POLYMERS

Polymers are giant molecules made by linking together smaller molecules called **monomers**.

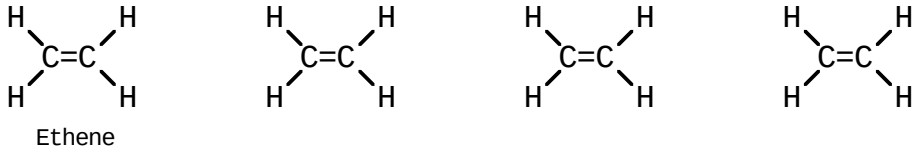
The reaction is called **polymerisation**.

The linking can be done in two ways: by **addition** or **condensation**.

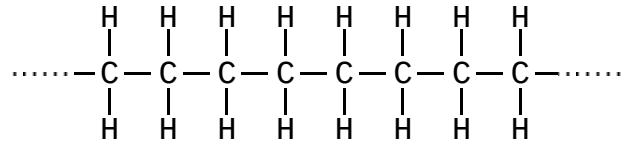
ADDITION POLYMERS

Addition polymers are very long-chain molecules made from small, unsaturated monomers produced by cracking. The small unsaturated monomers join together by the opening of C=C double bonds.

1. Polyethene



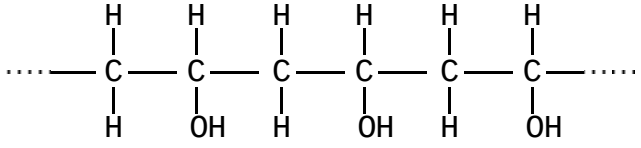
Ethene



Polyethene

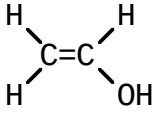
The structure of low density Polyethene can be modified during manufacture to produce a photodegradable polymer.

2. Polyethenol



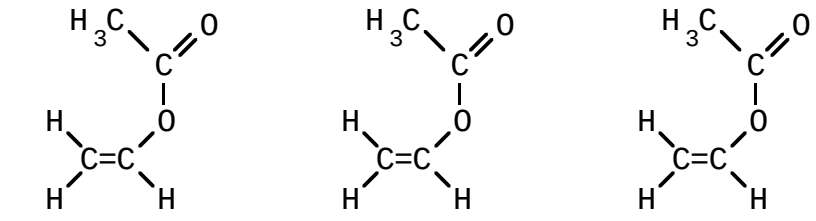
Polyethenol

Since the monomer:

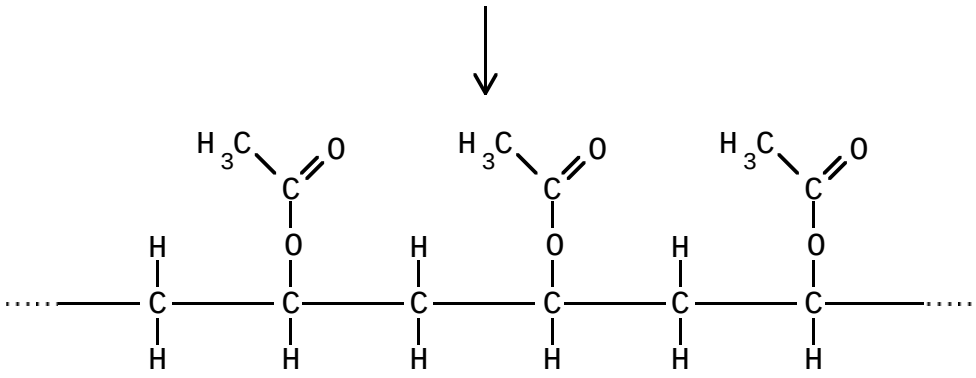


is unstable, Polyethenol must be made by a more indirect route:

Ethenyl ethanoate is polymerised to form Polyethenyl ethanoate:

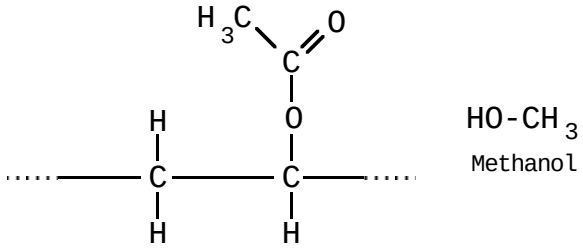


Ethenyl ethanoate



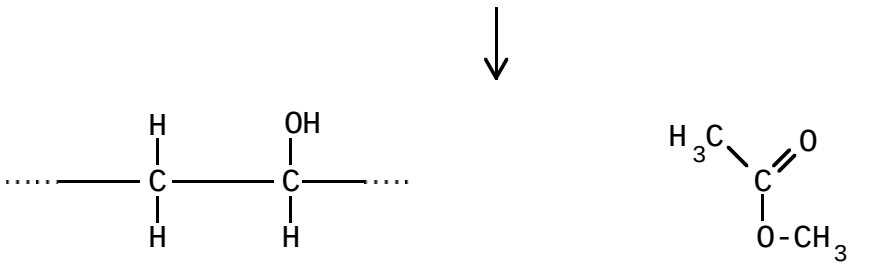
Polyethenyl ethanoate

The Polyethenyl ethanoate is then reacted with Methanol to form Polyethenol and Methyl ethanoate in a process known as ester exchange:



