UNIT : IV
CLOTHING AND TEXTILE

CHAPTER : 19

FIBER SCIENCE

Cloth is one the basic requirements for human life. A human being has to use cloth whether he is rich or poor. Cloth is the only thing which stays with a human being at all times. In ancient times man used skin hides, plant leaves to cover his body and protect himself from sun, rain, cold and heat. As the human civilization developed the art of cloth manufacturing also developed. The ancient clothing was different from that of modern times. In hot weather we wear cotton apparel while in cold weather we wear woolen clothes. In rainy season we wear special types of clothes. We wear different clothes also everyday and have different and special clothes for occasions like weddings and festivals. Similarly there are different dresses for different professions like police, fireman, doctor, nurse, and student. It is an old saying that 'clothes make the man' which is true to some extent. Clothes also have a effect on human mind. Wearing clothes according to an occasion boosts confidence and suitable clothes enhance personality. Clothes protect our body and some articles are used in our homes as well such as carpet on floor, curtains and drapery which makes home attractive and beautiful. Even for dusting and bathing different clothe is used. Thus, we can say that clothes have a strong relation with different human activities. Clothes are a symbol of our civilization and culture.

The art of textile manufacturing is continuously developing. Initially all the fibers were provided by nature. In ancient times, to make clothes fibers were obtained from plants and trees and from animal hair. With the development of culture and civilization more and more beautiful textiles have been manufactured. The initial and smallest unit of a cloth is fiber. Without fiber textile manufacturing is not possible. Fiber is a thread like structure whose length is at least 100 times more than its diameter.

Fibers can be classified on the basis of their raw sources and manufacturing process—

Table 19.1 Classification of fibers useful for clothing–

Natural fibers	**Artificial fibers**	**Specialized fibers**
Vegetable–Cotton, linen, jute, hemps	**Man-made–** rayon	Mixed fibers
Animal– wool, silk	**Chemical–** nylon, polyester	
From metals– Asbestos, brocade, gold-silver wires		

I. Natural fibers

A. Vegetable fibers– These fibers are formed from the cellulose obtained from plant cells.

1. Cotton–

This fiber is obtained from the cotton plant. It is the best of all fibers of vegetable origin. Cotton plant grows in summer. Cotton is a soft, fluffy staple fiber that grows in a pod, or protective case, around the seeds of the cotton plants. The pool of cotton is collected and the cotton fiber is manufactured from this cotton pool.

Properties and uses:

Physical properties–

(i) 80-90 % cellulose is present in cotton fiber.

(ii) Microscopically a cotton fiber is a thin and thread like structure.

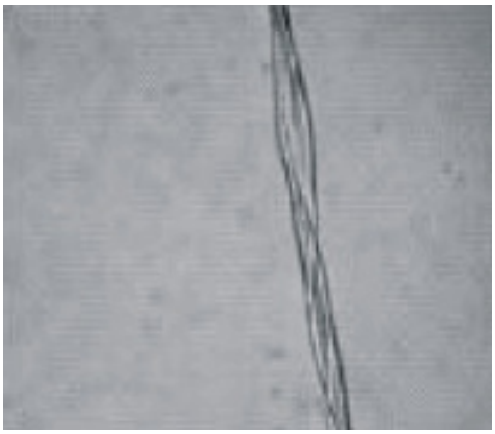

Figure : 19.1 Cotton fiber

(iii) The length of a cotton fiber is two and half inches less than other fibers.

(iv) The surface of cotton fiber is rough and lacks smoothness and shine.

(v) Cotton fiber is very strong and its strength increases when it is wet.

(vi) Cotton fiber lacks elasticity and so cannot be stretched and it shrinks very soon.

(vii) Cotton fiber breaks when pulled strongly.

(viii) Cotton fiber absorbs moisture that is why it is worn in summers. It absorbs sweat and gives cooling effect. Ex- towels, undergarments, etc.

(ix) As the cotton fiber is strong it does not break even on vigorous washing.

Chemical properties–

(i) Cotton fiber gets damaged when dipped in concentrated acid.

(ii) Cotton fiber is not affected by bases. Hence, bases are used for cleaning cotton fibers.

(iii) Bleaching does not affect cotton fibers and so bleach can be used on white cotton clothes.

(iv) Cotton fiber is resistant to even high temperatures but they get damaged and turn yellow when kept under the sun for long time.

(v) Cotton fibers do not take other dyes easily.

(vi) Fungus grows on cotton if cotton is kept in wet, hot and dark place for a long time.

