Further classes of materials and applications

building & construction materials

carbon structures based materials

nanomaterials

apparel & textiles

paper



wood: see Biomass course prof. Zanetti/Tondi

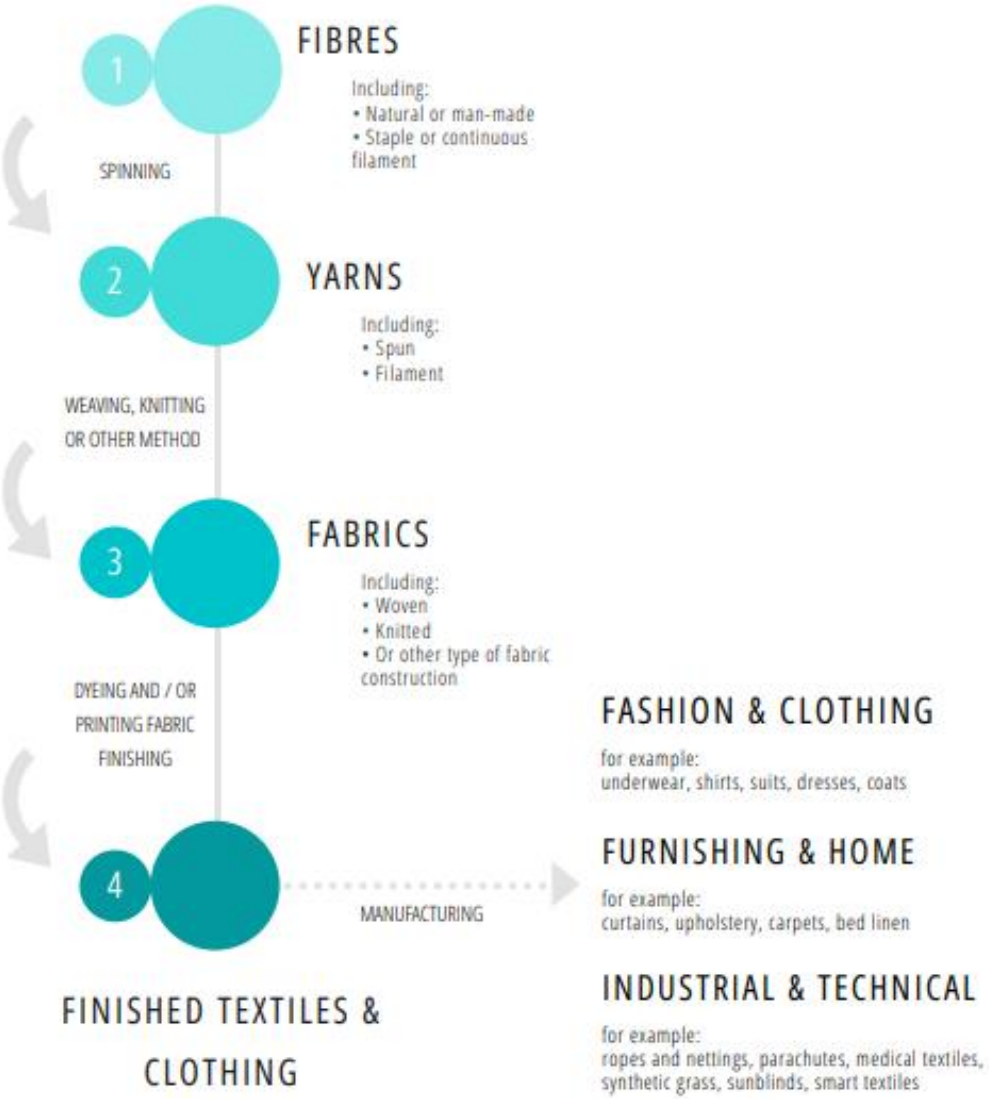
Textiles, apparel, fabrics



Translations in Italian

Tow	stoppa di lino
Fibre	fibra
Filament	filamento
Fabrics	tessuto
Hair	setola
Staple fibre	fibra in fiocco
Yarn	filo
Yarn making	filatura
Flax	lino
Apparel	abbigliamento
Weaving	tessitura
Knitting	intreccio
Bast	corteccia

Applications of textiles



Applications of textiles

- apparel and clothes
- furnishing and interior textile products
- technical textiles (functional products where aesthetic characteristics are not the main priority)
- industrial textiles and geotextiles (lightweight synthetic woven textiles, prized for their versatility, strength, and non-corrosive properties, developed for use in engineering, and for the manufacture of bridges, house building, and hybrid fabric structures)
- smart fabrics (can sense different environmental conditions and intelligent textiles or e-textiles can not only sense environmental changes, but can automatically respond to their surroundings or stimuli)
- medical textiles (products for the healthcare and hygiene sectors)

Textiles: the global context

- textiles are fundamental to our society, providing us with clothing, shoes, carpets, curtains, furniture, etc. for homes, offices and public buildings.
- the textiles industry employs millions of people worldwide, making it among the largest in the world and an important part of Europe manufacturing industry.
- however, textile production and consumption cause significant environmental, climate and social impacts by using resources, water, land and chemicals and emitting greenhouse gases and pollutants.
- consumption and production is highly globalised, involving millions of producers and billions of consumers across the world.
- In Europe, the sector employs 1.7 million people and Europeans consume on average 26 kg of textiles per person per year.
- the past decade, the price of clothes has fallen relative to inflation, and each item is used less than in the past.

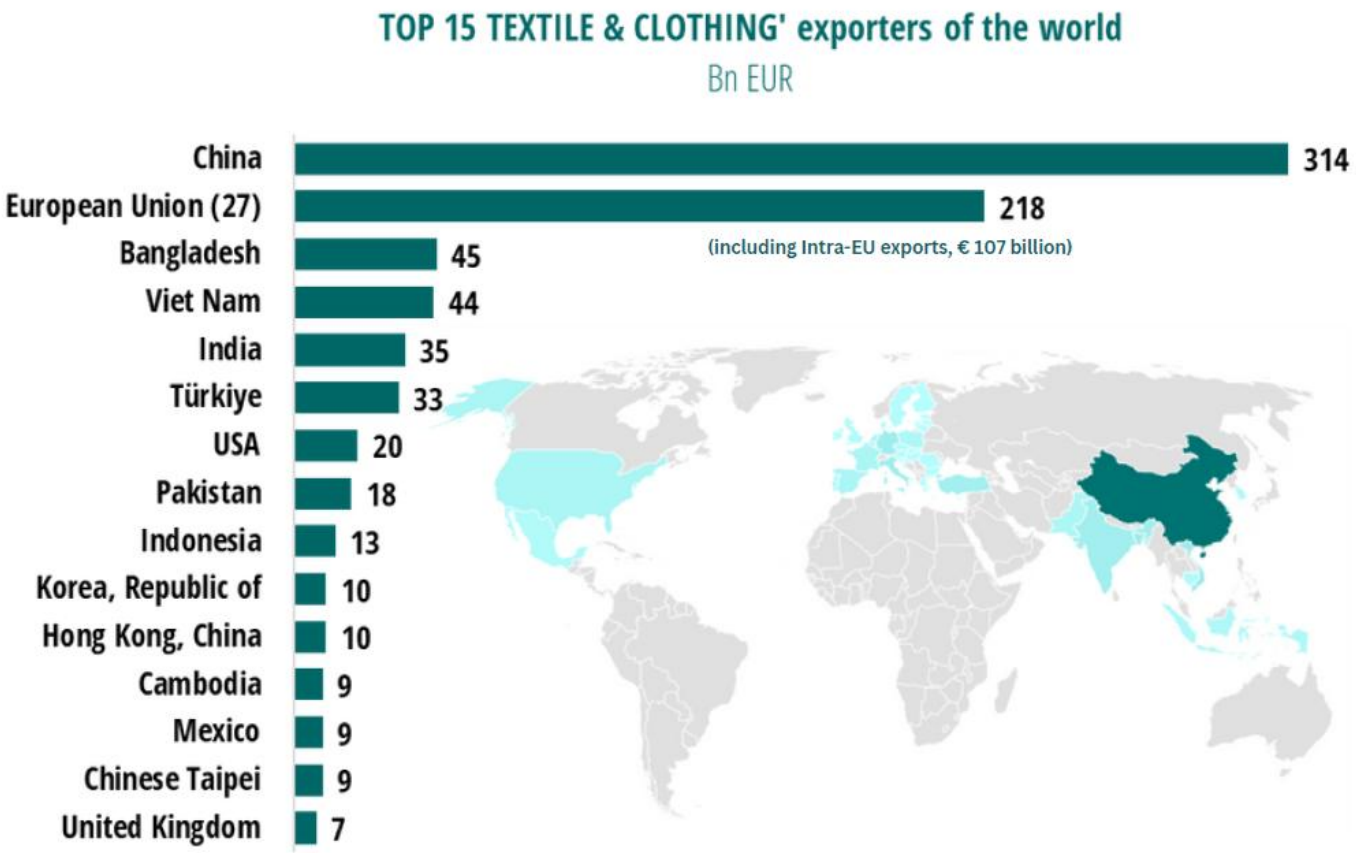
Textiles: the global context

- The textiles market is highly globalised, and millions of producers and billions of consumers across the world are involved in so-called linear value chains.
- These chains — from raw material extraction to production, transport, consumption and waste — include little or no reuse or recycling.
- Since 1975, the global production of textile fibres has almost tripled.
- Today, 60 % of textile fibres are synthetic.
- Polyester is the most commonly used fibre, produced from carbon-intensive processes requiring more than 70 million barrels of oil each year. The remaining fibres are mainly from cotton, which uses land and water.
- In 2014, the number of garments produced globally amounted to nearly 14 new items of clothing per person.

Textiles: the EU context

- About 5 % of household expenditure in the EU is spent on clothing and footwear, of which about 80 % is spent on clothes and 20 % on footwear.
- In the EU, there are around 143,000 companies in the textile (including wearing apparel) industry, employing 1.3-1.7 million people.
- In 2017, the EU produced 7.4 kg of textiles per person while consuming nearly 26 kg. The EU is therefore a net importer of textiles (mainly finished products from Asia).
- It has been estimated that in 2015 EU citizens bought 6.4 million tonnes of new clothing (12.66 kg per person).
- According to European Environment Agency (EEA) estimates, between 1996 and 2012, the amount of clothes bought per person in the EU increased by 40 %. At the same time, more than 30 % of clothes in Europeans' wardrobes have not been used for at least a year.
- Once discarded, over half the garments are not recycled, but end up in mixed household waste and are subsequently sent to incinerators or landfill.

Textiles: the global context



EU refers to EU27

Source: EURATEX calculations, based on EuroStat

Source of the picture: FACTS & KEY FIGURES 2024 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: the EU context (2021)



EU refers to EU27
Source: EURATEX calculations, based on EuroStat
Source of the picture: FACTS & KEY FIGURES 2022 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: the EU context (2023)



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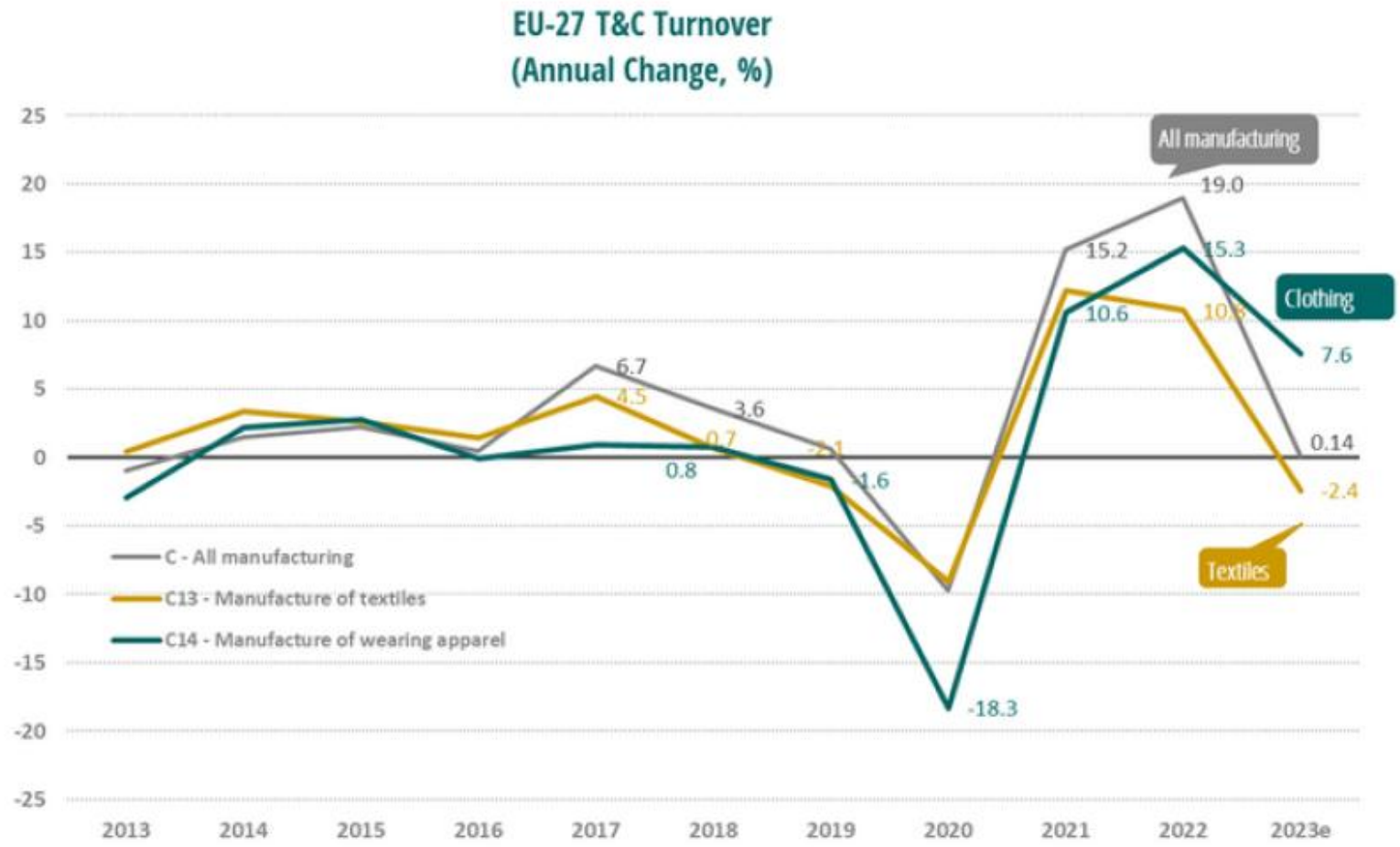
Source: EURATEX calculations, based on EuroStat
Source of the picture: FACTS & KEY FIGURES 2024 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: the EU context (2023)



