Unit 1 Textile Technology
Lecture 1.2 Advances in non-woven production

D 2.1 Training toolkit and e-book

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Advances in non-woven production

Lecture 1.2

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Nonwovens definition

- ISO standard 9092: "Engineered fibrous assembly, primarily planar, which has been given a designed level of structural integrity by physical and/or chemical means, excluding weaving, knitting or papermaking."
- Made with fibres, filaments, or chopped yarns, of any nature (natural or man-made) and in a certain random distribution, that are bonded together.

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General characteristics

- In general:
  - High versatility
  - Innovative
  - Cost-effectiveness
- Their properties can be tailored to create solutions suited for specific applications, typically reaching a good balance between product use-life and cost.

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General properties

- Their properties depend on many factors, such as the appropriate raw materials selection, the production method used, and the finishing treatments applied later, such as printing, embossing, moulding, laminating, etc.
    - Mechanical response: elastic, resilient, smooth, soft, stiff, stretchable, strong and stable
    - Weight: Light by definition, but can be obtained dense fabrics when necessary
    - Technical: abrasion resistance, tear resistance, flame resistance, sound and heat insulation, absorbency or liquid repellence (depending on sort of fibre or treatment)
    - Durability: can have a short or long lifespan, depending on the end-use, and can even be biodegradable
    - Porosity: they can be breathable or impermeable depending on treatment applied, so they can have filtration properties
    - Easy to process: can be welded, sewn, glued, dyed, washed, ironed, moulded, etc.

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Applications

- In fashion:
  - interlinings (inside the garments) for shape-retention and to increase the stiffness of some parts
  - background stabilizers for embroidery, to avoid damaging the fabric due to the needle action
  - shoe and bag components, typically interlinings to reinforce the aesthetic fabrics
  - background of synthetic leathers
  - decorations or exterior fabrics in and fashion garments
  - Etc.
- In technical applications:
  - Agrotextiles: as crop covers, weed control fabrics, plant protection, greenhouse shading, textile plant pots, etc.
  - Geotextiles: as canal and pond linings, soil stabilization and reinforcement fabrics, drainage layers, leak control fabrics, etc.
  - Healthcare and medical textiles: in diapers, feminine hygiene products, medical disposable caps, gowns, masks, scrub suits and shoe covers, sponges, contamination control gowns, examination gowns, lab coats, isolation gowns, transdermal drug delivery, sterilisation wraps, etc.
  - Automotive: car insulation, carpets, flooring, seats, interior trimming, filters, etc.
  - Building: thermal and sound insulation, roofing, vapour barriers, flooring, concrete reinforcement, etc.
  - Household products: abrasives, furniture and upholstery, tea bags, cleaning wipes, etc.
  - Smart textiles

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Conventional nonwoven production technologies

Web formation	Web bonding	Finishing
Dry-lay route Carding Air-laid	**Chemical route** Impregnation with binders	Washing Coating Printing Dyeing
Wet-lay route Suspension in a screen belt	**Thermal route** Calendering Hot air	
Spun-melt route (extrusion) Spun-laid Meltblown	**Mechanical route** Needle-punching Hydroentanglement (spunlacing) Stitchbonding	

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New trends in nonwoven production

Electrospinning	Sustainable nonwovens	Industry 4.0 technologies

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Electrospinning

- Electrospinning is a spinning technique based on the use of high electrostatic forces to produce continuous fibres with diameters ranging from microns to nanometres in size. However, those nanofibers are collected in a grounded surface. Depending on the shape and size of the collector, nanofibers can present a random distribution that corresponds to a nonwoven structure.
- After deposition, the charges are quickly dissipated, but the low conductivity of most materials used can limit this dissipation, leading to residual changes on the deposited fibres' surface that might produce a repulsion of the jet due to the similarity of their charges. This effect not only affects the behaviour of the electrified jet, but also limits the thickness of the nonwoven mat to around 0.5-1 mm.

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Electrospinning

- There are many parameters that affect the electrospinning process:
  - Environmental conditions (relativity humidity, temperature)
  - Polymer solution used (polymer concentration, viscosity, solvent and solution conductivity)
  - Equipment settings (applied voltage, solution flow rate, collector type, distance between the needle and collector, or needle diameter, among others) [5]
- The effects of these parameters affect not only the fibre diameter, morphology and regularity, but also the fibre distribution, thickness and porosity of the resulting structure, among others, defining the final properties of the resulting nonwoven.

