This page looks at the formation, structure and uses of a common polyester sometimes known as Terylene if it is used as a fibre, or PET if it used in, for example, plastic drinks bottles. A polyester is a polymer (a chain of repeating units) where the individual units are held together by ester linkages.

The diagram shows a very small bit of the polymer chain and looks pretty complicated. But it is not very difficult to work out - and that's the best thing to do: work it out, not try to remember it. You will see how to do that in a moment.

The usual name of this common polyester is poly(ethylene terephthalate). The everyday name depends on whether it is being used as a fibre or as a material for making things like bottles for soft drinks. When it is being used as a fiber to make clothes, it is often just called polyester. It may sometimes be known by a brand name like Terylene. When it is being used to make bottles, for example, it is usually called PET.

Making polyesters as an example of condensation polymerisation

In condensation polymerisation, when the monomers join together a small molecule gets lost. That's different from addition polymerisation which produces polymers like poly(ethene) - in that case, nothing is lost when the monomers join together. A polyester is made by a reaction involving an acid with two -COOH groups, and an alcohol with two -OH groups. In the common polyester drawn below.

\[
\begin{align*}
\text{HOOC} & \quad \text{COOH} \quad \text{HO-CH}_2\text{CH}_2\text{-OH} \\
\text{benzene-1,4-dicarboxylic acid} & \quad \text{ethane-1,2-diol}
\end{align*}
\]

*Figure: The acid is benzene-1,4-dicarboxylic acid (old name: terephthalic acid) and the alcohol is ethane-1,2-diol (old name: ethylene glycol).*

Now imagine lining these up alternately and making esters with each acid group and each alcohol group, losing a molecule of water every time an ester linkage is made.

That would produce the chain shown above (although this time written without separating out the carbon-oxygen double bond - write it whichever way you like).
Manufacturing poly(ethylene terephthalate)

The reaction takes place in two main stages: a pre-polymerisation stage and the actual polymerisation. In the first stage, before polymerization happens, you get a fairly simple ester formed between the acid and two molecules of ethane-1,2-diol.

\[
\begin{align*}
\text{HOC}_2\text{H}_2\text{OH} & \quad \text{HOC} & \quad \text{COOH} & \quad \text{HOC}_2\text{H}_2\text{OH} \\
\downarrow & & & & & \\
\text{HOC}_2\text{H}_2\text{COC} & \quad \text{COOH} & \quad \text{CH}_2\text{OH} & + 2\text{H}_2\text{O}
\end{align*}
\]

In the polymerisation stage, this is heated to a temperature of about 260°C and at a low pressure. A catalyst is needed - there are several possibilities including antimony compounds like antimony(III) oxide. The polyester forms and half of the ethane-1,2-diol is regenerated. This is removed and recycled.

\[
\begin{align*}
n \quad \text{HOC}_2\text{H}_2\text{COC} & \quad \text{COOH} & \quad \text{CH}_2\text{OH} \\
\downarrow & & & & & \\
\left(\text{OC} \quad \text{COOH} \quad \text{CH}_2\text{OH}\right)_n & + n \quad \text{HOC}_2\text{H}_2\text{OH}
\end{align*}
\]

Hydrolysis of polyesters

*Simple esters* are easily hydrolyzed by reaction with dilute acids or alkalis. *Polyesters* are attacked readily by alkalis, but much more slowly by dilute acids. Hydrolysis by water alone is so slow as to be completely unimportant. (You wouldn't expect your polyester fleece to fall to pieces if you went out in the rain!). If you spill dilute alkali on a fabric made from polyester, the ester linkages are broken. Ethane-1,2-diol is formed together with the salt of the carboxylic acid. Because you produce small molecules rather than the original polymer, the fibers are destroyed, and you end up with a hole! For example, if you react the polyester with sodium hydroxide solution:

\[
\begin{align*}
\text{OC} & \quad \text{COOH} & \quad \text{CH}_2\text{OH} & \quad \text{COOH} & \quad \text{CH}_2\text{OH} \\
\downarrow & & & & & \\
\text{OC} & \quad \text{COOH} & \quad \text{CH}_2\text{OH} & \quad \text{Na}^+ & \quad \text{COONa} & \quad \text{Na}^+
\end{align*}
\]

\[
\begin{align*}
\text{OC} & \quad \text{COOH} & \quad \text{Na}^+ & \quad \text{HOC}_2\text{H}_2\text{OH} & \quad \text{Na}^+ & \quad \text{COONa} \\
\downarrow & & & & & \\
\text{OC} & \quad \text{COONa} & \quad \text{Na}^+ & \quad \text{HOC}_2\text{H}_2\text{OH} & \quad \text{Na}^+ & \quad \text{COONa}
\end{align*}
\]
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