# Textile chemistry 7. Finishing

Textile → finishing


Jakub Wiener

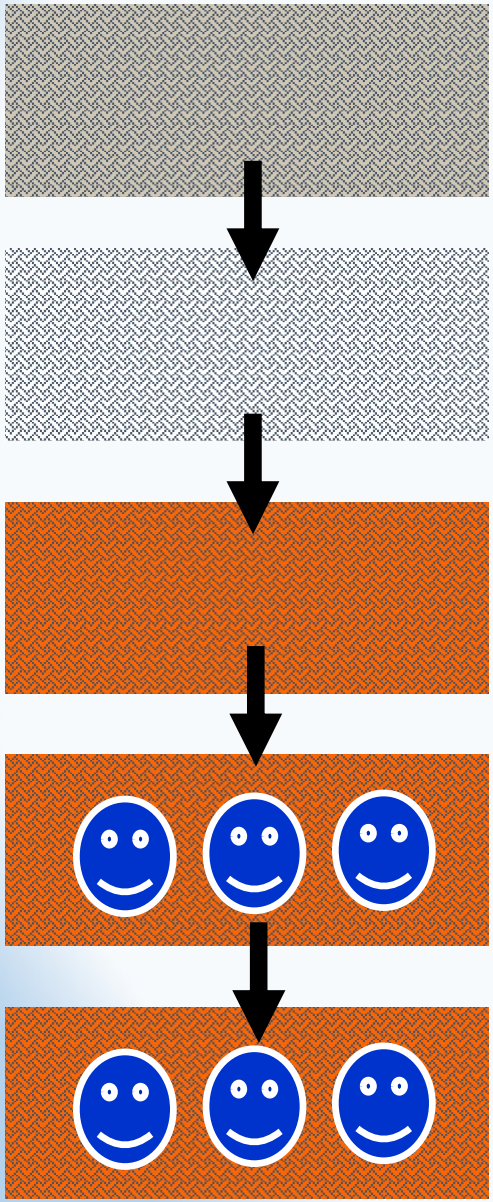
# Finishing - introduction

Textile → finishing


**Finishing = all chemical textile technology + special mechanical treatments (e.g. brushing, cutting, grinding...)**

**Finishing = improving the properties of textiles by chemical and mechanical processes**

# Finishing - introduction



Pretreatment

*aim: basic properties*

Dyeing

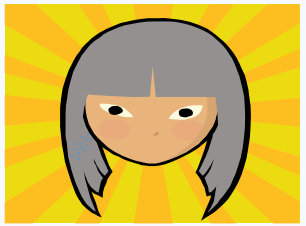
*aim:* color

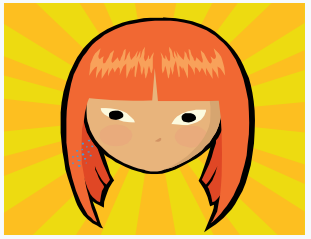
Printing

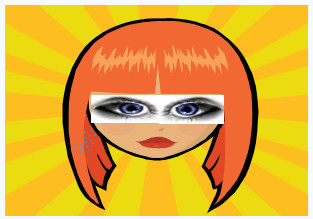
*aim:* pattern

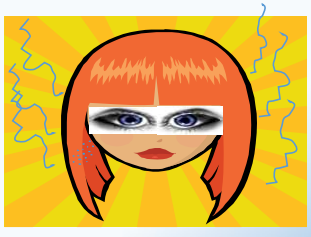
Final Finishing

*aim:* properties for customers

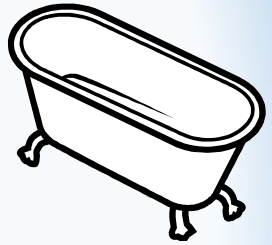








Human „finishing“



# Finishing - introduction

Mechanical technology

as a change of macroscopic structure

- polymer
– fibers
– sliver
– yarn
– fabric
– product

???

connections

???

- pretreatment
– dyeing
– printing
– final finishing

*Without direct connection !!!*

# Finishing - introduction

- discontinual

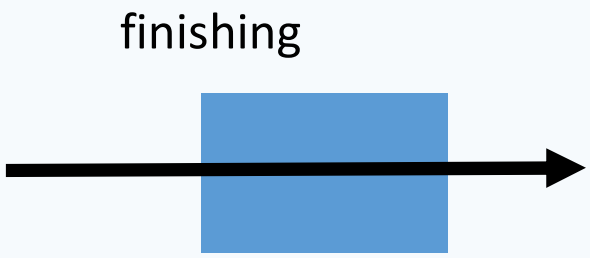
(washing at home, cooking)


http://www.vesko.cz/hrnec-16cm-belis-standart-1-78-41575.html

http://www.jakbydlet.cz/clanek/500_jak-vybirat-spotrebice-do-domacnosti-i--pracky.aspx

- continual

(mangle, self made of noodles)

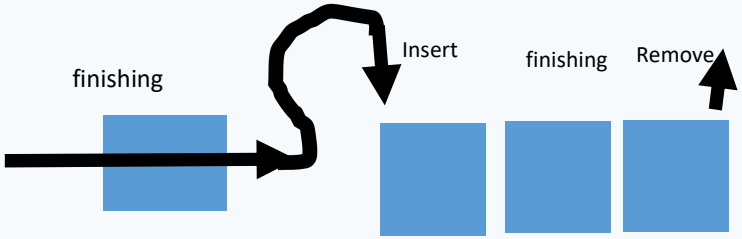



http://www.amaterske-vareni.cz/clanky/moje-nakupni-taska/strojek-na-nudle.html

http://www.pro-salony.cz/zbozi/mandl-ironnette-85

- semicontinual

(cooking of noodle soup)




http://www.e-ott.info/2012/04/06/jak-uvarit-kureci-polevku-a-kolik-to-stoji-pro-linuxaky-man-polivka

# Finishing – used chemicals

**Textile auxiliaries:**

**Chemically produced compounds and mixtures thereof which facilitate, accelerate or generally enable technological processing used in the manufacture and finishing of textiles**

**= chemicals in finishing**

# Finishing – according to fibre type

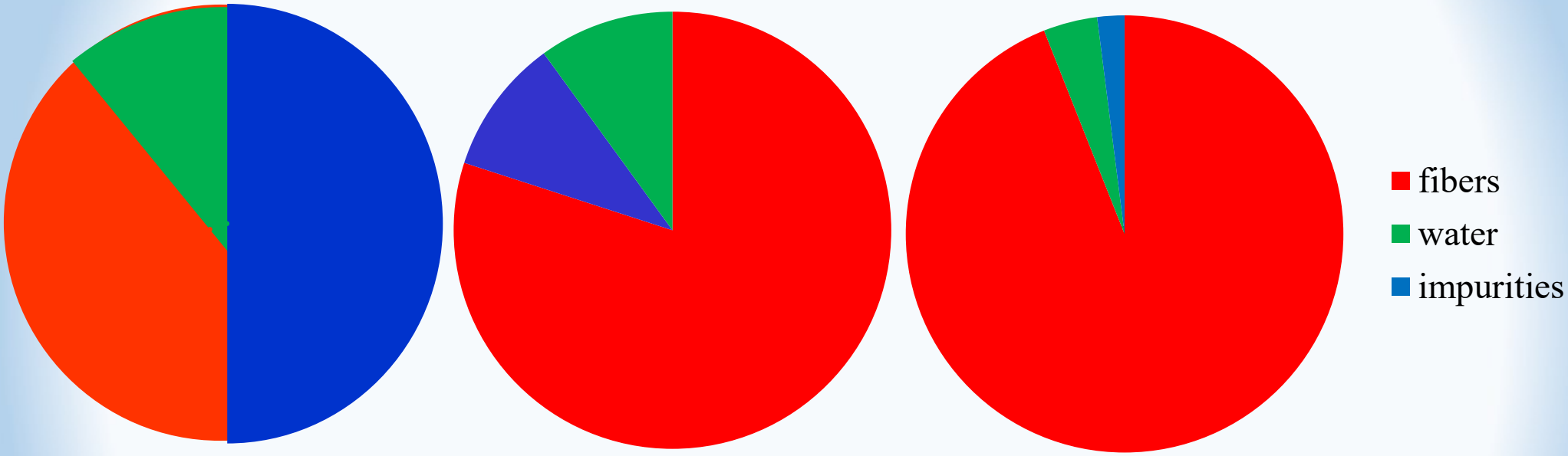
**Textiles - a large number of different fibres are used**

**Worldwide about 95% are cotton, wool, viscose, polyester, polyamide, polypropylene, acrylic, polyethylene (learn the formulas of these fibres - not just for the exam in this subject !)**

**Each fibre has different properties - e.g. chemical resistance to acids and alkalis, resistance to temperature**

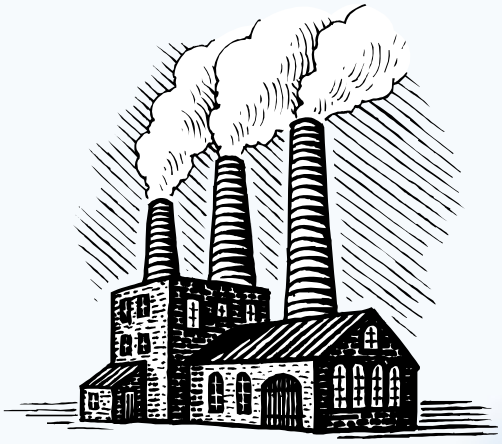
# Finishing - introduction

Natural fibers – more contaminated by impurities = more complicated pretreatment




http://tvbythenumbers.zap2it.com/2014/06/19/prime-instant-video-becomes-the-exclusive-subscription-streaming-home-for-wallace-gromit-shaun-the-sheep-and-other-top-series-from-aardman-animations/274966/

http://cottonaustralia.com.au/cotton-library/video



# Pretreatment

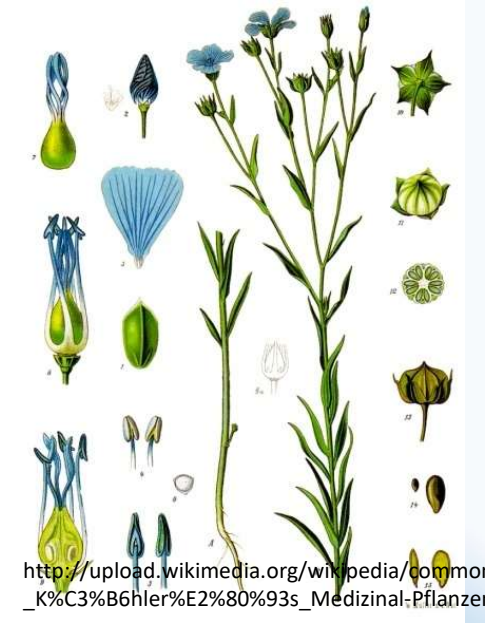
The purpose of pre-treatment of textile materials is to prepare them for further refining operations (dyeing, printing, finishing) and to improve properties important in terms of utility values required for the respective textile product, such as adding whiteness, absorbency, dimensional stability, gloss, strength, affinity to dyes, etc.

The purpose of pre-treatment is also to remove impurities of natural origin from natural fibres and impurities from the production process in chemical and synthetic fibres.
In our opinion, impurities are e.g. wool grease (lanolin), lipophilic components of cotton ...

