Photo: Wood chips by Lignum Group. Wikipedia CC BY-SA 3.0 DEED

1.1/ 2 Definition, Classification and Properties of Textile Fibres

This open educational resource has been developed by:

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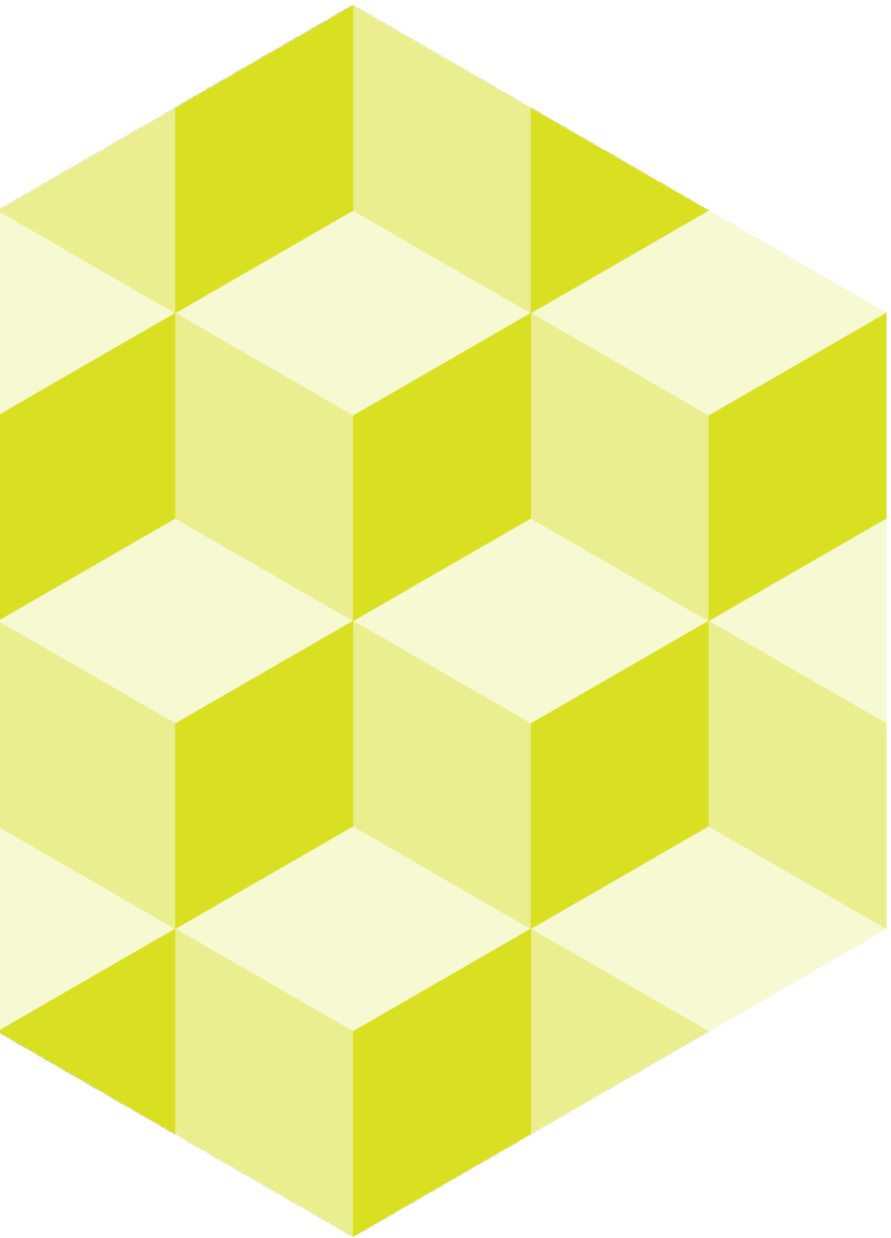

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This learning material was developed in the Erasmus+ funded project Education Partnership of Textile and Clothing Sector Materials & Sustainability (SusTexEdu)

The goal of the project is to research and develop education in the textile and clothing sector related to textile materials, sustainability and circular economy.

The learning material has been prepared for piloting, and students will be asked for voluntary feedback after the course for the further development of the material.

Project coordinator: Metropolia UAS

Partners: Hogent (BE), Mome (HU), Omnia (FI), TTHK (EE), TTK UAS (EE), University of Borås (SE)

Funding: Erasmus+

Project period: 2022-2024

About this learning unit

CONTENT DESCRIPTION

- Basic knowledge about definition and classification of fibres
- The structures and properties of different fibres
- The areas of use of different textile fibres

LEARNING OUTCOMES

Student will be able to:

- classificate different textile fibres by origin and chemical structure
- manage the general terms regarding the characteristics and properties of textile fibres
- identify the structures, properties of different textile fibres
- knows different ways how to use textile fibres for different products

STUDENT WORKLOAD

2 ECTS, which is equal to 50-60 hours of work:
for example:

- Lectures 26-30 h
- Group activities 6-10 h
- Independent study 10-28 h

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Contents

- Classification of textile fibres
- Timeline of textile fibres
- Textile fibre world markets
- Man-made textile fibres
- Man-made regenerated fibres
- Natural raw materials of textile fibres: Cellulose and protein
- Viscose
- Modal
- Lyocell
- Cupro
- Acetate
- Triacetate
- New regenerated cellulosic fibres
- Indentification of textile fibres
- Assignments
- Learning material
- Tips for learning more

