Scouring

Define - Scouring

Scouring is an important pre-treatment stage especially for natural fibres which tend to have a significant presence of natural impurities such as oil, wax, fat, hand dust, etc. They are removed to produce hydrophilic and clean textile material.

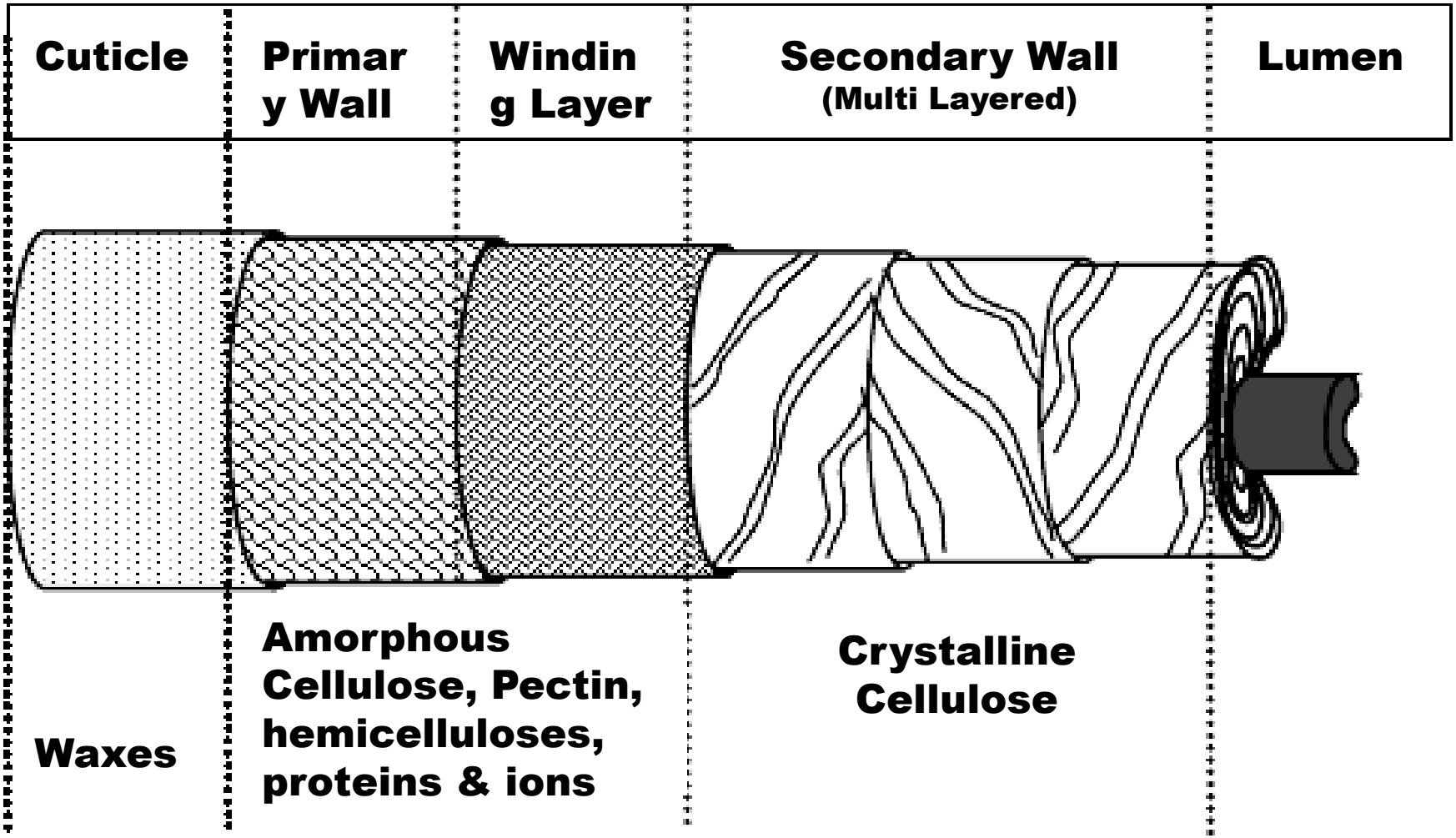
Objective:

To reduce the amount of impurities sufficiently to obtain level results in dyeing & finishing operations by bringing the substrate to a **highly absorbent state.**

