

Plastics forever?

Robert Brook/SPL

Polymers affect every day of our lives. They have such diverse characteristics and applications that their usefulness can only be limited by our imagination. Polymers are materials of our past, present and future so a responsible and systematic recycling programme is both economically and environmentally advantageous.

In the distant future, archaeologists will unearth objects that we have thrown away today. When they sift through all the rubbish laid down in the twentieth and twenty-first centuries they will find a mass of synthetic (man-made) materials. They will surely ask the question: 'Why did we suddenly decide to make our own materials?'

They will look back at layers of debris from earlier and later periods and make guesses. They will probably realise that we were trying to substitute expensive and strategically important materials for cheaper, home-made alternatives. They might also notice that

Box 1 Making polymers

Polymers are formed by chemical reactions in which a large number of molecules (called monomers) are joined sequentially, forming a long chain. In many polymers, only one monomer is used. In others, two or three different monomers may be combined.

Polymers are classified by the characteristics of the reactions by which they are formed. If all atoms in the monomers are incorporated into the polymer, the polymer is called an **addition polymer**. If some of the atoms of the monomers are released as small molecules, such as water, the polymer is called a **condensation polymer**.

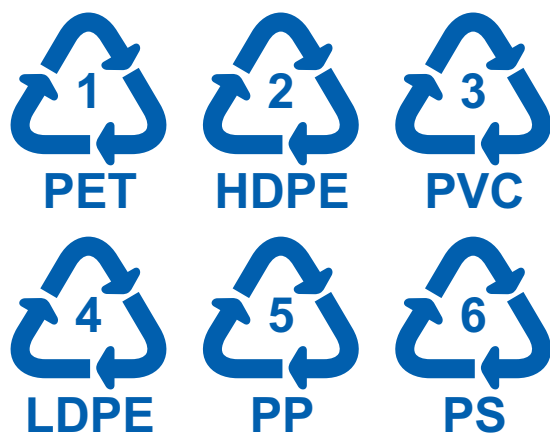
Most addition polymers are made from monomers containing a double bond between carbon atoms. Such monomers are called alkenes, and most commercial addition polymers are poly(alkenes). Condensation polymers are made from monomers that have two different groups of atoms which can join together to form, for example, polyesters and polyamides (nylon).

we were trying to improve on the properties of natural resources: synthetic materials can be stronger, lighter, more flexible or longer-lasting. Much of what the archaeologists will find will be in the same condition as it is today. Many of the materials we are making are, by the very nature of their improved attributes, difficult to recycle, redesign or degrade.

GCSE key words

Polymer
Recycling
Addition
Condensation

Right: Recycling logos. These indicate the type of plastic, to aid recycling. Some kerbside recycling schemes only accept particular types of plastic, e.g. 1 (PET) and 2 (HDPE)



For every seven lorries needed to deliver paper bags to the shops, only one lorry is needed to carry the same number of plastic bags.

Without plastics, 400% more material by weight would be needed to make packaging.

Foam polystyrene containers take 30% less total energy to make than cardboard containers.

Polymers

Polymers are substances whose molecules have high molecular mass and are composed of a large number of repeating units (see Box 1). They can be naturally occurring (e.g. proteins, starches, cellulose and latex) or synthetic. Synthetic polymers, which include materials commonly called **plastics**, are produced commercially on a very large scale and have a wide range of properties and uses.

Types of plastics

Plastics are divided into two distinct groups: **thermo-plastics** and **thermosets**. The majority are thermo-plastic – this means that once the plastic is formed it can be heated and reformed repeatedly. This property allows for easy processing and facilitates recycling. The other group, the thermosets, cannot be remelted. Once these plastics are formed, reheating will cause the material to decompose rather than melt.

Each plastic has its own distinct characteristics, but most share the general attributes listed in Box 2. Scientists and engineers are always producing better materials by manipulating the molecular structure that affects the final polymer produced. Manufacturers

introduce various fillers, reinforcements and additives into the base polymers to expand product possibilities.

Additives

Additives are incorporated into plastics to alter and improve their basic mechanical, physical or chemical properties. For example:

- to protect plastics from the degrading effects of light, heat or bacteria
- to change such plastic properties as flow
- to provide colour
- to provide special characteristics such as improved surface appearance or reduced friction

Plasticisers are incorporated into certain plastics to increase flexibility and workability. They are found in many plastic film wraps and in flexible plastic tubing, both of which are commonly used in food packaging and processing.

