Viscose

Recommendations for
Pre-treatment,dyeing
and finishing

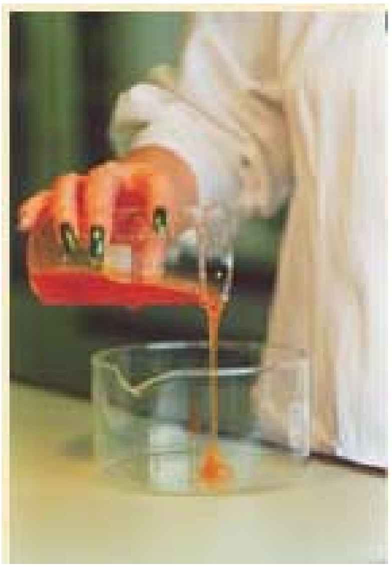
Yohji Yamamoto viscose shirt
Spring-Summer 2006

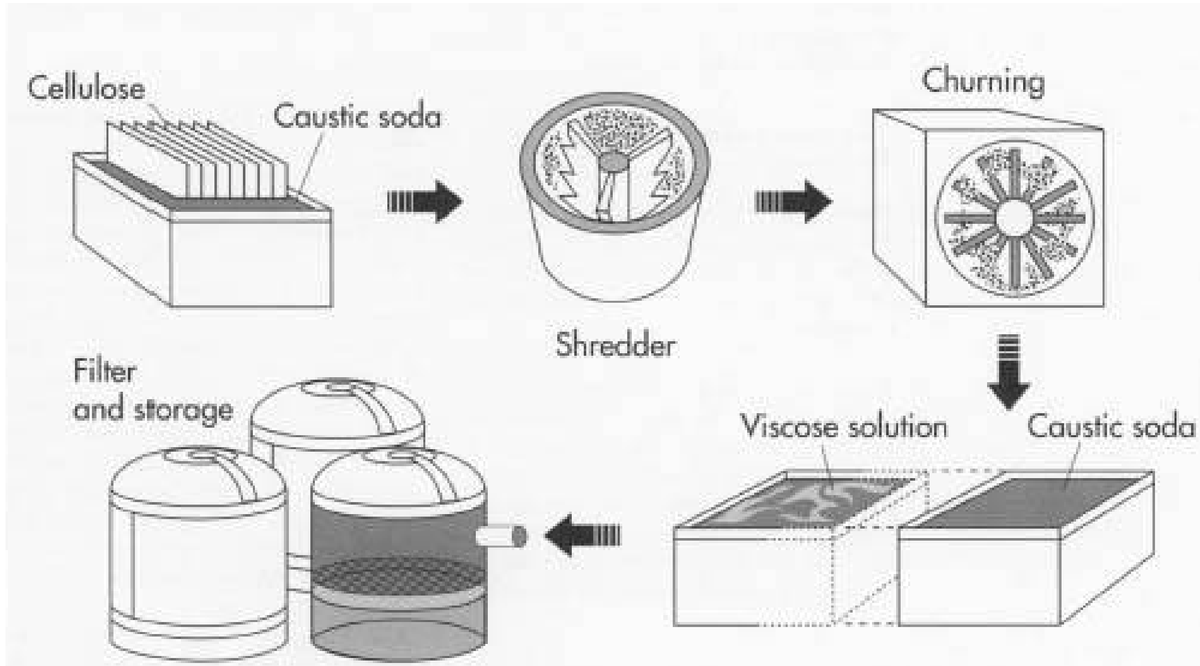
Viscose

- Viscose manufacture
- Viscose physical properties
- How manufacture and physical properties influence dyeing
- Pre-treatment
- Dyeing
- Finishing

Versace viscose polo shirt

Viscose manufacture

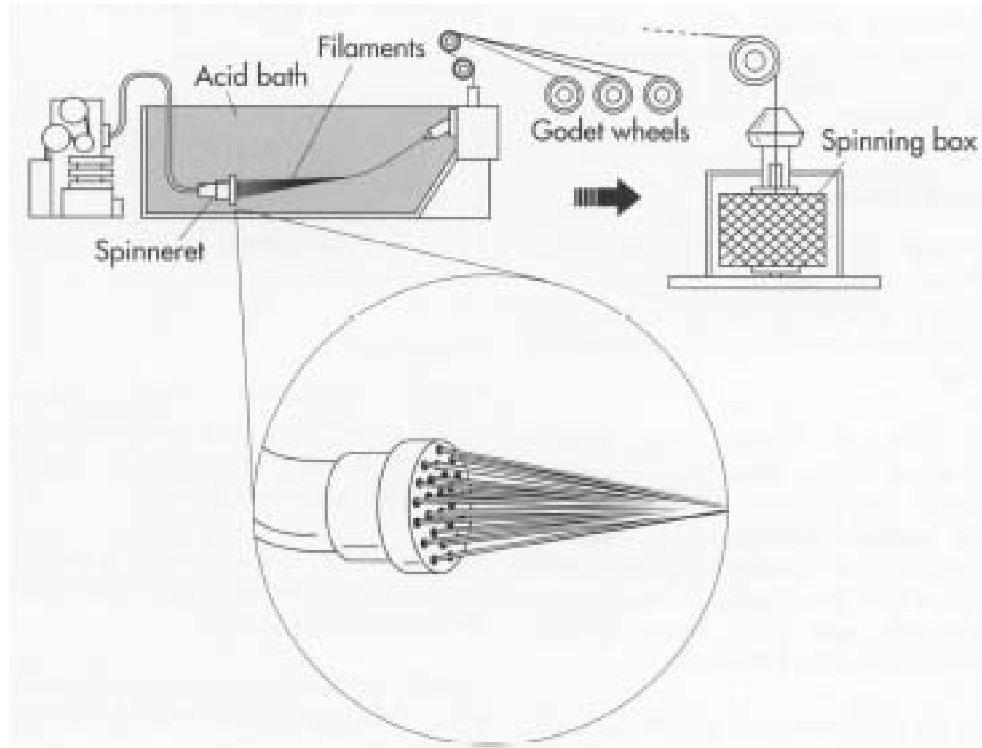




To make rayon, sheets of purified cellulose are steeped in caustic soda, dried, shredded into crumbs, and then aged in metal containers for 2 – 3 days. The temperature and humidity in the metal containers are carefully controlled. After ageing, the crumbs are combined and churned with liquid carbon disulphide, which turns the mix into orange-coloured crumbs known as sodium cellulose xanthate. The cellulose xanthate is bathed in caustic soda, resulting in a viscose solution that looks and feels like honey.

