

# Polymers

## What are polymers?

- Plastics and proteins are macromolecules
- Macromolecules are very large molecules made up of repeating units
- We make plastics from lots of small molecules that join together to form long chains
- We call the small molecules that join together monomers
- The long-chain molecule formed by joining the monomers is called a polymer
- The process of joining monomers together to form polymers is called polymerization
- Polymers are often formed by addition reactions
- We call this type of polymerization, where there are no other substances formed, addition polymerization
- Poly(ethene), commonly just called polythene is a plastic that is easy to shape and quite strong
- It is made by joining ethene monomers together

## Plastics

- Plastics are particular types of polymers that can be molded
- Plastics have a wide range of uses:
  - i. Poly(ethene) for bowls, buckets, dustbins and plastic bags
  - ii. Poly(propene) for milk crates and ropes
  - iii. Poly(chloroethene) (polyvinyl chloride, PVC) for insulation around electrical wires and for rainwater pipes and gutters
  - iv. Nylon for ropes, clothes and fishing nets
  - v. Terylene for clothing
- Many plastics are non-biodegradable
- This means they are not broken down in the soil or water by micro-organisms when they are thrown away
- If plastics get into drains they can block them and cause flooding
- Plastics can kill wildlife by trapping small animals or blocking the digestive systems of animals and birds that eat plastic along with their normal food
- How can we deal with unwanted plastics?
  - i. Put them into landfills. These fill up very quickly and use up land that could be used for agriculture or housing
  - ii. Burn them- we can use the heat produced to provide electricity or heating. But many plastic produce poisonous gases when they burn. PVC produces acidic hydrogen chloride. Plastics containing nitrogen may produce toxic hydrogen cyanide. Many plastics when burnt at high temperatures also produce poisonous compounds called dioxins. It is very expensive to put filters on the furnaces used to burn plastics so this is rarely done
  - iii. Recycling- some plastics can be melted and then molded to make new articles. Not all plastics can be recycled. The ones that can be recycled have to be sorted out, which takes time and money
  - iv. Cracking- some plastics can be melted, then cracked and then re-polymerized to make new articles
- Plastics has now been made biodegradable but many are not

## Polymer structure

- To add an addition polymer you have to put the name of the monomer inside the brackets and put 'poly' in front
- Some polymers are often called by their common names so it is not always easy to deduce the structure from the name of the monomer

## From monomer to polymer

- Write down the formulae for the number of monomer units you want but change each double bond to a single bond
- Draw single bonds between the monomer units
- Put continuation bonds at either end of the chain to show that the chain carries on in the same way

We can also write the structure of the polymer much more simply:

- Draw the structure of the monomer but change the double bond to a single bond
- Put continuation bonds at either end of the molecule
- Put square brackets through the continuation bonds
- Put an  $n$  at the bottom right-hand corner. This means that the unit repeats itself  $n$  times

## From polymer to monomer

You can find the structure of the monomer from a diagram of the polymer:

- Identify the repeating unit in the polymer and draw this
- Ignore the brackets, the continuation bonds and the  $n$
- Make the single bond between the carbon atoms of the polymer into a double bond

## Polyamides and polyesters

- We make addition polymer by joining the monomers together to make a long chain
- No other substance is formed
- However, many polymers such as nylon and Terylene are formed in a different way-by condensation polymerization
- In condensation polymerization, the monomers react together to form the polymer and another product
- The other product is usually a small such as water or hydrogen chloride
- We say that the small molecule is eliminated
- Condensation polymerization usually involves two different monomer, each with a different functional group
- These groups react together to form the polymer

## Polyamides

- Nylon is a typical polyamide
- The two types of monomer that form a polyamide are carboxylic acids and amines
- An amine is a compound with an  $NH_2$  functional group
- A carboxylic acid reacts with an amine to form an amide

- This type of reaction, where two molecules join together and a small molecule is eliminated is called a condensation reaction
- Each monomer has two functional group
- We put the word di- in front of the names to show that there are two functional groups per monomer
- Because each end of the monomer has a reactive functional group, a long chain is formed

### Polyesters

- Terylene is a typical polyester
- The two types of monomer that form a polyester are carboxylic acids and alcohols
- An ester linkage is formed