On the methods for assessing and the causes of brightness reversion

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Objective

Establishing proper conditions to evaluate brightness reversion of Eucalyptus pulps and determine their relevance to the reversion problem in the industry

Understanding how different pulps and their chemical composition influence the brightness reversion
Brightness reversion

Brightness stability - a prioritized area especially for bleached eucalyptus pulps

External factors of importance:
- light
- heat
- moisture
- chemicals
- air pollution
- exposure time
- pH

Internal factors of importance:
- lignin residuals
- HexA residuals
- carbonyl groups
- carboxyl groups
- metals
- extractives
- other wood components
Brightness reversion

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External factors of importance:
- light
- heat
- moisture
- chemicals
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- exposure time
- pH

Internal factors of importance:
- lignin residuals
- HexA residuals
- carbonyl groups
- carboxyl groups
- metals
- extractives
- other wood components
# Bleached pulp characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Bleaching sequence¹</th>
<th>Bright. % ISO</th>
<th>HexA mmol/kg</th>
<th>Visc. dm³/kg</th>
<th>OX mgCl⁻/kg</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>ECF D</td>
<td>90.8</td>
<td>6.2</td>
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¹ Eucalyptus, Birch, Acacia
## Bleached pulp characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Bleaching sequence&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Glucose (%)</th>
<th>Xylose (%)</th>
<th>Extractives (DCM) (%)</th>
<th>Carboxyls meq/100g</th>
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<tbody>
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<td>13.7</td>
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<sup>1</sup> Bleaching sequence: ECF = Environmentally Friendly Chlorine Free, D = Double, P = Peroxide, TCF = Totally Chlorine Free.
Carboxylic groups vs HexA

Before aging

R² = 0.7381

Carboxylic groups meq/100g vs Initial HexA mmol/kg

Acacia pulp
Aging methods

(I) 105°C for 4 h and ~0% relative humidity (RH),
(II) 70°C for 64 h and 10% pulp moisture content,
(III) 45°C for 720, 1080, 1440 h and 50% RH,
(IV) 30°C for 720, 1080, 1440 h and 50% RH,
(V) 45°C for 720, 1080, 1440 h and 90% RH,
(VI) 30°C for 720, 1080, 1440 h and 90% RH.

TAPPI handsheets at pH 4.5 and 8
Results

(I) 105°C for 4 h and ~0% relative humidity (RH),
Brightness reversion at condition I

105°C 4h 0% RH

Brightness reversion, %ISO

Pulp No

pH 4.5
pH 8

AkzoNobel eka
Brightness reversion vs HexA

105°C 4h 0% RH

Brightness reversion, %ISO

Aging condition (l)

R^2 = 0.9251
R^2 = 0.7106

HexA mmol/kg

pH 4.5
pH 8

HexA mmol/kg

AkzoNobel eka
Brightness reversion vs HexA

105°C 4h 0% RH

PC number (457) nm vs HexA mmol/kg

- pH 4.5
- pH 8

R² = 0.946
R² = 0.78
Brightness reversion vs HexA

105°C 4h 0% RH

PC number (457nm)

Aging condition (l)

Reacted HexA (mmol/kg)

TCF

- pH 4.5
- pH 8.0
Results

(II) 70°C for 64 h and 10% pulp moisture content,
PC number vs reacted HexA

70°C 64h

PC number, (457 nm)

Reacted HexA (mmol/kg)

Aging condition (II)

R² = 0.9568

- pH 4.5
- pH 8.0
Reacted HexA vs viscosity loss

70°C 64h

R^2 = 0.7028

Viscosity loss, dm^3/kg

Reacted HexA, mmol/kg

Aging condition (II)

pH 4.5

pH 8.0
PC number vs OCl in pulp

70°C 64h

\[ R^2 = 0.4387 \]

PC number (457 Nm)

OCl, ppm

Aging condition II

ECF Eucalyptus

pH 4.5
PC number vs delta carboxylic groups

70°C 64h

PC number (457 nm)

R² = 0.8505

Aging condition (II)

-5 -4 -3 -2 -1 0 1 2 3 4 5

delta carboxylic groups (meq/100g)

pH 4.5

pH 8.0

-5 -4 -3 -2 -1 0 1 2 3 4 5

delta carboxylic groups (meq/100g)
Ageing methods

(III) 45°C for 720, 1080, 1440h and 50% RH,
(IV) 30°C for 720, 1080, 1440 h and 50% RH,
(V) 45°C for 720, 1080, 1440 h and 90% RH,
(VI) 30°C for 720, 1080, 1440 h and 90% RH.

