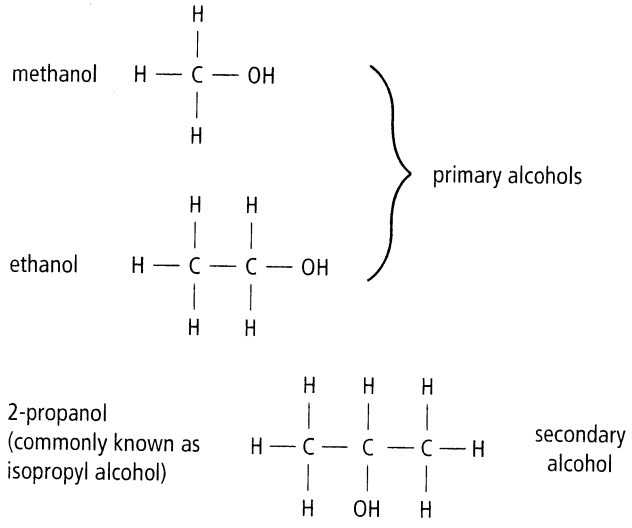
Oxidation of Alcohols

15D

One of the amazing features of organic chemistry is the tremendous number of organic compounds which can react in a variety of ways to form new organic compounds. As a result, the number of organic compounds which can be synthesized in the laboratory is limitless. Many of the materials people take for granted today are a result of organic synthesis reactions. Some of the most familiar synthetic compounds include nylon, Teflon, rayon, polyester, and a variety of plastics. Since the molecules of these synthetics are quite complex in structure, it is preferable to study synthesis reactions involving simpler molecules first.

One typical method of synthesis involves the process of oxidation. Oxidation, as it applies to organic molecules, usually involves the addition of an oxygen atom or the removal of hydrogen atoms, or both. Oxidation reactions can be carried out by reacting organic compounds either with oxygen or with oxidizing agents such as potassium dichromate ($K_2Cr_2O_7$).

In the three parts of this experiment, three alcohols, methanol, ethanol, and 2-propanol, will undergo separate oxidation reactions to form new organic compounds. Alcohols can be classified as primary or secondary depending on where the hydroxyl (OH) group is attached to the carbon chain. Primary alcohols have their hydroxyl groups attached to the end carbon, whereas secondary alcohols have their hydroxyl groups attached to an intermediate carbon on the chain.



When each of the above alcohols is oxidized, the products of oxidation can be identified by characteristic odors.

OBJECTIVES

1. to investigate different methods of carrying out oxidation reactions
2. to oxidize primary and secondary alcohols
3. to identify the synthesized organic compounds by comparing their odors with those of known samples

SUPPLIES

Equipment

3 test tubes (16 mm × 150 mm)
test-tube rack
graduated cylinder (10 mL)
medicine dropper
bare copper wire (22 gauge)
lab burner
crucible tongs
metric ruler
beaker (250 mL)
lab apron
safety goggles

Chemical Reagents

methanol
ethanol
2-propanol
methanal sample
propanone sample
3*M* sulfuric acid
0.1*M* potassium dichromate solution

CAUTION

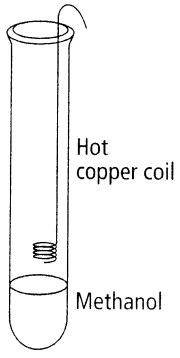
You should always detect odors with caution. Hold the test tube half an arm's length away from your nose. Waft the odor toward your nose with your hand, sniffing cautiously.

PROCEDURE

Part I: Simple Oxidation of Methanol

1. Put on your lab apron and safety goggles.
2. Place about 3 mL of methanol in a clean test tube. Observe and record its odor in your copy of Experimental Results in your notebook.
3. Obtain a 30 cm length of bare copper wire. Make a coil at one end by wrapping the wire around a pencil 6 times; use the rest of the wire as a handle. Lower the coil into the test tube to just above the surface of the methanol and bend the handle over the edge of the test tube so that the coil is suspended above the methanol. (See Figure 15D-1.)
4. Hold the bent handle of the wire in a pair of crucible tongs and heat the coil in a burner flame for a few minutes.
5. Remove the hot coil from the flame, then immediately reinsert it in the test tube. Observe both the appearance of the copper coil and – cautiously – any odors produced during the process.
6. Compare the odor produced with the odor of methanal and propanone and record your observations in your notebook.
7. Clean up, following the instructions for reagent disposal. Save your copper coil for Part III.

Figure 15D-1 *Apparatus for the oxidation of methanol*



Part II: Oxidation of Ethanol

1. Place 3 mL of 0.1*M* $K_2Cr_2O_7$ solution in a test tube, then add 3 mL of 3*M* sulfuric acid.
2. Obtain a 2 mL sample of ethanol and note its odor. Add the sample of ethanol to the contents of the test tube.
3. Set the test tube upright in a beaker containing hot tap water. Record any color changes that occur during the next 5 min. (Cr^{3+}(aq) ions have a characteristic green color.)
4. Compare the odor produced with the odors of methanal and propanone and record your observations.
5. Clean up, following the reagent disposal instructions.

3M sulfuric acid is corrosive to the skin, eyes, and clothing. When handling it wear safety goggles and a lab apron. Wash spills and splashes off your skin and clothing immediately, with plenty of water. Notify your instructor of any spills.

Part III: Oxidation of 2-Propanol

1. Repeat Part I, using 2-propanol instead of methanol.
2. Clean up all materials following the reagent disposal instructions.
3. Before leaving the laboratory, wash your hands thoroughly with soap and water.

Most of the organic liquids used in this experiment are poisonous and flammable. Therefore, do not get any in your mouth and keep them away from open flames.

REAGENT DISPOSAL

Collect all liquids in the designated waste container(s).

POST LAB CONSIDERATIONS

The reaction in Part I involved the oxidation of a primary alcohol, methanol, by the removal of hydrogen atoms from the methanol molecule.

The reaction in Part II also involved the oxidation of a primary alcohol, ethanol, during which hydrogen atoms were removed from the ethanol molecule. Ethanal, whose odor is similar to that of methanal, was produced. The color change was merely an indication of a change in the oxidizing agent as $Cr_2O_7^{2-}$ ions (orange) changed to Cr^{3+} ions (green).

The alcohol in alcoholic beverages is ethanol. Upon being consumed, it is absorbed into the bloodstream and slowly metabolized by the body. However, a small amount of it is vaporized from the blood into the lungs. The subsequent ethanol concentration in the exhaled air can be related to that in blood. One type of "breathalyzer" used by police to detect drinking drivers utilizes a reaction similar to the one carried out in Part II of this experiment. The breathalyzer contains an acid solution of potassium dichromate solution. When a deep breath is exhaled through it, the ethanol in the exhaled air is oxidized to ethanal by the dichromate ion.

$$3CH_3CH_2OH + Cr_2O_7^{2-} + 8H^+ \rightarrow 3CH_3C(=O)H + 2Cr^{3+} + 7H_2O$$

ethanol (orange color) → ethanal (green color)