Active and intelligent packaging

Introduction

This activity requires students to use their existing knowledge of redox reactions, word equations, respiration and micro-organisms, as well as knowledge of polymer structure and function, and to apply this knowledge in a new context – that of packaging materials. The student sheet guides them through some of the research and development chemists have carried out in recent years in the area of food packing.

They may need access to texts to assist them in recalling what they have learnt previously.

The activity provides an example of a positive contribution science is making to people's everyday lives, even though they are largely unaware of it.

Suggestions for running the activity

Students could work on their own or in small discussion groups. They could either all write down the answers to the questions or have one scribe and then work together to produce a leaflet or poster to explain the new packaging to customers. At the end of the activity, students are asked for their opinions and feelings on the issues raised. Question 27 on the student sheet could be set as a follow-up homework task.

Timing

1 lesson + possible homework.

Answers

1. Reasons could include: keeps liquids in one place, prevents spillages, protects food, standardises the amount in a pack, allows marketing/branding of products, can put list of ingredients on pack, helps stop the food going off, hygiene, convenience, improves how food looks.
2. Possible aims for packaging include: pre-weighed packs, stop food going off/increase shelf-life, increase speed at check-outs. Students might give a range of other answers.
3. Widgets are expensive so they are only used in relatively expensive products and where there is really no alternative.
4. The reasons people like fresh food include: taste, texture, contains more vitamins and minerals, they enjoy cooking it.
5. Fresh food goes off. Since you cannot keep it for a long time, you either have to go shopping more often or accept a certain amount of wastage.
6. Moulds and bacteria grow on the food and cause it to go off. (Another cause is oxygen reacting with the food, but students will probably not give this answer based on their previous knowledge of science.)
7. Warm, damp conditions make food go off quickly.
8. Glucose + oxygen → carbon dioxide + water $C_6 H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
9. Wet swimming kit left in a plastic bag for a few days starts to smell.
10. Micro-organisms, especially moulds, grow on the kit because there is plenty of water for them. They release the gases that you smell.
11. Fresh fruit and vegetables contain living cells which are respiring. They produce water which cannot escape from the bag. The water encourages micro-organisms (especially moulds) to grow.
12. Moulds need oxygen to survive.
13. An oxygen scavenger is something that removes oxygen.

14. If you remove oxygen from the pack, moulds are less likely to grow because they need oxygen to respire.
15. Oxidise in this context means to react with oxygen.
16. Iron + oxygen → iron oxide
17. They might think their food could get contaminated with a non-edible/poisonous substance.
18. If consumers cannot see the oxygen scavenger, they will not know it is there. Consumers are used to seeing food wrapped in clear plastic and will not notice a difference.
19. Retailers might like the packaging because it will help make the food last longer so less will go past its 'sell-by' date before it is sold. This will reduce the retailer's waste and save money.
20. The new packaging might be more expensive than conventional packing. Questions 21–24 require knowledge of polymers, their structure and function. If this topic has not been covered, you may wish to direct students to leave these questions out or remove them from the worksheet.
21. Polymer: a long chain molecule made of lots of small molecules (monomers) joined together. Side chain: a group of atoms sticking off/attached to the main polymer chain.
22. As the polymer warms up, the molecules move more and vibrate faster.
23. A polymer with long side chains needs more energy to move apart from the other polymer molecules. This is because there are stronger intermolecular forces holding the molecules with long side chains together so it will take more energy to pull them apart.
24. Long side chains are likely to lead to a higher melting point as there are stronger attractions between the polymer chains. The side-chained polymers move more as the material warms up, leading to the opening of pores in the polymer film.
25. Supermarkets might want to use the labels to give consumers confidence in what they are buying.
26. Various answers are possible here – students might answer 'yes' because the labels would allow consumers to see if what they are buying is fresh or not; they might answer 'no' because unscrupulous supermarkets could just change the labels.
27. Paragraph about students' own reaction to the information. Mark by impression.

References and further information

http://www.foodscience.afisc.csiro.au/actpac.htm – good factsheet from the Australian government.
http://www.newscientist.com – a search for 'active packaging' gives some interesting results (the full content of some articles can only be accessed by subscribers).
http://www.chemsoc.org/chembytes/ezine/2003/birkett_oct03.htm – an interesting article but probably beyond most 14–16 year olds; gives more detailed chemical explanations about how the packaging works.
http://www.dupont.com/packaging/structures/index.html – the Dupont website has information about various types of packaging, including food packaging.
(All sites accessed December 2005.)

