Fashion DIET

Finishing in the context of sustainability

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Learning Objectives

After this lecture, you should be able to:

- Understand the main issues related to sustainability in textile finishing.
- Understand the sustainability issues associated with the use of textile auxiliaries.
- Identify the possibilities of optimizing existing technologies and replacing environmentally aggressive products.
- Apply the revolutionary new finishing technologies that are environmentally friendly.

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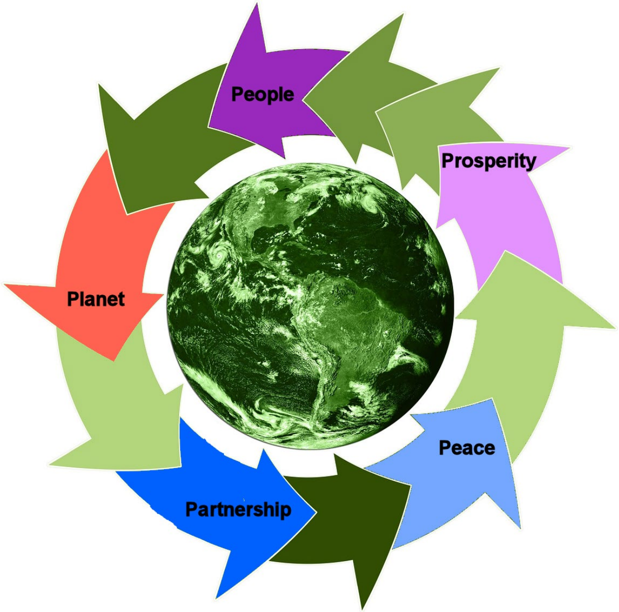
Introduction

Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987"



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Major Ecological and Social Challenges in Textile Industry

	Water	Effluent	Energy	Chemistry	Land	Society
Raw materials						
Spinning						
Weaving/ Knitting						
Wet processing						
Garment						

No effect

Low effect

High effect

Very high effect

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Ecological issues regarding textile finishing

- High effluent and water consumption.
- Use of formaldehyde as an agent during the manufacture and processing of flame retardants or in Easy-care finishing.
- Potential environmental risks associated with halogen containing flame retardants, etc.

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Optimizations of existing technologies and substituting environmentally aggressive products

- Multifunctional finishing
- Free ethylene urea and melamine derivatives in their “not cross-linked form” (cross-linking agents in easy-care finishes)
- Substitution of formaldehyde compounds with those that contain no formaldehyde or with compounds that contain reduced amounts of formaldehyde, etc.
- Impart crease recovery, UV protection, and antibacterial properties in single step by simultaneous application of organic and inorganic environmental friendly chemicals (Aslam et al., 2018)

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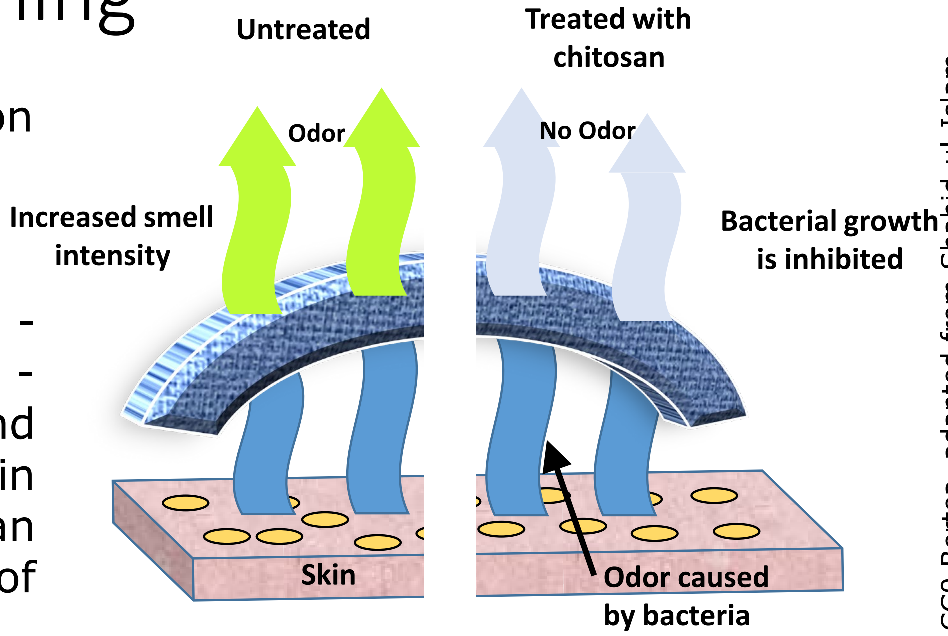
Optimizations of existing technologies and substituting environmentally aggressive products

