CHAPTER 3

Man-made Materials

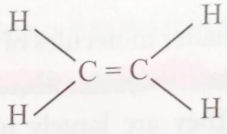
Suppose your family is planning a monsoon holiday in Kerala. What kind of clothes would you pack for your trip? Remember that in Kerala, it rains heavily in the monsoon. You should choose clothing made of materials that dry quickly and need no ironing. You may need a plastic raincoat as well. What footwear would be suitable during monsoon?

Early man used **natural materials** like cotton, silk, wool and jute for his clothes. Animal skins provided leather for footwear and other accessories like coats, bags and belts. Modern man has found ways of changing these natural materials to make them more useful. You use a variety of **man-made materials** which make your life easier and more comfortable. Some of them are used for clothes suited to the climate; others help build better homes, make furniture, automobiles and other products.

Man-made materials are often made from raw materials available in nature. One of the oldest man-made materials is **paper**. **Nylon** and other **synthetic fibres, plastics** of various kinds and **steel** are examples of commonly used man-made materials. The study of chemistry enabled scientists to design new molecules with special properties. Scientists discovered that the addition of one or more substances can change the properties of a compound. Thus, they could develop several new materials. Most of these synthetic materials are polymers. **A polymer is a substance having a large molecule made of many smaller molecules (called monomers) linked together.** Cotton is made of cellulose, a naturally occurring polymer.

Exercise 1

Which one of the following figures is a polymer? Justify your answer.



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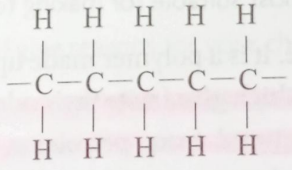


ii.

Man-made or Synthetic Fibres

Clothes made of synthetic fibres, like rayon, nylon, polyester and acrylic, are now being widely used. Sometimes, clothing made of natural fibres is quite expensive and such materials usually need more care.

Activity 1

You can do this activity over the weekend when you have an opportunity to visit a shopping centre. An adult in your family could help you. Find out:

i. the cost of a sari made of pure printed silk and one made of nylon, polyester or any synthetic material.

ii. the cost of a superior quality shirt made of pure cotton and another one made of terry cotton.

iii. from your mother or another adult, which materials are easier to maintain for daily use and why.

One of the first synthetic fibres, **rayon**, was produced from cellulose. Cellulose is a naturally-occurring fibre. The walls of all plant cells are made of cellulose. Wood contains a large amount of cellulose. Rayon is obtained by chemical treatment of wood pulp. It resembles silk in appearance. Hence, it is also called **artificial silk**. It is used to make clothing, curtains, car upholstery and carpets.

Exercise 2

Though rayon has a silky sheen, it is otherwise similar to cotton. Can you say why?

Nylon is a polymer which was developed after World War II. The first fully-synthetic fibre, it was made without using any natural material. It was prepared from coal, water and air. The word 'nylon' is formed from the initial letters of New York (NY) and London (LON), as it was first produced in these cities. It is one of the strongest, most elastic and lightest fibres. Nylon was first used to make stockings for women. It remains stable and strong even when wet. It absorbs very little water. Thus, it is most suitable for making fishing nets. Nylon is not affected by the action of bacteria and fungus. Nylon fabrics do not form wrinkles. It is also used to make swimwear, ropes, combs, zip fasteners, hooks and even machine parts. Nylon is mixed with wool to make it last longer.

Exercise 3

What properties of nylon make it most suitable for making toothbrush bristles?

Polyester is another synthetic fibre. It is a polymer made up of many smaller molecules of the chemical called **ester**. Esters are chemicals which give fruits their odour and flavour. Polyester fibres like **dacron**, **terylene** and **terene** are manufactured from petroleum products. They are largely used to make readymade garments like shirts and trousers, and for saris, dress material and curtains. They dry very quickly and need no ironing. Cotton materials get crushed easily. This can be partly prevented by blending synthetic fibres with cotton or other natural fibres. **Polycot** is one such example of a **blended fibre**. It is made by blending polyester with cotton. Shirts made of polycot are easy to care for and do not get crushed or creased as compared to shirts made from 100 per cent pure cotton.

Acrylic is another commonly used synthetic clothing material. Lightweight, soft and warm, with a wool-like feel, it can be dyed easily and does not shrink or wrinkle. It is easy to maintain and is often used as an alternative to expensive, natural woollen fabrics, like cashmere. Acrylic is also resistant to insects. However, it tends to form fuzz and is not as warm as pure wool. It is used for jackets and blankets, and blended with wool to make material for trousers.

