Pasta Polymers

YEAR 6/7 – working in groups of 4

What is green chemistry?

Green Chemistry aims to change the mindset and practices associated with everyday chemistry, to be safe, sustainable, environmentally friendly, re-used and non-toxic.

Polymers

Plastics are all around us. Conventional plastics are made from non-biodegradable materials that take centuries to break down and sometimes end up polluting our environment. Most plastics are made up from polymers. Polymers are large molecules made from reacting lots of smaller ones (monomers) to form a long chain.

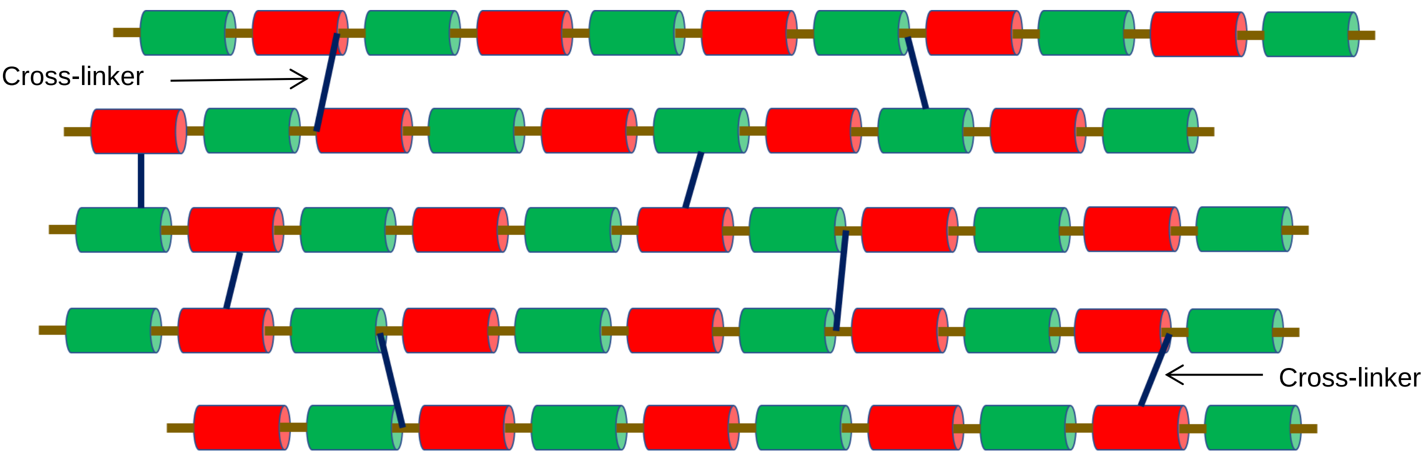
Understanding what polymers are is important in the development of greener replacements for traditional plastics.

The two different kinds of polymer chains we will be focussing on today are:

1. Homopolymer – a polymer consisting of only one kind of monomer.

2. Alternating copolymer – a polymer consisting of repeating units of monomers

Polymer chains can also be joined in different ways, changing their physical properties. To join polymer chains, you use a cross-linker (shown in the figure below). This stops the chains sliding past each other and creates a structure like a net.



In this exercise, you'll make homopolymers and alternating copolymer chains. Then, you'll join the polymer chains using cross-linkers.

Materials Working in groups of four, please provide each group with the following.

- Green and red pasta (2 different monomer units)
  - **Homopolymer** Each group needs 40 pieces of green pasta (from the homopolymer ziplock bag). This will allow students to create 1 homopolymer chain each.
  - **Alternating polymer**: Each group requires 20 pieces of red and 20 pieces of green pasta from the appropriate alternating polymer bags.
- Brown/white twine There is 80m of brown twine included in your student kit. Each polymer chain requires ~60 cm of twine. Please cut 8 x 60 cm pieces of brown twine for each group
- Paper clips (cross-linker 1) - There is a box of 100 paperclips in your student kit. Each group requires 10 paperclips to cross-link their polymer chains.
- Black twine (cross-linker 2) - There is black twine included in your kit. For each group they will need 8 pieces of approx 30 cm.

Read through the method and discussion questions below before starting.

Method

1. Collect all materials.
2. In your group, create 4 **homopolymer** chains using the green pasta - thread the monomers onto the twine provided to create your polymer. Tie each end of the twine to stop the pasta falling off. Each chain should contain 10 pastas. Use the image on page 1 to help you.
3. In your group, create 4 **alternating copolymer** chains using the green and red pasta - thread the monomers onto the twine provided to create your polymer. Each chain should contain 10 pastas. Use the image on page 1 to help you.
4. Once you've created your polymer chains, try joining them using the paper clips - use up to 10 paperclips. Observe your cross-linked polymer chain. Take note of the way it moves. When using the paperclips to crosslink the chain - the students should see a less flexible crosslinked polymer.
5. Remove the small paper clips, and join your polymer chains with the black twine pieces. Observe the difference in your cross-linked chain compared to previously.

Questions

1. What does each single green/red pasta represent?

Each red or green pasta represents a single monomer - when joined together, they form a polymer.

2. What does the paperclip represent? What is the difference between the paperclip and the black twine?

Cross-linker. The black twine is also a cross-linker; however, it will cross-link polymers chains more flexibly.

3. If you connect your chain with paper clips and compare it to the chains connected with black twine, does your polymer more or less freely?

The paperclips are smaller and move less freely than the black twine, therefore, if you cross-link the polymer chains with the paperclip, compared to the twine it will move less freely (more rigid or stiff).

4. Can you create a polymer that will hold an object on your desk? (consider a fishing net)

This will encourage the students to conceptualise the flexible/rigid and small/large crosslinker and how it changes the properties of the crosslinked polymer.

5. Be creative in modifying the existing polymer chain (for example: connect the two ends of the chain together, add another chain via a cross-linker). How does this flexibility of making plastics relate to our daily lives?

Students could make branched chain polymers (a straight chain with several arms) and connect these with cross-linkers.

A more flexible polymer will usually relate to a less cross-linked polymer and a softer more flexible plastic. You could compare a vessel made from hard plastic to ziplock bags.

6. How would you, as a Scientist, develop plastics that are more biodegradable and "green"?

In answering this question, we want to engage students in thinking about 'green alternatives'. Ask the students to think about what part of the 'polymer' could be changed to make the polymer green. The monomers and cross-linker make up the polymers, so if they were to substitute a non-biodegradable monomer with a greener alternative, this may result in a more environmentally friendly plastic.

Extra notes:

If the students would like more information, the following delves into green and biodegradable polymers, how they differ from each other and how they are defined.

When are polymers biodegradable

- When polymers can be broken down into individual monomer units and further break them down into natural elements in a short span of time, then they are biodegradable.
- Biodegradable polymers can be synthetic, natural or a combination of both.
- Natural biodegradable polymers- Silk, Keratin, cellulose, even our DNA!
- Synthetic biodegradable polymers- some types of polyester, poly(lactic acid).

What are green polymers

- Green polymers are polymers made using sustainable methods.
- Green chemistry focusses of either replacing a synthetic polymer with a natural counterpart and if that is not possible, reducing the effect on the environment while synthesizing them.
- The green nature of polymers can be improved by using biodegradable crosslinkers that join the polymer strands.
- While all biodegradable polymers can be considered green polymers (if they are made in a sustainable way), not all green polymers may be biodegradable.