This page looks at esterification - the reaction between alcohols and carboxylic acids to make esters.

Esters have a hydrocarbon group of some sort replacing the hydrogen in the \(-\text{COOH}\) group of a carboxylic acid. We shall just be looking at cases where it is replaced by an alkyl group, but it could equally well be an aryl group (one based on a benzene ring). The most commonly discussed ester is ethyl ethanoate. In this case, the hydrogen in the \(-\text{COOH}\) group has been replaced by an ethyl group. The formula for ethyl ethanoate is:

\[
\text{CH}_3\text{C}^\circ\text{O}\text{O}\text{CH}_2\text{CH}_3
\]

Notice that the ester is named the opposite way around from the way the formula is written. The "ethanoate" bit comes from ethanoic acid. The "ethyl" bit comes from the ethyl group on the end. In each case, be sure that you can see how the names and formulae relate to each other.

Esters are produced when carboxylic acids are heated with alcohols in the presence of an acid catalyst. The catalyst is usually concentrated sulphuric acid. Dry hydrogen chloride gas is used in some cases, but these tend to involve aromatic esters (ones containing a benzene ring). The esterification reaction is both slow and reversible. The equation for the reaction between an acid \(\text{RCOOH}\) and an alcohol \(\text{R'OH}\) (where \(\text{R}\) and \(\text{R'}\) can be the same or different) is:

\[
\text{R-C}^\circ\text{O-H} + \text{ROH} \rightleftharpoons \text{R-C}^\circ\text{O-R} + \text{H}_2\text{O}
\]

So, for example, if you were making ethyl ethanoate from ethanoic acid and ethanol, the equation would be:
Doing the reactions

- Carboxylic acids and alcohols are often warmed together in the presence of a few drops of concentrated sulfuric acid in order to observe the smell of the esters formed.
- You would normally use small quantities of everything heated in a test tube stood in a hot water bath for a couple of minutes.
- Because the reactions are slow and reversible, you don't get a lot of ester produced in this time. The smell is often masked or distorted by the smell of the carboxylic acid. A simple way of detecting the smell of the ester is to pour the mixture into some water in a small beaker.
- Esters are virtually insoluble in water and tend to form a thin layer on the surface. Excess acid and alcohol both dissolve and are tucked safely away under the ester layer.
- Small esters like ethyl ethanoate smell like typical organic solvents (ethyl ethanoate is a common solvent in, for example, glues).
- As the esters get bigger, the smells tend towards artificial fruit flavoring - "pear drops", for example.

On a larger scale

If you want to make a reasonably large sample of an ester, the method used depends to some extent on the size of the ester. Small esters are formed faster than bigger ones. To make a small ester like ethyl ethanoate, you can gently heat a mixture of ethanoic acid and ethanol in the presence of concentrated sulfuric acid, and distil off the ester as soon as it is formed.

This prevents the reverse reaction happening. It works well because the ester has the lowest boiling point of anything present. The ester is the only thing in the mixture which doesn't form hydrogen bonds, and so it has the weakest intermolecular forces.

Larger esters tend to form more slowly. In these cases, it may be necessary to heat the reaction mixture under reflux for some time to produce an equilibrium mixture. The ester can be separated from the carboxylic acid, alcohol, water and sulfuric acid in the mixture by fractional distillation.

Contributors

- Jim Clark (Chemguide.co.uk)