Synthetic fibres have now become quite popular as they are convenient to use, relatively less expensive and need very little care. However, they do have some disadvantages. The main problem is that they catch fire easily. There is always a risk of getting burnt; hence, they should not be used when working in a kitchen or in a chemistry laboratory. When these fabrics catch fire, they melt and stick to the body of the wearer. Also, these fibres do not absorb sweat. Therefore, if used in hot weather, the wearer may feel uncomfortable.

Exercise 4

Fill in the blanks.

i. The fibre similar to cotton is _____.

ii. Rayon is obtained from the chemical treatment of _____.

iii. The first fully-synthetic fibre, _____, was prepared from _____, _____ and _____.

iv. A synthetic fibre that resembles wool is _____.

v. Synthetic fibres, plastics and natural fibres are made of very large units called _____.

vi. Polymers are made up of smaller units called _____.

vii. _____, _____, _____, are examples of polyester fibres.

viii. Fabrics made by mixing two types of fibres are called _____, _____.

Exercise 5

Find the odd one out in the following sets and give reasons for your choice.

i. terylene, nylon, dacron, terene

ii. polyester, rayon, acrylic, polycot

iii. plastics, polycot, cotton, rayon

iv. polyester, acrylic, nylon, ester

Exercise 6

List the advantages of using acrylic sweaters over woollen ones.

Did you know?

Polyester or nylon microfibres are 100 times thinner than human hair. These can be blended with other synthetic fibres. One common modern microfibre in use is **lycra.** This is always used in a blend with other fibres. It is used to make sportswear, body-hugging clothes and bandages. It is long lasting, does not crease, stretches and is comfortable. It is easy to care for, absorbs moisture and is comfortable to wear in summers.

Exercise 7

Which of the following is correct about blended fabrics?

i. They have the combined properties of each component fibre.

ii. They need less care.

iii. They are less expensive.

iv. All the above.

Exercise 8

The passage below outlines why particular fabrics are used for certain types of clothes. Pick the correct words out of the list and write them in the blank spaces.

warm, cool, dyes, dry, lustre, ironing, strong, lightweight

Cotton is used for T-shirts because it is _____ to wear and _____ well. Wool is used to make sweaters because it is _____ to wear. Silk is used for evening wear because it has good _____ and drapes well. Nylon is used to make fishing nets as it is very _____ and _____. Indian women who wear saris regularly prefer polyester saris as they need no _____ and _____ quickly after washing.

Exercise 9

Why is polyester not suitable for summer wear?

i. Polyester creases easily.

ii. Polyester does not absorb sweat.

iii. It is soft to handle

iv. It does not dry easily.

▲ rubber plant and latex being tapped

Rubber and Plastic

Some other materials used by human beings are **rubber** and different kinds of **plastic**. Rubber was originally a natural product **made from latex** that was tapped from the rubber plant. These plants were grown in large plantations in parts of South-East Asia. Today, the rubber we use is a synthetic product made in a factory. Being waterproof, it can be used to make raincoats, caps, gum boots and other kinds of footwear.

Plastics of different kinds are the most widely used man-made materials. They are made from chemicals which come from crude oil. These are substances that can be moulded or set into a desired shape.

Plastics have some properties which make them very useful.

- They are light, strong and durable.
- They can be spun into fibres to make cloth and carpets.
- They can be reinforced and made stronger by combining with other materials.
- They can be coloured and moulded to any desired shape.
- They can be made into sheets of varying thickness and coloured or printed, as required.
- They are non-reactive.

These properties allow us to use plastics for a wide variety of things. From tablecloths, bathroom curtains and raincoats to waterproof shoes and fashionable footwear, plastics are used in every home today. Plastic film is used to cover foodstuffs, plastic bags are widely used to carry food and vegetables, and to pack rice, *dal* and other edible items. However, plastics have to be used with care as some of them catch fire very easily.

In addition to the properties mentioned before, plastics also have other properties and uses.

- They can be made soft or hard, as required. Can you think of examples?
- They do not get corroded easily.
- They are usually not too expensive, especially in comparison with materials like wood and metals.
- They are efficient as heat and electrical insulators.

