Textile fibres

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Fibre classification

Textile fibres fall into two basic families: natural and man-made. The first and oldest is the **natural** textile fibre group, which includes wool and cotton. The earliest known use of natural fibre was about 7000 years ago.

The second is the **man-made** textile fibre group. This group can be divided into two sections:

1. **regenerated cellulose fibres**, such as Tencel, viscose and acetate. These fibres use a naturally occurring polymer, cellulose, obtained from plant material, which is chemically extracted from the plant material, then regenerated as a fibre
2. **synthetic fibres** such as Nylon, polyester and polypropylene.

Synthetic fibres have only been developed in the last 100 years, with the greatest developments occurring in the last 60 years. These fibres are made from chemically engineered long-chain polymers derived generally from petroleum by-products, coal and gases. An example is Polyamide 6.6 (Nylon 6.6) synthesised from hexamethylene diamine and adipic acid.

The fibre families can be divided into groups according to:

- where the fibre comes from – its origins
- what the fibre is made from – its polymer nature.

Polymers

Polymers are the very large (long-chain) molecules that form a fibre. These can be thought of in the same way as fibres in a yarn because many polymer molecules make up a fibre, just as many fibres make a yarn.

Polymer molecules are built up from many (thousands) of small molecules (monomers) in a chain-like formation (see below). This process of ‘polymerisation’ is carried out by complex chemical engineering processes using reaction chemicals derived from coal, oil, gas, air, minerals and water. Refer to the Fact Sheet on each fibre for more details.

This is a representation of monomers joined end to end, and is a generalisation only. It has been used to show the general process. Each fibre polymer will have its own configuration.

Naturally occurring polymers include:

- **cellulose**, from which plant fibres are made
- **protein** – animals produce protein fibres as hair (keratin), wool (keratin) or a filament such as silk (fibroin).

Man-made and synthetic polymers include:

- **regenerated cellulose** – processed cellulose (recovered plant fibre, usually wood pulp), regenerated into a filament form. Viscose and Tencel are two examples of fabrics made from regenerated cellulose fibres
- **synthetic polymers** – synthetic fibres are produced from a synthetic polymer. These are made from chemicals derived from petroleum, coal and gases, and include polyamides (Nylons), polyester, polypropylene, polyacrylonitrile (acrylic), elastanes (Lycra, Spandex), aramids (Kevlar) and many more.

Note that the names in brackets are usually the *trade* name. The first names, for example, polyester and polyamide, are *generic* names.

The fibre forming process (extrusion) will depend on the nature of the polymer; that is, whether it melts or dissolves, or how the viscous spinning solution is prepared. Refer to the Fact Sheet on each fibre for this information.

Thermoplastic polymers are produced in the form of small plastic-like chips, which are melted to form the fibre. Refer to the section on Production. Fibre producers often buy polymer chips from chemical companies.

To make fibre, first the polymer is prepared as a spinning solution. At this stage a colouring agent in the form of a powdered pigment can be added. This is known as dope dyeing and is usually done to colour polymers that are difficult to dye, for example, polypropylene. The liquid is forced through a spinneret, a steel block with hundreds or thousands of holes in it. Each hole forms one fibre.

The fibres are then 'set' by various means, depending on whether they are thermoplastic, dissolved or in solution. Drawing (stretching) now aligns the polymer molecules into a more parallel (crystalline) configuration. Further processing may involve:

- texturising, followed by cone winding
- cutting into staple, followed by baling.

Other fibre forming substances

Special purpose fibres are made from:

- glass
- ceramic
- metal
- carbon.

These are used for textiles with properties such as fire resistance, protective abilities, abrasion resistance, strength or chemical resistance.

Essential fibre properties

To be useful, a fibre must meet some minimum performance standards. Fibre properties will vary according to the end-use required of the fibre; for example, a fibre to be used for clothing (apparel) will have different performance parameters from a fibre to be used in geotextiles.

However, there are some essential properties shared by all fibres.

- Strength – to withstand processing and to give a serviceable product.
- Flexibility – the ability to bend many times and recover without breaking is essential during processing, and in use. The final drape, handle and feel of the fabric will be affected by this, also its durability.
- Elasticity – the ability to stretch and recover its original length gives greater life and wearer comfort to the finished fabric.
- Chemical composition – fibres must be dyed, washed, bleached, dry-cleaned, and so on, so they must have resistance to the chemicals used in these processes.

- Availability – fibres must be readily available at a reasonable price.

The following properties may be considered to be ‘desirable’ and are most likely found in apparel fibres.

- Texture – waviness or crimp is essential in staple-spun fibres to give strong yarns.
- Absorbency – for apparel fibres the ability to absorb water affects the comfort of the fabric.
- Length to diameter ratio – a staple fibre must be very long in relation to its length for spinning reasons. (Refers only to staple fibres.)

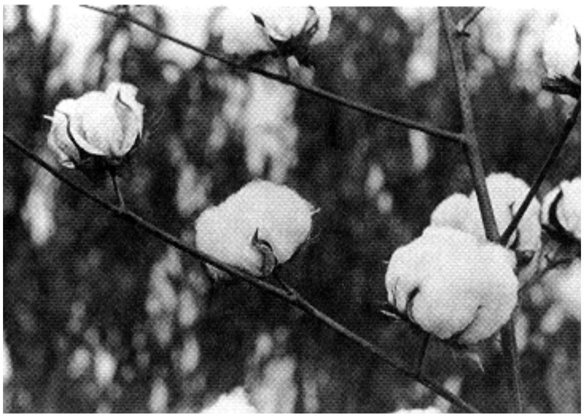
Fibre production

Natural fibres

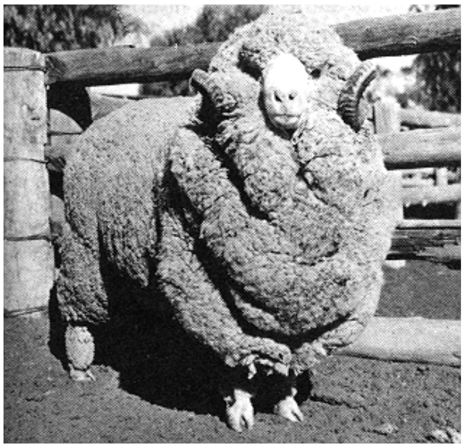
Natural fibres are first grown then harvested. The raw material is then cleaned and separated from any materials unsuited to making textiles; for example, when wool is shorn from the sheep it has dirt, lanolin (grease) and vegetable matter such as grass, seeds and burrs in it. All this has to be removed.

After cleaning, if the fibre is to be made into a yarn, it goes into the spinning process. This process will vary depending on the fibre. Wool generally cannot be spun using cotton equipment because of differences in diameter, staple length, surface friction co-efficient, longitudinal configuration and so on.

The processes make the fibres parallel then control the fibre so the finished yarn has the desired weight (count) twist and appearance.



Cotton bolls ready for harvesting.



Typical Australian fine Merino ram.

Flax plants ready for harvesting.

Man-made fibres

There are two main classes of man-made fibres:

- cellulose (plant)-based regenerated fibres (for example, viscose, Tencel, acetate)
- synthetic fibres (for example, Nylon, polyester).

The production of both classes requires several common steps:

- obtaining, preparing or synthesising a polymer in solution or chip form
- extruding this material to form a fibre – melt, wet, dry spinning
- modifying the fibre by drawing
- texturising the fibre to alter its properties and shape
- cutting into staple if required.

Regenerated cellulose fibres

These are made by chemically treating wood pulp to form a spinning solution and extruding this material to form fibres.

Viscose

Traditionally, viscose these fibres were made using strong environmentally damaging chemicals, and the resultant fibre, rayon, had problems with dry and wet strength. A weak fibre, viscose loses 40% of its strength when wet.

Tencel

Tencel is a new fibre made with an environmentally friendly process that uses a recyclable organic solvent to produce the spinning solution. Full recovery of the solvent is made as part of the wet spinning (extrusion) process.

Cellulose acetate and tri-acetate

Cellulose acetate and tri-acetate are modified cellulose ester fibres produced by chemically modifying recovered cellulose into cellulose acetate which is dissolved in acetone to produce a spinning solution.

Acetates are dry spun.

