Activity 23: Making esters from alcohols and carboxylic acids

Objective

- Be able to carry out esterification reactions safely.
- Appreciate the range of smells produced by different esters.

Safety

- Alcohols are flammable.
- Butan-1-ol is harmful and irritant.
- Conc sulfuric acid is corrosive.
- Liquid carboxylic acids are corrosive.
- Wear goggles


Highly flammable


Corrosive


Harmful


Irritant

Procedure

1. Place 1 cm^3 of methanol and 3 g of salicylic acid in a boiling tube. Mix well and *carefully* add a few drops of conc sulfuric acid.
2. Place the boiling tube in a water bath at about 80 °C for five minutes.
3. Pour the contents of the boiling tube into a beaker of cold water.
4. Carefully smell the ester floating on the water.
5. Place 1 cm^3 of ethanol and 1 cm^3 of ethanoic acid in a boiling tube. Mix well and *carefully* add a few drops of conc sulfuric acid.
6. Repeat steps 2 – 4.
7. Try other alcohol/carboxylic acid combinations.

Equipment/materials

- Conc sulfuric acid
- A range of alcohols
- A range of carboxylic acids
- 3 x boiling tubes
- Large beaker to act as a water bath
- 250 cm^3 beaker for the cold water
- 0-100 °C thermometer
- 10 cm^3 measuring cylinder
- Stirring rod
- Spatula
- Access to kettle
- Mass balance
- Dropping pipette

Data

Methyl salicylate is also known as *oil of wintergreen* and is found in wintergreen, Germolene™ and Ralgex™ ointments.

Ethyl ethanoate is a solvent used in modelling paints and glue.

Analysis of results

- Record your observations in an appropriate form.
- Write an equation for each reaction.

From the examiner…

- You should be able to draw the ester produced from a particular alcohol/carboxylic acid combination.
- You should be able to name the esters correctly.
- You should appreciate that the conc sulfuric acts as a catalyst.
- Know some uses for esters.

Questions

1. In these reactions the OH in the carboxylic acid is lost to water. Suggest how this could be proved using ^{18}O.
2. Draw displayed formulae for ethanol and propanoic acid and ring the atoms which produce the water molecule.
3. Describe the flavours/smells for the esters you have made – two are already described in the data section.

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Notes

- Conc sulfuric acid should be dispensed from a fume cupboard.
- The students should be instructed *not* to add water to a spillage of conc sulfuric acid on the skin.
- If time is restricted, the teacher may wish to dictate the alcohol/carboxylic acid combinations.

From the examiner…

- You should be able to draw the ester produced from a particular alcohol/carboxylic acid combination.
- You should be able to name the esters correctly.
- You should appreciate that the conc sulfuric acts as a catalyst.
- Know some uses for esters.

Answers

1. If ethanoic acid with the isotope ^{18}O incorporated into it is used, the water molecules formed will also contain the ^{18}O isotope as $H_2{}^{18}O$. A peak at 20 in a mass spectrometer will be obtained.

2. $CH_3CH_2O\text{-}H$ $H\text{-}O\text{-}CO.CH_2CH_3$

3. Butyl butanoate: pineapple
   Ethyl butanoate: banana; pineapple; strawberry
   Ethyl cinnamate: cinnamon
   Methyl ethanoate: peppermint
   Methyl butanoate: pineapple; apple
   Methyl cinnamate: strawberry
   Pentyl ethanoate: apple; banana
   Pentyl butanoate: apricot; pear; pineapple
   Propyl ethanoate: pear

4. Alcohols react with carboxylic acids to make long chain compounds with ester functional groups.

5. $n\ HOCH_2{\cdot}CH_2{\cdot}CO.OH = [\ OCH_2{\cdot}CH_2{\cdot}CO.O\ ]_n$

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Requirements per student*/group of students	Notes
Conc sulfuric acid	Dispensed from a fume cupboard
A range of alcohols	Methanol, ethanol, propan-1-ol, propan-2-ol, butan-1-ol, pentan-1-ol
A range of carboxylic acids	Ethanoic acid, butanoic acid, salicylic acid, cinnamic acid
3 x boiling tubes	
Large beaker to act as a water bath	Kettles
250 cm^3 beaker for the cold water	
0–100 °C thermometer	
Stirring rod	
1 x 10 cm^3 measuring cylinder per liquid chemical	Or graduated dropping pipette with pipette filler to measure 1 cm^3
Spatula	
Mass balance accurate to at least 0.01 g	
Dropping pipette for sulfuric acid	

Notes

Butanoic acid has a very unpleasant smell which will linger in the laboratory and the teacher may wish not to use this carboxylic acid. Propanoic acid is a possible substitute.