TVET CERTIFICATE IV IN TAILORING

CARING TEXTILE FIBERS

TALTF 401 **CARE OF TEXTILE FIBER**

Competence

Learning hours: 90

Credits: 9

Sector: Art and Craft

Sub-sector: Tailoring

Module Note Issue date: July, 2020

PURPOSE STATEMENT

This module describes the skills and knowledge required to perform care of textile fibers. The module will allow trainees to identify, use textile fibers and apply basic technical of treatment textile fibers such as washing, drying, bleaching, stain remover and pressing.

By the end of the module, the trainee will be able to:

Elements of competence and performance criteria		**Page No.**
Learning Unit	**Performance Criteria**	
1. Distinguish history of textiles fibers	1.1. Precise different origin of textile fibers	
	1.2. Proper Classification textiles fibers according to their origin	
	1.3. Proper identification of product countries textile fibers	
2. Differentiate textile fibers	2.1. Accurate classification of the nature textiles fibers	
	2.2. Accurate classification of semi synthetic textiles fibers	
	2.3. Accurate classification of the synthetics textiles fibers	
3. Use textile fiber	3.1.Appropriate utilization nature textile fibers	
	3.2. Appropriate utilization semi synthetic textile fibers	
	3.3. Appropriate utilization synthetic textile fibers	
4. Apply care of textile fibers	4.1Proper identification materials of washing cloth	
	4.2.Proper selection techniques of stain remover	
	4.3 Proper selection techniques of pressing cloth	

Total Number of Pages:

LEARNING UNIT 1.DISTINGUISH HISTORY OF TEXTILE FIBERS

LEARNING OUTCOME 1.1: DIFFERENTIATE ORIGIN OF TEXTILE FIBRES

- **CONTENT/TOPIC 1. INTRODUCTION OF TEXTILE**

Technology: is a process which is used by human to modify nature and meet their need and wants

Textile technology: is a science to study matted fibers which modify the yarn, threads and clothes

Yarn: is a long continuous length of interlocked fibers used in production of textile

Threads: is tightly twisted strand of two or more plies of yarns that are circular when cut in cross section

Clothes: is an item worn to cover the body

- **CONTENT/TOPIC 2.ORIGIN OF TEXTILE FIBERS**

Textile has two origins

Natural origin and chemical origin

- **CONTENT/TOPIC DEFINITION OF NATURE FIBERS AND CHEMICAL FIBERS**

DEFINITION OF NATURAL FIBERS

Natural fibers: are the substances produced by plants, animals and minerals that can spun into filaments, threads

Chemical fibers: are substances produced by chemical product which is organic and inorganic

- **CONTENT/TOPIC PROPERTIES OF TEXTILE FIBERS**

PROPERTIES OF NATURAL FIBERS

Belong to the earliest known cultivated plants properties are: low weight, low cost, high specific strength, elasticity, absorbency

PROPERTIES OF CHEMICAL FIBERS

Polyester fiber has a good resistance to wear mineral acid even at boiling temperature

Most strong

Are flammable a spreading the flame

Natural

Chemical

LEARNING OUTCOME 1.2: CLASSIFY TEXTILE FIBERS ACCORDING TO THE ORIGIN

❖ **CONTENT/TOPIC 1. NATURAL FIBRES**

Introduction

Recently natural and made-man polymer fibres are used for preparation of functionalized textiles to achieve smart and intelligent properties. There are numerous application possibilities of these modified materials. Main pathways for functionalizaton of fibres are: inclusion of functional additives (inorganic particles, polymers, organic compounds); chemical grafting of additives on the surface of fibres and coating of fibres with layers of functional coatings. A new approach to produce new materials is by nanotechnology, which offers a wide variety of possibilities for development of materials with improved properties. Composites of cellulose fibres with nano-particles combine numerous advantageous properties of cellulose with functionality of inorganic particles, hence yielding new, intelligent materials. For preparing cellulose composite materials profound knowledge about fibres properties is needed. Besides, new fibre qualities are demanded to guaranty the modification efficiency. Therefore non-standard methods are involved to determine physical properties of fibres.

In addition to, manufacture, use and removal of traditional textile materials are now considered more critically because of increasing environmental consciousness and the demands of legislative authorities. Natural cellulose fibres have successfully proven their qualities when also taking into account an ecological view of fibre materials. Different cellulose fibres can be used for textile and technical applications, e.g. bast or stem fibres, which form fibrous bundles in the inner bark (phloem or bast) of stems of dicotyledonous plants, leaf fibres which run lengthwise through the leaves of monocotyledonous plants and fibres of seeds and fruits. Flax, hemp, jute, ramie, sisal and coir are mainly used for technical purposes. Recently, the interest for renewable resources for fibres particularly of plant origin is increasing. Therefore several non-traditional plants are being studied with the aim to isolate fibres from plant leaves or stems.

A review of different conventional and non-conventional fibres is presented. For extraction of fibres different isolation procedures are possible, e.g. using bacteria and fungi, chemical and mechanical methods. The procedure used influences fibres surface morphology. By fibre isolation procedures mainly technical fibres are obtained, which means that cellulose fibres are multicellular structures with individual cells bound into fibre bundles.

Natural fibers are classified into three main types

Vegetable fibers: are composed by cellulose or similar compounds

Animal fibers: are composed by protein, the fibers are structurally strong and resistant to chemical attack

Mineral fibers: are composed by minerals like asbestos and metallic fibers

VEGETABLES FIBERS

Vegetable fibers are classified into many types

Cotton	Sisal
Ramie	Linen/flax
Jute	Coco
Rubber	Kapok

THE VEGETABLES FIBERS HAVE DIFFERENT EXTRACTION

Vegetable fibres extract from leaves

Example: sisal

Vegetable fibres extract from steam

Example linen/flax, jute, ramie

Vegetable fibers extract from fruits

Example cotton, coco, kapok

Vegetable fibers extract from sap

Example rubber

THE MOST USEFUL PLANT/VEGETABLE FIBERS USED IN TEXTILE

COTTON

LINEN/FLAX

JUTE

RAMIE

Sisal

❖ CONTENT/TOPIC 2. CHEMICAL FIBRES

HISTORY OF CHEMICAL FIBERS

Fibers made from natural and synthetic organic polymers. Depending on the type of raw material, chemical fibers are divided into synthetic (from synthetic polymers) and natural (from natural polymers) categories.

Fibers prepared from inorganic compounds (glass, metal, basalt, or quartz) are sometimes also regarded as chemi cal fibers.

Chemical fibers are manufactured industrially in the form of monofilament (a single, very long fiber), staple fiber (short pieces of fine fibers), and filament threads (a packet consisting of a large number of fine and very long fibe rs that are twisted together). Depending on the purpose for which they are intended, filament threads are divide d into textile and industrial, or cord, threads (thicker threads of greater strength and twist).

History. The possibility of making chemical fibers from various substances (glue or resins) was predicted as early as the 17th and 18th centuries, but it was not until 1853 that the englishman audemars first proposed the format ion of endless threads from a solution of cellulose nitrate in a mixture of ethanol and ether. In 1891 the french en gineer h. De chardonnet was the first to organize the manufacture of such threads on an industrial scale. From th at time the manufacture of chemical fibers developed rapidly. In 1896 cuprammonium fiber was manufactured fr om cellulose dissolved in aqueous ammonia containing cupric hydroxide. In 1893 the englishmen cross, bevan, an d beadle proposed a method of making viscose fibers from aqueous alkaline cellulose xanthate solutions; this wa s performed on an industrial scale in 1905. In 1918-
20 a method for making acetate fiber from partly hydrolyzed cellulose acetate dissolved in acetone was develope d, and in 1935 the production of protein fiber from milk casein was begun. Production of synthetic fibers began i n 1932 with the manufacture of polyvinyl chloride fiber (germany). In 1940 the best-known synthetic fiber, poly-amide fiber (usa), was made on an industrial scale. From 1954 to 1960 polyester, polyacrylonitrile, and polyolefin synthetic fibers were produced on an industrial scale.

Properties. Chemical fibers often have high tensile strength (up to 1,200 meganewtons per sq m, or 120 kilogram s-
force per sq mm), high ultimate elongation, good shape retention and crease resistance, and high resistance to re peated and alternating load and to the action of light, moisture, mold, bacteria, chemicals, and heat. The physico mechanical and physicochemical properties of chemical fibers can be changed during formation, stretching, finish ing, and heat treatment, as well as through modification of both the raw material (the polymer) and the actual fi ber. That makes possible the creation, even from a single fiber-
forming polymer, of chemical fibers with diverse textile and other properties (see table 1). Chemical fibers can be used in combination with natural fibers to make new varieties of textile articles, with considerable improvement in the latter’s quality and appearance.

Production. Of the large number of existing polymers, only those that consist of flexible, long macromolecules th at are linear or only slightly branched and that have a sufficiently high molecular weight and can melt without de composition or dissolve in available solvents are used in the manufacture of chemical fibers. Such polymers are

called fiber-forming polymers. The process of producing fibers consists of the following operations:

(1) preparation of the spinning solutions or melts,

(2) formation of the fiber, and

(3) finishing of the formed fiber.

The preparation of the spinning solutions (melts) starts with the passage of the raw polymer into a state of viscous flow (solution or melt). Then the solution (melt) is cleansed of mechanical impurities and air bubbles, and various additives are mixed in to make the fibers resistant to heat and light and to give them a dull polish. The solution (melt) thus made is fed into a spinning machine to form the fibers.

The formation of the fibers involves pressing the spinning solution (melt) through the fine holes of a spinneret into a medium that causes the polymer to solidify into fine fibers. The number and diameter of the holes in a spinneret can vary depending on the intended use and thickness of the formed fiber.

In forming chemical fibers from a polymer melt (for example, polyamide fibers), cold air is the medium used to solidify the polymer. If the fibers are formed from a solution of a polymer in a volatile solvent (in the case of acetate fibers), a suitable medium is hot air, in which the solvent

Table 1. Main properties of chemical fibers

		Strength			**Elongation (percent)**			
	Density (g/cm^3)	**dry timber (kgf/mm^2)**	**wet fiber (percent of dry strength)**	**looped fiber**	**dry fiber**	**wet fiber**	**swellign in water (percent)**	**Moisture absorption at 20°C and 65% relative humidity (percent)**
Artificial fibers								
Acetate (textile thread)	1.32	16-18	65	85	25-35	35-45	20-25	6.5
Triacetate staple fiber	1.30	14-23	70	85	22-28	30-40	12-18	4.0
Viscose fibers								
ordinary staple fiber	1 52	32-37	55	35	15-23	19-28	95-120	13.0
high-strength staple fiber	1 52	50-60	75	40	19-28	25-29	62-65	12.0
high-modulus staple fiber	1.52	50-82	65	25	5-15	7-20	55-90	12.0
ordinary textile thread	1.52	32-37	55	45	15-23	19-28	95-120	13.0
high-strength textile thread	1 52	45-82	80	35	12-16	20-27	65-70	13.0
Cuprammonium fibers								
staple fiber	1.52	21-26	65	70	30-40	35-50	100	12.5
textile thread	1 52	23-32	65	75	10-17	15-30	100	12.5
Synthetic fibers								

Table 1. Main properties of chemical fibers								
		Strength			Elongation (percent)			
	Density (g/cm^3)	dry timber (kgf/mm^2)	wet fiber (percent of dry strength)	looped fiber	dry fiber	wet fiber	swelling in water (percent)	Moisture absorption at 20°C and 65 % relative humidity (percent)
Polyamide (kapron)								
ordinary textile thread	1 14	46-64	85-90	85	30-45	32-47	10-12	4.5
high-strength textile thread	1.14	74-86	85-90	80	15-20	16-21	9-10	4.5
staple fiber	1 14	41-62	80-90	75	45-75	–	10-12	4.5
Polyester (lavsan)								
ordinary textile thread	1 .38	52-62	100	90	18-30	18-30	3-5	0.35
high-strength textile thread	1 38	80-100	100	80	8-15	8-15	3-5	0.35
staple fiber	1 38	40-58	100	40-80	20-30	20-30	3-5	0.35
Polyacrylonitrile (nitron)								
industrial thread	1.17	46-56	95	72	16-17	16-17	2	0.9
staple fiber	1.17	21-32	90	70	20-60	20-60	5-6	1.0
Polyvinyl alcohol staple fiber	1 30	47-70	80	35	20-25	20-25	25	3.4
Polyvinyl chloride staple fiber	1 38	11-16	100	60-90	23-180	23-180	0	0
Polypropylene fiber								
textile thread	090	30-65	100	80	15-30	15-30	0	0
staple fiber	0 90	30-49	100	90	20-40	20-40	0	0
Polyurethane thread (spandex)	1.0	5-10	100	100	500-1.000	500-1.000	–	1.0

evaporates (the socalled dry forming method). When forming fibers from a polymer solution in a nonvolatile solvent (for example, viscose fiber), the threads solidify upon falling from the spinneret into a special solution—the socalled precipitating bath (the wet forming method). The forming rate depends on the thickness and intended use of the fibers, as well as on the forming method. In the case of forming from a melt, speeds reach 600-1,200 m/min; with a solution by the dry method, 300-600 m/min; and by the wet method, 30-130 m/min. In the process of conversion of a small jet of viscous liquid into a fine fiber, the spinning solution (melt) is stretched simultaneously (spinneret stretching). In some cases the fiber undergoes additional stretching immediately after emerging from the spinning machine (plastification stretching), resulting in increased strength of the chemical fibers and an improvement in their textile properties.

The finishing of chemical fibers involves treating freshly formed fibers with various reagents. The nature of the finishing operations depends on the conditions of formation and on the fiber type. During finishing, low-molecular compounds (for example, from polyamide fibers) and solvents (from polyacrylonitrile fibers) are removed, and acids, salts, and other substances drawn out of the precipitating bath by the fibers (for example, viscose fibers) are washed away. To give fibers such properties as pliability, improved sliding, and surface adhesion of separate fibers, they are given a dressing treatment or are lubricated after washing and cleaning. The fibers are then dried on drying rollers or cylinders or in drying chambers. After finishing and drying, some chemical fibers are given an additional heat treatment, called heat setting (usually under stress, at 100°-180° C), which results in stabilization of the thread form and a decrease in shrinkage—both of the actual fibers and of articles made from them—during dry and wet treatments at high temperatures.

The world production of chemical fibers is growing rapidly; this is primarily due to reasons of economics (lower labor costs and capital investment) and to the high quality of chemical fibers relative to natural fibers. In 1968 world production of chemical fibers reached 36 percent (7,287,000 tons) of the total volume of production of all fibers. In various fields chemical fibers are displacing natural silk, flax, and even wool. It is thought that by 1980 the annual output of chemical fibers will reach 9 million tons and by 2000, 20 million tons, and that production will be comparable with that of natural fibers. In 1966 the output of the USSR was about 467,000 tons, and in 1970, 623,000 tons.The composition of chemical fibers is similar as possible to that of natural fibers in the mixture of several chemical with natural fibers can.

The chemical fibers can be classified into two main parts by **Polycondensation and Polymerisation**

ORIGIN OF SEMI SYNTHETIC

Semi-synthetic fibers are made from raw materials with naturally long-chain polymer structure and are only modified and partially degraded by chemical processes, in contrast to completely synthetic fibers such as nylon (polyamide) or dacron (polyester), which the chemist synthesizes from low-molecular weight compounds by polymerization (chain-building) reactions. The earliest semi-synthetic fiber is the cellulose regenerated fiber, rayon.[5] Most semi-synthetic fibers are cellulose regenerated fibers.

Semi-synthetic fibers are fiber that are derived from originally naturally-occurring fibers, usually with the addition or treatment by synthetic chemicals. An example of a semi synthetic fiber is Rayon, which was also known as "viscose" which was originally developed after several un-industrious methods of developing artificial silk were devised, which treated cellulose derived from wood with an alkali and carbon disulfide to produce a viscose substance.

Types of semi-synthetic fiber

Acetate

Artificial silk

Rayon (viscose)

Tencel

ARTIFICIAL

An artificial fiber is a threadlike material invented by human researchers. Such fibers do not exist naturally. Some examples of artificial fibers include nylon, rayon, Dacron™, and Orlon™. These terms illustrate that some names of artificial fibers are, or have become, common chemical names (nylon and rayon), while others (Dacron™ and Orlon™) are proprietary names. Proprietary names are names that are owned by some company and are properly written to indicate that the name is a registered trademark (™).

Most artificial fibers are polymers. A polymer is a chemical substance that is produced when one or two small molecules are reacted with each other over and over again. The beginning molecule used in making a polymer is called a monomer. When two different monomers are used, the product that results is called a copolymer.

An example of a copolymer is nylon, first invented by American chemist Wallace Carothers (1896–1937) in 1928. The two monomers of which nylon is made are complicated substances called adipic acid and hexamethylenediamine. For simplicity, call the first monomer A and the second monomer B. A molecule of nylon, then, has a structure something like this:

-A-B-A-B-A-B-A-B-A-B-A-B

The dashes at the beginning and end of the molecule indicate that the -A-B- sequences goes on and on until it contains hundreds or thousands of monomer units.

The usual process by which artificial fibers are produced is called spinning. When a polymer is first produced, it is generally a thick, viscous (sticky) liquid. That liquid is forced through a disk containing fine holes known as a spinneret. The spinneret may be suspended in the air or it may be submerged under water. As the polymeric liquid passes through the spinneret holes, it become solid, forming long, thin threads.

The properties of an artificial fiber can be changed in a number of ways, including the way in which the polymer is first produced, additives that may be attached to the polymer, and the way the polymer is processed through the spinneret.

A scanning electron micrograph of fibers of a dacron polyester material used in sleeping bags. The core of each fiber has up to seven air cavities that increase its insulating ability. *(Reproduced by permission of*

Photo Researchers, Inc.

Other synthetic fibers

Artificial fibers can be made by processes other than polymerization. Glass fibers, for example, can be produced by melting certain kinds of glass and then forcing the melted material through a spinneret to form long, thin threads. Many of these artificial fibers not made from polymers are the result of recent chemical research and show exciting promise for new applications in industry.

ORIGIN OF SYNTHETIC

Synthetic fibers (or synthetic fibres in British English; see spelling differences) are fibers made by humans through chemical synthesis, as opposed to natural fibers that are directly derived from living organisms. They are the result of extensive research by scientists to improve upon naturally occurring animal and plant fibers. In general, synthetic fibers are created by extruding fiber-forming materials through spinnerets, forming a fiber. These are called synthetic or artificial fibers. Synthetic fibers are created by a process known as polymerization, which involves combining monomers to make a long chain or polymer. The word polymer comes from a Greek prefix "poly" which means "many" and suffix "mer" which means "single units". (Note: each single unit of a polymer is called a monomer). There are two types of polymerization: linear polymerization and cross-linked polymerization.

The first fully synthetic fibre was glass. Joseph Swan invented one of the first artificial fibers in the early 1880s; today it would be called semisynthetic in precise usage. His fiber was drawn from a cellulose liquid, formed by chemically modifying the fiber contained in tree bark. The synthetic fiber produced through this process was chemically similar in its potential applications to the carbon filament Swan had developed for his incandescent light bulb, but Swan soon realized the potential of the fiber to revolutionise textile manufacturing. In 1885, he unveiled fabrics he had manufactured from his synthetic material at the International Inventions Exhibition in London.

The next step was taken by Hilaire de Chardonnet, a French engineer and industrialist, who invented the first artificial silk, which he called "Chardonnet silk". In the late 1870s, Chardonnet was working with Louis Pasteur on a remedy to the epidemic that was destroying French silkworms. Failure to clean up a spill in the darkroom resulted in Chardonnet's discovery of nitrocellulose as a potential replacement for real silk. Realizing the value of such a discovery, Chardonnet began to develop his new product, which he displayed at the Paris Exhibition of 1889. Chardonnet's material was extremely flammable, and was subsequently replaced with other, more stable materials.

Nylon was first synthesized by Wallace Carothers at DuPont.

The first successful process was developed in 1894 by English chemist Charles Frederick Cross, and his collaborators Edward John Bevan and Clayton Beadle. They named the fiber "viscose", because the reaction product of carbon disulfide and cellulose in basic conditions gave a highly viscous solution of xanthate.The first commercial viscose rayon was produced by the UK company Courtaulds in 1905. The name "rayon" was adopted in 1924, with "viscose" being used for the viscous organic liquid used to make both rayon and cellophane. A similar product known as cellulose acetate was discovered in 1865. Rayon and acetate are both artificial fibers, but not truly synthetic, being made from wood.

Nylon, the first synthetic fiber in the "fully synthetic" sense of that termwas developed by Wallace Carothers, an American researcher at the chemical firm DuPont in the 1930s. It soon made its debut in the United States as a replacement for silk, just in time for the introduction of rationing during World War II. Its novel use as a material for women's stockings overshadowed more practical uses, such as a replacement for the silk in parachutes and other military uses like ropes.

The first polyester fiber was patented in Britain in 1928 by the International General Electric company.It was also produced by British chemists working at the Calico Printers' Association, John Rex Whinfield and James Tennant Dickson,, in 1941. They produced and patented one of the first polyester fibers which they named Terylene, also known as Dacron, equal to or surpassing nylon in toughness and resilience. ICI and DuPont went on to produce their own versions of the fiber.

The world production of synthetic fibers was 55.2 million tonnes in 2014.

Description

Synthetic fibers are made from synthesized polymers of small molecules. The compounds that are used to make these fibers come from raw materials such as petroleum based chemicals or petrochemicals. These materials are polymerized into a chemical that bonds two adjacent carbon atoms. Differing chemical compounds are used to produce different types of synthetic fibers

Synthetic fibers account for about half of all fiber usage, with applications in every field of fiber and textile technology. Although many classes of fiber based on synthetic polymers have been evaluated as potentially valuable commercial products, four of them - nylon, polyester, acrylic and polyolefin - dominate the market. These four account for approximately 98 percent by volume of synthetic fiber production, with polyester alone accounting for around 60 per cent.

Advantages

Synthetic fibers are more durable than most natural fibers and will readily pick-up different dyes.

In addition, many synthetic fibers offer consumer-friendly functions such as stretching, waterproofing and stain resistance. Sunlight, moisture, and oils from human skin cause all fibers to break down and wear away. Natural fibers tend to be much more sensitive than synthetic blends. This is mainly because natural products are biodegradable. Natural fibers are susceptible to larval insect infestation; synthetic fibers are not a good food source for fabric-damaging insects.

Compared to natural fibers, many synthetic fibers are more water resistant and stain resistant. Some are even specially enhanced to withstand damage from water or stains.

Disadvantages

A device for spinning Viscose Rayon dating from 1901

Most of synthetic fibers' disadvantages are related to their low melting temperature

The mono-fibers do not trap air pockets like cotton and provide poor insulation.

Synthetic fibers burn more rapidly than natural.

Prone to heat damage.

Melt relatively easily.

Prone to damage by hot washing.

More electrostatic charge is generated by rubbing than with natural fibers.

Not skin friendly, so it is uncomfortable for long wearing

Non-biodegradable in comparison to natural fibers.

Most of the synthetic fibers absorb very little moisture so become sticky when the body sweats.

Synthetic fibers are a source of microplastic pollution from laundry machines.

Common synthetic fibers

Common synthetic fibers include:

Nylon (1931)

Modacrylic (1949)

Olefin (1949)

Acrylic (1950)

Polyester (1953)

Specialty synthetic fibers include:

Rayon (1894) artificial silk

Vinyon (1939)

Saran (1941)

Spandex (1959)

Vinalon (1939)

Aramids (1961) - known as Nomex, Kevlar and Twaron

Modal (1960's)

Dyneema/Spectra (1979)

PBI (Polybenzimidazole fiber) (1983)

Sulfar (1983)

Lyocell (1992) (artificial, not synthetic)

PLA (2002)

M-5 (PIPD fiber)

Orlon

Zylon (PBO fiber)

Vectran (TLCP fiber) made from Vectra LCP polymer

Derclon used in manufacture of rugs

Other synthetic materials used in fibers include:

Acrylonitrile rubber (1930)

Modern fibers that are made from older artificial materials include:

Glass fiber (1938) is used for:

Industrial, automotive, and home insulation (glass wool)reinforcement of composite materials (glass-reinforced plastic, glass fiber reinforced concrete)

specialty papers in battery separators and filtration

Metallic fiber (1946) is used for:

adding metallic properties to clothing for the purpose of fashion (usually made with composite plastic and metal foils)

elimination and prevention of static charge build-up

conducting electricity to transmit information

conduction of heat

LEARNING OUTCOME 1.3: IDENTIFY PRODUCTS COUNTRIES OF TEXTILE FIBERS

- **CONTENT/TOPIC CATEGORISATION OF TEXTILE PRODUCT COUNTRIES**

VEGETAL TEXTILE FIBRES

- ✓ **USA**
- ✓ **INDIA**
- ✓ **CHINA**
- ✓ **EGYPT**
- ✓ **BRASIL**
- ✓ **PAKISTAN**
- ✓ **RDC**
- ✓ **TURKEY**
- ✓ **SUDAN**
- ✓ **INDONESIA**
- ✓ **MEXICO PERU**

ANIMAL TEXTILE FIBRES

The World's Top Wool Producing Countries

Wool is obtained from the fleece of sheep, muskoxen, goats, rabbits, camelids, and other animals that possess long hair. The Merino wool fiber is considered the best quality, especially with regards to textile production. Animals are normally sheered annually and their fleece is taken to industries for processing. The main use of wool is in the production of clothing. However, it is also used to make carpets, upholstery, saddle cloths, and horse rugs. In 2016-2017, the top wool producers were Australia, China, the United States, and New Zealand.

Australia is the highest wool producing country in the world. It is responsible for the production of 25% of the world's wool. According to the Department of Agriculture and Water Resources in Australia, the amount of wool produced in Australia in the year 2015-2016 was worth approximately $3 billion. The highest production in Australia is brought in by two states: New South Wales and Victoria. Australia's high wool production is related to the high number of sheep bred. Additionally, Australia is also among the largest suppliers of wool used for apparel in the world. Therefore, the nation strives to meet its worldwide demand as much as it possibly can.

One major reason for the high wool production in **China** is the political and economic importance that is placed on it by the ethnic minorities who live in the pastoral region. In some of the districts in this region, wool is the major source of income. The second reason why China produces about 18% of the world's wool is its significance in the textile and clothing industries in the country. In fact, China is currently the world's largest and 2nd largest exporter of clothing and textiles respectively. China also has very large farms for sheep to graze on.

In 2016, the **United States** produced 25.7 million pounds of wool. The top wool producing states are Texas, Colorado, California, Utah, and Wyoming. Although the United States produces 17% of the world's wool, its production has been gradually decreasing since the mid-1940s. The decrease is as a result of the invention of the synthetic fibers. Hence, most of the US wool is currently sold in form of raw fleece wool. The major competitors of the US with regard to wool are New Zealand and Australia.

New Zealand is the fourth largest producer of wool in the world. It contributes 11% of the world's wool due to the high number of sheep that it possesses. In New Zealand, there are 6 sheep for every one resident. Most of the wool in the country is sold by auction and the rest of it is sold to private buyers and individual consumers. New Zealand is known to produce high quality of wool.

How does one judge the quality of wool?

The quality of wool varies depending on two major factors; the diameter of the fiber and its fineness. Other quality factors are strength, length, contaminants, uniformity, and color. High quality wool is normally used to process clothing. Low grades can produce upholstery, blankets, and carpets among other items.

Rank	**Country**	**Share of World Production (%)**
1	Australia	25
2	China	18
3	United States	17
4	New Zealand	11
5	Argentina	3
6	Turkey	2
7	Iran	2
8	United Kingdom	2
9	India	2
10	Sudan	2
11	South Africa	1

LEARNING UNIT 2: DIFFERENTIATE TEXTILE FIBRES

LEARNING OUTCOME 2.1: CLASSIFY NATURAL TEXTILE FIBERS

- **CONTENT/TOPIC 1. INTRODUCTION OF NATURE FIBERS**

Natural fibre, any hairlike raw material directly obtainable from an animal, vegetable, or mineral source and convertible into nonwoven fabrics such as felt or paper or, after spinning into yarns, into woven cloth. A natural fibre may be further defined as an agglomeration of cells in which the diameter is negligible in comparison with the length. Although nature abounds in fibrous materials, especially cellulosic types such as cotton, wood, grains, and straw, only a small number can be used for textile products or other industrial purposes. Apart from economic considerations, the usefulness of a fibre for commercial purposes is determined by such properties as length, strength, pliability, elasticity, abrasion resistance, absorbency, and various surface properties. Most textile fibres are slender, flexible, and relatively strong. They are elastic in that they stretch when put under tension and then partially or completely return to their original length when the tension is removed.**rattan**A weaver making a basket from rattan, Malaysia

- **CONTENT/TOPIC 2. CLASSIFICATION OF NATURAL TEXTILE FIBERS**

Natural fibers: are the substances produced by plants, animals and minerals that can spun into filaments, threads

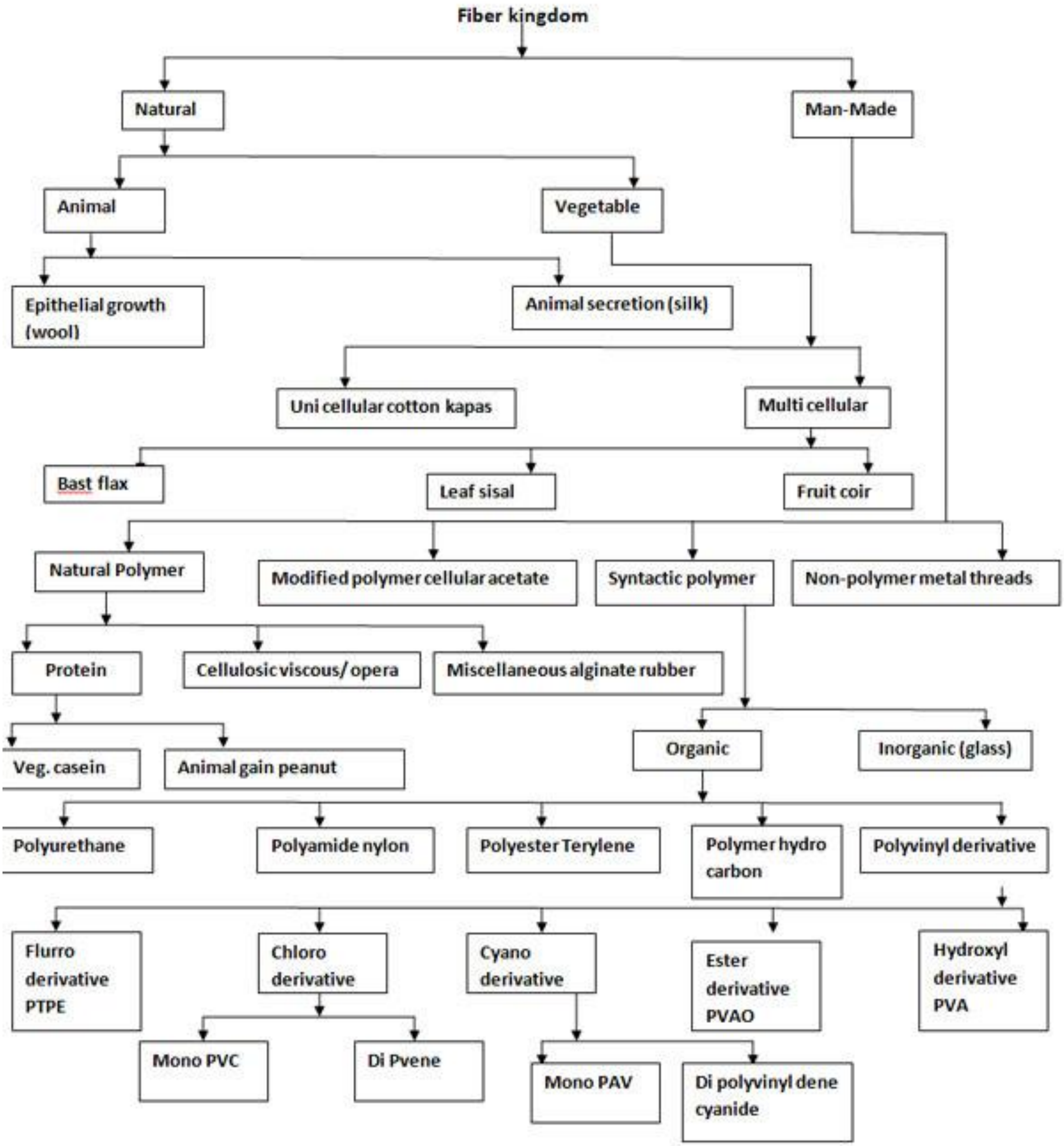
Natural fibers are classified into three main types

Vegetable fibers: are composed by cellulose or similar compounds

Animal fibers: are composed by protein, the fibers are structurally strong and resistant to chemical attack

Mineral fibers: are composed by minerals like asbestos and metallic fibers

Classification of Textile Fiber



They range from cotton, which dominates world fibre production, to other, specialty fibres such as cashmere which, though produced in far smaller quantities, have particular properties that place them in the luxury textiles market.

Plant fibres include seed hairs, such as cotton; stem (or bast) fibres, such as flax and hemp;leaf fibres, such as sisal; and husk fibres, such as coconut.

Animal fibres include wool, hair and secretions, such as silk

- **CONTENT/TOPIC 3 .VEGETABLE FIBERS**

COTTON

INTRODUCTION

Cotton today is the most useful textile fiber in the world, the first source of cotton is INDIA but cotton is now grow in every temperature parts of the world, cotton become an important industrial commodity during the 19th century.Due to fibres properties and low cost, cotton represents the most used textile fibre in the world. Fibres are obtained from seeds of the plant species *Gossypium*, which belongs to the *Malvaceae* family.

Cotton fibres consist of unicellular seed hairs of the bolls of the cotton plant. Cotton fruit bursts when mature, revealing a tuft of fibres with the length from 25 to 60 mm and diameters varying between 12 and 45 µm.

Cotton fibres have a pronounced three-wall structure. The cuticle layer consists of wax and pectin materials. This outer wax layer protects the primary wall, which is composed of cellulose crystalline fibrils. The secondary wall of the fibres consist of three distinct layers, which include closely packed parallel fibrils with spiral winding of 25 – 30° and represent the majority of cellulose within the fibres. Lumen is surrounded by the tertiary wall.

The cross section of fibres is bean-shaped; however by swelling it is almost round when moisture absorption takes place Cotton fibres consist of 80-90% cellulose, 6-8% water, 0.5-1% waxes and fats, 0-1.5% proteins, 4-6% hemicelluloses and pectins and 1-1,8% ash.

Cotton is hydrophilic and the fibres swell considerably in water. Fibres are stable in water and its wet tenacity is up to 20% higher then its dry tenacity (25-40cN/tex). The toughness and initial modulus of cotton are lower compared to hemp fibres, whereas its elongation at break (5-10%) and its elastic recovery are higher. The fibres are resistant to alkali but degraded by acids. The microbial resistance of cotton is low, it burns readily and quickly, can be boiled and sterilized, and does not cause skin irritation or other allergies

THE SOURCE OF COTTON FIBERS

1. **INDIA**
2. **USA**
3. **CHINA**
4. **EGYPT**
5. **BRASIL**
6. **PAKISTAN**
7. **R.D.C**
8. **TURKEY**
9. **SUDAN**
10. **INDONESIA**
11. **MEXICO**
12. **PERU**

CHARACTERISTICS OF COTTON FIBERS

Cotton is industrial and natural cellulose fibers have characteristics such as

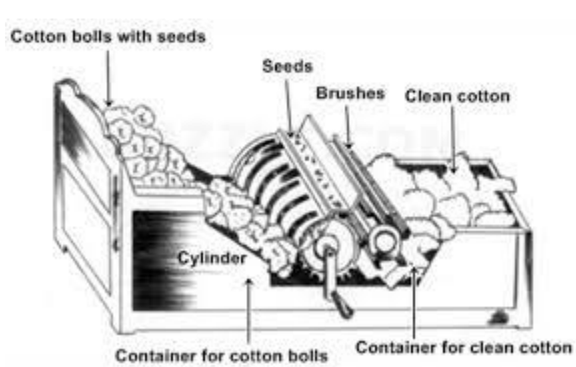
1. Comfortable In Hand
2. Good Absorbency
3. Color Rentation
4. Print Well
5. Machine Washable
6. Dry-Cleanable
7. Good Strength
8. Easy To Handle and Sew

USE OF COTTON

Cotton is used to make different garment such as: blouse, dresses, children wears, jackets, costume of men and women, shirt, sweaters and neck wear. And also it can be used in home fashions such as: curtains, bed covers, table clothes, table mats

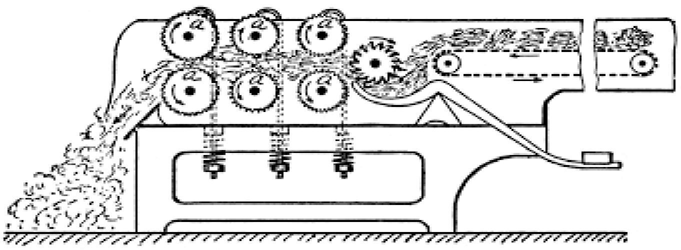
PRODUCTION OF COTTON CLOTH/TISSUE

Ginning: The raw cotton is passed through a machine which separates the seeds from fibers and removes most of lost piece of plant

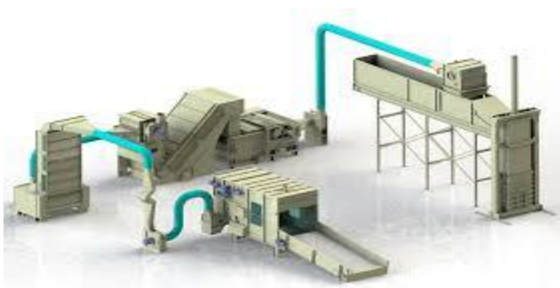


Baling: Is the packing of cotton lint into bundles for shipping to the factors

Bale Breaking: at the spinning the bales are feed into machine which breakdown the matted fibers and rid them of impurities



Opening and Cleaning: Continuing the breaking down and cleaning process and producing and blocked sheet of cotton fibers know as a LAP



Carding : separating the fibers and removing the short threads thin process procedures a loose rope of cotton fibers known as SLIVER

The carding is the second process of spinning which converts fed material (lap) into uniform strand of fibres called ***"sliver"***. The good quality carding of cotton is very important because the yarn quality very much depends upon it. The neps percentage in the yarn varies according to quality of carding process. ***"The carding is called heart of spinning".*** In the carding process, the material gets passed through carding machine. The fibres are made parallel to each other. The fibres tangle in this operation, thus it makes possible to remove the all types of impurities present in the cotton.

The carding, stripping and raising action take place during carding operation. In this way, continuous uniform sliver having parallel fibre arrangement almost free of impurities is obtained after carding process.

OBJECTIVES OF CARDING

The main objectives of carding process are given below

• To open the cotton tufts fully (individual fibres of cotton tuft get opened in carding process).

• To make the fibres parallel to one another along the length of sliver.

• To eliminate maximum impurities present in the cotton. (to achieve higher degree of cleanness. Today's carding machine achieves 90 to 95% degree of cleanness. In this way overall degree of cleanness in the blow room and carding is 95 to 99%. A card sliver still contains 0.03 to .05 % foreign matter in it).

• To remove very short fibres which could not be spun into yarn.

• To remove all the neps present in the material generating in the previous process like blow room and mixing.

• To blend the fibres and to achieve fibre to fibre mixing.
• To finally convert the web of cotton into uniform sliver.

STRUCTURE OF CARDING MACHINE

The common structure of a carding machine is illustrated in below schematic diagram

• Pipe ducting.

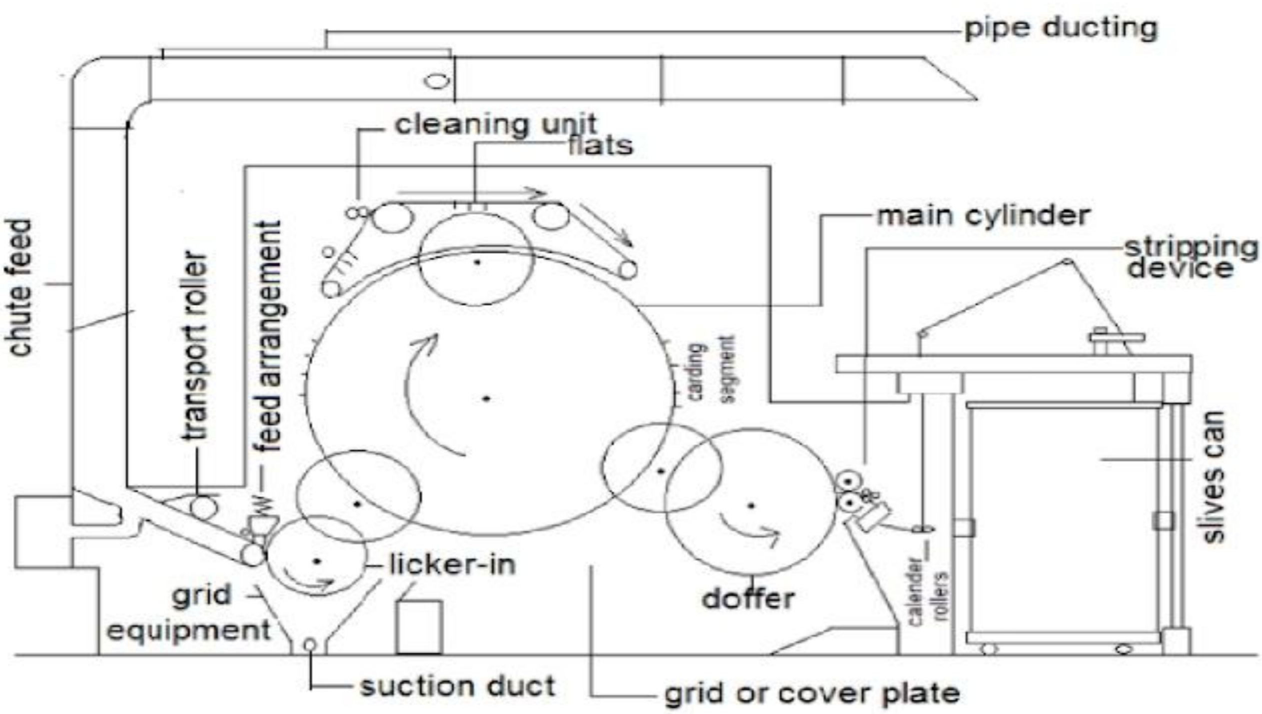
• Chute feed.

• Transport roller

• Feed arrangement

• Licker-in,

SCHEMATIC DIAGRAM OF CARDING MACHINE



- Suction duct.l
- Main cylinder.
- Carding segments.
- Flats.
- Cleaning unit.
- Grid or cover plate.
- Doffer.
- Stripping device.
- Calendar rollers.
- Sliver can.

WORKING PROCEDURES OF CARDING MACHINE

Working of a carding machine can be understand in following steps

CHUTE FEED SYSTEM

The fibre mat to be fed in the carding requires high degree of evenness (uniformity). This evenness of fibre mat ensures the consistent opening and carding .in the carding process. This evenness is obtained through using the chute feed system. The main objective of chute feed system is to maintain continuous and consistent feeding of fibre sheet of a uniform packing density and uniform linear density (weight per unit length) to the carding machine. A chute feed system of a carding machine has following common parts in it:

1. High volume upper trunk.

2. Integrated air volume separator.

3. Feed roll, electrically coupled to the feed roll of the card.

4. Segmented tray to secure clamping.

5. Opening roll with pins.

6. Closed air circuit with integrated fan.

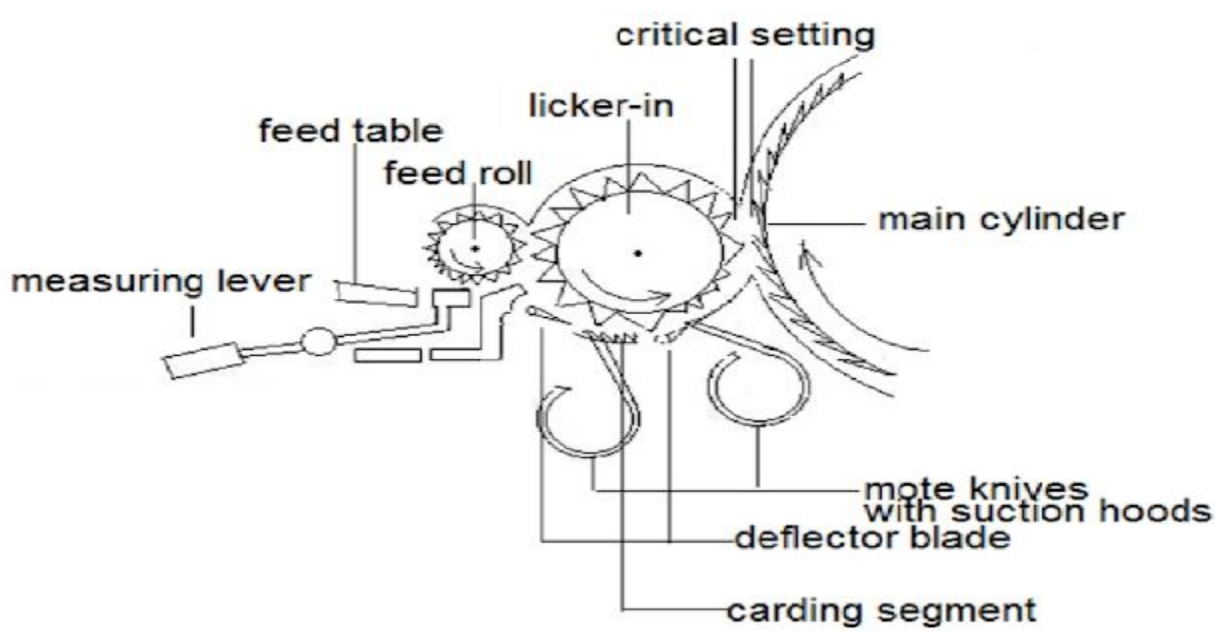
7. Self-cleaning air outlet combs.

FEEDING SYSTEM

The uniform fibres mat coming out from the chute feed system is supplied to the carding machine with the help of feed roller. The linear density (weight per unit length) of the fibre mat typically ranges from 400 to 1000 gram per metre (K tex). Weight per metre depends upon the number of fibres present in the mat cross section which ranges from 2 to 6millions of fibres depending on fibre fineness.

OPENING SYSTEM

The fed material needs maximum opening and the linear density of material is reduced up to 3 – 5 grams per metre as per sliver count to be produced. The number of fibres in the card sliver cross section downs to approximately 40,000. This intense reduction is mainly obtained in the region between the feed roll and the licker-in. The feeding rate is normally kept low to allow exposition of small portion of the fibres mat to the action of the high speed licker-in. Licker-in has diameter of 25 centimetre. It rotates at a speed of 700 – 1200 rpm for cotton fibres and 400 – 600 rpm for synthetic fibres. The licker-in is covered with saw toothed wire clothing. These saw tooth wire removes the fibre tufts from the input fibre mat. The draft between licker-in and feed roll is kept around 100. The ratio of surface speed between the licker-in and the feed roll is equal to draft. High rotational motion of the licker-in creates centrifugal force. This centrifugal force tries to eject the heavy trash particles, and seed coats fragments out at the mote knives with the assistance of air draft. The licker-in eliminates about half of all trashes present in the cotton fibres.



The carding zone

The opened and cleaned fibres by licker-in gets transferred to the main cylinder using stripping action. The cylinder strips the fibres from licker-in. Now these fibres begin to travel between cylinder and flats, this area is called carding zone.

The surface speed of the main cylinder is kept higher than the licker-in to perform fibre removal by main cylinder from licker-in. The surface speed of the licker-in varies between 700 – 950 metres per minute. The surface speed of the cylinder ranges from 1000 metres per minute to 2400 metres per minute. (at diameter is 1290 mm, and 260 to 600 rpm.). In this way, the draft varies between1.5 to 2.5.
The carding action with the cotton tufts takes place between cylinder and flat region. According to carding principle, carding action takes place when two surfaces having wires inclined in opposite direction and rotating in opposite directions one surface passes other point against point.
The flats are the bars which are covered with wire clothing. These flats rotate at very slow speed in the opposite direction of cylinder rotating at high speed. The speed of he flats varies with in the range of 8 – 20 centimetres per minute. Both are closely set to each other. The clearance between flats and cylinder is set by considering following factors:

• Mechanical factors.

• Material to be processed.

MECHANICAL FACTOR

The bearing condition, the shape and dimensions of the wires are some of mechanical factors which affect the clearance between flat and cylinder.

Types of materials to be processed

Fibre length, fibre fineness and fibre to fibre friction is some of the factors which affect the clearance between flats and cylinder.

This setting is so important because it plays very critical role in neps formation. The main cylinder is the central part of the card. It has a diameter of approximately 1.3 metres and a working width of 1.0 metre. It contains an area of 4.0 square metres covered with wire clothing. The carding surface of the cylinder is made up of more than 10.000 metres of clothing wire with around 6 million single wire's points.

By shifting the web feed unit and the doffer below the cylinder, more room has been made for the functions of pre- carding and post-carding.

In the pre-carding and in the post-carding area of the cylinder, 10 special elements of the multi web clean system can be mounted in the most different combinations. The first and the last elements are fixed.

Cleaning system

The cleaning system consists of a mote knife with a hood under permanent suction. It separates dirt particles, seed coat fragments and dust particles.
Carding segment consists of two clothing strips with one support (twin top). A number of different clothing types and point populations are available depending upon the installation and the raw material.

The doffing system

The fibres come out of carding region in the form of a very thin web. The weight of carding web depends upon setting of flats v/s cylinder, carding speed, type of wire clothing used on the both cylinder and flats. Formed web is stripped from the main cylinder by another cylinder called a doffer. It has diameter of 700 mm. and rotates at up to 96 rpm. Since doffer rotates at very low surface speed in comparison of main cylinder. Thus condensation effect results in the web. The fibre web is stripped from the doffer using a stripper roller. It is then passed through a pair of squeezing or crush rolls before it is finally accumulated width wise into a fibre stand form. The calendar rolls compress the fibre strand to provide better integrity and stable flow of material.

Coil formation system

The fibre strand (the card sliver) proceeds upward over guide pulleys then it enters into the coil formation system. The coil formation system has a trumpet guide and a second pair of calendar rollers. These calendar rollers sends the sliver in to the sliver can with the help of revolving tube.

The sliver web speed forms the web to a sliver and helps to guide it into the measuring funnel. The sliver former is opened by pushing a button when sample for optical assessment of web quality is made.

Neps controller

This system registers the number of neps, trash particles and seed coat fragments. These data are transferred to the main control system of machine. These data are evaluated and displayed on the machine monitor.

Card Auto leveling system

An auto levelling system controls the variation of linear density of sliver and helps to maintain the uniformity consistently. The main objectives of an auto leveller are given below:

1) To measure sliver thickness variation on real-time basis.

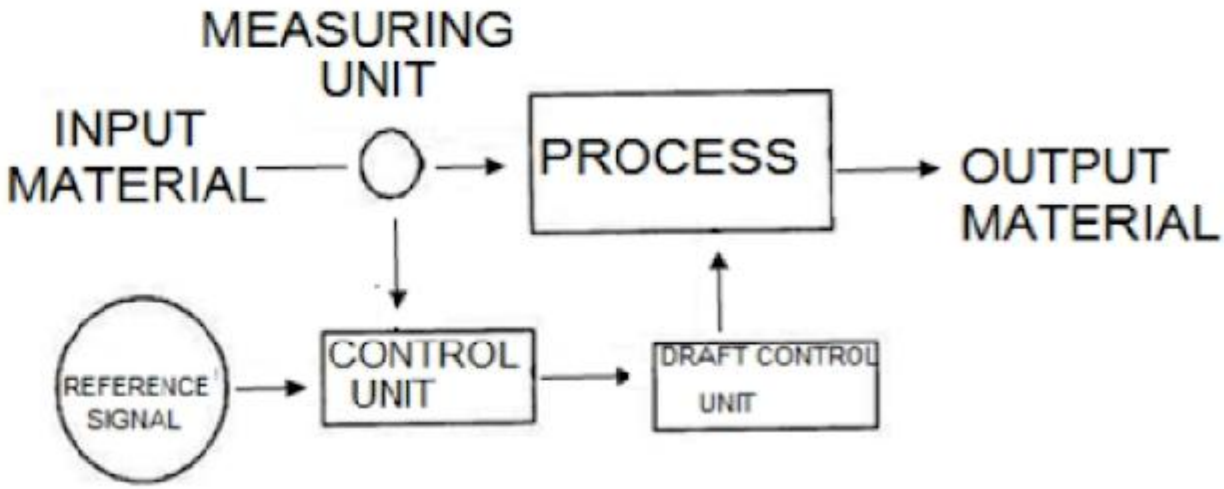
2) To alter the machine draft, so that a high consistent sliver linear density is continuously produced.

Generally two types of auto levelling systems are use depending upon the working principle which are

a) Open-loop auto levellers

b) Closed-loop auto levellers.

Open-loop auto leveling system
The open-loop system is generally used to correct the short-term variations of sliver.

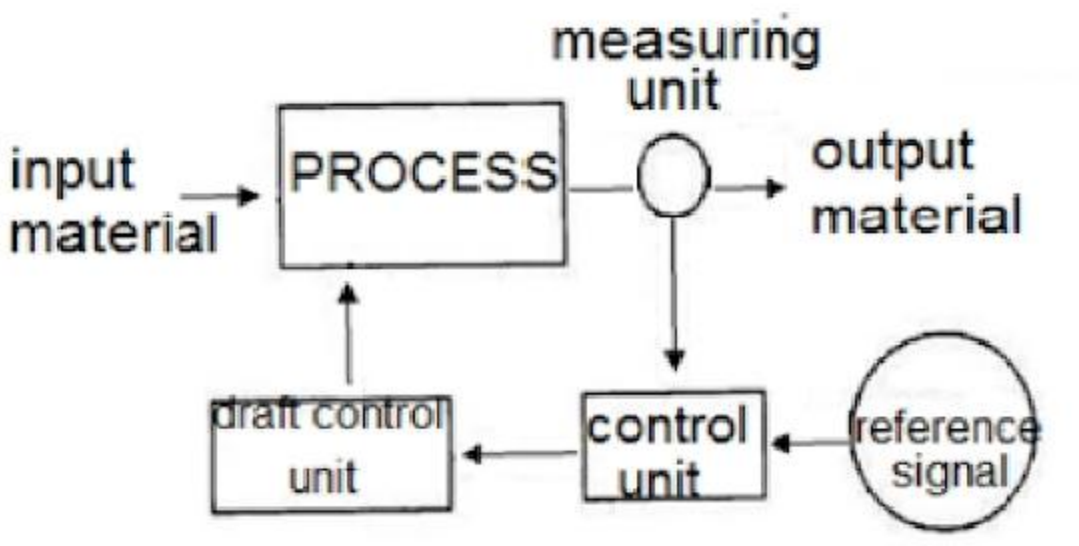


OPEN LOOP AUTO LEVELLING SYSTEM

The input material the variation of sliver is measured with the help of a measurement unit. A comparison is made by a control unit between measured signal and reference signal (normal value). If control unit finds any difference between them, then it sends a command to draft control unit. This draft control unit takes necessary action to correct the variation. The open-loop system does not check the delivered sliver. Thus we can say that it makes the correction in draft when it read a variation in input material.

Claused loop auto levelling system

It is generally used to correct long-term variations in linear density of sliver. This system takes the measurements of the delivered sliver. In other words, we can say that the closed loop auto leveller monitors the results of corrective actions taken by it to maintain the sliver uniformity.



CLOSED LOOP AUTO LEVELLING SYSTEM

Combing: laying the fibers side by side passing the slivers overs revolving drum set with teeth
For getting high quality of yarn, one extra process is introduced which is called combing process.

Combing: is an operation in which dirt and short fibers are removed from sliver lap by following ways.

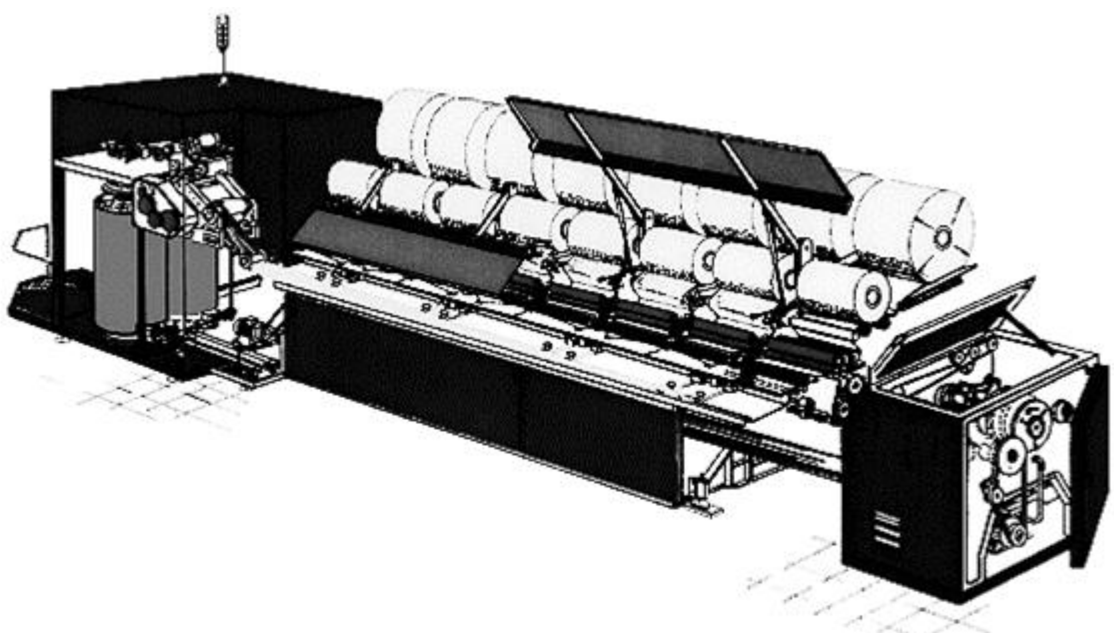
- In a specially designed jaws, a narrow lap of fiber is firmly gripped across its width
- Closely spaced needles are passed through the fiber projecting from jaws.

The combing process is carried out in order to improve the quality of the sliver coming out of the card. The process eliminates short fibres, it achieves better parallelisation of fibres, it straightens curls, and it removes neps and residue impurities. It is clear from these functions that the combing process is essentially aimed at obtaining excellent quality yarns and to fulfill this objective raw materials with above average physical and mechanical features must be used from the very beginning of the spinning process.

Depending on what is being produced, waste from combing varies from 12% to 25%, and this can be employed to obtain yarns with a medium coarse count using the open-end process.

As far as parallelisation of curls is concerned, when curls are combed they tend to behave in a very similar way to short fibres and therefore if they do not straighten they are removed, and this produces a notable amount of waste fibres; it is therefore necessary to reduce the curls before the combing stage. Some of the .curls. Straighten when drawn in the combing preparation stage.

Furthermore, it is a good idea for the curls to be presented head first to the **combing machine**, as the latter are to a large extent straightened by devices on the combing machine. The direction of the curls depends on the number of passages the material is subject to following carding, as between one passage and another the direction of the material is inverted and consequentially the curls are too. Therefore, considering that mainly tail curls come out of the card, in order for them to arrive at the combing machine as head curls, it is fundamental to carry out an even number of preparation passages, usually two, one to the drawframe and one to the lap drawing frame.



Combing machine

The lap **drawing frame** has, furthermore, the task of forming the interfacing, which is employed to feed the combing machine. The interfacing is obtained by doubling a certain number of slivers (from 16 to 32) previously subject to a drawing passage. In the lap drawing frame, the material undergoes a light draft of around 1.5 to 2 times one a drawing aggregate of the type 2 on top of 3 cylinders.

Drawing: pulling out or DRAWING the slivers and twisting several into one repeated several times

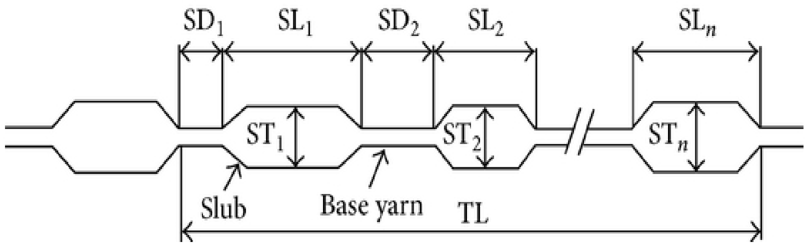
Slubbing: further drawing into a thin SLIVES now called a roving and winding the roving on the bobbins(this twist the threads slightly

What is Slub Yarn?
Slub yarn refers to **yarn** that has been purposely spun with slubs (thicker sections along the yarn) while it was once seen only as a defect, slub yarn is now intentionally created to give fabric more personality.

Affect the visual effect of slub yarn

There are four factors are affect the visual effect of slub yarn. They are:-

1. Number of slubs per kilometer (NSm)
2. Diameter (dia) of slub
3. Length of slub
4. Distance between slub.



All these parameters are selected by computer. Slub vision software is used for this purpose.

Types of slub yarn on the basis of visual effect:

1. Pattern/regular slub yarn
2. Non-pattern/irregular slub yarn
3. Multicount slub yarn
4. Both are pattern and non-pattern slub yarn.

Suppliers of slub yarn attachment m/c:

1. Amsler - Germany
2. Jiangyin CF Tex Tech Co Ltd - China
3. Caipo - Italy
4. Pinter - Spain
5. Slub-O-Generator of Fancytex - Gwalior, India, etc.

Some ring frame machine manufacturer are supplying the ring frame with inbuilt mechanisms for slub and multicount yarns. Some popular machine manufacturers are-

1. Marzoli - Italy
2. Zinser - Germany
3. Toyota - Japan, etc.

Production of slub yarn in ring frame

1. In the ring frame, there is a servo motor with slub gear and another with twist gear.

2. Back and middle rollers get motion from the same gearing and the front rollers get motion from separate gearing.

3. Slub is produced by the speed variation of back and middle rollers.

4. Break draft is always maintained properly, otherwise roving breakage will be created.

5. Back roller speed will be increased continuously after a certain time. As a result more material will be feed, whereas during that time the draft of front zone remains constant. So a thick place in the final yarn will be created after a certain time.

6. The controller controls the following

- After how much time (mili second) the speed of back roller will be increased.
- How longer the increased speed will remain.
- Amount of speed that to be increased.

7. Twist gear is optional; the speed of front roller is fixed when twist gear is not used.

8. Twist is controlled by changing the speed of front roller.

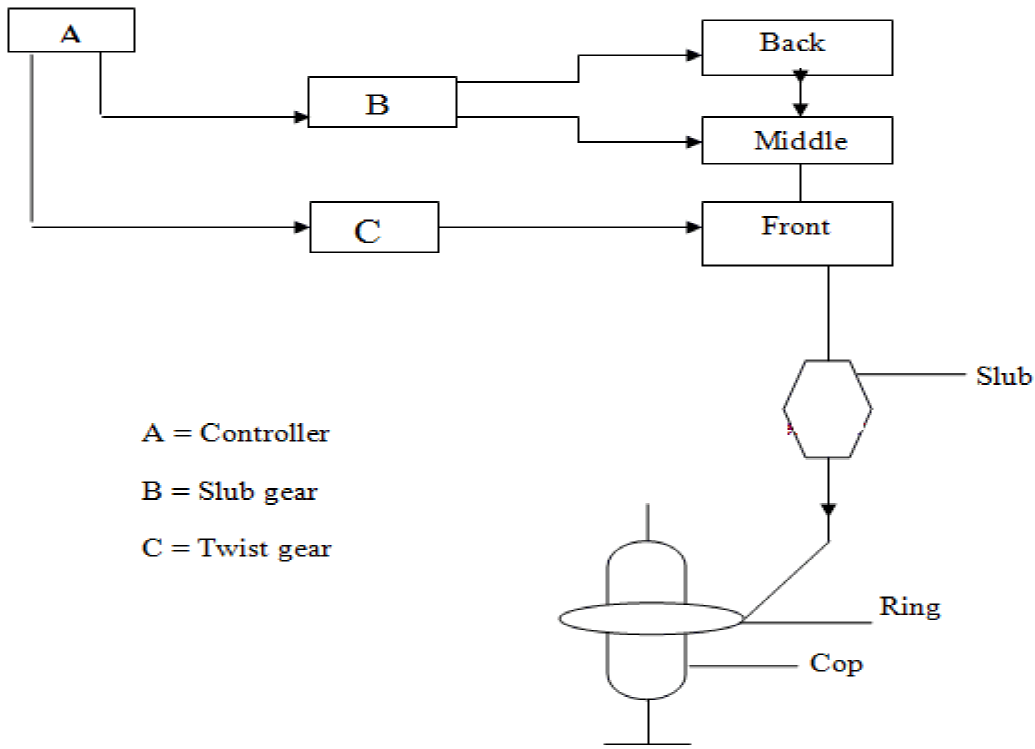
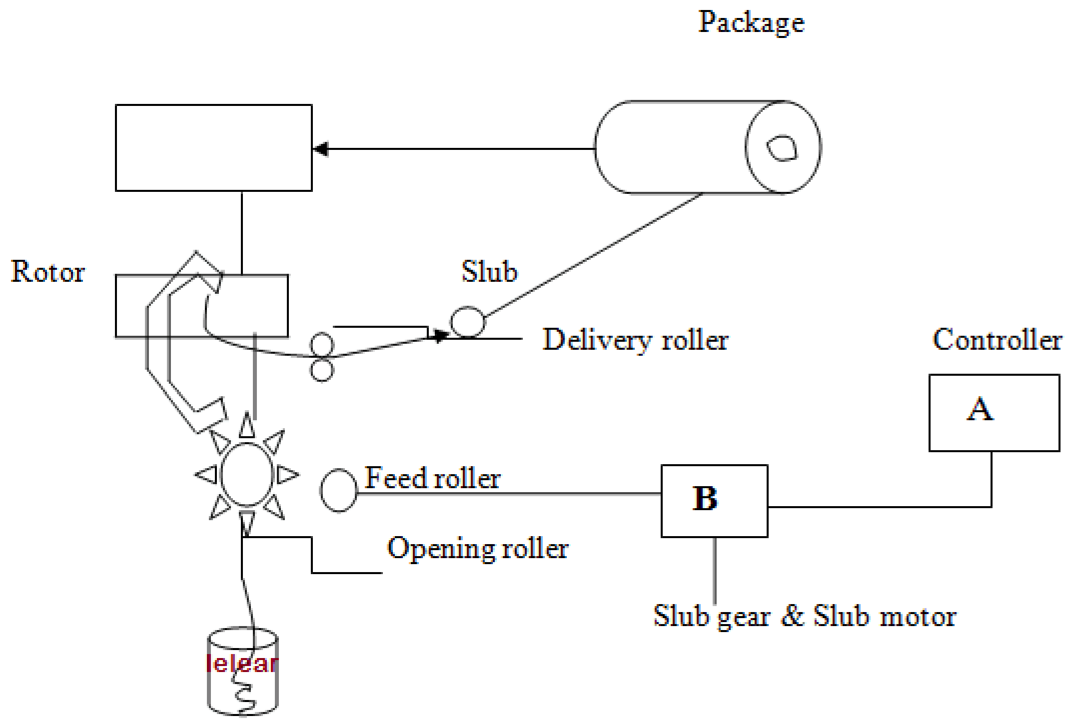


Fig.: Production of slub yarn in ring frame

Production of slub yarn in rotor

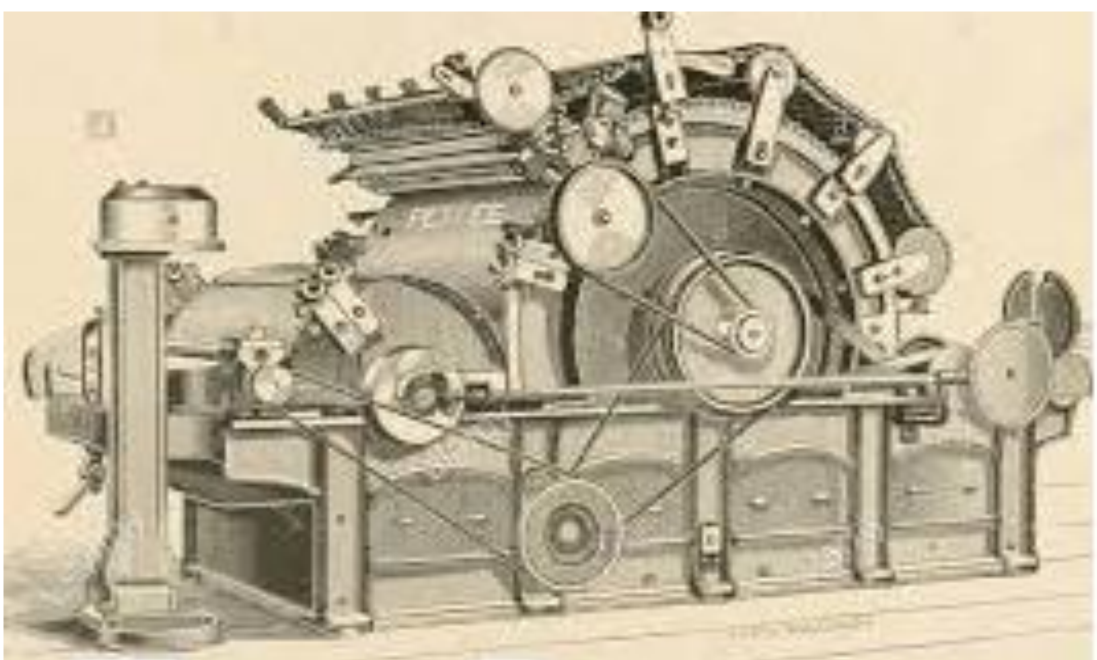


In , slub is produced by the speed variation of feed roller. When the feed roller speed is increased, the over feed takes place and as a result slub is created.

