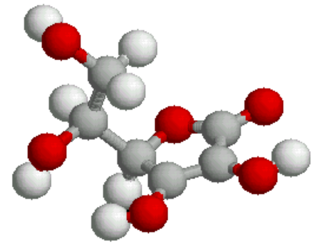
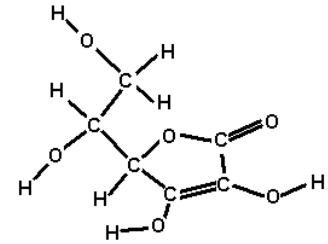
Analysis of Vitamin C

Minneapolis Community and Technical College
CHEM 1151
v.9.08





I. Introduction

Consumption of vitamin C is an essential part of good nutrition. Before lab meets be sure to examine the following website for important vitamin C related information

Linus Pauling Institute: ***http://lpi.oregonstate.edu/infocenter/vitamins/vitaminC/index.html***

The Titration:

In today's experiment you will determining the amount of vitamin C in both tablets and in a juice sample. The procedure involves the careful addition potassium iodate (KIO_3) solution to the vitamin C containing sample via a titration. The KIO_3 is added to the reaction mixture *using a buret* while stirring constantly with a magnetic stir plate. By knowing the concentration and volume of the KIO_3 required, the moles & grams of vitamin C can be determined.

As $\mathbf{KIO_3}$ is added to the reaction container, it reacts with loose $\mathbf{I^-}_{(aq)}$ ions to form $\mathbf{I_2}_{(aq)}$ (reaction "a" below). The $\mathbf{I_2}_{(aq)}$ product molecules are then chemically reduced by vitamin C, a strong reducing agent, to reform $\mathbf{I^-}_{(aq)}$ (reaction "b"). Thus, $\mathbf{I_2}_{(aq)}$ never builds up to appreciable levels because of the vitamin C that is present.

This process can't go on forever since eventually there will be no more vitamin C to react with $\mathbf{I_2}_{(aq)}$. At some point, when all of the vitamin C is completely gone (i.e. the limiting reactant), reaction "b" can no longer take place and the concentration of $\mathbf{I_2}_{(aq)}$ will increase. The end of the titration is signaled by the build up of $I_{2(aq)}$ and its reaction with excess I^- to form I_3^- (reaction "c") . This in turn reacts with starch to turn the solution **blue**. This point, when the solution turns *faintly* blue, is the endpoint of the titration.

Summarizing, we titrate with KIO_3. KI and HCl are present in excess and are responsible for the I^- and H^+ concentrations respectively. As long as there is vitamin C present no significant amount of I_2 can form. However, when all of the vitamin C is used up, I_2 concentrations rise and a blue color is observed. This process can be summarized by the following sequential reactions:

a. $\mathbf{IO_3^-}$ *(buret)* $\mathbf{+\ 5I^-}$ *(KI)* $\mathbf{+\ 6H^+}$ *(HCl)* ® $\mathbf{3I_2}$ $\mathbf{+}$ $\mathbf{3\ H_2O}$

b. $\mathbf{C_6O_6H_8}$ *(vitamin c)* $\mathbf{+}$ $\mathbf{I_2}$ ® $\mathbf{C_6O_6H_6}$ $\mathbf{+}$ $\mathbf{2\ H^+}$ $\mathbf{+}$ $\mathbf{2I^-}$

c. $\mathbf{I_2}$ $\mathbf{+\ I^-}$ ® $\mathbf{I_3^-}$

(***blue*** *in presence of starch)*

II. MSDS: Material Safety Data Sheets

Read through the following MSDS information and become familiar with the hazards associated with the chemicals used in this experiment before coming to lab.

Potassium Iodide Hazards Identification: KI

Route Of Entry Inds - Inhalation: YES **Skin**: YES **Ingestion**: YES **Carcinogenicity Inds - NTP:** NO **IARC:** NO **OSHA**: NO
Effects of Exposure: May be harmful if swallowed, inhaled or absorbed through the skin. Eye contact may cause irritation. Skin contact may cause irritation. Ingestion may cause gastrointestinal discomfort. Inhallation may cause irritation to respiratory tract.
Explanation Of Carcinogenicity: This compound contains no incredients at concentrations of 0.1% or greater that are carcinogens or suspect carcinogens.
Signs And Symptions Of Overexposure: Eye irritation, skin irritation, gastrointestinal discomfort, respiratory tract irritation.
Medical Cond Aggravated By Exposure: Not specified by manufacturer.
First Aid: Eyes: Flush with water for 15 minutes while holding eyelids open. Get medical attention. Skin: Remove contaminated clothing. Wash with soap and water. If irritation persists, get medical attention. Inhalation: Move to source of fresh air. Restore breathing. Get medical attention. Ingestion: Do not induce vomiting. Drink water. Get medical attention.