Hence the emphasis is on removal of hydrophobic impurities

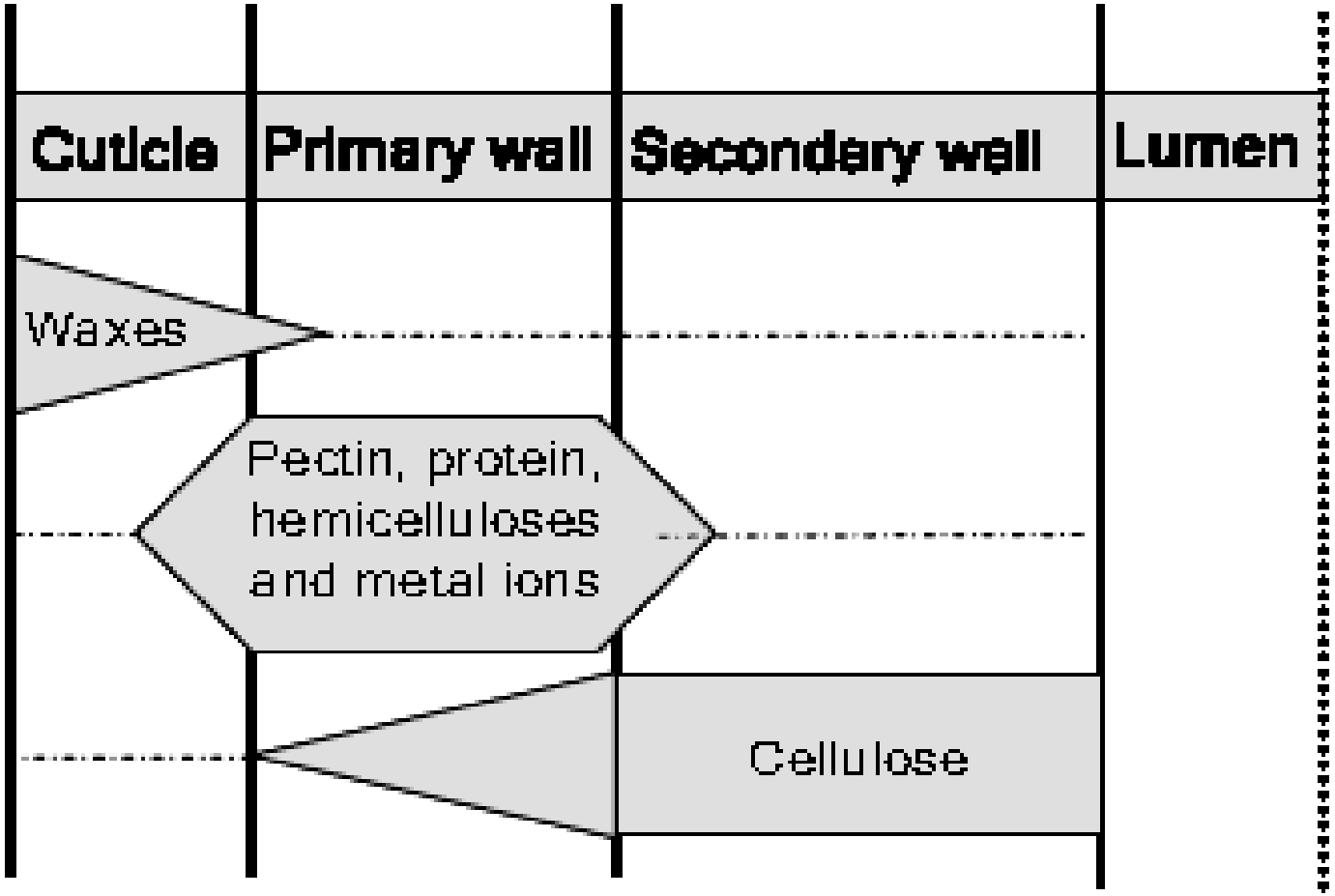
Impurities in Cotton

Impurities	Percentage (%)
Waxes	0.4-1%
Nitrogenous Matter (Proteins)	1-2.8%
Pectic Matter	0.4-1%
Minerals	1-1.8%
Motes (seed coat fragments)	-
Natural Coloring Matter	Variable
Added	Lubricants/Knitting oils, grease stains



A schematic representation of nature of cotton fibre showing its various parts

A Schematic Representation of the Cellulosic and Non-cellulosic Materials in the Cotton Fibre



Scouring Systems for Cotton fibres

The wax is present in the outermost layer of cotton fibres.

- It is **non-absorbent in its natural state**
- Wax present on a fibre is low (0.4- 1%)
- It is not easy to remove

WAX:

- Higher Monohydric aliphatic alcohols, C_{24} to C_{30}
- Fatty acids, C_{16} to C_{34}
- Esters
- Hydrocarbons, C_{30}

Scouring Systems for Cotton fibres

- Conventional system
- Solvent based system
- Enzyme based system

Conventional System

Chemicals used in Scouring Process:

Different Agent	Descriptions
Alkali	Mainly Sodium hydroxide (NaOH), sometimes mix of NaOH and Na_2CO_3 (washing soda)
Wetting agent	To reduce the surface tension of scouring liquor so as to wet out the goods uniformly, generally anionic surfactants are used
Emulsifier	To emulsify non-saponifiable wax, generally nonionic surfactants are used

How are the impurities removed ?

Impurities	Mechanism of removal
Fats and waxes	**Saponification:** The saponifiable parts of waxes (fatty acid, glycerides and other esters) are converted into soap.
	Emulsification: The non-saponifiable parts of the waxes such as alcohols and hydrocarbons are emulsified by the soap formed.
Pectin & related Substances	Pectins are converted to water soluble salts of pectic acid.

How are the impurities removed?

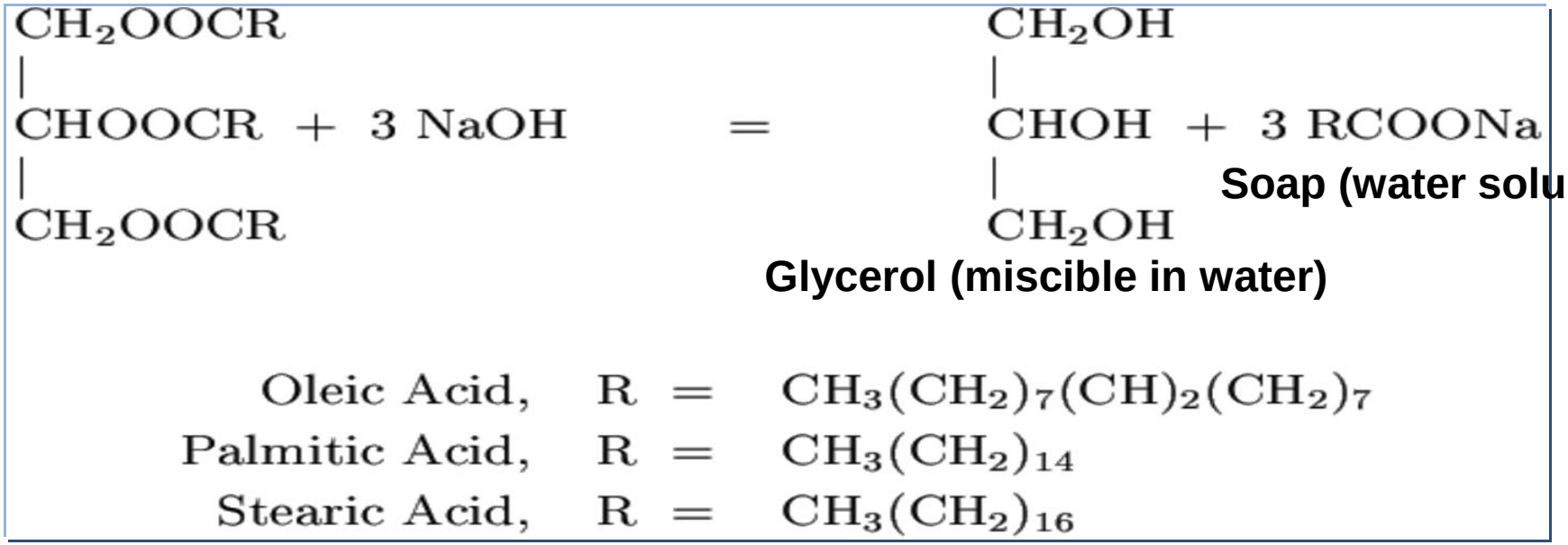
Impurities	Mechanism of removal
Proteins and Amino acids	Proteins are hydrolyzed with the formation of soluble sodium salts of amino acid. Amino compounds are hydrolyzed to ammonia by alkali.
Minerals & heavy metals	• Partially dissolve in NaOH • By use of sequestering or chelating agents

How are the impurities removed ?

Impurities	Mechanism of removal
Hemicelluloses	Dissolution: Hemicelluloses with low DP are dissolved in NaOH
Motes	• Cellulose of low crystallinity swells in alkali and becomes sodium cellulosate, water soluble. • Residual motes are destroyed in bleaching.
Other organic compounds	Cellobiose, Cellotriose, Organic acid (i.e. Malic acid, etc.)

Mechanism of Saponification

- Wax, fats, oils and lubricants are esters in the form of triglycerides
- The triglycerides form **glycerin** and **soap** when reacted with NaOH



Soap also acts as a surfactant

Mechanism of Saponification……..

