CLIL - Redox titrations with iodine

Introduction

The shelf life of pharmaceutical products must always be tested. Hydrogen peroxide (**H_2O_2**) used in disinfectants is slowly reduced to water; it also photodegrades. Vitamin C in vitamin tablets is inherently unstable, being slowly oxidized by air. The ability to accurately and reliably determine the concentration of the active ingredients in various formulations is an important one. In this lab you will determine the content of hydrogen peroxide in a pharmaceutical disinfectant, as well as the concentration of ascorbic acid in Vitamin C supplemental tablets. Both analyses will involve the potentiometric titration of aqueous iodine with sodium thiosulfate using an automatic titrator. A platinum ring indicator electrode is used to follow the progress of the titration curve by potentiometry. Background Titrations Involving Iodine Iodine is a moderately weak oxidizing agent; it is reduced to form the iodide anion, as follows:

$$I_2 + 2\bar{e} \rightarrow 2I^- \qquad E° = 0.621\ V$$

The above redox reaction is completely reversible, and so the iodide anion is a moderately weak reducing agent that will react with oxidizing analytes to produce iodine. Titrations involving iodine have evolved for the analysis of a number of oxidizing and reducing agents. In iodimetric titrations, the analyte (a reducing agent) reacts with iodine to produce iodide:

$$A_{ox} + I_2 \rightarrow A_{red} + 2I^- \text{ (iodimetry)}$$

where **A_{ox}** and **A_{red}** are the oxidized and reduced forms, respectively, of the analyte. In iodometric titrations, the analyte (an oxidizing agent) reacts with an unmeasured excess of iodide to produce iodine:

$$A_{red} + 2I^- \text{ (excess)} \rightarrow A_{ox} + I_2 \text{ excess (iodometry)}$$

The iodine produced in this reaction is stoichiometrically related to the amount of analyte originally present in the sample. The iodine may then be titrated to determine the analyte concentration in the sample. The nearly universal titrant for iodine is thiosulfate; they react quantitatively as follows:

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

So we see that reactions involving iodine can be used for the analysis of moderately strong reducing agents (by reacting with **I_2** in iodimetry) or moderately strong oxidizing agents (through reaction with excess iodide in iodometry).

Analysis of Ascorbic Acid by Iodimetry

Ascorbic acid (vitamin C) is sometimes called an "anti-oxidant" (i.e., a reducing agent) by pharmacists and food nutritionists. Iodine rapidly oxidizes ascorbic acid, $C_6H_8O_6$, to produce dehydroascorbic acid, $C_6H_6O_6$:

$$C_6H_8O_6 + I_2 \rightarrow C_6H_6O_6 + 2I^- + 2H^+$$

Ascorbic acid is readily water-soluble, and direct iodimetric titration is a standard method for the analysis of vitamin C in a variety of citrus fruits and in vitamin tablets. In our experiment, we actually perform an iodimetric back-titration: we generate a measured excess of iodine in the sample solution and then titrate the unreacted iodine with sodium thiosulfate (**$Na_2S_2O_3$**). This back titration is still an iodimetric titration, since it is based on the reaction of analyte with aqueous iodine (**I_2**); however, using a back titration allows us to use the same titrant (**sodium thiosulfate → $Na_2S_2O_3$**) as we use in the iodometric analysis of hydrogen peroxide (**H_2O_2**).

Analysis of Hydrogen Peroxide by Iodometry

Solutions of hydrogen peroxide (**H_2O_2**) are widely sold as disinfectants. Since hydrogen peroxide (**H_2O_2**) is an oxidizing agent, it will react with iodide in a redox reaction:

$$H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$$

The reaction is not instantaneous, but it is fast enough to form the basis of a practical analysis by iodometric titration. The sample is added to an acidic solution containing an unmeasured excess of iodide. After the reaction is complete, the iodine produced by the above reaction is titrated with sodium thiosulfate (**$Na_2S_2O_3$**).

Adapted from: facultystaff.richmond.edu

TEACHING AIMS:

- Understanding the meaning of iodimetry;
- Understanding the meaning of iodometry;
- Understanding the differences between iodimetry and iodometry.

EXERCISE

1 Read the text and answer the following questions

1) Describe the iodimetry analytical technique.
2) Describe the iodometry analytical technique.
3) Describe the differences between iodimetry and iodometry.