Synthetic fibres

Synthetic fibres are produced from a synthetic polymer. The method of extrusion depends on the nature of the polymer; for example, thermoplastic polymers are produced in the form of small plastic-like chips that are melted to form the fibre. (Ask your instructor for a sample of polymer chips.) The word ‘polymer’ is also applied to the building blocks or molecules that form the basis of natural fibres. (Refer to the section on Polymers.) Fibre producers often buy polymer from chemical companies.

To make thermoplastic fibres, first the polymer is heated. At this stage a colour can be added. This is known as dope dyeing and is done for several reasons:

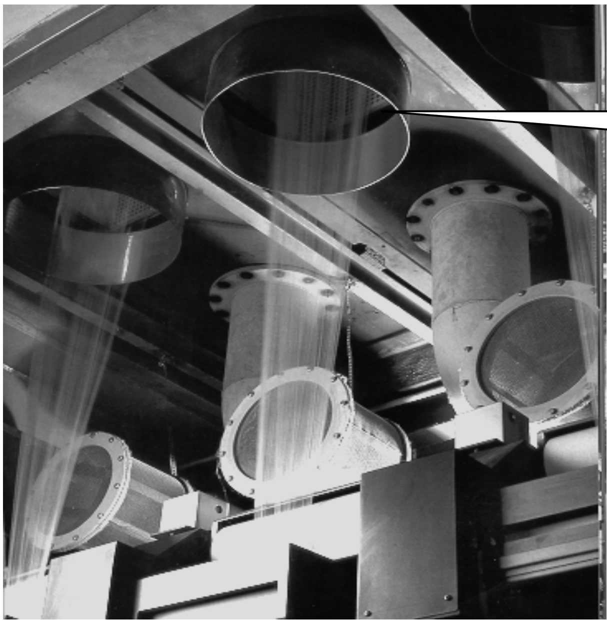
- the resultant fibre is very difficult to dye in aqueous solution (polypropylene)
- high colour fastness is required (washing and light)
- high rub fastness is required
- mass production for a large market offers economies of scale.

The molten liquid is forced through a spinneret – a steel block with hundreds or thousands of holes in it. Each hole forms one fibre. The fibres are then cooled by air and drawn (stretched) before being wound into packages.

Extrusion

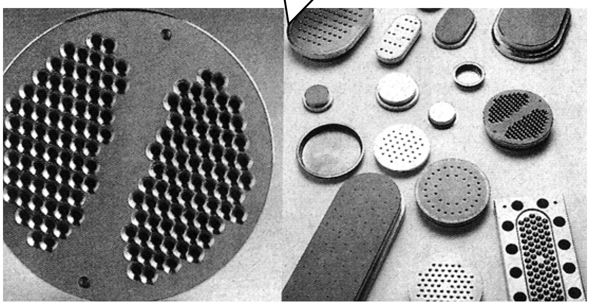
After the spinning solution (polymer) is prepared, the next process involves pumping the thick, viscous solution through a metal nozzle called a spinneret.

The spinneret contains many holes that are very small (cut by electron beam or laser). Each hole forms one filament. The shape of the hole determines the fibre's cross-section.

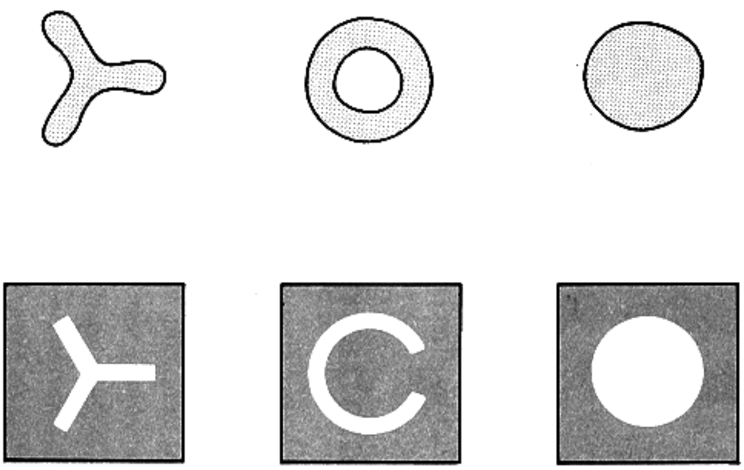


Polyester filaments being extruded from spinnerets.

Typical spinnerets.



Common fibre cross-sections.

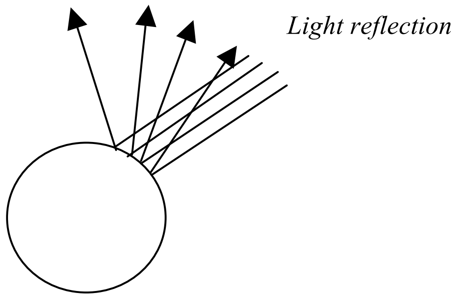


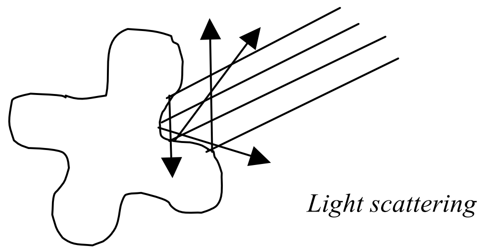
After extrusion, the fibre is coagulated (hardened) by cooling, evaporation (drying) or chemical reaction, depending on how it was prepared.

The diameter of the filament is determined by the size of the spinneret hole, amount of polymer pumped through and rate of drawing. Control of drawing and polymer pumping is essential to produce even filaments with the required polymer orientation.

Fibre cross-sectional shape will affect the following properties:

- lustre – a smooth fibre will reflect light and a rough fibre will scatter it
- brightness or dullness of colour
- surface friction co-efficient – smooth fibres will slide over one another
- handle
- insulation
- density
- ratio of surface area to volume – this has a major effect on the moisture transfer (wicking) properties.

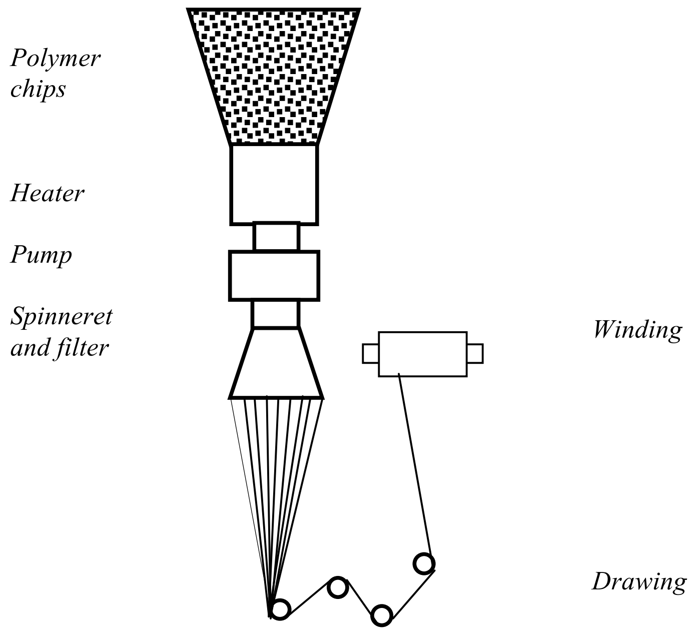




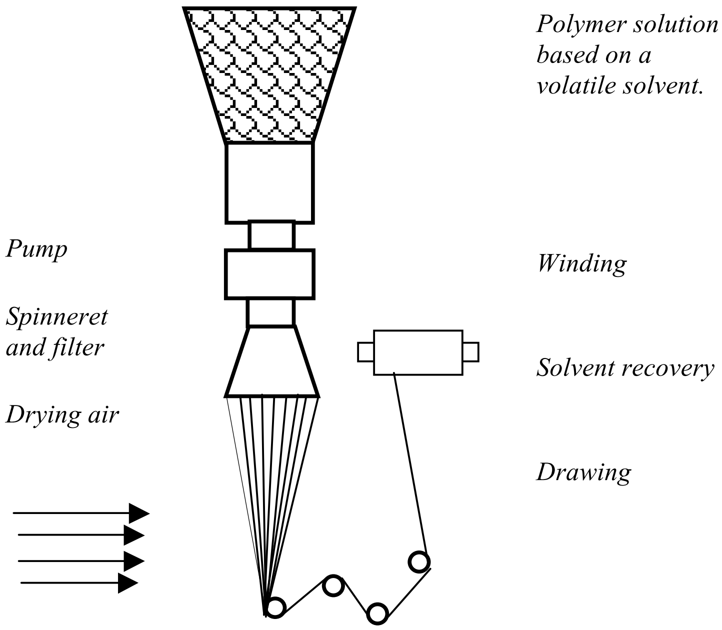
Melt, wet and dry spinning

The three different methods of spinning (extrusion) are needed to handle the different polymer solutions.

