Measuring the amount of vitamin C in fruit drinks

Topic

Food, scientific methodology. Quantitative chemistry/mole calculations.

Timing

20 min.

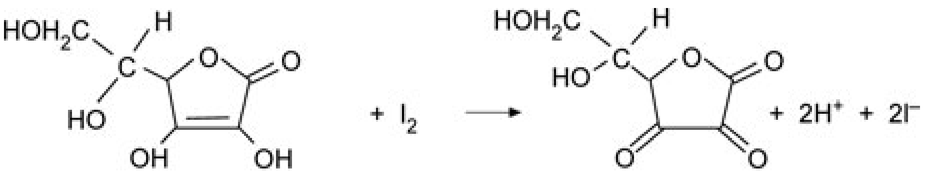
Description

In this experiment students use the microscale titration technique to measure the amount of vitamin C (ascorbic acid) in fruit drinks. The basis of the measurement is as follows.

A known excess amount of iodine is generated by the reaction between iodate, iodide and sulphuric acid:

$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(aq)$

A measured amount of fruit drink is added. The ascorbic acid in the drink reacts quantitatively with some of the iodine:



Ascorbic acid Dehydroascorbic acid

The excess iodine is then titrated against standard thiosulphate solution:

$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

Chemicals (per group)

- Sodium thiosulphate
- Potassium iodate
- Potassium iodide

Solutions contained in plastic pipettes, see 'Apparatus and techniques for microscale chemistry' handout.

- Starch solution (freshly made)
- Sulfuric acid 1 mol dm^3
- Sample(s) of fruit juice.

Apparatus (per group)

- One student worksheet
- Microscale titration apparatus (see 'Apparatus and techniques for microscale chemistry' handout)
- One 1 cm^3 pipette (glass)
- One 2 cm^3 pipette (glass)
- Pipette filler
- One 25 cm^3 beaker
- One 5 cm^3 measuring cylinder
- One 10 cm^3 beaker (for filling titration apparatus).

Stock solutions

1. Sodium thiosulphate solution 0.010 mol dm^{-3}

Weigh out, accurately, *ca* 0.620 g of $Na_2S_2O_3.5H_2O$, dissolve in deionised water and make up to 250 cm^3 in a volumetric flask. Store this stock solution in a dark glass bottle.

2. Potassium iodate solution 0.001 mol dm^{-3}

Weigh out, accurately, *ca* 0.054 g of KIO_3, dissolve in deionised water and make up to 250 cm^3 in a volumetric flask.

3. Potassium iodide solution 0.005 mol dm^{-3}

Weigh out 0.21 g of KI, dissolve in deionised water and make up to 250 cm^3 with deionised water.

Health & Safety

Wear eye protection.

Sulfuric acid 1 mol dm^3 is a skin/eye irritant.

Sodium thiosulphate 0.010 mol dm^{-3}, Potassium iodate 0.001 mol dm^{-3} and Potassium iodide 0.005 mol dm^{-3} solutions are of low hazard, as are the starch solution and fruit juices.

Note

The reaction to generate the iodine is based on using an accurately known volume of the potassium iodate solution (the concentration of which is accurately known). The potassium iodide solution and the sulphuric acid are added in slight excess and thus the concentrations of these solutions is not critical.

Observations

The titre volume should be in the range 0.5–1 cm^3, the disappearance of the blue-black colour marking the end-point.

This experiment offers possibilities for assessing students' abilities in following instructions and/or processing results.

A survey of a range of fruit drinks (and maybe other products containing vitamin C) could form the basis of a class project or as an activity for a school or college chemistry club.

Specimen result and calculation

Volume of thiosulphate delivered during the titration = 0.74 cm^3.

Concentration of thiosulphate = 0.010 mol dm^{-3}.

Therefore number of moles thiosulphate =

$$\frac{0.74 \times 0.01}{1000} = 7.4 \times 10^{-6}$$

Therefore the number of moles of iodine that this reacted with during the titration = 3.7 x 10^{-6}.

The total number of moles of iodine produced in the reaction between iodate, iodine and sulphuric acid based on using 2 cm^3 of iodate with a concentration of 0.0012 mol dm^{-3} =

$$\frac{3 \times 2 \times 0.0012}{1000} = 7.2 \times 10^{-6}$$

Therefore the number of moles of iodine which reacted with the ascorbic acid = 7.2 x 10^{-6} – 3.7 x 10^{-6} = 3.5 x 10^{-6}

Since 1 mole of iodine reacts with 1 mole of ascorbic acid then the number of moles of ascorbic acid is also 3.5 x 10^{-6}.

The volume of the fruit juice used was 1 cm^3. Therefore the number of moles of ascorbic acid in 1000 cm^3 = 3.5 x 10^{-3}.

The relative molar mass of ascorbic acid = 174.12 g. Therefore mass of ascorbic acid (in 1000 cm^3) = 174.12 g x 3.5 x 10^{-3} = 0.609 g.

The vitamin C content of the fruit drink = 61 mg per 100 cm^3.

Reference

J.Chem.Ed., 1992, **69**, A213-4.

Note

Instead of generating the iodine *in situ*, it is possible to use standard iodine solution in this procedure. This would need to be diluted to give an aliquot containing 7.2 x 10^{-6} moles of iodine (see above) for each determination.

Health & Safety

Students must wear eye protection.

Sulfuric acid, 1 mol dm^{-3} H_2SO_4(aq), is an IRRITANT.

Credits

Health & safety checked May 2018

Page last updated August 2018