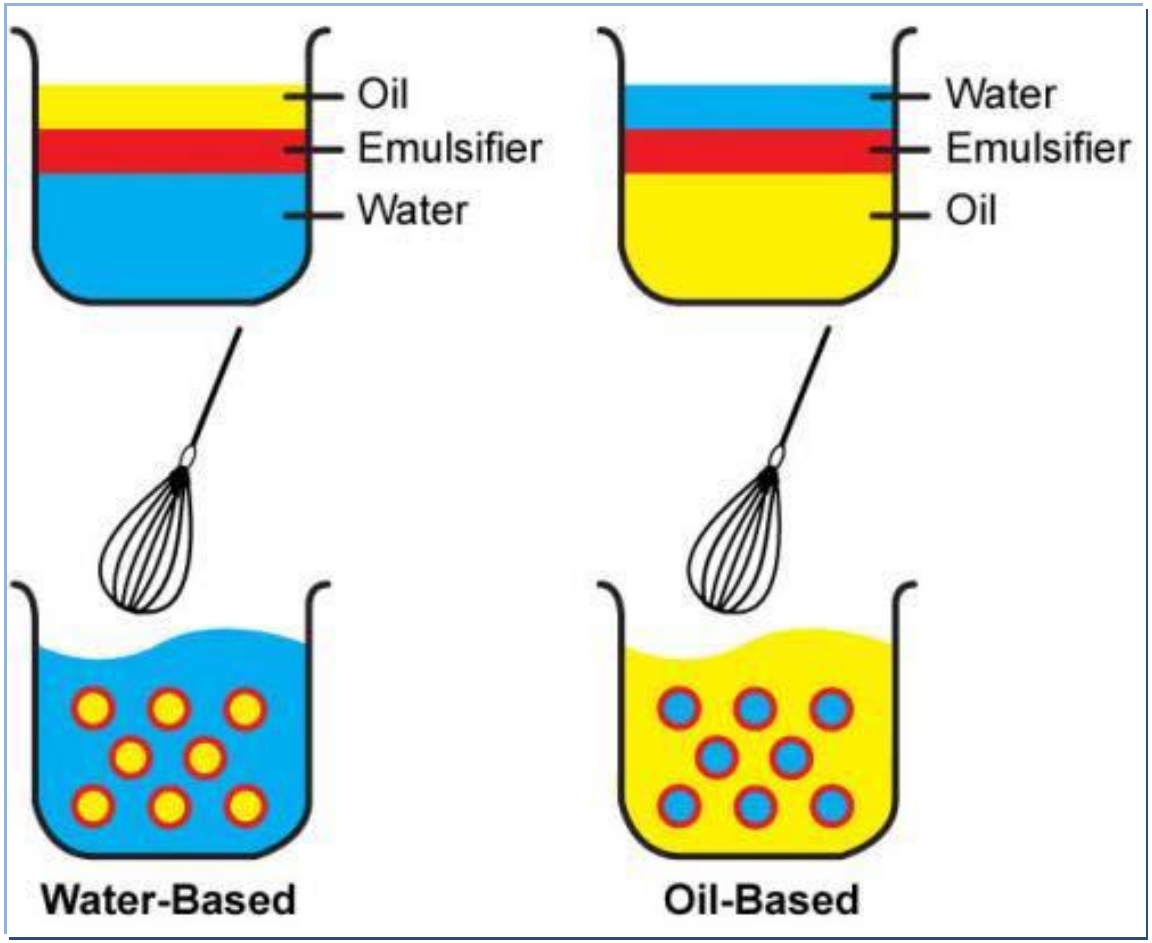
- Hence fat/oil forms glycerol (miscible in water) and soap (RCOONa)

- Soap is soluble in water and acts as a surfactant to reduce the surface tension of scouring liquor

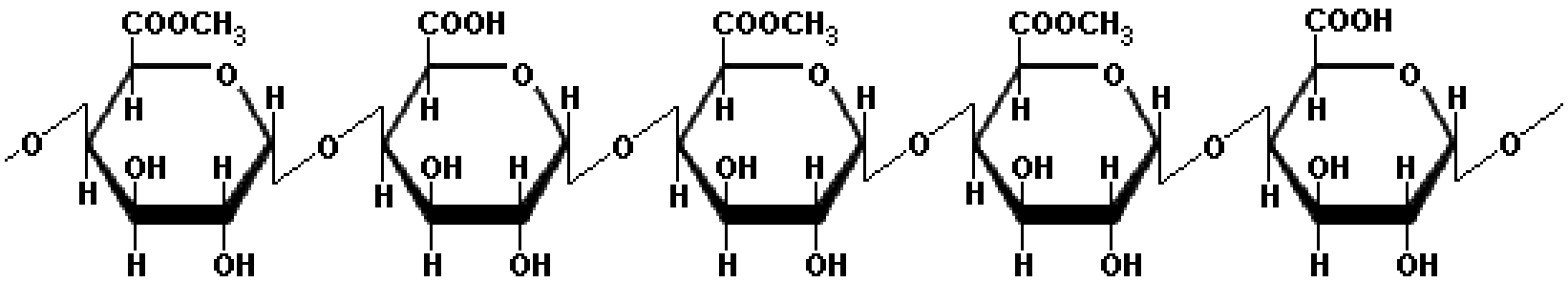
- However, since the amount of saponifiable matter present in cotton may be very low (< 0.5%) one has to make additions of wetting agents in the liquor

Mechanism of Emulsification

An emulsion is a dispersion of two immiscible liquids



Pectin and related substances

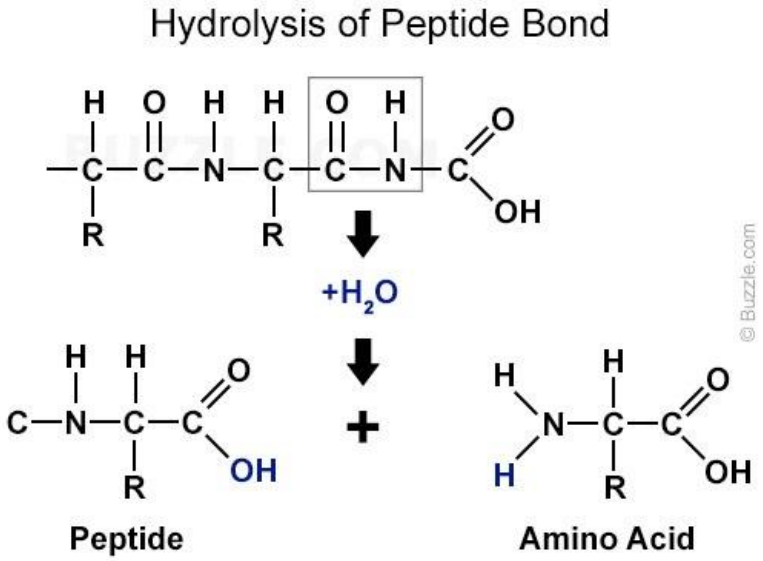


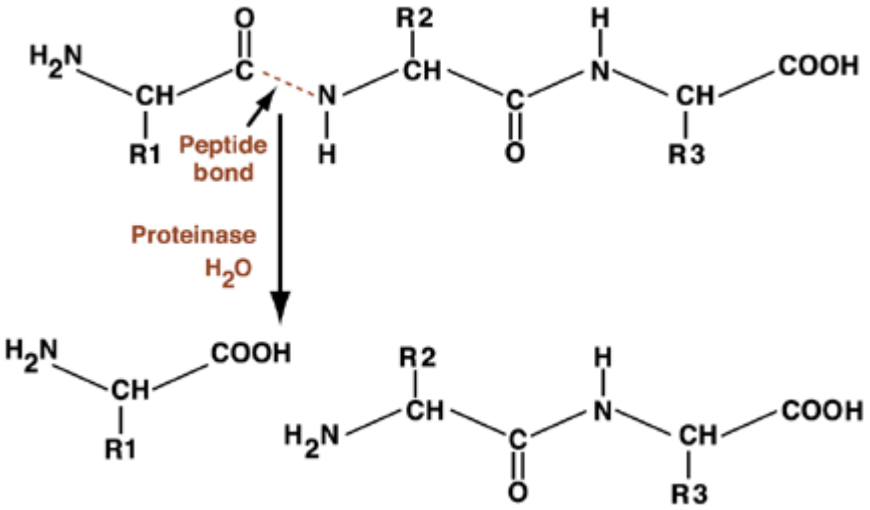
Pectin molecules have a linear backbone composed of units of (1,4)-linked α-D-galacturonic acid and its methyl ester.