2. Linen–

This fiber is obtained from the stem and stalk of flax plants. When the plant grows fully, it is uprooted and tied and is kept for drying. When the plant dries up seeds and leaves are separated from the stems and the remaining bundle is soaked in water. During soaking, fermentation occurs which destroys gum, pectin, wax present in the stems and the fibers get separated. After this the bundles are dried again. The bark is removed mechanically and fibers are separated. These fibers then undergo combing, Thread from these fibers is prepared which can be used for textile manufacturing.

Figure : 19.2 Linen fiber

Properties and uses:

Physical properties–

(i) 70% cellulose and 30% pectin, water and other impurities are present in linen.

(ii) Microscopically linen fiber is cylindrical and has nodes.

(iii) Linen fiber is the longest natural fiber after silk.

(iv) Linen has low tensile strength and so it breaks on stretching.

(v) Linen fiber is less flexible and so linen clothes get wrinkles.

(vi) Linen is a good conductor of heat. It absorbs body heat during summers and cools the body down.

(vii) Linen absorbs moisture and thus the towels and clothes made from linen are good to use.

(viii) Linen fiber is soft and shiny and it does not catch dust easily.

(ix) Linen gets strong when wet, it can be washed easily.

(x) Germs and bacteria do not grow on linen easily.

(xi) Linen fibers are not affected by light and sun but they get damaged when exposed to light and sun for longer time. Towels, bed sheets and table covers are made from linen.

Chemical properties–

(i) Linen fiber gets destroyed in concentrated acid.

(ii) Bases do not affect linen. But linen turns yellow when strong basic soaps are used persistiully.

(iii) Linen cannot be dyed because of hard surface.

(iv) Bleaching damages linen. Only home-made bleaching agents must be used.

(v) Linen absorbs sweat readily but then it should be washed soon because sweat is acidic in nature.

3. Jute–

Jute fibers are obtained from jute plant. In India, after cotton this is the most used fiber. The stem of the jute plant is separated and is soaked in water so that the bark gets dissolved and the jute fibers get separated. Jute fibers are smooth and shiny but are brittle in nature. Therefore shiny but stiff and rough fibers are formed from jute. That is why apparels cannot be made from jute fibers. They are used for making carpets, cords, sacks and sackcloth. Mainly jute is used in making sacks and for other packing purposes because they are naturally resistant to insects.

4. Hemp–

Hemp fiber is dark brown in color. This fiber is always straight and shiny but is stiff, rough and coarse. Hemp fiber is very strong and long lasting. It is used in making carpets, canvas, cordage, cords, belt, etc. Hemp fibers gets damaged in concentrated and hot bases.

5. Kapok –

Kapok is similar to cotton. But it can not be used for making thread because it is resistant to spin. It is used as an alternative for filling in mattresses, pillows, upholstery, and stuffed toys such as teddy bears, and for insulation. It is resistant to water and is used in airplanes. These fibers are easily dried.

B. Animal fibers

The fibers obtained from animals and insects are called animal fibers. These fibers are made of protein and so are also called protein fibers. Silk is obtained from silkworm while wool is obtained from sheep, goat and camel hair.

1. Silk

The fiber made from silk is beautiful and excellent. That is why silk is known as 'Queen of all fabrics'. Silk fiber is most shining, soft beautiful and

attractive. Silkworms are fed on mulberry leaves. A minute opening is present near the mouth of silkworm. Silkworm secretes saliva from these openings which gets wound around the silkworm's body. When this saliva comes in contact with air, saliva dries up and forms a cocoon. To obtain silk, the cocoon is dropped in hot boiling water. Silkworm is killed and the fiber is wrapped on a reel. Silk fiber was first produced in China.

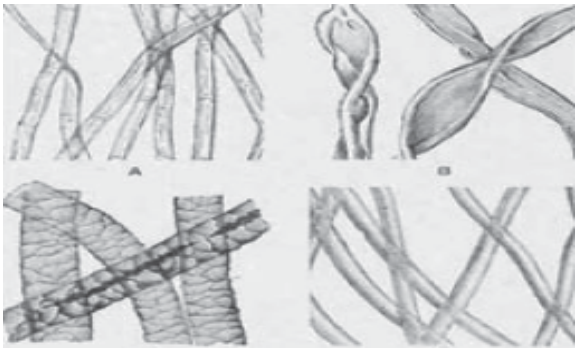

Figure : 19.3 Silk Fiber

Properties and uses–

Physical properties–

(i) 95% of silk fiber is made up of serecin and fibroin protein. Remaining 5% is made of wax, fats and salts.

(ii) Microscopically silk fiber is fine, straight, smooth, shiny, and transparent and rod shaped.

(iii) In between fibers some sticky substances are also seen. These are serecin.

