**Ester Formation**

General description

Students are introduced to organic synthesis through the production of esters. A general background and basic nomenclature is covered.

Age group

**High School Chemistry**

Estimated time

55 minutes

Background

Esters are organic molecules of the general form

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where R1 and R2 are any carbon chain. Esters are unique in that many of them have strong, pleasant odors. As such, they are often used in fragrances, and many artificial flavorings are in fact esters.

Esters are produced by the reaction between alcohols and carboxylic acids. For example, reacting ethanol with acetic acid to give ethyl acetate is shown below.

ethyl acetate.tifacetic acid.tifethanol.tif

water.tif+ → +

In the case of ethyl acetate, R1 is a CH3 group and R2 is a CH3CH2 group.

Naming esters systematically requires naming the functional groups on both sides of the bridging oxygen. In the example above, the right side of the ester as shown is a CH3CH2 group, or ethyl group. The left side is CH3C=O, or acetate. The name of the ester is therefore ethyl acetate. Deriving the names of the side from the carboxylic acid merely requires replacing the suffix –ic with –ate.

Concepts

The principle concept introduced in this lesson is organic synthesis of esters. General nomenclature of esters is also introduced.

Vocabulary

Ester – general organic molecule containing the functional group R1-(C=O)-O-R2

Alcohol – general organic molecule containing the function group R-OH

Carboxylic acid – general organic molecule containing the function group R-(C=O)-OH

Materials

1-Pentanol (n-amyl alcohol)

Ethanol (ethyl alcohol)

Methanol (methyl alcohol)

Butanol (butyl alcohol)

Glacial acetic acid

Formic acid

Salicylic acid

Butyric acid

18M Sulfuric acid

5% Sodium bicarbonate solution

**Caution**: Concentrated sulfuric acid is highly corrosive and should remain in the hood. Glacial acetic acid and formic acid are also corrosive. Pentanol, ethanol, methanol, butanol, and glacial acetic acid are flammable. Methanol is toxic. Great care should be used when handling these materials. Goggles, gloves, and aprons/lab coats should be worn at all times.

**Ester Formation**

Answer key

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Given below are 7 recipes for different esters and a procedure for making them. In each case, the reaction proceeds spontaneously but slowly; the concentrated sulfuric acid is added as a catalyst to speed up the reaction. Try to identify the name and the odor of each ester that is produced.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Alcohol** | **Carboxylic Acid** | **Ester name** | **Scent** |
| Ester 1 | 1-pentanol (n-amyl alcohol) | acetic acid | 1-pentyl acetate (n-amyl acetate) | banana |
| Ester 2 | ethanol (ethyl alcohol) | formic acid | ethyl formate | rum |
| Ester 3 | methanol (methyl alcohol) | salicylic acid | methyl salicylate | wintergreen |
| Ester 4 | ethanol (ethyl alcohol) | butyric acid | ethyl butyrate | pineapple/  strawberry |
| Ester 5 | butanol (butyl alcohol) | acetic acid | butyl acetate | pear |
| Ester 6 | 1-pentanol (n-amyl alcohol) | butyric acid | 1-pentyl butyrate (n-amyl butyrate) | pear/apricot |
| Ester 7 | methanol (methyl alcohol) | butyric acid | methyl butyrate | pineapple/apple |

Procedure

1. Add 1 mL alcohol and 1 mL carboxylic acid (or 1 scoop if using salicylic acid)
2. Carefully ad 3-4 drops of sulfuric acid
3. Put the tubes in a hot water bath (50-60°C) for 5-10 minutes
4. Try to identify the smell of the resulting product. If the smell of the sulfuric acid is too strong (giving it a sour odor), it can be neutralized with a few drops of 5% NaHCO3.

**Ester Formation**

Student worksheet

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| Ester 2 | ethanol (ethyl alcohol) | formic acid |  |  |
| Ester 3 | methanol (methyl alcohol) | salicylic acid |  |  |
| Ester 4 | ethanol (ethyl alcohol) | butyric acid |  |  |
| Ester 5 | butanol (butyl alcohol) | acetic acid |  |  |
| Ester 6 | 1-pentanol (n-amyl alcohol) | butyric acid |  |  |
| Ester 7 | methanol (methyl alcohol) | butyric acid |  |  |

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