- **Pectins are converted to water soluble salts of pectic acid**
- **Solubilisation: by the action of alkali, which also acts as a swelling agent to facilitate removal**

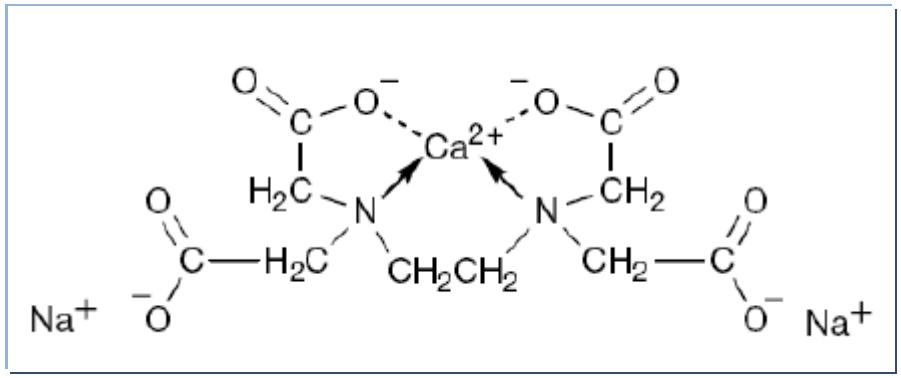
Protein substances

Compounds of Aspartic acid and Glutamic acid (Amino acids)

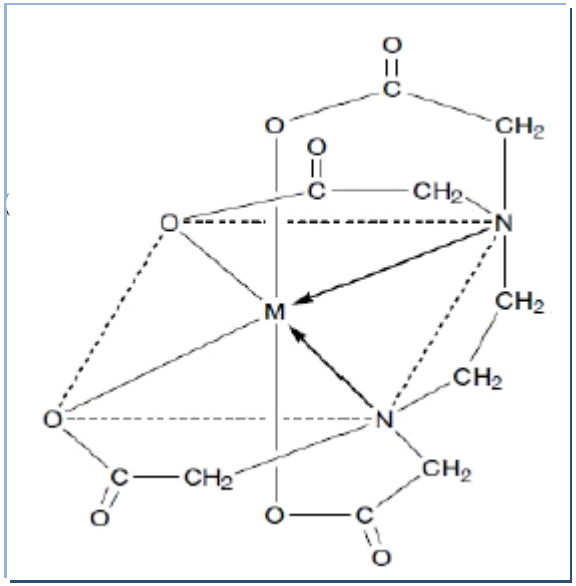




Sequestering Agent

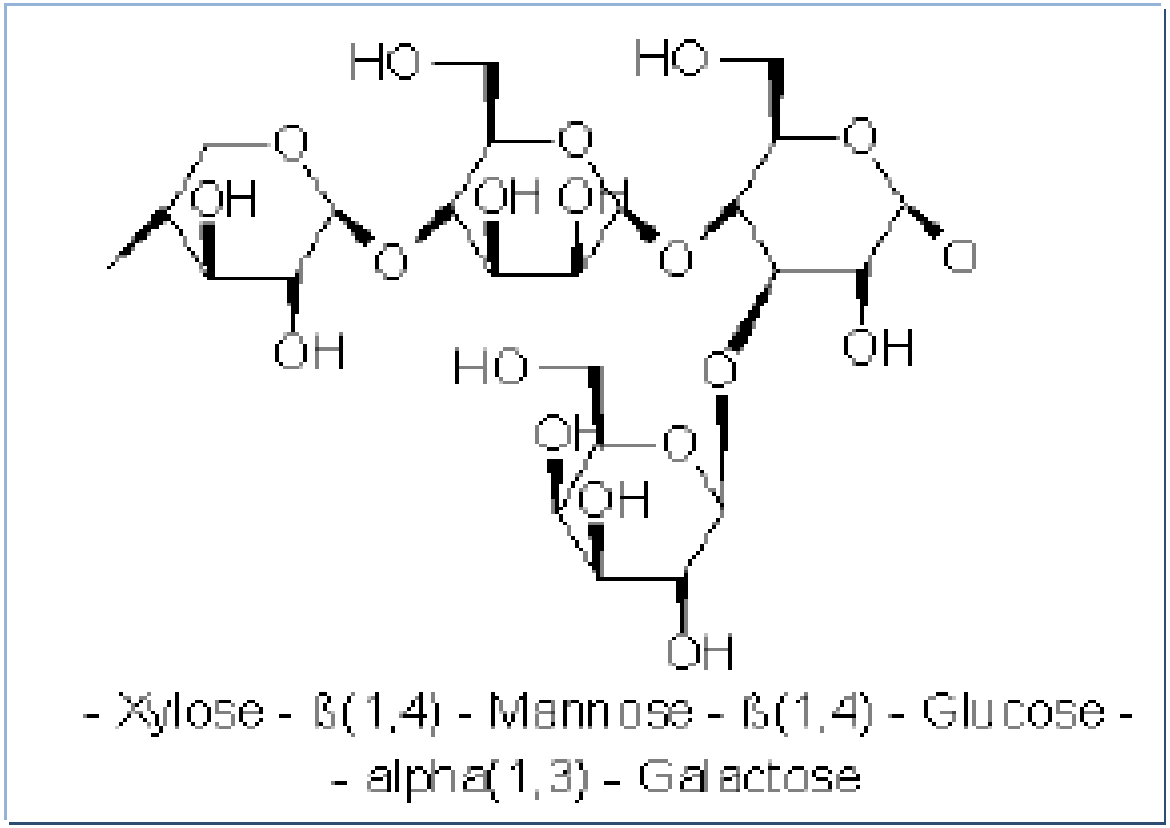


Simplified 2-D structure of EDTA-metal complex



More elaborate 3-D EDTA-metal complex

Hemicellulose



- Xylose - ß(1,4) - Mannose - ß(1,4) - Glucose -
- alpha(1,3) - Galactose

Cellulose is crystalline, strong, and resistant to hydrolysis. Hemicellulose has a random, amorphous structure with little strength and is easily hydrolyzed by dilute acid or base as well as hemicellulase enzymes

Conventional Scouring Recipe

Chemicals	Amount
NaOH	4% owf for normal fabric 6% owf for heavier fabric
Wetting agent	1 – 3 gpl
Emulsifying agent	Non-ionic surfactant (1-3 gpl)
Temperature	130 ^{o}C

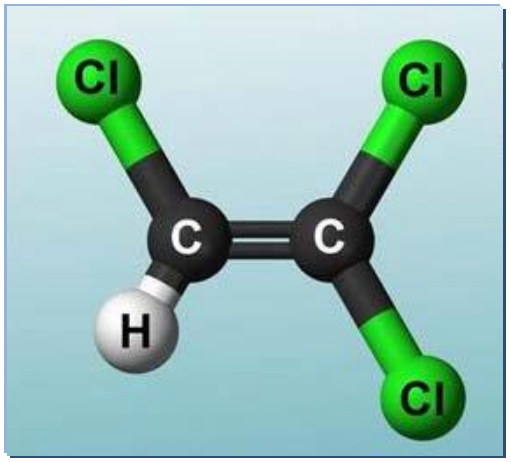
Solvent System

- Developed in 1970s in Europe and given up towards the end of 70s.

