Viscose, Modal and Lyocell (TENCEL®)
## Who’s who in fibers

<table>
<thead>
<tr>
<th>Natural fibers</th>
<th>From natural polymers</th>
<th>From synthetic polymers</th>
<th>From anorganic polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein based</td>
<td>Cellulose based</td>
<td>Cellulose based</td>
<td>Protein based</td>
</tr>
<tr>
<td>Wool</td>
<td>Cotton</td>
<td>Viscose</td>
<td>Polyester</td>
</tr>
<tr>
<td>Silk</td>
<td>Flax</td>
<td>Modal</td>
<td>Polyamide</td>
</tr>
<tr>
<td>Angora</td>
<td>Hemp</td>
<td>Lyocell (TENCEL®)</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>Cashmere</td>
<td>Jute</td>
<td>Cupro</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Acetate</td>
<td>Elastane</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Acrylic</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Polytetrafluor-ethylene</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Carbon</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Glass</td>
</tr>
<tr>
<td>Etc.</td>
<td>Etc.</td>
<td>Etc.</td>
<td>Metal</td>
</tr>
</tbody>
</table>
Man-made cellulose fibers

- combine the natural wearing properties of natural fibers and the advantages of synthetic fibers such as purity, consistent quality etc.
- occupies a middle position between natural and chemical fibers.
How fibers differ?

- fiber production
- fiber properties
- fiber swelling during wet processes
- dimension stability
- stability to certain processing step
- dye uptake, dyeability
Viscose and Modal production process

Chemical solution

- cellulose + NaOH + CS₂ = Xantogenate (derivatization)
- viscose = quick (aggressive) derivatization
- modal = more gentle derivatization
- raw material beechwood
Lyocell (TENCEL®) production process

Wood → Pulp → Fiber production → Fiber

Physical solution
- lyocell (TENCEL®) = without derivatization
- NMMO, N-methyl morpholine N-oxide is an aqueous, non-toxic, biodegradable, organic solvent
- raw material eucalyptus wood

Water
NMMO / water recovery
<table>
<thead>
<tr>
<th>Fiber properties</th>
<th>Viscose (CV)</th>
<th>Modal (CMD)</th>
<th>Lyocell (CLY)</th>
<th>Cotton (CO)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Titer / Length</strong></td>
<td>1.3 dtex / 39 mm</td>
<td>1.3 dtex / 39 mm</td>
<td>1.3 dtex / 38 mm</td>
<td>depends on cotton type</td>
</tr>
<tr>
<td><strong>Tenacity cond. [cN/tex]</strong></td>
<td>25</td>
<td>35</td>
<td>41</td>
<td>30</td>
</tr>
<tr>
<td><strong>Elongation cond. [%]</strong></td>
<td>19</td>
<td>13</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td><strong>Tenacity wet [cN/tex]</strong></td>
<td>11</td>
<td>20</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td><strong>Elongation wet [%]</strong></td>
<td>22</td>
<td>14</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td><strong>Bisfa Modulus [cN/tex] at 5 % elongation</strong></td>
<td>2</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td><strong>Dye uptake</strong></td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Natural moisture content [%] (65 % rel H)</strong></td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td><strong>Polymerisation degree DPv</strong></td>
<td>250 - 300</td>
<td>300 - 600</td>
<td>550 - 600</td>
<td>2000 - 3000</td>
</tr>
</tbody>
</table>

Data according Lenzing AG specification
Distribution of water and swelling data

Fiber **length** increase in water %

- TENCEL®
- Modal
- Viscose

Fiber **diameter** increase in water %

- TENCEL®
- Modal
- Viscose
TENCEL® fiber specialities

Fibrillating man made cellulose fiber
Standard TENCEL®
Surface modification
- clean finish
- peach skin
- wash out / used look effects

Non fibrillating man made cellulose fiber
chemical crosslinked

TENCEL® LF cross linker stable under alkaline conditions
TENCEL® A100 cross linker stable under acid conditions
Recommended blending partner *

<table>
<thead>
<tr>
<th></th>
<th>VISCOSE</th>
<th>MODAL</th>
<th>TENCEL® Standard</th>
<th>TENCEL® LF</th>
<th>TENCEL® A100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Linen</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Silk</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Wool</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Polyamide</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Polyester</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Polyacrylic</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Polyester</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

* If the blending partner needs to be dyed
### Stability to alcaline processing steps

<table>
<thead>
<tr>
<th></th>
<th>6–7 °Bé</th>
<th>12–14 °Bé</th>
<th>26–28 °Bé</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VISCOSE</strong></td>
<td>+ (tension)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>MODAL</strong></td>
<td>+</td>
<td>-</td>
<td>- (only blends with cotton)</td>
</tr>
<tr>
<td><strong>TENCEL® Standard</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>TENCEL® LF</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>TENCEL® A100</strong></td>
<td>+ (70 °C)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
# Fiber specialties – processing

<table>
<thead>
<tr>
<th></th>
<th>VISCOSE</th>
<th>MODAL</th>
<th>TENCEL® Standard</th>
<th>TENCEL® LF</th>
<th>TENCEL® A100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prewash neutral / soda ash 85-90 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bleaching 90 °C</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Bleaching 98 °C / 120 °C</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Neutral reductive bleach</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mercerisation</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>After treatment: neutralize 30 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>After treatment: neutralize 60 °C</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Biopolishing – Cellulases (Enzymes)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Resination (easy care)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

- fiber/fabric tenacity loss
- fiber inhibits enzyme function
- chemical crosslinking systems destroyed
Dye uptake, dyeability