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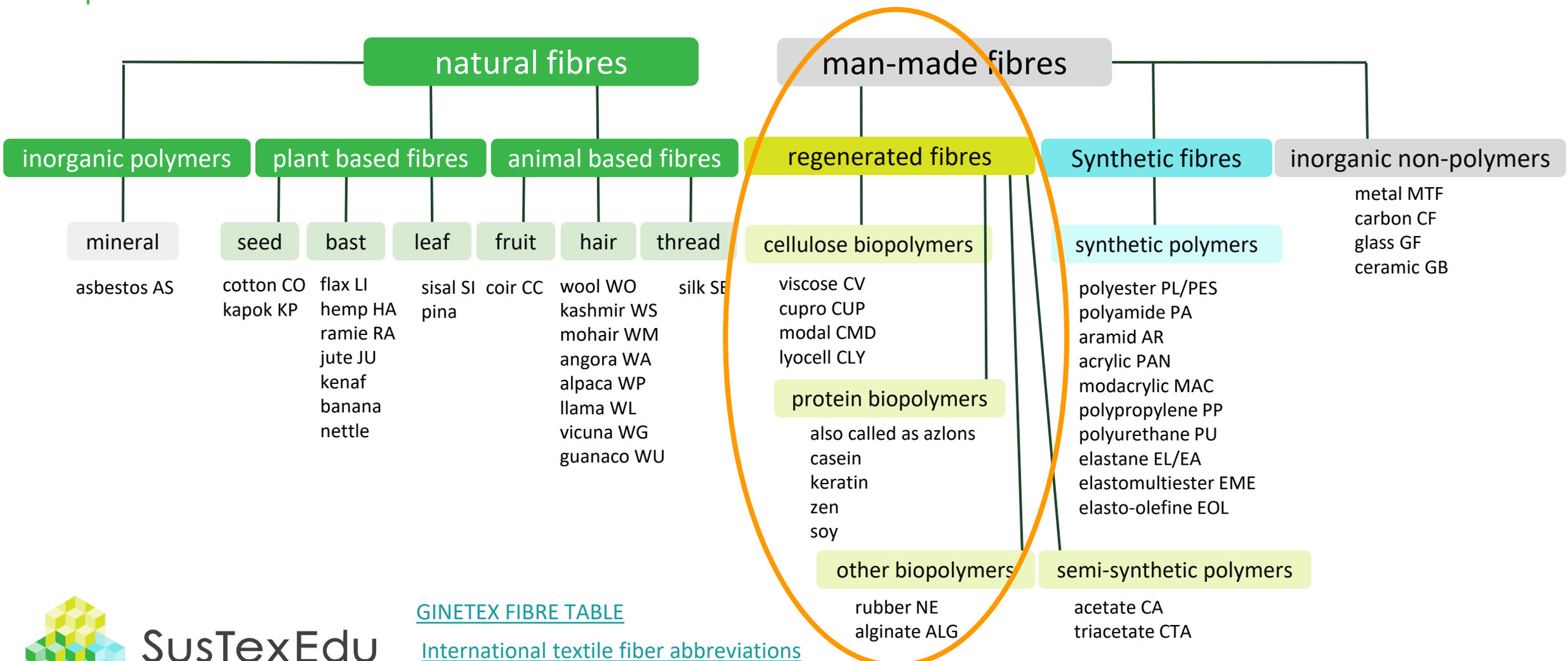
Classification of textile fibres



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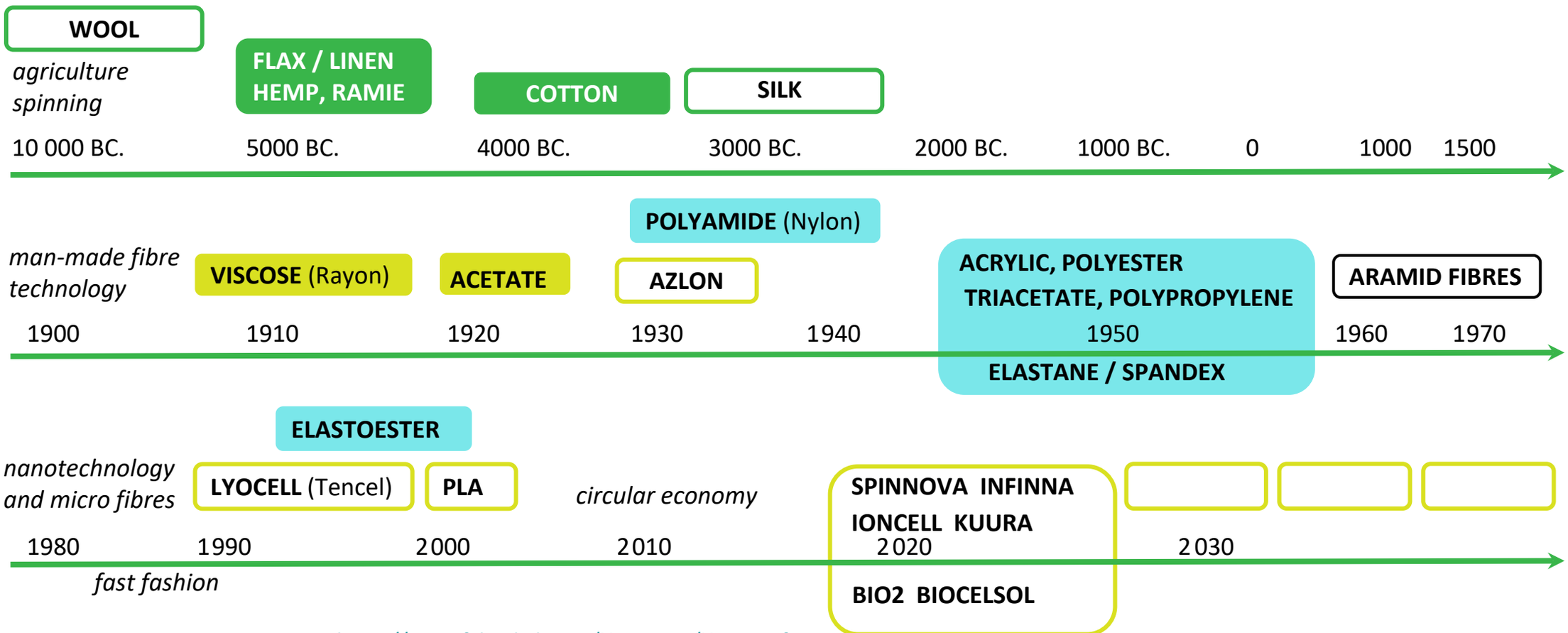
GINETEX FIBRE TABLE

International textile fiber abbreviations

Timeline of textile fibres



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https://www.fabriclink.com/University/History.cfm
https://iwto.org/wool-supply-chain/history-of-wool/
https://heritagecrafts.org.uk/spinning/

Textile fibre world markets

- Global fibre production has increased at an accelerating rate total and also per person.
- The growth in fibre production has significant impacts on people and the planet. Awareness of the urgent need for more responsible use of resources and decoupling growth from resource consumption is growing; however, change is not yet happening at the scale and speed required.
- Polyester is the most used textile fibre in the world and cotton comes as second.
- The current situation of the textile fibre production you can follow on statistics which are yearly published:
  - *Preferred Fiber & Materials Market Report (https://textileexchange.org)*
  - *An overview on global fiber and yarn market (https://www.textiletoday.com)*

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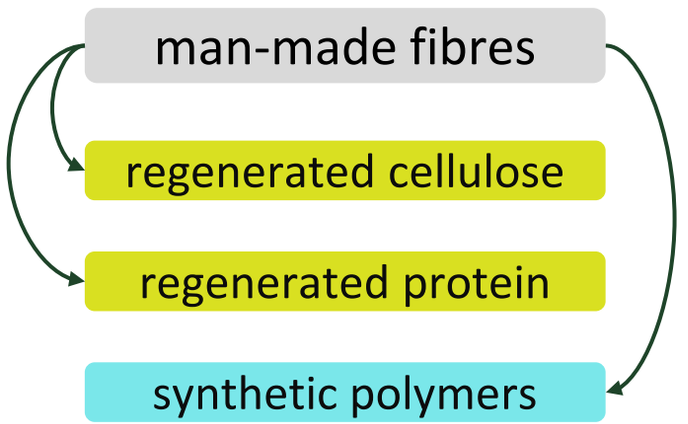
Man-made textile fibres

- Any fibre or filament which is manufactured by human efforts is called man-made fibre.
- Synthetic and regenerated fibres are two types of man-made fibres used extensively in the textile industry.
- Both of these have unique chemical, physical, thermal and optical properties and characteristics that make them suitable for distinct applications.