(iv) Of all the natural fibers, silk fibers are the longest. They are called filaments.

(v) Because silk fiber is longest, it is also strongest.

(vi) Because silk fiber is straight and long, they are flexible and elasticity is better. That is why silk clothes are the softest.

(vii) Silk fibers are not affected by stretching and pressures.

(viii) Silk fibers lose up to 20% of their strength when wet and so they should be dry cleaned.

(ix) Silk absorbs water and is comfortable for wearing.

(x) Silk is a bad conductor of heat. So, they should not be worn in summers.

(xi) Silk fibers weaken when dried in sun. Similarly ironing at high temperatures also affects silk.

Chemical properties–

(i) Strong acids damage silk fibers while carbonic acids increase smoothness of fibers.

(ii) Fibers are not affected by mild or weak bases.

(iii) Strong bleacing damages silk. Hydrogen peroxide should be usedfor bleaching.

(iv) Silk fiber is insect-repelling but fungus can grow on wet and packed silk.

(v) Silk fiber can be dyed easily with acidic, basic dyes.

2. Wool

This is natural protein-rich fiber obtained from animals. Mostly wool is obtained from sheep and also from hair of camel, rabbit, deer and goat. To prepare wool, animals are first washed with anti-bacterial solution. Thereafter, wool is sheared from animal skin using machines. This removed wool is known as fleece. This wool removing process is carried in spring season. Wool from a dead animal is removed using some chemical products and the hair are pulled out. Such wool is known as pulled wool.

Wool obtained from different parts of animals is different. Wool is separated according to difference in length, color, shape, flexibility and fineness. The separated wool is immersed in mild basic solution to remove impurities like sweat, wax, etc. if the wool is not cleaned properly in this solution then wool is cleaned using carbonizing process and is dried the presere of

sulphuric acid or hydrochloric acid so that the softness and flexibility of fiber is maintained. Thereafter olive oil is sprayed on wool and fibers are arranged in parallel rows by the process of cording. The fibers are cut accordingly for dyeing and spinning.

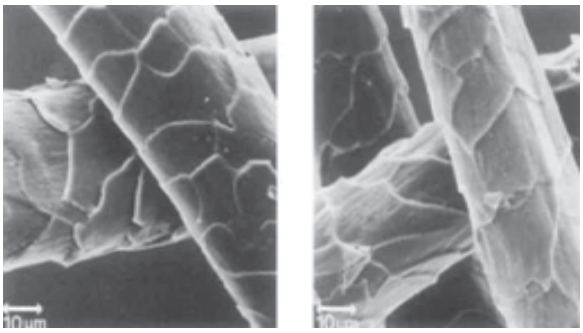

Figure : 19.4 Wool Fibers

Properties and uses–

Physical properties–

(i) Wool fiber is mainly made of keratin protein.

(ii) Sulphur is present in wool fiber.

(iii) Microscopically wool fiber is multicellular, criss-crossed with sharp ends and is round in the middle.

(iv) The softness, colour and shine of wool fiber depend on the body part of the animal from which it is removed.

(v) Wool fiber is the weakest natural fiber. The strength of wool fiber reduces up to 25% when wet. Thus woolen fiber should not be washed vigorously.

(vi) In the presence of moisture, heat and pressure woolen fibers stretch out and separate and get back to original position.

(vii) Woolen fibers are elastic in nature. That is why they are reformed when stretched and they do not get wrinkled.

(viii) Woolen fiber cannot tolerate dry heat. A soft cloth should be placed on woolens before ironing.

(ix) Woolen cloths absorb water.

(x) Woolen fiber does not catch fire easily. That is why woolen blankets are used to put out fire.

(xi) Small woolen fibers are used to make clothing.

(xii) Because protein is present in woolen fibers air gets trapped in vacant spaces which gets heated due to atmosphere and the warming capacity of woolen increases.

Chemical properties–

(i) Acid solution does not affect woolen fibers.

(ii) Bases turn woolen fibers stiff and yellow.

(iii) Woolen fibers get damaged in strong basic solution. Woolen should be washed in mild liquid soaps.

(iv) Ammonium carbonate and borax are safe on woolen fibers.

(v) Woolen fiber is easily dyed by all types of dyes such as acidic, basic, etc.

(vi) Bleaching powder should not be used on woolen clothes. if necessary mild bleaching agents like hydrogen peroxide should be used.

(vii) Fungus grows on woolen fibers if they are kept in wet places. Insects too damage wool. Therefore woolen should be stored in closed boxes with naphthalene balls or neem leaves. Keeping woolen wrapped in newspaper also protects them.