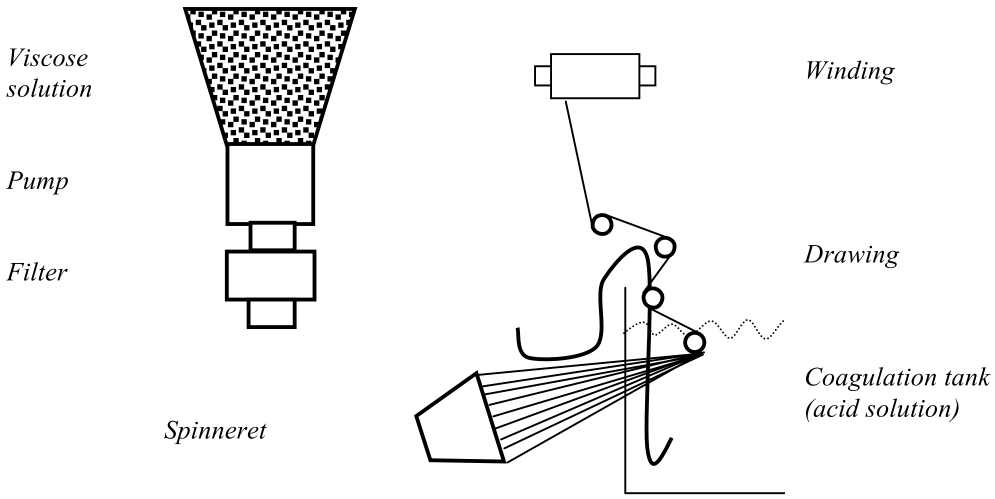
Melt spinning is used for synthetic polymers that are thermoplastic (melt when heated). The fibres must be cooled slowly to provide for controlled extrusion, which helps to provide even fibre properties.



Dry spinning is used for synthetic and regenerated fibres. The polymer is dissolved in a solvent chemical to form the thick spinning solution (dope). Solvent-laden air is processed through a condenser to recover the solvent.



Wet spinning is used for synthetic and regenerated fibres where the polymer is dissolved in a solvent chemical to form the thick spinning solution (dope). Coagulation (hardening) is caused by a chemical reaction between the polymer solution and the bath chemicals.



Modifying fibre properties

Fibre properties may be modified by adding chemicals, such as delustring agents (titanium dioxide a dull, white powder), to the spinning solution or polymer chips for extrusion.

Some chemicals can modify the degree of polymerisation (linking) between adjacent polymer molecules, which can affect fibre properties such as:

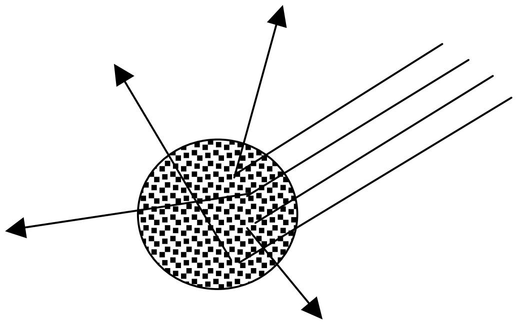
- melting point
- elastic recovery
- tensile strength

- cross-sectional shape
- longitudinal surface texture (fibre friction).

Delustring agents and pigments (solid colourant particles) can change:

- opacity
- lustre – fibres can be made with lustres varying from full bright to full dull
- colour.

Light scattering due to delustrant particles inside a fibre.



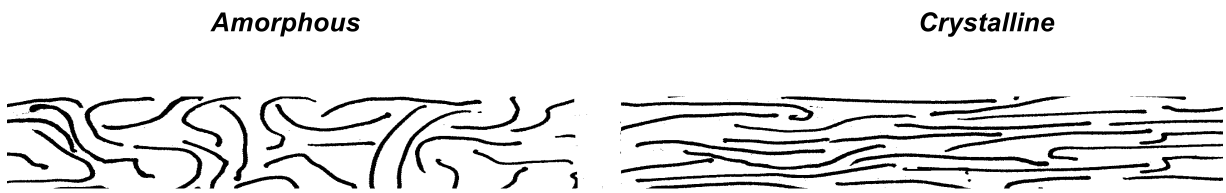
Drawing

Drawing is the process of stretching the fibre to arrange the polymer molecules in a more crystalline form, thereby changing the fibre properties to make it:

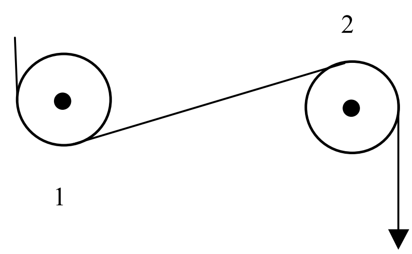
- stronger
- stiffer
- less elastic
- less reactive
- less water absorbent (hydrophobic).

Amorphous and crystalline regions

When polymers are synthesised they can be arranged physically in two configurations within the solid polymer 'chips'. These regions are known as amorphous and crystalline.



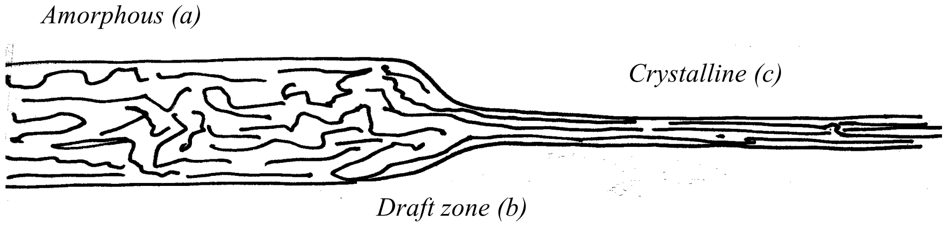
Filaments are wrapped several times around each roller.



To winding texturising or staple cutting.

The drawing process

Roller 2 rotates faster than Roller 1, thus the extruded filaments are stretched, pulling the polymers into a more crystalline arrangement. This is known as the draw ratio and could be up to five times for general apparel fibres and even more for special purpose fibres having very high polymer crystallinity.



Texturising

When the fibre is extruded it is smooth and has no crimps or waves. This is called a ‘flat’ yarn. To alter the fibre so it resembles a natural fibre in terms of crimp and surface texture, it may be texturised. Refer to the diagrams of texturising methods on the next page.

Texturising is a mechanical process utilising the thermoplastic (heat setting) nature of synthetic fibres such as Nylon or polyester, to change the following properties of the fibre:

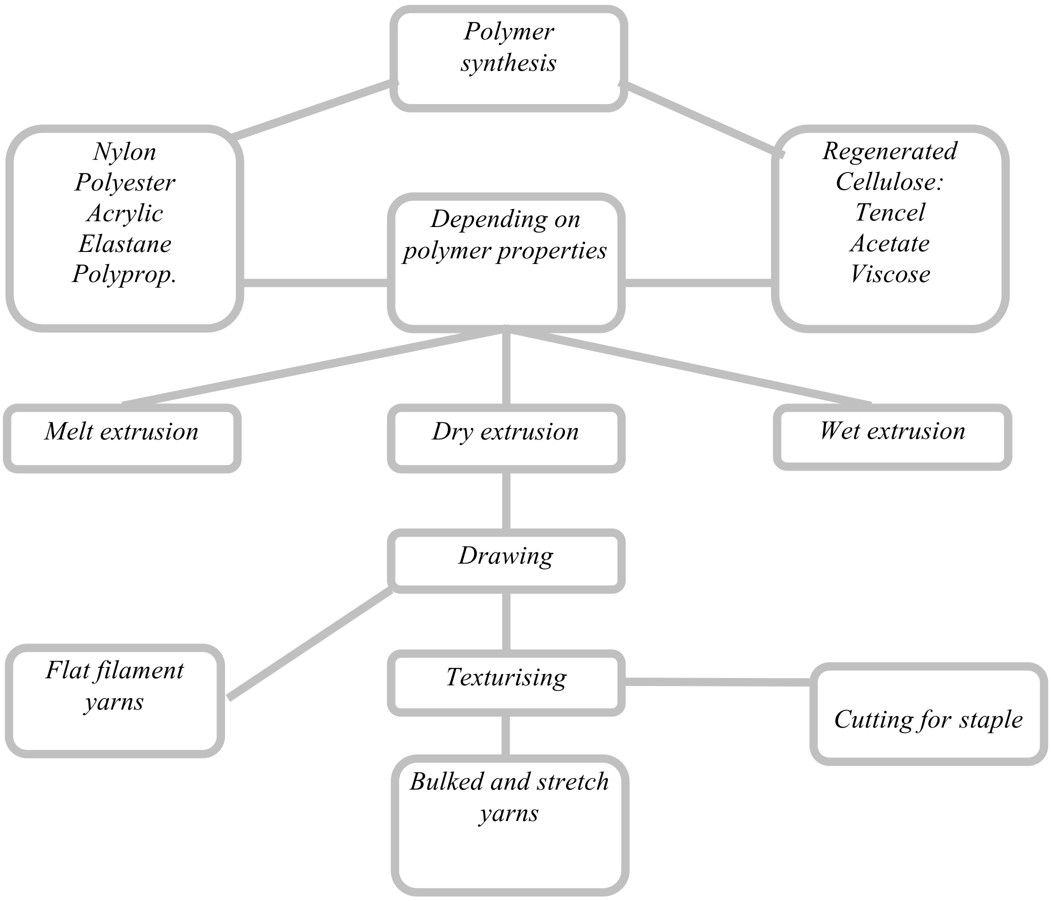
- stretch
- bulk
- handle
- absorbency
- insulating properties.

The idea is to mimic or even improve upon the natural crimp and convolutions found in cotton, wool and other natural fibres. This is necessary for blending staple fibres, such as wool, with polyester. The synthetic polyester must be made to match the wool in fibre diameter, staple length and texture. Thus the fibres are crimped and set to match the wool fibres.

Cutting

Cutting can be done in several ways, after texturising, to produce staple to the required length. The cutting may be ‘randomised’ to simulate natural fibres.

The following is a flow chart of man-made fibre processes.



Flow chart of man-made fibre processes.

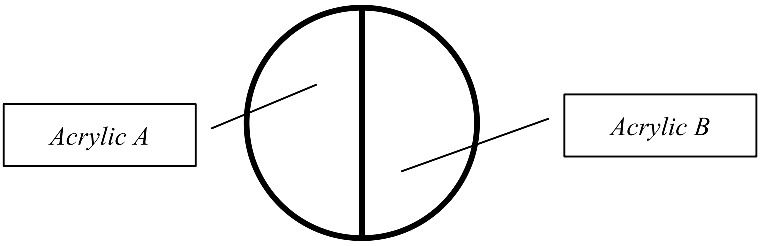
Bi-component and bi-constituent fibres

Bi-component fibres are made by combining 'generically simila' polymers at the spinning (extrusion) stage to produce fibres with enhanced properties. Thus a 'high bulk' acrylic is made by extruding two forms of acrylic in a 'side by side' configuration. See below.

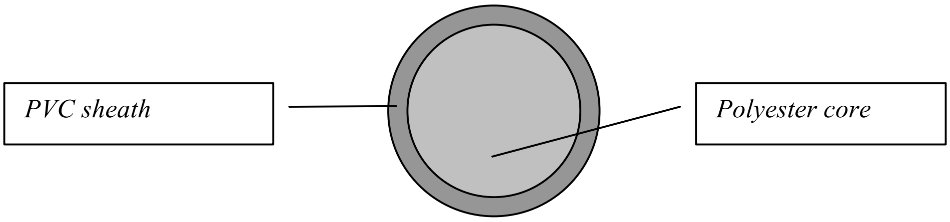
Bi-constituent fibres are made by combining 'generically different' polymers at extrusion. An example is a 'core-sheath' fibre with a polyester core surrounded by a PVC sheath to form a melt bondable fibre for non-woven applications.

Bi-component fibres

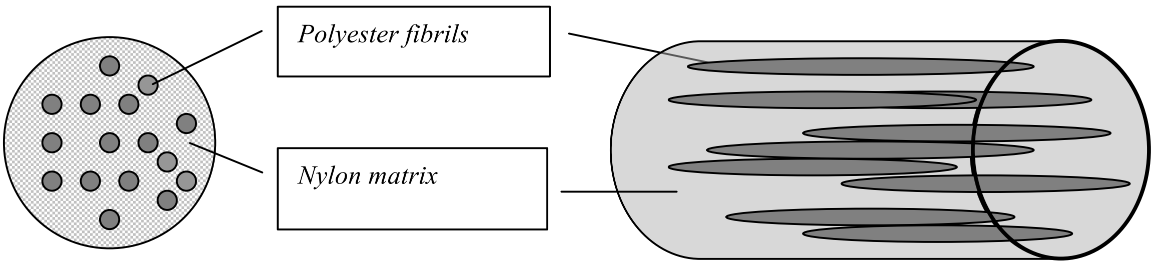
Side-by-side – 'high bulk acrylic'



Core sheath – 'Tontine'



Matrix – Fibril – Fortran



Bi-constituent fibres

Bi-constituent fibres produced are:

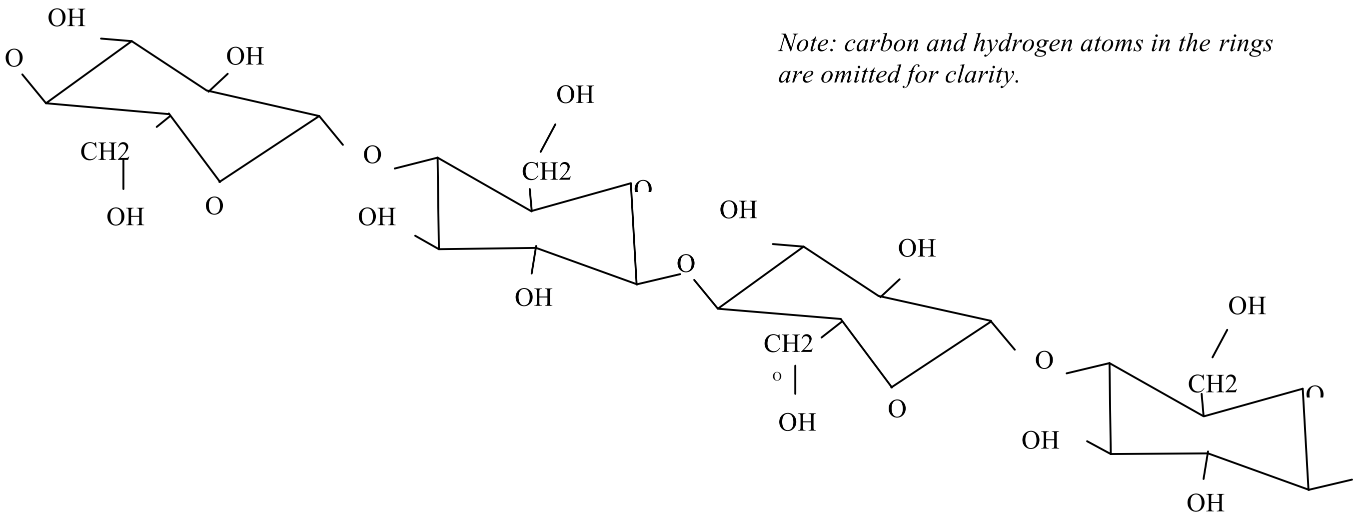
- Source – 70% Nylon 6 matrix, 30% polyester fibrils
- Mirafi – Polypropylene matrix + Nylon fibrils (geotextiles)
- Fortran – Nylon matrix + Polyester fibrils (carpet pile).

Fact sheet – Cotton

Cotton is a vegetable or plant fibre. It comes from the seed or fruit of the cotton plant, genus *Gossypium*.

Cotton is composed of cellulose polymer, which is polymerised from beta-glucose monomers (a simple sugar) by plants. It is used as a reinforcing material in the plant's stem and leaves. It has high strength and when found in fibrous formations, such as cotton, provides a fibre of good strength.

