ChemMatters October 1993 Page 11

Crazy Candies

by Joseph Alper

Foaming at the Mouth

Mad Dawg™ is not your typical bubble gum. For one thing, it is noticeably sour when you first start chewing. But the real surprise comes after seven or eight chews, when brightly colored froth begins oozing out of your mouth. Though the effect is dramatic, the cause is a simple acid-base reaction.

$$NaHCO_3 \Rightarrow Na^+ + HCO_3^-$$
$$H^+ + HCO_3^- \Rightarrow H_2O + CO_2$$

The foam is a mixture of sugar and saliva, churned into a bubbly mess by carbon dioxide released when three of Mad Dawg's ingredients—sodium bicarbonate, citric acid, and malic acid—are mashed together in the moist environment of the mouth. In water, all three chemicals ionize. Citric and malic acids produce hydrogen ions, which react with the bicarbonate ion to produce water and carbon dioxide. The acids also stimulate salivation, providing the extra moisture needed to produce great-looking foam. Water-soluble food coloring creates a more colorful mess.

The chemistry is straightforward, but Mad Dawg's creation was not a simple matter. In fact, early versions exploded as they came out of the candy-making machinery. The problem was keeping the acids and sodium bicarbonate from reacting before chewing begins. As solids, sodium bicarbonate and citric or malic acids do not react, but if the combined ingredients are exposed to even the slightest moisture, they dissolve and reaction begins. Alka Seltzer™, which fizzes because of the same acid-base reaction, is made by compressing dry, solid citric acid, sodium bicarbonate, aspirin, and flavoring ingredients into a tablet. When dropped in water, the ingredients dissolve and react. But Mad Dawg's colors and flavors are applied to the bubble gum core as aqueous solutions. How do they keep the ingredients from reacting before you chomp on the candy? If you closely examine the inside of a Mad Dawg, you may be able to discover the manufacturer's secret.

Cotton Candy

Ninety years ago, in 1903, inventors William J. Morrison and John C. Wharton created cotton candy. Their new confection was unveiled the following year at the World Exposition in St. Louis, which also saw the first ice cream cone, and it was a big hit among fairgoers. Today, cotton candy machines, little changed from Morrison and Wharton's, are spinning out millions of cotton candy cones worldwide in at least a dozen flavors and colors.

Though making a beautiful cotton candy cone is considered an art, the process that produces the sugary cotton is straightforward. Flavored and colored sugar is poured into what's called the spinner head in the center of the machine. An electric heater melts the sugar while the spinner head rotates at several hundred revolutions per minute. The molten sugar shoots from small holes in the spinner head and solidifies into cotton floss as it hits the air. The whirl grip, a plastic netting material that lines the sides of the floss pan, catches the emerging threads. The cotton candy maker makes two passes around the floss pan with a paper cone, gently twisting the cone as 25 to 30 grams (about an ounce) of spun sugar collects on it. The biggest cotton candy machines can make 500 cones an hour.

If the cone of cotton candy is not sold immediately, it must be sealed in a plastic bag to keep it clean and dry. The fine threads of glassy sugar are very hygroscopic (absorb moisture from the air). If you place a piece of cotton candy on a dish, you can watch this happen. After some hours the floss will become moist and shrink as it dissolves in the water it attracts from the air.

Super Sour

The expression "sourpuss" takes on a whole new meaning when you try a piece of Face Slammers™ bubble gum, the sourest of sour candies.

Your lips pucker, your eyes scrunch up, shivers run through your body, and there is a brief burning sensation on the sides of your tongue. The culprit is a coating of a mixture of malic acid and citric acid. Malic acid is the compound that gives apples their bite, and citric acid is the chief sour chemical in lemons and limes.

The human tongue has four kinds of taste buds — sweet, bitter, salty, and sour—each concentrated in a specific area. Sweet taste buds, for example, are on the tip of the tongue, whereas those that signal "sour" are on the sides. Substances that taste sour are always acids, which is why both citric acid and malic acid are sour. Citric acid is far more sour than malic acid, however, so there must be something, probably relating to a chemical's overall structure, that determines its sour power.

