CLEANTEX

Clean and Innovative Textiles Strategy for Circular Economy

MODULE 3
Sustainable Fibre/Material Resourcing

Unit 3.2
Man-Made Fibers With Low Environmental Impact

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3.2.1 Introduction

In the *Module 2.3. Man-made fibers with low environmental impact* we are going to discover the main characteristics, properties and uses of the most well-known man-made fibres that have a low environmental impact.

The content of this module is divided in two different topics:

- Natural polymer-based fibres and,
- Synthetic polymer-based fibres

Textile fibres can be organized regarding its chemical structure, source, utility, etc. The most extended classification is the one obtained when separating the fibres by its source, dividing them into two main types: natural fibres and man-made fibres.

Depending on their origin, natural fibres can be subdivided in other groups, and the same happens with man-made fibres, which can be organic or inorganic depending on their chemical structure. Organic polymers are distinguished from inorganic polymers because of presence of carbon atom in the main chain.

In this module we are focusing on the man-made organic fibres. These include:

- Man-made organic fibres coming from a natural polymer.
- Man-made organic fibres coming from a synthetic polymer.

Polymer is a material constructed of smaller molecules of the same substance that form larger molecules. The polymers are any of numerous natural and synthetic compounds of usually high molecular weight and consisting of up to millions of repeated linked units, each a relatively light and simple molecule.

Natural organic polymers include polysaccharides or polycarbohydrates such as starch and cellulose, lignin, and proteins. Synthetic organic polymers include polyethylene, polypropylene, polyamides, polyesters and polyurethanes, among others.

3.2.1 Natural polymer-based fibres

The use of organic chemical fibres from natural polymers is considered a valuable eco-design strategy because it allows to incorporate a high percentage of recycled fibre (post-consumer, for example) into a new yarn with better physical properties than a mechanically transformed recycled yarn. In addition, the process allows the use of a wide range of materials, some of which are considered waste, that is, if they were not used, they would go to landfill.

However, from an environmental point of view, it is always important to take into account the production process, since it usually involves the use of chemical products, which could compromise the fibre's environmental footprint. In any case, advances in the field are proposing new solutions to the problems by changing the processes (turning them into a closed-loop ones), the chemicals (using ones less harmful for its users and the environment) and raw materials (coming from certified sources or being recycled).

CHITOSAN

Chitosan fibres are made from chitin, which is extracted from shrimp or crab shells, a waste of the food industry. Some of the most important characteristics/properties of chitosan are:

- It is a safe material since it comes from nature and, more specifically, from food.
- Biocompatible, not toxic or allergenic.
- Biodegradable.

- Promote healing by acting on the immune system and accelerating the regeneration of epidermal tissue.
- Improves body immunization against possible diseases.
- Anti-fungal and anti-mite properties.
- Provides softness and comfort to garments.

In spite of these good properties, its low-performance manufacturing process makes the fibre expensive, and in addition its mechanical properties are low. In order to use it in yarns, it must be blended with other raw materials such as viscose.

Due to their characteristics, the main applications for chitosan are for underwear (also specially in medical cases), toiletries and fabrics for decoration such as pillows or towels (because of its anti-fungal properties) and also in general clothing due to the softness and comfort the fibre can give. Sports is one of the areas that chitosan is useful as well, again due to its anti-fungal and anti-bacterial properties.

PLA

Next fibre we are going to speak about is polylactic acid.

Polylactic acid fibre (also known as PLA) is made from lactic acid obtained by fermenting corn-starch (dextrose). As it is not obtained from a by-product but from a food source, the use of this fibre causes some controversy.

Although compostable, polylactic acid is quite durable in most applications. In fact, PLA does not readily degrade unless it is exposed to high humidity and elevated temperatures (≥ 60°C) which results in rapid decomposition of the fibre. Thus, for most applications, its durability is acceptable or good.

Those fibres offer a comfort and an insulation comparable to the natural fibres and an easy care just like synthetic fibres. They can be mixed with wool, cotton, or viscose, both in knit and in openwork.