- Regenerated fibres are manufactured from nature based materials as wood cellulose and protein by regeneration.
- Synthetic polymers are manufactured from petrochemical waste by polymerization..



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Comparison between Synthetic Fibers and Regenerated Fibers. Tariq Bin Mutalib in Textilefact.com

Types of Man-Made Fibers Used in Textiles. Tariq Bin Mutalib in Textilefact.com

Man-made regenerated fibres

- Fibres to be modified occur in nature in forms (e.g. wood cellulose and protein) from which they can be converted into fibres suitable for apparel and textile industry by chemical and physical methods.
- Regenerated fibres are synthesized by regeneration of natural polymeric materials (wood pulp, cotton waste, milk casein, soy, corn…). They are chemically treated to convert them into a liquid state and passed through a spinneret to create continuous filament fibres.

Photos: Wikipedia
Wood chips /Lignum Group. CC BY-SA 3.0 DEED
Soybeans / H. Zell. GDFL
Milk / NIAID. CC BY 2.0 DEED

- As cellulose and protein, man-made regenerated fibres are biodegradable.
- Cellulose fibres generally absorb moisture and are poorly resistant to acids, but good to alkalis. They are reasonably resistant to sunlight, are non-melting, easy to dye and clean.

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Comparison between Synthetic Fibers and Regenerated Fibers. Tariq Bin Mutalib in Textilefact.com
Types of Man-Made Fibers Used in Textiles. Tariq Bin Mutalib in Textilefact.com

… man-made regenerated fibres

Cellulose regenerated fibres · viscose, modal · cupro · lyocell · deacetylated acetate fibres	**Protein regenerated fibres** · obtained from animals (casein, fibroin) · obtained from plants (peanut, soy, corn)
Cellulose acetate fibres · acetate · triacetate	**Other regenerated fibres** · alginate obtained from seaweed · natural rubber · paper yarns · carbon fibres

Natural raw materials of textile fibres: Cellulose and protein

- As natural and organic materials, cellulose and protein both are biodegradable.
- They are biodegradable by many micro-organisms. This makes them excellent alternative when developing new, fully biodegradable materials and avoiding microplastics.
- Their lifeloop depends on the use and treatments made to them.
- Cellulose is a molecular compound containing only carbon and hydrogen.
- Proteins are very large molecules (macromolecules) composed of many peptide-bonded amino acids.

Photos from wikipedia:
Birch tree forest in Finland by SeppVei. CC0 1.0 DEED
A cow taking rest by Kim Hansen. CC BY-SA 3.0 DEED

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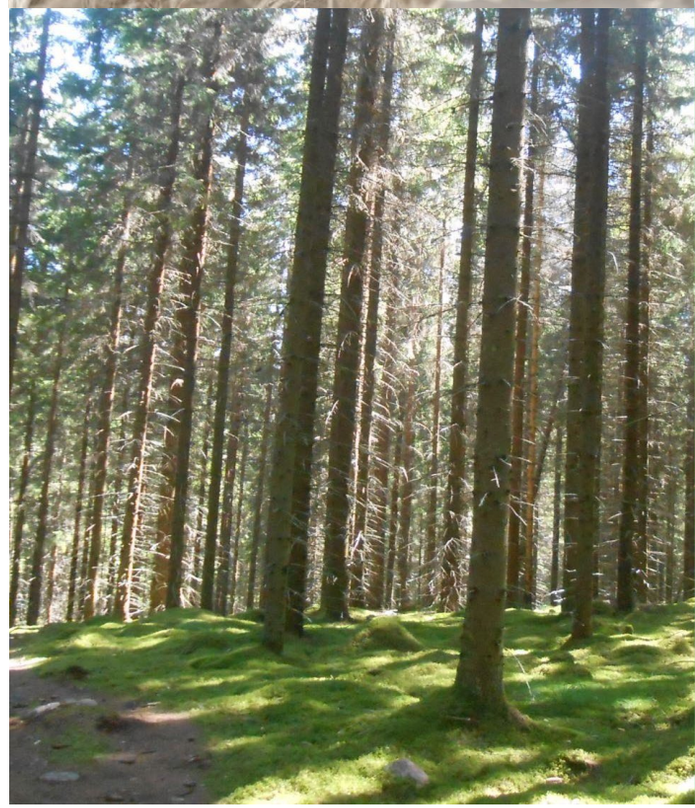
Protein biochemistry. Britannica.com

Viscose (VI, CV)

- Viscose is the most common regenerated cellulosic fibre.
- Viscose is also called as rayon. Its trade names are e.g. *Veocel, Ecovero, Argentea, Tairiyon, Viscofil.* The largest producers are China, Japan, India, Indonesia, USA.
- Viscose is made from wood cellulose, from birch or spruce, but also beech, eucalyptus wood, reeds and bamboo. The wood pulp content must be at least 90%.
- The production of viscose is seen to have environmental impacts, as the production uses harmful chemicals, water and energy. Also deforestation and forest exploitation create environmental risks.



Viscose cellulose fiber, photo by Lusto (The Finnish Forest Museum) on Finna.fi, CC BY 4.0
Fir forest in Finland, photo by Puppe100 on Wikipedia, CC BY-SA 4.0 DEED

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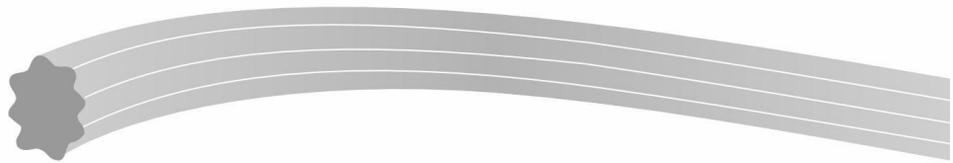
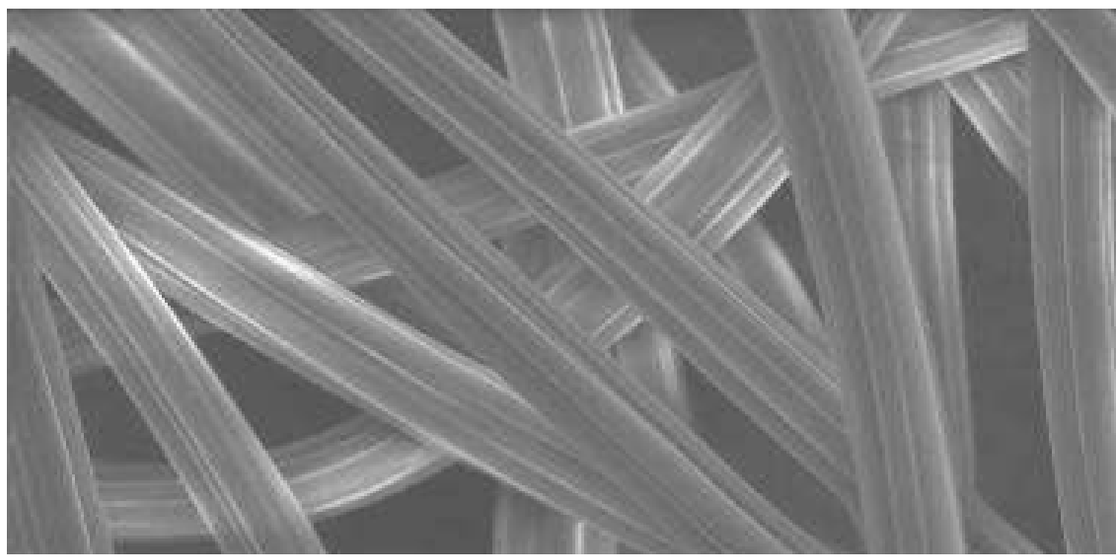
Manmade cellulosic fibers are commonly made from wood pulp
Textileexchange.org
Viscose is the most used manmade cellulosic fiber. Textileexchange.org

