO2 gas space in the can is enough to cause the unopened diet cans to barely float. Thus, this makes a great density demonstration using materials which students are extremely familiar with and interested in.

Materials:

- 2 twelve oz. cans of regular Sprite
- 2 twelve oz. cans of regular Coke
- 2 twelve oz. cans of diet Sprite
- 2 twelve oz. cans of diet Coke
- enough colored aquarium rocks or marbles to fill a 2 liter bottle about 1/3 full.
- Foil
- Large clear container (aquarium or transparent plastic tube, or 4 two liter bottles cut off at the shoulder)
- Dropper or plastic straw
- 2 test tubes

Preparation:

1) To make models of regular and diet soda: add rocks or marbles to one of the 2 liter bottles until it is about 1/3 full. Fill the rest of the bottle with water and cap. Fill the other 2 liter bottle with water and cap (see fig. 1).

2) Using a permanent marker, mark a regular coke can with a small dot on its top.

3) Open one can of each soda type the previous night to allow all the CO2 to evolve into the air. (Or on the same day, shake the soda in a large closed container and then open it to release the gas. Repeat until the soda is completely flat.)

4) Completely wrap with foil one unopened can of each soda type. Wrap the can smoothly and with as little excess foil as possible while still allowing the foil edges to wrap around the top and bottom edges of the cans. Make sure the mark on the regular Coke can is showing.

5) Fill the large tank or tub of water so that it is deep enough to allow the cans to obviously sink to the bottom. If you are using the 2 liter bottles, cut each off at the shoulder and fill with water just to the point that it won't overflow with the displacement of water from a sinking soda can.

Procedure:

(Before beginning, advise the students not to say anything if they have already seen this demonstration so that other students will have a chance to figure it out and learn about it on their own.)

1) Show the students the four cans wrapped in foil and tell Them that all you know is that they are 2 cans of coke and 2 cans of Sprite. They have not been opened.

2) One at a time, put the cans in the water tank. Be sure to Enter the cans into the water at an angle so that an air pocket Is not formed by the concave bottom of the cans. Two Should float and two should sink (see fig. 2).

3) Ask the students what they notice. Elicit from the class what causes something to sink or float in the water. If students say that the can is heavier than the water, lift the tank and then lift a can and say, "I don't think so!" When the term density is brought up, take the opportunity to define it. Density is the amount of mass in a certain volume. Since all of the cans have the same volume, then the heavier cans are more dense. Something sinks if it is denser than water.

4) Brainstorm a list with the students of what things from the cans of soda contribute to its density and which of those things are denser or less dense than water. The list should include: aluminum foil (denser), aluminum can (denser), sugar (denser), acid (denser), coloring (denser), water (denser), CO2 gas (less dense). Invariably, the students will come up with water and CO2 last. To elicit water, tell them that this ingredient makes soda one of the biggest ripoffs there is, you pay $.60 for mostly.....water. To elicit the gas, ask the students: "What's wrong with the list so far in terms of the cans which are floating?" Most students will say that there is a pocket of air in the space at the top of the can. Ask what other gas do they know of that it might be. Soda is bottled and canned inside a chamber pressurized with carbon dioxide. The CO2 dissolves into the soda which comes out when the can or bottle is opened and pressure is released. You burp CO2 after drinking soda, not air.

(This is a great chance to discuss th solubility of carbon dioxide in water. Discuss how the fizz in soda is simply the carbon dioxide gas being released from the water when the pressure is released as the can is opened. The reason a soda can explodes when opened after it is shaken is because the gaseous space inside the can is dispersed throughout the soda, creating tiny bubbles all along the inside surface of the can. These bubbles allow other bubbles to form on them easily so that when the can is opened lots of carbon dioxide is released from the water all at once. Tapping the top of the can knocks most of these bubbles off the inside walls of the can, returning them to one large gaseous space, thus preventing an explosion of bubbles)

(Also, this is a great buoyancy link. Take a piece of foil and ask a student if aluminum is denser than water. If they say no, add a flat piece of foil forming a shallow cup, then float it on the water. Ask them what's going on. Relate the foil and the floating soda cans to metal ships, especially the Titanic. Draw a cross section of the foil floating on the water showing the rounded bottom displacing water, causing air to be where the water was. Explain that trapped air can make metal float as long as the water doesn't fill the air space. The weight of the displaced water is the same buoyancy force pushing upward on the hull of the boat to keep the boat floating. Then Titanic sank because after the forward compartment was punctured by an iceberg, water flowed over the bulkheads of each compartment of the ship pulling it further and further into the water by one end. This is like filling a tilted ice cube tray by running water into one end square. Now they build ships which have bulkheads sealed at the top so damage to one compartment cannot sink the entire ship.)

