Edexcel Chemistry A-Level

Topic 17: Organic Chemistry II

Detailed Notes

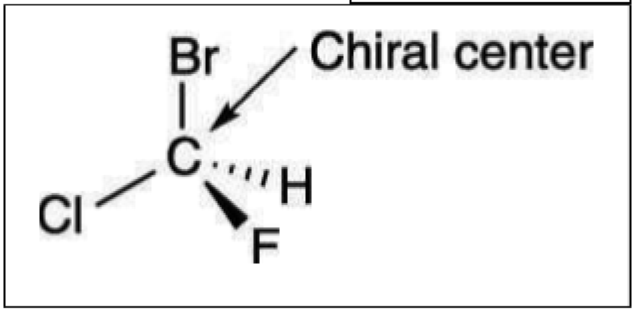
Topic 17A: Chirality

Chiral Centres

A chiral centre is a carbon atom with **four different groups** bonded around it so there is **no line of symmetry** to the molecule.

Example:

Image courtesy of Dummies.com

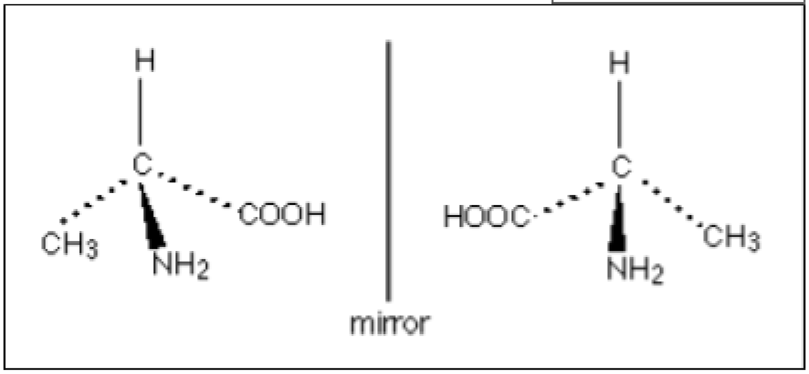


The chiral centre is commonly **indicated using *** next to the asymmetric carbon.

Optical Isomers

Optical isomerism is a type of **stereoisomerism** where molecules have the **same molecular formula** but different **spatial arrangement** of atoms.
The presence of a chiral centre leads to the presence of **two possible isomers** that are **mirror images** of each other. These are optical isomers.
Example:

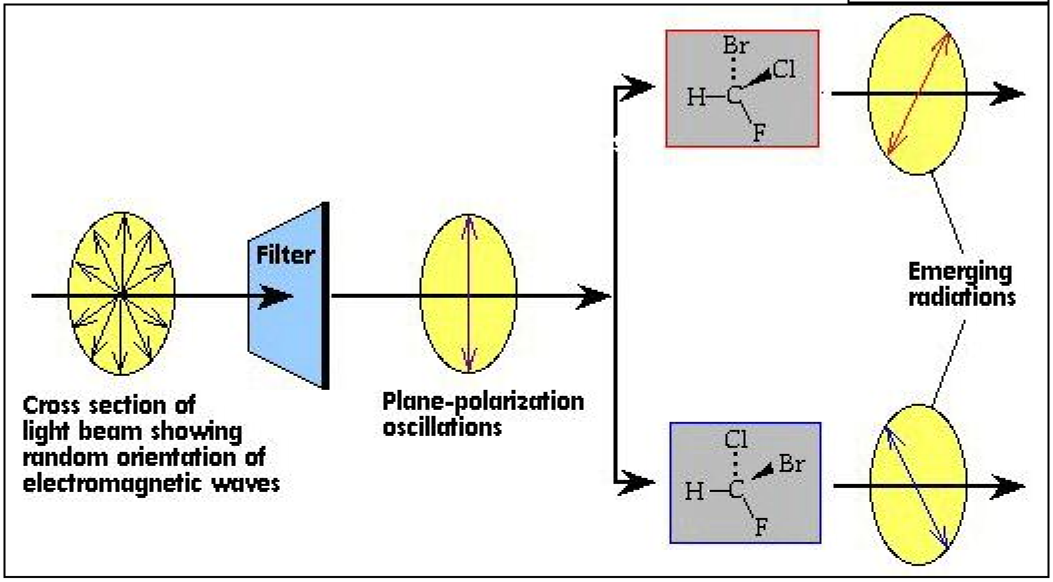
Image courtesy of Chemguide



The two different isomers are called **enantiomers** and are unique due to their effect on **plane polarised light**. Each enantiomer causes the rotation of plane polarised light by **90° in opposite directions.**