Viscose fibre

- The viscose surface is smooth and may have spots or longitudinal lines.
- There are many cross-sectional shapes and they vary according to the method of preparation, but usually it is an oval with a gingerbread edge.
- The surface layer may be separate, but it is also the same raw material as the rest of the fibre.
- Compared to natural cellulose fibres, viscose molecular chains are much shorter, about half that of cotton. The density is similar to cotton.





Above: Image up by authors
Below: Rayon fiber, microscope image by Jan Široky, Barbora Široka and Thomas Bechtold on Wikipedia, CC BY 3.0

Appearance of Viscose Fiber. Textilelearner.net

TASK 6

Properties of viscose

- Viscose is yellowish and transparent, when bleached its white.
- The strength depends on the spinning method and the dimensions of the fibre (about two times smaller than natural silk).
- Filament fibres are weaker than staple fibres.
- Viscose is a stiff fibre and it wrinkles easily, it also has poor shape and dimensional stability. Anti-wrinkle resin treatment is typical for viscose fabrics.
- The fibre conducts heat well and is very hygroscopic (up to 11%)
- When wet, the fibre swells and weakens (up to 40-50%). After drying, the former strength is restored.
- As the wet elongation increases, the elasticity decreases.
- Shrinks in hot water
- Prone to mold

Properties of Viscose Rayon. Textilecoach.net

The use of viscose

- Viscose is used both on its own and mixed. This is to achieve the best properties of each fibre for a specific purpose.
- It is used for both woven fabrics and knitwear and also for the production of faux fur.
- Non-woven fabrics are often made of viscose, as they absorb water well: filters, diapers, cosmetic and cleaning pads.

A surgical mask from non woven-fabric,
photo by Artur Bergman on Wikipedia, CC BY-SA 2.0

Viscose is the most used manmade cellulosic fiber. Textileexchange.org

The care of viscose

- Short-term heating (up to 160 C) does not harm, long-term heating (120 C) does.
- Dry cleaning is recommended.
- Prolonged sunlight is damaging.
- Clothes should not be left standing damp, as moisture stains may appear on the clothes.

Viscose tricot tunic by Nanso Group on Finna.fi CC BY 4.0

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Modal (MD, CMD)

- Modal differs from viscose based on a different fibre structure, it also has a higher cellulose content than viscose.
- The raw material is usually obtained from beech trees.
- In the modal manufacturing process, 95% of the solvents and chemicals used can also be recycled, which reduces water and chemical consumption compared to viscose manufacturing.
- Modal is generally considered an ecological alternative to viscose, due to the sustainably grown beech wood and the sparing use of water and chemicals.

American beech, photo by Jean-Pol Grandmont on Wikipedia, CC BY 3.0

What Is Modal Fabric & Is This Material Really Sustainable?
Raf Chomsky 2023. Sustainablereview.com

Modal fibre

- The cross-sectional form is roundish.
- The fibre surface is smooth.
- The fibre has a dull sheen and can be produced in a matte finish like viscose.
- Modal can also be produced as hollow fibre and as microfibre.

Modal fibres, image by authors

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Properties of Modal

Modal is a fibre from which part of the disadvantages of viscose have been eliminated. It is similar to cotton in many ways.

- It is more flexible and less wrinkled than viscose (the dimensions and shapes of the products hold better than viscose).
- It has high tensile strength and high wet strength, which is significantly higher than viscose.
- Modal is less hygroscopic than viscose.
- It is resistant to acids, alkalis, light and heat.
- Dyeability of modal is similar to cotton.

Photo by authors

What is modal fabric? Masterclass.com

Study of mechanical and comfort properties of modal with cotton and regenerated fibers blended woven fabrics. 2018 Taylor & Francis

TASK 8

The use and care of Modal

- It is used both in its pure form and mixed -mainly with cotton, but also with wool.
- Modal is a strong fibre, so it is often used in underwear, sleepwear, casual and work clothes.
- Modal gets dirty less and is more easy care than viscose.

Modal tricot shirt (Nanso), photo by authors

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Lyocell (LY)

- In 1978 a procedure was developed to dissolve cellulose without a prior chemical process. 1990 lyocell pilot started and 1992 the fibre name lyocell was set.
- Lyocell fibre is classified as a subcategory of viscose. Raw material of lyocell is usually wood pulp.
- Trade names: *Lyocell by Lenzing, NewCell* (filament fibers), *Tencel.*

Wood pulps, photo of authors
Lyocell fabric, photo by authors

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Lyocell fibre in Textiles and Fashion 2015
https://lyocell.info/

Lyocell fibre

- Lyocell is a cellulose fibre that is precipitated from an organic solution in which no chemical intermediates are formed. Lyocell process uses non-toxic NMMO solvent, which is an organic compound.
- The cross-section of the fibre is round. In terms of molecular length, it is comparable to modal.
- Its mainly used as cotton type staple fibre.

Lyocell fibre, image by authors

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Properties of Lyocell

- Lyocell fibre is strong, the strength decreases a bit when wet. It also has a good moisture absorption.
- Fibrillation of lyocell and other regenerated cellulosic fibres occurs during their manufacturing and usage. This leads to consumer fabric dissatisfaction phenomenon such as pilling.
- Fibrillation of lyocell can be used via enzymatic treatment to produce an appealing fabric touch called ‘peach-skin effect’ with a frosty appearance.

Fibrillation of lyocell may produce a "peach-fuzz" feel, image by W. Zhang on Wikipedia CC BY 3.0

The use and care of Lyocell

- Lyocell is soft and silky, with good drapeability. Compared to viscose, the lyocell fabric keeps better the size and shape and wrinkles less. There is neither any pilling on surface-finished products.
- Lyocell is used for heavier and lighter fabrics suitable for jeans, blouses, dresses, including workwear and sportswear.
- Textiles for technical purposes are produced both as woven and non-woven material, felt, sewing thread, filters, etc.
- The care is as for the other cellulose fibre products.
- Lyocell fibre made from recycled materials are already available.

