Peanut Brittle Lab: An Endothermic Reaction for the Holidays.

Materials needed:
pan
wooden spoon
measuring cups with metric measurements
scale
15 grams butter + some to grease pan with
75 grams of peanuts
115 grams sugar
70 ml corn syrup
1 capfull vanilla
1 square foot of aluminum foil
2.5 grams sodium bicarbonate

Procedure:

1. Wash down lab tables well. Prepare a pan of soapy warm water in the sink.
2. Place 115 grams of table sugar (sucrose) and 70 ml of corn syrup (glucose) into your pan. Add 60 ml of water, and stir with a wooden spoon.
3. Heat the mixture, stirring constatnly with a wooden spoon.
4. Add 15 grams of butter (stearic acid). Continue to heat, stirring contantly.
5. Add 75 grams of peanuts (protein). Continue to stir.
6. Coat a one square foot piece of aluminum with butter.
7. When the mixture reaches 150 degrees C, remove the pan from the heat, and quickly add 2 ml (1 capfull) of vanilla (4-hydroxy-3-methoxy-benzaldehyde)and 2.5 grams of sodium bicarbonate. Stir until the mixture foams, and quickly pour the mixture onto the square of aluminum foil. Scrape as much of the mixture onto the foil as possible and spread with spoon. Immediately put the pan, spoon, and thermometer into the pan of warm water in the sink.

Peanut Brittle Laboratory Questions

1) What type of solid is peanut brittle? Define this term.

2) Describe the process of making crystalline candy and amorphous candy. Give an example of both types.

3) Why do you want to heat your candy rapidly?

4) What is carmelization?

ChemMatters December 1991 Page 4

Peanut Brittle

By Elizabeth Catelli

Whack! The clear solid shatters into small pieces when dropped onto a table. What is it? It looks like glass, and it certainly breaks like glass, but it tastes sweet. It's peanut brittle!

It is no accident that peanut brittle resembles light brown glass. It is an amorphous solid, also known as a glass. Many common solids are crystalline, which means that their molecules are arranged in an orderly pattern that resembles a three-dimensional grid. In contrast, the molecules of an amorphous solid are randomly dispersed. (Amorphous means without shape, or lacking a definite pattern.) Lollipops and Life Savers are amorphous candies; fudge and fondant (creamy candy or filling) are crystalline. The difference in texture is due to the way they are made.

Sugar and spice

Candies are chiefly solutions of ordinary table sugar, sucrose, and water. Other ingredients such as chocolate, cream, glucose, and flavoring agents may add flavor, texture, and enjoyment, but the structural characteristics are determined mainly by the relative amounts of sucrose and water and the size of the sucrose crystals. The cook must use an excess of water in the initial sucrose solution to be sure that all of the sucrose dissolves. The solution is then heated to boil off the excess water. When it is removed from the heat, the solution cools and becomes supersaturated, that is, it contains more sugar than can normally dissolve at the lower temperature. You might expect that sucrose would start to precipitate or crystallize out of the solution at this point, but if no seed crystals of undissolved sugar are present, the solution can be cooled considerably before crystallization takes place.

To form crystalline candy, the solution is cooled well below its normal crystallization temperature, then whipped very hard to form many microscopically small crystals. In making amorphous candies, however, the object is to have NO crystals form. To bring this about, it is necessary to heat the sucrose solution until nearly all of the water has evaporated. When the solution is greater than 95% sucrose, it becomes very thick, or viscous, and movement of the sucrose molecules is restricted. They cannot move into the orderly array necessary to form a crystal lattice. If the solution is cooled quickly, the molecules are frozen where they are, forming a glass-like amorphous solid.

This process is aided by adding a small amount of corn syrup, which contains another sugar, glucose. Because glucose molecules are the wrong size to fit into the sucrose crystal lattice, they can't add to the crystals. They may, however, join other glucose molecules to form long chains which block the motion of sucrose molecules and prevent them from joining a sucrose crystal.

Our favorite compound

Most of the foods we eat are mixtures of chemicals, but sucrose is a pure compound—the most widely produced organic compound in the world. Plants produce sucrose as an intermediate product of photosynthesis. It seems that plants produce sucrose in order to have a stable way to transport sugar from the leaves, where it is made, to other parts of the plant. Other forms of sugar are too susceptible to breakdown by enzymes for this purpose. The main sources of sucrose are sugar cane, which has been grown since 6000 B.C., and sugar beets, which were discovered in the 1700s.

Sucrose is a disaccharide, a double sugar. It consists of one molecule of the monosaccharide glucose and one molecule of another monosacharide, fructose (see Figure 1). These monosaccharides are *isomers* of one another—they have the same formula, but different arrangement of their atoms. This gives them different properties. Fructose, for example, is sweeter than glucose and dissolves more easily in water.

Animals cannot absorb sucrose without separating it into its component monosaccharide in a reaction called hydrolysis.

$$C_{12}H_{22}O_{11} + H_2O \Rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

In animals hydrolysis is catalyzed by the enzyme *invertase*. In the kitchen, a solution of sucrose can be hydrolyzed by heating it slowly in the presence of acid. During candy making, a certain number of sucrose molecules are split in this way. Fructose molecules freed by hydrolysis make the candy sweeter, but may keep it from hardening as the candy maker would like. Heating the sugar rapidly keeps the number of hydrolyzed molecules to a minimum.

Above 160 °C different chemical reactions occur. Glucose loses two water molecules and rearranges to form hydroxymethyl furfural, which polymerizes into brown pigments that add flavor and color to the candy. This process is called caramelization (see Figure 2).

If heating continues longer, the color changes from golden brown to dark brown. A variety of products are formed as sucrose breaks down into smaller organic molecules that are not sweet and may have unpleasant, scorched flavors. If all the hydrogen and oxygen are removed from the sugar, only carbon is left—an expensive and time-consuming way to make charcoal. Ideally, peanut brittle doesn't go that far. It is golden brown, clear as glass, and delicious.

SIDE BARS

Playing hard ball

Each type of candy requires cooking the sugar solution to a particular temperature. As the sugar concentration of the boiling solution passes 60%, the temperature begins to increase quickly (see graph). Experienced candy makers can tell the temperature of a candy solution without a thermometer. They drop a ball of the hot solution into cold water and check its consistency—a technique that has been used by cooks for many years that is accurate to within 5 °F. First, a small amount of boiling syrup is removed from the pan, then dropped into a cup of cold water.

- If you find a "soft ball," which holds together but flattens when removed from water, the temperature is 235 °F. This is suitable for fondant and fudge.
- If you find a "hard ball," which retains its shape when removed from water, this means the temperature is 250 °F, good for nougat and marshmallows.
- Finally, if you find it does not form a ball, but pulls from the pan as thin, brittle threads that "crack" when dropped into the water, then the temperature is 295 °F, which is used for butterscotch and brittle.