

Chemistry of Synthetic Fibers

Synthetic fibers (British English: synthetic fibres) 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 fibres 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 polymerisation: linear polymerisation and cross-linked polymerisation. For example: rayon, nylon and polyester.

Synthetic fibers are made from synthesized polymers of small molecules. The compounds that are used to make these fibers come made through 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 accounts for approximately 98 percent by volume of synthetic fiber production whereas polyester alone accounts for around 60 percent.

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.

- 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

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

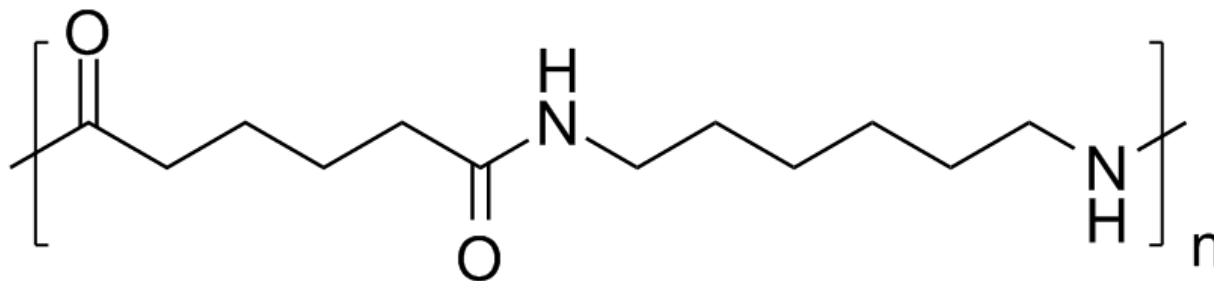
- Nylon (1931)
- Acrylic (1950)
- Polyester (1953)

What is Nylon?

Nylon is the most useful synthetic material with applications varying from daily life activities to industries. It is a plastic which can be drawn into fibres or moulded into daily products for making amenities. We can live our entire life with nylon on our side. You hop across the nylon carpet to the kitchen, eat your breakfast on a nylon bowl after cleaning your teeth with a toothbrush whose bristles are made of nylon. A nylon umbrella over your head is used to move out of the house in heavy sunlight or to keep out of the rain.

The Science of Nylon

The term nylon points towards a polymer family known as linear polyamides. There are two approaches to making nylon for fibre applications. In the first approach, the molecules that consist of an acidic group (COOH) on every end react with molecules that contain amine (NH₂) groups at each end. The resulting nylon gets a name based on the number of carbon atoms that separate two amines and two acidic groups. Hence nylon 6,6 is widely used as fibres made from adipic acid and hexamethylene diamine.



Structure of Nylon – 6,6

The salt which is formed by two compounds (adipic acid and hexamethylene diamine) is known as nylon that has an exact ratio of 1:1 acid to base. This salt is dried and then heated under vacuum to remove water and form the polymer.

In the other approach, a compound that contains an amine at one end and acid at the other are polymerized to produce a chain with repeating units of (-NH-[CH₂]_n-CO-)x.

The nylon is referred to as nylon 6 if n = 5 which is another common form of this polymer. The commercial production of nylon 6 starts with caprolactam that use an open-ring polymerization.

In both the approaches, the polyamide is melt and drawn after cooling to obtain the desired properties of every intended use.

Properties of Nylon

- Lustrous
- Elastic
- Very strong
- Damage resistant to oil and many chemicals
- Resilient
- Does not absorb water
- Dries quickly

Types of Nylon

- Nylon 6 – It was developed by Paul Schlack. It is formed by ring-opening (of caprolactam) polymerization.
- Nylon 510 – It is obtained from sebacic and pentamethylene diamine acid.
- Nylon 1,6 – It is produced from dinitriles with the help of acid catalysis.
- Nylon 66 – Wallace Carothers patented nylon 66 with the use of amide.