Example:

Image courtesy of Pinterest



Racemic Mixtures

A **racemate** is formed when optical isomers are produced as a **pair of enantiomers** in a **1:1 ratio**. The optical rotational effect on polarised light caused by each enantiomer causes the overall effect to be **zero** as the opposite directions of rotation cancel out. As a result the mixture produce is **optically inactive**, known as a racemic mixture.

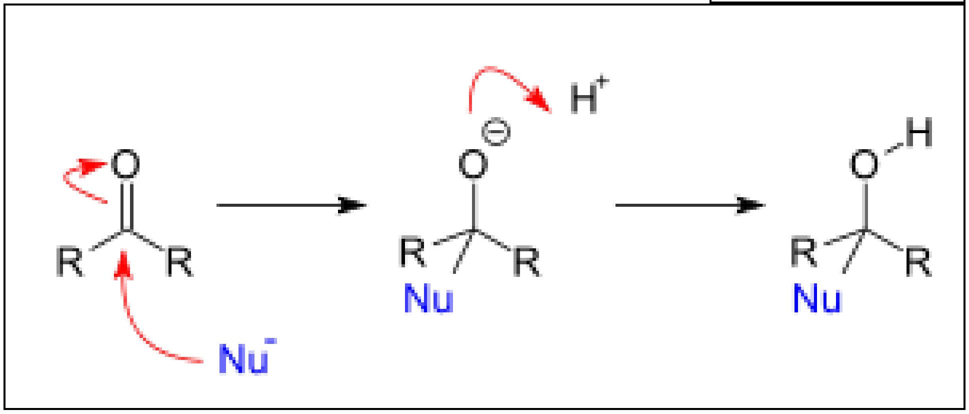
These two isomers are able to form in this way due to a **nucleophilic addition reaction**.

Nucleophilic Addition

In these reactions, nucleophiles are able to attack a molecule with a **carbonyl group** from **above or below** the carbon-oxygen double bond. This means the two possible products of the reaction are **mirror images** and therefore **optical isomers**.

Mechanism

Image courtesy of Wikipedia



Topic 17B: Carbonyl Compounds

These organic compounds are recognised by the **functional group -CHO** containing a **carbonyl group** (C=O). The most common are aldehydes and ketones. This group allows these molecules to form hydrogen bonds with water, between a lone electron pair on the oxygen and a ∂+ hydrogen atom; showing they are soluble.

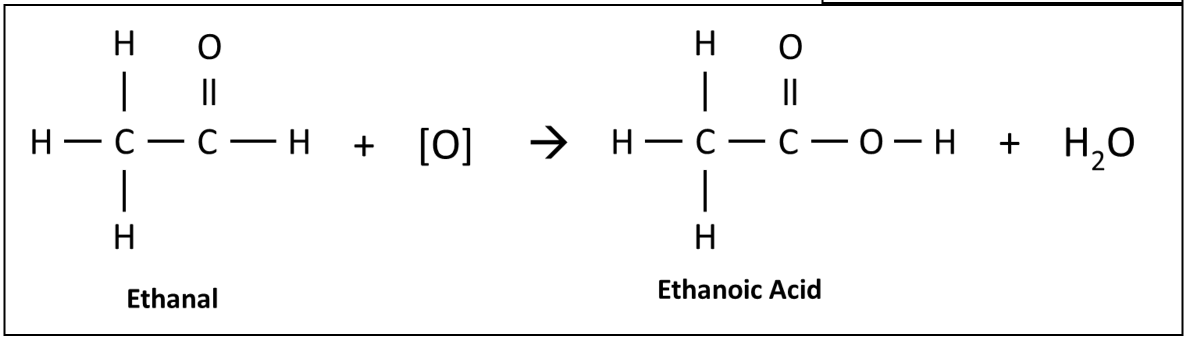
Aldehydes

These are produced from the initial oxidation and distillation of 1° alcohols, producing the C=O functional group.

