THE ALKANOLS (ALCOHOLS)

(General formula: $C_nH_{2n+1}OH$)

The alkanols are a large group of chemicals with a wide range of uses. Ethanol and the other alkanols undergo a number of reactions based on the presence of the hydroxyl (-OH) functional group.

Reactions with More Reactive Metals

Highly reactive metals such as sodium, lithium and calcium, react with low molecular mass alkanols, such as methanol, ethanol and propanol. These reactions give hydrogen gas and salts of the alkanols, called alkoxides. The equation for the reaction of ethanol with sodium metal is:

$$2Na_{(s)} + 2CH_3CH_2OH_{(l)} \rightarrow 2CH_3CH_2O^-Na^+_{(s)} + H_{2\,(g)}$$

Sodium ethoxide

This reaction is similar to that of sodium and water, but is less vigorous.

Oxidation of Alkanols

Powerful oxidizing agents, such as acidified potassium dichromate (VI) or acidified potassium manganate (VII), convert alkanols to organic acids. In these reactions, an intermediate alkanal (or aldehyde) is formed.

$$CH_3CH_2OH(l) + [O] \xrightarrow{warm\ KMnO_4/H^+} H_2O + CH_3CHO(l)$$

Ethanal (intermediate)

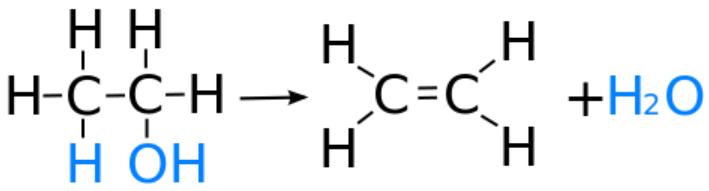
$$CH_3CHO(l) + [O] \xrightarrow{warm\ KMnO_4/H^+} CH_3COOH(aq)$$

Ethanoic acid

During this reaction, the reaction mixture changes from purple to colourless. The same reactions take place with potassium dichromate (VI), but the colour change is from orange to green.

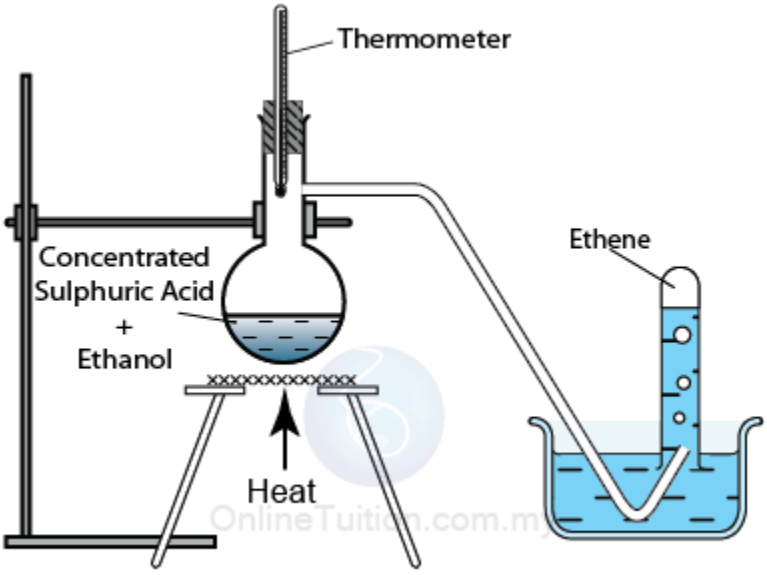
Dehydration of Alcohols to form Alkenes

Alkanols react with dehydrating agents, such as concentrated sulphuric acid or anhydrous aluminium oxides, to form alkenes. The reaction is described as a dehydration. The water is lost across two adjacent carbon atoms in the alkanol. This results in the formation of a double bond between the two carbon atoms.