Methanol

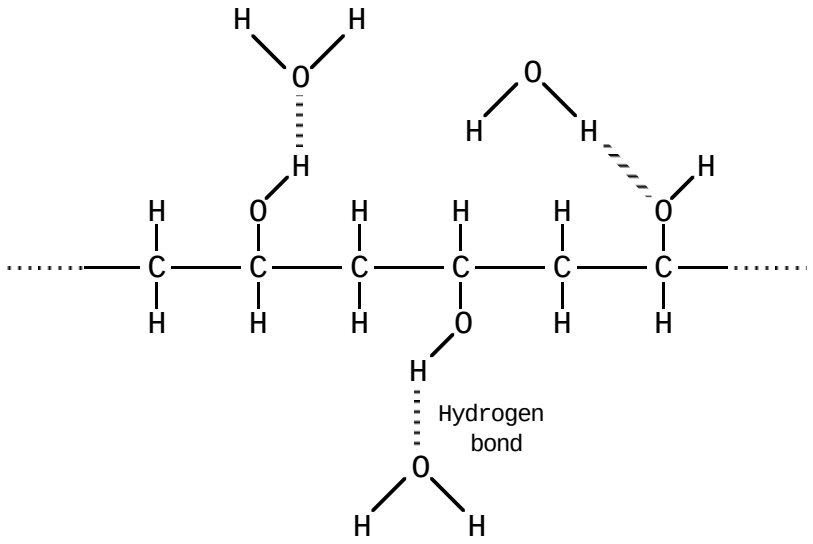
Polyethenyl ethanoate



Polyethenol

Methyl ethanoate

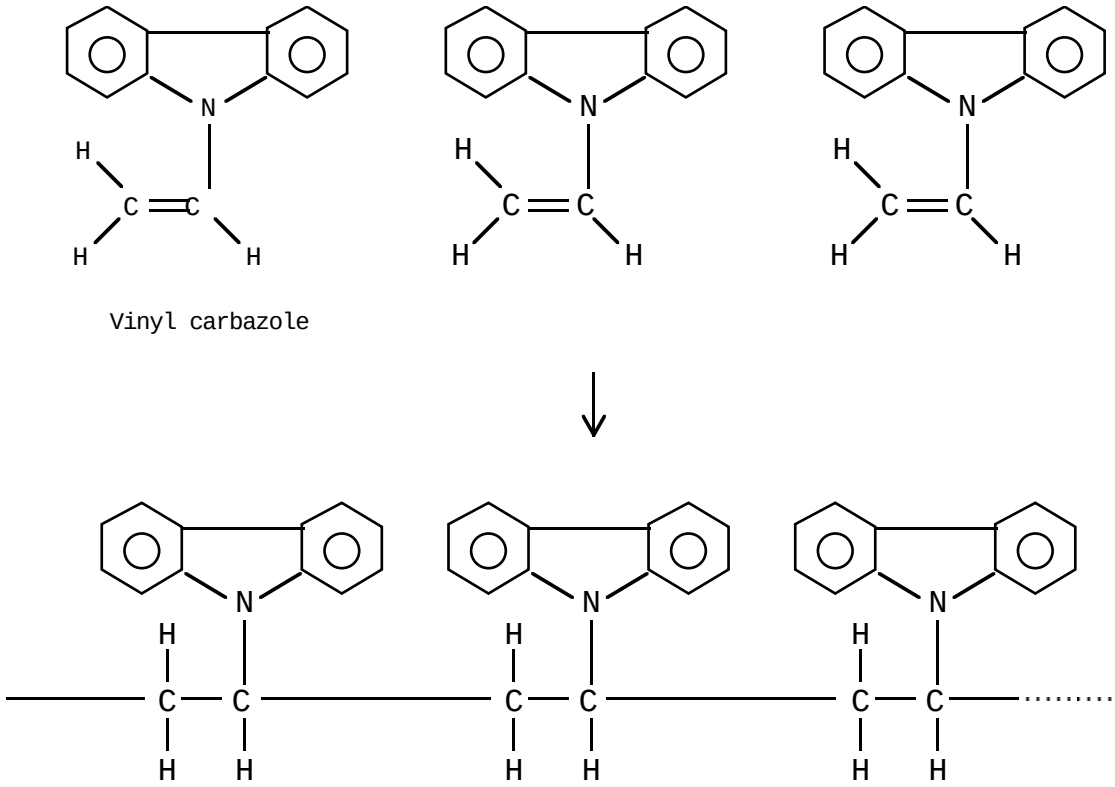
Polyethenol is soluble in water. Water molecules Hydrogen bond to the OH groups along the length of the polymer:



By varying the percentage of the CH_3CO groups replaced by OH during ester exchange, Polyethenols of varying solubility can be produced.

Polyethenol is used as a thickening agent and wood adhesive.

3. Polyvinyl carbazole

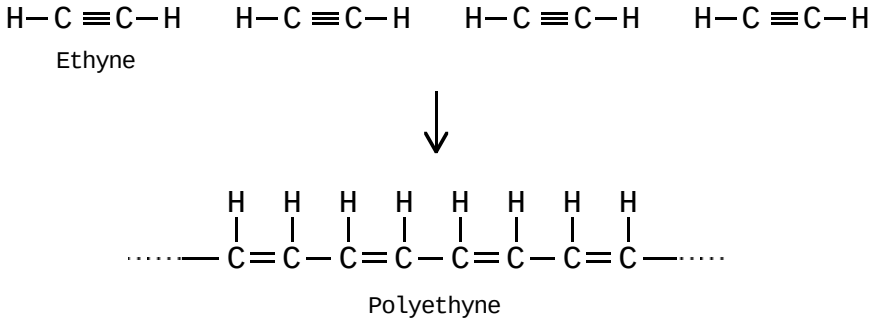


Vinyl carbazole

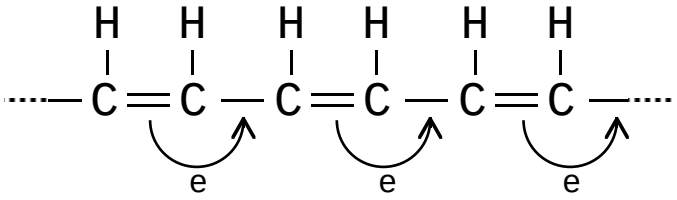
Polyvinyl carbazole

Polyvinyl carbazole is photoconductive and is used in photocopiers.