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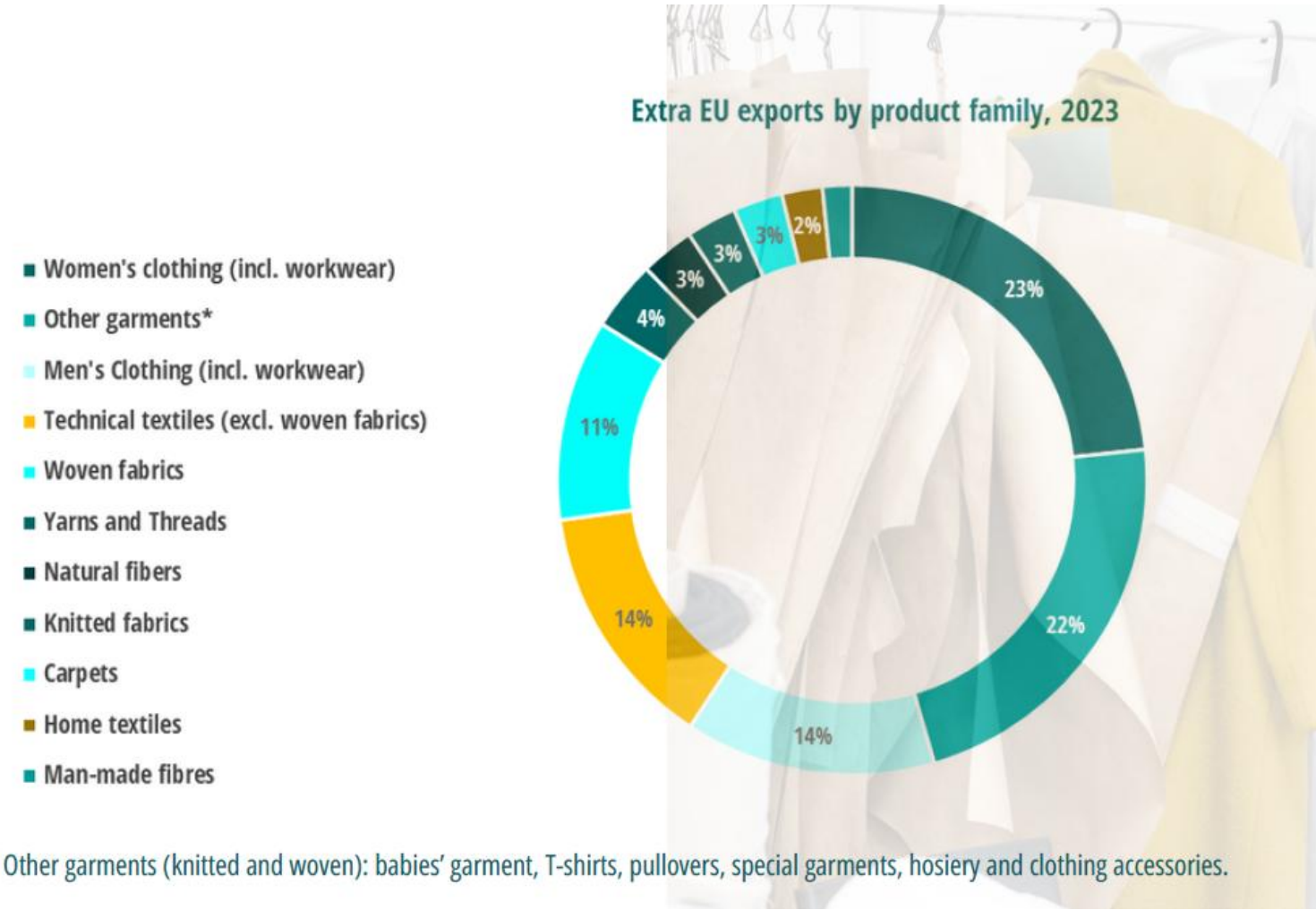
Textiles: the EU context (2023)



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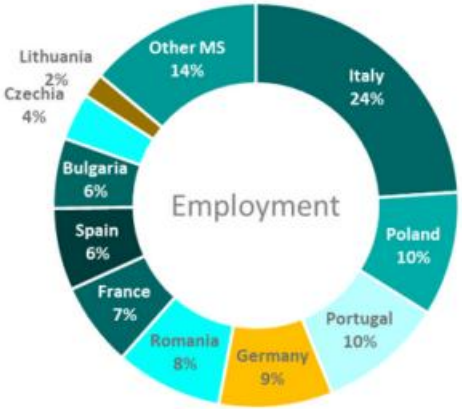
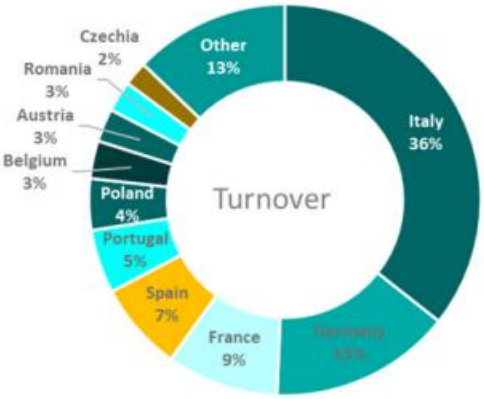
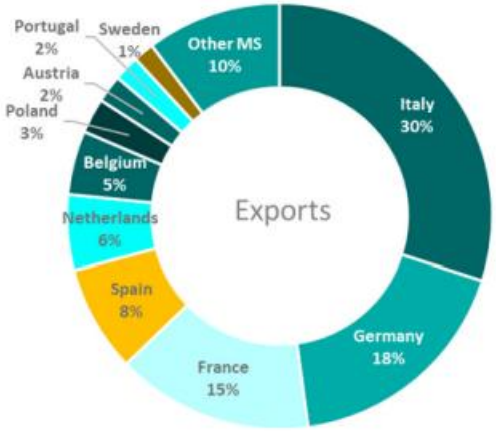
Textiles: the EU context









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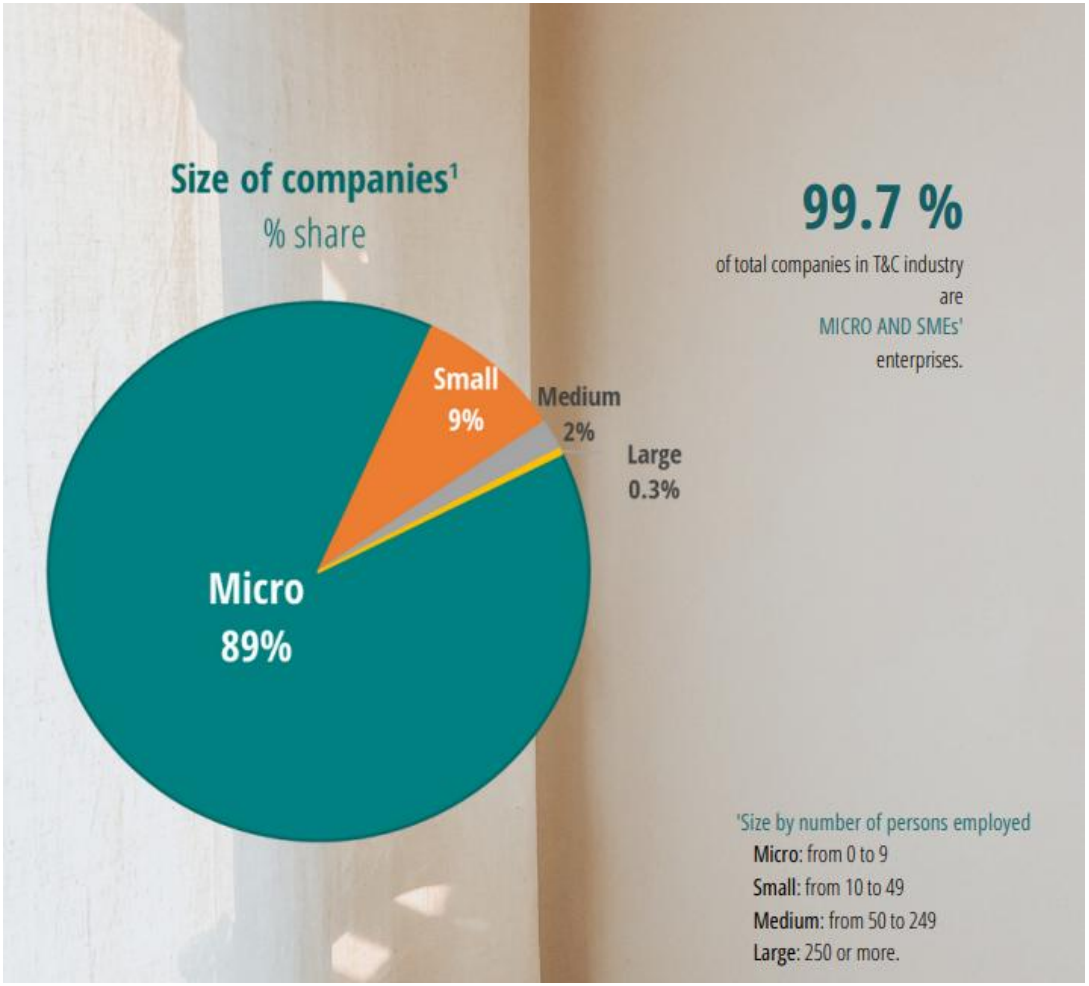
Source: EURATEX calculations, based on EuroStat

Source of the picture: FACTS & KEY FIGURES 2024 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: size of EU companies

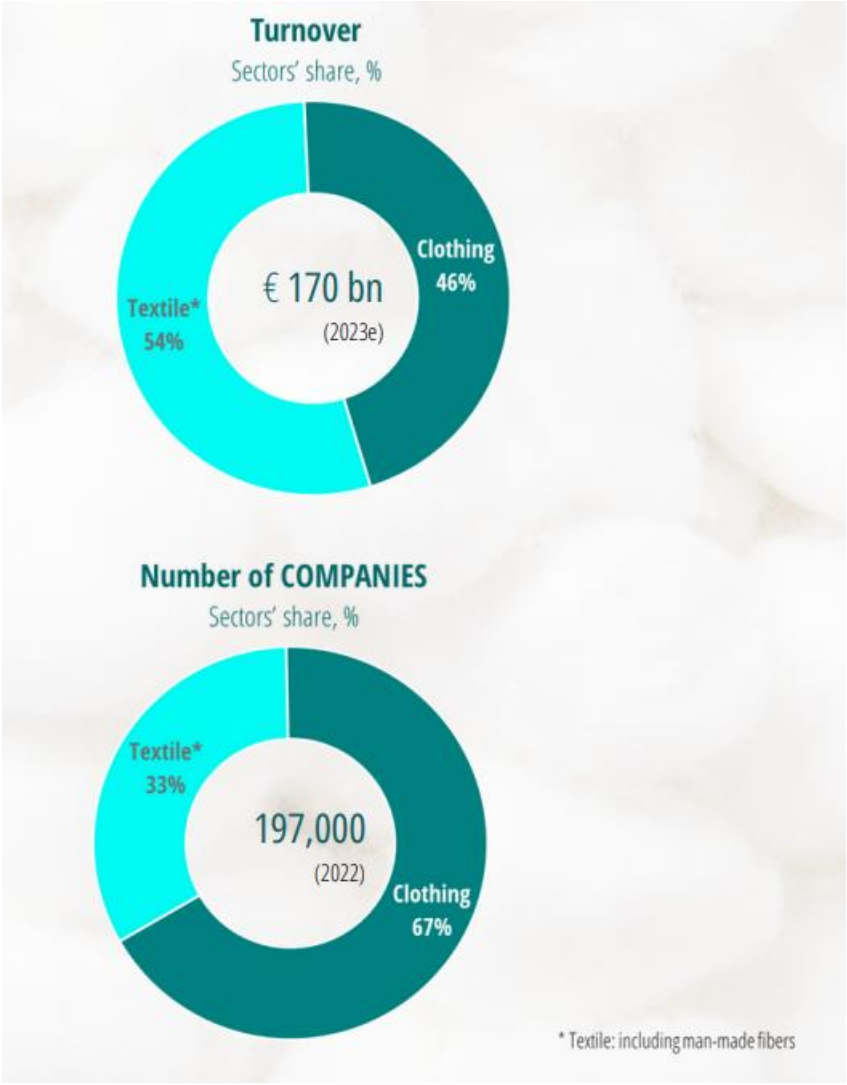


EU refers to EU27

Source: EURATEX calculations, based on EuroStat

Source of the picture: FACTS & KEY FIGURES 2024 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: turnover of EU companies



EU refers to EU27

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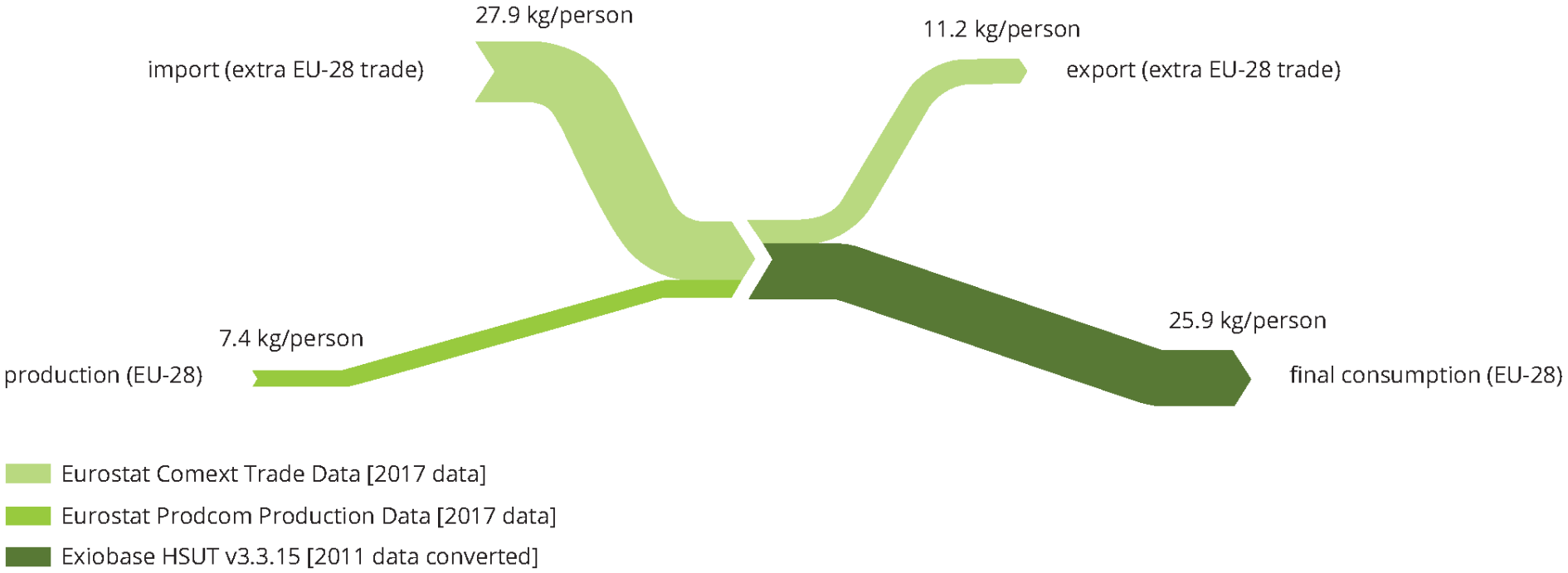
Textiles: the EU context