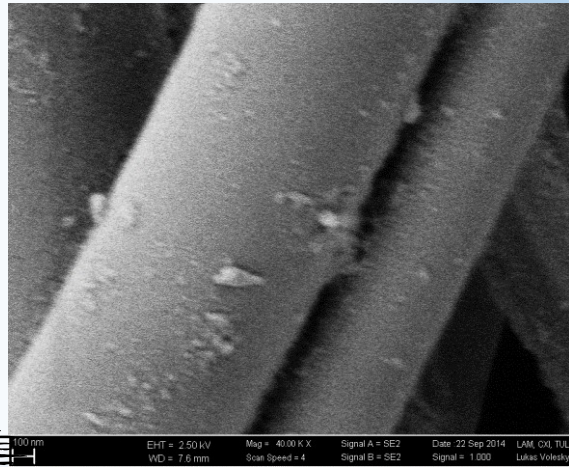
# Pretreatment

http://cottonaustralia.com.au/cotton-library/video

- cotton – singeing, desizing, scouring, bleaching, mercerization
- wool - washing, carbonization, bleaching
- flax (linen) – singeing, desizing, scouring, bleaching
- synthetic fibres - desizing, washing, setting



http://upload.wikimedia.org/wikipedia/commons/2/2b/Linum_usitatissimum_-_K%C3%B6hler%E2%80%93s_Medizinal-Pflanzen-088.jpg



# Pretreatment - scouring

**scouring s an operation for obtaining good and uniform absorbency, which is crucial for the quality of further finishing operations (bleaching, dyeing, printing).**

**Good and uniform absorbency is achieved by the perfect removal of impurities and impurities.**

**The main alkali used is sodium hydroxide NaOH or sodium carbonate Na2CO3 as alkali.**

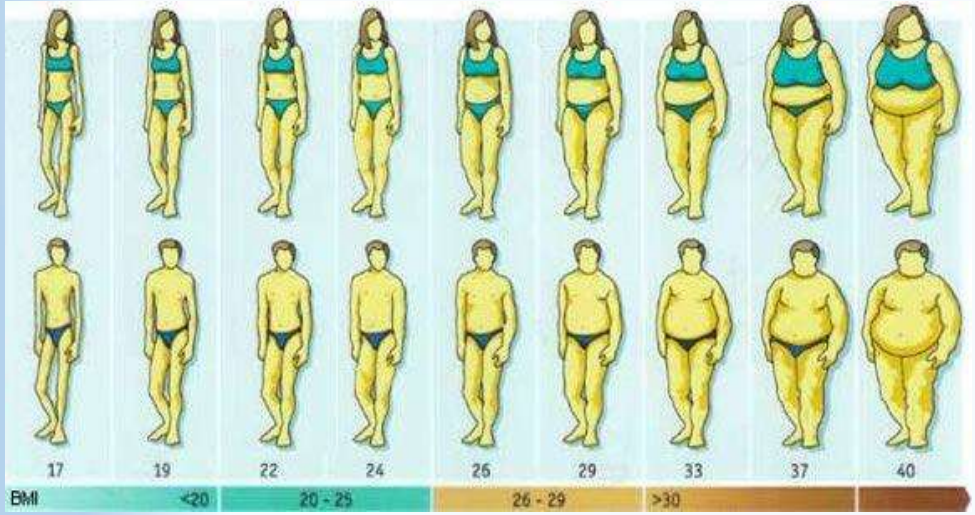
**+ wetting, emulsifying and special balance auxiliary agents**

Aim: to remove impurities, especially fats and waxes from cotton, to improve the absorbency of the fabric

For cotton and linen textiles, the scouring is necessary..

# Lipids

Fats, oils - esters of glycerol with Long-chain fatty acids


Palmitic acid: $C_{15}H_{31}COOH$

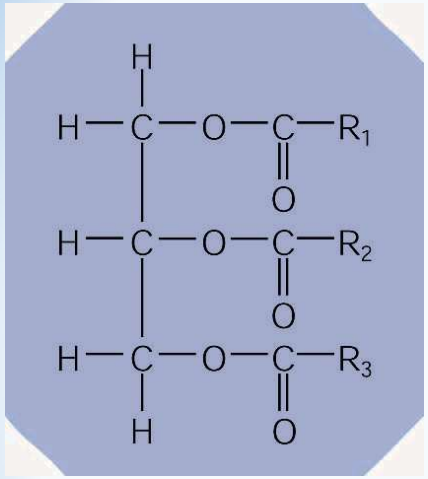
Stearic acid: $C_{17}H_{35}COOH$

Oleic acid: $C_{17}H_{33}COOH$

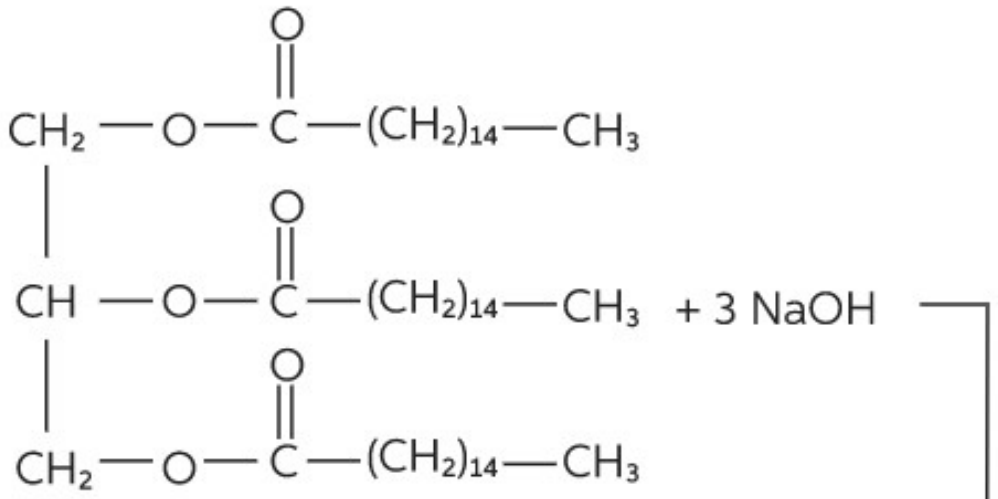
glycerol: $CH_2OH - CHOH - CH_2OH$

Waxes - esters of higher alcohols with higher fatty acids, more stable than fats

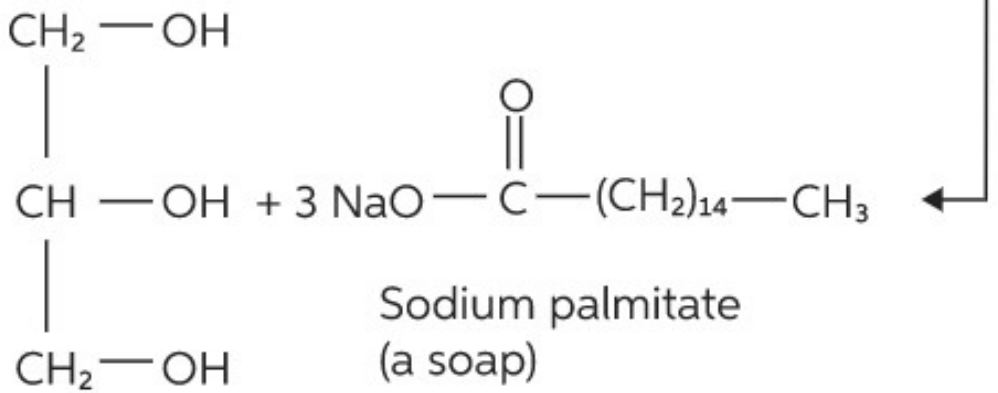
# Hydrolysis of fats (Saponification)








Triglyceride



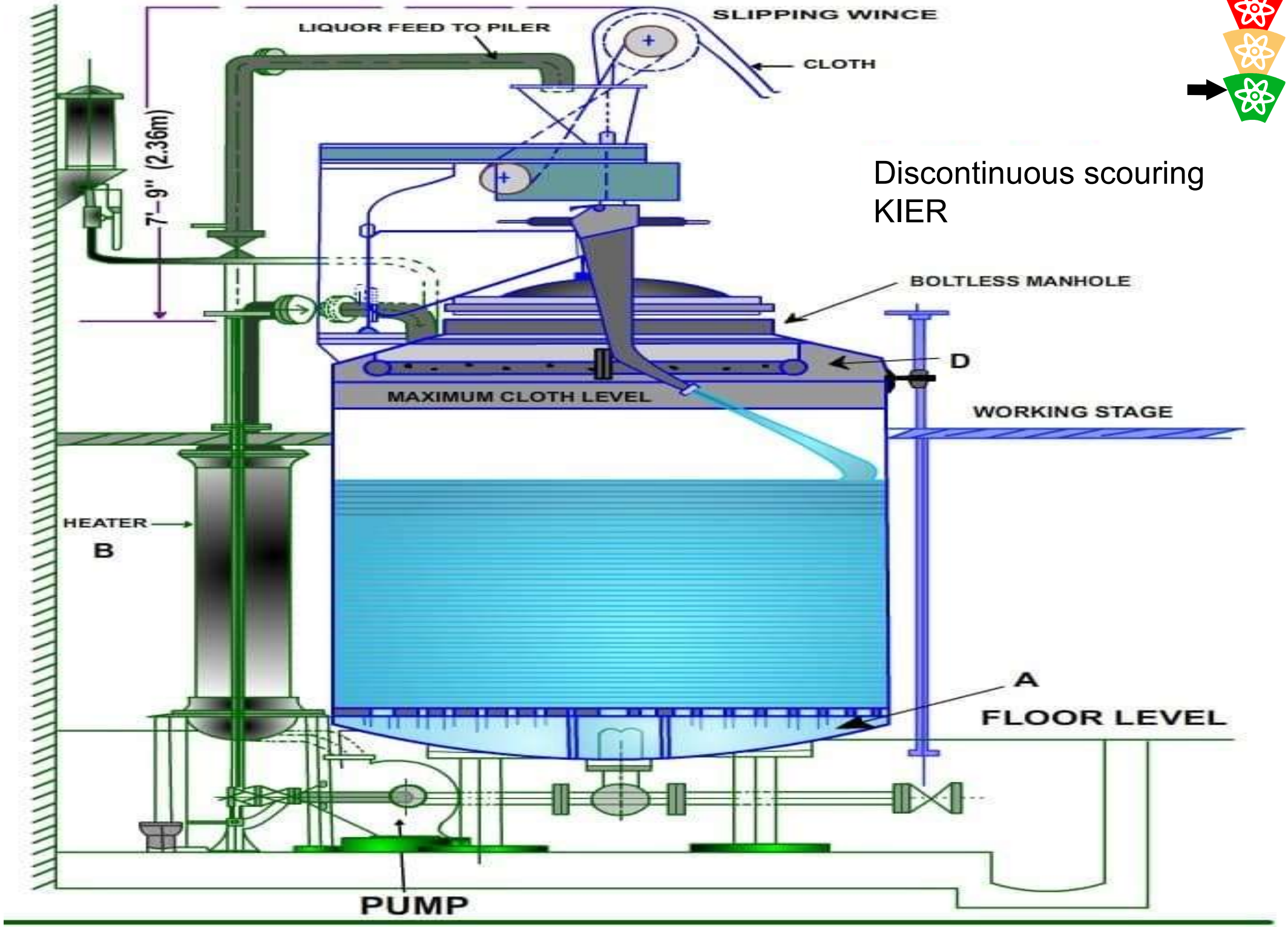

Glycerol

Sodium palmitate
(a soap)

# Pretreatment – cotton scouring

- Discontinuous scouring – in machines as dyeing vessels, winches, jiggers and Kier
- Kier is a large cylindrical vessel, upright, with egg shaped ends made of boilerplate that has a capacity of treating one to three tonnes of material at a time. Kier boiling and "Boiling off" is the scouring process that involves boiling the materials with the caustic solution in the Kier, which is an enclosed vessel, so that the fabric can boil under pressure. *This boiler scouring process : 120 °C, 6 hours, 10 g/l NaOH or 20 g/l Na2CO3.*
- Scouring with enzymes (bio-scouring) is more environmentally friendly method removing impurities. Pectinase enzymes break down pectin – for flax nad hemp.

# Discontinuous scouring KIER



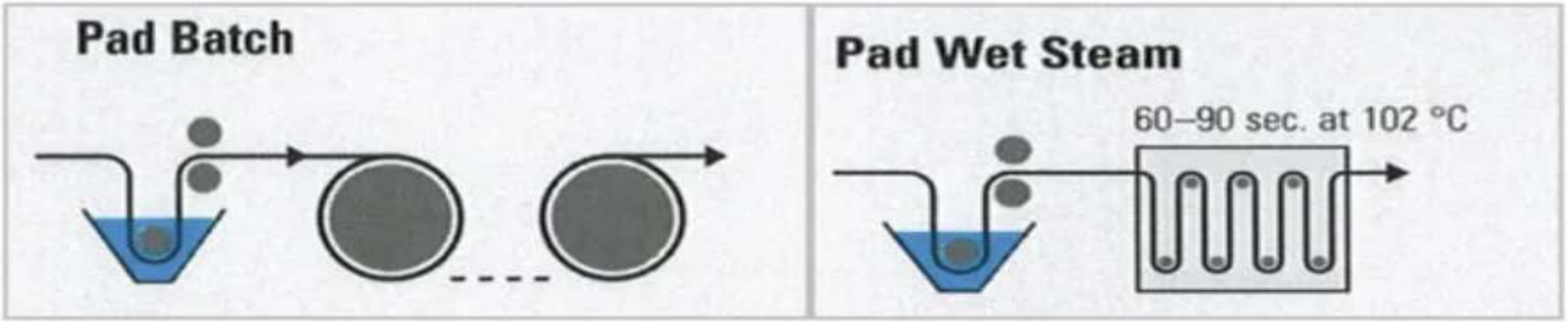
# Machine construction materials

Corrosion resistant steels in the textile industry
Main alloy element - chromium + iron
Chromium brings its passivation capability also to alloys with iron, starting from a certain minimum content, which is 12% with the simultaneous presence of no more than 0.1% carbon.