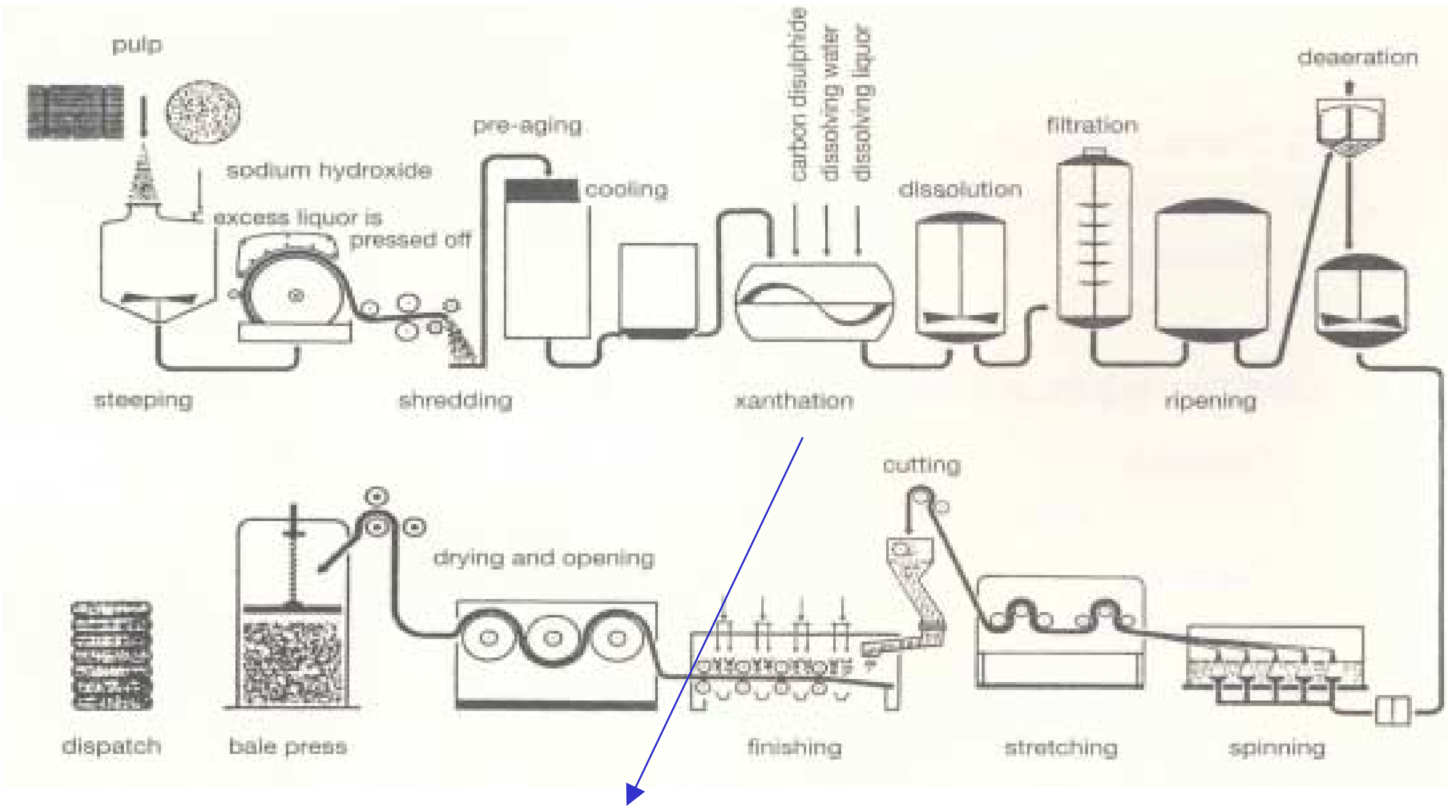
Spinning

spinneret



After the syrupy viscose solution is prepared it is forced through a spinneret into an acid bath containing sulphuric acid, sodium sulphate and, usually, Zn^{++} ions, causing the cellulose to be regenerated and precipitate from solution. The resulting strings or filaments are then stretched on godet wheels to strengthen them, and put into a spinning Topham box. The result is the formation of fine filaments of cellulose, or rayon.

Viscose manufacture

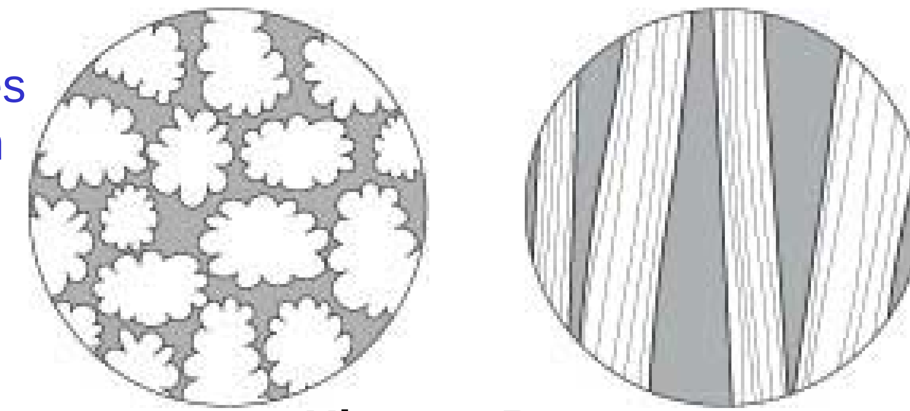


- Possible sulphur residues can generate reducing conditions – destroying or changing the shade of dyestuffs

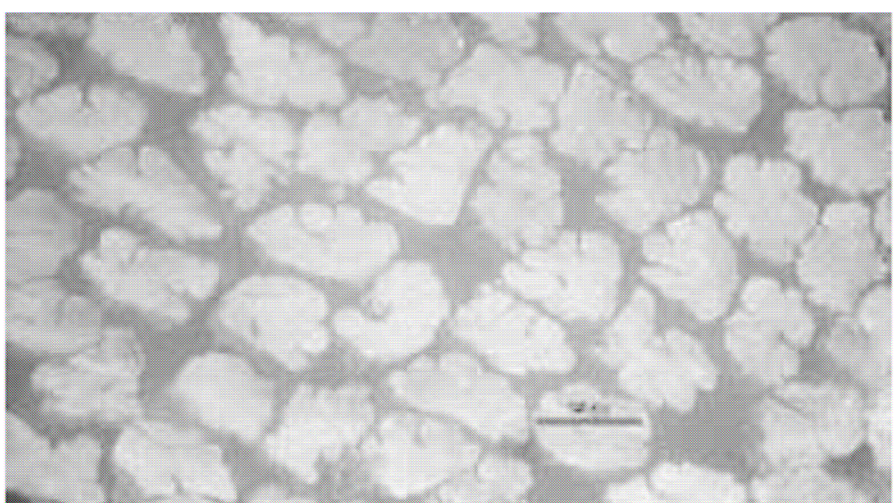
Viscose manufacture

After initial skin formation, the core of the fibre decomposes, hardens and shrinks. Viscose fibres are therefore characterised by an irregular, serrated skin and cross section. The skin is said to consist of many small crystalline regions. The core, on the other hand, develops a coarser crystalline structure.

Cross-section Longitudinal-section



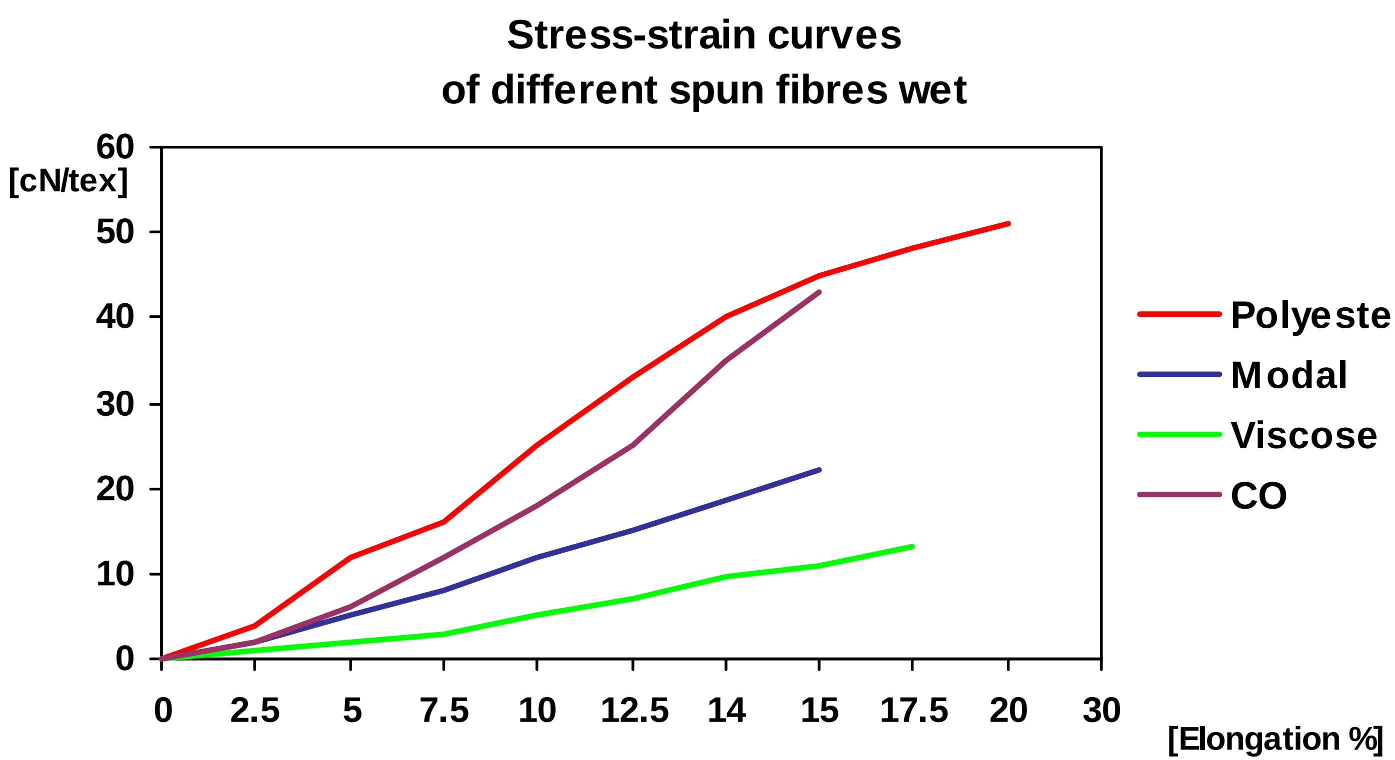
Viscose Rayon



Differences in the ratio of skin to core impact on fibre properties and dyeing behaviour. Dye diffusion is therefore crucial to dyeing speed and extra kinetic energy is needed for dye penetration – especially when swollen to its maximum by heat.