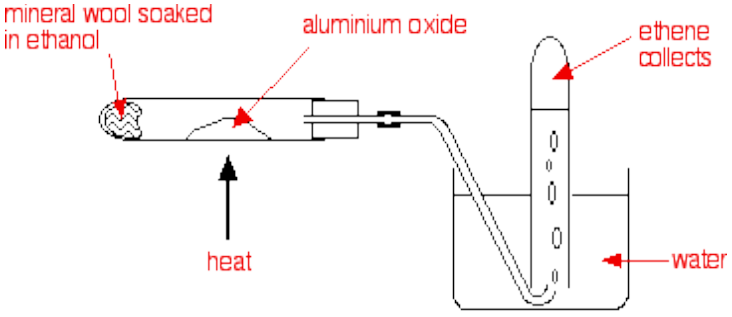


Dehydration can be achieved by:

- Heating the ethanol with excess concentrated sulphuric acid at a temperature of 170°C;



- Passing ethanol vapour over activated alumina (Al_2O_3) heated to 450°C.



Conversion of Alkanols to Esters

Another reaction of alkanols is their conversion to esters.

$$Alkanoic\ acid + alkanol \overset{conc.H_2SO_4}{\Longleftrightarrow} ester + water$$

Combustion of Alkanols

The combustion of alkanols is a highly exothermic reaction; hence the use of alkanols, especially methanol and ethanol, as fuel. Ethanol burns with a blue flame to yield carbon dioxide and water.

$$2CH_3OH_{(l)} + 3O_{2\,(g)} \rightarrow 2CO_2 + 4H_2O_{(g)} + heat$$
$$C_2H_5OH_{(l)} + 3O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 3H_2O_{(g)} + heat$$

These equations represent the complete combustion of the alkanols. In an insufficient supply of oxygen, carbon monoxide, carbon and even hydrogen may be formed. This is similar to the combustion of hydrocarbons.

Properties and Uses of Alkanols

Like water, ethanol is a polar covalent compound. However, when compared with water, it has a higher molar mass and higher heat of combustion, but lower melting and boiling points. The boiling point of water is 100°C, whereas the boiling point of ethanol is 78°C. This suggests that the intermolecular forces are weaker in ethanol than in water. Ethanol is therefore a more volatile liquid than water.

These properties make ethanol useful as:

- a solvent;
- a fuel;
- a germicide;
- an antifreeze.

Uses of Ethanol

- Ethanol is a solvent with a wide range of uses:

- Ethanol dissolves a wide range of substances, both polar and non-polar.
- Ethanol dissolves many compounds that do not readily dissolve in water, so it is a complementary solvent to water.
- Many useful products are obtained by dissolving suitable substances in ethanol or ethanol-based solvents. Among these are paints, thinners and polish, inks, lacquers and varnishes, adhesives, deodorants and colognes, and a wide range of pharmaceutical preparations.
- Ethanol's volatility makes its removal as a solvent easy.
- Ethanol's miscibility with water allows it to act as a solvent in reactions between ionic and covalent substances.

- Large amounts of energy are released when alkanols are burnt. Alkanols, particularly ethanol, are finding increasing use as fuels or fuel substitutes for transport and in industry. In the Caribbean, ethanol is mixed with gasoline to produce gasohol, which is used as an automobile fuel called E10. E10 is gasoline blended with 10% ethanol. The ethanol contains oxygen, which raises the octane level of gasoline to prevent engine knocking.

Production of Rum

Ethanol, the main ingredient in many alcoholic drinks such as beer, wine and rum, is obtained by the anaerobic fermentation of grapes, sugar, molasses and other carbohydrate materials. In the Caribbean, molasses, which is a by-product of cane sugar manufacture, is frequently used in fermentation.

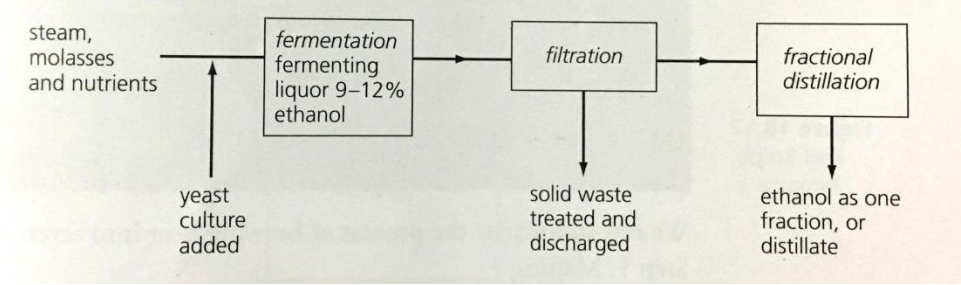
The fermentation process can be summarized as follows:

$$sugar, starchy\ materials\ or\ molasses + enzymes\ supplied\ by\ yeast \rightarrow ethanol + carbon\ dioxide$$

$$C_6H_{12}O_6 \xrightarrow{enzymes;37^{\circ}C} 2C_2H_5\,OH + 2CO_2$$

Yeasts are unicellular fungi and are the source of the enzymes that are necessary for fermentation. Yeast cells grow rapidly and bud freely if sucrose, water, specific nitrogen sources, vitamins and mineral salts are present.

