

# Chemistry

**The world wrapped in plastic**

RecyCOOL Lessons

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# The world wrapped in plastics

## Description of the lesson

The lesson begins with learners recalling what they already know about plastics and plastic pollution. Then the learners will explore some basic chemistry of plastics with the example of the most common type of synthetic plastic – polyethylene. At the end of the lesson, students in the class will be recalling what they have learned, by answering some questions.

## Objective

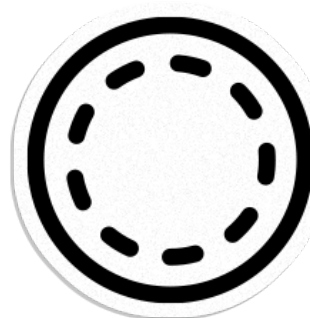
The objective of this lesson is to explain the basic chemistry and environmental impact of plastics, with the example of the most common type of synthetic plastic – polyethylene.

## After this lesson you will be able to

- describe what plastics are
- describe the basic chemistry of polyethylene
- describe synthesis of polyethylene
- name the factors and conditions needed for the degradation of polyethylene in nature

## Tools and materials:

pen and paper



## **THE CHEMISTRY OF POLYETHYLENE:**

Polyethylene is a commonly used plastic material that consists of a long chain of carbon atoms with two hydrogen atoms attached to each carbon atom.

**Almost every product humans make either contains or is wrapped in plastics. Think about the following scenarios.**

**When buying clothes, are they wrapped in plastics? Do they contain plastic labels? Is there a difference in the amount of plastics involved in your clothing, depending on if you buy the clothes in a store or online?**

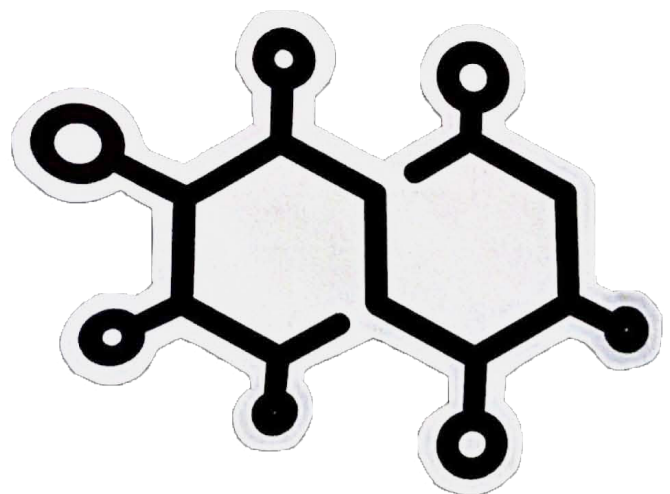
**What do you do, or what could you do – to minimise the use of plastics in your everyday life? What do you think plastic is?**

**Nowadays, there is more and more information about plastics all over the world. Did you know that plastics were found inside glaciers, and at the bottom of the ocean (8, 9)? Why do you think plastics are such a problem for the environment? Write down some of your conclusions.**

**Can you live without plastics?** Think of what you would lose if you stopped using it. Nowadays it is impossible to avoid it, and our lives would have to change dramatically if we decided not to use it anymore.

The textile industry, as with every other industry, isn't devoid of plastics. **As the factories need to make sure that their products come to their destination in mint condition, clothes** – mainly shirts, t-shirts, trousers and so on – **are usually folded neatly and wrapped in plastic packaging.** Coats, dresses and other clothes that are transported while hanging, are also wrapped in plastics.

Furthermore, textiles that come to the factories as a raw material are often wrapped around a plastic cylindrical cone. **It is known that 342 million barrels of petroleum is used to produce plastics for the fashion industry, for packaging and material production, which is 1.35% of global oil consumption.**



- Did you know that...

Fashion Revolution's Global Fashion Transparency Index finds that of the 250 major brands and retailers reviewed on their level of public disclosure across various human rights and environmental targets, 45% disclose measurable, time-bound targets for the reduction of virgin plastics for packaging whereas just 31% publish measurable, time-bound targets for the reduction of textiles deriving from virgin fossil fuels.