Viscose properties

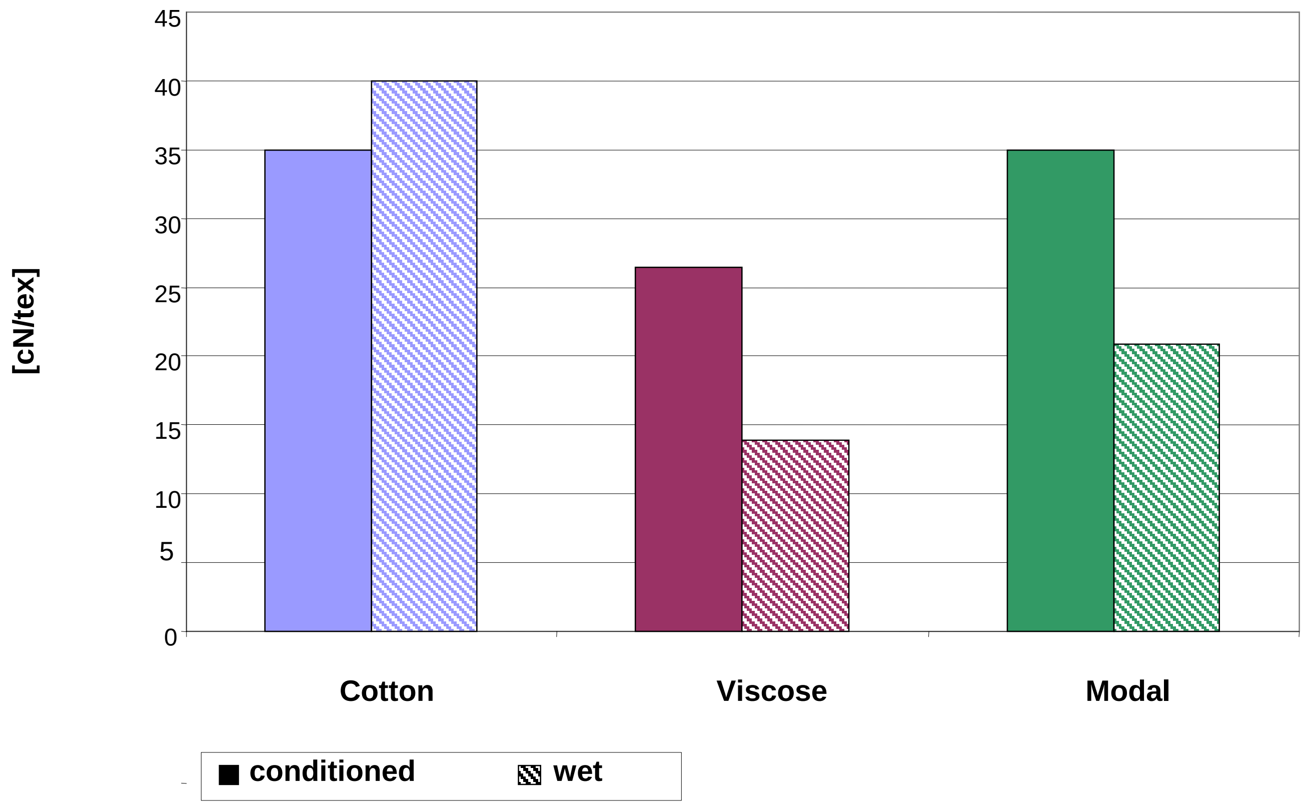
Viscose has lower tenacity in both wet and conditioned state than cotton



Viscose properties

Viscose has lower tenacity in both wet and conditioned state than cotton – more care is necessary to prevent fabric breakages and tears in wet processing

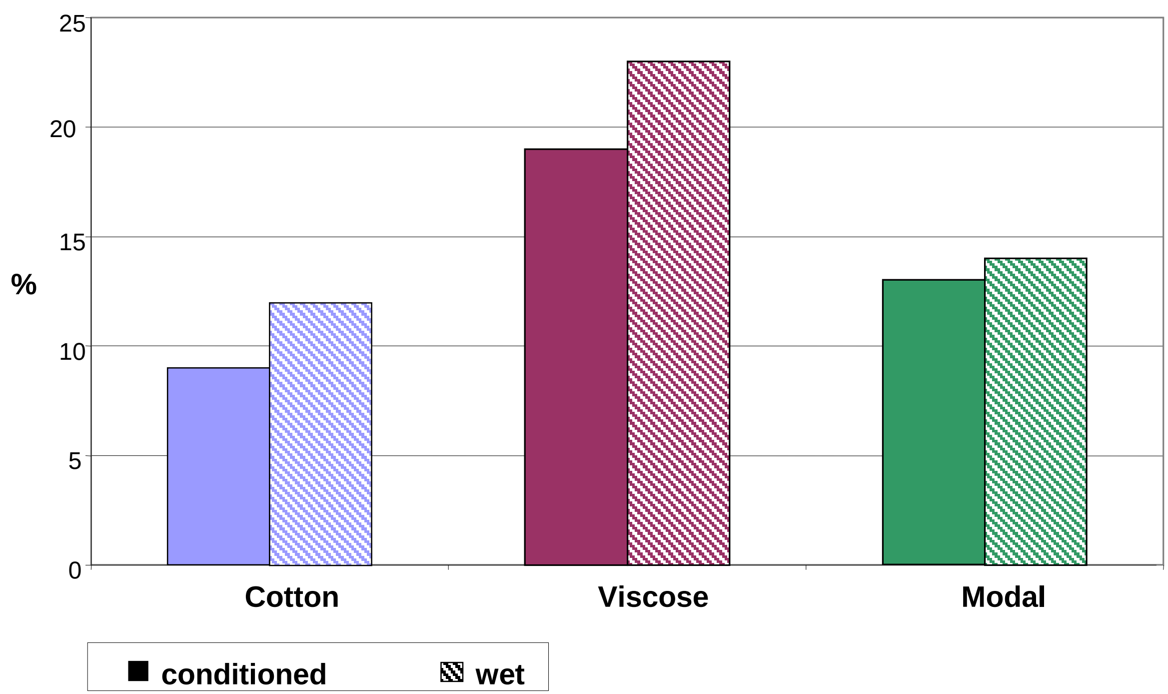
- **Dry and wet tenacity**



Viscose properties

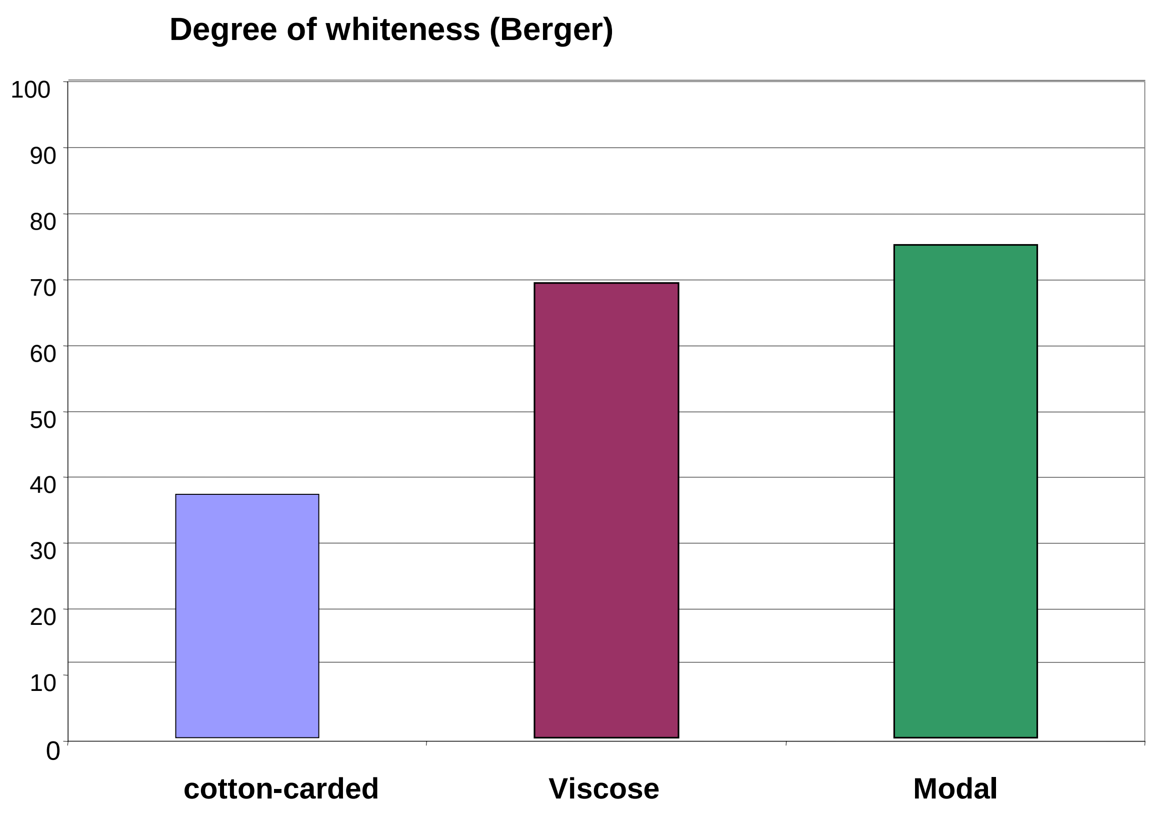
Viscose has greater elongation in both wet and conditioned state than cotton – it will be stretched or distorted more under tension.