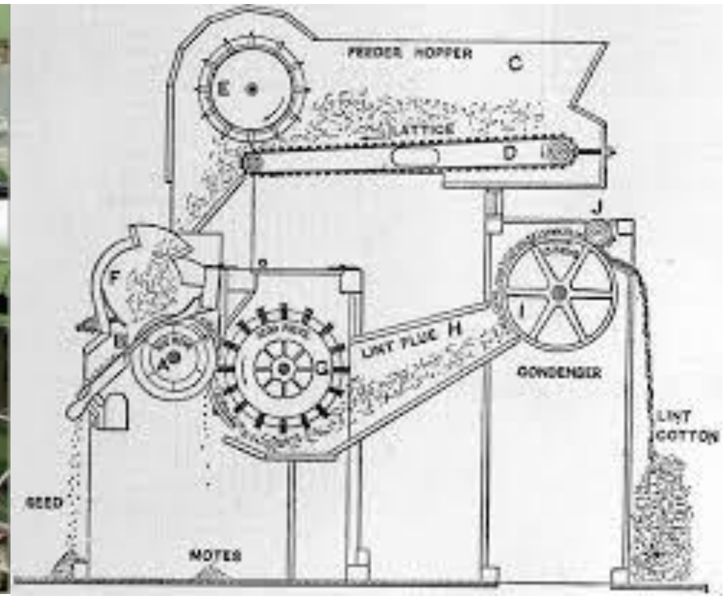
End uses of slub yarn:

Slub yarn is used in traditional fabrics such as upholstery, lace, curtains and household fabrics in general. But it is becoming more popular in the production of denim on **ring spinning**, shirting and knitwear.

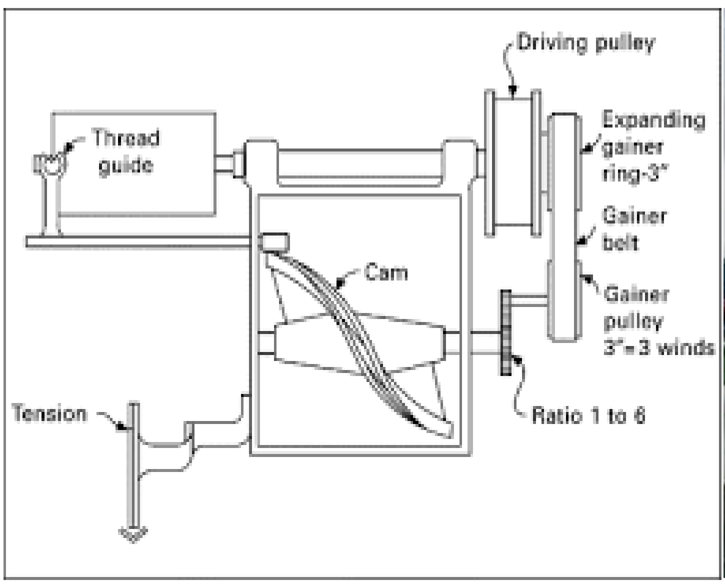
Roving: drawing out single threads fine enough for spinning



Spinning: the further drawing out and twisting of the threads into a continuous length for working



Winding: removing faults in threads and winding them onto larges and more convenient



Doubling: Twisting together two or more threads for greater strength

Weaving: the passing of weft threads alternately over and under wraps one

Printing: passing of the completed clothes through rollers which print on pattern

ADVANTAGE OF COTTON

1. Comfortable
2. Absorbent
3. Good color retention
4. Dyes & prints well
5. Washable
6. Strong
7. Drapes well
8. Easy to handle and sew
9. Inexpensive
10. cotton fiber are stronger when wet than when dry

DISADVANTAGE OF COTTON

1. Shrinks in hot water
2. Wrinkles easily
3. Weakened by perspiration and sun
4. Burns easily
5. Affected by mildew
6. LOOSELY WOVEN

HISTORY OF LINEN TEXTILE

Linen is a type textile made from the fibers of the flax plant. Linen textiles are one of the oldest textiles in the world. They are cool to touch, smooth and get softer with repeated washing. The fibers do not stretch but because of this very low elasticity, the fabric will eventually break if it is folded and ironed at the same place constantly.

History of linen use goes back many thousands of years. Dyed flax fibers are found in a prehistoric cave in Georgia which is evidence that woven linen fabrics from wild flax were used some **36,000 years ago**.

Fragments of straw, seeds, fibers, yarns, and various types of fabrics have also been found in Swiss lake dwellings that date from **8000 BC**.

In **ancient Egypt** linen was used for mummification and for burial shrouds because it symbolized light and purity as well as wealth. Linen was so valued in ancient Egypt that it was used as currency in some cases.

Linen was also produced in **ancient Mesopotamia** and reserved for higher classes. It always had high cost because it was always difficult to work with the thread (flax thread is not elastic and it is very difficult to weave it into a cloth without breaking threads) and also because the flax plant requires a lot of attention during cultivation.

The first written evidence of a linen comes from the Linear B tablets of Pylos, **Greece**, where linen hast its own ideogram and is also written as "li-no" in **Greek**. The Phoenicians, who had their merchant fleet, brought flax growing and the making of linen into **Ireland**.

Belfast became in time the most famous linen producing center in history. The majority of the world's linen was produced there during the **Victorian era**. Some religions even made rules that involved linen or they just mention them in religious concept.

The Jewish faith restricts wearing of mixture of linen and wool. **Linen** is also mentioned in the **Bible in Proverbs 31. Bible also mentions that angels wear linen**.

Quality is very important in linen production. The longest possible fibers are got when the flax is either hand-harvested by pulling up the entire plant or when stalks are cut very close to the root. Seeds are then removed from the plant and fibers are loosened from the stalk. Woody portion of the stalks are removed by crushing between two metal rollers which separates fibers. They are then separated between themselves - longer from shorter. Longer, softer ones are then spun into yarns and then woven or knit into linen textiles.

Linen is used for variety of uses: from bed and bath fabrics, home and commercial furnishing items, apparel items to industrial products. It was even used for **books** and for a type of body **armour**. Use for linen has changed in time and especially in the last **30 years**.

While in the **1970s** only about **5%** of world linen production was used for fashion fabrics, **70%** of linen production in the **1990s** was used for apparel textiles.

The discovery of **dyed flax fibers** in a **cave in Georgiadated to thirty-six thousand years ago** suggests that ancient people used wild flax fibers to create linen-like fabrics from an early date.

In **ancient Mesopotamia**, flax was domesticated and linen was first produced.

History of Linen and how it is Made. Linen is the most ancient of fabrics, with a **rich** and **Romantic heritage**.

Its widely accepted birth as a textile was in Egypt some **10,000 years** ago but there is evidence found in pre-historic caves in Georgia that suggests it might have been used as a textile some 36,000 years ago

Linen is made from a plant called flax. Linen is famous because of its strength and durability hence it is known as versatile fabric. It is highly absorbent and can absorb up to 20% of its own weight. Linen is 100% natural and oldest fabric used by ancient Mesopotamia, ancient Egypt, ancient Greece. Russia is the largest cultivator and China is the largest producer of linen. Linen is one most stylish and charming bedding and clothing fabric, you can buy any kind of bedding which can be planned or printed. Presently, it is commonly viewed as a lavishness texture, not this time to its high generation cost. If you are asking that "what is linen?", there is much more to read about it. People love to read about it. Let's discuss each and every aspect of it. Linen is the oldest fabric that comes from nature. Linen is thicker and crisper fabric. Comparing to cotton it is expensive too. The Linen fabric is also designers favorites Fabric and that can be appreciated by all Linen and bedding lovers.

What is Flax?

Flax is a plant that is grown for seeds and fiber. It is cultivated in a cooler place as a food and fiber crop. There are so many countries in the world those who are producing linen but the Western European countries are famous for producing the finest quality fabric. Western Europe and China are producing large amounts but still, Russia is a larger cultivator of it. Poland, Austria, France, Sweden, Denmark, Germany, Switzerland, India and some more countries are in the queue.

Olden times of Linen:

Linen is the most established regular yarn at any point used to weave texture. It is evaluated that its first use was back in the human progress exactly a thousand years ago. Cloth missing its reputation in a few centuries ago as cotton generation twisted out to be a lot simpler and faster with turning technology. Pieces of evidence have found that 36000 years ago it was used. Egyptians have used it for mummification as it is a durable fabric. It was valuable that it was used as currency in Egypt. Mesopotamia is a region in Western Asia. In ancient Mesopotamia, it was used and produced. This was used by royal families. It is a laborious process to get it from flax fibers. It cost too much so Mesopotamian royals only had used it. Once in history, Belfast was famous for linen production but in Victorian-Era large production had taken place.

HOW WAS LINEN MADE IN THE MIDDLE AGES?

Medieval linen. Over the past month we've been looking at the manufacture of fabric for outer clothes in the middle Ages: wool and silk. ... Linen is made from flax stems. It was harvested before the seeds ripened and soaked in water, often rivers, to rot the cord

Benefits of Linen

Some best and positive result after using **Linen bedding** makes your Home attractive and gives a huge bunch of refreshed ambience. Let's discuss the benefits of this fabric.

- You can wash and dry it in a washing machine.
- We can hand wash it.
- The biggest advantage of linen is strong flax fibers. Due to strong fibers, we can use it in various textures.
- Its bedding and clothes can be used in any kind of weather.
- It can even be used in a sticky climate since it is very permeable.
- It shrinks and the shrinkage percent of it is 4-5% that is natural but in the case of "hot tumble dry" it increases to 10-15%.

Nature

Linen fabrics have a refreshed natural shine. In linen, there is the widest colour range shades like Ivory, tan, light grey but white is the main colour of it, which shows the Luxury feeling and the royalty. It is natural fabric which is fully biodegradable. It is naturally moth resistant and good for people those who are suffering from allergies. Stylish clothes, bed linens and bath linens are made from it because of its strong fabric. This question what is linen helps all users that what makes your linen perfect for Home improvement.

The Texture

Quality texture may at first be gentler than cloth however material is known to mollify after some time without losing any of its tough properties. Linen cloth is additionally a superior cover responding to seasons and considering better air and dampness dissemination. It is additionally progressively spongy more Eco-accommodating and has great hypoallergenic properties ailing in cotton.

Truly in spite of the fact that cloth and linen might be comparative items in both their look and feel when thinking about the best texture for your sheets stonewashed material sheet material turn out tops. As cotton blurs and passes on following 2-3 years of utilization cloth sheets start to sparkle and make their mark staying around for the following couple of decades whenever took care of appropriately. I think this Confusion question, What is Linen, now understandable, easily.

ARE THERE DIFFERENT TYPES OF LINEN?

A few linen fabric types are plain woven and sheeting. Plain woven linen fabric is also known as glass toweling linen as the most common use of this type is wiping glassware. ...

There are many different types of linen, but **Irish Linen, Belgian Flax Linen, and Japanese Linen** are being highly used in today's date.

Types of Linen

- Damask
- Plain Woven
- Loosely Woven
- Sheeting

What is linen used for?

- Used in Gent's wear like Shirts, Pants, Blazers.
- Used in women's wear like dresses, skirts, undergarments.
- Table and Kitchen Clothes
- Bathroom items like bath sheet, bath towel, hand towel, face towel.
- Bedroom items like Sheets Sets, Bed Skirts, Pillows Covers, Duvet Covers, etc.
- Some painter uses its sheets for canvas painting.
- Uses in currency making.

Difference between Linen and Cotton

Difference between linen and cotton is plants, from fibres are obtained to make textiles from them. Linen is made from the flax plant and cotton is made from cotton plants. According to the evidence collected from Peru, Indus valley and Swiss Lake Dwelling, Linen is almost 8000 BC old and cotton is 6000 BC old Linen is thicker, crisper and long-lasting than cotton, sometimes expensive too.

- **Thicker** than cotton
- **Long-lasting** than cotton.
- **Crisper** than cotton.
- **Older** than cotton.
- **Expensive** fabric than cotton.
- **Source** of linen is a **flax plant** and cotton is a **cotton plant**.

The similarity in Linen and Cotton.

- Both are 100% natural fabrics.
- Both have a feature of moisture absorbency.
- Linen and cotton both the fabrics are breathable.
- Both are naturally hypoallergenic.
- Both are soft and comfortable fabric.

Production Process

- **Growing:** Climate condition plays a vital role in it. The best climate condition for growing flax is a cool climate. Flax plant needs deep. rich soil.
- **Harvesting:** If you see only seed bolls instead of flowers it is a good time for harvesting. Make sure it is not raining on the day of harvesting choose a dry day for harvesting.
- **Drying:** The bundles are laid on the farm to dry.
- **Rippling:** Rippling is a process of removing seeds from the plant.
- **Retting:** According to Wikipedia retting flax is the process of freeing the flax fibers from between the inner core and the outer layer of the flax stalks. There are two ways to do so and they are naturally and chemically.
- **Scutching:** Removing the woody portion of the stalks.
- **Heckling:** Heckling is a process of separating short fibers from large fibers by heckling combs.
- **Spinning**
- **Bleaching/Printing/Finishing:** This is the final step where coloring and printing take place.

WHAT ARE THE SOURCES OF LINEN?

Technically, linen is a vegetable. Linen fabric is made from the cellulose fibers that grow inside of the stalks of the flax plant, or Linum usitatissimum, one of the oldest cultivated plants in human history. Flax is an annual plant, which means it only lives for one growing season.

PHYSICAL PROPERTIES OF LINEN FIBERS ARE GIVEN BELOW

Tensile Strength: Linen is a strong fiber. ...

Elongation at break: Linen does not stress easily.

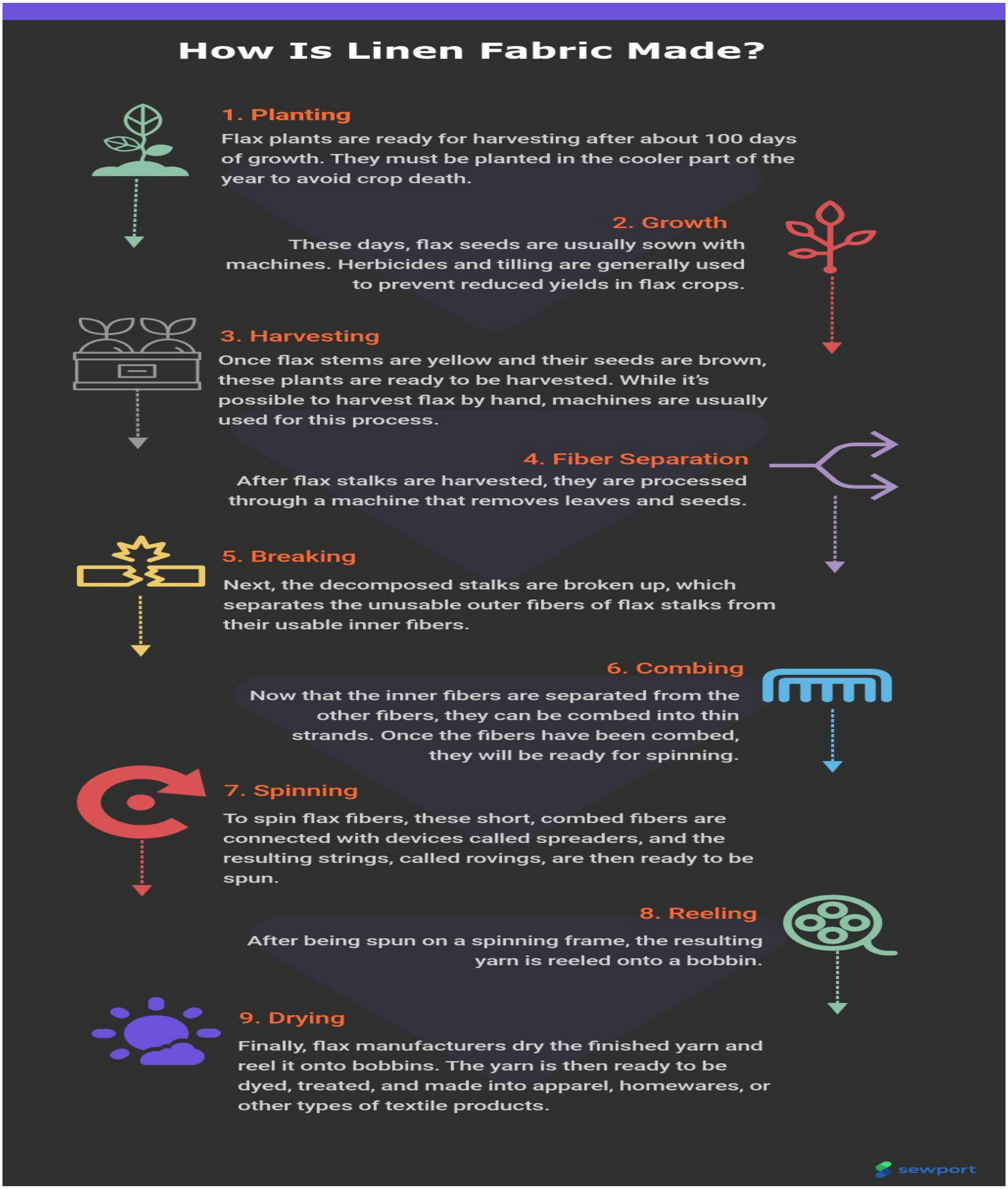
Color: The color of linen fiber is yellowish to grey.

Length: 18 to 30 inch in length.

Lusture: It is brighter than cotton fiber and it is slightly silky.

China: China is the world's largest exporter of flax yarn. The flax plant produces a fiber known as linen

HOW LINEN/FLAX FABRIC IS MADE



The constituent material for linen fabric is the cellulose fiber found in the stems of linen plants. Like the stalks of many similar plants, linen stalks consist of a woody, reedy interior section and a fibrous, stringy exterior section.To prepare for linen production, manufacturers of this fiber start by separating flax fibers from the woody interior of flax stems. Traditionally, this step has been accomplished by soaking raw flax stalks, but these days, manufacturers may use chemicals to achieve the same effect. Before flax fibers are spun into yarn, these chemicals are washed away, but residual toxic substances may remain on chemically-separated flax fiber.

1. Planting

Flax plants are ready for harvesting after about 100 days of growth. Since flax plants do not tolerate heat, they must be planted in the cooler part of the year to avoid crop death.

2. Growth

These days, flax seeds are usually sown with machines. Since flax plants don't effectively prevent the incursion of weeds, herbicides and tilling are generally used to prevent reduced yields in flax crops.

3. Harvesting

Once flax stems are yellow and their seeds are brown, these plants are ready to be harvested. While it's possible to harvest flax by hand, machines are usually used for this process.

4. Fiber Separation

After flax stalks are harvested, they are processed through a machine that removes leaves and seeds. Then, manufacturers separate flax's fibrous outer stalk from its soft, woody interior. This process is called retting, and unless it is expertly accomplished, the delicate flax fibers used for textile production could be damaged.

5. Breaking

Next, the decomposed stalks are broken up, which separates the unusable outer fibers of flax stalks from their usable inner fibers. To accomplish this step, the flax stalks are sent through rollers that crush them, and then rotating paddles remove the outer fibers from the stalks.

6. **Combing**

Now that the inner fibers are separated from the other fibers, they can be combed into thin strands. Once the fibers have been combed, they will be ready for spinning.

7. Spinning

Spinning of flax yarn used to be accomplished with a foot-powered flax wheel, but these days, flax producers use industrial machines for this process. To spin flax fibers, these short, combed fibers are connected with devices called spreaders, and the resulting strings, called rovings, are then ready to be spun.

8. Reeling

After being spun on a spinning frame, the resulting yarn is reeled onto a bobbin. To ensure that flax yarn won't fall apart, it's necessary to perform this reeling process in wet, humid conditions, and the spun yarn is run through a hot water bath to further ensure yarn cohesion.

9. Drying

Finally, flax manufacturers dry the finished yarn and reel it onto bobbins. The yarn is then ready to be dyed, treated, and made into apparel, homewares, or other types of textile products.

JUTE


Fabric name	Jute
Fabric also known as	Burlap, hessian cloth, gunny cloth
Fabric composition	Fibers of the jute plant composed of cellulose and lignin
Fabric breathability	High
Moisture-wicking abilities	High
Heat retention abilities	Medium
Stretchability (give)	Low
Prone to pilling/bubbling	Low
Country where fabric was first produced	Indus valley civilization
Biggest exporting/producing country today	India
Recommended washing temperatures	Cool, warm, or hot
Commonly used in	Bags, ropes, agricultural erosion prevention, sapling bags, upholstery, carpet, rugs, linoleum backing, curtains, canvas, sweaters, cardigans, ghillie suits

JUTE FABRIC

What Is Jute Fabric?

Jute fabric is a type of textile fiber made from the jute plant. While there are a few different botanical varieties of jute, one of the main species used to make jute fabric is *Corchorus olitorius* (white jute). However, another species of jute, called *Corchorus capsularis* (tossa jute) is considered to be superior even though it is harder to cultivate.

Cotton takes the title of most-produced plant-based fiber, but jute is a close second. While jute isn't very popular in the Western world, it is one of the primary textile fibers of India and neighboring countries. Jute plants grow to be over 10 feet high, and the fibers derived from these plants are harvested in a single long string. Therefore, jute fibers are among the longest natural textile fibers in the world.

Jute grows in similar conditions to rice, and this plant is best suited to warm areas that have annual monsoon seasons. This crop cannot grow in hard water, and ambient humidity level of approximately 80% are necessary for jute production.

History of Jute

Jute has been grown for textile purposes on the Indian subcontinent for at least 5,000 years. The earliest evidence for the production of this plant fiber dates to approximately 3000 BC, but it's entirely possible that the Indus valley civilization or preceding societies also cultivated jute for fiber purposes before this date.

Even though cotton production was also popular in India, jute played a more central role in the development of Indian society for the millennia preceding the effects of European colonialism. With the advent of British involvement in India, jute became a cash crop that helped fuel British colonial efforts.

While jute had also been grown in Scotland for several centuries, jute production in Bengal and other parts of India quickly overtook Scottish production. Due to the immense profits being made by jute barons in India, many Scottish jute producers emigrated to this British colony to partake in the jute boom.

Jute production remained a significant sector of the economy of the British Empire until the late 19th century, and after Indian independence, jute remained a major export of this region. With the advent of synthetic fibers, however, jute production slackened in the latter half of the 20th century, and it wasn't until the early 21st century that production of this plant fiber again became a major economic factor in Bengal, Bangladesh, and other areas of the Indian subcontinent.

Attributes of Jute

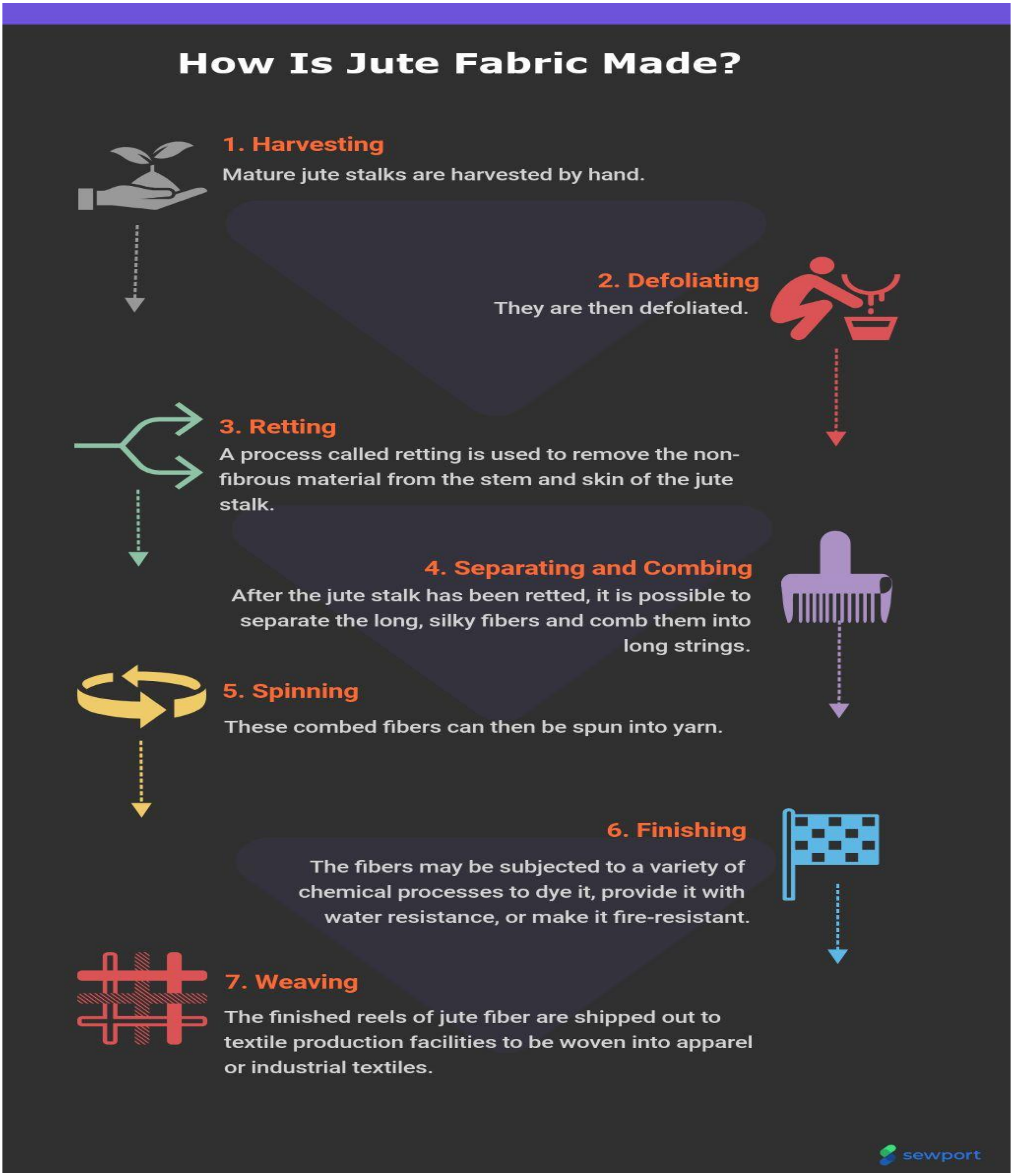
Jute is a relatively rough fiber, which means that it isn't well-suited for apparel applications unless it goes through an extensive production process. Instead, jute's roughness and durability make it ideal for industrial applications. Most types of jute fabric are loose with woven networks of thick yarn.

While jute absorbs water readily, it also dries quickly, and it is highly resistant to abrasion and stains. Being plant-based, however, jute biodegrades relatively quickly, and it isn't known for its long-term durability in outdoor **applications.**

Most types of jute fiber are light brown, but some off-white varieties also exist. Generally speaking, white forms of jute are considered to be inferior to brown forms, but white jute may be more useful for apparel applications.

Since it is thick and pliable, jute fiber is generally easy to work with, and since this fiber is long and shiny in its unprocessed state, manufacturing jute yarn is relatively easy. Jute is highly breathable, but it doesn't naturally retain much heat, which makes it an ideal apparel material for hot and humid climates.

HOW JUTE FABRIC IS MADE?



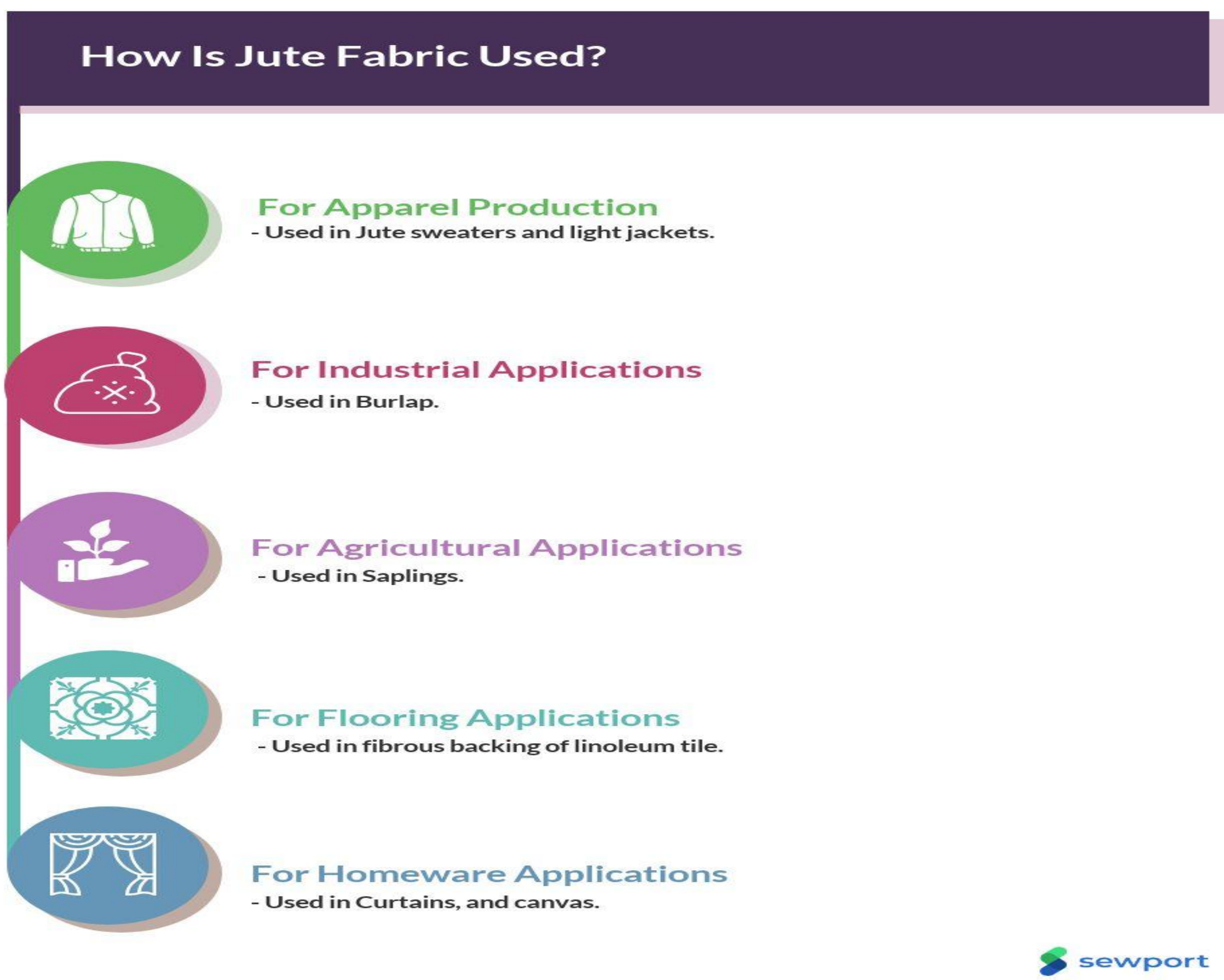
The production of jute fabric has remained largely the same for centuries. In most cases, mature jute stalks are harvested by hand, and they are then defoliated. Jute fibers can be derived from both the inner stem and the outer skin of the stalk.

A process called retting is used to remove the non-fibrous material from the stem and skin of the jute stalk. Retting softens the stalks and makes it possible to separate the fibrous material from the unusable material by hand.

After the jute stalk has been retted, it is possible to separate the long, silky fibers and comb them into long strings. These combed fibers can then be spun into yarn. While it's technically possible to make jute yarn with automated machines, most jute-producing communities still rely on analog spinning wheels for this process.

Once jute fiber has been spun into yarn, it may be subjected to a variety of chemical processes to dye it, provide it with water resistance, or make it fire-resistant. Then, the finished reels of jute fiber are shipped out to textile production facilities to be woven into apparel or industrial textiles.

In the case of jute apparel, a variety of softening techniques are used to make the finished apparel products more comfortable. Some manufacturers may agitate the jute yarn to reduce its roughness, or chemical techniques may be used to achieve the same effect. Jute fiber used for industrial purposes can generally be left in its original condition without using any softening techniques.



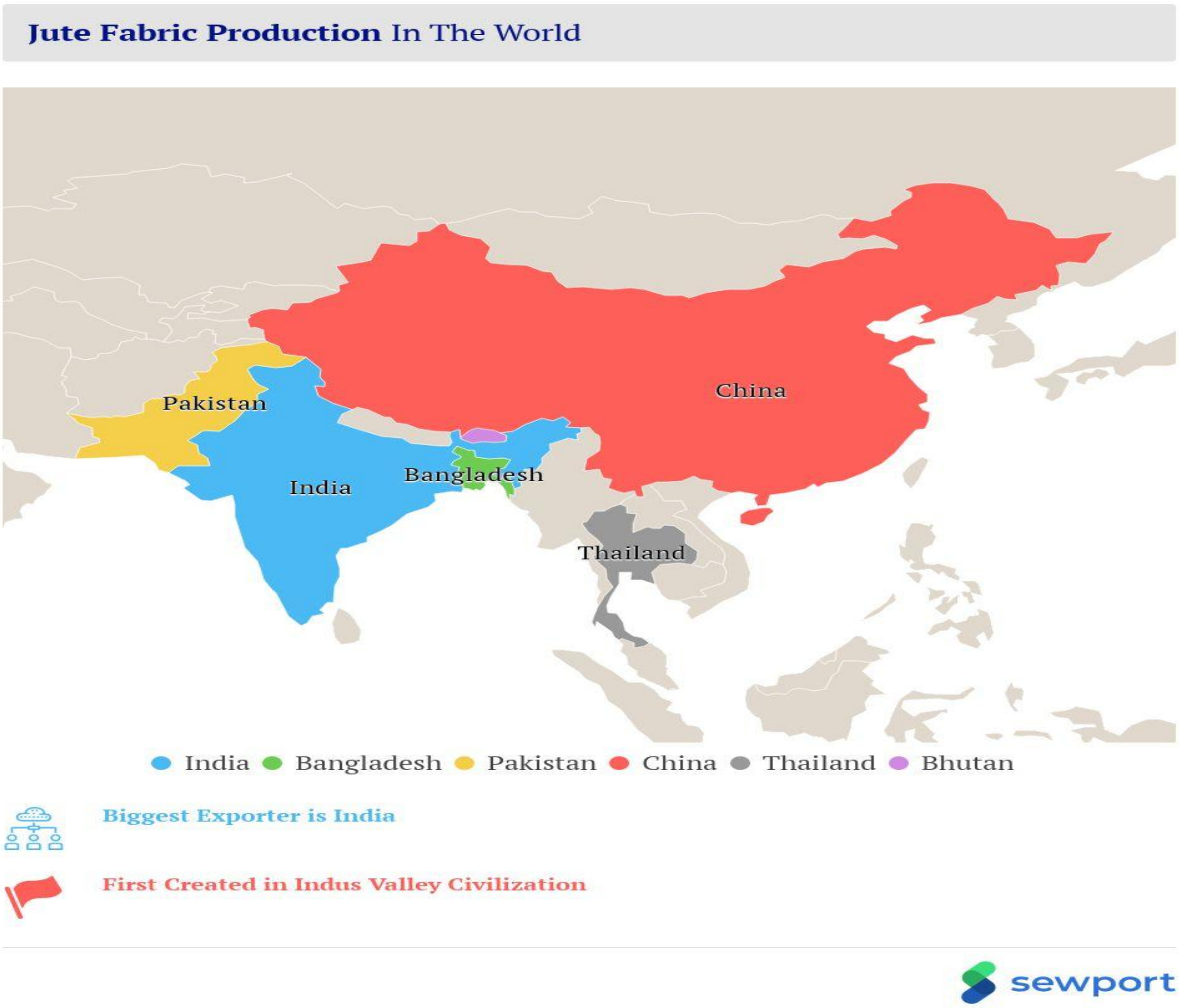
Due to its rough texture, jute is not commonly used for apparel production. Recent advancements in jute processing, however, have made it possible to use this traditionally uncomfortable textile for certain types of garments. While it's still uncommon to find jute used in undergarments or apparel that makes direct contact with the skin, jute sweaters and light jackets are rapidly gaining popularity worldwide.

The traditional uses of jute, however, remain the most popular applications of this fiber. For instance, jute is synonymous with burlap, which has been used for centuries as an industrial material in the Western world. Burlap sacks have long been used to transport vegetables, fruits, and other goods, and burlap has also been used as an insulative material.

Jute also continues to be used in agricultural applications. It's common for jute fabric to return to its point of origin as a protective measure against erosion in jute and rice fields. This fabric is also used to make the protective wrappings around sapling roots when these juvenile trees are transplanted. Since jute is readily biodegradable, saplings can push their roots right through jute fabric bags without encountering any significant resistance.

Basic fibers made from jute are used in a variety of flooring applications. The fibrous backing of linoleum tile is generally made from jute, and this fiber may also be used to make rugs, carpeting, or other types of fibrous flooring.

Due to its roughness and durability, jute is popular in general homeware applications. For instance, this fabric is popular for upholstery (especially for outdoor furniture), and it is also used to make curtains and canvas. Intriguingly, jute is a major constituent of ghillie suits, which are advanced forms of camouflage that allow military combatants to blend into grassy or otherwise foliage-rich environments.



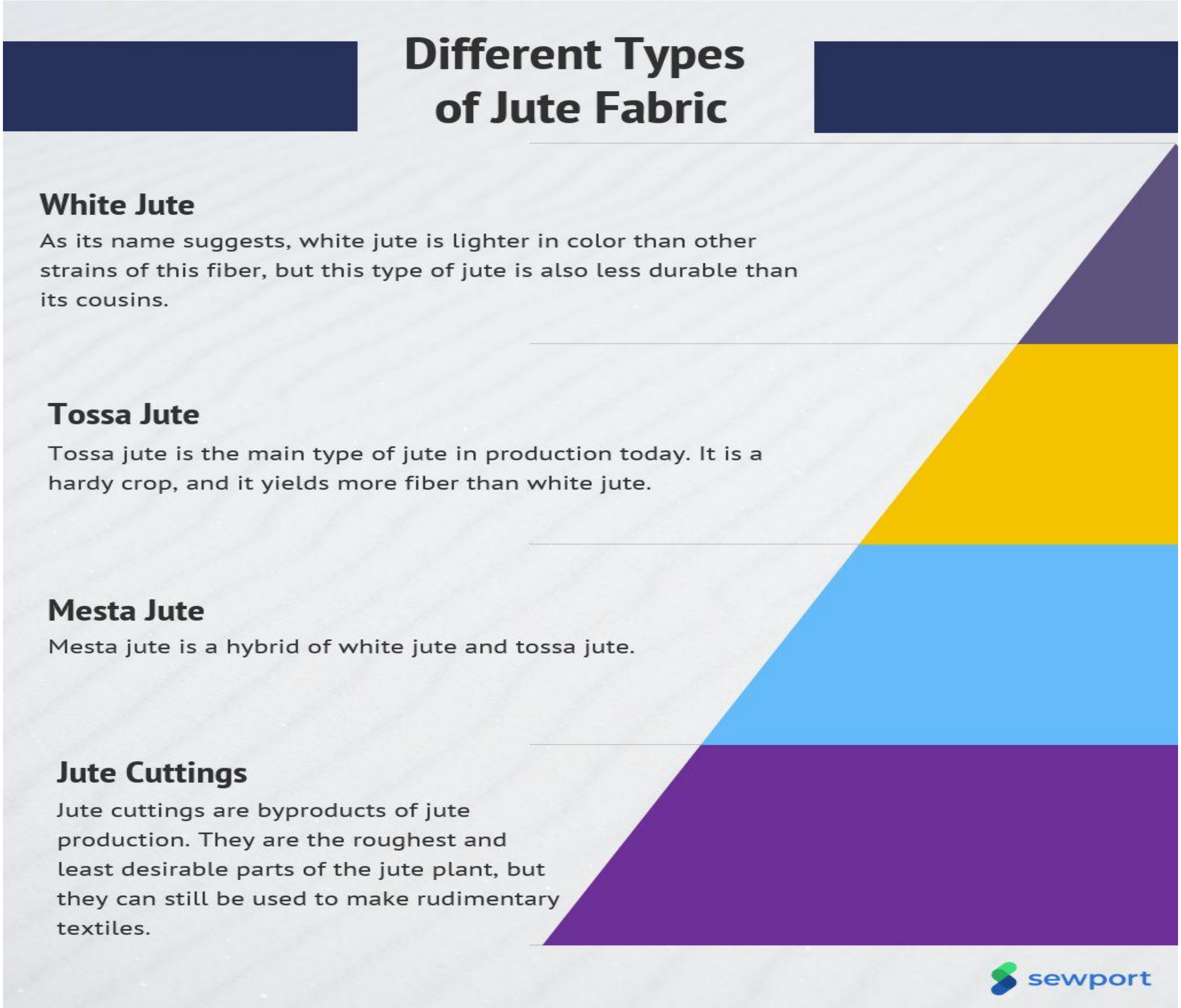
The majority of the world's jute is produced in India, Bangladesh, and Pakistan. Specifically, 85% of jute production is localized to the Ganges River Delta, which spans throughout Bangladesh and the Bengal region of India.

While China doesn't produce as much jute as China or Bangladesh, it is still one of the world's largest jute producers. A variety of other Asian countries also produce jute including Thailand, Burma, and Bhutan.The largest market for textiles, in general, is China, and jute fabrics are no exception. A large degree of the world's jute market remains localized to Asia, but countries like India and Bangladesh also export jute to the United States, the European Union, and other fertile markets throughout the Western and developing worlds.

How Much Does Jute Fabric Cost?

Jute fabric is one of the world's least expensive textiles. While artisan forms of jute may be more expensive, most types of this fabric cost around $1 per yard. This price is comparable to cotton, and it is significantly less expensive than many types of synthetic fabrics.

The most inexpensive way to purchase jute fabric is to work directly with a manufacturer in India, Bangladesh, or another jute-producing country. Taking this approach stimulates the local economy, and it empowers textile producers to overcome exploitative crop production paradigms.



While there are two main varieties of jute, these forms of this prominent textile fabric aren't the only types of jute in existence:

1. White Jute

White jute isn't anywhere near as popular as it once was, but historical records suggest that this fabric used to be the main textile used to clothe the common people of the Bengal region of India. As its name suggests, white jute is lighter in color than other strains of this fiber, but this type of jute is also less durable than its cousins.

2. Tossa Jute

Tossa jute is the main type of jute in production today. It is a hardy crop, and it yields more fiber than white jute. In color, tossa jute is more brown than off-white, and its fibers are just as long and strong as any other type of jute in existence.

3. Mesta Jute

Mesta jute is a hybrid of white jute and tossa jute. While this type of jute wasn't popular historically, political complications during India's tumultuous independence period led to the prominence of this type of jute's production.

4. Jute Cuttings

Jute cuttings are byproducts of jute production. They are the roughest and least desirable parts of the jute plant, but they can still be used to make rudimentary textiles.

How Does Jute Fabric Impact the Environment?

Jute has an overall positive impact on the environment. In fact, it is one of the few natural fibers that actually provides environmental benefits instead of being detrimental.

Both rice and jute are generally grown in the same areas since these crops require similar growing environments. While rice depletes the soil in which it is grown, jute production actually returns nutrients to the soil and helps retain soil moisture. Therefore, rice and jute are symbiotic crops, and growing these two agricultural products together diminishes the environmental impact of rice cultivation.

As with all types of fiber crop cultivation, however, there is both a right and a wrong way to cultivate jute. If jute is not grown sustainably by following basic practices like crop rotation, this crop could hurt the surrounding soil. While jute production generally does not necessitate the use of chemical fertilizers and pesticides, if cultivators of this crop use these toxic chemicals in their production processes, jute's environmental impact can rapidly become negative.

The Environmental Impact of Jute: Post-Production

Like all natural textile fibers, jute is biodegradable. Therefore, it does not accumulate in the environment, and it does not release microfibers, which continually cause more and more pollution of waterways and other aquatic ecosystems.

All disposal methods for jute, including burning, produce a negligible environmental impact. While synthetic fibers release toxic chemicals into the air when incinerated or remain in the environment for centuries when they are discarded in landfills, jute and other natural fibers rapidly reabsorb into surround ecosystems whether they are disposed of properly or not.

Jute Production: Humanitarian Concerns

The one major way in which jute production could be harmful is in its effects on local economies. Most jute producers in Bangladesh and other areas are independent; they are locally-owned, and the majority of their products are sold into the surrounding region instead of being exported overseas.

Jute production facilities that are owned by major corporate conglomerates, however, may absorb value from local jute-producing communities without giving back. This lack of economic stimulus disempowers jute producers from pursuing proper environmental stewardship, and exploitative cultivation policies may also encourage unsustainable or environmentally-unfriendly production processes.

Therefore, it's best to purchase jute fabric produced by independent companies that follow strict organic environmental stewardship protocols. Failing to do so could contribute to perennial cycles of worker exploitation that discourage upward mobility in impoverished rural farming communities.

Jute Fabric Certifications Available

Since jute is a plant-based fiber, it is eligible for organic certification from governmental organic certification agencies such as the U.S. Department of Agriculture and the European Union's organic certification agency. Since most jute is grown outside of the United States or EU, however, these certifications aren't highly relevant. On the other hand, the Global Organic Textile Standard (GOTS) provides organic certification for textile fibers produced all around the world. All jute fibers are eligible for GOTS certification as long as they meet certain stringent criteria.

Additionally, an organization called SGS also provides certification services for jute fiber. Unlike GOTS or other organic certification agencies, however, SGS does not certify jute fiber as organic. Instead, it certifies the general quality and grade of this prominent textile crop.

RAMIE



Introduction

Innovation sees no limit and Indian consumers can expect something big coming up in the textile industry like fabrics and textiles woven from fine quality Ramie fiber. Ramie (pronounced Ray-me) is one of the oldest vegetable fibers and has been used for thousands of years. It was used in mummy cloths in Egypt during the period 5000 - 3000 BC, and has been grown in China for many centuries.

Ramie (Boehmeria nivea), commonly known as China grass, white ramie, green ramie and rhea, is one of the group referred to as the bast fiber crops. The ramie plant is a hardy perennial belonging to the Urticaceae or Nettle family, which can be harvested up to 6 times a year. It produces a large number of unbranched stems from underground rhizomes and has a crop life from 6 to 20 years. The fibers need chemical treatment to remove the gums and pectins found in the bark.

The process of transforming the ramie fibers into fabric is similar to the process used for manufacturing linen from flax. The true ramie or 'China Grass' is also known as 'white ramie' and is the Chinese cultivated plant. It has large heart shaped, crenate leaves covered on the underside with white hairs that give it a silvery appearance. Boehmeria nivea var. tenacissima is believed to have originated in the Malay Peninusula and is known as 'green ramie' or 'rhea'. Green ramie has smaller leaves than true ramie and is better suited to tropical climates.

The fiber is very fine like silk, and being naturally white in colour does not need.Chemically ramie is classified as a cellulose fiber, just as cotton, linen, and rayon. The leading global producers of ramie are China, Taiwan, Korea, the Philippines and Brazil. Ramie is often blended with cotton to make woven and knit fabrics that resemble fine linen to coarse canvas. Ramie is commonly used in clothing, tablecloths, napkins and handkerchiefs. It is often blended with cotton in knit sweaters. Outside the clothing industry, ramie is used in fish nets, canvas, upholstery fabrics, straw hats and fire hoses.

In this Article we investigate the characteristics of Ramie Fiber.

Characteristics

- ✓ Ramie is one of the strongest natural fibres.
- ✓ It exhibits even greater strength when wet.
- ✓ Ramie fibre is known especially for its ability to hold shape, reduce wrinkling, and introduce a silky luster to the fabric appearance.
- ✓ It is not as durable as other fibres, and so is usually used as a blend with other fibres such as cotton or wool.
- ✓ It is similar to flax in absorbency, density and microscopic appearance.
- ✓ However it will not dye as well as cotton.
- ✓ Because of its high molecular crystallinity, ramie is stiff and brittle and will break if folded repeatedly in the same place; it lacks resiliency and is low in elasticity and elongation potential.

Advantages of Ramie

- ✓ Resistant to bacteria, mildew, alkalis, rotting, light and insect attack.
- ✓ Extremely absorbent (this makes it comfortable to wear)
- ✓ Dyes fairly easy.
- ✓ Natural stain resistance.
- ✓ Increases in strength when wet.
- ✓ Withstands high water temperatures during laundering.
- ✓ Smooth lustrous appearance improves with washing.
- ✓ Keeps its shape and does not shrink.
- ✓ Strong and durable (It is reported to have a tensile strength eight times that of cotton and seven times greater than silk).
- ✓ Can be bleached.

Disadvantages of Ramie

- ✓ Low in elasticity.
- ✓ Lacks resiliency.
- ✓ Low abrasion resistance.
- ✓ Wrinkles easily.
- ✓ Stiff and brittle.
- ✓ Necessary de-gumming process.
- ✓ High cost (due to high labour requirement in production, harvesting and decortication.)

The main producers of ramie today are :

- ✓ China,
- ✓ Brazil,
- ✓ Philippines,
- ✓ India,
- ✓ South Korea and

- ✓ Thailand.
  Only a small percentage of the ramie produced is available on the international market.

- ✓ Japan,
- ✓ Germany,
- ✓ France and the
- ✓ UK are the main importers;
  the remaining supply is used domestically (in the country in which it is produced).

Uses

Despite its strength, ramie has had limited acceptance for textile use. The fibers extraction and cleaning are expensive, chiefly because of the several steps involving scraping, pounding, heating, washing, or exposure to chemicals. Some or all are needed to separate the raw fiber from the adhesive gums or resins in which it is ens heathed. Spinning the fiber is made difficult by its brittle quality and low elasticity; and weaving is complicated by the hairy surface of the yarn, resulting from lack of cohesion between the fibres. The greater utilization of ramie depends upon the development of improved processing methods.

Ramie is used to make such products as industrial sewing thread, packing materials, fishing nets, and filter cloths. It is also made into fabrics for household furnishings (upholstery, canvas) and clothing, frequently in blends with other textile fibres (for instance when used in admixture with wool, shrinkage is reported to be greatly reduced when compared with pure wool.) Shorter fibres and waste are used in paper manufacture.

Ramie is a herbaceous perennial plant in the nettle family *Urticaceae*, native to eastern Asia. Ramie fibres are extracted from the stem of the plant *Boehmeria nivea* of the nettle family. Individual fibre cells in stems are bound together in fibre bundles by waxes, hemicelluloses, lignin and pectins that are difficult to remove Therefore the efficiency of the retting process usually used for e.g. hemp fibres extraction is not sufficient to extract ramie fibres from stems. But, a combined microbial and chemical treatment is very effective and economical. Chemical composition of ramie fibres is: cellulose (91-93%), hemicelluloses (2.5%), pectin (0.63%) and lignin (0.65%). Ramie fibres exhibit excellent mechanical properties, i.e. the best in the group of bast fibres (45-88 cN/tex) and, as most of the natural cellulose fibres the strength increases by 25% when fibres are wet. The ultimate fibre length is between 120-150mm and fibre diameter is 40-60 μm. Fibres are durable and they have good resistance to bacteria, mildew and insect attack. The main disadvantage of ramie is its low elasticity (elongation at break is 3-7%), which means that it is stiff and brittle Fibres are oval to cylindrical in shape and their colour is white and high lustrous. Fibres surface is rough and characterized by small ridges, striations, and deep fissures. Ramie fibre can be easily identified by its coarse, thick cell wall, lack of twist, and surface characteristics

KENAF

Kenaf fibres are obtained from *Hibiscus cannabinus*. Kenaf contains two fibre types: long fibre bundles situated in the cortical layer and short fibres located in the ligneous zone. Elementary fibres are short; their fibre length ranges from 3 to 7 mm, with average diameter of 21 µm. The cross-sections are polygonal with rounded edges and the lumens are predominantly large and oval to round in shape

The lumen varies greatly in thickness along the cell length and it is several times interrupted. Kenaf fibres contain about 45-57% of cellulose, 21.5% hemicelluloses, 8-13% lignin and 3-5% pectin. Kenaf fibres are coarse, brittle and difficult to process. Their breaking strength is similar to that of low-grade jute and is weakened only slightly when wet. There are many potential specific utilization possibilities for kenaf whole stalk and outer bast fibres, including paper products, textiles, composites, building materials, absorbents, etc.

LEAF FIBRES

Leaf fibres are often referred to as hard fibres, and have limited commercial value, mainly because they are generally stiffer and coarser texture than the bast fibres. The fibres are usually obtained from the leaves by mechanically scraping away the non-fibrous material. Above all the leaves fibres are used for production of cordage and ropes. The most important fibres of this group are sisal, henequen and abaca.

Sisal


Sisal, (*Agave sisalana*), plant of the family Asparagaceae and its fibre, the most important of the leaf fibre group. The plant is native to Central America, where its fibre has been used since pre-Columbian times.

Commercial interest in sisal was stimulated by the development of the machine grain binder in the 1880s, which brought a demand for low-cost twine, and plantings were soon established in the Bahamas and Tanganyika (now Tanzania).

By the late 1930s sisal was being cultivated in Kenya, Mozambique, Angola, Madagascar, and elsewhere in Africa and in the Philippines, Taiwan, Brazil, Venezuela, Indonesia, and Haiti. Sisal ropes and twines are widely employed for marine, agricultural, shipping, and general industrial use, and the fibre is also made into matting, rugs, millinery, and brushes.

The plant stalk grows to about 90 cm (3 feet) in height, with a diameter of approximately 38 cm (15 inches). The lance-shaped leaves, growing out from the stalk in a dense rosette, are fleshy and rigid, with gray to dark green colour. Each is 60–180 cm (2–6 feet) long and 10–18 cm (4–7 inches) across at the widest portion, terminating in a sharp spine. Within four to eight years after planting, the mature plant sends up a central flower stalk reaching about 6 metres (20 feet) in height. Yellow flowers, about 6 cm (2.5 inches) long and with an unpleasant odour, form dense clusters at the ends of branches growing from the flower stalk. As the flowers begin to wither, buds growing in the upper angle between the stem and flower stalk develop into small plants, or bulbils, that fall to the ground and take root. Like other *Agave* species, the old plant dies when flowering is completed.

The plants grow best in moderately rich soil with good drainage and in warm moist climates. Young plants, propagated from bulbils or rhizomes (underground stems) of mature plants, are usually kept in nurseries for the first 12 to 18 months. At the beginning of the rainy season, the plants are transferred to the field. Sisal matures about three to five years after planting, depending upon the climate, yielding satisfactory fibre for seven or eight years thereafter and producing about 300 leaves throughout the productive period. Outer leaves are cut off close to the stalk as they reach their full length. The initial harvest is about 70 leaves; subsequent annual production averages about 25.

A field of sisal in south-eastern Kenya.

Sisal fibre is made from the leaves of the plant. The fibre is usually obtained by machine decortication in which the leaf is crushed between rollers. The resulting pulp is scraped from the fibre, and the fibre is washed and then dried by mechanical or natural means. The lustrous fibre strands, usually creamy white, average 100 to 125 cm (40 to 50 inches) in length and are fairly coarse and inflexible. Sisal fibre is especially valued for cordage use because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in salt water. The fibre is very similar to that of the related henequen (*Agave fourcroydes*).

The sisal fibre is a “hard” fibre extracted from fresh leaves of sisal plant *Agave sisalana*. It is usually obtained by a decortication process, in which the leaf is crushed between rollers and then mechanically scraped. The length of the sisal fibre varies between 0.6 and 1.5 m and its diameters range from 100 to 300 µm].

Cellulose content in sisal fibres is about 70%. The fibre is composed of numerous elongated fibre cells that are narrowed towards both ends. Fibre cells are linked together by middle lamellae, which consist of hemicelluloses, lignin and pectin. A sisal fibre in cross-section is built up of about 100 fibre cells.

The cross section of sisal fibres is neither circular nor fairly uniform in dimension.

The lumen varies in size but is usually well defined. The longitudinal shape is approximately cylindrical. Longitudinal view and cross-section of sisal fibres is demonstrated on .

Physically, each fibre cell is made up of four main parts

namely the primary wall,

the thick secondary wall,

the tertiary wall

and the lumen.

The fibrils are, in turn, built up of micro-fibrils with a thickness of about 20 µm.

The microfibrils are composed of cellulose molecular chains with a thickness of 0.7 µm and a length of a few µm Sisal fibre is fairly coarse and inflexible. The tensile properties of sisal fibres are not uniform along its length.

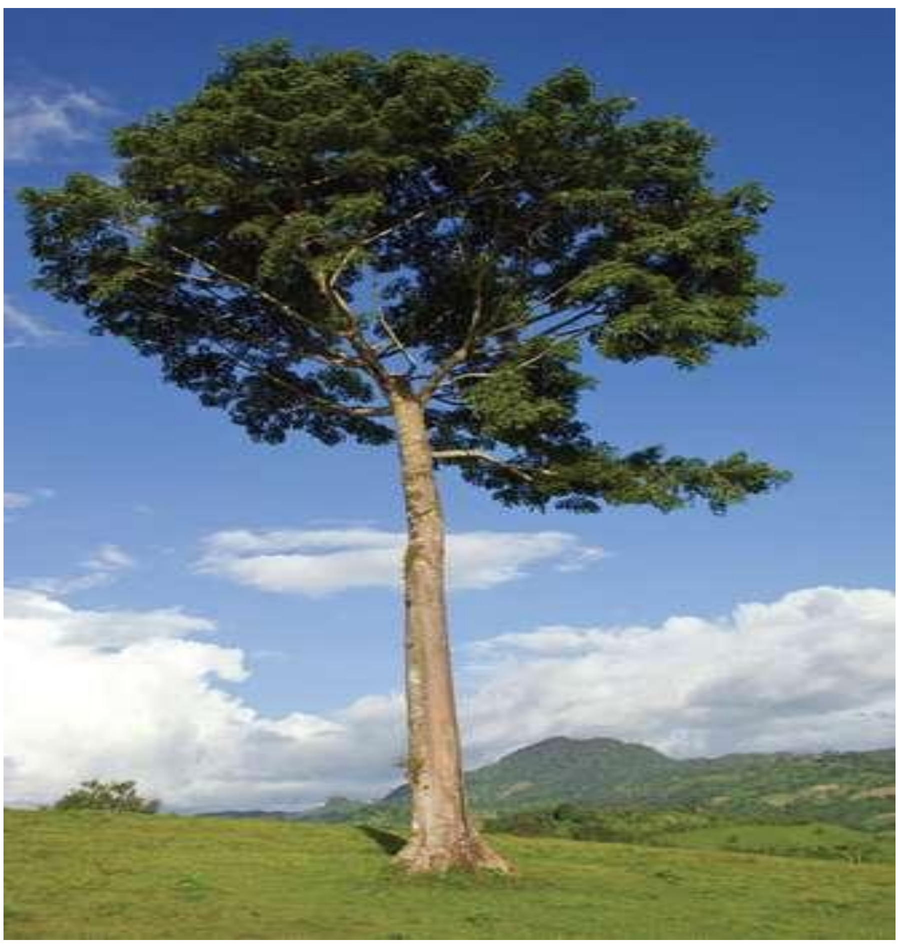
The fibres extracted from the root or lower parts of the leaf have a lower tensile strength and modulus.

The fibres become stronger and stiffer at midspan, and the fibres extracted from the tip have moderate properties. The lower grade fibre is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium grade fibre is used in the cordage industry for making ropes, baler and binders twine.

The higher-grade fibre after treatment is converted into yarns and used by the carpet industry.

KAPOK


KAPOK, (*Ceiba pentandra*), also called **Java cotton, ceiba**, or **Java kapok**, seed-hair fibre obtained from the fruit of the kapok tree or the kapok tree itself. The kapok is a gigantic tree of the tropical forest canopy and emergent layer. Common throughout the tropics, the kapok is native to the New World and to Africa and was transported to Asia, where it is cultivated for its fibre, or floss. The kapok's huge buttressed trunk tapers upward to an almost horizontal, spreading crown where large, compound leaves are made up of five to eight long, narrow leaflets. In full sun, the kapok can grow up to 4 metres (13 feet) per year, eventually reaching a height of 50 metres (164 feet).



Kapok tree (*Ceiba pentandra*). ***Jacinto Yoder/Shutterstock.com***

Woolly seeds produced by the seed pods of the kapok tree (*Ceiba pentandra*).*Norman Myers—Bruce Coleman Inc.*The kapok is deciduous, dropping its foliage after seasonal rainy periods. Flowering occurs when the tree is leafless, thereby improving access for the bats that feed on the sugar-laden nectar of kapok blossoms. In doing so, the bats unwittingly pollinate the tree's flowers. The flowers open at night and have five petals that are white or pink on the outside. Only a few flowers on a given branch will open on any particular night during the two or three weeks that the tree blooms.

Kapoks do not bloom every year, and some may go 5–10 years without flowering. When the tree does bloom, however, it is prolific, producing up to 4,000 fruits measuring up to 15 cm (6 inches) long. Eventually these pods open on the tree, exposing the pale kapok fibres to the wind for dispersal. The fibres, in which over 200 seeds are loosely embedded, is sometimes referred to as silk cotton and is yellowish brown, lightweight, and lustrous.

In harvesting kapok fibre, the pods are either cut down or gathered when they fall, then broken open with mallets. The seed and fibre, removed from the pods by hand, are stirred in a basket; the seeds fall to the bottom, leaving the fibres free. The seeds may be processed to obtain oil for making soap, and the residue is used as fertilizer and cattle feed.

Individual fibres are 0.8 to 3.2 cm (0.3 to 1.25 inches) long, averaging 1.8 cm (0.7 inch), with diameters of 30 to 36 micrometers (a micrometer is about 0.00004 inch). Kapok is a moisture-resistant, quick-drying, resilient, and buoyant fibre. The fibres contain both lignin, a woody plant substance, and cellulose, a carbohydrate. The inelastic fibre, or floss, is too brittle for spinning, but it weighs only one-eighth as much as cotton. The floss has been used in life preservers and other water-safety equipment, supporting as much as 30 times its own weight in water. Buoyancy is lost slowly, with one test showing only 10 percent loss after 30 days of water immersion. Kapok is also used as stuffing for pillows, mattresses, and upholstery, as insulation material, and as a substitute for absorbent cotton in surgery. Kapok is chiefly cultivated in Asia and Indonesia; the floss is an important product of Java. It is highly flammable, however, and the fibre's importance has decreased with the development of foam rubber, plastics, and synthetic fibres.

Although kapok wood does not hold screws or nails well, the timber is used for a variety of wood products, including paper. Local peoples have long used kapok logs for carving into canoes.

Indian kapok, floss from the simal cotton tree (*Bombax malabarica*), native to India, has many of the qualities of the Java type but is more brownish yellow in colour and less resilient. Immersed in water, it supports only 10 to 15 times its own weight.All these trees are members of the hibiscus, or mallow, family (Malvaceae), some members of which produce tree cotton (bombax cotton) in Brazil and the West Indies, and to which cotton itself also belongs. The genus name of the Java kapok, *Ceiba,* is thought to be derived from a Carib word for a dugout boat.

Kapok *(Ceiba pentandra)* is a highly lignified organic seed fibre, containing 35-50% of cellulose, 22–45% of hemicelluloses, 15–22% of lignin and 2–3% of waxes. It also contains smaller quantities of starch, about 2.1% of proteins, and inorganic substances, notably iron (1.3–2.5%). Kapok contains 70–80% of air and provides excellent thermal and acoustic insulation. The absolute density of a kapok cell wall is 1.474 g/cm^3, whilst the density of fibres by considering about 74% of lumen is only 0.384 g/cm^3 [Cook 2006]. Kapok is a smooth, unicellular, cylindrically shaped, twist less fibre. Its cell wall is thin and covered with a thick layer of wax. A wide lumen is filled with air and does not collapse like cotton. By the microscope observation kapok fibres are transparent with characteristic air bubbles in the lumen. The cross section of fibres is oval to round.

The kapok cell wall structure differs from other natural cellulosic fibres. A primary cell wall, which is directly related to the superficial properties of fibres, consists of short microfibrils, which are oriented rectangular to the surface of fibres. In the secondary cell wall microfibrils run almost parallel to the fibre axis.

Considering the content of alpha cellulose, kapok is more like wood than flax and other plant fibres. The average degree of polymerisation is 6600 Kapok fibres are 10–35 mm long, with a diameter of 20–43 µm. The cell wall thickness is about 1–3 µm. The tensile strength is 0.84 cN/dtex (93.3 MPa), Young's module 4 GPa, and breaking elongation 1.2%

Due to its wide lumen, kapok has an exceptional capability of liquids retention. Its excellent thermal and acoustic insulating properties, high buoyancy, and good oil and other non-polar liquids absorbency distinguish kapok from other cellulosic fibres. Kapok is mainly used in the form of stuffing and nonwovens; it is rarely used in yarns, mostly due to low cohesivity of its fibres and their resilience, brittleness, and low strength. New potentials of kapok are in the field of technical textiles, yachts and boats furnishing, insulating materials in refrigeration systems, acoustic insulation, industrial wastewaters filtration, removal of spilled oil from water surfaces, and reinforcement components in polymer composites

Bast fibres

Bast fibres i.e. flax, jute, hemp, ramie, kenaf, and abaca are soft woody fibres, which are obtained from stems or stalks of dicotyledonous plants. The fibres occur in bundles or aggregates

The bundles consist of 10 to 25 elementary fibres, with the length of 2 to 5 mm and a diameter of 10 to 50 µm. The bundles are connected by lateral ramification, which forms a three dimensional network. The elementary fibrils and bundles are cemented by lignin and pectin intercellular substances, which must be removed during the processing of fibres extraction

Bast fibres have a long utilization tradition. They have been used for more than 8000 years. Currently bast fibres are raw materials not only used for the textile industry but also for modern environmentally friendly composites used in different areas of applications like building materials, particle boards, insulation boards, food, cosmetics, medicine and source for other biopolymers etc.

HEMP

How Are Hemp Varieties Chosen?

Depending on the desired final product, hemp cultivars are chosen based on several factors, including:

Stem quality

Cannabinoid content

Resistance to disease

Time to harvest

Hemp oil content

Seed production per acre

CBD production, in particular, has become a major factor in recent years. As the CBD market continues to grow, more and more cultivars are also being chosen based on their CBD production and unique aromatic, or terpene, profiles.

What is Hemp Used For?

CBD oil is extracted from hemp leaves and flowers. The CBD oil extracted from hemp can be used for treating a wide variety of ailments, hence the ever-growing popularity of CBD-focused cultivation.

Hemp fibers are primarily used for textiles, paper, building materials, and other industrial products. Raw materials such as hurds, or shives, are short woody fibers typically found inside the stalk. They're used for making bedding materials, absorbents, particle board, ceiling panels, compost, and other industrial products.

Bast fibers make up the outer portion of the stalk and are typically split into three categories — primary, or line fiber, secondary, and tow. They are categorized according to their cell strength and cell wall thickness, which will determine the fiber's strength, durability, and ultimately what it can be used for.

How is Hemp Used as a Food Product?

