Pasta Polymers

YEAR 8/9 – working in groups of 4

What is green chemistry?

Green chemistry aims at changing the mindset and practices associated with everyday chemistry, to be safe, sustainable, environmentally friendly, renewable and non-toxic.

Plastics are all around us. Conventional plastics are made from non-biodegradable materials that take centuries to break down in landfill and sometimes end up polluting our environment.

The main composition of most plastics is polymers. You will remember from the biodegradable water bottle experiment that polymers are large molecules made up from lots of smaller ones (monomers) in a long chain.

Polymers are formed by a process called polymerisation, which reacts the smaller monomers to form a long polymer chain. Some polymers have longer, free flowing chains that make the plastic more **flexible**, while other polymers are more tightly packed, making the material more **rigid**.

Understanding what polymers are is important in the development of greener replacements for traditional plastics. The four different kind of chain polymers we will be focussing on are:

1. Homopolymer – a polymer consisting of only one kind of monomer.
2. Alternating copolymer – a polymer consisting of repeating units of monomers.
3. Block copolymer – a polymer consisting of two (or more) repeating units of monomers.
4. Random polymer – a polymer consisting of two or more monomers arranged randomly.

Cross-linkers are also present in many natural and synthetic polymers. A cross-linker binds chains of polymers together. You have already explored what happens when you add a cross-linker (calcium) to alginate when you made biodegradable water bottles. Below is a picture to help you refresh your memory.

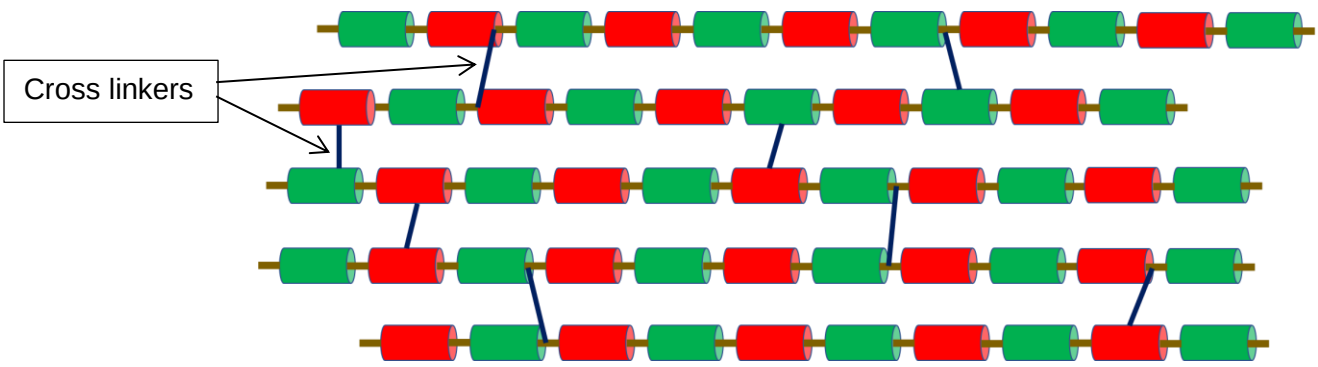

Figure 1: Structure of a copolymer following the addition of a cross-linker.

Get thinking!

What are some objects that help to visualise polymers?

In this exercise, you will make four different kinds of polymers (a homopolymer, alternating copolymer, block copolymer and random polymer). Following this, you will explore the properties of the polymer upon cross-linking and discuss what applications the different outcomes may have.

Materials:

Part 1: Red and green pasta (2 different monomer units) - 1 bag of monomers.
Part 1: Brown or white twine.
Part 2: Paper clips (cross-linker 1).
Part 2: Black twine (cross-linker 2)

Method - Part 1: Creating polymer chains from pasta (groups of 4)

1. Collect all materials.
2. Each person in the group should make one each of the following polymers using 10 - 15 pastas (monomers) per polymer chain. Tie a large knot in the brown/white twine provided and thread monomers onto the twine to create your polymer.

    - Homopolymer (using green pasta)
    - Alternating copolymer (using red and green pasta)
    - Block copolymer (using red and green pasta)
    - Random polymer (using red and green pasta)

Method - Part 2: Cross-linking your polymers (groups of 4)

1. From part 1, each person in the group should have 4 polymer chains, one of each type of polymer. If you don't, go back to part 1 and make the four polymer chains.
2. As a group, cross-link your **homopolymer** chains using ~8 paperclips. Pay attention to how much movement your polymer complex has.
3. As a group, cross-link your copolymer chains using ~8 pieces of black twine.
4. As a group, using up to 10 crosslinkers of any kind, create a polymer that is **flexible** from your block copolymer
5. As a group, using up to 10 crosslinkers of any kind, create a polymer that is **rigid** from your block copolymer

Questions

1. What do the individual red and blue pastas represent?
2. What is the reason(s) for using different types of monomers to make polymers?
3. What is the effect of adding the cross-linker?
4. Define rigid and flexible. How does the type and number of cross-linkers used correlate with the definitions?
5. Which cross-linker (paperclip or black twine) formed a more rigid polymer?
6. Which cross-linker would you use to hold a marble in your polymer structure? What is the reason for your selection?
7. Think about how you, as a Scientist, could design plastics to be biodegradable and 'green'?