AQA Chemistry A-level

3.3.9: Carboxylic Acids and Esters

Detailed Notes

3.3.9.1 - Carboxylic Acids and Esters

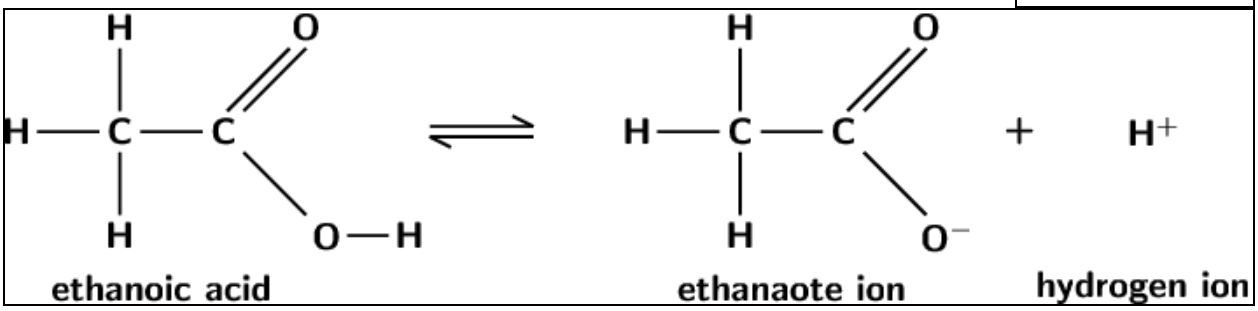
Carboxylic Acids

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:

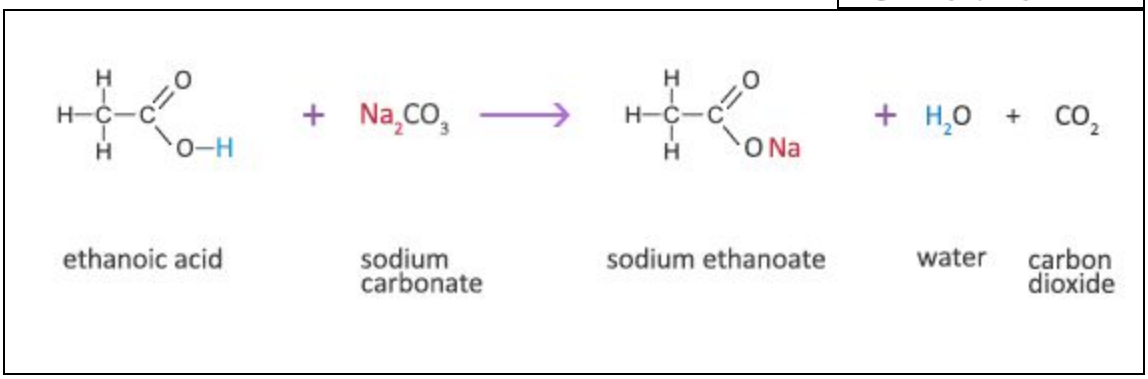
Image courtesy of GoogleSites



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

Example:

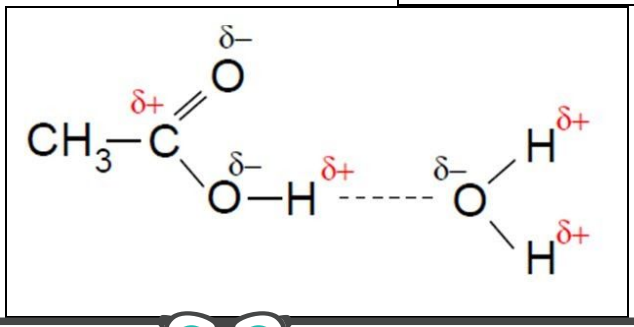
Image courtesy of passmyexams.co.uk



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

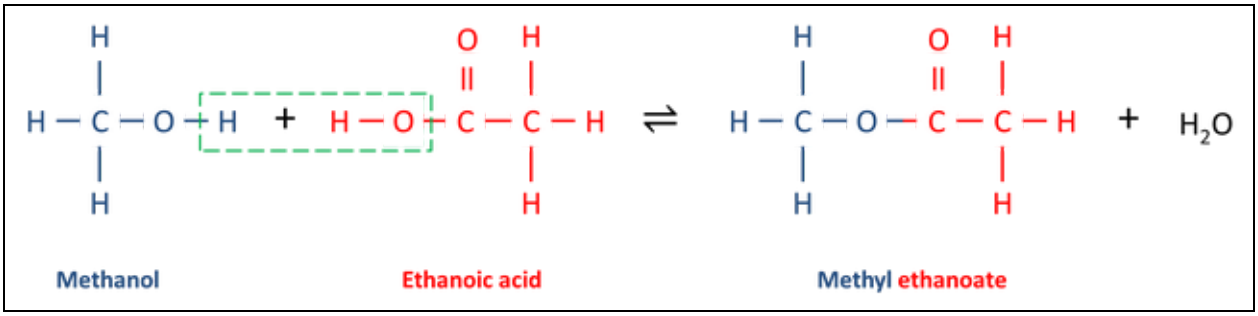


Esters

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'.