Hemp seeds are rich in protein, dietary fiber, vitamins, and minerals. They contain an optimal ratio of omega-6 to omega-3 fatty acids for healthful consumption. A 2008 study also found that hemp proteins are more digestible for humans than common soy protein isolates (SPIs) used in food products.

Hemp can be used as a food product as either raw seeds or oils. Hemp oil is pressed from the seeds for a concentration of protein, meaning both food product forms are utilizing hempseed as a nutritional resource. Seeds can also be ground up for flour or mixed with water to create hemp seed milk.

What Are Hemp Fibers and Leaves Used For?

CBD oil is extracted from hemp leaves and flowers. The CBD oil extracted from hemp can be used for treating a wide variety of ailments, hence the ever-growing popularity of CBD-focused hemp cultivation.

Hemp fibers are primarily used for textiles, paper, building materials, and other industrial products. **Hurds**, or shives, are short woody hemp fibers typically found inside the stalk. They're used for making hempcrete, bedding materials, absorbents, particle board, ceiling panels, compost, and other industrial products. **Bast fibers** make up the outer portion of the stalk and are typically split into three categories — primary, or line fiber, secondary, and the tow. They are categorized according to their cell strength and cell wall thickness, which will determine the fiber's strength, durability, and ultimately what it can be used for.

How is Hemp Processed?

Many types of processing techniques are utilized to process hemp seeds and stalks. The technique used depends on the purpose of the final product.

Hemp Seeds

Seeds can be consumed whole, or refined by being pressed or crushed to produce hemp seed oil and flour. These seeds are also hulled, or shelled, to make them more palatable. The remaining shells, which are rich in fiber, can also be used for making flour.

Seeds can be consumed whole, or refined by being pressed or crushed to produce hemp seed oil and flour. (Photo by: Gina Coleman/Weedmaps)

Hemp Stalks

Hemp stalks are processed through **decorticating,** a multistep method for removing the long fibers from the rest of the plant. The steps taken during the intermediate processing period include:

1. Retting

Hemp stalks have tough cellular tissue that makes up their surface and must be dissolved through a process called retting. There are three modes of retting:

- **a. Field retting:** The plants are cut and laid on the field for four to six weeks, turned periodically. During this time, any bacteria on the plant's surface will break down the outer layer of the stalk. The retted stalks are then dried.
- **b. Water retting:** The stalks are immediately dried after harvesting, then placed into water for a few days. The water is used to soften the outer layer of the stalks and to help promote the growth of additional bacteria which helps accelerate the process.
- **c. Chemical retting:** Acids, bases, and special enzymes are used to break down the compounds that hold together the strong bast fibers.

All retted stalks should be dried until they have less than 15% moisture. Anything above 15% can potentially harbor and promote the growth of fungi and bacteria. If the stalks get too dry, meaning less than 10% moisture, they can become too brittle to transport.

2. Decorticating

The decorticating process typically involves three stages:

Scutching: The stalks are passed through a series of rollers to break apart the hemp fibers. During this step, the woody core is pushed out and separated from the pliable fibers. This is another step where proper drying comes into play. The sweet spot is between 10% and 15% moisture and is key here. If the stalks are too dry, they will be crushed into a powder. If they are too moist, they won't break and separate properly.

Hackling: The short and intermediate fibers are combed out of the stalk.

Twisting: The fibers are individually twisted into yarn.

Modern decorticating techniques employ steam explosion (treating the fibers with steam through a pressurized chamber) and ultrasonic breaking (breaking down fibers using ultrasonic waves) to maintain the integrity of the fibers throughout the process. These techniques are not as harsh on the stalks and allow processors to use the fibers on already fabricated cotton and wool processing machinery.

3. Baling and Storing

Hemp stalk is baled for transportation and long-term storage using traditional farming balers. Large, round balers are best because they allow for more thorough drying as they don't pack the hemp as tightly as square balers. Hemp bales should be stored in a dry environment in conditions intended to reduce as much humidity as possible. It's also important to check for wet patches during baling to further avoid mold.

How is Hemp Cultivated Differently than Marijuana?

Other key differences between hemp and marijuana have to do with cultivation and harvesting. Male plants flower much faster than females and do not produce nearly as much fiber. In stark contrast to marijuana fields, most female hemp fields include sporadically placed males. The male hemp plants release pollen for the female plant to produce seeds that will either be used for future crops or sold as food.

In marijuana fields, male plants are typically eliminated to ensure the maximum production of sinsemilla flowers.

While marijuana cultivation requires ample spacing to reduce the risk of mold or bacteria, hemp can be planted more densely. Most marijuana crops are planted at one plant per four square feet. Hemp plants that are grown for oil are planted at roughly 40 to 60 plants per four square feet. Those grown for fiber are even more densely planted at a rate of about 100 to 120 plants per four square feet.

Hemp plants are almost always cultivated outdoors, as opposed to marijuana plants, which are often planted in greenhouse or indoor settings. Because hemp is susceptible to the same predators, diseases, and insects that attack marijuana, many cultivators employ a technique called **crop rotation**, in which alternating crops are planted in the same place, to avoid any buildup of these organisms and to allow nutrients to return to the soil.

Hemp plants are almost always cultivated outdoors, as opposed to marijuana plants, which are often planted in greenhouse or indoor settings. (Photo by: Gina Coleman/Weedmaps)

The specific order of crop rotation and types of crops being rotated with hemp will depend on the location of the farm. Hemp is also used as a rotational crop at farms where it is not the primary agricultural product.

Is Hemp Cultivation Legal in the U.S.?

Federal Action

The 2014 Agricultural Act, more commonly known as the 2014 Farm Bill, signed by Democratic President Barack Obama, includes section 7606, which allows for universities and state departments of agriculture to cultivate industrial hemp, as long as it is cultivated and used for research. Under the 2014 Agricultural act, state departments and universities must also be registered with their state, and defer to state laws and regulations for approval to grow hemp.

As part of the Agriculture Improvement Act of 2018, or the 2018 Farm Bill, signed by Republican President Donald Trump, the Hemp Farming Act of 2018 reclassified hemp (with less than 0.3% THC) from Schedule I, the most restrictive classification of controlled substances by the federal government, and are considered highly prone to abuse and to not have any medicinal benefits. This move to federally legalize industrial production of the plant allowed for cultivation and distribution as a legal agricultural product.

Under the Hemp Farming Act, hemp cultivation is no longer limited to state departments and universities. In addition, the act allows farmers rights to water, crop insurance, and federal agricultural grants, as well as legal access to national banking. Hemp may also be transported across state lines.

State Laws

Prior to the Hemp Farming Act of 2018, 41 states had passed industrial hemp-related legislation. Thirty-nine of those states legalized statewide cultivation programs that defined hemp specifically to differentiate it from marijuana, establish licensing requirements, and regulate production.

The Hemp Farming Act now requires state departments of agriculture to consult with their governors and chief law enforcement officers on a regulatory program, which will then be submitted to the United States Secretary of Agriculture for approval. According to Section 297B of the bill, state hemp regulatory programs must include a system to maintain information on all land where cultivation takes place, procedures for testing THC levels in hemp, and procedures for disposing of products that violate THC content restrictions.

World History of Hemp

Hemp has been cultivated on a global scale for thousands of years. The oldest documented evidence of hemp cultivation is a rope, which dates back to 26,900 BCE, found in today's Czech Republic.

Some of the earliest known prolific uses of hemp began in China about 10,000 BCE, where it was used for making clothing, rope, and paper. The Yangshao people, who lived in China from roughly 5000 BCE, wove hemp and pressed it into their pottery for decorative purposes. From about 5000 to 300 BCE, the plant was also grown in Japan and used for fiber and paper.

Cannabis played a large role in the Greco-Roman cultures as a source of fiber, intoxication, and medicine. Cannabis seeds were discovered in the ruins of Pompeii, and Greek rhetorician Athenaeus made note of hemp being used to make rope between 170 and 230 CE. Roman author and naturalist Pliny the Elder also made reference to a cannabis root decoction as a treatment for joint stiffness and gout in the first century BCE.

Exactly how and when hemp originated in the New World is still highly debated. Though long thought to be introduced to the Americas by Christopher Columbus, hemp has been discovered in Native American civilizations that predate Columbus' arrival. William Henry Holmes' "Prehistoric Textile Art of Eastern United States" report from 1896 notes hemp from Native American tribes of the Great Lakes and Mississippi Valley.

Hemp products from pre-Columbian native civilizations were also found in Virginia. Vikings, who used the plant for making rope and sails, may also have brought seeds with them when they attempted to colonize the New World.

Jamestown settlers introduced hemp to colonial America in the early 1600s for rope, paper, and other fiber-based products; they even imposed fines on those who didn't produce the crop themselves. U.S. presidents George Washington and Thomas Jefferson grew hemp.

Hemp was a prominent crop in the United States until 1937, when the Marihuana Tax Act virtually obliterated the American hemp industry. During World War II, the crop saw a resurgence in the U.S., as it was used extensively to make military items including uniforms, canvas, and rope. The U.S. Department of Agriculture (USDA) even released a short documentary, "Hemp for Victory," in 1942, which promoted the plant as a useful crop for the war cause.

The World War II hemp resurgence was short-lived, though. Until the passing of the 2014 Farm Bill, the Controlled Substances Act of 1970 kept industrial production dormant. Today, hemp is rapidly becoming an indispensable resource for CBD oil and other CBD products.

Hemp is the bast fibre obtained from stems of *Cannabis sativa* L plants. It grows easily to a height of 4 m without agrochemicals and captures large quantities of carbon. The most important components of fibres are cellulose (77%), pectin (1.4%) and waxes (1.4%). Pectin is found in the middle lamellae and glues the elementary fibres to form bundles. The lignin (1.7%) is an incrusting component of the fibre. It is incrusting cellulose and contributes to the hardness and strength of fibres. It is located in the middle lamellae and fibre primary cell wall. Other components of hemp fibres are tannin, resins, fats, proteins etc. The content of these components is much higher in hemp than in cotton.

Therefore the processing of those fibres requires different technology [Blackburn 2005]. The diameter of the cell varies considerably from 16 to 50 µm, with broad flat lumen. The length of the individual or elementary fibres is ranging from 2 to 90 mm (average length is 15 mm). Elementary fibres are thick walled and the cross-section of fibres is polygonal with rounded edges (Figure 6). In longitudinal view, the fibre is roughly cylindrical, with surface irregularities and lengthwise deformations caused by dislocations. The ends of fibres are slightly tapered and blunt [Hearle 1963]. Hemp fibres are coarser when compared to flax and rather difficult to bleach. The fibres have an excellent moisture resistance and rot only very slowly in water. Hemp fibres have high tenacity (53-62 cN/tex); about 20% higher than flax, but low elongation at break (only 1.5%).

In recent years because of the interest for alternative renewable resources, hemp gained again relevance. Beside the traditional textile application of hemp numerous new directions emerge: building and isolation materials, composite materials, special cellulose materials (papers), technical textile, geotextiles and agricultural textile, oil based products, items for agriculture and horticulture etc

ABACA

The plant

Also called manila hemp, abaca is extracted from the leaf sheath around the trunk of the abaca plant (Musa textilis), a close relative of the banana, native to the Philippines and widely distributed in the humid tropics. Harvesting abaca is labour intensive as each stalk must be cut into strips which are scraped to remove the pulp. The fibres are then washed and dried.

The fibre

Abaca is a leaf fibre, composed of long slim cells that form part of the leaf's supporting structure. Lignin content is a high 15%. Abaca is prized for its great mechanical strength, resistance to saltwater damage, and long fibre length – up to 3 m. The best grades of abaca are fine, lustrous, light beige in colour and very strong.

Environmental benefits

Erosion control and biodiversity rehabilitation can be assisted by intercropping abaca in former monoculture plantations and rainforest areas, particularly with coconut palms. Planting abaca can also minimize erosion and sedimentation problems in coastal areas which are important breeding places for sea fishes. The water holding capacity of the soil will be improved and floods and landslides will also be prevented. Abaca waste materials are used as organic fertilizer.

Uses of abaca

During the 19th century abaca was widely used for ships' rigging, and pulped to make sturdy manila envelopes. Today, it is still used to make ropes, twines, fishing lines and nets, as well as coarse cloth for sacking. There is also a flourishing niche market for abaca clothing, curtains, screens and furnishings, but paper-making is currently the main use of the fibre.

Paper

Most of abaca fibre is pulped and processed into specialty papers. This includes: tea and coffee bags, sausage casing paper, currency notes (Japan's yen banknotes contain up to 30% abaca), cigarette filter papers, medical /food preparation/disposal papers , high-quality writing paper, vacuum bags and more.

Automotive

Currently abaca is being used for 'soft' applications in the automotive industry as a filling material for bolster and interior trim parts. However given its strong tensile strength it can also be used for 'harder' applications for exterior semi-structure components as a substitute for glass fibre in reinforced plastic components.

Mercedes Benz has used a mixture of polypropylene thermoplastic and abaca yarn in automobile body parts. Replacing glass fibres by natural fibres can reduce the weight of automotive parts and facilitates more environmentally friendly production and recycling of the parts.

Owing to the extremely high mechanical strength of the fibre as well as its length , application of abaca even in highly stressed components offers great potential for different industrial applications.

Producers

The world's leading abaca producer is the Philippines, where the plant is cultivated on 130 000 ha by some 90 000 small farmers .While the crop is also cultivated in other Southeast Asian countries, the second largest producing country is Ecuador, where abaca is grown on large estates and production is increasingly mechanized.

Production and trade
In 2010, the Philippines produced about 57 000 tonnes of abaca fibre, while Ecuador produced 10 000 tonnes. World production is valued at around USD60 million a year. Almost all abaca produced is exported, mainly to Europe, Japan and the USA. Exports from the Philippines are increasingly in the form of pulp rather than raw fibre.

Market Outlook
Abaca has a high potential to substitute glass fibres in multiple automotive parts and is currently well recognized as a material for paper products. Although abaca is mainly cultivated in the Philippines today, supply could be increased if other countries in tropical and humid locations were to establish industry. The knowledge and the experience about production and processing gained can easily be transferred to other countries.

Abaca or Manila hemp is extracted from the leaf sheath around the trunk of the abaca plant (*Musa textilis*). The commercial fibres are utilized in the form of strands, and the strands in turn are composed of bundles of individual fibres. Individual fibres, when removed from the strands by boiling in an alkali solution, are smooth and fairly uniform in diameter. The lumens are large in relation to wall thickness. Cross-marking is rare, and fibre tips pointed and often flat and ribbon –like. The technical fibres are 2 to 4 m long. The single fibres are relatively smooth and straight and have narrow pointed ends. Individual fibre diameters range from 14 to 50 µm and the lengths from 2.5 to 13 mm

Chemically, abaca comprises 76.6% cellulose, 14.6% hemicelluloses, 8.4% lignin, 0.3% pectin and 0.1% wax and fat. Abaca is considered as one of the strongest of all natural fibres, being three times stronger than cotton and twice that of sisal, and is far more resistant to saltwater decomposition than most of the vegetable fibres. Abaca is a lustrous fibre and yellowish white in colour. Abaca fibres are used manly to manufacture ropes and handicraft goods

Henequen

Henequen (*Agave fourcroydes*) plant of the family agave is a close relative to the sisal plant. The henequen plant is native to Mexico, where it has been a source of textile fibre since pre-Columbian times. Many factors can influence the properties of the fibre including weather conditions, age of the plant, type of soil, extraction method, etc. Henequen fibre is composed of approximately 77% cellulose, 4-8% hemicelluloses, 13% lignin and 2-6% pectin and waxes by weight

Fibres have variable diameter, being larger at the butt end and the smaller at the tip end of the fibre. Also, the diameter is connected with the fibre's origin, fibres cultivated at different locations have different diameters. The fibre cross-section changes from a beanlike shape at the butt end to rounded form at the tip end of the fibres. Like sisal, henequen fibres are smooth, straight, yellow, and easily degraded in salt water. Compared to other leaf fibres, henequen has low elongation at break and low modulus, but relatively high tenacity which makes them suitable as reinforcement for polymers Fibres obtained from pineapple leaves are the longest in this group and because of high crystallinity and high content of cellulose (70-82%) they express good mechanical properties

Fibre	**Length (mm)**	**Width (µm)**	**Crystallinity (%)**
cornhusk	0.5-1.5	10-20	48-50
pineapple leaf fibre	3-9	20-80	44-60
coir	0.3-1.0	100-450	27-33
bagasse	0.8-2.8	10-34	-
banana	0.9-4.0	80-250	45
wheat straw	0.4-3.2	8-34	55-65
rice straw	0.4-3.4	4-16	40
sorghum stalks	0.8-1.2	30-80	-
barley straw	0.7-3.1	7-24	-

WHEAT STRAW FIBRES

The microstructure, thermal and mechanical properties of wheat straw fibres have been examined and compared to flax straw fibres with an idea of using these natural fibres as reinforcing additives for thermoplastics Of crucial importance in this regard is the manner by which their inherent mechanical properties alter on exposure to elevated temperatures, which are encountered during melt processing of the polymer.

Under all test conditions flax straw was significantly stronger and stiffer than wheat straw. The tensile strength and elastic modulus decreased with increasing temperature up to 200^{0}C. This effect was minor for wheat straw than flax straw.

The differences are due to fibres structural form. The form of wheat straw is much more cellular than flax. Due to different lignin content the thermal stability of flax fibres was significantly higher than it was for wheat straw

FIBRES FROM HOP STEMS

Hop (*Humulus lupulus* L.) belongs to the family *Cannabaceae* and genus cannabis that includes hemp. The use, production or properties of natural cellulose fibres from hop stems was studied by Reddy and Yang [Reddy 2009].

The single sclerenchyma cells in hop stem fibres are small. Their length is 2.0 ± 1.0 mm and width 16.5 ± 5.5µm. Fibres extracted from hop stems contain 84% of cellulose, 6% of lignin in 2% of ash. From the diffraction patterns of cellulose in hop stem fibres cellulose crystalline structure was determined. The crystallinity index is 44 ± 5% (65–70% for cotton and 81–89% for hemp cellulose) and microfibrillar angle of cellulose fibrils 8 ± 0.7^{0}. The diffraction pattern is very similar to the diffraction pattern of hemp. Cellulose crystallites in hop and hemp fibres are regularly distributed and are also parallel to the fibre axis and to each other.

Mechanical properties of hop stem fibres are close to that of hemp fibres. Shorter single cells and low crystallinity of cellulose in the fibres should be the major reasons for the lower breaking tenacity of hop fibres compared to hemp. Sorption properties of hop fibres are comparable to cotton properties and slightly lower than that of hemp

Fabric name	Banana fabric
Fabric also known as	Banana fiber, banana silk, musa fiber
Fabric composition	Yarn spun from strands derived from the soft inner lining or coarser outer lining of banana peels
Fabric possible thread count variations	Upward of 1,000
Fabric breathability	High
Moisture-wicking abilities	High
Heat retention abilities	Low
Stretchability (give)	Low
Prone to pilling/bubbling	Low
Country where fabric was first produced	Unknown
Biggest exporting/producing country today	India
Recommended washing temperatures	Cold or warm - Theoretically, banana silk should be able to withstand hot water, but it is delicate
Commonly used in	Light clothing, tropical clothing, shawls, cardigans, blouses, slacks, pants, skirts, hats, scarves, ropes, mats, etc.

What is banana fabric?

Just as you'd expect, banana fabric is fabric made from bananas. Not the mushy, fruity part, though—the outer and inner peels, which are both quite fibrous.

Just like hemp, which produces a flowering and a stem section, banana stems and peels yield fibers that can be made into textile products. This practice has actually been done for many centuries, but it's only recently that the world of Western fashion has caught on to the textile potential of the common banana.

Banana fabric in history

It's likely that the Philippines was the first place where banana peels and stems were made into fiber.

This island chain is home to countless banana trees, and the industrious indigenous peoples of the area have made banana fabric for millennia.

A few other Asian cultures historically experimented with banana-based fibers, but the concept never caught on quite like it did in the Philippines. The closest example would be India, which has gradually supplanted the Philippines as the world's banana fiber hub.

As Western interaction with Southeast Asia increased, textile manufacturers from Britain and the United States became curious about the potential of banana fiber. Since then, Western fashion has occasionally flirted with this exotic fabric, but basic drawbacks make it less commercially viable than common alternatives.

Attributes of banana fiber

- The inner layer is soft like silk
- The outer layer is rough like burlap or cotton
- The silky interior fiber is very delicate
- At the same time, it is often more expensive to produce than silk
- Since silk is already one of the planet's most sustainable fibers, banana fiber is not in high demand worldwide

Banana fabric today

Very little banana fiber is still produced in the Philippines. Instead, it's mainly made in India, and many manufacturers in this country focus extensively on sustainable and organic practices. While there's some opportunity for unsafe cultivation practices during the banana growth cycle, it's unlikely that the presence of trace amounts of pesticides or fertilizers will significantly affect the end user.

How is banana fabric made?

There are a few steps in the banana fabric production process:

Separation

First, the fibers in banana peels and stems must be separated from the non-usable components. Various techniques may be used to achieve this end result, including retting, which involves the soaking of banana peels in water or a chemical substance to soften and separate the components. The unusable parts of the banana peel may also be sliced off, but this approach is more labor-intensive.

Bunching and drying

Once the separated fibers are acquired, they are bunched together and dried. At this stage, the inner and outer fibers are usually kept together since it's hard to separate them when wet.

Dividing into groups

Once dry, the fibers are separated into groups based on quality. The "A" group consists of the best-of-the-best, and it is used for silk-alternative applications. Some manufacturers may only have two groups, but others might produce a variety of different banana fiber grades.

Spinning and weaving

The separated fibers are then spun into yarn. The yarn is treated and dyed, and it is woven into garments, accessories, decor items, or industrial products.

How is banana fabric used?

Banana fiber is used very differently depending on whether it is made with the inner or outer peel and stem lining. The inner lining is so soft that it's been likened to silk, and much like silk, banana fabric is highly temperamental and delicate. Banana fiber is used as an alternative for any garment commonly made from silk, so that includes blouses, shirts, negligees, lingerie, slips, gowns, robes, eveningwear, etc.

Use in accessories

When it comes to accessories, expect to see banana fiber used more frequently to make scarves, hats, and gloves as sustainable, organic products become increasingly popular.

Use in industry and decor

Traditionally, a lack of technological sophistication limited banana fiber use to rough applications like doormats, wall weaves, and ropes. In some indigenous communities, banana fiber is still used for these ancestral purposes, but applications of this fiber outside the realm of wearable products are usually limited to tropical-themed decor items.

Where is banana fabric produced?

At 28.4 million tonnes per year, India is the world's largest producer of bananas, so it only makes sense that this Asian country is also the biggest producer of banana fiber. The Philippines is no longer a banana fiber production hub, but this fabric is still made for traditional purposes in small quantities in this island chain nation. Almost all banana fiber that reaches Western markets was manufactured in India.

How much does banana fabric cost?

High-quality, inner-lining banana fiber is generally quite expensive. It's tricky to produce, and it has the same qualities as silk, which means this lustrous fabric has a lot of market value.

Rougher, outer-lining fabric is usually cheaper. You can also often save by choosing conventional over organic fabric, but remember that you're exposing yourself to potential toxin contamination if you go that route.

What different types of banana fabric are there?

There are only two main types of banana fiber, but there are four terms you should be familiar with:

1. Inner-peel banana fiber

This type of banana fabric is very soft like silk. It is relatively expensive to produce, and it is reasonably delicate.

2. Outer-peel banana fiber

Used for centuries in industrial applications, this rough, coarse fiber is perfect for mats, ropes, and in some cases, outerwear and thick garments.

3. Banana cotton

High-grade outer-peel banana fiber is sometimes called banana cotton. Its texture is similar to cotton, and the two fabrics share many other attributes as well.

4. Banana silk

"Banana silk" is another term for inner-peel banana fiber.

How does banana fabric impact the environment?

Banana fiber production has a negligible impact on the environment. Even among the natural fibers, banana fabric is in a special category in terms of sustainability. That's because this fabric is derived from what would otherwise be a waste product; banana peels are discarded anyway when banana fruit is used, so why not turn them into clothing?

With that said, there's no guarantee that banana production is always done sustainably and with the environment in mind. While it has come a long way under Modi's leadership, India is still a far cry from a first-world country, which means that synthetic pesticide use is rampant in this poverty-stricken nation. When you're struggling just to survive, you'll do anything to make money, and the consequences of unsustainable agricultural practices seem very far away.

If done properly, banana fabric production can be in perfect harmony with the environment. We encourage banana producers around the world to look into offering their peels to textile manufacturers, and we're sure the global trend toward sustainability will gradually uplift banana fiber to its rightful place in the natural fabric pantheon.

Banana fabric certifications available

At present, certification has very little relevancy in the banana fiber industry since it is a niche product. As banana fiber becomes more popular, it's possible that specific certifications may arise catering to this emerging industry.

You'll need to content yourself with the knowledge that your bananas were grown organically for now. The USDA provides organic certification for bananas even if it doesn't offer certification for banana fiber, and the end result is the same. You want safe, sustainable banana fiber, and going organic is the way to get it.

BAMBOO FIBRES

Fabric name	Bamboo fabric
Fabric also known as	Bamboo rayon, bamboo yarn, retting, bamboo linen
Fabric composition	Semi-synthetic viscose cellulose extracted from bamboo or yarn made from bamboo fibers
Fabric possible thread count variations	300-600
Fabric breathabilityn	Very breathable
Moisture-wicking abilities	High
Heat retention abilities	Medium
Stretchability (give)	High
Prone to pilling/bubbling	High
Country where fabric was first produced	Countries in East Asia
Biggest exporting/producing country today	China
Recommended washing temperatures	Warm
Commonly used in	Clothing and household textiles

Vintage Bamboo Fabric Green Chartreuse

What Is Bamboo Fabric?

The term "bamboo fabric" widely refers to a number of different textiles that are made from the bamboo plant. Fabrics have been made from bamboo for thousands of years, but it is only in contemporary times that the process of making this hardy and fast-growing wood into fabric has been perfected.

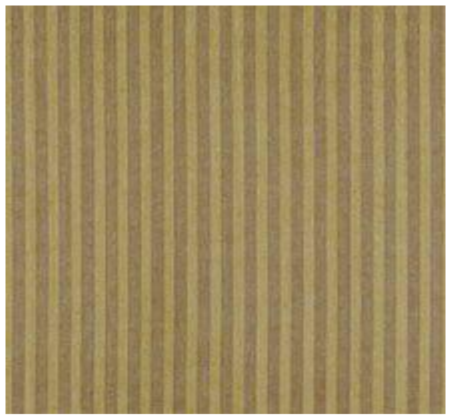
The story of bamboo fabric is a mixed bag. While some types of this fabric are environmentally sustainable and produced ethically, other types may be harmful to the environment or the workers who make it. To ensure that you select the right type of bamboo fabric, it's important to learn more about the textile industry surrounding this plant.

How Is Bamboo Fabric Made?

Depending on the type of fabric that is being made, bamboo textiles can be produced using a number of different methods. The majority of bamboo fabric produced worldwide is bamboo viscose , which is cheap to produce even though it has environmental downsides and represents workplace hazards.

Viscose is a term used to refer to any type of fabric that is made using the viscose method developed in the early 20th century. This type of fabric is one of the newest versions of rayon , which is a semi-synthetic fabric that was originally developed to mimic the desirable qualities of silk.

The process of producing viscose rayon is lengthy and involved, and it is incredibly wasteful. Any type of fabric made with tree cellulose produces a great deal of waste, but this waste can be handled sustainably when the right manufacturing processes are used. The waste produced by viscose rayon production, however, is contaminated with carbon disulfide , which is a toxic chemical that can cause a variety of health problems.



Berkshire Hill Dash Stripe Bamboo Fabric

Production of viscose rayon begins with the extraction of cellulose from wood pulp. Wood is broken down into tiny chunks, and it is then exposed to chemical solvents to remove the cellulose. Quite a few different processes are used to make viscose rayon, and almost all of them include additional harmful chemicals like caustic soda.

To produce a wearable fabric, extracted cellulose is compressed into sheets, exposed to carbon disulfide, and filtered. It is then pushed through a spinneret, which transforms the cellulose into strands. These strands are immersed in a vat of sulfuric acid to create filaments, and these filaments are then spun into yarn that can be woven into fabric.

Alternatively, bamboo cellulose can also be created with a closed-loop production process. Unlike the process used to create viscose rayon, closed-loop rayon production doesn't chemically alter the structure of the cellulose that is used, which results in a fabric that can be considered purely organic. While the solvent used to make traditional viscose rayon is wasted and usually ends up in the biosphere, the solvents used in closed-loop rayon production can be reused again and again, which significantly limits the environmental impact of this industry.

Bamboo fabric of the highest quality is made with production practices that do not extract cellulose. Instead, a natural enzyme is used on crushed bamboo wood fibers, and these fibers are then washed and spun into yarn. This yarn usually has a silky texture, and the fabric made by this process is sometimes called bamboo linen. When bamboo fabric is made with this method, it is not environmentally harmful, and the resulting textile is strong and long-lasting. However, most types of bamboo fabric are not made with this mechanical process; to ensure that you're getting high-quality bamboo fabric, make sure that it is manufactured with a mechanical rather than a chemical process.

How Is Bamboo Fabric Used?

In general, this type of fabric can be used for practically every application in which cotton is used. Some consumers may even prefer this type of fabric to cotton due to its notable beneficial attributes.

For instance, bamboo fabric is highly breathable, and it is also stretchier than cotton. It's easy to weave this fabric into fabrics with high thread counts, and the resulting textiles are often thinner than their cotton counterparts while remaining similar or greater in tensility.

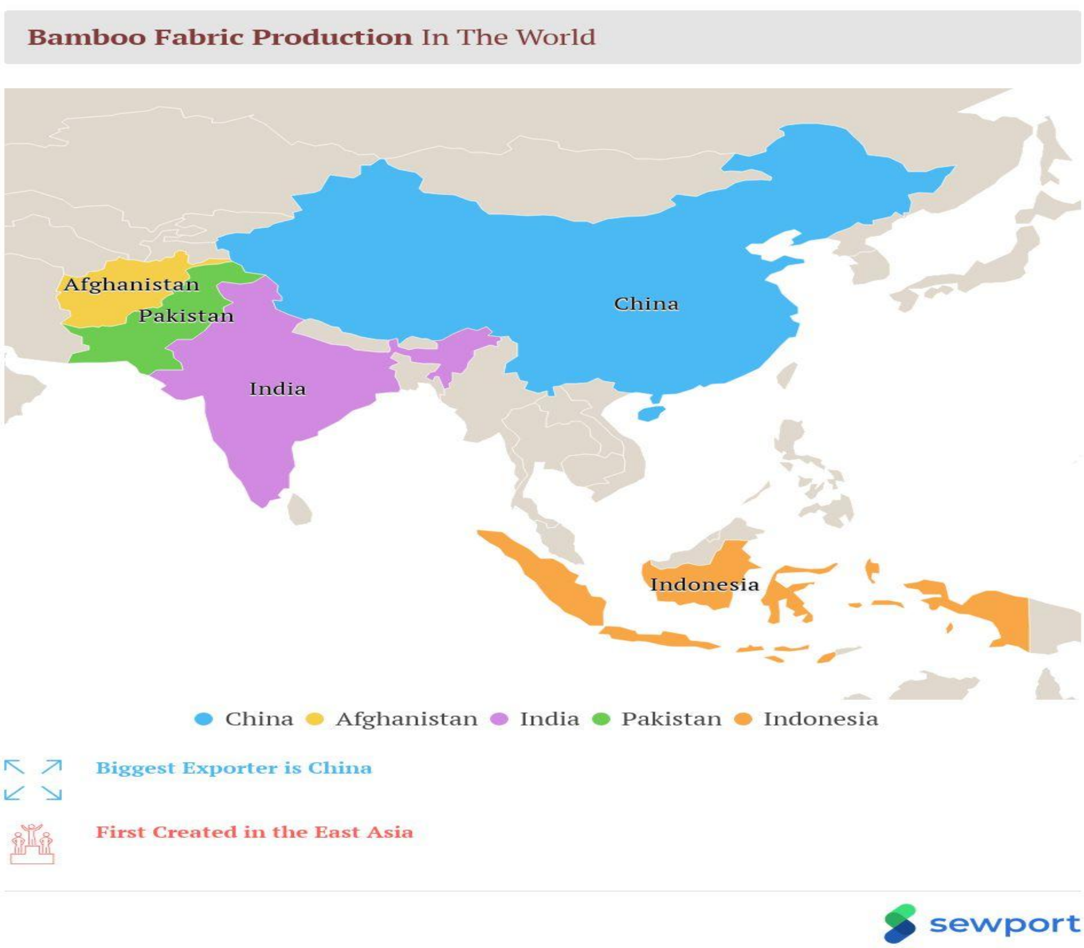
Beige Embroidered Organic Bamboo fabric Dress

Bamboo fabric may be used in sheets, blankets, towels, hand towels, or a number of other household textiles. Due to its softness and durability, however, this fabric is most commonly used in garments. Underwear made from this fabric is particularly popular, and socks, T-shirts, and other garments that make direct contact with the skin are commonly made with this fabric.

Some consumers prefer to use this type of fabric for intimate garments because of its purported antibacterial claims. However, research has indicated that the antibacterial properties for which bamboo is widely known are only majorly present in the raw product; once this type of wood has been processed into garments, these antibacterial benefits are mainly nonexistent.

It's important to remember that only bamboo fabric that has been made with mechanical processes will have the beneficial properties that make it desired by consumers. Bamboo rayon and similar semi-synthetic fabrics are not as soft or tensile as the real thing, and they certainly have negligible antibacterial benefits.

Where Is Bamboo Fabric Produced?



Bamboo fabric has been produced in East Asia for thousands of years. For instance, cultures in India and China have been producing this textile for untold generations, and bamboo fabric festivals are still held in rural India every year.

The relative environmental sustainability of growing this type of wood has stimulated the production of bamboo across the world. Producing this type of wood is even popular in Western nations such as the United States and Europe since it can be grown in a wide variety of climates. Therefore, almost every semi-developed or developed country in the world produces or exports at least some amount of bamboo fabric.

However, the single largest producer of this type of crop is China. In some ways, this economic fact is only natural; after all, bamboo has been an integral part of Chinese culture for millennia, and it has long been a favorite substance for making into textile products in this area.

There's also a darker side to why production of bamboo fabric is so popular in China. Since the late 1970s, China has become more and more popular among international textile corporations due to this communist country's lax environmental standards and rampant human rights abuses in the consumer goods production sector.

It remains the case that producing textiles and consumer products of all kinds is, in many instances, the cheapest in China, which has caused a variety of bamboo fabric manufacturers to gravitate toward this country for their production needs. Since Chinese companies are not highly incentivized to grow their products in an ethical or sustainable manner, production of this textile crop in China is more environmentally damaging than is reasonable or necessary, but it is undeniably inexpensive to produce bamboo fabric in this country.

Other major exporters of this fabric include India, Pakistan, and Indonesia. While a significant amount of this type of fabric is also produced in the United States, most of it is manufactured for domestic consumption, which means that it does not contribute to this country's exports.

How Much Does Bamboo Fabric Cost?

Vintage Bamboo Fabric Natural Linen

Viscose or similar semi-synthetic fabrics made from this type of wood are generally less expensive than cotton. In some cases, this decreased cost is passed on to the consumer. Genuine bamboo fabric that is made using mechanical methods, however, is almost always more expensive than cotton, but it may be more affordable than forms of luxury cotton like Egyptian cotton, Pima cotton, and Supima cotton.

What Different Types of Bamboo Fabric Are There?

There are three main types of bamboo fabric. These variations include

- Bamboo viscose: This type of bamboo fabric is nearly identical to other types of viscose. The only reason why bamboo is used in the production of this fabric instead of another type of wood is reduced manufacturing costs; the benefits of this fiber are not present in its viscose form, and consumers should be wary of the conflating this type of textile with true mechanically-produced bamboo fabric.

- Lyocell-type bamboo fabric: This type of fabric is similar to viscose, but it is made with a closed-loop production method. In addition, the chemical structure of the cellulose used to make this type of fabric is not altered in the production process, which means that it retains many of the beneficial qualities that are also noted in mechanically-produced bamboo fabric.
- Mechanically-produced fine bamboo fiber: This type of fabric is the only option that can be considered to be true "bamboo fabric." It is relatively expensive and time-consuming to produce, but it offers far greater benefits than the types of fabrics that are not produced via mechanical means. This type of bamboo fabric is very strong, durable, and soft.

How Does Bamboo Fabric Impact the Environment?

Bamboo is often touted as an eco-friendly fabric, and in some ways, this designation may be accurate. For instance, bamboo is incredibly easy to grow; it matures very quickly, and it can grow in areas that are not suitable for other crops. Therefore, the environmental impact of cultivating bamboo is relatively minimal in theory, and it's up to individual bamboo cultivators to ensure that their crop is obtained in a sustainable manner.

Ironically, the modern demand for bamboo led many Chinese manufacturers to fell forests of other trees to plant bamboo, which practically eliminates the environmental benefits of this crop. In the late 1990s, however, the Chinese Communist Party instated regulations prohibiting this behavior.

Bamboo Fabric Biker Jeans – Khaki

Even if contemporary bamboo cultivation is relatively easy on the environment, the process of producing bamboo viscose is anything but environmentally friendly. While there is generally no risk of consumers encountering toxic chemicals when they wear or use bamboo fabric, a variety of dangerous substances are used to transform raw bamboo into the cellulose that is used to make rayon.

For instance, the lye used to transform bamboo wood into a substance suitable for cellulose extraction isn't usually reused. In addition, carbon disulfide is an integral aspect of the rayon production process, and it's impossible to recapture this toxic chemical once it has been used.

Bamboo production in developing nations, such as China, has encountered a great deal of controversy. For instance, many Chinese bamboo fabric factories expose their workers to the gaseous carbon disulfide that is emitted in the bamboo rayon production process.

Carbon disulfide is a neurotoxin, and it also causes organ damage. Workers who are exposed to this chemical can develop psychosis, liver damage, coma, and blindness, and this chemical can also cause heart attacks. While some factories may protect their workers from carbon disulfide, the legal limits of this substance that have been determined by the Chinese government are far above the safety threshold indicated by medical scientists.

Bamboo Linen Fabric

Unlike cellulose from many of the other trees that are commonly used for viscose rayon production, bamboo cellulose is suitable for closed-loop production processes. Therefore, fabrics similar to lyocell can be made with bamboo, and the lyocell production process doesn't produce any toxic waste.

However, the vast majority of bamboo fabric is rayon, which means that environmentally degrading processes are used to make this textile. It's important to point out that genuine bamboo fiber can be produced with methods that are not harmful to the environment. If you want to experience the benefits touted by bamboo fabric manufacturers, it's necessary to avoid bamboo viscose and choose genuine fibers or lyocell-like bamboo cellulose fabrics instead.

Bamboo Certifications Available

It is possible to have bamboo fabric that has been produced with mechanical means certified as organic. This fabric can receive this certification if the bamboo fibers used in its production were cultivated with means determined by the USDA or a similar regulatory agency to be environmentally sustainable and economically ethical.

Since bamboo fabric made with the viscose rayon process is transformed into a semi-synthetic substance, it is impossible for this substance to be considered organic. Be wary of companies that claim to offer organic bamboo rayon

QUINOA FIBRES

Quinoa originates from Andes in South America and it belongs to the family Chenopodiaceae (Chenopodium quinoa Willd). It is a grain-like crop grown primarily for its edible seeds and it has become highly appreciated for its nutritional value. It has been recognized as a complete food due to its protein quality. It has remarkable nutritional properties; not only from its protein content (15%) but also from its great amino acid balance. It is an important source of minerals and vitamins, and has also been found to contain compounds like polyphenols, phytosterols, and flavonoids with possible nutraceutical benefits

The plant is not problematic and it can be cultivated everywhere. Quinoa has a high nutritional value and has recently been used as a novel functional food because of all these properties; it is a promising alternative cultivar.

The elementary fibres can be isolated from Quinoa stems. It is possible to use different processes for fibre isolation. Sfiligoj et al. reported about fibres which were obtained from untreated stems by mechanical isolation. Besides, stems were subjected to chemical treatment in alkaline medium (1%NaOH; different treatment times and temperatures were used; sample A – 1day treatment, room temperature; sample B – 11days treatment, room temperature; sample C – 1 hour T = 100^0C). In addition to they were water treated, respectively. Thereby the pectin structures connecting fibres with other plant tissues were loosed and the mechanical separation of the elementary fibres or fibre bundles was performed

Quinoa – ripe plant and the stem

GRASS FIBRES

Grass because of its huge available amounts represents a great potential. It is an annual plant with bundles of elementary fibre cells bound by pectin middle lamellae. Parenchyma cells separate fibre bundles from each other.

The most important representatives in the group of grasses are: Perennial Ryegrass (*Lolium perenne*), Italian ryegrass (*Lolium multiflorum*), Hybrid ryegrasses (*Lolium perenne x multiflorum*), tetraploid varieties of perennial and Italian ryegrass, Timothy (*Phleum pratense*), Cocksfoot (*Dactylis glomerata*), Fescues (Meadow fescue - *Festuca pratensis*; tall fescue – *F.arundinasea*; red fescue – *F.rubra*), Bromes (*Bromus willdenowii*). Legumes are presented by: White clover (*Trifolium repens*), Red clover (*Trifolium pratense*), Lucerne The elementary grass fibres were studied. They were isolated from different grass and legumes sorts, i.e. Ryegrass (*Lolium hybridum* Gumpenstein), Trefoil (*Trifolium pratense*) and Lucerne (*Medicago sativa*).

The fibre-samples were obtained in a bio-refinery, after the liquid phase containing proteins and lactic acid was eliminated from the ensiled and green grasses, respectively. For the isolation of elementary grass fibres different processes were used. Cross section of a Trefoil stem is presented

Sea grass – Zostera marina

Researchers report about different new cellulose sources, however mainly from terrestrial plant origin. But fibres from marine sources offer addition options when appropriate species are identified. Sea grasses belong to angiosperm and are found in most of the oceans. Among sixty different species *Zostera marina* called eel-grass is the most widespread.

P.Davis et al. reported about Baltic species of *Zostera marina* which was collected on the German Baltic coast. The diameter of the plant stem was about 2-5 mm and it was 3-8 times branched. The plant was up to 1.2 m long.In *Zostera marina* a very interesting plant structure was observed. Fibres were reinforcing a matrix and thereby forming a composite structure. Fibres were organized in bundles. Individual fibres with the diameter around 5µm and approximately circular cross section were mechanically extracted from sea grass *Zostera marina*. Fibres are composed of 57% cellulose, 38% of non-cellulosic polysaccharides (10%pectins and 28% hemicellulose) and 5% of residual matter [Davies 2007]. Single fibre stiffness was determined. It was 28 GPa

Due to sea-grass fibres mechanical properties and its low density fibres present an attractive reinforcement for composite materials, especially when bio-degradability is required.

Applications of non-conventional cellulose fibres

Depending on their physical properties and cellulose content lingocellulose fibres can be used for various applications. The typical fibre morphology with a lumen in the centre, reduces the bulk density, thereby acoustic and thermal insulation properties of biofibres are increased and therefore these fibres are preferable for lightweight composites for noise and thermal automobile insulators.

In addition to insulation, these materials are used in Civil Engineering as building materials. From industrial hemp Cannabis Sativa L useful cellulose fibres to manufacture fibre cement products for roofing are obtained. The disadvantages of some cellulose fibres are: lower modulus of elasticity, high moisture absorption, decomposition in alkaline environments, they are susceptible to biological attack, variable mechanical and physical properties. Hemp fibres with a higher durability than traditional cellulose fibres are more suited for this kind of application, and therefore a lot of research was performed about the use of hemp fibres as reinforcement for building materials based on cement. In addition to, hemp core fibres from agricultural waste industrial hemp straw with the length between 5-10 mm were studied by Jarabo et al.

An important aspect of natural fibres is associated with their hierarchically built anatomies developed and optimized in a long term evolution process. A variety of non-wood plants offer multiple possibilities in dimensions, composition and morphology of fibrous structures that can be useful for pulp and paper making industries.

Therefore based on high cellulose content they are replacing wood pulp in paper and fibres production. Grass stems and leafs fibres could be utilized for this purpose

Natural fibres are currently attracting a lot of attention for reinforcement. Fibre reinforced composites consists of fibre as reinforcement and a polymer as a matrix. Their special advantage is their low cost, low density, good mechanical properties, biodegradability, etc. The advantage of natural fibre composites includes lack of health hazards and non-abrasive nature

Natural fibres provide stiffness and strength to the composite and are easily recyclable. Hemp fibres represent a good potential for this utilization. The use of hemp fibres as reinforcement in composite materials has increased in recent years as a response to the increasing demand for developing biodegradable, sustainable and recyclable materials

Hemp fibres are used for reinforced thermoplastics (composites hemp fibres - polypropylene PP, polyethylene PE, polystyrene PS, hemp fibres - maleated polypropylene MAPP, kenaf-hemp nonwoven impregnated with acrylic matrix., etc.), thermosets (polyester, epoxy resin, vinylester, phenolics) [Shahzad 2012] and biodegradable polymers (thermoplastic starch, polyhydroalkanoates (PHA), polyactides (PLA), lignin based epoxy, soy based resin, etc

Also other natural cellulose fibres have been used for composite preparation. Polymers including high density polyethylene (HDPE), low density polyethylene (LDPE) polypropylene (PP) polyether ether ketone (PEEK), have been reported as matrices

A major disadvantage of cellulose fibres is their highly polar nature which makes them incompatible with non-polar polymers. These fibres therefore are inherently incompatible with hydrophobic thermoplastics, such as polyolefins

This characteristic results in compounding difficulties leading to non-uniform dispersion of fibres within the matrix which influences composite properties. To achieve strong adhesion at the interfaces which is needed for an effective transfer of stress and load distribution through out the interface, sometimes surface modification is needed.

Surface modifications include

(i) physical treatments, such as solvent extraction;
(ii) physico-chemical treatments, like the use of corona and plasma discharges or laser, and UV bombardment; and
(iii) chemical modifications, both by direct condensation of the coupling agents onto the cellulose surface and by its grafting by free-radical or ionic polymerizations.

Therefore different coupling agents which introduce chemical bonds between the matrix and fibre are involved (e.g. silane, isocyanate and titanate based products, alkaline treatment, acetylation, benzoylation, acrylation, maleated coupling agents, permanganate, etc) . or methods of physical fibre treatments (e.g. surface fibrillation, plasma treatment) are used . An additional possibility is to impregnate cellulose fibres in monomer solution, follows the in-situ catalyst, heat or UV polymerisation

Different natural fibres species have been used for preparation of composites. Some examples are: aspen fibre, abaca fibre, bagasse fibres, bamboo fibre (BF), banana fibre, etc.

Unidirectional isora fibre reinforced polyester composites were prepared by compression moulding. Isora is a natural bast fibre separated from the *Helicteres isora* plant by a retting process. Untreated and alkali treated fibres were used for composite preparation and influence of fibre content on composite properties was studied. It was observed that the pre-treatment process conditions the fibre content for achieving optimum composites mechanical properties .

Green composites were prepared from pineapple leaf fibres and soy-based resin. The addition of polyester amide grafted glycidyl methacrylate (PEA-g-GMA) as compatibilizer increased the mechanical properties of composites. For preparing composites from pineapple leaf fibres in natural rubber fibres were pre-treated in NaOH solutions and benzoyl peroxide (BPO) of different concentrations. It was found that all surface modifications enhanced adhesion and tensile properties .

Elephant grass (*Pennisetum purpureum*) is available abundantly in nature and is renewable. It is a tall grass growing in dense clumps along lake and riverbeds up to 3 m height. The diameter of the stem is 25 mm and leaves are 0.6 to 0.9 m long and about 25 mm wide. It represents a potential and economic source compared to other natural fibers, however it is still underutilized, therefore K. Murali Mohan Rao with co-workers suggest fibres from the grass for reinforcement of polyester composites .

The density of the elephant grass fiberres is very low compared to other lignocellulose fibres.

This property is a good base for designing lightweight material from these fibres. The diameter of fibers is between 70 lm to 400 µm. Fibres mechanical properties are: tensile strengh is 185 MPA, tensile modulus is 7.40 GPa and elongation at break 2.50%

The positive impact of elephant grass fibres on tensile strength of fiber reinforced composites was determined and it was found that composite mechanical properies increase with percentage volume of fibers. Whereas the fibre extraction is simple, fibres are cheap and of appropriate properties elephant grass is also suitable for composites used for lightweight structures preparation.

Cellulose nanofibres and crystals have gained a large interest, not only in the academic research society but also in industries, during the last few years .

It is well known that isolation of nanocrystals from cellulose is possible by strong acid hydrolysis.

Under controlled conditions, acid hydrolysis allows removal of the amorphous regions of cellulose fibres whilst keeping the crystalline domains intact in the form of crystalline nanoparticles.

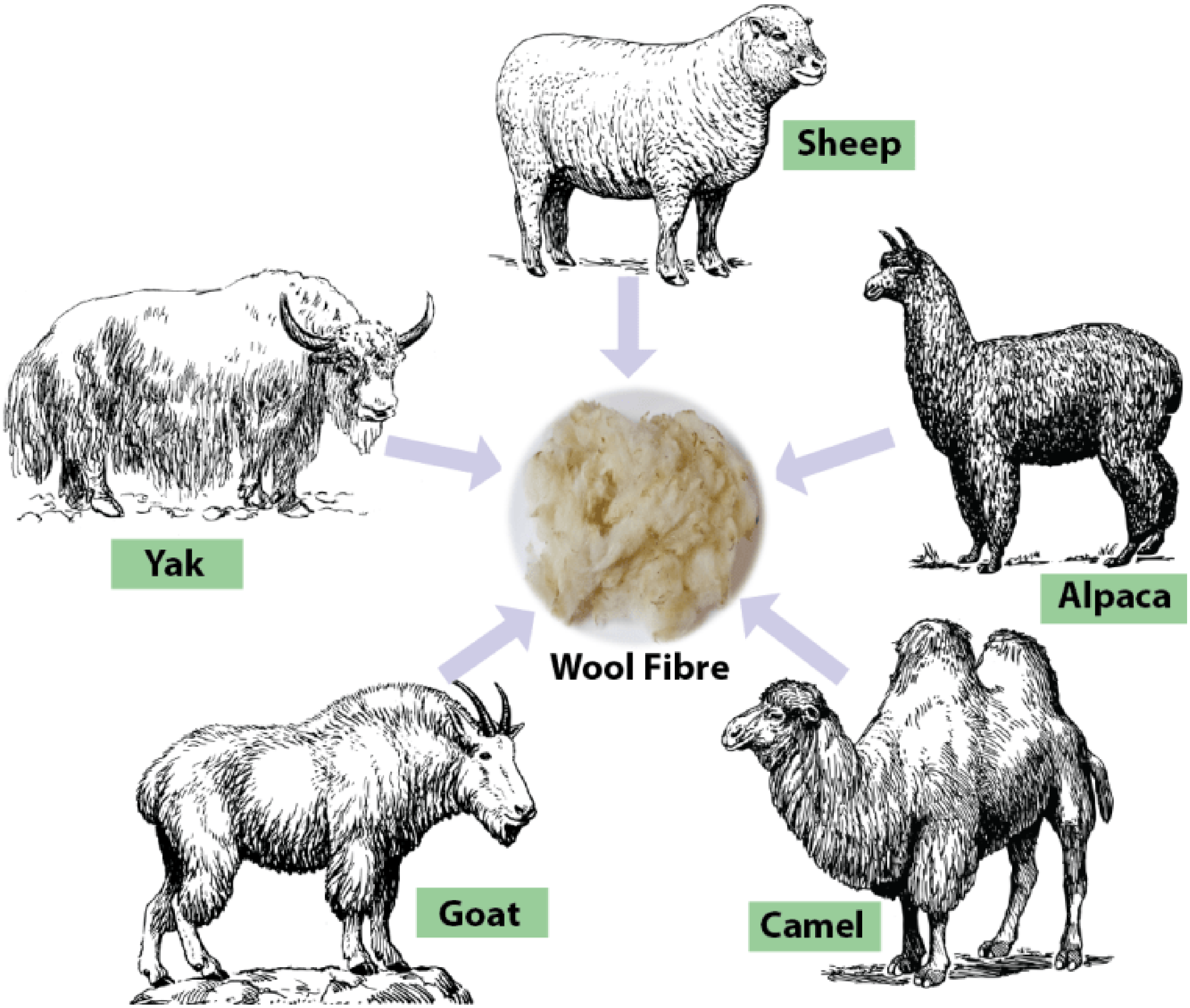
The diamensons of nanofibres are usually around 20–30 nm in diameter with the length of few µm. Nanocrystals are much smaller. Their length is about 200nm and diameter about 3–5 nm . Cellulosic nanomaterials are obtained form different resources, i.e. wood, bioresidues and annual plants, e.g. wood fibres, sisal, pineapple leaves, coconut husk fibres and bananas, mengkuang leaves (*Pandanus tectorius*), mulberry bark. The use of isolated cellulose nanocrystals as reinforcements in the field of nanocomposites has attracted considerable attention since it was first reported in 1995 . Natural fibre reinforced composites can be applied in the plastic, automobile and packaging industries.

Conclusions

Lignocellulosic natural fibres have a very long tradition for textile materials manufacturing. Especially are these fibres important for technical textiles production. The series of plants yielding conventional textile fibres, e.g. flax, hemp, etc. has been recently extended by several abundant plant species traditionally not-connected with fibres extraction. Of huge interest are especially agricultural wastes from cultures which are primary grown for food industry, and their plant wastes additionally containing fibres. Different fibres have been studied by several authors; their properties were determined and compared to the properties of conventional fibres. Regardless of the origin fibre cells are elongated sclerenchyma cells of different geometrical characteristics, associated in fibre bundles with adequate mechanical properties. Several plant species were suggested for utilization from different geographic areas.

Natural fibres from conventional and unconventional source are considered as potential replacement for man-made fibres in composite materials for their reinforcement. Natural fibres from annual plants have advantages of being low cost and low density and therefore they are light. They are a renewable material. In addition to, an important advantage of these materials is their biodegradability and low toxicity. It was confirmed by many researchers that properties of natural fibres of different origin improve composites properties, e.g. the mechanical properties of natural fibres - polymer composites are superior to those of the unreinforced materials.

❖ **CONTENT/TOPIC 4. ANIMAL FIBRES**



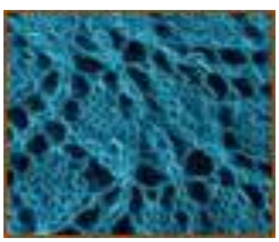
ANIMAL FIBRES

Alpaca: It is partly hollow, from 20 to 70 microns in diameter and comes in 22 natural colours. It is light, stronger than sheep's wool, and provides excellent insulation. Huacayo alpacas produce soft, dense, short fibres, while the fleece of the rarer suri is lustrous, silky and straight. Alpaca blends well with wool, mohair and silk. Soft and dense, or lustrous and silky, alpaca is used to make high-end luxury fabrics and outdoor sports clothing.

Angora: The silky white hair of the angora is a hollow fibre classed as wool. With a diameter of 14-16 microns, it is one of the silkest animal fibres. Angorawool is very soft to the touch, thanks to the low relief of its cuticle scales. Fine, silky and exceptionally soft to the touch, the woolof the Angora rabbit is used in high quality knitwear.

Camel: The fine down fibre of the Bactrian camel averages around 20 microns in diameter and varies in length from 2.5 to 12.5 cm. Baby camel hair, which can measure as little as 16 microns (on a par with fine cashmere), is the softest and most prized. Owing to its quality and scarcity, camelhair is used in luxury textiles. The best quality camel yarn is spun on drop spindles by womenin nomadic households of Mongolia and Inner Mongolia, China.

Cashmere: US standards set an average fibre diameter for cashmere of no more than 19 microns, and top quality fibre is just 14. It has natural crimp, allowing it to be spun into fine, lightweight fabrics. Cashmere has small air spaces between the fibres, which makes it warm without weight, while thin cuticle cells on the fibre surface make it smooth and lustrous. Its luxurious, rare and expensive: the wool of six kashmir goats is enough to make just one cashmere sports jacket.



Mohair: Light and insulating, its tensile strength is significantly higher than that of merino wool. Like wool, mohair has surface scales, but they are thinner, making it smooth to the touch. Light reflected from the surface gives mohair a characteristic lustre. Thin surface scales make mohair smooth to touch, while light reflected from its surface gives it a characteristic lustre.

Silk: It's filament is a continuous thread of great tensile strength measuring from 500 to 1 500 metres in length, with a diameter of 10-13 microns. In woven silk, the fibre's triangular structure acts as a prism that refracts light, giving silk cloth its highly prized "natural shimmer". It has good absorbency, low conductivity and dyes easily. Developed in ancient China, where its use was reserved for royalty,silk remains the "queen of fabrics".

Wool: It has natural crimpiness and scale patterns that make it easy to spin. Fabrics made fromwool have greater bulk than other textiles, provide better insulation and are resilient, elastic and durable. Fibre diameter ranges from 16 microns in superfine merinowool (similar to cashmere) to more than 40 microns in coarse hairy wools. Limited supply and exceptional characteristics have made woolthe world's premier textile fibre.

What Is Wool Fabric?

Wool is a type of fabric derived from the hairs of various animals. While most people associate the word “wool” with sheep, there are, in fact, a variety of distinct types of wool that producers derive from animals other than sheep.

To make wool, producers harvest the hairs of animals and spin them into yarn. They then weave this yarn into garments or other forms of textiles. Wool is known for its durability and thermally insulating properties; depending on the type of hair that producers use to make wool, this fabric may benefit from the natural insulative effects that keep the animal that produced the hair warm throughout the winter.

Throughout the centuries, wool and cotton have vied for supremacy as the most-used textile in the world. Today, each of these fabrics fills a particular niche, and wool remains prized for its unique attributes. While cotton consists almost entirely of plant cellulose, wool consists of approximately 97 percent protein and 3 percent fat, which makes it uniquely suited for certain applications that cotton isn’t suited for.

When it is woven into textiles, wool has a natural waviness called “crimp.” This crimp contributes to wool’s insulative properties, which exist because the bulkiness of wool naturally traps air.

Some types of wool have more crimp than others, and the more crimp there is in a woolen garment, the more insulative it is.

Compared to cotton and other plant-based or synthetic textile materials, wool is highly flame-resistant. It doesn’t spread flame, and instead, it chars and self-extinguishes. Therefore, this type of textile is highly useful in applications in which the reduction of flammability is desired.

Felting Wool Sweaters

Prior to domestication, sheep were more hairy than wooly. Their hair, therefore, was not highly useful as a textile material. Once sheep were domesticated around 11,000 years ago, sheep breeders started selecting certain traits in their flocks, and sheep gradually became woolier.

The earliest evidence of garments made from sheep wool is from around 4000 BC, but it's possible that human beings started making woolen garments as long as 8,000 years ago. While there's evidence that wooly sheep were introduced into Europe around 4,000 BC, the first piece of hard evidence of wooly sheep domestication in Europe is a wool textile from around 1500 BC that was preserved in a Danish bog.

Along with linen and leather, wool was an important textile in the Roman empire, and this textile became even more central to European life during the Middle Ages. By around 1200 AD, in fact, wool production had become a major component of the Italian economy.

Modest Vintage Stylish Plaid Wool Dress

Famous Italian families, such as the Medici, built their entire fortunes from wool production. By the dawning of the Renaissance, wool production had spread through the rest of Europe, but it wasn't until the Colonial Era that Europeans exported wooly sheep to other continents.

As soon as the British Empire introduced sheep to the Australian continent, the trajectory of the global wool industry changed drastically. With such an immense expanse of ideal grazing land at its disposal, the Australian sheep population exploded within a few decades. Australia remains the wool capital of the world, and New Zealand is another significant wool-producing country.

With the advent of synthetic fibers, the global demand for wool sharply decreased. Even so, wool innovations have continued unabated. Superwool is a kind of wool that you can wash in a washing machine and tumble dry, and a Japanese company even invented a type of wool suit in 2007 that you can wash in the shower and dry within a matter of hours.

How Is Wool Fabric Made?

The **production of wool** begins with the shearing of wool-bearing animals. Some animals bear wool once per year, and others bear wool multiple times throughout the year.

Next, the shorn wool is cleaned and sorted into bales. There are a variety of ways to remove the greasy lanolin in raw wool, but most large wool producers use chemical catalysts for this process.

Once the wool fibers are clean and sorted, they are carded, which is the process of making the fibers into long strands. These carded strands are then spun into yarn, and after a final washing, this yarn can be woven into garments and other types of woolen textiles.

Vintage Colors Hand Dyed Wool

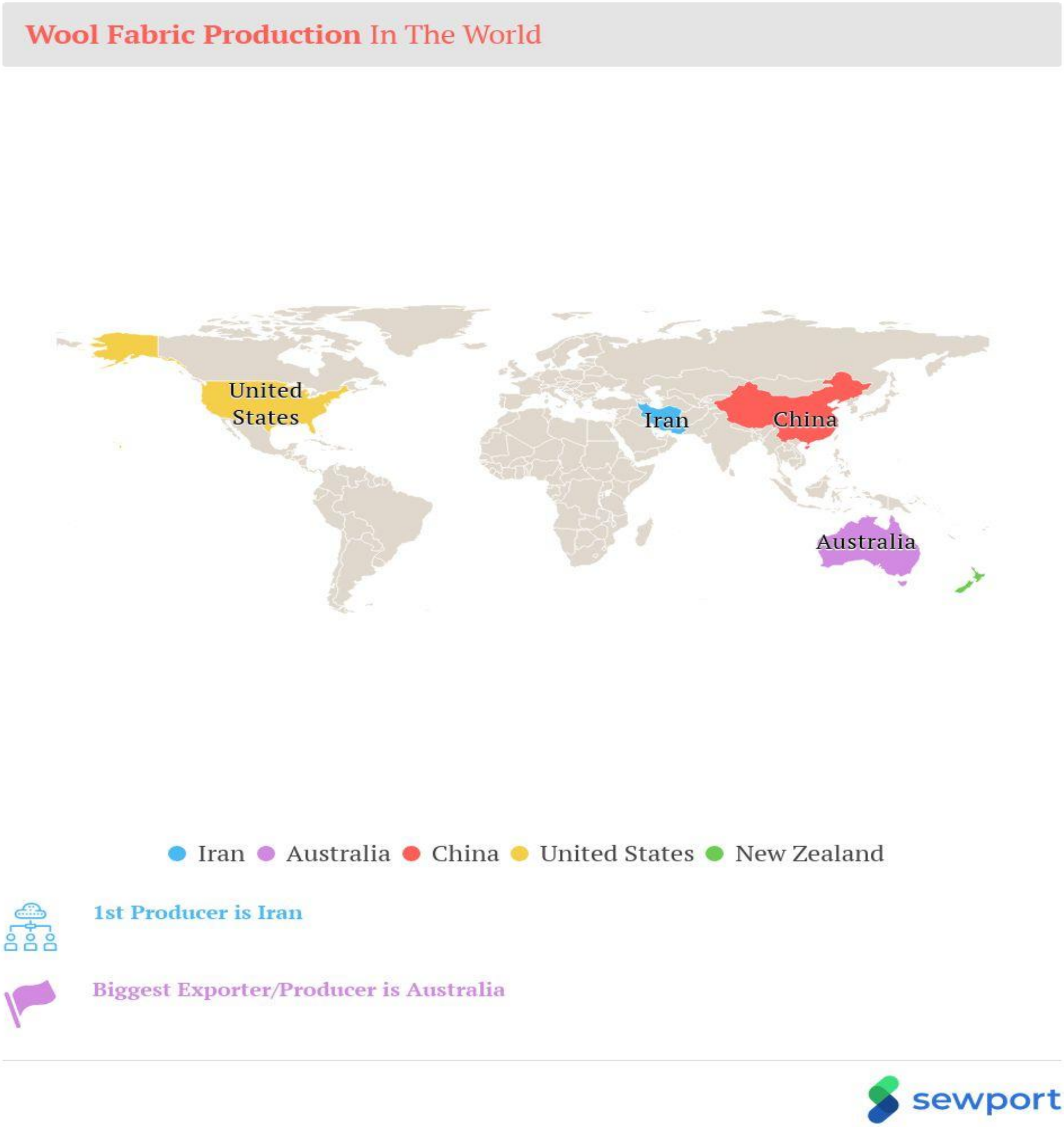
Lastly, the finished textiles may be exposed to a variety of post-production processes to develop certain attributes. Fulling, for instance, is the immersion of a wool textile in water to make the fibers interlock, and crabbing is the process of permanently setting this interlock. Lastly, wool producers may decate their products for shrink-proofing purposes, and rarely, they may also dye their finished wool products.

How Is Wool Fabric Used?

Over the years, human beings have found hundreds of ways to use wool. While wool is primarily used in consumer applications, this substance is also popular in industrial applications for its durability and flame-retardant qualities.

While finer types of wool might be used to make garments that directly contact the skin, it's much more common to find wool used for outerwear or other types of garments that don't make direct bodily contact. For instance, most of the world's formal suits consist of wool fibers, and this textile is also commonly used to make sweaters, hats, gloves, and other types of accessories and apparel.

Where Is Wool Fabric Produced?



According to World Atlas, Australia produces 25 percent of the world's wool, which makes it the most prominent wool-producing country. China, which has one of the world's largest textile markets and textile industries, produces 18 percent of the world's wool. At 17 percent, the United States is the third-largest wool producer, and New Zealand comes in fourth since it produces 11 percent of the world's wool supply.

How Much Does Wool Fabric Cost?

Australian Wool Innovation Limited provides weekly price reports for wool per kilogram. You can use this organization's price reports to gauge the current prices of Australian wool. At present, clean Australian wool is going for about $19.60 per kilogram.

Wool is, therefore, significantly more expensive than cotton, which is its main competitor on the world stage. It is quite a bit more expensive than most synthetic alternatives, but it also offers unique benefits that synthetic fabrics do not.

What Different Types of Wool Fabric Are There?

There are quite a few different types of wool, and not every variety is derived from sheep

1. Merino Wool

Merino wool is one of the world's most common types of wool. The vast majority of merino sheep are bred in Australia, and wool from merino sheep is used to make all sorts of different kinds of garments and industrial materials.

This type of wool can have a diameter of under 20 microns, which makes it one of the finest types of woolen products in existence. While merino sheep were originally bred in Spain, hardly any merino wool production still occurs in this European country. Since merino wool is relatively greasy before it is processed, it's necessary to remove lanolin from this type of textile before it can be spun into yarn.

Upcycled Wool Blanket & Vintage Fabric Oven Mitts

2. Cashmere Wool

Cashmere is one of the most expensive and luxurious types of wool. The name “cashmere” comes from the Kashmir region of India, which is the area where the furry goats that supply cashmere wool originated.
With hair diameters as small as 18 microns, cashmere is just as soft and fine as merino wool. The high price of cashmere wool, however, comes from the fact that cashmere goats can only produce around 150 grams of wool per year, which makes this type of wool a highly desired commodity.

3. Mohair Wool

Mohair wool comes from angora goats, which have incredibly thick, wavy wool. While it’s possible to gather mohair wool without hurting angora goats, the mohair industry has been mired in controversy for generations over the widespread mistreatment of these wool-bearing animals.
While other types of wool may not be highly crimped, the wavy hair of angora goats naturally leads to high-crimp woolen textiles. During the 1970s and 1980s, mohair was very much in vogue, and trendy urbanites wore mohair sweaters and put mohair carpeting in their homes until the rampant animal abuses in the mohair industry came to light.

4. Alpaca Wool

People in South America have been breeding alpacas for their wool for thousands of years. Younger alpacas can yield hairs as small as 15 microns, but alpaca wool roughens as it ages, which makes the hair fibers of older alpacas unusable for apparel purposes.
There are a few different breeds of alpacas that breeders use for wool, and Suri alpaca wool is among the most prized varieties of this natural textile. While some manufacturers use pure alpaca wool to make garments, most producers mix this type of wool with less expensive wool varieties to take advantage of the draping qualities of alpaca fibers without incurring unreasonable costs.

Vintage inspired wool dress

5. Camel Wool

During the early 20th century, camel hair suits were all the rage. Camel wool is incredibly insulative, but it is also less durable than other types of wool. Since camel hair is relatively rough, it isn't well-suited for any garments that directly touch the skin.

6. Virgin Wool

Also known as lamb's wool, virgin wool is wool made from a lamb's first shearing. This term can also refer to wool that hasn't been recycled.