Example of steel composition for dyeing machines Cr17 Ni12 Mo2

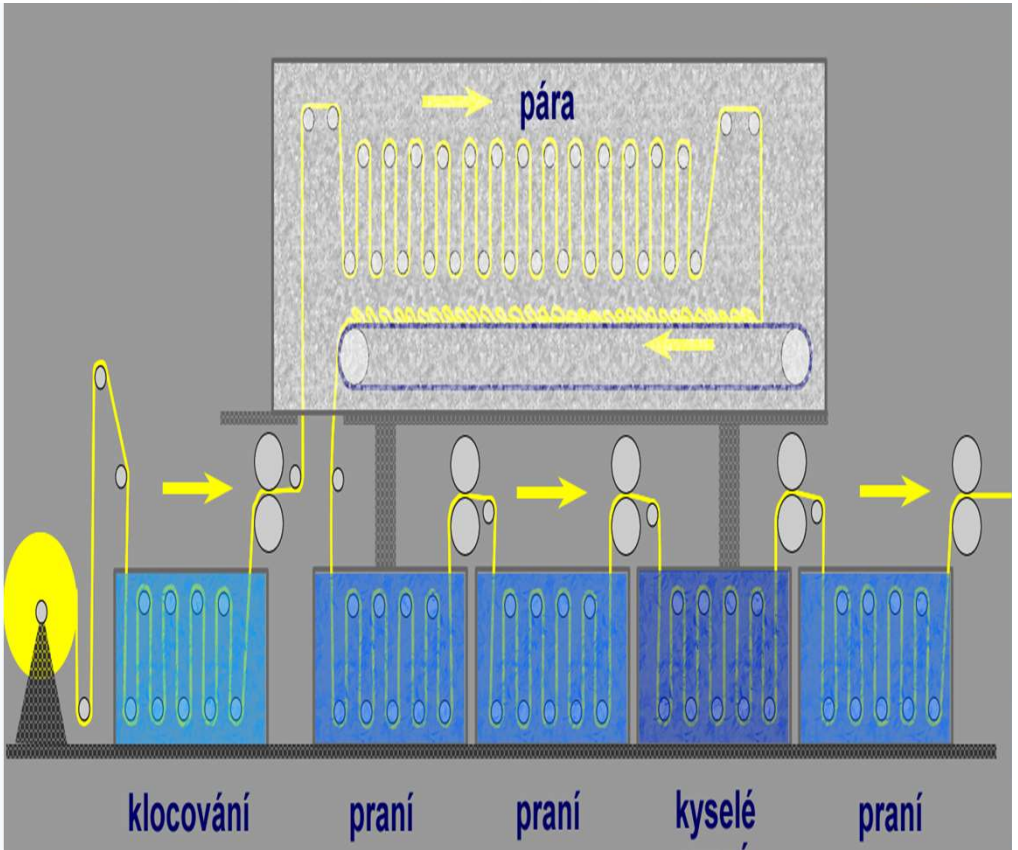
Nickel resists water and air very well.
It is used for the production of alloys, for electroplating.
In the textile industry - rotary printing stencils

# Continuous scouring



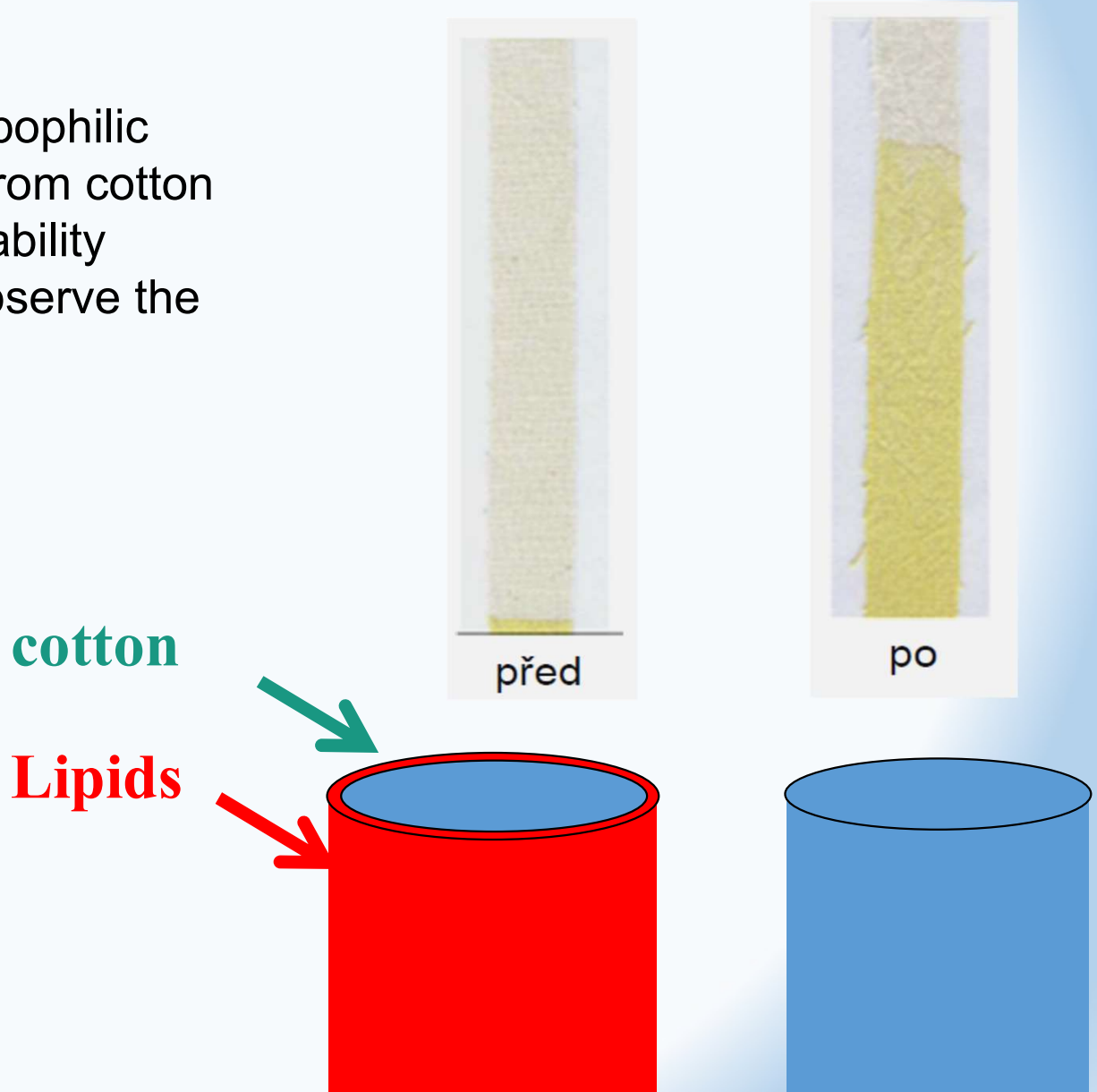

***Alkaline steaming can also be used instead of cotton scouring. In this method, the fabric is impregnated with an alkaline solution and then introduced into a steamer (pressure sealed boiler) where steaming takes place at 110 to 130 °C for about 60 minutes.***

Impregnation techniques - padding-steaming ( PAD - STEAM )



# Pretreatment – cotton scouring

Decomposition and removal of lipophilic and non-cellulosic components from cotton
Evaluation: improvement in wettability (take-off test, indicative just to observe the droplet in contact with the fabric)



# *Mercerisation of cotton*

**improves dye uptake and fiber strength,**
**reduces fabric shrinkage,**
**imparts a silk-like luster.**

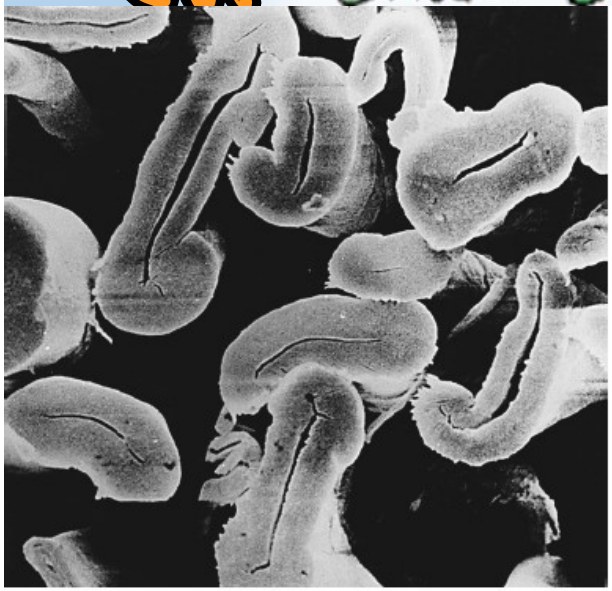
Merceration is a process in which cotton fabrics or yarns are treated with concentrated lye, i.e. NaOH at a concentration of about 22-26%, 28°-30° Bé, 270-330 g/l., 1 minute

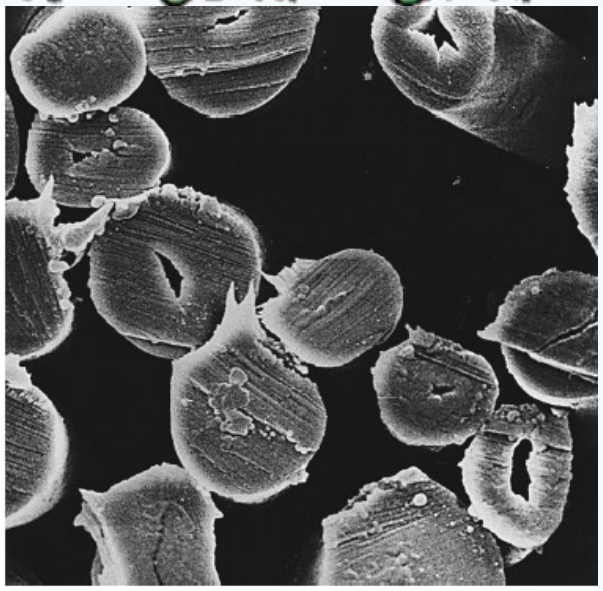
This is an exothermic process - it is most preferably carried out cold. In the case of thick fabrics, hot (60°C) mercerisation is used - the treatment is more uniform throughout the fabric).

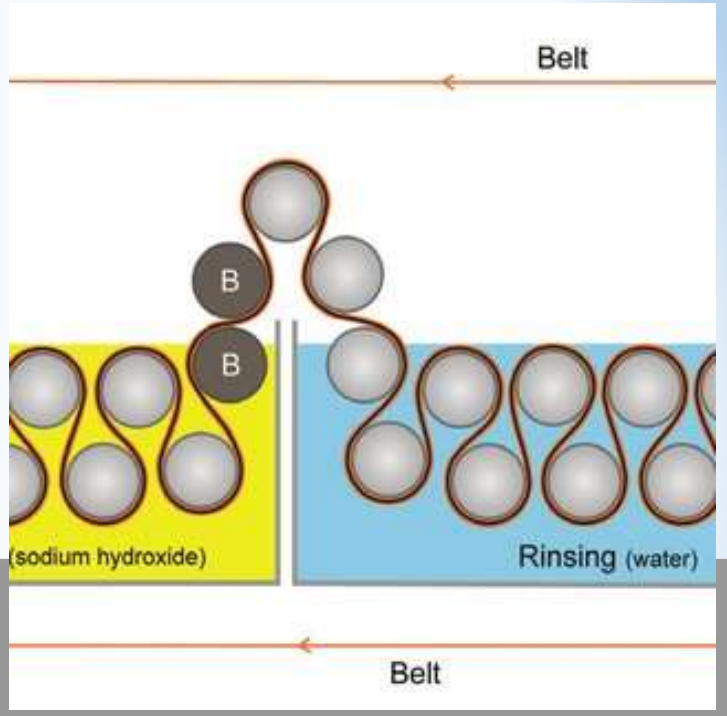
Ammonia (more precisely: liquid ammonia NH3, low temperature) can also be used - ammonia treatment.