This, despite the fact that **more than half of the world's garments** are made from synthetic fibres, with the four most common being polyester, nylon, polyolefins and acrylic. The fact that more brands have targets to reduce usage of virgin plastic when it comes to packaging (as opposed to textiles) signals that they are responding firstly toward something that consumers more easily recognise as plastic. According to the **International Energy Agency**, the production of synthetic fibres is estimated to account for 15% of plastic use and 1.35% of crude oil consumption globally. **The textile sector is target user of plastic after packaging and construction.**

So, textiles and clothes are often packed with plastics. But why is everything wrapped in plastics nowadays? Why not textile, paper or something else?

Plastic is a good material as it is easy to produce and form, it's cheap, light and it's very durable. All those things are perfect for the logistics of transportation. But, plastics, when improperly discarded, cause huge environmental damage.

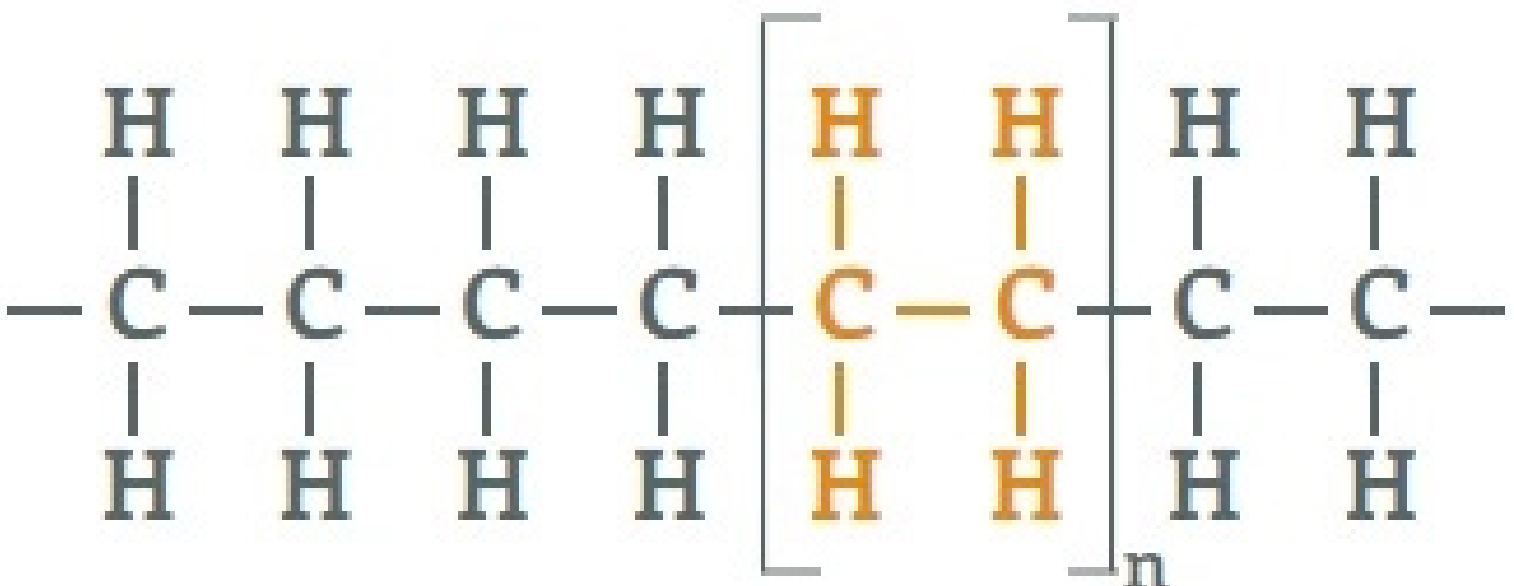
## What exactly is in plastic?

What's the chemistry around it?

Plastic is a group of synthetic and naturally occurring materials that can be easy to shape when softened, and then hardened to retain their shape.