7. Angora Wool

Angora wool comes from a special breed of rabbit that produces incredibly fine and soft hair. This type of wool is very expensive, and the rabbits that produce it are not commonly kept in humane conditions.

8. Vicuna Wool

The vicuna is a relative of the alpaca that is exclusively native to Peru. Vicuna wool is the most expensive type of wool in existence, which is partially due to the Peruvian government's attempts to protect this endangered species.

9. Llama Wool

Llama wool is generally too rough to be worn next to the skin, but it is suitable for outerwear garments. It's relatively rare to find a breeder that produces llama wool.

10. Qiviut Wool

The qiviut is a type of musk ox native to Alaska. While the fibers produced by this animal are very rough, they are eight times more insulative than sheep wool, which makes qiviut wool ideal for gloves, hats, and other types of cold weather gear.

How Does Wool Fabric Impact the Environment?

Since wool is a natural textile, it is inherently non-impactful on the environment. As long as wool-producing animals are allowed to live free, happy lives and they aren't crowded or subjected to inhumane practices, it's possible to produce wool sustainably.

Just because wool production can be sustainable, however, doesn't mean that it always is. In fact, the vast majority of wool production is either inhumane, environmentally degrading, or both. In search of maximum profits, wool producers everywhere disregard the effects that their industry has on the environment and the animals they depend on, and an inherently sustainable practice that human beings have pursued for thousands of years becomes harmful to both wool animals and their natural surroundings.

For instance, the animal rights advocacy organization PETA has dire things to say about the wool industry.

Since PETA is a relatively radical organization, you should take everything it says with a grain of salt. For instance, it's unclear whether "enteric fermentation," (sheep farts) is actually bad for the environment.

It's undeniably true, however, that sheep breeding can cause soil degradation and other types of land damage. Fecal matter from sheep can also pollute waterways, and the toxic chemical "sheep dip," which is used to kill parasites, often overflows into the surrounding environment.

Plus, sheep breeders routinely kill animals like coyotes and kangaroos that they deem to be detrimental to their sheep breeding plans. Wool production can also be harmful to wool animals themselves; the mohair wool industry, for instance, has been locked in a constant state of controversy ever since groups like PETA exposed the horrific conditions that angora goats are subjected to in the production of this textile.

End uses of wool fibre

Alpaca fibres are used for many purposes, including making clothing such as hats, mitts, scarves, gloves. And jumpers. Rugs and toys can also be made from alpaca fibres. Alpaca fleeces is generally used only in the expensive luxury items of textile and apparel

Lama fibres are used in expensive knitted fabrics, jackets, over – coats, and blankets.

Camel hair is used for outer wear and used for under linings

Cashmere is used in luxury applications where a soft, warm, fine fibre with beautiful drape is desired.

Mohair is used for outer – wear.

Difference between Silk & Wool Fibre

SUBJECT	SILK	WOOL
Composition	It has carbon, hydrogen, oxygen and nitrogen. It is attacked by carpet beetles.	It has hydrogen, carbon, Sulphur and nitrogen. It is harmed by moths and beetles
Elasticity	It has extended poly peptide chains and is less elastic and resilient.	It has folded poly – peptide chains and more elastic and resilient.
Strength	It is very crystalline and is less absorbent.	It has more amorphous areas and more absorbent.
Dimensional Stability	It is a solid fibre.	It has four parts in its fibre structure and therefore shrinks and felts.
Texture	It is smooth. White silk is smoother and more lustrous.	White wool fibre has crimp which is molecular. Therefore, wool is warmer and more resilient.
Length	It is usually a filament and is smooth.	It is staple fibre and is fuzzy.
Hydroscopic nature	Since it has a very crystalline polymer system, it is less absorbent than wool.	It is more absorbent.
Thermal properties	It is more sensitive to heat.	It is less sensitive to heat.

Effect of acids	It is degraded more than wool because of absence of disulphide bonds, perspiration which is acidic will cause breakdown of silk polymer.	It is degraded less than silk.

Wool Fabric Certifications Available

sewport

A variety of organizations certify wool based on certain criteria. Common certification criteria include the quality of the wool and the sustainability of the breeding and production processes that went into preparing it for consumer use.

The **Responsible Wool Standard (RWS)** is one of the world's most prominent wool certification groups, and it certifies wool from various animals.Woolmark, which is a major wool producer, offers third-party testing for other wool companies, and the **International Wool Textile Organization (IWTO)** also offers reputable wool certification services.

When you think of "wool," you may remember that scratchy pullover your mom made you wear during winter years ago. But that couldn't be further from the truth. In fact, the wool family actually includes fancier knits including cashmere, mohair, and angora. So before you head to the stores, we break down everything you need to know to build the best sweater collection — ever!

Wool

Comes from: Sheep

Described simply as "wool" on fiber labels, it has a scaly exterior. While these scales protect the fiber, they can also make it feel itchy. Sheep's wool is also prone to shrinkage and felting (pilling) if it isn't cared for properly. Still, it's perfect for winter wear since it's so warm — it traps air, providing good insulation. You'll also often find that it's less expensive (and more widely available) than other knits on the market.

Lambswool

Comes from: Lamb

Not to be confused with sheep's wool, lambswool is the wool from the first shearing of a sheep when it's just several months old. The fresh wool is extra soft, smooth, and resilient, meaning it won't wrinkle as easily. It's rarer since you can only shear a baby sheep's virgin hair once, thus it's more expensive.

Merino

Comes from: Merino sheep

Compared to sheep's wool, merino wool is finer and has smaller scales, so it's not as bulky. And, because it's full of finer fibers, there's less pilling and shrinkage. Merino is great at temperature regulation (keeping you warm when it's cold and cool when it's hot), so you'll find it year round. It's also popping up a lot in athletic gear. Yes, you can even rock wool during your workout.

Cashmere

Comes from: Cashmere goat

Often considered the most luxurious type of wool, cashmere is a fine fiber that is stronger, lighter, less itchy, and more durable than traditional sheep's wool. It provides excellent insulation yet can be worn in the spring and you won't overheat. Because it's rare and harder to produce than traditional wool, it's more expensive. One reason: Sometimes it takes the fibers from two cashmere goats to make just one sweater.

Mohair

Comes from: Angora goat

It has a silk-like texture, so it's very soft and shiny, but still has a lot of insulation to keep you warm. Unlike traditional wool, mohair doesn't have many scales, so it's smoother. It's also strong and resilient, so it won't wrinkle easily.

Angora

Comes from: Angora rabbit

Not to be confused with the goat, Angora rabbit fibers are hollow, meaning that while they are lightweight and fluffy, they still offer great insulation. In fact, they are much warmer than traditional wool and perfect for colder climates. However, because the fibers are more fragile you'll often find them as accents — perhaps on a collar only — or blended with other fibers to make it stronger. Angora is also rare and requires a lot of work to produce, so it's generally more expensive than other varieties.

Alpaca

Comes from: Alpaca (a llama-like mammal)

Alpaca wool is lightweight, soft, silky, and durable. It's similar to traditional sheep's wool but is warmer and less scaly. (Read: not as itchy.) There are two different types of Alpaca: Huacaya, which you'll find in knits, and Suri, which is silkier and often used in woven garments like suits. Unlike other types of wool, it's naturally available in a wide variety of colors (though it can still be dyed)

What Is Wool Fabric?

Wool fabric is made from the natural fibers that form the fleece of animals such as sheep, goats, rabbits, camels, and more. This raw material is primarily made up of keratin-based proteins, which makes wool a remarkably elastic material. After cotton and synthetic fibers, wool is one of the most common textiles in the world. The biggest appeal of wool garments is that they hold in heat extremely well. Additional benefits of wool include its durability and its versatility, as it can be woven into both heavy, coarse fabrics and lightweight, soft fabrics.

The Australian wool industry leads the world in wool production with 25 percent of the total global wool output. China and the United States are next, each with 18 percent, followed by New Zealand with 11 percent.

9 Different Types of Wool

The pros and cons of each type of wool depend on the animal it comes from

1. **Alpaca**: A versatile medium-weight wool fabric used for many purposes like high-end suiting, coats, blankets, outerwear lining, and bedspreads, alpaca wool is a lustrous material that's soft, lightweight, warm, and durable. There are two breeds of alpaca—Huacaya and Suri—that produce different types of wool: Huacaya fleece is thicker and often used for knit items, while Suri is silkier and used more in woven apparel.
2. **Angora**: Taken from the Angora rabbit (not the Angora goat which produces mohair wool), Angora wool is a soft and fluffy fiber that retains the most heat and has the best moisture-wicking ability of any natural fiber. Since Angora fibers are fragile, Angora is often blended with other fibers to make it stronger. Due to a combination of its valuable attributes and difficult cultivation process, Angora wool products are typically very expensive.

3. **Camel hair**: A luxurious and warm fine wool with a natural golden-brown color, camel hair is typically combined with other less expensive types of wool to make it softer and more economical. Camel hair coats first became popular in the United States among polo players in the 1920s. Today, the softer undercoat of camels is still used for coats and other apparel, while its coarser outer hair is used as backing for carpets and upholstery.
4. **Cashmere**: One of the most luxurious natural fibers, cashmere has a high natural crimp, which results in an incredibly soft and lightweight fabric. Cashmere is costly because it's difficult to obtain (fibers must be combed from cashmere goats instead of sheared), and the cashmere goat produces a very scarce amount of cashmere wool per year. One other downside of cashmere is that it's not as durable as sheep's wool.
5. **Lambswool**: Also known as "virgin wool" since it's taken from a baby sheep's first shearing when it's only several months old, lambswool is extremely smooth, soft, hypoallergenic, and is difficult to wrinkle. Since every sheep can only produce lambswool once, it's a rarer and more expensive wool to purchase.
6. **Melton**: One of the toughest and warmest wools available, Melton contains thick wool fibers and is typically woven into a twill weave. Melton is relatively wind-resistant and good at water-wicking, making it one of the more weatherproof wools and a prime choice for woolen outerwear and heavy blankets.
7. **Merino**: This superfine, shiny wool is one of the softest types of wool and is perfect for regulating body temperature in both cold and hot weather, making it a popular choice for athletic apparel. Merino wool comes from the Merino sheep, which is native to Spain but today has its largest populations in Australia and New Zealand.
8. **Mohair**: Sheared from the angora goat, mohair is a lustrous but durable wool that drapes well and is often woven into a plain weave. Despite being relatively lightweight, it has good insulation to keep you warm. Mohair is often used in dresses, suits, baby clothes, sweaters, and scarves.
9. **Shetland**: Cultivated from the undercoat of sheep native to Scotland's Shetland Islands, this wool is an ideal choice for knitting due to its durable but soft nature. It's lightweight, warm, and available in one of the largest ranges of natural colors of any breed of sheep

How Is Wool Fabric Manufactured?
The following are the main steps needed to manufacture wool.

1. **Shear the animal**. The first step in the wool production process is to sheer the fleece coat off the wool-bearing animal.
2. **Scour the wool**. Sheep wool in particular contains a fatty grease called lanolin which must be cleaned from the raw wool before it's spun into yarn. It's a time-consuming process that can be achieved by soaking the wool in warm water, but typically large wool producers use chemical additives to speed up the process.
3. **Sort the wool**. Once scoured, the clean wool is sorted into bales.
4. **Card the wool**. Carding is a process of separating and straightening the raw wool fibers into long strands in order to make it easier to spin into wool yarn. Carding can be done by hand or using carding machines.

5. **Spin the wool into yarn**. The next step is to spin the wool into yarn using a spinning machine and one of two spinning systems: the worsted system or the woolen system. Worsted wool has the air squeezed out of it, creating a smooth, dense, and even wool. Woolen wool, on the other hand, is spun with air between the fibers, creating a lighter, fuzzier, and irregular wool. After the wool yarn is formed, it's wrapped around cones, bobbins, or commercial drums.
6. **Weave the yarn**. The yarn is now ready to be woven into wool garments or other wool textiles. Woolen yarns are typically woven into fabric using a looser plain weave pattern, where worsted yarns are ideal for a more tightly woven twill weave pattern.

7. **Add the finishing touches**. Wool manufacturers may choose to put the final item through any number of procedures to improve the wool quality. For example, fulling is a process where the wool item is soaked in water to interlock its fibers. Crabbing is a process that perpetually keeps those fibers in place. Decating is a process that uses heat to shrink-proof the item.

Woollen fabric types

This A-Z guide to woollen fabrics – from clothes-press – covers fabric properties, main uses in sewing and washing care instructions.

Woollen fabrics are warm and comfortable to wear, and come in a variety of weights and textures. Fabric made from fibres spun from sheep wool is the most common, but you can also buy mohair, angora, cashmere (all from goats) and alpaca (similar to llamas). Woollen fabrics tend to be more expensive than cottons, and mostly need to be either hand washed or dry cleaned.

Main types of wool fabrics

- **Alpaca** - a soft medium-weight fabric with a loose weave and silky texture. Alapaca fibres are often mixed with sheep's wool and other fibres to create blends that have a soft, lustrous finish. Mainly used for coats and suits. *Care: dry clean and cool iron.*
- **Boiled wool** - this is a heavy-weight fabric which is produced by shrinking woven or knitted wool fabric (using water and mechanical agitation) to create a dense, non-fraying material with a textured surface. It's generally either pure wool or a wool-synthetic blend. As it's warm and weatherproof, boiled wool is mainly used to make cardigans, jackets and coats. *Care: gentle cool hand wash (don't wring or rub), avoid ironing.*
- **Cashmere** - a very soft, fine fabric that's comfortable and warm to wear. It's made from the fleece of the Kashmir goat, and is often used for scarves, like pashminas, as well as coats. *Care: hand wash or dry clean, avoid ironing.*
- **Challis** - this is a soft, lightweight, plain-weave wool that drapes well and is easy to handle. It may be plain or printed, often with floral or paisley patterns. It's main use is for dresses. *Care: hand wash and warm iron using a damp cloth.*
- **Coating** - a heavy-weight, bulky woollen fabric. Coating sometimes has quite a coarse weave and may have a napped, soft-textured surface. As the name suggests, its main uses are for coats and capes. *Care: dry clean, warm iron on wrong side using a damp cloth.*

- **Crêpe** - lightweight, fine, soft woollen fabric with an open weave and springy, textured surface. It drapes well and is used for dresses and suits. Crêpe can be a bit tricky to sew as it tends to stretch and slip. You'll need to adjust your stitch length and tension to avoid puckering – usually you need a longer stitch length and lower tension. *Care: hand wash or dry clean, warm iron on wrong side.*
- **Double coating** - heavy-weight, bulky reversible woollen fabric which is made from two layers woven together. It's mainly used to make casual coats and capes. *Care: dry clean, warm iron on wrong side using a damp cloth.*
- **Double jersey** – this is a medium-weight knit stretchy wool fabric. It has fine vertical ribs on both sides and is firmer than single jersey. It's mainly used for suits. *Care: hand wash or dry clean, warm iron on the wrong side using a damp cloth.*
- **Flannel** - medium-weight, strong wool fabric with a plain or twill weave. Like cotton flannel, it has a napped finish on one or both sides so is soft and cosy to the touch. Often used for suits, jackets, skirts and trousers. *Care: hand wash or dry clean, and warm iron on wrong side.*
- **Gabardine** - medium-weight, hardwearing fabric with a close twill weave. Gabardine may be pure wool or a mix of wool and other fibres such as polyester or cotton. It's mainly used for coats, jackets, skirts and trousers. *Care: dry clean, warm iron on wrong side using a damp cloth.*
- **Mohair** - produced from the fleece of the Angora goat, this is a heavy-weight, plain-weave fabric with a distinctive fluffy and hairy texture. It's generally mixed with sheep's wool and is mostly used for coats. *Care: hand wash or dry clean, cool iron on the wrong side with a dry cloth on the right side and a damp cloth next to the iron.*
- **Silk-wool mix** – medium-weight soft fabric which combines the softness of wool with the sheen and lustre of silk. Mainly used to make posh suits and jackets. *Care: dry clean, warm iron on wrong side using a pressing cloth.*
- **Single jersey** – a light- to medium-weight knit, stretchy wool fabric. It has fine horizontal ribs on the wrong side and vertical ribs on the right side. Its main uses are for casual clothes and children's wear. *Care: hand wash or dry clean, avoid ironing.*
- **Tartan** - a checked, twill-weave, medium-weight woollen fabric that comes in a wide variety of colour schemes. It's not difficult to handle but needs careful cutting out and sewing to match the checks across seams. Tartan is mainly used for kilts, skirts, coats, dresses and sometimes trousers. *Care: dry clean and warm iron on wrong side.*
- **Tweed** - traditional tweed is a heavy-weight, durable, coarse-textured fabric woven in mixed muted shades of wool. The fabric generally tends to be either plain-weave, twill or herringbone. It's traditionally associated with Scotland (such as Harris tweed) and Ireland (Donegal tweed). Modern tweed is a similar a thick, woven woollen fabric that is produced in a wider range of colours and patterns than traditional tweed. Tweed is most commonly used for coats, jackets and suits but is sometimes also used for skirts and dresses. *Care: hand wash very carefully or dry clean, warm iron on wrong side using a damp cloth.*
- **Venetian** - medium-weight wool fabric which is woven with either a twill or satin weave and has a shiny finish. Used to make dresses, skirts, jackets and suits. *Care: dry clean and warm iron.*
- **Wool felt** – a non-woven textile produced by matting and pressing fibres together. This creates a soft, dense non-fraying wool fabric which is generally medium- to heavy-weight. Can be pure wool or a wool-polyester mix. It's mostly used to make hats and slippers. Care: gentle cool hand wash (don't wring or rub), avoid ironing.

- **Worsted** – medium- to heavy-weight woollen fabric with a smooth surface. As it's tightly woven, it's hardwearing and doesn't sag easily so is mainly used for suits and coats. *Care: dry clean and warm iron using a damp cloth.*

Note on washing instructions

I've included general care instructions for each fabric but please check any information that comes with the fabric you're buying. Alternatively, test a sample to check that the general recommendations given here are right for your specific fabric. The temperatures given are the maximum suggested for each fabric – obviously you can do lower temperature washes if you prefer. Fabrics made from natural fibres can shrink quite a bit (sometimes 10%) when you first wash them, so do make sure you buy enough fabric to allow for this and pre-wash it before sewing.

SILK

History

According to Confucian text, the discovery of silk production dates to about 2700 BC, although archaeological records point to silk cultivation as early as the Yangshao period (5000–3000 BC).

In 1977, a piece of ceramic created 5400–5500 years ago and designed to look like a silkworm was discovered in Nancun, Hebei, providing the earliest known evidence of sericulture.Also, by careful analysis of archaeological silk fibre found on Indus Civilization sites dating back to 2450–2000 BC, it is believed that silk was being used over a wide region of South Asia. By about the first half of the 1st century AD, it had reached ancient Khotan, by a series of interactions along the Silk Road.

By AD 140, the practice had been established in India. In the 6th century AD, the smuggling of silkworm eggs into the Byzantine Empire led to its establishment in the Mediterranean, remaining a monopoly in the Byzantine Empire for centuries (Byzantine silk).

In 1147, during the Second Crusade, Roger II of Sicily (1095–1154) attacked Corinth and Thebes, two important centres of Byzantine silk production, capturing the weavers and their equipment and establishing his own silkworks in Palermo and Calabria, eventually spreading the industry to Western Europe.

SILK - AN INTRODUCTION

"If fashion is a fine art, then silk is its biggest canvas,and if silk is the canvas, then all its weavers, dyers,designers, embroiders are the greatest artists"

Silk is a natural fibre and was amongst the earliest fibres discovered by man with others being wool, hemp, linen and cotton. Silk is a fibroin made of proteins secreted in the fluid state as single filament by a caterpillar, popularly known as 'silkworm'. These silkworms feed on the selected food plants and spin cocoons as a 'protective shell' to perpetuate the life. Silkworm has four stages in its life cycle *viz.*, egg, silkworm, pupa and moth. Man interferes this life cycle at the cocoon stage to obtain the silk, a continuous filament of commercial importance, used in weaving of the dream fabric.

Life cycle of the silkworm

Silk has several natural properties that make it distinct from all other fibres both natural and man made. It has a natural sheen, and inherent affinity to rich colours, high absorbance, light weight yet stronger than a comparable filament of steel, poor heat conduction that makes it warm in the winter and cool in summer, low static current generation, resilience and an excellent drape.

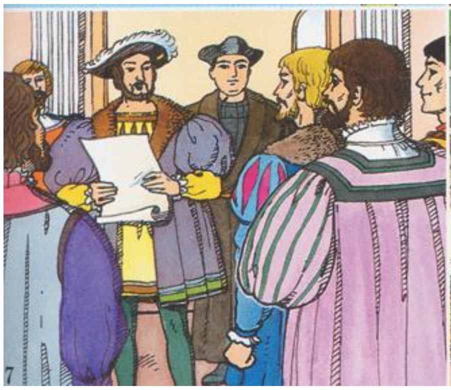
Various types of silks produced for a diverse range of applications like fashion apparel, furnishings and upholstery, carpets and rugs and silk is also blended with other fibres to manufacture fabrics. Another important uses of silk are the sewing, knitting and embroidery sectors among others.

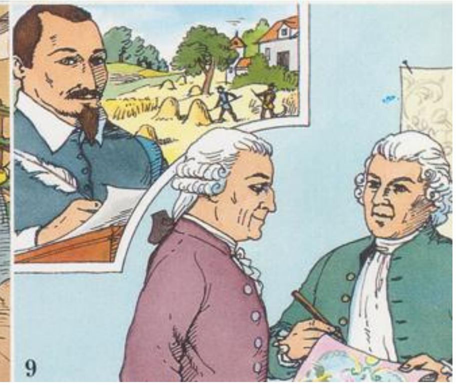
EVOLUTION OF SILK

Historical evidence shows that silk was discovered in China and that the industry spread from there to other parts of the world. Mankind has always loved this shimmering fibre of unparalleled grandeur from the moment Chinese Empress Shiling Ti discovered it in her tea cup during 2640 BC. The earliest authentic reference to silk is to be found in the Chronicles of Chou-King (2200 BC), where silk figured prominently in public ceremonies as a symbol of homage to the emperors.

The silk industry originated in the province of Chan-Tong and the secret was jealously guarded by the Chinese for about 3000 years. When commercial relations were established between China and Persia, and later with other countries, the export of raw silk and silk goods assumed greater importance. Traders from ancient Persia (now Iran) used to bring richly coloured and fine textured silks from Chinese merchants through hazardous routes interspersed with dangerous mountainous terrains, difficult passes, dry deserts and thick forests. Though, commodities like amber, glass, spices and tea were also traded along with silk, which indeed rapidly became one of the principal elements of the Chinese economy and hence, the trade route got the name 'SILK ROUTE'.

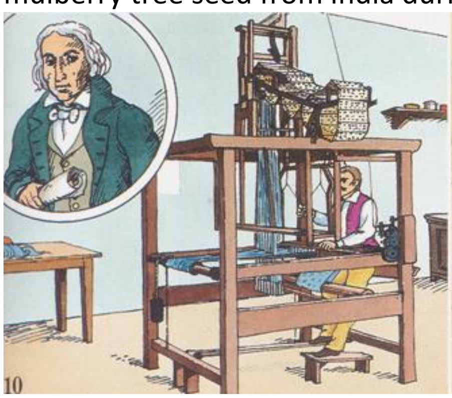
According to some sources, the first country after China to learn the secret was Korea, where Chinese immigrants started sericulture in about 1200 BC. The industry later spread to Japan. According to another version, what was instrumental in bringing the silk industry to Japan during the third century B.C. was when Semiramus, a General in the army of Empress Singu-Kongo, invaded and conquered Korea. Among his prisoners were some sericulturists whom he brought back to Japan. Under royal patronage the industry continued, through haltingly, till the Meiji Restoration in 1868. During the latter part of the 19th century, Japan gave serious attention to the development of the industry by introducing the use of modern machinery and improved techniques and carrying out intensive research in sericulture science. The industry is said to have spread to Tibet when a Chinese princess, carrying silkworm eggs and mulberry tree seeds in her headdress, married the king of Khotan in Tibet. From Tibet the industry spread slowly to India and Persia.

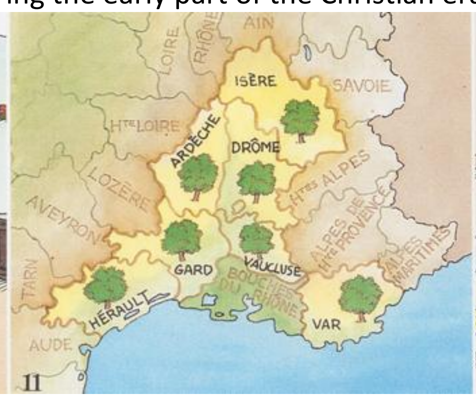


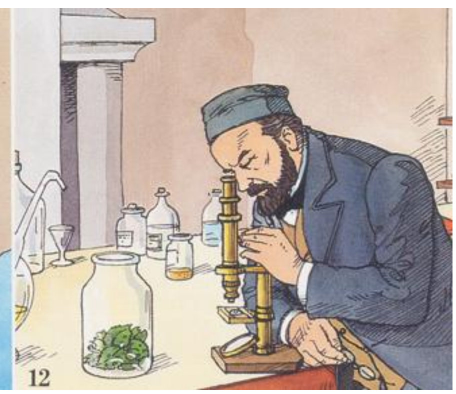


By the first century B.C. markets as far in southern Europe began to receive silk fabrics made in the East. According to Western historians, mulberry tree cultivation had spread to India through Tibet by about 140 B.C. and the cultivation of mulberry trees and the rearing of silkworms began in the areas flanking the Brahmaputra and Ganges rivers. According to some other Indian scholars, silkworms *(Bombyx mori)* were first domesticated in the foothills of the Himalayas. There is also evidence in ancient Sanskrit literature that certain kind of wild silks were cultivated in India from time immemorial. After the British arrival in India the silk industry had flourished and spread to many other areas like, Mysore, Jammu & Kashmir, etc.

The Arabs were also familiar with silkworms and even in Pre-Islamic times studied the life history of the silkworm. It has been suggested on the basis of early legends that the Arabs obtained silkworm eggs and mulberry tree seed from India during the early part of the Christian era.

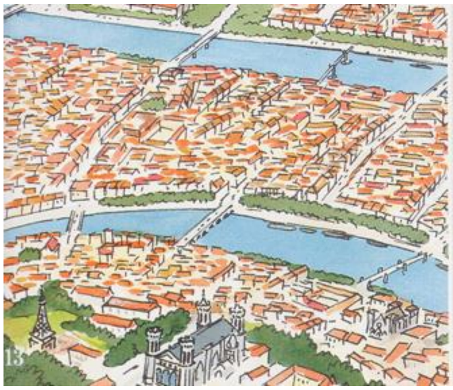


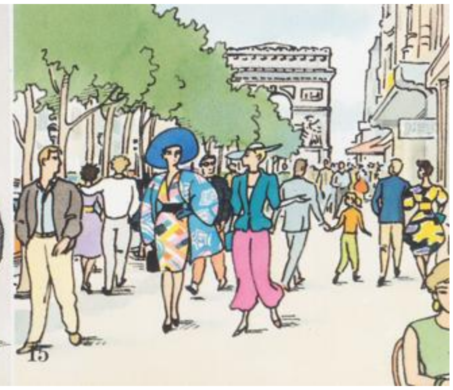




By the fourth century A.D., sericulture was well established in India and Central Asia. Raw silk and silken goods were exported from the East to Persia and then to Rome. The Persians held a monopoly on some of the silken goods most prized by Roman society but in the 6th century A.D. two monks from Rome, having learnt the art of sericulture in Tibet, introduced the industry into Constantinople in 553 A.D. The Romans were thus able to produce their own raw silk and this marked the beginning of silk production in Europe. For three or four centuries, the rearing of silkworms was confined to the eastern areas of the Roman Empire and factories were set up in Athens, Corinth, and the Aegean Islands for manufacture of silk fabrics.

The industry moved gradually from the east to the Venetian Republic and by the end of the ninth century and during the tenth and eleventh centuries the Venetians developed the industry to such an extent that they were able to meet almost the entire requirements of Europe.





From Italy, the industry spread to France where silkworm rearing was introduced in 1340 by French noblemen who brought in the silkworm eggs and the mulberry tree seeds. The industry was firmly established in France by the end of 17th century and prospered during the 18th century. In 19th century, when sericulture was at its peak in France, an epidemic called pebrine – a destructive disease of silkworms – broke out and wiped out sericulture not only in France but major part of Europe and the Middle East. Sir Louis Pasteur in 1870 discovered that pebrine could be controlled by the examination of mother moth that saved the industry from extinction. Although the industry revived to some extent in France, it was not a complete revival mainly because of socio-economic changes and industrialisation.

Silk dates back thousands of years, and still to this day is highly regarded as one of the most valuable, luxurious fabric. Even after all of those years, little has changed in the way silk is produced.

Despite advances in production method technologies, silk production still very much remains a labour intensive process, and a lot of hard work is involved.

What is silk made of?

While there are now a huge variety of different types of insects used to produce silk, the most commonly used species is the larvae of 'Bombyx mori' – (*the caterpillar of the domestic silkmoth)*. These incredible silkworms produce one of the most highly sought after materials with a plethora of excellent properties.

While silk is lustrous and lightweight, it's also impressively strong, with one filament of silk being stronger than a comparable filament of steel.

How is silk made?

Here is a step-by-step guide to the fascinating process in which silk is produced…

1. Sericulture

This is the term used to describe the process of gathering the silkworms and harvesting the cocoon to collect the materials.

Female silkmoths lay anything from around 300 – 500 eggs at any one time. These eggs eventually hatch to form silkworms, which are incubated in a controlled environment until they hatch into larvae (caterpillars).

The silkworms feed continually on a huge amount of mulberry leaves to encourage growth. It takes around 6 weeks to grow to their full potential (about 3 inches). At this time, they'll stop eating and begin to raise their heads – that's when they're ready to spin their cocoon.

Attached to a secure frame or tree, the silkworm will begin spinning its silk cocoon by rotating its body in a figure-8 movement around 300,000 times – a process which takes around 3 to 8 days. Each silkworm produces just one single strand of silk, which measures about 100 metres long and is held together by a type of natural gum, called sericin.

Did you know? It takes around 2,500 silkworms to produce one pound of raw silk.

2. Thread extraction

Once the silkworms have spun their cocoon, they will eventually enclose themselves inside it and then it's time to extract the silk threads.

The cocoons are placed into boiling water in order to soften and dissolve the gum that is holding the cocoon together. This is a crucial step in the silk production process as it ensures that there is no damage to the continuity of each thread.

Each thread is then carefully reeled from the cocoon in individual long threads, which are then wound on a reel. Some of the sericin may still remain on the threads to protect the fibres during processing, but this is usually washed out with soap and boiling water.

3. Dyeing

When the silk threads have been washed and degummed, they will be bleached and dried before the dyeing process commences.

Traditional silk dyeing techniques take the dyes from natural resources found in the surrounding environment, such as fruit or indigo plant leaves. The threads will be soaked together in bundles, inside a pot of hot indigo leaves and water. This process will occur multiple times over a span of days to ensure proper colour tone and quality.

However, these traditional dyeing methods have almost become extinct in the commercial manufacturing of silk. Advances in technology mean that manufacturers instead opt for using various dyes such as acid dyes or reactive dyes. This gives a greater range of choice in colours and shades to be able to serve wider demand.

That being said, the general idea behind the technique remains similar as the silk is immersed in a dye bath to soak up the colour. The silk may be fed into the bath through two cylinders, or fixed to a round jig which is immersed in the bath.

In many cases, this will be one of the last steps of the processes as manufacturers generally now prefer piece-dyeing in an attempt to reduce waste.

By holding plain white stock ready to be dyed, it reduces the need to hold too much stock in specific colours that have not been ordered and so may never be used.

Here at Biddle Sawyer Silks we hold large quantities of our silks in various colours in order to be able to provide an immediate service with next day delivery on silk we already have in stock. We also work with clients who provide their own bespoke colour palettes, and are able to match their samples via lap dips.

4. Spinning

The traditional spinning wheel has always, and will always be an integral part of the silk production process. Although updated industrial processes are now able to spin silk threads much quicker, it simply mimics the functions of the classic spinning wheel.

The process of spinning essentially unwinds the dyed fibres on to a bobbin, so that they lay flat ready for the weaving process. This can be done in many different ways from hand-spinning to ring-spinning and mule spinning.

5. Weaving

Weaving is the process in which the final piece of silk comes together. There are many different ways in which silk can be woven – satin weave, plain weave and open weave are most common, and the finish of the silk will depend on the type of weave.

Generally, weaving involves interlacing two sets of threads so that they lock around each other and create a strong, uniform piece of fabric. The threads will be woven at right angles to each other, and the two different angles are called a warp and a weft. The warp will run up and down the fabric, while the weft runs across it.

6.Printing

Should a piece of silk require a special pattern or design, it will need to be printed after pre-treatment. This can be done in two different ways: **Digital Printing** or **Screen Printing**.

Digital silk printing uses a specially designed textile printer, using ink to transfer hand drawn or digitally produced artwork on to fabrics.

Screen printing is the traditional, more hands-on method of essentially creating the same outcome – though in some cases, a bolder, more vibrant look may be achieved due to a thicker application of ink.

Read more: Digital Silk Printing – The process explained

7. Finishing

In order to be deemed ready for use, silks must be finished. Finishing a piece of silk gives it that highly lustrous sheen that it is so commonly known for, and is the reason that the desired look and feel can be achieved.

Silk finishing can be done in many different ways, mainly by applying different chemical treatments which can add a host of valuable properties including fire resistance and crease-proofing.

TYPES OF SILK

There are four types of natural silk which are commercially known and produced in the world. Among them mulberry silk is the most important and contributes as much as 90 per cent of world production, therefore, the term "silk" in general refers to the silk of the mulberry silkworm. Three other commercially important types fall into the category of non-mulberry silks namely: Eri silk; Tasar silk; and Muga silk. There are also other types of non-mulberry silk, which are mostly wild and exploited in Africa and Asia, are Anaphe silk, Fagara silk, Coan silk, Mussel silk and Spider silk.

Mulberry silk

Bulk of the commercial silk produced in the world comes from this variety and often generally refers to mulberry silk. Mulberry silk comes from the silkworm, *Bombyx mori* L which solely feeds on the leaves of mulberry plant. These silkworms are completely domesticated and reared indoors. Mulberry silk contributes to around 90 percent of the world silk production.

Non-Mulberry Silk

Tasar silk

The tasar silkworms belong to the genus Antheraea and they are all wild silkworms. There are many varieties such as the Chinese tasar silkworm Antherae pernyi Guerin which produces the largest quantity of non-mulberry silk in the wo Antheraea mylitte Dury, next in importance, and the Japanes tasar silkworm Antheraea yamamai Querin which is peculia to Japan and produces green silk thread.

The Chinese and Japanese tasar worms feed on oak leaves and other allied species. The Indian tasar worms feeds on leaves of Terminalia and several other minor host plants. The worms are either uni- or bivoltine and their cocoons like the mulberry silkworm cocoons can be reeled into raw silk.

Eri silk

These belong to either of two species namely *Samia ricini* and *Philosamia ricini*. *P.ricini* (also called as castor silkworm) is a domesticated one reared on castor oil plant leaves to produce a white or brick-red silk popularly known as Eri silk.

Since the filament of the cocoons spun by these worms is neither continuous nor uniform in thickness, the cocoons cannot be reeled and, therefore, the moths are allowed to emerge and the pierced cocoons are used for spinning to produce the Eri silk yarn.

Muga silk

The muga silkworms (Antheraea assamensis) also belong to the same genus as tasar worms, but produce an unusual golden-yellow silk thread which is very attractive and strong. These are found only in the state of Assam, India and feed on Persea bombycina and Litsaea monopetala leaves and those of other species.

The quantity of muga silk produced is quite small and is mostly used for the making of traditional dresses in the State of Assam (India) itself.

Anaphe silk

This silk of southern and central Africa is produced by silkworms of the genus Anaphe: A. moloneyi Druce, A. panda Boisduval, A. reticulate Walker, A. ambrizia Butler, A. carteri Walsingham, A. venata Butler and A. infracta Walsingham. They spin cocoons in communes, all enclosed by a thin layer of silk.

The tribal people collect them from the forest and spin the fluff into a raw silk that is soft and fairly lustrous. The silk obtained from A. infracta is known locally as "book", and those from A. moleneyi as "Trisnian-tsamia" and "koko" (Tt). The fabric is elastic and stronger than that of mulberry silk. Anaphe silk is used, for example, in velvet and plush.

Fagara silk

Fagara silk is obtained from the giant silk moth Attacus atlas L. and a few other related species or races inhabiting the Indo-Australian bio-geographic region, China and Sudan. They spin light-brown cocoons nearly 6 cm long with peduncles of varying lengths (2-10 cm).



Coan silk

The larvae of *Pachypasa atus* D., from the Mediterranean bio-geographic region (southern Italy, Greece, Romania, Turkey, etc.), feed primarily on trees such as pine, ash cypress, juniper and oak.

They spin white cocoons measuring about 8.9 cm x 7.6 cm. In ancient times, this silk was used to make the crimson-dyed apparel worn by the dignitaries of Rome; however, commercial production came to an end long ago because of the limited output and the emergence of superior varieties of silk.


Mussel silk

Whereas the non-mulberry silks previously described are of insect origin, mussel silk is obtained from a bivalve, Pinna squamosa, found in the shallow waters along the Italina and Dalmatian shores of the Adriatic.

The strong brown filament, or byssus, is secreted by the mussel to anchor it to a rock or other surface. The byssus is combed and then spun into a silk popularly known as "fish wool". Its production is largely confined to Taranto, Italy.


Spider silk

Spider silk – another non-insect variety – is soft and fine, but also strong and elastic. The commercial production of this silk comes from certain Madagascan species, including *Nephila madagascarensis, Miranda aurentia* and *Epeira.* As the spinning tubes (spinne-rules) are in the fourth and fifth abdominal segments, about a dozen individuals are confined by their abdominal part to a frame from which the accumulated fibre is reeled out four or five times a month. Because of the high cost of production, spider silk is not used in the textile industry; however, durability and resistance to extreme temperature and humidity make it indispensable for cross hairs in optical instruments.

Production

The silkworms are fed with mulberry leaves, and after the fourth moult, they climb a twig placed near them and spin their silken cocoons. The silk is a continuous filament comprising fibroin protein, secreted from two salivary glands in the head of each worm, and a gum called sericin, which cements the filaments. The sericin is removed by placing the cocoons in hot water, which frees the silk filaments and readies them for reeling. This is known as the degumming process.[8] The immersion in hot water also kills the silkmoth pupa.

Single filaments are combined to form thread, which is drawn under tension through several guides and wound onto reels. The threads may be plied to form yarn. After drying, the raw silk is packed according to quality.

Stages of production

The stages of production are as follows:

The female silkmoth lays 300 to 500 eggs.

The silkmoth eggs hatch to form larvae or caterpillars, known as silkworms.

The larvae feed on mulberry leaves.

Having grown and moulted several times, the silkworm extrudes a silk fibre and forms a net to hold itself.

It swings itself from side to side in a figure '8', distributing the saliva that will form silk.

The silk solidifies when it contacts the air.

The silkworm spins approximately one mile of filament and completely encloses itself in a cocoon in about two or three days. The amount of usable quality silk in each cocoon is small. As a result, about 2,500 silkworms are required to produce a pound of raw silk.

The intact cocoons are boiled, killing the silkworm pupa.

The silk is obtained by brushing the undamaged cocoon to find the outside end of the filament.

The silk filaments are then wound on a reel. One cocoon contains approximately 1,000 yards of silk filament. The silk at this stage is known as raw silk. One thread comprises up to 48 individual silk filaments.

Mahatma Gandhi was critical of silk production based on the Ahimsa philosophy "not to hurt any living thing". He also promoted "Ahimsa silk", made without boiling the pupa to procure the silk and wild silk made from the cocoons of wild and semiwild silkmoths.[10][11] The Human League also criticised sericulture in their early single "Being Boiled". In the early 21st century, the organisation PETA has also campaigned against silk.

Silk is produced by various insect ,but by the largest quantity comes from the silk worm .this is the silk worm which feeds on mulberry leaves and forms a cocoons of silk before pupating

The threads from several cacoons are subsequently wound together to form a single strand of raw silk this fine tr=hreads is the basic component of all silk yarn and fabric .some and the gum which the silk worm uses tohold the cacoon together ,remains to assist the delicate fiber during processing it's subsequently washed away

SERICULTURE

Sericulture

A branch of agriculture, the raising of silkworms for their cocoons, which are the raw materials used in the ma nufacture of silk.

In the USSR the domesticated Asiatic silkworm moth *Bombyx mori* is cultivated; other countries also use the co coons of some wild silkworms (*Antheraea pernyi, Philosamia cynthia*, and *Philosamia ricini*).

The raising of Asiatic silkworm moths to obtain silk began about 5,000 years ago in China.

In the territory of what is now the USSR, sericulture developed in Middle Asia and Transcaucasia between the f ifth and seventh centuries.

In Russia silkworm raising was mainly concentrated in the households of peasants; the facilities were usually n ot large, producing 10–15 g of silkworm eggs.

The first large

Scale specialized sericultural sovkhozes were established in the USSR. State silkworm egg farms, centers for th e primary processing of cocoons, and silk
reeling factories have also been built, and state and kolkhoz silkworm farms have been organized.

A unified state system has been created for breeding and pedigree work and for the procurement and primary processing of cocoons. Soviet scientists have developed highly productive white-
cocoon breeds and hybrids of silkworms and highly productive varieties of mulberry trees; more effective met hods for cultivating the trees have also been developed. Such efforts have resulted in an average yield of 56–57 kg of cocoons per box of silkworm eggs containing 29 g of eggs. Cocoon production was 34,800 tons in 196 5 and 45,000 tons in 1976. The production of raw silk totaled 2,600 tons in 1965 and 3,400 tons in 1976.

Production processes in sericulture include cultivation of mulberries, the leaves of which are the only food for the larvae of the silkworm moth , production of silkworm eggs incubation and hatching of the eggs; rearing of the silkworms; and primary processing of cocoons, including killing and drying.

Incubation takes place in incubators having a capacity of 150-
200 boxes of silkworm eggs. It is timed to coincide with the appearance of the first five-
six leaves on the mulberry trees. The hardiest larvae obtained in the course of the first three days of hatching are kept for rearing. The silkworms are reared in special breeding houses, where a constant temperature and humidity are maintained according to the age of the silkworms. Larvae in the first three stages of growth are f ed chopped leaves and young shoots. An average of 17–
18 kg of leaves is needed to produce a 1 kg cocoon; 11–12 kg of leaves suffices on the best-run farms.

Feeding is halted during the periods of sleep and molting, and the temperature is raised somewhat.

Rearing is completed in approximately 35 days; the best-run farms complete rearing in 22-
25 days. The majority of the cocoons are obtained from the spring generation. On some farms in the Ukraine, Moldavia, and the Northern Caucasus, several generations are reared by using the silkworm eggs of the hardiest varieties and hybri ds and by planting the mulberries so that they produce young leaves during the period from summer to fall.

The aim of selective breeding in sericulture is the development of new, highly productive varieties. A notable a chievement in the selective breeding of silkworms has been the genetic development of varieties that, when c rossed, lay viable eggs of only the male sex. The males produce cocoons with more silk, and such an advance e liminates the labor-

Intensive operation of sorting out female eggs. Of crucial importance in the development of sericultural

selective breeding were the works of B. L. Astaurov on the regulation of sex and the development of polyploid strains of silkworms, the introduction of commercial hybridization, and the use of the biological effects of ther mal shock

to disinfect live silkworm eggs infected with the pathogenic organism of pébrine (*Nosema bombycis*). Research i n selective breeding is conducted at the Middle Asia Scientific Research Institute of Sericulture in Tashkent, the Azerbaijan Scientific Research Institute of Sericulture in Kirovabad, the Georgian Agricultural Institute, various i nstitutes of the academies of sciences of the USSR and of the Union republics, and test stations. Sericultural sta tions or the corresponding shops on silkworm egg farms are responsible for increasing the number of silkworm varieties and improving their economic characteristics.

World production of silkworm cocoons totaled 438,700 tons in 1938 and 270,000 tons in 1974. Other major pr oducers include Japan (106,000 tons in 1974), China (90,000 tons), and India (30,000 tons). Sericulture is also d eveloped in Korea, Indochina, southern Europe, and Brazil.

Sericulture industry is the combination of agriculture, animal husbandry, cottage industry and pure textile activities. The quality of end products directly relates to any minute variations taking place in all these varied phases, which calls for careful planning, skill requirement and an effective delivery mechanisms at the governmental and private sectors. There are many activities termed as components in the silk industry.

Food Plant Cultivation

Mulberry, the food plant of mulberry silkworm is cultivated following the prescribed package of practices evolved by the research institutes over the years. Mulberry is a perennial crop which can easily give yield for 25-30 years. Mulberry grows in almost all types of soil, but the plantation requires sufficient exposure to sun, organic inputs and availability of water in sufficient quantities. Mostly mulberry is cultivated in bush form and in some areas as trees. It is generally pruned twice in a year and the leaves can be harvested five times in a year.

The food plants of the non-mulberry silkworms are mostly found in the nature. However, systematic plantations of some of these food plants are done in many countries to enhance productivity, thereby making the avocation economically viable. These food plants are cultivated in forest fringe areas and other places which are found to be unsuitable for food crop cultivation.

Rearing

Mulberry silkworm rearing is generally conducted in indoor as an animal husbandry occupation. The rearing is a complex process wherein the various factors like, temperature, humidity, leaf quality, rearing house, control of diseases, etc., play a vital role for a successful crop. The leaves or twigs are brought from the field and feed to the silkworms in separately erected platforms or trays. After the gestation period of about 25 to 28 days, the matured worms are picked up and transferred into the mountages for spinning the cocoons. The spinning process will be completed within three days and the cocoons can be harvested for marketing after five days. The mulberry and eri silkworms are reared in this fashion in separate rearing houses.

In case of Tasar and Muga, the young age silkworms are transferred to naturally grown trees to feed on the leaves and to form cocoons there itself. The gestation period of the rearing is about 30 days. The cocoons are then harvested manually by the farmers.

Seed Production

Healthy seed is the backbone of sericulture industry. Poor seed health is the primary reason for poor productivity. Seed, at the same time, may act as one of the main vehicles for dissemination of diseases. Seed-borne pathogens, such as protozoa, fungi, bacteria and viruses are serious constraints to sericulture industry. Hence, healthy seed material, free from diseases and having high viability is essential for establishing the crop in the first instance. And also availability of quality silkworm seed in adequate quantities is the pre-requisite in achieving the targeted silk production besides improving upon the productivity parameters. To produce quality seed, it is very important to adopt scientific methods of egg production right from seed crop rearing to egg incubation.

The silkworm seeds are produced through a four-tier seed multiplication network to retain the inherent genetical characters like hybrid vigour and disease freeness. While the breeders stock is supplied by the R & D institutions (first level), the basic seeds in the next three levels are produced in different basic seed farms. The commercial seeds are produced in the seed multiplication centres from the F1 seed supplied from the basic seed farms.

The seed is produced in specially designed buildings called as Seed Production Centres. There are various production processes like cocoon selection, cocoon preservation, ovi position, egg laying, moth examination, etc. In case of the nucleus and basic seed production units, separate plantations are maintained for undertaking seed cocoon rearing. For the production of commercial seeds, the seed cocoons are mostly reared among the seed cocoon farmers.

Reeling

Reeling is the process at which the compact untwisted and undegummed silk thread is formed by combining the required number of silk filaments drawn from as many separate cocoons by a special technique. There is a series of skilled operations dealing with the raw material which is composed of extremely fine continuous silk filament of great length unlike other natural textile fibres. Reeling demands constant attention and care on the part of the reeler since during the process of reeling the cocoon filament may break continuously and the reeler must properly attach and fresh filament which is always kept ready in reserve. However nowadays with the introduction of Automatic Reeling Machines, there is an automated system to pick up the cocoons during the breakage of cocoons.

The art of reeling is believed to have originated in China nearly 3000 years back. Reeling is generally done as a cottage industry in most of the developing countries. Different types of machines are used for the reeling activities. The most recent one is the Automatic Reeling Machines (ARM) which are very famous in China. But, the countries like India and Thailand, the traditional machineries like charkha, cottage basin and multi-end reeling machines continue to dominate the reeling industry.

The Muga and Tasar silks are also generated through silk reeling. However, Eri silk yarn is produced by spinning of cut cocoons.

Marketing

In most of the countries cocoons and raw silk are transacted through Government owned cocoon markets silk exchanges to ensure transparency and fair pricing in trading.

Throwing

Silk throwing is the industrial process where silk that has been *reeled* into skeins, is cleaned, receives a twist and is wound onto bobbins. The yarn is now twisted together with threads, in a process known as *doubling*. Colloquially silk throwing can be used to refer to the whole process: reeling, throwing and doubling. Silk had to be thrown to make it strong enough to be used as '*organizine'* for the warp in a loom, or *tram* for weft.

Wet Processing

Wet process is usually done on the manufactured assembly of interlacing silk fibers, filaments, and/or silk yarns having substantial surface (planar) area in relation to its thickness, and adequate mechanical strength to give it a cohesive structure. In other words, wet process is done on manufactured silk fabric. The processes of this stream is involved or carried out in aqueous stage and thus it is called silk wet process which usually covers pre-treatment, dyeing, printing and finishing.

All these stages are required aqueous medium which is created by water. A massive amount of water is required in these processes per day. It is estimated that, on an average, almost 100 liters of water is used to process only 1 kg of silk goods. Water can be of various quality & attributes. Not all water can be used in the process; it must have some certain properties, quality, color & attributes for being used in the processes. Hence, water is a prime concerned in silk wet processing.

Silk Weaving

Weaving is the operation which creates a fabric by interlacing the wrap yarns (lengthwise) and the weft yarns. Weaving is carried out on looms, after a series of preliminary operations including warping and pirning. Weaving in silk industry is generally done in handlooms and powerlooms. The powerlooms are mostly prevalent in China. In India, 60% of the silk weaving is done on handlooms and the handloom products are geographically famous for its unique designs and weaving patterns. In Thailand, the handloom weaving is very strong and the designs produced by Thai weavers are exclusive and famous across the world.

Enormous improvements have been made in improving not only the machines but also the loom itself. Automatic weaving machines, machines for weaving wider fabrics, shuttle less looms, Jacquard looms, etc., are some of the advancements in this direction.

Dyeing

Dyeing is the process of adding colour to silk fibres, yarns, and fabrics. Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have uncut chemical bond with fiber molecules. The temperature and time controlling are two key factors in

dyeing.

There are mainly two classes of dye: (i) natural and (ii) man-made. Although, acid dyes have been traditionally used in silk, the trend is now changing with more focus on vegetable dyes. The ban on certain azo dyes in

European countries has reasoned the exporters to pay more attention to the selection and use of dyes to exported goods.

Printing

Printing consists of transferring a pattern to the fabric. The printing is carried on the following manner:
Block printing - Raised parts of the block transfer the dyestuff to the fabrics
Roller printing - Fabric to be passed through the rollers engraved with design
Screen printing - A fine gauze is stretched tightly over a metal frame, and the design to be reproduced is transferred to the gauze.
The pores in the gauze is partially blocked off allowing the dye stuff to be squeezed through the gauze where the design is to be printed
Discharge printing - Is the combination of dyeing and printing. While dyeing the fabric, those parts of fabric to be decorated are protected by resin which is later removed, and the 'holes' are printed over the design. Alternatively, the base fabric is completely dyed, the dye is then removed from the parts to be decorated, and the design is then printed over
Hand printing - A handicraft activity
Spray printing - The dyestuff is sprayed directly on the fabric covered with stencils
Warp printing - Only the warp yarns are printed before weaving

Finishing

All fabrics have to be finished with the exception of pattern weaves. It is the finisher who gives satin its shimmering suppleness and its 'hand'. Finishing gives a fabric the desired appearance and feel. There are numerous finishing processes, physical and chemical. Finishing includes treatments such as crease proofing, water proofing, fire proofing, etc.

Spun silk and silk noil

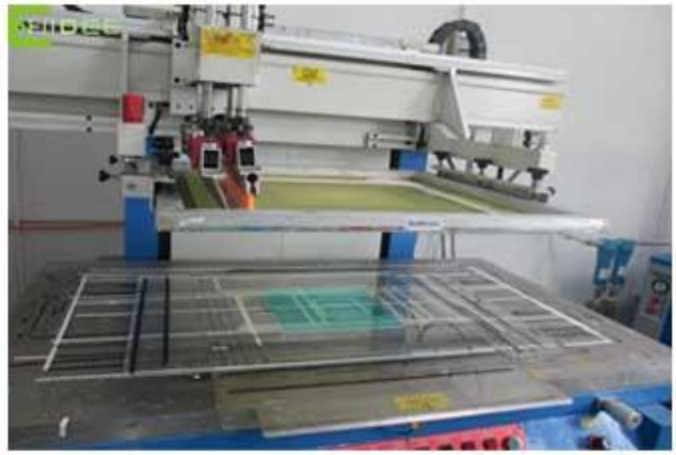
Silk waste includes all kinds of raw silk which may be unwindable, and therefore unsuited to the throwing process. The waste materials are partially boiled off to remove some of the gum, and are then carded and combed to make staple fibres parallel to each other. The resulting strips of fibre, silvers, are then transformed into yarn: the longer filaments become spun-silk, or schappe, and the shorter one silk noil.

Dupion silk

The double cocoons are reeled by special technique and give thicker, uneven silk yarn which when woven makes an irregualr appearance to the fabric. This fabric yarn is highly prized among the fashion designers.

Raw Silk Testing

Raw silk is tested and graded according to specified and accepted standards before marketing. Testing has been done generally in the testing houses operated by the Government and private agencies. At present, the cocoon testing evolved by the erstwhile International Silk Association has been followed in the world.



The raw silk classification is based on the grade, which is derived from the denier (thickness of silk in value terms) and other tests conducted for the purpose.
These grades are expressed in the order of 4A, 3A, 2A, A, B

MERITS OF SILK INDUSTRY

- ✓ The industry activities align with the 4 major Millennium Development Goals set by UN like; eradicate extreme poverty and hunger, promote gender equality and empower women, ensuring environmental sustainability, and develop a global partnership for development.
- ✓ High **Labour Force Participation Rate (LFPR)** in comparison to any other rural avocation due to which silk industry has emerged as the ideal tool for employment generation and rural development.
- ✓ Major participation (80%) by the tribal and downtrodden people, due to which significantly contribute to the poverty alleviation programmes of the Government.
- ✓ Participation of women (60%) and family members leads to higher income flow to the family.

- ✓ 60% of the income from the sericulture industry is flowing to the primary producers; i.e. farmers. Enable flow of equity from rich (the higher level consumers) to poor (the farmers, reelers, weavers etc.)
- ✓ Prevents urban migration and contribute to preserve the bio-diversity of rural areas and natural vanya food plant forest areas.

- ✓ Low investment and higher return, short gestation period, and steady income throughout the year.
- ✓ The activities are simple and can be taken by women and other family members along with their regular house hold chores.
- ✓ Eco friendly production process, increases green cover, helps soil conservation and prevents soil erosion.
- ✓ Carbon emitting is minimal as the industry is agro-based and labour intensive.

- ✓ Land unsuitable for food crop cultivation could be used for sericulture.
- ✓ The waste generated from the industry could be utilized various useful purposes.
- ✓ A strong and assured domestic demand for silk and silk products which is consistently in the upward trajectory for the last 5 decades.
- ✓ Increasing consumption of silk products witnessed in most of the developed countries leads to high demand in global market also.

Foreign exchange earning opportunity for the developing countries.

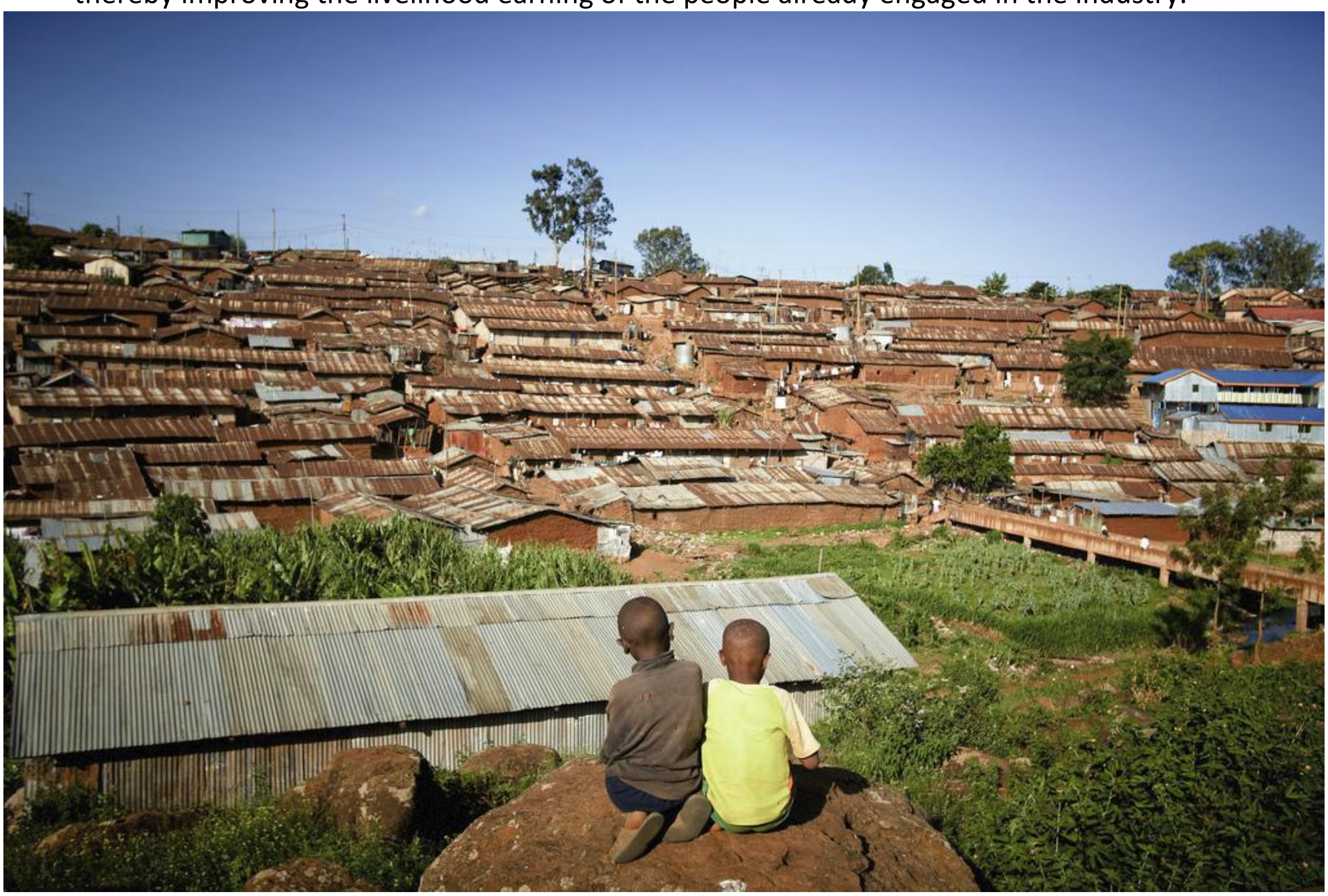
- ✓ Sericulture and Silk Industry is considered as an effective tool for poverty alleviation.
- ✓ The Labour Force Participation Rate in sericulture is highest in comparison to similar rural occupations.

The industry provides

As a developmental institution committed to improve the livelihood of the rural people, the International Sericultural Commission (ISC) has given priority to support its Member Countries and countries associated with silk industry to achieve few of the above goals through its various programmes. The Commission is mainly focusing on the following goals that can be achieved through the activities of Sericulture and Silk Industry.

Job opportunities to all family members, especially, women and elderly persons. It has the unique nature of converting family labour into useful income to the family. Hence, this occupation could bring significant revenue to the households, thereby helped several poverty stricken families in the rural areas, especially the marginalised population and forest dwellers.

- ✓ The sericulture and silk industry, per se is highly labour intensive and gives employment to mostly the tribal and the extremely backward rural people.
- ✓ Hence, the ISC has been making serious efforts to introduce sericulture practice in many poverty ridden areas of Africa, South Asia and Latin American Countries.
- ✓ Through continued efforts in R&D sector, the productivity and quality of silk has enhanced significantly thereby improving the livelihood earning of the people already engaged in the industry.



- ✓ The women participation in sericulture and silk industry is about 60%.
- ✓ By introducing the sericulture industry to larger areas, more women and family members are able to generate substantial income for the family.
- ✓ Many of the studies undertaken in China, Thailand and India proved that the sericulture and industry is an ideal tool for women empowerment and gender equality.

4) Climate Action

The sericulture is an agro based industry where the food plants of the silkworm need to be cultivated for undertaking the animal husbandry activities. Since, most of the food plants are perennial in nature; the cultivated area gives substantial green cover.

The industry is labour intensive and hence carbon emitting in the production process is very minimal. The industry need not compete with other agricultural crops as the land unsuitable for food crop cultivation could be used for sericulture. Thus, the industry contributes for the sustainability of environment like; eco friendly production process, increases green cover, helps soil conservation and prevents soil erosion.

5) Decent Work and Economic Growth

Since sericulture provides employment opportunities to people in different age groups, the occupation emerged as a alternative source of income to many under privileged people. The industry provides regular dependable income on a consistent basis. Most of the activities can be taken up indoor thereby making it as a decent occupation for a wide range of age groups and social stratum. The economic returns of the occupation directly benefits the family requirement as the family members are deeply associated in its various activities. This would ultimately benefit the economic growth of the family

6) Partnerships for the Goals

The Silk Industry plays a major role in creating global partnerships for development in various regions. The prime advantage of the silk industry is that the major consumers of the silk are from the developed countries and the affluent people of the other regions whereas the major silk producers are from the developing countries comprising the poor farmers, reelers and weavers. This would enable flow of equity from rich to poor. This mechanism of equity flow created major and critical partnerships among these divergent sectoral groups under the leadership of the Government agencies and other agencies. The International Sericultural Commission is playing a crucial role in building partnership among the various sectoral groups and other agencies to ensure that there shall be equitable growth for all the stakeholders of the silk value chain

STATISTICS

Global Silk Industry

The major silk producing countries in the world are; China, India, Uzbekistan, Brazil, Japan, Republic of Korea, Thailand, Vietnam, DPR Korea, Iran, etc. Few other countries are also engaged in the production of cocoons and raw silk in negligible quantities; Kenya, Botswana, Nigeria, Zambia, Zimbabwe, Bangladesh, Colombia, Egypt, Japan, Nepal, Bulgaria, Turkey, Uganda, Malaysia, Romania, Bolivia, etc.

The major silk consumers of the world are; USA, Italy, Japan, India, France, China, United Kingdom, Switzerland, Germany, UAE, Korea, Viet Nam, etc.

Even though silk has a small percentage of the global textile market - less than 0.2% (the precise global value is difficult to assess, since reliable data on finished silk products is lacking in most importing countries) - its production base is spread over 60 countries in the world. While the major producers are in Asia (90% of mulberry production and almost 100% of non-mulberry silk), sericulture industries have been lately established in Brazil, Bulgaria, Egypt and Madagascar as well. Sericulture is labour-intensive. About 1 million workers are employed in the silk sector in China. Silk Industry provides employment to 7.9 million people in India, and 20,000 weaving families in Thailand. China is the world's single biggest producer and chief supplier of silk to the world markets. India is the world's second largest producer. Sericulture can help keeping the rural population employed and to prevent migration to big cities and securing remunerative employment; it requires small investments while providing raw material for textile industries.

1. **Global Silk Production (in Metric Tonnes)**

#	Countries	2014	2015	2016	2017	2018
1	Bangladesh	44.5	44	44	41	41
2	Brazil	560	600	650	600	650
3	Bulgaria	8	8	9	10	10
4	China	1,46,000	1,70,000	1,58,400	1,42,000	1,20,000
5	Colombia	0.5	0.5	-	-	-
6	Egypt	0.8	0.8	1.2	1.1	1.25
7	India	28,708	28,523	30,348	31,906	35,261
8	Indonesia	10	8	4	2.5	2.5
9	Iran	110	120	125	120	110
10	Japan	30	30	32	20	20
11	North Korea	320	350	365	365	350
12	South Korea	1.2	1	1	1	1
13	Philippines	1.1	1.2	1.82	1.5	2
14	Syria	0.5	0.3	0.25	0.25	0.25
15	Thailand	692	698	712	680	680
16	Tunisia	4	3	2	2	2
17	Turkey	32	30	32	30	30
18	Uzbekistan	1,100	1,200	1,256	1,200	1,800
19	Vietnam	420	450	523	520	680
20	Madagascar	15	5	6	7	7
	Total	**178057.62**	**202072.83**	**192512.27**	**177507.35**	**159648.00**

.**SILK PRODUCTS**

Tasar materials

Spider silk product

Mulberry silk tops

Mulberry silk sarees

Zardosi table cloth

Muslin silk scarf

Tasar life style products

Tasar Upholstery and Cushions

Valets and Clutches

Emerald jersey dress

Silk ties

Eri Socks

Properties

Silk has a smooth, soft texture that is not slippery, unlike many synthetic fibers. **Silk** is one of the strongest natural fibers, but it loses up to 20% of its strength when wet. It has a good moisture regain of 11%. Its elasticity is moderate to poor: if elongated even a small amount, it remains stretched.

a)means silk is shine

b) length :the threads of silk is continued the cacoons gives 700 to 1000m of silk

c) finess : the threads is very fine

sthrengs of their determination determination : is very big ,the cacoon of 3gr give 1000m of the threads

QUANTITY

The biggest light and biggest smooth

Good elasticity

Good strength

CARE FABRIC

Washing Silk

Silk is a very delicate fabric, and you may feel nervous about washing any silk clothing you own. Although you need to give your silk scarf, blouse, or dress tender loving care on laundry day, you can keep your items beautiful and soft even when you wash silk at home. We'll take the anxiety out of washing silk and show you a few simple steps you can take to give this luxurious fabric the care it deserves.

How to Wash Silk: The Basics

How to Wash Silk: The Basics

When it comes to washing silk, there are a few rules you'll need to bear in mind to protect the garment you're washing. Whether you need to wash by hand or in a machine, it's important you keep the following in mind.

Check the instructions on the garment's fabric care label. The fabric care label tells you how that specific item needs to be washed and cared for.

Never wash with chlorine bleach. It can damage your clothing's natural fibers.

Do not dry in direct sunlight. Exposing your garment to long bursts of sunlight can cause the colors to fade or even damage your silk fabrics.

Do not tumble dry. Silk is very delicate and the high temperatures of the tumble dryer can shrink or damage your silks.

Use a detergent for delicates.

Studio by Tide Delicates Liquid Laundry Detergent has been specifically designed to take care of silk.

Check for colorfastness. Some silk garments may bleed in the wash, so test a damp area by dabbing with a wet, white cloth to see if any color leaks onto it.

Your fabric care label can tell you a lot about the garment. If the label says "Dry Clean," this is usually just a recommendation to take the item to a dry cleaner, but it's best to gently hand wash the garment if you chose to wash it at home. "Dry Clean Only" on the other hand means that the piece of clothing is very delicate, and it's safer to take it to a professional.

How to Wash Silk in a Washing Machine: Step-by-Step Instructions

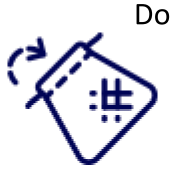
Despite what you've heard, you can wash silk in a washing machine. However, it's worth investing in a mesh bag to protect your delicate items from tangling or getting caught on other items during the wash. Follow the instructions for washing silk items in a washing machine.

1. Check the fabric care label

Before you put a silk item in the machine, check the tag to see if it can be machine washed. Some silk items may lose color or get damaged in the machine.

2. Sort the laundry

Don't wash silk and delicate fabric with heavy pieces of clothing like jeans.



3. Place silk items in a mesh bag

Using a delicates wash bag will protect your silks from any abrasive damage.

4. Load the machine

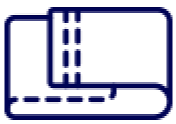
Make sure you leave enough of a gap to fit in a hand, so you don't overload the washing machine.

5. Add silk wash or delicate detergent

Studio by Tide Delicates Liquid Laundry Detergent is detergent specifically designed to care for your silk garments. Follow the dosing instructions on the bottle.