- **Dry and wet elongation**



Viscose properties

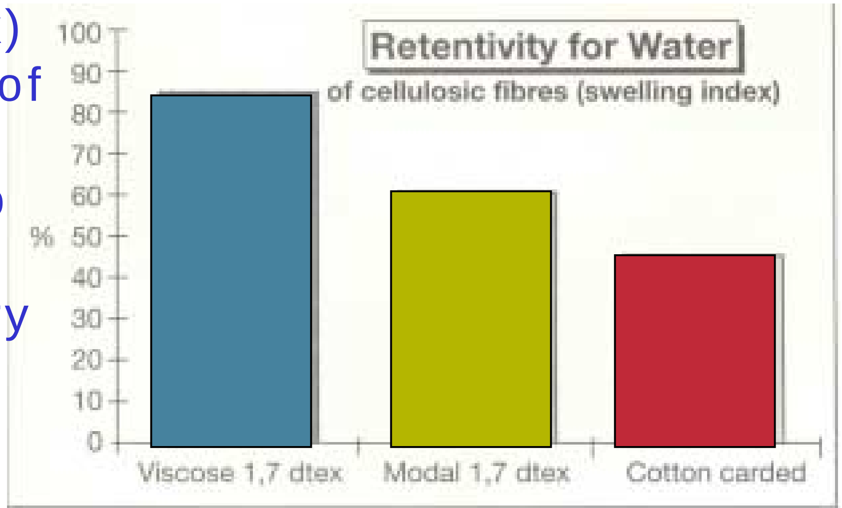
Viscose and Modal fibres are supplied in a pure state and with a higher degree of whiteness than cotton. Bleaching is only required for a full white or pastel shades. Viscose/cotton blends require bleaching baths with a reduced chemical content.

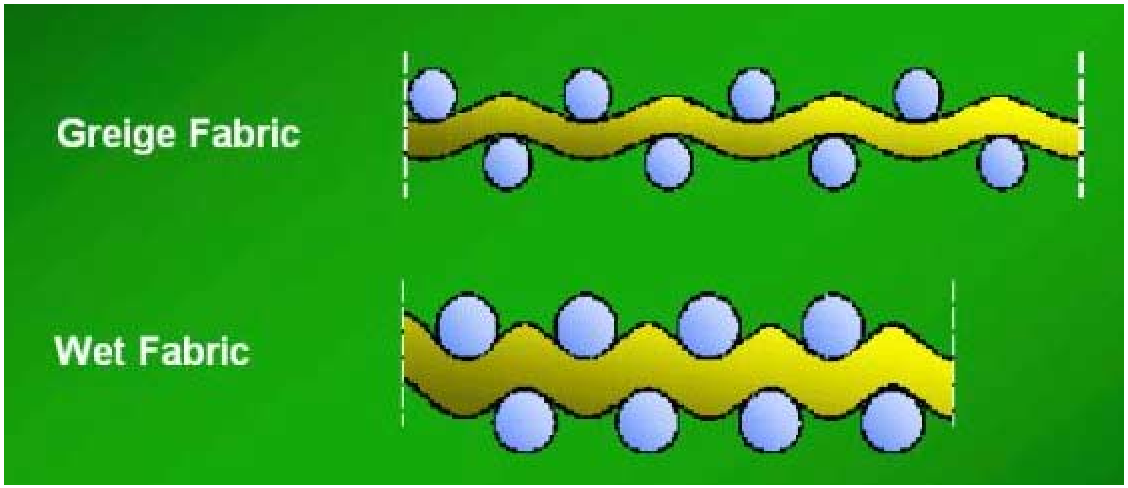


Viscose properties

The water retention value (swelling index) of viscose is very much higher than that of cotton.

In aqueous liquors, viscose fibres tend to swell more strongly than Modal fibres or cotton. This swelling process happens very quickly and is almost complete after ten seconds at the lower temperature range.





Fabrics become much more stiff when wet because the fibres are so swollen.

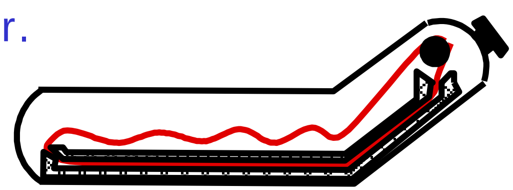
In their swollen state, viscose fibres can become set to a certain extent. This is called hydro plasticity.

How manufacture and physical properties influence dyeing

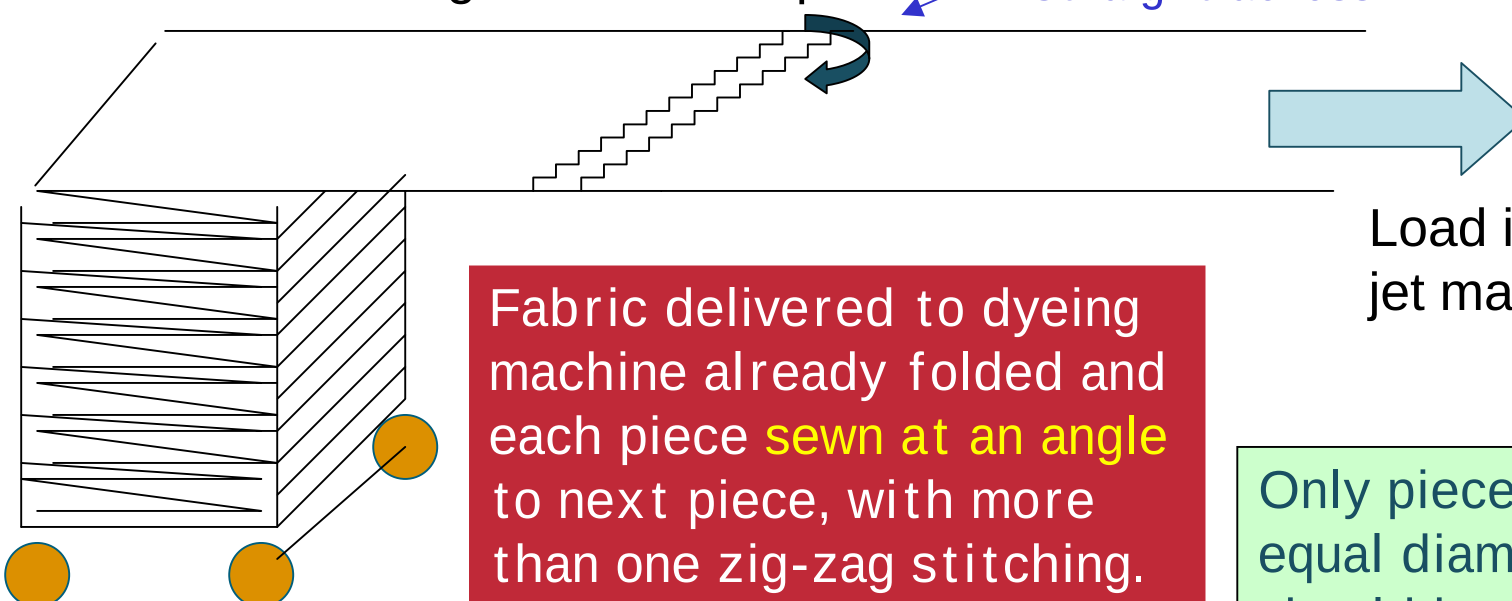
Different ratio of crystalline and amorphous regions compared to cotton	Viscose has higher dye affinity than cotton.
Viscose has irregular serrated skin and cross section.	Inferior diffusion and penetration. More kinetic energy needed. Hot reactive dyes.
Viscose loses tenacity when wet.	More care needed to avoid damage.
Wet swelling increases with temperature	Very important in package dyeing. Liquor circulation should mainly be IN to OUT. OUT to IN should be < 30 seconds.
Swelling of fibres makes wet fabrics stiff. Swelling and heat can set creases.	Use longer L.R. than for cotton. Keep liquors above 50° C, Cool at maximum 1° C per min. Use suitable anti-crease lubricants.
Viscose may contain residues of sulphur.	Mild peroxide bleach may be necessary to remove sulphur.
Viscose is creamy white in colour, naturally clean. Fabrics free from natural fats and waxes, motes and seeds.	Little preparation required. Bleaching chemicals can be reduced. Always give SOME preparation to avoid carry over of sulphur.
Dyes have higher substantivity and faster fixation	Use 'Migration' dyeing techniques (at up to 110° C). Add salt after dye.