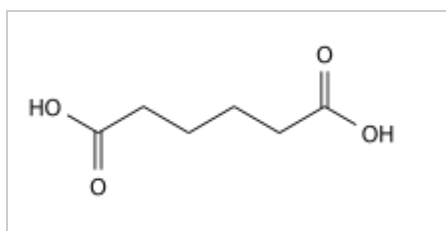
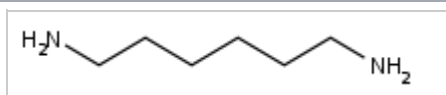
Uses of Nylon

- Clothing – Shirts, Foundation garments, lingerie, raincoats, underwear, swimwear and cycle wear.
- Industrial uses – Conveyer and seat belts, parachutes, airbags, nets and ropes, tarpaulins, thread, and tents.
- It is used to make a fish net.
- It is used as plastic in manufacturing machine parts

Nylon 66

Nylon 66 (nylon 6-6, nylon 6/6 or nylon 6,6) is a type of polyamide or nylon. It, and nylon 6, are the two most common for textile and plastic industries. Nylon 66 is made of two monomers each containing 6 carbon atoms, [hexamethylenediamine](#) and [adipic acid](#), which give nylon 66 its name.

Synthesis and manufacturing



- [Hexamethylenediamine](#) (top) and [adipic acid](#) (bottom), monomers used for [polycondensation](#) of Nylon 66.
- Nylon -6,6 is synthesized by [polycondensation](#) of hexamethylenediamine and adipic acid. [Equivalent](#) amounts of hexamethylenediamine and adipic acid are combined with water in a reactor. This is crystallized to make nylon salt, an [ammonium/carboxylate](#) mixture. The nylon salt goes into a reaction vessel where polymerization process takes place either in batches or continuously.
$$n \text{HOOC}-(\text{CH}_2)_4\text{-COOH} + n \text{H}_2\text{N}-(\text{CH}_2)_6\text{-NH}_2 \rightarrow [-\text{OC}-(\text{CH}_2)_4\text{-CO-NH}-(\text{CH}_2)_6\text{-NH-}]_n + (2n-1) \text{H}_2\text{O}$$
- Removing water drives the reaction toward polymerization through the formation of amide bonds from the acid and amine functions. Thus molten nylon 66 is formed. It can either be extruded and granulated at this point or directly spun into fibers by extrusion through a [spinneret](#) (a small metal plate with fine holes) and cooling to form filaments.

How is Nylon Fabric Made?



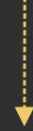
1. Extraction of Diamine Acid

A monomer, called diamine acid, is extracted from crude oil.



2. Combining

Diamine acid is forced to enter into a reaction with adipic acid to create a polymer, known as nylon salt.



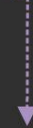
3. Heating

This crystallized substance is then heated to form a molten substance.



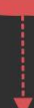
4. Extrusion

This substance is then extruded through a metal spinneret.



5. Loading

It is then loaded onto a type of spool called a bobbin.



6. Stretching

These fibers are then stretched to increase their strength and elasticity.



7. Drawing

They are then wound onto another spool in a process called "drawing".



8. Spinning

The resulting fibers are ready to be spun into garments or other forms of fibers.



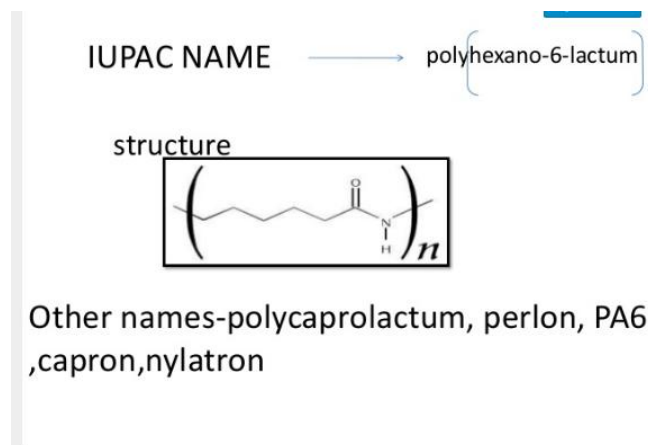
9. Finishing

It is then dyed to produce the color that is desired for the end product.

Applications

- Nylon 66 is frequently used when high mechanical strength, rigidity, good stability under heat and/or chemical resistance are required. It is used in fibers for textiles and carpets and molded parts.
- It is also used in airbags, apparel, and carpet fibres.
- Nylon 66 used well to make 3D structural objects, mostly by **injection molding**. It has broad use in automotive applications; these include "under the hood" parts such as **radiator** end tanks, rocker covers, air intake manifolds, and oil pans, as well as numerous other structural parts such as hinges, and ball bearing cages.
- Other applications include electro-insulating elements, pipes, profiles, various machine parts, **zip ties**, conveyor belts, hoses, polymer-framed weapons, and the outer layer of **turnout blankets**.
- Nylon 66 is also a popular used in **guitar nut** material.
- Nylon 66, especially **glass fiber reinforced** grades, can be effectively fire retarded with halogen-free products. Phosphorus-based flame retardant systems are used in these **fire-safe polymers** and are based on **aluminium diethyl phosphinate** and synergists.