Active and intelligent packaging

Why use packaging at all?

What do beer, fruit and prepacked sandwiches have in common?

The answer is that scientists are working to improve the quality or safety of all these products by developing active or intelligent packaging for them.

It might seem hard to believe that a piece of plastic packaging could be either active or intelligent. You are going to consider why we use packaging and learn about how scientists are working to make it more efficient.

Think about the last time you were in a supermarket. Most of the food comes in some kind of package. Why is this?

1. Write a list of 10 good reasons why food is put in packages.

_____

_____

_____

_____

_____

For many of the things in your list, the packaging currently available will be completely adequate. What else might it be useful for a package to do?

2. Write a list of things that a supermarket or a customer might like a food package to be able to do. Be creative and imaginative

There are already examples of packets for food that do more than just keep the product in one place and stop it getting all over your other shopping. Some packages can control and even react to things taking place inside them. This is called active packaging. For some years now, it has been possible to get cans which heat or cool themselves. You can also buy a can of beer with a 'widget' in it that ensures a perfect head forms on the drink. The widget is a ball containing nitrogen gas at high pressure. When the ring-pull on the can is pulled, the pressure inside goes down so the nitrogen in the widget comes out and quickly mixes with the drink, causing it to foam and bubble as it is poured out.

3. Why do you think more drinks (cappuccinos or milkshakes, for example) are not sold with a widget?

The widget does not need to be active for very long because the problem it is solving is only an issue for a short amount of time (as the drink is poured out). Some food products raise problems that need to be dealt with over a longer period of time and scientists aim to solve these by developing packaging that can actively help to overcome them.

Fresh food

Many people prefer to eat fresh foods rather than ones which have been frozen, canned or preserved in some way.

4. Why do many people prefer to eat fresh food? What do they think are the benefits of it?

_____

_____

_____

5. What are the problems with fresh food?

_____

_____

_____

6. What causes food to spoil or go off?

_____

_____

_____

7. What conditions make food spoil or go off quickly?

_____

_____

_____

The exact answer to the question above will depend on what the food is.
Different foods keep best under different conditions and manufacturers are now trying to make packaging that keeps food fresh for longer by helping to keep the conditions ideal.

8. Many foods are made of living cells that are respiring. Complete the equation to show what happens during respiration:

Glucose + _____	→ carbon dioxide	+ _____
$C_6H_{12}O_6$ + _____	→ CO_2	+ _____

9. What happens if you leave your wet swimming kit in a plastic bag for a few days?

10. Why does this happen?

The same can happen to fruit and vegetables left in a sealed plastic bag

11. Why does this happen to fruit and vegetables when they are left in a plastic bag? (Hint: look at the equation above.)

Packaging has now been developed that can remove water vapour from inside the pack. Reducing the amount of water present makes it more difficult for bacteria or mould to grow and helps make the product last longer. Mouldy food Growth of bacteria and moulds on food is the reason why a lot of it goes off. Look at the respiration equation. Bacteria and moulds are living organisms so they respire too.

12. Which gas do moulds need to survive?

This gas causes problems for food in other ways too. It reacts with the food itself and can cause it to go 'rancid' or bad, even if no bacteria or mould are present. It also reacts with vitamin C and other nutrients and destroys them.

Scavengers

Below is an extract from an article in New Scientist magazine:

> *Another way to slow decay is to control the atmosphere inside a package with an oxygen scavenger. At the moment, this is done by placing a sachet filled with iron powder in the package. Oxygen in the package is then consumed by the iron as it oxidises. But consumers don't like finding sachets marked "Don't eat!" in their food, so a company called Sealed Air of Saddle Brook, New Jersey, is making a wrap that itself*

scavenges oxygen. The material includes an inner layer of an oxidisable polymer that traps oxygen in the same way as iron. New Scientist, 24 April 2004

13. What is an ‘oxygen scavenger’?

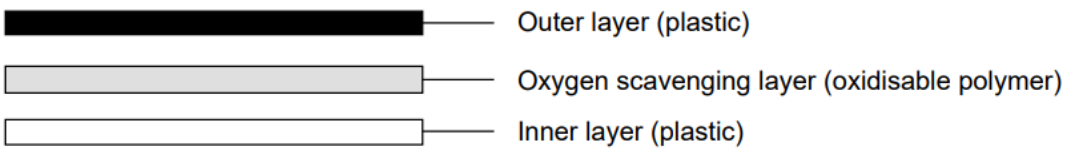
14. Why might you want one in the packaging of your food?

