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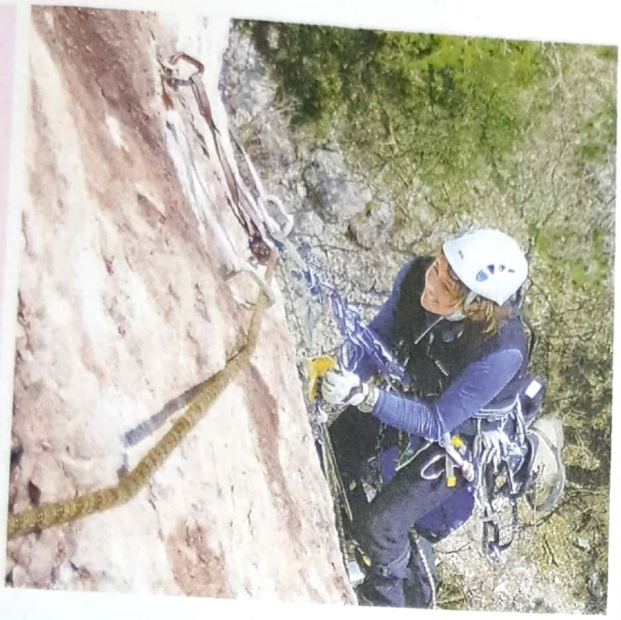


Synthetic Fibres and Plastics

We use a number of materials in our daily life. Some of these such as wood, cotton, stones and clay are **natural materials**. However, most of the materials we see around us do not occur as such in nature. They have been changed from their natural state by chemical processes. Plastics, paints, medicines, cement, fertilizers and synthetic fibres are some such **human-made materials**. These materials are made from **raw materials** such as coal, crude oil, natural gas, air, water, salt and limestone. Chemical processes are used to change these raw materials into materials with special properties which we can use for specific purposes.

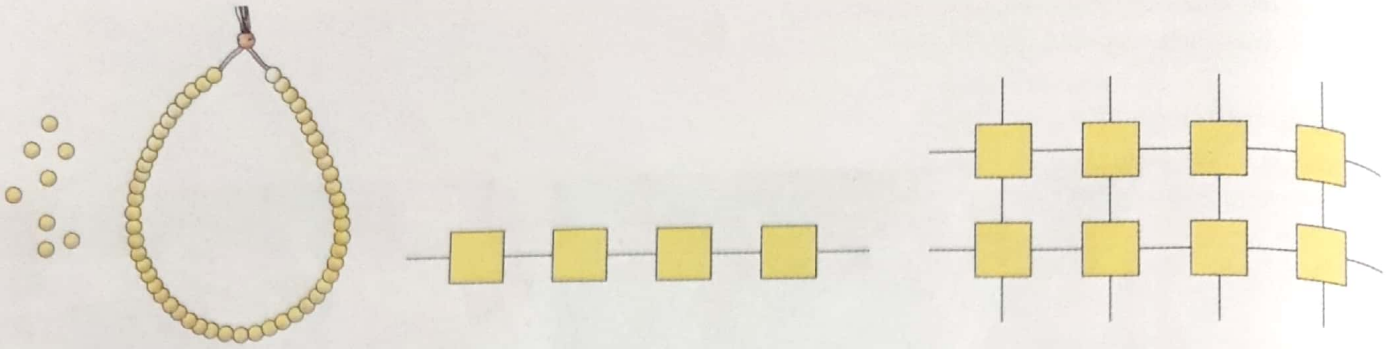
Human-made materials are made in factories called industrial plants. Raw materials are converted into useful materials by chemical reactions. The human-made materials industry is one of the largest industries in the world today.

WHAT ARE POLYMERS?

Synthetic fibres and plastics are made up of molecules called **polymers**. Polymers are huge molecules—usually consisting of long chains made from thousands of similar small molecules called **monomers**. The name polymer is derived from two Greek words—*'poly'* meaning many and *'mer'* meaning part or unit. As the name implies, a polymer is made up of many repeating units.