Nylon 6

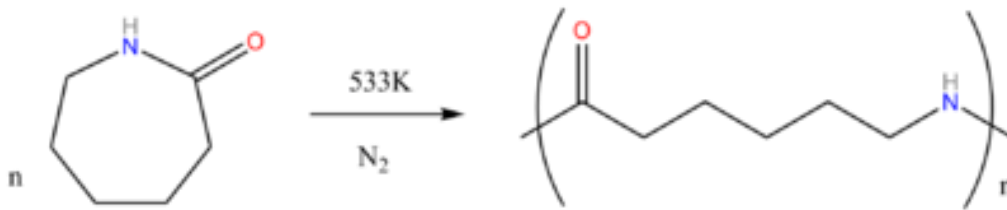


- **Nylon 6** or **polycaprolactam** is a **polymer** developed by **Paul Schlack** at **IG Farben** to reproduce the properties of **nylon 6,6** without violating the **patent** on its production.
- It is a **semicrystalline polyamide**.

- Unlike most other **nylons**, nylon 6 is not a **condensation polymer**, but instead is formed by **ring-opening polymerization**; this makes it a special case in the comparison between condensation and **addition polymers**.
- Its has shaped the economics of the **synthetic fiber** industry.

Synthesis

Nylon 6 is synthesized by **ring-opening polymerization** of **caprolactam**. Caprolactam has 6 carbons, hence 'Nylon 6'. When caprolactam is heated at about **533 K** in an inert **atmosphere** of **nitrogen** for about 4-5 **hours**, the ring breaks and undergoes **polymerization**. Then the molten mass is passed through **spinnerets** to form fibres of nylon 6.



polymerization of caprolactam to produce Nylon 6

During **polymerization**, the amide bond within each caprolactam **molecule** is broken, with the active groups on each side re-forming two new bonds as the **monomer** becomes part of the polymer backbone. Unlike nylon 6,6, in which the direction of the **amide** bond reverses at each bond, all nylon 6 amide bonds lie in the same direction

Nylon 6 can be modified using stabilizers during polymerization to introduce new chain end or functional groups, which changes the reactivity and chemical properties. It's often done to change its dyeability or flame retardance.

Properties

- Nylon 6 fibres are tough, possessing high tensile strength, as well as elasticity and lustre.
- They are wrinkleproof and highly resistant to abrasion and chemicals such as acids and alkalis.
- The fibres can absorb up to 2.4% of water, although this lowers tensile strength.
- The glass transition temperature of Nylon 6 is 47 °C.

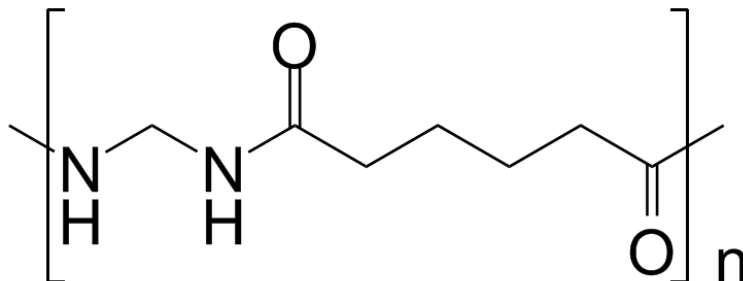
- As a synthetic fiber, Nylon 6 is generally white but can be dyed to in a solution bath prior to production for different color results.
- Its **tenacity** (**Tenacity** is the customary measure of **strength** of a **fiber** or **yarn**. It is usually defined as the ultimate (breaking) force of the fiber (in **gram-force** units) divided by the **denier**) is between 6 and 8.5 gm/den.
- Density of it is 1.14 gm/cc.
- Its melting point is at 215 °C and can protect heat up to 150 °C on average.
- Nylon 6 has poor **biodegradability**.