Aldehydes will readily **oxidise further**, in the presence of acidified potassium dichromate to produce **carboxylic acids**.

Example:

Image courtesy of anhourofchemaday.wordpress.com



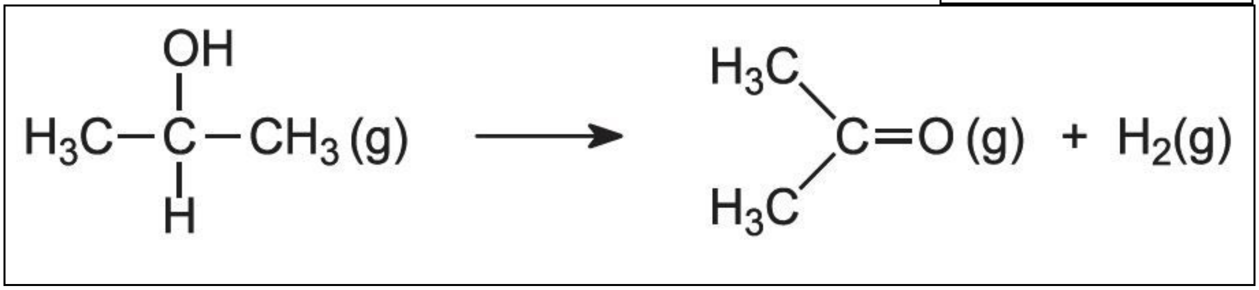
Aldehydes are tested for using **Tollen's reagent or Fehling's solution** as they produce a positive result in both tests if present.

Ketones

These organic compounds are recognised by the **functional group -C=O,** a carbonyl group. They are produced from the oxidation of 2° alcohols with acidified potassium dichromate.

Example:

Image courtesy of essentialchemicalindustry.org



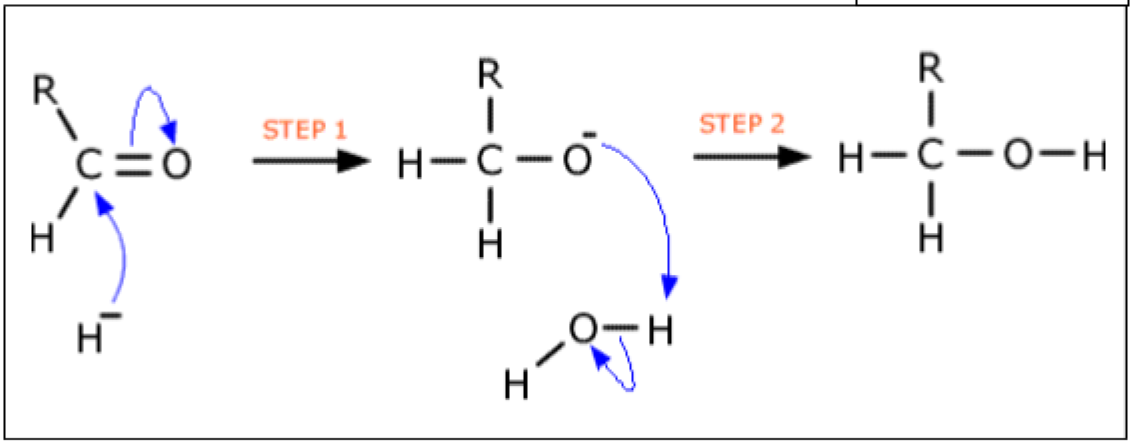
There is **no further oxidation of ketones** and they produce no visible change with both Tollen's reagent and Fehling's solution.

Reduction

All of the oxidation reactions involved in the production of the species above can be **reversed via reduction reactions**. In these reactions, a **reducing agent of $NaBH_4$** is used and it is an example of **nucleophilic addition**.