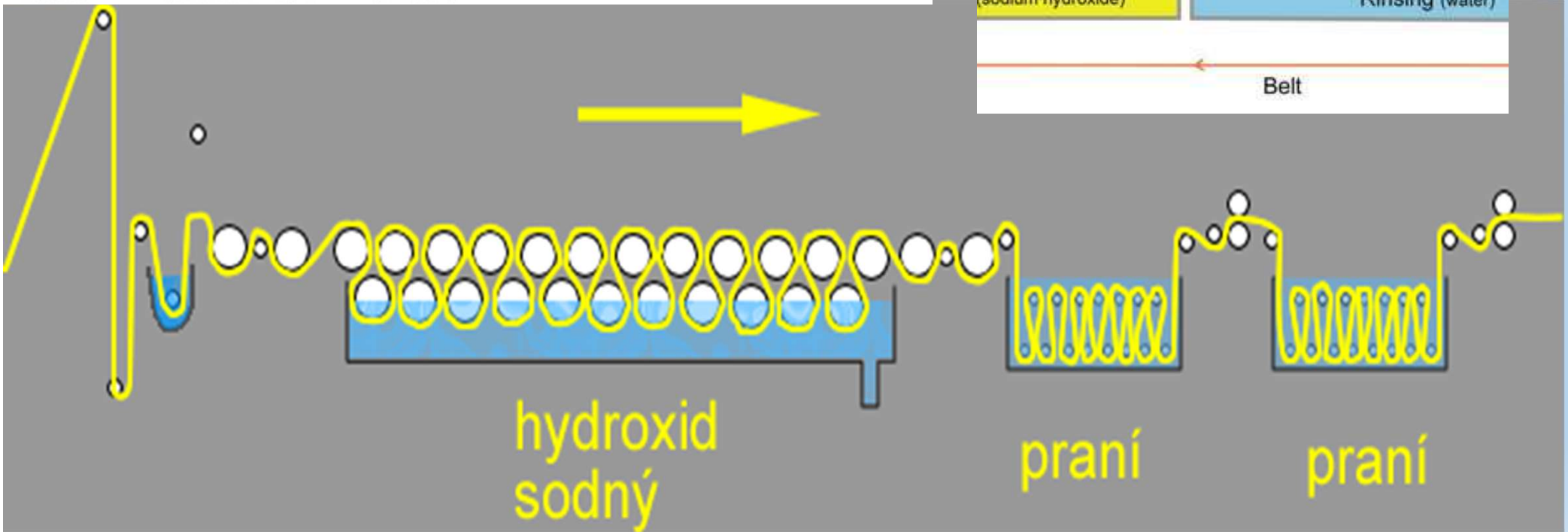
Tension is maintained by rollers and chains.

# Mercerisation of cotton







# *Bleaching of coton*

The purpose of bleaching is to achieve the desired whiteness, or degree of whiteness with minimal damage to the fibres.

This is achieved by removing all colouring substances, especially natural colour pigments and unwanted colour impurities.

It is therefore a matter of converting coloured substances into colourless or soluble substances. This can be achieved primarily by oxidation. Oxidative bleaching provides a relatively permanent whiteness.

Reductive bleaching is less stable and little used. It is inexpensive.

Na2S2O4 - sodium dithionite

# Sodium dithionite ($Na_2S_2O_4$)

Sodium dithionite ($Na_2S_2O_4$) is a white crystalline, an inorganic sodium salt, a bleaching agent that has a reducing agent role and is generally used as food additive

**Strong reducing agent in alkaline medium**

$$Na_2S_2O_4 + 2NaOH + H_2O \rightarrow Na_2SO_3 + Na_2SO_4 + 4H$$

**Use of sodium dithionite :**

**To reduce vat dyes**

**for the reduction of incorrect colours**

$$R_1\text{- } N = N - R_2 \rightarrow R_1\text{- } NH_2 + R_2\text{- } NH_2$$

# Cotton pretreatment - Bleaching

Cotton and its blends are bleached only by oxidation. Bleaching is of practical importance:

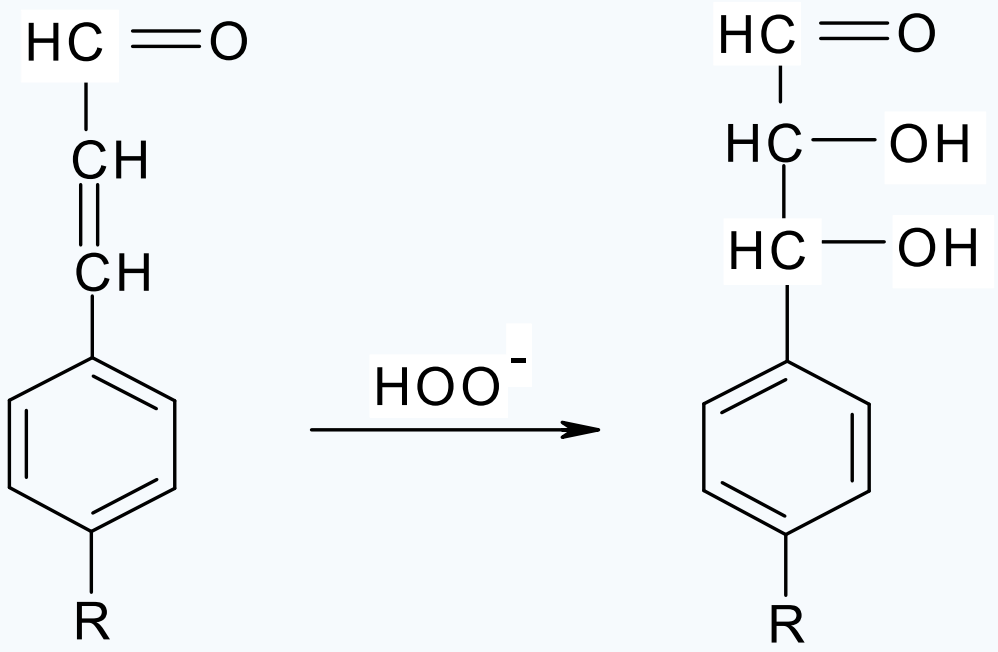
- sodium hypochlorite NaClO
- sodium chlorite NaClO2
- hydrogen peroxide H2O2

The decomposition of coloured pigments into colourless substances can also be carried out by their reduction. However, the whiteness thus obtained is not permanent, since the residues of these substances remain on the fibre, oxidise again (e.g. by air oxygen) to coloured compounds and cause yellowing of the material.

# Cotton pretreatment - Bleaching

**Cotton bleaching - oxidize and wash out color pigments**

**Example of oxidation of a coloured substance:**




**The yellow-brown colouration of natural cellulose fibres is caused by high molecular weight compounds with very different structures.**

**They contain a complicated system of conjugated double bonds.**

# Cotton pretreatment - Bleaching

Cotton can be bleached with sodium hypochlorite, which is cold bleached at 20°C for up to 120 minutes.

The bath contains:

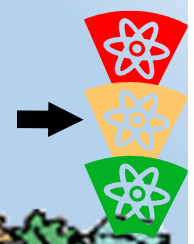
5 g/l of active chlorine from the hypochlorite solution.

1 g/l sodium hydroxide - NaOH

At the end of the bleaching process, the so-called antichlorination must be carried out to remove any chlorine bound to the cotton, which could later be damaged by the hydrochloric acid HCl produced.

The antichlorination bath contains, for example: 1 g/l sodium bisulphite - NaHSO3 or 1 ml/l hydrogen peroxide - H2O2Antichlorinate at 20 °C for up to 20 minutes. Wash well at the end.

# Cotton pretreatment – Bleaching NaClO



$$NaClO \rightleftharpoons Na^+ + ClO^-$$

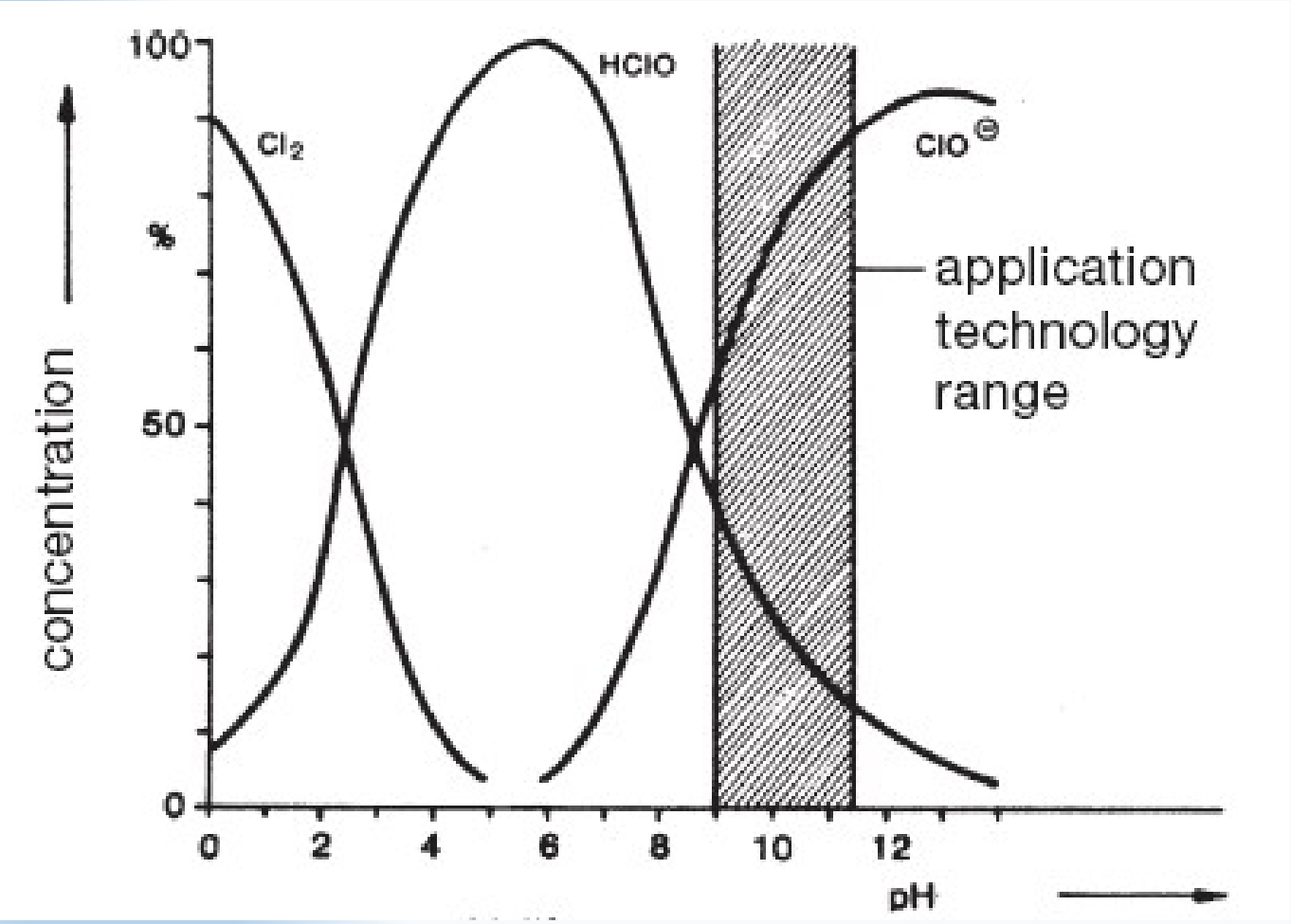
$$ClO^- + H_2O \rightleftharpoons HClO + OH^-$$

$$HClO \longrightarrow HCl + O$$

**Bleaching must be carried out in buffered bleaching baths so that the concentration of active chlorine does not exceed the optinal limit. In a neutral environment - degradation of the cellulose fibre, pH must not drop below 10.**

# Cotton pretreatment – Bleaching NaClO

NaClO




**pH 2 - 3 bath contains HClO and chlorine**

**pH 3 - 6 bath contains more HClO than elemental chlorine**

**pH 6 - 8 bath contains HClO and ClO- ions**

**pH 8 - 11 bath contains decreasing amounts of HClO and increasing amounts of ClO- ions**

# Cotton pretreatment – Bleaching $H_2O_2$

- liquid, freely soluble in water
- behaves like a very weak acid
- has strong oxidizing effects

USES

- Bleaching of textiles, paper, etc.
- disinfectant
- for the manufacture of chemicals, e.g. sodium perborate for detergents

# Cotton pretreatment – Bleaching H2O2

Hydrogen peroxide alone has only a slight bleaching effect on cellulose fibres.

