Microfibrillated Cellulose for Next Generation Sustainable Packaging

Tom Larson, Robyn Hill, David Skuse
FiberLean Technologies Ltd

FiberLean® Technologies

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Introduction

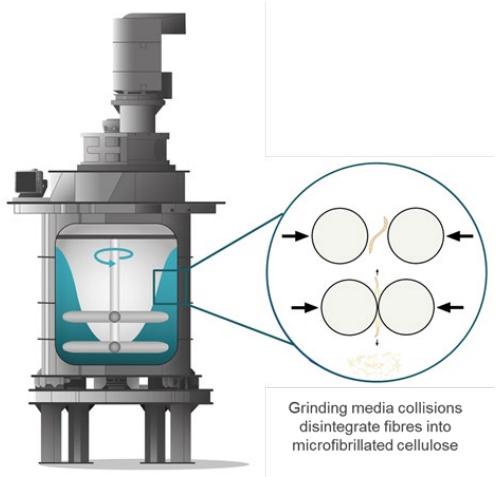
- Microfibrillated Cellulose (MFC) – produced by mechanical treatment of cellulose
- Highly viscous suspension in water
- Typically 1-2% solids content
- Satellite production adjacent to final use location
- Produced using stirred media mills

Product families

- MFC from 100% virgin pulp
- MFC from recycled fibres
- MFC mineral composites

- NB Two of these families have no added minerals. MFC only

Stirred Media Mills



Stirred vessel containing small grinding media beads, which are agitated by an impeller

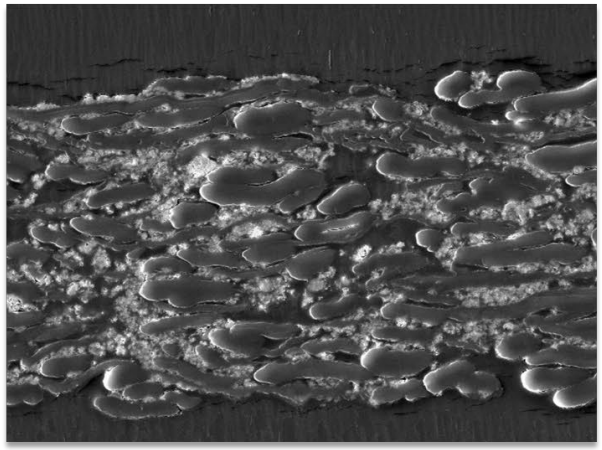
- Grinding media collide with each other, breaking and fibrillating fibres that are caught in the interstices
- High media surface area enhances fibrillation
- Highly tuneable -> highly fibrillated network structure with optimised structure for target application

Advantages

- No close tolerances or precision engineered components
- Robust proven technology
- Continuous single stage process
- Availability > 95%
- Low Capex and Opex
- High throughput
- Small footprint
- Modular easily-scalable design
- No additives or pre-treatments

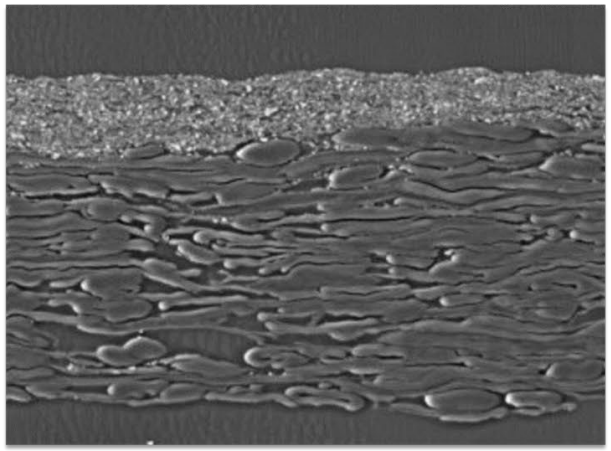
MFC applications in paper and board

In the sheet…
"Internal application"



- MFC is mixed into the pulp stock to provide increased web bonding.

On the sheet…
"Surface application"



- MFC is coated onto the surface to improve barrier properties.
- Or where MFC is used as the sole binder for a mineral coating.