6. Start a delicate cycle

Your machine should have a delicate wash option, and also choose the shortest spin cycle and wash on the temperature recommended by the fabric care label.



7. Use a towel to soak up water after the wash

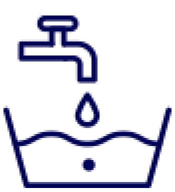
Take the garment out of the machine and use a towel to soak up excess moisture.

8. Hang garment or lay flat to dry

Depending on the garment, you will want to hang it up or lay it flat. Don't dry in direct sunlight.

How to Hand Wash Silk Clothes: Step-by-Step Instructions

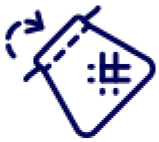
The safest way to wash delicate silk garments at home is to hand wash them. If the fabric care label tells you to "Dry Clean" or not machine wash, then it's best to wash by hand. Follow the step-by-step instructions below on how to hand wash silk.



1. Fill a basin with cool water

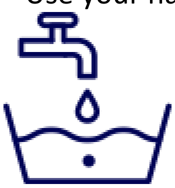
Take a basin or use the sink and fill it with lukewarm to cold water. Submerge the garment.

2. Add a few drops of detergent for delicates
Mix in a few drops of gentle detergent and use your hand to stir it into the solution.

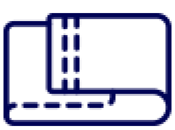


3. Soak the garment
Leave the item to soak for three minutes.

4. Agitate the item in the water
Use your hands and plunge the garment up and down in the water gently to remove any dirt.



5. Rinse in cold water
Take the garment out and get rid of the dirty water. Rinse the item under cold water till it runs clear and all the soap has been washed out.



6. Absorb excess water with a towel
Use a towel to soak up the moisture from your silk garment, but don't rub or agitate the item.

7. Hang the garment to dry
Place the item on a hanger or a drying rack and leave to dry out of the way of direct sunlight.

How to Remove Stains from Silk

What can you do if you get stains on silk? You may think you need high washing temperatures and a lot of agitation to get rid of any stains from silk, but luckily you can use a few tricks to remove stains and keep the garment looking beautiful.

Tip: *Spot* **How to Care for Silk After Washing**
Silk is a high maintenance fabric, but the steps you can take to keep it looking its best are simple and worth the effort. Apart from taking care of the garment when washing and drying, you can also do more to care for your silks, from handling wrinkles and creases to storing silk.

- Turn garment inside out and turn the iron to low heat or the silk setting.
- Only iron silk when dry.
- Put a cloth between the silk and the iron.
- Do not spray or wet silk when ironing.
- Hang silk garments in a cool, dry place.
- Store silk in a breathable plastic back if you're planning to put it away for a long time.
- Keep silk out of the sun.
- Use moth repellant when storing silk.

Silk is a beautiful, luxurious fabric so it's worth taking a few measures to care for it, however it's not the only delicate fabric that needs a little looking after. If you have other delicates like lace, wool, or sheepskin, they will also need special care in the laundry room. Fortunately, when it comes to cleaning washing and caring for delicate clothing, Studio by Tide is here to help

Use water soap and dry on sun

Pressing

How to Iron Silk in 4 Simple Steps

Silk has enjoyed a virtually unrivaled reputation as a luxury fabric, whether used in undergarments, dresses, or anything else. It's no wonder why silk is one of our favorite textures; it looks and feels incredible. Although, with luxury comes high-maintenance, and one of the trickiest aspects of silk is knowing how to keep it looking fresh and wrinkle-free. Whether you're laundering your favorite work blouse, packing a silk slip for your next getaway, or attempting to restore a vintage silk item, knowing how to iron silk is essential. Here's how to maintain your favorite silk garments to perfection.

1. Prep the Fabric
To help silk retain its texture and integrity, **the fabric must always be damp when ironing**. Keep a spray bottle handy and consider ironing the garment immediately after it's been hand-washed. **Turn the garment inside out** while ironing.

2. Focus on Steam, Not Heat
To iron silk without damaging it, it's crucial that you **use the lowest heat setting on your iron**. Many irons have an actual silk setting, in which case this is the best way to go. Simply lay the garment flat on the ironing board, place the press cloth on top, and then iron. You can also use a handkerchief, pillowcase, or hand towel instead of a press cloth.

3. Pressing vs. Ironing
When most of us think of ironing, we think of dragging the iron across the fabric. One of the key tips in properly ironing silk is to **minimize ironing back and forth**. When ironing silk, focus on key areas of wrinkling. **Gently press downward through the press cloth.** Lift the iron, allow the area to briefly cool, and then repeat on another section of fabric. Keep in mind that pressing silk does *not* mean leaving the iron in place for a long period of time. Minimizing the length of time the iron is in contact with the fabric (even with the press cloth) will prevent the silk from burning.

4. Avoid Further Wrinkling
One of the most important aspects of ironing silk is to prevent wrinkles before they happen. During ironing, make sure that each section of fabric is laid perfectly flat. Also, ensure that the garment is taut to avoid creating new wrinkles. Another common mistake is removing the garment from the ironing board before it's completely cooled. **Before taking your clothing off the board, make sure that it's cool and dry.** This will help your hard work pay off in smooth, wrinkle-free silk.

Burning of silk

Featured snippet from the web

Protein (**Silk**/Wool, Cashmere, Alpaca etc):

Burns slowly and shrinks or curls away from the flame. Will not stay lit after flame is removed. Very little smoke is produced but it smells like burnt hair (wool) or feathers (**silk**). Ash is a gritty powder or a dark brittle, easily crushable bead

Physical Properties of Silk Fiber

Tenacity - The silk filament is strong. This strength is due to its linear, beta configuration polymers and very crystalline polymer system. These two factors permit many more hydrogen bonds to be formed in a much more regular manner. Silk loses strength on wetting. This is due to water molecules hydrolyzing a significant number of hydrogen bonds and in the process weakening the silk polymer.

Specific gravity - **Degummed silk** is less dense than cotton, flax, rayon or wool. It has a specific gravity of 1.25. **Silk fibres** are often weighted by allowing filaments to absorb heavy metallic salts; this increases the density of the material and increases its draping property.

Elastic-plastic nature - Silk is considered to be more plastic than elastic because it's very crystalline polymer system does not permit the amount of polymer movement which could occur in a more amorphous system. Hence, if the silk material is stretched excessively, the silk polymers that are already in a stretched state (They have a betaconfiguration) will slide past each other. The process of stretching ruptures a significant number of hydrogen bonds.

Elongation - Silk fibre has an elongation at break of 20-25% under normal condition. At 100% R.H. the extension at break is 33%.

Hygroscopic nature - Because silk has a very crystalline polymer system, it is less absorbent than wool but it is more absorbent than cotton. The greater crystallinity of silk's polymer system allows fewer water molecules to enter than do the amorphous polymer system of wool. It absorbs water well (M.R.11%), but it dries fairly quickly.

Thermal properties - Silk is more sensitive to heat than wool. This is considered to be partly due to the lack of any covalent cross links in the polymer system of silk, compared with the disulphide bonds which occur in the polymer system of wool. The existing peptide bonds, salt linkages and hydrogen bonds of the silk polymer system tend to break down once the temperature exceeds 1000C.

Electrical properties - Silk is a poor conductor of electricity and tends to form static charge when it is handled. This causes difficulties during processing, particularly in dry atmosphere.

Hand feel - The handle of the silk is described as a medium and its very crystalline polymer system imparts a certain amount of stiffness to the filaments. This is often misinterpreted, in that the handle is regarded as a soft, because of the smooth, even
and regular surface of silk filaments.

Drapes Property - Silk fibre is flexible enough and if silk fibre is used to make garments, then the fabric drapes well and this is why it can be tailored well too.

Abrasion resistance - **Silk fabric** possess good abrasion resistance as well as resistance to pilling.

Effect of sunlight - Silk is more sensitive light than any other natural fibre. Prolonged exposure to sunlight can cause partially spotted color change. Yellowing of silk fibre is generally occurred due to photo degradation by the action of UV radiation of sunlight. The mechanism of degradation is due to the breaking of hydrogen bonds followed by the oxidation and the eventual hydrolytic fission of the polypeptide chains.

Chemical Properties of Silk Fiber

Action of water - The absorption of water molecules takes place in the amorphous regions of the fibre, where the water molecules compete with the free active side groups in the polymer system to form cross links with the fibroin chains. As a result, loosening of the total infrastructure takes place accompanied by a decrease in the force required to rupture the fibre and increase extensibility. Treatment of silk in boiling water for a short period of time does not cause any detrimental effect on the properties of silk fibre. But on prolonged boiling, silk fibre tends to loss its strength to some degree, which thought to occur because of hydrolysis action of water. Silk fibre withstands, however, the effect of boiling better than wool.

Effect of acids - Silk is degraded more readily by acids than wool. Concentrated sulfuric and hydrochloric acids, especially when hot, cause hydrolysis of peptide linkages and readily dissolve silk. Nitric acid turns the color of silk into yellow. Dilute organic acids show little effect on silk fibre at room temperature, but when concentrated, the dissolution of fibroin may take place. On treating of silk with formic acid of concentrated about 90% for a few minutes, a swelling and contraction of silk fibre occur. Like wool, silk is also amphoteric substance, which possesses the ability to appear as a function of the pH value either as an acid or as a base.

Effect of alkalis - Alkaline solutions cause the silk filament to swell. This is due to partial separation of the silk polymers by the molecules of alkali. Salt linkages, hydrogen bonds and Van der Waals' forces hold the polymer system of silk together. Since these inter-polymer forces of attraction are all hydrolyzed by the alkali, dissolution of the silk filament occurs readily in the alkaline solution. Initially this dissolution means only a separation of the silk polymers from each other. However, prolonged exposure would result in peptide bond hydrolysis, resulting in a polymer degradation and complete destruction of the silk polymer. Whatever, silk can be treated with a 16-18% solution of sodium hydroxide at low temperature to produce crepe effects in mixed fabric containing cotton. Caustic soda, when it is hot and strong, dissolves the silk fibre.

Action of oxidizing agent - Silk fibre is highly sensitive to oxidizing agents. The attack of oxidizing agents may take place in three possible points of the protein 1. At the peptide bonds of adjacent amino groups,

1. At the N-terminal residues and
2. At the side chains

Though fibroin is not severely affected by hydrogen peroxide solution, nevertheless may suffer from the reduction of nitrogen and tyrosine content of silk indicate that hydrogen peroxide may cause breakage of peptide bonds at the tyrosine residues resulting in the weight loss of the fibre. The action of chlorine solution on the silk fibroin is more harmful than does the solution of hypochlorite. These solutions, even at their lower concentration, cause damage to fibroin.

Action of reducing agents - The action of reducing agents on silk fibre is still a little bit obscure. It is, however, reported that the reducing agents that are commonly found in use in textile processing such as hydrosulfite, sulfurous acids and their salts do not exercise any destructive action on the silk fibre

❖ **CONTENT/TOPIC 5. MINERAL FIBERS**

ASBESTOS

Asbestos Textiles

The history, manufacturing process & uses of asbestos textiles, fabrics, and fibers used in such products as fireproof blankets, safety clothing, packings, clutch facings, brake linings, plastics, and filters. Page top photo: an asbestos textile weaving operation showing standard magazine creel and loom creel - Adapted from Rosato (1959) .

This articles series about the manufacture & use of asbestos-containing products includes detailed information on the production methods, asbestos content, and the identity and use of asbestos-containing materials.

We also provide a **MASTER INDEX** to this topic, or you can try the page top or bottom **SEARCH BOX** as a quick way to find information you need.

Asbestos Textiles: Manufacture, Uses, History

Introduction to the Production & Uses of Asbestos Fabrics

The following text is Adapted from Rosato (1959) p. 130-141 [1]

Next to the asbestos-cement industry, probably the most important use of asbestos is in the manufacture of yarn and cloth.

These textiles are used in such different products as safety clothing, packings, clutch facings, brake linings, plastics, and filters.

The process of manufacturing asbestos textile products follows the process that is used for other textiles. The nature and characteristic of asbestos fibers differ from organic fibers.

The asbestos cloth vibration dampener shown at left is discussed

ASBESTOS DUCT VIBRATION DAMPERS.

Cotton fibers are rough, twisted and irregular; wool fibers are covered with scaly bands. However, asbestos fiber has none of the characteristics which enable the individual fibers to cling to each other.

This lack of spinning bond can make the manufacture of pure asbestos yarns difficult and costly, especially if fine yarns are required. Special opening and blending processes for asbestos fibers are necessary. The fibers are processed in carding machines similar to those used for wool.

The main reason for the use of asbestos fiber in the manufacture of textiles is because of its fire and heat resistance, acid resistance, and durability.

ASBESTOS TEMPERATURE PROPERTIESAND ASBESTOS CHEMICAL PROPERTIES

Asbestos textiles, being mineral, are durable even under severe service conditions; e.g., they are used as padding and cover cloths on flat work ironers in commercial laundries. Another example of the durability of asbestos is its use as belting for the conveying of hot materials.

In the manufacture of wire, or galvanized materials, other materials could probably be used for the hot-metallic wiping process but they would need constant replacement. Asbestos lasts much longer.

The largest quantities of asbestos textile fibers are used for friction materials, industrial packing, electrical insulation and thermal insulation, applications where heat resistance and durability are required.

Engineering has made possible the combination of asbestos with natural and synthetic fibers into useful yarns, threads, cloths, and tapes.

The utility of fibers, filaments and yarns, both natural and man made, as textile raw materials depends principally upon the physical properties of the fibers, which include mechanical, thermal, optical and electrical properties. Among the properties which make asbestos interesting is its modulus of elasticity which is 25 x 106 psi.

The asbestos cloth pipe or duct wrap shown at left is discussed at **ASBESTOS DUCT VIBRATION DAMPERS**.

The longer and better grades of asbestos fiber, which are the Quebec Standard Crudes No. 1 and 2, and Group 3 are generally the only fibers used for the manufacture of asbestos textiles.

Combining or blending fibers is considered an art; it involves mixing different grades of asbestos.

Chrysotile is used predominantly. Crocidolite and amosite are sometimes blended with chrysotile. Blue asbestos textiles are manufactured for special acid-resistant applications.

In these applications, crocidolite (blue) is generally used by itself. Coarse yarns are manufactured which are considered highly specialized products.

Asbestos is the only mineral that may be fabricated into finished products by using spindles, looms, and other textile equipment. Amosite asbestos, even though it has long fiber and fairly high tensile strength, is very difficult to fabricate into textile products because of the coarse nature of the fiber. It has a tendency to pulverize in the textile operation.

The fibrous structure of long asbestos permits its use by itself in textile equipment.

The long asbestos fibers as well as other types of fibers which have length can provide the carrying action for shorter asbestos fibers such as Group 3.

The carrier fibers are definitely required for handling shorter asbestos fibers. When cotton is used with short asbestos fibers, low cost products can be produced which still provide certain degrees of heat resistance and good physical properties.

Most of the asbestos yarns manufactured are plied yarns. Single yarns are not a very satisfactory product because asbestos fibers are lacking in uniformity. Uniformity can be achieved by such special processes as chemically dispersing asbestos.

The fault of nonuniformity in mechanically opened fibers is overcome by doubling two or more strands of yarn. In twisted yarns, there are two important points to be considered; i.e., uniformity and strength. Uniformity identifies the diameter and weight of yarn.

The strength of the yarn depends principally upon the fiber length and the grade of fibers used.

Identification of Asbestos Textiles

Standards for numbering asbestos yarn are used. For example, ASTM (D299-52) pertains to asbestos yarns and describes methods of identifying the yarn.

The asbestos textile industry uses a numbering system for the yarn; it designates the cut, number of plies, and whether the yarn is plain or metallic. In a four digit figure, the first two digits indicate the cut, the next digit indicates the number of plies and the final digit indicates the number of metallic strands.

If the final digit is a zero, it indicates a plain yarn. In a three digit system, only the first digit indicates the cut.

The term "cut" is derived by cutting (dividing) 7,000 grains into linear mass units by the grain weight of one hundred yards of a single yarn. The number of such units expresses the number of the cut and when multiplied by one hundred, indicates the nominal yards per pound.

The term "ply" identifies the number of strands of single asbestos yarn twisted together to form a heavier yarn. Ply is a term used principally in combination with a number to designate the strands of single yarn twisted together— 2 ply, 3 ply, etc.

Plain, single asbestos yarn is generally identified by cut numbers ranging from 5 to 50 cut. A 5 cut yarn represents 500 yd of yarn weighing one pound. For a 10 cut yarn, 1,000 yd weighs one pound. The 50 cut yarn involves 5,000 yd per pound. Examples of yarn designations are No. 931 yarn (9 cut, 3 ply, 1 wire yarn) and No. 1420 yarn (14 cut, 2 ply, plain yarn).

Various methods of identifying woven asbestos cloth are used.

ASTM Specification (D677-50) pertains to asbestos cloth. An example of the Asbestos Textile Institute designation for cloth is No. 20P28. The digits that precede the letter identify the weight of the cloth in ounces per square yard. The letter identifies the weave and the remaining digits identify the cut of the yarn used in weaving.

The asbestos content of an asbestos textile is the principal and sole criterion upon which the grade of the asbestos product is based. Within each grade there may be a variety of constructions, weights, weave designs and insertions which may serve to yield fabrics having different properties for different applications.

The ASTM has established standards which classify asbestos products in accordance with the percent of asbestos content. Table 8.1 lists these percentages.

TABLE 8.1. PERCENTAGE OF ASBESTOS CONTENT IN ASBESTOS TEXTILE PRODUCTS

ASTM Grade	**Asbestos Content, % by wt**
Commercial	75 up to but not including 80
Underwriter	80 up to but not including 85
Grade A	85 up to but not including 90
Grade AA	90 up to but not including 95
Grade AAA	95 up to but not including 99
Grade AAAA	99 up to and including 100 % asbestos

Adapted from Rosato (1959) p. 133

Percentage of Asbestos Content in Asbestos Textile Products

One practical method of determining chrysotile asbestos content of an asbestos textile product which is not treated with resins or other foreign matter is to determine the cotton or organic content of the product in accord with ASTM procedures.

This method describes that one test specimen, weighing not less than 5 grams taken from each sample roll, dried to constant weight in an oven at 105 to 110°C, and the weights of the dried specimens reported. The specimens are placed in an electric oven and heated for not less than one hour at 800 to 8100C.

After removal from the oven they are cooled to room temperature in a desiccator, and then weighed. The weight of the residue is divided by the factor 0.86 in order to determine the original weight of the asbestos content.

This weight of asbestos content is divided by the weight of the dried specimens in order to obtain the percentage of asbestos.

The average of the determination shall be the asbestos content. In this particular example, the average of 14 per cent water of crystallization is used for chrysotile fiber. In other examples the per cent would of course vary.

High Temperature Data for Asbestos Textiles

In Table 8.2 the tensile strength of asbestos cloth at room temperature, with a 24 hr exposure at 800°F, is reported. All tensile tests were conducted at room temperature after the exposure. Tests were conducted in accord with ASTM (D577-52, Method D39, Section 10). This test is often called the tensile grab test.

These data are presented for general information based on different weaves. Temperature test data under different conditions are also reported in the chapter on Properties of Asbestos.

The weave specification affects many properties of the finished textile.

TENSILE STRENGTH OF ASBESTOS CLOTH VS. TEMPERATURE*									
		Lb Break				**% Retained**			
Sample	**Temp °F**	**1 Hr**	**8 Hr**	**12 Hr**	**24 Hr**	**1 Hr**	**8 Hr**	**24 Hr**	**12Hr**
127	400	254.0	237.0	234.0	232.0	96.6	90.1	89.0	88.3
	600	238.0	237.0	236.0	222.0	90.5	90.1	89.8	84.5
	800	258.0	254.0	249.0	248.0	98.1	96.5	94.8	94.4
166	400	150.0	125.0	125.0	119.0	92.6	77.2	77.2	73.5
	600	120.0	108.0	106.0	106.0	74.0	66.6	65.5	65.5
	800	110.0	111.0	106.0	108.0	68.5	68.5	65.5	66.5

134	400	143.0	116.0	114.0	105.0	95.0	77	75.0	70.0
	600	106.0	101.0	99.0	97.0	70.0	66	76.5	65.0
	800	103.0	95.0	91.5	88.0	69.0	63	60.5	59.0
147	400	159.0	133.0	131.0	122.5	94.0	78.7	77.5	72.5
	600	110.0	109.4	98.0	97.0	65.0	64.6	58.0	57.5
	800	94.5	98.5	96.6	96.0	56.0	58.4	57.2	56.8
126	400	157.0	100.5	92.9	82.8	80.5	51.5	47.5	42.5
	600	60.9	58.2	58.1	56.2	31.2	29.8	29.8	28.8
	800	56.5	54.0	54.0	53.0	29.0	27.7	27.7	27.2
124	400	98.0	52.0	39.0	39.0	81.5	43.3	39.0	32.5
	600	31.5	30.6	27.9	27.9	26.2	25.4	24.0	23.2
	800	28.5	28.1	28.0	28.0	23.8	23.4	23.4	23.3

Notes to the Table Above

* Asbestos Textile Institute, Philadelphia, Penna., Report No. 23 (Dec., Tests conducted at room temperature after temperature exposure.)

Adapted from Rosato (1959) p. 135

[Note that apparently the order of the two right-most columns were reversed in the original text; also we inserted decimal places missing in the original text - Ed.]

Table of Asbestos Textile Samples & Properties Used in the Tensile Strength Tests Above				
Sample No.	**Type**	**Asbestos Content %**	**Grade**	**Warp-Grab Tensile Strength (Lb, RT)**
127	48P10	96%	AAA	263
166	36P10-GS		AAA	162
134	36P10	92%	AA	151
147	30P14	87%	A	169
126	48P10	779%	Commercial	195
124 	36P10	82%	Underwriters	120

Notes to the table above

Adapted from Rosato (1959) p. 135

Manufacturing Processes for Asbestos Textiles

Basically the first step in the textile mill involves fiberizing asbestos and freeing it from rock impurities.

The fibers are first carded into a sheet, then separated into rovings which are wound on jack spools, and spun into yarn. Yarn can be made into thread, cord or rope.

Metallic yarns are made by adding strands of fine brass, copper or lead wire to the strands of asbestos. The yarns can be put into looms and woven into fabrics by dry or wet processes using textile operations.

Asbestos loom showing weaving operation with standard magazine creel and creel for loom. Courtesy The Johns-Manvill Corporation.

Crude fiber is generally prepared for spinning at the factory where it is to be spun. Preliminary treatment of fiber is usually accomplished in a pan crusher.

This type of equipment consists of steel wheels approximately 1 1 /2 to 2 ft in diameter with a flat surface on the periphery which in turn rolls around in a circular pan.

Crude fiber is fed into the pan and scrapers push .the fiber under the rotating wheel. This operation is very critical since it can mechanically break the fibers. Special techniques and such engineered rolls as rotary-toothed cylinders have been devised to reduce damage of fibers.

After crushing, the fibers are transferred to opening devices which actually fiberize the product further. The opened or fiberized fibers pass over shaking screens or through trommel screens where they are again cleaned. Final operation generally involves lifting of suitable asbestos fibers by air suction.

Blending of such fibers as asbestos with cotton can be preformed in the preliminary mixing operation prior to the carding operation. However, the blending is generally performed during the carding operation.

Carding rolls are fitted with a series of sharp steel bristle rotating brushes which comb the fibers into specific positions.

During this combining operation short fibers and minute contaminating products such as rocks are removed. The result of carding is that opened asbestos fiber is formed into a loose continuous sheet or blanket.

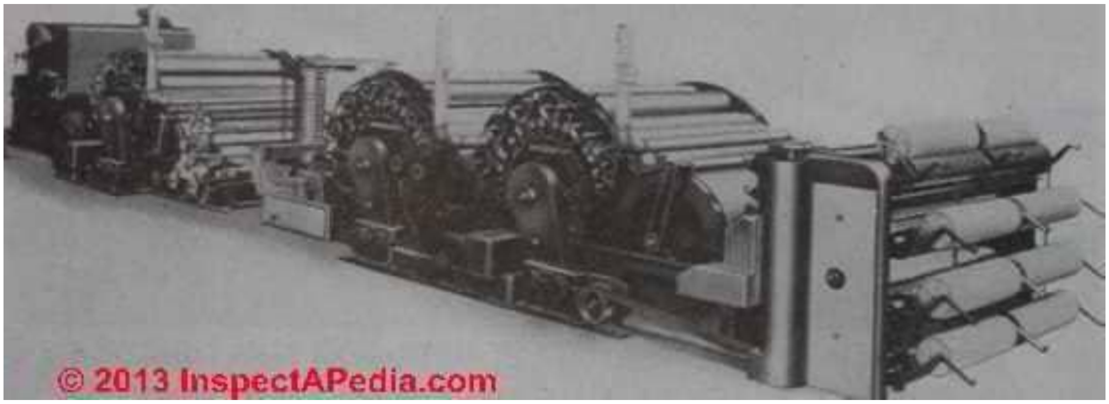


Figure 8.2. A line of up-to-date carding machinery. Courtesy Davis & Furber Machine Co.

he carding process involves fiber material which is fed from a hopper to a weighing pan on the lifter apron of the carding machine.

A comb which passes over the apron spreads the moving mass and prevents accumulation of fibers. The weighing pan continuously supplies a predetermined amount of fibers.

The fibers drop onto a conveyor apron of the carding table which carries it to the "licker-in" rolls.

In the carding machine, the fibers are combed by passing them between the main cylinder and the worker cylinders. The combining action is provided by the excess surface speed of the main cylinder over that of the worker The fibers are rubbed into loosely compact strands between oscillating surfaces.

These strands or rovings are then wound on jack spools for spinning.

Asbestos roving is being wound on jack spools after asbestos sheets leave carding machines. Courtesy Johns-Manville Corporation.

When fibers such as cotton are added to asbestos, they are added during the carding process. By means of a weighing scale, different percentages of fibers can be made into a web.

The web is lifted from the main cylinder of the carding machine by the doffer comb.

From there it is divided into narrow ribbons corresponding to the number of rovings. Figure 8.3 shows roving being wound on jack spools as it leaves an asbestos carding machine.

The rovings are condensed in a rub apron and are spooled singly on paper cores or together on a jack spool. These rovings obtain strength by a spinning process.

The strength which asbestos roving lacks is supplied by twisting in the spinning frames which are standard textile equipment. After the spinning operation, it can be plied with similar rovings.

Asbestos yarns can be made up with such different core as fine metal wires, cotton, glass and nylon. The uniformity of the asbestos yarn is principally directly related to the carding operation.

Description of Asbestos Textile Products

In the manufacture of asbestos textiles, the carded blanket or web is cut into narrow strips identified as slivers. Asbestos lap is made by combining in a parallel layup varying numbers of slivers to form different weights. Asbestos lap is wound into roll form which is supplied to fabricators which recard them for insulating electrical wires and cables.

These narrow strips of the carded web (or lap) when rubbed mechanically into untwisted strands are called rovings.

Yarn can be made as plain and metallic (or wire-inserted yarn). The standard insert is one or more strands of 8-mil brass wire but for special purposes wire of different diameter may be used. Other metals or alloys of copper, zinc, nickel, "Nichrome," "Inconel," and "Monel" are used in place of the brass.

When yarns are wetted with water during the weaving operations, the finished product is harsher and more open than cloth woven dry. Numerous patents have been issued for improving strength properties of asbestos yarn. American Cyanamid Company has British Patent 563,678 (1944) which specifies that in order to strengthen asbestos yarn, the yarn is impregnated with a melamine resin.

Flue cleaning hose is covered with a braid of heat resistant asbestos cord. Such a cover protects the hose from the hot walls of flues and resists the transfer of heat to the hands of the operator. (Courtesy The Gates Rubber Co.)

Such varied methods have been developed to produce new textile products as combining asbestos fibers with glass or ceramic fiber strands. Another interesting process is the use of short asbestos fiber with no long fiber carriers to produce yarn.

Asbestos, paper strips are used to produce the yarn.

The fiber is separated in a beater and mixed with a liquid to form a pulp. The pulp is transferred to a paper machine where the fibers adhere to moving rolls.

An endless blanket picks up the matted fiber and carries it on into a continuous sheet. The sheet is peeled off, dried and wound in a large roll. Then it can be cut into narrow strips andwith special machines it can be spirally wound into single yarns.

Other textile products include braided and knitted fabrics, wick for caulking and seals, rope for boiler expansion joints and gaskets, loose carded fiber for filtration, felts for belting and packing, tape for electrical and thermal barriers, tubing or sleeving for electrical cables, and mechanical abrasion protection of items subject to heat.

They provide for

- parachute pack covers
- theater curtains,
- firesmothering blankets **ASBESTOS FIRE BLANKETS**
- fire fighting suits,
- fuel and oil hose,
- conveyor belts,
- clothing for industrial plants,

ironing pads, and others as listed in the introductory chapter.

Asbestos fabrics coated with metallic or rubber base compounds have been developed as heat and flame reflectors or insulators.

Various ASTM and Federal Specifications have been prepared which pertain to these different textile products.

Asbestos fabrics are also used in and discussed

METALLIC FIBERS

Metallic fiber

Bundle drawn, stainless steel fiber

Metallic fibers are manufactured fibers composed of metal, metallic alloys, plastic-coated metal, metal-coated plastic, or a core completely covered by metal.

Having their origin in textile and clothing applications, gold and silver fibers have been used since ancient times as yarns for fabric decoration. More recently, aluminium yarns, aluminized plastic yarns, and aluminized nylon yarns have replaced gold and silver.

Today's metal fiber industry mainly offers fibers in stainless steel, nickel, titanium, copper and aluminium for various applications.[] Metallic filaments can be coated with transparent films to minimize tarnishing.

Metal fiber may also be shaved from wire (steel wool), shaven from foil, bundle drawn from larger diameter wire, machined from an ingot, cast from molten metal, or grown around a seed (often carbon).

History

Gold and silver have been used since ancient times as decoration in the clothing and textiles of kings, leaders, nobility and people of status. Many of these elegant textiles can be found in museums around the world Historically, the metallic thread was constructed by wrapping a metal strip around a fiber core (cotton or silk), often in such a way as to reveal the color of the fiber core to enhance visual quality of the decoration. Ancient textiles and clothing woven from wholly or partly gold threads is sometimes referred to as *cloth of gold*. They have been woven on Byzantine looms from the 7th to 9th Centuries, and after that in Sicily, Cyprus, Lucca, and Venice. Weaving also flourished in the 12th Century during the legacy of Genghis Khan when art and trade flourished under Mongol rule in China and some Middle Eastern areas.[] The Dobeckmum Company produced the first modern metallic fiber in 1946

During the early 1960s, Brunswick Corp. conducted a research program to develop an economically viable process for forming metallic filaments. They started producing metallic filaments in a laboratory-scale pilot plant. By 1964 Brunswick was producing fine metal fibers as small as 1 µm from 304 type stainless steel. Their first large scale production facility, located in the USA, was brought on stream in 1966. Metal fibers are now widely produced and used in all kinds of technology. With a wide range of applications, it is a mature sector.

In the past, aluminium was often the base in a metallic fiber. More recently stainless steel has become the dominant metal for metallic fibers. Depending on the alloy, the metallic fibers provide properties to the yarn which allow the use in more high tech] applications .

Fiber properties

Machined fibers in various metals and alloys

Metal fibers exists in different forms and diameters. Generally, the sector offers metal fiber diameters from 100µm down to 1µm.

Metallic fibers exists in both long, continuous fibers as well as short fibers (with a length/diameter ratio of less than 100).

Compared to other fiber types, like carbon, glass, aramid or natural fibers, metal fibers have a low electrical resistance. This makes them suitable for any application that requires electrical conductivity. Their excellent thermal resistance makes them withstand extreme temperatures. Corrosion resistance is achieved through the use of high-quality alloys in stainless steels or other metals. Other advantageous mechanical properties of metal fibers include high failure strain, ductility, shock resistance, fire resistance and sound insulation.

Sintered metal fiber structures and products display high porosity properties, while remaining structurally strong and durable. This benefits the function and structure of specific applications like filtration or electrodes.

Coated metallic filaments helps to minimize tarnishing. When suitable adhesives and films are used, they are not affected by salt water, chlorinated water in swimming pools or climatic conditions. If possible anything made with metallic fibers should be dry-cleaned, if there is no care label. Ironing can be problematic because the heat from the iron, especially at high temperatures, can melt the fibers.

Production method

There are several processes which can be used for manufacturing metallic fibers.

The most common technology is known as *bundle drawing.* Several thousands of filaments are bundled together in a so-called composite wire, a tube which is drawn through a die to further reduce its diameter. The covering tube is later dissolved in acid, resulting in individual continuous metal fibers. This composite wire is drawn further until the desired diameter of the individual filaments within the bundle is obtained. Bundle drawing technology allows for the production of continuous metal fiber bundles with lengths of up to several kilometers. Due to the nature of the process, the cross-section of the fibers is octagonal. In order to achieve high-quality fibers, this technology can be fine-tuned, resulting in uniform, very thin fibers with a very narrow equivalent diameter spread. Special developments within the last couple of years have allowed this technology to be used for the production of fibers with diameters as small as 200 nm and below.

In the *laminating process*, one seals a layer of aluminium between two layers of acetate or polyester film. These fibers are then cut into lengthwise strips for yarns and wound onto bobbins. The metal can be colored and sealed in a clear film, the adhesive can be colored, or the film can be colored before laminating. There are many different variations of color and effect that can be made in metallic fibers, producing a wide range of looks.

With *foil-shaving* technology, fibers with diameters down to 14 µm and a more rectangular crosssection are feasible. This produces semicontinuous bundles of fibers or staple fibers

Machining of staple fibers can produce semicontinuous bundles of fibers down to 10 µm. Improving staple fiber manufacturing allows a narrow diameter spread on these kinds of fibers as well as tuning of the geometry of the fiber. This technology is unique compared to foil shaving or fibers from melt spinning, due to the small diameters that can be reached and the relatively small diameter spread

Metallic fibers can also be made by using the *metalizing process*. This process involves heating the metal until it vaporizes then depositing it at a high pressure onto the polyester film .

This process produces thinner, more flexible, more durable, and more comfortable fibers.

Metal fiber may also be shaved from wire (steel wool), cast from molten metal, or grown around a seed (often carbon).

Types of metallic fiber products

Sintered metal fibers

Sintered media

metal fibers are converted into fiber media either as non-woven fleece or sintered structures composed of fibers ranging from 1.5 to 80 µm in diameter. These porous metal fiber media have been used for their uniqueness in highly demanding applications. The benefit of having the combination of an outstanding permeable material (porosities up to 90% for sintered and up to 99% for non-woven structures) combined with high corrosion and temperature resistance is highly valued. The sintered porous structure has no binder as the individual fibers are strongly bonded together by inter-metallic diffusion bonding. 3D sintered structures have also become a standard product. Some of the latest developments are relate to filtration media using a combination of metallic and non-metallic fibers, allowing the best of both worlds.

Short metal fibers

Short fibers

A specially designed process allows the production of individual powder-like metal fibers known as short fibers with a length over diameter (L/D) range of 100. These short fibers can be used as such or in combination with metal powders to produce sintered filtration structures with ultra-high levels of filtration while allowing unique levels of permeability.

Metal fibers in polymer pellets, ready for injection moulding

Polymer pellets

Other metal fiber products are polymer pellets or grains composed out of metal fibers. Several bundles of fibers are glued together with a variety of sizings and an adequate compatible extrusion coating is applied. After chopping these coated bundles into pellets they can be used as additives in the production of engineered conductive/ shielding plastic pieces by injection molding and extrusion. The unique benefit of metal fibers is the conductive network formation with a relatively limited volume of conductive additives.

Metal fiber nonwoven

Non-wovens

Non-wovens or felts can be produced with metal fibers, just like with traditional textile fibers. In a very limited number of cases, needle punching can be applied to entangle the fibers and obtain needle-punched felt.

Metal fiber yarns, blended with other textile fibers

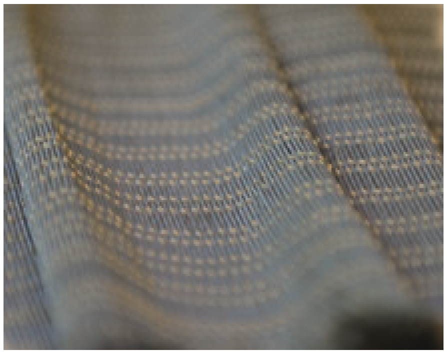
Yarns

A bundle of endless stainless steel fibers can be converted to yarns by textile spinning processes. There are two forms of yarn: one with a low amount of fibers and one with a high amount of fibers. The former, with a number of filaments of around 275, can be converted into a filament yarn by adding twist to the bundle. Bundles with several thousands of fibers are typically used to convert fibers into spun yarn. That can be done by stretch breaking and subsequent traditional yarn spinning technologies. This results in 100% metal yarns. During the spinning process, tows can be blended and blended yarns can also be produced. Blends with cotton, polyester and wool are possible. Subsequently, metal yarns can be further converted into various textile products using textile processes. Knitting (circular, flat, warp) and weaving are possible, as well as braiding. Blended textile products can be obtained by combining metal yarns with other yarns, or by using yarns that have two kinds of fibers inside and hence are already blends by themselves.

Metal fibers processed to highly durable electrical cables

Electrical cables

To make cables, two or more filaments are twisted together a number of times. During the process, a cable's torsion and straightness are monitored. The cable can be fine-tuned for a certain application by combining different filament strengths, diameters or the number of twists, or by preforming.



UD fabric for composite reinforcement

Fiber Reinforced Composites

Metal fiber can be used as reinforcement fiber for composite materials, improving breaking behavior upon impact and electrical conductivity. Traditional carbon or glass fiber reinforcement fibers have very limited elongation possibilities, which results in a brittle and explosive breaking behavior. Metal fibers act perfectly complementary to this, and can absorb much more energy before breaking. Processing is no different from any other reinforcement fiber for composite material. It is even possible to combine metal fibers with other fibers into a 'hybrid' composite structure, which combines all the benefits of carbon, glass and steel.

Producers

Currently metallic fibers are manufactured primarily in Europe. The largest and most integrated metal fiber producer worldwide is the multinational company Bekaert, headquartered in Belgium, but with manufacturing footprint in Europe, Asia and the Americas

Three manufacturers are still producing metallic yarn in the United States. Metlon Corporation is one of the remaining manufacturers in the U.S. that stocks a wide variety of laminated and non-laminated metallic yarns & Brightex Corporation, Japan and South Korea, such as Hwa Young, is also manufacturing Metallic fibers

[1] China also produces metallic yarns; the city Dongyang contains more than 100 factories, though some of these are home based production sites rather than conventional factories. Two of the more popular factories are Salu Metallic Yarn and Aoqi Textile.

Trademarks

Metallic yarn

Bekaert manufactures metal fibers and many derived products such as continuous fiber, sintered media, nonwoven structures, polymer pellets, braids, woven fabrics, cables, yarns and short fibers. Well established brand names are Bekipor, Beki-shield and Bekinox.

The Lurex Company has manufactured metallic fibers in Europe for over fifty years. They produce a wide variety of metallic fiber products including fibers used in apparel fabric, embroidery, braids, knitting, military regalia, trimmings, ropes, cords, and lace surface decoration. The majority of Lurex fibers have a polyamide film covering the metal strand but polyester and viscose are also used. The fibers are also treated with a lubricant called P.W., a mineral-based oil, which helps provide ease of use.

Metlon Corporation is a trademark of Metallic Yarns in the United States and has been producing metallic yarns for over sixty years. Metlon produces their metallic yarn by wrapping single slit yarns with two ends of nylon. One end of nylon is wrapped clockwise and the other end is wrapped counterclockwise around the metallic yarn. The most commonly used nylon is either 15 denier or 20 denier, but heavier deniers are used for special purposes.

Uses

Metallic fibers are used in a wide range of sectors and segments.

Automotive

Metal fiber sintered sheets are used for diesel and gasoline particulate filtration and crankcase ventilation filters.

Heat-resistant textile materials are made from metal fibers for automotive glass bending processes. These metal fiber cloths protect the glass during the bending process with highly elevated temperatures and high pressures.

Also heating cables for car seat heating and Selective Catalytic Reduction tubes, adblue tanks. Metal fiber heating cables show an extremely high flexibility and durability when compared to copper wire.

Aerospace

Metal fiber filters are used for Hydraulic fluid filtration in aircraft hydraulic systems. When compared to glass fiber filtration media, metal fibers show excellent durability, as the fibers are metallically bonded together by sintering, instead of kept together by a binder material.

Metal fiber sintered porous sheets are used as a sound attenuation medium in the aircraft cabin, reducing HVAC sounds, and auxiliary power unit noise.

Technical textiles

Metal fibers can serve as antistatic fibers for textiles, which can be used in, amongst others, electrical protective clothing or antistatic big bags.

Not only antistatic, but also shielding from electromagnetic interference (EMI) can be achieved by metal fiber textiles.

Stainless steel fiber textiles can be heated by applying electrical current and can also be used for cut resistant clothing (gloves). Let's say it's the modern chain mail.

Power

Metal fiber filters can reach very high porosity, at very low pore sizes, which makes them suitable for HEPA and ULPA filtration. These filters are used in, amongst others, nuclear power plants as a safety measure to prevent eventual release of radio-active steam.

Marine

Metal fiber filters are used for the purification of marine fuel and lube oil.

Other uses of metal fibers

Another common use for metallic fibers is upholstery fabric and textiles such as lamé and brocade. Many people also use metallic fibers in weaving and needlepoint. Increasingly common today are metallic fibers in clothing, anything from party and evening wear to club clothing, cold weather and survival clothing, and everyday wear. Metallic yarns are woven, braided, and knit into many fashionable fabrics and trims. For additional variety, metallic yarns are twisted with other fibers such as wool, nylon, cotton, and synthetic blends to produce yarns which add novelty effects to the end cloth or trim.

Stainless steel and other metal fibers are used in communication lines such as phone lines and cable television lines.

Stainless steel fibers are also used in carpets. They are dispersed throughout the carpet with other fibers so they are not detected. The presence of the fibers helps to conduct electricity so that the static shock is reduced. These types of carpets are often used in computer-use areas where the chance of producing static is much greater. Other uses include tire cord, missile nose cones, work clothing such as protective suits, space suits, and cut resistant gloves for butchers and other people working near bladed or dangerous machinery.

Metal fibers can be used as a reinforcement or electrical conductivity fiber for fiber reinforced composites.

The hallmark of all Indian festivities is the golden glitter of the sarees and similarly-adorned dresses worn on such occasions. All that glitters may not be gold and the ‘zari’ (metallic yarn), responsible for this lustrous appearance, may or may not contain any gold. This paper reviews the different types of metallic fibres and their production.

INTRODUCTION

Metallic yarns or threads, in general, have been known for more than 3000 years. Gold and silver were hammered into extremely thin sheets, then cut into ribbons and worked into fabrics. These were the first ‘man made’ fibres, which came thousands of years before nylon or rayon. The Persians made fabulous carpets with gold thread and the Indians, ornamental sarees with it. The metal threads were twisted, doubled or wrapped around some other thread such as cotton.

With the advancement of technology, metal/conductive textiles found extensive functional applications. These materials have high electrical conductivity and radar reflecting property, yet are lightweight and flexible. Various methods have been developed to coat fibers and textile materials by metals.

» sputter coating
» coating metal powder with binders
» electro less coating
» vacuum deposition

Many technical applications demand properties which cannot be obtained by simply processing common textile material into single textile fabric. However, combination of knitted structure, textile and metal yarn of wire make it possible to create innovative products for multipurpose technical application. Thus knitted fabrics are flexible and extensible and metal wire possess properties which are advantageous in technical textile with regard to their permanent antistatic behavior, known conductivity, shielding from electro magnetic field & resistance to cutting.

METALLIC FIBRE

The term metallic fibre, in its general sense, means simply a fibre that is made from metal. The generic term "metallic" was adopted by the U.S. Federal Trade Commission and is defined as: A manufactured fibre composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal. Thus, metallic fibres are: fibres produced from metals, which may be alone or in conjunction with other substances.

These metal filaments were made by beating soft metals and alloys, such as gold, silver, copper and bronze, into thin sheets, and then cutting the sheets into narrow ribbon-like filaments. The filaments were used entirely for decorative purposes, providing a glitter and sparkle that could not be achieved by other means.

As textile fibres, these metal filaments had inherent short comings which restricted their use. They were expensive to produce; they tended to be inflexible and stiff, and the ribbon-like cross-section provided cutting edges that made for a harsh, rough handle; they were troublesome to knit or weave, and they had only a limited resistance to abrasion. Apart from gold, the metals would tend to tarnish, the sparkle being dimmed with the passage of time.

Despite these shortcomings, the metallic ribbon-filament has remained in use for decorative purposes right up to the present day. The development of modern techniques of surface-protection has brought cheaper metals into use; aluminium foil, for example, may be anodized and dyed before being slit into filaments which are colourful and corrosion-resistant.

Ribbon-filaments are now manufactured in considerable quantity, e.g. as tinsel, but they remain an essentially decorative material. The filaments are weak and inextensible, and are easily broken during wear; they lack the flexibility that is essential in a genuine textile fibre.

Multicomponent Metallic Filaments

In recent years, the ribbon filament of metal has undergone a transformation, which has changed the commercial outlook, for this ancient product. The metal of the filament is now sandwiched between layers of plastic, which protect it from the atmosphere and from other corrosive influences. The multicomponent filaments produced by slitting sandwich materials of this type are stronger and more robust than the filaments cut from metal foil alone. They retain the glitter of the metal during prolonged periods of use, and have a soft, pleasant handle. Coloured pigments may be added to the adhesive used in sticking the plastic films to the metal foil or metallized film.

Metallic fibres of this type are now widely used in the textile industry, and are produced in a range of colours and forms by many manufacturers. They remain, however, essentially decorative materials and their applications are restricted to this type of use.

Metal-foil and metal-coated yarns are characterised by a flat ribbon-shape with knife-slit edges. Metallic fibres of this type are now widely used in the textile industry and are popularly known as "Lurex" yarn (Trade name).

The main constructions of metallic yarns in order of commercial importance are as follows:

i) Mono ply yarns made from polyester film of 12 or 24 um thickness, metallised and coated both sides either with dear or coloured lacquer (Lurex C 50 and C 100) or with heat and chemical resistant resin-lacquer (Lurex-TE and TE 100). Lurex TE 50 and TE 100 are non-tarnishing and have greatly enhanced resistance to scouring and dyeing treatments of suppleness, brilliance, and yield.

ii) Laminated yarns based on one layer of aluminium foil sandwiched between two layers of 12 um thick polyester film using clear or coloured adhesives (Lurex MF 150). This yarn has higher strength and abrasion resistance.

iii) Mono ply yarns made from 12 um polyester film (transparent - Lurex N 50) or treated with a surface dispersion to give a rainbow effect (Lurex N 50 Irise).

iv) Lurex yarn types C 50, N 50 (Transparent and Irise), and TE 50 can also be obtained supported with two ends of either 17 dtex or 33 dtex monofil nylon. Metallic yarns are usually described in terms of the nominal thickness of the composite film(s) and not the overall thickness of the yarns; the thickness of the resin-lacquer coating or adhesive layer is ignored.

Chemical nature

The modern and cheap metallic yarn consist of filaments of aluminium covered with plastics: two kinds of plastics are mainly used for the covering. The first and most common is cellulose acetate-butyrate and the second and better is Mylar, DuPont's polyester film which is chemically similar to Dacron and Terylene. The mixed ester of cellulose with acetic and butyric acids is used more popularly than cellulose acetate, mainly because it has a lower melting point and is more easily worked.

Lurex MM

Lurex MM is different from other varieties of Lurex which consist of a sandwich of aluminium between two films of cellulose acetate-butyrate or Mylar. Lurex MM has a basis of metallised Mylar produced by the vacuum deposition of aluminium on Mylar film. A layer of metallised Mylar is either, (a) bonded to one layer of clear Mylar or (b) sandwiched and bonded to two layers of clear Mylar.

Colour is introduced with the adhesive. The important difference is that the metallic layer in Lurex MM consists of discrete particles and not a continuous ribbon. This construction gives Lurex MM particular softness and thinness, and it affects some other properties, too.

Width and yield

The ribbon-like shape of metallic yarns makes width an important factor and all Lurex designations bear a width reference. The amount of yarn cover and metallic lustre of a fabric depends upon the width. Lurex is slit to seven standard widths: 1/128, 1/100, 1/80, 1/64, 1/50, 1/32 and 1/16 inch. The 1/64 inch width is established as standard for weaving and knitting yarn. The various types and widths of metallic yarns are not designated by any standard textile yarn numbering system. Yields are in yards per pound.

Gauge

Metallic yarns are described by width and by gauge. The gauge is the thickness in one hundred thousandths of an inch of the two layers that form the Lurex sandwich. The gauge figure does not indicate total yarn thickness because it does not take into account the adhesive, pigment or the aluminium layer. For e.g., 260 Butyrate Lurex consists of two layers of 0.00130 inch cellulose acetate-butyrate with a 000045 inch aluminium foil and adhesives between its total thickness is 0.003 2 inch, indicating that the two layers of adhesives must each be about 0.0008 inch. A 260 gauge 1/64 inch yarn yields about 10,500 yards per lb. corresponding roughly to about 430 denier, 1 gauge = 0.00001 inch.

Supported Lurex

When additional strength and/or special effects are desired, Lurex is available in combined form. Most combining yarns are continuous filament yarns: silk, nylon, fortisan, cotton and rayon are commonly used. Combining is usually done on a hollow spindle twister and is carried out in such a way that the metallic yarn remains flat and the supporting yarn wraps around it. The number of turns per inch in the support yarn can vary but usually number 6.

a) All properties are based on 1/64 inch width yarn gold and silver only.

b) Reflectance results are reported from photo volt reflectometer with green filter against an ASTM standard measuring 89.9%.

c) Some ‘whitening’ can occur on Lurex at boil. This is due to a mechanical pick up of water by the bonding adhesive or protective film and may be cleared by drying.

d) Flammability is evaluated on fabrics. Figures reported are typical for Lurex provided that the accompanying fibres and/or finishes do not influence the behavior of Lurex

New developments

a) Multi-Functional Textiles
b) Sensing yarn, woven/knitted into garments.
c) Intelligent textile applications.
d) Heatable textiles as the heating element.
e) Conductive seam ribbons for Clean room garments.
f) Stimulation electrodes knitted into garments.
g) Weavable /knittable lead wires.
h) Heatable textiles.
i) EMI Shielding wall-coverings and other textile structures.

METAL FIBRE PROPERTIES

Metal Fiber Fineness

Due to its history as a wire drawn product and its abnormally high specific gravity, metal fiber sizes are typically described in terms of their actual diameter in microns as opposed to their linear weight in denier. As an illustration, a single human hair is 70 micron in diameter, and the current working range of bundle drawn stainless steel fibers is from 1- micron diameter to 100-micron diameter. Most textile applications utilize fibers in the range of 8 to 14 microns. As a way of comparison with polyester, a 12-micron metal fiber has the same diameter as a 1.4 denier polyester fibre.

(a) Electrical Conductivity / Electro-Magnetic Shielding

Certainly, the most distinguishing property of metal fibers is its electrical conductivity. When compared on a sq.cm basis, metal fibers can be classified as true conductors. Carbon fibers and anti-static finishes, on the other hand, are electrically classified as Semi-conductors. These differences can be significant in anti-static applications where atmospheric humidity is low and washing durability is an issue. Tests have been run on fabrics with a grid of stainless steel spun yarns where the same anti-static behavior is maintained after more than 200 wash cycles. In Europe it is reported that stainless steel is the only fiber type to consistently exceed EN 1149 after washings.

This high electrical conductivity also leads to good EMI shielding characteristics. Stainless steel fibers have long been utilized as an additive to plastic casings as a way to shield internal components from electromagnetic radiation. As concerns around EMI shielding grow, these conductive plastic applications have expanded a variety of textile applications for metal fibers. Garments, seals, gaskets and wall-coverings are all commercial application areas for shielding fabrics. There is even ongoing research into the possible therapeutic value of such fabrics for various medical treatments.

(B) Heat Resistance and Strength:

Since the early 1990’s a growing market segment for solid metal fibers has developed in the area of industrial, heat-resistant textiles. There exist many industrial environments that operate above the long-term working temperature of fiber glass and aramid fibers. This is especially true in glass forming processes where temperatures can range from 450 to 6000 C. In this particular application, there are other fibers that can withstand these temperatures from decomposition or melting standpoint, but they experience such a significant loss in strength or flexibility, that their resistance to mechanical load dramatically affects the fabric life.

Yet another important attribute to metal fibers is the ability of certain metals to behave in a chemically inert way, regardless of the environment that they are exposed to.

MANUFACTURING BRAND

Metallic yarn of the type discussed here is manufactured by American and French firms under different trade names. Some of these are:-

Dow Chemical Co.	Lurex
Fairtex Corp.	Fairtex
Melton Corp.	Melton
Reynolds Metals Co.	Re Aluminium
Standard Yarn Mills	Lame
Sildorex SA,France	Lurex C, Lurex TE.

Properties

i) Chemical resistance

Metallic yarns, although protected at the top and bottom of their flat sides, are vulnerable at their cut sides. However, as the area exposed is small, tarnishing due to atmospheric exposure is negligible. Chemical attack is serious only if the chemical is one that dissolves aluminium. Any of the Lurex yarns, if immersed in caustic soda, loses metal due to the aluminium dissolving in caustic soda through the cut side of the yarn. Lurex MM is unaffected by 2% hydrochloric acid at 99°C for 2 hours whereas Lurex MF loses metal.

ii) Strength
Strength of the acetate - butyrate Lurex yarn is not very high, but is sufficient to enable it to be used as warp or weft unsupported. The Mylar coated yams are much stronger because of the strength of the polyester film. They can be used for weaving and knitting.

iii) Heat
The acetate-butyrate-coated metallic yarns can be washed at temperatures as high as 70°C, otherwise delamination occurs at higher temperatures. Mylar coated yarns can be washed at boil and are safe upto 145°C.

Identification

The following procedure will identify the three standard types of Lurex yarn:

1. Burn yarn sample - butyrate Lurex yarn has a rancid odour.

2. Immerse in isopropyl alcohol - butyrate Lurex (film portion) will dissolve, Lurex MM and Lurex MF are insoluble.

3. Stretch yarn sample - Lurex MM and Lurex MF exhibit a stretch of 120-150%, butyrate Lurex will stretch about 20-30%. The aluminium in Lurex MF fractures (separates) on stretching, the aluminium in Lurex MM does not fracture on stretching

Asbestos Fiber
Asbestos is a nonmetallic mineral fiber, which is nonflammable. The fiber is woven into fabrics and used for theater curtains and industrial uses where flame-resistant materials are needed. The fibrous form of several minerals and hydrous silicates of magnesium. The name may also be applied to the fibrous forms of calcium and iron. Asbestos fibers can be molded or woven into **various fabrics**. Because it is nonflammable and a poor heat conductor, asbestos has been widely used to make fireproof products such as safety clothing for fire fighters and insulation products such as hot-water piping.

History of Asbestos Fiber
The first recorded use of the word asbestos is by Pliny the Elder in the 1st century ad, although the substance itself was known as early as the 2nd century bc. The Romans made cremation cloths and wicks from it, and centuries later Marco Polo noted its usefulness as cloth.

Manufacturing Process of Asbestos
Asbestos is of two principal classes, the amphiboles and the serpentines, the former of relatively minor importance. Chrysotile, in the serpentine class, constitutes most of the world supply of asbestos. Countries that have produced asbestos include Russia, Kazakhstan, China, Brazil, and Canada.

Asbestos is obtainable by various underground mining methods, but the most common method is open-pit mining. Only about 6 percent of the mined ore contains usable fibers.

The fibers are separated from the ore by crushing, air suction, and vibrating screens, and in the process are sorted into different lengths, or grades. The most widely used method of grading, the Québec Standard Test Method, divides the fibers into seven groups, the longest in group one and the shortest, called milled asbestos, in group seven. The length of the fibers, as well as the chemical composition of the ore, determines the kind of product that can be made from the asbestos. The longer fibers have been used in fabrics, commonly with cotton or rayon, and the shorter ones for molded goods, such as pipes and gaskets.

Application of Asbestos

Asbestos has been used in building-construction materials, textiles, missile and jet parts, asphalt and caulking compounds and paints, and in friction products such as brake linings.

LEARNING OUTCOME 2.2: CLASSIFY OF SEMI SYNTHETIC FIBERS

❖ **CONTENT/TOPIC 1 INTRODUCTION OF SEMI SYNTHETIC FIBERS**

THE TRADE - MARKS OF ...

POLYCONDENSATION.

* On polyamide : Nylon, Nyfrance, Rilson.
* on polyester : Tergal, Terital, Terylene, terival

The trade - marks of the fiber obtained polymerisation.

_ Dacron, Teflon, **orlon**.

1. POLYAMIDES

A. History of polyamide

The polyamides are the oldest of all the textile; first of them Baptiste Nylon was discovered in the United states in 1937 by CAROTHERW on the laboratories of the Company may Nemours - point ay un laboratories of the Isociete made in France or in the laboratories

Rhodiaceta society during the second world war in 1933-1945 in immediate sucess that time the industrial manufacture of polyamide did not cease to grow to perfection, to diversify nylon market was the end of the war.

B. COMMERCIAL NAMES of Polyamide

- Polyamide 66 or Nylon : France, USA.
- Polyamide 11 or Rilson : France, Italy
- Polyamide 6 or **lilion** : Italy
- Polyamide 6 or celon : France
- Polyamide 6 or Enkalon : Holland

- Polyamides 6 or perlon : Germany

c. The three types of Polyamide.

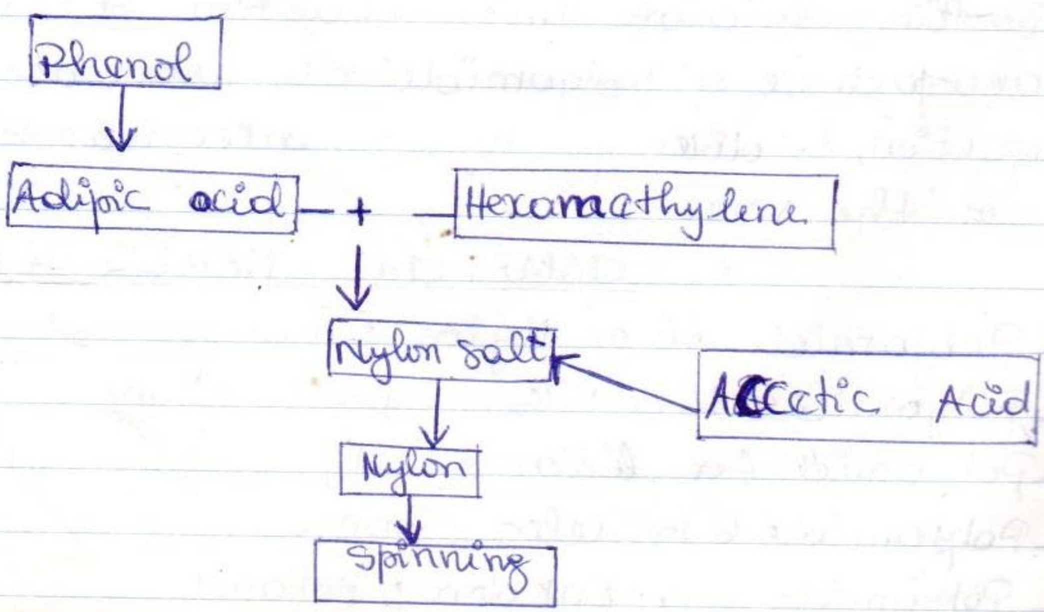
They are different as a result of raw material and subsenquently chemical process which service synthetizing their.

* 66 polyamide whose basic product is Phenol
* 6 Polyamide whose basic product is phenol (Chemical tretment different)
* 11 Polyamide obtained from castor oil

Δ. Basic product.

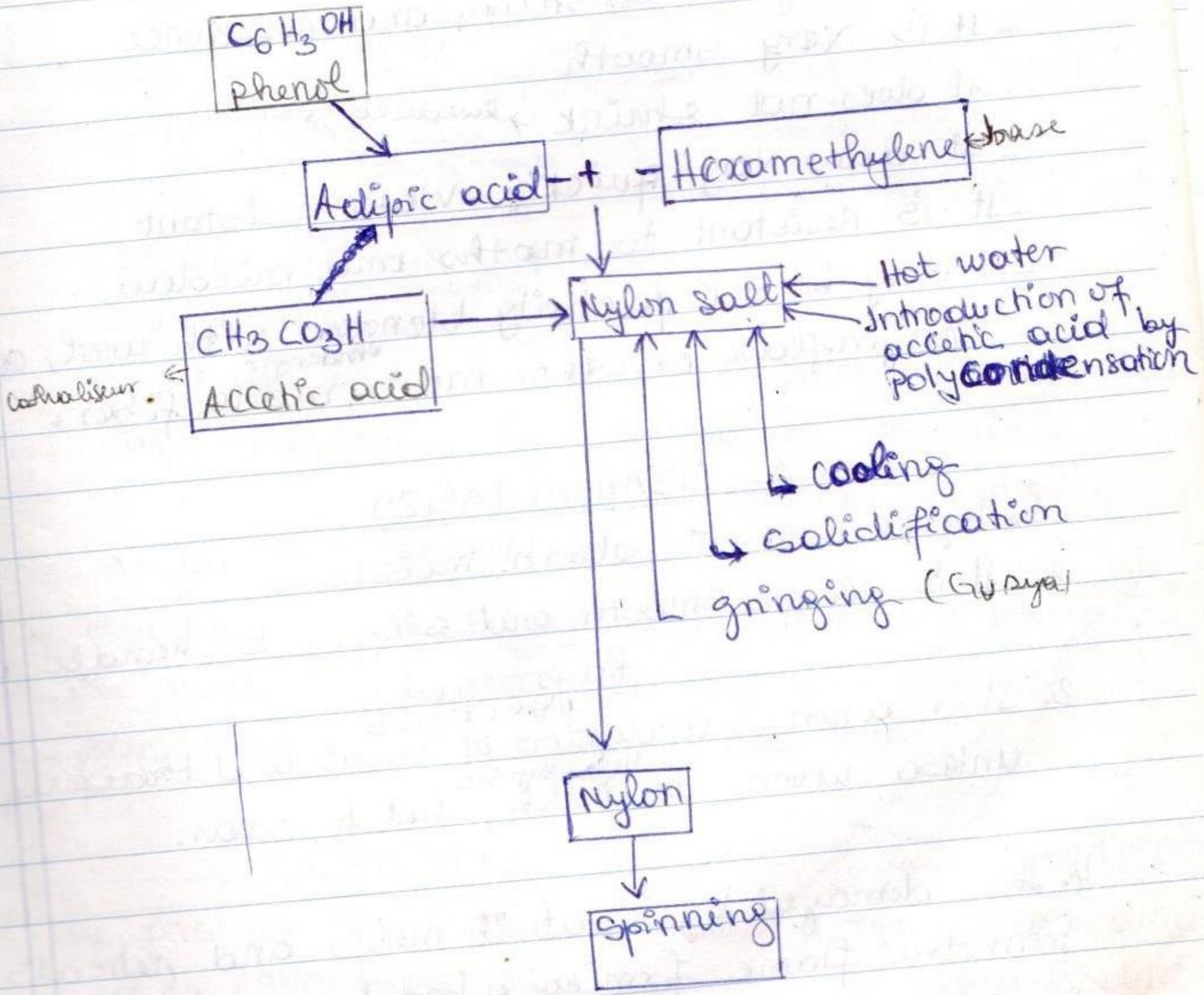
* petrolium, extracts in which banzene or Phenol Benzene & phenol from Rilsan

Transformation of Polyamide



After: Nylon cold in water
- Nylon solidified on air
- Nylon gringing on 300°c t.

CYCLE PRODUCTION POLYAMIDE



Spinning

Nylon sent in channels and the yarn solidify on air

Stretching: Nylon stretched for giving elasticity and increased strengh

www.tigo.co.rw

PROPERTIES OF POLYAMIDE

1. ADVANTAGES

- Like rayon, Nylon may be produced in a great varie of textures, thickness and finishes
- It is extremely strong when dry
- It is nearly as strong when wet
- It has great elasticity and resilience
- It is very smooth
- It does not shrink → kwiduka gake.
- It dries very quickly - water resistant
- It is resistant to moths and mildew
- It may be satisfactorily blended with wool, cotton, rayon, flax or other man-made fiber. (blended: kuvanga)

2. DISADVANTAGES

1. Nylon does not absorb moisture
2. It is very smooth and slippery to handle and frays easily (frays: gusozoka)
3. It is a non-conductor of heat and therefore, unless woven as mesh, hot to wear. (mesh: yubushyuhe)

4. It is damaged by heat it melts and retreats from the flame forming a bead, and gives of smell of celery

5. Charges of static build up in the fibers causing fabric to cling to other clothing and to attack
→ ubuntu ubona mu myenda, akisa n'ibishashi by'umuri

- diff. anti static type off Nylon are being developped

3. CARE OF POLYAMIDE (Nylon)

- Read labels attached to fabrics of special instructions
- Wash in warm (→ akazuyazi.) soapy (→ isabune) water and rinse (→ kunyuguza) well
- Iron in wrong side using a label
- Test a sample (→ piece of material) of the material for correct heat of iron whenever possible
- Do not dry (→ sécher (kwanika)) over or in front of direct heat
- Roll in the towel to remove surplus moisture and dry completely in the current of air.

Bya = tremper = kwinika

4. PRESSING

- Test first on a scrap (sample) of the same material
- Use medium - warm iron
- press seam under a dampened cloth

Nylon was the first commercially successful synthetic thermoplastic polymer.] DuPont began its research project in 1927. The first example of nylon (nylon 6,6) using diamines on February 28, 1935, by Wallace Hume Carothers at DuPont's research facility at the DuPont Experimental Station. In response to Carothers' work, Paul Schlack at IG Farben developed nylon 6, a different molecule based on caprolactam, on January 29, 1938.

Nylon was first used commercially in a nylon-bristled toothbrush in 1938,[11][12] followed more famously in women's stockings or "nylons" which were shown at the 1939 New York World's Fair and first sold commercially in 1940.[13] During World War II, almost all nylon production was diverted to the military for use in parachutes and parachute cord. Wartime uses of nylon and other plastics greatly increased the market for the new materials

History

Wallace Carothers

DuPont and the invention of Nylon

DuPont, founded by Éleuthère Irénée du Pont, first produced gunpowder and later cellulose-based paints. Following WWI, DuPont produced synthetic ammonia and other chemicals.

DuPont began experimenting with the development of cellulose based fibers, eventually producing the synthetic fiber rayon. DuPont's experience with rayon was an important precursor to its development and marketing of nylon.

DuPont's invention of nylon spanned an eleven-year period, ranging from the initial research program in polymers in 1927 to its announcement in 1938, shortly before the opening of the **1939 New York World's Fair**.

The project grew from a new organizational structure at DuPont, suggested by Charles Stine in 1927, in which the chemical department would be composed of several small research teams that would focus on "pioneering research" in chemistry and would "lead to practical applications".

Harvard instructor Wallace Hume Carothers was hired to direct the polymer research group. Initially he was allowed to focus on pure research, building on and testing the theories of German chemist Hermann Staudinger

He was very successful, as research he undertook greatly improved the knowledge of polymers and contributed to science.

In the spring of 1930, Carothers and his team had already synthesized two new polymers. One was neoprene, a synthetic rubber greatly used during World War II.

The other was a white elastic but strong paste that would later become nylon. After these discoveries, Carothers' team was made to shift its research from a more pure research approach investigating general polymerization to a more practically-focused goal of finding "one chemical combination that would lend itself to industrial applications".

It wasn't until the beginning of 1935 that a polymer called "polymer 6-6" was finally produced. Carothers' coworker, Washington University alumnus Julian W. Hill had used a cold drawing method to produce a polyester in 1930. This cold drawing method was later used by Carothers in 1935 to fully develop nylon.[20] The first example of nylon (nylon 6,6) was produced on February 28, 1935, at DuPont's research facility at the DuPont Experimental Station.

It had all the desired properties of elasticity and strength. However, it also required a complex manufacturing process that would become the basis of industrial production in the future.

DuPont obtained a patent for the polymer in September 1938, and quickly achieved a monopoly of the fiber.] Carothers died 16 months before the announcement of nylon, therefore he was never able to see his success.