Cellulose is the most abundant bio-polymer on earth.



Note: carbon and hydrogen atoms in the rings are omitted for clarity.

Cotton is the most used textile fibre, accounting for 50% of the world's fibre usage.

Properties

Moisture handling	Water-liking fibre, with a natural moisture content of 8–10%; can absorb up to 25%
Fibre length	10–55 mm
Elongation at break	5–10%
Tenacity	27–45 cn/tex.; strong fibre that gets stronger when wet
Effect of heat	Burns readily and will discolour at temperatures above 110°C
Resistance to acid	Disintegrates in hot diluted or cold concentrated acids
Resistance to alkali	Excellent resistance
Organic attack	Not attacked by moths or beetles; affected by microorganisms
Handling characteristics	Soft, cool to touch; poor wrinkle resistance due to fair flexibility and elasticity properties

Uses

Cotton's uses include apparel, household goods, workwear, industrial goods, geotextiles and medical textiles.

Fact sheet – Wool

Wool is an animal or protein fibre. Different styles of wool are produced by the different breeds of domestic sheep. Large, heavy-bodied animals will produce coarse, long fibre suited to carpet manufacture, while fine wools are produced by the Australian Merino breed. Numerous crossbreeds produce a range of fibre types (styles) between these extremes.

Wool has only a small percentage of overall fibre usage.

Production

Wool grows from follicles in the skin of the sheep. Different breeds produce different styles of wool, which vary in their length and diameter and have different end uses.

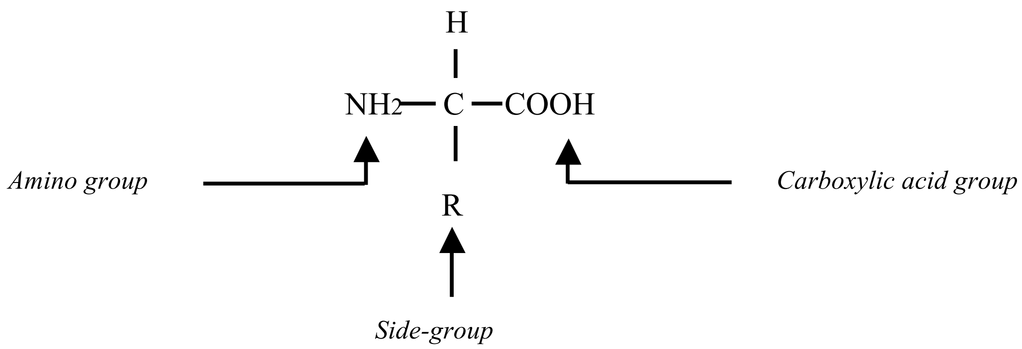
After shearing the greasy fibre is classed (separated into different styles of wool) and baled for transport to a scouring plant. Scouring removes the water-scourable contaminants, such as grease, suint (sweat products) and wax. Other acquired impurities, such as vegetable matter (VM), are removed during the spinning process. Heavily contaminated wool may need to be carbonised (treated with an acid solution). This process burns the VM, allowing it to be crushed to a powder and removed.

Keratin

Wool is a protein composed of amino acid monomers which collectively are called ‘keratin’, the wool polymer.

It is generally accepted that 18 monomers make up keratin.

Proteins are giant molecules built up by the condensation of a number of comparatively simple amino acids in which the amino nitrogen is attached to the CH2 group adjacent to the carboxyl radical, for example CH3 CH2 (NH2) COOH (alanine). See the diagram below.



Properties

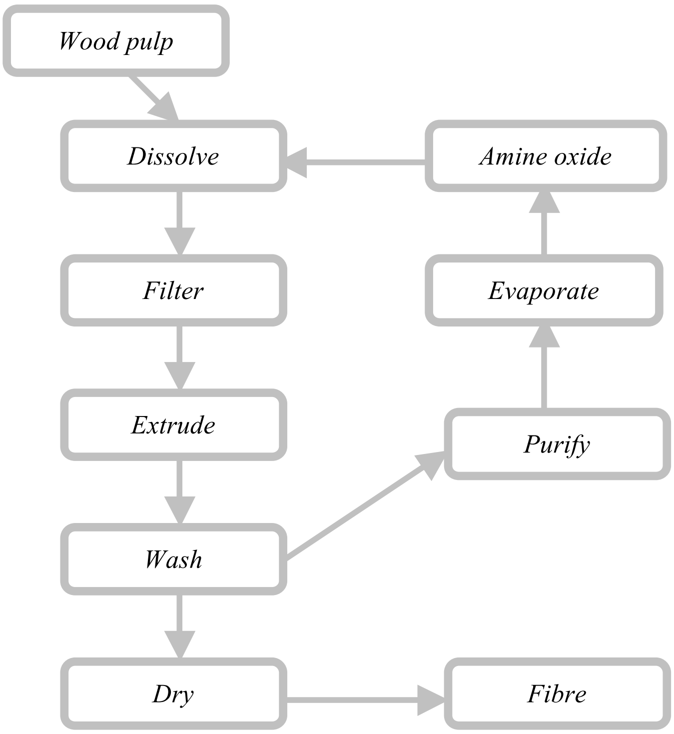
Moisture handling	Water-liking fibre with a natural moisture content of 16%. Can hold up to 30% without feeling unduly damp
Fibre length	50–400 mm
Elongation at break	25–35 % dry, 25–50% wet
Tenacity (cn/tex)	9–15 dry, 7–14 wet
Effect of heat	Does not burn readily; loses softness after boiling; yellows at 130°C; chars at 300°C
Resistance to acid	Good resistance to most acids; decomposes in strong sulphuric acid; damaged by nitric acid
Resistance to alkali	Poor resistance
Organic attack	Attacked by moths and insects; good resistance to microorganisms
Handling characteristics	Excellent wrinkle resistance due to its excellent flexibility and elasticity properties; wonderful handle and draping properties due to its structure and mechanical properties (flexibility and elasticity)
Shrinkage	Care must be used when washing due to wool's tendency to shrink (felt)
Insulation	Superb insulation properties

Uses

Wool's uses include apparel, carpets, blankets, handcrafts, industrial felts and upholstery.

Fact sheet – Tencel

Tencel is a new generation viscose fibre made using an environmentally sensitive chemical path. See the diagram below.



Flow chart for the manufacture of Tencel.

Properties

- Regenerated cellulose fibre, which has good wet and dry strength.
- Hydrophilic fibre with a standard regain of 6–8%.
- Poor elasticity and resilience, similar to cotton in its creasing properties.
- Easily dyed.
- Alkali-resistant; damaged by acids.
- Tencel can be blended with other fibres to produce a product that combines the best features of each fibre in the blend.
- Versatile material that can be engineered for many end uses.

Uses

Tencel is used for apparel.

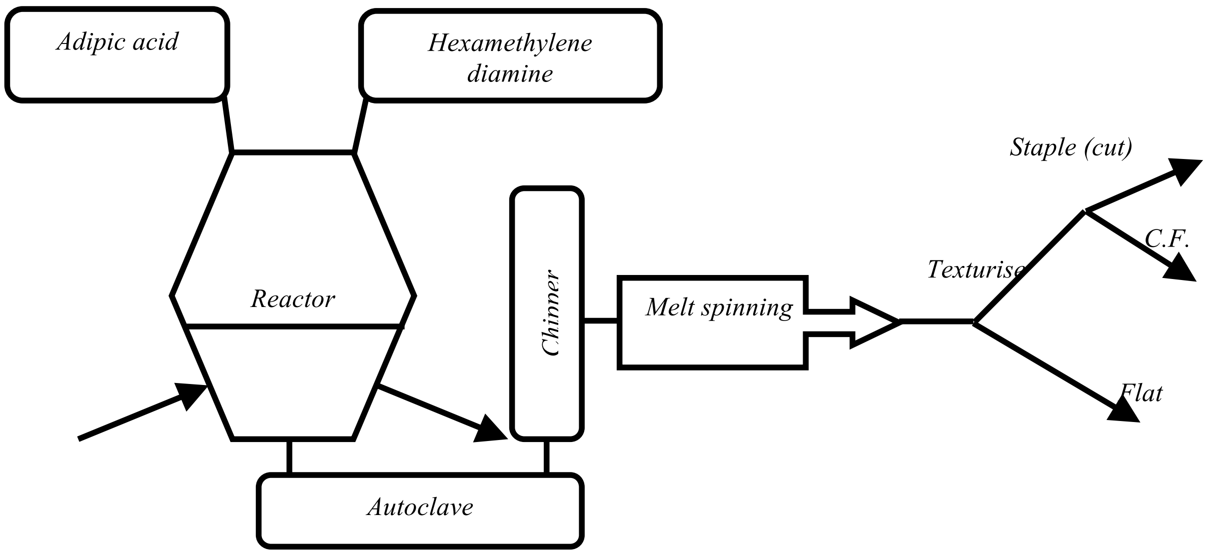
Fact sheet – Nylon

The generic name for Nylon is polyamide. Nylon was the first commercially successful synthetic. It was introduced in 1938 and is the second most used synthetic fibre.