4. Polyethyne

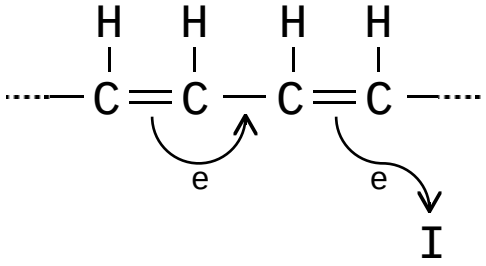


Polyethyne conducts electricity because of delocalisation of electrons from C=C into C-C bonds:



It is, however, a very poor conductor since the delocalised electrons are unable to 'hop' from one molecule to another.

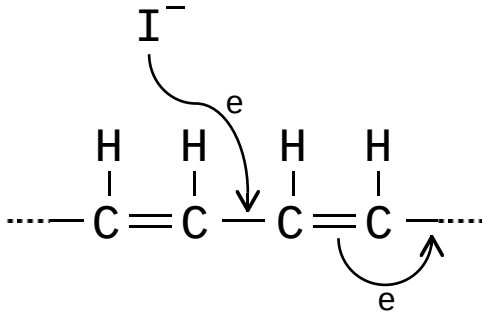
Doped with Iodine, it becomes a very good conductor of electricity. The Iodine atoms between the Polyethyne molecules accept electrons from the Polyethyne molecules:



and, in turn, become reduced to Iodide ions:

$I + e \rightarrow I^-$

The Iodide ions then push electrons on to adjacent Polyethyne molecules:



and, in turn, are oxidised back to Iodine atoms:

$I^- \rightarrow I + e$

Iodine therefore acts as a **bridge** for the electrons allowing conduction.

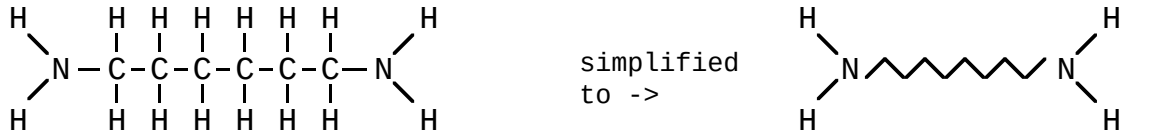
Since Polyethyne is unstable in air it has no uses ..... yet !

CONDENSATION POLYMERS

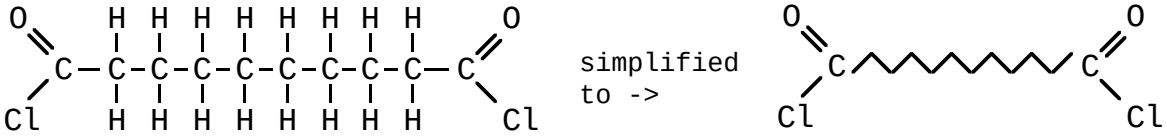
There are two functional groups per monomer. Links between monomers are formed by a condensation reaction between these functional groups.

1. Nylon

Nylon is a polyamide made by the condensation reaction between the amine, 1,6-Diaminohexane, and Decanedioyl chloride:



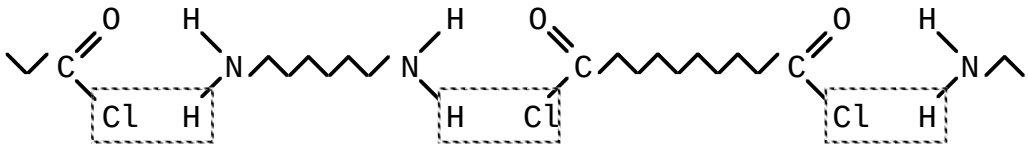
1,6-Diaminohexane

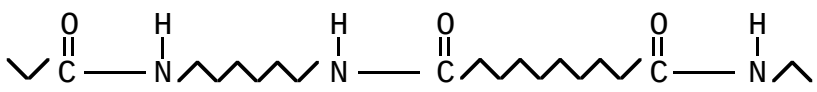


Decanedioyl chloride

The two monomers polymerise by condensation forming an amide link:

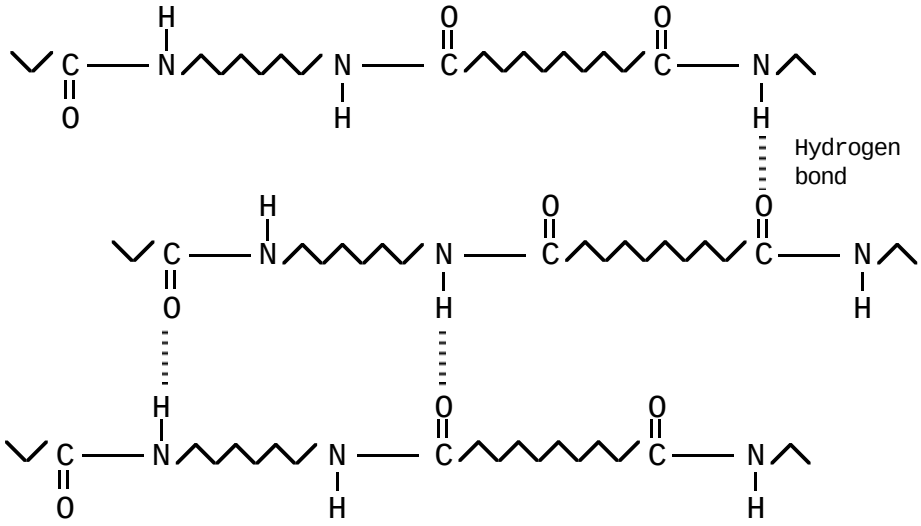
Hydrogen chloride is given off:





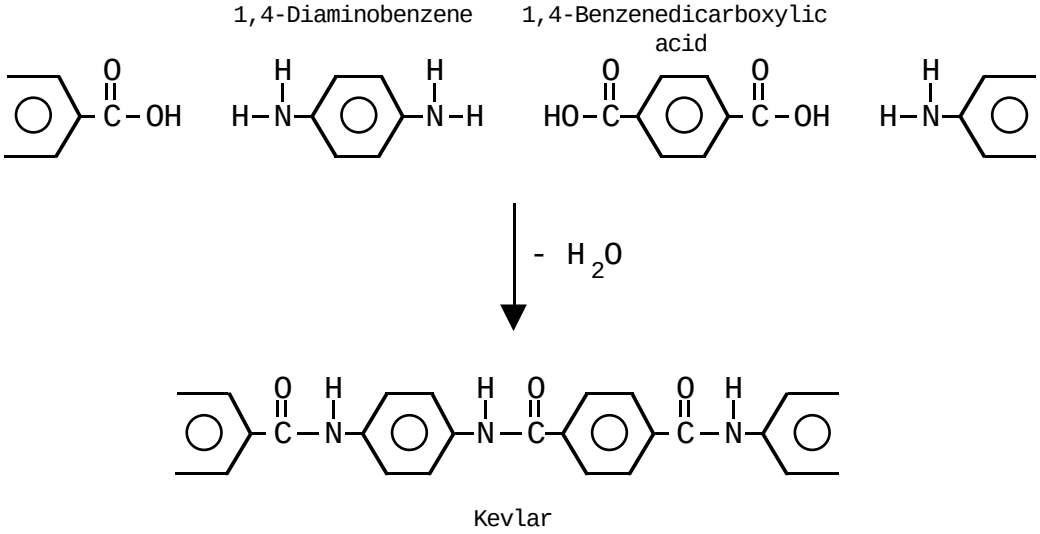
Nylon

The strength of Nylon fibre is the result of Hydrogen bonding between the chains:



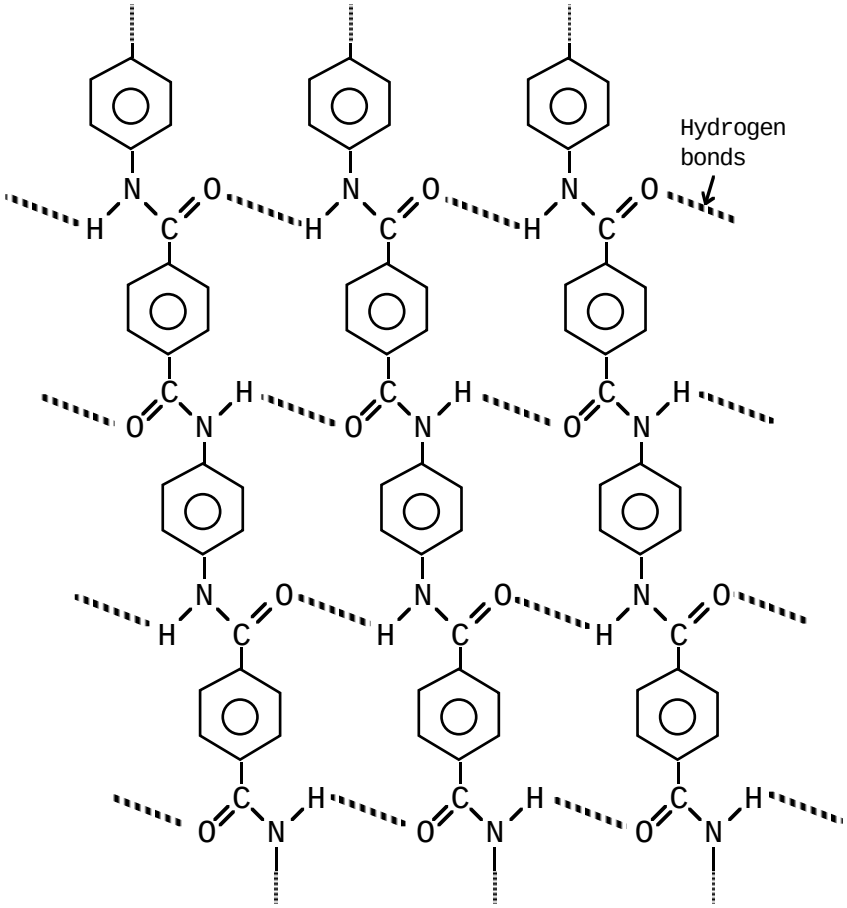
2. Kevlar

Kevlar is an aromatic polyamide made by the condensation reaction between 1,4-Diaminobenzene and 1,4-Benzenedicarboxylic acid:

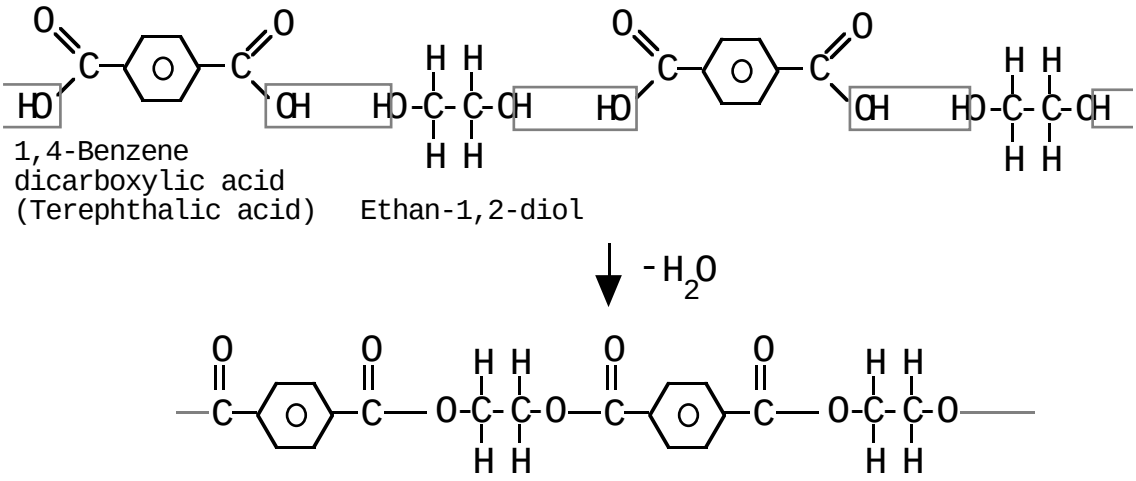


Kevlar

It is an extremely strong polymer used to make military helmets, bulletproof vests etc. Like Nylon it owes its strength to the Hydrogen bonding between the molecules:



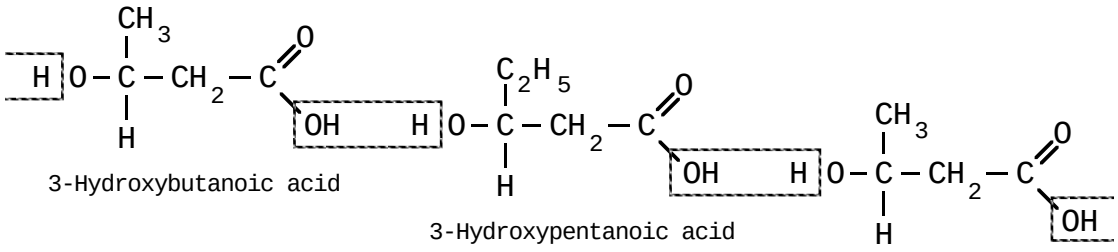
3. Polyetheneterephthalate (Terylene) :

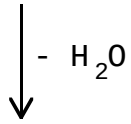


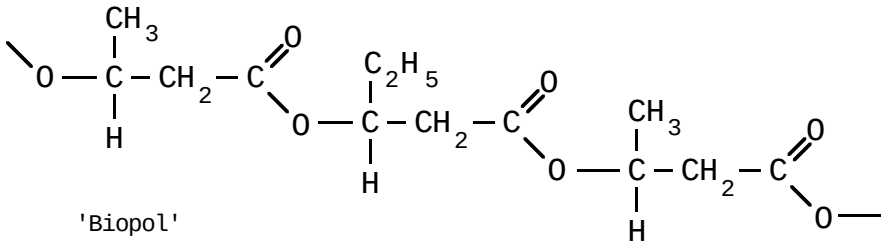
Polyetheneterephthalate (Terylene)

Since the monomers are a carboxylic acid and an alcohol the polymer is called a polyester. Hydrogen bonding between polyester molecules is not possible. Polyester fibres are therefore flexible since the molecules are only loosely bonded to each other.

4. Biopol





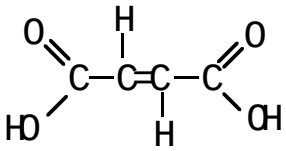


Biopol is a polyester.
Biopol is biodegradable.

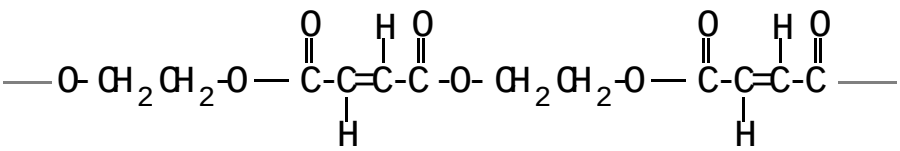
[http://www.denison.edu/chem/journal/scottv1n1.html]

5. Polyester Resins

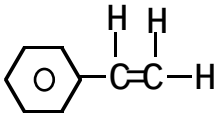
Cured polyester resins have a rigid three dimensional structure. They are hard plastics with a wide variety of uses (e.g. boat hulls). A curing agent is added during polymerisation to cause cross-linking between the chains e.g. the polymerisation of Fumaric acid