Shirt made of lyocell, photo by Matti Blume on Wikipedia CC BY-SA 4.0

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Cupro (CU, CUP)

- Copper silk was invented 1897. Continuous cupro spinning process was developed in 1953 and the fibre got its first trade name *Bemberg*.
- Other trade names are e.g. *Bembleise, Bemsilke, Cupioni* and *Cupresa.*
- Cupro is a cellulose fibre manufactured via copper ammonia process.
- The main producing country is China

Cupro staple fibres, photo by authors
Cupro fabric, photo by Enby on Wikipedia, CC BY-SA 4.0 DEED

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What is Cupro fabric? Sewport.com

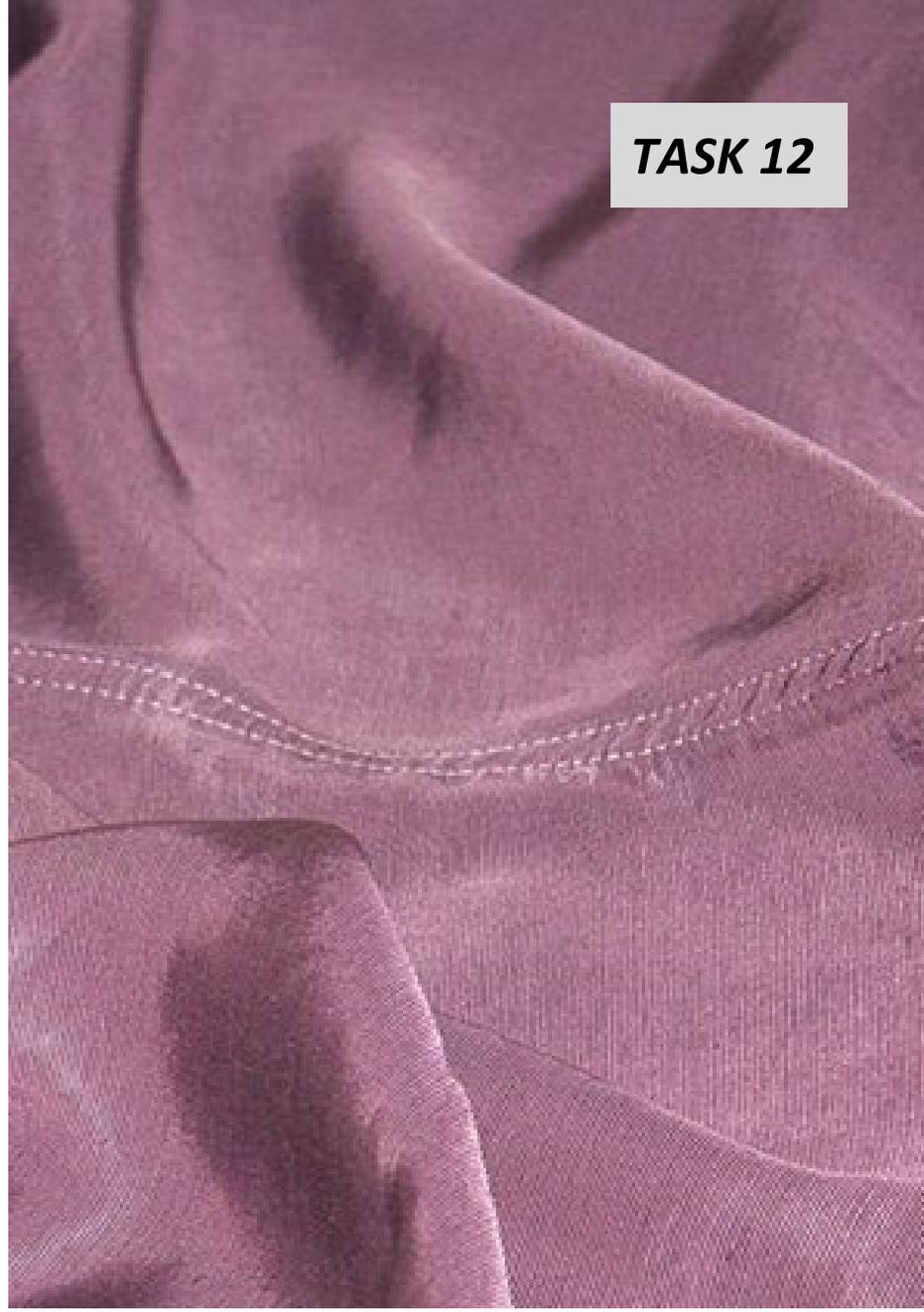
Cupro fibre and its properties

- Cupro fibre is made through a process that involves dissolving the cellulose from wood pulp or cotton linters in a solution of copper oxide and ammonia.
- The cross-section of cupro fibre is almost round, which gives the fibre a characteristic silky sheen in same as modal.
- Cupro is mainly produced as silky filament, both glossy and matte. Staple fibres are mainly produced in wool and mohair types. Cupro is also produced as hollow fibres.
- The strength is similar to viscose, the stretch is lower, but the elasticity is higher. Strength decreases a bit when wet (less than viscose)
- The molecules are larger than viscose, so the chemical stability is better.
- When heated for a short time up to 120ºC, the strength decreases by about 2x, when heated for a long time it breaks down.

What is Cupro fabric? Sewport.com
Cuprammonium Rayon Fibers on Molecular Expressions website

Use of Cupro

- Cupro filaments are used for silk-like products, underwear, soft and silky lining fabric, embroidery thread and chiffon and organdy type fabrics.
- Staple fibres are mixed to make costume clothes and knitwear.
- Washing and care conditions are the same as of other cellulose regenerated fibres.