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MFC applications in paper and board

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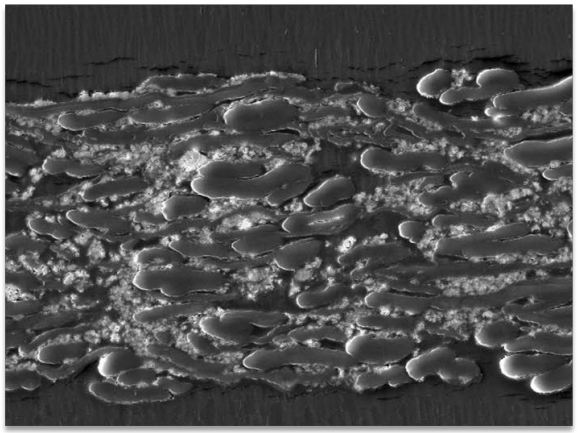

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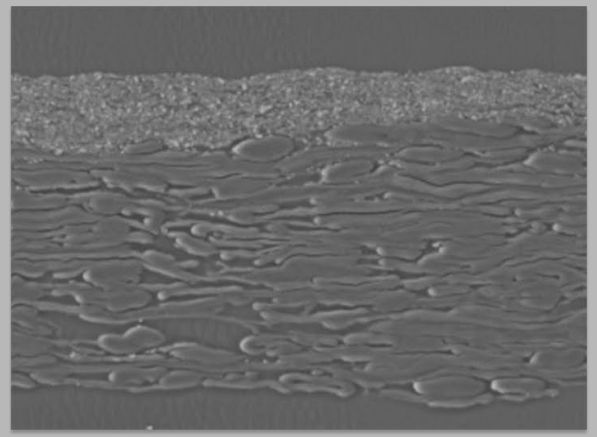

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Add MFC into the base paper furnish "**Internal Application**":

IMPROVE PROPERTIES

- Increase web strength (wet & dry).
- Porosity control & coating hold-out.
- Improve stiffness.
- Improve fold-cracking resistance.
- Improve print quality.

REDUCE RAW MATERIAL COSTS

- Replace fibre with filler.
- Reduce Softwood consumption.
- Light weighting / dematerialization.
- Reduce chemical consumption.
- Reduce starch dependency.

GAIN EFFICIENCY

- Reduce web breaks.
- Improve retention.
- Increase machine speed.
- Reduce steam consumption.
- Reduce refining energy.

IMPROVE SUSTAINABILITY

- Improve quality of recycled feedstocks.
- Use more recycled material.
- MFC is: Recyclable, repulpable, biodegradable and compostable.


