# EXPERIMENT: PREPARATION OF TWO ESTERS

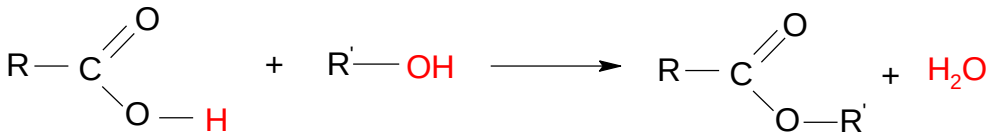
## INTRODUCTION

Esters are sweet smelling substances most of which are found in nature as components of flowers, fruits and natural essences. Others are manufactured synthetically as artificial flavours and scents.

In this experiment we will make two different esters and compare their smell as well as their chemical structure.

## BACKGROUND TO ESTERIFICATION REACTIONS

Esterification involves the chemical reaction between an alcohol and an organic (carboxylic) acid. This type of reaction is also known as a ***condensation reaction*** so named because water is also produced during the reaction and two functional groups are reacting.
A general equation for the reaction, using structural formulae is as follows:




**R** represents the carbon chain of the carboxylic acid while **R'** represents the carbon chain of the alcohol.

The reaction is usually carried out at higher than room temperature (about $100^0$C in this case) and in the presence of a catalyst.

Esters are named by putting the alkyl group of the alcohol first, followed by the alkyl group of the acid.

**For example:**

If propanol and methanoic acid were reacted, the ester would be *propyl methanoate*.

## AIM

To produce and compare two different esters.

## MATERIALS

- Large test tubes
- Electric hot plate or Bunsen burner with tripod and wire gauze
- 10 mL measuring cylinder
- Stirring rod
- Retort stand with clamp
- Beakers (600 mL and 100 mL)
- Boiling chips
- Pasteur pipettes
- 18.0 M sulphuric acid ($H_2SO_4$)
- Butanoic acid ($CH_3CH_2CH_2COOH$)
- Methanoic acid ($HCOOH$)
- Ethanol ($CH_3CH_2OH$)
- Methanol ($CH_3OH$)

## METHOD AND SAMPLE RESULTS

### First ester

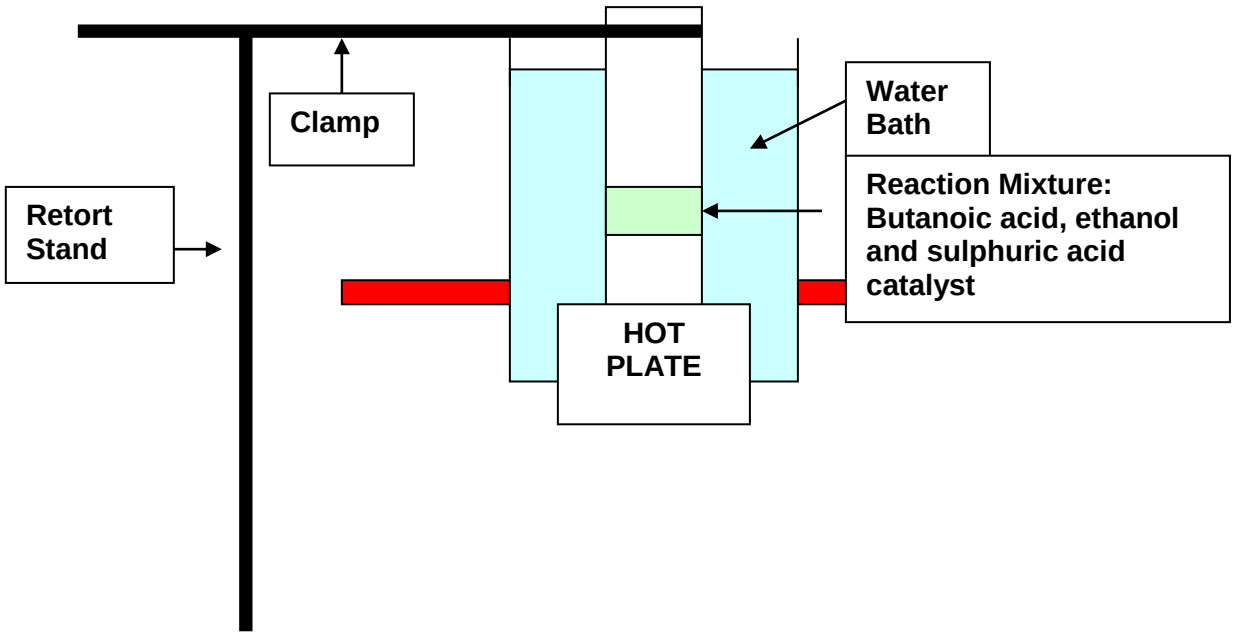
The first ester will be produced by reaction ethanol and butanoic acid according to the following method:

1. Set up a water bath with a three quarter filled 600 mL beaker with water on top of a hot plate (see diagram below). Alternatively, a Bunsen burner with tripod and wire gauze can be used. Set the temperature to boiling.