On the basis of their physical characteristics, plastics are usually divided into **thermoplastics** and **thermosetting plastics**. Thermoplastics become soft when heated. When they are cooled, they become hard again. It is possible to heat and cool thermoplastics again and again. They can be shaped in a number of ways. Polythene, polyvinyl chloride (PVC), polystyrene, perspex, teflon are all thermoplastics. Have you ever poured hot water into a plastic bottle? What happens? It gets deformed and can be bent easily. This is an example of a thermoplastic material.

Exercise 10

Match the thermoplastic material in column I to its use in column II.

Column I	Column II
i. polythene (easily moulded, can be rolled into thin sheets, strong and flexible)	**a.** non-sticky pans
ii. PVC (tougher than polythene, can be coated on a cloth base)	**b.** contact lenses
iii. polystyrene (very light, can be blown up into very large foam containing air bubbles, in this form it is known as styrofoam or thermocol)	**c.** bags for food storage, plastic bins
iv. perspex (clear, transparent like glass, soft)	**d.** raincoats, seat covers
v. teflon (high melting point, very low friction, non-reactive)	**e.** plastic cups

Exercise 11

Teflon that is used to make non-sticky pans, is also used to make the windscreen wipers of cars. Why?

Thermosetting plastics are the kind that become firm on heating. These get soft only once—the first time they are heated. On heating, the plastic sets firmly into its new shape. It remains hard even when it is reheated.

Exercise 12

Which kind of plastic, thermosetting or thermoplastic, is most suitable to make the following?

i. handles of cooking utensils
ii. electrical plugs and sockets
iii. furniture

Exercise 13

Bakelite, melamine and **formica** are commonly used plastics. Find out what items are made from them and why they are useful for these items.

Since plastics do not rot, they can be used to make heart valves and other body parts as well.

Activity 2 Getting Rid of Waste Materials

We get rid of most of our waste by burying it in landfills. Some of the garbage might break down and disappear; much of it won't. Try burying different kinds of garbage and observe how they are degraded. If possible, start this activity at least fifteen days before beginning the chapter.

You will need: paper, egg shell, leftover apple or other fruit, lid from can, piece of nylon, alumunium foil, piece of bread, plastic packet, ice sticks, water

What to do:

1. Collect equal-sized pieces of garbage.
2. Fill several small pots halfway, with garden soil.
3. Place each garbage sample in different pots. You may place two in one pot.
4. Cover each sample with soil, pressing down firmly.
5. Label each pot with the help of the ice-cream sticks.
6. Place the pot in a warm area.
7. Keep the soil moist, but not wet. This is like a landfill.

8. Every two weeks, dig up the samples. Examine them closely. What biodegrades quickly?
9. Which material does not degrade quickly? What does this tell you about garbage? Continue observing the pots until you think the waste materials have degraded as much as possible.

As you already know, the use of plastics is not without problems. A large part of our household wastes are made of plastic. Every day, we throw away plastic bags in which we have bought foodstuffs, vegetables, clothes and other materials. The plastic used for packaging is not biodegradable. It takes thousand of years for a plastic bag to disintegrate. When burnt, plastics give off poisonous fumes. For example, PVC gives off fumes of hydrogen chloride. This forms hydrochloric acid (HCl) with the moisture present in the air. The acid can damage your eyes and throat.

Recycling plastic is expensive. Scientists have now developed biodegradable plastic that will rot when acted upon by bacteria. However, these plastics are not used on a large scale yet. We should avoid the use of plastics as far as possible. Use bags made of cotton or jute when you go shopping.

Unusual Modern Materials

You are aware of the several kinds of **glass** that are used in homes. Apart from the glasses used for drinking water and other liquids, you must have seen and used glass bowls, plates, vases and other decorative items. Glass is made from sand (silicon dioxide, SiO_2), sodium carbonate, Na_2CO_3, and limestone, $CaCO_3$. These three are mixed together and heated to a temperature of 1500°C. On melting the three materials together, a clear jelly-like substance is formed, which on cooling hardens into glass. The glass can be coloured by adding small amounts of compounds such as iron compounds for brown glass or copper compounds for green glass.

Molten glass can be poured into moulds or blown into different shapes. The glass for electric bulbs is blown on machines in modern factories. The finished glass has to be **annealed** or cooled

Did you know?