Plastics are polymers (**poly-** many, **meros-** units), meaning that they are made from many repeating units. There are many types of synthetic plastics, like **polyethylene** (PE), **polystyrene** (styrofoam; PS), **polypropylene** (PP), and so on.

The types of plastic materials that are softened under elevated temperature, and hardened on the low temperatures are called **thermoplastics**. One example of thermoplastics, commonly used in packaging, is PE - which is also the most widely used plastic in the world. PE is a **hydrocarbon** (chemicals made of hydrogen and carbon atoms) with the formula  $(C_2H_4)_n$  (where  $C_2H_4$  is one unit that's repeated multiple times (n)).



## How is the PE synthesised?

PE is created from the ethene gas ( $C_2H_4$ ; usually obtained from the process of refinement of crude oil) under specialised conditions, such as **high pressure or addition of catalyzers**.

The process of synthesis is called **addition polymerisation**, meaning that one unit per time **is added to the end of a growing chain**.

The first step of the process is called **initiation** and it involves the **breaking of the double bond between two carbon atoms in the ethene molecule**. That is achieved by the free radical molecule ( $X^*$  on the image; each molecule with an asterisk represents a free radical molecule), and the result is the **new free radical molecule**.

**Free radicals** are the molecular species with the unpaired, free electron, that makes them highly reactive and capable of tearing chemical bonds in molecules. The new radical can break the double bond of the next ethene molecule, thus joining the two units of PE, in the process called **propagation**.

The last step is **termination**, in which two free radicals come into contact and stop the reaction (not shown in the image). The final product is usually PE pellets that are shipped as **a raw material to various factories**.



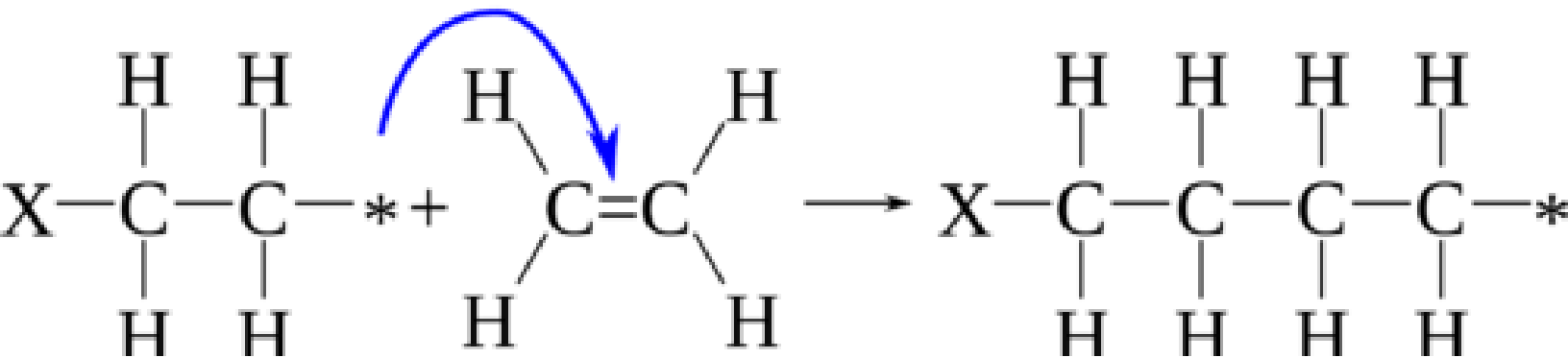
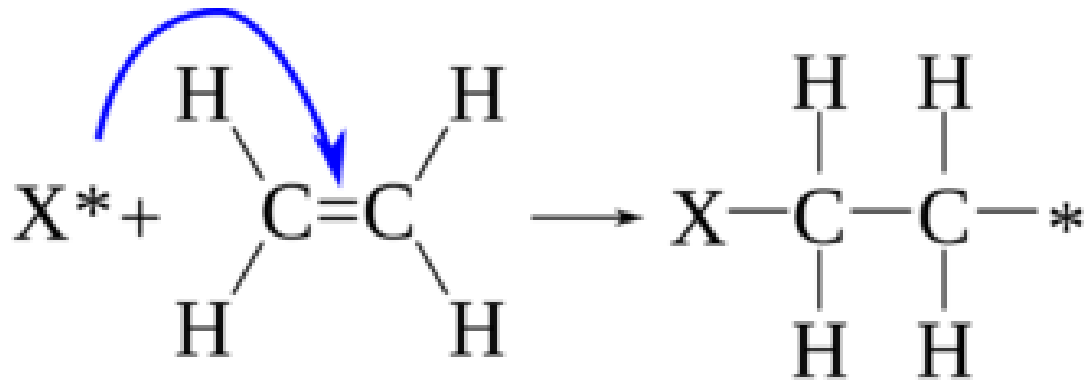