Bleaching occurs only when the peroxide is activated and stabilized (so that it does not decompose into radicals that damage the fibres).

The activation is carried out with alkalis.

$$HOOH + NaOH \rightarrow Na^{+} + HOO^{-} + H_2O$$

hydrogen peroxide anion

# Cotton pretreatment – Bleaching $H_2O_2$

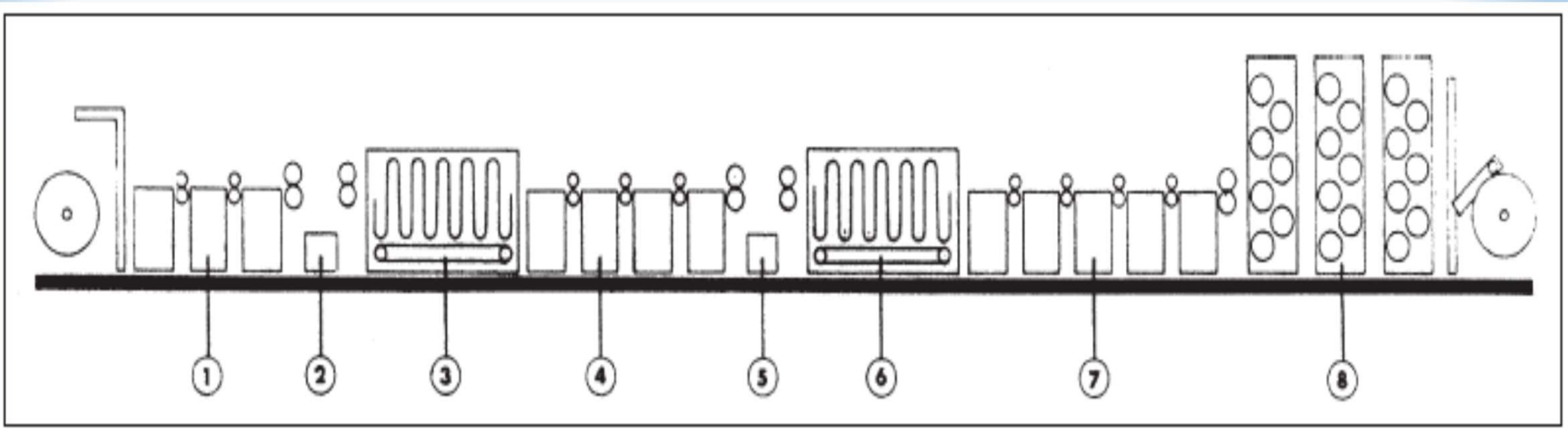
Atomic oxygen is formed from the hydrogen peroxide anion HOO-, which oxidizes the coloured fibre impurities to easily washable fumes.

$$HOO^- = OH^- + O$$

Bleaching with $H_2O_2$ is carried out at pH 10 to 12, T = 90°C

Under normal bleaching conditions, the cellulose chain is not damaged by the HOO- ion reaction.

# Cotton pretreatment – Bleaching H2O2



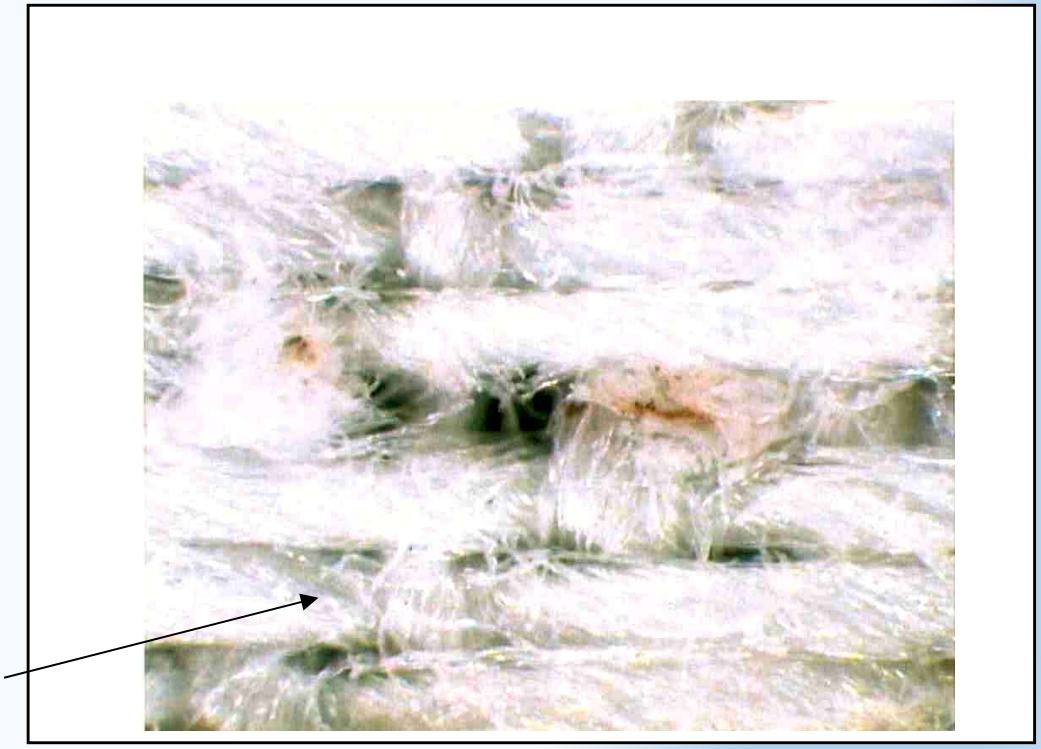

**1= desizing 2-4 = scouring 5-7 = H2O2 bleaching 8 = drying**

# Cotton pretreatment – Bleaching H2O2

Damage can occur when H2O2 comes into contact with Fe ions.

$$Fe^{2+} + HOOH \rightarrow Fe^{3+} + HO^{-} + \bullet OH$$

The hydrogen peroxide radical HOO is able to attack the stable -C-H bond and damage the cellulose fibre.



Damage to cotton in the presence of iron ions.

# Cotton pretreatment – Bleaching $H_2O_2$

Too high an alkali content leads to the decomposition of part of the peroxide into oxygen and water.

$2H_2O_2 = 2H_2O + O_2$

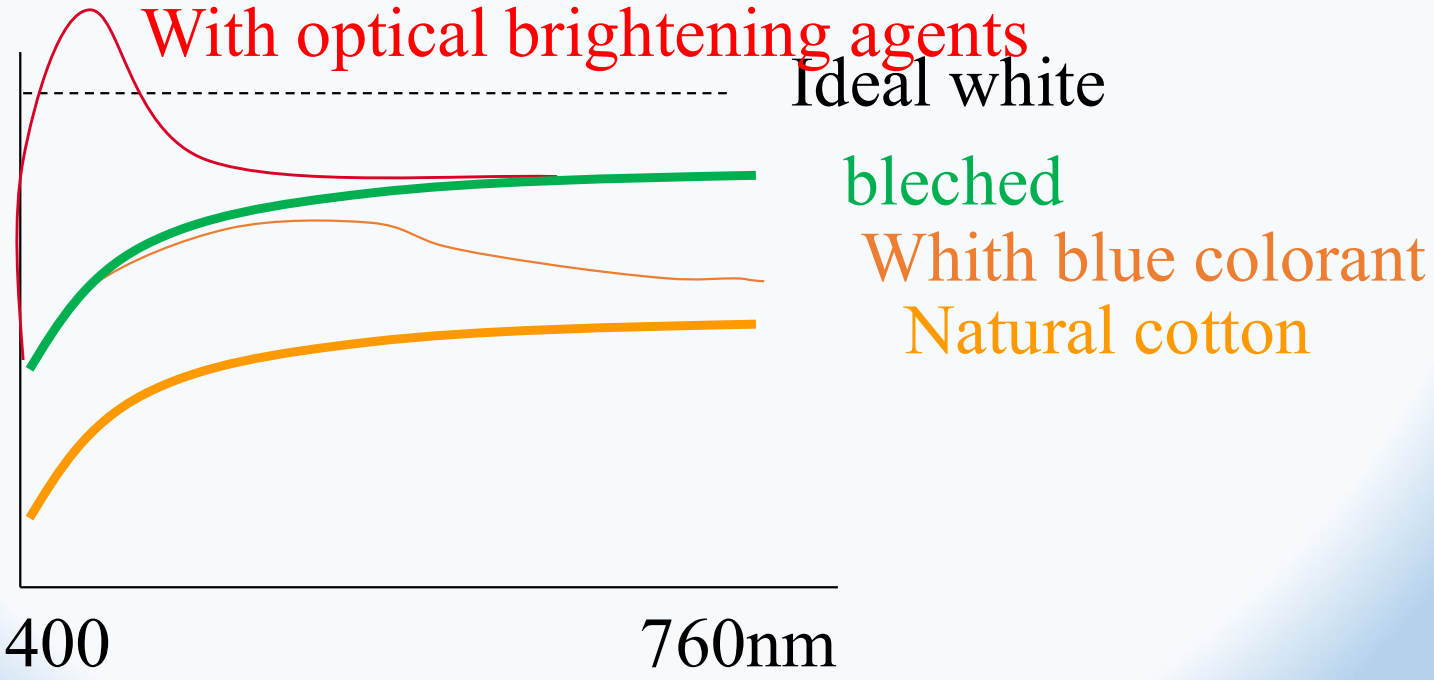
This reduces the bleaching ability.

Stabilizers for peroxide baths - compounds that help reduce the decomposition of $H_2O_2$ :

- stabilize $H_2O_2$
- inhibit radical formation (prevent the effect of Fe)

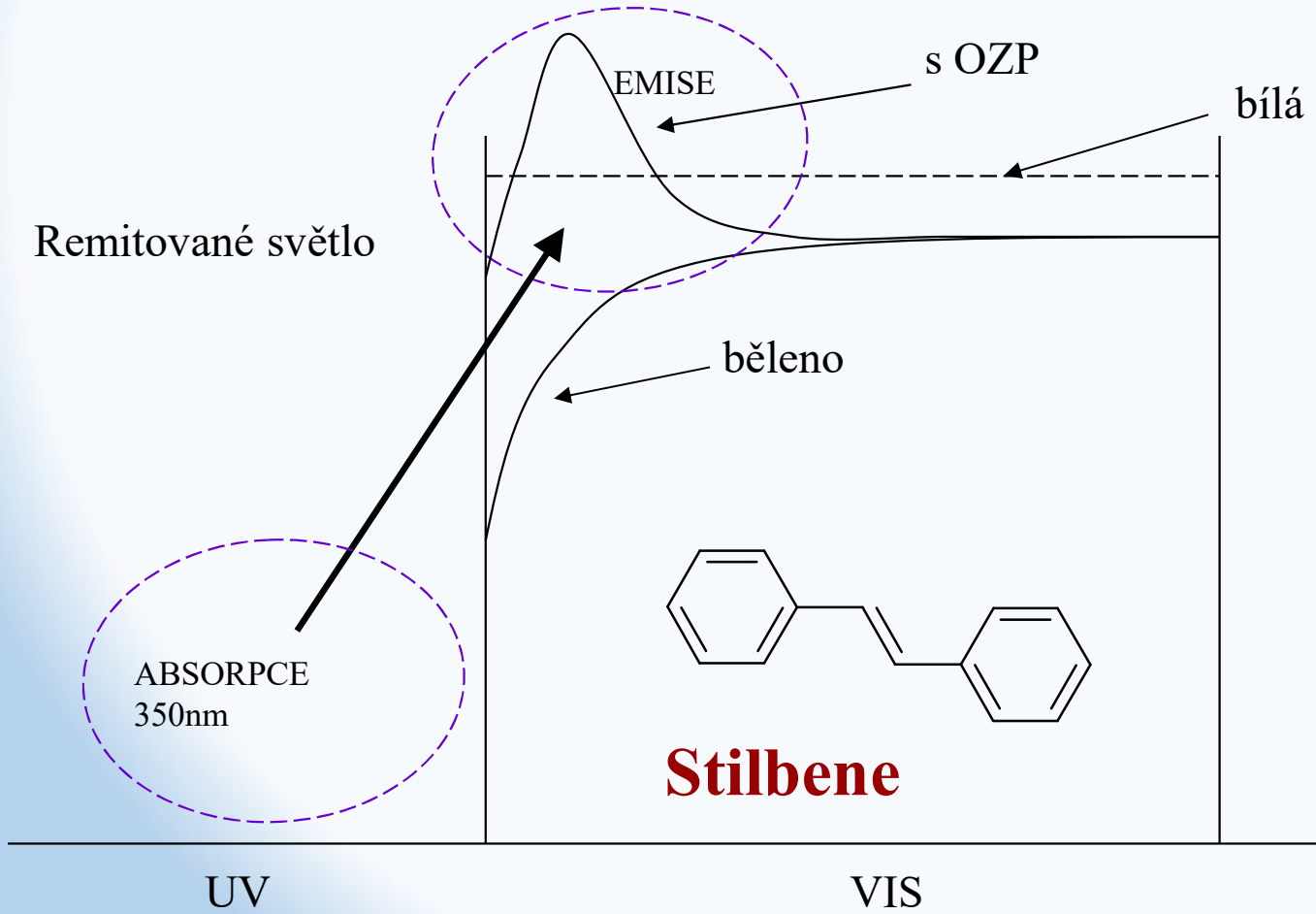
# *Cotton pretreatment - Optical brightening*

