The Viscose Process – Scope and Limitations

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Lenzing (Austria) 2015

293,000 to pulp
339,000 to wood-based cellulose fibers
Highly efficient use of the raw materials

The Lenzing site is fully integrated. Dissolving wood pulp production at the Lenzing site achieves a wood utilization rate of about 50%.
Development of waste water emissions
Lenzing site

Development of waste water population equivalents (calculated as $\text{BSB}_5 - \text{EW}_{90}$)  
Fiber production in tons/year

- 67,000 TENCEL®

BKE: Vapor condensate extraction facility  
ARA 1: Wastewater treatment plant, 1st expansion stage  
ARA 2: Wastewater treatment plant, 2nd expansion stage


1,500,000 1,200,000 900,000 600,000 300,000 0

1,500,000 1,200,000 900,000 600,000 300,000 0

BKE  ARA 1  ARA 2
Development of emission and odor levels
Lenzing site

- Hydrogen sulfide in tons/day
- Fiber production in tons/year

+ 67,000 TENCEL®
Fiber production sites

Viscose capacity: 773,000 tons/year

Lenzing / AT
272,000 tons/year

Purwakarta / ID
323,000 tons/year

Nanjing / CN
178,000 tons/year

TENCEL® capacity: 222,000 tons/year

Mobile / USA
50,000 tons/year

Grimsby / UK
40,000 tons/year

Heiligenkreuz / AT
65,000 tons/year

Lenzing / AT
67,000 tons/year

1) all capacities as at 31/12/2015
History of man-made fibers

Cellulose nitrate
- 1846 discovered by Karl-Friedrich Schönbein
- 1892 first factory in Besançon (France), (Comte Hilaire de Chardonnet) "Chardonnet silk"

Cuprammonium rayon (Cupro)
- 1857 discovered by Eduard Schweizer
- 1899 first factory for textile yarns in Elberfeld (Germany)

Cellulose acetate (CA)
- 1865 discovered by Paul Schützenberger
- 1921 first factory for CA fibers in Spondon/UK

Cellulose xanthate (CV viscose process)
- 1891 discovered by Cross, Bevan and Beadle
- Since 1910 in industrial scale
- During World War I: development of staple fibers as cotton substitute
- Between 1920 and 1931 strong increase in fiber production: from 14 kt to 225 kt/a
Viscose process – schematic overview
Viscose spinning

wet spinning process
Viscose staple fiber vs. filament

**Staple fibers**
- cut during production
- most common ~40mm
- also long staple & short cut
- nature: cotton & wool
- delivery in bales

**Filaments**
- “endlessly” long fiber
- according to DIN >1000mm
- nature: silk
- wound on bobbins
Modified viscose processes

Modal

- same chemistry
- different viscose composition (lower cellulose content)
- different spinning bath
- other additives
- fibers with higher (wet) strength

Cellulose carbamate

- reaction of cellulose with urea
- same process steps as for viscose
- no salts in spinning bath needed
Viscose type fibers – fiber properties

- Viscose type fibers: viscose, modal, viscose tire cord, viscose filament
- Variation of cellulose DP, CS$_2$-consumption, alkali concentration, spin bath → wide variety of fiber properties

<table>
<thead>
<tr>
<th></th>
<th>titre [d tex]</th>
<th>Tenacity cond. [cN/tex]</th>
<th>Elongation cond. [%]</th>
<th>Tenacity wet [cN/tex]</th>
<th>Elongation wet [%]</th>
<th>BISFA modulus [cN/tex/5%]</th>
<th>modulus cond. [cN/tex/5%]</th>
<th>Commercial/ experimental fibre com.</th>
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<tbody>
<tr>
<td>CV</td>
<td>1,4</td>
<td>23,9</td>
<td>20,1</td>
<td>12,5</td>
<td>22,0</td>
<td>2,4</td>
<td>5,3</td>
<td>com.</td>
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<tr>
<td>CV tyre cord</td>
<td>1,9</td>
<td>52,3</td>
<td>15,1</td>
<td>38,4</td>
<td>22,9</td>
<td>3,1</td>
<td>11,1</td>
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<tr>
<td>CMD</td>
<td>1,3</td>
<td>33,1</td>
<td>13,5</td>
<td>18,4</td>
<td>14,1</td>
<td>5,2</td>
<td>6,3</td>
<td>com.</td>
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Structural differences induced by regeneration (example viscose)

28.5 cN/tex 27 cN/tex 21 cN/tex  
25.04.2017 - 13

60 g/L 100 g/L 160 g/L H₂SO₄

Crystallinity (¹³C-NMR)
56.4% 51.4% 45.1%

Speed of regeneration
## Viscose fibers

**Product overview**

<table>
<thead>
<tr>
<th>Key products</th>
<th>Key applications</th>
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<tbody>
<tr>
<td>Textile fibers</td>
<td>Terry products (towels)</td>
</tr>
<tr>
<td></td>
<td>Underwear</td>
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<tr>
<td></td>
<td>Socks</td>
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<td></td>
<td>Knit material</td>
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<td>Woven and knit garments for fashion trade</td>
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<tr>
<td>Nonwoven fibers</td>
<td>Wipes</td>
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<td></td>
<td>Wound dressings, surgical swabs and components for outer garments for medical surgery</td>
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<td></td>
<td>Tampons in the hygiene segment</td>
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</table>
Viscose fibers
Modifications by incorporation

- Spun-dyeing
  - Reduction of textile processing steps
  - Resistant to light
  - Bright colors
  - High color uniformity

- Functional additives (examples)
  - Silver nano-particles
  - Cationic polymers
  - Phase change materials
  - Flame-resistant materials

Lenzing Modal® COLOR
Fashionable and ecological

Lenzing FR®
Flame-resistant fiber
Viscose fibers
Modified cross section

Examples* from Kelheim Fibres GmbH in Germany:

Flat cross section of Viloft®
Trilobal cross section of Galaxy®
Segmented hollow fiber Bramante
Dante fiber

Modification of water imbibition*
Standard CV ~ 85%
Bramante CV ~ 240%
Dante CV ~ 400%

*taken from Walter Roggenstein, VISCOSE FIBRES WITH NEW FUNCTIONAL QUALITIES, Lenzinger Berichte 89 (2011) 72-77
Viscose type fibers – fiber properties

Wide range of properties – wide range of applications
Global fiber market
Global fiber consumption 2015

Global fiber market

Global fiber consumption 2015

- Wool: 1.2%
- Synthetic fibers: 62.1%
- Cellulose & protein-based fibers: 6.4%
- Cotton: 25.2%
- Other natural fibers: 5.1%

¹ Wood-based and cotton linter-based cellulose fibers

Source: ICAC, CIFRS, TFY, FEB, Lenzing estimates
Wood-based cellulose fiber production (staple)

Lenzing 2015: 339 kt (incl. TENCEL®)

Number of production sites

- World
- Western Europe

Staple fiber production [kt/a]

- World
- Western Europe
- Lenzing (site) *(incl. TENCEL®)*

4618 kt
Summary and outlook

3 Fiber Generations - Viscose, Modal, TENCEL®

The future will bring a mix of all 3 man-made cellulosics with a strong increase in TENCEL®
Thank you for your attention!