- Certain organic solvents dissolve oils, fats and waxes and these solvents can be used to purify textiles

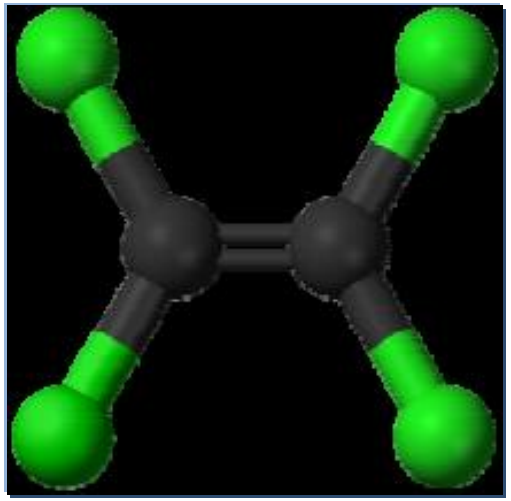
- Removal of impurities by solvent dissolution is called Extraction

Trichloro ethylene
(B.P. : 87^{o}C, Non-flammable)



Trichloroethylene (TCE)

Perchloro ethylene
(B.P. : 121^{o}C, Non-flammable)



Perchloroethylene (PCE)

Solvent Scouring

Advantages:

- Good solvents for cotton wax
- Removal of wax at room temperature
- Removal of solvent from fabric more favorable due to low specific heat of solvent
- Chlorinated solvents are non flammable

Disadvantages:

- The economy of the process depends on the recovery of solvent
- Very low amount of wax is removed with the help of large amount solvent

*Hence **solvent assisted scouring was developed***

Solvent Assisted Scouring

The system has following components:

- Solvent
- Wetting agent (Pine oil)
- Emulsifier

✓ Transparent mixture of all three produced with same HLB values (HLB Value: 13 - 13.5 for all the components)

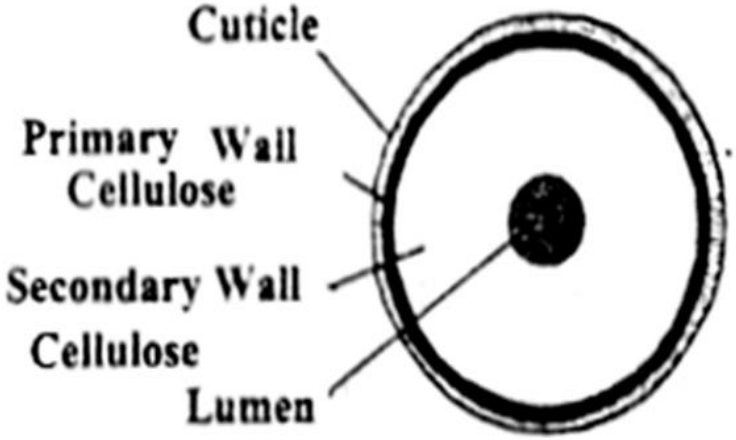
✓4% concentration of the above recipe used for scouring

Enzymatic Scouring

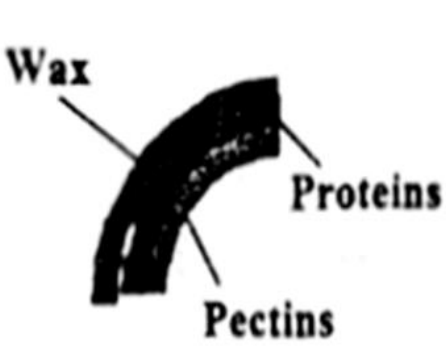
Greek word ***enzymos, which means*** **‘in the cell or ferments’.**

- Enzymes are very large, complex, protein molecules consisting of amino acid
- Bio-catalysts, not consumed in the reaction
- Substrate specific, acts under narrow range of conditions of temperature, pH and agitation

Possible Structures of Cotton Surface



Raw cotton fiber in its swollen state



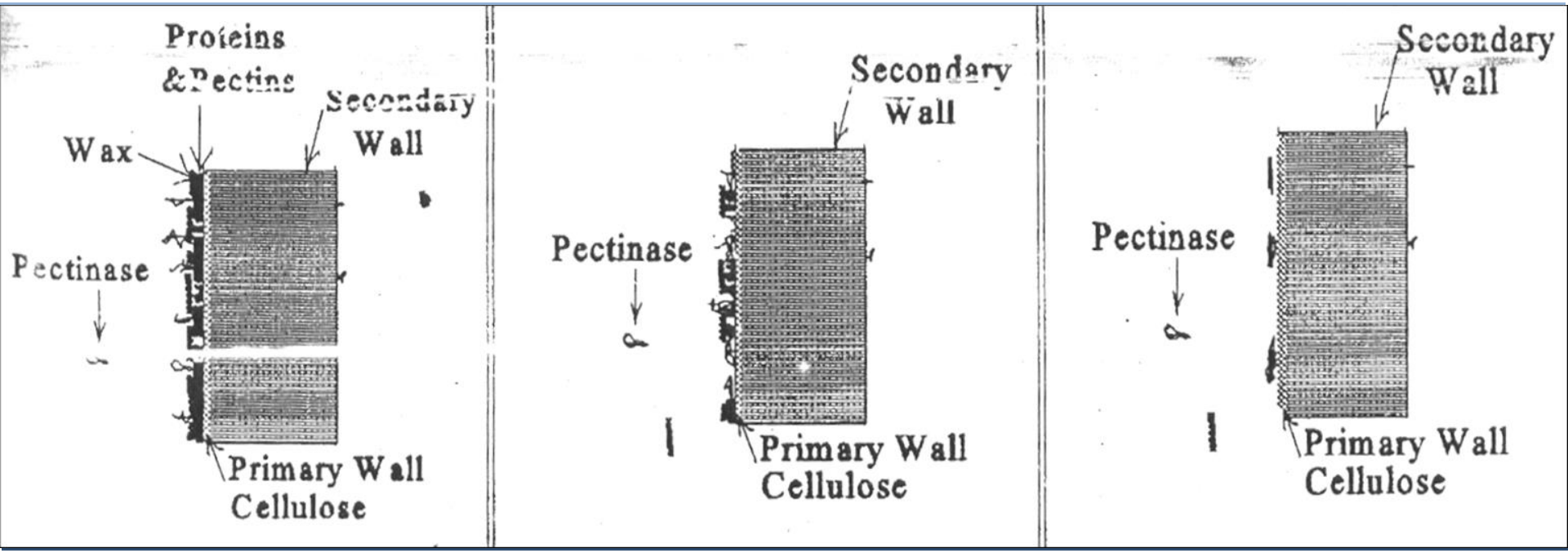
(a)

(b) + (c)

Three possibilities for the structure of the cuticle
a) layered b) matrix
c) matrix with micropores in the wax layer

- The proteins, pectins and waxes are present as distinct layers in the cuticle
- The matrix of pectins and proteins is covered by a microporous thin layer of waxes

Mechanism of Pectinases on Cotton surfaces



- Pectinases penetrate the cotton cuticle through cracks or micro pores
- Pectic substances are hydrolyzed with the aid of pectinases
- Link between the cuticle and the cellulose body breaks, absorbent fibres formed

Commercial product (Scourzyme® L)

Alkaline pectinase: The removal of non-cellulosic components from fabric is done (scouring).