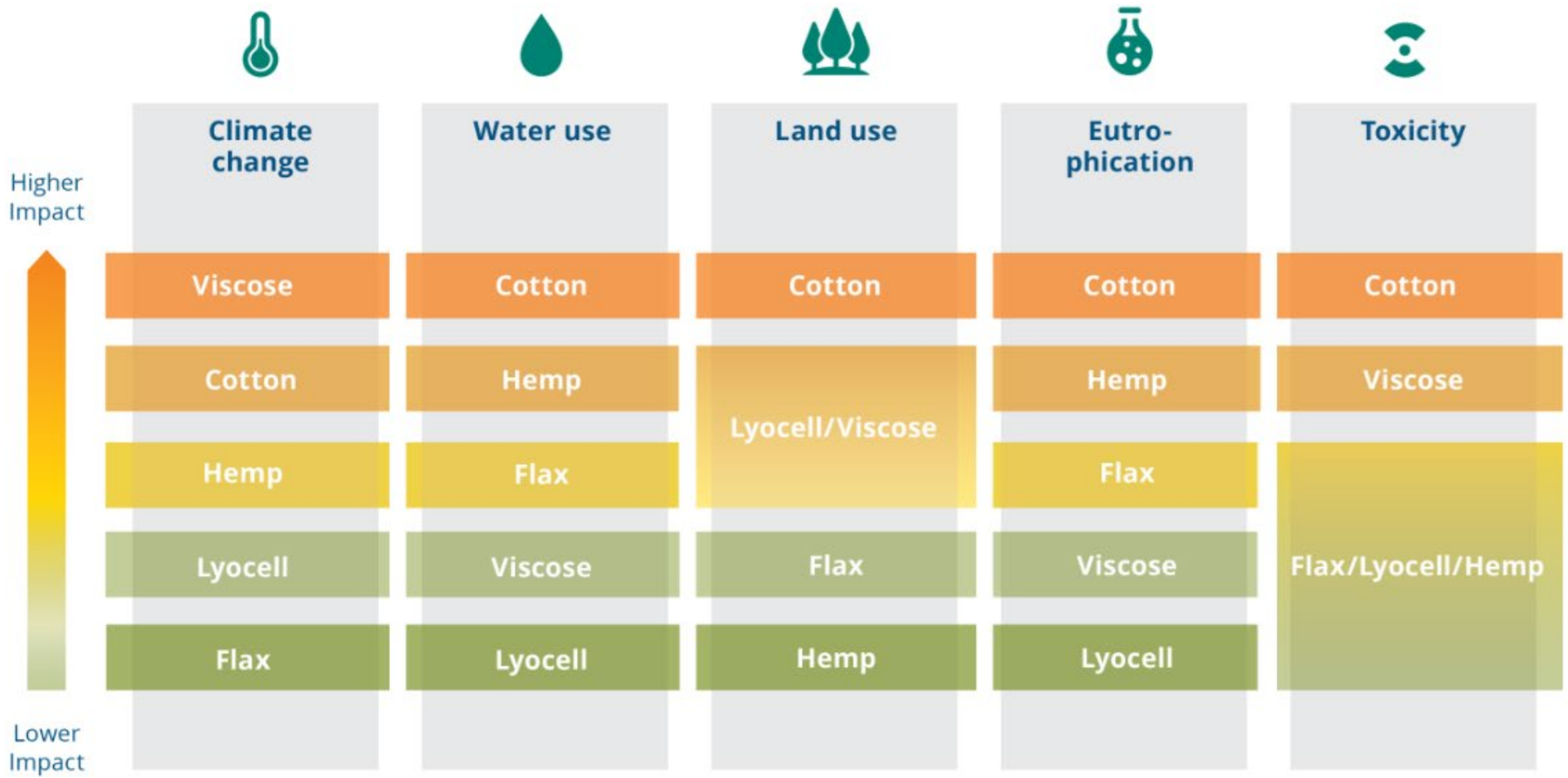
Cupro fabric, photo from Wikipedia, GDFL

Sustainability of Cupro

- Cupro is considered a fairly responsible textile fibre, as its raw material uses side streams from cotton production.
- The disadvantage is the toxic copper sulfate formed in the cupro manufacturing process, which must be prevented from entering the wastewater.
- Compared to the production of viscose, cupro requires less energy and, when properly managed, the production produces fewer harmful emissions.

Cupro and its sustainability? Goodonyou.eco

The main impacts associated with the production of different plant-based textile fibres



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ETC CE Report 2023/5 page 15

Acetate (AC)

- Acetate is the second oldest regenerated fibre after viscose
- Acetate is a cellulose acetate fibre.
- Its trade names are e.g. *Carolan, Celebrete, Celanese, Dicel and Silcor*
- Its produced as cupro from wood pulp or cotton waste with acetone as solvent.
- The most important acetate producing countries are USA and Japan.

Acetate lining, photo by authors

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Acetate and Triacetate fibres. Textile and fibre science Gate Prepration

Acetate fibre

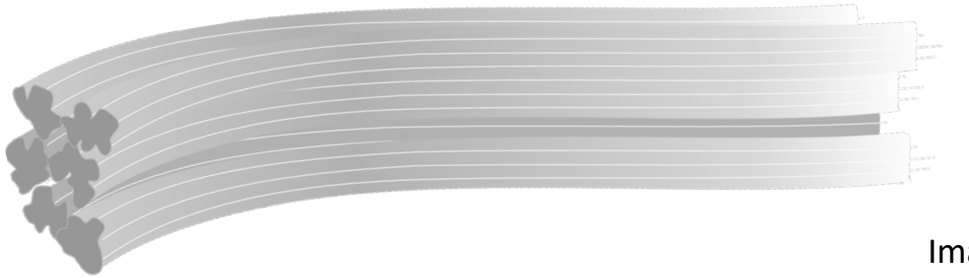

Image by authors

- Acetate is lighter than viscose, belonging to the category of medium weight fibres.
- It is possible to spin very fine fibres, soft with silky matte sheen.
- The cross-section of the fibre is an irregular star. The grooves on surface are deeper than viscose has.
- Acetate is not very chemically stable and is damaged by strong acids, alkali and bleaching.
- Acetate is slightly more stable and elastic than viscose, so it wrinkles less, but more than modal, cupro and lyoncell.
- It is a bit weaker than viscose. In wet the strength decreases, but less than viscose.
- Above 140ºC acetate melts. It is thermoplastic which allows durable pleating.
- It tolerates sunlight better than viscose and is not susceptible to mold and insect damage.

Use of Acetate

- Acetate is used both in pure form and in blends.
- Acetate is used in products that require a silky sheen and drapeability.
- Antimicrobial acetate is used for clothing and home textiles, as well as for hospital textiles.
- Disadvantage is, that the fabric does not breath and is not absorbent. So, the main use nowadays is for cigarette filters. Also e.g. Lego blocks and many eyeglass frames are made from acetate.

Acetate/polyamide under skirt in a package, on Finna.fi CC BY 4.0 DEED
Duplo and Lego bricks, photo by Klasbricks on Wikipedia, Public Domain

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Cellulose acetate. Britannica.com
What is acetate? Goodonyou.eco

Triacetate (TA, CTA)

- Production of triacetate started 1954 for camera film rolls.
- Triacetate is produced from triacetyl cellulose, the cellulose must be very pure.
- Trade names are e.g. *Soalon and Tricel*
- The production process is similar to the acetate production process, but the solvent chemicals are different: methylene chloride and methanol instead of acetone.
- The main production is in North America, followed by Europe and Asia Pacific

Triacetate feels harder than acetate but it has many better properties:

- It is more durable due to its construction, and also more stable than acetate.
- It is more resistant to the effects of chemical substances (including acetone).
- Its heat resistance is better (ironing 170ºC) than acetate´s, so its thermoplastic and its possible to create durable pleats to the fabric.
- Also the elasticity is better, i.e. it wrinkles less and springs more easily.
- Its resistant to sunlight, bacteria and mould is good.