Recycling

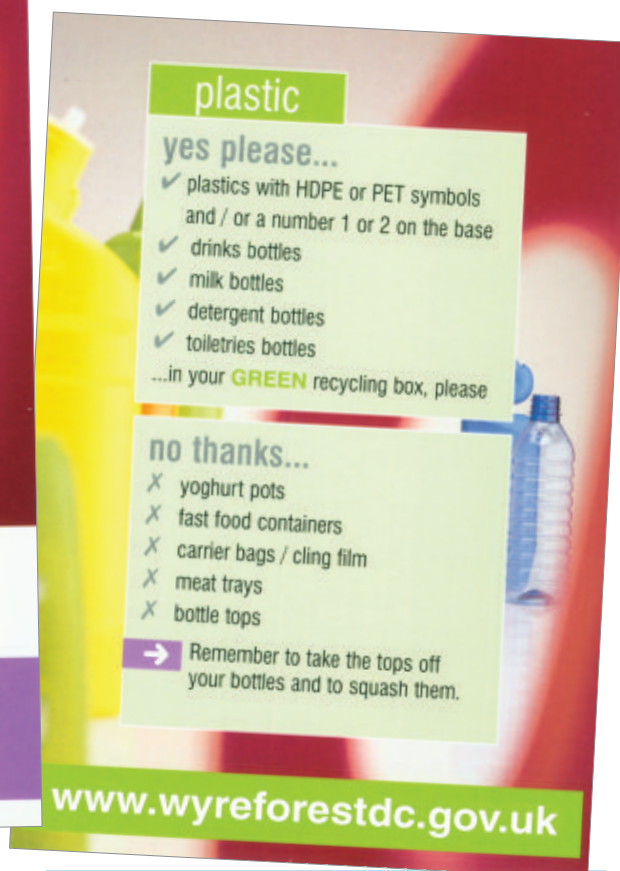
Recycling of plastic packaging began in the early 1980s with schemes for plastic bottle returns, similar to those for glass. Once collected, the plastics are delivered to a material recovery facility for sorting. Reclamation is the next stage, in which the plastics are chopped into flakes, washed to remove contaminants and sold to manufacturers who produce new products from the old materials, such as bottles, containers, clothing and carpets.

Another method of recycling plastics uses pyrolysis. This involves heating plastics in the absence of oxygen to break down the long polymer chains into small molecules. Under mild conditions poly(alkenes) can yield a petroleum-like oil. Special conditions can yield monomers such as ethene and propene.

Chemical recycling is another possible method. In this method condensation polymers, such as nylon, are chemically broken down (hydrolysed) to deliver useful starting materials for reuse in polymer manufacture.

Box 2 Characteristics of plastics

- (1) **Plastics can be very resistant to chemicals.** Most of the cleaning fluids in your home are packaged in plastic because plastics are so resistant. The warning labels describe what happens and what to do if the chemical comes into contact with skin or eyes or is ingested, providing a stark illustration of how tough plastic can be.
- (2) **Plastics can be electrical insulators.** All electrical appliances, cords, outlets and wiring are covered with plastics.
- (3) **Plastics can be thermal insulators.** Thermal resistance is evident in the kitchen where plastics are used for pan handles, coffee-pot handles, the foam core of refrigerators and freezers, insulated cups and microwave cookware. The thermal underwear that many skiers wear is made of polypropylene and the insulation for many winter jackets is acrylic.
- (4) **Generally, plastics are very light in weight with varying degrees of strength.** Consider the range of applications, from toys to the frame structure of space stations, or from delicate nylon fibre in stockings to Kevlar, which is used in bullet-proof vests.
- (5) **Plastics can be processed in various ways to produce thin fibres or very intricate parts.** Plastics can be moulded into bottles or components of cars, such as dashboards and bumpers. Some plastics stretch and are flexible, while others, such as polystyrene and polyurethane, can be foamed (contain trapped air).



Left: Plastics section of Wyre Forest District Council recycling leaflet

By using plastic in packaging, product manufacturers in the USA alone could save enough energy to power 3.5 million homes.

Waste prevention

Although it is now possible to recycle used plastic materials, there are two major drawbacks:

- It requires a lot of energy to perform the degradation and reconstitution processes.
- Breaking down plastics can create toxic materials which are far more harmful to the environment than the original polymers.

Ways have therefore been sought to minimise these problems. The best method is obvious — use less plastic in the first place. This can be achieved by:

- redesigning products or packages to reduce the quantity of the materials used
- lengthening the life of products to reduce the frequency of disposal
- using packaging that reduces the amount of damage or spoilage to the product
- reusing products or packages already manufactured in their original state

What are recycled plastics used for?

Applications for recycled plastics are growing every day. Recycled plastics can be blended with plastic that has not been processed before without sacrificing properties in many applications. Recycled plastics are used to make 'plastic wood' for use in picnic tables, fences and outdoor toys, thus saving trees. Plastic from 2-litre bottles is even being spun into fibre for the production of carpets.

One option for plastics that are not recycled, especially those that are soiled, such as used

Box 3 Wyre Forest District Council recycling scheme

The government has set targets for all local councils to increase the amount of waste they recycle. Since its recycling scheme started, Wyre Forest District Council estimates that it is bringing in an average of 600 tonnes of materials for recycling every month from 35 000 properties. Approximately 42 tonnes of this is plastic which would otherwise have gone into landfill sites.

Box 4 Useful websites

To find out more facts, figures and recycling novelties about plastics, log onto:

<http://lifecycle.plasticsresource.com>

<http://www.nationalgeographic.com/resources/ngo/education/plastics>

<http://www.recoup.org>

<http://www.recoveredplastics.com>

microwave food wrap or disposable nappies, can be a waste-to-energy scheme, in which the controlled combustion of the polymers is used to produce heat energy which can then be converted to electrical energy.

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Most supermarkets operate 'Bag for life' schemes. You pay for heavy duty plastic bags which you reuse until they wear out, when they are replaced free of charge.

The number of plastic recycling businesses has nearly tripled over the past decade.

'Plastic wood', made from recycled plastic, holds nails and screws better than wood, is virtually maintenance free and is very durable.