Container board


White Top Liner


Coated recycled board


Folding box board


Copy / uncoated paper


Specialty papers


Coated paper


Tissue


3D Moulded Fibre

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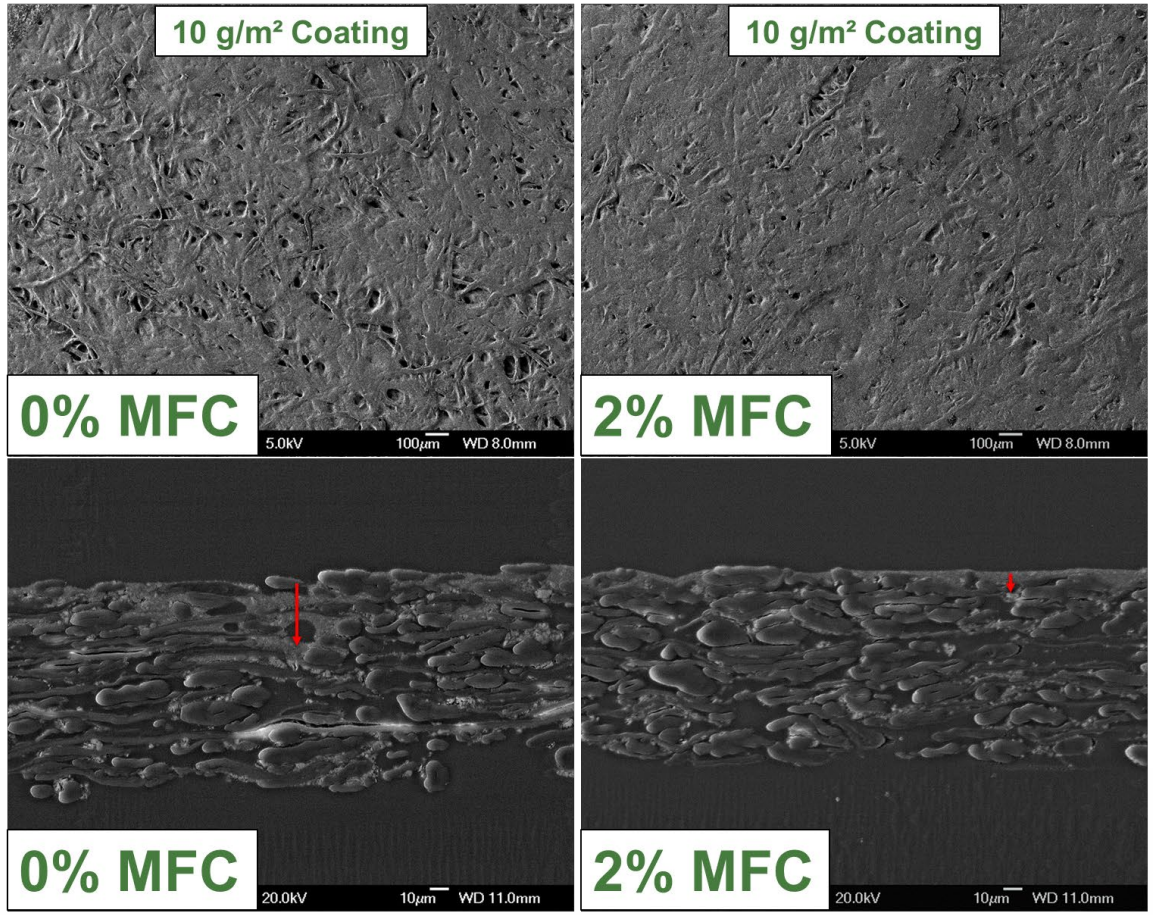

MFC in Base Paper	Base Paper Porosity (Bendtsen, ml/min)	Base Paper Porosity (Gurley, Sec/100 ml)
0%	2633	4
2%	1591	7

- Less coating penetration when using MFC due to smoother and more closed surface structure of the base.
  - Equivalent properties at lower coat weights when using MFC.
    - Typically, for every 1% MFC, coat weight can be reduced by up to 10-15%.
  - Improved properties at equal coat weight (added value).
- **Applications: Graphic, barrier & specialty.**

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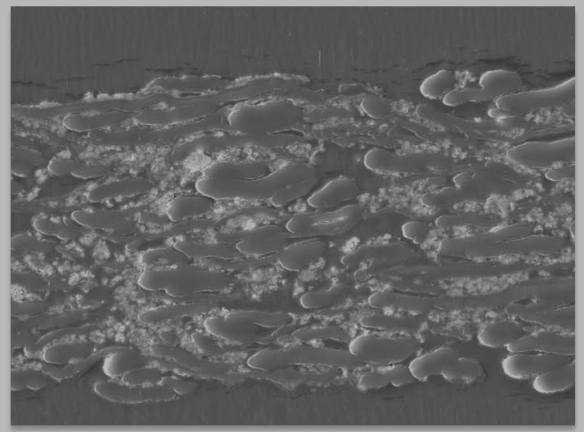

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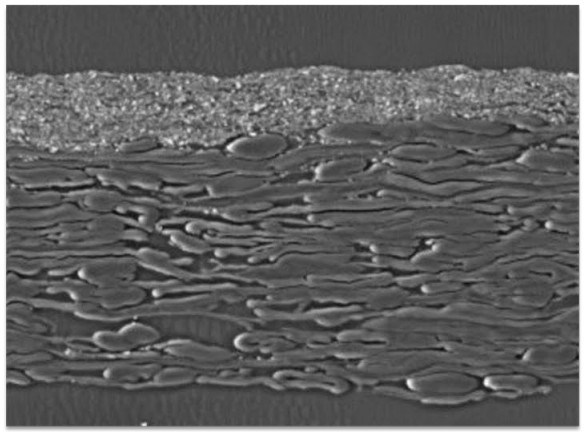