Manufacture

Nylon is made from chemicals derived from coal and gas. It is an extremely versatile material that can be engineered for many end uses. Nylon is melt spun and is produced in staple and continuous filament form.

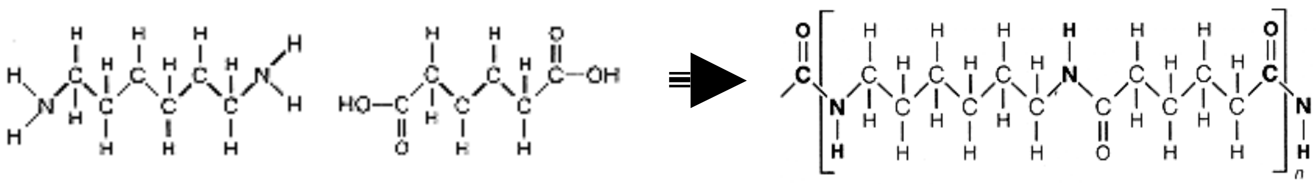
Nylon polymer is not produced in Australia; however, the fibre is spun from imported polymer.



Flow chart for the manufacture of Nylon.

There are three main types of Nylon: Nylon 6, Nylon 6.6 and Nylon 11. The numbers refer to the carbon atoms in the monomer.

Starting chemicals for polyamide Nylon 6.6.



Hexamethylene diamine adipamide *Adipic acid* *Polyhexamethylene*

Properties

Moisture handling	Hydrophobic fibre with a natural moisture content of 1.5–4%. depending on version (6.6, 6, 11) Can be engineered to 'wick' moisture away from the body

Fibre length	Any length required
Elongation at break	15–50%. depending on tenacity style (high, medium or low)
Tenacity (cn/tex)	20–85 cn/tex depending on tenacity, that is high, medium or low
Effect of heat	Shrinks from flame; melts and burns; sometimes described as self-extinguishing. A thermoplastic fibre, Nylon 6 melts at 215°C, Nylon 6.6 at 250°C; heat settable
Resistance to acid	Poor
Resistance to alkali	Excellent
Organic attack	No problem
Handling characteristics	Reasonable handle and excellent elasticity
Shrinkage	Not a problem
Insulation	Depends on fibre shape

Uses

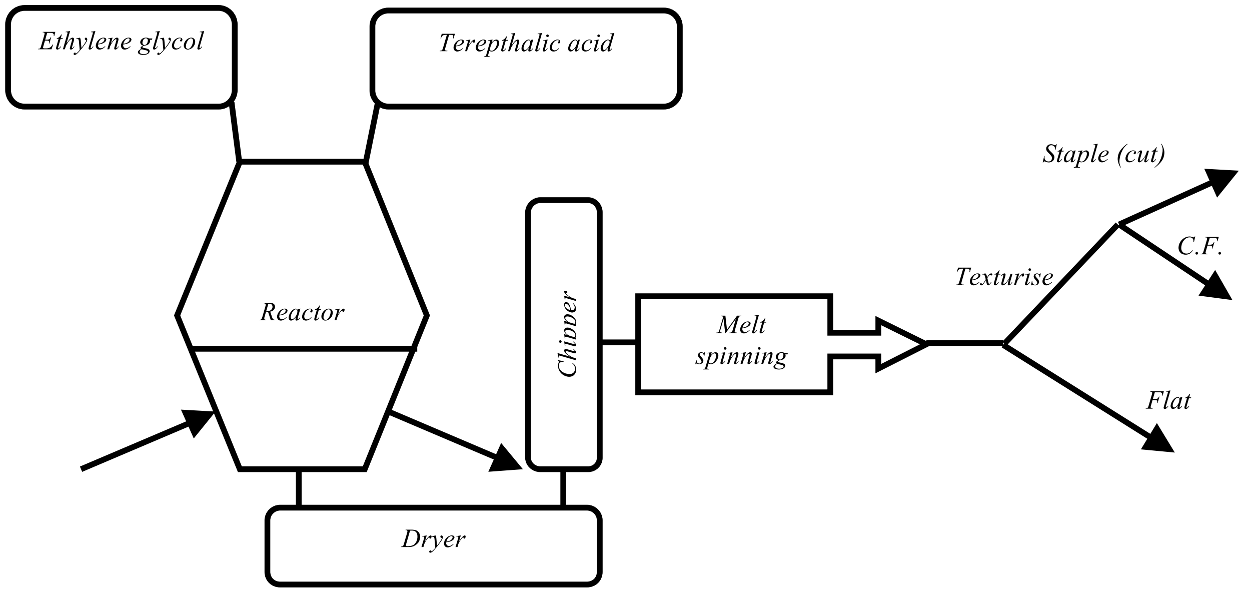
Nylon has apparel, industrial, geotextile, medical and domestic uses.

Fact sheet – polyester

Manufacture

Polyester is made from chemicals derived from petroleum, coal, air and water. It is melt spun, see the diagram below. Polyester is the most used synthetic fibre, especially in apparel. Polyester drink bottles can be recycled into useful apparel fibres.

Polyester polymer is not produced in Australia; however, the fibre is spun from imported polymer.



Properties

Moisture Handling	Hydophobic fibre with a natural moisture content of 0.5%
Fibre length	Comes as continuous filament or staple of any length
Elongation at break	8–50%, depending on tenacity style (high, medium or low)
Tenacity	50–80 cn/tex, depending on tenacity (high, medium or low)
Effect of heat	Melts at 260°C; thermoplastic; heat settable; softens at 230–240°C
Resistance to acid	Good
Resistance to alkali	Satisfactory for textile use
Organic attack	No problem
Handling characteristics	Stiff, hard handle; excellent crease resistance

Uses

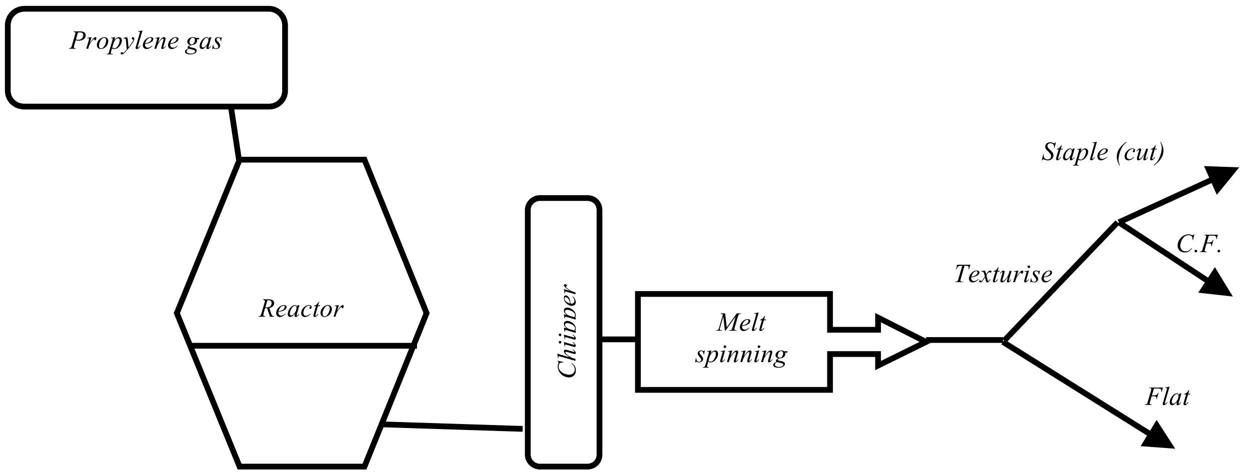
Polyester has apparel, domestic textile, industrial, geotextile and medical uses.