Multifunctional finishing

- ZnO nanoparticles for UV protection and antibacterial properties and butanetetracarboxylic acid for crease recovery;
- chitosan with DMDHEU - dimethyloldihydroxyethyleneurea - for wrinkle free, antibacterial and flame retardant properties; in addition, the presence of chitosan contributes to the removal of odours.



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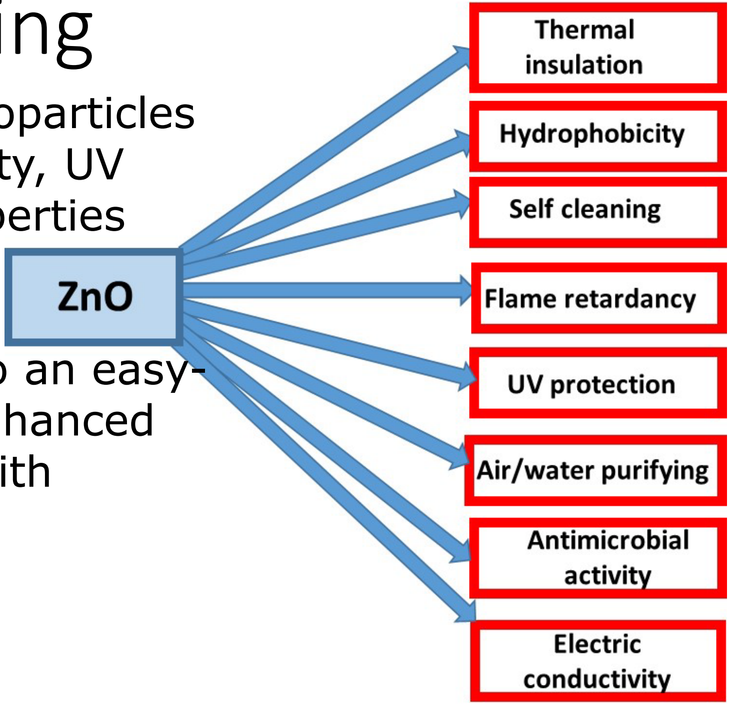
Optimizations of existing technologies and substituting environmentally aggressive products
Multifunctional finishing

- butanetetracarboxylic acid and zinc oxide nanoparticles to impart wrinkle recovery, antibacterial activity, UV protection, bending rigidity and antistatic properties (Aslam et al., 2018; Verbic et al., 2019);

- incorporation of metal oxide nanoparticles into an easy-care/softener finishing formulation leads to enhanced fabric resiliency and surface softness, along with improved UV-protection and antibacterial functionalities.



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Optimizations of existing technologies and substituting environmentally aggressive products

Multifunctional finishing

- WET-ON-WET foam application of both crease-resist and antistatic finishes
- uses successive foam treatments without intermediate drying to apply successive crease-resist and antistatic finishes
- This process avoids the shortcomings of the traditional process, namely the release of significant amounts of effluent, which contains excess finishing and auxiliaries and the consumption of large amounts of energy to remove water (Miraftab and Horrocks, 2004).

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Optimizations of existing technologies and substituting environmentally aggressive products

Non-formaldehyde Polyfunctional Crosslinking of Cotton

- Because formaldehyde has been recognized as a probable human carcinogen, durable press finishes of cotton fabrics that do not contain formaldehyde, such as polycarboxylic acids, has become increasingly important.
- Crosslinking of cotton with polycarboxylic acid, applied with catalysts based on phosphorus-containing inorganic acids, produces fabrics that release no formaldehyde at any stage of preparation or on storage.

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Optimizations of existing technologies and substituting environmentally aggressive products

Reduction/Removal of Formaldehyde from Textile Flame Retardants avoiding N-methylol species

- Equivalent or superior ease of application.
- Zero formaldehyde-releasing properties.
- Comparable textile service-life properties in terms of durability, effect on handle and tensile properties.
- Overall comparable cost-effectiveness (and preferably cheaper).
- Equivalent or superior toxicological and environmental impacts.