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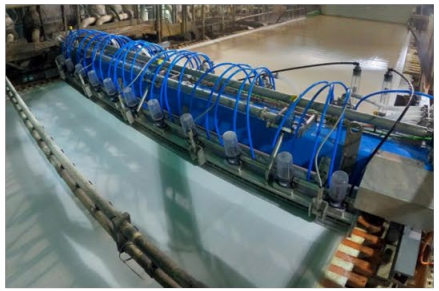

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MFC applied at the paper machine wet end:

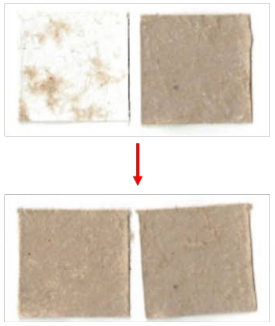
- Drain, press and dry using existing paper machine equipment.
- Low CapEx requirement.
- Convert existing production lines to new grades.
- 2-layer sheet functionality achieved with 1 forming section and no coaters.
- Patented technology.

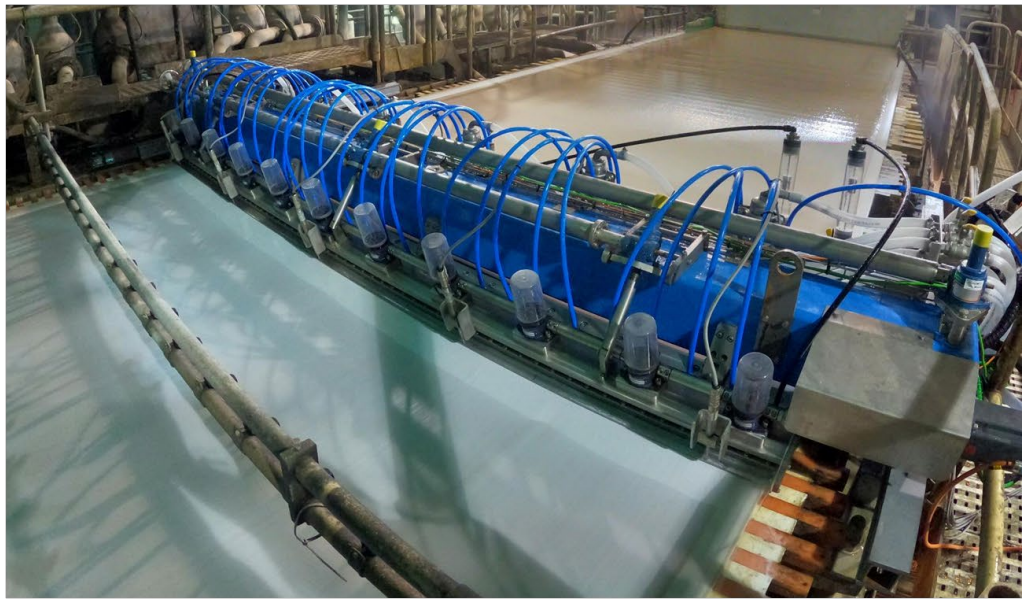
Multiple application uses:

White Top Liner

Barrier

Interlayer Bonding





Commercial-scale application of MFC:

3 m wide paper machine operating at 500 m/min.