Potassium Iodate Hazards Identification: KIO_3

Health Rating: 1 - Slight **Flammability Rating: 1** - Slight **Reactivity Rating: 0** - None **Contact Rating: 1** - Slight
Lab Protective Equip: GOGGLES; LAB COAT

Ascorbic acid is relatively non-hazardous in routine industrial situations.
It is not expected to present significant health risks to the workers who use it.

Inhalation: May cause mild irritation to the respiratory tract.
Ingestion: Large oral doses may cause gastrointestinal disturbances.
Skin Contact: May cause mild irritation.
Eye Contact: May cause mild irritation.
Chronic Exposure: No information found.
Aggravation of Pre-existing Conditions: No information found.

Ascorbic Acid Hazards Identification

Health Rating: 1 - Slight **Flammability Rating: 1** - Slight **Reactivity Rating: 0** - None **Contact Rating: 1** - Slight
Lab Protective Equip: GOGGLES; LAB COAT

Ascorbic acid is relatively non-hazardous in routine industrial situations.
It is not expected to present significant health risks to the workers who use it.

Inhalation: May cause mild irritation to the respiratory tract.
Ingestion: Large oral doses may cause gastrointestinal disturbances.
Skin Contact: May cause mild irritation.
Eye Contact: May cause mild irritation.
Chronic Exposure: No information found.
A**ggravation of Pre-existing Conditions:** No information found.

0.1 - 2.0 Molar $HCl_{(aq)}$ Hazards Identification

DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED.

Health Rating: 3 - Severe (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 2 - Moderate
Contact Rating: 3 - Severe (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES

Health hazards given on this data sheet apply to concentrated solutions of hydrochloric acid. Hazards of dilute solutions may be reduced, depending upon the concentration. Degree of hazard for these reduced concentrations is not currently addressed in the available literature.

Inhalation: Corrosive! Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death.
Ingestion: Corrosive! Swallowing hydrochloric acid can cause immediate pain and burns of the mouth, throat, esophagus and gastrointestinal tract. May cause nausea, vomiting, and diarrhea, and in severe cases, death.
Skin Contact: Corrosive! Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and discolor skin.
Eye Contact: Corrosive! Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
Chronic Exposure: Long-term exposure to concentrated vapors may cause erosion of teeth. Long term exposures seldom occur due to the corrosive properties of the acid.
Aggravation of Pre-existing Conditions: Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

III. Vitamin C Procedure

You will be working individually on this experiment.

A. Tablet Vitamin C Determination:

In this part of the experiment you will experimentally determine the amount of vitamin C in a vitamin C tablet. *Because vitamin C degrades over time, manufacturers produce tablets with slightly more than the stated amount of vitamin C in them. This way, as long as the vitamins are purchased before the expiration date, they should have at least as much vitamin C as is stated on the bottle label. Do not be surprised if your tablet results are slightly greater than the bottle label claims.*

The order of these steps is important. Don't mix up this procedure!

Obtain two 100 mg vitamin C tablets. Weigh each tablet and record their masses. Be careful not to mix up the two tablets. Place each tablet in its own 250 mL Erlenmeyer flask and add approximately 50 mL of distilled water to each flask.

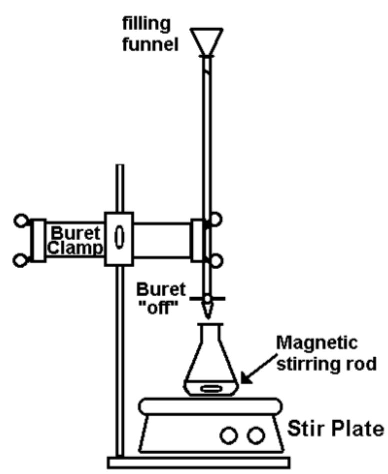
Rinse (twice) a buret with 2-3 mL portions of KIO_3 solution. Next, fill the buret and eliminate air bubbles that may have lodged in the valve assembly by draining bursts of liquid into a waste beaker. When no air bubbles are detected, refill the buret and prepare to titrate.

Use a glass stirring rod to break up the first tablet and stir the mixture for several minutes. Letting the second tablet soak in the water will make it easier to break up later.

Did all of the tablet dissolve? If not, what might be the identity of the solid that doesn't dissolve?

- Add approximately 1g KI to the first flask and continue stirring until completely dissolved.
- Add approximately 5mL of 1 M HCl. Stir.
- Add approximately 2-3 mL of 0.5% starch solution. Stir.

Set up the apparatus at right.



Add the stir bar to the Erlenmeyer flask and position the flask on the stir plate. Start the magnetic stirrer being careful to leave the heat turned off. When properly adjusted, the liquid should be stirred with no splashing.

Record the initial buret reading on your data sheet.