Fact sheet – Polypropylene

Manufacture

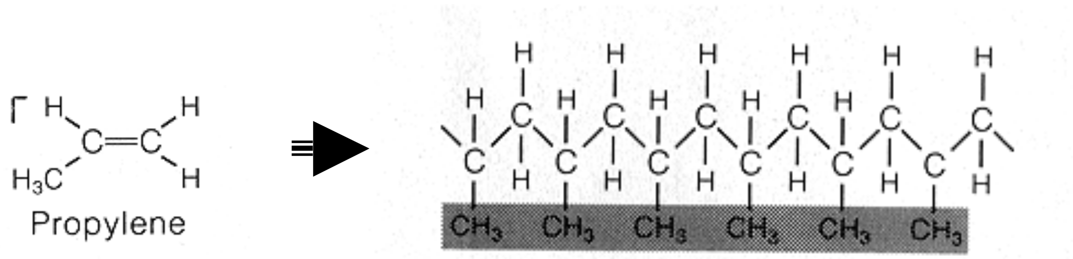
Polypropylene was first produced in Italy in 1952. It is made by polymerising propylene gas and is melt spun. It is very difficult to dye as a fibre and is generally dope dyed when extruded.

Polypropylene polymer is produced in Australia and spun in various places around the country.



Melt spinning of polypropylene

Starting chemicals for polypropylene.



Isotactic configuration:
All methyl groups are on the same side.

Properties

Moisture handling	Hydophobic fibre, which has a natural moisture content of 0.1% but can be engineered to 'wick' moisture
Fibre length	Comes as continuous filament or staple of any length
Elongation at break	8–60%, depending on tenacity style (high, medium or low)
Tenacity	50–80 cn/tex, depending on tenacity (high, medium or low). A special version of this fibre (Dyneema) is currently the strongest readily available fibre

Effect of heat	Has a low melting point at 135–170°C (depending on version); thermoplastic; heat settable; softens at 127–160°C (depending on version)
Resistance to acid	Good
Resistance to alkali	Good
Organic attack	No problem
Handling characteristics	Soft handle and drape, depending on version. Lightest of all synthetic fibres

Uses

Uses include carpet, sportswear, carpet backing, thermal wear, sacks, ropes, fleecy-lined fabric, polypropylene–wool blend blankets; outdoor uses, ropes and twine.

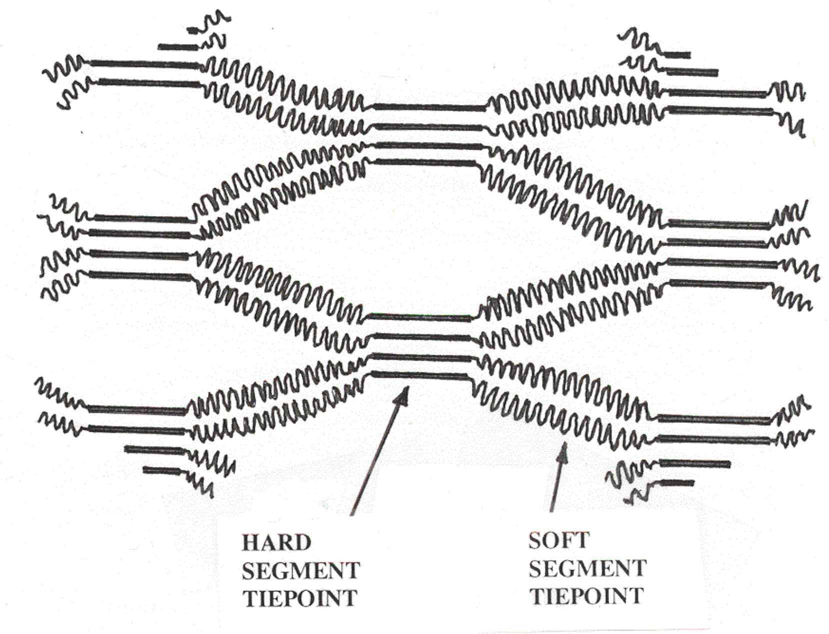
Fact sheet – Lycra

Lycra is the elastane fibre made by Dupont. It was first made in the 1940s. It is made of 85% segmented polyurethane polymer.

Lycra is used in garments in two ways: in the fabric, blended with other (80% Nylon, 20% Lycra) and in elastic banding.

Production

Lycra is a chemically complicated fibre to make, going through several stages before extrusion. It is extruded in monofilaments and multi-filaments.



Representation of an elastane molecule.

Properties

- Lycra has rubber like properties, after stretching it will recover its original length (100% recovery). It can stretch up to seven times its length and return.
- Lycra can be readily dyed.
- Lycra has better chemical resistance than rubber.
- Lycra is resistant to sunlight, perspiration, laundering and cosmetic oils.

Uses

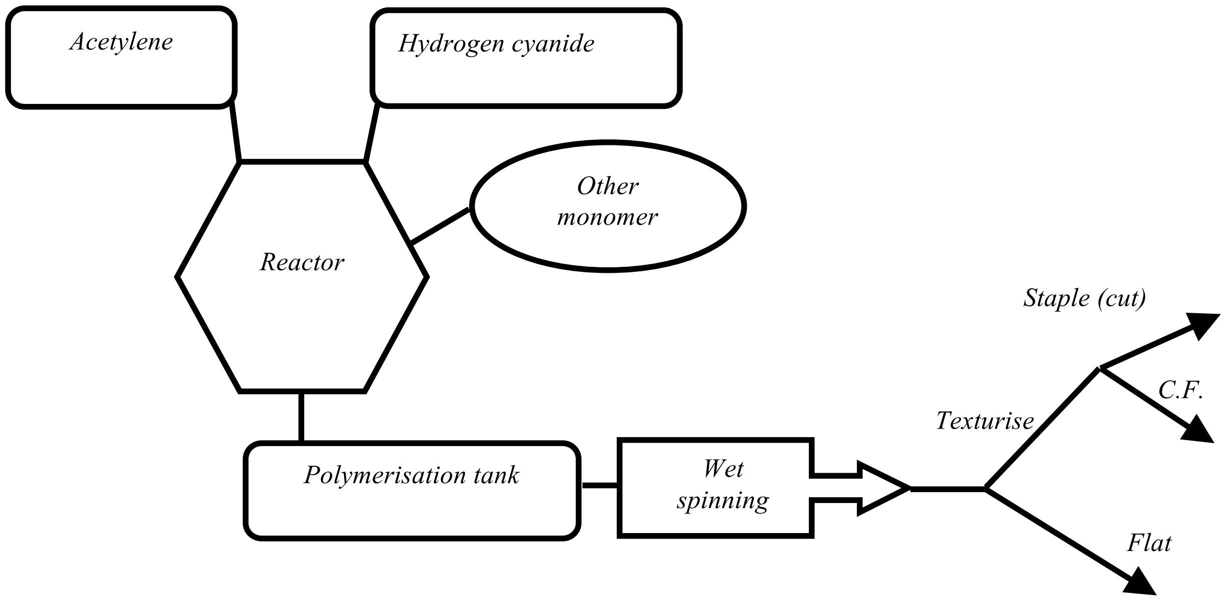
Lycra is used in car upholstery, swimwear, active sportswear, hosiery, socks, jeans and medical items, for example, bandages.

Facts sheet – Acrylic

Manufacture

Acrylic is made from chemicals derived from petroleum, coal, air and water. It can be either wet or dry spun.

Acrylic is not produced in Australia. It is imported in staple and continuous filament form.



Flow diagram showing the process of acrylic manufacture.

Properties

- May be blended with other fibres
- Melts at between 215° and 255°C
- Hydrophobic fibre. Does not absorb much water (between 1 and 3%)
- Strong
- In bi-component form is able to be texturised to resemble wool
- Excellent chemical resistance
- Excellent sunlight resistance

Uses

Acrylic is used in apparel, carpets, blankets, awning materials and industrial materials.

