Experiment 4

QUANTITATIVE ANALYSIS OF VITAMIN C

Objective

The purpose of this experiment is using a reduction-oxidation titration to determine the content of vitamin C in commercial vitamin C tablets and fruit juice.

Lab techniques

- Weighing chemicals.
- Operating of pipet, buret, volumetric flask, and stirrer/hot plate.

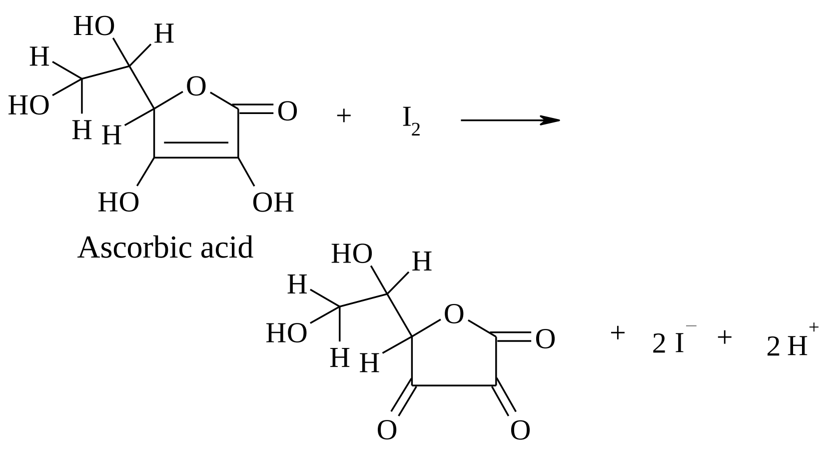
Introduction

Of all vitamins, vitamin C is probably one of the most commonly taken, in the form of dietary supplement tablets or orange juice, to prevent vitamin C deficiency and to boost the immune system. Commercial vitamin C tablets usually come in 100, 200, 500 or 1000 mg per tablet. As for orange juice, the vitamin C content can be ranged from 137.9 mg to 15 mg per 100 g depending on the types of juice. As consumers, we may sometimes wonder whether these tablets or juices really contain the indicated amounts as claimed. In this experiment, we will check the amounts of vitamin C in different samples with redox titrations.

Vitamin C is also called ascorbic acid ($C_6H_8O_6$) and is a reducing agent capable of reducing Fe(III) to Fe(II), or I_2 to I^-. Hence, in this experiment, we will use potassium iodate (KIO_3) solution as a titrant to titrate a sample solution containing sodium iodide (NaI) in acidic medium, thus producing iodine (I_2) as in equation 4-1.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l) \quad (4\text{-}1)$$

Meanwhile, iodine can undergo a rapid redox reaction with ascorbic acid (4-2):



(4-2)

When ascorbic acid in the solution is completely consumed in the redox reaction, any I_2 produced thereafter reacts with excess I^- in the solution to form triiodide ion I_3^-. The I_3^- yields a blue-black complex with a previously added starch indicator, indicating that the titration end-point is reached. From the number of moles of IO_3^-, we can calculate the vitamin C content of the sample via equation 4-3.

$$\frac{IO_3^-(mol)}{1} = \frac{I_2(mol)}{3} = \frac{C_6H_8O_6(mol)}{3} \quad (4\text{-}3)$$

Apparatus

Transfer pipet (25 mL), pipet filler, volumetric flask (100 mL), beaker (100 mL, 2), stirrer/hot plate, magnetic stirring bar, buret (25 mL), Erlenmeyer flask (125 mL, 2), and electronic balance.

Chemicals

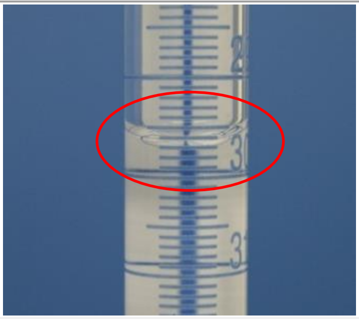
Commercial vitamin C tablets, $C_6H_8O_6$ (self-prepared)
1 M Sodium iodide, NaI
0.025 M Potassium iodate, KIO_3
1 M Hydrochloric acid, HCl(aq)
2% Starch solution
Fruit juice (light-colored and pulpless type, self-prepared)

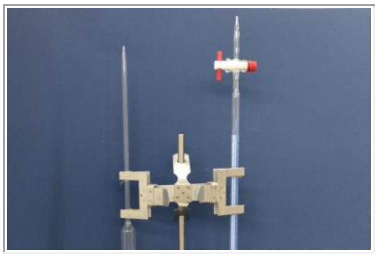
Procedure

Procedure		Illustration
I. Ascorbic acid content of a low-dosage vitamin C tablet (indicated dose of 250 mg or lower)		
1.	Prepare two vitamin C tablets, and record the dose of the vitamin indicated on the package. Note: Bring your own vitamin C tablet for analysis. If the group cannot provide its own tablet, the one provided by the lab preparation room should be used. If the tablet has a dosage higher than 250 mg, perform the analysis in section II instead of section I.	