5) Now its time to ask for the theories: "Why are two cans floating and why did two cans sink?" Students most often think that Coke is heavier than Sprite. This misconception probably stems from a false thinking that darker liquids have more stuff in them and are therefore thicker or heavier. The ingredients list promotes this idea since caramel coloring is added to cola but not to lemon-lime drinks. Also students think there is more sugar in coke, probably because coke has had more negative publicity such as "rotting teeth" and such. Also in this vein, some kids have heard of the acids in coke and think this may make it more dense. These misconceptions will work in favor of the big surprise if you don't have to many students who have already seen this demo and sabotage your ending. Write all the theories down on the board.

(There is pefect anti-soda soapbox just waiting for you to hop on here. Sugar feeds the bacteria which produce tooth decay. Also, the acids in cike dissolve the tooth enamel directly, so much so that a tooth left to soak in coke completely dissolves after a while.)

6) First, retrieve the regular coke (which should be marked) from the bottom of the tank and unwrap it. Students may then change their predictions if they wish. "If you know there are 2 sprites and 2 cokes and one sunken can is a coke, what do you think the other sunken can is?" Most students will say coke unless they have already thought of the diet theory.

7) Uncover the other sunken can to reveal that it is a sprite. At this point some students may catch on, others may accuse you of various forms of cheating. Reemphasize that you have done nothing to the cans. Elicit a new theory by asking: "Is there an ingredient in our list which may not be in some types of coke or sprite?" Usually they throw out the diet soda theory with avengence at this point.

8) Unwrap the remaining two diet sodas. Explain that phenylalanine (commonly known as nutrisweet) is a chemical which has a similar shape to the shape of sugar which reacts with the sweet taste receptors on our tongues. In fact it is much more efficient at binding t these receptors and therefore much less of it is needed to make something taste sweet. (Compare the amount of nutrisweet in a single packet to the amount of real sugar in a single packet.)

9) Draw large outlines of two soda cans on the board. Label one "diet" and the other "regular". Explain that each is made up of mostly water and draw about the same number of small circles inside of each outline, randomly spaced. Then explain that a can of coke has 39g of sugar (or about 9 teaspoons!) of sugar dissolved in it. Compare the molecular formula of water (H_2O) with that of sucrose ($C_{12}H_{24}O_{12}$). Explain then molecules of sugar are like boulders compared to water. So draw a bunch of big circles randomly around inside the regular soda outline. Nutrisweet molecules are also big compared to water molecules, but there are a lot less of them. Draw a few large circles in the diet soda outline. Now, compare the two drawings, showing more mass in the same volume for regular soda.

10) Hold up the 2 liter bottles as models of regular and diet soda. The rocks/marbles represent sugar molecules mixed in with the water. These make the bottle of water dense enough to sink. The bottle with just water represents diet soda which is mostly water. That in addition to the gas space at the top is less dense than the water and floats.

11) Explain that you would like to prove that this was not simply a result of some trick with the can or the foil. You want to show that the actual liquids have certain densities. Ask the students if they've ever seen oil and vinegar salad dressing. Elicit from them that the less dense oil floats on top even when

the two liquids are directly mixed together. This is because the oil is less dense than the vinegar. (This, incidentally, may be another reason most students think that dark colored liquids are more dense than lighter colored liquids!) Is there any way that we could mix the regular and the diet sodas together to see which is less dense? Have students give possible ways. Then ask anyone if they've had a "diet sproke". "You've never heard of a 'diet coca sprola'? Let me show you how to make one." Add flat regular sprite to one of the test tubes until it is half full. With a dropper (Or a straw, using your finger to block the end) carefully add flat diet coke slowly to the surface of the regular sprite in the test tube. Layer it on slowly trying not to let the two sodas mix. If you do it correctly, you will have a dramatically two tone diet spoca sprola. Lets hope that showing this combination with the darker colored soda on top may dispel some myths. Of course the students will all want to make a diet sproca cola as well. Do the same procedure except adding regular coke first and then layering diet sprite on top. Tell students that these drinks are perfect for people who are on a diet but want to finish a meal feeling satisfied. If students would like to try stacking these fluids when they are out at a restaurant, show them that they can trap some diet soda in the bottom of a straw by sealing the end with their finger tip, then they can submerge the straw even further into the regular soda, letting up on the finger just enough to let some soda rise up into the straw. Then they can seal the straw with their fingers again, lifting out a tiny two tone snack.