Applications

1. Used as thread in bristles for tooth brushes
2. As gears ,fittings & bearings, automotive industry
3. Threads, ropes, filaments , nets
4. Gun frames
5. Surgical sutures, strings for musical instruments
6. In hosiery and knitted garments

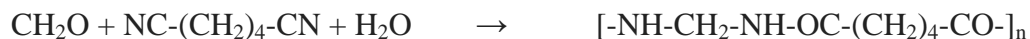
Nylon 1,6

Nylon 1,6 (aka **polyamide 1,6**) is a type of **polyamide** or **nylon**.^[1] Unlike most other **nylons**, nylon 1,6 is not a **condensation polymer**, but instead is formed by an acid-catalyzed synthesis from **adiponitrile**, **formaldehyde**, and water. Synthesis can be performed at room temperature in open beakers.



Synthesis of Nylon 1,6

Nylon 1,6 is synthesized from adiponitrile, formaldehyde, and water via acid catalysis. Adiponitrile and formaldehyde (aqueous, paraformaldehyde, or trioxane) are combined with an acid (typically sulfuric acid) in a reactor. The reaction can be performed at room temperature. However, the reaction is exothermic, and especially at high ratios of formaldehyde to adiponitrile, cooling may be required.



Addition of water to the reaction mixture readily precipitates the nylon 1,6 product, which can then be isolated and washed with water to afford high purity polymer.

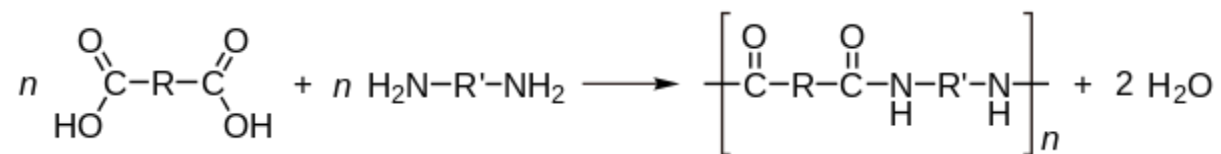
Properties

- Nylon-1,6 is less acid stable than nylon 66.
- Melts over 300-325 °C, with some decomposition.
- Molecular weight is ~22,000 – 34,000 via an osmotic pressure method.
- The polymer branched and cross-linked owing to side reactions occurring during the acid catalyzed polymerization.
- Melting point of Nylon 1,6 is found to increase with increasing synthesis formaldehyde/adiponitrile ratio, along with apparent increase in cross-linking, and reduction in crystallinity. Nylon 1,6 is a rare example of a polyamide thermoset resin.
- Nylon 1,6 has been reported to exhibit a high moisture absorbance owing to the significant density of amide residues in the polymer.

Nylon 510

Nylon 510, made from pentamethylene diamine and sebacic acid, it has superior properties, but is more expensive to make it. Properties of nylon are decided by the R and R' groups.

The general reaction of synthesis is:



Other commercial Nylon: properties and uses

Table 1 – Properties of commercially used nylons

Property	Unit	Nylon 6	Nylon 66	Nylon 11	Nylon 12	Nylon 46
Density	g/cm ³	1.13	1.14	1.04	1.02	1.18
Tensile Strength	MPa	83	80	48	66	100
Water Absorption	%	1.2	1.6	1.9	0.7	3.7
Tensile Strain @ break	%	100	-	49	51	40
Melting Temperature	°C	220	255	190	184	295
Glass Transition Temperature	°C	47	70	42	97	80
Shore Hardness	D	85	88	71	75	85
Coefficient of Friction	-	1.4	0.55	0.36	0.38	0.45

Nylon applications

Nylon comes in four main grades of polyamide nylon: nylon 66, 11, 12 and 46. These names come from the length of their polymeric chains. The first number is the number of carbon atoms in the diamine and the second the number of carbon atoms in the acid. Typical applications include:

- Toothbrushes
- Wear pads
- Wheels
- Gloves
- Guitar strings and pics
- Tennis racket strings
- Medical implants
- Electrical connectors
- Fishing line

- Tents
- Gears

Advantages of Nylon

- High Abrasion Resistance – Higher levels of resistance to wear by mechanical action
- Good Thermal Resistance – Special grades of nylon can have a melting point of almost 300°C
- Good Fatigue Resistance – This makes it ideal for components in constant cyclic motion like gears
- High Machineability – Cast billets can be machined into various components that would be too costly to cast into intricate shapes
- Noise Dampening – Nylon is a very effective noise dampener

Disadvantages of Nylon

- Water Absorption – Water absorbed results in lower mechanical properties. Nylon 6/12 is specially formulated to resist moisture absorption
- Chemical Resistance – Nylon has low resistance to strong bases and acids
- High Shrinkage – High percentages of shrinkage in cast applications

The table below indicates some of the main nylon grades used in industry.