Pre-treatment

- Scouring and bleaching need to be mild in nature. The fabrics should always be scoured, and never put straight into dye because it is important to remove any residual sulphur to prevent dye reduction. Spinning lubricants used on viscose tend to yellow with heat, and so should be removed for best whites and bright pastels.
- The liquor ratio may need to be a little higher than for cotton, because of the higher water retention but also because of the high swelling. (Reduce jet capacity)
- Break outs are always an issue on viscose, particularly where there is lengthways tension on the fabric. Best avoided by sewing the fabric at an angle, not straight across. Use multiple "zig-zag" stitching for additional security.
- Fabrics will tend to stiffen in tight constructions so lubrication is important. There should be as little tension on the fabric as possible, because of the low wet modulus it will stretch easily and dimensional stability may never be achieved. Usually means slower turn around times and dyeing machines with winches to help the fabric into the jet, or the cigar-type machines with the fabric movement into the jet being downwards (like the Gaston County Futura or Hisaka). The more "so the dyeing machine – the better.



Creasing and breaking of sewings



Fabric delivered to dyeing machine already folded and each piece sewn at an angle to next piece, with more than one zig-zag stitching. Rope is loaded into dyeing machine without twist

Only pieces of equal diameter should be sewn together

Pre-treatment

Better base white than cotton, therefore bleaching mainly required only for full white or pastel shades.

Woven fabrics

Warps of viscose rayon can be sized with a variety of agents : starch based systems, polyvinyl alcohol systems or a combination of both, modified starch, starch ethers or CMC or combinations of these. Identification of the size present is important prior to deciding on a suitable desizing procedure, however, many factories will opt to use their standard cotton desize treatment :

e.g. applying in the quench box of a singeing machine :

pad 2 - 4 g/l amylase enzyme (Nearzim 610)
1 - 2 g/l wetting agent (Nearfil PO)

impregnate at 60°C ; pick-up 80 % ; batch minimum 4 hours - normally overnight ; wash-off.

Pre-treatment

Relax / scouring

Viscose rayon fibres, unlike natural cellulosic fibres, are free from natural fats and waxes, motes and seeds, and the scouring process, therefore, need not be as severe as for cotton, and can be based on soda ash or tetra sodium pyrophosphate recipes rather than caustic soda. A typical scouring recipe on a 5 box continuous open width washing range would be :

Box 1
3 g/l Nearpon CLF
2 g/l Soda Ash
1 g/l Nearchel TMC
at 95°C

Box 2
1 g/l Nearchel TMC at 95°C

Box 3
2 g/l Nearchel TMC at 95°C

Box 4
Water only at 70°C

Box 5
Water only – cold

Knitted fabric – on jet or overflow machine

2 – 4 ml/l Lubrifil LV, Lubrifil TFS or 0.5 – 1 g/l Lubrifil LAF
0.5 – 1 g/l Nearpon BW-LF or Nearpon LF-JET
0.5 – 2 g/l Nearchel SA
1 – 3 g/l Soda ash (about pH 9)

Run 20 to 30 minutes at 60-90° C
Hot rinse

Pre-treatment

NearChimica

Peroxide bleach on jet or overflow machine

For full white

1.0 – 3 ml/l Lubrifil LV or Lubrifil TFS, or
0.5 – 1 g/l Lubrifil LAF
2 – 4 g/l Nearcand OP-LF
2 – 6 ml/l Hydrogen peroxide 35%
0.3 – 0.7 % Nearoptic LNC
or
0.2 – 0.6% Nearoptic CD-2F

Run 40 minutes at 85° C
Hot rinse at 60 – 80° C
Neutralise with **Nearchel MTB**
for 10 – 15 minutes at 50-60° C

If dyeing after bleaching, omit optical brightening agent, add 0.1 – 0.5 ml/l catalase enzyme, **Neareduxol EX** to same bath after neutralising with **Nearchel MTB**, to prevent oxidative damage to dyes by residual peroxide.

There is a high risk of forming permanent creases in rope dyeing machines because viscose fibre swells and fabrics become stiff. Fabric will therefore not run well at temperatures below 50° C. Fabric must always be run at temperatures of 50° C or higher. Cool at a gradient of not more than 1° C per minute to prevent hydro plastic creasing.

Pre-treatment

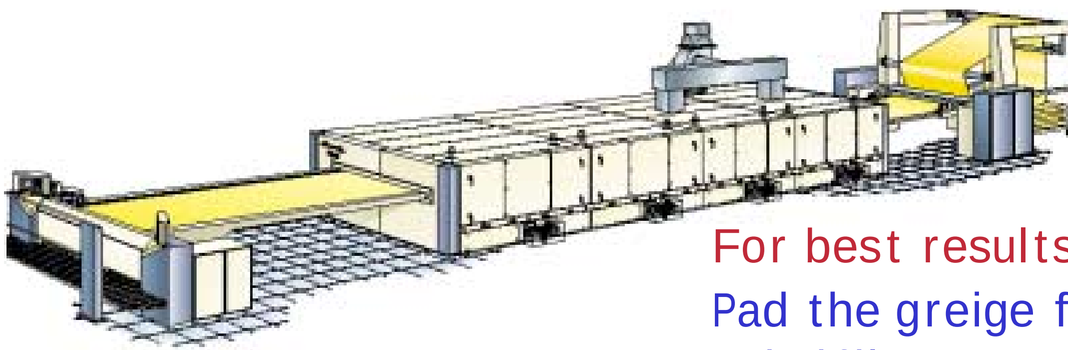
Causticising

Causticisation modifies the viscose fibre surface or skin to enable more rapid diffusion of dye into the fibre. Benefits are therefore more obvious in printing than in dyeing, where long diffusion times are employed, and with selected reactive dyes, yield gains of up to 50% are possible. Typical conditions for pure viscose are treatment with 6° - 8° Bé caustic soda at 25° - 30° C for at least 2 minutes followed by low tension washing with boiling water to assist the rapid removal of alkali.

Pad-Batch processing is popular although dedicated continuous plant, employing a scray or conveyor for tensionless swelling and reaction, is preferable. Liquor pick-up of about 120% should be achieved. The best after-washing device is probably a sieve drum continuous open-width range. Low uniform processing tensions are essential for consistent results and good quality. Rinsing should be done as hot as possible to minimise swelling and ensure rapid and complete removal of caustic soda. An addition of 2 – 4 g/l soda ash in the initial wash boxes will promote removal of alkali, and help maintain a good fabric handle. Neutralisation with **Nearchel MTB** is also advisable.

Pre-treatment – Viscose/Lycra®

Where blends of viscose/elastane contain more than about 5 or 6% elastane, it will be very difficult to achieve satisfactory dimensional stability in the final garment (e.g. less than 5% shrinkage on washing) unless the fabric is pre-set before wet processing.



For best results we recommend:

Pad the greige fabric in:

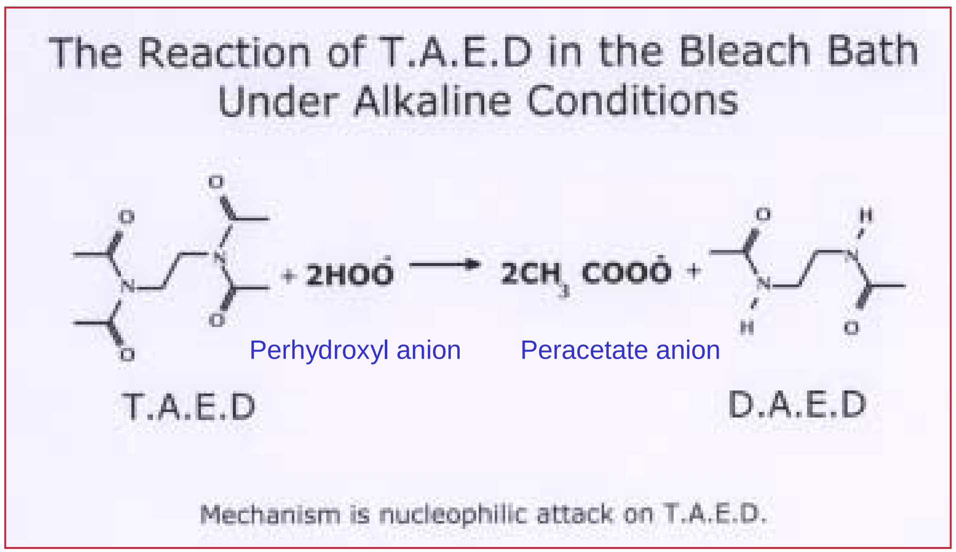
Lubrifil LAF	20 g/l
Nearpon BW-LF	5 g/l

Heat set for 30 – 60 seconds at 190° - 195° C (depending on type of elastane)

After heat setting the fabric will feel very soft and bulky compared to fabric heat-set without auxiliaries, and when put into water the knitting and spinning oils and charred colour are immediately rinsed out of the fabric. When the heat set fabric is loaded into the dyeing machine, a quick hot rinse is applied, then the fabric is scoured/bleached with Nearpon KR to complete the removal of silicone oil. Because the fabric already contains Lubrifil LAF, no further addition of anti-crease agent is necessary in the scouring/bleaching bath.

