**Required Training**

UC Lab Safety Fundamentals

Performers Required: 1

**Equipment**

Empty 581 mL (20-oz) Coca-Cola bottle or 50 mL sealable container

Three graduated 25-mL beakers or vials, labelled Solution 1, Solution 2, and Solution 3.

**Chemicals**

Soluble starch

Potassium iodate (KIO₃)

Sodium sulfite (Na₂SO₃)

Sulfuric acid (H₂SO₄), 18M

**Procedure:**

1.) Preparation of solutions:

Solution 1: add 0.4 g soluble starch to 200 mL boiling water. Let cool to room temperature before use.

Solution 2: add 3 mL H₂SO₄ to 200 mL water, then add 10 g KIO₃ and stir until dissolved.

Solution 3: add 4.2 g Na₂SO₃ to 200 mL water and stir until dissolved.

2.) Place ~500 mL of water inside a clean, empty Coca-Cola bottle. This comes to just above the top of the label.

3.) Add 20 mL of Solution 1 (starch), then recap the bottle and shake well for several seconds. Performance tip - shaking the bottle by rotating the wrist rather than shaking up and down vertically provides a more evenly distributed solution that performs better..

4.) Add 15 mL of Solution 2 (KIO₃/H₂SO₄), then recap the bottle and shake well again.

5.) Add 25 mL of Solution 3 (Na₂SO₃), then quickly recap the bottle and shake very well for ~3-5 seconds to thoroughly mix the contents. It will take ~18 seconds from the moment Solution 3 is added for the solution to abruptly (almost instantaneously) turn a dark blue/black color. With practice it is possible to add Solution 3, re-cap the bottle, and shake
to mix in the first 8 seconds; you can then lead the audience in counting up, once per second, such that the transition happens exactly at 10.

**Table Demo Procedure:**

1. Place 20 mL of water inside a clean, empty 50 mL sealable container.
2. Add 1 mL of Solution 1 (starch), then recap the container and shake well for several seconds.
3. Add 0.5 mL of Solution 2 (KIO$_3$/H$_2$SO$_4$), then recap the container and shake well again.
4. Add 1 mL of Solution 3 (Na$_2$SO$_3$), then *quickly* recap the container and shake very well for ~3-5 seconds to thoroughly mix the contents. It will take ~8 seconds from the moment Solution 3 is added for the solution to abruptly (almost instantaneously) turn a dark blue/black color.

**Clean-up:** Wash the bottle/container out with water. All waste can be rinsed down the drain.

**Hazards:** KIO$_3$ is an oxidizer and should be kept away from flammable materials and reducing agents. H$_2$SO$_4$ is strongly oxidizing and corrosive, and will cause immediate chemical burns on contact.

**Principle:** Bisulfite anions (HSO$_3^-$) from Na$_2$SO$_3$ reduce KIO$_3$ to form iodide anions (I$^-$), which further react with KIO$_3$ to form iodine (I$_2$). In solution I$_2$ reacts with I$^-$ to form triiodide anions (I$_3^-$). I$_3^-$ is immediately reduced back to I$^-$ by any remaining HSO$_3^-$ once the supply of HSO$_3^-$ is exhausted. I$_3^-$ persists in solution and reacts with starch molecules to form a dark blue starch-iodine complex. Excess I$_3^-$ is a brown color in solution, and together this produces the dark blue/black/brown color of coca-cola. As the concentration of I$_3^-$ rises extremely quickly, the color change is almost instantaneous. The volume of Solution 3 (Na$_2$SO$_3$) added to the reaction will change the time required for the color change – larger volumes will increase the delay, and smaller volumes will decrease it.

**Notes:** It has not yet been conclusively determined if starch-I$_3^-$ or starch-I$_5^-$ is responsible for the blue-black color. In general, the reaction occurs faster if more of solution 2 is added. Sodium bisulfate or sodium carbonate can remove any staining that occurs in the reusable plastic bottle. Several different problems can be encountered with this demo, each relating to a different starting solution:

1. The solution gradually transitions to a medium brown color, rather than an abrupt change, indicating a problem with the starch solution. Make sure the mixture is brought to a boil in order to dissolve a sufficient amount of starch. Over time bacteria will eat the starch and decompose the solution; if this occurs, remake Solution 1.

2. The solution takes a very long time (> 25-30 seconds) before the abrupt color change occurs, indicating a problem with the KIO$_3$ solution. Over a long period of time the KIO$_3$ can crystallize out of the solution; if this occurs, remake Solution 2.

3. The solution changes to a dark blue/black color much too quickly (< 5 seconds), indicating a problem with the Na$_2$SO$_3$ solution. Na$_2$SO$_3$ is slowly oxidized by air to Na$_2$SO$_4$, losing its reducing ability; if this occurs, remake Solution 3.