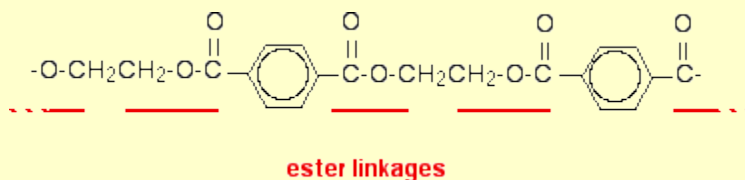
POLYESTERS

A common polyester sometimes known as Terylene if it is used as a fibre, or PET if it is used in, for example, plastic drinks bottles.

Poly(ethylene terephthalate)

What is a polyester?

A polyester is a polymer (a chain of repeating units) where the individual units are held together by ester linkages.



The diagram shows a very small bit of the polymer chain and looks pretty complicated. But it isn't very difficult to work out - and that's the best thing to do: work it out, not try to remember it. You will see how to do that in a moment.

The usual name of this common polyester is poly(ethylene terephthalate). The everyday name depends on whether it is being used as a fibre or as a material for making things like bottles for soft drinks.

When it is being used as a fibre to make clothes, it is often just called *polyester*. It may sometimes be known by a brand name like *Terylene*.

When it is being used to make bottles, for example, it is usually called *PET*.

Making polyesters as an example of condensation polymerisation

In condensation polymerisation, when the monomers join together a small molecule gets lost. That's different from addition

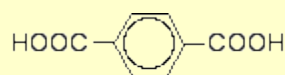
polymerisation which produces polymers like poly(ethene) - in that case, nothing is lost when the monomers join together.

A polyester is made by a reaction involving an acid with two -COOH groups, and an alcohol with two -OH groups.

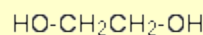
In the common polyester drawn above:

The acid is benzene-1,4-dicarboxylic acid (old name: terephthalic acid).

The alcohol is ethane-1,2-diol (old name: ethylene glycol).

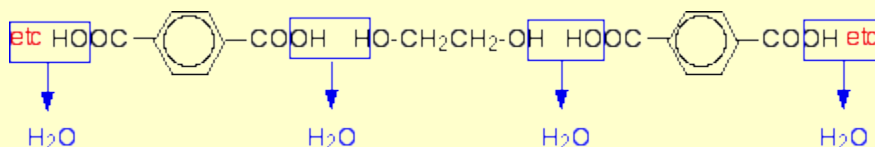


benzene-1,4-dicarboxylic acid

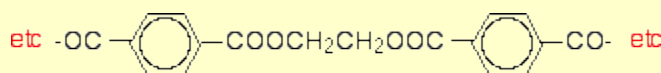


ethane-1,2-diol

Now imagine lining these up alternately and making esters with each acid group and each alcohol group, losing a molecule of water every time an ester linkage is made.



That would produce the chain shown above (although this time written without separating out the carbon-oxygen double bond - write it whichever way you like).



Note: *This does NOT describe the way the actual reaction happens - it is a way of working out the structure of the polymer.* The chemistry of the reaction is more complicated than this.

The diagram shows a slightly shorter bit of chain than the corresponding one at the top of the page. However, it is exactly consistent with the loss of water from the last diagram. It was impossible to include another ethane-1,2-diol in that diagram for

space reasons. If any of this offends you, draw it again yourself so that everything matches! In fact, it would be good practice to draw a bit of chain starting from a few more monomers.

This is what I meant further up the page by working the structure out rather than remembering it. The structures of both monomers are easy to remember. If you line them up and remove water as I have shown, the structure follows automatically.