The production of nylon required interdepartmental collaboration between three departments at DuPont: the Department of Chemical Research, the Ammonia Department, and the Department of Rayon. Some of the key ingredients of nylon had to be produced using high pressure chemistry, the main area of expertise of the Ammonia Department. Nylon was considered a “godsend to the Ammonia Department”which had been in financial difficulties. The reactants of nylon soon constituted half of the Ammonia department's sales and helped them come out of the period of the Great Depression by creating jobs and revenue at DuPont.

DuPont's nylon project demonstrated the importance of chemical engineering in industry, helped create jobs, and furthered the advancement of chemical engineering techniques. In fact, it developed a chemical plant that provided 1800 jobs and used the latest technologies of the time, which are still used as a model for chemical plants today.

The ability to acquire a large number of chemists and engineers quickly was a huge contribution to the success of DuPont's nylon project.

The first nylon plant was located at Seaford, Delaware, beginning commercial production on December 15, 1939. On October 26, 1995, the Seaford plant was designated a National Historic Chemical Landmark by the American Chemical Society.

Early marketing strategies

An important part of nylon's popularity stems from DuPont's marketing strategy. DuPont promoted the fiber to increase demand before the product was available to the general market. Nylon's commercial announcement occurred on October 27, 1938, at the final session of the *Herald Tribune*'s yearly "Forum on Current Problems", on the site of the approaching New York City world's fair. The "first man-made organic textile fiber" which was derived from "coal, water and air" and promised to be "as strong as steel, as fine as the spider's web" was received enthusiastically by the audience, many of them middle-class women, and made the headlines of most newspapers.Nylon was introduced as part of "The world of tomorrow" at the 1939 New York World's Fair and was featured at DuPont's "Wonder World of Chemistry" at the Golden Gate International Exposition in San Francisco in 1939. Actual nylon stockings were not shipped to selected stores in the national market until May 15, 1940. However, a limited number were released for sale in Delaware before that.[17]:145–146 The first public sale of nylon stockings occurred on October 24, 1939, in Wilmington, Delaware. 4,000 pairs of stockings were available, all of which were sold within three hours.

Another added bonus to the campaign was that it meant reducing silk imports from Japan, an argument that won over many wary customers. Nylon was even mentioned by President Roosevelt's cabinet, which addressed its "vast and interesting economic possibilities" five days after the material was formally announced.

However, the early excitement over nylon also caused problems. It fueled unreasonable expectations that nylon would be better than silk, a miracle fabric as strong as steel that would last forever and never run.Realizing the danger of claims such as "New Hosiery Held Strong as Steel" and "No More Runs", DuPont scaled back the terms of the original announcement, especially those stating that nylon would possess the strength of steel.

Also, DuPont executives marketing nylon as a revolutionary man-made material did not at first realize that some consumers experienced a sense of unease and distrust, even fear, towards synthetic fabrics.

A particularly damaging news story, drawing on DuPont's 1938 patent for the new polymer, suggested that one method of producing nylon might be to use cadaverine (pentamethylenediamine),a chemical extracted from corpses. Although scientists asserted that cadaverine was also extracted by heating coal, the public often refused to listen. A woman confronted one of the lead scientists at DuPont and refused to accept that the rumour was not true.[17]:146–147

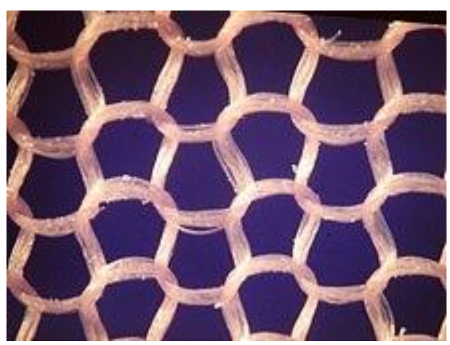
DuPont changed its campaign strategy, emphasizing that nylon was made from "coal, air and water", and started focusing on the personal and aesthetic aspects of nylon, rather than its intrinsic qualities.[17]:146–147 Nylon was thus domesticated,[17]:151–152 and attention shifted to the material and consumer aspect of the fiber with slogans like "If it's nylon, it's prettier, and oh! How fast it dries!".[15]:2

Production of nylon fabric

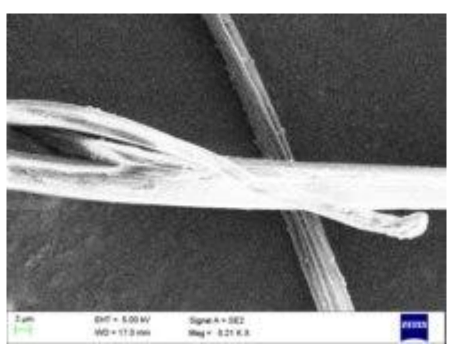
Nylon stockings being inspected in Malmö, Sweden, in 1954

After nylon's nationwide release in 1940, production was increased. 1300 tons of the fabric were produced during 1940. During their first year on the market, 64 million pairs of nylon stockings were sold.

In 1941, a second plant was opened in Martinsville, Virginia due to the success of the fabric.



Close-up photograph of the knitted nylon fabric used in stockings



Nylon fibers visualized using scanning electron microscopy

While nylon was marketed as the durable and indestructible material of the people, it was sold at almost twice the price of silk stockings ($4.27 per pound of nylon versus $2.79 per pound of silk)

Sales of nylon stockings were strong in part due to changes in women's fashion. As Lauren Olds explains: "by 1939 [hemlines] had inched back up to the knee, closing the decade just as it started off". The shorter skirts were accompanied by a demand for stockings that offered fuller coverage without the use of garters to hold them up.

However, as of February 11, 1942, nylon production was redirected from being a consumer material to one used by the military. DuPont's production of nylon stockings and other lingerie stopped, and most manufactured nylon was used to make parachutes and tents for World War II. Although nylon stockings already made before the war could be purchased, they were generally sold on the black market for as high as $20.

Once the war ended, the return of nylon was awaited with great anticipation. Although DuPont projected yearly production of 360 million pairs of stockings, there were delays in converting back to consumer rather than wartime production.[16] In 1946, the demand for nylon stockings could not be satisfied, which led to the Nylon riots. In one case, an estimated 40,000 people lined up in Pittsburgh to buy 13,000 pairs of nylons.

In the meantime, women cut up nylon tents and parachutes left from the war in order to make blouses and wedding dresses.

Between the end of the war and 1952, production of stockings and lingerie used 80% of the world's nylon. DuPont put a lot of focus on catering to the civilian demand, and continually expanded its production.

Introduction of nylon blends

As pure nylon hosiery was sold in a wider market, problems became apparent. Nylon stockings were found to be fragile, in the sense that the thread often tended to unravel lengthwise, creating 'runs'.

People also reported that pure nylon textiles could be uncomfortable due to nylon's lack of absorbency.

Moisture stayed inside the fabric near the skin under hot or moist conditions instead of being "wicked" away.

Nylon fabric could also be itchy, and tended to cling and sometimes spark as a result of static electrical charge built up by friction.

Also, under some conditions stockings could decomposeturning back into nylon's original components of air, coal, and water. Scientists explained this as a result of air pollution, attributing it to London smog in 1952, as well as poor air quality in New York and Los Angeles.

The solution found to problems with pure nylon fabric was to blend nylon with other existing fibers or polymers such as cotton, polyester, and spandex. This led to the development of a wide array of blended fabrics. The new nylon blends retained the desirable properties of nylon (elasticity, durability, ability to be dyed) and kept clothes prices low and affordable. As of 1950, the New York Quartermaster Procurement Agency (NYQMPA), which developed and tested textiles for the army and navy, had committed to developing a wool-nylon blend. They were not the only ones to introduce blends of both natural and synthetic fibers. *America's Textile Reporter* referred to 1951 as the "Year of the blending of the fibers".

Fabric blends included mixes like "Bunara" (wool-rabbit-nylon) and "Casmet" (wool-nylon-fur) In Britain in November 1951, the inaugural address of the 198th session of the Royal Society for the Encouragement of Arts, Manufactures and Commerce focused on the blending of textiles.

DuPont's Fabric Development Department cleverly targeted French fashion designers, supplying them with fabric samples. In 1955, designers such as Coco Chanel, Jean Patou, and Christian Dior showed gowns created with DuPont fibers, and fashion photographer Horst P. Horst was hired to document their use of

DuPontfabrics *American Fabrics* credited blends with providing "creative possibilities and new ideas for fashions which had been hitherto undreamed of."

Origin of the name

DuPont went through an extensive process to generate names for its new product.[17]:138–139 In 1940, John W. Eckelberry of DuPont stated that the letters "nyl" were arbitrary and the "on" was copied from the suffixes of other fibers such as cotton and Rayon.

A later publication by DuPont (*Context*, vol. 7, no. 2, 1978) explained that the name was originally intended to be "No-Run" ("run" meaning "unravel"), but was modified to avoid making such an unjustified claim. Since the products were not really run-proof, the vowels were swapped to produce "nuron", which was changed to "nilon" "to make it sound less like a nerve tonic". For clarity in pronunciation, the "i" was changed to "y."

Longer-term popularity

In spite of oil shortages in the 1970s, consumption of nylon textiles continued to grow by 7.5 per cent per annum between the 1960s and 1980s Overall production of synthetic fibers, however, dropped from 63% of the worlds textile production in 1965, to 45% of the world's textile production in early 1970s.

The appeal of "new" technologies wore off, and nylon fabric "was going out of style in the 1970s".

Also, consumers became concerned about environmental costs throughout the production cycle: obtaining the raw materials (oil), energy use during production, waste produced during creation of the fiber, and eventual waste disposal of materials that were not biodegradable.

Synthetic fibers have not dominated the market since the 1950s and 1960s. As of 2007, nylon continued to represent about 12% (8 million pounds) of the world's production of synthetic fibers.

As one of the largest engineering polymer families, the global demand of nylon resins and compounds was valued at roughly US$20.5 billion in 2013. The market is expected to reach US$30 billion by 2020 by following an average annual growth of 5.5%.

Although pure nylon has many flaws and is now rarely used, its derivatives have greatly influenced and contributed to society. From scientific discoveries relating to the production of plastics and polymerization, to economic impact during the depression and the changing of women's fashion, nylon was a revolutionary product.

The Lunar Flag Assembly, the first flag planted on the moon in a symbolic gesture of celebration, was made of nylon. The flag itself cost $5.50, but had to have a specially-designed flagpole with a horizontal bar so that it would appear to "fly".

One historian describes nylon as "an object of desire", comparing the invention to Coca-Cola in the eyes of 20th century consumers.

Chemistry

Nylons are condensation polymers or copolymers, formed by reacting difunctional monomers containing equal parts of amine and carboxylic acid, so that amides are formed at both ends of each monomer in a process analogous to polypeptide biopolymers. Most nylons are made from the reaction of a dicarboxylic acid with a diamine (e.g. PA66) or a lactam or amino acid with itself (e.g. PA6).[45] In the first case, the "repeating unit" consists of one of each monomer, so that they alternate in the chain, similar to the so-called ABAB structure of polyesters and polyurethanes. Since each monomer in this copolymer has the same reactive group on both ends, the direction of the amide bond reverses between each monomer, unlike natural polyamide proteins, which have overall directionality: C terminal → N terminal. In the second case (so called AA), the repeating unit corresponds to the single monomer.

Nomenclature

In common usage, the prefix "PA" (polyamide) or the name "Nylon" are used interchangeably and are equivalent in meaning.

The nomenclature used for nylon polymers was devised during the synthesis of the first simple aliphatic nylons and uses numbers to describe the number of carbons in each monomer unit, including the carbon(s) of the carboxylic acid(s).[47][48] Subsequent use of cyclic and aromatic monomers required the use of letters or sets of letters. One number after "PA" or "Nylon" indicates a homopolymer which is *monadic* or based on one amino acid (minus H_2O) as monomer:

PA 6 or Nylon 6: $[NH-(CH_2)_5-CO]_n$ made from ε-Caprolactam.

Two numbers or sets of letters indicate a *dyadic* homopolymer formed from two monomers: one diamine and one dicarboxylic acid. The first number indicates the number of carbons in the diamine. The two numbers should be separated by a comma for clarity, but the comma is often omitted.

PA or Nylon 6,10 (or 610) : $[NH-(CH_2)_6-NH-CO-(CH_2)_8-CO]_n$ made from hexamethylenediamine and sebacic acid;

For copolymers the comonomers or pairs of comonomers are separated by slashes:

PA 6/66 : $[NH-(CH_2)_6-NH-CO-(CH_2)_4-CO]_n-[NH-(CH_2)_5-CO]_m$ made from caprolactam, hexamethylenediamine and adipic acid ;

PA 66/610 : $[NH-(CH_2)_6-NH-CO-(CH_2)_4-CO]_n-[NH-(CH_2)_6-NH-CO-(CH_2)_8-CO]_m$ made from hexamethylenediamine, adipic acid and sebacic acid.

The term polyphthalamide (abbreviated to PPA) is used when 60% or more moles of the carboxylic acid portion of the repeating unit in the polymer chain is composed of a combination of terephthalic acid (TPA) and isophthalic acid (IPA).

Types of nylon

Nylon 66

Wallace Carothers at DuPont patented nylon 66 using amides.[21][49][50] In the case of nylons that involve reaction of a diamine and a dicarboxylic acid, it is difficult to get the proportions exactly correct, and deviations can lead to chain termination at molecular weights less than a desirable 10,000 daltons (u). To overcome this problem, a crystalline, solid "nylon salt" can be formed at room temperature, using an exact 1:1 ratio of the acid and the base to neutralize each other. The salt is crystallized to purify it and obtain the desired precise stoichiometry. Heated to 285 °C (545 °F), the salt reacts to form nylon polymer with the production of water.

Nylon 6

The synthetic route using lactams (cyclic amides) was developed by Paul Schlack at IG Farben, leading to nylon 6, or polycaprolactam — formed by a ring-opening polymerization. The peptide bond within the caprolactam is broken with the exposed active groups on each side being incorporated into two new bonds as the monomer becomes part of the polymer backbone.

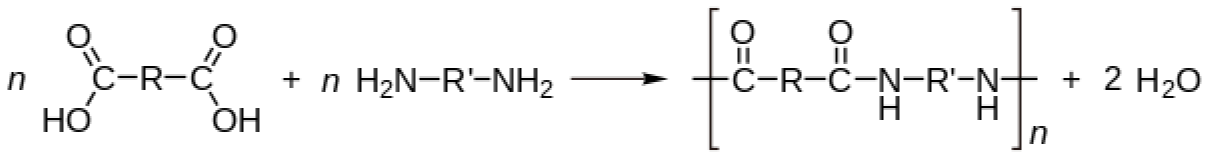
The 428 °F (220 °C) melting point of nylon 6 is lower than the 509 °F (265 °C) melting point of nylon 66.[51]

Nylon 510

Nylon 510, made from pentamethylene diamine and sebacic acid, was studied by Carothers even before nylon 66 and has superior properties, but is more expensive to make. In keeping with this naming convention, "nylon 6,12" or "PA 612" is a copolymer of a 6C diamine and a 12C diacid. Similarly for PA 510 PA 611; PA

1012, etc. Other nylons include copolymerized dicarboxylic acid/diamine products that are *not* based upon the monomers listed above. For example, some fully aromatic nylons (known as "aramids") are polymerized with the addition of diacids like terephthalic acid (→ Kevlar, Twaron) or isophthalic acid (→ Nomex), more commonly associated with polyesters. There are copolymers of PA 66/6; copolymers of PA 66/6/12; and others. In general linear polymers are the most useful, but it is possible to introduce branches in nylon by the condensation of dicarboxylic acids with polyamines having three or more amino groups.

The general reaction is



Two molecules of water are given off and the nylon is formed. Its properties are determined by the R and R' groups in the monomers. In nylon 6,6, R = 4C and R' = 6C alkanes, but one also has to include the two carboxyl carbons in the diacid to get the number it donates to the chain. In Kevlar, both R and R' are benzene rings.

Industrial synthesis is usually done by heating the acids, amines or lactams to remove water, but in the laboratory, diacid chlorides can be reacted with diamines. For example, a popular demonstration of interfacial polymerization (the "nylon rope trick") is the synthesis of nylon 66 from adipoyl chloride and hexamethylene diamine.

Nylon 1,6

Nylons can also be synthesized from dinitriles using acid catalysis. For example, this method is applicable for preparation of nylon 1,6 from adiponitrile, formaldehyde and water. Additionally, nylons can be synthesized from diols and dinitriles using this method as well.

Monomers

Nylon monomers are manufactured by a variety of routes, starting in most cases from crude oil but sometimes from biomass. Those in current production are described below.

Amino acids and lactams

ε-Caprolactam: Crude oil → benzene → cyclohexane → cyclohexanone → cyclohexanone oxime → caprolactam

11-aminoundecanoic acid: Castor oil → ricinoleic acid → methylricinoleate → methyl-11-undecenoate → undecenoic acid → 11-undecenoic acid → 11-bromoundecanoic acid → 11-aminoundecanoic acid[54]

Laurolactam: Butadiene → cyclododecatriene → cyclododecane → cyclododecanone → cyclododecanone oxime → laurolactam

Diacids[edit]

Adipic acid: Crude oil → benzene → cyclohexane → cyclohexanone + cyclohexanol → adipic acid

Sebacic acid (decanedioic acid): Castor oil → ricinoleic acid → sebacic acid

Dodecanedioic acid: Butadiene → Cyloclododecatriene → cyclododecane → (oxidation) → Dodecanedioic acid

Terephthalic acid: Crude oil → p-xylene → terephthalic acid

Isophthalic acid: Crude oil → m-xylene → isophthalic acid

Diamines

Various diamine components can be used, which are derived from a variety of sources. Most are petrochemicals, but bio-based materials are also being developed.

Tetramethylene diamine (putrescine): Crude oil → propylene → acrylonitrile → succinonitrile → tetramethylene diamine

Hexamethylene diamine (HMD): Crude oil → butadiene → adiponitrile → hexamethylene diamine

1,9-diaminononane: Crude oil → butadiene → 7-octen-1-al → 1,9-nonanedial → 1,9-diaminononane[55]

2-methyl pentamethylene diamine: a by product of HMD production

Trimethyl Hexamethylene diamine (TMD): Crude oil → propylene → acetone → isophorone → TMD

m-xylylene diamine (MXD): Crude oil → m-xylene → isophthalic acid → isophthalonitrile → m-xylylene diamine

1,5-pentanediamine (cadaverine) (PMD): starch (e.g. cassava) → glucose → lysine → PMD.[57]

Polymers

Due to the large number of diamines, diacids and aminoacids that can be synthesized, many nylon polymers have been made experimentally and characterized to varying degrees. A smaller number have been scaled up and offered commercially, and these are detailed below.

Homopolymers[edit]

Homopolymer nylons derived from one monomer

Monomer	Polymer
caprolactam	6
11-aminoundecanoic acid	11
ω-aminolauric acid	12

Examples of these polymers that are or were commercially available

PA6 Lanxess Durethan B

PA11 Arkema Rilsan

PA12 Evonik Vestamid

Homopolymer polyamides derived from pairs of diamines and diacids (or diacid derivatives). Shown in the table below are polymers which are or have been offered commercially either as homopolymers or as a part of a copolymer.

Commercial homopolymer polyamides										
	1,4-diamino-butane	**1,5-diamino-pentane**	**MPMD**	**HMD**	**MXD**	**Nonane-diamine**	**Decane-diamine**	**Dodecane-diamine**	**bis(para-amino-cyclohexyl)-methane**	**trimethyl-hexamethylenediamine**
Adipic acid	46		D6	66	MXD6					
Sebacic acid	410	510		610			1010			
Dodecanedioic acid				612				1212	PACM12	
Terephthalic acid	4T		DT	6T		9T	10T	12T		TMDT
Isophthalic acid			DI	6I						

Examples of these polymers that are or were commercially available

PA46 DSM Stany

PA410 DSM Ecopax

PA4T DSM Four Tii

PA66 DuPont Zyte

Copolymers

It is easy to make mixtures of the monomers or sets of monomers used to make nylons to obtain copolymers. This lowers crystallinity and can therefore lower the melting point.

Some copolymers that have been or are commercially available are listed below:

PA6/66 DuPont Zytel

PA6/6T BASF Ultramid T (6/6T copolymer)

PA6I/6T DuPont Selar PA

PA66/6T DuPont Zytel HTN

PA12/MACMI EMS Grilamid TR

Blends

Most nylon polymers are miscible with each other allowing a range of blends to be made. The two polymers can react with one another by transamidation to form random copolymers.[69]

According to their crystallinity, polyamides can be:

semi-crystalline:

high crystallinity: PA46 and PA66;

low crystallinity: PAMXD6 made from m-xylylenediamine and adipic acid;

amorphous: PA6I made from hexamethylenediamine and isophthalic acid.

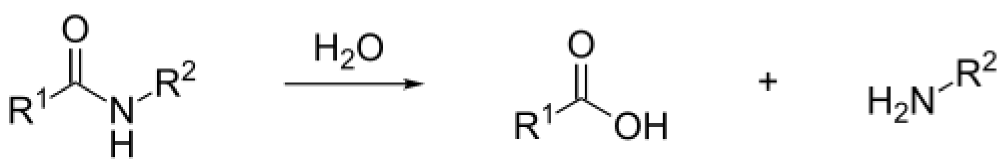
According to this classification, PA66, for example, is an aliphatic semi-crystalline homopolyamide.

Hydrolysis and degradation

All nylons are susceptible to hydrolysis, especially by strong acids, a reaction essentially the reverse of the synthetic reaction shown above. The molecular weight of nylon products so attacked drops, and cracks form quickly at the affected zones. Lower members of the nylons (such as nylon 6) are affected more than higher members such as nylon 12. This means that nylon parts cannot be used in contact with sulfuric acid for example, such as the electrolyte used in lead–acid batteries.

When being molded, nylon must be dried to prevent hydrolysis in the molding machine barrel since water at high temperatures can also degrade the polymer.

The reaction is of the type:



Environmental impact, incineration and recycling

Berners-Lee calculates the average greenhouse gas footprint of nylon in manufacturing carpets at 5.43 kg CO_2 equivalent per kg, when produced in Europe. This gives it almost the same carbon footprint as wool, but with greater durability and therefore a lower overall carbon footprint.

Data published by PlasticsEurope indicates for nylon 66 a greenhouse gas footprint of 6.4 kg CO_2 equivalent per kg, and an energy consumption of 138 kJ/kg.

When considering the environmental impact of nylon, it is important to consider the use phase. In particular when cars are lightweight, significant savings in fuel consumption and CO_2 emissions are achieved.

Various nylons break down in fire and form hazardous smoke, and toxic fumes or ash, typically containing hydrogen cyanide. Incinerating nylons to recover the high energy used to create them is usually expensive, so most nylons reach the garbage dumps, decaying slowly. Discarded nylon fabric takes 30–40 years to decompose. Nylon is a robust polymer and lends itself well to recycling. Much nylon resin is recycled directly in a closed loop at the injection molding machine, by grinding sprues and runners and mixing them with the virgin granules being consumed by the molding machine

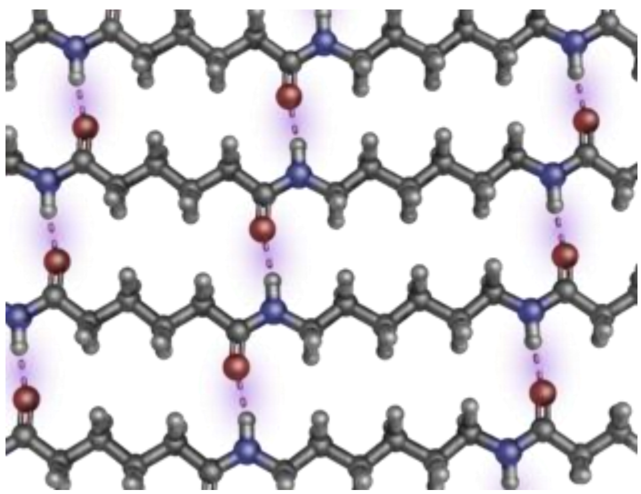
Nylon can be recycled but only a few companies do so. Aquafil has demonstrated recycling fishing nets lost in the ocean into apparel Vanden recycles Nylon and other polyamides (PA) and has operations in UK, Australia, Hong Kong, UAE, Turkey and Finland.

Bulk properties

Above their melting temperatures, T_m, thermoplastics like nylon are amorphous solids or viscous fluids in which the chains approximate random coils. Below T_m, amorphous regions alternate with regions which are lamellar crystals.

The amorphous regions contribute elasticity and the crystalline regions contribute strength and rigidity. The planar amide (-CO-NH-) groups are very polar, so nylon forms multiple hydrogen bonds among adjacent strands. Because the nylon backbone is so regular and symmetrical, especially if all the amide bonds are in the *trans* configuration, nylons often have high crystallinity and make excellent fibers.

The amount of crystallinity depends on the details of formation, as well as on the kind of nylon.



Hydrogen bonding in Nylon 6,6 (in mauve).

Nylon 66 can have multiple parallel strands aligned with their neighboring peptide bonds at coordinated separations of exactly 6 and 4 carbons for considerable lengths, so the carbonyl oxygens and amide hydrogens can line up to form interchain hydrogen bonds repeatedly, without interruption (see the figure opposite). Nylon 510 can have coordinated runs of 5 and 8 carbons.

Thus parallel (but not antiparallel) strands can participate in extended, unbroken, multi-chain β-pleated sheets, a strong and tough supermolecular structure similar to that found in natural silk fibroin and the β-keratins in feathers. (Proteins have only an amino acid α-carbon separating sequential -CO-NH- groups.) Nylon 6 will form uninterrupted H-bonded sheets with mixed directionalities, but the β-sheet wrinkling is somewhat different. The three-dimensional disposition of each alkane hydrocarbon chain depends on rotations about the 109.47° tetrahedral bonds of singly bonded carbon atoms.

When extruded into fibers through pores in an industry spinneret, the individual polymer chains tend to align because of viscous flow. If subjected to cold drawing afterwards, the fibers align further, increasing their crystallinity, and the material acquires additional tensile strength. In practice, nylon fibers are most often drawn using heated rolls at high speeds.

Block nylon tends to be less crystalline, except near the surfaces due to shearing stresses during formation. Nylon is clear and colorless, or milky, but is easily dyed. Multistranded nylon cord and rope is slippery and tends to unravel. The ends can be melted and fused with a heat source such as a flame or electrode to prevent this.

Nylons are hygroscopic, and will absorb or desorb moisture as a function of the ambient humidity. Variations in moisture content have several effects on the polymer. Firstly, the dimensions will change, but more importantly moisture acts as a plasticizer, lowering the **glass transition temperature (T_g)**, and consequently the elastic modulus at temperatures below the T_g

When dry, polyamide is a good electrical insulator. However, polyamide is hygroscopic. The absorption of water will change some of the material's properties such as its electrical resistance. Nylon is less absorbent than wool or cotton.

Characteristics

The characteristic features of nylon 6,6 include:

Pleats and creases can be heat-set at higher temperatures

More compact molecular structure

Better weathering properties; better sunlight resistance

Softer "Hand"

High melting point (256 °C, 492.8 °F)

Superior colorfastness

Excellent abrasion resistance

On the other hand, nylon 6 is easy to dye, more readily fades; it has a higher impact resistance, a more rapid moisture absorption, greater elasticity and elastic recovery.

Variation of luster: nylon has the ability to be very lustrous, semi-lustrous or dull.

Durability: its high tenacity fibers are used for seatbelts, tire cords, ballistic cloth and other uses.

High elongation

Excellent abrasion resistance

Highly resilient (nylon fabrics are heat-set)

Paved the way for easy-care garments

High resistance to insects, fungi, animals, as well as molds, mildew, rot and many chemicals

Used in carpets and nylon stockings

Melts instead of burning

Used in many military applications

Good specific strength

Transparent to infrared light (−12 dB)

Flammability

Nylon clothing tends to be less flammable than cotton and rayon, but nylon fibers may melt and stick to skin.

Uses of nylon]

Nylon was first used commercially in a nylon-bristled toothbrush in 1938, followed more famously in women's stockings or "nylons" which were shown at the 1939 New York World's Fair and first sold commercially in 1940.

Its use increased dramatically during World War II, when the need for fabrics increased dramatically.

Nylon fibers

These worn out nylon stockings will be reprocessed and made into parachutes for army fliers c. 1942

Blue Nylon fabric ball gown by Emma Domb, **Science History Institute**

DuPont, and other individuals and corporations worked diligently during the first few months of World War II to find a way to replace Asian silk and hemp with nylon in parachutes. It was also used to make tires, tents, ropes, ponchos, and other military supplies. It was even used in the production of a high-grade paper for U.S. currency. At the outset of the war, cotton accounted for more than 80% of all fibers used and manufactured, and wool fibers accounted for nearly all of the rest. By August 1945, manufactured fibers had taken a market share of 25%, at the expense of cotton. After the war, because of shortages of both silk and nylon, nylon parachute material was sometimes repurposed to make dresses.

Nylon 6 and 66 fibers are used in carpet manufacture.

Nylon is one kind of fibers used in tire cord. Herman E. Schroeder pioneered application of nylon in tires.

Molds and resins

Nylon resins are widely used in the automobile industry especially in the engine compartment.

Molded nylon is used in hair combs and mechanical parts such as machine screws, gears, gaskets, and other low- to medium-stress components previously cast in metal. Engineering-grade nylon is processed by extrusion, casting, and injection molding.

Type 6,6 Nylon 101 is the most common commercial grade of nylon, and Nylon 6 is the most common commercial grade of molded nylon.

For use in tools such as spudgers, nylon is available in glass-filled variants which increase structural and impact strength and rigidity, and molybdenum disulfide-filled variants which increase lubricity. Nylon can be used as the matrix material in composite materials, with reinforcing fibers like glass or carbon fiber; such a composite has a higher density than pure nylon. Such thermoplastic composites (25% to 30% glass fiber) are frequently used in car components next to the engine, such as intake manifolds, where the good heat resistance of such materials makes them feasible competitors to metals.

Nylon was used to make the stock of the Remington Nylon 66 rifle The frame of the modern Glock pistol is made of a nylon composite.

Food packaging

Nylon resins are used as a component of food packaging films where an oxygen barrier is needed

Some of the terpolymers based upon nylon are used every day in packaging. Nylon has been used for meat wrappings and sausage sheaths. The high temperature resistance of nylon makes it useful for oven bags.

Filaments

Nylon filaments are primarily used in brushes especially toothbrushesand string trimmers. They are also used as monofilaments in fishing line. Nylon 610 and 612 are the most used polymers for filaments.

Its various properties also make it very useful as a material in additive manufacturing; specifically as a filament in consumer and professional grade fused deposition modeling 3D printers.

Nylon resins can be extruded into rods, tubes and sheets.

Powder coating

Nylon powders are used to powder coat metals. Nylon 11 and nylon 12 are the most widely used.

Instrument strings

In the mid-1940s, classical guitarist Andrés Segovia mentioned the shortage of good guitar strings in the United States, particularly his favorite Pirastro catgut strings, to a number of foreign diplomats at a party, including General Lindeman of the British Embassy. A month later, the General presented Segovia with some nylon strings which he had obtained via some members of the DuPont family. Segovia found that although the strings produced a clear sound, they had a faint metallic timbre which he hoped could be eliminated.

Nylon strings were first tried on stage by Olga Coelho in New York in January, 1944.

In 1946, Segovia and string maker Albert Augustine were introduced by their mutual friend Vladimir Bobri, editor of Guitar Review. On the basis of Segovia's interest and Augustine's past experiments, they decided to pursue the development of nylon strings. DuPont, skeptical of the idea, agreed to supply the nylon if Augustine would endeavor to develop and produce the actual strings. After three years of development, Augustine demonstrated a nylon first string whose quality impressed guitarists, including Segovia, in addition to DuPont.

Wound strings, however, were more problematic. Eventually, however, after experimenting with various types of metal and smoothing and polishing techniques, Augustine was also able to produce high quality nylon wound strings.

Fabric name	Nylon
Fabric also known as	Polymer fabric
Fabric composition	Various types of synthetic polymers
Fabric breathabilityn	Low breathability
Moisture-wicking abilities	Medium
Heat retention abilities	Medium
Stretchability (give)	High
Prone to pilling/bubbling	High
Country where fabric was first produced	United States
Biggest exporting/producing country today	China
Recommended washing temperatures	Warm
Commonly used in	Tights, stockings, sportswear, yoga pants, and other form-fitting types of apparel

Coyote Brown 1,000 Denier Cordura Nylon Fabric

What Is Nylon Fabric?

Nylon is the name of a family of synthetic polymers that are commonly used to make a variety of different types of apparel and consumer goods. Unlike other organic or semi-synthetic fibers, nylon fibers are entirely synthetic, which means that they have no basis in organic material.

The use of this type of synthetic polymer in clothing began with a desire to find alternatives to silk and hemp for parachutes in World War II.

At the time the war began, cotton was used for more than 80 percent of textile applications in the United States, and almost all other textiles were made from wool. By 1945, however, synthetic fibers like nylon constituted around 25 percent of the textile market share, and once the war ended, manufacturers sought new ways to market this new class of synthetic fabrics.

Directly after the war, there was a shortage of traditional dress materials like cotton and silk, so some individuals made dresses from repurposed nylon parachutes. Thus, the idea to use nylon in women's garments gained popularity, and the production of nylon stockings and lingerie rapidly picked up steam.

Nylon Fabric Replacet

Buckle Wrist Watch Band Bracelet for Apple Watch

At the same time, nylon was finding ever greater popularity in a variety of other consumer and military markets. This substance had originally been developed by the DuPont Corporation in the early 1920s, and it's creation was officially announced at the 1939 World's Fair. At the time, DuPont had no intention of using nylon for scientific and industrial applications, and the main purpose of this new polymer was deemed to be for textiles.

At the time of its unveiling, nylon did not have its current name; upon recognizing this polymer's potential for use in fabrics, DuPont originally planned to market it under the name "no-run" due to its perceived ability to resist "runs" when used in fabric, which are forms of damage to tights that cause these garments to become aesthetically displeasing. However, it was soon discovered that nylon was, in fact, subject to runs, so the name was changed to "nuron." This name was also unsatisfactory, however, so it was changed to "nilon," and the "i" was replaced with a "y" to clarify pronunciation.

During the early days of nylon fabric, consumers noted a variety of issues with nylon fabric. Despite early marketing efforts that described nylon as "stronger than steel," nylon was found to be highly susceptible to runs and tears, and this fabric's lack of moisture-wicking properties also became a subject of concern. In extreme cases, nylon stockings would revert to coal and water.

Rose Nylon Fabric Umbrella

Nylon would have been considered to be a failed experiment if producers of this material hadn't started mixing it with other textiles. It was found that when nylon fabric was mixed with polyester, spandex, or cotton, the desirable attributes of this fabric were retained, but many of the undesirable aspects of this fabric were eliminated. These days, most nylon garments consist of a blend of various fabrics.

This fabric remained popular throughout the 1940s and 1950s, but nylon and other synthetic textiles have experienced a steady drop in popularity since the 1970s. Over time, the novelty of nylon started to wear off, and consumers also became concerned about the environmental impact of this fabric. The main ingredient of nylon fabric is petroleum oil, and this textile is not biodegradable. As of 2008, however, around 12 percent of the world's synthetic fiber production consists of nylon fabric.

Even though nylon fabric for consumer garments has declined in popularity, this polymer family has become increasingly popular for industrial and scientific purposes. For instance, nylon can be made into a plastic that is highly durable and versatile, and nylon resins are commonly used in hair combs, machine screws, gun parts, food packaging, toothbrushes, and hundreds of other applications.

How Is Nylon Fabric Made?

Nylon fabric is a polymer, which means that it is composed of a long chain of carbon-based molecules called monomers. There are quite a few different types of nylon, but most of them are derived from polyamide monomers that are extracted from crude oil, which is also known as petroleum.

In most cases, a monomer called hexamethylenediamine is used in the production of nylon, and this substance is sometimes called diamine acid for short. This monomer is extracted from crude oil, and the remaining components of this oil are sometimes used for other purposes, but they may be discarded.
To make the polymer known as nylon, diamine acid is forced to enter into a reaction with adipic acid. This type of polymer is commonly known as PA 6,6, and it was the first type of polymer to be used for nylon fabric. PA 6,6 is a type of substance called a nylon salt, and this crystallized substance is then heated to form a molten substance.

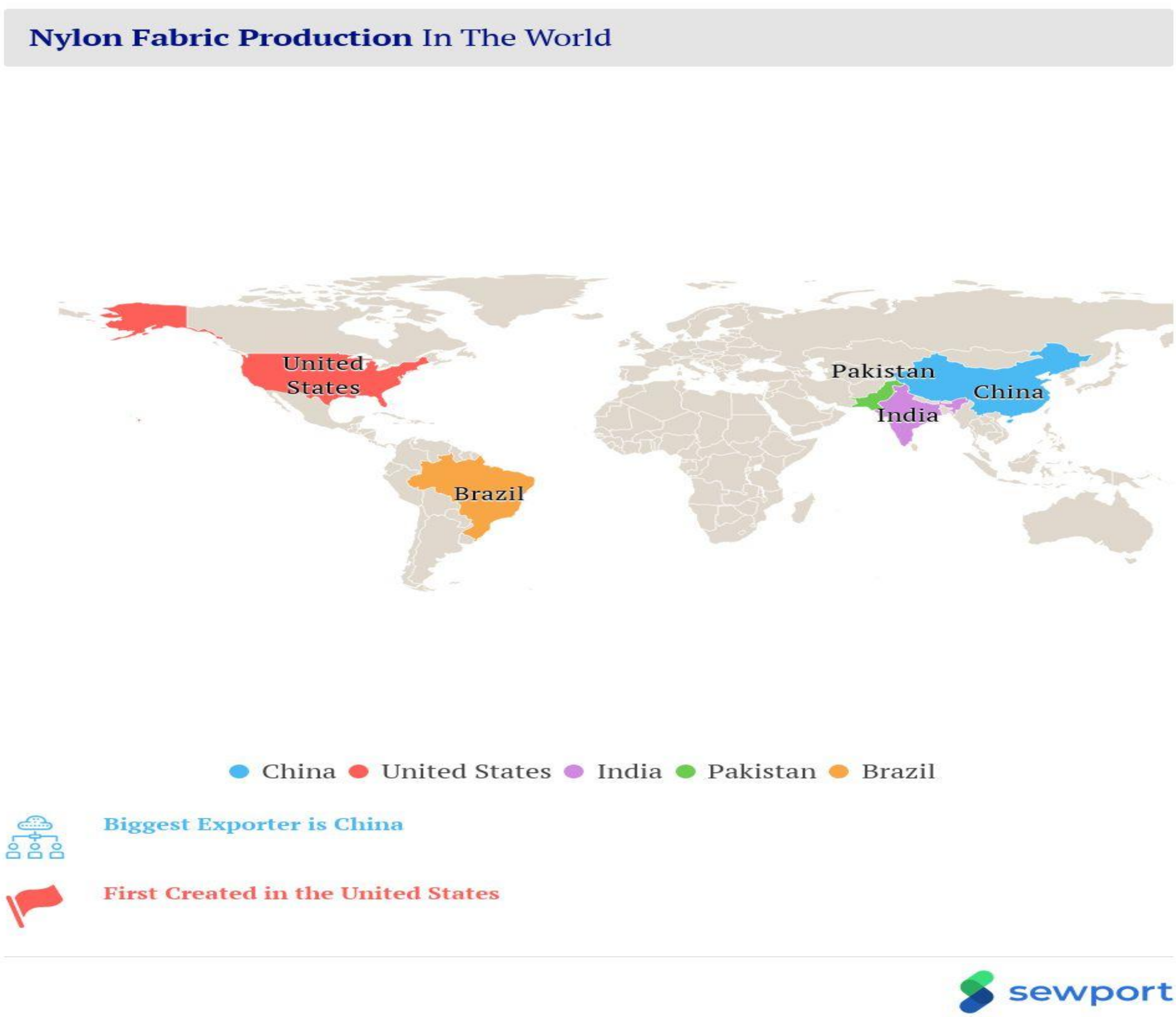
Nylon Fabric Apple Watch Band (38mm) - Solid Black – Casetify

This substance is then extruded through a spinneret, which is a device that looks similar to a showerhead that has dozens of tiny holes. Upon extrusion through the spinneret, nylon immediately hardens, and the resulting fibers are then ready to be loaded onto bobbins.

These fibers are then stretched to increase their strength and elasticity, and they are then wound onto another spool in a process called "drawing." This process causes the polymer molecules to arrange in a parallel structure, and after the drawing process is completed, the resulting fibers are ready to be spun into garments or other forms of fibers.

In some cases, nylon may be spun into fabrics on its own, but it is usually combined with other fabrics to create mixed textiles. It is then dyed to produce the color that is desired for the end product.

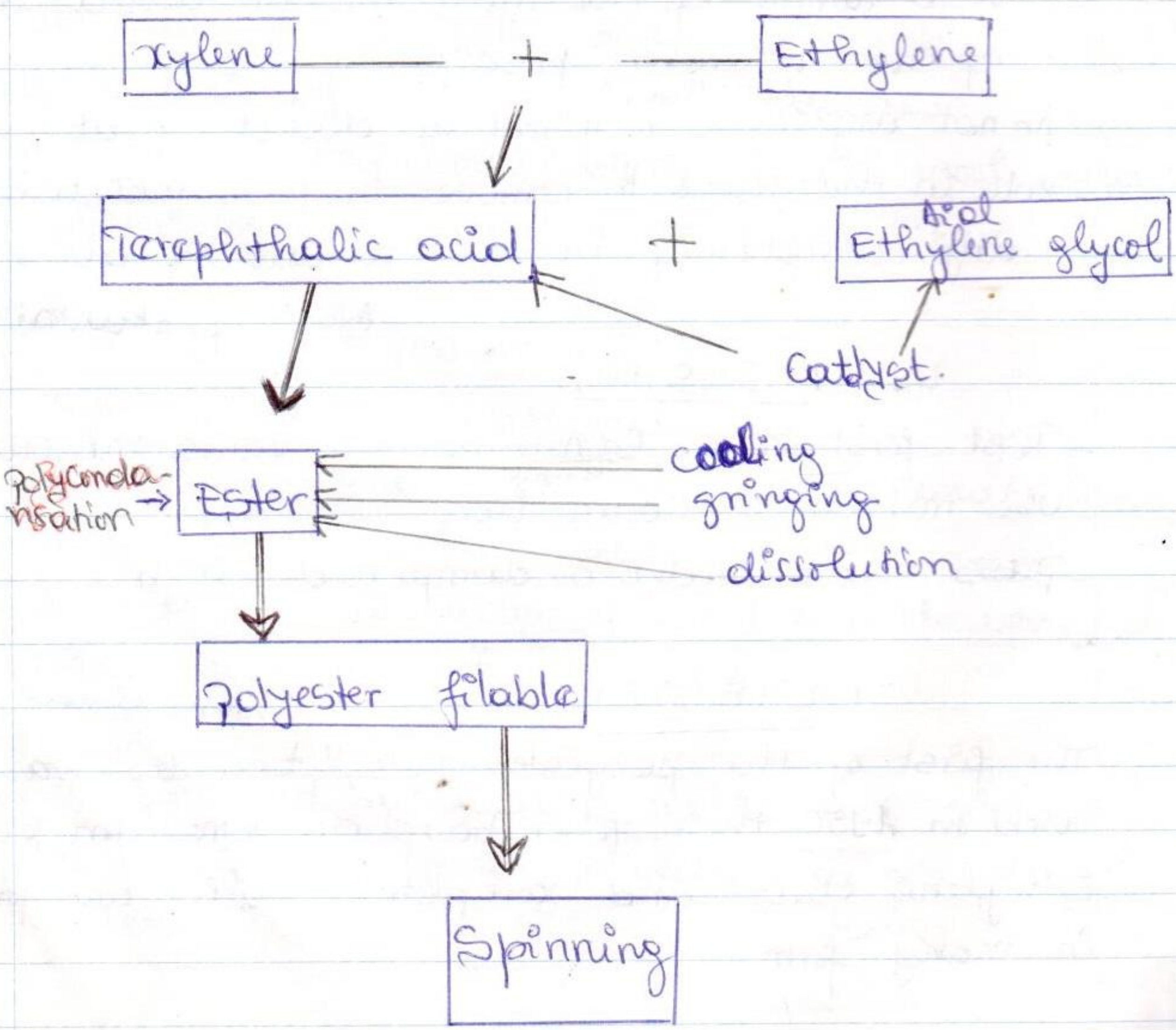
Where Is Nylon Fabric Produced?



COMMERCIALS NAMES

- The terylene made in Great Britain
- The dialene and the trevira made in Germany
- The telenkon made in Hollande
- The tetorn and teroton made in Japan
- The Doceron made in USA.
- Tergales made in France

CYCLE PRODUCTION OF POLYESTER



BRIEF OF POLYESTER FIBER

polyester fiber is a "manifactesed fiber in which the fiber forming ~~distance~~ substance is any long chain synthetic polymer composed at least 85% by weight of an ester of a dihydric alcohol (HOROH) and terephthalic acid.

The most widely used polyester fiber in made form the linaer polymer (ethylene terephthalate) and this polyester clan is generally referred to simply as PET (polymethylene terephthalate). Heigh strength modulus, low shrinkage, heat set stability light fastness and chemical resistance accornt for the great.

$$H-\left(OCH_2\,CH_2O-\overset{O}{\overset{\|}{C}}-\langle O\rangle-\overset{O}{\overset{\|}{C}}-\right)_n OH$$

(Formula chaine of polyester

POLYMER FORMATION

Polymethylene terephthaalate (PET) is a condensation polymer and is industrially produced by either terephthalic acid or dimethyl terephthalate with ethylene ~~gly~~glycol other polyester fiber of interest to the mon wovens field include:

a) Terephthalic acid (PTA)

produced directly form P-xylene with bromide-controlled oxidation

b) Dimethyl Terephthalate (DMT)

Made in the early stages by esterification of terephthalic acid a different process involving two oxidation and esterfication stages now accounts for most DMT

c) Ethylene glycol (EG)

Initially generated as an intermediate product by oxydation of Ethylene. Futher ethylene glycol is obtained by reaction of ethylene oxide with water.

GENERAL POLYESTER FIBER CHARACTERISTICS

* strong
* Resistance to stretching and shrinking
* Resistance most chemicals
* Quick dryinel
* Crisp and resistant
* Wrinkle resistant
* Abrasion resistant
  ↳ rider → solid
* Retains heat - set pleats and crease
  ↳ kurishifona kumuei
* Easily washed

RELATIONSHIP BETWEENS STRUCTURE, PROPERTIES AND PROCESSING PARMENTERS OF PET FIBERS

Properties of Polyesters fiber are strongly effected by fiber structure. The fiber structure with has strong influance on the applicability of the fiber depends heavily on the process parameters of fiber formation such as spinning speed (thread like stress) hot drawing (stretching stress relaxation and heat setting (stabilisation) speed

↳ temper. or tension of threads are the sames

As the stress in the spinning thread is increased by higher wind-up speed the PET molecules are extended resulting in better as-spun uniformity.

PROPERTIES

* Polyester fiber has good resistance to weak (tired) mineral acids even at boiling t° and to most strong acid at room temperature. but are desarved with partial decomposition by consentrated sulfuric acid. Hydralysic is highly dependent temperature.

* Sookad in water 70°c for several weeks do not show a measurable less instrength but after one week at 100°c the strength is reduced by appoximatery 20% (Appries)

* Polyester are highty sensitive to bases such as Sodium Hydroxyde and methylamine which serve as catalysts in hydrolysis reaction.

* It is absorb very little dye in convational dye system the polyester fiber are therefore dyed almost exclusively with disperse dyes.

* Is flamcable febers the fabric usualy malt and drap away of speading the flame polyester born inblends with cotton with support combustion

* Polyester fiber display good resistance to sun light but long-term degradation appears to be initiated by wetravialet radiation

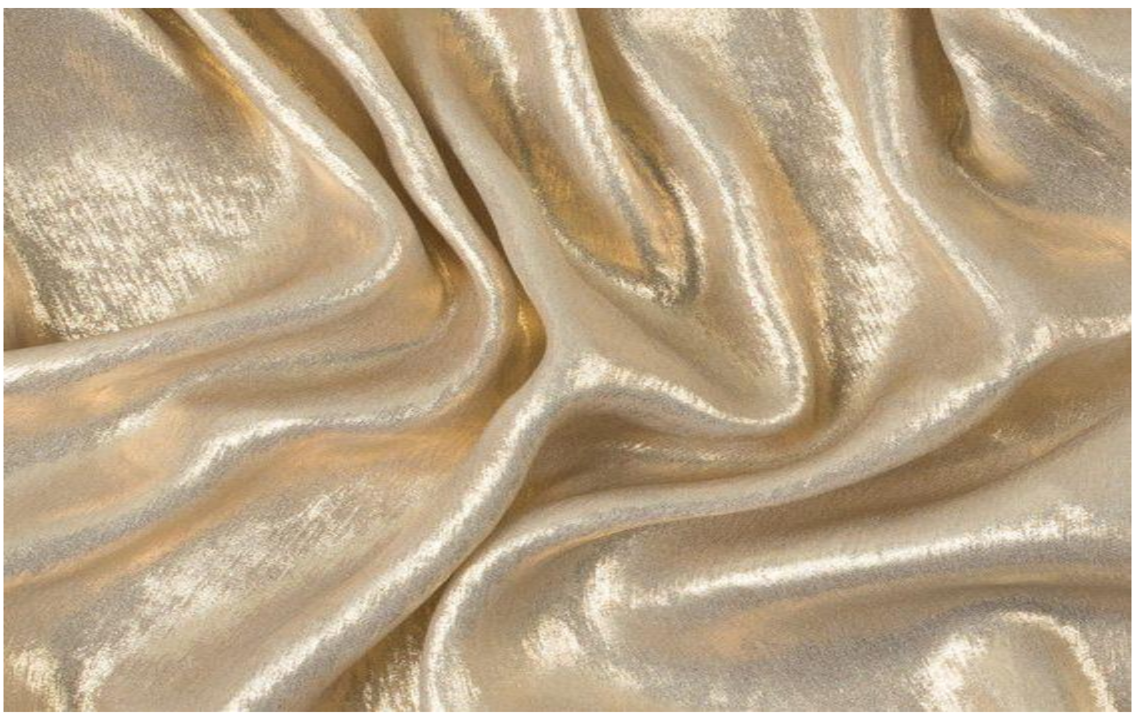
* Has good oxydation and thermal resistance.
* Calor forming species are produced and carboxyl end groups are increased.

APPLICATION

du part company produced the first US commercial polyester fiber in 1953 since polyester fiber has a a lot of special characteristic most of then are used in the following three major areas
* apparail : Every form clothing
* Home furnishing = carpets, curtains, drapenies

POLYESTER

Fabric name	Polyester
Fabric also known as	Polyethylene terephthalate, PET, microfiber
Fabric composition	Polymers derived from fossil fuels or organic sources
Fabric possible thread count variations	200-1,000
Fabric breathability	Very breathable
Moisture-wicking abilities	High
Heat retention abilities	Medium
Stretchability (give)	Medium
Prone to pilling/bubbling	Medium
Country where fabric was first produced	United States
Biggest exporting/producing country today	China
Recommended washing temperatures	Cold, warm, or hot
Commonly used in	Shirts, pants, hoodies, dresses, jackets, underwear, socks, blankets, hats, sheets, rope, upholstery



Metallic Gold Polyester Lame

What Is Polyester Fabric?

Polyester is a synthetic fabric that's usually derived from petroleum. This fabric is one of the world's most popular textiles, and it is used in thousands of different consumer and industrial applications.

Chemically, polyester is a polymer primarily composed of compounds within the ester functional group. Most synthetic and some plant-based polyester fibers are made from ethylene, which is a constituent of petroleum that can also be derived from other sources. While some forms of polyester are biodegradable, most of them are not, and polyester production and use contribute to pollution around the world.

In some applications, polyester may be the sole constituent of apparel products, but it's more common for polyester to be blended with cotton or another natural fiber. Use of polyester in apparel reduces production costs, but it also decreases the comfortability of apparel.

When blended with cotton, polyester improves the shrinkage, durability, and wrinkling profile of this widely-produced natural fiber. Polyester fabric is highly resistant to environmental conditions, which makes it ideal for long-term use in outdoor applications.

Cactus Shower Curtain Polyester Fabric Bath Curtain

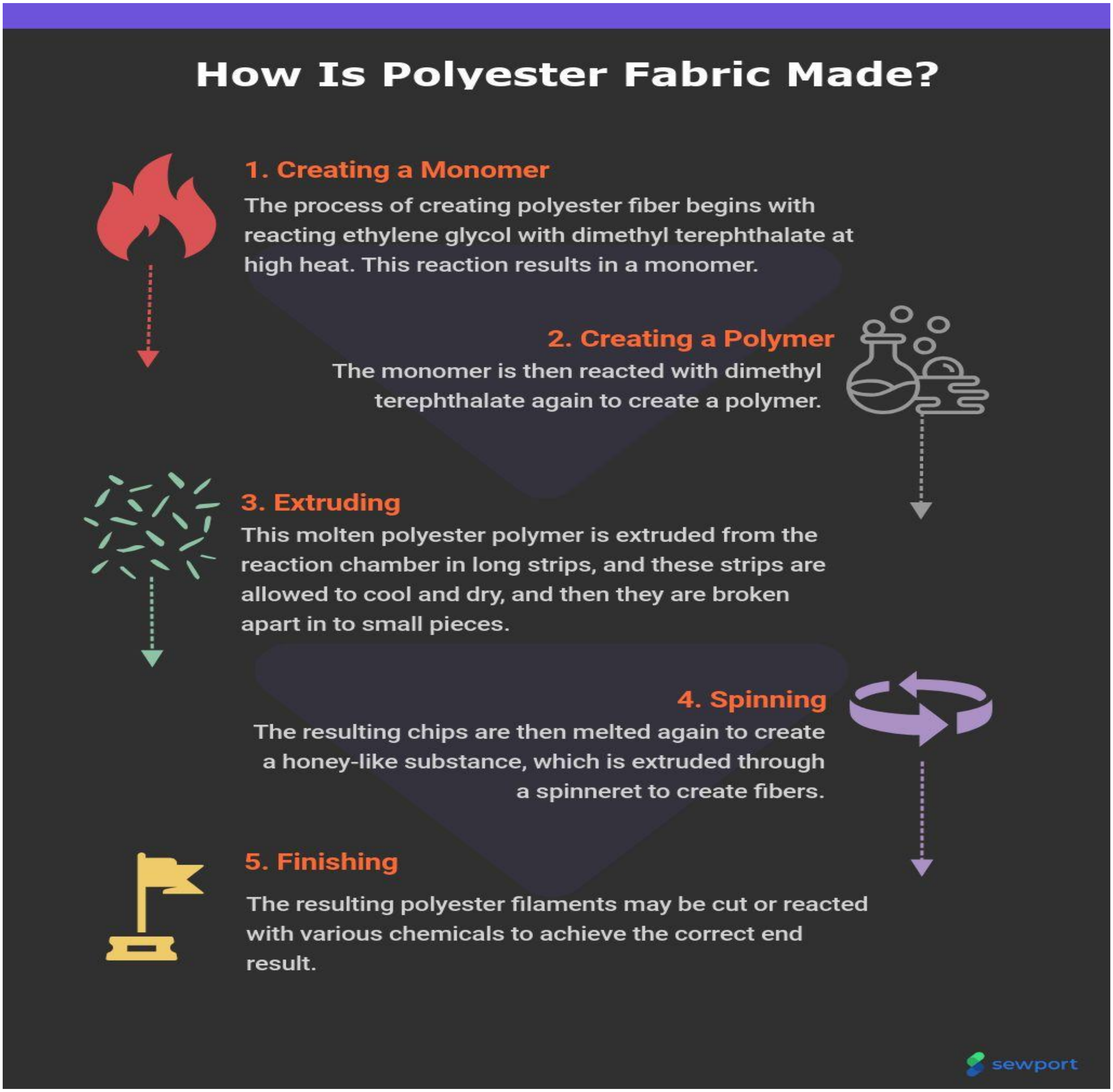
The fabric we now know as polyester began its climb toward its current critical role in the contemporary economy in 1926 as Terylene, which was first synthesized by W.H. Carothers in the UK. Throughout the 1930s and 1940s, British scientists continued to develop better forms of ethylene fabric, and these efforts eventually garnered the interest of American investors and innovators.

Polyester fiber was originally developed for mass consumption by the DuPont Corporation, which also developed other popular synthetic fibers like nylon. During World War II, the Allied powers found themselves in increased need of fibers for parachutes and other war materiel, and after the war, DuPont and other American corporations found a new consumer market for their synthetic materials in the context of the postwar economic boom.

Initially, consumers were enthusiastic about the improved durability profile of polyester compared to natural fibers, and these benefits are still valid today. In recent decades, however, the harmful environmental impact of this synthetic fiber has come to light in great detail, and the consumer stance on polyester has changed significantly.

Nonetheless, polyester remains one of the most widely-produced fabrics in the world, and it's hard to find consumer apparel that doesn't contain at least some percentage of polyester fiber. Apparel that contains polyester, however, will melt in extreme heat, while most natural fibers char. Molten fibers can cause irreversible bodily damage.

How Is Polyester Fabric Made?



The production processes used to make polyester may vary depending on the type of polyester is made:

Ethylene Polyester

Ethylene polyester (PET) is the most commonly-produced form of polyester fiber. The primary component of PET is petroleum-derived ethylene, and in the process of creating polyester fiber, ethylene serves as the polymer that interacts with other chemicals to create a stable fibrous compound.

There are four ways to make PET fiber, and the polyester production process varies slightly depending on which method is used:

Chalky - Solid Polyester Cloth

1.Filament: Polyester filaments are continuous fibers, and these fibers produce smooth and soft fabrics.

2.Staple: Polyester staples resemble the staples used to make cotton yarn, and like cotton staples, polyester staples are usually spun into a yarn-like material.

3.Tow: Polyester tow is like polyester filament, but in polyester tow, the filaments are loosely arranged together.

4.Fiberfill: Fiberfill consists of continuous polyester filaments, but these filaments are produced specifically to have the most possible volume to make bulky products like pillows, outerwear, and stuffing for stuffed animals.

The process of creating polyester fiber begins with reacting ethylene glycol with dimethyl terephthalate at high heat. This reaction results in a monomer, which is then reacted with dimethyl terephthalate again to create a polymer.

This molten polyester polymer is extruded from the reaction chamber in long strips, and these strips are allowed to cool and dry, and then they are broken apart in to small pieces. The resulting chips are then melted again to create a honey-like substance, which is extruded through a spinneret to create fibers.

Depending on whether filaments, staple, tow, or fiberfill fibers are desired, the resulting polyester filaments may be cut or reacted with various chemicals to achieve the correct end result. In most applications, polyester fibers are spun into yarn before they are dyed or subjected to other post-production processes.

Polyester Waterproof Shoe Bag Handle Cubes Tote

PCDT Polyester

The process of creating PCDT polyester is similar to the process of creating PET polyester, but this polyester variant has a different chemical structure. While PCDT also consists of ethylene glycol reacted with dimethyl terephthalate, different production processes are used to make these two common polyester variations.

Plant-Based Polyester

Most types of plant-based polyester are also made from ethylene glycol reacted with dimethyl terephthalate. While the source of the ethylene used in PET and PCDT polyester is petroleum, however, producers of plant-based polyester use ethylene sources like cane sugar instead.

This type of fabric was originally developed in the United States by the DuPont Corporation, and production of nylon fabric remained localized to the U.S. until the latter half of the 20th century. As the benefits of this type of fabric became more recognized around the world, other developed nations started to produce nylon fabric, but the United States remained the primary producer of this fabric until the 1980s.

A restructuring of the global economy in the late 1970s and throughout the 1980s saw many international corporations pivot toward China as a manufacturing base. Therefore, many nylon fabric production operations moved to this East Asian country, and production of this fabric has since picked up steam in other regional nations such as India, Pakistan, and Indonesia.

To some degree, nylon fabric is still produced in the United States, but the majority of this fabric's production occurs overseas. Despite the contemporary revival of the manufacturing industry in the USA, it's unlikely that production of nylon fabric will return to this country; for the last few decades, production of this fabric has been on the decline, and even China has consistently been producing less and less of this polymer textile.

How Much Does Nylon Fabric Cost?

One of the primary benefits of nylon fabric is its relatively low cost of manufacture. While this fabric was more expensive than silk when it was first developed, it rapidly dropped in price, and it is especially inexpensive when mixed with other fabrics.

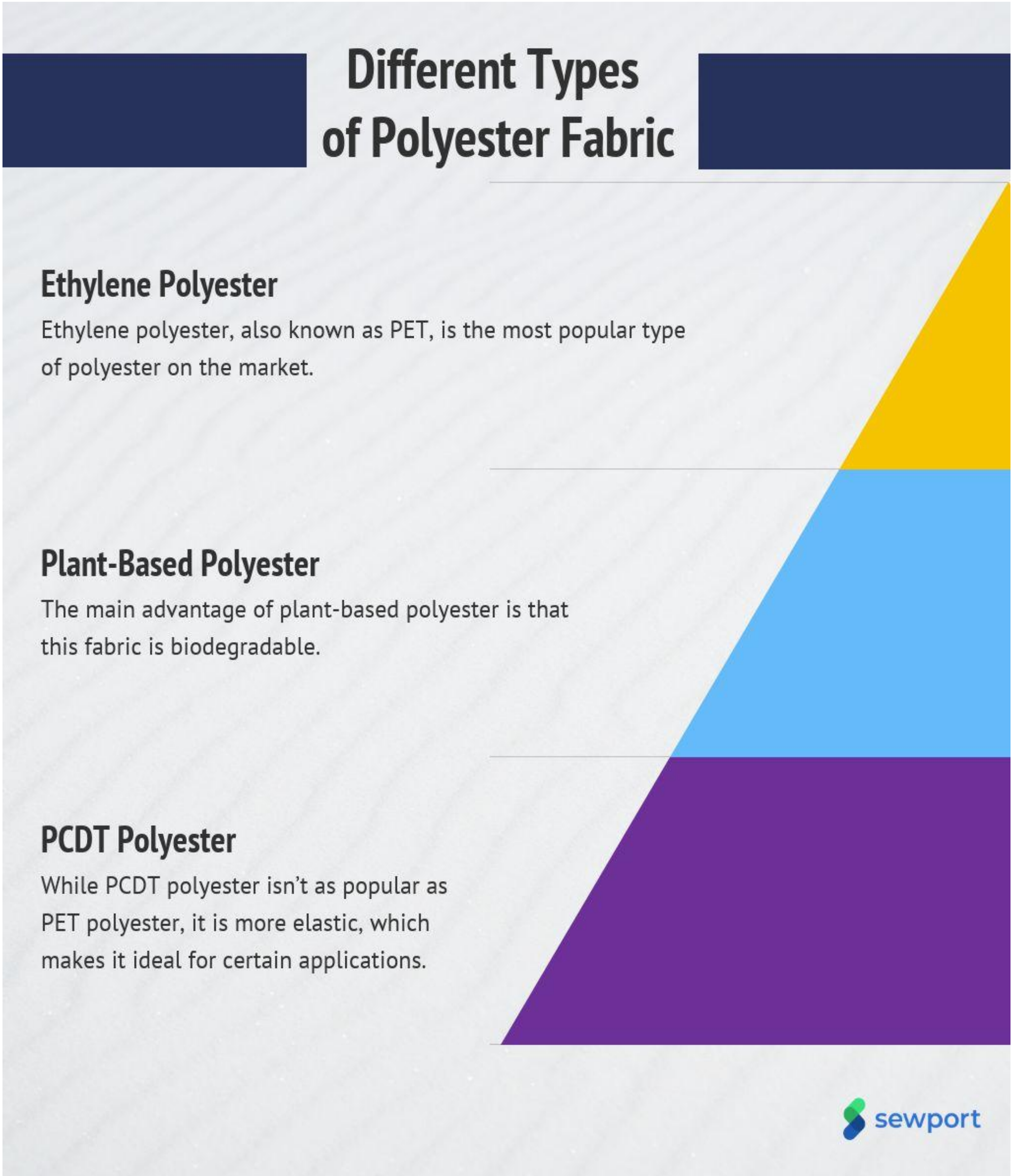
How Much Does Polyester Fabric Cost?

The current price of raw polyester fiber is approximately $1 per pound, but this price rises and falls on a daily bases. Even accounting for minor fluctuations, polyester remains one of the most inexpensive textile products in the world, and this factor contributes greatly to its global popularity.

Once manufacturers have made polyester into fabric, its price rises to approximately $10 per yard. Producers of apparel and other polyester consumables then turn this fabric into final products, and these products are marketed to the consumer.

While the price differences between polyester and other fabrics equalize significantly by the time this fabric reaches the consumer market, low global prices of polyester have traditionally contributed to the overall popularity of this fiber in consumer apparel applications. The continued affordability of polyester keeps apparel prices down, but it also disincentives consumers from trying natural fibers with less harmful environmental impacts.

What Different Types of Polyester Fabric Are There?



To further your knowledge of polyester fabric, it's important to learn more details about the three major types of this textile:

1. Ethylene Polyester

Ethylene polyester, also known as PET, is the most popular type of polyester on the market. In most contexts, the word "polyester" is synonymous with "PET" even though other types of polyester exist.

2. Plant-Based Polyester

The main advantage of plant-based polyester is that this fabric is biodegradable. Plant-based polyester, however, costs more to make, and it may be less durable than its PET or PCDT textile equivalents.

3. PCDT Polyester

While PCDT polyester isn't as popular as PET polyester, it is more elastic, which makes it ideal for certain applications. PCDT polyester is also more durable than PET polyester, so this fabric is frequently preferred for heavy-duty applications like upholstery and curtains.

How Does Polyester Fabric Impact the Environment?

Polyester has a generally negative impact on the environment. From its production to its use to its disposal, this fabric has unfortunate environmental impacts at every stage of its use cycle.

To derive the basic materials used in the production of polyester, it's necessary to obtain fossil fuels, which are limited resources that are also used for vital energy and plastics production applications. The process of refining crude oil into petroleum introduces various toxins into the environment, which can harm living things both in the water and on land.

Once refineries have produced petroleum, further refinement processes are required to produce the ethylene that is used to make polyester. These extraction processes are wasteful, and they introduce more toxins into the environment.

The process of transforming ethylene into polyethylene terephthalate fibers produces more harmful synthetic byproducts, and the dyes and treatment processes used by polyester fabric manufacturers may also make their way into the surrounding environment and poison the area's ecosystems.

Furthermore, the manufacture of polyester often has significant social and cultural costs. The vast majority of polyester producers worldwide essentially engage in slave labor, and polyester workers are exposed to toxic chemicals that may cause neurological damage, cancer, or other potentially fatal conditions. Major polyester manufacturing companies are almost always owned by major international corporations, which enrich themselves while exploiting uneducated people in impoverished countries.

The environmentally harmful impacts of polyester continue as this fabric makes its way into the consumer market. According to a groundbreaking 2014 study, washing polyester fabrics by hand or in washing machines releases tiny synthetic microfibers into the water supply.

While acrylic fabric was found to be the worst offender in terms of microfiber pollution, polyester came in as a close second. Microfiber pollution in the water supply harms the health of marine life, and it also contaminates drinking water in locations all over the world.

As they do with all types of apparel, consumers inevitably discard their polyester garments. Unlike biodegradable fibers like wool, cotton, or silk, however, polyester does not naturally degrade in the environment. While it's impossible to know exactly how long polyester will remain in the Earth's ecosystems before it degrades, environmental scientists all agree that synthetic fabrics like polyester may take centuries to fully break down due to natural environmental conditions.

Overall, polyester harms the environment at every stage in its production, and it inevitably accumulates in the world's ecosystems with no viable methods for removing it. The advent of plant-based polyester fiber would seem to be a step toward reversing this unfortunate state of affairs, but it's unclear whether this alternative to petroleum-based PET alternative will gain traction within the textile market significant enough to make an impact on the polluting effects of polyester

Polyester Fabric Certifications Available

Polyester fabric may be eligible for a variety of certifications, and recycled polyester is eligible for more certifications than new forms of this fabric. For instance, OEKO-TEX provides its Standard 100 certification for certain polyester textiles, and the Global Recycle Standard (GRS) certifies recycled polyester as genuine. Other organizations, such as Intertek, also certify recycled PET fabric, and consumers may view certified recycled polyester more favorably. Since polyester is a synthetic fabric, however, it is not eligible for organic certification; even plant-based forms of polyester have gone through such significant chemical manufacturing processes that the organic status of the original plant materials is irrelevant.