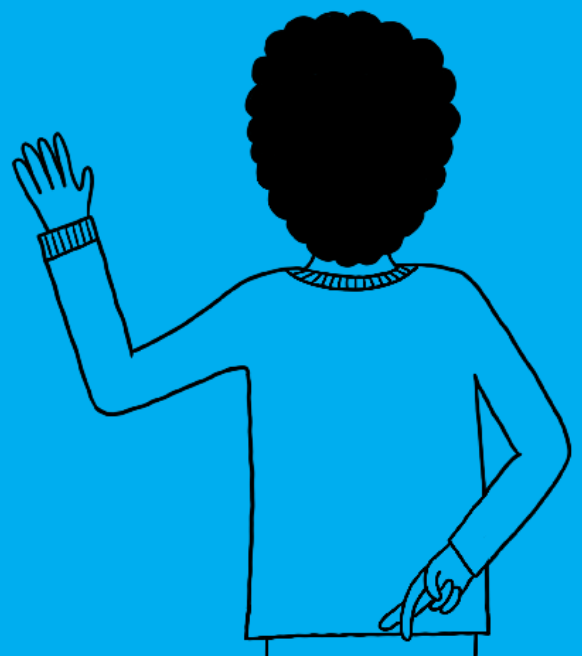
Photo credit: [LibreTexts](#)

Although a wonderful material, PE has a huge drawback – PE is remarkably **resistant to degradation in nature**. The process of degradation of PE takes a combination of factors that can be divided into abiotic and biotic factors.

Abiotic factors include things like temperature and UV light, and biotic factors include microorganisms that can use PE as the source of carbon (food).

Although the degradation is possible, it takes a long time for PE to fully degrade and in that period, PE products can cause a lot of environmental damage.

- What are plastics?
- Can you name three types of synthetic plastics?
- What are polymers? Can you name three polymers except plastics?
- Please draw the chemical formula and structure of ethene and polyethylene.
- Name three stages of polyethylene synthesis.
- What are free radicals?
- What are biotic, and what are abiotic factors (in general)?
- Is it possible for polyethylene to degrade in nature? What does it take for degradation to happen?



# Reflection

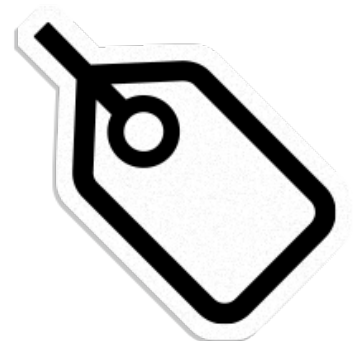
**Plastics are polymers, meaning that they are made of many repeating units. Plastics can be synthetic (man made) or natural.**

There are many types of synthetic plastics, of which the most common is polyethylene. Polyethylene is a thermoplastics, meaning that it can be softened using elevated temperature, made into liquid, and then moulded into any desired shape.

**Do you think thermoplastics can be recycled? Explain how! The synthesis of polyethylene goes from the gas molecule ethene and it consists of 3 general steps: initiation, propagation and termination.**

Although previously thought that the degradation of polyethylene in nature is not possible, today we know the requirements for it to happen, although the process is extremely slow. As the process of degradation is very slow, the polyethylene products, such as plastic bags, can linger on in nature for a long time, and thus create huge environmental damage.

**Do you think you're ready for life without plastics? Can you think of an alternative to plastics? If not, please dispose it correctly.**



# Resources

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