The figure below summarizes the stages in the manufacture of rum from molasses. The final distillation can be controlled to obtain ethanol for either industrial purposes (99.6% ethanol) or rum (40% ethanol).



The distillate is processed further. Some flavours are removed during the processing and the raw spirit is matured in oak casks before it acquires the characteristics (colour and taste) of rum.

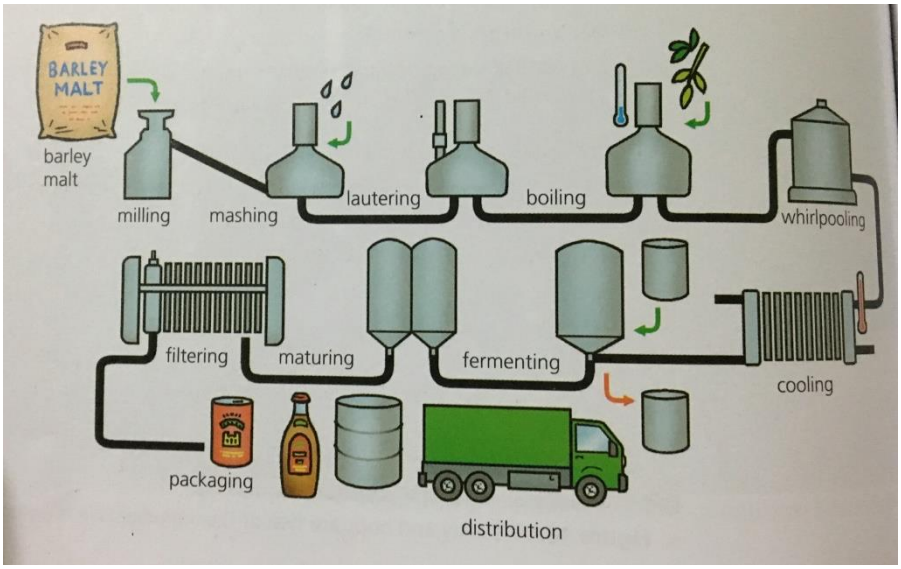
Production of Beer

Beer is an alcoholic beverage that is brewed mainly from malted barley. Barley is a cereal grain. Other ingredients involved in the brewing process include hops, yeast and water. Fruit, wheat and spices are sometimes also used. During the brewing process, the yeast turns the sugars in malt into alcohol, and the hops provide the bitter flavours in beer and the flowery aroma.

The process of beer-brewing is summarized below into seven (7) major steps:

1. Malting
2. Mashing
3. Fermentation
4. Storage
5. Filtration
6. Pasteurization
7. Packaging

The following flowchart shows the steps involved in brewing:



The Effects of Ethanol on the Body

Ethanol can have both short-term and long-term effects on the body. Many of the immediate effects are linked to the small size of the ethanol molecule, which allows it to pass through the lining of the stomach, and directly into the bloodstream. This is particularly the case if ethanol is consumed on an empty stomach. Body mass, size of liver, gender and type of alcoholic drink all influence how rapidly the effects of drinking ethanol become evident.

Some of the short-term effects are:

- initial relaxation
- euphoria
- loss of inhibitions
- impaired co-ordination
- slowed reflexes
- slowed mental processes
- attitude changes

Ethanol is a toxic drug. A concentration of 4 parts per 1,000 in the blood can lead to a deep anaesthetic effect or even death. When a person consistently consumes more ethanol than the body can break down, there is a significant rise in the blood ethanol level, which leads, among other things, to:

- impaired circulation
- accumulation of toxins
- excessive loss of fluids via urination

- problems of digestion, hence stomach problems
- malfunction of organs such as the pancreas, liver and brain in the long term

In addition, many common drugs, e.g. aspirin and antihistamines, contain ingredients that react unfavourably with ethanol. The simultaneous use of ethanol and such drugs can lead to complicated health problems.