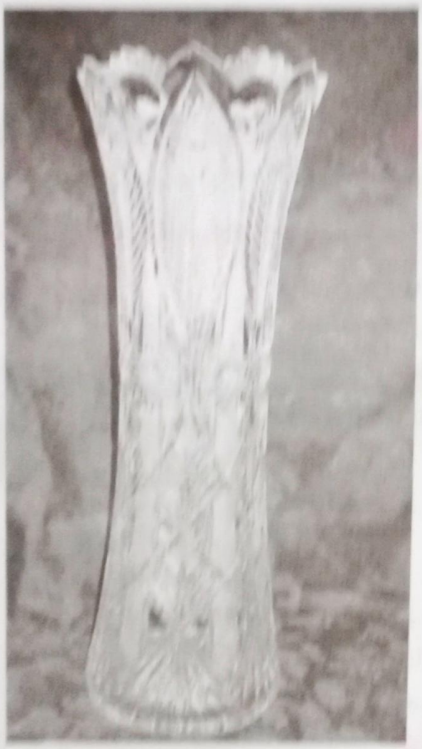
Asbestos was used for fireproof suits due to its high resistance to fire and heat. However, it was found that the inhalation of asbestos fibres can cause a number of serious illnesses, including cancer. Now the use of asbestos is banned in many countries.

Nomex, a polymer, is a type of nylon that is fire resistant. Fireproof suits are now made of nomex. Another fibre used in heat and flame protection clothing is **kermel**. It is used as protective clothing in military uniforms.

slowly to make it tougher. Ordinary glass is brittle and cracks easily when subjected to sudden changes in temperature. New types of glass that are strong and resistant to heat have been developed. Have you seen glass dishes used for baking food in homes?

Glass can also be drawn into fine fibres. These are mainly made of silicon oxide. They are very strong and are resistant to corrosion. They are produced by a spinning process, in which molten glass is pulled out through a very fine nozzle. Glass fibres are used to reinforce sports equipment like tennis racquets and in the production of ropes and cables. They can be woven into strong, light, weatherproof, fireproof, corrosion-resistant fabric. This material is used to make space suits. Similarly, glass fibre material is used to make soundproof and insulating material in industry, in automobiles and in homes.

Optical fibres are very fine strands of pure glass which are used in medical instruments called endoscopes. These help doctors to view the inside of a patient's body. Optical fibres are also used to transmit messages in modern communication.



▲ Highly expensive, decorative items like these are made of cut glass. This a special kind of heavy glass, on which patterns can be cut and chiselled out by hand.

Exercise 14

Match the items in column I to those in column II.

Column I	Column II
i. rubber	a. endoscope
ii. non-biodegradable	b. silicon oxide
iii. glass fibres	c. used in non-stick pans
iv. optical fibres	d. bakelite, melamine, formica
v. thermoset	e. becomes soft when heated
vi. teflon	f. sand, sodium carbonate, limestone
vii. thermoplastic	g. latex
viii. polyvinyl chloride	h. plastics
ix. glass	i. emit fumes of HCl gas when heated

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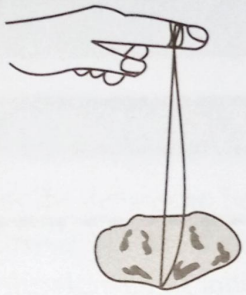
Activity 3 Testing the Properties of Different Materials

Make a collection of different kinds of threads—cotton, silk, nylon/polyester/terrycot, (drawn from the edge of saris or cut cloth), wool and plastic.

You should also collect a variety of different materials—cotton, silk, wool and synthetic materials, blended materials, plastic, etc.

Given below are guidelines for performing simple experiments to check the properties of these materials. Work in groups, under the guidance of your teacher. Put up your results on the bulletin board and compare your findings.

i. **Tensile strength** measures how difficult it is to break a thread when stress is applied to it. You will need to have threads of different materials all of the same length. Can you say why?



Use weights from a weight box in the school laboratory and those used by fruit/vegetable sellers. Compare how much weight a thread will hold up before it breaks.

Which was the strongest thread in your collection? What other factors might affect the amount of weight a thread can lift up without breaking?

ii. **The action of water and heat:** Take small pieces of different types of fabric. Immerse all of them in basins, each containing the same amount of water, for the same time, say a few seconds. Are there any fabrics that do not get wet? Are there any fabrics that absorb less water? Spread them out to dry under similar conditions—they should be in the same place, get the same exposure to sunlight or wind. Which one of the fabrics dries fastest? Which ones take longer? Which ones get crumpled? Which ones stay wrinklefree? Also compare the volume of water remaining in each basin.