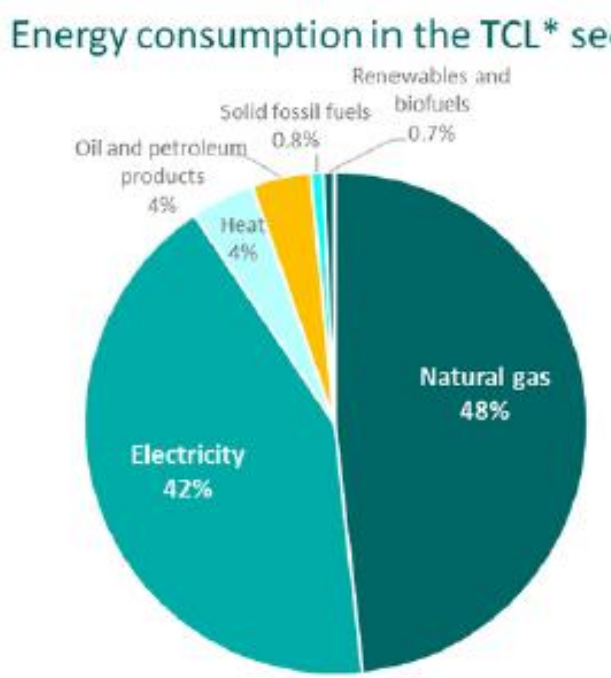


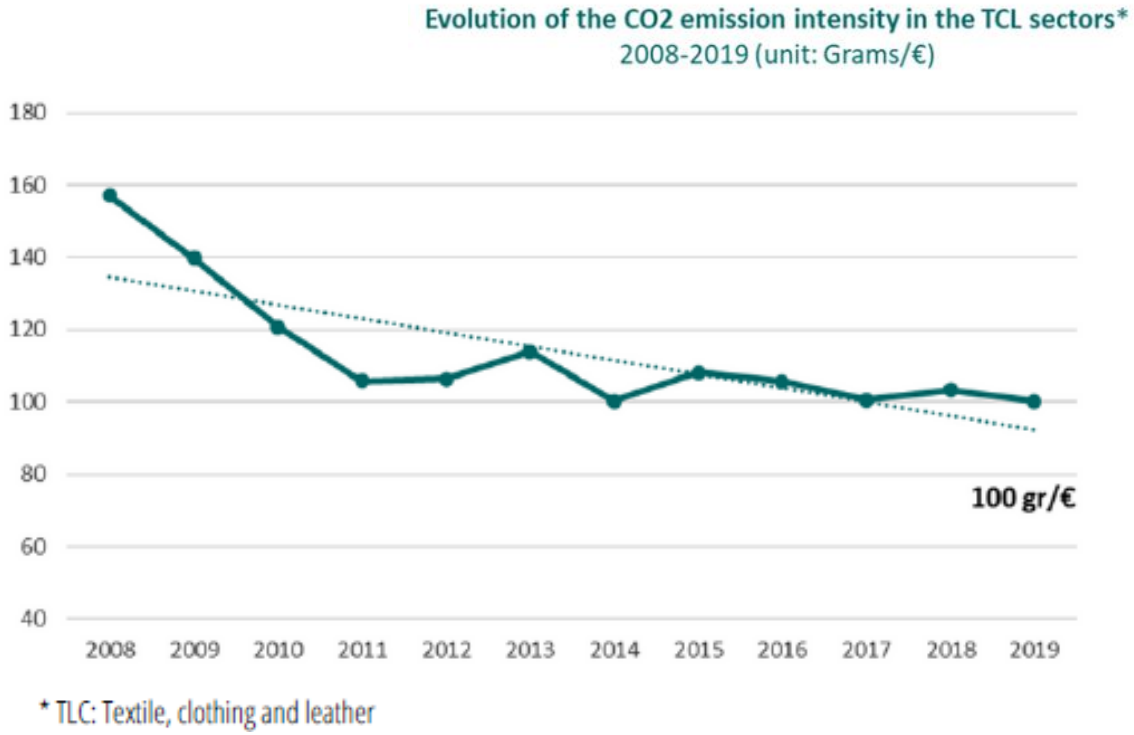
In 2017, the EU produced 7.4 kg and imported 27.9 kg of textiles per person, while exporting 11.2 kg and consuming nearly 26 kg per person. This implies that the EU is a net importer of textiles.

Data is provided in kilogram and a quantity unit. Quantity data is converted to mass data via the quantity conversion factors to kilogram from Eurostat EW-MFA background data.

Source of figure: https://www.eea.europa.eu/data-and-maps/figures/import-export-production-and-consumption

Textiles: the energy footprint

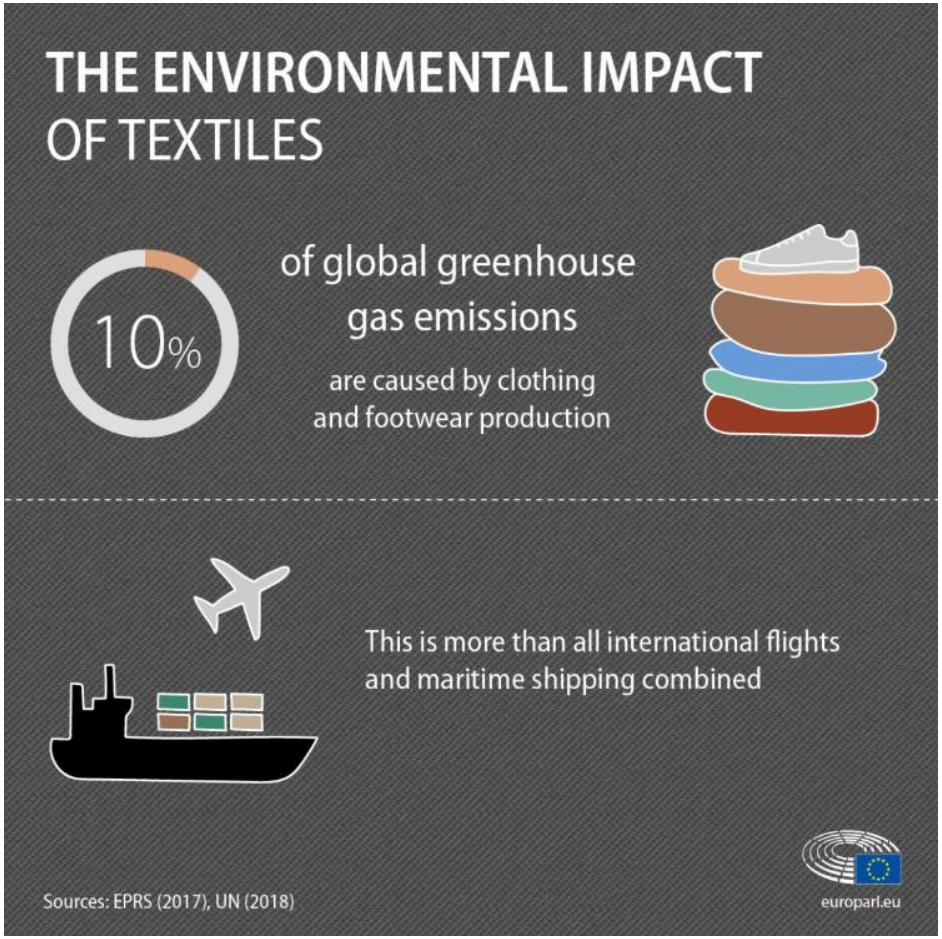




Source: EuroStat

Source of the picture: FACTS & KEY FIGURES 2022 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles: the carbom footprint



- It is estimated that the fashion industry is responsible for 10% of global carbon emissions – more than international flights and maritime shipping combined.
- According to the European Environment Agency, textile purchases in the EU in 2017 generated about 654 kg of CO_2 emissions per person.

Source: European Parliament
Source of the picture:
https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic

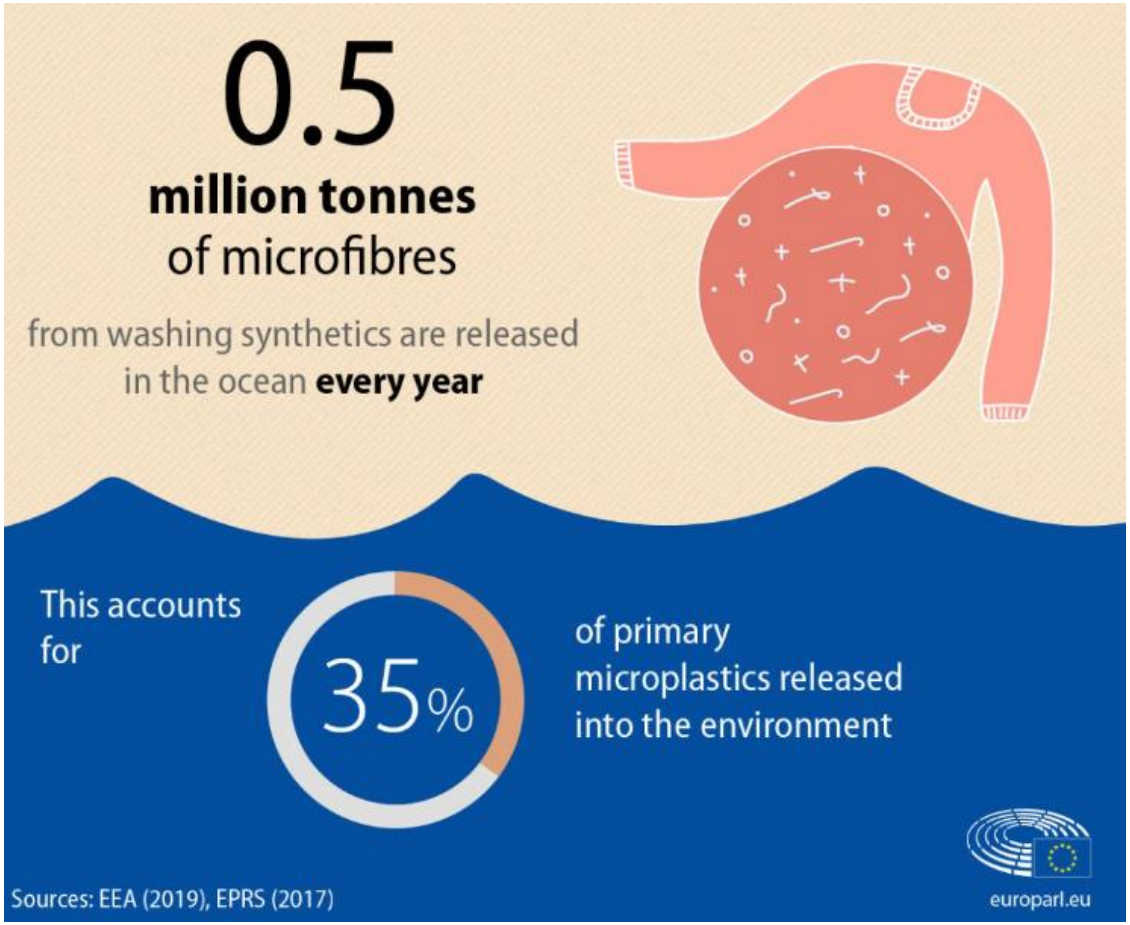
Textiles: the water footprint



- It takes a lot of water to produce textile, plus land to grow cotton and other fibres.
- It is estimated that the global textile and clothing industry used 79 billion cubic metres of water in 2015, while the needs of the EU's whole economy amounted to 266 billion cubic metres in 2017.
- To make a single cotton t-shirt, 2,700 litres of fresh water are required according to estimates, enough to meet one person's drinking needs for 2.5 years.

Source: European Parliament
Source of the picture:
https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic

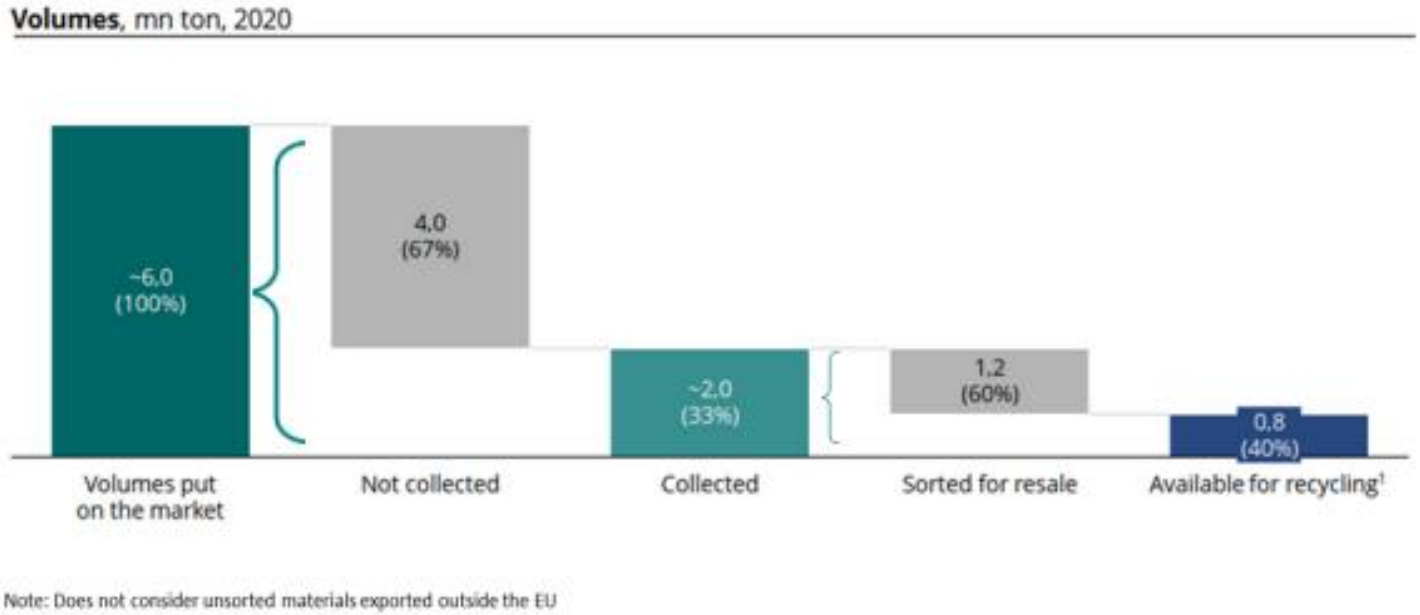
Textiles: the impact on environment



- Textile production is estimated to be responsible for about 20% of global clean **water pollution** from dyeing and finishing products.
- Washing synthetics releases an estimated **0.5 million tonnes of microfibres** into the ocean a year.
- Laundering synthetic clothes accounts for 35% of primary microplastics released into the environment. A single laundry load of polyester clothes can discharge 700,000 microplastic fibres that can end up in the food chain.