IN THIS CHAPTER

POLYMERS ◆ SYNTHETIC FIBRES ◆ PLASTICS



a. Beads to necklace b. Monomers to polymers (linear) c. Cross-linked structure

FIG. 3.1 The structure of a polymer can be compared with that of a bead necklace.

The structure of a polymer can be compared to that of a bead necklace—with the beads being the monomers.

All polymers are not linear in structure. In some the structure is cross-linked, as shown in Figure 3.1c.

Most polymers are light, strong, long-lasting, easy to form into shapes, and cheap. This is what makes them so useful.

SYNTHETIC FIBRES

The common natural fibres used for making cloth are wool, cotton and silk. They are obtained from plants and animals. They are natural polymers. Other fibres are man-made. They are polymers, many of which are obtained from petroleum. They are called **synthetic fibres**. Rayon, nylon, polyester and acrylic are some synthetic fibres.

Rayon

Silk is a natural fibre with a beautiful texture. However, it is expensive. Attempts at making a synthetic fibre with similar texture succeeded towards the end of the nineteenth century, when scientists made **rayon**. Rayon is also called **artificial silk**. It is cheaper than silk and can be woven like silk fibres.

Rayon is made from wood pulp. Wood pulp is first dissolved in an alkaline solution. The thick liquid produced is then passed through tiny holes to make fibres. The fibres are hardened by passing them into a bath of sulphuric acid. The fibres are then spun into yarn and woven into cloth.

Rayon is called a **regenerated fibre** because the original raw material, cellulose, is broken down and then reformed. This makes it stronger and easier to dye in a variety of colours. Another useful property of rayon is that it absorbs sweat. Rayon clothes are therefore comfortable to wear in summers.

Uses of rayon

- It is used to make apparel, such as suits, ties, blouses, jackets, stockings, slacks, sportswear, etc.
- Home furnishings, such as bedspreads, bedsheets, blankets, curtains, tablecloths, upholstery, carpets, etc., are made from rayon fibre, as it has a silky lustre.

Nylon

Nylon was the first synthetic fibre to be made entirely of chemicals. It derives its name from the cities of **New York** and **London**, where it was first marketed.

Nylon fibre is very **strong** and **elastic**; in fact, nylon thread is stronger than steel wire. It is **light** and **wrinkle-resistant**. It is also **wear-resistant**; that is why nylon garments last for a long time. It is **easy to wash** and **absorbs**

very little water; therefore, garments made from nylon dry quickly. It is **lustrous** in appearance.

ACTIVITY 1 (Experimental investigation): Tensile strength of fibres

Take threads of cotton, wool, silk and nylon of about the same length and thickness. Hang one of them from a stand. Attach a pan at the other end of the thread. Add weights, one by one, to the pan until the thread breaks. Note the total weight required to break the thread. This gives a measure of the tensile strength of the thread. Repeat with the other threads. Tabulate your results and compare the strengths of the threads.

TABLE 3.1

THREAD	WEIGHT REQUIRED TO BREAK THE THREAD
Cotton	
Wool	
Silk	
Nylon	

Uses of nylon

- Garments such as saris are made from nylon. Since it is wear-resistant, garments made from it last for a long time.
- Being very strong, nylon fibre is used to make ropes (including ropes used during rock-climbing), tents, fishing nets and parachutes.
- It has good elasticity and is, therefore, useful for making socks and stockings.
- Nylon is also used to make toothbrushes, combs, zip fasteners and machine parts.

NYLON STOCKINGS

NYLON TOOTHBRUSH

FIG. 3.2 Some uses of nylon

Polyester

Polyester is manufactured from petroleum. Polyester (poly + ester) is made by repeating units of a chemical called an ester. It has properties similar to those of nylon. It is very strong, crease-resistant, light, elastic and absorbs very little water. It is often mixed with natural fibres to make clothes. With cotton it makes **polycot**, and with wool it forms **polywool**. Clothes made of these mixed fibres are more comfortable to wear than those made of pure polyester.

Terylene, terene and dacron are different types of polyester fibres.

Uses of polyester

Because of many desirable qualities, polyester has many uses.

