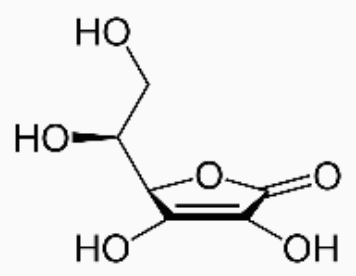
Vitamin C Determination by Iodine Titration



Vitamin C - Ascorbic Acid ($C_6H_8O_6$)

Introduction

Vitamin C (ascorbic acid) is an antioxidant that is essential for human nutrition. Vitamin C deficiency can lead to a disease called scurvy, which is characterized by abnormalities in the bones and teeth. Many fruits and vegetables contain vitamin C, but cooking destroys the vitamin, so raw citrus fruits and their juices are the main source of ascorbic acid for most people.

One way to determine the amount of vitamin C in food is to use a redox titration. The redox reaction is better than an acid-base titration since there are additional acids in a juice, but few of them interfere with the oxidation of ascorbic acid by iodine.

Iodine is relatively insoluble, but this can be improved by complexing the iodine with iodide to form triiodide:

$I_2 + I^- \leftrightarrow I_3^-$

Triiodide oxidizes vitamin C to form dehydroascorbic acid:

$C_6H_8O_6 + I_3^- + H_2O \rightarrow C_6H_6O_6 + 3I^- + 2H^+$

As long as vitamin C is present in the solution, the triiodide is converted to the iodide ion very quickly. Howevever, when all of the vitamin C is oxidized, iodine and triiodide will be present, which react with starch to form a blue-black complex. The blue-black color is the endpoint of the titration.

This titration procedure is appropriate for testing the amount of vitamin C in vitamin C tablets, juices, and fresh, frozen, or packaged fruits and vegetables. The titration can be performed using just iodine solution and not iodate, but the iodate solution is more stable and gives more accurate results.

Problem

How can we determine the amount of vitamin C in samples, such as fruit juice? Also, which has the most Vitamin C: Fresh OJ from the Fruit, Packaged Juice (Sunny D, Minute Maid, etc…), Frozen Juice made to instructions, or Fresh Vegetables? (Hint – A hypothesis is needed). You will need to test 4 different types of samples.

Prelaboratory Assignment

- ✓ Create a proper Pre-Lab and get 2 clean, 500 mL empty water bottles for storage.
- ✓ Answer the Prelaboratory Question:
  1. If 22.3 mL of 0.085 *M* NaOH solution are needed to completely neutralize 13.5 mL of an unknown acid, what is the concentration of the acid solution?

Procedures

The first step is to prepare the solutions. I've listed examples of quantities, but they aren't important. What matters is that you know the concentration of the solutions and the volumes that you use.

Part 1: Preparing Solutions

1% Starch Indicator Solution

1. Add 0.50 g soluble starch to 50 mL of near-boiling DI water.
2. Mix well and allow to cool before use. (doesn't have to be 1%; 0.5% is fine)

Iodine Solution

1. Dissolve 2.50 g potassium iodide (KI) and 0.15 g potassium iodate (KIO_3) in 200 ml of DI water.
2. Add 15 ml of 3 M sulfuric acid.
3. Pour this solution into a 500 ml graduted cylinder and dilute it to a final volume of 250 ml with DI water.
4. Transfer the solution to a 600 ml beaker to use during the lab and mix the solution.
5. Store in an empty, 500 mL water bottle and label it as your iodine solution.

Vitamin C Standard Solution

1. Dissolve 0.250 g vitamin C (ascorbic acid) in 100 ml DI water.
2. Dilute to 250 ml with DI water in a volumetric flask. Transfer to an empty 500 mL water bottle and properly label as your vitamin C standard solution.

Part 2: Standardizing Solutions

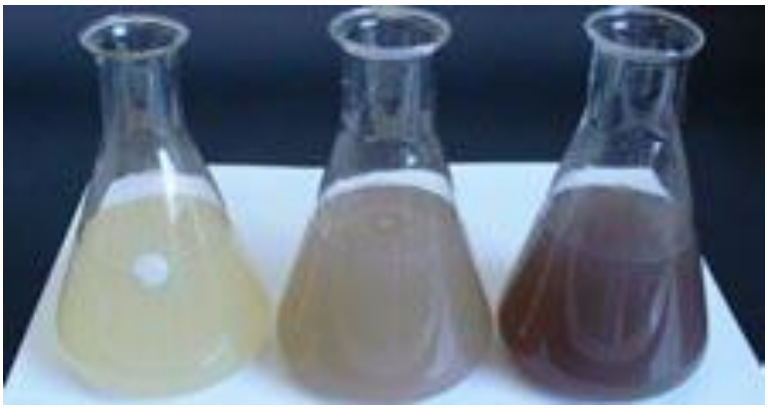
1. Add 25.00 ml of vitamin C standard solution to a 125 ml Erlenmeyer flask.
2. Add 10 drops of 1% starch solution.
3. Rinse your buret with a small volume of the iodine solution and then fill it. Record the initial volume.
4. Titrate the solution until the endpoint is reached (see Fig 1.) This will be when you see the first sign of blue color that persists after 20 seconds of swirling the solution. This is shown in the picture below as the **middle** flask.
5. Record the final volume of iodine solution. The volume that was required is the starting volume minus the final volume.
6. Repeat the titration at least twice more. The results should agree within 0.1 ml.

(Fig 1 –Vit. C Standard Solution)

Titrating Juice Samples

You titrate samples exactly the same as you did your standard. Record the initial and final volume of iodine solution required to produce the color change at the endpoint.

1. Add 25.00 ml of juice sample to a 125 ml Erlenmeyer flask.
2. Titrate until the endpoint is reached. (Add iodine solution until you get a color that persists longer than 20 seconds, about like the middle flask of the Fig 2 below.)
3. Repeat the titration until you have at least three measurements that agree to within 0.1 ml.



(Fig 2 – Juice Endpoint)

- Fresh Fruit Juice – Try to remove pulp and seeds, since they could get stuck in the glassware.
- Packaged Fruit Juice - This also may require straining.
- Vegetables - Blend a 100 g sample with ~50 ml of DI water. Strain the mixture. Wash the filter with a few milliliters of DI water. Add DI water to make a final solution of 100 ml in a volumetric flask.

Titrate these samples in the same way as the juice sample described above.

Cleaning Up 

1. Clean up your lab station, returning all equipment to its proper location.
2. Wash your hands thoroughly before leaving the laboratory.

Math Help!

Titration Calculations: How to Calculate Vitamin C

1. Calculate the ml of titrant used for each flask. Take the measurements you obtained and average them.

   average volume = total volume / number of trials

2. Determine how much titrant was required for your **standard**.

   If you needed an average of 10.00 ml of iodine solution to react 0.250 grams of vitamin C, then you can determine how much vitamin C was in a sample. For example, if you needed 6.00 ml to react your juice (a made-up value - don't worry if you get something totally different):

   $$\frac{\text{10.00 ml iodine solution}}{\text{0.250 g Vit C}} = \frac{\text{6.00 ml iodine solution}}{\text{X g Vit C}}$$

   X = 0.15 g Vit C in that sample

3. Keep in mind the volume of your sample, so you can make other calculations, such as grams per liter. For a 25 ml juice sample, for example:

   0.15 g / 25 ml = 0.15 g / 0.025 L = 6.00 g/L of vitamin C in that sample