

2.7 – Alcohols and carboxylic acids

Industrial preparation of ethanol

Hydration of ethene

Ethene, obtained on a large scale by cracking hydrocarbons produced from petroleum, reacts with steam to produce ethanol.



The conditions used are a temperature of about 300 °C, a pressure of 60-70 atm and a catalyst of phosphoric acid.

Fermentation

In this process sugars are converted into ethanol. Sugar, e.g. glucose, is dissolved in water, yeast is added, and the mixture is left in a warm place. Yeast contains enzymes that catalyse the reaction.



CO₂ escapes as a gas but the ethanol (boiling temperature 78 °C) has to be separated from the remaining liquid mixture by distillation.

Biofuels

These are fuels that are produced from living organisms. The two main types are bioethanol, obtained from sugars, and biodiesel, obtained from oils and fats.

Advantages

They are **renewable**. Plants can be grown each year and biofuels can also be produced using waste materials from animals.

They are **carbon neutral**. Although CO₂ is produced in exactly the same way by biofuels as fossil fuels when combusted, CO₂ is taken in by plants when they are grown during photosynthesis.

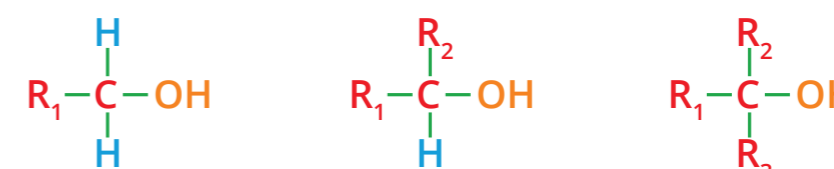
Disadvantages

Land use. Land that is used to produce plants for biofuels cannot be used to produce food. Some environmentally significant areas, such as forests, are being destroyed to create land for biofuel production.

Use of resources. Growing crops suitable for biofuels needs large quantities of water and fertilisers. The use of water can strain local resources and the use of large quantities of fertilisers can cause water pollution.

Alcohols have the general formula C_nH_{2n+1}OH. An alcohol can be primary, 1°, secondary, 2° or tertiary, 3°.

In 1° alcohols the carbon attached to the -OH is joined to one alkyl group. In 2° alcohols it's joined to two alkyl groups. In 3° alcohols it's joined to three alkyl groups.



1° alcohol

2° alcohol

3° alcohol

In everyday language, ethanol is called alcohol since it is present in alcoholic drinks.

Reactions of alcohols

Dehydration

Many alcohols can be dehydrated to form alkenes, e.g.



The most common dehydrating agents are concentrated sulfuric acid or heated aluminium oxide.

Oxidation

Acidified potassium dichromate(VI) (K₂Cr₂O₇/H₂SO₄) is used as the oxidising agent.

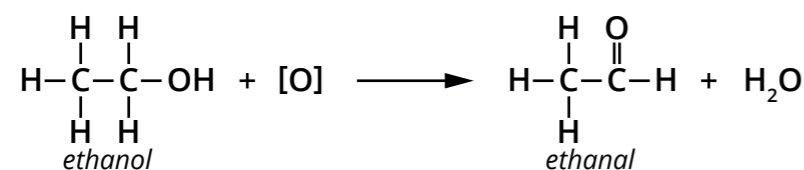
Primary alcohols are oxidised to aldehydes and then to carboxylic acids. Secondary alcohols are oxidised to ketones only. Tertiary alcohols are not oxidised. In these reactions the dichromate(VI) ion, Cr₂O₇²⁻, changes colour from orange to green. This colour change can be used as a test to distinguish tertiary alcohols from primary and secondary alcohols.

In equations showing oxidation, you can use [O] to represent the oxidising agent.