Mechanism

Image courtesy of alevelchem.com



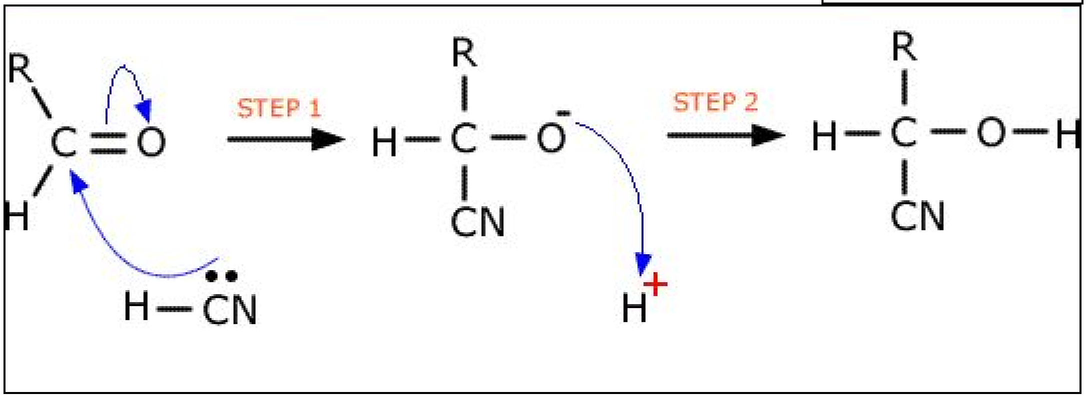
The reducing agent $NaBH_4$ provides the **$H:^-$ nucleophile**. However, a **H^+ ion** is also required so the reaction takes place under **aqueous** conditions.

Hydroxynitriles

Nucleophilic addition reactions can also take place with the **$:CN^-$ nucleophile**. This is a form of **synthesis** as it causes the carbon chain to be **extended** by one carbon atom. The product of the reaction is a **hydroxy-nitrile**.

Mechanism

Image courtesy of Get Revising



KCN (potassium cyanide) is often used as the reagent to provide the nucleophile instead of **HCN** (hydrogen cyanide). This is because HCN is **hard to store** as a gas and reacts to produce **dangerous byproducts**.

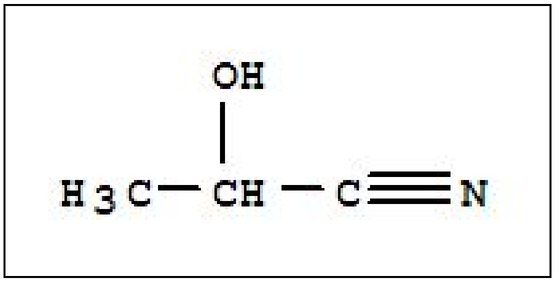
Hydroxy-nitriles commonly contain a **chiral carbon centre** meaning optical isomers of the product exist. The :CN- nucleophile can attack from either above or below the double bond, causing different **enantiomers** to be produced.

Naming Hydroxynitriles

When naming these compounds, the carbon on the nitrile group is **included in the carbon chain** and is taken to be **carbon number one**.

Example:

The following compound is 2-hydroxypropanenitrile.



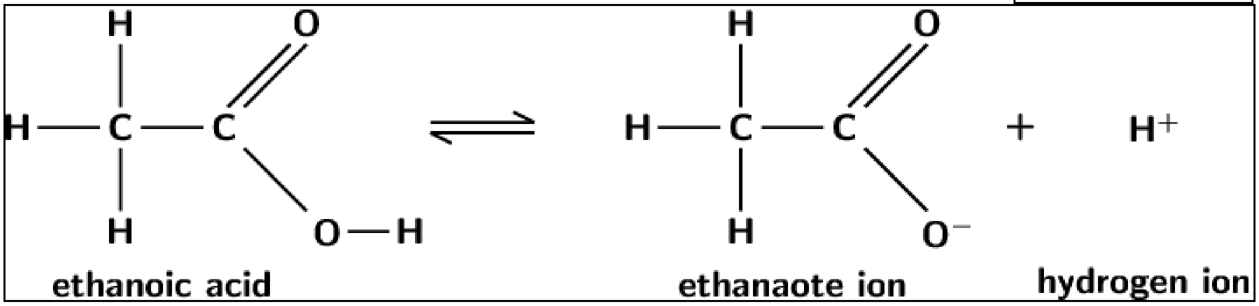
$H_3C-CH(OH)-C \equiv N$

Topic 17C: Carboxylic Acids

These organic compounds are recognised by the **functional group -COOH** containing a carbonyl group (C=O) and an -OH acid group. They are produced from the oxidation of 1° alcohols under **reflux**.