Hydrolysis of polyesters

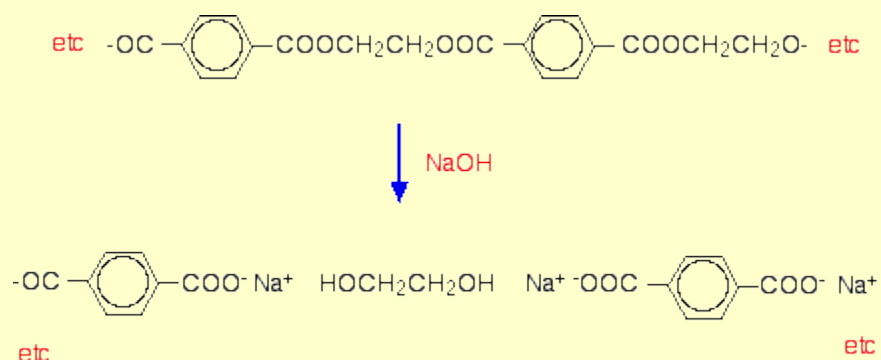
Simple esters are easily hydrolysed by reaction with dilute acids or alkalis.

Polyesters are attacked readily by alkalis, but much more slowly by dilute acids. Hydrolysis by water alone is so slow as to be completely unimportant. (You wouldn't expect your polyester fleece to fall to pieces if you went out in the rain!)

If you spill dilute alkali on a fabric made from polyester, the ester linkages are broken. Ethane-1,2-diol is formed together with the salt of the carboxylic acid.

Because you produce small molecules rather than the original polymer, the fibres are destroyed, and you end up with a hole!

For example, if you react the polyester with sodium hydroxide solution:



Types of Polyester: according to the composition of their main chain, polyesters can be:

Main chain composition	Type	Examples of	
		Polyesters	Manufacturing methods
Aliphatic	Homopolymer	Polyglycolide or polyglycolic acid (PGA)	Polycondensation of glycolic acid
		Polylactic acid (PLA)	Ring-opening polymerization of lactide
		Polycaprolactone (PCL)	Ring-opening polymerization of caprolactone
		Polyhydroxyalkanoate (PHA)	
		Polyhydroxybutyrate (PHB)	
	Copolymer	Polyethylene adipate (PEA)	
		Polybutylene succinate (PBS)	Polycondensation of succinic acid with 1,4-butanediol
		Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV)	Copolymerization of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid , butyrolactone , and valerolactone (oligomeric aluminumoxane as a catalyst)
	Semi-aromatic	Copolymer	Polyethylene terephthalate (PET)
Polybutylene			Polycondensation of terephthalic acid

		terephthalate (PBT)	with 1,4-butanediol
		Polytrimethylene terephthalate (PTT)	Polycondensation of terephthalic acid with 1,3-propanediol
		Polyethylene naphthalate (PEN)	Polycondensation of at least one naphthalene dicarboxylic acid with ethylene glycol
Aromatic	Copolymer	Vectran	Polycondensation of 4-hydroxybenzoic acid and 6-hydroxynaphthalene-2-carboxylic acid

Increasing the aromatic parts of polyesters increases their [glass transition temperature](#), melting temperature, [thermal stability](#), chemical stability.

Polyesters can also be [telechelic oligomers](#) like the polycaprolactone diol (PCL) and the polyethylene adipate diol (PEA). They are then used as [prepolymers](#).

Polyester Fiber Characteristics

- **Strong**
- **Resistant to stretching and shrinking**
- **Resistant to most chemicals**
- **Quick drying**
- **Crisp and resilient when wet or dry**
- **Wrinkle resistant**
- **Mildew resistant**
- **Abrasion resistant**
- **Retains heat-set pleats and crease**
- **Easily washed**

USES OF POLYESTER FIBER

- Apparel: Every form of clothing .Polyester fibers are the first choice for apparel and are used in trousers, skirts, dresses, suits, jackets, blouses and outdoor clothing
- Polyester fabrics used for conveyor belts, safety belts, coated fabrics and plastic supporting with high-energy absorption.
- Home Furnishings: Carpets, curtains, draperies, sheets and pillow cases, wall coverings, and upholstery
- Other Uses: hoses, power belting, ropes and nets, thread, tire cord, auto upholstery, sails, floppy disk liners, and fiberfill for various products including pillows and furniture

Advantages and Disadvantages of

+ Advantages

- Tough and rigid and PET has low moisture absorption
- Processed by thermoplastic operations
- Recycled into useful products as basis for resins in such applications as sailboats, shower units, and floor tiles
- PET flakes from PET bottles are in great demand for fiberfill for pillows and sleeping bags, carpet fiber, geo-textiles, and regrind for injection and sheet molding

Polyesters

+ Disadvantages

- Subject to attack by acids and bases
- Low thermal resistance
- Poor solvent resistance
- Must be adequately dried in dehumidifier prior to processing to prevent hydrolytic degradation.