Beneath Face Slammer's sour coating lies a piece of bubble gum, made primarily of sugar, corn syrup, flavoring, softeners derived from vegetable oil, and synthetic rubber. Some bubble gums also contain chicle, the dried latex of the sapodilla tree, which grows in Central and South America and yielded the first material used widely in chewing gum.

Pop Rocks

Fizzzz. Pop. Your tongue tickles, and your back teeth vibrate. POP. A tiny explosion tingles your front teeth. A highly carbonated cola? No, but close. It's carbonated candy. The fizzing and popping sensations occur when sugar-coated bubbles of carbon dioxide—the same gas that gives soda its pop—escape from the candy as the sugar dissolves in the mouth.

Pop Rocks™, Cosmic Candy™, and other carbonated sweets start out as a mixture of crystalline sucrose and lactose plus corn syrup, containing the sugars glucose, maltose, and dextrin. The candy maker adds a small amount of water to the cooking vessel filled with the sugars, heats the mixture to between 138 °C and 160 °C (280-320 °F) until the sugars dissolve, and then turns on a vacuum pump to evaporate most of the water. When the amount of moisture in the now viscous sugar mixture, called a melt, is between 1% and 5% by weight, the candy maker adds whatever flavors and colors are desired. So far, the process is similar to making ordinary sugar candy (see *Peanut Brittle, Chem Matters*, December 1991).

Next comes the critical step, worked out over two decades by researchers at the General Foods Corp. With the temperature no higher than 138 °C, carbon dioxide, CO_2, is pumped into the cooking vessel to a pressure of 34 to 51 atmospheres (500 to 700 psi), and the mixture is stirred for several minutes. This forces bubbles of carbon dioxide into the candy "melt." The proper adjustment of time, temperature, and pressure makes bubbles the right size—the largest are 300-350 microns in diameter—to give the final product a satisfactory pop. If the melt is carbonated at higher temperatures, the bubbles are smaller and the resulting candy fizzes more than it pops.

With the cooking vessel still pressurized, but with the stirrer turned off, the melt is allowed to cool. The candy hardens into a glassy (noncrystalline) solid with carbon dioxide bubbles frozen inside. The pressure is then released rapidly, cracking the carbonated candy into the small pieces that are packaged and sold.

How much CO_2 can be stored in the candy? You can measure the amount yourself (see Classroom Guide).

CAPTIONS

When sodium bicarbonate dissolves in water, it separates into sodium ions and bicarbonate ions (top). When hydrogen ions from an acid mix with bicarbonate, the ions react to give water and carbon dioxide gas (bottom). You can duplicate this reaction by adding some lemon juice to baking soda (sodium bicarbonate).

Cotton candy begins as crystals of ordinary sugar (top scanning electron micrograph) that are coated with a small amount of coloring and flavoring. The sugar is poured into a heated spinner where it melts at about 150 °C. The rapid rotation forces the liquid out through tiny holes in the wall of the spinner, and the thin streams of molten sugar freeze instantly when they hit the colder air. The results are delicious but unstable. When sucrose is finely divided it becomes hygroscopic—it readily absorbs moisture from the air. The bottom electron micrograph was taken one day after the cotton candy was made, and moisture has melted some of the strands into beads. Both micrographs are magnified 50 times.

Malic acid and citric acid are super sour compounds. They are used in novelty candies because they are natural products (lemon juice is about 6% citric acid) and are solid at room temperature. When dissolved in water, one or more of the hydrogen atoms (shown in color) leave the molecule as hydrogen ions, H^+.

Pieces of Pop Rocks candy, magnified 50 times, show cavities that held compressed CO_2 gas.

BIOGRAPHY

Joseph Alper is a freelance science writer living in Ft. Collins, Colorado. He is the recipient of the American Chemical Society's Grady-Stack Award for excellence in interpreting chemistry for the public.

REFERENCES

McGee, Harold. *On Food and Cooking: The Science and Lore of the Kitchen*. Charles Scribner's Sons: New York, 1984; 684 pages.