15. What does the word ‘oxidise’ mean?

16. Write a word equation to show what happens when iron is oxidised.

17. Why do you think consumers ‘don’t like finding a sachet marked “Don’t eat!” in their food’?

The new food wrap is clear, just like the ones you see in the shops now. However, unlike most plastics, this wrap has a layer structure.



Layer structure of oxygen scavenging food wrap

18. Why might consumers feel differently about the new method of oxygen scavenging than they do about the old one?

19. Why might some food retailers be keen to have this new type of packaging?

20. Why do you think retailers might not want to use it?

Active plastics

The type of oxygen scavenger described above merely absorbs any oxygen that is present. One company is developing a more 'intelligent' way of dealing with oxygen to protect fresh foods that have long transport times. Freshly cut vegetables and fruit respire at different rates depending on the temperature.

The company has developed a new wrapping film made of a mixture of polymers with side chains of different lengths. The polymer chains with longer side chains have stronger intermolecular forces holding them to other polymer chains. The polymer chains move and melt at different temperatures. As the temperature increases, tiny invisible holes form in the polymer film. The number of holes increases as the temperature rises, allowing more and more oxygen to diffuse through the film.

21. What do the terms polymer and side chain mean?

22. As the solid polymer is warmed up, what happens to the movement of the molecules?

23. Will a polymer molecule with long side chains need more or less energy to move apart from the other polymer chains? Why?

24. Will a polymer whose molecules have long side chains melt at a lower or higher temperature than one with short side chains? Why? Explain your answer in terms of intermolecular forces.

We have seen that active packaging can do three things: make beer foam, remove water and scavenge oxygen. Scientists are not stopping there – they are continuing to develop novel ways of wrapping food.

Another new idea is a special label which can tell you how fresh your food is and whether it is safe to eat. This is called ‘intelligent packaging.’ It can communicate some information to the consumer about the state of the product. There are fewer intelligent packaging systems used for food than active packaging ones because there are strict legal guidelines on the use of intelligent packaging.

However, one type of intelligent packaging is already used by a supermarket in France on packets of meat and fish. There is a chemical in the label that changes colour from light to dark when it reacts. If the packet is kept cool, the reaction is slow, but increasing the temperature speeds up the reaction. As bacteria on food also grow faster if it is warm, it is useful to know if food has been kept cool or not. The ‘intelligent’ label alerts consumers if the meat on sale has been kept too warm for too long. Once the label has gone dark, the product is not guaranteed to be fresh.

25. Why might a supermarket want to have labels like this on their produce?

    _____

    _____

    _____

26. Do you think it would be a good thing for consumers if these labels were widely used? Why?

    _____

    _____

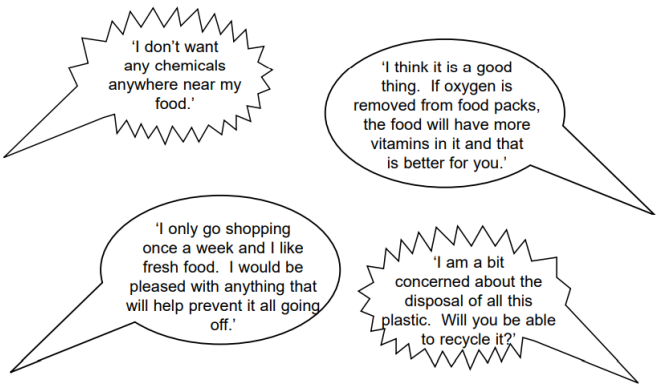
    _____

Another new type of label is being developed for use on foods that give off gases when they decay, eg fish. You can smell these gases if you open the sealed packet, but from the outside the food may look fine. The labels will change colour if they detect the gases so you can tell if the food is fresh before you open the pack.

Other developments include food wraps that kill bacteria and a sandwich wrap which changes colour if it detects the presence of harmful bacteria.

Opinions

Here are some comments that people have made about active packaging:



In groups, discuss these comments and your own opinions about this new packaging. You may like some of the ideas but not others. Do you have any other ideas for active or intelligent packaging that you would like to see scientists develop?

27. Write a paragraph explaining what active packaging is and what you think about it.