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Optimizations of existing technologies and substituting environmentally aggressive products

Reduction/Removal of Formaldehyde from Textile Flame Retardants - reactive flame-retardant bonding types

Cellulose combination after treatment	Properties
Cellulose-diacidhypophosphite	Resists 20 home wash cycles.
Cellulose/BCTA/triethanolamine	Resists 30 home wash cycles.
Cellulose phosphonate and derivatives	Resists >30 home wash cycles
Cellulose-polymer systems	Resists >30 home wash cycles
Cellulose ester with butyl tetracarboxylic acid (BCTA)	Modest wash resistance

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Optimizations of existing technologies and substituting environmentally aggressive products

Replacing Bromine in Coating and Back-Coating Formulations

Toxic polybrominated dioxins are formed during incineration of brominated flame retardants, especially in the case of compounds based on polybrominated diphenyls and diphenyl oxides.

To avoid this, formulation mixtures formed by gradual replacement of the decabromodiphenyl ether-antimony III oxide content with bromine-free alternatives such as ammonium polyphosphate can be used.

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Optimizations of existing technologies and substituting environmentally aggressive products

Replacing alkyl and perfluoroalkyl compounds in textile formulations

Per- and polyfluorinated compounds are used in a variety of textile finishing applications, especially as water and oil repellents, in digital printing or as anti-microbial agents. Some of the commercial used products release per- and polyfluoroalkyl substances, which are persistent and accumulate in the human body.

In 2009, perfluorooctane sulfonic acid and related substances were declared persistent organic pollutants by the Stockholm Convention. Alternatives that can be used to replace toxic compounds include replacement of long-chain per- and polyfluoroalkyl compounds with shorter chain-length compounds d (e.g., perfluorobutansulfonic acid-based compounds) and non-fluorinated alternatives (siloxanes / polysiloxanes, dendrimers and wax).

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New technologies for sustainable textile finishing

- **Smart (Nano) Coatings**
- **Biofinishing (biopolishing, shrinkproofing for wool, etc);**
- **Plasma treatment;**
- **Use of bio-polymers, etc.**

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New technologies for sustainable textile finishing

Smart (Nano) Coatings technologies

- Nanoparticle adsorption
- Layer-by-Layer (LbL) deposition
- Sol-gel treatments
- Cold plasma deposition
- Biomacromolecular engineering (Alongi et al, 2013)

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New technologies for sustainable textile finishing

Nanoparticle adsorption

The adsorption of nanoparticles, which is one of the simplest ways to use nanoparticles to change the surface of a textile material, involves immersing the fabric in an aqueous suspension of nanoparticles, thus achieving the adsorption of nanoparticles on the surface of textile fibres. Using this technique on polyester with a hydrotalcite–silica combination proved to be a most efficient flame-retardant system, while on cotton best results are obtained with selected clays such as sodium Cloisite (Alongi et al., 2015).

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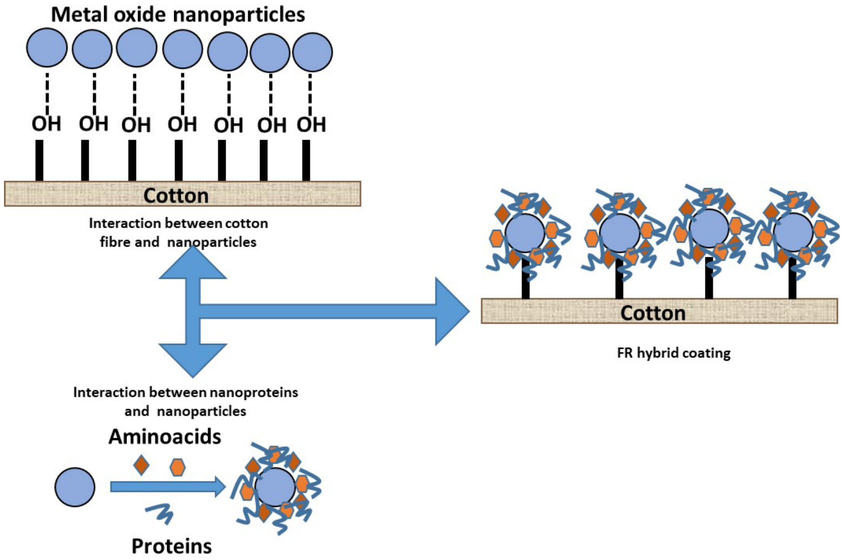
New technologies for sustainable textile finishing

