

CARBOXYLIC ACIDS & ESTERS



Name Form

CARBOXYLIC ACIDS	CARBOXYLATE IONS	ESTERS
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H}$	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}^-$	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{R}'$
$\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H}$	$\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}^-$	$\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{CH}_2-\text{CH}_3$
$\text{CH}_3-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H}$	$\text{CH}_3-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}^-$	$\text{CH}_3-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{CH}_3$

Carboxylic acids as weak acids

- Carboxylic acids are weak acids.

$$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H} + \text{H}_2\text{O} \rightleftharpoons \text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}^- + \text{H}_3\text{O}^+$$

- They react with bases, such as carbonates and alkalis like other acids do, producing carboxylate salts. With carbonates and hydrogencarbonates, they give off carbon dioxide gas.

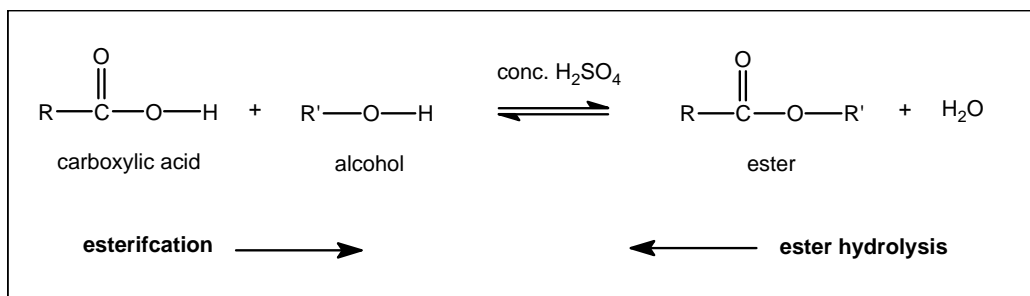
e.g. sodium hydroxide + ethanoic acid →

e.g. sodium carbonate + propanoic acid →

e.g. potassium hydrogencarbonate + methanoic acid →

Esters

- Carboxylic acids react with alcohols in the presence of strong acid catalysts (such as concentrated sulphuric acid) to form esters (**esterification**).



e.g. ethanoic acid + propan-1-ol \rightarrow

e.g. propanoic acid + methanol \rightarrow

e.g. methanoic acid + ethanol \rightarrow

e.g. benzenecarboxylic acid + butan-2-ol \rightarrow

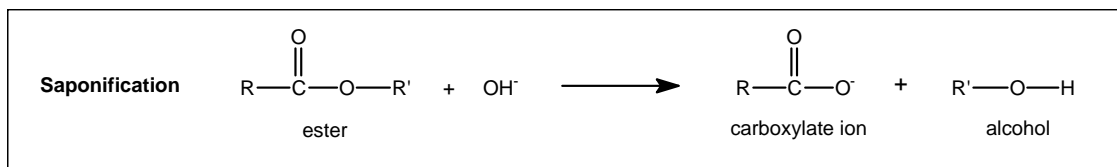
- The reaction is an equilibrium.
- The acid acts as a catalyst (for both reactions).
- Both forward and reverse reactions are very slow in the absence of the catalyst, although they are still quite slow in the presence of the catalyst.
- The C-OH bond of the carboxylic acid breaks, not the C-OH bond of the alcohol - so the O of the OR' ester group is the O from the alcohol.

Uses of esters

- a) *Food flavourings*
- Esters are responsible for the smell and flavour of many fruits and flowers.
 - They are used as artificial flavourings.
- b) *Solvents*
- Solvents for antibiotics, drugs, glues, printing inks, etc.
- c) *Plasticisers*
- Plasticisers are incorporated into plastics to improve flexibility.

Ester hydrolysis

- The reverse reaction is called **ester hydrolysis**, again catalysed by strong acid (or alkali), producing a carboxylic acid and an alcohol.
- If ester hydrolysis is carried out in the presence of alkali, then the carboxylic acid formed reacts with the alkali to form a carboxylate salt, and the reaction is known as **saponification**.
- The reaction is slow so the ester and alkali are normally boiled together.