Optical white – Viscose/Lycra ®

Viscose/Lycra ® (e.g. 90.5%/9.5%) fabrics can be susceptible to damage and loss of mechanical strength when bleached by conventional high temperature peroxide bleaching processes. A batch bleaching process using TAED (tetra acetyl ethylene diamine) at lower temperatures has been developed to provide improved whiteness and minimum strength losses, especially when the fabric is so brown after setting.



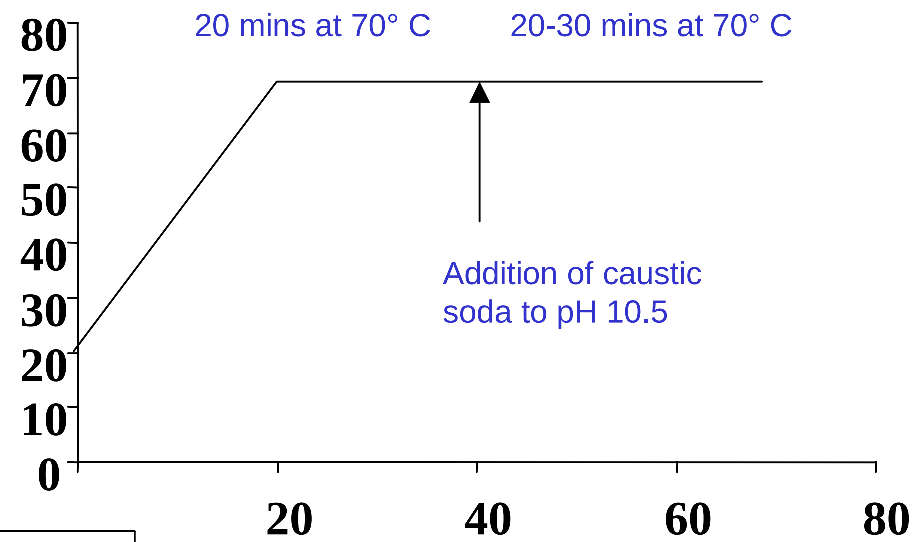
The bleaching process is carried out at 70° C for 20 minutes at near neutral pH followed by pH adjustment to higher alkalinity and a further 20-30 minutes bleaching.

2-3 g/l NEARCAND OP-LF
3-5 ml/l hydrogen peroxide 35%
2 g/l Nearstabil 110 (TAED)
Caustic soda to adjust to pH 10.5
Run 20-30 minutes at 70° C.

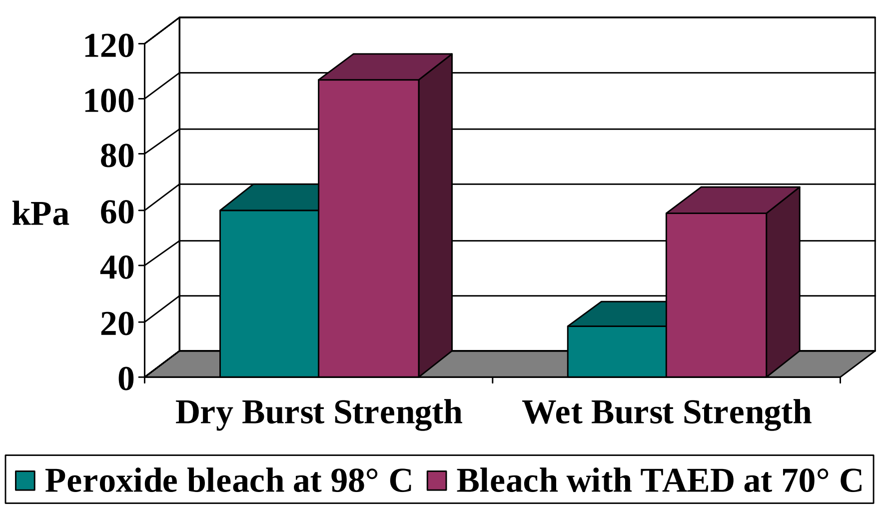
Apply OBA in second bath
1.0 – 2.0 g/l sodium dithionite, stabilised (hydrosulphite)
0.2 – 0.6 % Nearoptic BC , Nearoptic LNC or Nearoptic CD-2F

Set bath at 40 – 50° C. Raise to 60 – 80° C at 1-2 deg.C per minute. Run at 60° - 80° C for 20 minutes. Cool and drain.

Optical white – Viscose/Lycra®



Burst strength



CIE Whiteness produced with
Peroxide only at 98° C = 157.6
Peroxide +TAED at 70° C = 161.5

Dyeing - Yarn

Without salt, swelling of viscose increases with temperature. This must be remembered in package dyeing where high swelling and high pump pressure can lead to flattening of the yarn cross section at cross over points. Flow should be predominantly IN to OUT so that the yarn layers float apart and the liquor can circulate more easily. With OUT to IN flow the yarn layers are compressed and flow is reduced. OUT to IN flow cycles should therefore only be 30 seconds or so.

Conical cones:

The cones must be homogeneously wound to ensure an even dye result and the bobbin edges should be carefully rounded off (bumped).

The winding hardness should be approx. 25 Shore. Taking the relatively high swelling of the material into account this equals a volume of approx. 360 – 380 g/l.

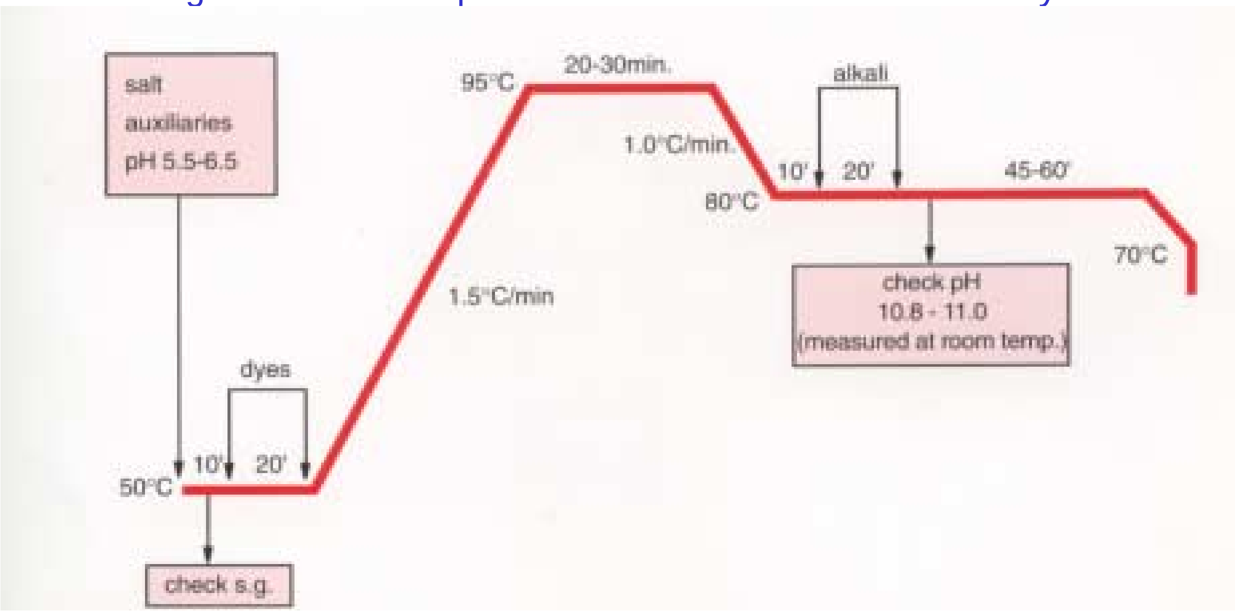
Due to the higher swelling of the material we recommend that the winding diameter is limited to 160mm. Dyeing problems have been experienced where the yarn tube diameter has reached 170mm (approximately 850g / cone).