Nanoparticle adsorption

Schematic representation of the coupling between inorganic phase (metal oxide TiO_2 NPs) and biomacromolecules to create a waterproof flame retardant treatment for cotton textile (Ortelli et al., 2018)



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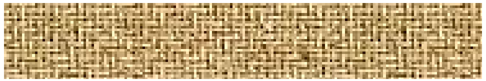
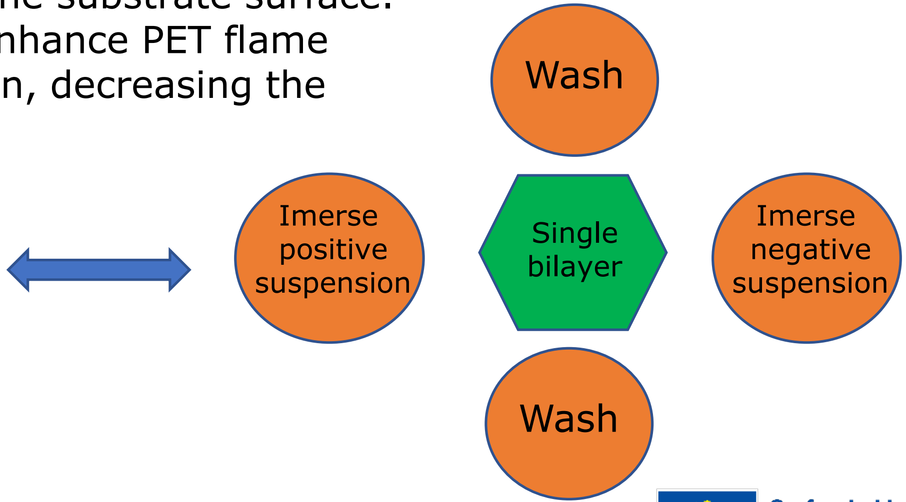
New technologies for sustainable textile finishing

Layer-by-Layer (LbL) deposition

- Layer by Layer deposition represents the repeated adsorption of nanoparticles using different reagents at each adsorption stage, creating a structure of positively and negatively charged layers ‘piled up’ on the substrate surface.
- The LbL nanoarchitectures are able to enhance PET flame retardancy by increasing the time to ignition, decreasing the combustion kinetics and reducing the smoke production (Xu, 2021).



Fabric



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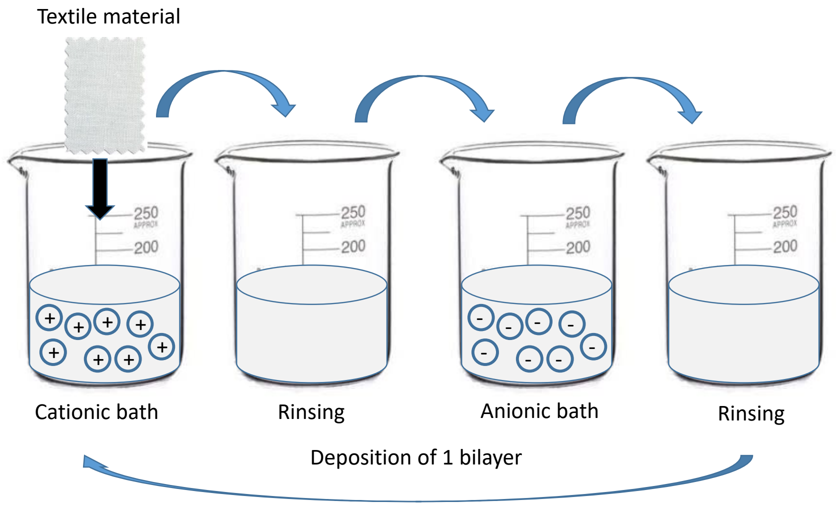
New technologies for sustainable textile finishing

Layer-by-Layer (LbL) deposition

A general scheme of the process is shown in the figure. The number of layers thus obtained is usually up to 10, but 50 layers can also be deposited. The techniques used are diving (used mostly in the laboratory phase) or spraying, which can be used on an industrial scale. The duration of each stage of the cycle varies from seconds to minutes, depending on the pH, the deposition temperature, the adsorption time and the type of substrate used.