C. Fibers from metals

There are many minerals present in nature which can be melted, stretched, flattened and twisted to form fibers. Gold, silver, copper can be processed to form fibers. Textile made from metallic fibers are heavy. Washing and keeping them clean is a herculean task. Asbestos is used for making fire-resistant clothes.

II. Artificial fibers–

Artificial fibers are the ones that are not obtained from nature**.** They are manufactured using various chemicals and mechanical methods**.** Artificial fibers are stronger, long lasting than the natural fibers and are washable.

A. Man-made fibers – Rayon

This fiber is also called artificial silk because its shine is similar to that of silk. It is known as man-made fiber because some chemicals and bamboo and wood pulp along with cotton are used in its preparation this fiber. All the ingredients are then dissolved and forced through a spinneret to produce filaments which are chemically solidified, resulting in synthetic fibers of nearly pure cellulose. Rayon is of many types depending on the method and materials used in its preparation – nitro cellulose rayon, viscose rayon, cuprammonium rayon, acetate cellulose rayon, etc.

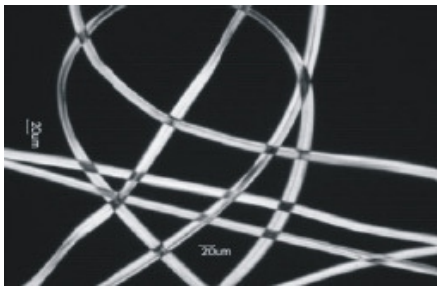

Figure : 19.5 Rayon fiber

Properties and uses–

Physical properties–

(i) Rayon is chiefly made of cellulose whatever may be its method of preparation.

(ii) The microscopic structure of rayon depends on the method of preparation. Ex- viscose rayon is rod like and has thread like stripes on the surface. These stripes shine. Cuprammonium rayon is fine, smooth, and rod-like and shines like silk. Acetate rayon is also rod like but is less shiny.

(iii) Being man made the length of the fiber can be chosen. Long fibers are known as filaments. Beautiful apparels are manufactured from these smooth and soft fibers. Small fibers are known as staples. Clothes with fluffy surface are manufactured from these fibers.

(iv) Rayon fiber is stronger than woolen fiber but less strong than silk fiber. Rayon is stronger when dry. Its strength reduces by 40-70% when wet. Rayon apparels should not be washed vigorously.

(v) Acetate rayon does not absorb water and water remains on it surface only. That is why they dry up so easily. Acetate rayon is thus, used for making curtains, umbrellas, raincoats, etc.

(vi) Cuprammonium rayon is good conductor of heat. This rayon is worn in summers. Clothes made from this rayon are light in weight.

(vii) Viscose rayon can be worn in summer but because its fiber is thick they are heavy in weight.

(viii) Acetate rayon being a bad conductor of heat is used as an undercoat for dresses in summer.

(ix) Rayon fiber melts in the presence of high heat. Steam press gives rayon a distinct shine.

Chemical properties–

(i) Acids have harmful effect on rayon. Fibers get damaged in hot, concentrated and strong acids.

(ii) Rayon can tolerate bases but fibers weaken and lose their shine in solution concentrated bases.

(iii) Rayon can be easily dyed.

(iv) Rayon gets affected by bleaching agents. Hydrogen peroxide can be used with rayon.

(v) Germs and bacteria do not affect rayon. But fungus can grow on wet rayon.

B. Chemical fibers –

1. Nylon–

In these fibers oxygen, hydrogen, nitrogen and carbon are present in fixed ration and composition. To prepare nylon, adipic acid and hexamethylene diamne from coal tar are mixed together and heated in an autoclave in which nylon polymer gets ready. This polymer is poured in cold water and a layer of it is prepared. This is known as flakes. These flakes are melted and are passed through a spinneret. Fibers come out from the holes of spinneret and get dried up on coming in contact with air.

Figure : 19.6 Nylon fiber

Properties and uses–

Physical properties–

(i) Nylon is a synthesized artificial fiber. Microscopically these fibers are cylindrical, smooth, shiny, straight and transparent.

(ii) Nylon fiber is a strong fiber. It does not break on rubbing, twisting and folding. Sharp scissors is required to cut the nylon fiber.

(iii) Nylon clothes do not absorb water and so they get dried up easily. They are not suitable in summers.

(iv) Nylon is a bad conductor of heat and so should be worn in winters.

(v) At high temperatures nylon fibers melt to form beads.

(vi) Nylon fiber is flexible and so is used for making hosiery apparels.

(vii) At room temperature, nylon fibers neither stretch nor shrink.