Enzyme product	Temp. (°C)	pH	Continuous	Pad–roll	Jet, jig, winch
Scourzyme® L	50–65	7.5–9.0	+/–	+++	+++

Excellent: +++
Good: +
Possible under certain conditions: +/-

Machinary

Conventionally the following machines have been used for scouring:

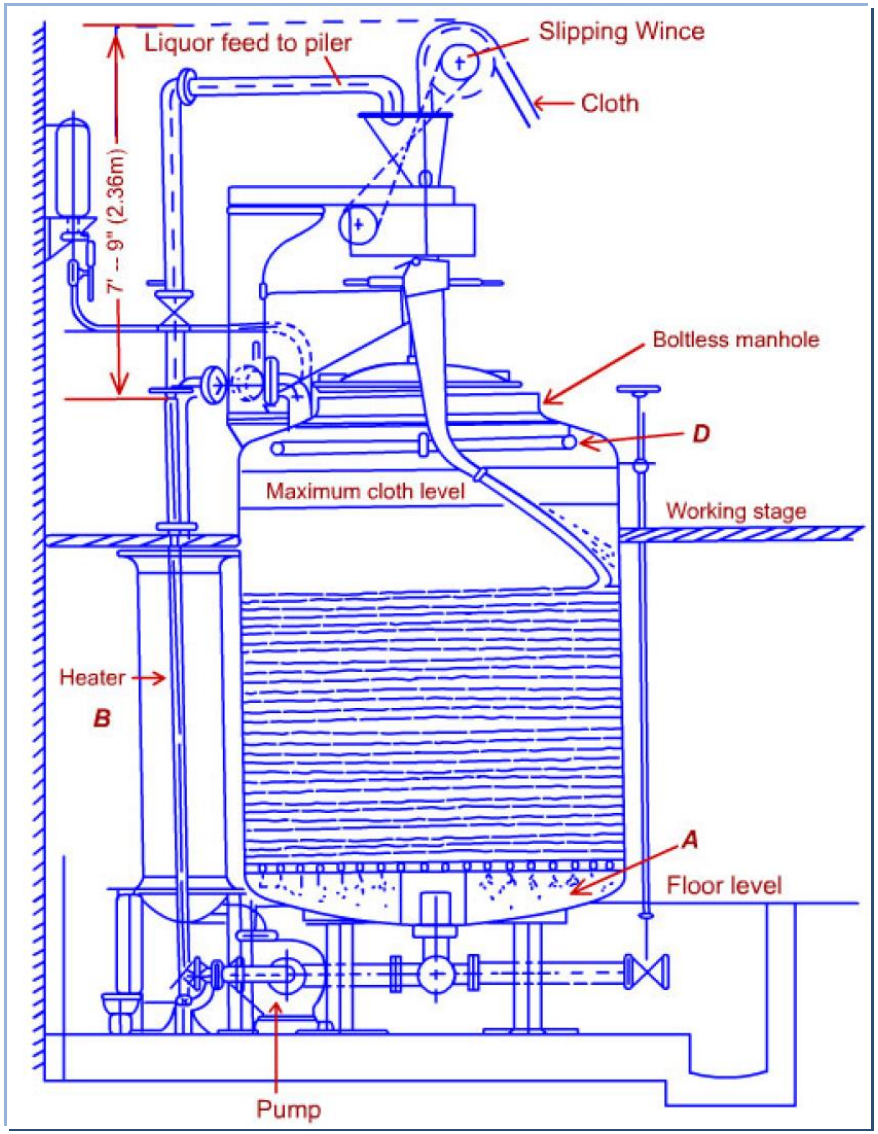
- **Pressure kier (batch system)**
- **J-BOX (continuous system)**
- **Vaporloc System (continuous)**

Pressure kier (batch system)

Kier, closed vessel in which the desized fabric is heated at high temperature for prolonged time.

Conditions	Range
M:L Ratio	1:3
NaOH Concentration	10 gpl
Temperature	130°C
Time	6-10 hr

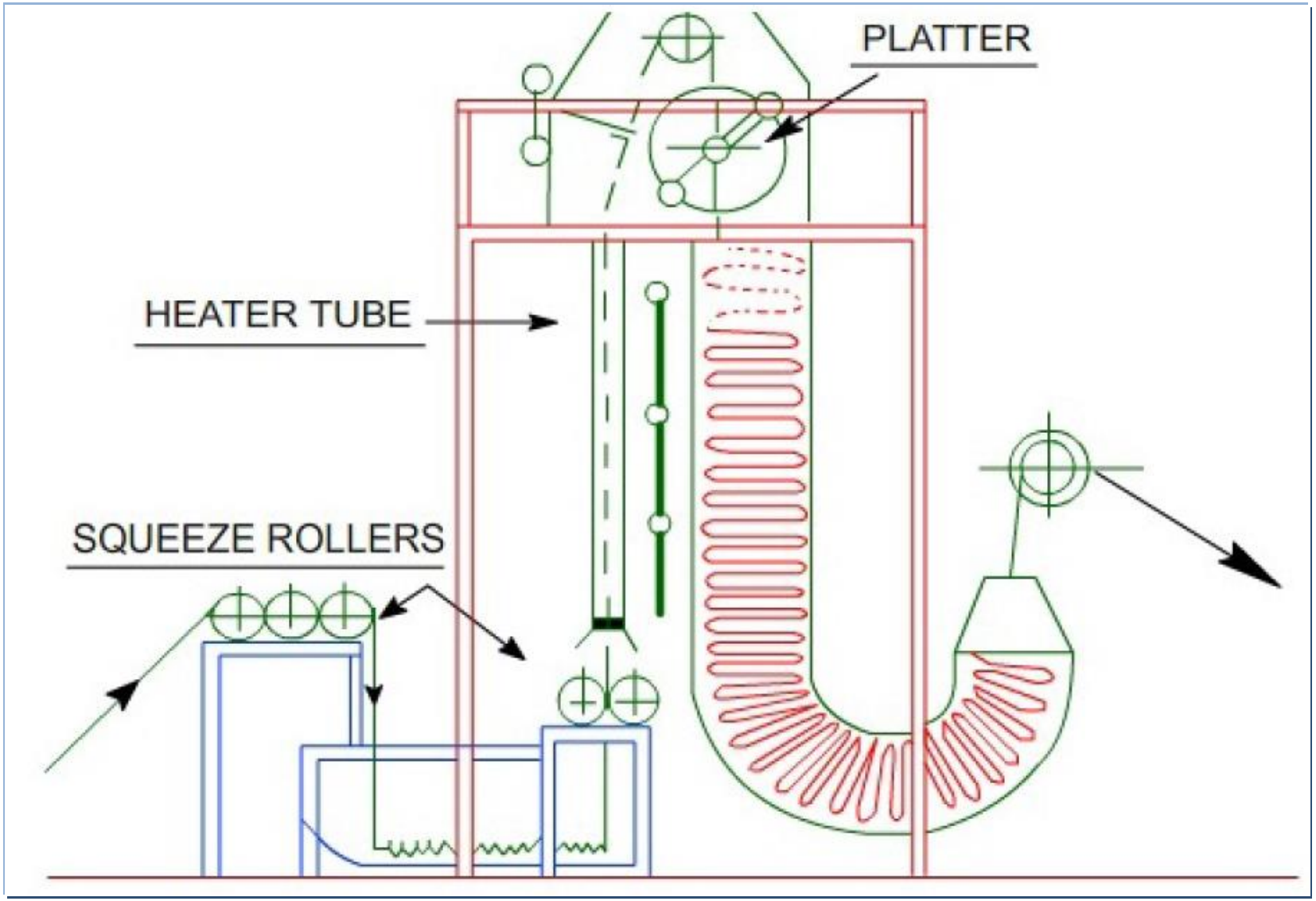
Pressure kier (batch system)