❖ CONTENT/TOPIC 2. CLASSIFICATIONS OF SEMI SYNTHETIC FIBERS

Types of semi-synthetic fiber

- Acetate.
- **Artificial** silk.
- Rayon (viscose)
- Tencel.

VISCOSE FIBERS

Viscose is a type of rayon fiber that is made from natural sources such as wood and agricultural products that are regenerated as cellulose fiber. The molecular structure of natural cellulose is preserved in the process. The many types and grades of viscose fibers can imitate the feel and texture of natural fibers such as silk, wool, cotton, and linen. The types that resemble silk are often called artificial silk. The fibre is used to make textiles for clothing and other purposes.[1]

Rayon is manufactured from naturally occurring cellulose; hence, it is not considered to be synthetic. Technically, the term synthetic fiber is reserved for fully synthetic fibers made from synthetic polymers. In manufacturing terms, rayon is classified as "a fiber formed by regenerating natural materials into a usable form"[*citation needed*]. Specific types of rayon include viscose, Modal (a trade name for high-wet-modulus rayon) and lyocell (more exactly a *production process*; the manufactured product is known as Tencel), each of which differs in the manufacturing process and the properties of the finished product.

Viscose can mean:

- A viscous solution of cellulose
- A synonym of rayon
- A specific term for viscose rayon — rayon made using the viscose (cellulose xanthate) process

The viscose fiber is made from dissolving wood pulp and regenerating it in the form of fibers. Pulp made from wood or bamboo is the most common raw material for making viscose. Viscose process dissolves cellulose pulp with aqueous sodium hydroxide in the presence of carbon disulfide. This viscous solution bears the name *viscose*. The cellulose solution is used to spin the viscose or the rayon fiber. Viscose rayon fiber is a soft fiber commonly used in dresses, linings, shirts, shorts, coats, jackets, and other outerwear. It is also used in industrial yarns, tyre cord, upholstery and carpets, to make disposable wipes, cleaning cloths and in the casting of cellophane

Manufacture

Cellulose is treated with alkali and carbon disulfide to yield viscose.

Rayon fiber is produced from the ripened viscose solutions by treatment with a mineral acid, such as sulfuric acid.

Viscose rayon is a fiber of regenerated cellulose; its molecular structure is that of cellulose in cotton and many other plants such as soy, bamboo, and sugar cane.

Cellulose is a linear polymer of β-D-glucose units with the empirical formula $(C_6H_{10}O_5)_n$. To prepare viscose, dissolving pulp is treated with aqueous sodium hydroxide (typically 16-19% w/w) to form "alkali cellulose", which has the approximate formula $[C_6H_9O_4\text{-}ONa]_n$. This is allowed to depolymerize to an extent. The rate of depolymerization (ripening or maturing) depends on temperature and is affected by the presence of various inorganic additives, such as metal oxides and hydroxides. Air also affects the ripening process since oxygen causes depolymerization. The alkali cellulose is then treated with carbon disulfide to form sodium cellulose xanthate.

$[C_6H_9O_4\text{-}ONa]_n + nCS_2 \rightarrow [C_6H_9O_4\text{-}OCS_2Na]_n$

The higher the ratio of cellulose to combined sulfur, the lower the solubility of the cellulose xanthate.

The xanthate is dissolved in aqueous sodium hydroxide (typically 2-5% w/w). The solution's viscosity is determined by the extent of depolymerization of the alkali cellulose.

Rayon fiber is produced from the ripened solutions by treatment with a mineral acid, such as sulfuric acid. In this step, the xanthate groups are hydrolyzed to regenerate cellulose and release dithiocarbonic acid that later decomposes to carbon disulfide and water.

$[C_6H_9O_4\text{-}OCS_2Na]_{2n} + nH_2SO_4 \rightarrow [C_6H_9O_4\text{-}OH]_{2n} + 2nCS_2 + nNa_2SO_4$

$H_2COS_2 \rightarrow H_2O + CS_2$

Aside from regenerated cellulose, acidification gives hydrogen sulfide (H_2S), sulfur, and carbon disulfide. The thread made from the regenerated cellulose is washed to remove residual acid. The sulfur is then removed by the addition of sodium sulfide solution and impurities are oxidized by bleaching with sodium hypochlorite solution or hydrogen peroxide solution.

Pollution

Though highly toxic carbon disulfide is used in the production of viscose, it is carefully recovered in the manufacturing process. Historically, however, several incidents have resulted in many poisonings. With production facilities often located in developing countries, concerns for worker safety continue. Newer control technologies have enabled improved collection of carbon disulfide and reuse of it, resulting in a reduction in carbon disulfide consumption as well as significantly reduced emissions of sulfur to air. In recent years, more stringent processes based on European Standards have started to be implemented by leading viscose producers. These standards are based on application of latest technologies, collectively referred to as the closed loop viscose manufacturing process, which allows recovery and reuse of chemicals and other natural resources, reducing the exposure to workers as well as making the viscose process much safer.

Viscose or rayon may also be manufactured using the Lyocell process, which uses N-methylmorpholine N-oxide as the solvent and produces little waste product, making it more environmentally benign.

History

French scientist and industrialist Hilaire de Chardonnet (1838–1924), inventor of the first artificial textile fiber, *artificial silk*, created viscose. British scientists Charles Frederick Cross and Edward John Bevan took out British Patent No. 8,700, "Improvements in Dissolving Cellulose and Allied Compounds" in May, 1892

In 1893 they formed the Viscose Syndicate to grant licences, and in 1896 formed the British Viscoid Co. Ltd. to exploit the process.

Products made from viscose

- Art silk
- Cellophane
- Rayon
- Sausage casings
- Synthetic velvet

Fabric name	Viscose
Fabric also known as	Rayon
Fabric composition	Wood cellulose and synthetic substances
Fabric possible thread count variations	300-600
Fabric breathability	Very breathable
Moisture-wicking abilities	Very breathable
Moisture-wicking abilities	High
Heat retention abilities	Medium
Stretch ability (give)	Medium
Prone to pilling/bubbling	Medium
Country where fabric was first produced	United Kingdom
Biggest exporting/producing country today	China
Recommended washing temperatures	Cold
Commonly used in	Clothing, household items, industrial belts, silk alternatives

Viscose Linings

Viscose fabric is durable and soft to the touch, and it's one of the world's most beloved textiles. But what exactly is viscose fabric, and how is it produced and used?

What Is Viscose?

Viscose, which is also commonly known as rayon when it is made into a fabric, is a type of semi-synthetic fabric. The name of this substance comes from the process that's used to make it; at one stage, rayon is a viscous, honey-like liquid that later settles into a solid form.

The primary ingredient of rayon is wood pulp, but this organic ingredient goes through a lengthy production process before it becomes a wearable fabric. Because of these attributes, it's hard to determine whether rayon is a synthetic or natural fabric; while its source material is organic, the process this organic material is subjected to is so strenuous that the result is essentially a synthetic substance.

How Is Viscose Fabric Made?

Other types of rayon-like fabric require lignin-free cellulose as a starting material, but this type of fabric can be made with cellulose from wood pulp. This method of manufacturing rayon is much cheaper than many alternatives, and rayon made with this process can be manufactured on a large scale.

1. Cellulose extraction: The rayon production process begins with the creation of wood pulp cellulose. To create quality fabric, the cellulose used should be at least 90 percent pure.
2. Alkali cellulose conversion: This cellulose is then dissolved in caustic soda, which produces a chemical reaction that converts cellulose to alkali cellulose. This process removes impurities from the cellulose and prepares it for the next step of the manufacturing process.
3. Pressing: The alkali cellulose is then pressed between two rollers, which removes excess liquid. These pressed sheets are then shredded and crumbled into a substance called "white crumb."
4. Aging and xanthation

The white crumb is then aged via exposure to pure oxygen, and next, it is exposed to carbon disulphide to make a new substance called "yellow crumb."

5. Ripening: The yellow crumb is then dissolved and allowed to "ripen" for a period of a few hours.
6. Filtering and extruding: After it has ripened, the yellow crumb is filtered, and any gas bubbles are removed. Next, it is extruded through a spinneret, which is a device with many holes like a showerhead.

7. Acid bath and completion: Finally, the resulting substance is immersed in a bath of sulfuric acid, which results in rayon filaments. Thee filaments are then spun, drawn, and washed to produce a fabric that can then be cut to a desired shape and size.

How Is This Fabric Used?

Rayon is commonly used as a substitute for cotton. This fabric shares many traits with cotton, but in some cases, it may be easier or cheaper to produce. Most consumers can't tell the difference between cotton and rayon by touch, and since this fabric is made from organic materials, it is sometimes seen as superior to fully synthetic fabrics such as polyester.

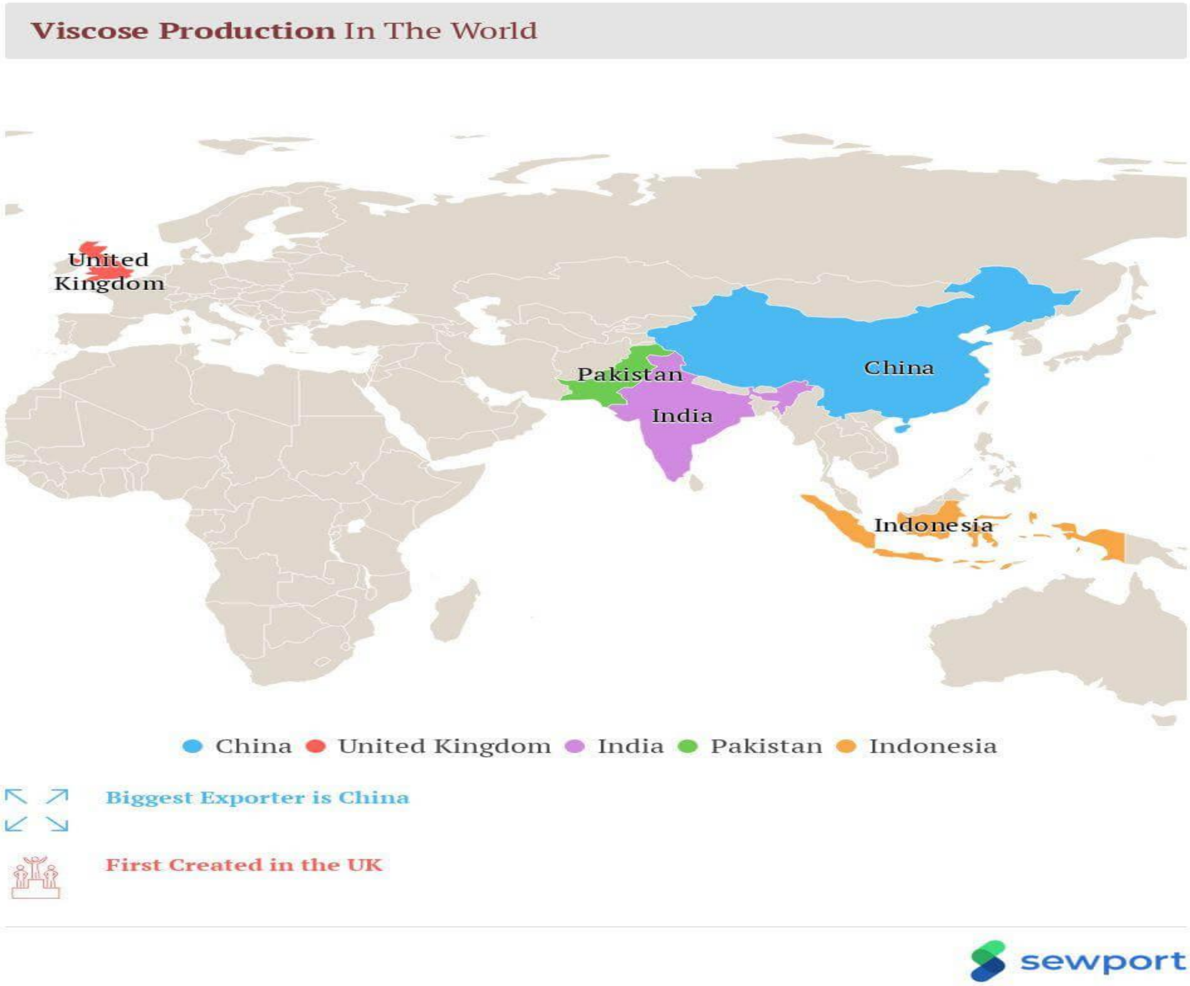
This fabric is used for most applications for which cotton is used. Whether it's dresses, shirts, or pants, rayon is used to make a wide variety of different articles of clothing, and this fabric may also be used to make household items like towels, washcloths, or tablecloths.

Attractive Viscose Fabric

Rayon is also sometimes used in industrial applications. Some business owners feel that rayon is a cheap and durable alternative to cotton. For instance, rayon has taken the place of cotton fibers in many types of tires and automotive belts. The type of rayon that is used in these applications is significantly stronger and more elastic than the type of rayon that is used for clothing.

In addition, it's important to point out that rayon was originally developed as an alternative to silk. Over the years, consumers have accepted that rayon does not have all of the beneficial qualities of silk, and rayon manufacturers now predominantly produce rayon as a cotton substitute. However, some companies may still produce rayon as a substitute for silk, and it's relatively common to see scarves, shawls, and nightgowns that are made from this light and soft fabric.

Where Is This Fabric Produced?



Rayon is predominantly produced in large-scale factory settings.

The rayon production process is too complex to be attempted in a small business setting; to make this fabric, it's necessary to have dozens of different types of chemicals and textile manufacturing machines. In most cases, rayon is made in large factories where other types of textiles are also made.

While most of the world's rayon used to be made in the United States and the United Kingdom, production of this fabric has largely moved overseas. These days, most rayon is made in countries like India, Pakistan, Indonesia, and China.

H&M Viscose Skirt with Tassels

In these developing countries, labor is cheap, and manufacturing regulations are non-existent or not enforced. These factors give rayon manufacturers leeway to generate more profit without having to absorb the high level of overhead that is a necessary aspect of operating in first-world countries.

In many cases, raw rayon is made into a final product in the same facility where it was produced or in a nearby facility. However, some rayon manufacturers may prefer to ship their raw product overseas to have it made into clothing, household textiles, or another type of product.

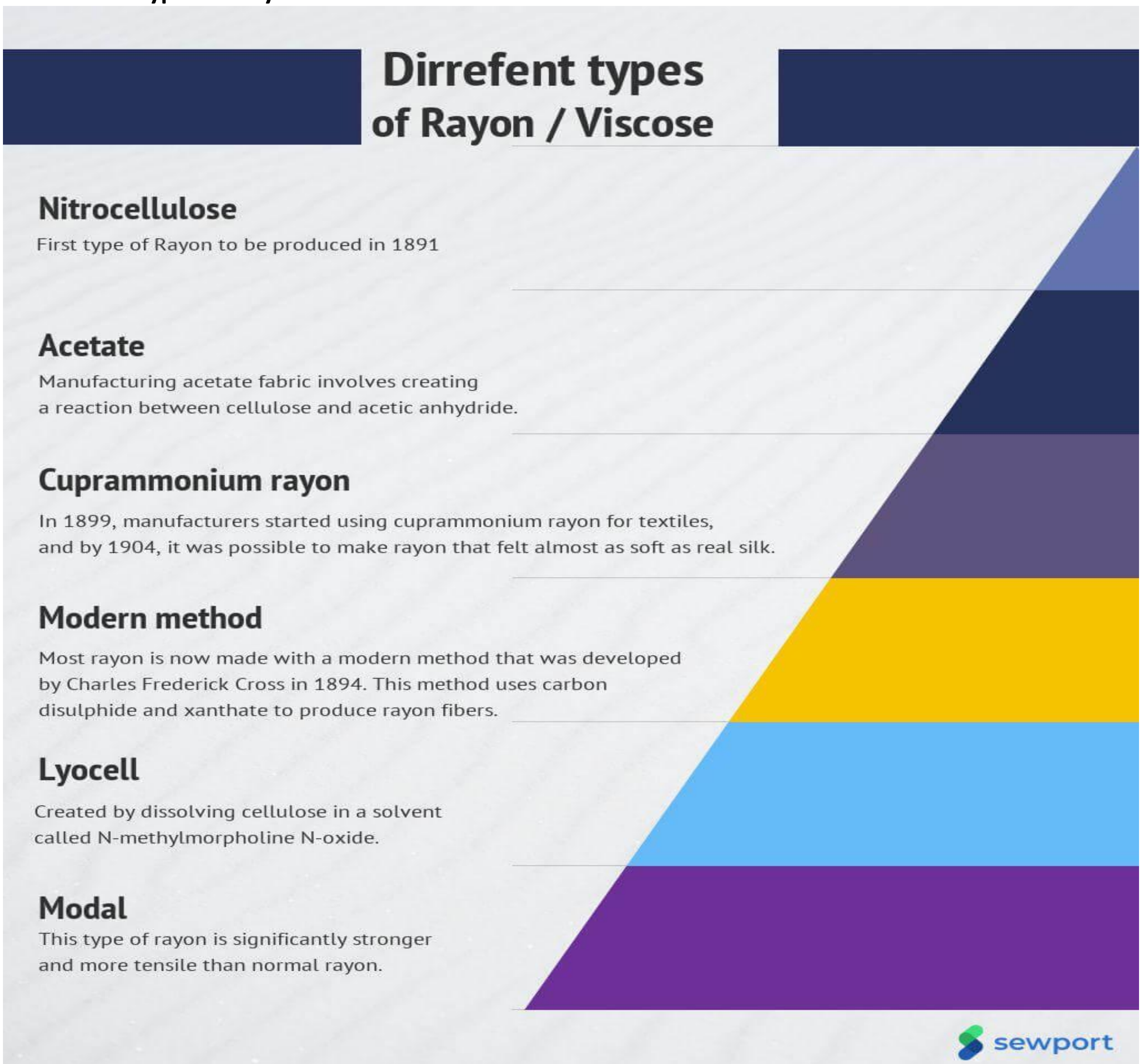
How Much Does Rayon Cost?

Blouse in woven viscose fabric with a printed pattern

One of the reasons why textile manufacturers produce rayon is that it is somewhat cheaper than cotton. The exact degree to which this fabric is cheaper than cotton depends on the manufacturing processes that are used and where it is made, but enhanced economic viability is one of the driving factors pushing rayon production. Rayon is certainly cheaper to produce than silk, but it's commonly accepted that rayon is inferior in quality to genuine silk. The raw materials used to make rayon are significantly cheaper than raw cotton or silk fibers, but the process of creating rayon fabric is much more complicated than the process used to create cotton or silk. Therefore, rayon is only cheaper to produce than cotton if it is manufactured in an area where labor costs are incredibly low.

From the consumer perspective, garments and household goods made from rayon are generally equal in price to items made from cotton. Items made from rayon are significantly cheaper for consumers than items made from silk, however.

What Different Types of Rayon Are There?



What Different Types of Rayon Are There

Rayon is made in a variety of different ways, and each production method results in a different type of fabric. In some cases, the original methods of rayon production that were developed at the end of the 19th century are still used, but some manufacturers may have switched to modern modernized methods of rayon production. Here are some examples of the different types of rayon that are available for consumer use:

• Nitrocellulose: The first type of rayon to be produced was called nitrocellulose rayon. This version of rayon fabric was first developed in 1855 under the name "artificial silk," and it went into commercial production in 1891. However, nitrocellulose rayon was highly flammable, and it was more expensive to produce than acetate or cuprammonium rayon. Therefore, production of this type of rayon ceased in the early 1900s, but not before it acquired the colloquial name of "mother-in-law silk."

• Acetate: Rayon and acetate fabrics are chemically different, but acetate was previously referred to as rayon, which has confused things to a degree. While both fabrics are made from cellulose, the process of manufacturing acetate fabric involves creating a reaction between cellulose and acetic anhydride. Since rayon is significantly stronger than acetate, production of acetate fabric ceased decades ago.

• Cuprammonium rayon: In the mid-1800s, it was discovered that cellulose dissolves in tetraaminecopper dihydroxide, and the resulting substance was originally used to produce carbon fibers for light bulbs. In 1899, manufacturers started using cuprammonium rayon for textiles, and by 1904, it was possible to make rayon that felt almost as soft as real silk. With the advent of new rayon production methods, however, manufacture of cuprammonium rayon ceased.

• Modern method: Most rayon is now made with a modern method that was developed by Charles Frederick Cross in 1894. This method uses carbon disulfide and xanthate to produce rayon fibers, and rayon made with this process became incredibly popular in the United States and the United Kingdom in the first few decades of the 20th century. It is much cheaper to produce rayon with the modern method than it was with any of the methods that came before, which is why this type of rayon became the first version of the textile to enter into mass production. Rayon made with the modern method was the first type of rayon to be used in industrial applications.

• **Lyocell:** Since it is created by dissolving cellulose in a solvent called N-methylmorpholine N-oxide, lyocell is actually chemically different from rayon. However, since these two substances are nearly identical in both feel and durability, lyocell is commonly considered to be a type of rayon. While lyocell was originally developed in the United States, this fabric is now predominantly produced in China.

• **Modal:** This type of rayon is significantly stronger and more tensile than normal rayon, and it is often used in combination with cotton and spandex to make household and apparel items like underwear and bedsheets. Most modal rayon is produced with cellulose derived from beech trees, and it is created by spinning reconstituted cellulose. Modal rayon pills less than cotton, and unlike normal rayon, it is safe to tumble dry this fabric.

Viscose Tunic

How Does Rayon Impact the Environment?

Since rayon is made with substances derived from plants, it isn't inherently a pollutant. Cellulose itself is a natural substance that is naturally recycled by automatic processes in the ecosystem. The fact that rayon is considered to be a semi-synthetic fiber has led many consumers and business owners to regard rayon as being equal to cotton in terms of sustainability and environmental impact.

Rayon, however, doesn't simply consist of cellulose. A number of toxic chemicals are used in the rayon production process, and it's hard to dispose of these substances properly once the manufacturing process is complete. In fact, the contaminated water that is produced during rayon production has been a major concern since the development of this type of fiber; these concerns persisted throughout the environmental movement of the 1970s, but they died down after the majority of rayon production moved overseas during the 1990s and 2000s.

Producing cotton is another notoriously dirty process; unless cotton is cultivated and produced organically, a number of chemicals are used to process raw cotton into a textile fiber. However, these chemicals are an optional part of the cotton production process; they can be substituted for non-toxic agents if businesses want to produce cotton sustainably.

The use of toxic chemicals is, however, an integral part of the rayon production process. It is impossible to produce rayon, for instance, without using sodium hydroxide, which pollutes waterways and reduces air quality. Carbon disulfide is another integral part of the rayon production process, and this chemical has been linked to adverse effects in humans such as birth defects, cancer, skin conditions, and heart disease. Furthermore, extracting pulp wastes about 70 percent of a tree, and the remaining chemically-contaminated tree material is usually indiscriminately dumped.

Dark Pink Viscose Dress

Producing rayon requires quite a few more steps than producing cotton, and every pound of rayon fiber produced generates many more pounds of waste material that usually isn't disposed of properly. Since rayon production primarily takes place in third-world countries, most consumers in the developing world have a disconnected viewpoint on the manufacture of this popular textile material.

However, the ecosystems in developing countries are negatively impacted by rayon production. Plant and animal life are harmed by the creation of this fabric, and the human ecosystem is also polluted. In addition, the production of rayon depletes forests at a rapid rate.

Viscose Fabric Certifications Available

Organic certification for viscose is a complicated subject. While it’s certainly possible to make this substance with organic sources of cellulose, the process by which viscose is made essentially transforms cellulose into an entirely new material. The resulting material can’t be called either organic or synthetic, which makes it hard to consider viscose to be “organic” even if it is made from USDA or EU-certified organic cellulose.

Most manufacturers of viscose don’t even try to certify their products as organic. On the other hand, most forms of lyocell, including Lenzing’s Tencel, are not chemically modified during the production process, which means that if they are made from organic cellulose, they can be certified organic by third-party or government-run regulatory agencies.

LYOCELL FIBERS

abric name	Lyocell
Fabric also known as	Tencel
Fabric composition	Wood cellulose and synthetic substances
Fabric possible thread count variations	300-600
Fabric breathabilityn	Very breathable
Moisture-wicking abilities	High
Heat retention abilities	Medium
Stretchability (give)	Low
Prone to pilling/bubbling	Medium
Country where fabric was first produced	United States
Biggest exporting/producing country today	Europe and China
Recommended washing temperatures	Cold
Commonly used in	Denim, dress shirts, underwear, towels, conveyor belts, medical dressings, specialty paper

Organic Bamboo Lyocell

What Is Lyocell Fabric?

Lyocell is a semi-synthetic fabric that is commonly used as a substitute for cotton or silk. This fabric is a form of rayon, and it is composed primarily of cellulose derived from wood.

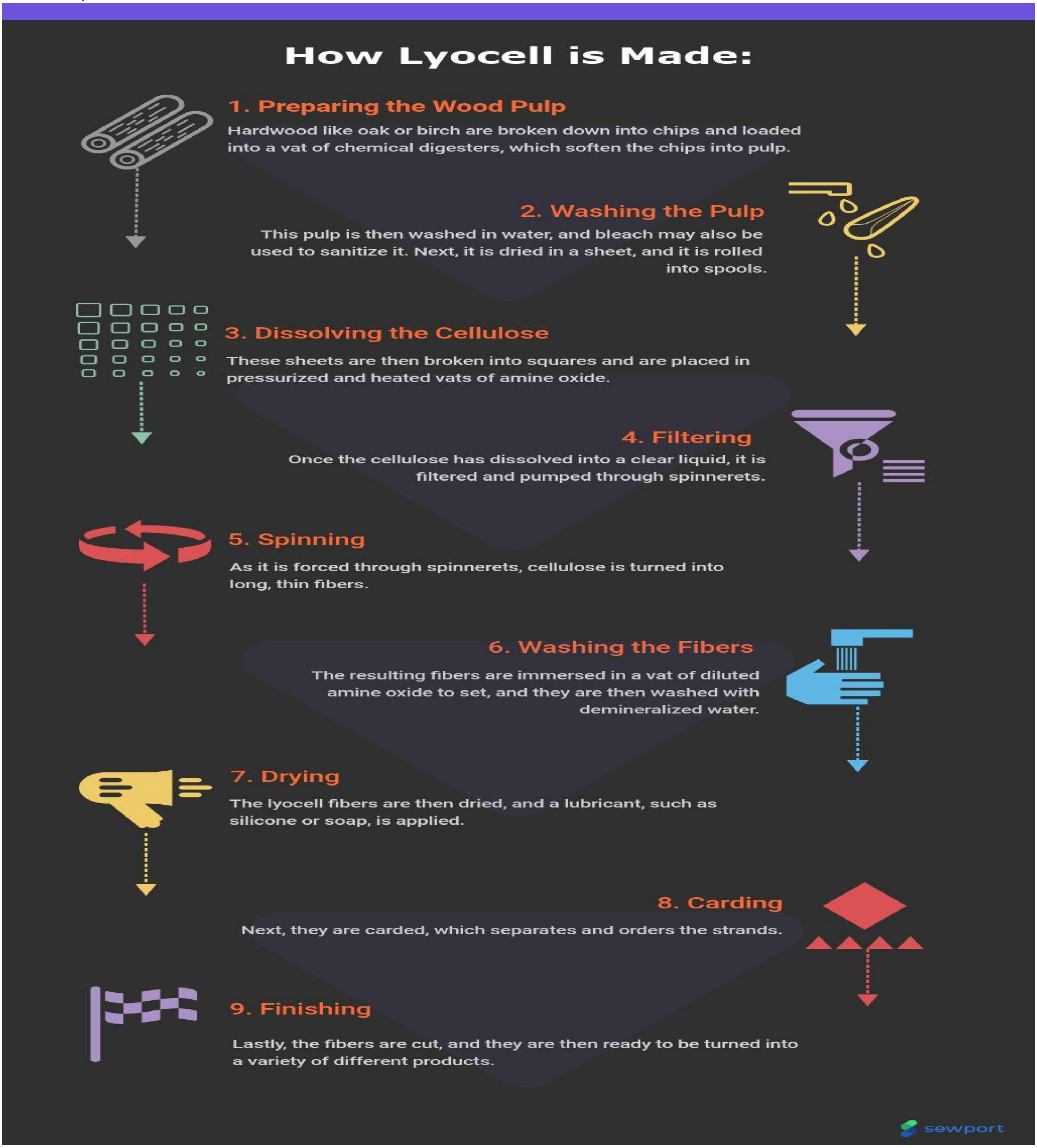
Originally developed by American Enka in 1972, lyocell burst into popularity in the latter decades of the 20th century, and it is still relatively popular around the world. Since it is primarily made from organic ingredients, this fabric is seen as a more sustainable alternative to fully synthetic fibers like polyester, but whether or not lyocell fabric is truly better for the environment is questionable.

H&M Long Lyocell Shirt – Blue

At American Enka, lyocell fabric only made it through the pilot phase of development before the project was abandoned. It wasn't until the 1980s that a British company called Courtaulds Fibres picked up the pieces and created a new fabric called Tencel based on lyocell research. These two fabrics are chemically identical, and the terms Tencel and lyocell can be used interchangeably.

Consumers generally find lyocell fabric to be soft to the touch, and many people can't tell the difference between this fabric and cotton. Lyocell fabric is very strong whether it is wet or dry, and it is more resistant to pilling than cotton. Textile manufacturers like the fact that it's easy to mix this fabric with other types of textiles; for instance, it plays well with cotton, silk, rayon, polyester, nylon, and wool.

How Is Lyocell Fabric Made?



Tencel is almost chemically identical to rayon, but a somewhat different process is used to make this rayon derivative. Unlike the rayon production process, the lyocell fabric production process involves the use of a direct solvent instead of an indirect solvent. A solvent spinning technique is used to create Tencel, which means that unlike the case in the production of rayon, the Tencel production process doesn't cause any significant chemical changes to the chemical structure of cellulose.

While fabrics derived from cellulose have been around for nearly 200 years, they have only been in mass production since the beginning of the 20th century. These fabrics were originally designed as substitutes for silk, and pioneers of cellulose fabrics attempted to recreate the process that silkworms use to make real silk. The first cellulose fabric to be mass-produced was rayon, and to this day, rayon is made with an extrusion method. As one of the newest cellulose fabric production methods, production of lyocell improves on the production methods used to make rayon. It is more efficient, it produces less waste, and it results in a product that is less synthetic than rayon.

The Production Process

Chips of hardwood like oak or birch are used as the raw materials for the cellulose that is used in this fabric. The trees used for these purposes are usually grown on managed tree farms. Once the trees arrive at a Tencel production facility, they are broken down into chips and loaded into a vat of chemical digesters, which soften the chips into pulp.

This pulp is then washed in water, and bleach may also be used to sanitize it. Next, it is dried in a sheet, and it is rolled into spools. Most cellulose rolls are enormous and weigh about 500 pounds.

These sheets are then broken into squares measuring approximately one inch across, and these squares are placed in pressurized and heated vats of amine oxide, which is the primary solvent used to make lyocell fabric. Once the cellulose has dissolved into a clear liquid, it is filtered and pumped through spinnerets.

As it is forced through spinnerets, cellulose is turned into long, thin fibers. The resulting fibers are immersed in a vat of diluted amine oxide to set, and they are then washed with demineralized water.

The lyocell fibers are then dried, and a lubricant, such as silicone or soap, is applied. The fibers are now considered to be in a state called tow, and these bundles of tow are placed in a crimper that compresses the fiber. Next, they are carded, which separates and orders the strands. Lastly, the fibers are cut, and they are then ready to be turned into a variety of different products.

Compared to rayon, the Tencel production process requires far fewer steps and takes much less time. Also, since the amine oxide used to make this fabric can be recovered, making lyocell fabric is much less wasteful than making rayon.

How Is Lyocell Fabric Used?

Tencel is usually used as a substitute for cotton or silk. This fabric feels like soft cotton, and it is used to make everything from dress shirts to towels to underwear.

While some garments are made entirely from lyocell, it is more common to see this fabric mixed with other types of fabrics like cotton or polyester. Since Tencel is so strong, when it is mixed with other fabrics, the resulting composite fabric is stronger than cotton or polyester on its own.

In addition to garments, this fabric is used in a variety of commercial settings. For instance, many manufacturers have substituted lyocell for cotton in the fabric parts of conveyor belts; when belts are made with this fabric, they last longer, and they are more resistant to wear and tear.

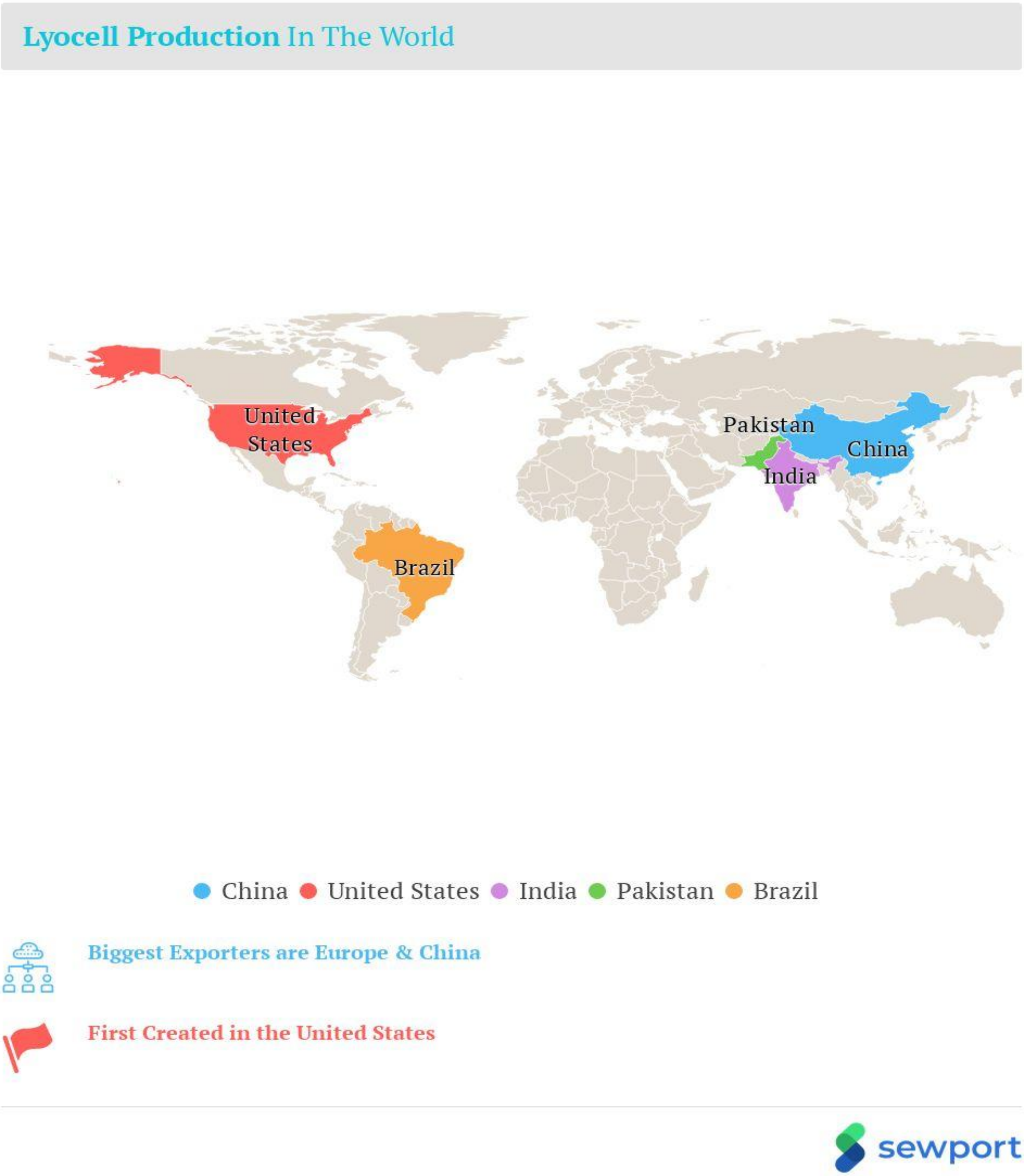
Furthermore, Tencel is quickly becoming a favorite fabric for medical dressings. In life or death situations, having a fabric that is highly tensile is very important, and Tencel has proved itself to be stronger than fabrics that were used for medical dressings in the past. This fabric's high absorbancy profile also makes it an ideal material to use in medical applications.

Tencel lyocell sheet

Soon after its development, scientific researchers recognized the potential of lyocell as a component in specialty papers. While you wouldn't want to write on Tencel paper, many different types of filters are made primarily from paper, and since this fabric has low air resistance and high opacity , it is an ideal filtration material.

Since lyocell fabric is such a versatile substance, it may also be used in a variety of specialty applications. Research into this fabric is ongoing, which means that more uses for Tencel may be discovered in the future.

Where Is Lyocell Fabric Produced?



When lyocell fabric was first created, it was only produced at the American Enka factory in Enka, North Carolina. When Enka stopped producing this substance, however, production moved entirely to the United Kingdom when Courtaulds Fibers branded this fabric as Tencel.

Eventually, Tencel production expanded to the Courtaulds plant in Mobile, Alabama, and until the late 1990s, this fabric was not made anywhere else in the world. In 1998, however, Courtalds was sold to Akzo Nobel, which is a Dutch international corporation specializing in paints. Akzo Nobel went on to sell the rights to Tencel to a private equity firm named CVC partners, which promptly sold its Tencel division to Lenzing AG, which is an international textile corporation based in Austria.

Bamboo Lyocell Pj Pants

While Lenzing AG has a variety of different factories in Europe, a great deal of their production has moved overseas to countries like China and Indonesia. While some Tencel is still produced in countries like Austria, the United Kingdom, and the USA, the majority of this fabric is now produced in China.

Since Lenzing now holds the Tencel patent, it remains the largest producer of this textile in the world. A variety of smaller companies may also make this fabric in minuscule quantities, but if you've worn a lyocell garment, chances are it was made by Lenzing AG in one of their Chinese factories.

How Much Does Lyocell Fabric Cost?

Rayon and other cellulose fabrics were originally produced as cheaper alternatives to silk. While silk production is all-natural and relatively sustainable, it's hard to produce silk in large quantities, which prompted the birth of the "artificial silk" revolution that ultimately resulted in the development of modern rayon.

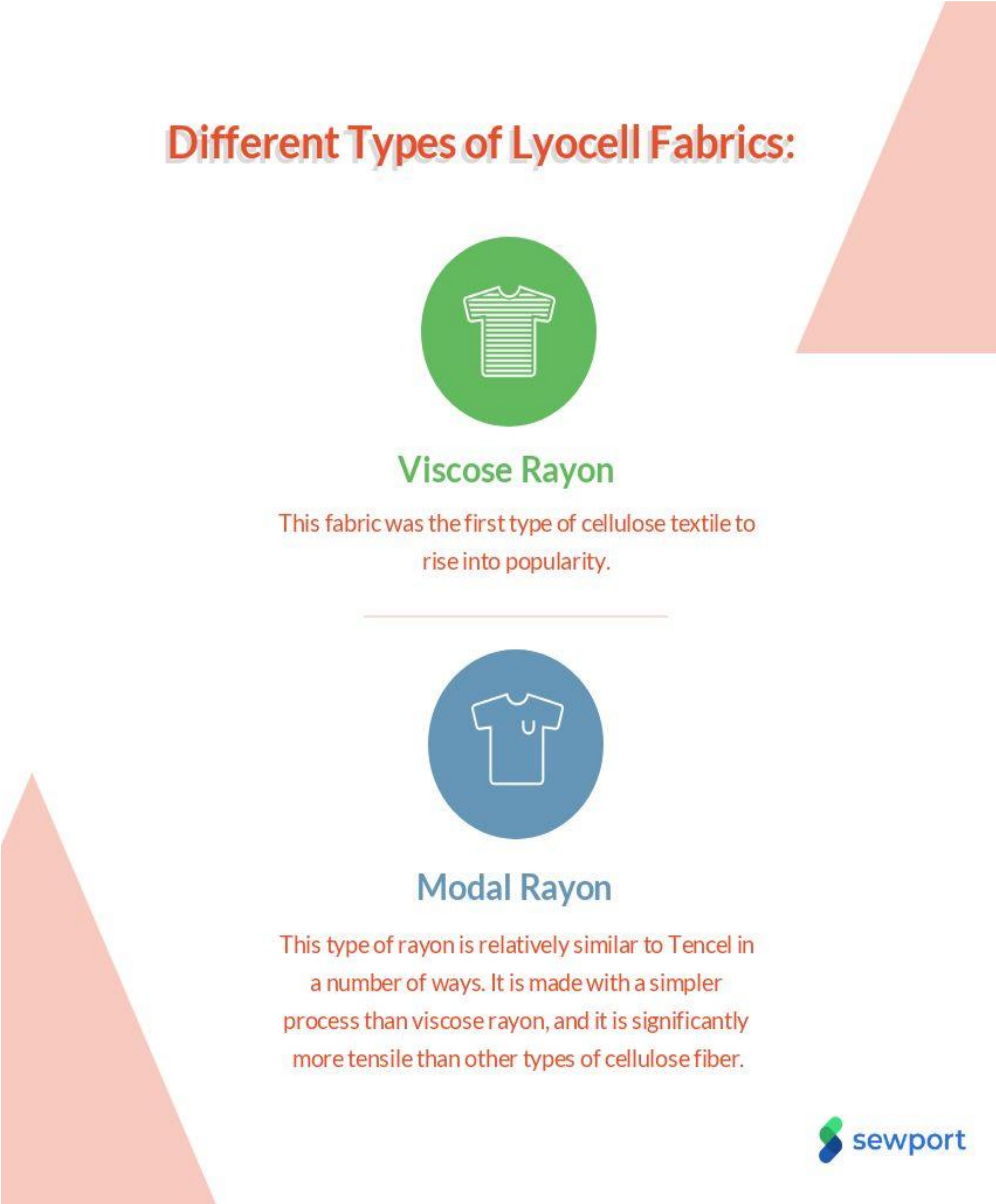
While it's true that cellulose fabrics remain cheaper to produce than silk, the same can't be said for cotton. While prices of cotton and cellulose fabrics fluctuate, cotton has been significantly cheaper to produce in the last decade or so. If global economic trends remain stable, cotton will remain less expensive than lyocell and similar fabrics from a production standpoint.

Organic Bamboo Lyocell fabric

However, the difference in price between cotton and Tencel is nearly negligible, and some manufacturers may prefer the process of producing cellulose fabrics to the process of manufacturing cotton. Lyocell, in particular, is one of the simplest cellulose fabrics to produce, and it generates very little waste.

Even if cellulose fabrics become less popular than cotton due to price fluctuations, lyocell fabric is much more useful than cotton in a number of applications. This textile's tensility is off the charts, and it is highly durable in commercial applications. Manufacturers are more than happy to pay slightly higher prices for these benefits.

What Different Types of Lyocell Fabric Are There?



There is, from a chemical point of view, only one type of lyocell fabric. Even when this substance is called Tencel, it has the same chemical composition, and it is made using the same process.

However, there are a couple of fabrics that are very similar to lyocell fabric that you should be aware of as you learn more about this textile. Examples of these similar fabrics include:

- Viscose rayon: This fabric was the first type of cellulose textile to rise into popularity. Viscose rayon has been produced since the first few decades of the 20th century, and it was preceded by a number of cellulose fabric prototypes that were discontinued due to flammability or untenable production processes.

  Viscose rayon remains a popular fabric, and it is produced around the world. However, the viscose production process is much more complicated than the process that is used to create lyocell, and it is much more impactful on the environment. In some cases, viscose rayon may be cheaper to produce than Tencel, but it's clear that this fabric is technologically outdated.

- Modal rayon: This type of rayon is relatively similar to Tencel in a number of ways. It is made with a simpler process than viscose rayon, and it is significantly more tensile than other types of cellulose fiber. This rayon production method was discovered in the 1940s, and it represents a technical leap forward in cellulose fabric production. However, many manufacturers around the world still produce viscose rayon instead of modal rayon.

How Does Lyocell Fabric Impact the Environment?

Compared to other cellulose textiles, lyocell is much better for the environment. While the process of producing this fabric is similar to that which is used to make rayon and other cellulose fabrics, production of Tencel doesn't introduce any toxins into the environment if it is done correctly.

Unlike similar textiles, lyocell production employs a "closed loop" extraction process, which means that the same batch of amine oxide is used to extract multiple batches of Tencel. For comparison, production of viscose rayon involves a number of different chemical processes that do not employ a closed loop system, and these chemicals are then introduced into the environment in the form of contaminated water.

It is, however, important to remember that lyocell is made from trees, and a great deal of tree material is wasted in the production of this fabric. If trees for Tencel production are not grown sustainably, production of this material could have a negative environmental impact, and not all Tencel producers are guaranteed to follow the sustainable closed-loop extraction model.

Lyocell Certifications Available

Lyocell can be certified as organic under certain circumstances. To receive this certification, producers of this fabric must use organic practices to produce the trees that they use for cellulose, and they must avoid using certain toxic chemicals in the production process.

Unlike rayon, the structure of Tencel isn't altered by any chemicals, which means that the cellulose-based fabric that is produced and labeled as Tencel is technically made solely from cellulose derived from trees. However, since amine oxide is used in the Tencel production process, some purists may not view this fabric as completely organic.

ACETATE FIBERS

ACETATE FIBERS

PROPERTIES

Acetate fibers are one of the principal types of synthetic fibers. The fiber forming substance is cellulose acetate in which at least 92% of the hydroxyl groups are acetylated. This fiber is called *triacetate* or triacetate cellulose. Secondary acetate contains only about 76 percent acetylated cellulose groups. The *diacetate* fiber is officially called acetate while the triacetate cellulose is called triacetate.

Conventional secondary acetate fibers can be manufactured by treating wood pulp, cellulose or cotton linters with acetic acid. The pretreated cellulose or secondary acetate is converted to triacetate when treated with acetic anhydride in the presence of an acid catalyst.

Acetate fibers, the so-called acetate silk fibers, are molded from solutions of cellulose acetate in organic solvents, usually a mixture of methylene chloride and alcohol (triacetate), or acetone (secondary acetate).

Acetate fibers are soft and pleasant to the touch. They are dyed only with special types of dyes, which are unsuitable for most other fibers. Triacetate fibers are less hygroscope and have a greater elasticity and wrinkle resistance than articles made of diacetate fibers.

The tensile strength of acetate fibers is rather low. The loss of strength upon moist testing is up to 45 percent for acetate fibers and up to 20 percent for triacetate fibers.

Acetate fibers have a low thermal stability. For this reason, articles made of acetate fibers have to be ironed through a damp cloth. Furthermore, acetate fibers have a low stability in the presence of dilute solutions of alkalis. Other disadvantages of acetate fibers include low durability and high tendency to gather static electricity. To offset or remedy these deficiencies, acetates are often chemically modified or blended with other fibers.

Cellulose acetate fibers can be de-acetylated by sodium hydroxide saponification under controlled conditions. The product is a true regenerated cellulose filament. This process was developed by Celanese who called the fiber “Fortisan”. The fibers generic name is Rayon. It has outstanding strength and low elongation and finds many industrial uses where these two properties are required.

FIBER PROPERTIES	
Tensile Strength (Tenacity)	Fair to Poor
Abrasion Resistance	Poor
Absorbency	Fairly Good
Static Resistance	Fair
Heat Resistance	Fair to Poor
Wrinkle Resistance	Fair to Poor
Resistance to Sunlight	Fair to Poor
Elasticity	Poor (Similar to Rayon)
Flame Resistance	Slowly Combustible
Resilience	Poor

COMMERCIAL CELLULOSE ACETATE FIBERS

Major manufacturers of acetate fibers are Celanese, Eastman, Viscocel, and Mitsubishi Rayon.

APPLICATIONS

Acetate fibers are mainly used in the production of general consumer articles including clothing, lining, felts, upholstery, carpets, umbrellas, and cigarette filters. The staple acetate fibers are also used as partial substitutes for wool in the manufacture of fine fabrics and various kinds of knitwear, for example, to reduce fiber / fabric shrinkage, to improve wrinkle resistance, and to lower raw material costs.

Basic Principles of Acetate Fiber Production: Acetate is derived from cellulose by reacting purified cellulose from wood pulp with acetic acid and acetic anhydride in the presence of sulfuric acid. It is then put through a controlled, partial hydrolysis to remove the sulfate and a sufficient number of acetate groups to give the product the desired properties. The anhydroglucose unit, is the fundamental repeating structure of cellulose, has three hydroxyl groups which can react to form acetate esters. The most common form of cellulose acetate fiber has an acetate group on approximately two of every three hydroxyls. This cellulose diacetate is known as secondary acetate, or simply as "acetate".

After it is formed, cellulose acetate is dissolved in acetone for extrusion. As the filaments emerge from the spinneret, the solvent is evaporated in warm air *(dry spinning)*, producing fine filaments of cellulose acetate.

Acetate Fiber Characteristics:

- Luxurious feel and appearance
- Wide range of colors and lusters
- Excellent drapability and softness
- Relatively fast drying
- Shrink, moth and mildew resistant

Special dyes have been developed for acetate since it does not accept dyes ordinarily used for cotton and rayon. This dye selectivity makes it possible to obtain multi-color effects in fabrics made from a combination of fibers *(cross-dyeing)*. In cross-dyeing, yarns of one fiber *(e.g., acetate)* and those of another fiber *(cotton or rayon)* are woven into a fabric in a desired pattern. After the fabric has been dyed in one bath, this pattern will appear in different colors or shades according to the distribution of the respective fibers. Solution-dyed or spun-dyed acetate provides excellent color fastness under the effects of sunlight, perspiration, air contaminants and washing.

Some Major Acetate Fiber Uses:

- **Apparel:** Blouses, dresses, linings, wedding and party attire, home furnishings, draperies, upholstery
- **Industrial Uses:** Cigarette filters

General Acetate Fiber Care Tips: — Most acetate garments should be dry-cleaned, but if laundering is indicated, use the following guide:

- Handwash in warm water with mild suds.
- Do not twist or wring out garment.
- Do not soak colored items.
- Press while damp on wrong side with cool iron. For finishing on the right side, use a pressing cloth. *(For specific instructions, refer to garment's sewn-in care label.*

Note: Acetate is adversely affected by acetone and other organic solvents, such as nail polish remover and perfumes containing these solvents.

Basic Principles of Acetate Fiber Production: Acetate is derived from cellulose by reacting purified cellulose from wood pulp with acetic acid and acetic anhydride in the presence of sulfuric acid. It is then put through a controlled, partial hydrolysis to remove the sulfate and a sufficient number of acetate groups to give the product the desired properties. The anhydroglucose unit, is the fundamental repeating structure of cellulose, has three hydroxyl groups which can react to form acetate esters. The most common form of cellulose acetate fiber has an acetate group on approximately two of every three hydroxyls. This cellulose diacetate is known as secondary acetate, or simply as "acetate".

After it is formed, cellulose acetate is dissolved in acetone for extrusion. As the filaments emerge from the spinneret, the solvent is evaporated in warm air *(dry spinning)*, producing fine filaments of cellulose acetate.

Acetate Fiber Characteristics:

- Luxurious feel and appearance
- Wide range of colors and lusters
- Excellent drapability and softness
- Relatively fast drying
- Shrink, moth and mildew resistant

Special dyes have been developed for acetate since it does not accept dyes ordinarily used for cotton and rayon. This dye selectivity makes it possible to obtain multi-color effects in fabrics made from a combination of fibers *(cross-dyeing)*. In cross-dyeing, yarns of one fiber *(e.g., acetate)* and those of another fiber *(cotton or rayon)* are woven into a fabric in a desired pattern. After the fabric has been dyed in one bath, this pattern will appear in different colors or shades according to the distribution of the respective fibers. Solution-dyed or spun-dyed acetate provides excellent color fastness under the effects of sunlight, perspiration, air contaminants and washing.

Some Major Acetate Fiber Uses:

- **Apparel:** Blouses, dresses, linings, wedding and party attire, home furnishings, draperies, upholstery
- **Industrial Uses:** Cigarette filters

General Acetate Fiber Care Tips: — Most acetate garments should be dry-cleaned, but if laundering is indicated, use the following guide:

- Handwash in warm water with mild suds.
- Do not twist or wring out garment.
- Do not soak colored items.
- Press while damp on wrong side with cool iron. For finishing on the right side, use a pressing cloth. *(For specific instructions, refer to garment's sewn-in care label.)*

Note: Acetate is adversely affected by acetone and other organic solvents, such as nail polish remover and perfumes containing these solvents.

LEARNING OUTCOME 2. 3: CLASSIFY SYNTHETIC FIBERS

Classification of Synthetic Fibers

Following are some of the most commonly used synthetic fibres: Know more about Classifications of Fibers

Synthetic Fibre

1. Rayon

- This is a type of synthetic fibre obtained from wood pulp.
- Rayon fabric is soft, absorbent and comfortable.
- It is easy to dye in a wide range of colours.
- Rayon is mixed with cotton to make bedsheets.
- Rayon is mixed with wool to make carpets.

2. Nylon

- This type of synthetic fibre is obtained from coal, water and air.
- Nylon is very lustrous, easy to wash and elastic.
- It dries quickly and retains its shape.
- Nylon finds its application in seat belts of car, sleeping bags, socks, ropes, etc.
- Nylon is also used in ropes for rock climbing, making parachutes and fishing nets.

3. Polyester

- This type of synthetic fibre is obtained from coal, water, air and petroleum.
- Polyester is made from repeating units of a chemical known as esters.
- Polyester is easy to wash and it remains wrinkle-free and it is quite suitable in making dress material.
- Polyester retains its shape and remains crisp.
- Polyester is used in making ropes, nets, raincoats, jackets, etc.

Synthetic Fibres Examples

The modern textile industry is unthinkable today without synthetic fibres. Man-made fibres like silk have always been greatly valued for its gloss and fineness. Man-made fibres are smooth. They can be distinguished by looking at a cross-section. Some of the synthetic fibres are listed below.

1. **rayon**
2. **nylon**
3. **polyester**

❖ **CONTENT/TOPIC 1. INTRODUCTION OF SYNTHETIC FIBERS**

Synthetic fiber

A **synthetic fiber** is a man made fiber. But all man-made fiber are not synthetic fiber. **Nylon**, polyester are synthetic fiber. Rayon and acetate from cellulose or regenerated protein fibers from zein or casein are the man-made fiber but not synthetic fiber. Most synthetic and cellulosic manufactured fibers are created by "extrusion" — forcing a thick, viscous liquid (about the consistency of cold honey) through the tiny holes of a device called a spinneret to form continuous filaments of semi-solid polymer.

Fig: Synthetic fiber

In their initial state, the fiber-forming polymers are solids and therefore must be first converted into a fluid state for extrusion.
This is usually achieved by melting, if the polymers are thermoplastic synthetics (i.e., they soften and melt when heated), or by dissolving them in a suitable solvent if they are non-thermoplastic cellulosics. If they cannot be dissolved or melted directly, they must be chemically treated to form soluble or thermoplastic derivatives. Recent technologies have been developed for some specialty **fibers** made of polymers that do not melt, dissolve, or form appropriate derivatives. For these materials, the small fluid molecules are mixed and reacted to form the otherwise intractable polymers during the extrusion process.

Spinneret

A spinneret is a device used to extrude a polymer solution or polymer melt to form fibers. The spinnerets used in the production of most manufactured fibers are similar, in principle, to a bathroom shower head. A spinneret may have from one to several hundred holes. The tiny openings are very sensitive to impurities and corrosion. The liquid feeding them must be carefully filtered (not an easy task with very viscous materials) and, in some cases, the spinneret must be made from very expensive, corrosion-resistant metals. Maintenance is also critical, and spinnerets must be removed and cleaned on a regular basis to prevent clogging.

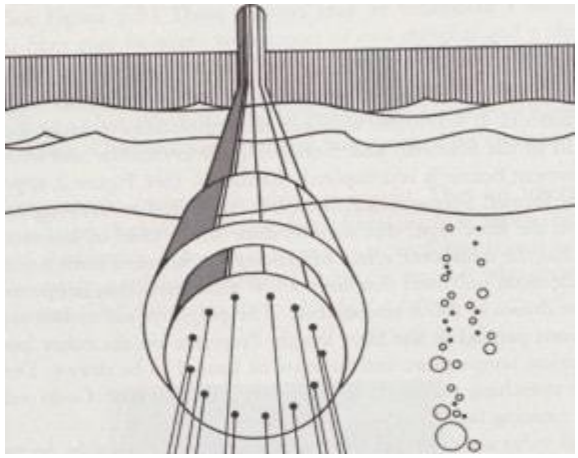


Fig: Spinneret

Production Process of Different Synthetic Fibers:

As the filaments emerge from the holes in the spinneret, the liquid polymer is converted first to a rubbery state and then solidified. This process of extrusion and solidification of endless filaments is called spinning, not to be confused with the textile operation of the same name, where short pieces of staple fiber are twisted into yarn. There are four methods of spinning filaments of manufactured fibers: wet, dry, melt, and gel spinning.

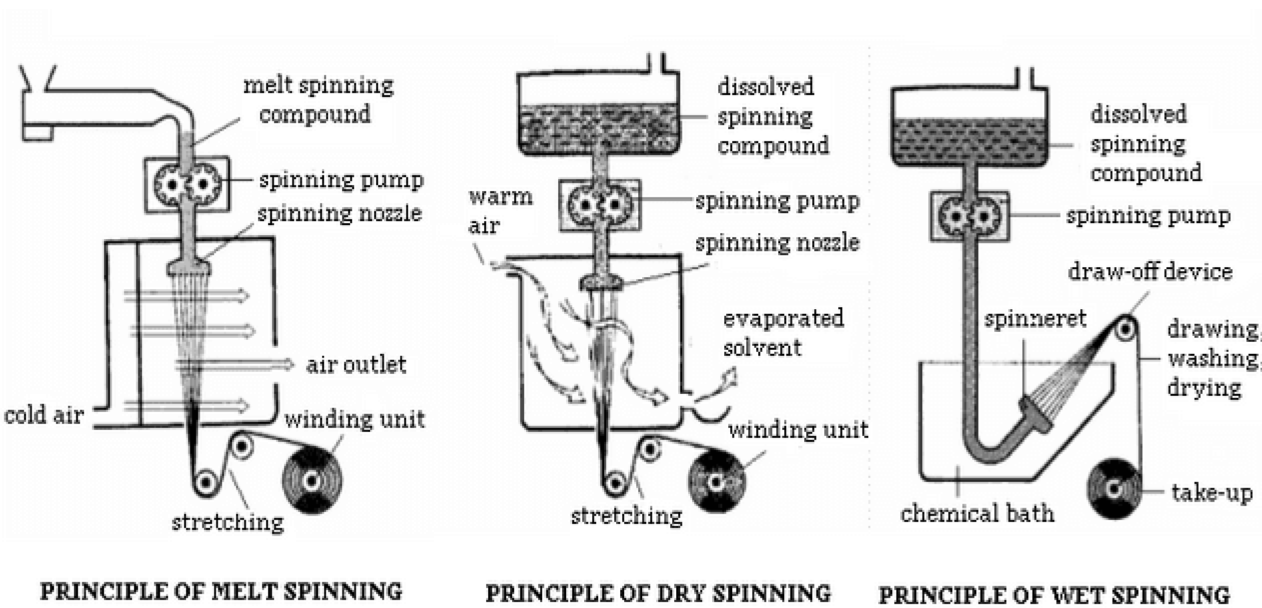


Fig: Different synthetic fibers production

Wet spinning

Wet spinning is the oldest process. It is used for polymers that need to be dissolved in a solvent frist.

The spinnerets are submerged in a chemical bath and as the filaments emerge they precipitate from solution and solidify.

Because the solution is extruded directly into the precipitating liquid, this process for making fibers is called wet spinning. Acrylic, rayon, aramid, modacrylic and spandex can be produced by this process.

Dry spinning

In dry spinning the polymer is dissolved in its solvent and then extruded, as the fibres emerge through the spinneret the solvent is evaporated off with hot air, in most cases this is then collected and re-used.

Dry spinning is also used for fiber-forming substances in solution. Dry spinning technique is used for such kind of Polymers which won't melt but degrade on heating.

The filaments do not come in contact with a precipitating liquid, eliminating the need for drying and easing solvent recovery. This process may be used for the production of acetate, triacetate, acrylic, modacrylic, PBI, **spandex**, and vinyon.

Melt spinning

In **melt spinning**, the fiber-forming substance is melted for extrusion through the spinneret and then rapid cooling of liquids. **Nylon**, olefin, polyester, saran and sulfar are produced in this manner.

Melt spun fibers can be extruded from the spinneret in different cross-sectional shapes (round, trilobal, pentagonal, octagonal, and others). Trilobal-shaped fibers reflect more light and give an attractive sparkle to textiles.

Pentagonal-shaped and hollow fibers, when used in carpet, show less soil and dirt. Octagonal-shaped fibers offer glitter-free effects. Hollow fibers trap air, creating insulation and provide loft characteristics equal to, or better than, down.

Detailed production flowcharts:

- Acrylic
- Nylon (Polyamide)
- Polyester

Gel spinning:

Gel spinning, also known as dry-wet spinning, is used to obtain high strength or other special properties in the fibers. It is an old technique that has come into use commercially only since the 1980s. It is a special process used to obtain high strength or other special fiber properties. The polymer is not in a true liquid state during extrusion. Not completely separated, as they would be in a true solution, the polymer chains are bound together at various points in liquid crystal form. This produces strong inter-chain forces in the resulting filaments that can significantly increase the tensile strength of the fibers. In addition, the liquid crystals are aligned along the fiber axis by the shear forces during extrusion. The filaments emerge with an unusually high degree of orientation relative to each other, further enhancing strength. The process can also be described as dry-wet spinning, since the filaments first pass through air and then are cooled further in a liquid bath. Some high-strength polyethylene and **aramid fibers** are produced by gel spinning.

Stretching and orientation:
After spinneret, while extruded fibers are coagulating, or in some cases even after they have hardened, the filaments may be drawn to impart strength. Drawing pulls the molecular chains together and orients them along the fiber axis, creating a considerably stronger yarn

❖ CONTENT/TOPIC 2. CLASSIFICATION OF SYNTHETIC FIBERS

POLYMERISATION FIBERS

Polymerization, any process in which relatively small molecules, called monomers, combine chemically to produce a very large chainlike or network molecule, called a polymer. The monomer molecules may be all alike, or they may represent two, three, or more different compounds. Usually at least 100 monomer molecules must be combined to make a product that has certain unique physical properties—such as elasticity, high tensile strength, or the ability to form fibres—that differentiate polymers from substances composed of smaller and simpler molecules; often, many thousands of monomer units are incorporated in a single molecule of a polymer. The formation of stable covalent chemical bonds between the monomers sets polymerization apart from other processes, such as crystallization, in which large numbers of molecules aggregate under the influence of weak intermolecular forces

POLYCONDENSATION FIBERS

Polycondensation
Polycondensation or step-growth polymerization is often used for the processing of adhesives, coatings, engineered plastics, fibers, films and many high-performance polymers.
During the polycondensation reaction, the volatile monomers are evaporated from the lower molecular weight pre-polymers to form polymers with a higher molecular weight.
In LIST KneaderReactors the high process temperatures and low vacuum levels in combination with robust mixing and frequent surface renewal allow a quick removal of the monomers, maximizing the mass transfer efficiency.
Highly flexible LIST KneaderReactors enable the polycondensation of various polymer grades in one single machine without having to retool between the production campaigns.
Example

Polyamide
High performance polyamides for high temperature applications

❖ CONTENT/TOPIC TECHNICAL TERMS FOR PRODUCES DIFFERENT TEXTILE CLOTHES

FABRIC	CHARACTERISTICS
AFGALAINE	Suitable For Almost Any Style Of Garments Tailored Cashal ,Pleats,Gathers And Tucks Well Frags Is Very Loosely Wooven Creases Badly Width 140 Cm Fiber: Wool,Rayon Uses Dresses,Jumperssuits
BOUCLE OR VELOURS	Velour or velours is a plush, knitted fabric or textile similar to velvet or velveteen. It is usually made from cotton, but can also be made from synthetic materials such as polyester. Velour is used in a wide variety of applications, including clothing and upholstery. Velour can also refer to a rough natural leather sometimes called velour leather. Chrome tanned leather is ground from the inside, which forms a delicate, soft layer on the surface. It is used for footwear, clothing, and upholstery. This type of leather is often confused with velvet suede and chamois. WIDTH:140-150cm Fiber:wool Uses:Dresses ,suits and coats
BRUSHED NYLON	Advanced Seals & Gaskets Ltd manufacture a diverse range of Brushed Nylon fabric products. Textiles are widely used in manufacturing processes, their specific properties determine how they are used, but are frequently combined with other other materials, such as cork, neoprene or rubber to meet the required end-users needs. Warm to handle Flame resistant WIDTH:90-115 to 150 cm FIBER:nylon USE:night wear
BRUSHED RAYON	Soft warm to handle WIDTH:90cm FIBER: Viscose rayon USE: Dresses, Blouses, Children Garment

CALICO	WIDTH:90cm,100cm to 180cm FIBER: Cotton USE: interfacing ,house hold goods
CHIFFON	WIDTH:90cm to 115cm FIBER: rayon, nylon and silk USE: blouses, night dresses, evening wear
CARDURAY	WIDTH: 70cm,90cm FIBER: Cotton USE: Children's clothes Dresses, House, Coat ,Suits and jeans
COTTON SATIN	WIDTH: 90cm FIBER: Cotton,Vincel USE: Dresses, Shirts, Skirts, Blouses
CREPE	WIDTH:90cm to 115cm FIBER: Wool, Nylon ,Tricel and Silk USE: Blouses, , Lingerie, Dresses
CREPON	WIDTH:90cm to 115cm FIBER: Wool, Nylon ,tricel and Silk USE: blouses, Slips , Dresses
DEMIN	WIDTH:90cm,120cm FIBER: Cotton, Rayon USE: Short, Jeans, Shirts, Overable, Dresses, Children's wear
FLANNELS	WIDTH:70cm,140cm FIBER:WOOL,RAYON,COTTON USE: Shirts, Suits, Dresses, Short
FAULAND	FIBER: Rayon ,Silk USE: Dresses, Foulard, Shirts

GABERDINE	Width: 90cm ,140cm,150cm Fiber: Wool, Cotton Use: Suits,shirts, Jackets, Coats, Dresses and rain coat
VOILE	Width: 90cm To 115cm Fiber: Cotton, Nylon, Other Man Made Fibers Use: Blouses ,Children's Wear, Dresses
GEORGETTE	Width: 90cm To 115cm Fiber: Cotton, Nylon, Silk Use: Blouses ,Children's Wear, Dresses
JERSEY FABRICS	Width:90cm ,140cm and 150cm Fiber: cotton ,courtelle, acrilon, orlon Use: Dresses, Coats and Suits
PIQUE	Width:90cm Fiber:cotton,rayon Use: Suits, shirts, Jackets, Coats, Dresses and summer coat
POPLIN	Width:90cm Fiber:cotton,rayon Use: Blouses ,Children's Wear, Dresses,shirts,rain coat
SATIN	Width: 90cm to 115cm Fiber:rayon,nylon,silk Use:Evening wear,blouses,lingeries and night wear

LEARNING UNIT 3: USE TEXTILE FIBERS

LEARNING OUTCOME 3.1: UTILIZE NATURE TEXTILE FIBERS NATURE TEXTILE FIBERS

❖ **CONTENT/TOPIC 1. APPLICATION OF VEGETABLE FIBRES**

SEED HAIR FIBERS

Seed/Fruit-hair Fibers

The seeds and fruits of plants are often attached to hairs or fibers or encased in a husk that may be fibrous. These fibers are cellulosic based and of commercial importance, especially cotton, the most important natural textile fiber.

Major Seed/Fruit-hair fibers

Cotton Fiber

Cotton is a soft, staple fiber that grows in a form known as a boll around the seeds of the cotton plant, a shrub native to tropical and subtropical regions around the world, including the Americas, India, and Africa. The fiber most often is spun into yarn or thread and used to make a soft, breathable textile, which is the most widely used natural-fiber cloth in clothing today. The English name derives from an Arabic word which began to be used circa 1400.