- Polyester is used to make pants, shirts, suits, and bedsheets either by itself or as a blend.
- Its water-resistant property makes it ideal for garments and jackets that are to be used in wet or damp environments.
- It is used to make jackets and quilted garments.
- PET is a form of polyester used to make bottles, films, utensils, wires, etc.

POLYESTER BAG

POLYESTER PANTS

POLYESTER COAT

FIG. 3.3 Some uses of polyester

Acrylic

Acrylic is a type of synthetic fibre that resembles wool in its properties. It is lightweight, soft and warm, with a wool-like feel. It resists shrinkage and wrinkles. It can also be dyed very well in a variety of colours. Clothes made from acrylic are cheaper than wool.

Characteristics of synthetic fibres

Synthetic fibres have become very popular due to the many advantages that they have over natural fibres. They are strong, crease-resistant, elastic (ability to regain original shape after being stretched), mothproof, easy to wash and last for a long time. However, since they **do not absorb water** or sweat, clothes made of synthetic fibres are not very comfortable to wear. In hot and humid weather, these clothes stick to the body and make us feel uncomfortable.

Some synthetic fibres catch fire very readily. They are easily **inflammable**. Also, they melt on heating and stick to the body of the person wearing them. Therefore, they cause severe burn injuries. Synthetic clothes should not be worn in the kitchen or in the laboratory.

Activity 2 (Experimental investigation): Absorption of water by fibres

Take two pieces of cloth of same size, each about half metre square, but made of different fibres. Let one piece be of a natural fibre, such as cotton, and the other of a synthetic fibre, such as nylon. Take two beakers, both containing the same amount of water. Soak each piece in different beakers. After ten minutes, take the pieces out of water. Put them in the sun to dry. Which piece dries first? Compare the amount of water left behind in each beaker. Which beaker has lost more water?

ORAL QUESTIONS FOR FORMATIVE ASSESSMENT

1. There is a difference between the raw materials used in rayon and other synthetic fibres like nylon or polyester. What is the difference?
2. The prefix 'poly' means 'many' for example, 'polygon' means a figure with many sides. What is the significance of the prefix 'poly' in 'polyester'?
3. Synthetic fibres are strong, elastic, light, wrinkle-resistant, and easy to wash and dry. Even with so many advantages, we do not wear clothes made of pure synthetic fibres, but a mixture of synthetic and natural fibres. Why is this necessary?

PLASTICS

A material is said to be 'plastic' if it can be moulded or formed into different shapes. Thus, dough and plasticine are plastics; so is clay and heated glass. However, the word plastics is now commonly used for several human-made materials that can be moulded into desired shapes or drawn into fibres. All these materials have one common property—they are made of polymers. Scientists have created an enormous range of human-made plastics with different properties. The main source of these plastics is **crude oil**.

Plastics can be classified into two groups, depending on their reaction to heat.

- Thermoplastics, and
- Thermosetting plastics.

In thermoplastics, the process of softening by heating and hardening on cooling can be repeated again and again to soften the plastic

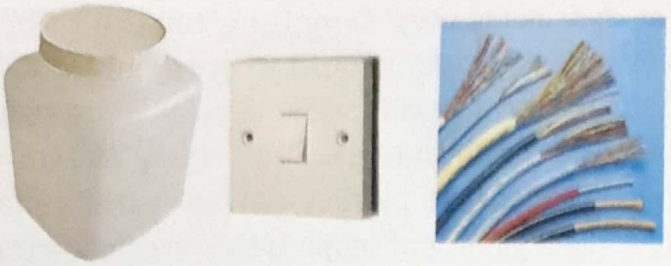
to get different shapes. However, thermosetting plastics can be softened by heating only once. Once they are put into a mould and allowed to harden on cooling, they cannot be softened again on heating, e.g. bakelite and melamine. They can maintain their shape and size even at very high temperatures.