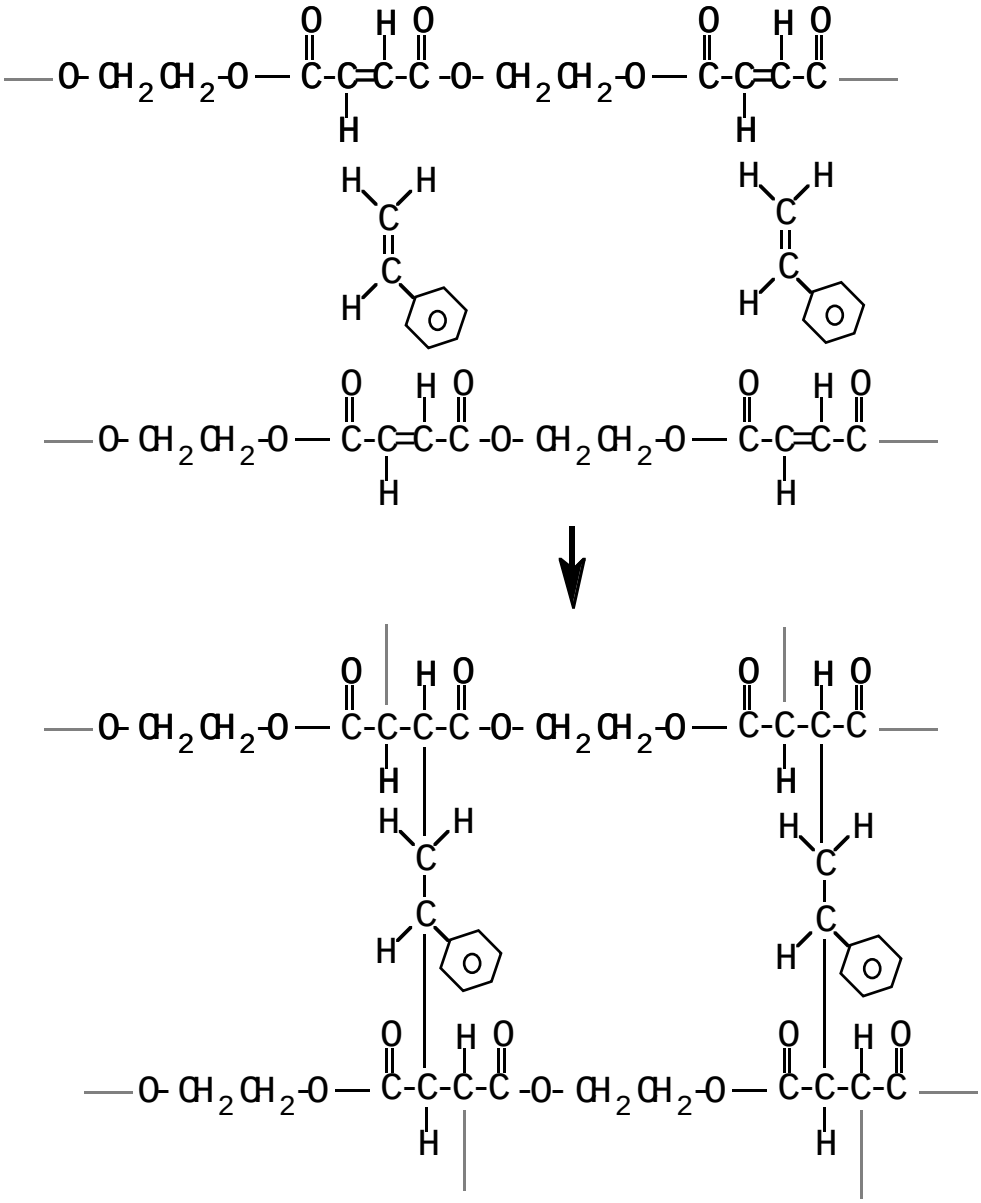
and Ethan-1,2-diol produces the polyester :



Addition of Styrene



during polymerisation produces a hard, cross-linked, polyester resin :



6. Urea-methanal

All the examples of polymers shown so far have been **thermoplastic** - they melt on heating. Urea-methanal is a **thermosetting** polymer - it does not melt on heating.