Some of the advantages they can offer are:

- Low humidity absorption
- Low flammability
- Low resistance to abrasion
- Biodegradability
- Resistance against ultraviolet radiation
- Toughness
- Prevention of bacterial colonies formation
- Similar touch to cotton

PLA is fully biodegradable and biocompatible, which makes this fibre attractive for medical applications like wound dressing. The fibre is also useful as an eco- and people-friendly alternative to existing textile fibres for industrial and consumer apparel applications such as outdoor furniture, automotive interior fabrics, activewear, shoe linings, and disposable products like diapers and wipes, either at 100% or in blends with natural fibres such as cotton.

ALGINATE

Alginate (ALG) is a natural polymer organic chemical fibre obtained from alginic acid metal salts. It is obtained from some algae and is extracted from them by a specific treatment.

Alginate fibres are made from sodium alginate, which is a natural polymer extracted from brown seaweeds. Over the last two decades, alginate fibres have become well established in the wound management industry where their ion-exchange and gel-forming abilities are particularly useful for the treatment of exuding wounds. In order to deliver functional performances for advanced wound management products, many improvements have been made in recent years to enhance the absorption and gel-forming capabilities and the anti-microbial properties of alginate fibres. In addition, attempts have been made to use alginate fibres as a carrier to deliver zinc, silver and other active

ingredients that are beneficial to wound healing.

Alginate have the following properties:

- Biodegradable
- Absorption of up to 20 times its weight
- Good resistance to solvents
- Good phytosanitary properties
- Late ignition
- Low mechanical resistance

Alginate has found numerous applications in biomedical science and engineering due to its favourable properties, including biocompatibility and ease of gelation.

The main applications of this material for the manufacture are medical/hygiene products (due to the absorption capacity it has) but also decorative fabrics, underwear and socks.

REGENERATED CELLULOSE FIBRES

Cellulose fibres are fibres obtained, through a chemical process, from the polysaccharide known as cellulose, which at the same time can be obtained from the bark, wood or leaves of plants, or from other material that contains this molecular chain. With this process, we can also recycle cotton by chemically if we undo its structure and rebuild it.

There are different types of cellulosic-based fibres depending on the chemical process used to make them and also the source of cellulose. Each one has different characteristics, specifically regarding its environmental performance.

Regenerated cellulose fibres have a lower environmental impact since the products made with them can be made using recycled fibres, and they are biodegradable because their cellulosic nature. Although the processes for obtaining them are different, some are more respectful towards the environment than others.

In general, items made from regenerated cellulose are comfortable thanks to their ability to absorb moisture, which is superior to that of cotton or silk.

There are some fibres in this group that they are quite similar, let's differentiate them:

- **Rayon** is a regenerated cellulose fibre, usually derived from wood pulp. Rayon is usually made from eucalyptus, but any plant (such as bamboo, soybean, cotton, etc.) can be used. Viscose, modal, lyocell and bamboo are different types of rayon.
- **Viscose** uses regenerated cellulose polymer obtained by the viscous process from wood and vegetable fibres. Its process uses a large amount of chemicals, which are very harmful to the environment when released into effluents. However, we can find few sustainable options available in the market that are worth mentioning such as ENKA®, Eastman Naia ™, ECOVERO ™.
- **Modal** production process uses beech trees with a process similar to that of viscose. Lenzing sells modal under the name Lenzing Modal® and only uses trees from sustainably exploited forests (PEFC-certified) and uses an environmentally friendly bleaching method. However, modal is produced by many other manufacturers that do not necessarily use sustainable processes.
- **Lyocell** is a much more environmentally friendly rayon manufacturing process than its modal and viscose relatives. Lyocell is manufactured in a close circuit loop system that recycles almost all the chemicals used. "Lyocell" is the generic name for the manufacturing process and fibre. Tencel® is the brand of lyocell marketed by Lenzing AG. Tencel® is made from eucalyptus from PEFC-certified forests. Eucalyptus grows quickly without the use of pesticides, fertilizers or irrigation.
- **Cupro** is an artificial cellulose fibre made from linen cotton (or cotton waste). To have the yarn ready for weaving, the extracted cellulose is soaked in a bath of a chemical solution called "cupramonium". The whole process is performed in a closed loop circuit.

Cellulose fibres are cheap to produce and is a versatile fabric used for clothing items such as blouses, dresses, and jackets, and around the home in carpets and upholstery.

