The Use of Microfibrillated Cellulose in Barrier Coating Applications

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Introduction

• Microfibrillated cellulose (MFC) is well established as an additive in graphic papers
  • Increased wet web, tensile and Z direction strength
  • Increased filler content
  • Improved smoothness, formation and filler retention
  • Reduced porosity

• Packaging grades present new challenges
  • Bending stiffness and delamination resistance
  • Water-intensive printing methods (flexography and ink-jet)
  • Replacement of plastics / laminates
  • Waterbased barrier coatings
FiberLean process for MFC manufacture

Pulp

Mineral

FiberLean Mineral/MFC composite
Impact of MFC on Graphical paper physical properties

- In current applications, MFC is added as a filler.
- It is possible to increase filler content by 10% or more and suffer no strength loss.
- Wet web strength is also increased – typically by more than dry strength.
- MFC increases fibre bonding and fills voids in sheet – rapid decrease in permeability.

Lab study: Messmer recirculating hand sheets (12 sheets) 70% Eucalyptus, 30% NBSK, 550 CSF, Intracarb 60 filler.
Impact of MFC on coating holdout

- Reduction in permeability and pore size improves holdout of coating components on surface

- Benefits in graphical papers
  - Reduced Coatweight
  - Improved Gloss
  - Improved printing properties

- Benefits for barrier coatings
  - Reduced Coatweight
  - Reduced permeability (improved barrier)
  - Elimination of precoat

Pilotmachine basepaper, Helicoater (short dwell) 500 m min⁻¹: 80 gsm base 70% Eucalyptus, 30% NBSK, 450 CSF, 20% GCC filler. 10gsm coating of Kaolin/GCC 10pph latex
Coating MFC at the wet end

- MFC holds too much water for conventional coating.
- ..but it can be applied at the wet end near the wet line.
- Dewatering is achievable with existing elements – vacuum boxes, presses and dryers.
- MFC immobilises rapidly and keeps coating on surface.

Increased drainage time, rougher base

Decreased drainage time, smoother base

100µm
Properties of wet-end coated sheets

Pilot coated papers: 100 gsm base (100% Unbleached long fibre Kraft). Coatings of 50/50 MFC/GCC and 20/80 MFC/GCC. Speed ~25 m min⁻¹

Porosity and smoothness – 50% MFC/50% GCC* coatings

Brightness – all coatings

*GCC = Ground Calcium Carbonate
MFC as a precoat for barrier applications – lab studies

- Form Base on Rapid Köthen Sheetformer
- Roll Couch
- Wet Press on British Handsheet Former
- Transfer to vacuum sheetformer
- Filter MFC suspension through sheet
- Press and dry
- Apply barrier coating
MFC coatings as barrier substrates

Base Paper

Base paper + MFC Layer

Base Layer + MFC + barrier coating

Base Paper + barrier coating
Surfaces of lab coated papers

- Optical images taken at boundaries between base, mfc layer and coating
- Relative height of surface measured with LaserScape profiler
## Barrier properties of lab coated papers

<table>
<thead>
<tr>
<th></th>
<th>Base Layer</th>
<th>Base Layer /w MFC Layer</th>
<th>Base Layer /w Barrier coating</th>
<th>Base Layer /w MFC Layer &amp; Barrier coating</th>
<th>Plastic Coated Freezer Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Basis Weight</td>
<td>32 g/m²</td>
<td>41 g/m²</td>
<td>46 g/m²</td>
<td>52 g/m²</td>
<td>65 g/m²</td>
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<tr>
<td>Estimated MFC Layer Basis Weight</td>
<td>0 g/m²</td>
<td>9 g/m²</td>
<td>0 g/m²</td>
<td>9 g/m²</td>
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<tr>
<td>Estimated Coat Weight</td>
<td>0 g/m²</td>
<td>0 g/m²</td>
<td>14 g/m²</td>
<td>12 g/m²</td>
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<tr>
<td>Bendtsen Porosity</td>
<td>5462 ml/min</td>
<td>0 ml/min</td>
<td>4 ml/min</td>
<td>0 ml/min</td>
<td>0 ml/min</td>
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<tr>
<td>COBB 60 (water absorption, 60 seconds)</td>
<td>50 g/m²</td>
<td>58 g/m²</td>
<td>46 g/m²</td>
<td>1 g/m²</td>
<td>0.8 g/m²</td>
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<tr>
<td>KIT Test (Oil Resistance, 16=best, 1=worst)</td>
<td>&lt;1</td>
<td>16</td>
<td>3</td>
<td>16</td>
<td>16</td>
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<tr>
<td>Moisture Vapour Transmission Rate (MVTR) 23°C 50% RH</td>
<td>272 g/m² day⁻¹</td>
<td>239 g/m² day⁻¹</td>
<td>104 g/m² day⁻¹</td>
<td>5 g/m² day⁻¹</td>
<td>14.4 g/m² day⁻¹</td>
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<tr>
<td>MVTR 38°C 90% RH</td>
<td>1031 g/m² day⁻¹</td>
<td>992 g/m² day⁻¹</td>
<td>351 g/m² day⁻¹</td>
<td>23 g/m² day⁻¹</td>
<td>45 g/m² day⁻¹</td>
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</tbody>
</table>
Pilot 50:50 MFC-mineral coated papers