Slowly add the 0.0100 M KIO_3. As you get close to the endpoint of the titration, a blue color burst will be observed for longer periods of time. Slowly add KIO_3 until a ***faint blue*** color *persists*.

Record the final buret reading on your data sheet and determine how many milliliters KIO_3 was dispensed.

Repeat the above procedure a second time using the second 100mg vitamin C tablet.

From your tablet results, calculate the mass of vitamin C contained in each tablet in mg. Record your result both on your data sheet and on the whiteboard.

B. Titration of an unknown fruit juice.

The order of these steps is important. Don't mix up this procedure!

Measure out approximately ~50 mL of one fruit juice into a clean 250 mL Erlenmeyer flask.

Accurately record the amount of juice you dispensed, the type and name of the juice on your data sheet.

Locate the nutrition information on the carton and record the % daily vitamin C intake information for the juice sample. Record this value on your data sheet.

- Add approximately 1g KI and continue stirring until dissolved. Stir.
- Add approximately 5mL of 1 M HCl. Stir.
- Add approximately 2-3 mL of 0.5% starch solution. Stir.

Titrate the mixture as you did above with the KIO_3 solution.

Note: The expected color change will be disguised by the original color of the juice. Keep a small amount of fresh juice nearby as a reminder of the original juice color. Do the best job you can in determining the endpoint of the titration.

Repeat the titration a second time with another portion of the same juice if time permits.

C. End of titration: Sequential calculations

a. IO_3^- (buret) + $5I^-$ (KI) + $6H^+$ (HCl) ® $3I_2$ + $3\ H_2O$

b. $C_6O_6H_8$ (vitamin c) + I_2 ® $C_6O_6H_6$ + $2\ H^+$ + $2I^-$

c. I_2 + I^- ® I_3^- (**blue** in presence of starch)

In this experiment we have a sequence of chemical reactions. The iodine produced by reaction "a" used up in reaction "b"

In reaction "a" the mole ratio that relates IO_3^- *to* I_2 *is :* **1 mole IO_3^- = 3 mole I_2**

In reaction "b" the mole ratio that relates I_2 *to* $C_6O_6H_8$ *is:* **1 mole I_2 = 1 mole $C_6O_6H_8$**

These mole ratios can be combined to convert moles of IO_3^- into moles of $C_6O_6H_8$

$$\frac{3\ \text{mole}\ I_2}{1\ \text{mole}\ IO_3^-} \times \frac{1\ \text{mole}\ C_6O_6H_8}{1\ \text{mole}\ I_2}$$

1. Use the potassium iodate volume (experimentally determined) and molarity information to calculate moles of iodate ion.
2. Use reaction "a" and the appropriate mole ratio to determine the number of moles of I_2 that are produced by the iodate from step 1.
3. Use the moles of I_2 you calculate in reaction "b" to calculate the number of moles of vitamin C consumed.
4. Convert moles of vitamin C into grams and mg of vitamin C.

C1151 Data Sheet
Determination of Vitamin C
Instructor Initials_____

Name__________________________
Date of Exp. _________________
Lab Section _________________

Your ***individual*** *experimental report will be due at the beginning of class next week.*

Data Table: (All entries must be in written in ink before you leave the lab).

Juice information:

Juice ID ________________ **Serving size…** ________**mL** **Claimed % vitamin C** __________**%**

	Tablet 1	Tablet 2	Tablet 3	Juice 1	Juice 2	Juice 3
Concentration of KIO_3						
Tablet mass						
Juice volume						
Initial buret reading						
Final buret reading						
mL of KIO_3 *dispensed*						
moles of IO_3^-						
moles of $C_6O_6H_8$						
milligrams of $C_6O_6H_8$						
Male % vitamin C (see below)						
Female % vitamin C (See below)						
Δ% (Use 100 mg as known)						

!!!NOTE: I will grade your data and calculations by entering your data table measurements into an Excel Spreadsheet. You will not receive full credit for your calculations unless your results match mine <u>exactly</u>.

Answer the following questions.

- Answers must be readable and make sense for full credit.
- Copied answers will result in all involved students receiving a zero score

1. In the space below, show how you calculated the mass ascorbic acid for the second tablet beginning with the original buret measurements.

2. In the space below, show how you calculated the mass of ascorbic acid for the second juice trial beginning with the original buret measurements.

3. You have determined the vitamin C in a 50 mL juice sample. How many mg of vitamin C are there in ***one serving***?

4. The % vitamin C is based on its "recommended <u>daily</u> allowance" (RDA), which is approximately 75 mg for the average adult female and 90 mg for the average adult male. Calculate the % vitamin C based on your result from part 3 for the average male <u>and</u> average female.

5. How does the % vitamin C value you calculated compare with the advertised values? Are the manufactures advertising their product accurately? Are the manufacturers advertising their product fairly?