J-Box (Continuous System)

- It is a continuous system
- Fabric is fed from one end and the scoured fabric comes out from the other end
- The capacity is such that sufficient residence time, allowed inside the machine for degradation and removal of impurities
- Inside temperature: 100 ^{o}C
- Saturation of fabric with recipe before treatment in the J-Box
- Time: 40 – 60 min

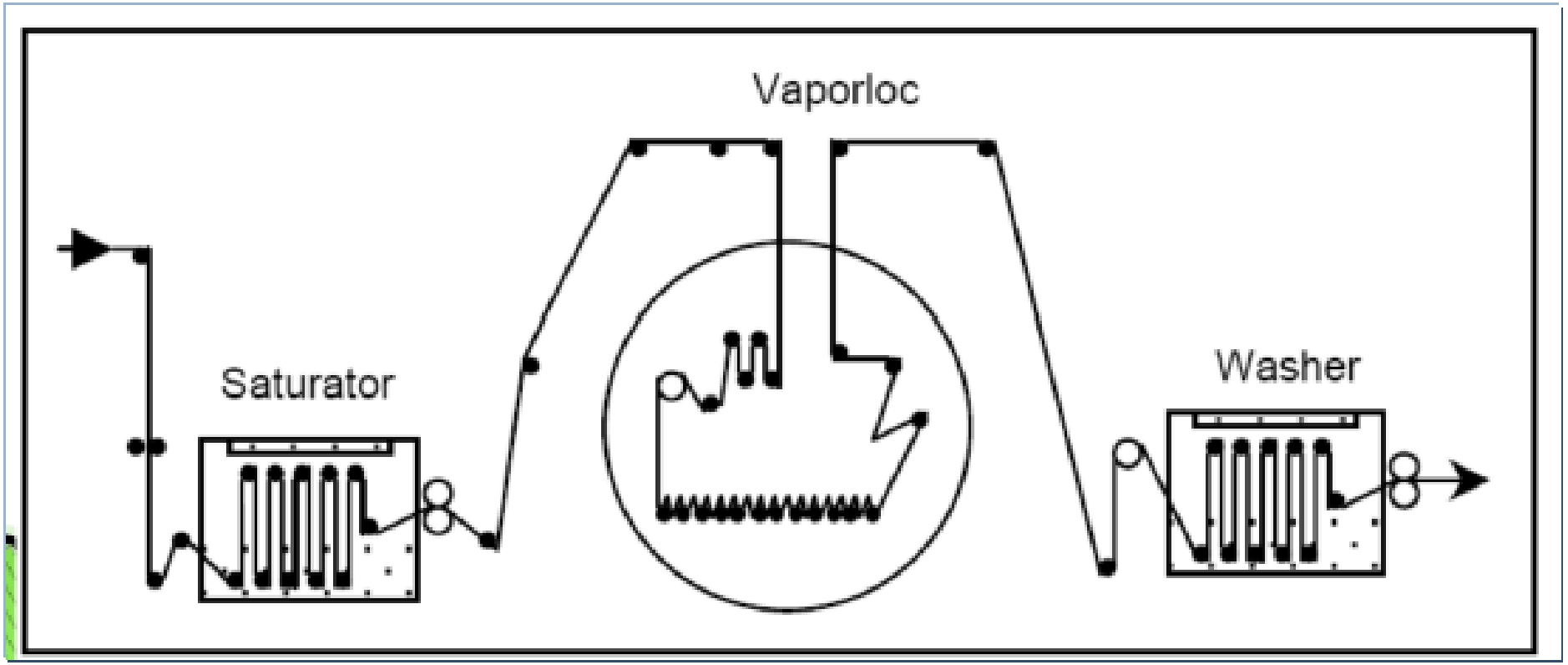
J-Box (Continuous System)



Vapor lock system (Continuous System)

- A continuous system, pressure maintained inside the system
- Shorter treatment times at higher processing speeds
- Saturation of fabric with NaOH + Wetting agent solution
- Pressure inside the chamber: 30 lb/in^2
- Temperature: 134 ^oC
- Time: 90 – 120 sec

Vapor lock system (Continuous System)



Assessment of scouring efficiency

Assessment of scouring efficiency

- **Practical tests of absorbency**

- **Measurements of:**

✓ **Weight loss**
✓ **Protein content**
✓ **Residual wax content**
✓ **Methylene blue absorption (removal of pectic substances)**