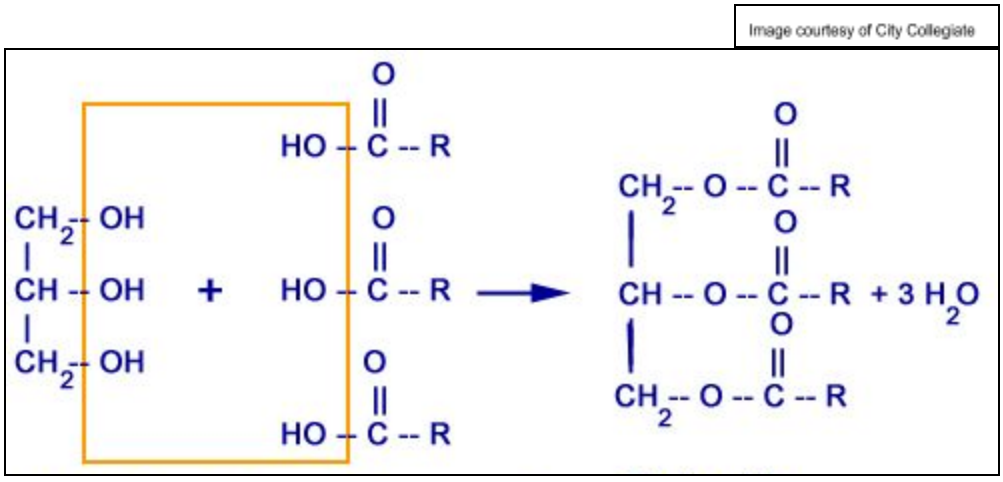
Esters are **sweet smelling compounds** used in food flavourings and perfumes. They have **low boiling points** and also make **good solvents** for other polar molecules.

Triglyceride Esters

Vegetable oils and fats are esters of naturally occuring **glycerol** (propane-1,2,3-triol). This alcohol undergoes esterification to form **triglyceride esters**.

Example:

Image courtesy of City Collegiate



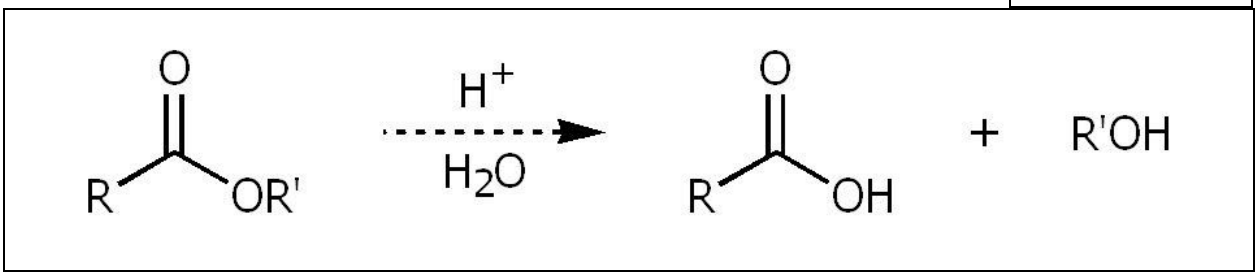
Biodiesel is an ester produced from **vegetable oils and methanol** in the presence of a strong acid catalyst.

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

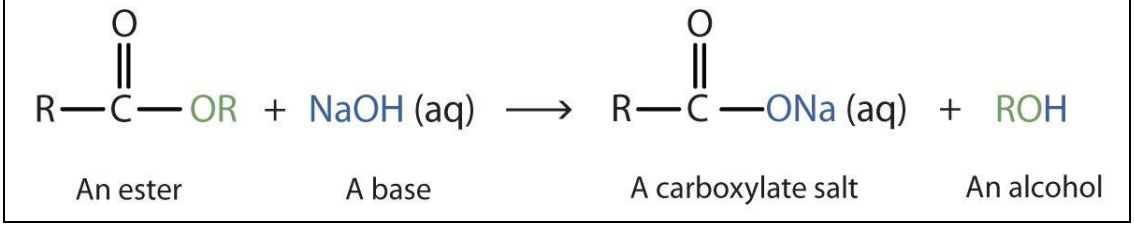
Image courtesy of SlidePlayer



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.