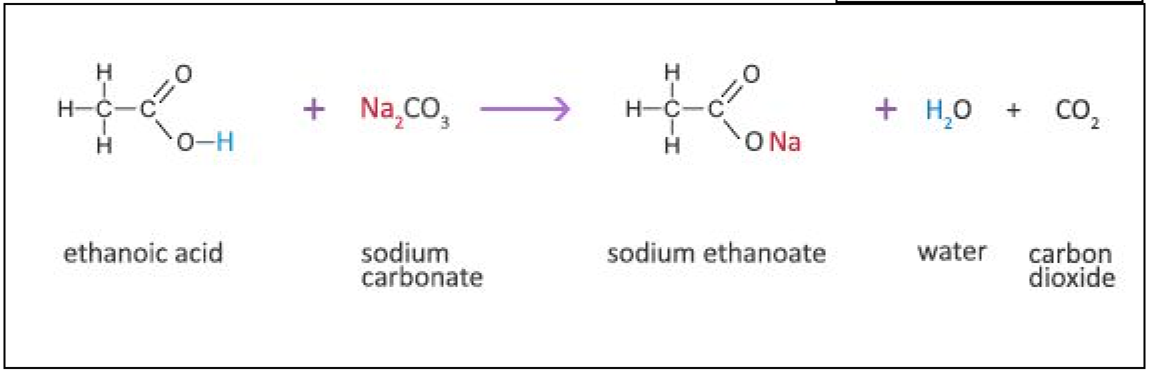
Carboxylic acids are **weak acids that slightly dissociate** when in solution, forming a **H^+ ion** and a **carboxylate ion**, RCOO-.
Example:

Image courtesy of GoogleSites



They react **as acids with carbonates** to produce a carboxylate salt, water and CO_2.
Example:

Image courtesy of passmyexams.co.uk



Small chain carboxylic acids are able to form **hydrogen bonds with water molecules** between the lone electron pair on an oxygen atom and a ∂+ hydrogen atom. This makes them **soluble in water**.

Example:

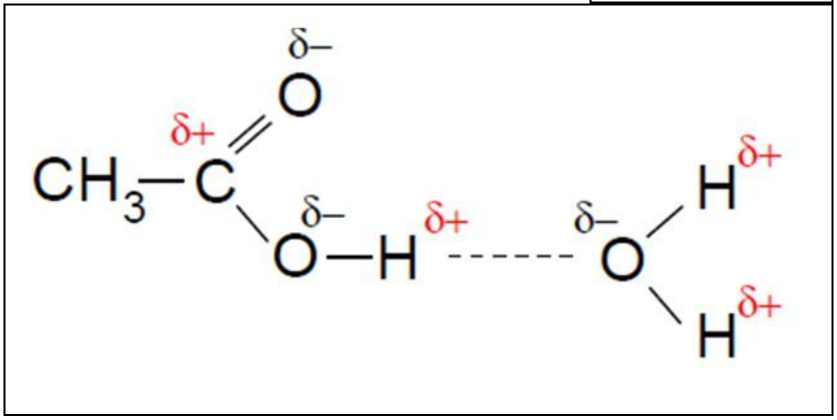


Image courtesy of SlidePlayer

Acylation

Carboxylic acids have **derivative molecules** where the -OH group is replaced by another group. **Acyl Chlorides** are one such derivative that react violently due to the very polar -COCl group.