TAPPI handsheets at pH 4.5 and 8
Sheet moisture
at different relative humidity and temperature

Sheet moisture, %

Relative humidity, %

- 30°C
- 45°C
- 60°C
PC number vs aging time

Pulp No 4

PC number (457 nm)

- Aging condition (III) pH:4.5
- Aging condition (IV) pH:4.5
- Aging condition (V) pH:4.5
- Aging condition (VI) pH:4.5

Aging time (hours)

90% RH
50% RH
PC number vs aging time
Pulp No 4

PC number (457 nm)

- Aging condition (III) pH:8
- Aging condition (IV) pH:8
- Aging condition (V) pH:8
- Aging condition (VI) pH:8

Aging time (hours)
Brightness reversion vs viscosity

30°C 50% RH, pH 4.5

Brightness reversion vs Viscosity, dm$^3$/kg

R$^2 = 0.9764$
R$^2 = 0.8877$
R$^2 = 0.986$

Aging condition (III)

Pulp 4
Pulp 3
Pulp 2
Comparison and ranking between different methods

ECF P Eucalyptus pulps pH 4.5

<table>
<thead>
<tr>
<th>Method (PC number)</th>
<th>(I)</th>
<th>(II)</th>
<th>(III)</th>
<th>(IV)</th>
<th>(V)</th>
<th>(VI)</th>
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<td>(PC number)</td>
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</table>
Brightness reversion at condition (I)

Different pre-treatment of the handsheets

Brightness reversion, %ISO

- **Pulp 2**
  - pH 4.5
  - pH 8

- **Pulp 6**
  - pH 4.5
  - pH 8

<table>
<thead>
<tr>
<th>pH</th>
<th>Normal treatment</th>
<th>Dried</th>
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<td>4.5</td>
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<td>4.5</td>
<td></td>
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<tr>
<td>8</td>
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</tr>
</tbody>
</table>

**Legend**:
- Normal treatment
- Dried
Conclusions

• The method (dry, wet, high/low RH, high/low temperature, short/long time) has in most cases no effect on overall brightness reversion trends but significantly influences the absolute reversion values.

• Dry and wet heat-induced brightness reversion correlates positively and significantly with pulp hexenuronic acid content.

• Pulps produced by TCF and ECF bleaching sequences with low charge of chlorine dioxide are more prone to reversion than regular ECF pulps.
Conclusions

- Brightness reversion causes a decrease in pulp kappa number, HexA and viscosity values, especially for aging at pH 4.5.
- Pulp carboxyl group content decreases during humid aging at high brightness reversion.
- Pulp brightness stability is substantially improved by raising pulp slurry pH from 4.5 to 8.0.
- Pulp organically bound chlorine content has no significant effect on the extent of reversion.
Conclusions

- Relative humidity in the range of 50-90% influence reversion much more strongly than temperature in the interval 30-45°C.
- Hand sheet moisture content decreases from 9.9 to 8.5% by raising surrounding temperature from 30 to 45°C at 50% RH, and increases from 9.9% to 17.8% by increasing RH from 50 to 90% at 30°C.
Beatability

- Aging of pulp decreases the carboxylic group content at pH 4.5 at sheetforming
- High content of carboxylic groups (and HexA) increase the beatability of bleached pulps
- The PFI revolutions needed to reach the same °SR and tensile index, consequently increase
Beatability

- SR°- number
- Tensile index, Nm/g

Graphs showing the comparison between unaged and aged samples for both SR°- number and Tensile index, Nm/g, plotted against PFI revolutions.