3 m wide applicator available now for trials

4.5 m wide applicator under construction

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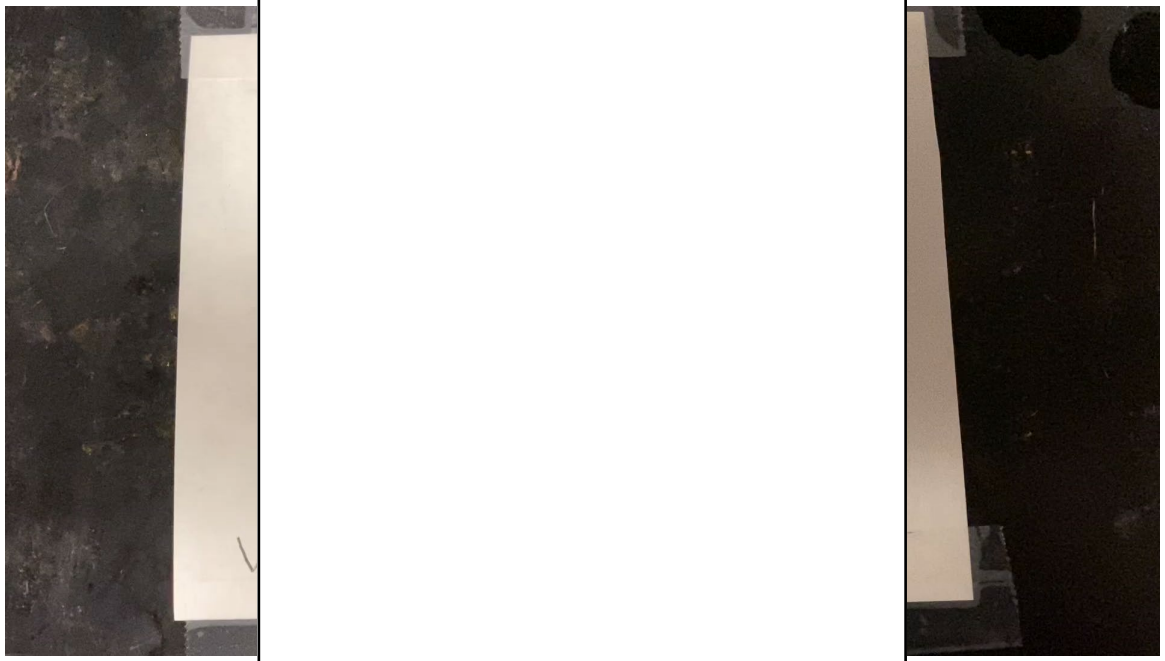
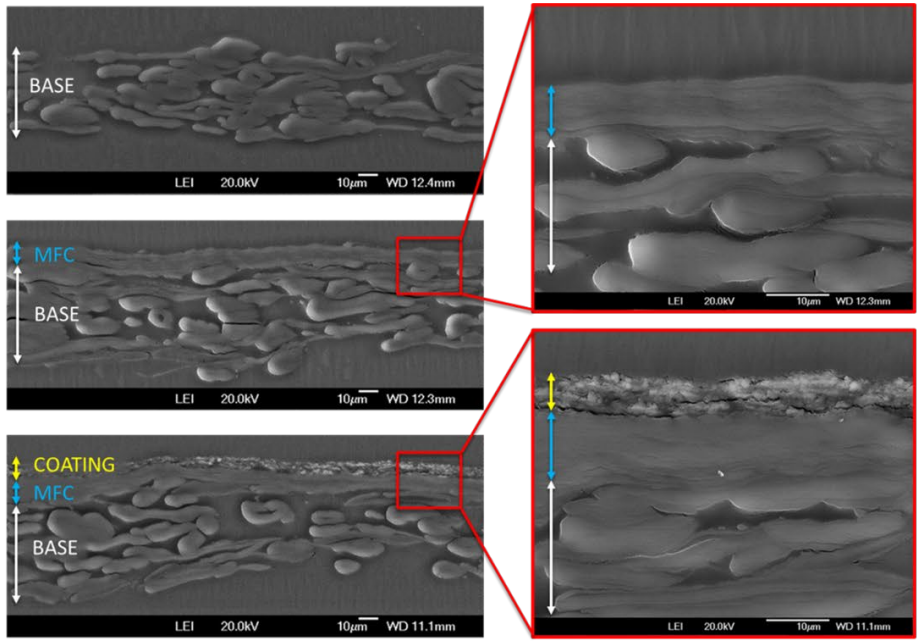
MFC ap…many interesting properties for barrier products





Cross-section Imaging: Scanning Electron Microscopy (SEM)

- ✓ Oil & grease re…faces.
- ✓ Oxygen & aron… coatings.
- ✓ Mineral oil barr…ayer.
- ✓ Very smooth &…ustainable
- × MFC is not a water/moisture barrier.

- MFC remains on the surface, forming a fibril-film.
- The MFC layer has a very closed structure, preventing penetration of oil and permeability of air.
- The surface serves as a substrate (primer) for subsequent coatings (i.e., topcoats to achieve moisture / water barrier).