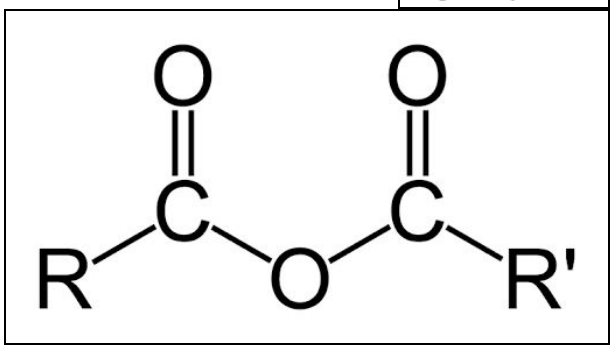
The production of this salt is called **saponification**. Salts such as this are commonly used as **soaps** because they have **hydrophilic and hydrophobic** properties.

3.3.9.2 - Acylation

Carboxylic acids have **derivative molecules** where the -OH group is replaced by another group. There are three main derivatives:

Acid Anhydrides - Formed when water is removed from two carboxylic acids.

Image courtesy of Quora



Acyl Chlorides - React violently due to the very polar -COCl group.

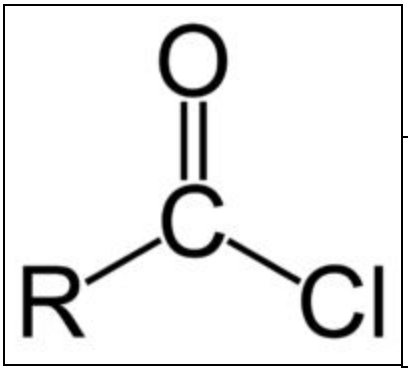
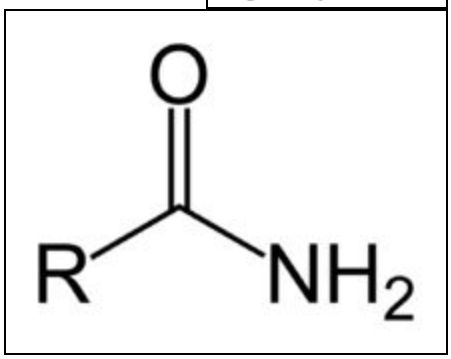


Image courtesy of Wikipedia

Amides - Reacts to form N-substituted amides.

Image courtesy of Wikibooks

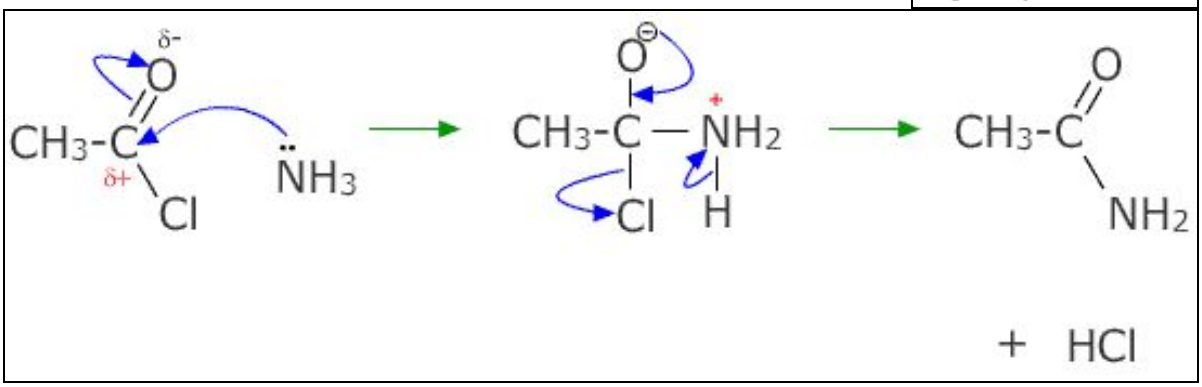


Reactions of Derivatives

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

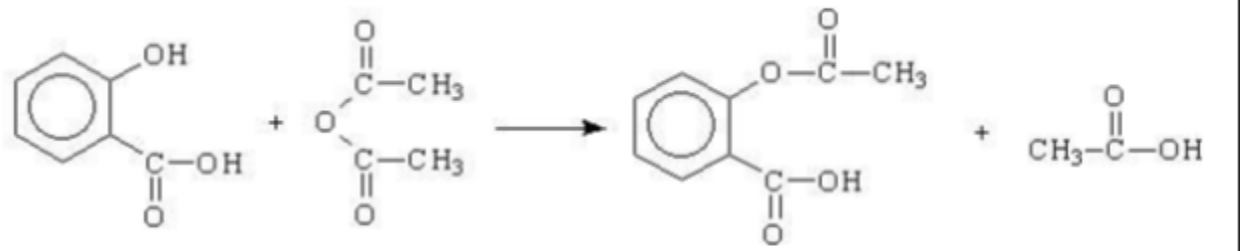
+ Amines = N-substituted Amide

Aspirin

This is an ester produced from **salicylic acid and ethanoic anhydride**.

Example:

Image courtesy of www.chem.latech.edu



Ethanoyl chloride can also be used to produce aspirin however it is not used in industry as it is **expensive** and produces **harmful HCl fumes** as part of the reaction. **Ethanoic anhydride** is much safer for industrial use.