Polymers

There are two **types** of **polymerisation**: **addition** and **condensation**

Addition Polymerisation

An <u>addition polymer</u> forms when unsaturated monomers react to form a polymer
Monomers contain C=C bonds

Poly(alkenes) are chemically inert due to the strong C-C and C-H bonds and **non-polar** nature of the bonds and therefore are non-biodegradable.

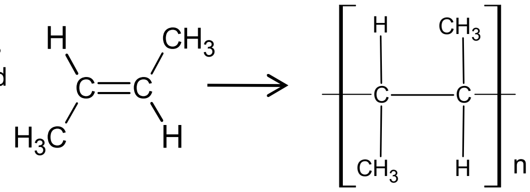
Chain forms when same basic unit is repeated over and over.

You should be able to draw the polymer repeating unit for any alkene

e.g. For but-2-ene

$H_3C—CH=CH—CH_3$

It is best to first draw out the monomer with groups of atoms arranged around the double bond



Condensation Polymerisation

The two most common **types** of condensation polymers are **polyesters** and **polyamides** which involve the formation of an **ester** linkage or an **amide** linkage

In condensation polymerisation there are two different monomers that add together and a small molecule is usually given off as a side-product e.g. H_2O or HCl.

The monomers usually have the same functional group on both ends of the molecule e.g. di-amine, di carboxylic acid, diol, diacyl chloride

Forming polyesters and polyamide uses these reactions we met earlier in the course

Carboxylic Acid + Alcohol → Ester + water

Acyl chloride + Alcohol → Ester + HCl

Carboxylic Acid + Amine → amide + water

Acyl chloride + Amine → amide + HCl

If we have the same functional group on each end of molecule we can make polymers so we have the analogous equations:

dicarboxylic acid + diol → poly(ester) + water

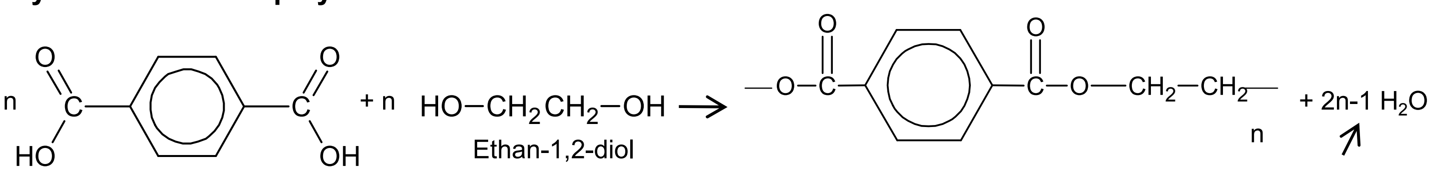
diacyl dichloride + diol → poly(ester) + HCl

dicarboxylic acid + diamine → poly(amide) + water

diacyl dichloride + diamine → poly(amide) + HCl

Using the carboxylic acid to make the ester or amide would need an acid catalyst and would only give an equilibrium mixture. The more reactive acyl chloride goes to completion and does not need a catalyst but does produce hazardous HCl fumes

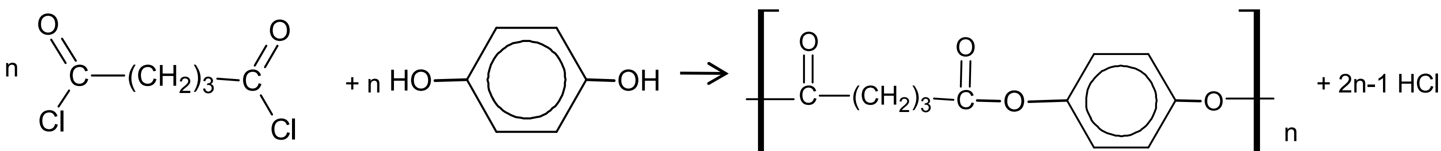
Terylene- a common polyester



Benzene-1,4-dicarboxylic acid

The -1 here is because at each end of the chain the H and OH are still present

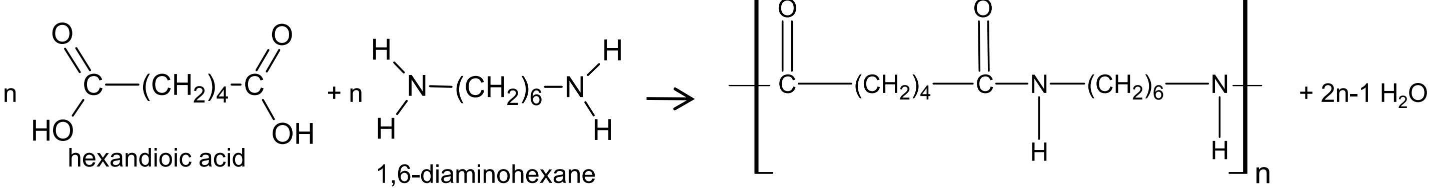
Terylene fabric is used in clothing, tire cords