Innovation with fibre-based barrier packaging to replace plastics is critical for a more sustainable future

Drivers:

- Consumer awareness
- Single-use plastics directive (SUPD)
- Reduction of petroleum-derived materials use
- PFAS bans
- Demand for sustainability (recyclable, biodegradable and compostable bio-based packaging)
- Natural-themed packaging is on trend

"As governments and brands increasingly look for alternatives to plastic packaging and food service formats, the paper and board sub-segment will assume an increasingly critical role."

Smithers, 2019

'The Future of Functional & Barrier Coatings for Paper & Board to 2024'

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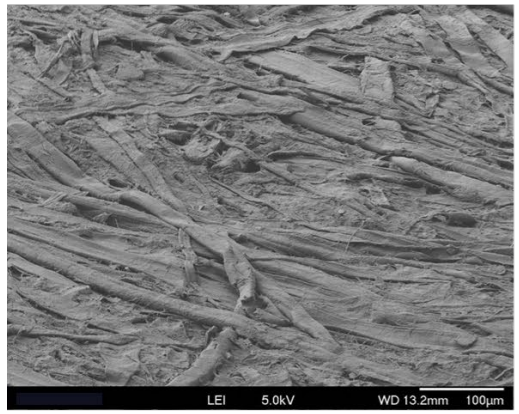
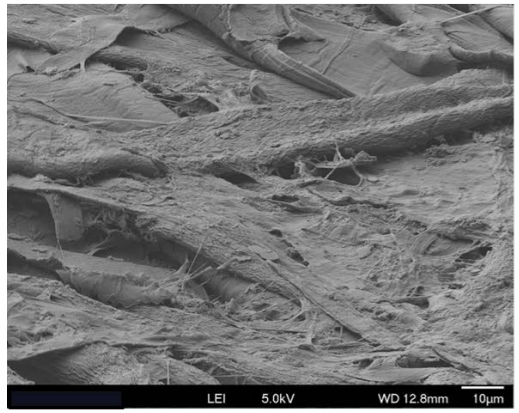
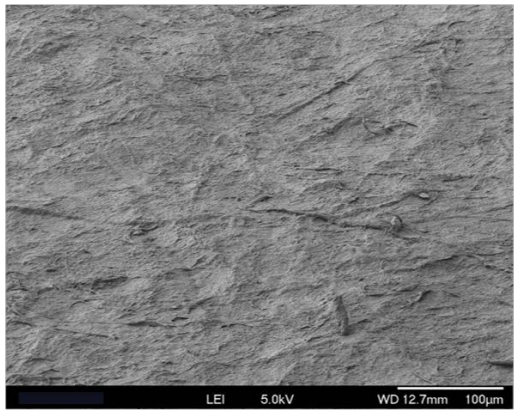
Scanning Electron Microscope (SEM) Imaging of MFC coated papers

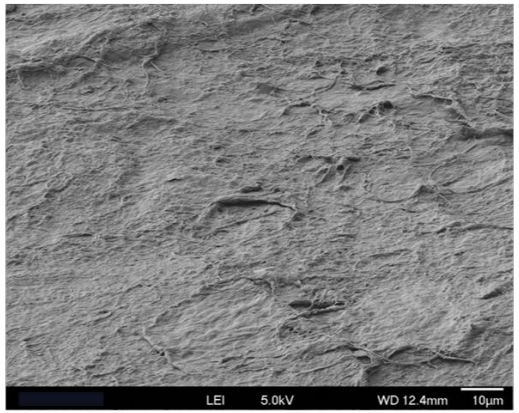
0 g/m² (No coating)