Common uses of plastics

Today, plastics play an important part in our lives. It is the versatility of plastics that is responsible for their many uses. Carry bags, toys, soft drink bottles, car parts, computer parts, refrigerator parts, telephones and many other things around us are made of plastics. Such variety of uses is possible because plastics can be manufactured to have a variety of properties. They can be thin and flexible as well as thick and tough; transparent or coloured; soft or hard; smooth or rough. They are inexpensive, lightweight, resistant to corrosion and action by bacteria, and last much longer than any other material.

TABLE 3.2 Some common man-made plastics and their uses

MAN-MADE PLASTIC	TYPE OF PLASTIC	PROPERTY	USES
1. polythene (or polyethylene)	thermoplastic	strong but flexible; can be rolled into sheets or moulded into any shape; water resistant	sheets of polythene are used to pack liquids such as milk; polythene pipes are used to transport liquids such as oil or water; polythene containers are used to store liquids
2. polyvinyl chloride (PVC)	thermoplastic	tougher than polythene; insulator	used as a covering for electric wires; used to make shoes, handbags, furniture, upholstery, floor coverings, raincoats and bottles
3. polystyrene	thermoplastic	easily moulded	used as a packaging material for delicate objects like electronic items and to make thermocol; used to insulate the hollow walls of refrigerators
4. perspex	thermoplastic	transparent like glass, but much stronger	used as a substitute for glass, for making windows in aeroplanes and windscreens of cars
5. teflon or PTFE (polytetra-fluoroethene)	thermoplastic	slippery, not affected by heat and does not react chemically with other substances	used as a non-stick coating on pans and other cooking utensils
6. bakelite	thermosetting	harder than other plastics and a good electrical insulator	used for making buttons, plugs, switches and other electrical fittings
7. formica and melamine	thermosetting	hard and smooth surface	used as table-tops, and for making crockery



FOOD CONTAINER BAKELITE SWITCH ELECTRIC WIRE COVERING

FIG. 3.4 Some common plastic articles

FIG. 3.5 Plastic waste materials needs to be properly managed.

Characteristics of plastics

- **Thermal conductivity:** Plastics are poor conductors of heat ('thermal' means 'heat'). Therefore, they are used to make handles of cooking utensils, and as insulating wool used in refrigerators to prevent heat from outside to enter inside it.
- **Electrical conductivity:** Plastics are poor conductors of electricity. This is the reason why electric wires, cords of electrical appliances and cables have a plastic coating.
- **Solubility in water:** Plastics are insoluble in water; that is why buckets to store water and glasses to drink water are made from plastics.
- **Effect of flame:** Plastics are inflammable, that is, they burn easily. This explains why a polythene bag burns so easily.
- **Reactivity:** Plastics have no reaction with water and air. They are non-reactive and do not corrode easily. That is why they are used to store chemicals and other materials.

Problems with plastics

When plastics were introduced, they were hailed as a wonder material. However, today plastics have become a serious worldwide environmental and health concern. This is because of their non-biodegradable nature and widespread use.

One of the most significant environmental problems associated with plastics is the improper disposal of plastic goods by people. Do you know that plastic bags and bottles thrown on the roadside could stay in the ground or soil for years? This is because plastics are non-biodegradable, i.e. they cannot be decomposed by the microorganisms in the soil. Careless disposal of plastic bags chokes drains, chokes the soil and hinders the absorption of water by the soil. If eaten by animals such as cows, it can kill them. Plastic bags can also contaminate foodstuffs because of poisonous dyes getting absorbed into food. If burnt, they release poisonous fumes and pollute the air.

Thankfully over the last decade or so, a countrywide network for collection of plastic waste through rag pickers, waste collectors and waste dealers, and recycling enterprises has sprung up all over the country.

Because of this, approximately 60–80 % of the plastic bags generated as waste are collected to be recycled. You must have seen the rest strewn on the ground, littered around in open drains, or in garbage dumps. It is this portion that is of concern as it causes extensive damage to the environment.

In India, some municipal areas have banned the use of plastics and they seem to have achieved success, for example, in Ladakh and Sikkim. Several other states have followed suit but the implementation of the ban is still not satisfactory everywhere.