Cylindrical Cones:

Lighter dyeing results on the edges can be avoided by using winding hardness's of approx. 25 Shore and a pressure rate of 20 %.

Dyeing - Fabric

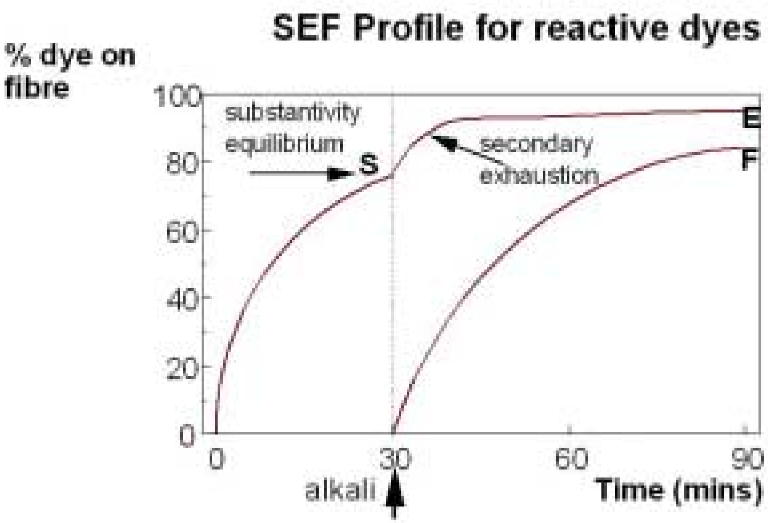
As viscose is a high affinity fibre, special consideration must be given to the choice of dyestuff and exhaust application technique. Hot dyeing reactive dyes are preferred for exhaust application in order to secure the highest migration and diffusion through the high affinity fibre when dyeing in rope form. Dye suppliers will thus generally recommend a migration technique to give levelness and reproducibility. This technique offers high dye mobility at temperatures as high as 110° C before cooling to 80° C for optimum fixation of the reactive dye to the cellulose chain.

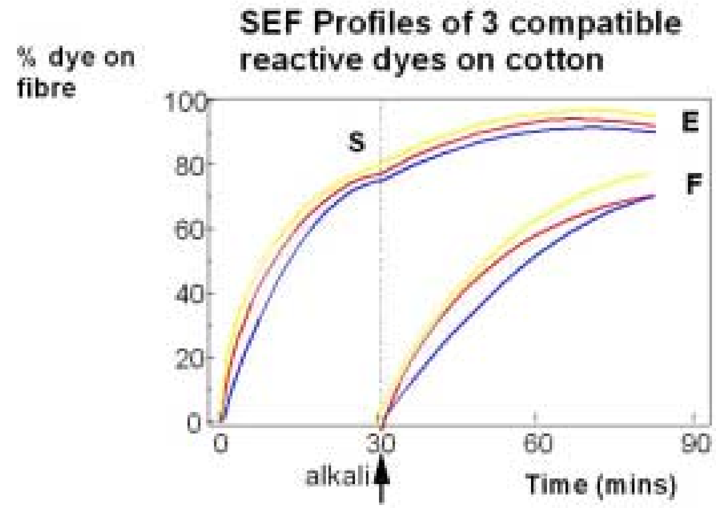


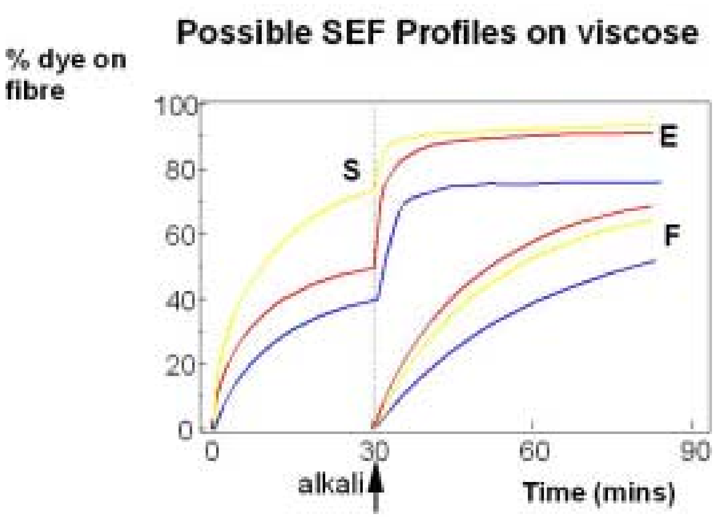
For higher substantivity dyes, the salt should be added gradually (over 30 mins) at 95° C, or at the highest temperature at which additions can be made.

The bath is set at 50° C with the required amount of electrolyte, auxiliaries and the pH adjusted with acetic acid to around pH 6.0. Predissolved dyes are then added in a linear manner over 15 – 20 minutes. The temperature is raised to 95° C (or even up to 110° C) at 1.5 to 2° C per min. and held for 20 minutes at 95° C before cooling back to 80° C at 1° C per min. Hold at 80° C for 10 minutes before adding the alkali in a linear manner over 15-20 minutes. Continue for 45-60 mins.

Dyeing - Fabric







If the dyeing is started at a higher temperature, S is increased and secondary exhaustion is less – more similar to cotton.

This can solve problems of colour separation – e.g. blue – yellow skitteriness in greens.

Dyeing - Fabric

Further precautions

Under alkaline conditions, in enclosed machines, viscose is especially prone to cause problems of dye reduction. It is essential that viscose is thoroughly desulphurised, otherwise appreciable colour value will be lost. Mild peroxide bleaching and addition of reduction inhibitor **Nearoxidol PL** (or **Nearoxidol SBR**) from the start of dyeing is recommended.

When dyeing in rope form, there must be sufficient displacement and this is best achieved for woven fabrics in jets with aerodynamic systems. The liquor temperature should not fall below 50° C and a suitable running crease inhibitor should be used in all hot baths.

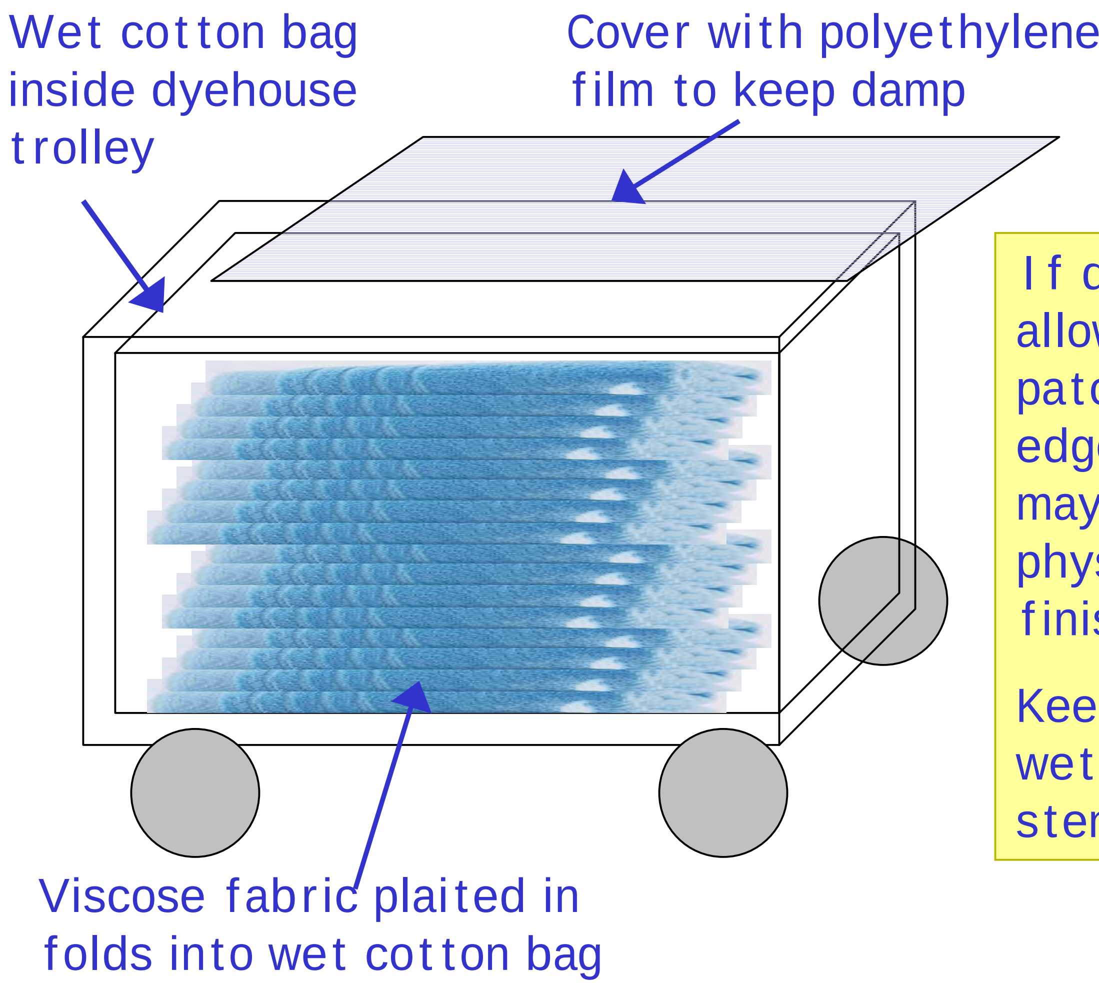
In order to guard against the danger of formation of running creases, the size of the load should not exceed approx. 80% of the maximum load.