Example:

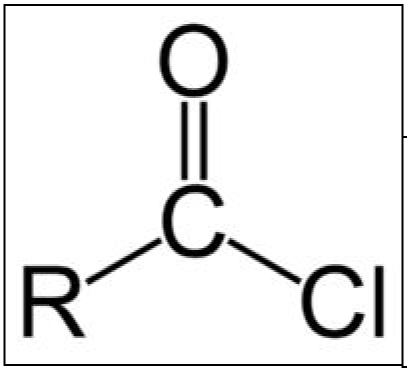


Image courtesy of Wikipedia

Reactions of Acyl Chlorides

These compounds react via **nucleophilic addition-elimination reactions**. In these reactions, the addition of a nucleophile leads to the elimination of a product under **aqueous conditions**.

Mechanism

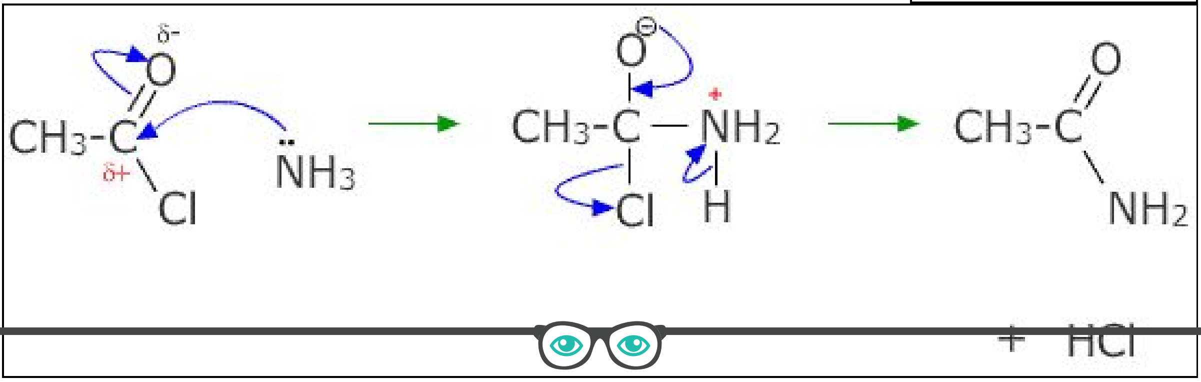


Image courtesy of alevelchem.com

Acyl chlorides can react with other compounds too:

+ Water = Carboxylic Acid

+ Alcohol = Ester

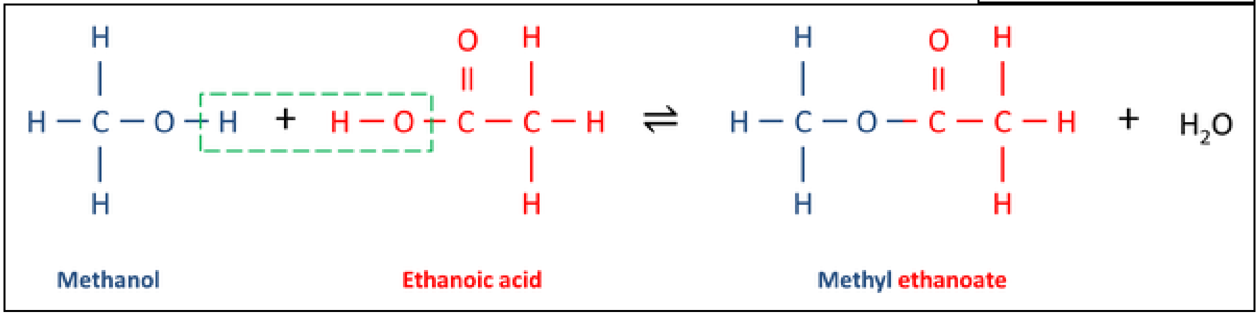
+ Ammonia = Amide

+ Amines = N-substituted Amide

Esters

Carboxylic acids can **react with alcohols** in the presence of a **strong acid catalyst** to form **esters**. This reaction is **esterification** and is carried out under reflux.
Example:

Image courtesy of anhourofchemaday



A method for remembering the reaction is: 'remove the -OH from the acid and the hydrogen from the alcohol to make water. Then stick the acid and alcohol together'.

Esters are **sweet smelling compounds** used in food flavourings and perfumes. They have **low boiling points** and also make **good solvents** for other polar molecules.