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Electrospinning applications

- Filtration: facemasks for protection against Covid-19
- Desalination
- electronic nanosensors
- Medical field: substrates for drug delivery systems, tissue regeneration, wound dressings or scaffolds, among others.

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Sustainable nonwovens

- The use of nonwoven fabrics is often associated to the production of disposable or short life span products (low cost and easy fabrication)
- However, near 70% of the materials used for nonwoven production (both binders and fibres) are synthetic
- Combination of these two factors leads to problems of disposability and microplastics contamination, among others.
- More sustainable approaches :
    1. increase the durability of nonwovens products: switch from the “disposable” to the “resusable”
    2. use of recycled raw materials
    3. use of bio-based raw materials

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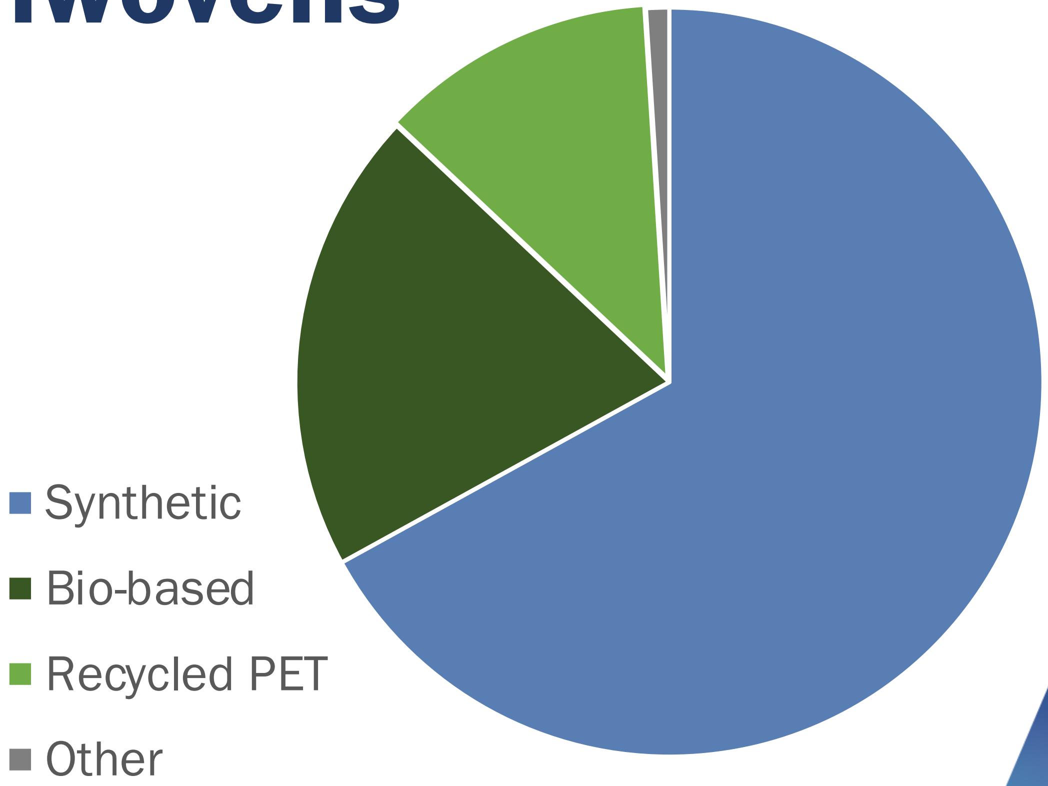
Sustainable nonwovens

- Worldwide trend towards a greener production



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Sustainable nonwovens

It has to be taken into account that the raw materials selection does not only affect the nonwoven properties and their durability, but also their possibilities for further recycling, and hence, for their circularity.

1. Increase durability, reduce the need of binders and reach highly technical specifications by increasing the bonding capabilities of natural fibres; by promoting self-bonded cellulosic nonwovens with ionic liquids; or by using enzymes or plasma to minimize the amount of binders needed.