Polyester



Disadvantages

- Holds oily stains
- Static and piling problems
- Hydrophobic

What do you predict will happen when polyester is ignited? Why?
What would happen if it was mixed with another fiber?

Characteristics

- Most used synthetic fiber in the US
- Polymer created from coal, water, and petroleum
- Fine to heavy weight
- Often mixed with other fibers to create a blended fabric

Proper Care

- Washes easily on any temperature
- The more often you wash polyester the more likely piling is to occur

Advantages

- Best "wash and wear" fabric
- Very good strength and abrasion resistance
- Will not shrink or stretch
- Resists wrinkles
- Washable



Acrylic Fiber:

A manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of acrylonitrile units [-CH₂-CH(CN)-] (FTC definition). Acrylic fibers are produced by two basic methods of spinning (extrusion), dry and wet. In the dry spinning method, material to be spun is dissolved in a solvent. After extrusion through the spinneret, the solvent is evaporated, producing continuous filaments which later may be cut into staple, if desired. In wet spinning, the spinning solution is extruded into a liquid coagulating bath to form filaments, which are drawn, dried, and processed.

Acrylic fibers are synthetic fibers made from a polymer (polyacrylonitrile) with an average molecular weight of ~100,000, about 1900 monomer units. To be called acrylic in the U.S, the polymer must contain at least 85% acrylonitrile monomer. Typical comonomers are vinyl acetate or methyl acrylate. The Dupont Corporation created the first acrylic fibers in 1941 and trademarked them under the name "Orlon".

Raw Material

Acrylonitrile is the main raw material for the manufacture of **acrylic fibers**. It is made by different methods. In one commercial method, hydrogen cyanide is treated with acetylene:

1st Method

Acetylene + Hydrogen cyanide --> Acrylonitrile

2nd Method

Ethylene--Air Oxidation--> Ethylene oxide + HCN--> Ethylene cyanhydrin--Dehydration at 300 deg C (catalyst)--> Acrylonitrile

Production Process of Acrylic Fiber

The acrylic process is a "one step technology", with the following main characteristics:

1. Polymerization in solution
2. Direct feeding of the dope to spinning
3. Wet **spinning**
4. DMF as solvent for both polymerization and spinning