Hydrolysis

Ester hydrolysis is the **reverse reaction** to esterification, converting esters back into alcohols and carboxylic acids. This is done by **adding water** but can be carried out under **different conditions** to produce different products.

Acidic Conditions

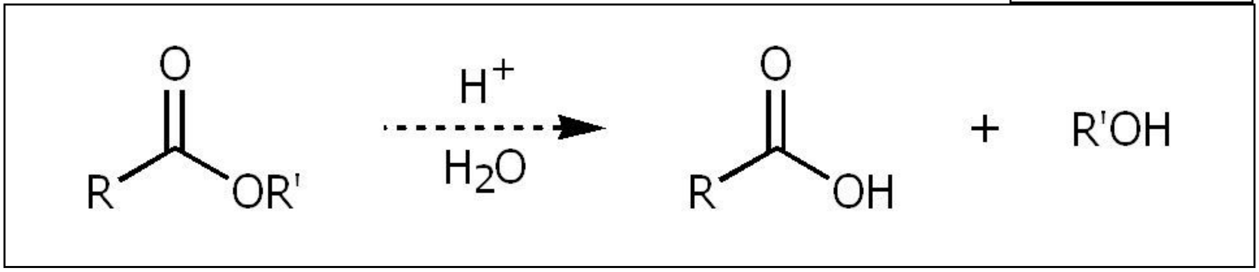


Image courtesy of SlidePlayer

This produces a simple reverse reaction back to an alcohol and a carboxylic acid.

Alkaline Conditions

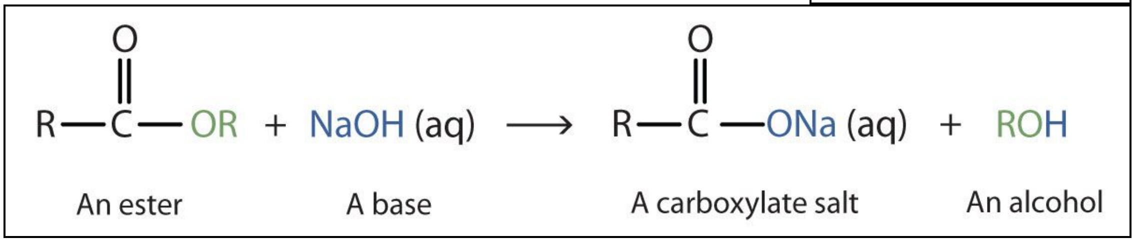


Image courtesy of Chemistry LibreTexts

The carboxylic acid produced reacts further with the base to form a salt.

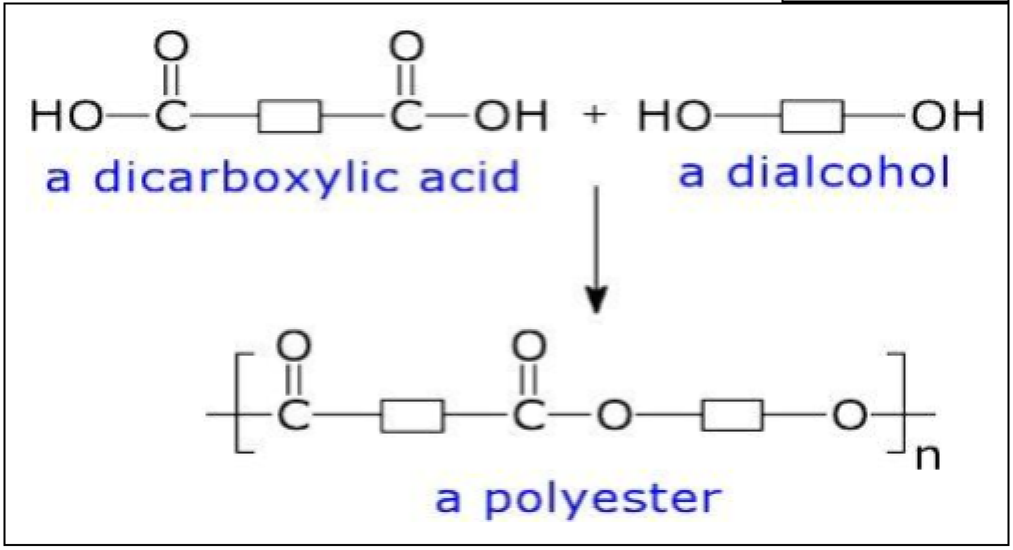
The production of this salt is called **saponification**. Salts such as this are commonly used as **soaps** because they have **hydrophilic and hydrophobic** properties.