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Sustainable nonwovens

Circularity concept: once a product piece arrives to its end-of-life, it can be transformed into the raw material required for the production of the following piece, ideally leaving zero waste behind.

2.1. **Use of fibres from shredded pre- and post-consume fashion textiles**. But this is a complex reality, is not always a possible option (problems of classification and fibre separation, limited technologies to process)… but often used to obtain nonwovens for insulation in building and automotive sectors, and for cushioning and similar applications.

2.2. Use of **polyester fibres obtained from the recycling of PET bottles.**

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Bio-based fibres

- **Plant fibres** (often processed by air-laid and wet-laid techniques and bonded with biodegradable or water-soluble binders):
  - Cotton, for absorption-related applications (especially organic cotton)
  - Hemp, for automotive and building insulation applications
  - Flax, for composite reinforcement
  - Jute, for composite reinforcement, insulation and geotextiles
  - Bamboo, for composites but even for healthcare applications if combined with other fibres
- **Fibres from agrowaste:** such as straw, sugarcane bagasse, corn, coconut or oil palm fibres, and many others; used in composites and agrotextiles, among others.

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Bio-based fibres

- **Wood pulp fibres** (processed by air-laid and wet-laid, and chemically bonded. Most common use is in disposable absorbing products.
- **Man-made cellulosic fibres**, also called **regenerated cellulose fibres.** Higher biodegradation and recycling potential with good technical performance:
  - Viscose (or rayon), for spunlaced wipes, healthcare applications or reinforcements, among others
  - Lyocell, for hygiene products
  - Cellulose acetate fibres, for cigarrette filters
- **Other plant-based, animal-based and microbial fermentation-based fibres**:
  - Alginate fibres,
  - Chitosan fibres, for medical applications
  - PLA fibres

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Bio-based binders

- Used for web bonding, to replace those synthetic ones:
  - Cellulose acetate fibre binders
  - PHA fibre binders
  - Bacterial cellulose suspension
  - Alginated-based solutions
  - Bio-latex dispersions
  - Starch and starch-based aqueous dispersions or polymer solutions, which are non-toxic, biodegradable and low-cost
  - Lignin-based and tannin-based adhesives
  - Soy-protein bio-based resins
  - Polymers based in cottonseed-protein and several natural gums
  - Microfibrillated cellulose, cellulose nanocrystals and bacterial cellulose

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Industry 4.0 technologies

- Industry 4.0 means an increased automatisation of production processes
- This helps companies to improve efficiency in their production and energy and resources consumption, while having real-time information about the manufacturing process.
- Industry 4.0 technologies are based in intelligent machines:
  - connected to the IoT
  - with enhanced machine operation
  - that achieve a smart energy consumption
  - that determine needs for predictive maintenance
  - that work with assistance systems for maintenance, repair and operation
  - that control production with advanced process control systems
  - use the big data analytics

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Industry 4.0 technologies

- **The incorporation in production equipment of such a technology is currently a reality.**
- The most relevant points for the implementation of industry 4.0 in the nonwoven production are:
  - Self-optimizing machines to reduce the waste production, energy consumption and machine downtime
  - Big data analytics to reduce the machine downtime
  - Assistance systems to reduce the machine downtime and increase the labour efficiency

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Challenges and opportunities for nonwoven textiles

- The global nonwoven market, even within the Covid pandemic, was estimated at $38.3B in 2020, increasing by 6.9% the results of the previous year.
- Analysers point to the booming demand for facemasks and other medical textile goods as the reason, owing that this has been being a key driver for the nonwovens market.

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Challenges and opportunities for nonwoven textiles

Challenges

- Changes in all markets and trends, different values and criteria for purchasing goods
- Need for differentiation: positioning of the product by its specifications and the search for new developments and applications
- Stock keeping unit: production runs tend to be shorter, higher need to have a larger variety of products available, which presents some cons along the supply chain (higher complexity, additional costs and more exigent delivery times)

Opportunities

- The low cost, easy production, innovation and development of the material, which has positioned nonwoven textiles as the preferred alternative, before woven and knitted fabrics, in many high-value goods.
- Opportunities arise from the research and development in order to ensure that nonwovens can cope the expectations for highly technical solutions and/or more sustainable products.

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