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Cellulose acetate. Britannica.com
Triacetate on Fabricsight.com

Use of Triacetate

- Triacetate is used both in pure form and mixed, as filament and staple fibre for knits and woven fabrics. The fabric is easy to care and it dries quickly.
- Triacetate fibre has a silky sheen. Triacetate is better for clothing that needs to be more durable and wrinkle-resistant, while acetate may be more suitable for clothing that needs to be soft. Triacetate is used for casual wear but also sportswear and linings. As a strong fibre triacetate also suits to interior textiles.
- As very thermoplastic, triacetate is also used for film or sheet for packaging, membrane filters and photographic film.

Triacetate/polyamide sport pants 1983, photo by Mauri Jormakka for Finnish Sport Museum, CC BY 4.0 DEED
Triacetate curtains, photo by authors

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Sustainability of acetate and triacetate

- In the manufacturing process of acetate the main solvent is acetone. That a.o. chemicals used requires making acetate fibre in highly regulated and sustainable production facilities to ensure healthy working conditions.
- In the manufacturing process of triacetate, methylene chloride and methanol are used as solvents. They are toxic and thus banned in many countries, so the production of triacetate has decreased considerably.
- Although acetates come from natural and renewable sources, such as wood pulp and cotton waste, they are considered semi-synthetic fibres with synthetic plasticizers*.
- They are biodegradable but they anyway cause microplastic wastes to the nature. There is developed “bio-acetate”, which means a higher percentage of the material is made from plants with plant based of plasticizers.

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What is acetate? Goodonyou.eco
Recycling of bioplastic waste. G.Fredi, A. Dorigato 2021

New regenerated cellulosic fibres

New regenerated fibres for sustainability are continuously developed, below examples:

- **SPINNOVA®**: SPINNOVA® by Spinnova makes pulp by mechanically refining it into microfibrillated cellulose (MFC) textile fibre without dissolving and hazardous chemicals.
- **Infinna™**: Infinna™ by Infinited Fiber Company turns textile waste into a new, finest textile fiber that has a natural, cotton-like feel. By incorporating cellulose carbamate technology. – Infinited Fiber Company enables the manufacturing of totally new textile fibre from cotton-rich textile waste.
- **Ioncell®**: Ioncell® technology made by Aalto University in collaboration with the University of Helsinki uses a solvent which belongs to the category of ionic liquid. Tests have shown that the tensile strength of Ioncell® fibre is even 2-3 times higher compared to virgin cotton.

Six Finnish textile fiber innovations to replace cotton and viscose. BTT Desk Report on Textile Today

…new regenerated cellulosic fibres

- **Kuura™**: Kuura™ fiber by Metsä Group – it is based on paper-grade pulp instead of dissolving pulp. Thus, Kuura™ fibre manages a higher produce of textile fibre from trees and saves energy.

- **Bio2™**: Fortum's Bio2™ Textile is made from agricultural waste that are leftover. The company's cellulose is made from fractionated straw. The pulp is spun into textile fibres.

- **Biocelsol**: Biocelsol fibre by VTT uses textile waste by dissolving pulp. The pulp is treated using enzymes and water-based, cheap and non-toxic chemicals. The Biocelsol finished fibre has properties like viscose, but the fibre captivates moisture better than cotton or viscose.

Six Finnish textile fiber innovations to replace cotton and viscose. BTT Desk Report on Textile Today

…new regenerated cellulosic fibres

- **Sorona**: DuPont formed the Bio-Based Materials business (BBM) unit in 2000. BBM's first commercial product is the SoronaÒ family of poly (trimethylene terephthalate) (PTT, or ''3GT'') polymers.

  Sorona is 37% plant-based polymer, a co-polymer, an application of industrial biotechnology. The diol component of this polymer, 1,3-propanediol, is manufactured via biological fermentation process from corn sugar by converting it into monomers and further into polymers.

  Sorona fibre is soft, light, breathable and quick-drying. At a molecular level the polymer has a zig zag orientation which makes fibres elastic. Sorona is used for replacing fully synthetic elastane for its more sustainable production and recyclability.

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About Sorona on texintel.com
A New Polymer Platform for the Future — Sorona®. J.Kurian

…new regenerated cellulosic fibres

- **HeiQ AeoniQ** is developed by Swiss fibre company Heiq with partners and launched in 2021.
- The fibre can be manufactured from different cellulosic raw materials which can be locally sourced depending on regional availability.
- The fibre is told to have properties of polyester and nylon yarns.
- End-of-life products are fully biodegradable and designed for eternal circularity.

Filament yarn, photo by authors

MAS Holdings Invests In HeiQ AeoniQ™. Textile World 2023
Homepage of Heiq

Regenerated protein fibre: Azlon

- Azlon is the generic name for a man-made fibre in which the fibre-forming substance is composed of any regenerated, naturally occurring protein.
- The fibre-forming substance can be derived from various naturally occurring proteins such as skimmed milk (casein), eggs (albumin), corn and soy (zein), chicken feathers (keratin), leather and hide waste (collagen).

Photos from Wikipedia: corn field by Christian Fischer CC BY-SA 3.0 DEED; egg by Renn West CC BY 2.0 DEED; feather by Joao Estevao Andrade de Freitas Public Domain; milk by H.Zell GFDL; leather by Gaz Davidson Public Domain; soybean by United Soybean Board CC BY 2.0 DEED

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About Azlon on britannica.com

Milk or Casein Fiber: Properties, Manufacturing Process, Benefits and Uses M.I. Kiron 2012

Properties of Azlon

- Azlon is pretty weak fibre and it has poor elastic recovery, especially when wet, which is decreasing its use.
- Advantages are soft and warm touch, excellent breathability and good dyeability with bright and shiny colors.
- In order to improve the mechanical properties, the proteins are blended with synthetic polymers and natural fibres.

52% cotton, 43% azlon (soybean), 5% spandex shirt.
Source: https://adventuresingreenmarketing.com/tag/azlon/

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Identification of textile fibres

- **Cellulose fibres** as cotton, linen and viscose burn evenly with light grey smoke, don't melt or shrink, smell like burning paper, and leave grey feathery ash.
- **Acetate and triacetate** burn evenly and slowly, with a yellow flame and smell sour. A dark brown charred lump remains on the end of the fibre.
- **Proteins** (silk and wool) burn slowly, curl away from the flame, smell like burning hair and leave crushable black ash.
- **Acrylic** melts and burns, moves away from the flame, with a chemical smell and leaves a black, brittle hard bead.
- **Polyester** melts and burns, with a sweet smell and leaves a hard, black bead.
- **Polyamide** melts and burns, with a celery smell and leaves a hard, grey, tan bead.
- **Elastane** melts and burns, with a chemical smell and leaves soft, black ash.