Source: European Parliament
Source of the picture:
https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic

Textiles and circular economy



Post consumer household waste

is the #1 waste stream by size with ~2 mn ton (33%) collected volumes and ~0.8 mn ton (40%) available to recycling today



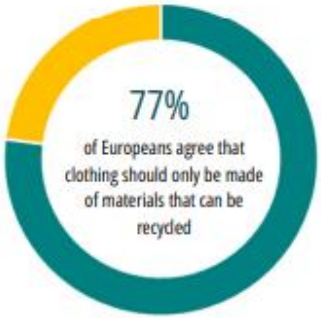
Source: EURATEX ReHubs TES Study, 2022

Source of the picture: FACTS & KEY FIGURES 2022 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Textiles and circular economy



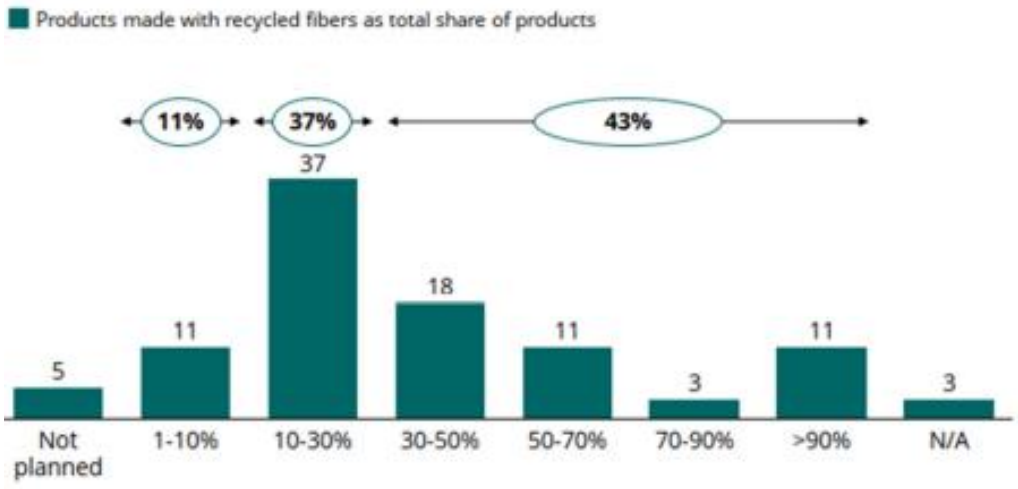
Source: European Commission, Eurobarometer, 2020
80% of respondents expressed a desire for clothing lasting longer on the market



Survey based on interviews to more than 27,000 people in the EU Member States



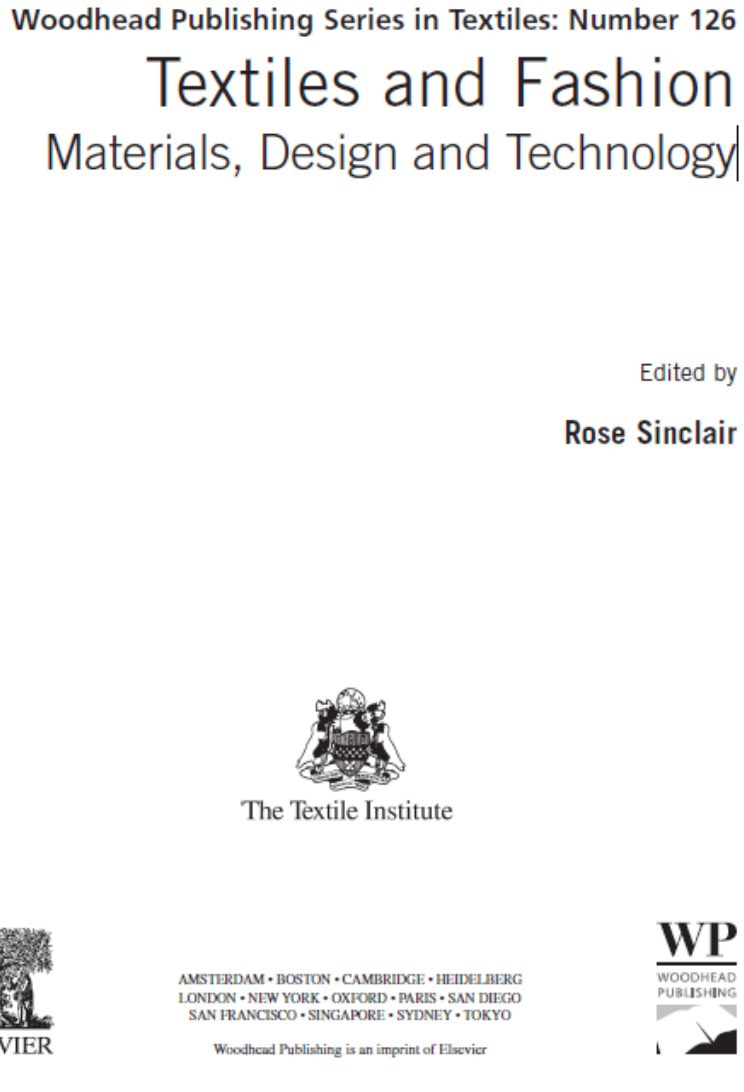
43% of retail brands' respondents expect that recycled fibers will be included in more than 30% of their products by 2025.



Note: Survey of European brands n=38

Source: EURATEX ReHubs TES Study, 2022
Source of the picture: FACTS & KEY FIGURES 2022 OF THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Bibliographic source of materials



Source of texts and figures
(Sistema Bibliotecario di Ateneo)

Basics of textiles chemistry

Fibres: basis for all textile products and can either be natural (natural fibres) or man-made (manufactured or man-made regenerated).

Within these two types or groups, there are two main kinds of fibres:

- Fibres of indefinite (very great) length, called filaments
- Fibres of much shorter length, called staple fibres

Filaments: generally combined and twisted to form yarns (filo)
Staple fibres: spun to create yarns. Yarns are then typically woven or knitted into fabrics

Fibre defintions:

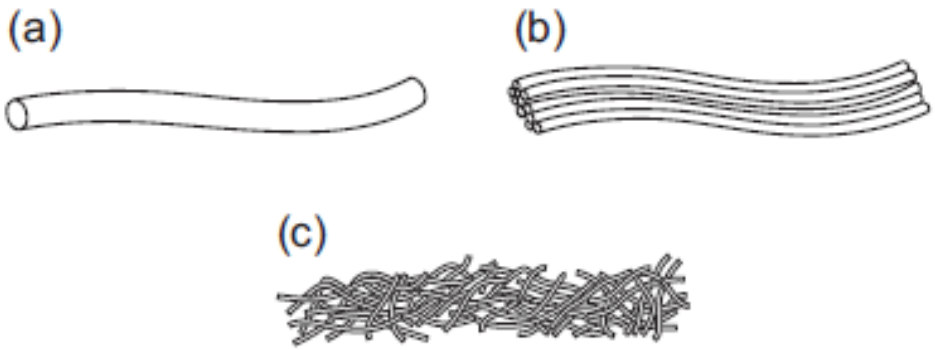
1. generic term for any one of the various types of matter that form the basic element of a textile, and it is characterised by having a length at least 100 times its diameter (ASTM);
2. textile raw material, generally characterised by flexibility, fineness and high ratio of length to thickness (Textile Institute)

Note: a small piece of lightweight fabric may contain over 100 million fibres

Common features of fibres

- The diameter of a fibre is small relative to its length
- Properties of 'flexibility' and 'fineness' (a way of describing the thickness of a fibre)

Types and processing of yarns



Types of yarn: (a) monofilament; (b) multifilament; (c) staple/spun.

Yarn fineness, thickness or size is characterised by two main types of numbering systems:

- Direct yarn numbering system: Based on weight or mass of a fixed length of yarn (mass per unit length).
- Indirect yarn numbering system: Based on the length of yarn of a fixed weight (length per unit mass).

Both systems provide a measure of the fineness (or thickness) of the yarn, which is important for its appropriate application in fabric construction techniques such as knitting and weaving. Once yarns are processed, they then need to be assembled in some way to produce a fabric.

Source of thr picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

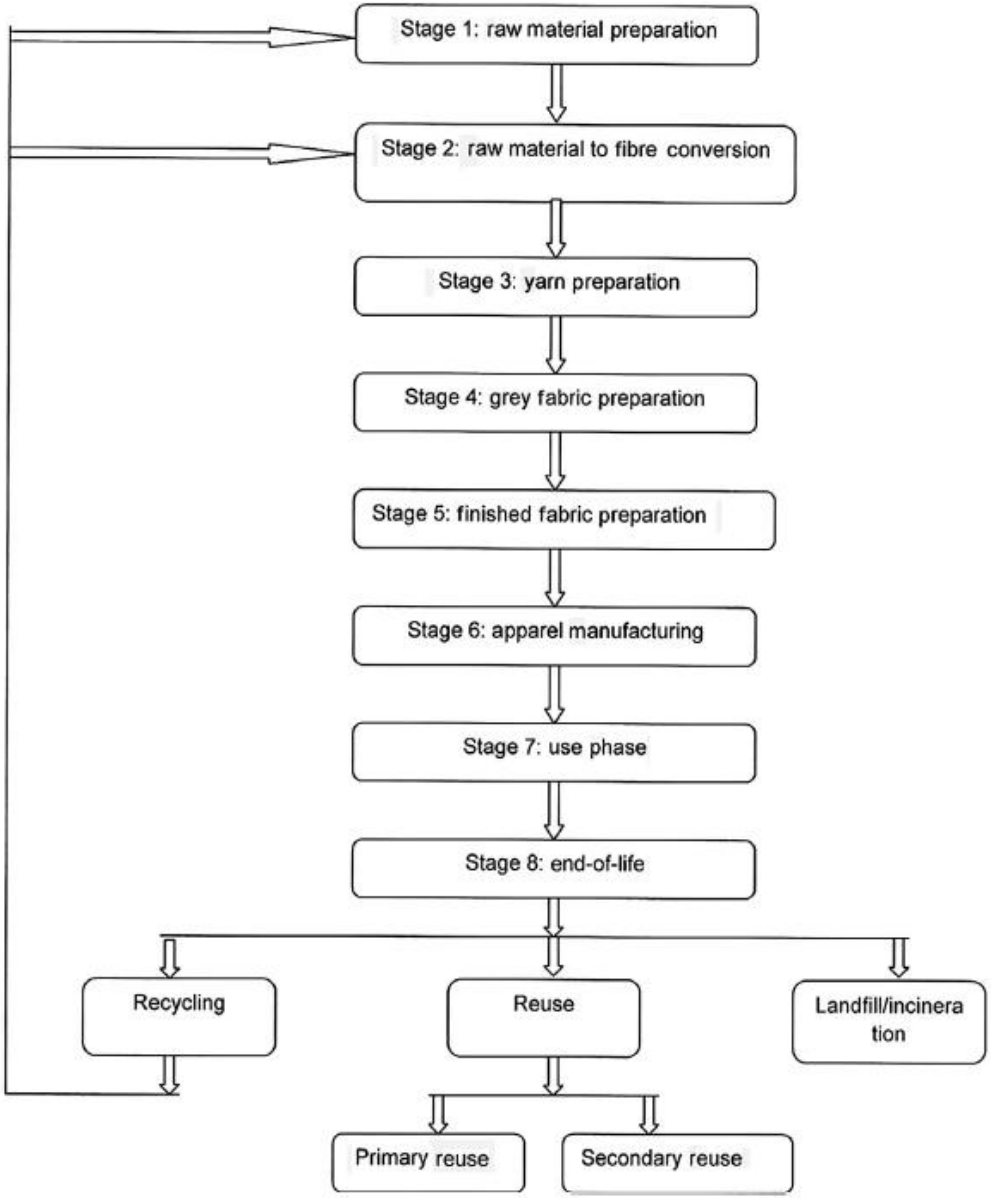
Textiles: blending

Individual types of fibres can be used on their own or combined with other types of fibres to enhance the quality of the end-product. The process for combining fibres is known as blending.