2.	Measure and record the exact weight of a tablet. Compare this weight with the weight claimed by the manufacturer to see if there is any difference. Note: Refer to the experimental skills videos to learn weighing chemicals.	
3.	Crush one tablet to pieces, transfer to a 125 mL Erlenmeyer flask, and add 50 mL DI water. Stir and dissolve it completely. Note: You may crush the tablet with tool to help dissolving.	
4.	Measure and add approximately 2 mL of 1 M NaI, 2 mL of 1 M HCl, and 1 mL of 2% starch indicator to the Erlenmeyer flask.	
5.	Use a 100 mL beaker to take ca. 50 mL KIO_3 solution. Wash a 25 mL buret and rinse with small portions (ca. 5 mL) of 0.025 M KIO_3 twice. Fill the buret with the iodate solution and record the readings of initial volume (V_i) to 0.01 mL. Note 1: Expel air from the buret tip and make sure the liquid level below the zero mark before starting titration. Note 2: Refer to the experimental skills videos to learn the operation of a buret.	 
6.	Use the 0.025 M KIO_3 to titrate the vitamin C solution. The end-point is reached when the solution turns blue-black. Read and record the final volume (V_f) to 0.01 mL.	
7.	Get another vitamin C tablet. Repeat the procedures and perform a duplicate titration.	

8.	Use the titration volume of 0.025 M KIO_3 to calculate the ascorbic acid content of the tablet (in mg/tablet).	$\frac{IO_3^-(mol)}{1} = \frac{I_2(mol)}{3} = \frac{C_6H_8O_6(mol)}{3}$
II.	Ascorbic acid content of a high-dosage vitamin C tablet (above 250 mg)	
9.	Measure and record the exact weight of a tablet. Compare this weight with the weight claimed by the manufacturer to see if there is any difference. Note: According to the dosage of your vitamin C tablet, conduct the experiment of section I or II.	
10.	(1) Crush the tablet to pieces, transfer it into a 100 mL beaker and add 50 mL DI water. Stir and dissolve it completely. (2) Transfer the solution into a 100 mL volumetric flask. Rinse the beaker several times with small portions of DI water and transfer the rinsing water into the flask. Fill the volumetric flask to the 100 mL mark with DI water. Stopper the flask and invert it several times to mix the solution thoroughly. Transfer this solution into a clean beaker. Note: Refer to the experimental skills videos to learn how to use a volumetric flask.	  
11.	Wash a 25 mL transfer pipet and rinse it with 5 mL of vitamin C solution twice. Use the pipet to transfer accurately 25.0 mL of vitamin C solution into a 125 mL Erlenmeyer flask. Note: Refer to the experimental skills videos to learn how to use a transfer pipet.	
12.	Measure and add approximately 2 mL of 1 M NaI, 2 mL of 1 M HCl, and 1 mL of 2% starch indicator to the Erlenmeyer flask.	

13.	Titrate the vitamin C solution with 0.025 M of KIO_3. Record the titration volume to 0.01 mL.	
14.	Obtain another 25.0 mL of vitamin C solution and perform a duplicate titration.	
15.	Use the titration volume of 0.025 M KIO_3 and consider the dilution of vitamin C to calculate the ascorbic acid content of the tablet (in mg/tablet).	$\frac{IO_3^-(mol)}{1} = \frac{I_2(mol)}{3} = \frac{C_6H_8O_6(mol)}{3}$
III.	Ascorbic acid content of a commercial fruit juice	
16.	Each group prepares a 200 mL sample of commercial fruit juice. Ideal one is light-colored, pulpless, and has indicated vitamin C content on the package. Note: Use graduated cylinder to measure, if there is pulp in the juice.	
17.	Wash a 25 mL transfer pipet and rinse it with 5 mL of fruit juice twice. Transfer accurately 50.0 mL of fruit juice into a 125 mL Erlenmeyer flask.	
18.	Measure and add approximately 2 mL of 1 M NaI, 2 mL of 1 M HCl, and 1 mL of 2% starch indicator to the Erlenmeyer flask.	
19.	Titrate with 0.025 M KIO_3 and record the titration volume to 0.01 mL.	

20.	Prepare another 50.0 mL of sample of fruit juice and perform a duplicate titration.	
21.	Use the titration volume of 0.025 M KIO_3 to calculate the ascorbic acid content of the fruit juice (in mg/100 mL).	$\frac{IO_3^-(mol)}{1} = \frac{I_2(mol)}{3} = \frac{C_6H_8O_6(mol)}{3}$
22.	The buret and transfer pipet should be rinsed clean thoroughly with water. Let buret inverted clamped and left dry after the experiment.	

References

1. Roberts, J. L., Jr. *Chemistry in the Laboratory*, 4th ed., 1997, W. H. Freeman: New York.