Conservation action

The problem of plastic pollution is serious and immediate action is required, such as:

- Reduction of the amount of plastic used in packaging that is usually immediately thrown away.
- Recycling and reuse of plastic should be encouraged.
- Plastic wrappings and bags should carry a warning label stating the dangers of plastic pollution and shoppers should be encouraged to use their own bags or recycled paper bags.

What you can do

- Buy products with less plastic packaging.
- Shoppers should use their own bags or recycled paper bags.
- Support recycling schemes and promote support for one in your local area.
- Practise and promote proper disposal of plastics in your home. Never dispose off plastics in the sewage system.
- Pick up any plastic litter that you see in the vicinity and dispose it off in a proper place. Encourage others to do likewise.
- Never throw plastic litter in the streets, on the pavement or in drains.
- Set an example to others and encourage them to help.

As a responsible citizen, always remember the 4R principle—Refuse, Reduce, Reuse and Recycle.

ORAL QUESTIONS FOR FORMATIVE ASSESSMENT

1. The molecular structures of synthetic fibres and plastics have one common feature. What is it?
2. Bakelite and polythene are both plastics. However, there is one major difference in their nature. What is the difference?
3. Can bacteria break down plastics?

NOW YOU KNOW

- Human-made materials are obtained from natural raw materials by chemical processes.
- Polymers are materials with long chain molecules containing thousands of smaller molecules called monomers.
- Synthetic fibres are made of polymers, many of them obtained from petroleum. They are cheaper and stronger than natural fibres.
- Rayon is made from cellulose obtained from wood pulp. Nylon, polyester and acrylic are made entirely of chemicals and are strong, crease-resistant and absorb very little water.
- Human-made plastics can be classified as thermoplastics and thermosetting plastics depending on their behaviour on heating.
- Polythene, polyvinyl chloride (PVC), polystyrene, perspex, teflon (PTFE), bakelite, formica and melamine are different types of plastics with properties suitable for specific uses.

NEW WORDS

POLYMER—long chain of molecules containing thousands of similar smaller molecules called monomers

SYNTHETIC FIBRES—human-made fibres made from polymers

PLASTIC—a material that can be moulded or formed into different shapes

FOR FORMATIVE AND SUMMATIVE ASSESSMENT

A. MULTIPLE-CHOICE QUESTIONS: Choose the most appropriate answer.

1. Which of these is a natural fibre?
   a. rayon b. cotton c. nylon d. polyester
2. Which of these is a fibre derived from chemicals?
   a. rayon b. cotton c. nylon d. silk
3. Which of these fibres is made from a raw material obtained from plants?
   a. rayon b. nylon c. terylene d. polyester
4. Which of these is a thermosetting plastic?
   a. polystyrene b. bakelite c. polythene d. polyvinyl chloride
5. Which of these plastics is a polymer?
   a. bakelite b. polystyrene c. polythene d. all of these
6. Which of these plastics can be repeatedly heated and moulded into any desired shape?
   a. bakelite b. polythene c. formica d. melamine
7. Which of these can you use as a substitute for glass in windows?
   a. polythene b. PVC c. perspex d. teflon
8. Which of these is not a property of plastics?
   a. bad conductor of heat b. bad conductor of electricity
   c. inflammable d. soluble in water

B. VERY SHORT-ANSWER QUESTIONS: Give one-word answers.

1. What name is given to natural materials that are used to manufacture human-made materials?
2. What is the most common source for synthetic fibres?
3. Which artificial fibre is made from wood pulp?
4. Cotton and wool are natural polymers. True or false?
5. Which synthetic fibre is commonly used to make strong ropes?
6. Which synthetic fibre is also called artificial silk?
7. All plastics are made of long chain molecules called _____
8. Name the plastic whose sheets are used for packing liquids.
9. From which plastic material is thermocol made?
10. Which plastic material is used to make non-stick pans?

11. Name one thermosetting plastic which is a good insulator and is used to make plugs and switches.

C. SHORT-ANSWER QUESTIONS (TYPE I): Answer in a sentence or two.

1. Give two examples each of natural and synthetic fibres.
2. What is a polymer?
3. Why is rayon called a regenerated fibre?
4. List two disadvantages of synthetic fibres.
5. What is a plastic? All plastics have one common property—what is it?
6. Why are plastic bottles commonly used to store chemicals in a chemistry laboratory?