There are several reasons why different fibres may be blended or mixed:

- To compensate for weaker attributes or properties of one type of fibre
- To improve the performance of the resulting yarn or fabric
- To improve or provide a different appearance
- To improve the efficiency of processing, especially of spinning, weaving and knitting
- To reduce costs

Apparel production



Key stages in the apparel life cycle

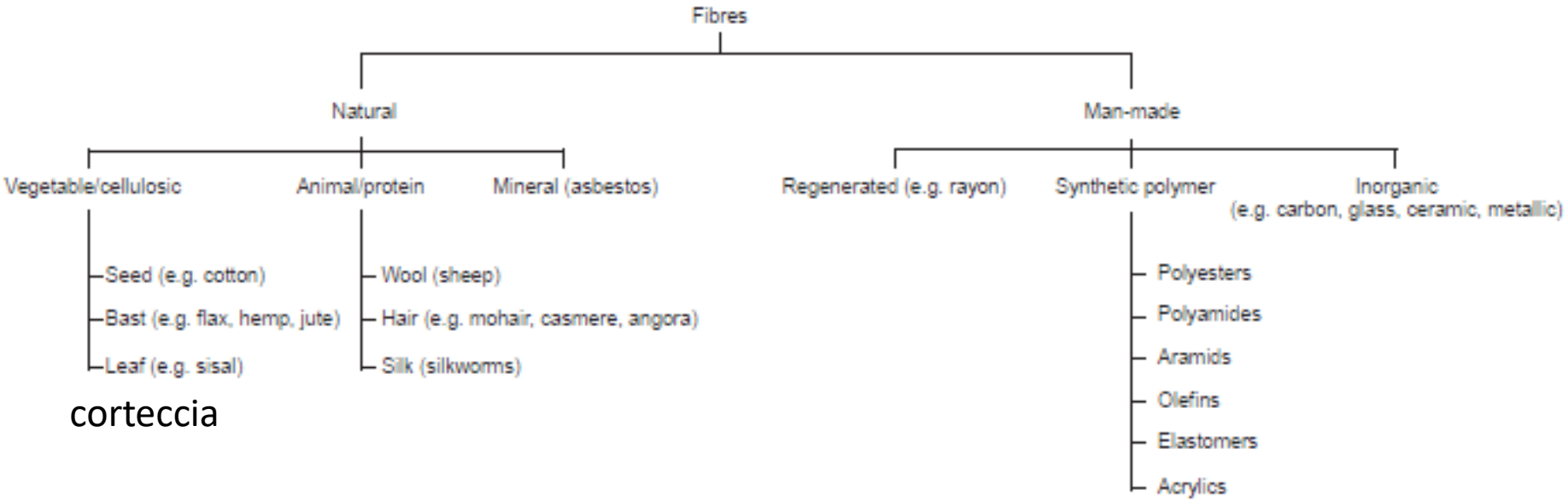
Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Classification of fibers

There are three basic types of fibre groups:

- Natural fibres
- Regenerated fibres
- Synthetic fibres

} man-made or manufactured fibres



corteccia

Source of thr picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Natural fibres

- Vegetable or cellulosic fibres
- Animal or protein fibres
- Inorganic fibres (e.g. asbestos): CARCINOGENIC



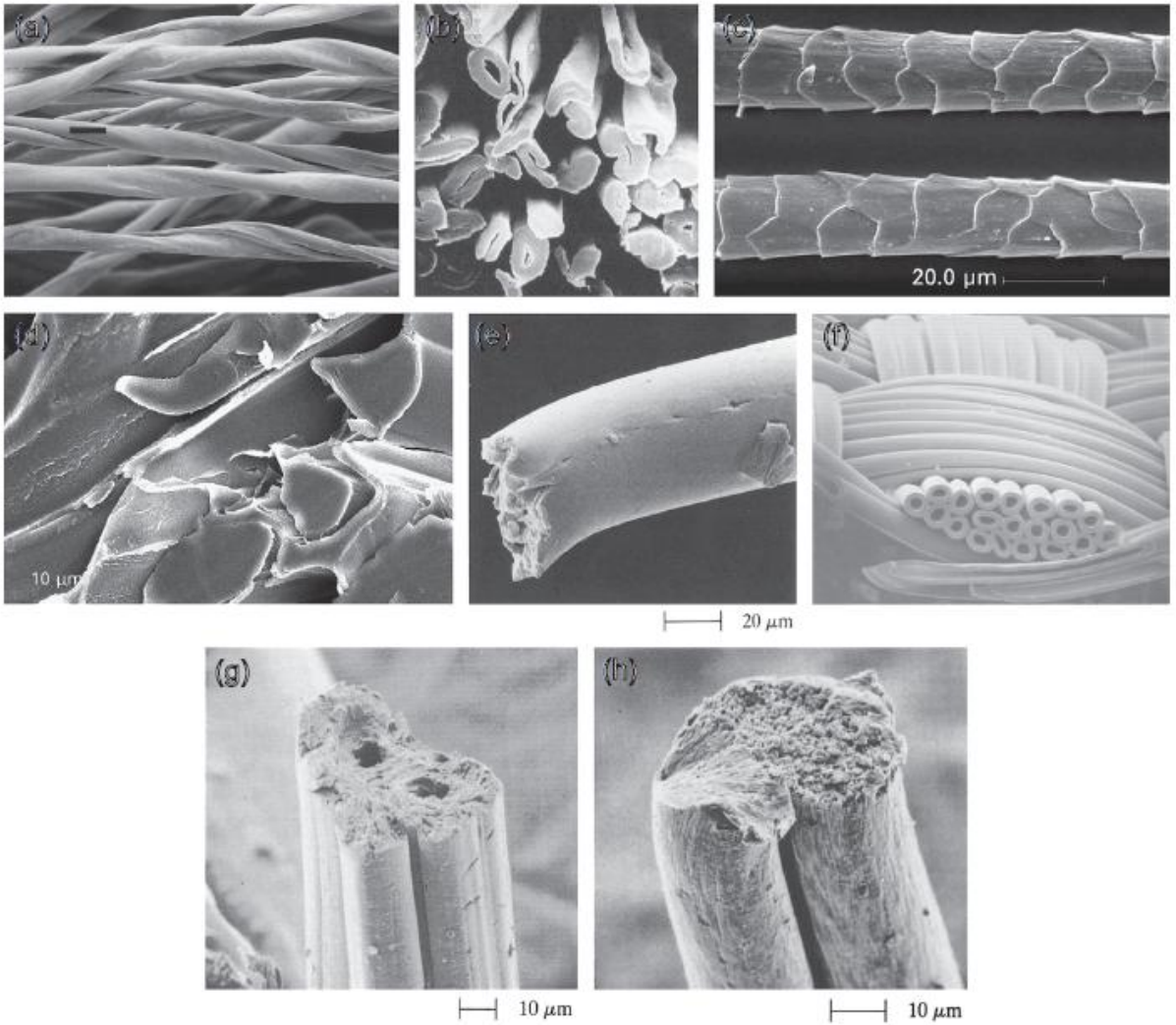
Animal (protein)-based fibres can be divided into:

- Wool (from sheep)
- Hair (e.g. from goats, such as mohair and cashmere; or from rabbits, such as angora)
- Silk (from silkworms)

Vegetable fibres can be divided into:

- Seed (e.g. cotton)
- Bast (fibres derived from the outer, or bast, layers of plant stems, e.g. flax, hemp and jute)
- Leaf (e.g. sisal)

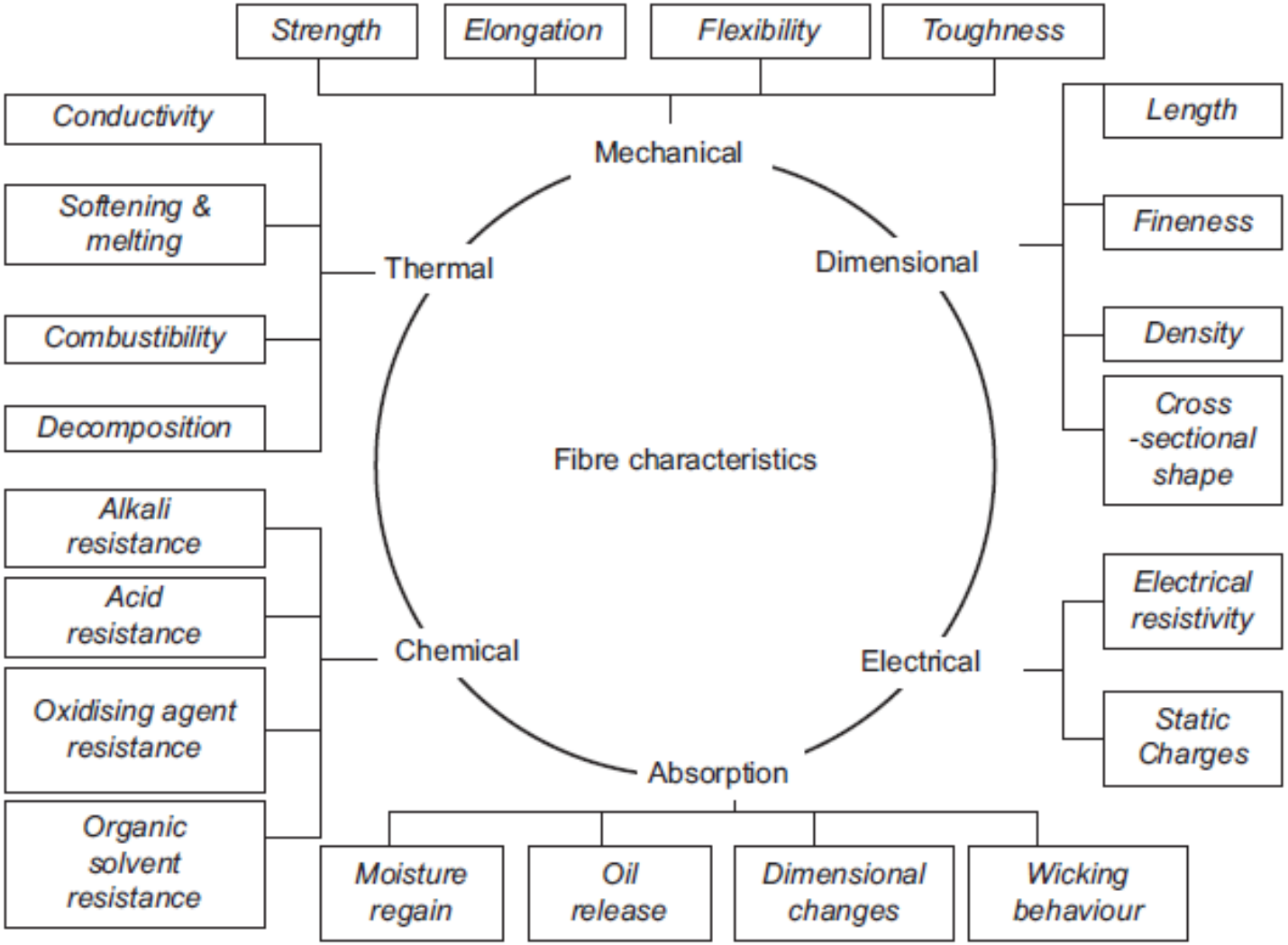
Fibres morphology



SEM images of a range of fibres: (a) longitudinal view of cotton fibres showing their characteristic twist; (b) view of cross-sections of cotton fibres showing their characteristic dog-bone shape; (c) wool fibres showing scales on the fibre surface; (d) silk fibres showing a trilobal cross-section; (e) nylon fibre with round cross-section; (f) nylon fibres with hollow cross-sections in a woven fabrics; (g) viscose rayon fibre with a multilobal cross-section; (h) acrylic fibre showing a dog-bone shaped cross-section.

Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Fibres properties



Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Fibres properties

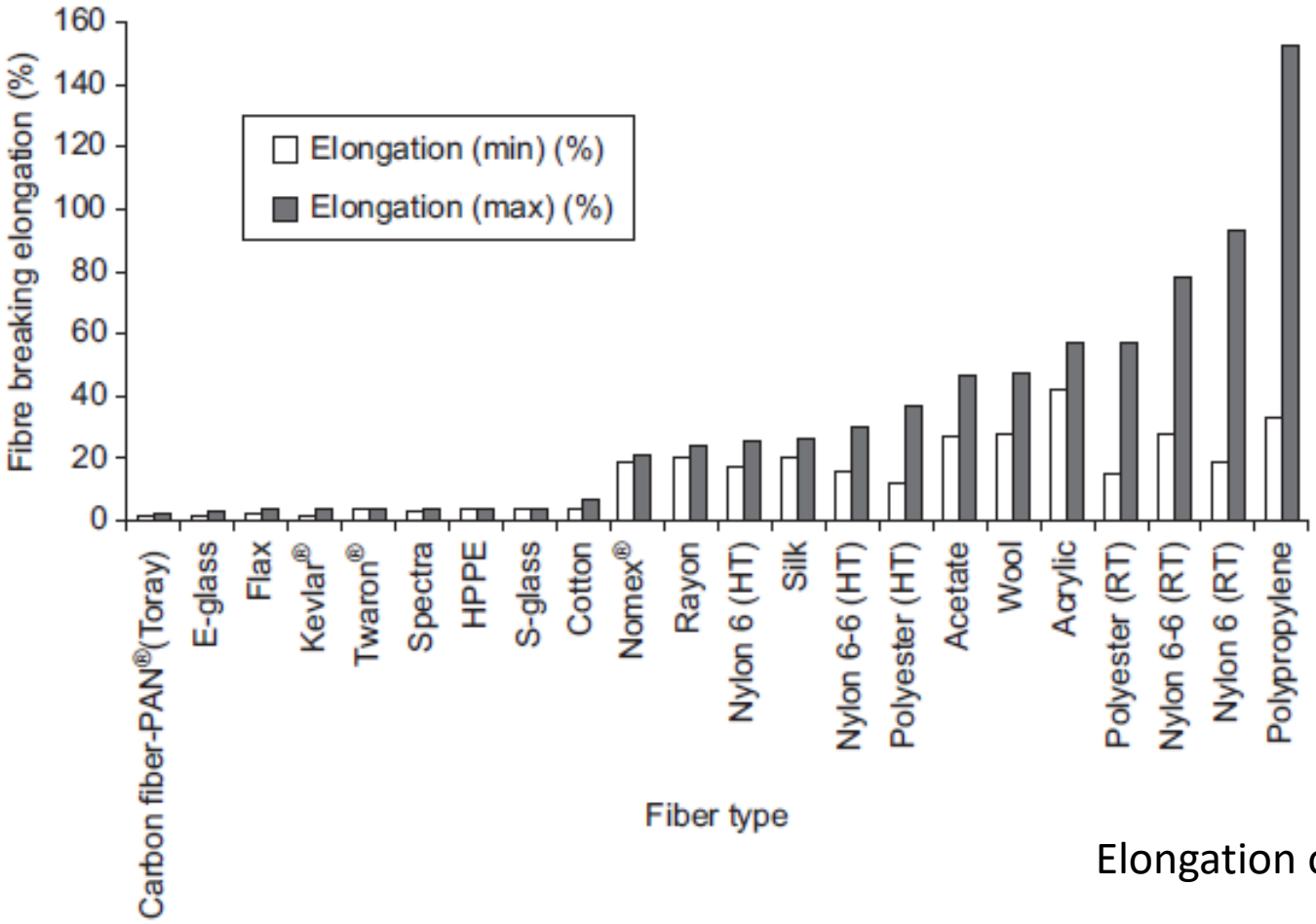
- Length, shape and diameter (fineness)
- Colour and lustre
- Strength and flexibility
- Abrasion resistance
- Handle (or feel), e.g. soft (cashmere), harsh (coir), crisp (linen), elastic (Lycra)
- Moisture absorbency
- Electrical properties
- Important chemical properties, including fire resistance
- Chemical reactivity and resistance (e.g. resistance to acids, alkalis, solvents, light, etc.)
- Antimicrobial properties

Moisture regain

The way fibres respond to moisture is both an important property in itself and one that has a major influence on other properties. 'Moisture regain' is the ability of a dry fibre to absorb moisture under set conditions of humidity, and can be determined by using the following equation:

$$\text{Regain } (\%) = \frac{\text{Mass of conditioned specimen} - \text{Mass of dry specimen}}{\text{Mass of dry specimen}} \times 100$$

Fibres properties



Elongation of various fibres

Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Manufactured fibres

Manufactured, or man-made, fibres can be classified as:

- Synthetic polymers, e.g. polyester, nylon (polyamide), acrylic, lycra
- Regenerated, e.g. viscose, modal, acetate
- Inorganic, e.g. carbon, glass, ceramic and metallic fibres

