Starch Developments for the Surface Treatment of Paper

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55th Starch Convention
Detmold, April 22, 2004
Global Raw Material Input in Papermaking
(2003: approx. 320 mio. t)

- pigments: 9.0%
- starch: 1.7%
- cellulose/gw: 48.0%
- waste paper: 40.0%
- other chemicals: 1.3%
Starch Applications in Papermaking

(2000: Europe approx. 1.7 mio t)
Function of Surface Starch

**Dry strength properties**
- CMT
- SCT
- burst
- tear strength
- etc.

**Paper surface properties**
- dusting
- pick resistance
- printability
- etc.

**Carrier for surface additives**
- hydrophobing/
- lipophobing
- agents
- OBA
- pigments
- etc.

**Other paper and water properties**
- porosity
- COD
- etc.
Superficial Starch Application Systems

Two Roll Pond „Size Press“
- flooded nip with starch solution
- direkt starch absorption of the paper

Premetered Film Size Press „Film Press“
- premetering system
- transfer of a starch film on the paper
Starch Penetration in Paper and Board

Coated board, 500 g/m²

Inkjet paper, 80 g/m²
Factors influencing Starch Penetration

<table>
<thead>
<tr>
<th>Starch parameter</th>
<th>Change</th>
<th>Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Viscosity</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Temperature</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Starch e. g. modification, molecular weight distr.</td>
<td>↑</td>
<td>↓↑</td>
</tr>
</tbody>
</table>

↑: increasing  ↓: decreasing
Surface Starches: Products

<table>
<thead>
<tr>
<th>non degraded</th>
<th>degraded</th>
<th>degraded + modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>conversion in the mill</td>
<td>ready made products</td>
<td>ready made products</td>
</tr>
<tr>
<td>-native starches</td>
<td>-oxidized (NaOCl, H₂O₂)</td>
<td>-single modification ethers/esters</td>
</tr>
<tr>
<td>-modificates</td>
<td>-hydrolysed (acid)</td>
<td>-multiple modification combination of ethers/esters</td>
</tr>
<tr>
<td>-starches with conversion agent</td>
<td>-thermally treated (dextrins)</td>
<td></td>
</tr>
</tbody>
</table>

Potato, Tapioca, Corn, Wheat
Single Modified Surface Starches: Hydroxypropylation (HP)

**HP Starches**
- high viscostability
- flexible film
- transparent film

**Preferred application**
- low porosity papers
- barrier layers
- high starch visco-stability demands
Single Modified Surface Starches: Cationization

**Principle**
- charge interactions: reduce starch penetration
- cationic starch film: can interact with anionic substances

→ on paper surface (e.g. ink)
→ after recycling (e.g. remains on fibres)

**Products**
- low cationicity: DS 0.015-0.025
- high compatibility with anionic size press additives

**Main benefits**
- inkjet printability
  - wicking
  - bleeding
  - color density
- surface strength
  - dry pick
  - dusting
- water quality
  - COD
Single Modified Surface Starches: Cationization

Cationized Starches

Cationicity influencing inkjet printability
- bleeding
- wicking
- mottling
- optical density

native starch, ca. 2 g/m²
cat. starch, ca. 2 g/m²
Double Modified Surface Starches: HP + Cationization

Extra stability enables:
- high storage conc.
- high liquor conc.
- low liquor temp.

Preferred application:
- specialty
- multipurpose office
- inkjet papers
### AP/HA Starches: Effect of Amylose/Amylopectin

<table>
<thead>
<tr>
<th>HA corn/potato</th>
<th>potato/tapioca/corn/wheat</th>
<th>WM, AP potato</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 % AP/70 % AM</td>
<td>80-75 % AP/20-25 % AM</td>
<td>100 % AP</td>
</tr>
</tbody>
</table>

**Effect on starch**

- low molecular weight: high
- low viscostability: high

**Expected effect conc. paper treatment**

- high starch penetration: low
- good film formation: bad
- good barrier properties: bad
- low paper strength: high
AP/HA Starches: Molecular Weight after Degradation

MW (average, mio g/mole)

Viscosity (mPas, 8%, 50°C)

<table>
<thead>
<tr>
<th></th>
<th>MW (average)</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP POT</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>POT</td>
<td>3.1</td>
<td>0.2</td>
</tr>
<tr>
<td>HA POT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Detmold 2004
AP/HA Starches: Paper Strength Development

<table>
<thead>
<tr>
<th>Starch</th>
<th>Paper Strength Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP POT</td>
<td>e. g. dry pick,</td>
</tr>
<tr>
<td>POT</td>
<td>surface abrasion,</td>
</tr>
<tr>
<td>HA POT</td>
<td>tear strength</td>
</tr>
<tr>
<td></td>
<td>no significant difference!</td>
</tr>
</tbody>
</table>
AP Starches: Viscostability of oxidized Starch

Viscosity [Brookfield, mPas]

- Emox POT
- Emox AP POT

Storage time (30% conc., 40 °C)
HA Starches: Barrier Properties (e. g. Air Permeability)

Air permeability (Gurley, s/300 ml)

- Base paper: 9
- AP POT: 19
- POT: 21
- HA POT: 48