However, even well bleached materials have a more or less yellowish tint, which is inherent in the textile material concerned. The use of optical brightening agents (OBAs) makes it possible to achieve a true intense whiteness in a pure shade. Their brightening effect is based on the principle of fluorescence.



# Cotton pretreatment - Optical brightening

Fluorescence is the ability of OZP molecules to absorb radiation invisible to the eye and convert it to visible radiation in the blue-violet light region (wavelength λ = 430-450 nm).




**This created white is highly brilliant with a blue-violet tint, it is more appealing than neutral white, as the human eye is most perceptive in this area of light.**

# WOOL pretreatment

Raw wool contains more or less impurities, which vary according to the origin of the wool. The following ranges are commonly given:

15 to 72 % keratin, i.e. wool fibre;

12 to 47 % wool fat (lanolin) and sweat;

3-24 % dirt and impurities of vegetable origin;

4-24 % moisture .

The yield of pure wool is called rendement, and for normal wool it is 55-65 %.

# Lanolin

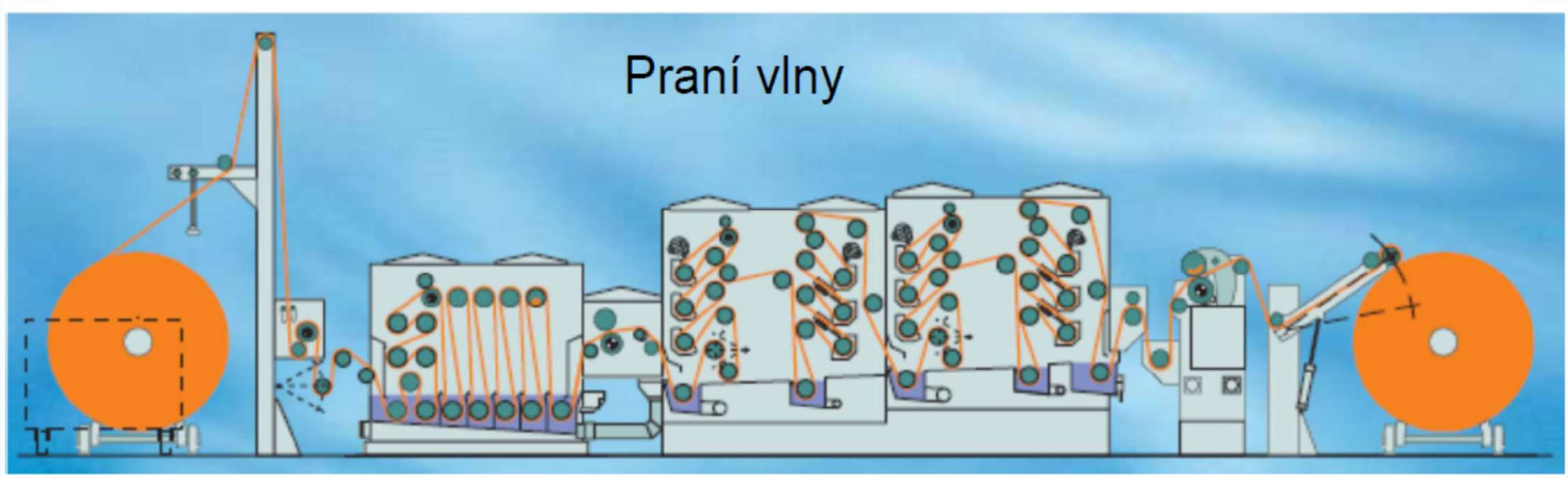
**Lanolin (originally from Latin lāna "wool" and oleum "oil") a yellow oily substance secreted by the sebaceous glands of sheep.**
**The waterproof properties of lanolin protect sheep from getting their wool wet.**
**More than 200 different acids and 100 alcohols = 10,000 different esters have been identified in lanolin. The melting point is around 40 °C.**
**Lanolin is insoluble in water but can form very stable emulsions with it.**


**Usage : cosmetics + protection wax (shoe cream)**

# WOOL pretreatment

**The basic technological operations carried out in the pre-treatment of wool are:**

**washing of raw wool - carbonisation - stabilisation of the wool**



# WOOL pretreatment - washing

Washing of wool can be carried out in classic ways, i.e. in a water environment, but also by using organic solvents, or by freezing or ultrasound.

Wool flakes, yarn, fabrics and knitted fabrics can be washed using classical methods.

**In addition to washing finished woollen goods, it is important to wash wool flakes on a single-purpose machine**

# Counterflow Wash Systems

Ordinary soaps or anionic and non-ionic tensides are used as emulsifiers. The most common way of washing is on a leviathan (usually a 5-watt) in a so-called counter-current way.


– washing in an alkaline environment: + Na2CO3 soda - helps emulsify fats;

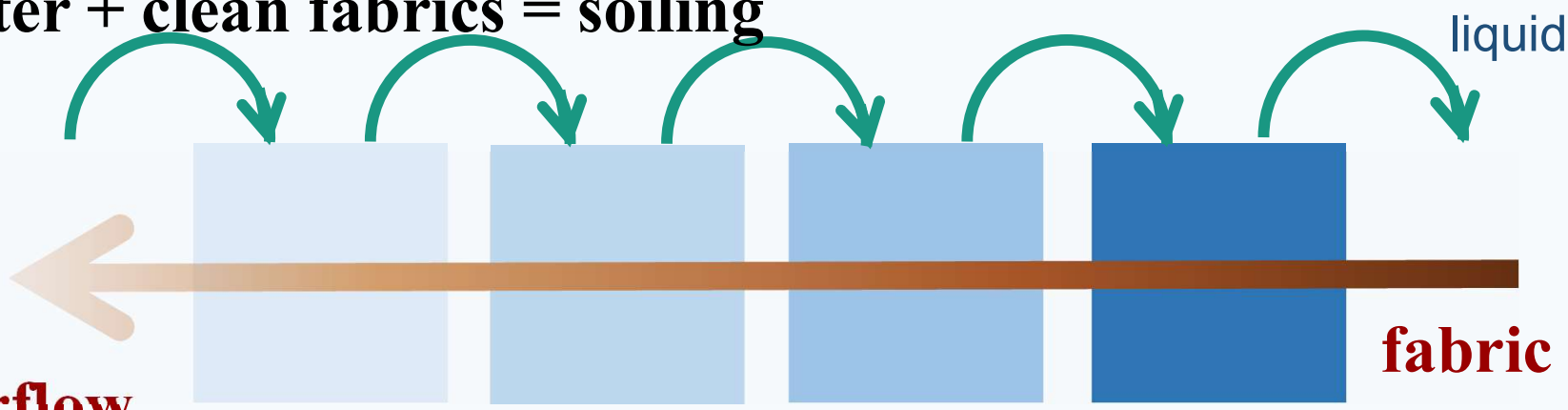
– washing in the isoelectric region (pH5): in a weakly acidic environment, it is the most gentle on wool.

# Counterflow Wash Systems

**Maximum dirt concentration gradient is required for effective washing**

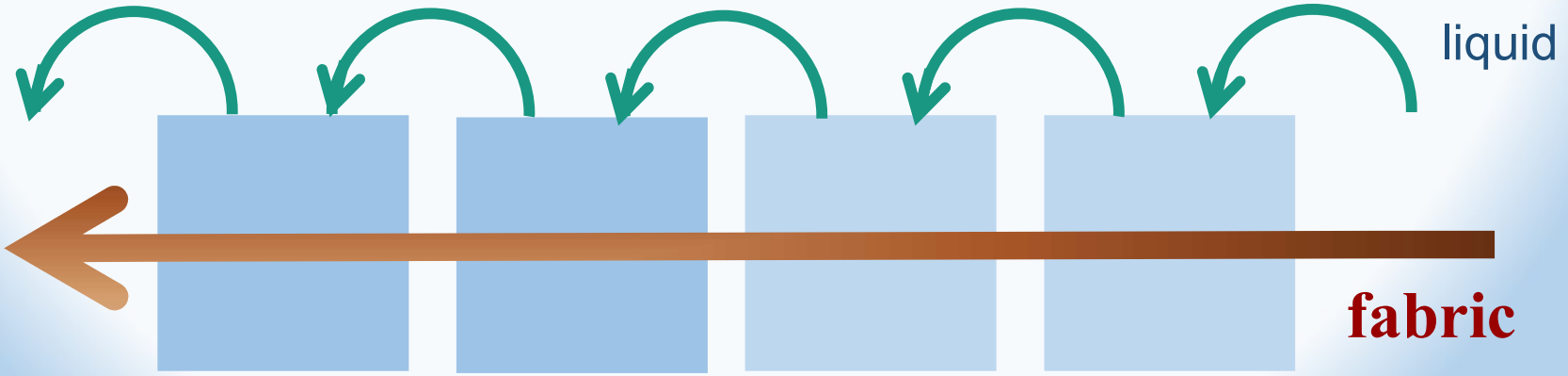
**clean water + clean fabrics = cleaning (washing)**

**dirty water + clean fabrics = soiling**




**Counterflow**

**parallel flow**



# Carbonising OF WOOL

Carbonization/Casrbonising removes from the wool those vegetable impurities that cannot be removed mechanically or by washing.

The most common method is carbonisation with sulphuric acid H2SO4, where the goods are first soaked in 3-5% acid for at least 30 minutes, followed by 'drying“ at 120°C - .

Carbonising is the chemical process used to remove vegetable matter (VM) from wool. The VM, which may be seeds, twigs, burrs, grass etc., is predominantly made up of cellulose, hemicellulose and lignin whereas wool is principally protein.
%VM typically in excess of 2% to 3%.

