Chem Factsheet

www.curriculumpress.co.uk Number 58

Applied Organic Chemistry

Before working through this Factsheet you should ensure that you understand all the organic chemistry covered so far on AS and A2

This Factsheet concentrates on the uses of organic chemistry to produce:
- pharmaceuticals
- fertilisers
- esters, oils and fats
- soaps and detergents
- polymers

After working through this Factsheet you will have met
- the use and impact of fertilizers in modern agriculture
- the concept of pharmaceuticals being chemical compounds used in medicine based on their structure
- examples and uses of esters, oils and fats
- the making of soaps
- some polymers, their impact on the environment and biodegradability

***Exam Hint** – In this area of the A2 specifications you need to learn the basic facts – there is no shortcut to learning thoroughly the information provided!*

1. Pharmaceuticals (Drugs used as medical treatments)
Drugs need to be targeted to particular parts of the body and there are two major groups to consider:

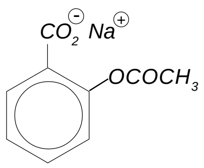
(a) **Water soluble** - go into the blood and aqueous tissue of the body. They are soluble because they have ionic groups (e.g. COO^-Na^+) or groups which form hydrogen bonds (e.g. $-NH_2$, -OH).

They are called '**hydrophilic**' groups (literally 'water liking').

(b) **Fat soluble** - go into fatty tissue. They are soluble in fat because they have '**lipophilic**' groups (literally 'fat liking') on the molecule (e.g. alkyl side chains – $CH_2CH_2CH_2CH_2CH_3$).

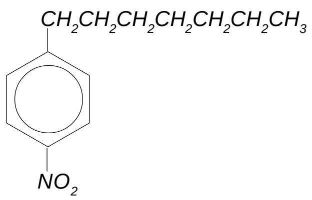
***Exam Hint** - In your revision, focus on learning the hydrophilic and lipophilic groups so when presented with an unknown molecule you will be able to say if it is soluble in water or fat.*

e.g.



*Note the presence of the ionic side-chain that will make the molecule **water-soluble**.*

e.g.



*The long side chain makes this molecule **soluble in fat**.*

2. Nitrogenous fertilizers
Plants need to take in nitrogen to produce proteins and nucleic acids. Green plants can only do this by taking in the inorganic nitrate ion, NO_3^-.

Fertilizers do not need to contain the nitrate ion if they contain the ammonium ion, NH_4^+ because,

$$NH_4^+ \xrightarrow[\text{soil bacteria}]{\text{oxidised by}} NO_3^-$$

You need to remember the above basic facts as well as the fact that the nitrate ion needs to be **dissolved in water** for plants to be able to absorb it.

Fertilizers are best remembered in three categories:
(a) **Natural organic fertilizers** e.g. manure, compost, dried blood. These natural materials have been used for thousands of years and, apart from producing nitrates by being broken down by bacteria, they also improve the quality of the soil.

- **ADVANTAGES** - slow release of the nitrate ion so no damage to plants and they also improve soil quality generally.
- **DISADVANTAGES** - low solubility in water; the time taken to break them down to the nitrate ion; low nitrogen content.

(b) **Manufactured inorganic fertilizers** e.g. potassium nitrate, KNO_3; ammonium nitrate, NH_4NO_3; ammonium sulphate, $(NH_4)_2SO_4$.

The need to produce more food because of increasing world population led to the development of inorganic fertilizers. They could be made as powders or pellets for easy spreading over the ground.

- **ADVANTAGES** - higher nitrogen content and soluble in water (ionic) encouraging quick plant growth.
- **DISADVANTAGES** - being very soluble, they can be washed through the soil ('leached') and cause 'eutrophication' (excessive plant growth in rivers/ponds which leads to bacterial growth which lowers the oxygen content and affects aquatic life) before they are broken down.

If they remain in the soil, they are released in 'one dose'and can damage the plant with a too high concentration of nitrate – they need to be applied in carefully measured amounts.

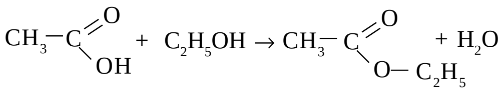
N.B. The slower breakdown of the ammonium ion, NH_4^+ by soil bacteria has to be balanced against the 'leaching out' effect and the concentration of the fertilizer applied.

(c) **Manufactured organic fertilizer** e.g. urea, H_2NCONH_2
Urea is an intermediate between the 'natural organic' and the 'manufactured inorganic' fertilizers. Urea is a manufactured organic fertilizer.

- **ADVANTAGES** - very soluble in water; high nitrogen content (47%) compared to other fertilizers; releases its nitrogen slowly by hydrolysis (i.e. reaction with water) $(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$
- **DISADVANTAGES** - its high solubility means it can be 'leached away' by rainwater.

3. Esters, oils and fats

***Remember**: Carboxylic acid + alcohol → ester + water*

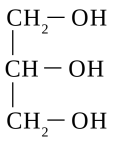


Oils and **Fats** are **both naturally occurring esters.**

The difference is the source:

OILS - from vegetables and marine animals e.g. whales

FATS - from land animals



The commonest ester is based on the alcohol propane – 1,2,3 – triol (glycerol), The triol then reacts with a variety of long-chain carboxylic acids e.g. stearic acid, $CH_3(CH_2)_{16}CO_2H$.