Fabric circulation speed should be set to between 80 – 120 seconds.

To prevent abrasion marks, the slippage (difference between winch speed and fabric speed) should be as low as possible.

Neargal LU-SRV (yarn and fabric), **Neargal CS 350** (garments) can be used to increase migration – especially with difficult large molecule dyes.

Dyeing - Fabric

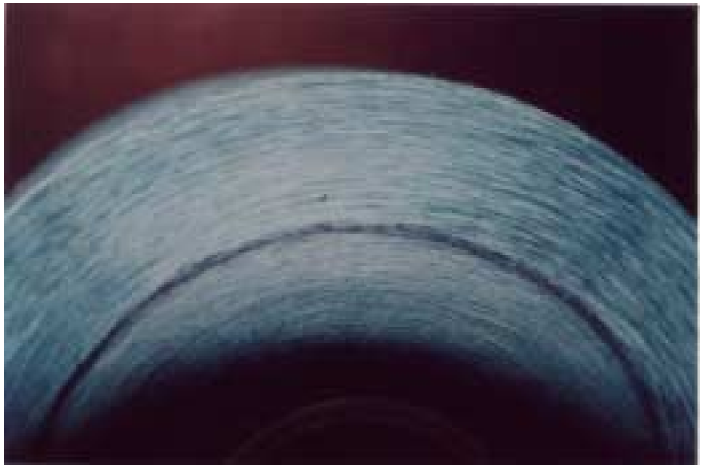


If dyed viscose fabrics are allowed to begin to dry in patches – top of trolley – edges of folds – these areas may be visible as a physical/optical patch after finishing.

Keep fabric thoroughly wetted until drying machine/ stenter is available

Preventing predrying of the fabric is important, but it is far better to ensure that production flows quickly and fabric does not stand wet for a long time.

Dyeing – Yarn & Fabric



Unfixed dye, residual hydrolysed dye, will tend to migrate more in dyed viscose than in cotton. If dyed yarn or fabric is kept standing wet (bottleneck at drying machine), Nearfix RTS will prevent migration

Unfixed yarn left to stand damp for 8 hours before drying

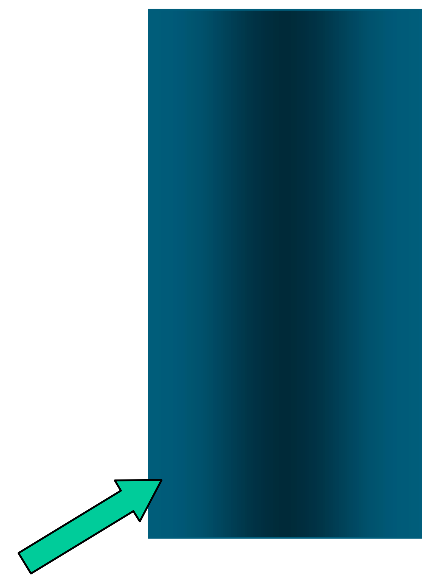
Yarn treated with Nearfix RTS left to stand damp for 8 hours before drying

Dyeing - Summary

- Remove oils and waxes in preparation
- No twists in loading – load machine below capacity
- Sewing – sew more than once – at an angle
- Abrasion – avoid slippage – always run at 50° C or higher
- Cooling creases – cool at 1° C per minute
- Danger of sulphur residues and reduction
- Tension in dyeing machine – problems with shrinkage
- Migration of unfixed dye while waiting for drying
- Fabric drying out in patches – watermarks (physical/optical effect). Keep fabric wet right up to the dryer

Finishing

With viscose/elastane blends, pre-setting is necessary. The dyer could run into creasing problems if attempting to pre scour and dye without setting. If pre-setting greige fabric – beware of temperature variation across the stenter, - temperature variation can have a marked effect on dye pick up on the viscose.



Whether stentering before dye or after dye, where a viscose fabric hangs down heavily at the entry to the stenter, this can result in a gross variation in weight per square metre from the bottom of the sag to the edges near to the pins, especially on a non-support stenter, and this can lead to side-centre-side shade variation. Take cuttings across the piece and determine weight per sq.m.. The results can vary greatly.

Finishing

Viscose fabrics will absorb relatively high amounts of water and will swell to a greater extent than cotton. Fabrics made of viscose show a low level of dimensional stability in their swollen state and a higher propensity to crease than in their dry state.

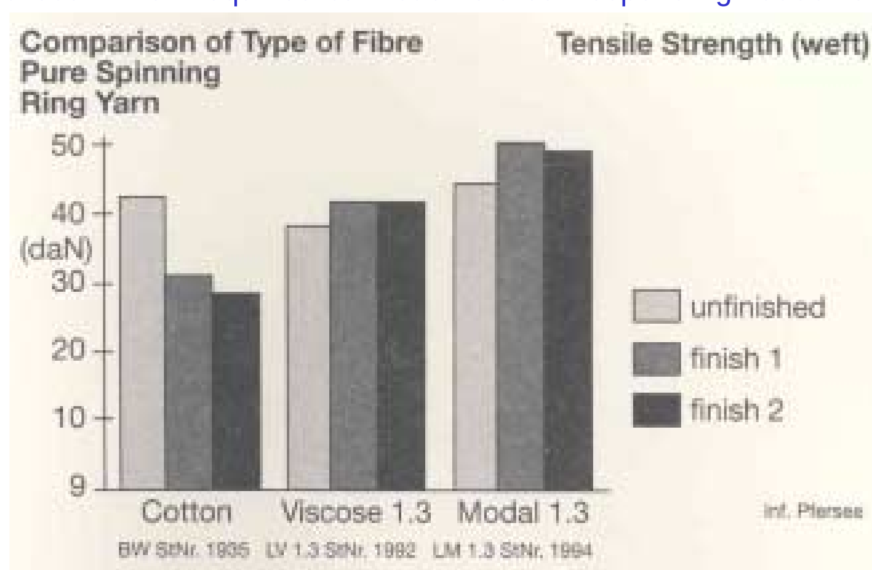
To give woven and knitted viscose dimensional stability and increase the fabric performance values it is beneficial to reduce the swelling capacity of the fibres. This can be achieved through the use of cellulose cross-linkers (low formaldehyde or zero formaldehyde – **NOFELDING FRC, NOFELDING LF**) and additives .

To ensure the efficiency of the cross-linker the fabric should not contain alkali and there should be sufficient time for the cross-linker to diffuse into the fibres and exchange with the swelling water already present.

Similarly, it is important not to dry the padded fabric at too high a temperature in order to prevent migration of the cross-linkers to the fibre or fabric surface. Resin migration leads to a higher surface concentration of the cross-linker which is contrary to the desired effects and can reduce abrasion resistance.

Viscose and Modal require a higher amount of cross-linker for easy-care finishing than cotton fabrics to achieve a comparable effect. The higher amount of cross-linker required can lead to a corresponding reduction in abrasion resistance.

Compared to cotton, articles made of viscose and Modal fibres display much lower losses in tenacity due to cross-linkage. No losses in tenacity result from cross-linking providing the goods are given low-tension treatment in the preceding stages.



Finishing

Examples of resin finishing on Viscose giving dimensional stability and 'bounce'

50 - 60 g/l	Nofelding LF
12 - 14 g/l	$MgCl_2$
0.2 g/l	sodium fluorborate
20 g/l	Nearlube HVS
20 g/l	Nearsopht BC9
0.5 g/l	Nearfil FB NEW

or

0.5 – 1 m/l	acetic acid 60%
50 – 60 g/l	Nofelding FRC
20 g/l	Nearlube HVS
20 g/l	Nearsopht BC9
0.5 g/l	Nearfil FB NEW

Liquor pick-up:	approx 80%
Drying:	110 – 130°C
Curing temperature:	155°C
Curing time:	4 min

Final compressive shrinkage of the fabric for example on a Toptex W or Tubetex leads to better fabric shrinkage values, to an attractive handle variation and visual fabric appeal.