Vitamin C and Chemical Reactions

Pillar: Healthy Eating
Division IV
Grade Level(s): 11-12
Core Curriculum Connections:

- **Science 20**: Unit A: Chemical Changes
- **Chemistry 20**: Unit D: Quantitative Relationships in Chemical Changes
- **Chemistry 30**: Unit B: Electrochemical Changes

I. Rationale:

Diet is very important to good health and longevity. Not only does a well-balanced diet supply you with the nutrients you need to grow, but it also protects you against the destructive action of oxygen and a group of particles called free radicals. Free radicals are atoms (or groups of atoms) that are highly reactive due to the presence of at least one unpaired electron. When molecules of atmospheric oxygen (O2) get struck by sunlight they can split into two oxygen radicals. Combining with cell compounds, these free radicals can injure cells and lead to a variety of disorders. Substances such as Vitamin C can reduce the damage caused by free radicals. By "sacrificing" their own electrons, they can quench the reactive needs of the free radical species. Have you ever taken a bite of an apple and then left the fruit exposed to air? If so, within minutes you may have observed a "browning" of the fruit surface. The discoloration is produced by the action of atmospheric oxygen upon the exposed apple tissue. Sunlight decomposes the diatomic oxygen molecule into its free radial form. Reacting with the apple compounds, the free radical steals away electrons and sets in motion other reactions that produce additional free radicals. During these events, the apple surface is quickly oxidized as evidenced in the rapid change in its appearance.

II. Activity Objective:

This activity will offer an understanding of oxygen free radical formation, an introduction to oxidation and free radicals, and the opportunity to observe the effect of oxidants and free radicals by using vitamin C to retard the actions of oxidants and free radicals.

III. Materials:

- Vitamin C (1000 mg capsules available at most grocery stores and pharmacies
- Water-filled beaker
- Cotton-tipped applicator
- Apple
- Knife
- Stopwatch or clock

IV. Procedure:

1. Assign students to work in pairs.
2. Instruct them to carefully slice off a section of apple so that the inner "meat" is exposed to the surrounding air. Begin timing.
3. Determine how long it takes for the apple to show signs of browning. Record your results.
4. Repeat steps one and two using different sections of the same apple and record. Add the results you've obtained for each of the two trials. Divide this number by two to obtain an average time for discoloration.
5. Add about 100 mL of water to a beaker. Hold a vitamin C capsule over the beaker. Carefully twist open the capsule allowing its contents to fall into the beaker. Use a cotton-tipped applicator to mix the solution. This applicator will also be used to "paint" the exposed apple tissue.
6. Expose another slice of apple to the air. As soon as the apple is cut, use the applicator to "paint" the exposed surface with the solution of vitamin C.
7. Determine how long it takes for this apple slice to show signs of browning. Record your results.
8. Repeat steps 5, 6 and 7. Add the results you've obtained for each of the two trials. Divide this number by two to obtain an average time for the discoloration with vitamin C.

Questions:

1. What happened to the appearance of the exposed apple surface without Vitamin C?
2. What caused this change?
3. From where did this oxygen come from?
4. Identify the substance that was "painted" onto the exposed apple surface.
5. Did the vitamin C covering affect oxidation? How could you tell?

Pooling Results:

Pool the class results. Then, find the average time for a slice of apple to brown. Did your apple brown before or after the class average time? What might account for differences in the rate?

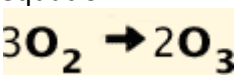
On your Own:

The speed of a reaction is dependent upon the temperature of its reactants: the lower the temperature, the slower the molecules. At slow speeds, collisions are less frequent as evidenced by a slower reaction rate. At high speeds, collisions increase in frequency and reactions speed up. Design an experiment that would illustrate the effect of temperature on the oxidation of exposed apple.

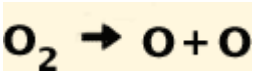
V. Extensions:

FREE RADICALS

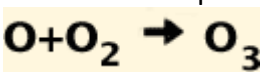
The existence of free radicals was first proposed as a way of explaining collisions that are unlikely to occur. Consider the formation of ozone (O3) from oxygen gas (O2). This reaction is represented by the following equation:



In this reaction, three particles of oxygen must collide at the same time to produce the ozone. As you might imagine, a 3-way collision is highly unlikely. If we reexamine the reaction in terms of free radicals, we can separate the reaction into two distinct steps. During the first reaction, sunlight splits oxygen gas into two free radicals of oxygen. No collision between molecules is required for this first step.



In the second step, a collision between only two particles needs to occur. As you might imagine, a 2-way collision is much more likely event. Here, the oxygen radical formed in the first step collides with an oxygen molecule . The product of this 2-way collision is a molecule of ozone.



Work in a team of three. Each team member gets a tennis ball. Position yourselves about two meters apart from each other (at the corners of an equilateral triangle). At a given signal roll the three balls towards the center of the triangle. Your objective is to have the collision of all three balls occur at the same time. Then, try to collide only two balls at the same time. Use this experience to explain the more plausible mechanics of free radical reactions.

WEB CONNECTION

The Anti-Oxidant Vitamin

A summary of vitamin C's benefits, including its role as an anti-oxidant.

Anti-Oxidants Cut Free Radical Risk

An informative study on the connection between anti-oxidants and free radicals.

What Are Free Radicals and What do Antioxidants Do?

Discusses the relationship between free radicals, antioxidants, and cell disorders.