Condensation Polymers

Condensation polymers form when **a water molecule is removed** from the species of a reaction. Polyesters are formed in this way from a reaction between **dicarboxylic acids and a diol**, producing an **ester linkage**.

Example:

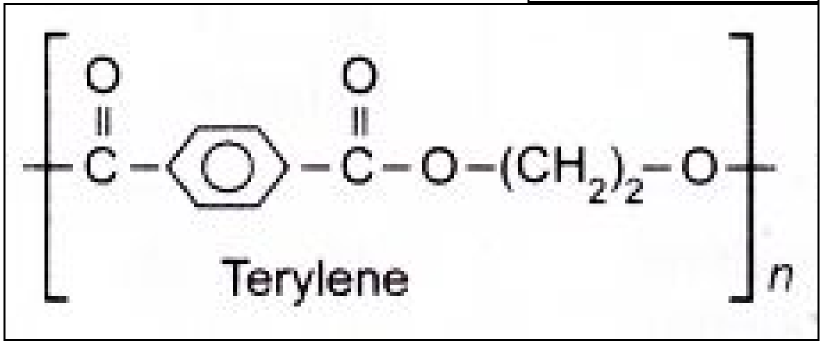
Image courtesy of QS Study



-COO- is the ester linkage.

Terylene (PET) is a common polyester made from ethanediol and 1,4-benzenedicarboxylic acid.
Example:

Image courtesy of aplustopper.com



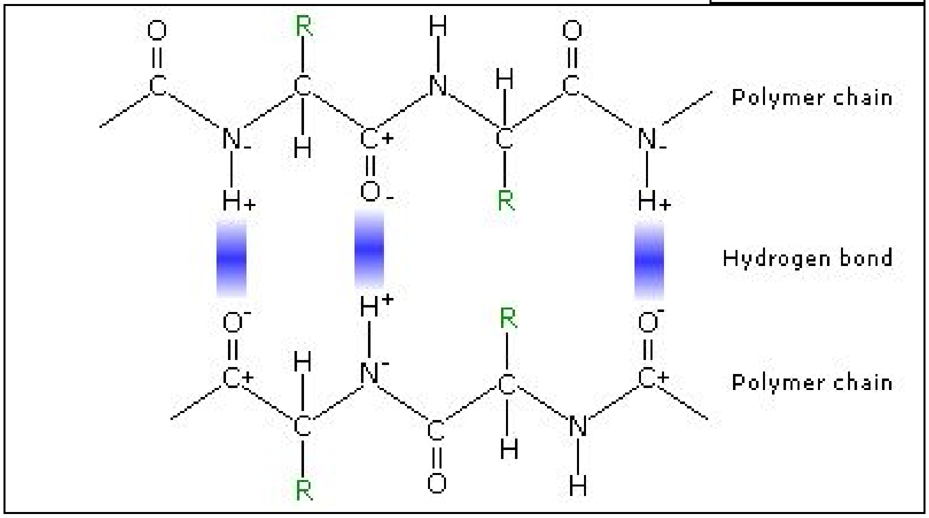
Polyesters are useful as they can be broken down through **hydrolysis** due to the **polarity** within the polymer molecules. Therefore they are **biodegradable** and can be broken down easily in nature by naturally occurring water or moisture. This means polyesters can be put into **landfill** and will gradually breakdown.

Uses of Condensation Polymers

Condensation polymers contain **polar bonds** such as those in the ester and amide links. **Hydrogen bonding** and **dipoles** can also form between separate polymer chains, holding them together in a strong structure.

Example:

Image courtesy of Textiles FR



This makes the polymers very useful for things such as **bulletproof vests** and **heat protective materials**.