Plastics

What use is plastic? This activity is intended as an introduction to work on plastics and polymers. It aims to get students thinking about the advantages as well as the disadvantages of using plastics. It could be set as homework or done as a group activity in class.

Answers

Item now made of plastic	What it used to be made from	Advantages of using plastic	Disadvantages of using plastic
Bucket	Metal	Lighter, does not rust, more colourful, cheaper	
Milk bottle	Glass	Lighter, cheaper	Cannot be re-used
Rope	Plant-based materials such as cotton or hemp	Lighter, can be coloured, does not corrode	If it is dropped as litter, *eg* in the sea, then does not break down and can be hazardous to wildlife
Disposable cups	Paper, but often not used	Lighter, cheaper	Cannot be broken down (degraded) if dropped as litter
Chairs	Wood, metal	Lighter, greater variety of colours, cheaper	
Water pipes	Metal (lead or copper) in homes; concrete for mains water pipes	Lighter, non-toxic, less likely to crack	
Nappies	Cloth	Waterproof, cheaper	Cannot be re-used or recycled, not biodegradable
There are various possibilities that could be included here			

Table 1 Sample answers

There are other possible answers that could be included in Table 1. The remaining questions can be used as part of a class discussion. Some points you may wish to consider are:

The main advantage of plastics is that they are light. This reduces transport costs and means that less petrol/oil is used to move them around than heavier materials. Many students do not appreciate this. The use of plastic parts in cars has greatly reduced their weight and contributed to the improved efficiency of modern cars. The main disadvantage of plastics is that they are often not biodegradable, so they remain in the environment when thrown away. This is very noticeable in the case of rope. Rope made from plastics (often polypropene) is often washed up on beaches after having been in the ocean for some time. It can kill sea life.

However, the longevity of plastics was initially seen by chemists as a real advantage. For example, if a plastic is used for underground pipe work the fact that it lasts a long time means that it needs less frequent replacement, and less water is wasted as a result of cracks and leaks than might be the case with some other materials.

It is when we litter or are wasteful that the disadvantages of plastics become most noticeable. It might seem easy to say that we should not use plastic packaging at all, but without it far more food would spoil and become inedible before it could be used. This would lead to greater fertiliser and pesticide use in an attempt to increase production to compensate for food wastage.

This is a brief introduction to some of the complex issues raised in the activities provided within this resource that relate to polymers, plastics and the environment.

Degradable plastics

The aims of this activity are to:

- Consider what makes a plastic biodegradable
- Learn the difference between biodegradable and photodegradable plastics
- Consider the social and environmental consequences of using either degradable or non-degradable plastics.

The activity is aimed at able 14–16 year olds and would fit into a unit on plastics, polymers or the environment. Two student sheets are required:

- Degradable plastics – worksheet including questions and a little information
- Degradable plastics – information sheet – more detailed background information; students will need this sheet if they are to tackle all the questions on the Degradable plastics worksheet.

Further information

http://www.co-op.co.uk/ – type ‘consumer issues’ into the search facility then click on ‘Consumer issues index page.’
http://www.foe.co.uk/resource/factsheets/plastics.pdf – this link goes directly to a pdf file. Alternatively, go to http://www.foe.co.uk and type ‘plastics’ into the search facility.
http://www.degradable.net/ – this company sells degradable bags and chemicals that can be added to plastic bags to make them degradable.
http://www.guardian.co.uk/supermarkets/story/0,12784,1274047,00.html – a newspaper story on degradable bags. Copies of the articles could be given to students and used to introduce the activity. (All sites accessed December 2005.)

When using websites, students should be encouraged to consider:

- Who is paying for the website?
- What is the sponsors’/owners’ point of view on the topic being researched?
- Why are they likely to hold that view?
- Is the information likely to be biased? If so, in which direction would you expect the bias to be?

Students should be encouraged not simply to take the information at face value.

Answers

1. Biodegradable means the material can be broken down by the action of living organisms. Photodegradable means it can be broken down by the action of light.

2. This question could be used to highlight the fact that there is no accepted international (or national) definition of biodegradable. The following answers are generally true.

- Polypropene: Not biodegradable – it is like polythene but with a group of atoms substituted for one of the hydrogen atoms.
- PVC: Not biodegradable – it is like polythene but with a chlorine atom substituted for one of the hydrogen atoms.
- Teflon: Not biodegradable – it has four fluorine atoms substitued for the four hydrogen atoms of polythene.
- Polyethene: Will biodegrade if its molecular weight is low enough.
- Polylactic acid: Biodegradable – it contains -CH2-CO- groups in its chain. Bacteria can easily remove this group, which will cause the chain to fall to pieces.