Properties of common fibres

Best and worst properties

Fibres	Best properties	Worst properties
Cotton	Strength (dry and wet) Good moisture absorption Durability Alkali resistance Low cost Readily bleached Antistatic Cool Low cost	Inelasticity (creasing) Acid resistance-poor Flammability Dull unless mercerised Attacked by micro-organisms (rots)
Flax	Durability Moisture absorption Strength (Dry and Wet) Good thermal contact (cool) Lustrous when ironed	Inelasticity (creasing) Flammability Cottonising Poor drape High cost
Silk	Strength Smoothness Lustre Moisture absorption	Cost Sensitivity to sunlight alkali and perspiration 'Yellowing' Only fair durability Very high cost
Wool	Moisture absorption Elasticity and resilience Insulating properties Flame retardant Drape Antistatic	Felting shrinkage Alkali sensitivity Poor sunlight resistance Attacked by micro-organisms and insects Relatively weak Moderate to high cost
Viscose rayon	Low cost Moisture absorption Variable lustre and fibre details Anti-static Versatile	Poor durability Acid and alkali sensitive Poor sunlight resistance Flammability Low wet strength Low wrinkle resistance
Tencel	High strength (wet and dry) Moisture absorption Variable lustre and fibre details	Flammability Low wrinkle resistance

Fibres	Best properties	Worst properties
	Anti-static Available in staple and continuous filament	
Acetate	Soft handle and drape Smoothness Lustre	Low strength Acid and alkali sensitive Poor durability Sensitive to heat
Nylon	Strength Durability-high abrasion resistance Elasticity Easy-care Thermoplasticity Alkali resistance	Poor absorption 'Yellowing' Affected by the weather Acid and sunlight sensitive Develops static Burns with melting
Polyester	Strength Durability Elasticity Thermoplasticity Easy care Chemically inert Remains white	Poor absorption Develops static Relatively expensive to dye Certain types subject to pilling Burns with melting
Acrylic	Sunlight resistance Resistant to acids and domestic alkali (washing) Durability Soft handle after texturising (bulky, wool -like)	Heat sensitive Poor moisture absorption Pilling May be subject to 'yellowing' Care is required to wash or dry clean Develops static Moderate abrasion resistance
Olefins: Polyolefin Polyropylene Polyethylene	Good insulating (thermal) properties Very low density (less than water) Good abrasion resistance Low cost	Low melting point Poor resilience Must be coloured during extrusion
Polyurethane elastomer (Lycra)	High extensibility and recovery Dyeable Resistant to sunlight, perspiration, laundering and cosmetic oils	High rate of stress decay relative to rubber

Regain of fibres

Natural fibres	Regain %	Natural fibres	Regain %
Abaca	14.00	Jute	17.00
Alfa	14.00	Kapok	10.90
Broom	14.00	Kenaf	17.00
Coir	13.00	Maguey	14.00
Cotton:		Ramie	8.50
• normal fibre	8.50	Silk	11.00
• mercerised fibres	10.50	Sisal	14.00
Flax	12.00	Sunn	12.00
Hemp	12.00	Wool and animal hair	16.00
Henequen	14.00		
Man-made and synthetic fibres	**Regain %**	**Man-made and synthetic fibres**	**Regain %**
Acetate	9.00	Paper yarn	13.75
Acrylic	2.00	Polycarbamide	2.00
Alginate	20.00	Polyester:	
Chlorofibre	2.00	• staple fibre	1.50
Cuproammonium viscose	13.00	• continuous filament	3.00
Elastane	1.50	Polyethylene	1.50
Elastodiene	1.00	Polynosic (modal) viscose	13.00
Fluorofibre	0.00	Polypropylene	2.00
Glass fibre:		Polyurethane:	
• continuous filament with a diameter of over 5 µm	2.00	• staple fibre • continuous filament	3.50 3.00
• continuous filament with a diameter of 5 µm or less	3.00	Protein	17.00
Metal fibre	2.00	Triacetate	7.00
Metallised fibre	2.00	Trivinyl	3.00
Modacrylic	2.00	Vinylal	5.00
Nylon (6.6) and Nylon 6:		Viscose	13.00
• staple fibre	6.25		
• continuous filament	5.75		
Nylon 11:			
• staple fibre	3.50		
• continuous filament	3.50		

(Source: Australian/NZ Standards.)

Fibre densities

Fibre	Density gm/cm^3	Fibre	Density gm/cm^3
Acetate		**Nylon**	
Diacetate (Dicel)	1.33	Nylon 11 (Rilsan)	1.10
Triacetate (Tricel)	1.30	Nylon 6 (Perlon)	1.13
		Nylon 6.6 (ICI Nylon)	1.14
Acrylic		**Polyester**	
Orlon	1.14–1.17	Kodel	1.22
Courtelle	1.14–1.18	Terylene, Vycron	1.38
Zefran	1.15		
Acrilan, Creslan	1.17		
Aramid		**Polyolefin**	
Nomex	1.38	Polypropylene (Ulstron)	0.90
Alginate		Polyethylene, Low-density (Courlene)	0.92
Calcium alginate	1.72	Polyethylene, High-density (Courlene X3)	0.95
Chlorofibre		**Polyurethane elastomers**	
Heat-treated PVC (Isovyl)	1.38	(approximate values)	
Unmodified PVC (Rhovyl, Fibravyl)	1.40	**Enkaswing, Lycra, Sarlane, Spanzelle**	1.1
Chlorinated PVC (Piviacid)	1.54	**Rabbit**	
Polyvinylidene (chloride)	1.70	Common	0.92
(Velan, Saran)		Angora	1.10
Cotton		**Ramie**	1.55
Scoured	1.55	**Regenerated protein fibre**	
Mercerised	1.54	Merinova	1.29
Acetylated	1.40–1.50'		
Cuproammonium Rayon	1.52	**Silk**	
FLAX	1.50	B, mori, raw	1.33
		Weighted	> 1.60
		Tussah	1.32
Fluorofibre		**Vinylal**	
Teflon	2.30	Kuralon	1.30
Glass			
E-glass	2.53	**Viscose**	1.51–1.52
C-glass	2.46		
A-glass	2.46	**Wool**	
S-glass	2.45	Non-medullated	1.31
Hemp	1.50		
Jute	1.50		

Modacrylic Dynel Teklan Verel	 1.31 1.34 1.37		

According to degree of acetylation.

Melting points

Fibre	Temperature (°C)
Acetate (secondary) Triacetate	250–255 290–300
Acrylic	Partial melting depending on proportion of copolymer, i.e. higher proportion of copolymer greater degree of melting
Aramid	Does not melt
Chlorofibre: • Clevyl • Isovyl • leavil	 185–190 210–212 Does not melt, decomposes with discolouration
Fluorofibres • Teflon FEP • Teflon TFE	 285 Does not melt, decomposes slowly
Modacrylic • Dynel 180 • others	 190 Partial melting depending on proportion of Copolymer, i.e. higher proportion of copolymer greater degree of melting
Nylon • 11 • 6 • 6.6	 182–186 210–216 252–260
Polyester • KodelI II • Terylene	 290 260–270
Polyolefin • Ulstron • Courlene • CourleneX3	 168–175 108–113 135
Vinylal • Mewlon	 232

References

All fibres

www.lib.rmit.edu.au

www.encyclopedia.com

(Some information is free, but generally a pay service.)

www.texguide.com/news_group

www.texmondo.com

www.texi.org/index-a.htm

Natural fibres

Wool

www.wool.com

Cotton

www.cottonaustralia.com.au

www.cotton-net.com

www.icac.org

www.fuster.com

Man-made fibres

www.fibersource.com

www.fibersource.com/f-tutor/techpag.htm

www.dupont.com

www.psrc.usm.com

The following sites are useful for information on the latest on government regulations and publications:

www.ausinfo.gov.au (State Government information)

www.agip.gov.au (Commonwealth Government publications)

www.standards.com.au (Australia and New Zealand Standards)

Recommended texts

Fritz & Cant, *Consumer Textiles,* Oxford University Press.

Gohl & Vilensky, *Textiles for Modern Living*, Longman.

Hatch, K.L., *Textile Science*, West Publishing.

Textile Institute, *Textile Terms and Definitions*.

Tortora, *Understanding Textiles*, Macmillan.

Wynne (Ed.), *Textiles – The Motivate Series*, Macmillan.

Other useful materials

Other useful materials include videos, CD-ROMs, databases, manufacturers' promotional and training materials (including pamphlets, brochures, videos and CD-ROMs) and software.