The esters formed are commonly called glycerides.

Fats have higher melting points than oils. This is because the acids that form the esters are saturated (no double bonds). These saturated chains can pack together easily so creating greater intermolecular forces and increasing melting points.

If **unsaturated** acids are used to make the ester, geometric isomerism (cis and trans) is present but mainly the cis-form. This makes packing of side-chains less easy, leading to the lower melting points of oils.

The result of this is that:

FATS tend to be **SOLIDS**

OILS tend to be **LIQUIDS**

If acids forming the esters have more than one double bond, the ester is described as '**polyunsaturated**' – a term you will have heard in connection with foodstuffs like margarines.

4. Soaps and detergents

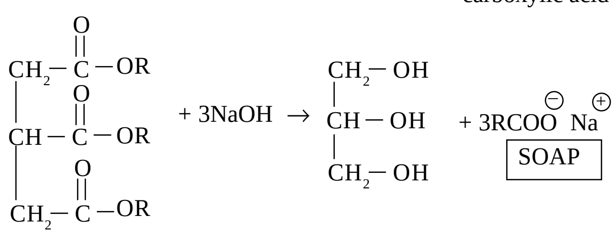
Soaps are directly linked to fats and oils because,

oil or fat	+	sodium hydroxide	→	propane-1,2,3-triol	+	salt of a carboxylic acid / SOAP

This is **alkaline hydrolysis** of **esters**.

The process is called **saponification** i.e. 'soap-making'

e.g. ester + alkali → alcohol + salt of a carboxylic acid



You make different types of soap depending on the oil or fat (the ester) you start with.

Modern detergents have gradually replaced soaps over the past fifty years. This is because detergents are more soluble in water and do not form scum in 'hard' water (as soap does). Detergents are made using acid instead of alkali.

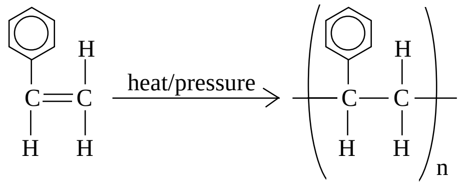
5. Polymers and biodegradability

There are two types of polymers:

(a) Addition polymers

The **monomers** contain a double bond which undergoes **electrophilic addition.**

e.g.

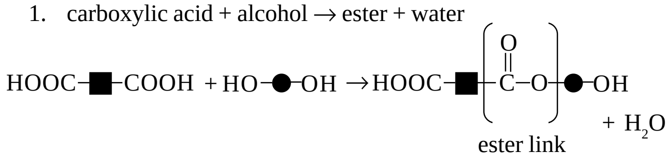


(b) Condensation polymers

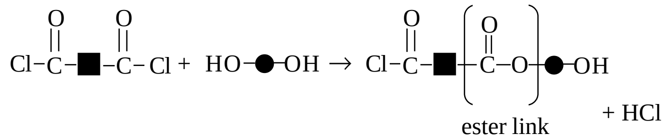
The **monomers** have **different functional groups** which react together to form the **link** in the **polymer** and release H_2O or **HCl**.

Four examples need to be learned:

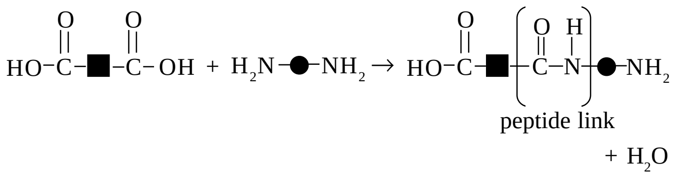
1. carboxylic acid + alcohol → ester + water



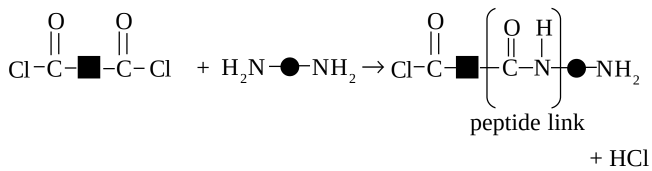
2. acyl chloride + alcohol → ester + hydrogen chloride



3. carboxylic acid + amine → + water



4. acyl chloride + amine → amide + hydrogen chloride



From the above four examples, you will see how the molecules can continue linking on to form the long polymer chains.

This will form **polyamides** (e.g. nylon) and **polyesters** (e.g. terylene).

The disposal of polymers (e.g. plastics) has been a long-term problem!

BURNING - produces poisonous fumes e.g. sulphur dioxide, and carbon dioxide i.e. contributes to the 'greenhouse effect' and so global warming.

LANDFILL SITES - plastics don't 'break down' so provide bulk which increases the amount of volume needed for landfill sites for waste disposal.

'Biodegradable polymers' (i.e. those that are broken down by bacterial attack when buried in the ground) have been developed. Research continues to address the problem of disposing of plastics.