MILK FIBRES

2 million tons of milk are disposed of around the world in a year. Milk protein fibre is manufactured from this waste through a bioengineering technique.

Milk fiber was invented in the 1930's in Italy. It was manufactured from milk casein to compete with wool.

Casein is obtained by the acid treatment of skimmed milk. The casein coagulates as a curd which is washed and dried, and then ground to a fine powder. Casein is dissolved in caustic soda solution. The solution is allowed to ripen until it reaches a suitable viscosity, and is then filtered and deaerated.

Milk fibre is made from 100% renewable resources and thanks to an eco-efficient production technology, it presents significant advantages:

- Biodegradable fibre.
- Antibacterial fibre and ideal for people who suffer from textile allergies.
- Fabrics made from milk fibre provide high wearing comfort and a silky feel.
- Milk fibre resembles wool in having a soft warm handle.

The production process allows the obtention of 1kg of fibre each 5 minutes and has a high level of water saving (2l for 1kg of fabric) compared to cotton production (20,000l for 1kg). this process does not have significant or pollutant wastes.

The uses of milk fibres go from clothing to towels or bed sheets.

SOY FIBRES

Soy fibres are made by a distilling soy protein and refining it. Then, an auxiliary agent and biological enzymes are added making the spatial structure of the protein change. Polymers are then added to the liquid mixture and temperature is applied. The threads are extracted by wet spinning technology.

Main properties of SP are:

- Biodegradability
- Can be dyed using acid and reactive dyes (especially the last ones, can give it a very good and bright colour)
- Good results to perspiration and light fastness
- Good hygienic and functional properties, has good affinity with the skin of the human body. It has the same ability to absorb moisture as cotton, which gives it a high level of comfort.
- It has the same ability to absorb moisture as cotton, which gives it a high level of comfort.
- It does not shrink.

The main applications for soy fibres are for home textiles, children's clothing, underwear and outerwear, and sportswear.

ELASTOMERIC YARN

Elastomeric fibres are those ones that are able to elongate themselves up until 400% and recover its original aspect rapidly and repeatedly. The most well-known brand of elastomeric yarn is Lycra (from the company Invista), a long chain polyurethane.

Rubber can be transformed into an elastomeric fiber. Rubber natural fibers are produced from the salvia extracted from a tree called *Hevea brasiliensis* and the rubber is produced after its coagulation.

The logical application for these fibres is in fabrics where a high elasticity grade is needed, such as sport clothes or lingerie.

3.2.1 Synthetic polymer-based fibres

The use of recycled polymers reduces the dependence on fossil raw materials. We are going to give you some information about recycled polyester and polyamide.

RECYCLED POLYESTER

Recycled polyester, also known as rPET, is made by melting down existing plastic (PET) and spinning it back into new polyester fibre. While much attention is paid to rPET made from consumer-discarded plastic bottles and packaging, it can also be made from post-industrial materials.

Some points in favour to use recycled polyester can be:

- Recycled polyester gives a second life to a material that is not biodegradable and would otherwise end up in a landfill or ocean.
- Its manufacture requires fewer resources: recycled polyester is almost the same as virgin polyester in terms of quality, but its production requires 59 percent less energy compared to virgin polyester.

Negative or to be improved aspects:

- Many garments are not made only from polyester, but from a mixture of polyester and other materials. In that case, it is more difficult, if not impossible, to recycle them.
- The PET recycling process also affects the environment as the chips generated by mechanical recycling can have different colours. In these cases, it is necessary to use chlorine-based bleaches to obtain a subsequent uniform dyeing and this may require a high use of water, energy, and chemical products.
- rPET produces microplastics as well as other synthetic fibres do.

Recycled polyester can be used in the same items as polyester does.

RECYCLED POLYAMIDE

The case for recycled polyamide is quite similar to what we have explained about polyester.

The raw material source for recycled polyamide (PA) uses to be old fishing nets and carpets, as well as waste from the manufacturing industry. Some companies have patented a recycling process that transforms post-industrial technical textiles, like airbags, into premium plastics. This technology offers new products that are more ecological and with similar performance to those made of PA.

The uses of recycled polyamide can be assimilated to those of non-recycled polyamide.

USED AND INTERESTING REFERENCES

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- https://www.econyl.com/
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