Advantages	Disadvantages
Very little plastic is actually recycled so using degradable plastic reduces waste build-up.	Most plastic goes into landfill and even biodegradable plastic cannot decompose there.
Even in landfill, ordinary plastic does not decompose.	If photodegradable plastics are mixed with ordinary plastic during recycling the resulting plastic mix is sometimes useless because it degrades.
Recycling can take more energy than making the plastics in the first place.	Some degradable plastics do not degrade completely and little bits of plastic which do not break down remain.
Recycled plastic cannot be used for any product that will come in contact with food so it makes sense for food packaging to be made of degradable plastic.	

Table 1 Some advantages and disadvantages of degradable plastics

3.

4. If photodegradable plastics are mixed with other plastics during recycling, the chemical additive used in these photodegradable plastics could begin to degrade the plastic mixture produced. Whatever item was made from the recycled plastic would degrade too. This is not appropriate for all applications. For example, a garden chair made from such recycled plastic could collapse after a year or two of use. This could lead to an even bigger disaster if it caused consumers to think recycled plastic is worthless.

5.

   a) There are fewer than 19 ethene molecules in a chain with a molecular weight of less than 500.
   b) Commonly used polythene consists of chains of 10s of 1000s of ethene molecule units.
   c) No, polythene bags are not biodegradable.

6. Mark letter/essay/leaflet/poster according to the science students have used to explain their arguments. They should distinguish between bio- and photodegradable plastics and consider the arguments for and against the use of each.

What use is plastic?

Many of the things that are now usually made of plastic used to be made from other materials. What are the advantages and disadvantages of using plastic? Think about this as you complete the table below.

Item now made of plastic	What it used to be made from	Advantages of using plastic	Disadvantages of using plastic
Bucket			
Milk bottle			
Rope			
Disposable cups			
Chairs			
Water pipes			
Disposable nappies			

1. Add two other items that are now made of plastic to the table.

2. What are the main advantages and disadvantages of using plastics?

3. Plastics last a long time before they corrode. When is this an advantage and when is it a disadvantage?

Degradable plastics – information sheet

UK plastic facts:

- We produce three million tonnes of plastic each year
- Households are the biggest producers of plastic waste
- 60 % of household waste comes from packaging
- More than 80 % of this plastic is used once and then goes to landfill sites
- Only 7 % of plastic is recycled.

In addition to household waste, there is also the issue of plastic litter (mainly packaging) which is discarded in the environment. On land it is ugly but in the sea it can be deadly – it can cause injury and death to birds, fish and other sea creatures. Given all this, it is not surprising that people are concerned about plastic waste and are increasingly looking to scientists to produce a degradable plastic to help solve the problem. However, there is much debate among scientists and environmentalists as to whether degradable or non-degradable plastic is better for the environment. The conclusions drawn by researchers studying this topic are not always what you might expect. To understand fully the effect a product has on the environment it is necessary to carry out a 'life cycle analysis,' which means looking at the impacts of production, use and disposal of the product.

There are two kinds of degradable plastic: photodegradable and biodegradable.

Photodegradable plastic is usually made of oil-based polymers, just like ordinary plastic. It either has bonds in its structure that can be weakened and broken by sunlight, or it contains a chemical additive which absorbs light and then attacks the polymer and breaks some of the bonds. Once a photodegradable plastic is exposed to light it begins to break down – whether you want it to or not. This can be disastrous if it is mixed in with other plastics during recycling. Photodegradable plastics tend to break down into small particles of plastic rather than decomposing completely.

The idea is that these small pieces will then biodegrade. Unfortunately, they are often not biodegradable and so remain in the environment. The effect that a build-up of small pieces of plastic in the soil might have on the environment has not been investigated. At present, most plastic waste ends up in a landfill site where it is buried in a dark hole in the ground. Under these conditions, photodegradation cannot take place.

Biodegradable plastics can be made from oil or from plant-based products. They are attacked by bacteria, fungi or other micro-organisms which use them as food. The most commonly used plastics have been tested to find out whether they are biodegradable. Polythene is biodegradable as long as its chains have a molecular weight of less than 500; most other polymers are not.

Polyesters are susceptible to biodegradation but they are used very little in packaging materials. As the majority of plastic waste is from packaging, using polyesters will not really help solve either the problem of the large quantity of waste produced or that of litter in the environment.

There is a lot of interest in the idea of making a plastic that can biodegrade in a landfill site. Unfortunately, once a landfill is covered with soil, there is limited oxygen and water available (the conditions are said to be 'anaerobic') and the rate of degradation of all materials (even

those that biodegrade rapidly on the surface) becomes extremely slow. Discarded food has been found in landfill sites several years after it was thrown away.

With this in mind, the British Plastics Federation (a trade association of plastics manufacturers) opposes degradable plastics on the grounds that plastic waste is best recycled. The environmental pressure group 'Friends of the Earth' agrees, arguing that degradable plastic does nothing to promote lasting solutions to plastic waste and that we should be aiming to reduce the amount of plastic we use in the first place and reuse or recycle what we do use.