2. In a large test tube add 3 mL of butanoic acid followed by the same volume of ethanol.

3. With a Pasteur pipette add approximately 1 mL of 18 M sulphuric acid to the mixture (Careful! Acid is very corrosive) and stir using a glass rod.

4. Add a few boiling chips to the mixture and suspend over the water bath using a retort stand and clamp as shown in the diagram below:




5. While the mixture is being heated for around 10 minutes, place about 20 mL of distilled water into a 100 mL beaker

6. At the end of the 10 minutes remove the butanoic acid/ethanol mixture from water bath and add content to 100ml beaker containing distilled water. Carefully waft fumes to smell the odour coming from the 100 mL beaker and record your observations. Also, make a note of the appearance of the water and the ester in the beaker.

   **Sample results**
   A distinct odour should be noticed, which should be different from the other ester produced in the second phase of the experiment.
   The ester should be noticed to float on top of the water with a slightly "oily" appearance.

7. Record the name of the ester.

### Second ester

Repeat the procedure again this time using methanol and methanoic acid. Do not forget to add the concentrated sulfuric acid to the mixture before heating.

**Note:**

Other combinations of acids and alcohols may be used depending on availability and time constraints.

## SAMPLE RESULTS

The name of the first ester is ethyl butanoate

The odour of the second ester should be markedly different from ethyl butanoate.
The name of this ester is methyl methanoate.

## SAFETY

- Safety goggles should be worn throughout the experiment.
- Safety gloves and protective clothing should also be worn, especially when handling the concentrated sulphuric acid or if using ethanoic acid (acetic acid). Dispense these in a fume hood.
- If using a Bunsen burner instead a hot plate, avoid water boiling over the bench and the apparatus.
- Do not directly sniff the test tubes carefully waft some of the vapours towards you. Teachers will demonstrate the correct procedure.

# DISCUSSION QUESTIONS

**QUESTION 1**
State the purpose of adding the concentrated sulfuric acid.

**QUESTION 2**
Suggest why the esters are not very water-soluble.

**QUESTION 3**
Write equations for each of the esterification reactions

**QUESTION 4**
Draw a structural formula for each of the esters formed in the experiment.

# SOLUTIONS TO DISCUSSION QUESTIONS

**QUESTION 1**

The concentrated sulfuric acid acts as a catalyst for the reaction.

**QUESTION 2**

Both carboxylic acids and alcohols have polar groups (-OH), which are capable of forming hydrogen bonds with water molecules, thus making them completely soluble. In esters, these polar groups are used to join the two reacting molecules, which lose their polarity. Esters are unable to form hydrogen bonds with water molecules and are therefore insoluble.

**QUESTION 3**

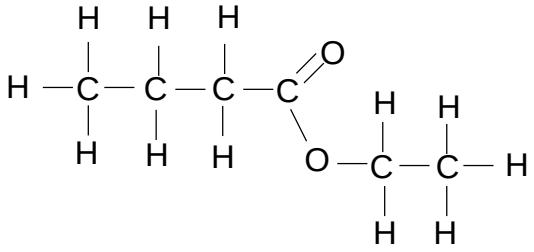
For ethyl butanoate:

$$CH_3CH_2CH_2COOH(aq) + CH_3CH_2OH(aq) \rightarrow CH_3CH_2CH_2COOCH_2CH_3(l) + H_2O(l)$$

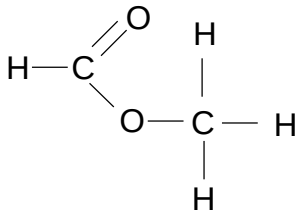
For methyl methanoate:

$$HCOOH(aq) + CH_3OH(aq) \rightarrow HCOOCH_3(l) + H_2O(l)$$

**QUESTION 4**



Ethyl butanoate



Methyl methanoate