(viii) Nylon fibers are heat set into a required shape and size. They do not change their size, pleats over time.

(ix) All nylon clothes have smooth surface. Thus, dust cannot stick on them and they can be washed easily.

Chemical properties–

(i) There are many types of chemical fibers– nylon, Dacron, acrylic, etc.

(ii) Nylon is severely affected by acids. Acids like sulphuric acid, hydrochloric acid, nitric acid damage fibers.

(iii) Nylon fiber is unaffected to bases. They can be washed with any soap.

(iv) Nylon is good surface for dyes.

(v) Light colored nylon is affected by light and sun.

(vi) Fungus and insects do not attack nylon clothes.

(vii) Nylon is used for making curtains and night dresses. They can be mixed with other fibers for many uses.

2. Polyester–

Polyester is manufactured in the same way as nylon. Dicarboxylic acid and dihydric alcohol reacts first to get polymerized in a polymerizing vessel. Ribbon shaped product is obtained from this vessel. Ribbons are cut into chips and are sent into hopper from where they are sent to melt spinning tank for mixing. This hot solution is passed through spinneret and the fibers so obtained are dried up in the presence of air. These fibers are stretched to form strong threads.

Properties and uses

(i) Clothes made from polyester have high breaking tenacity, elasticity and resiliency.

(ii) Polyester shrinks at high temperatures and melts into a black colour residue.

(iii) Polyester clothes are wrinkle resistant. So there is no need to iron them.

(iv) Polyester is a strong fiber. They can be mixed with other fibers to make comfortable clothes.

III. Specialized fibers–

Mixed fibers–

We have read about properties and limitations of various fibers. Every fiber has its own properties. All properties are not present in a single fiber. For example, cotton clothes provide cool effects but they get wrinkles. Nylon clothes are warm but they do not get wrinkles. If cotton and nylon are mixed to form clothes then such a cloth will be cool as well as free from wrinkle.

In this way we can mix two or more fibers to develop mixed fibers. Two types of fibers can be spun together to form a single thread to two types of threads can be used for making a single cloth. Some examples are terrycot, cots wool, terriwool, khadi silk, etc. Because these mixed fiber apparels are easy to maintain are, less expensive and are in fashion today.

Commonly available mixed fibers are–

Mixed fiber	**composition**
Terrycot	terylene + cotton
Cottswools	cotton + wool
Terrywool	terylene + wool
Terry silk	terylene + silk
Cotton silk	cotton + silk

1. Terrycot

This mixed fiber cloth has properties of both terylene and cotton. It has coolness, sweat absorbing capacity and comfort properties of cotton. Because of terylene it is durable, beautiful, shining, shrinkage resistant. These types of clothes are wash and wear type because they do not require ironing.

2. Terry silk

These mixed fibers are strong, durable and shrinkage resistant because of terylene and is shining and attractive because of silk.

3. Terry wool

Because of terylene it is wrinkle free, shrinkage resistant, strong, friction resistant and its flexible, beautiful and warm because of wool.

IMPORTANT POINTS:

1. Clothes are one of the basic requirements of humans.
2. Fiber is the smallest unit of cloth.
3. Fibers are classified on the basis of their sources and manufacturing process.
4. Fibers are of 3 main types– natural, artificial and mixed fibers.
5. Cotton and linen are vegetable fibers which are made of cellulose.
6. Silk and wool are animal fibers and are made of protein.
7. Artificial fibers are of two types–man-made and chemical.
8. Different fibers have different physical and chemical properties.
9. Two or more than two fibers are mixed together to form mixed fibers.
10. Mixed fiber clothes are more useful because they are made of different types of fibers and have qualities of each one of them.

EXERCISE:

1. Choose the correct option:

(i) Animal fiber is

(a) Cotton (b) Wool

(c) Linen (d) Kapok

(ii) Longest fiber is

(a) Silk (b) Cotton

(c) Wool (d) Linen

(iii) Chemical fiber is

(a) Hemp (b) Linen

(c) Nylon (d) Rayon

(iv) Linen is a ——— fiber

(a) Animal (b) Vegetable

(c) Mineral (d) None of the above

2. What is a mixed fiber?
3. How does water affects woolen clothes?
4. What percent of cellulose is present in cotton fiber?
5. What is fleece cotton?
6. What is the effect of acids and bases on silk?
7. Name the animal fiber.
8. Why is rayon known as man-made fiber? How is it different from chemical fibers?
9. Write in short about jute, hemp and kapok.
10. Explain composition, structure and properties of linen.
11. Write the classification textile useful fibers.

ANSWERS:

(i) b (ii) a (iii) c (iv) b