For further information you could try looking at:
http://www.co-op.co.uk/ – type 'consumer issues' into the search facility then click on 'Consumer issues index page.'
http://www.foe.co.uk/resource/factsheets/plastics.pdf – this link goes directly to a pdf file. Alternatively, go to http://www.foe.co.uk and type 'plastics' into the search facility.
http://www.degradable.net/ – this company sells degradable bags and chemicals that can be added to plastic bags to make them degradable.
http://www.guardian.co.uk/supermarkets/story/0,12784,1274047,00.html – a newspaper story on degradable bags. (All sites accessed December 2005.)

Degradable plastics

The Co-op chain of supermarkets has announced that it will use degradable plastics for both its plastic bags and its bread bags. It is suggesting that this is good for the environment. What is the chemistry behind making plastic degradable and is it a good idea? This activity will help you think through the science and the issues involved.

There are two main ways of making a plastic so that it can rot away. One is to make it out of a material that bacteria consider food so that they digest it in a process called biodegradation. The other way is to make the plastic sensitive to sunlight. The sunlight can then break some of the bonds in the plastic and cause it to break down in a process called photodegradation.

Photodegradation

There are two ways to make plastics photodegradable. Chemists can add a substance that absorbs sunlight to the plastic. The sunlight makes this substance more reactive and it attacks the polymer chains the plastic is made from. When a 'package' of light (a photon) hits a molecule of the added substance this molecule helps focus the energy of the sunlight in a way which causes some of the bonds in the polymer to break. The chains become fractured and brittle so the plastic falls apart.

Biodegradation

In order for a material to be biodegradable, enzymes must be able to attack it. A plastic biodegrades when enzymes chew up (metabolise) the polymer at specific points in the chain.
They can easily snip the chemical group -CH2-CO- from the chain. Polymers such as polythene, polystyrene and polyvinylchoride do not have such bite points along the chain and so cannot be attacked. Micro-organisms can attack polythene but only slowly and not if the polythene has a molecular weight greater than about 500 – above that it is too much of a 'mouthful' for the enzymes. Plastics with a polythene backbone are more resistant to attack by enzymes if one or more of the hydrogen atoms is replaced with another atom or group. In PVC (polyvinyl chloride) one of the hydrogen atoms from the polythene structure is replaced by a chlorine atom; in polystyrene it is replaced by a benzene ring.

Chlorine atoms and benzene rings are completely alien to the micro-organisms so they steer clear of them. These plastics are also very resistant to moisture (water does not soak into them). The micro-organisms are carried about by water so the lack of water in these polymers makes them even harder to break down.

Items such as plastic bags are often made biodegradable by including starch in the material. Starch is a natural polymer which can be consumed quickly by bacteria. This leaves behind the synthetic polymer, but without the starch it is fragile and quickly disintegrates.

1. Explain the meaning of the terms biodegradable and photodegradable.

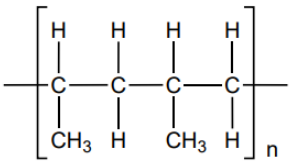
   _____

   _____

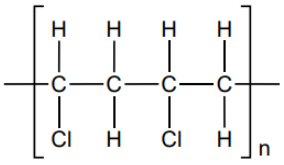
   _____

   _____

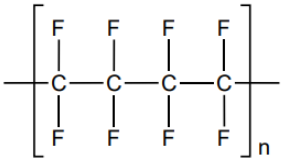
2. Which of the following polymers would you expect to be biodegradable and which do you think are very slow to degrade? Explain your answer



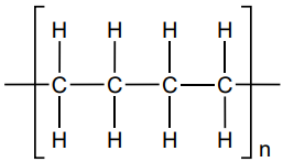
Poly(propene)



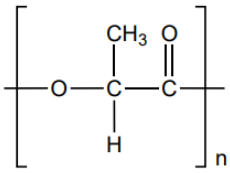
Poly(vinylchloride)
(PVC)



Poly(tetrafluoroethene)
(Teflon)



Poly(ethene)
(Polythene)



Poly(lactic acid)
(PLA)

3. Use the degradable plastics information sheet and/or the websites listed on the sheet to help you make a table showing the advantages and disadvantages of degradable plastics.

4. The information sheet says: ‘Once photodegradable plastic is exposed to light it begins to break down – whether you want it to or not. This can be disastrous if it is mixed with other plastics during recycling.’ Why would this be a disaster?

5. ‘Polythene is biodegradable as long as it has a molecular weight of less than 500.’

a. How many ethene molecules are there in a chain with a weight of less than 500?

b. Aproximately how many ethene molecules are there in the polymer chains found in commonly used polythene?

c. Is the polythene used for items such as plastic bags biodegradable?

6. In Ireland there is a tax on plastic bags of 5 cents in shops. The majority of Irish people now use reusable bags instead and the money funds recycling centres in every village and town.

Do you think we should change to using degradable plastics or should we concentrate on recycling ordinary plastics? Consider both photodegradable and biodegradable plastics. Produce a letter, an essay, a leaflet or a poster explaining your view. Include the science behind your arguments and explain why you have reached your conclusion.