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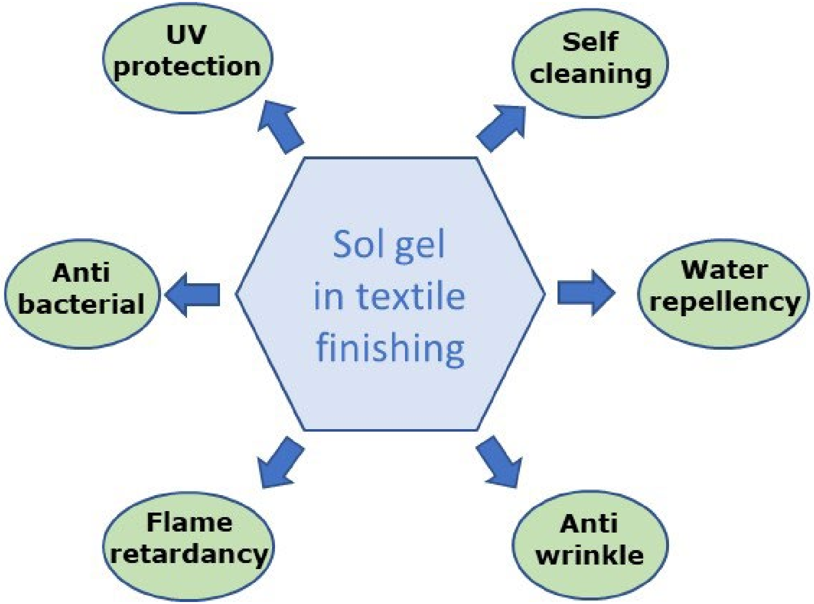
New technologies for sustainable textile finishing

Sol-gel treatments

Sol-gel technology has many applications in textiles finishing.

By sol-gel method, high chemical concentration used in conventional methods can be significantly decreased. Using chemical materials without halogen, ecological, and economical flame-retardant activity can be obtained.



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New technologies for sustainable textile finishing

Sol-gel treatments

- Sol-gel technology makes enabling multifunctional properties in one step.
- A layer of a fully inorganic or hybrid organic–inorganic 3D network is formed on the surface of the material that becomes Flame-Retardant.
- The reactions can be carried out at or near ambient temperature.
- The process produces low-MW (molecular weight) molecules (such as water and alcohols) as by-products during the condensation reactions.
- Sol-gel treated fabrics are usually resistant to washing cycles, especially the cellulosic substrate.
- On the other hand, sol-gel technology has a disadvantage of high costs of precursor materials used.

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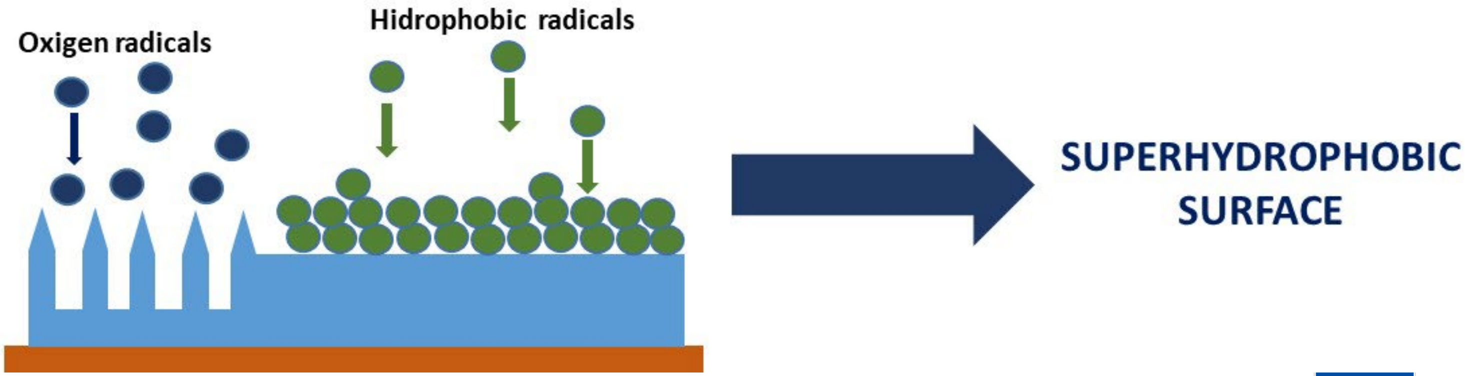
New technologies for sustainable textile finishing

Cold plasma deposition

A non-thermal plasma (cold plasma) - a partially ionized gas containing high-energy electrons mixed with low-energy molecular species (ions, free radicals, etc.) in a way that the overall system remains close to room temperature.