Pentandioyl dichloride

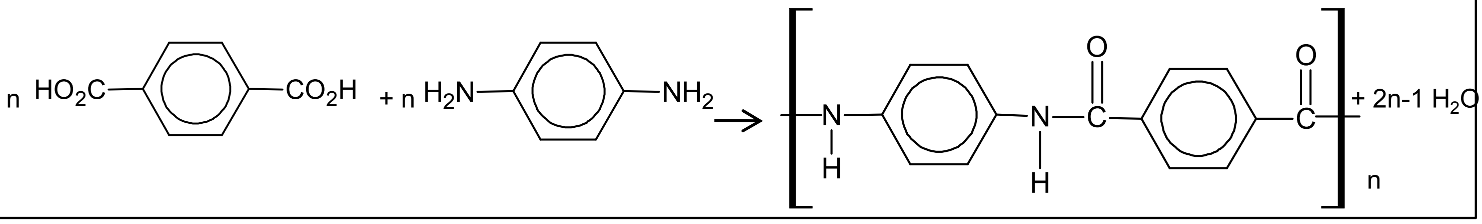
Benzene-1,4-diol

Nylon 6,6 - a common polyamide



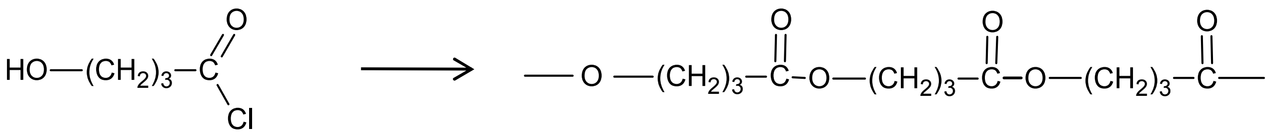
The 6,6 stands for 6 carbons in each of the monomers. Different length Carbon chains produce different polyamides

Kevlar- a common polyamide

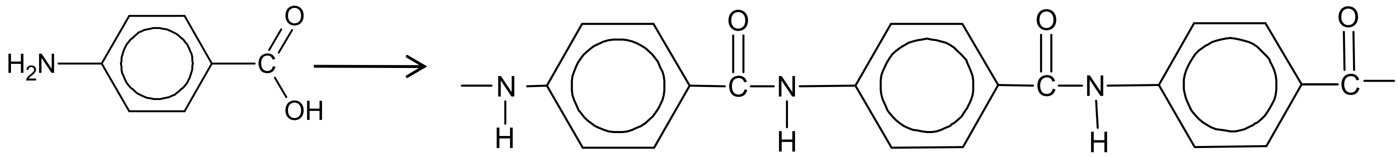


Note on classification for condensation polymers
If asked for **type of polymer**: It is polyamide or polyester
Whereas **type of polymerisation** is **condensation**

It is also possible for polyamides and polyesters to form from **one** monomer, if that monomer contains both the functional groups needed to react



3 repeating units



3 repeating units

Chemical reactivity of condensation polymers

polyesters and polyamides can be broken down by hydrolysis and are, therefore, biodegradable

The reactivity can be explained by the presence of **polar bonds** which can attract attacking species such as nucleophiles and acids

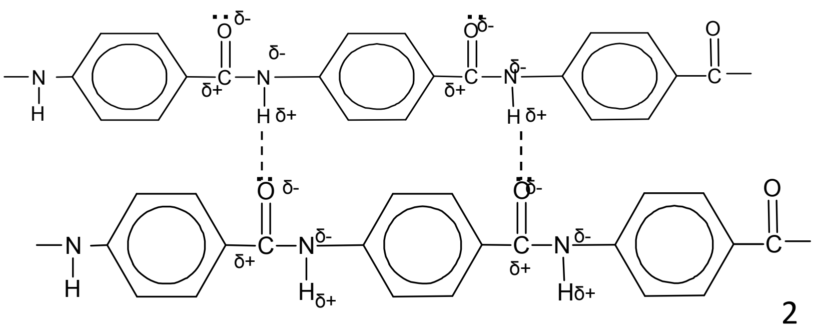
Polyesters can be hydrolysed by acid and alkali
With HCl a polyester will be hydrolysed and split up in to the original dicarboxylic acid and diol
With NaOH an polyester will be hydrolysed and split up into the diol and dicarboxylic acid salt.

Polyamides can be hydrolysed by aqueous acids or alkalis.
With HCl an polyamide will be hydrolysed and split up in to the original dicarboxylic acid and diamine salt
With NaOH an polyamide will be hydrolysed and split up into the diamine and dicarboxylic acid salt

Intermolecular bonding between condensation polymers chains

Polyesters has permanent dipole bonding between the $C^{\delta+}=O^{\delta-}$ groups in the different chains in addition to the van der waals forces.

Polyamides (and proteins) has hydrogen bonding between the oxygen in $C^{\delta+}=O^{\delta-}$ groups and the H in the $N^{\delta-}—H^{\delta+}$ groups in the different chains in addition to the van der waals forces.



Disposal of polymers

Landfill

The most common method of disposal of waste in UK
Many are now reaching capacity.
European regulations will mean councils are charged much more for using landfill.
Most polymers (polyalkenes) are non-biodegradable and take many years to break down.
Could use more biodegradable plastics, e.g. Polyamides and cellulose and starch based polymers to improve rates of decomposition

Incineration

Rubbish is burnt and energy produced is used to generate electricity.
Some toxins can be released on incineration. Modern incinerators can burn more efficiently and most toxins and pollutants can be removed. Greenhouse gases will still be emitted though.
Volume of rubbish is greatly reduced.

recycling

Saves raw materials- nearly all polymers are formed from compounds sourced/produced from crude oil. Saves precious resources.
Polymers need collecting/ sorting- expensive process in terms of energy and manpower.
Polymers can only be recycled into the same type – so careful separation needs to be done.
Thermoplastic polymers can be melted down and reshaped