# Carbonising OF WOOL

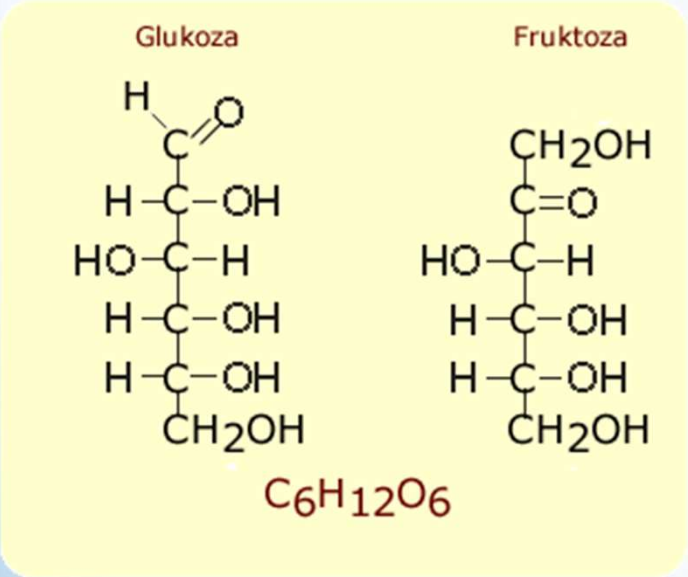
**H2SO4 Sulphuric acid**
**non-volatile acid = water flows out of solutions when heated, acid concentrates**

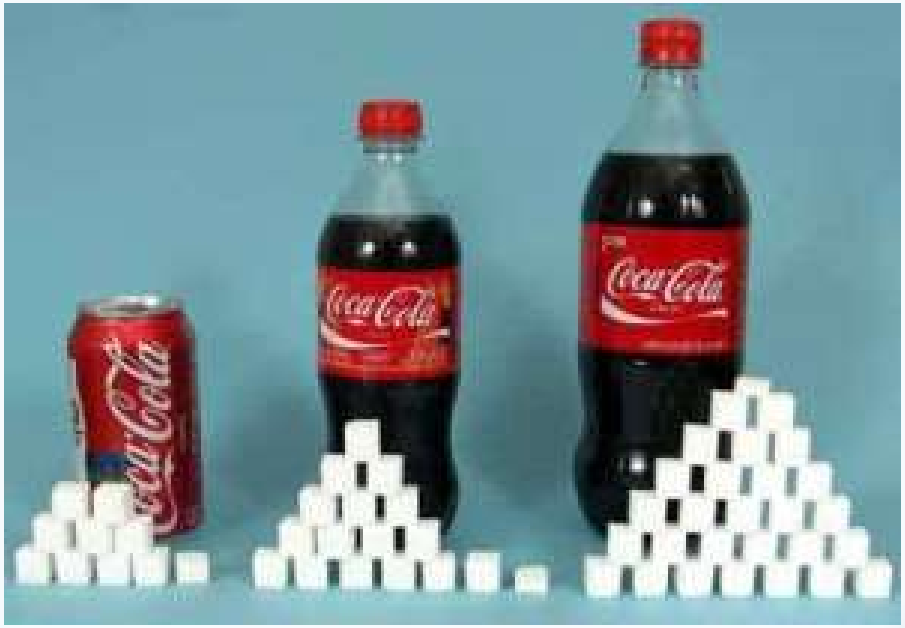
**In the case of sulfuric acid, spontaneous evaporation at 20°C leads to about 80% sulfuric acid**

# carbohydrates

**Cellulose = polysaccharide (polymerised glucose)**

**Carbohydrates = (C+$H_2O$) = saccharides**



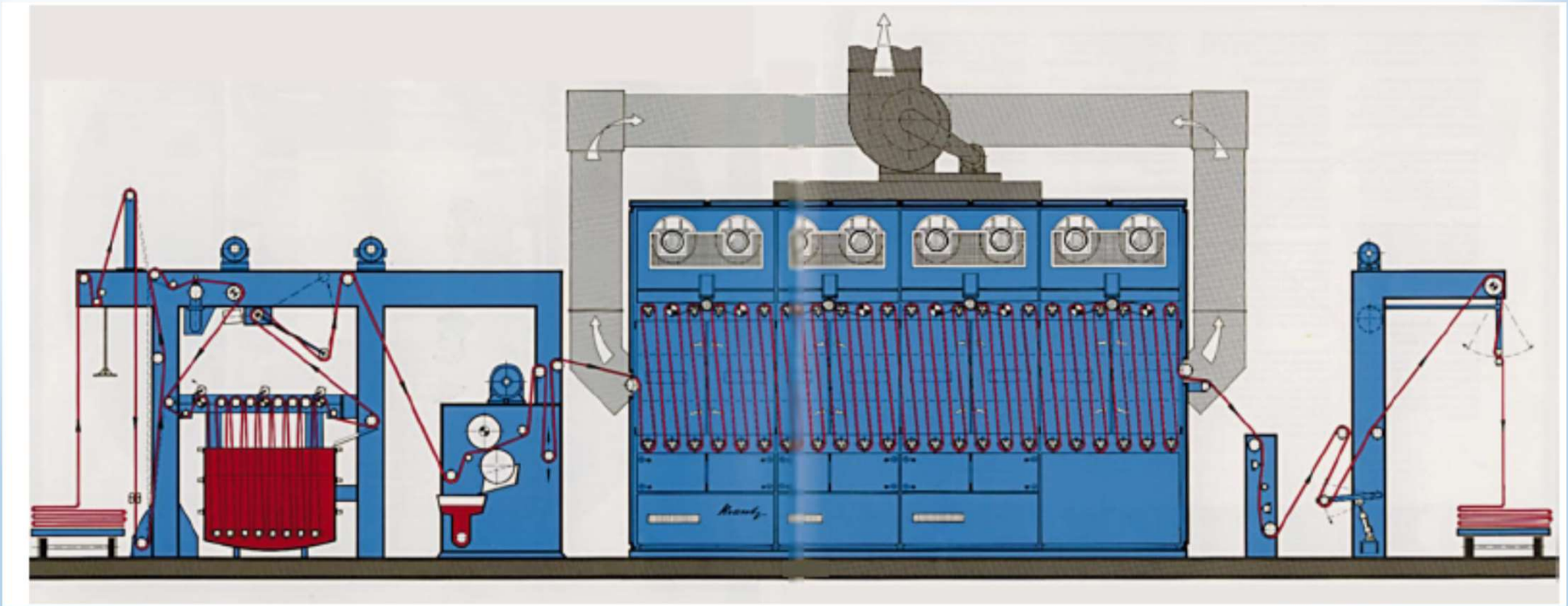



**Photosynthesis**

$$6CO_2 + 12H_2O + E \xrightarrow{\text{enzymy+barviva}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

# Carbonising OF WOOL

**line with sulphuric acid impregnation and drying.**



# Thermofixation of synthetic fibre

**At higher temperatures, thermoplastic fibres soften and can be moulded. This property is useful for heat fixing, which is important for the refinement of synthetic fibre textiles. It is carried out either as a pre-fixation during pre-treatment or during other finishing processes, e.g. after dyeing or printing.**

**If the fixation temperature is e.g. 200 °C, they can be processed up to approx. 170 °C without changing the properties**

| vlákno | podmínky | |
|---|---|---|
| | teplota / °C / | čas / sec / |
| polyamid 6 | 185 – 190 | 10 – 40 |
| polyamid 6.6 | 210 – 215 | 10 – 40 |
| polyester | 200 – 220 | 10 – 30 |
| polyester modifikovaný | 165 – 175 | 30 – 40 |
| polyakrylonitril | 170 – 180 | 30 – 40 |
| polypropylen | 135 - 145 | 30 - 40 |

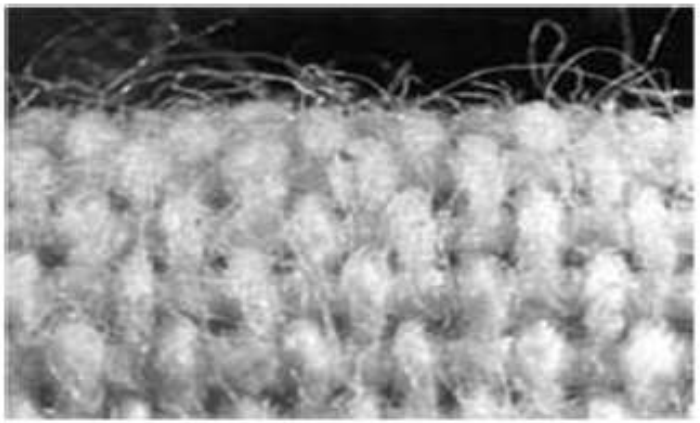
# Thermofixation of synthetic fibre

Fixation technology:
Contact heat (heated cylinders)
Hot air
Radiant heat (IR radiation)

**Isotonic fixation, when the fibre precipitation, chain retraction, stress relaxation and recrystallization occur, which fixes this state. Strength decreases and ductility increases. It is practically realized in the free state, when dimensional changes are not limited.**

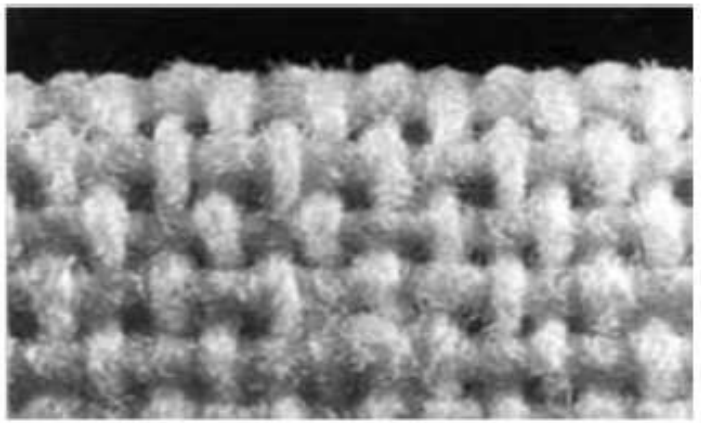
**Isometric fixation, where there are no dimensional changes. There is stress relaxation associated with chain slip and crystallization under tension. Orientation and strength are not changed. It is practically realised at constant length, when the fibres cannot deform.**

# Pretreatment



?

+ flame



? singeing ?

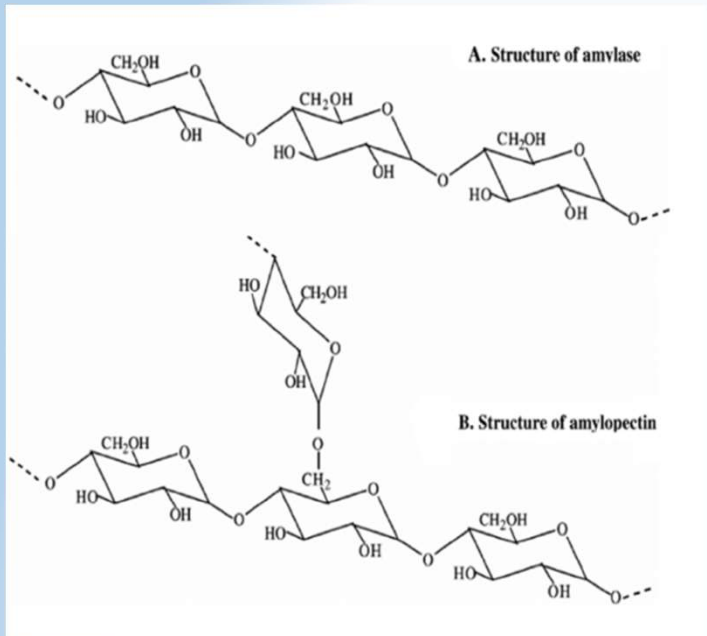
desizing

? scouring ?

bleaching

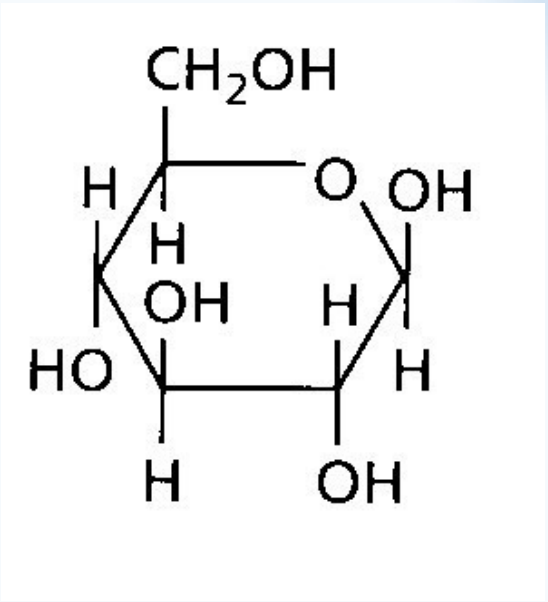
? mercerization ?

# Pretreatment



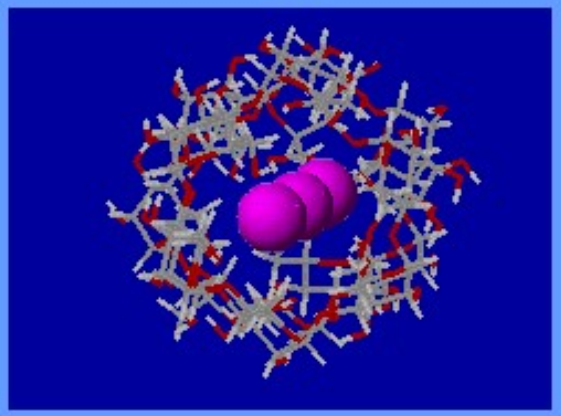

?