Each cotton fiber is composed of concentric layers. The cuticle layer on the fiber itself is separable from the fiber and consists of wax and pectin materials

BAST FIBERS

Bast fibers like jute, flax, hemp and kenaf had been thoroughly investigated by numerous researchers up till today where most of them had focused on the fibers chemical constituents, physical and mechanical properties as well as its cell wall architecture. These properties of bast fibers makes it a suitable reinforcement for thermoset polymers with the added benefits of being environmentally friendly and also possessing high specific strength comparable to synthetic fibers. Despite the advantages, bast fibers also lack behind in certain properties like moisture absorption. In order to offset what bast fibers are lacking, hybridization of bast fibers with other natural fibers or synthetic fibers were done and the results were promising as hybridization enhances the reinforced thermoset composites. To further improve the hybrid bast fiber thermoset composites, researchers had also conducted several studies on its fiber-matrix interface, bast fiber thermal stability, moisture content, biodegradability, and dispersion in the matrix. This had led to the development of hybrid bast fiber thermoset composites exhibiting properties comparable to synthetic thermoset composites with the exception of one or two lower properties for the hybrid composites. Due to these comparable properties, the hybrid composites has the potential for application in building and structural materials, automotive components, piping and body armor. However, there is still a need for future research to broaden its application to other utilizations by further improving the bast fibers moisture absorption, thermal stability and durability, allowing them to completely replace synthetic fibers one day.

Bioprocessing of bast fibers

Introduction

Bast fiber, also called phloem fiber, is a type of plant fiber that can be collected from the phloem or bast surrounding the stem of certain dicotyledonous plants. Bast fibers can be obtained either from cultivated herbs, such as flax, hemp, and ramie, or wild plants, such as linden, wisteria, and mulberry. The strands of bast fibers are usually released from the cellular and woody tissue of the stem by mechanical, biological, or chemical methods. Bast fibers have higher tensile strength than other natural fibers, thereby are usually used in the production of high-quality textiles (Faruk et al., 2012; Summerscales et al., 2010). Bast fibers are processed and utilized in many industries, such as textiles, ropes and nets, carpets and mats, brushes, and mattresses industries, in addition to paper and board materials industries (Paridah et al., 2011). In recent years, bast fibers, such as flax, kenaf, and hemp, have received attention from researchers and industries for their use as reinforcement in polymer–matrix composites because of environmental awareness of consumers and government regulation in some countries (Anuar and Zuraida, 2011; Bos et al., 2002; Saba et al., 2015; Stuart et al., 2006).

Biotechnological process has been used in textile processing of bast fibers, such as microbial retting of bast fibers, which took place during BC periods. During the past decades, textile biotechnology has been an important research area, and thus several enzyme-based processes have now been well-established and are available for use in bast fiber processing, such as retting, scouring, bleaching, and functionalization

Flax: Like cotton, flax fibre is a cellulose polymer, but its structure is more crystalline, making it stronger, crisper and stiffer to handle, and more easily wrinkled. Flax fibres range in length up to 90 cm, and average 12 to 16 microns in diameter. They absorb and release water quickly, making linen comfortable to wear in hot weather. One of nature's strongest vegetable fibres, flax was also one of the first to be extracted, spun and woven into textiles.

Hemp: Long, strong and durable, hemp fibres are about 70% cellulose and contain low levels of lignin (around 8-10%). The fibre diameter ranges from 16 to 50 microns. Hemp fibre conducts heat, dyes well, resists mildew, blocks ultraviolet light and has natural anti-bacterial properties. Shorter, woody core fibres ("tow") contain higher levels of lignin. Easy to grow without agrochemicals, hemp is used increasingly in agrotextiles, car panels and fibreboard, and "cottonized" for clothing.

Jute: Dubbed the "golden fibre", jute is long, soft and shiny, with a length of 1 to 4 m and a diameter of from 17 to 20 microns. It is one of nature's strongest vegetable fibres and ranks second only to cotton in terms of production quantity. Jute has high insulating and anti-static properties, moderate moisture regain and low thermal conductivity. The strong threads made from jute fibre are used worldwide in sackcloth - and help sustain the livelihoods of millions of small farmers.

HARD FIBERS

Abaca: It's a leaf fibre, composed of long slim cells that form part of the leaf's supporting structure. Lignin content is a high 15%. Abaca is prized for its great mechanical strength, buoyancy, resistance to saltwater damage, and long fibre length – up to 3 m. The best grades of abaca are fine, lustrous, light beige in colour and very strong. Once a favoured source of rope for ship's rigging, abaca shows promise as an energy-saving replacement for glass fibres in automobiles.

Coir: Among vegetable fibres, coir has one of the highest concentrations of lignin, making it stronger but less flexible than cotton and unsuitable for dyeing. The tensile strength of coir is low compared to abaca, but it has good resistance to microbial action and salt water damage. A coarse, short fibre extracted from the outer shell of coconuts, coir is found in ropes, mattresses, brushes, geotextiles and automobile seats.

Cotton: It's almost pure cellulose, with softness and breathability that have made it the world's most popular natural fibre. Fibre length varies from 10 to 65 mm, and diameter from 11 to 22 microns. It absorbs moisture readily, which makes cotton clothes comfortable in hot weather, while high tensile strength in soap solutions means they are easy to wash. Cotton is the world's most widely used natural fibre and still the undisputed "king" of the global textiles industry.

Ramie: It's is white with a silky lustre, similar to flax in absorbency and density but coarser (25-30 microns). One of the strongest natural fibres, it has low elasticity and dyes easily. Strands of ramie range up to 190 cm in length, with individual cells as long as 40 cm. Trans-fibre fissures make ramie brittle but favour ventilation. Not widely known outside the East Asian countries that produce it, ramie is lightweight, silky and made for summer.

Sisal: Lustrous and creamy white, sisal fibre measures up to 1 m in length, with a diameter of 200 to 400 microns. It is a coarse, hard fibre unsuitable for textiles or fabrics. But it is strong, durable and stretchable, does not absorb moisture easily, resists saltwater deterioration, and has a fine surface texture that accepts a wide range of dyes. Too coarse for clothing and upholstery, sisal is replacing glass fibres in composite materials used to make cars and furniture

❖ CONTENT/TOPIC 2. APPLICATION OF ANIMALS FIBERS

WOOL

Uses & Application of Wool Fibre

Wool is extensively used in textile applications where comfort and aesthetics are important. Some uses and application of wool fibre are given below –

Wool fibre used for clothing, blankets, insulation and upholstery.

It is used in men's and women's apparel, outer wear and cold weather clothing, suits, blankets, felts and carpeting.

It is often used in blends with cellulosic and man-made fibres.

It is also used for absorb noise of heavy machinery and stereo speakers.

As an animal protein wool, can be used as a soil fertilizers, being a slow release source of nitrogen.

End uses of wool fibre

Alpaca fibres are used for many purposes, including making clothing such as hats, mitts, scarves, gloves. And jumpers. Rugs and toys can also be made from alpaca fibres. Alpaca fleeces is generally used only in the expensive luxury items of textile and apparel

Lama fibres are used in expensive knitted fabrics, jackets, over – coats, and blankets.

Camel hair is used for outer wear and used for under linings

Cashmere is used in luxury applications where a soft, warm, fine fibre with beautiful drape is desired.

Mohair is used for outer – wear

SILK

Uses/Application of silk:

This combination of properties, together with fineness, high degree of lustre, softness and superb drape enables silk to be converted into many beautiful types of fabrics, from delicate chiffons to heavy brocades. The fineness, regularity, strength and elasticity of silk make it suitable for fine screens for printing and parachute fabrics.

Silk's good absorbency makes it comfortable to wear in warm weather and while active. Its low conductivity keeps warm air close to the skin during cold weather. It is often used for clothing such as shirts, blouses, formal dresses, high fashion clothes, negligees, pyjamas, robes, skirt suits, sun dresses and underwear.

Silk's elegant, soft luster and beautiful drape makes it perfect for many furnishing applications. It is used for upholstery, wall coverings, window treatments (if blended with another fiber), rugs, bedding and wall hangings.

It may be interesting to note that a 5 m saree weighing about 400 g will require 1.5 million mulberry leaves weighing 150 kg for the growth of silk worms. This is the quantity of mulberry leaves which 6000 silk worms consume before they spin full cocoons to yield enough raw silk for a 5 m silk saree. In other words, it involves stifling of 6000 silk worms nestling in their cocoons. In fact, however, twice the number of silk worms is required to be reared up because of 50% mortality rate in breeding.

- **CONTENT/TOPIC 3. APPLICATION OF MINERAL FIBERS**

Application of Asbestos

Asbestos has been used in building-construction materials, textiles, missile and jet parts, asphalt and caulking compounds and paints, and in friction products such as brake linings.

METALLIC FIBERS

Metallic fibers are used in a wide range of sectors and segments.

Automotive

Metal fiber sintered sheets are used for diesel and gasoline particulate filtration and crankcase ventilation filters.

Heat-resistant textile materials are made from metal fibers for automotive glass bending processes. These metal fiber cloths protect the glass during the bending process with highly elevated temperatures and high pressures.

Also heating cables for car seat heating and Selective Catalytic Reduction tubes, adblue tanks. Metal fiber heating cables show an extremely high flexibility and durability when compared to copper wire.

Aerospace

Metal fiber filters are used for Hydraulic fluid filtration in aircraft hydraulic systems. When compared to glass fiber filtration media, metal fibers show excellent durability, as the fibers are metallically bonded together by sintering, instead of kept together by a binder material.

Metal fiber sintered porous sheets are used as a sound attenuation medium in the aircraft cabin, reducing HVAC sounds, and auxiliary power unit noise.

Technical textiles

Metal fibers can serve as antistatic fibers for textiles, which can be used in, amongst others, electrical protective clothing or antistatic big bags.

Not only antistatic, but also shielding from electromagnetic interference (EMI) can be achieved by metal fiber textiles.

Stainless steel fiber textiles can be heated by applying electrical current and can also be used for cut resistant clothing (gloves). Let's say it's the modern chain mail.

Power

Metal fiber filters can reach very high porosity, at very low pore sizes, which makes them suitable for HEPA and ULPA filtration. These filters are used in, amongst others, nuclear power plants as a safety measure to prevent eventual release of radio-active steam.

Marine

Metal fiber filters are used for the purification of marine fuel and lube oil.

Other uses of metal fibers

Another common use for metallic fibers is upholstery fabric and textiles such as lamé and brocade. Many people also use metallic fibers in weaving and needlepoint. Increasingly common today are metallic fibers in clothing, anything from party and evening wear to club clothing, cold weather and survival clothing, and everyday wear. Metallic yarns are woven, braided, and knit into many fashionable fabrics and trims. For additional variety, metallic yarns are twisted with other fibers such as wool, nylon, cotton, and synthetic blends to produce yarns which add novelty effects to the end cloth or trim.[10]

Stainless steel and other metal fibers are used in communication lines such as phone lines and cable television lines.

Stainless steel fibers are also used in carpets. They are dispersed throughout the carpet with other fibers so they are not detected. The presence of the fibers helps to conduct electricity so that the static shock is reduced. These types of carpets are often used in computer-use areas where the chance of producing static is much greater. Other uses include tire cord, missile nose cones, work clothing such as protective suits, space suits, and cut resistant gloves for butchers and other people working near bladed or dangerous machinery.

Metal fibers can be used as a reinforcement or electrical conductivity fiber for fiber reinforced composites.

❖ LEARNING OUTCOME 3.2: UTILIZE SEMI SYNTHETIC TEXTILE FIBERS UTILITY OF SEMI SYNTHETIC TEXTILE FIBERS

VISCOSE

How Is This Fabric Used?

Rayon is commonly used as a substitute for cotton. This fabric shares many traits with cotton, but in some cases, it may be easier or cheaper to produce. Most consumers can't tell the difference between cotton and rayon by touch, and since this fabric is made from organic materials, it is sometimes seen as superior to fully synthetic fabrics such as polyester.

This fabric is used for most applications for which cotton is used. Whether it's dresses, shirts, or pants, rayon is used to make a wide variety of different articles of clothing, and this fabric may also be used to make household items like towels, washcloths, or tablecloths.

ACETATE

Some Major Acetate Fiber Uses:

- **Apparel:** Blouses, dresses, linings, wedding and party attire, home furnishings, draperies, upholstery
- **Industrial Uses:** Cigarette filters

General Acetate Fiber Care Tips: — Most acetate garments should be dry-cleaned, but if laundering is indicated, use the following guide:

- Handwash in warm water with mild suds.
- Do not twist or wring out garment.
- Do not soak colored items.
- Press while damp on wrong side with cool iron. For finishing on the right side, use a pressing cloth. *(For specific instructions, refer to garment's sewn-in care label.)*

Note: Acetate is adversely affected by acetone and other organic solvents, such as nail polish remover and perfumes containing these solvents.

LEARNING OUTCOME 3.3: UTILIZE SYNTHETIC TEXTILE FIBERS

- **CONTENT /TOPIC 1. UTILITY OF SYNTHETIC TEXTILE**

POLYAMIDE (NYLON)

Nylon is a generic designation for a family of synthetic polymers, based on aliphatic or semi-aromatic polyamides. Nylon is a thermoplastic silky material that can be melt-processed into fibers, films, or shapes.It is made of repeating units linked by amide linkssimilar to the peptide bonds in proteins. Nylon polymers can be mixed with a wide variety of additives to achieve many different property variations. Nylon polymers have found significant commercial applications in fabric and fibers (apparel, flooring and rubber reinforcement), in shapes (molded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging)

How Is Nylon Fabric Used?

Nylon fabric was originally marketed as an alternative to silk stockings. Until the advent of this fabric, silk was the only viable material for the types of sheer stockings that were then popular with women in the developed world, but silk lacks durability, and it is notoriously expensive.

While the performance of nylon fabric didn't quite live up to the hype that DuPont gave it at the inception of this textile, it remained a favorite stocking material among professional and domestic women for the majority of the latter half of the 20th century. To this day, women's stockings remain one of the major applications of this type of fabric, and it is also used in tights, yoga pants, and other types of form-fitting bottoms for women.

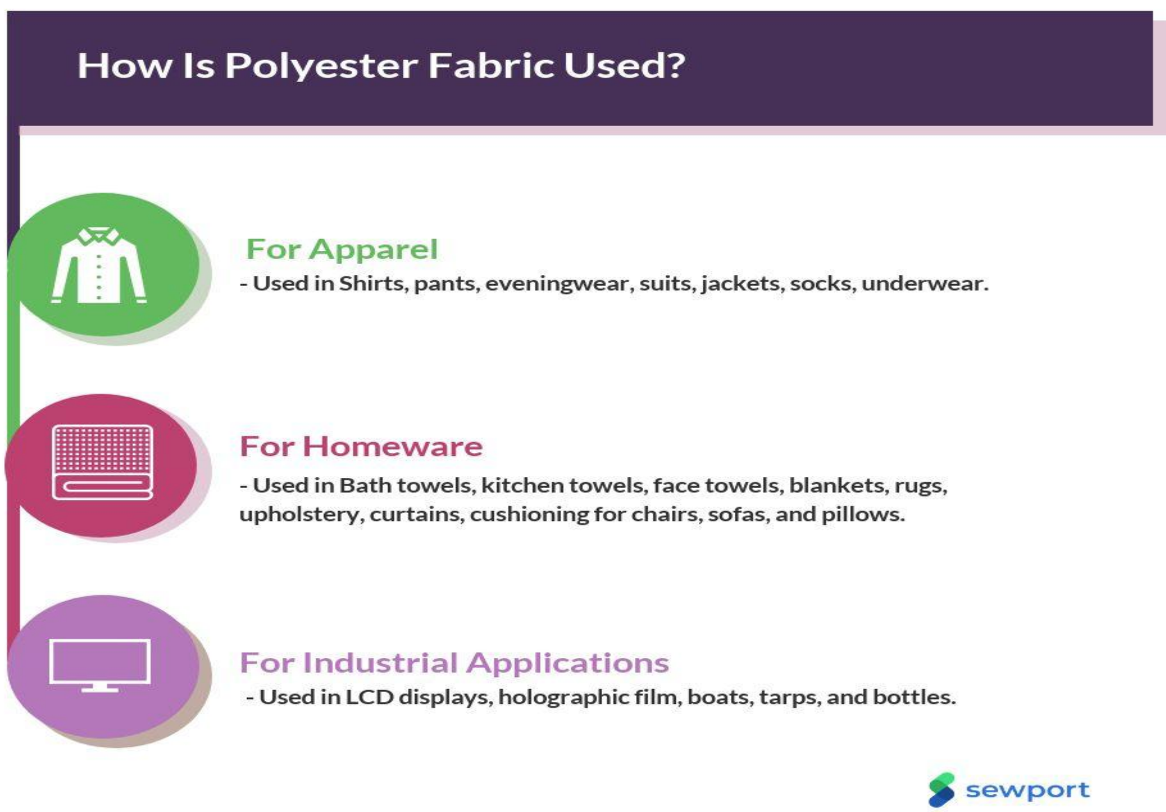
A restructuring of the global economy in the late 1970s and throughout the 1980s saw many international corporations pivot toward China as a manufacturing base. Therefore, many nylon fabric production operations moved to this East Asian country, and production of this fabric has since picked up steam in other regional nations such as India, Pakistan, and Indonesia.

To some degree, nylon fabric is still produced in the United States, but the majority of this fabric's production occurs overseas. Despite the contemporary revival of the manufacturing industry in the USA, it's unlikely that production of nylon fabric will return to this country; for the last few decades, production of this fabric has been on the decline, and even China has consistently been producing less and less of this polymer textile.

How Much Does Nylon Fabric Cost?

One of the primary benefits of nylon fabric is its relatively low cost of manufacture. While this fabric was more expensive than silk when it was first developed, it rapidly dropped in price, and it is especially inexpensive when mixed with other fabrics.

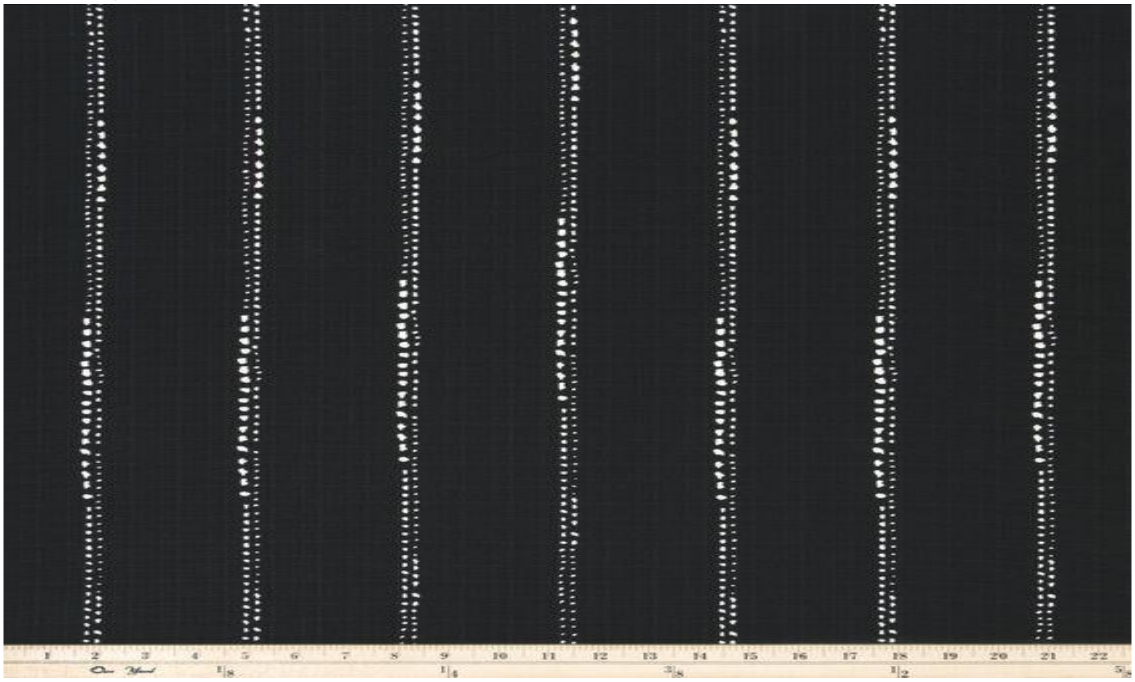
How Is Polyester Fabric Used?



It’s important to recognize that the PET used to make polyester fabric is the same type of petroleum-based plastic used to make many of the synthetic consumer products we use in our daily lives. For instance, this plastic is used to make food containers, water bottles, and a variety of other types of industrial and consumer products.

In its fiber form as polyester fabric, however, PET is used in hundreds of different consumer applications. Traditionally, PET has been used as an alternative to cotton, and in some applications, it may also serve as a reasonable alternative to other natural fibers like wool and silk.

Essentially, anything made from cotton can also be made with polyester. From everyday shirts and pants to glamorous eveningwear, the apparel applications of polyester fabric are endless. Manufacturers use polyester fabric to make suits, jackets, socks, underwear, and pretty much anything that you can wear for casual, business, or formal occasions.

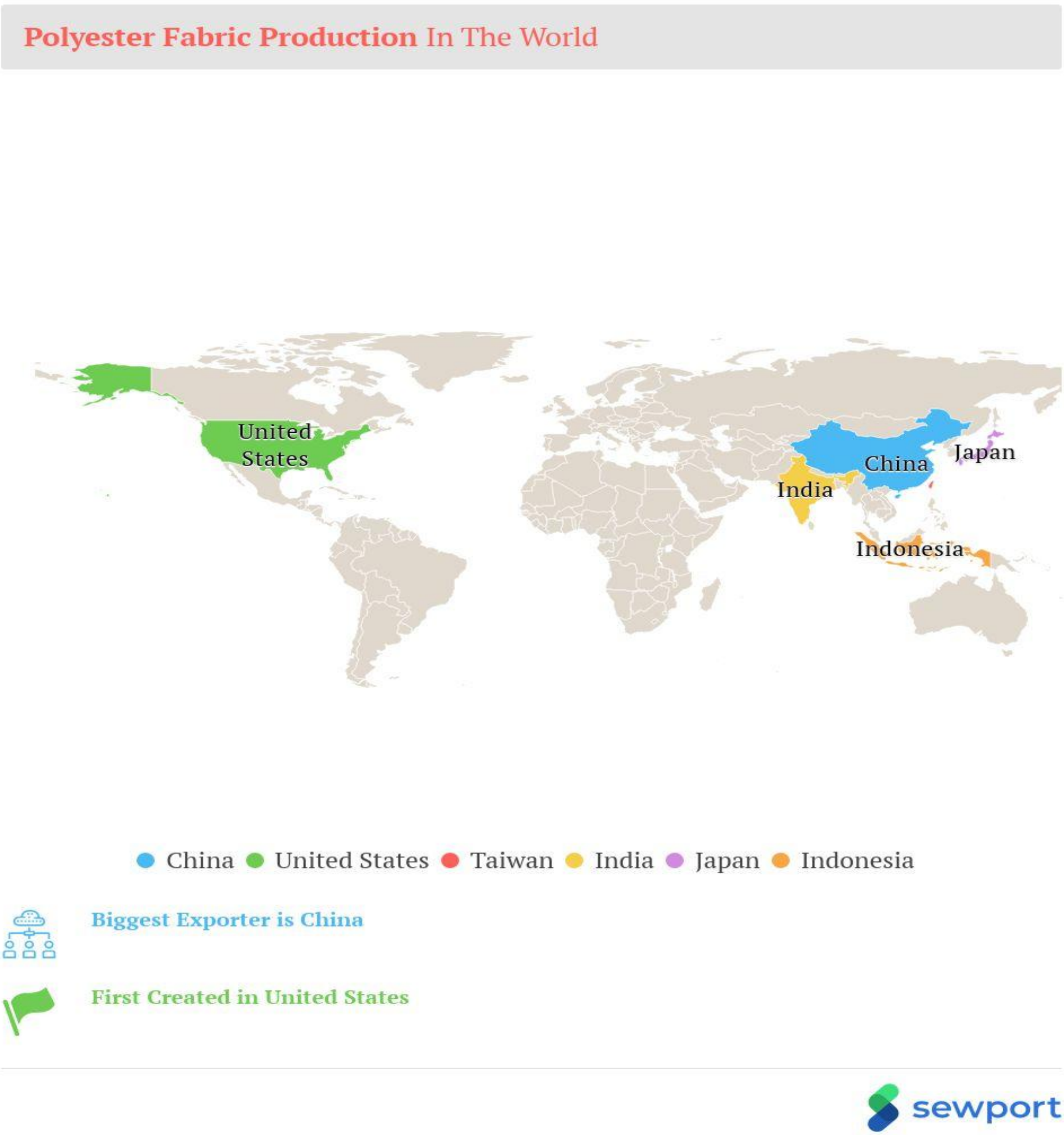


Carlo Black Luxe Polyester Fabric

Additionally, manufacturers also use polyester to craft various homewares. In particular, a type of polyester called microfiber has gained prominence in the bath and kitchen homeware categories. Consumers value the softness and absorbency of microfiber in applications like bath towels, face towels, and kitchen towels. Manufacturers may also use polyester to make homewares like blankets, rugs, upholstery, and curtains.

Polyester fabric may be used as cushioning for chairs, sofas, and pillows, and due to the impressive stain-resistance of this material, many parents and pet owners prefer polyester products. Industrial applications of polyester include LCD displays, holographic film, boats, tarps, and bottles.

Where Is Polyester Fabric Produced?



According to a 2006 study, China is the largest producer of polyester fibers. China is also the world's largest polyester market, which makes this nation the hub of the international polyester industry.

Taiwan, Korea, India, Japan, and Indonesia are also major manufacturers of polyester, and some polyester production still occurs in the United States. Once polyester fibers are produced in China and other Asian countries, they mainly remain in Asia to be made into apparel and other polyester-based consumables. From there, these finished pieces of polyester apparel are exported to various nations in the Western world and beyond.

LEARNING UNIT4: APPLY CARE OF TEXTILE FIBERS

LEARNING OUTCOME 4.1: IDENTIFY MATERIALS OF WASHING CLOTH

- **CONTENT /TOPIC 1. SELECTION OF WASHING MATERIALS CLOTH**

WASHING PRODUCT

10 Different types of Detergents & other Cleaning products for clothes

I never bothered to look carefully at the labels on the detergents I bought and always simply tossed the usual brand I buy into my shopping cart until the day my kid started breaking out in rashes. The doctor we consulted suggested that a change of laundry detergent from the current one to a PH Neutral one may help and it sure did. It was some kind of allergy to the ingredients in the detergent we used.

You do not have to wait till you break out. You never may, but you can as well. Knowledge about what you put **on your clothes may not be as important as the food we put inside us, but it is not unimportant.**

The different types of cleaning agents we use to clean our clothes

1 . Detergents

Image by Frank Habel from Pixabay

Detergents are the most commonly used cleaning agent for fabric – that which we put into the washing machine in powder or liquid form. They suspend, solubilize, dissolve or separate dirt and soil from fabric in a way that they will not re-deposit on the surface of the fabric but will stay put, suspended in the water.

They are usually called synthetic detergents as most of the detergents today are made from petrochemicals and contain wetting agents and emulsifiers – they are sulfate or sulfonate salts. Detergents are very effective for removing dirt/soil from manufactured and blended fabrics

Ingredients of Detergents.

Detergent: Product the formulation of which is specially devised to promote the development of detergency. *Note:* A detergent is a formulation comprising essential constituents (surface active agents) and subsidiary constituents (builders, boosters, fillers and auxiliaries).

Most of the detergents you use have the following ingredients – **Surfactants** are the dirt removing agents – they are named anionic surfactants, nonionic surfactants and cationic surfactants. Most of them are biodegradable. **Builders** like zeolites, phosphates are added to the surfactants to boost cleaning.

Fillers like Sodium sulfate, Borax, Sodium chloride, water , alcohol, Anti-foaming agents are added for various purposes. Other ingredients include, bleach, enzymes, whitening agents may also be added.

There are so many different types of detergents today since its introduction (said to be during the first world war) and every so often new ones are being discovered that promises to do exciting things in cleaning. Many even promising the sun shining on your clothes.

Many additives are added to the detergents to make them more efficient. Some of the additives added maybe counterproductive to the cleaning you have in mind so reading the label of the cleaning product you buy is very important.

Types of detergents

Powder detergents are more effective than **liquid detergents** but liquid ones are more gentle on fabric and best for cleaning lightly soiled clothes. Detergents are also available in a **cake form**.

Image by PDPics from Pixabay

Generally, detergents are of two types Anionic and non-anionic. Some are a combination.

The powder form detergents are of the **anionic class**. They are the fatty derivatives of aromatic sulfonic acids. They are good for cleaning natural fabrics like cotton, linen and work well to remove oily stains and clay. They work best with warm soft water. Do not use hard water with these detergents.

The **non-anionic detergents** are mostly in liquid form and do not produce much foam. They are good at cleaning synthetic fabrics and work well to remove oily soils and work ok in hard water.

Enzyme detergents, phosphate-free detergents, are terms commonly heard and very much desired. **Phosphate free detergents** promise to be good for the environment. Today most detergents are phosphate free.

Enzyme detergents are good for stain removal. They are good for removing protein stains like blood stains

Presoak detergents are used to soak clothes prior to cleaning and they are meant to loosen up and remove hard stains.

Hand washing detergents are used for hand laundering specific types of fabrics for eg. hand laundry detergents for woolen clothes. They have special properties that take care of the properties of the fabric they cater to.

2. Soaps

Image by B_A from Pixabay

Soap is a biodegradable cleaning agent (fatty acid salts) made by combining fats (animal or vegetable) with Lye (Sodium Hydroxide).

All our ancestors used soap to clean their clothes for a long long time. No one cared that their clothes increasingly became dull and grey. Even if they cared they had no alternatives; till the detergents were discovered.

Soap forms a deposit on clothes, especially with hard water. When you have access to only hard water (with dissolved salts of calcium, magnesium and/or iron) for cleaning clothes (even mildly hard water) these salts combine with soap to form a curd-like precipitate- very undesirable ugly looking scum

Soap is not as effective as detergents especially with synthetic fabrics like polyester, nylon, spandex, and acrylic. And not suitable to use in the washing machine because of the scum.

If you are hand washing and rinsing, the scum can be removed with many rinses. So if you are environment conscious (It is environment-friendly) and you do not mind a little extra labor, you may try washing clothes with soap.

3. Bleach

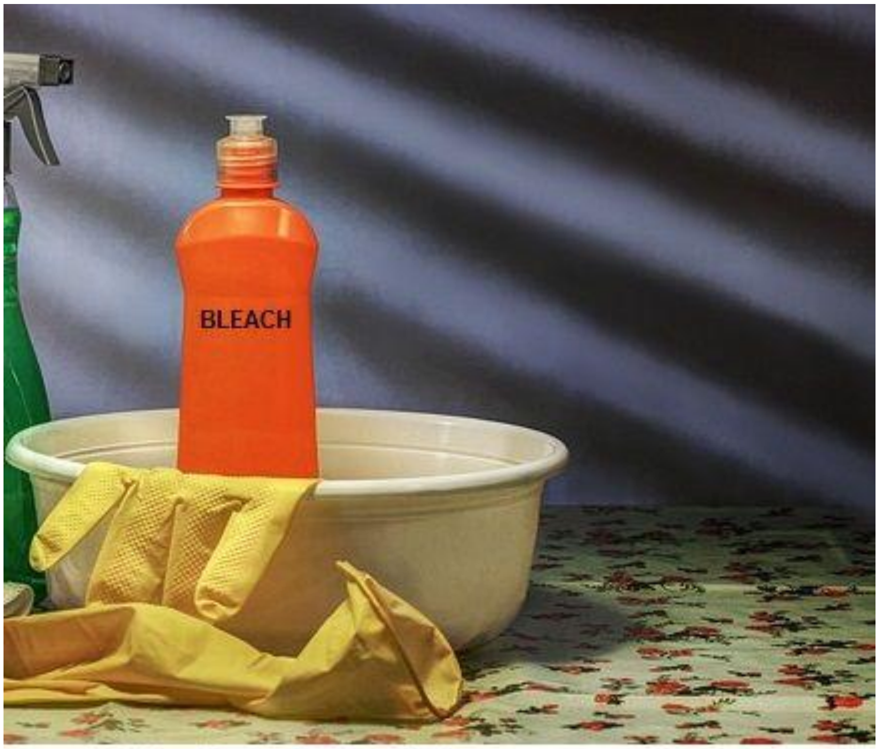


Image by Michael Tavrionios from Pixabay

There are two types of bleach – the chlorine bleach and oxygen bleach. Chlorine bleach is strong and can whiten clothes very effectively but it can weaken fabric fibers. So you are not supposed to use chlorine bleach on protein fabrics like silk, wool or on lycra, spandex, elastic. Oxygen bleach is color safe and more gentle on fabric fibers. Learn more about bleach use here.

4 . Laundry Boosters

They are added as an addition to detergents to improve the performance of detergents. They help in better removal of stains and brighten the colour of clothes. They may also have water softening properties

5 Stain removers

Image by Mimzy from Pixabay

Stain removers target stains and they are usually used before washing as spot stain removers. They may be a combination of detergents, alcohols, mineral spirits, and enzymes and work effectively in removing the stain without fading colours.

6. Optical Brighteners

These are additives that make the whites appear whiter. They absorb ultraviolet light from the sun or from fluorescent fixtures and emit it as blue light. They may be already added in your detergent. You can use bluing agents in a separate final rinse to get the same effect.

7 .Fabric Softener

Image by 200 Degrees from Pixabay

After the clothes are washed they take on a stiff scratchy feel – if you do not like this you can add fabric softeners to the water. They coat your clothes with a waxy lubricant that adds a soft hand to them.

They also reduce static buildup in the dryer and do not let the clothes tangle with each other. Fabric softeners also reduce wrinkling. Towels come out fluffy, bed sheets soft, and your blouses almost wrinkle free.

8 .Shampoo

The Hair shampoo is used for washing clothes by many people – especially for handwashing natural fibers. But not all shampoos are effective as cleansers- some may even do harm. They may have ingredients not suitable for the fabric fibers. Do not buy shampoo with additional ingredients like oil conditioning etc. They will leave an oily residue.

You should be looking for ingredients like Lauric acid, Myristic acid, palmitic acid, and stearic acid in your shampoo for it to be effective as a good cleaning agent for clothes.

9. Water softeners

Image by Steve Buissinne from Pixabay

So many homes have access to only hard water all over the world – those who have good soft water for drinking and cleaning should count themselves lucky.

Hard water is caused by minerals present in the water. As a result, detergent won't lather up and clean clothes as effectively as with soft water. The clothes will look dull and white clothes especially will start to look grey after some time.

Water softeners are added to the water to change the hard water property to soft. Usually, they are available as a tablet and they are added to each wash.

10 .Home remedies

Image by Monfocus from Pixabay

Baking soda, washing soda, Lime, Vinegar, Hydrogen Peroxide – there are many home remedies that we regularly use to clean things. Most of them can be used for clothes too. Dish washing liquid is used as a spot stain remover, especially for oily stains.

Washing symbols

The wash tub icon tells you exactly how to wash the garment, with underscored lines indicating the recommended cycle and black dots representing water temperature. An X, of course, warns to not machine wash at all.

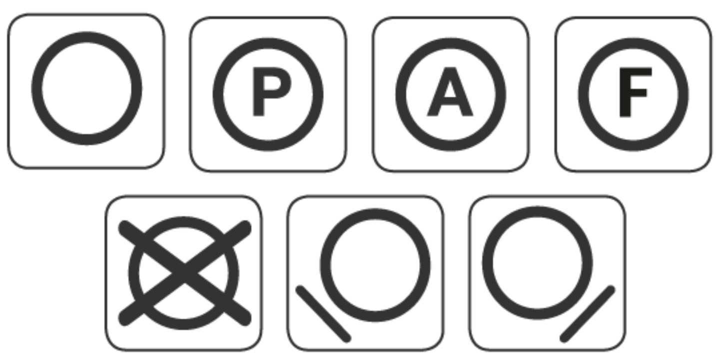
Active family members can be hard on their gym socks, white undershirts and little league uniforms. If your whites are looking a little dingy, consult the triangle on the clothes' label (if there is one) for bleaching instructions.

Bleaching symbols

- ✓ A triangle means you can safely use a cold, dilute solution of bleach
- ✓ If the triangle has two stripes, only a non-chlorine, colour-safe bleach should be used
- ✓ If the triangle has a cross over it, the item can't be bleached

Dry cleaning symbols

DRY CLEANING SYMBOLS



- ✓ Some clothes can – or must – be dry cleaned.
- ✓ A circle means the garment is suitable for dry cleaning

- ✓ If there's a letter inside the circle, it's to tell the dry cleaner which chemical wash and method to use
- ✓ If the circle has a cross over it, the item shouldn't be dry cleaned
- ✓ A line on the bottom left of the circle means short cycle
- ✓ A line to the bottom right is for low heat

Drying symbols

Drying your clothes can be where it all goes wrong and you either end up stretching your favourite wool jumper or shrinking your best top.

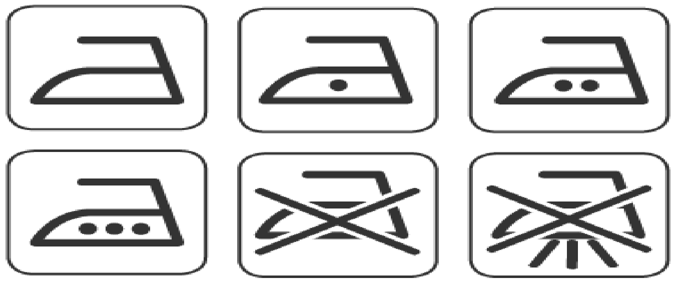
- ✓ In contrast to tumble drying, natural drying symbols can be harder to interpret.
- ✓ Here's what the natural drying symbols actually mean: If the square has one drooping line, this means you can hang your clothes to dry on a washing line outside
- ✓ If the square has three vertical lines in it, this means drip dry your clothes on a rack indoors
- ✓ If the square has one horizontal line, this means dry the garment flat to keep its shape

HAND WASHING

If the tub contains a handwash program, wash the item by hand at 40°C or lower.

- ✓ Many washing machines have a handwash program. This is for delicate garments such as cashmere or silk, and cleans more gently than the normal setting to prevent clothes snagging or shrinking.

Ironing symbols



The dots on ironing symbols correspond to the dots on an iron's temperature settings:

- ✓ the more dots there are, the more heat can be applied.
- ✓ If the iron symbol doesn't have any dots, the garment can be ironed at any temperature
- ✓ Three dots are for linen and cotton
- ✓ Two dots are for synthetics One dot is for the most delicate items such as woollens and silk
- ✓ If the iron symbol has a cross through it, that garment is not suitable to be ironed
- ✓ If the symbol has two or three lines protruding from the bottom of the iron with a cross over it, this means you must dry iron and not steam iron

Synthetics and cottons symbols

The bars underneath the tub icon refer to rinsing and spinning. Such items shouldn't be wrung by hand. If there are no bars, the garment can be spun and rinsed as normal One bar indicates that the spin speed should be reduced Two bars means the clothes need a mild wash action, but can be spun and rinsed normally If there's a cross through the tub, that item should not be washed and will probably need to be dry cleaned

Washing temperatures symbols

If your clothes are machine washable then you'll see this tub icon on the label.

- ✓ The number within the tub icon shows the maximum temperature that item of clothing can be washed at.
- ✓ This can range from 30°C to 95°C. Many claim that washing at 30°C instead of 40°C is the key to saving money and energy.
- ✓ For this reason you might opt for a lower temperature to the label guide.
- ✓ But while it may conserve energy and save on running costs, 30°C doesn't always remove tougher stains such as oil and grease.

Tumble drying symbols

Getting tumble drying right is easy if you use the correct temperature.

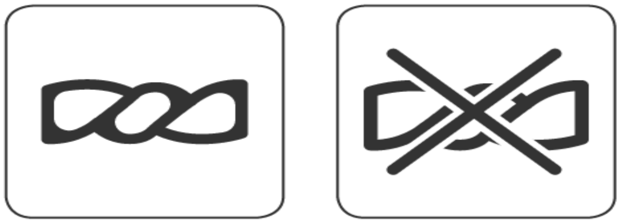
- ✓ A circle inside a square means you can tumble dry the garment the dots indicate temperature
- ✓ one for low heat, two for slightly higher heat, and three for high heat A cross over the symbol means you shouldn't tumble dry the garment Some clothes may appear similar but have different labels
- ✓ They're most likely made from different fibres or blends.
- ✓ Some fibres or blends can change size or become 'furred' by tumble drying.

An item that's suitable for tumble drying will have been treated to protect against these effects.

If you're currently looking to buy a new tumble dryer, not all models will dry clothes properly.

We've found some tumble dryers in our tests that leave clothes sopping wet as well as driving up your electricity bills

Wringing symbols



Wringing out your clothes is possibly the most common mistake made during hand washing or drying clothes without a dryer.

- ✓ Twisting the fabric by hand can seriously damage your favourite item of clothing.
- ✓ If you're not sure whether to wring out the excess water by hand, look out for the symbols above on your clothing label
- ✓ Symbol on the left - go ahead and wring your clothes with confidence Symbol on the right with a cross through it - do not attempt to wring your clothes

LEARNING OUTCOME 4.2: SELECT STAIN REMOVER ON DIFFERENT FIBERS

- **CONTENT/TOPIC 1. SELECTION OF STAIN REMOVER**

WASHING MATERIALS REMOVER

1. A Good Sponge

There are a huge variety of sponges out there. It's nice to have a classic sponge around—especially something with an abrasive side to tackle any grimy dirty surface. But if you want to explore your alternative side, you can try out **sponge cloths** that bridge the gap between sponge and towel, **spaghetti sponges** (they don't require soap!), **a Scrub Daddy** that changes texture based on temperature, or **silicone sponges** that last almost forever.

2. **White Towels**
3. **WASHIMG MACHINE**

What type of washing machine is better: top-loading or front-loading?

The first decision you'll have to make is whether you want a front- or top-loading machine. In Good Housekeeping Institute tests, both types clean so well you'll likely not notice a difference in your clothing, though our tests show front loaders do perform a bit better. Which you choose is really a matter of personal preference.

A front-loading washing machine is the most energy efficient option. It uses the least amount of water in each load. Clothes get cleaned when they tumble in a small pool of water that's added by the machine once it senses the weight and type of load. Front loaders can easily handle big, bulky items, like comforters and sleeping bags, but do require bending to load and unload the tub. Most manufacturers sell pedestal drawers to raise the appliances up off the floor and save some strain on your back.

If space is tight, a front load washer can be stacked with its matching dryer and placed in a closet, bathroom or any narrow area where water, electrical connections and venting are available. Keep in mind that water often puddles in the door gasket, dispensers and even the drum itself at the end of the cycle and can lead to mold growth and odors. If you choose a front loader, you'll need to be diligent about cleaning the gasket and dispenser and leaving the door ajar so the drum dries out and odors don't develop.

A top-loading washing machine is a good choice if you like a more traditional configuration. Because the water in top-loaders drains down and out, they are less likely to develop mold and odors than front-loadersare and that's the reason many consumers prefer them. However, it's a good idea to clean the tub and dispensers of all washing machines about once per month. Newer, high-efficiency top-loading models provide excellent cleaning and are still energy efficient even though they use more water than front loaders and they can come with or without center agitators.

Top loaders without agitators have huge tubs for extra-large loads and gently bounce clothing under a shower of water. Agitator models may be less expensive and can be a little less gentle on fabrics. They get clothes clean by moving them through a pool of water so fabrics are well rinsed and detergent, especially single-dose packs, are more likely to dissolve completely in them. Top loaders with agitatorsmay have smaller tubs and use the most water of any style washer.

LEARNING OUTCOME 4.3: APPLY TECHNIQUES OF CARING TEXTILE FIBERS

❖ **CONTENT/TOPIC 1. TECHNIQUES OF WASHING MATERIALS CLOTH**

Washing Techniques

These garment washing techniques were originally developed for denim garments, but are now being used for a wide variety of different garment types. The mills and commission houses involved in garment processing continually search for ways to achieve unique new looks.

Most of these garment processors have their own individual techniques, the details of which are not divulged. This technical bulletin describes the basic wash, stonewash, stonewash with chlorine, ice wash, and cellulase wash techniques used for cotton garments.

Any of these procedures can be modified to fit a particular situation, depending upon garment type (i.e., heavyweight denim versus lightweight chambray), available equipment, and process flow. Also, some of these procedures yield garments suitable for overdyeing, which may create a whole new look.

Garment Wash

Indigo jeans were once the only item processed by the garment wash method, but this is no longer the case. A wide variety of different types of woven and knit fabrics dyed by different systems are now used in apparel that is garment washed before retail distribution. Emphasis is on comfort and softness. Also, some fashion trends favour the broken-in look and worn/faded seams that can only be achieved through garment processing.

- Garments can be inverted to minimize unwanted abrasion streaks (especially useful when preset creases are present).
- Load machine with garments.
- Desize with alpha-amylase enzyme and detergent.
- Drain.
- Rinse.
- Fill machine with water and heat to 60°C. The liquor ratio can range from 10:1 to 20:1. A number of synthetic detergents can be used. Also, alkaline products such as soda ash or caustic soda can be added in amounts ranging from 0.5 to 2.0 grams/litre. Some chemical suppliers offer special products that accelerate the washdown process, dependent upon the particular dyestuff used.
- Wash/tumble action for 20-60 minutes, depending upon the desired effect.
- Drain and rinse.
- Apply softener.
- Tumble dry.
- Invert garments, if previously turned.
- Press, if required.

Stone-Wash

In order to accelerate the garment wash effect and to give garments an even more unique appearance and softer hand, abrasive stones were introduced to the wash bath. A variety of natural and synthetic stones are available for stone-washing with perhaps the most widely used being pumice or volcanic rock. As the stones are used, they slowly disintegrate, reducing the severity of the stonewashed effect over a period of time. The stones not only abrade the fabric but also gradually abrade the inside of the rotary drum. A machine used for stone washing should not be used to dye delicate articles or when abrasion would be detrimental to the fabric.

- Load stones into the machine.
- Load garments into the machine (ratio usually 0.5 – 3.0 part weight stones:1 part weight garments).
- Desize with alpha-amylase enzyme and detergent. Liquor ratio approximately 5-8:1.
- Rinse.
- Refill and tumble with stones 30 to 90 minutes, depending upon the desired effect. Liquor ratio 5-8:1 at 50-70°C. Scouring additives can also be used.
- Drain.Separate garments from stones (garments can be transferred to another machine).
- Rinse.
- Apply softener (garments can be transferred to another machine for softening).
- Extract and unload.
- De-stone and tumble dry.
- Press, if required.

Softeners and/or lubricants can be added during steps three and five to reduce creasing potential. Steps 8, 9, and 10 may vary depending upon individual mill arrangement.

Stone-Wash with Chlorine

By incorporating chlorine in the stone washing procedure, a colour reduction of the indigo (or other chlorine sensitive dyestuff) is obtained. It is very important that any residual chlorine is removed before drying to prevent fibre degradation. This is accomplished by using an antichlor step with sodium bisulfite or hydrogen peroxide.

Load stones into the machine.

Load garments into the machine (ratio usually 0.5 – 3.0 part weight stones:1 part garments).

Desize with alpha-amylase enzyme and detergent (liquor ratio approximately 10:1).

Rinse.

* Refill and add sodium or calcium hypochlorite.

Heat to 55°C.

Tumble 15 minutes.

Add the second portion of sodium or calcium hypochlorite.

Tumble 15 minutes, maintaining temperature of 55°C.

Drain.

Rinse well.

Antichlor with sodium bisulfite or hydrogen peroxide.

Drain.Separate garments from stones (garments can be transferred to another machine).

Rinse well.

Apply softener.

Extract and unload.

De-stone and tumble dry.

Press, if required.

* Amount of sodium or calcium hypochlorite required will vary depending upon the desired level of bleach down and the sensitivity of the colour to chlorine.Each addition can range from 0.075% to 0.225% available chlorine.pH should be kept above 9.0, preferably 10.5-11.0.This is accomplished with the addition of soda ash with each addition of hypochlorite.

Ice Wash

Either by accident or experimentation, a method was developed in which stones are used as a vehicle to deposit a chemical on garments to strip the colour. This surface deposit of chemical removes the colour only on the outer surface of the garment and produces a frosted appearance. Indigo and selected sulfur dyes are currently the most popular candidates for this procedure.

Soak stones in solutions of potassium permanganate for 1-2 hours. Concentrations ranging from 1.5% to 5% are being used commercially. (5% to 10% sodium hypochlorite can be substituted.)

Stones should be drained of excess liquor. This can be accomplished by placing stones in the net or mesh fabric prior to soaking. -Then the stones can be removed and the excess drained off. Another alternative is to place the stones in a rotary tumble machine along with “waste” fabric and tumbling for several minutes to remove the excess solution. A third alternative is to use any number of the pre-soaked stones or materials available from suppliers. These are available in many different shapes with varying levels of chemical and other additives that produce different effects. Trials should be conducted to determine the best method for achieving the desired effects.

Place stones and garments in the machine (garments should be scoured and/or desired and dry or slightly damp).

Tumble for 10-30 minutes or until desired effects is achieved. Results are dependent upon dyestuff, fabric, the concentration of chemicals, stones, additives, and equipment.

In some cases, the stones can be reused for another load before resoaking, depending upon their porosity. It is advantageous to transfer the garments to another machine for washing, minimizing the number of machines used for the corrosive process of ice washing.

* If potassium permanganate is used, manganese dioxide will form (a brown/orange colour) and must be removed by treatment with sodium bisulfite, hydroxylamine sulfate, or acidified hydrogen peroxide as the reducing agent. Fill the machine with water and add 1-5 g/l of the reducing agent. Heat to 50°C and run for 20 minutes.

The process is normally repeated twice to ensure complete removal of the manganese dioxide. When sodium hypochlorite is used, the residual chlorine should be removed with sodium bisulfite or hydrogen peroxide. Adding jeans to a machine already charged with after wash chemicals will increase contrast.

Rinse well.

Repeat step 6 if necessary.

Apply softener.

Tumble dry.

Press, if required.

* The selection of sodium hypochlorite versus potassium permanganate depends upon the dyestuff and desired effect. Also, consideration must be given to the safety aspects of handling either chemical.

Cellulase Wash

Cellulase enzymes have gained acceptance in the garment wash industry as a means to achieve a washdown appearance without the use of stones or with reduced quantities of stones. These enzymes are different from the alpha-amylase enzymes used for starch removal in that they are selective only to the cellulose and will not degrade starch. Under certain conditions, their ability to react with cellulose (cotton) will result in surface fibre removal (weight loss). This will give the garments a washed appearance and soft hand.

Load stones in the machine (normally 0.5 – 2.0 part weight stones: 1 part weight garments) if applicable.

Load garments.

Desize with alpha-amylase enzyme and detergent.

Rinse.

Add cellulase enzyme (amount, pH, temperature, and cycle time dependent upon the type of fabric and desired effects; manufacturer's recommendations should be followed).

Adjust pH as recommended.

Tumble 30-90 minutes.

Drain.

* Rinse well (70°C).

Drain.Separate garments from stones if used (garments can be transferred to another machine).

Apply softener.

Extract and unload.

De-stone and tumble dry.

Press, if required. After step 7, a chlorine bleach may be used as described in STONEWASH WITH CHLORINE.

* The increase in temperature serves to deactivate the cellulase. pH adjustment to 9.0-10.0 with soda ash can also be incorporated. Someoperations use both the increases in pH and temperature

❖ **CONTENT/TOPIC 2. TECHNIQUES OF REMOVER STAIN**

STAIN REMOVAL GUIDE

Life's messy. Have a stain you're not sure how to get out?

How to remove stains from clothes

1. Deal with it as early as possible. The less time a stain has to soak in, the easier it will be to remove, although there are ways to remove old stains out of clothes as well.
2. Pre-treat with a stain remover, then let it soak in.
3. Launder according to the fabric care instructions, using the warmest setting safe for the fabric. If the stain remains, repeat the steps above. **Do not** put it in the dryer until the stain is removed.

Choose a stain substance below for more specific advice on how to get stains out of clothes:

Adhesives

1. Apply ice or cold water to harden surface; scrape with a dull knife.
2. Saturate with prewash stain remover or cleaning fluid.
3. Rinse, then launder.

Baby Formula

1. Pretreat or soak stains using a product containing enzymes.
2. Soak for at least 30 minutes or several hours for aged stains
3. Launder.

Baked Beans

1. Working from the back of the stain, flush it with cold water.
2. Pretreat it with a liquid laundry detergent, using an up-and-down motion with a soft brush to break up the stain.
3. Rinse well.
4. Sponge with white vinegar and rinse again.
5. Repeat, treating the stain with liquid detergent, then with white vinegar until you've removed as much stain as possible.
6. Pretreat with a prewash stain remover and launder with bleach that's safe for the fabric.

Barbeque Sauce

1. Treat the same as for baked beans.
2. If the stain remains after laundering with bleach, rub in liquid laundry detergent and soak in warm water for up to 30 minutes.
3. Launder again.

Beverages

1. Sponge or soak stain in cool water.
2. Pretreat with prewash stain remover, liquid laundry detergent, liquid detergent booster or paste of powder laundry product and water.
3. Launder using sodium hypochlorite bleach, if safe for fabric, or oxygen bleach.

NOTE: Older stains may respond to pretreating or soaking in a product containing enzymes, then laundering.

Blood

Fresh Stains

1. Soak in cold water (do not use hot water as it will set blood stains).
2. Launder.

Dried Stains

1. Pretreat or soak in warm water with a product containing enzymes.
2. Launder.

NOTE: If stain remains, rewash using a bleach safe for fabric.

Bodily Fluids

1. Pretreat or soak in a product containing enzymes.
2. Launder using sodium hypochlorite bleach, if safe for fabric, or oxygen bleach.

Brown / Yellow Discoloration

1. Use a rust remover recommended for fabrics.
2. Launder.

NOTE: Do **not** use a sodium hypochlorite bleach to remove rust stains because it may intensify discoloration

Butter

1. Pretreat with a prewash stain remover
2. Launder, using the hottest water that's safe for the fabric.

Candle Wax

1. Scrape off surface wax with a dull knife.
2. Place stain between clean paper towels and press with a warm iron. Replace paper towels frequently to absorb more wax and to avoid transferring stains.
3. Place stain facedown on clean paper towels. Sponge remaining stain with prewash stain remover or cleaning fluid; blot with paper towels. Let dry.
4. Launder.

NOTE: If any color remains, rewash using sodium hypochlorite bleach, if safe for fabric, or oxygen bleach.

Chocolate

1. When the stain strikes, gently scrape off any excess chocolate.
2. Once you get the item home, soak it in cool water.
3. Then pretreat with a prewash stain remover
4. Launder in the hottest water that's safe for the fabric.

NOTE: If stain remains, rewash using a bleach safe for fabric.

Collar / Cuff Soil

1. Pretreat with prewash stain remover, liquid laundry detergent or paste of powder detergent and water.
2. Launder.

Coffee / Tea

1. Sponge or soak stain in cool water.
2. Pretreat with prewash stain remover, liquid laundry detergent, liquid detergent booster or paste of powder laundry product and water.
3. Launder using sodium hypochlorite bleach, if safe for fabric, or oxygen bleach. (Note: Older stains may respond to pretreating or soaking in a product containing enzymes, then laundering.)

Cosmetics / Lipstick

1. Pretreat with prewash stain remover, liquid laundry detergent, paste of powder detergent or laundry additive and water. Or, rub with bar soap.
2. Launder.

Visit our guide for how to remove lipstick from napkins.

Crayon

For a Few Spots

1. Treat the same as candle wax or dampen the stain and rub with bar soap,
2. Launder using hottest water safe for fabric.

For a Whole Load of Clothes

1. Wash with hot water using a laundry soap and 1 cup (212 g) baking soda.

NOTE: If color remains, launder using sodium hypochlorite bleach, if safe for fabric. Otherwise, pretreat or soak in a product containing enzymes or an oxygen bleach using hottest water safe for fabric, then launder.

Dairy Products

1. Pretreat or soak stains using a product containing enzymes.
2. Soak for at least 30 minutes or several hours for aged stains.
3. Launder.

Deodorants

Light Stains

1. Pretreat with liquid laundry detergent. Launder.

Heavy Stains

Pretreat with prewash stain remover. Allow to stand for 5 to 10 minutes.

1. Launder using an oxygen bleach.

Dye Transfer

1. Attempt restoration of white fabrics that have picked up color from other fabrics by using a packaged color remover, following label directions.
2. Launder.

NOTE: If dye remains, launder again using sodium hypochlorite bleach, if safe for fabric. For non-colorfast fabrics, soak in oxygen bleach, then launder.

NOTE: This type of stain may be prevented if proper sorting and laundering procedures are followed.

Egg

1. Pretreat or soak stains using a product containing enzymes.
2. Soak for at least 30 minutes or several hours for aged stains.
3. Launder.

Fabric Softener

1. Dampen the stain and rub with bar soap.
2. Rinse out, then launder.

Fruit Juices

1. Wash with bleach safe for fabric.

Grass

1. Pretreat or soak in a product containing enzymes.

NOTE: If stain persists, launder using sodium hypochlorite bleach, if safe for fabric, or oxygen bleach.

Grease and Oil

Light Stains

1. Pretreat with prewash stain remover, liquid laundry detergent or liquid detergent booster.
2. Launder using hottest water safe for fabric.

Heavy Stains

1. Place stain facedown on clean paper towels. Apply cleaning fluid to back of stain.
2. Replace paper towels under stain frequently.
3. Let dry, rinse. Launder using hottest water safe for fabric.

Ice Cream

1. Pretreat or soak stains using a product containing enzymes.
2. Soak for at least 30 minutes – longer if the stains are old.
3. Launder, using the warmest water that’s safe for the fabric.

Ink

1. Sponge the area around the stain with rubbing alcohol or cleaning fluid before applying it directly on the stain.
2. Place stain facedown on clean paper towels. Apply alcohol or cleaning fluid to back of stain. Replace paper towels frequently.
3. Rinse thoroughly. Launder.

Alternate Method

1. Place stain over mouth of a jar or glass; hold fabric taut.
2. Drip the alcohol or cleaning fluid through the stain so ink will drop into the container as it is being removed.
3. Rinse thoroughly. Launder.

NOTE: Some inks in each of the following categories – ballpoint, felt tip, liquid- may be impossible to remove.

Want to know what those symbols mean on the tags of our clothing? Do you really need to sort your laundry? How often should you wash jeans? Find out!

Ketchup

1. Remove any excess ketchup with a spoon or knife, but be careful not to rub it into the fabric.
2. If the garment is washable, remove the garment as soon as possible and run cold water through the stain from the backside to force the stain out of the clothing.

Note: Avoid dabbing at it as this can spread the stain.

Lipstick

1. To remove most lipstick stains from napkins, put the napkin stain down on top of a couple layers of paper towel or absorbent towel.
2. Dampen another towel with rubbing alcohol (70 or 90 percent), then dab, dab, dab the stained area.
3. Look underneath and you should see lipstick on the paper towels. Keep at it until all of the stain is gone. Some long-lasting lipsticks may need more work to get off.

NOTE: You also can spritz a prewash spray onto both sides of the fabric, let set for a few minutes to let the spray work, then scrub with a small brush. Rinse, wash as usual and air dry. If a little color is left, repeat the steps and it should take care of the problem.

See more holiday cleaning hints from Heloise.

Maple Syrup

Maple syrup or corn syrup stains should be removed as soon as possible.

1. Begin by using a blunt kitchen knife to remove any excess syrup still on the fabric.
2. For washable fabrics, flush with cool to warm water from the back of the stain.
3. Pretreat with a stain remover or liquid laundry detergent and let sit for several minutes. Rinse well.

4. Wash as recommended according to the garment label.
5. Don't put in the dryer until the stain is gone!

Mayonnaise

1. Pretreat with a prewash stain remover.
2. Launder, using the hottest water that's safe for the fabric.

Mildew

1. Launder stained items using a bleach safe for fabric and hottest water recommended for fabric.

NOTE: Badly mildewed fabrics may be damaged beyond repair.

Mud

1. When dry, brush off as much mud as possible.

Light Stains

1. Pretreat with a paste of powder detergent and water, liquid laundry detergent or a liquid detergent booster.
2. Launder.

Heavy Stains

1. Pretreat or presoak with a laundry detergent or a product containing enzymes.
2. Launder.

Mustard

1. Flush under cold water to loosen the stain, and then pretreat with a prewash stain remover.
2. Launder, using the hottest water that's safe for the fabric. Add bleach to the wash also – preferably chlorine bleach. (Check the care label to see if it is safe for the fabric.)

Nail Polish

1. Try nail polish remover but do not use on acetate or triacetate fabrics.
2. Place stain facedown on clean paper towels. Apply nail polish remover to back of stain. Replace paper towels frequently.
3. Repeat until stain disappears, if it does.
4. Rinse and launder.

❖ **CONTENT/TOPIC TECHNIQUES OF PRESSING**

Pressing Techniques: Basic Rules

Give these basic pressing rules a quick read. There might be something here you haven't tried yet.

1. Do not ignore any pressing directions given in patterns
2. Test on a scrap to compare pressed and unpressed portion
3. Check if any reaction to heat and moisture…water marks, puckering, or dulling?
4. When possible try to press with grain and be careful not to stretch edges, bias or curves by pulling

5. Press seams on the wrong side first and then again lightly on the right side.
6. Best to press seams toward darker colors when possible for quilt blocks and toward the back on garments
7. Use the tip of your iron moving the same direction as stitched

8. Never press over pins, markings or basting threads
9. To prevent ridges on right side…press on padded surface, over a seam roll or use brown paper strips under the seam allowance

10. Press long seams going across your ironing board to prevent distorting grain line
11. Always press seams before they are sewn with another seam for accurate fit
12. Intersecting seams are usually pressed in opposite directions to distribute bulk
13. Do a final "touch-up" press on completion, but not as a remedy for haphazard pressing during construction
14. Do not press after completing quilting top as pressing will flatten the batting
15. Keep sole plate clean and free of debris

16. Know your fabric fiber and do not over-press

References

1. BURKHARD WULFHORST, THOMAS GRIES, DIETER VEIT,
2. Textile Technology, Hanser, Aachen 1998. ISBN 1 – 56990 -371 -9 2. BROSSARD,
3. Technologies de textiles, 5eme edition BORDAS, Paris, 1977. ISBN 2- 04 – 010249 – 3 3. BROSSARD, Les fils et les tissus, BORDAS, Paris, 3eme édition Paris 1977. ISBN 2- 04 – 007772- 3 Mme Madeleine le FUSTEC,
4. Technologie des Matières et Industries Textiles, Edition EYROLLES Paris 1984
5. *Kharakteristika khimicheskikh volokon: Spravochnik.* Moscow, 1966.
   Rogovin, Z. A. *Osnovy khimii i tekhnologii proizvodstva khimicheskikh volokon,* 3rded., vols. 1-2. Moscow-Leningrad, 1964.
   Tekhnologiia khimicheskikh volokon. Moscow, 1965.
6. http://www.scienceclarified.com/Al-As/Artificial-Fibers.html#ixzz6TxXZbyAy
7. https://www.tandfonline.com/doi/abs/10.1080/19447015108663852?journalCode=jtip20
8. *"Sir Joseph Wilson Swan". Encyclopædia Britannica. Archived from the original on 7 May 2015*. Retrieved *27 April* 2015.
9. *How It Works: Science and Technology. Marshall Cavendish Corporation. 2003. p. 851. ISBN 9780761473145.*
10. *Garrett, Alfred (1963). The Flash of Genius. Princeton, New Jersey: D. Van Nostrand Company, Inc. pp. 48–49.*
11. *Editors, Time-Life (1991). Inventive Genius. New York: Time-Life Books. p. 52. ISBN 978-0-8094-7699-2.*
12. *Day, Lance; Ian McNeil (1998). Biographical Dictionary of the History of Technology. Taylor & Francis. p. 113. ISBN 978-0415193993.*
13. *Woodings, Calvin R. "A Brief History of Regenerated Cellulosic fibers". WOODINGS CONSULTING LTD. Archived from the original on 22 April 2012*. Retrieved *26 May* 2012.
14. https://www.tandfonline.com/doi/abs/10.1080/19447015108663852?journalCode=jtip20
15. *"World of Chemistry". Thomson Gale. 2005. Archived from the original on 28 October 2009*. Retrieved *1 November* 2009.
16. *Allen, P (1967). "Obituary". Chemistry in Britain.*
17. Frank Greenaway, 'Whinfield, John Rex (1901–1966)', rev. Oxford Dictionary of National Biography
18. Oxford University Press, 2004 accessed 20 June 2011
19. Man-Made Fibers Continue To Grow Archived 28 April 2016 at the Wayback Machine, Textile World
20. *J E McIntyre, Professor Emeritus of Textile Industries, University of Leeds, UK (ed.). Synthetic fibers: Nylon, polyester, acrylic, polyolefin. Woodhead Publishing - Series in Textiles.*
21. *. Cambridge. Archived from the original on 17 July 2011*. Retrieved *21 April* 2010.
22. *Katsnelson, Alla (2015). "News Feature: Microplastics present pollution puzzle". Proceedings of the National Academy of Sciences. **112** (18): 5547 5549. doi:10.1073/pnas.1504135112. PMC 4426466. PMID 25944930.*
23. https://encyclopedia2.thefreedictionary.com/Silk+farming
24. https://en.wikipedia.org/wiki/Sericulture
25. http://www.inserco.org/en/types_of_silk
26. https://www.biddlesawyersilks.com/how-is-silk-made-a-step-by-step-guide/
27. https://tide.com/en-us/how-to-wash-clothes/washing-different-fabrics/how-to-wash-and-care-for-silk-clothes

28. http://textilefashionstudy.com/silk-fiber-physical-and-chemical-properties-of-silk/
29. https://textilelearner.blogspot.com/2013/06/physical-and-chemical-properties-of.html
30. https://sewport.com/fabrics-directory/wool-fabric
31. https://www.goodhousekeeping.com/beauty/fashion/tips/a26326/wool-buying-guide/
32. https://www.masterclass.com/articles/guide-to-wool-fabric#how-is-wool-fabric-manufactured
33. https://sewguide.com/types-of-wool-fabric/
34. https://www.technicaltextile.net/articles/metallic-fibres-2471
35. https://textilelearner.blogspot.com/2012/01/asbestos-fiber-manufacturing-process-of.html
36. https://inspectapedia.com/hazmat/Asbestos_Textiles.php
37. https://en.wikipedia.org/wiki/Fiber#:~:text=Semi%2Dsynthetic%20fibers%20are%20made,from%20low%2Dmolecular%20weight%20compounds
38. https://en.wikipedia.org/wiki/Viscose
39. https://sewport.com/fabrics-directory/viscose-fabric
40. https://sewport.com/fabrics-directory/lyocell-fabric
41. https://www.dharmatrading.com/acetate-fiber.html
42. https://textilelearner.blogspot.com/2011/03/production-process-of-synthetic-fiber_9386.html
43. https://byjus.com/chemistry/synthetic-fibre/
44. https://www.britannica.com/science/polymerization
45. https://www.list-technology.com/processes/polycondensation/
46. https://www.textileadvisor.com/2019/12/carding-bb-process-objectives-of.html
47. https://textilelearner.blogspot.com/2011/04/combing-process-of-cotton-spinning_9182.html
48. https://textilelearner.blogspot.com/2011/07/printing-method-method-of-printing_5617.html
49. https://sewport.com/fabrics-directory/linen-fabric
50. https://sewport.com/fabrics-directory/jute-fabric
51. https://www.britannica.com/plant/sisal
52. http://www.fao.org/economic/futurefibres/fibres/abaca
53. Books for more in-depth information
54. The Sewing Book – of all the general sewing books I've read, I think this one has the best guide to fabric with excellent photos
55. The Fashion Designers Textile Directory – for the full works, lots of useful information here
56. Fabric for Fashion – The Swatch Book – a more expensive alternative but includes 120 actual fabric samples
57. https://textilestudycenter.com/wool-fibre-identification-use/
58. https://textilecourse.blogspot.com/2018/03/silk-fiber-properties-production.html
59. https://sewport.com/fabrics-directory/nylon-fabric
60. https://sewport.com/fabrics-directory/banana-fabric
61. https://sewport.com/fabrics-directory/polyester-fabric.
62. https://sewguide.com/detergents-and-cleaning-products/
63. https://www.which.co.uk/reviews/washing-machines/article/washing-symbols-explained

64. https://www.cleaninginstitute.org/cleaning-tips/clothes/stain-removal-guide

65. https://www.goodhousekeeping.com/appliances/washer-reviews/g105/washing-machine-reviews/