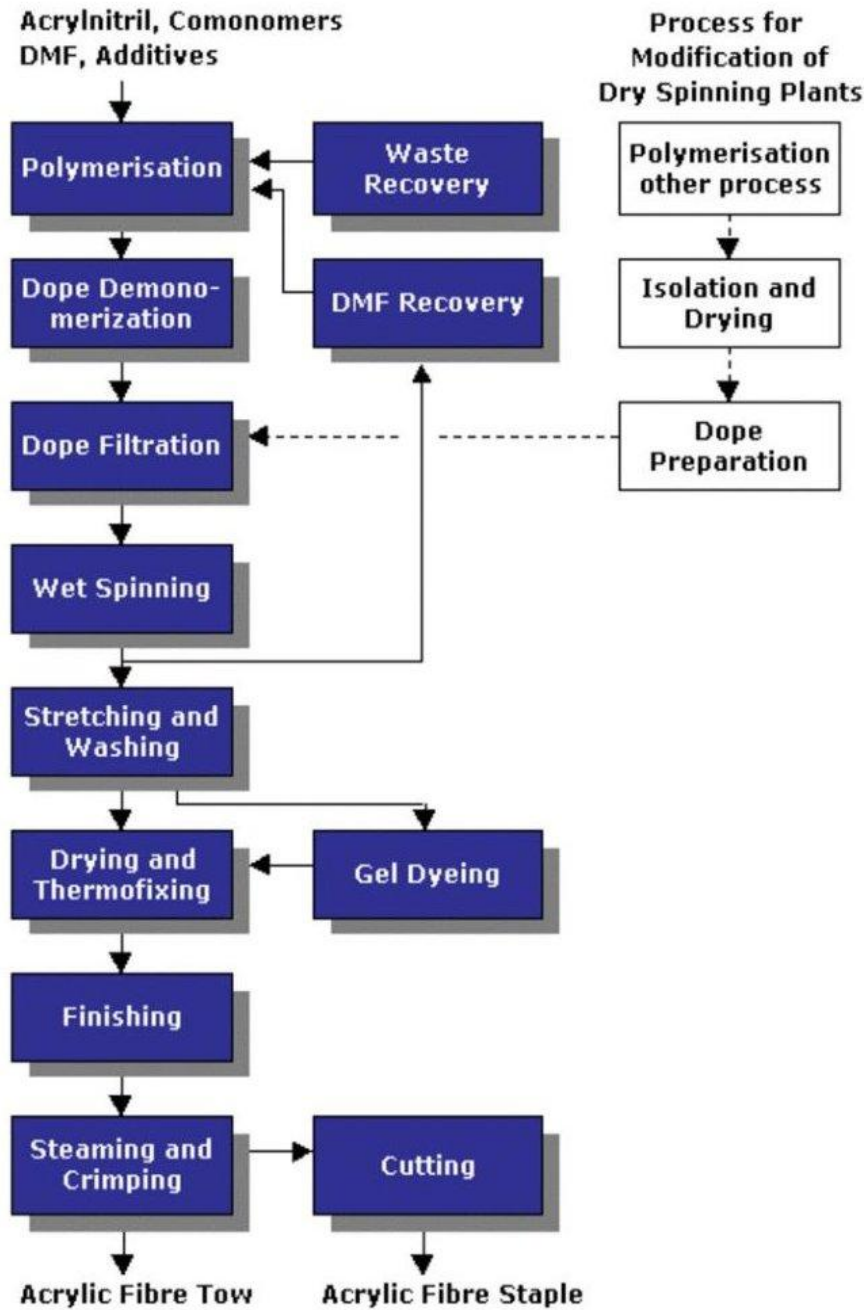


Fig: Production Process of Acrylic Fiber

In a continuous polymerisation process, 95% acrylonitrile and 6% methyl acrylate (400 parts) 0.25% aqueous solution of $K_2S_2O_8$ (600 parts), 0.50 % $Na_2S_2O_5$ solution (600 Parts) and 2N sulphuric acid (2.5 Parts) are fed into the reaction vessel at 52 deg C under nitrogen atmosphere giving a slurry with 67% polymer. The slurry is continuously withdrawn, filtered and washed till it is free from salts and dried.

Acrylonitrile is dry spun. The material is dissolved in dimethyl formamide, the solution contains 10-20 polymers. It is heated and extruded into a heated spinning cell. A heated evaporating medium such as air, nitrogen or steam moves counter current to the travel of filaments and removes the solvent to take it to a recovery unit. The filaments are hot stretched at 100 to 250 C depending on the time of contact in the hot zone, to several times their original length.

Properties of Acrylic Fibers

1. Acrylic has a warm and dry hand like wool. Its density is 1.17 g/cc as compared to 1.32 g/cc of wool. It is about 30% bulkier than wool. It has about 20% greater insulating power than wool.
2. Acrylic has a moisture regain of 1.5-2% at 65% RH and 70 deg F.
3. It has a tenacity of 5 gpd in dry state and 4-8 gpd in wet state.
4. Breaking elongation is 15% (both states)
5. It has a elastic recovery of 85% after 4% extension when the load is released immediately.
6. It has a good thermal stability. When exposed to temperatures above 175 deg C for prolonged periods some discolouration takes place.
7. Acrylic shrinks by about 1.5% when treated with boiling water for 30 min.
8. It has a good resistance to mineral acids. The resistance to weak alkalies is fairly good, while hot strong alkalies rapidly attack acrylic.
9. Moths, Mildew and insects do not attack Acrylic.
10. It has an outstanding stability towards commonly **bleaching** agents.

Uses of Acrylic Fiber

1. Knit Jersey, Sweater, blankets
2. Wrinkle resistant fabrics.
3. Pile and Fleece fabrics

4. Carpets and rugs.

Precaution of Acrylic Fiber

- Wash delicate items by hand in warm water. Static electricity may be reduced by using a fabric softener in every third or fourth washing. Gently squeeze out water, smooth or shake out garment and let dry on a non-rust hanger. (Sweaters, however, should be dried flat.)
- When machine washing, use warm water and add a fabric softener during the final rinse cycle.
- Machine dry at a low temperature setting. Remove garments from dryer as soon as tumbling cycle is completed.
- If ironing is required, use a moderately warm iron. (For specific instructions, refer to garment's sewn-in care label.)