Determination of Vitamin C (Ascorbic Acid) in Citrus Fruits

Color changes can often be used to monitor chemical reactions. Excess iodine complexes with starch, resulting in a purple color.\(^1\)

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Introduction

Vitamins are among those chemical compounds that nutritionists refer to as micronutrients, meaning that periodic consumption of small amounts of vitamins is essential to human survival. Vitamins are subcategorized as fat-soluble (A, D, E, K) and water-soluble (the B complex and C). Most vitamins act as cofactors for enzymes.

It is interesting to consider the historical importance that vitamin C played in the lives (and perhaps in the deaths) of some early trans-continental explorers and crews. In fact, sailors on voyages with little or no fresh fruits and vegetables often developed scurvy, as described, for example, by Jacques Cartier, when he documented his 1535 exploration of North America. In 1768, James Cook introduced lime juice to British sailors. His action ultimately earned the sailors the nickname "limeys" and by 1795, fresh citrus was described as a "cure for scurvy" by Lind. Later, Dutch and Hungarian sailors reportedly ate sauerkraut, whereas American sailors were known to consume cranberries—both significant sources of vitamin C.

A properly designed titration method can be used to determine the amount of vitamin C in an aqueous sample. Nutritionists often refer to vitamin C as an antioxidant which suggests, in chemistry terminology, that the molecule is relatively easy to oxidize. We can exploit this chemical property in designing the titration. Specifically, if we allow vitamin C to react with molecular iodine (I₂), the vitamin C is oxidized to dehydroascorbic acid, while the iodine is reduced to iodide ion, I⁻ (Equation 1). Iodine forms a purplish blue complex with starch, but the reduced form, iodide, is colorless. If we add a sufficient amount of iodine to a vitamin C solution, the vitamin C will be consumed. As we continue to add iodine, the excess iodine will complex with starch, as evidenced by a persistent purple or blue color. This color change is the basis for the titration reaction, serving to distinguish the endpoint.

\[
\text{Ascorbic acid} + I_2 \xrightleftharpoons{H^+} \text{Dehydroascorbic acid (oxidized ascorbic acid)} + 2HI
\]

Equation 1: The oxidation of ascorbic acid by iodine.

In this experiment, you will devise and execute a plan to determine the unknown concentration of Vitamin C in a solution.
**Pre-lab**

*Safety:* Goggles must be worn at all times.

Iodine is toxic and stains skin and clothing. Note: A small skin stain is not dangerous. Iodine solutions were once used to treat minor cuts.

*Pre-lab Assignment:* None

**Procedure**

The following reagents are provided:

- ascorbic acid (vitamin C)
- iodine solution (unknown concentration)
- 0.2 M acetic acid
- fruit juices, e.g., pineapple, lemon, grapefruit, orange
- 2% starch solution

The concentration of the iodine solution is not accurately known. Accordingly, you will need to prepare a vitamin C solution of known concentration (an analytical standard) to calibrate your method. Follow the strategy below to prepare and titrate the standard solution:

1. Prepare a 1.00 mg/mL standard solution of vitamin C. *What glassware and other equipment will be needed to accurately prepare this solution?*
2. Obtain a 25.0 mL aliquot of your standard solution for titration. *Must this volume be accurately known? If so, what glassware should you use to measure it?*
3. Add at least 25 mL of water to the aliquot.
4. Add ~20 drops of 0.2 M acetic acid to the aliquot.
5. Add ~10 drops of 2% starch solution.
6. Titrate to the endpoint (stable purplish or bluish/black color) with iodine solution.

After standardizing the iodine solution as described above, titrate the fruit juice to determine its vitamin C concentration. Your lab room is supplied with only one type of fruit juice. Compare the concentration value obtained by your group with that of other lab rooms who titrate different types of fruit juice.

*Record your method and results in your notebook.*

*No report is due for this lab.*

**Reference(s)**


Glossary

**Indicator**

a substance that provides a visual cue that a threshold level of some chemical change has occurred; indicators often change color upon reaching some concentration (for example, phenolphthalein turns pink when a solution has an excess of hydroxide present and becomes basic)

**Oxidation-reduction reaction (redox reaction)**
a type of chemical reaction that involves the transfer of one or more electrons between reactants; a chemical reaction involving a change in oxidation number for atoms participating in the reaction

**Oxidation**

the loss of electrons; an increase in oxidation number

**Reduction**

the gain of electrons; a decrease in oxidation number

**Oxidation number (oxidation state)**

the hypothetical charge an atom would have if the atom or compound containing it were composed only of ions

**Reducing agent**

a substance that facilitates the reduction of another substance; a substance that becomes oxidized.

**Oxidizing agent**

a substance that facilitates the oxidation of another substance; a substance that becomes reduced

**Titration (volumetric analysis)**
a laboratory procedure in which a solution of unknown concentration is reacted with a solution of known concentration, in order to determine the concentration of the unknown.