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Burn test / FabricLink Identification of textile fibres / The Textile Journal

Assignments and topics to discuss

1) When did industrialization begin? What does circular economy mean and why is it important? etc. questions and topics that open the background of the development of textile materials to students at a general level.
2) What does sustainable fibre mean (repetition of part 1/1) Question: What is fibrin?
3) Where can you find cellulose and where proteins?
4) Which kind of risks deforestation may create?
5) Looking at different viscose fabric samples and also fibres if possible
6) Question: What means hygroscopic?
7) Possible topic for discussion: what does profiled fibre mean, fibre profiling?
8) Looking at different modal products and also fibres if possible
9) Task or discussion topics: What does pilling mean? What is an enzyme?
10) Looking at different lyoncell products and also fibres if possible
11) Topic: When a fibre is elastic, what it mean to be elastic fibre?
12) Looking at different lining fabrics, viscose and cupro and compare them (if available)
13) Question: Are the regenerated fibres recyclable? (if not obvious by this point)
14) Looking at both acetate and triacetate samples if possible
15) Question: What other new cellulose fibres are under development or have come to market?
16) The burning of the regenerated fibres can be tested at the end of theís part 1.½ , or it can be done after the synthetic fibres have also been gone through.

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Learning material

Books: e.g.

- Textiles and Fashion Materials, Design and Technology. Part 1: Fibre Types. Rose Sinclair 2014
- Handbook of Textile Fibres Vol 2 - Man-Made Fibres. J.Gordon Cook 1984

Online learning material: e.g.

- Man-made fiber. J.Preston. Britannica.com
- Coming Full Circle: Innovating Towards Sustainable Man-made Cellulosic Fibres. R. Hugill, K. Lay, K. Rademan. 2020. PDF
- Textiles for Circular Fashion. Paulien Harmsen, Wouter Post, Harriette Bos. Wageningen University & Research 2022 PDF
- Textile Fibers © 2013 Cotton Incorporated PDF
- International textile fiber abbreviations
- "Textile University" by Fabriclink

Tips for learning more

Ecological textile fibres from Finland. Finnish Textile and Fashion Association 2023

The role of bio-based textile fibres in a circular and sustainable textiles system. J. Deckers, S. Manshoven, L.F. Mortensen. Eionet Portal 2023

The Potential for Regenerated Protein Fibres within a Circular Economy: Lessons from the Past Can Inform Sustainable Innovation in the Textiles Industry. M. Stenton, J.A. Houghton, V. Kapsali, R.S. Blackburn 2021

The end of petrochemical-based fabrics? Textile Technology Source 2022

Coming Full Circle: Innovating towards sustainable man-made cellulosic fibres Fashion For Good 2020

Modal, lyocell and viscose by Lenzing. lenzing.com

Lyocell fibre https://lyocell.info/

HeiQ AeoniQ fibre https://www.heiq-aeoniq.com/our-technology/

What is Corn Fiber? How is Cloth Produced from Corn? Textile Journey 2021

Mushroom Fiber: The Future of Sustainable Textile. M.I.Kiron. Textile Learner 2024

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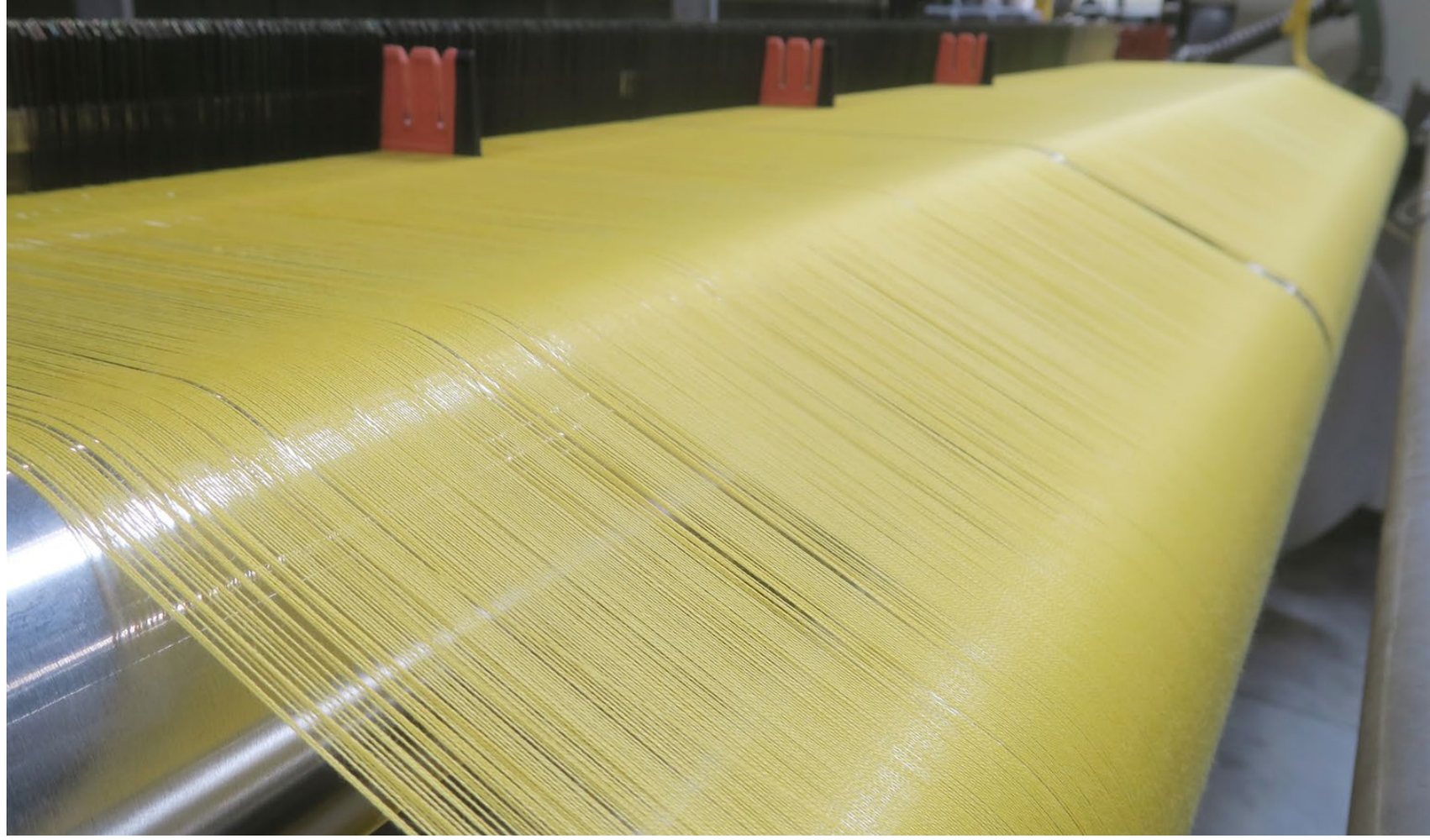
Visit the project website to see all the intellectual outputs of the project.



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