Applications of FiberLean microfibrillated cellulose in and out of the paper industry

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FiberLean microfibrillated cellulose – what is it?

- Simple wet media grinding process reduces cellulose paper pulp fibres to microfibrils
- Product has fibrils and fibre fragments over a wide range of length scales
- Fibres are mixed with micron-sized mineral particles to aid separation of fibrils
FiberLean microfibrillated cellulose – microstructure and properties

- Finest microfibrils form networks around mineral particles
- Very high surface area available for bonding and interaction
- Entangled fibrils can generate high viscosity in suspension
- Drying from water draws fibrils together to form strong bonds
- Dried and bonded fibrils are resistant to wetting and dispersion
FiberLean production for paper applications

- Satellite plant located at paper mill (3 operational)
- Pulp received, processed and delivered at low solids (<4% cellulose in water)
- Product fed direct to papermaking process (no dewatering or drying required)
Rheological properties of FiberLean mfc

- Entangled fibril networks
- High low-shear viscosity at low solid concentration (<2%)
- High yield stress
- Very shear-thinning – approaches water viscosity at > $10^4$ s$^{-1}$
- Can be sprayed or jetted at high speed

*HEC = hydroxyethyl cellulose
FiberLean in papermaking

Papermachine schematic
Paper structure, fillers and mfc

Filled paper with Mfc
Optimisation of filler content

- Excess opacity and strength
- Excess strength, insufficient opacity
- Excess opacity, insufficient strength
- Insufficient strength and opacity

Sheet weight / unit area (gsm) vs. Mineral content / %
Property Changes with mfc and filler increase

- Tensile Index
- Tear Index
- Density
- Porosity (Air Permeability)
- Opacity
- Tensile Energy Absorption
- Scott Bond (Z direction tensile)

20% filler, No MFC
30% filler, 3% MFC
Paperboard grades

Corrugated board

‘White Top’

Folding Boxboard

- Packaging grades are multilayer structures because they need to be resistant to bending
- Filler is used only in the surface layers for optical and printing properties
- Layers are formed individually and pressed together when wet – web is only placed in tension afterwards
Paperboard stiffness

- Bending a sheet of material causes stretching of the outer surface and compression of the inner surface.
- At small deformations, resistance to stretching and compression must be equal.
- Resistance to bending – bending stiffness – is therefore directly related to the elastic modulus of the material.

- Modulus \( (E) = \frac{\text{Force}}{(\text{x-section area} \times \text{strain})} \)
- For paper, x-section area depends on pressing and calendering, so instead we define tensile stiffness index (TSI): 
  \[ \text{TSI} = \frac{\text{Force}}{(\text{width} \times \text{gsm} \times \text{strain})} \]
- TSI is not very sensitive to pressing or calendering.

For a single layer, bending stiffness is 
\[ \frac{(E \times \text{thickness}^3)}{12} \]
\[ = \frac{(\text{TSI} \times \text{gsm} \times \text{thickness}^2)}{12} \]

*Stiffness is very sensitive to thickness*
Addition of mfc allows filler increase and weight reduction without loss of tensile stiffness.
FiberLean mfc in boxboard – full scale example

Improved brightness, constant stiffness, lower cost

![Graph showing improved brightness and constant stiffness with FiberLean mfc in boxboard](image-url)
Coating FiberLean mfc at the ‘wet end’

Alternative method for making white top paperboard

Increased drainage time, rougher base

Decreased drainage time, smoother base
Coating FiberLean mfc at the ‘wet end’

Coating onto wet, rough base at 500 m/min

Coating from 500 m/min trial

High quality print on low speed coated base
Using FiberLean MFC as a precoat for barrier coatings

- Food packaging needs water and/or oxygen vapour barrier
- Aim to replace laminated polyethylene layers with water-based latex barrier coatings
- Recyclable, repulpable, reduction in plastic content
- Current paperboard products are too rough to allow defect-free coatings
- Mfc applied by wet end technique provides enhanced smooth surface
## Porosity and Barrier properties

<table>
<thead>
<tr>
<th>Sample Details</th>
<th>Base Paper</th>
<th>Base paper + MFC Layer</th>
<th>Base Paper + barrier coating</th>
<th>Base Layer + MFC + barrier coating</th>
<th>Plastic Coated Freezer Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Layer g/m²</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>Unknown</td>
</tr>
<tr>
<td>MFC Layer g/m²</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Coating Layer g/m²</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>COBB (Water penetration) g/m²</td>
<td>50</td>
<td>58</td>
<td>46</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Solvent resistance (1=lowest, 16=highest)</td>
<td>&lt;1</td>
<td>16</td>
<td>3</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Water Vapour Transmission (38C, 95% RH) g/m² day⁻¹</td>
<td>1031</td>
<td>992</td>
<td>351</td>
<td>23</td>
<td>45.4</td>
</tr>
</tbody>
</table>
Using MFC as a thickener in decorative paint

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
<th>Weight% in dry film</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiO₂</td>
<td>White pigment</td>
<td>19%</td>
</tr>
<tr>
<td>Kaolin/talc</td>
<td>Mineral extender</td>
<td>30%</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Mineral extender</td>
<td>35%</td>
</tr>
<tr>
<td>PVA latex</td>
<td>Binder</td>
<td>14%</td>
</tr>
<tr>
<td>HEC/MFC</td>
<td>Thickener</td>
<td>0.75%</td>
</tr>
<tr>
<td>Others</td>
<td>Additives</td>
<td>1.25%</td>
</tr>
</tbody>
</table>

| Pigment Volume Fraction | 66% |
| Wt% solids             | 52% |

HEC (hydroxyethyl cellulose)  
FiberLean MFC
Dry film properties with MFC – illustrative example

- **Higher Opacity**
- **Replacing HEC with MFC**
- **Lower Gloss**

### Paint light scattering

- % replacement of HEC with MFC vs. $s$ coefficient / mm$^{-1}$

### Paint gloss 85°

- % replacement of HEC by MFC vs. Gloss / %

### % weight loss after 200 cycles

<table>
<thead>
<tr>
<th></th>
<th>100% HEC</th>
<th>50% HEC / 50% MFC</th>
<th>100% MFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>% weight loss</td>
<td>35%</td>
<td>30%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Spinning fibres from suspensions of FiberLean Mfc

• Fibre Spinning by hand from syringe with hypodermic needle

- Narrow needles and low solids make stronger fibres – fibril alignment
Thank-you for your attention