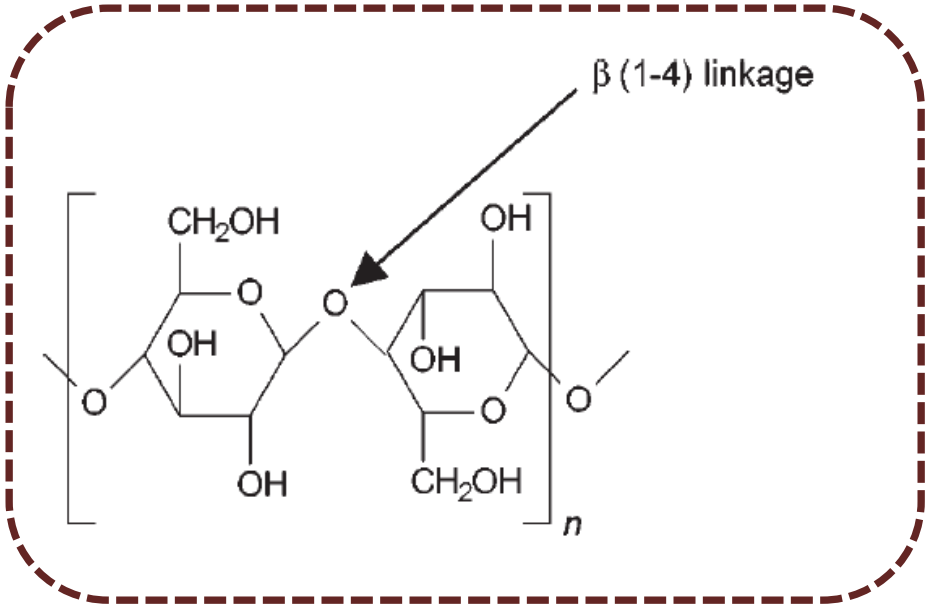
Test of Absorbency

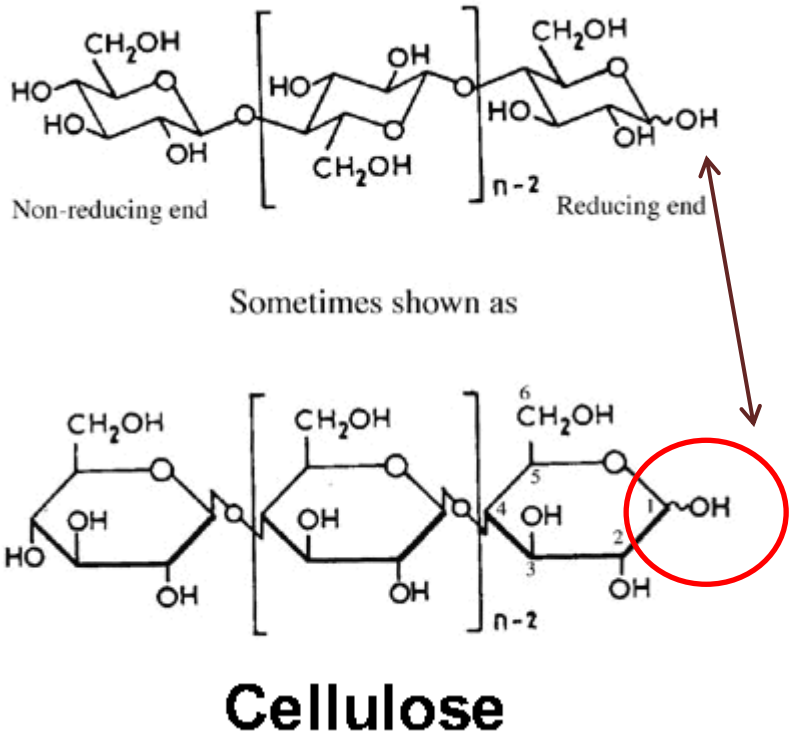
Drop test:

- Water drops are allowed **to fall by gravity from a burette placed at a certain height from the fabric** surface
- The fabric is placed straight on a table **without any creases**
- The time required for the drops to collapse is noted as **wetting time**

Degradation of Cotton

Cotton Structure:



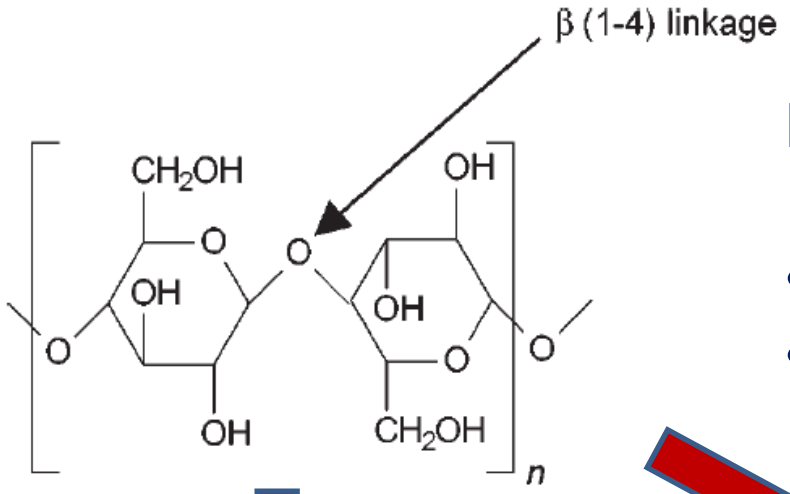


Cellulose

Cellulose molecule contains three different kinds of units:

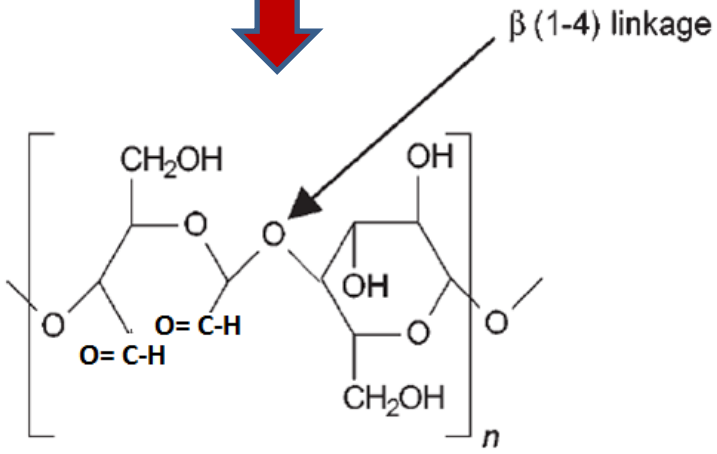
- Reducing end with a free hemi-acetal (or aldehyde) group at C-1,
- Non-reducing end with a free hydroxyl at C-4,
- Internal rings joined at C-1 and C-4.

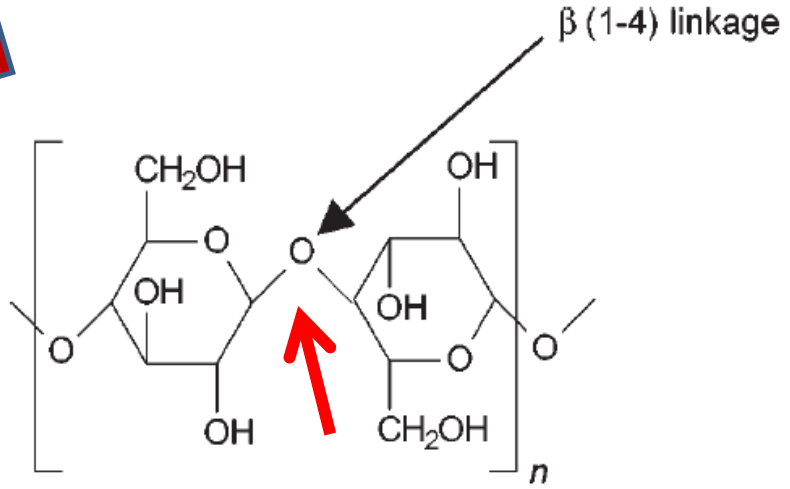
Way of degradation of cotton



Degradation results in creation of:

- aldehyde groups (-CHO) /
- acidic group (COOH)





Assessment of degradation of cotton

- ***Copper number,*** *a measure of the reducing groups present in cellulose*

- **Cuprammonium fluidity,** which is a measure of molecular chain length of cellulose.

- **Tensile strength** of the cotton material before and after scouring.

Copper Number

Copper Number, defined as grams of ***cupric copper reduced to*** **cuprous oxide** by 100 g of cellulose under standard conditions of boiling in alkaline medium.

✓ The formed **cuprous oxide** is dissolved in a solution of **iron alum and sulphuric acid** for reducing an equivalent amount of **iron to the ferrous state**.

✓The **reduced iron** is then determined by titration with a standard solution of **ceric ammonium sulphate**.

(Ortho ferrous phenathroline is used as an indicator)

Copper Number

$$\text{Copper number} = \frac{63.5 \times V \times N \times 100}{W \times 100}$$

- V is the ml of ceric ammonium sulphate solution consumed after deducting blank reading
- N is the normality of ceric ammonium sulphate solution
- W is the weight of the bone dry cellulose sample

Copper Number

Substate	Copper number
Pure cellulose	~ 0.05
Raw cotton	~ 0.9
Well-scoured and bleached cotton	> 0.3
Regenerated fibre	> 1.2

Cuprammonium Fluidity

Cuprammonium fluidity is a measure of molecular chain length of cellulose.

(By measuring the fluidity of cotton material dissolved in cuprammonium hydroxide solution)

- The degradation, in terms of reduction of the degree of polymerization, can be assessed by measuring fluidity.

- The DP of a polymer is directly proportional to the viscosity of its solution.

Substrates	Fluidity
Unscoured / Unbleached Cotton	2
Scoured / Bleached Cotton	5 or less
Unbleached viscose	10