TENCEL® A100  TENCEL® Std.  TENCEL® LF  MODAL  VISCOS
Processing TENCEL® Standard

TENCEL® Standard

woven fabrics, clean skin, open width
Processing TENCEL® Standard woven fabrics, clean skin, open width

- singeing (removing hairiness)
- causticizing / mercerizing
- cold pad batch or pad steam desizing / bleaching
- cold pad batch or pad steam dyeing

Resination MUST DO!

for better:
- crease resistance
- dimension stability
- pilling behaviour
- against fibrillation
Common resin finishing

40 – 60 g/l  PERFIXAN CLY
   (Crosslinking resin with a low content of formaldehyde)

16 – 24 g/l  PERISTAL KSV
   (Catalyst for resin finishing)

20 – 25 g/l  PERISOFT NIS/R
   (Universal softener for all types of fibres)

15 – 20 g/l  PERISOFT MSN
   (High-quality silicone macro emulsion)

- liquor pick up: approx. 70 %
- drying: as usual
- curing: 45 sec at 170 °C or 3 min at 150 °C
Processing TENCEL® Standard woven fabrics, clean skin, open width

Softener selection in case of pilling issues

15 – 20 g/l PERISOFT SML
High-quality silicone micro emulsion

or

15 – 20 g/l PERISOFT HSM NEW
Hydrophilic silicone micro emulsion

or

5 – 20 g/l PERISOFT NANO
Hydrophilic silicone micro emulsion
Processing TENCEL® Standard

TENCEL® Standard

woven fabrics, peach skin, rope
Processing TENCEL® Standard woven fabrics, peach skin, rope

- **Singeing (open width)**
- **Desizing (open width)**
- Recipe depending on kind of size and machinery
Processing TENCEL® Standard woven fabrics, peach skin, rope

**singeing / desizing**

- 90 - 120 g/l NaOH 100 %
  (approx. 12 - 14 °Bé, constant)

**causticizing**

- 3 g/l PERIWET MN NEW

**tensionless fabric guiding**

- liquor pick up: 100 - 110 %
- temperature: 25 - 30 °C
- time of exposure: depending on aggregate 10 - 20 min
- aggregate: padder, beck with rollers, jigger
- rinsing: start hot, neutralise
Processing TENCEL® Standard woven fabrics, peach skin, rope

**singeing / desizing**

- Initial temperature 60 °C
- 0.5 g/l PERLAVIN NIC
- 4.0 g/l PERILAN VF
- 0.4 g/l PERILAN RFC

**causticizing**

- 4.0 g/l soda ash (to be added prediluted via dissolving tank)

**fibrillation (rope)**

- Heat up with 2 °C/min to 95 °C
- Treat 90 min at 95 °C
- Cool down with 2 °C/min to 60 °C
- Rinse hot (approx. 60 °C)
Processing TENCEL® Standard woven fabrics, peach skin, rope

**singeing / desizing**

Initial temperature 55 °C

- 0.5 g/l PERLAVIN NIC
- 4.0 g/l PERILAN VF
- 0.4 g/l PERILAN RFC
- 2.0 g/l PERISTAL E

pH value approx. 4.5 - 5.5

**causticizing**

- Temperature 55 °C
- Treat 60 min at 55 °C
- Enzyme stop by fast temperature increase (2 °C/min) to 85 °C
- Treat 10 min at 85 °C
- Rinse thoroughly hot and warm

**fibrillation (rope)**

**enzymatic defibrillation (rope)**
Processing TENCEL® Standard woven fabrics, peach skin, rope

- **Singeing / Desizing**

- **Causticizing**

- **Fibrillation (rope)**

- **Enzymatic Defibrillation (rope)**

- **Dyeing (rope or pad batch)**

Initial temperature possibly > 50 °C

- 4.0 g/l PERILAN VF
- 0.4 g/l PERILAN RFC
- 1.0 g/l PERIQUEST BSD
- x g/l dyestuff / salt / fixing alkali
- Temperature profile/dosage depending on dyestuff

- Rinse warm, cold

**Soaping:**

- 4.0 g/l PERILAN VF
- 1.0 g/l PERLAVIN SRL

- Treat 15 min at 95 °C
- Rinse hot, warm
Processing TENCEL® Standard woven fabrics, peach skin, rope

- singeing / desizing
- causticizing
- fibrillation (rope)
- enzymatic defibrillation (rope)
- dyeing (rope or pad batch)
- tumbling

Removal of fibre fibrils/further development of the peach skin (if necessary)

- treatment on rope tumbler at approx. 80 °C
- initial speed: approx. 300 m/min
- accelerate up to 800 - 1000 m/min

repeat if necessary
Processing TENCEL® Standard woven fabrics, peach skin, rope

- **singeing / desizing**
- **causticizing**
- **fibrillation (rope)**
- **enzymatic defibrillation (rope)**
- **dyeing (rope or pad batch)**
- **tumbling**
- **resination**

Resin finishing for peach skin fabrics to reduce abrasion of fibrils

- 30 - 40 g/l PERFIXAN CLY
- 16 g/l PERISTAL KSV
- 40 g/l PERIPRET PUS
- 40 g/l PERISOFT ME SPECIAL

- liquor pick up: approx. 70 %
- drying: as usual
- curing: 45 sec at 170 °C or 3 min at 150 °C

If necessary, short repeat of tumbler treatment to obtain maximum softness and volume.
The above indications are based on the latest state of our knowledge. Due to different operational conditions and requirements these are guidelines only. A legally binding assurance cannot be drawn from our indications. Our technical staff will always be at your disposal to support you in testing our auxiliaries and to answer further technical questions.