**Table:**

<table>
<thead>
<tr>
<th></th>
<th>Base Layer</th>
<th>Base + MFC/CaCO₃</th>
<th>Base + MFC/CaCO₃</th>
<th>Base + MFC/CaCO₃</th>
<th>Base + barrier</th>
<th>Base + MFC/CaCO₃ + barrier</th>
<th>Base + MFC/CaCO₃ + barrier</th>
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</thead>
<tbody>
<tr>
<td><strong>Total Grammage</strong></td>
<td>g/m²</td>
<td></td>
<td></td>
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<td>84</td>
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<td>91</td>
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<tr>
<td><strong>Estimated Basis Weight from Base Layer</strong></td>
<td>g/m²</td>
<td>72</td>
<td>72</td>
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<td>72</td>
<td>72</td>
<td>72</td>
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<tr>
<td><strong>Estimated MFC/Mineral Layer Basis Weight</strong></td>
<td>g/m²</td>
<td>-</td>
<td>6</td>
<td>12</td>
<td>15</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td><strong>Estimated Barrier Coat Weight</strong></td>
<td>g/m²</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>10</td>
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<tr>
<td><strong>Bendtsen Porosity</strong></td>
<td>ml/min</td>
<td>1000</td>
<td>210</td>
<td>45</td>
<td>23</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td><strong>Moisture Vapour Transmission 23°C 50% RH</strong></td>
<td>g/m² day⁻¹</td>
<td>273</td>
<td>265</td>
<td>263</td>
<td>262</td>
<td>166</td>
<td>99</td>
</tr>
</tbody>
</table>

Pilot coated papers: 72 gsm base (Bleached Kraft 80/20 hardwood/softwood). Coating of 50% MFC/50% CaCO₃ Speed ~25 m min⁻¹
Pilot coated papers – calculated barrier coating permeability vs. MFC layer Coat Weight
Coating MFC at high speed

Many Challenges!

- Viscosity vs. Shear Rate
- Permeability & Drainage
- Coating strength vs. solids
- Coating Elongation

8.5% solids, 20% MFC/80% GCC coating – 500 m/min
Rheology of MFC suspensions
Viscosity and consolidation

20% MFC/80% GCC suspensions – viscosity vs. shear rate
Cup and Bob geometry

Elastic modulus (LVE region) vs. solids content

Typical Elastic modulus vs. strain – oscillation 1Hz
Parallel Plate geometry
Permeability and drainage of MFC suspensions

• Permeability of vacuum-dewatered suspensions determined by simple filtration experiments

• Permeability is independent of layer thickness and starting solids content

• Drainage time required on machine can be estimated

• Dwell time over vacuum boxes –
  • 20cm wide box @20 m/min – 0.6s
  • 50cm wide box @500 m/min – 0.06s
Visualisation of high speed coating

• Short exposure photography at point of application

• MFC/mineral suspension forms contour coating onto extremely rough wet base

• Coating remains on surface despite lack of base consolidation
Conclusions

• MFC is well established as a wet end additive
  • Increased strength and/or filler content
  • Reduced porosity
  • Improved coating holdout

• Wet end coating of MFC for barrier applications is very promising
  • Smooth, non-porous surface for further coating
  • Excellent oil and grease resistance

• High speed applications are developing quickly
Thank you