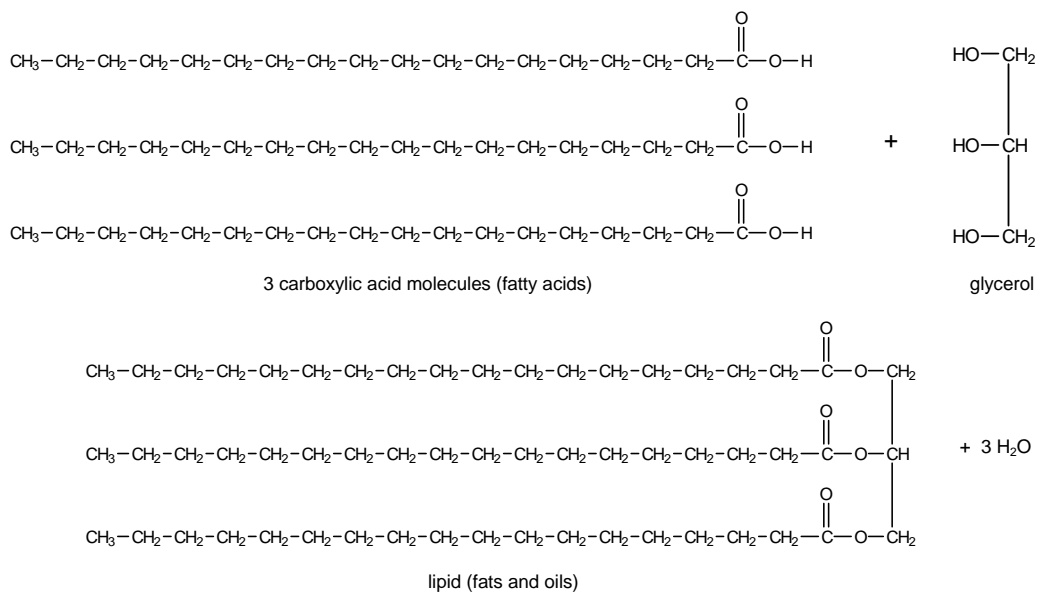


e.g. propyl ethanoate + potassium hydroxide →

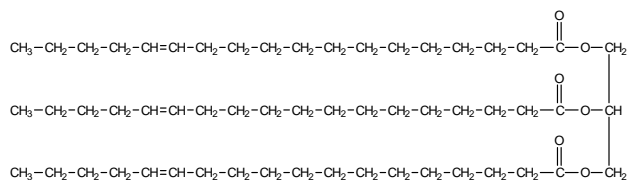
e.g. methylethyl methanoate + sodium hydroxide →

Fats and oils

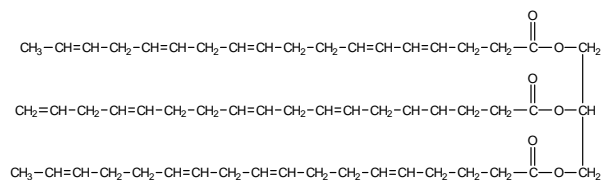
- Fats and oils (**lipids**) are naturally occurring esters of the alcohol glycerol, which has three -OH groups, and three carboxylic acids (known as fatty acids). The three fatty acids do not have to be the same.



- In a **saturated** fat, the fatty acid part of the molecule contains no C=C bonds.
- In a **monounsaturated** fat, each fatty acid part of the molecule contains one C=C bond.
- In a **polyunsaturated** fat, each fatty acid part of the molecule contains several C=C bonds.

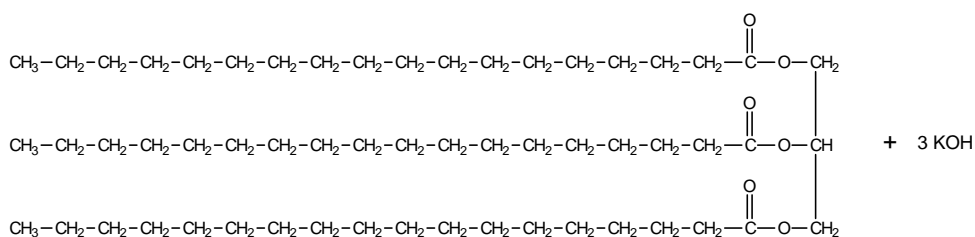


monounsaturated fat

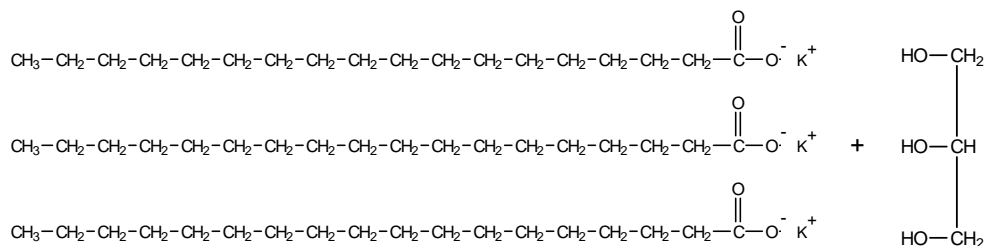


polyunsaturated fat

- The more unsaturated the fat, the lower its melting point. Saturated fats are solids at room temperature, while polyunsaturated fats are liquids at room temperature.
- Fats that are liquids at room temperature are called **oils**.
- Margarine is made by reacting polyunsaturated fats (e.g. sunflower oil) with hydrogen over a nickel catalyst to form solid saturated fats.
- Esters are hydrolysed by alkalis to form glycerol and carboxylic acid salts. In the case of fats and oils, this forms glycerol and fatty acid salts. Soap is fatty acid salts and is made by boiling fats and oils with potassium hydroxide.



lipid (fats and oils)

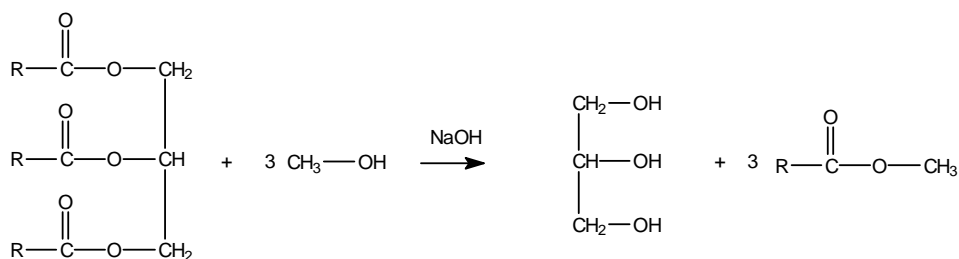


soap (fatty acid salts)

glycerol

Biodiesel

- Biodiesel is made from vegetable oils by reaction with methanol and sodium hydroxide. In the UK, rapeseed oil is the most common vegetable oil.



- In effect, the vegetable oil is hydrolysed by the sodium hydroxide to form the fatty acid salt which is then converted into the methyl ester by reaction with sodium hydroxide.
- The methyl ester of the fatty acid formed can be used in most diesel engines in place of diesel derived from crude oil.
- The advantages of biodiesel over diesel are that it is renewable and carbon neutral, but massive amounts of farm land are needed to make the vegetable oil.