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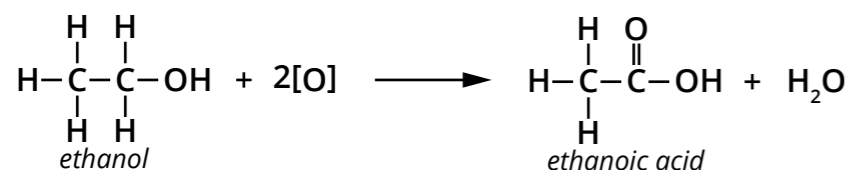
Primary alcohols

Gently heating a 1° alcohol with potassium dichromate(VI) solution and sulfuric acid should produce an aldehyde.

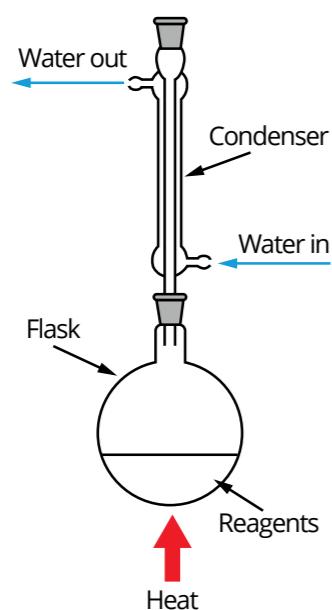


It's hard to control the amount of heat, and ethanal is usually further oxidised to ethanoic acid. To avoid this, you need to use **distillation** apparatus so that the ethanal (which boils at a lower temperature than ethanol) is distilled off immediately.

If the alcohol is mixed with excess oxidising agent and heated under **reflux**, the carboxylic acid forms.

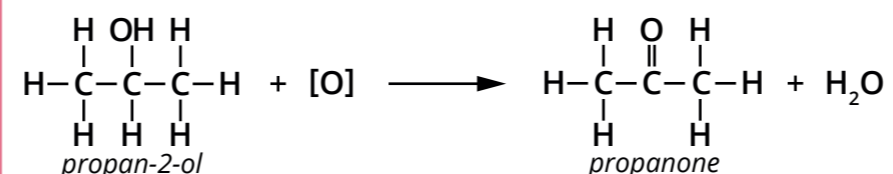


Heating under reflux means you can increase the temperature of a reaction to boiling without losing any reactants or products. Any vaporised compounds are cooled, condense and drip back into the reaction mixture.



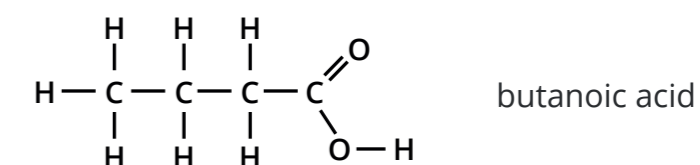
Secondary alcohols

Refluxing with $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ will produce a ketone.



Carboxylic acids

Carboxylic acids have a COOH group at the end of their carbon chain. The suffix for carboxylic acids is *-oic*, and you add the word 'acid' to the end of the name.



Reactions

1. As an acid

Carboxylic acids are weak acids but react in a similar way to strong acids to form salts with bases/alkalis and carbonates/hydrogencarbonates.

a. Bases and alkalis

They neutralise carboxylic acids to form a salt and water.



b. Carbonates and hydrogencarbonates

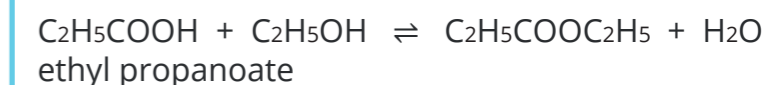
They react to form a salt, water and carbon dioxide.



Since a gas is produced, effervescence is seen and the gas can be shown to be CO_2 by testing with limewater. This is the test for carboxylic acids.

2. Esterification

Carboxylic acids react with alcohols to produce an ester and water. This reaction is catalysed by concentrated sulfuric acid.



If a pure sample of the ester is needed, the carboxylic acid, alcohol and concentrated sulfuric acid are heated together in a flask attached to a condenser, so the ester is removed by **distillation** as soon as it is formed.