D. SHORT-ANSWER QUESTIONS (TYPE II): Answer in about 30 words.

1. List the important properties of nylon that make it a useful synthetic fibre. Give two important uses of nylon.
2. Give three uses of polyester, and explain the reason for each use.
3. These days clothes made out of a mixture of synthetic fibres and natural fibres are more popular than those made purely out of synthetic fibres. Discuss the reasons for this.
4. Differentiate between thermoplastics and thermosetting plastics. Give two examples of each.
5. Plastics are very useful materials. Why then is there concern today about their increasing use?
6. List three steps you can take to reduce the danger that plastics pose to the environment.

E. LONG-ANSWER QUESTIONS: Answer in about 60 words.

1. How is rayon made? Why is it called artificial silk? List its important properties and uses.
2. List and explain four properties of plastics. Give one use of plastics linked to each of these properties.
3. Give the characteristic properties and important uses of the following:
   a. polythene **b.** polystyrene **c.** teflon **d.** bakelite

HOTS Questions: Think and answer.

1. Do you think rayon when burnt will stick to the body like other synthetic fibres?
2. Burning cotton smells like burning paper, whereas burning wool smells like burning hair. Why?
3. Which property of plastics makes them so useful but also makes them an environmental hazard?
4. Clay is a 'plastic' material. Does this imply that it is a polymer?
5. Ankit was learning how to cook. His father strictly told him not to wear nylon clothes in the kitchen. Why?

FOR FORMATIVE ASSESSMENT*

In the Library—Research Project

Plastics such as PVC or polythene do not react with chemicals. They are said to be chemically inert. This makes them useful for storing acids, alkalis and other corrosive chemicals. However, their

*For more tasks see Page 77

inertness, and also the fact that microbes cannot act on plastics and disintegrate them, creates a major problem. More and more plastics that degrade are now being designed. Chemists have worked out the following methods to make degradable plastics.

- **Plastics that absorb light:** The light breaks down the polymer chains. The plastics, therefore break down into small bits which degrade more quickly.
- **Plastics made by bacteria:** New plastics have been made by using bacteria. The bacteria are grown and they produce granules of a plastic. This plastic is totally biodegradable. It breaks down completely in about nine months. The problem however, is that it is very expensive.
- **Soluble in water:** A new plastic has been designed that is soluble in water.

Find out more about biodegradable plastics.

Talk to the Class—Presentation

Make a presentation on your findings about biodegradable plastics.

My Virtual Library—Research/Activities on the Internet

- Visit http://www.pslc.ws/macrog/kidsmac/wiap.htm to know more about the basics of polymers.
- Go to http://www.fabrics.net/fabricinfo.asp for loads of information on fibres. Explore the various links on the page.
- Go to http://www.bpf.co.uk/plastipedia/plastics_history/default.aspx to read about the history of plastics.

To Meet—Research on Scientist

Hermann Staudinger (1881–1965) In 1920, this German chemist proposed for the first time that plastics were made of giant long chain molecules. This lead to a sudden burst of scientific investigations on plastics. As a consequence, a large number of new plastics were introduced in the 1920s and 1930s. This included PVC. Staudinger won the Nobel Prize in 1953 for his contribution to the development of plastics.

Find out more about the life and work of Hermann Staudinger and make a presentation based on your findings.

Beyond the Classroom—Field Trip

A group project Make groups of 10. Visit shops and houses in your neighbourhood or in the vicinity of your school. Encourage shoppers, shopkeepers and the general public to use cloth bags or recycled paper bags. Also, discuss with them the proper ways of disposal of plastics.

You can take the help of organisations that carry out these kinds of awareness programmes.

TEACHER'S NOTES

- Bring different kinds of synthetic fibres and fabrics, and plastic materials to the class and let students examine them and study their properties.
- Create awareness about the problems with plastics and encourage them to organise campaigns against the use of plastic bags. This will involve them and help them imbibe the habit of saying no to plastics.