Manufactured fibres

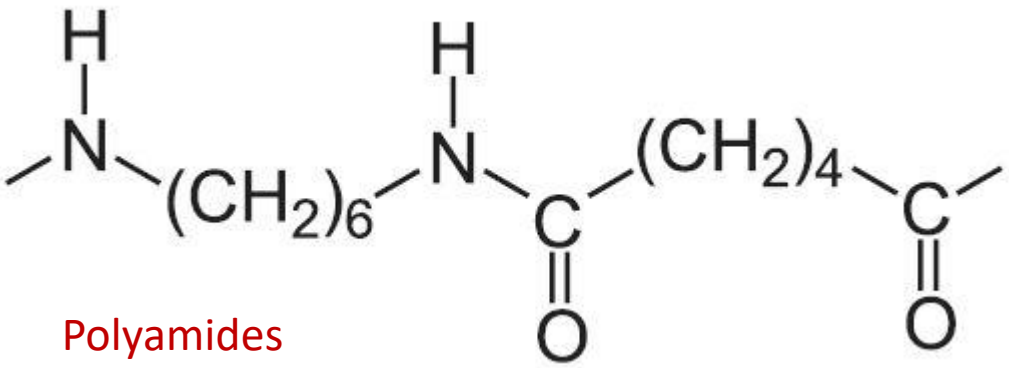
Manufactured, or man-made, fibres can be classified as:

- Synthetic polymers, e.g. polyester, nylon (polyamide), acrylic, lycra
- Regenerated, e.g. viscose, modal, acetate
- Inorganic, e.g. carbon, glass, ceramic and metallic fibres

Polymer-based fibres

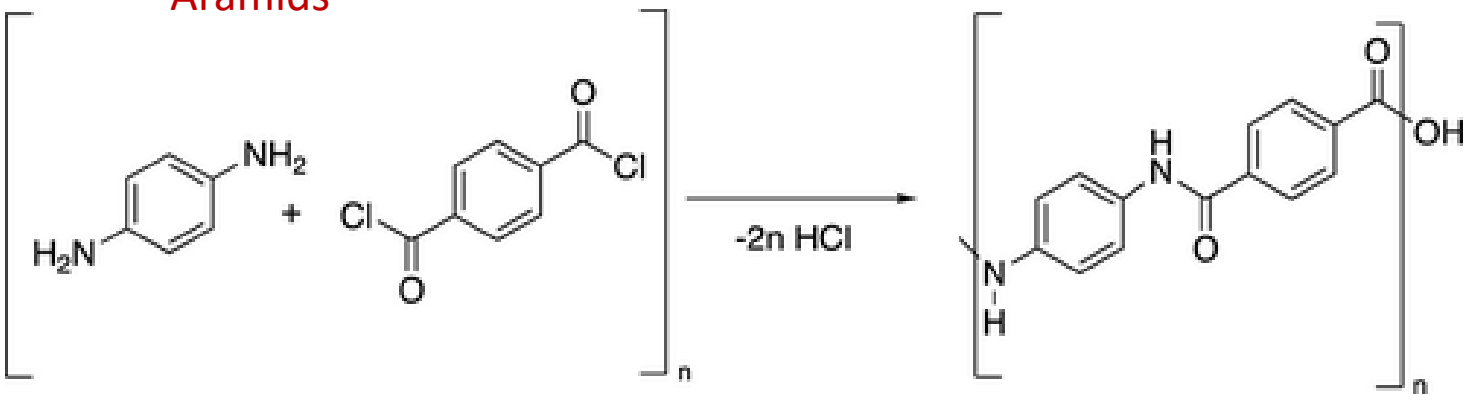
- Polyesters: Defined as any long-chain synthetic polymer composed of at least 85% by weight of an ester of a substituted aromatic carboxylic acid, including, but not restricted to, substituted terephthalate units and parasubstituted hydroxybenzoate units (e.g. PET, PTT, PBT, PEN, PLA, high-modulus high-tenacity (HM-HT) fibres).
- Polyamides: Defined as polymers having in the chain recurring amide groups, at least 85% of which are attached to aliphatic or cyclo-aliphatic groups (e.g. nylon).
- Aramids: These are defined as polyamides, where each amide group is formed by the reaction of an amino group of one molecule with a carboxyl group of another (e.g. Kevlar, Nomex).
- Olefins: Defined as manufactured fibres in which the basic unit is any long-chain synthetic polymer composed of at least 85% by weight of ethylene, propylene or other olefin units (e.g. polypropylene, polyethylene).
- Elastomers: Defined as materials that, at room temperature, can be stretched repeatedly to at least twice their original length, and upon immediate release will return to approximately the original length (e.g. polyurethane, Lycra, Spandex).
- Acrylics: Defined as manufactured fibres in which the basic substance is a long-chain synthetic polymer composed of at least 85% by weight of acrylonitrile units.

Polymer-based fibres



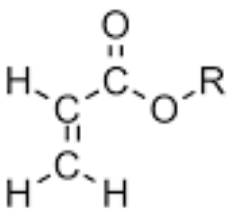
Polyamides

Aramids

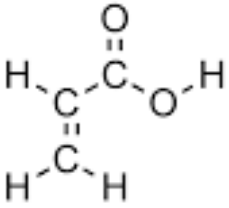


Synthesis of Kevlar by the Polymerization of Paraphenylenediamine and Terephthaloyl Chloride [https://pubs.acs.org/doi/10.1021/acsomega.2c03059]

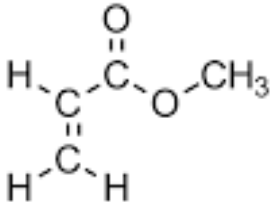
Polymer-based fibres



acrylates
R = alkyl ester
R = H acid

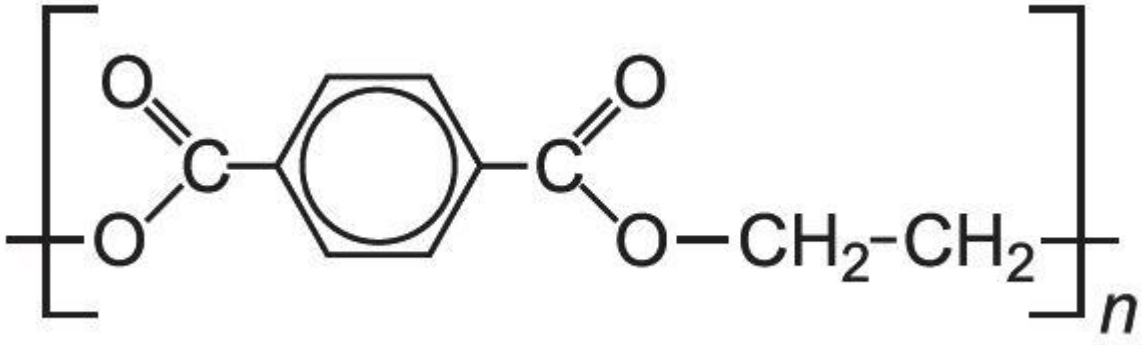


acrylic acid



methyl acrylate

Acrylates



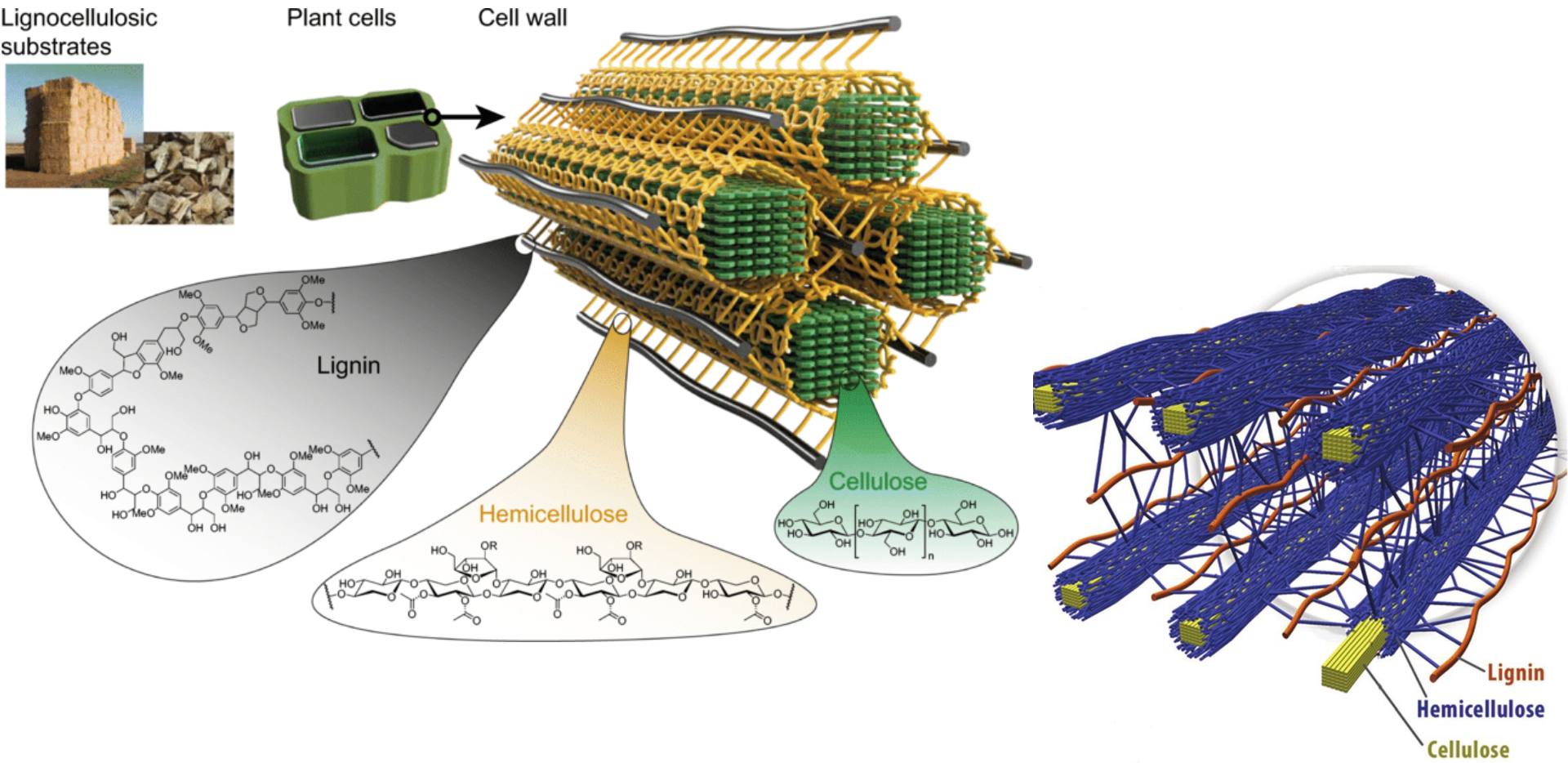
Polyesters

Manufactured fibres

Manufactured, or man-made, fibres can be classified as:

- Synthetic polymers, e.g. polyester, nylon (polyamide), acrylic, lycra
- Regenerated, e.g. viscose, modal, acetate
- Inorganic, e.g. carbon, glass, ceramic and metallic fibres

Lignin, cellulose and hemicellulose



Representation of lignin, cellulose, and hemicellulose structures.
Source of the picture: Brandt, Agnieszka & Gräsvik, John & Hallett, Jason & Welton, Tom. (2013). Deconstruction of lignocellulosic biomass with ionic liquids. Green Chem.. 15. 550-583. 10.1039/C2GC36364J.

Lignin, cellulose and hemicellulose

Lignocellulose is the structural component of plant cell walls. It consists of tubular bundles of cellulose surrounded and inter-connected by hemicellulose and ultimately by lignin.

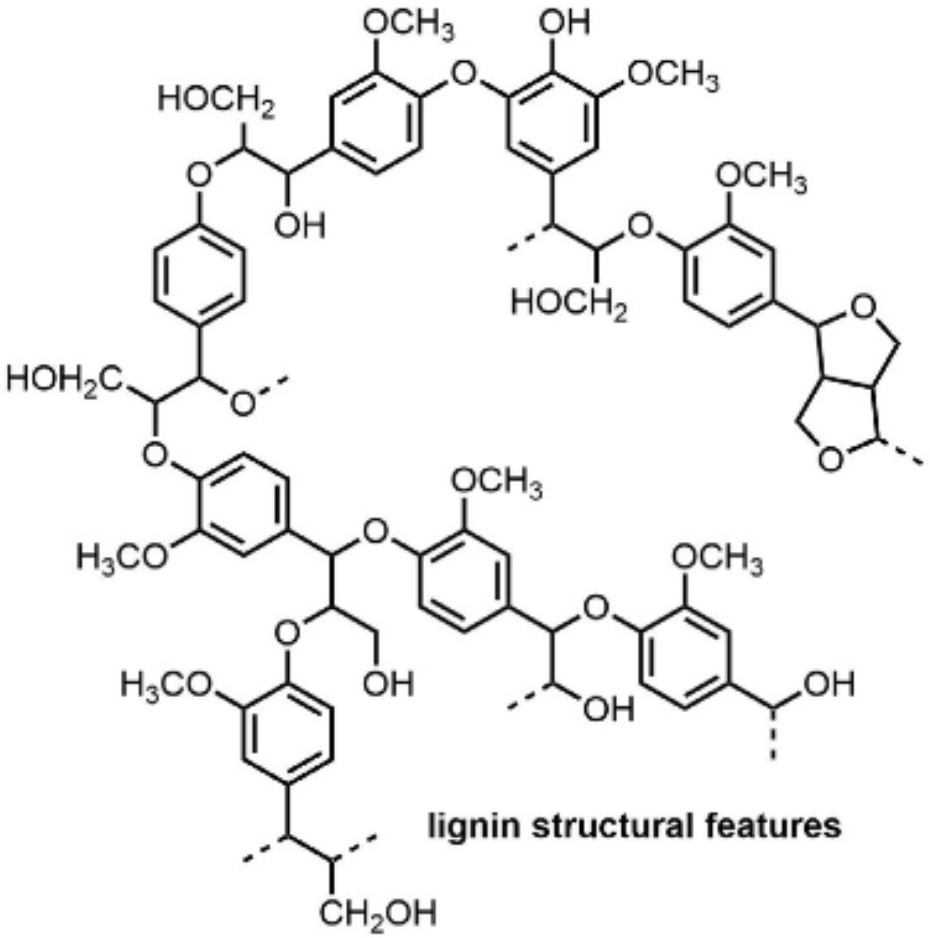
Cellulose is a polysaccharide composed of a linear chain of β-1,4 linked d-glucose units with a degree of polymerization ranged from several hundreds to over ten thousands, which is the most abundant organic polymer on the earth.