Enzymes




## Starch - Iodine Complex

$$I_2 + I^- \longrightarrow I_3^-$$



Iodine slides into starch coil
to give a blue-black color

C. Ophardt, c. 2003

? singeing ?

desizing

? scouring ?

bleaching

? mercerization ?

# Pretreatment

before

?

NaOH or

$Na_2CO_3$

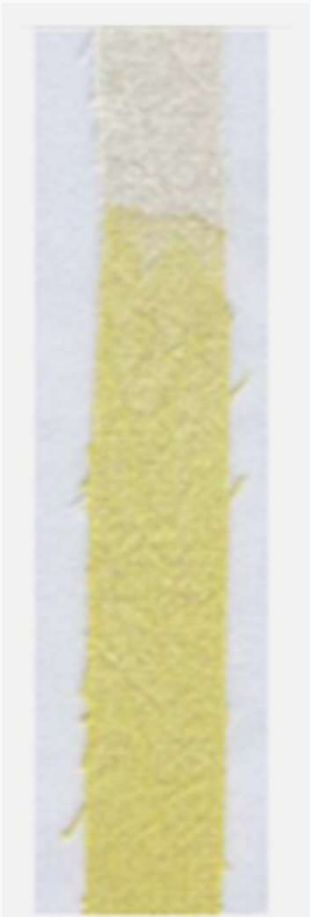
? singeing ?

desizing

? scouring ?

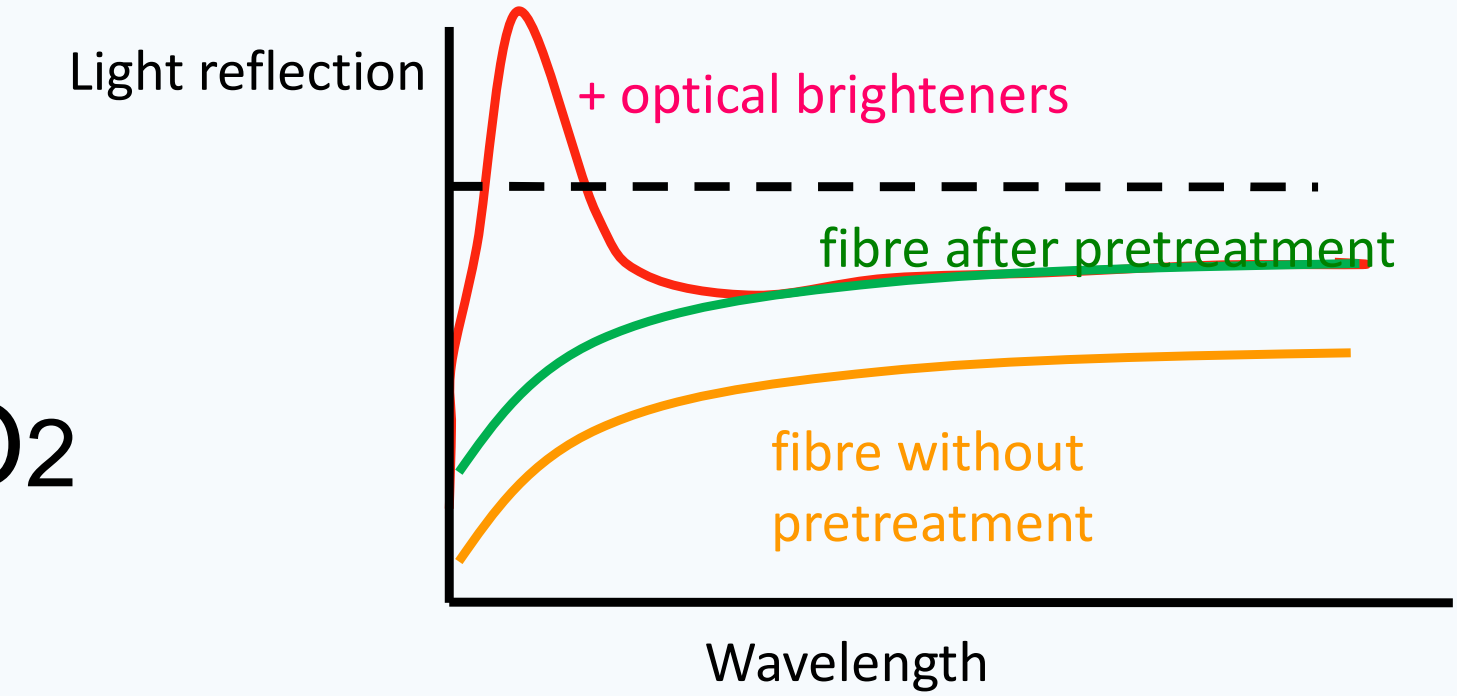
bleaching

? mercerization ?

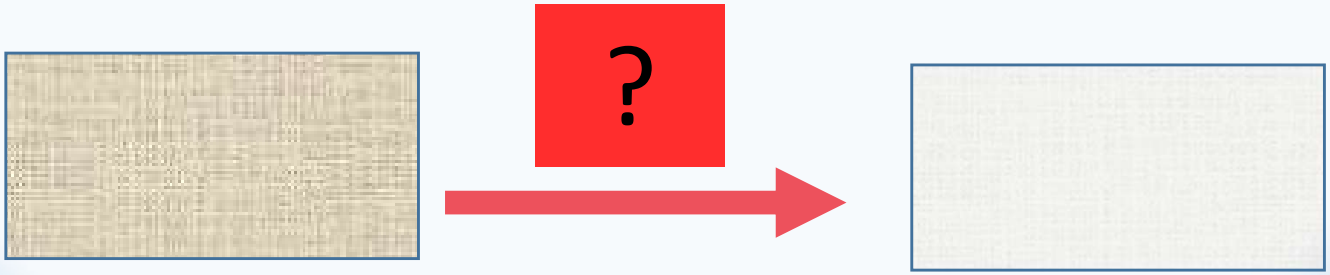


after

# Pretreatment




$H_2O_2$



# Pretreatment


25% NaOH

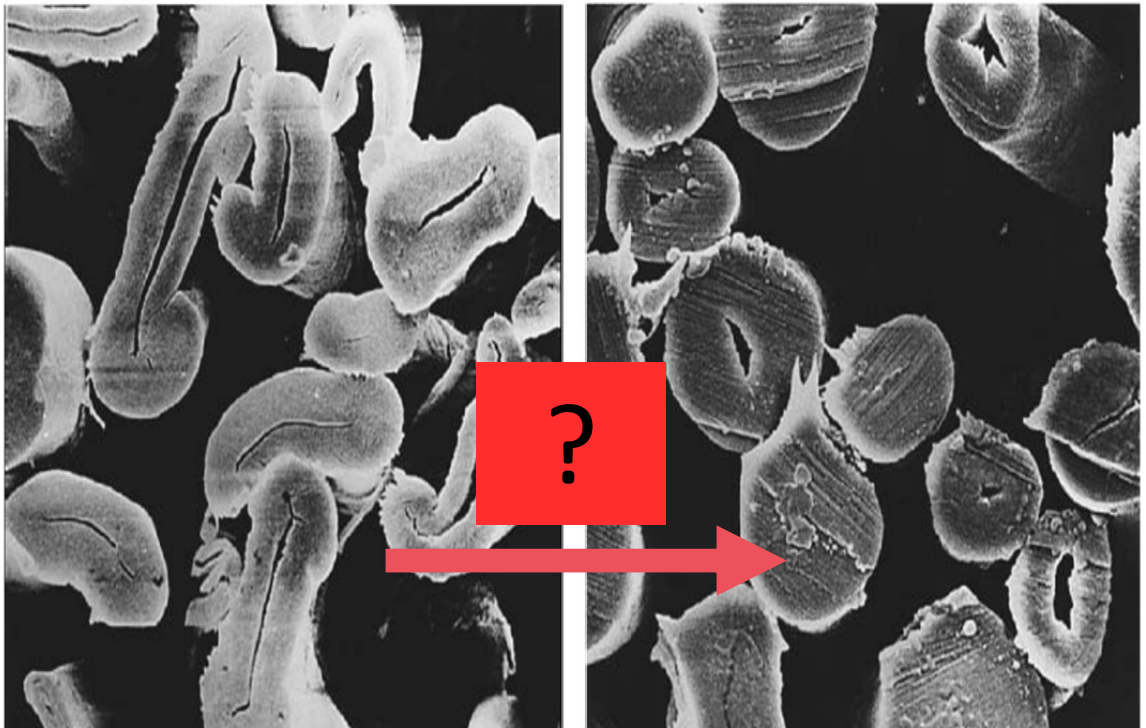
? singeing ?

desizing

? scouring ?

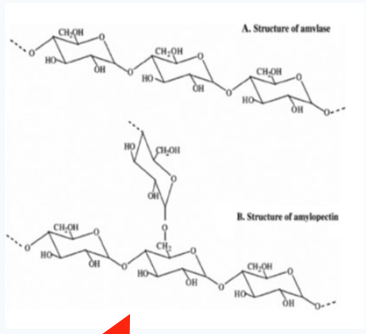
bleaching

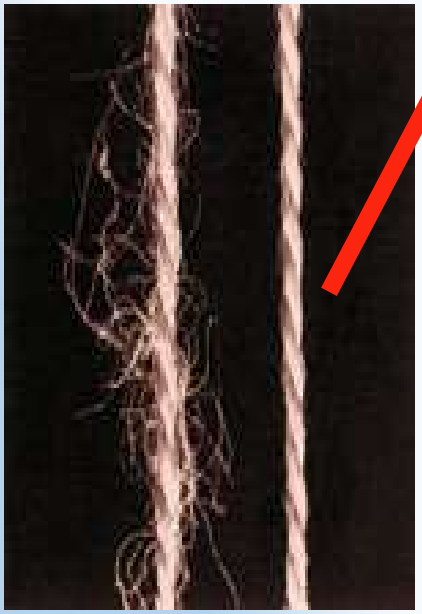
? mercerization ?

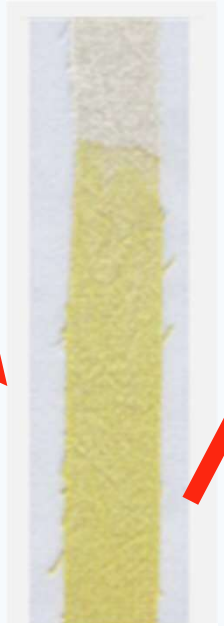


# Pretreatment

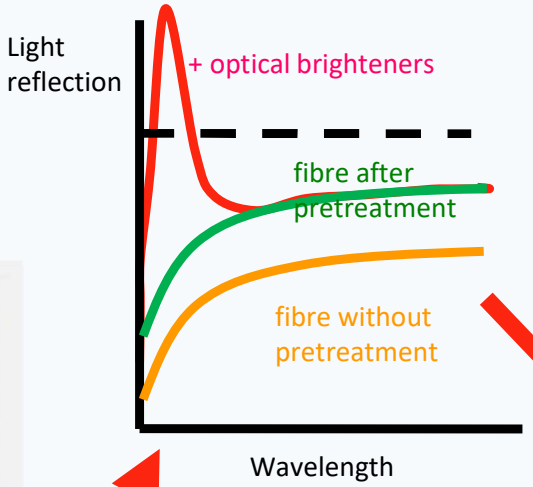
singeing, desizing, scouring, bleaching, mercerization

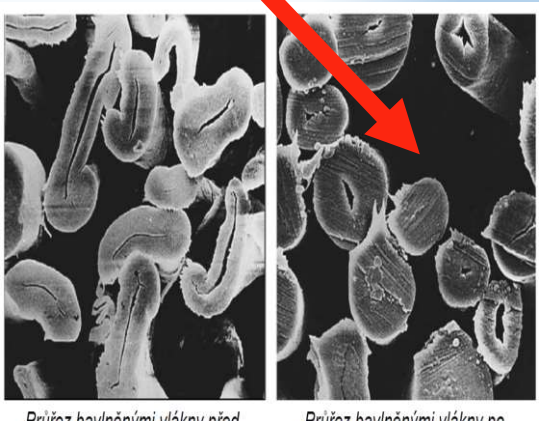




After



# thanks for your attention !