PLASTICS AND SYNTHETIC FIBRES

Plastics and synthetic fibres are man-made polymers, made by the chemical industry using raw materials obtained from crude oil.

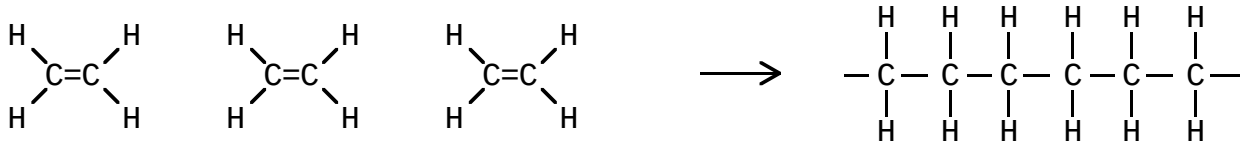
Polymers are made in two ways: by **condensation** or **addition**.

In both cases small molecules called monomers are linked together to form large molecules called polymers. The reaction is called **polymerisation**.

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.

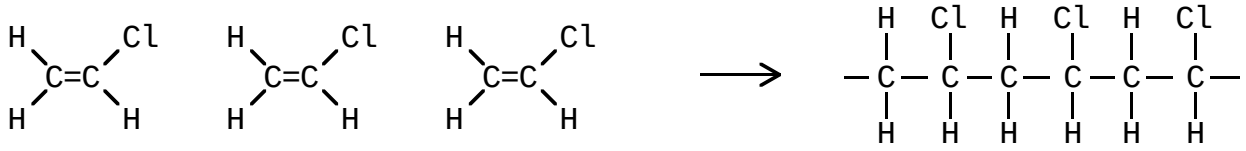
EXAMPLE 1 Polyethene, made by polymerisation of Ethene.



Ethene Polyethene

It is used to insulate electrical cables and to make plastic bags etc

EXAMPLE 2 Polychloroethene (formerly called Polyvinylchloride or PVC), made by polymerisation of Chloroethene.

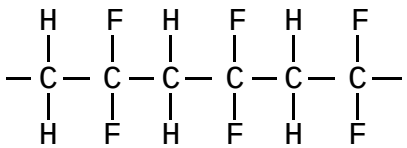


Chloroethene Polychloroethene

It is used to insulate electrical cables. It is also used instead of Iron to make buckets, drain-pipes, guttering etc. because of its much lower density and the fact that it does not rust!

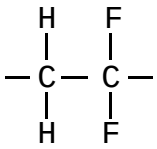
PROBLEM

For the addition polymer below, draw the structure of the repeating unit and thus deduce the structure of the monomer from which it was made:

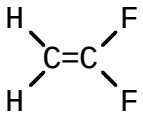


ANSWER

The repeating unit is:



The monomer is:

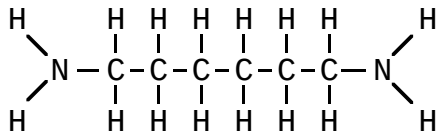


CONDENSATION POLYMERS

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

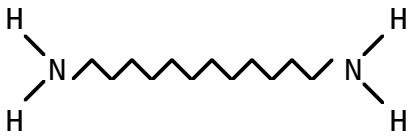
EXAMPLE 1: NYLON

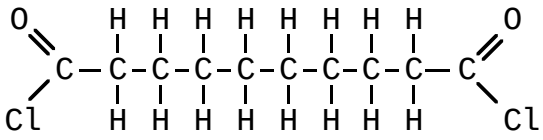
Nylon is made by polymerisation of the following two monomers:



1,6-Diaminohexane

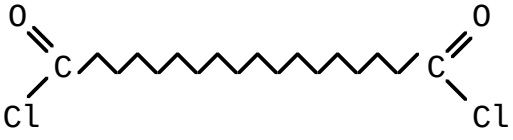
simplified to ->





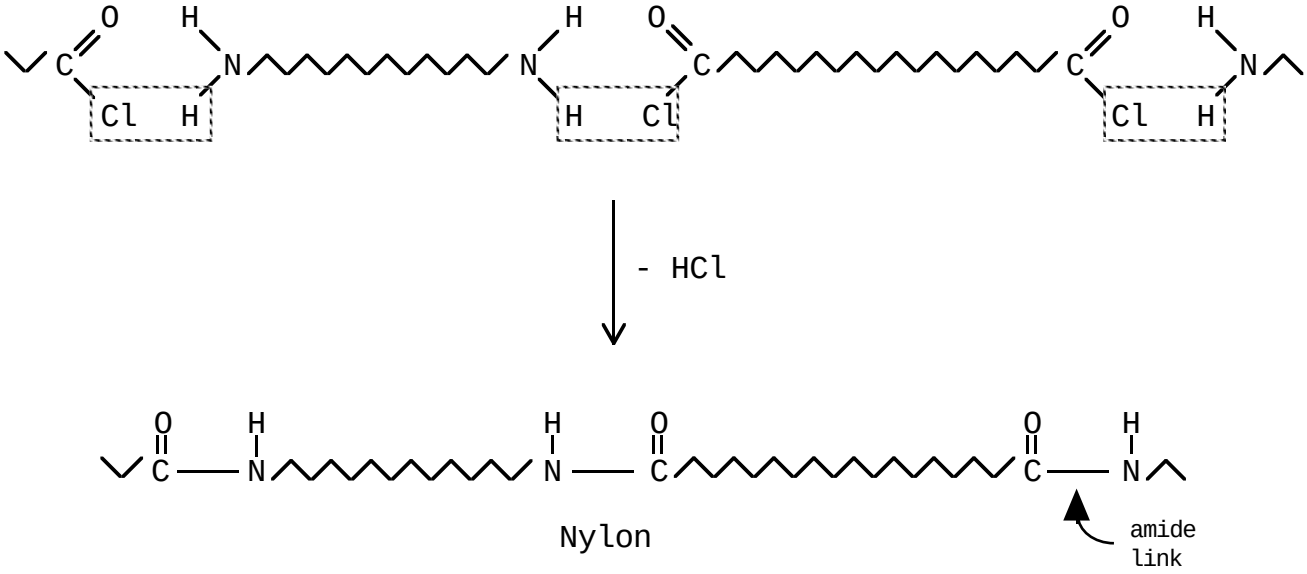
Decanedioyl chloride

simplified to ->



1,6-Diaminohexane is a primary amine (it contains the NH_2 group)

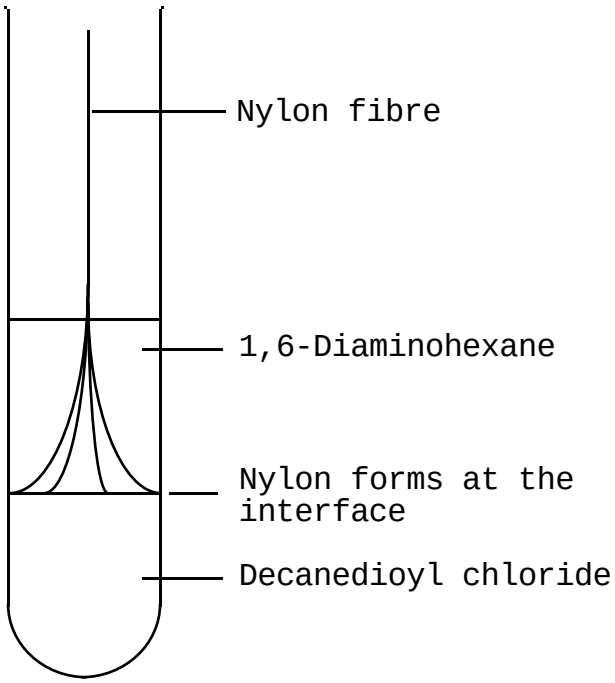
The two monomers polymerise by condensation. Hydrogen chloride is given off:



Both Nylon and proteins are polyamides: they both contain the amide (peptide) link. Proteins are **naturally occurring** condensation polymers.

EXPERIMENT

Prepare Nylon:

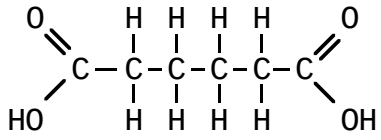


The strength and low density of Nylon makes it ideal for making clothes and ropes. It's low friction (slipperiness) makes it ideal for making gears and bearings.

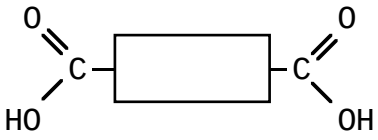
EXAMPLE 2: POLYESTERS

The monomers are carboxylic acids with TWO -COOH groups e.g.

Hexanedioic acid

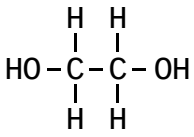


simplified to ->

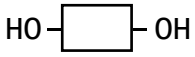


and alcohols with TWO -OH groups usually:

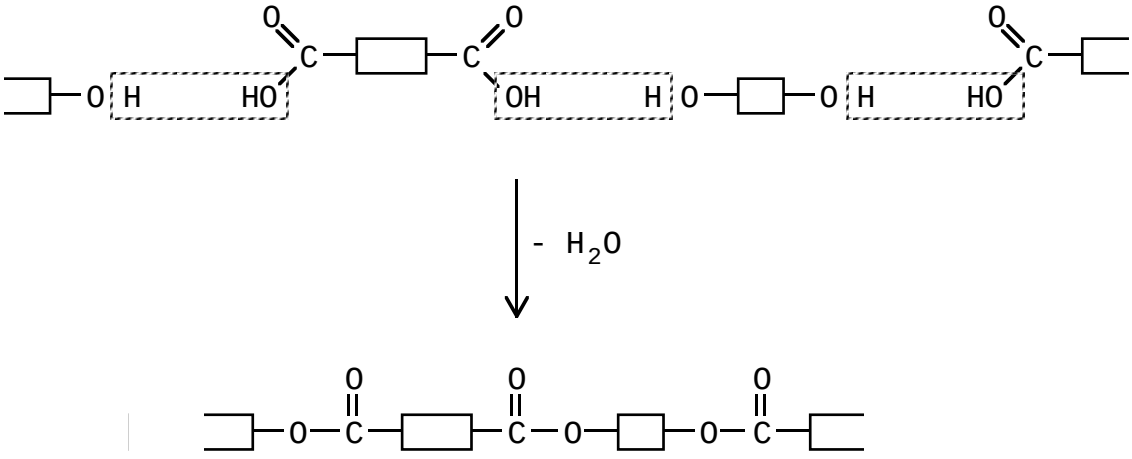
Ethan-1,2-diol



simplified to ->



Condensation involves loss of Water:

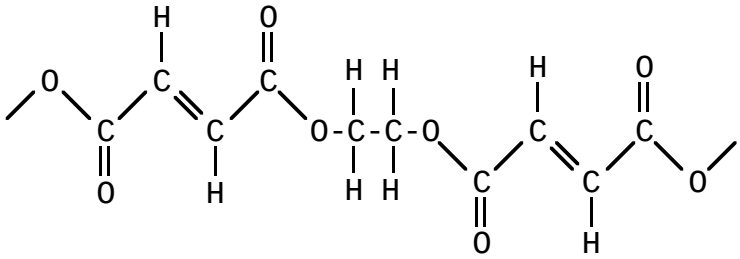


Polyester

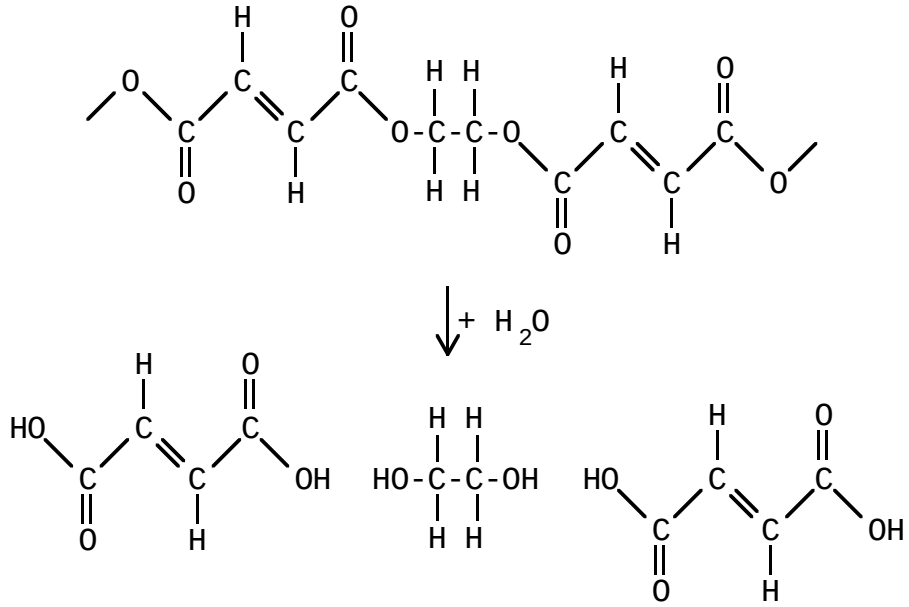
Polyesters are used in making clothes. Terylene is a polyester.

PROBLEM

Draw the structural formulae of the two monomers which were used to make the polyester below:



ANSWER Perform an imaginery hydrolysis!



Ethan-1,2-diol Fumaric acid

Polyesters, Nylon, Polyethene, PVC, Polystyrene, Perspex and silicones are all examples of thermoplastics (they melt on heating) so they can be moulded into the shapes required e.g. drain-pipes, plastic bags etc.

Some plastics do not melt on heating e.g. Urea-methanal, Bakelite and Formica. They are described as thermosetting. Their heat resistance makes them useful for making electrical sockets and plugs.

Uses of plastics depend on their properties.

- Polyethenol dissolves in water it is used as wet-strength adhesive.
- Kevlar, a polymer similar to Nylon, is very strong and is therefore used for making bullet-proof vests!!
- Biopol, a polyester, is biodegradable (broken down by bacteria or fungi) and is being used for carrier bags and other disposable items.

POLLUTION PROBLEMS

The strength and durability of all plastics is an obvious advantage but their durability can lead to environmental problems: since most are not biodegradable they last forever, polluting the environment.

Burning is not a suitable means of disposal: plastics burn to give off toxic fumes. The actual combustion gases depend on the elements present in the plastic:

- Polyethene contains Carbon and gives off Carbon monoxide CO when it burns
- PVC contains Hydrogen and Chlorine and gives off Hydrogen chloride HCl when it burns
- Polyurethanes (used to make foam rubber cushions) contain Hydrogen, Carbon and Nitrogen and give off Hydrogen cyanide HCN when they burn.