Hemicelluloses are a mixture of highly branched low-molecular-weight homo- and heteropolymers (comprised of anhydro-β-(1-4)-d-xylopyranose, glucopyranose, mannopyranose, and galactopyranose units). Hemicellulose plays an important role in fiber-to-fiber bonding in papermaking. It is similar to cellulose in composition and function.

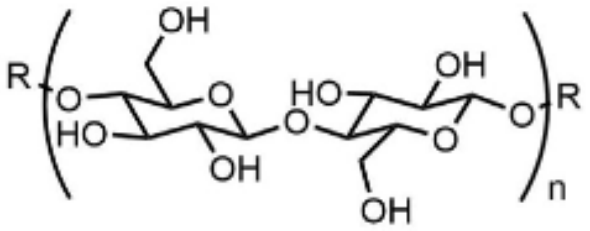
Lignin is the encrusting material in which the cellulose microfibrils are embedded. It is the second most abundant terrestrial organic material after cellulose, making up typically 15–40% wt. of the woody tissue mass in vascular plants. It is a basic 3D component that reinforces and provides rigidity and shape to plant tissues, is also considered as an important defense mechanism to microbial attack, and can prevent water destroys the polysaccharide-protein matrix of plant cells.

Source: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/cellulose

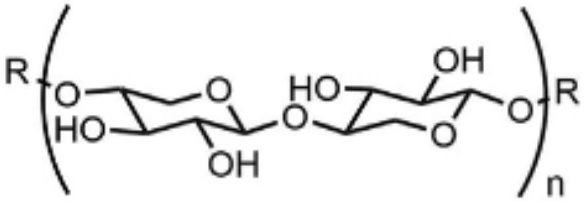
Lignin, cellulose and hemicellulose



lignin structural features



cellulose



hemicellulose example
(xylan)

Representation of lignin, cellulose, and hemicellulose chemical structures.
Source of picture: M.Z.H. Kazmi et al., Tetrahedron 75 (2019) 1465e14701466

Regenerated cellulose (rayon)

- Regenerated cellulose fiber is a type of manufactured or man-made fiber that uses cellulose (mainly from wood or plant fibers) as a raw material. Regenerated cellulose fiber was the first man-made fiber applied in the textile and apparel industry and in the early days of its development, during the 1850s, had the popular name “artificial silk” as manufacturers hoped to produce an artificial fiber to replace silk.

- In 1924, the generic name Rayon was adopted by the U.S. Department of Commerce and various industrial associations to label regenerated cellulose fiber. “Ray-” (ray of light) implied fiber brightness and “-on” represented the fibers cotton-like structure.

- There are four major types of regenerated cellulose or cellulose-derived fiber:
  - viscose
  - lyocell
  - cupro
  - acetate

Rayon Viscosa: A manufactured fiber composed of regenerated cellulose, as well as manufactured fibers composed of regenerated cellulose in which substituents have replaced not more than 15 percent of the hydrogens of the hydroxyl groups

Regenerated cellulose fibers

Classification of these different regenerated cellulose fibers is based on fiber production method:

Viscose rayon fiber is produced by making alkali cellulose and reacting it with carbon disulfide to form cellulose xanthate. Viscose rayon is the dominant regenerated cellulose fiber accounting for more than 93% of the regenerated-cellulose and cellulose-derived fiber market.

Lyocell rayon fiber is produced by directly dissolving cellulose into the solvent N-methylmorpholine-N-oxide (NMMO). Lyocell rayon is a new generation of regenerated cellulose fiber with environmentally friendly processing and improved fiber properties. Current production of lyocell fiber however is still limited, at less than 5% of the rayon fiber market.

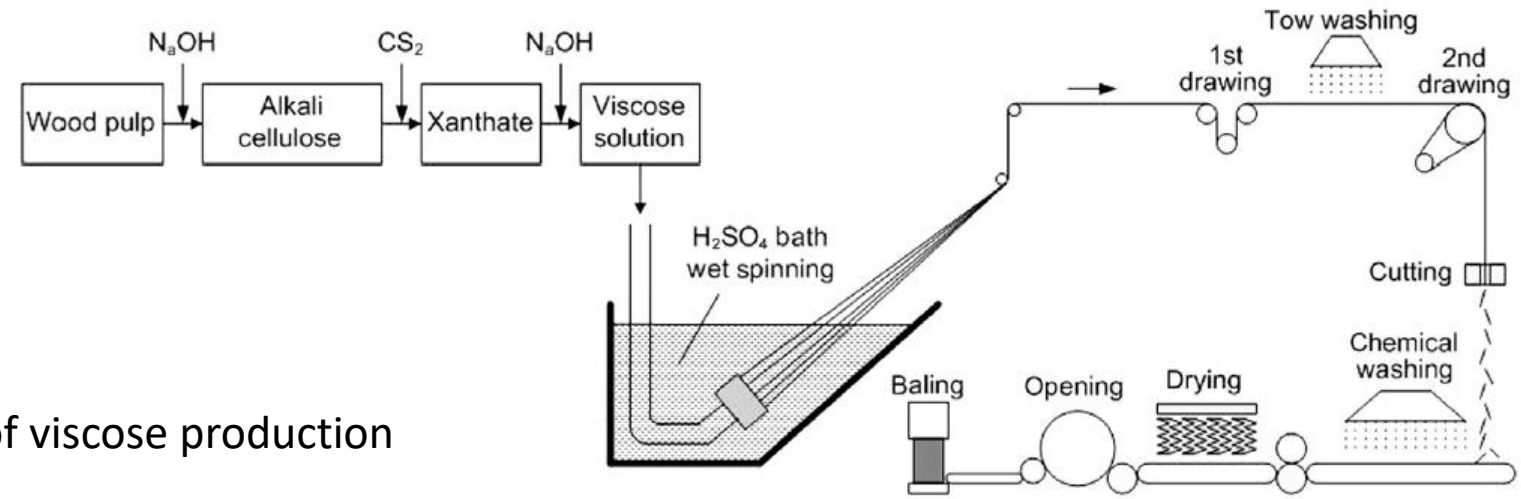
Cupro rayon fiber is produced by dissolving cellulose into cuprammonium solution and then wet-spinning to regenerate cellulose. Because this process needs to use high-price cotton cellulose and copper salts, cuprammonium rayon is not competitive with viscose rayon and ceased commercial development after World War I. Today, only a few manufacturers still produce cuprammonium rayon to supply a niche market for artificial silk and medical filter materials.

Acetate is a cellulose-derived fiber rather than a regenerated cellulose fiber. It is produced by acetylating cellulose using acetic anhydride liquid with a sulfuric acid catalyst. The resulting cellulose acetate is dissolved in acetone and spun into fiber through a dry spinning process. The application of cellulose acetate fiber is limited to cigarette filters only and it accounts for about 2% of the total market for cellulose fiber.

Regenerated cellulose (rayon)

- Rayon fiber is made from pure cellulose, often derived from wood pulp. For spinning purposes, the wood pulp needs to be dissolved into a solution via a conversion that takes place in two steps
- The production of regenerated cellulose fiber includes two essential steps:

1. dissolution of the raw cellulose using either chemical or physical methods, and
2. regeneration of cellulose through a spinning process (wet spinning, dry spinning, or dry-jet/ wet-spinning).



Scheme of viscose production

Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

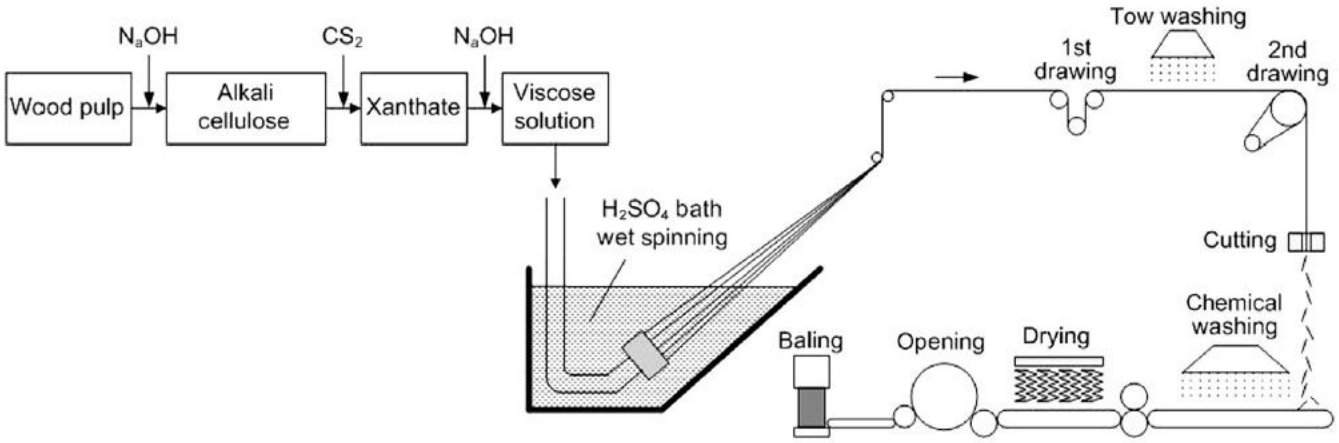
Regenerated cellulose (rayon)

$$\text{Cell-OH} \longrightarrow \text{Cell-ONa} + CS_2 \longrightarrow \text{Cell-OCSSNa}$$

Cellulose — Viscose

$$\longrightarrow \text{Cell-OH}$$

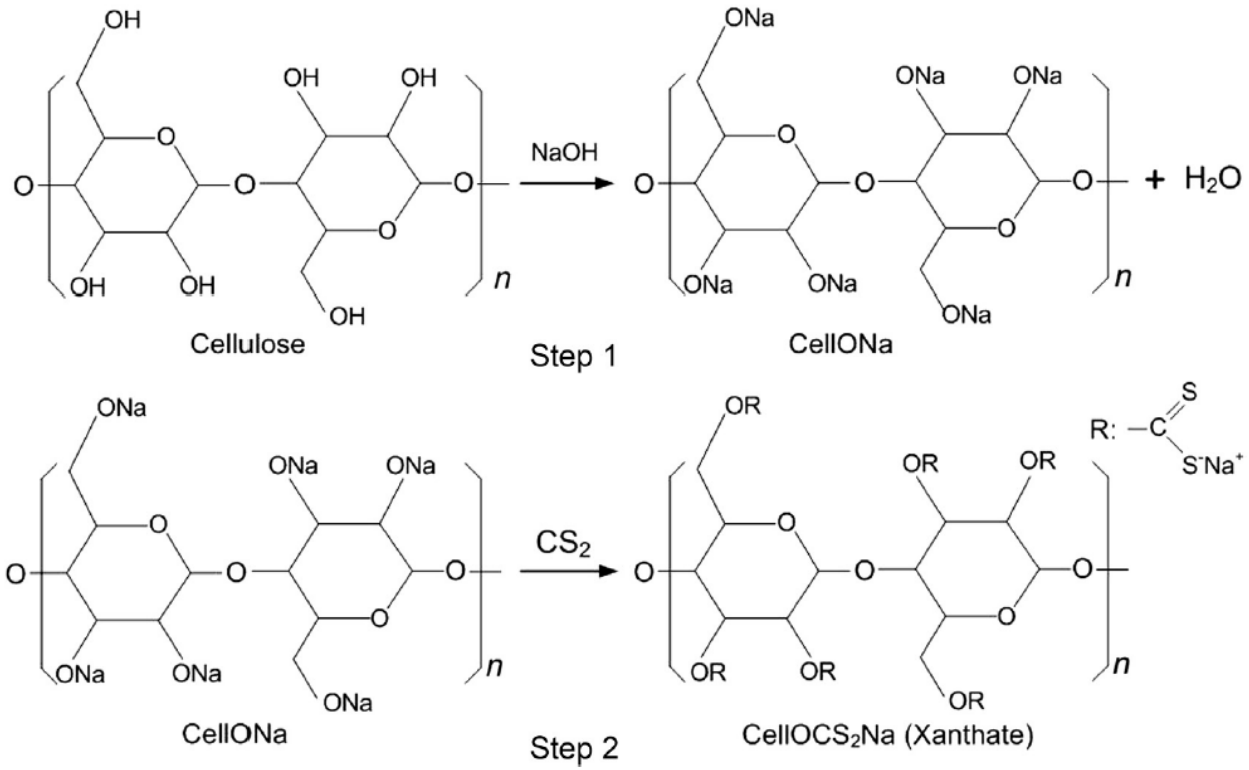
Viscose rayon



Regenerated cellulose (rayon)

1. caustic soda is mixed with wood pulp to make alkali cellulose, and
2. carbon disulfide is added to react with the alkali cellulose to form sodium cellulose xanthate.

Chemistry of viscose formation



Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Regenerated cellulose (rayon)

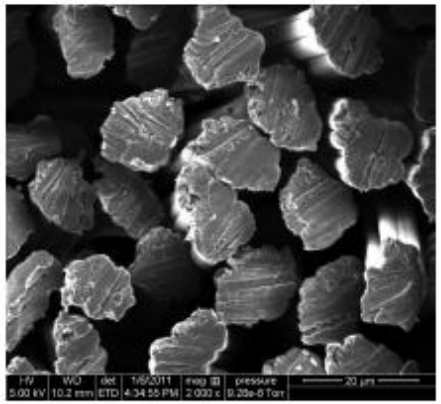


FIGURE 4.5
Viscose rayon fiber cross-sectional view (FEI QUANTA FEG 650).

Table 4.1 Viscose rayon fiber tensile strength and elongation

	Tenacity (g/denier)		Elongation (%)	
Fiber	Dry	Wet	Dry	Wet
Viscose	2.6–3.1	1.2–1.8	20–25	25–30
HWM	4.1–4.3	2.3–2.5	13–15	13–15
Tencel	4.8–5.0	4.2–4.6	14–16	16–18
Cotton	2.4–2.9	3.1–3.6	7–9	12–14
Polyester	4.8–6.0	4.8–6.0	44–45	44–45

Courtaulds Fibers Inc., 1999.

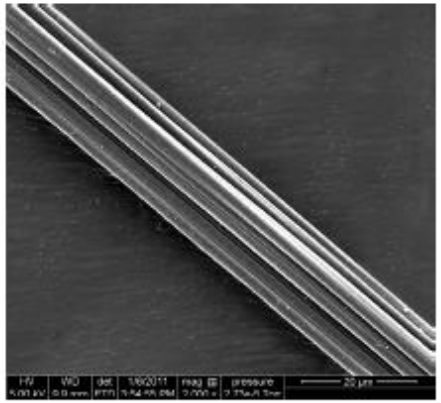


FIGURE 4.6
Viscose rayon fiber longitudinal view (FEI QUANTA FEG 650).

Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Regenerated cellulose (lyocell)

Lyocell fiber has a close to circular cross-section (Figure 4.8). Its longitudinal surface is very smooth and cylindrical without any striation (Figure 4.9). Lyocell rayon fiber is different from viscose rayon in fiber shape and appearance, and this differentiation allows lyocell rayon fabrics to exhibit better fabric feel and drape. Lyocell fiber is similar to viscose rayon fiber in many physical aspects, but exhibits enhanced properties in terms of softness, drapability, dimensional stability, dye uptake, and colorfastness. Moisture regain of lyocell fiber is around 11%, slightly lower than that of viscose rayon. This is mainly because the lyocell spinning process produces a higher cellulose crystallinity.

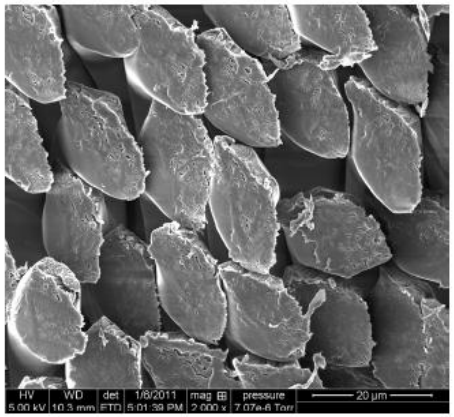


FIGURE 4.8
Lyocell rayon fiber cross-sectional view (FEI QUANTA FEG 650).

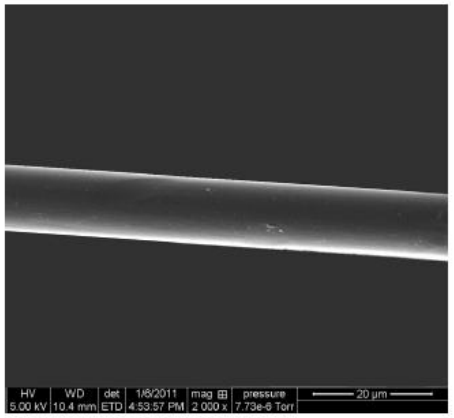


FIGURE 4.9
Lyocell rayon fiber longitudinal view (FEI QUANTA FEG 650).

Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Regenerated cellulose (acetate)

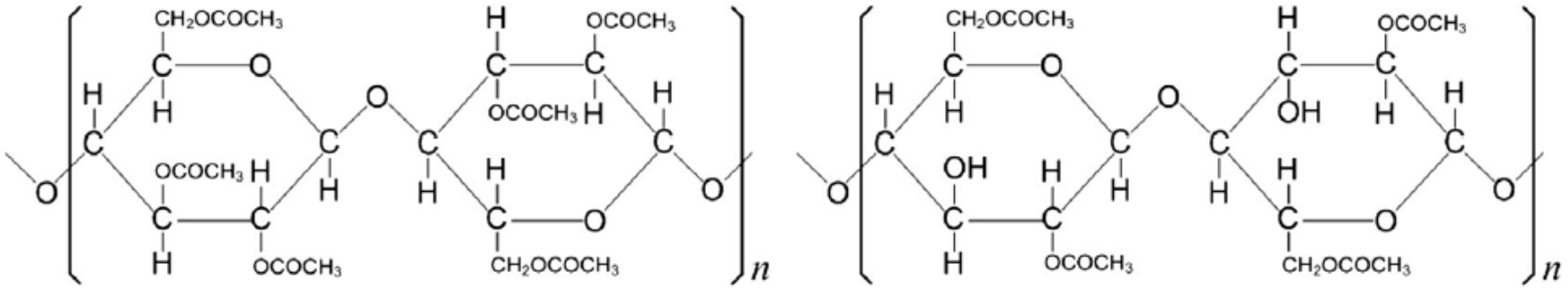


FIGURE 4.10

Molecular expression of diacetate and triacetate fibers.

The chemical formulae for these two fibers are indicated in Figure 4.10. These two fiber types are produced with two different fiber spinning approaches.

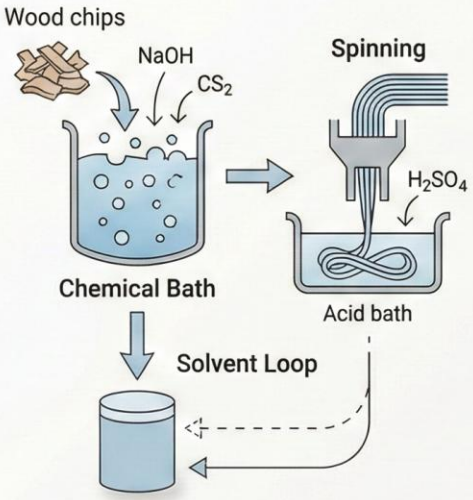
Source of the picture: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Regenerated cellulose (rayon)

Viscose



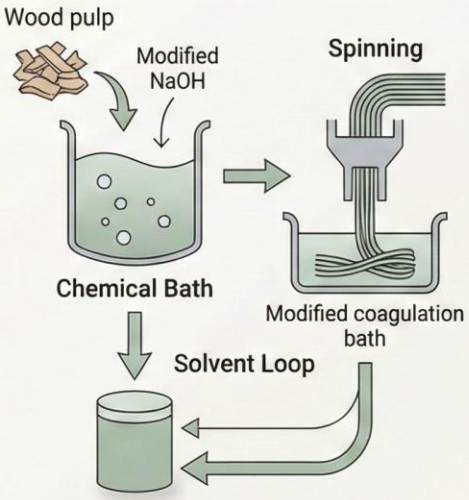
A semi-synthetic fiber from regenerated cellulose. The process involves multi-step chemical treatments, often with lower strength when wet.



Modal



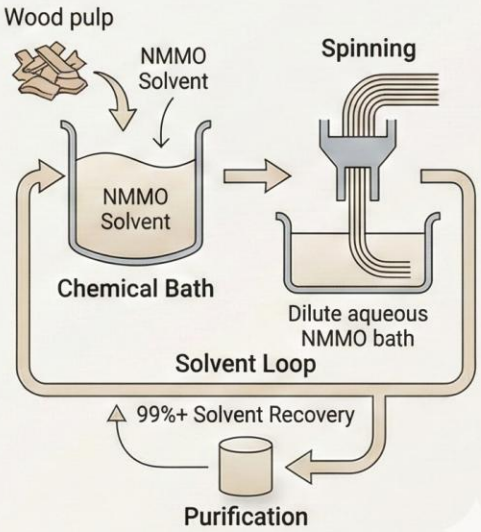
A modified viscose process with higher wet strength. It uses different chemical concentrations and spinning techniques for improved properties.



Lyocell



A more sustainable process using an organic solvent that is nearly completely recovered. Known for high strength and eco-friendliness.



Non-woven fabrics

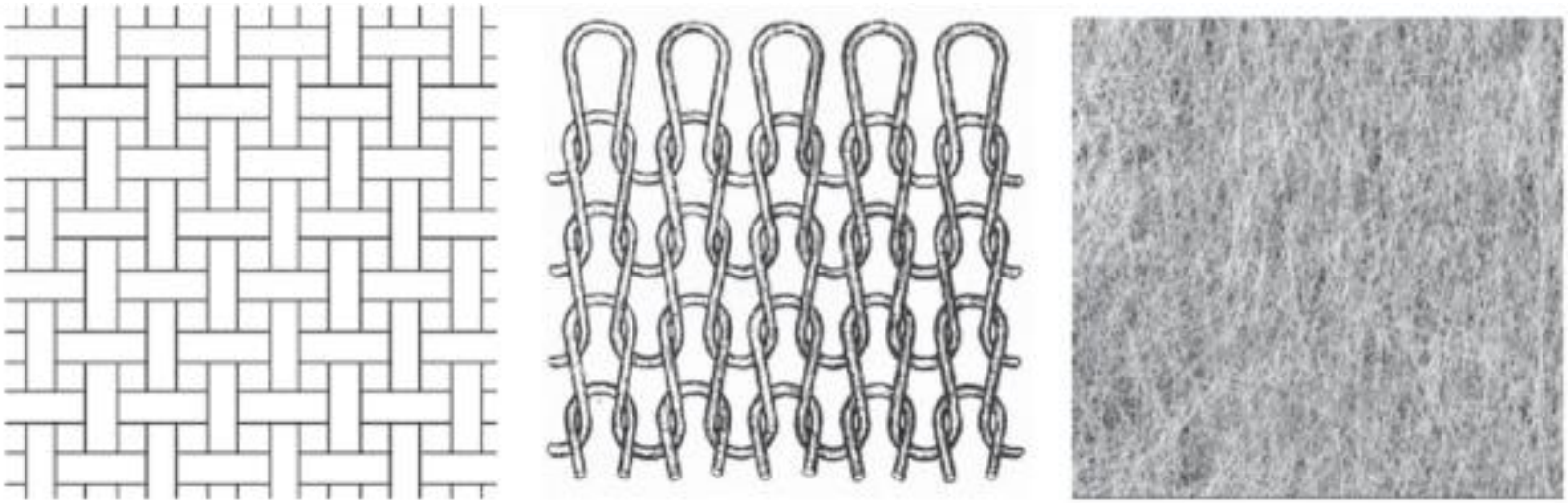
Nonwovens (= tessuto non tessuto) are structures of textile materials, such as fibres, continuous filaments, or chopped yarns of any nature or origin, that have been formed into webs by any means, and bonded together by any means, excluding the interlacing of yarns as in woven fabric, knitted fabric, laces, braided fabric or tufted fabric.

British Committee for Standards, International Organization for Standardization (ISO) and European Committee for Standardization (CEN) BS EN ISO 9092:2011

Nonwoven fabrics are engineered fibrous assemblies that are essential to the functional performance of products used in diverse medical, consumer and industrial applications as part of daily life.
Historically, the nonwovens industry has evolved from different sectors of the textile, paper and polymer industries, and today it has a separate and distinctive identity.
The main market segments for nonwoven fabrics in terms of volume are hygiene, construction, wipes and filtration.

Source: Woodhead Publishing Series in Textiles: Number 126 Textiles and Fashion Materials, Design and Technology, edited by Rose Sinclair

Non-woven fabrics

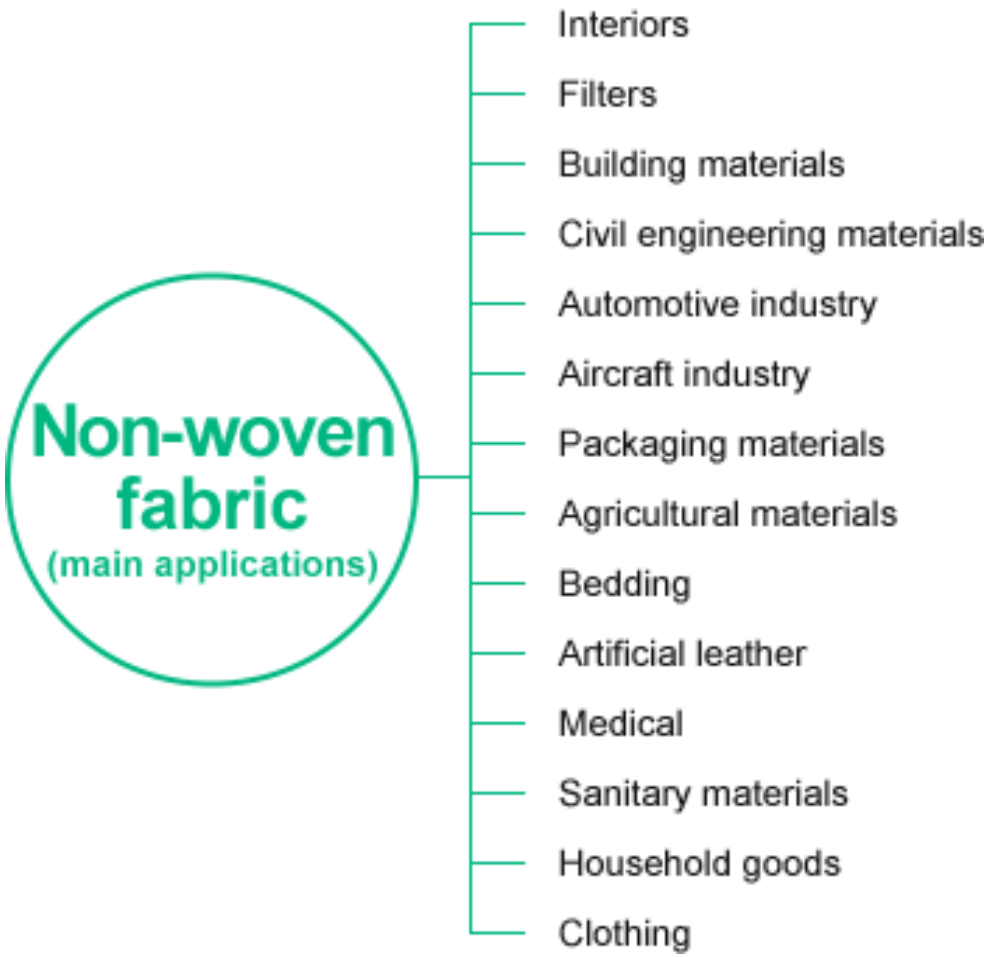


Types of common fabric; (a) woven, (b) knitted and (c) non-woven fabrics

Source of the picture: Misnon, Mohd Iqbal & Islam, Mainul & Epaarachchi, Jayantha & Lau, Kin tak. (2014). Potentiality of utilising natural textile materials for engineering composites applications. Materials & Design. 59. 359-368. 10.1016/j.matdes.2014.03.022.

Non-woven fabrics

Nonwoven fabrics have become an extremely important segment of the textile industry in recent years. The technical developments in polymers, nonwoven processing and fabric finishing have led to significant improvements in fabric physical and mechanical properties including fabric handling and drapability, tensile properties, abrasion resistance, pilling and washing stability, dyeing and printing that create prospects for nonwoven fabric applications in particular in apparel outerwear.



Source: https://www.sciencedirect.com/topics/engineering/nonwoven-fabric

Non-woven fabrics

The particular set of properties that a non-woven fabric may have is dependent upon the combination of factors in its production. The range of characteristics is wide.

- The appearance of non-woven fabrics may be paper like, felt like, or similar to that of woven fabrics.
- They may have a soft, resilient hand, or they may be hard, stiff, or broadly with little pliability.
- They may be as thin as thin as tissue paper or many times thicker.
- They also may be translucent or opaque.
- Their porosity may range from low tear and burst strength to very high tensile strength.
- They may be fabricated by gluing, heat bonding, or sewing.
- The drapability of this type of fabrics varies from good to none at all.
- Some fabrics have excellent launderability; others have none.
- Some may be dry-cleaned.

Additional references

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