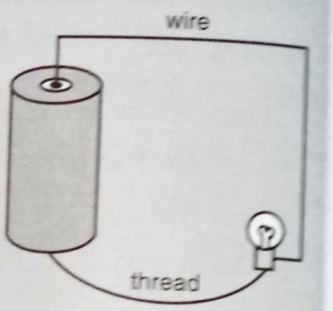
Did you know?

Advanced technology is creating more and more smart materials. Some materials, mixed with cloth, could monitor your health and stress levels, insulate you if you feel cold and even emit an alarm if you are having a heart attack! Skiers from USA and Canada at the 2006 winter Olympics wore suits that were made from smart material that instantly hardens upon impact, protecting the wearer from injury.

Scientists who work on creating such smart materials often find their inspiration from nature. Researchers are looking to nature for solutions to all sorts of problems. Inspired by nature, they're concocting stickier glues, stronger materials, better propellers, and much more. To put up a sturdy building, for example, a construction company could pound steel columns deep into the ground to create a firm foundation. Or, a builder could try to copy the root systems of ancient trees that have kept enormous trunks upright for thousands of years. The idea for Velcro developed from burrs, the plant seed-sacs that cling to animal fur or your dress in order to travel to fertile new planting grounds. Find out about more such creations.

iii. **Thermal Conductivity:** For this experiment you will need larger pieces of cloth, say 20 or 30 cm square. Which of these can be used to hold a hot cooking utensil? **Try this out, only with help from an adult.** Either at school or at home, place a small utensil containing water on a stove and let the water boil. Take the vessel off the fire and place it on the table. Can you use the cloth to lift the hot vessel? Which type of cloth is the best insulator from the heat of the vessel? Which type of cloth would you recommend for use as a kitchen duster? Why should you **not** use plastic material for this experiment?

iv. **Electrical Conductivity:** In earlier classes, you have made a simple circuit like this. What happened when you replaced one of the wires with a thread? Try it again. If possible, get a few strands of *zari* from an old sari. Replace the thread by the *zari*. Is there any change? In olden days, *zari* was made of metal threads; today it is more often made of synthetic material. Which one will allow an electric current to pass through it?



CHECK IT OUT

1. ii is a polymer. It is made up of similar small molecules joined together. **2.** *Both rayon and cotton are directly or indirectly obtained from plants.* **3.** *It absorbs very little water, is strong when wet and is not acted upon by bacteria and fungus.* **4.** *i. The fibre similar to cotton is* ***rayon****. ii. Rayon is obtained from the chemical treatment of* ***wood pulp****. iii. The first fully-synthetic fibre,* ***nylon****, was prepared from* ***coal****,* ***water*** *and* ***air****. iv. A synthetic fibre that resembles wool is* ***acrylic****. v. Synthetic fibres, plastics and natural fibres are made of very large units called* ***polymers****. vi. Polymers are made up of smaller units called* ***monomers****. vii.* ***Dacron****,* ***terylene****,* ***terene*** *are examples of polyester fibres. viii. Fabrics made by mixing two types of fibres are called* ***blended fabrics****.* **5.** *i. Nylon is the odd one out. All except nylon are examples of polyester fibres. ii. Polycot is the odd one out. It is a blended fibre. The others are not. iii. Cotton is the odd one out. It is a natural material. The others are all man-made materials. iv. Ester is the odd one out. It is a monomer. The others are all polymers.* **6.** *Acrylic is preferred over wool for the following reasons. It is soft and warm. Unlike wool it is inexpensive and resistant to insects. It is also easy to maintain, unlike wool.* **7.** *iv* **8.** *Cotton is used for T-shirts because it is* ***cool*** *to wear and* ***dyes*** *well. Wool is used to make sweaters because it is* ***warm*** *to wear. Silk is used for evening wear because it has good* ***lustre*** *and drapes well. Nylon is used to make fishing nets as it is very* ***strong*** *and* ***lightweight****. Indian women who wear saris regularly prefer polyester saris as they need no* ***ironing*** *and* ***dry*** *quickly after washing.* **9.** *ii* **10.** *i–c; ii–d; iii–e; iv–b; v–a* **11.** *Since teflon offers very low friction, windscreen*