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New technologies for sustainable textile finishing

Cold plasma deposition

Cold plasma can generally be classified into two categories:

● Low pressure or vacuum plasma.

● Atmospheric pressure plasma (Choudhury, 2017).

Applications of cold plasma treatments are numerous: plasma polymerization (gaseous monomers), grafting, polymer, chemicals and metal particles deposition.

Three categories of gases are used for cold plasma treatments:

● Chemically inert gases (most commonly helium, neon and argon).

● Reactive but non-polymerizable gases (ammonia, air and nitrogen).

● Reactive and polymerizable gases (tetrafluoroethylene, hexamethyldisiloxane).

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New technologies for sustainable textile finishing

Cold plasma deposition

A non-thermal plasma (cold plasma) many advantages:

- tailors the surface properties without changings the physical and mechanical properties of the bulk material;
- high quality;
- high productivity;
- low water, energy and chemical consumption
- low cost;
- environmentally clean (Muthu, 2018).

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New technologies for sustainable textile finishing

Spray Pyrolysis

Pyrolysis by spraying is a process of chemical modification of the surface of the textile material by thermal stimulation, in which the precursor solution of the desired compound is sprayed on the substrate. Applications of surface modification of textiles by spray pyrolysis include obtaining photocatalytic, antimicrobial and flame retardant effects.

The atomization of the precursor solution takes place beforehand, with the formation of particles and thin films. Spraying is most often done using compressed air, ultrasound or an electric field (Shahid and Adivarekar, 2020).

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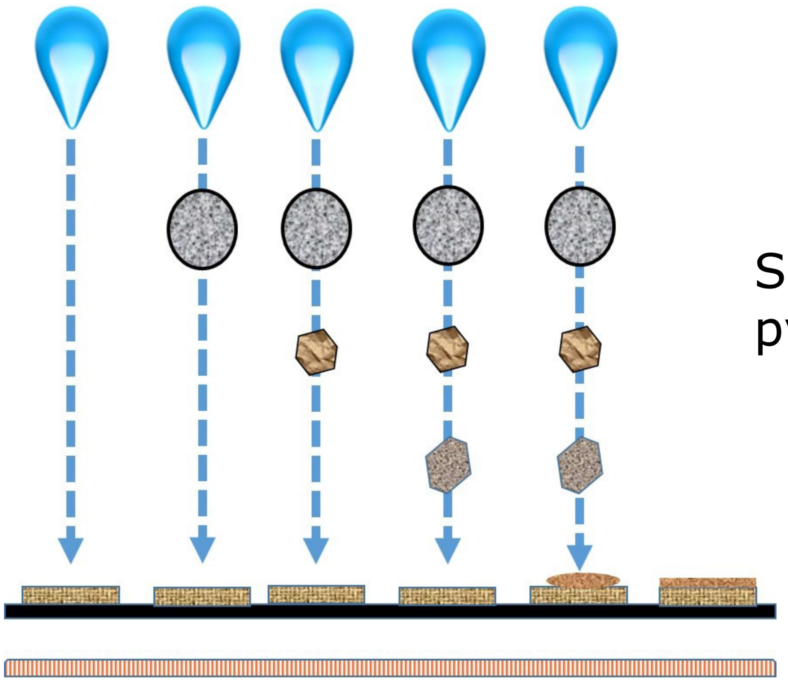
New technologies for sustainable textile finishing

Spray Pyrolysis



Stages of spray pyrolysis technique

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Conclusions

- The textile industry is one of the major polluters, which is why approaches to introduce processing with environmental protection are increasingly in demand. Greater than before consumer awareness of reducing environmental pollution leads textile manufacturers to eliminate or at least reduce toxicity during the production and life cycle of textiles.
- Modern textile finishing aims to use sophisticated processes that are more environmentally friendly. Nanotechnology has revolutionized the textile industry in recent decades as it offers a new way to give new properties to textile surfaces without affecting other properties.
- Although the use of nanotechnology is generally regarded as environmentally friendly, future research should aim to study in detail the environmental aspects of the use of nanoparticles.

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