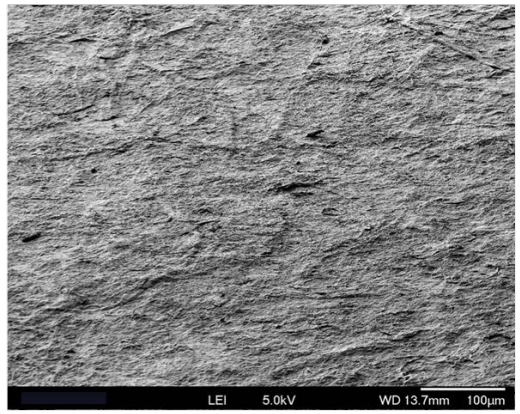


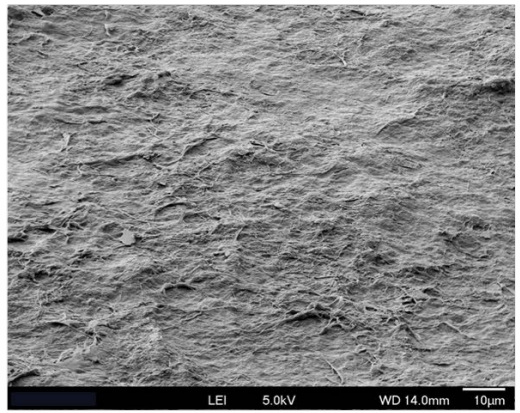
4 g/m² (MFC coating)





12 g/m² (MFC coating)





- The lowest coat weight, 4 g/m² provided substantial changes to the surface topography and structure.
- By 12 g/m², the MFC has formed a film and reached sufficient thickness to achieve high barrier properties.

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Barrier Application Results – MFC applied by wet end coating

Pilot Prototype Paper 1: Oil & Grease / Mineral Oil Barrier

- 50 g/m² Base paper coated with only MFC.
- Between 8 to 12* g/m² MFC applied at the wet end.

Oil & Grease
KIT Rating = 12
23 °C, 50% R.H. (0-12)

Mineral Oils (MOSH & MOAH)
HVTR = < 5
23 °C, 50% R.H. (n-Heptane, g/m² d⁻¹)

Oxygen Barrier
OTR = 40 to 100
23 °C, 50% R.H. (cm³ d⁻¹ m⁻² bar¹)

High Strength & Durability
Fold / cracking endurance

Smooth & Closed Surface
Precoat / primer layer for other top coats

>99% Bio-based
Mono-material packaging

Recyclable
With Paper & Cardboard
PTS-RH Method 021:202

Biodegradable
With no persistence
Certification in progress

*MFC coat weight required depends on substrate roughness/formation and desired properties.

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Barrier Application Results – MFC applied by wet end coating

Pilot Prototype Paper 2: Prototype 1 + Moisture / Water Resistance

- 50 g/m² Base paper coated with 10 g/m² MFC.
- 1-stage coating step of a water-based barrier coating (6 g/m²).

Oil & Grease
KIT Rating = 12
23 °C, 50% R.H. (0-12)

Mineral Oils (MOSH & MOAH)
HVTR = < 5
23 °C, 50% R.H. (n-Heptane, g/m² d⁻¹)

Oxygen Barrier
OTR = 200 to 500
23 °C, 50% R.H. (cm³ d⁻¹ m⁻² bar¹)

High Strength & Durability
Fold / cracking endurance

Water Barrier
COBB 60 = < 0.8
23 °C, 50% R.H. (g/m²)

Functionality added by top coat

Smooth & Closed Surface
Precoat / primer layer from MFC

>90% Bio-based
Packaging complex

Recyclable
Packaging complex

Biodegradable
Packaging complex

Moisture Barrier
MVTR = < 7
23 °C, 50% R.H. (g/m² d⁻¹)

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Barrier Application Results – MFC applied by wet end coating

Pilot Prototype Paper 3: Full Barrier With Improved Oxygen Barrier

- Initial results - Under development.

Oil & Grease
KIT Rating = 12
23 ℃, 50% R.H. (0-12)

Mineral Oils (MOSH & MOAH)
HVTR = < 5
23 ℃, 50% R.H. (n-Heptane, g/m² d⁻¹)

Oxygen Barrier
OTR = 10 to 30
23 ℃, 50% R.H. (cm³ d⁻¹ m⁻² bar¹)

High Strength & Durability
Fold / cracking endurance

Water Barrier
COBB 60 = < 0.8
23 ℃, 50% R.H. (g/m²)

Functionality added by top coat

Smooth & Closed Surface
Precoat / primer layer from MFC

>87% Bio-based
Packaging complex

Recyclable
Packaging complex

Biodegradable
Packaging complex

Moisture Barrier
MVTR = < 7
23 ℃, 50% R.H. (g/m² d⁻¹)

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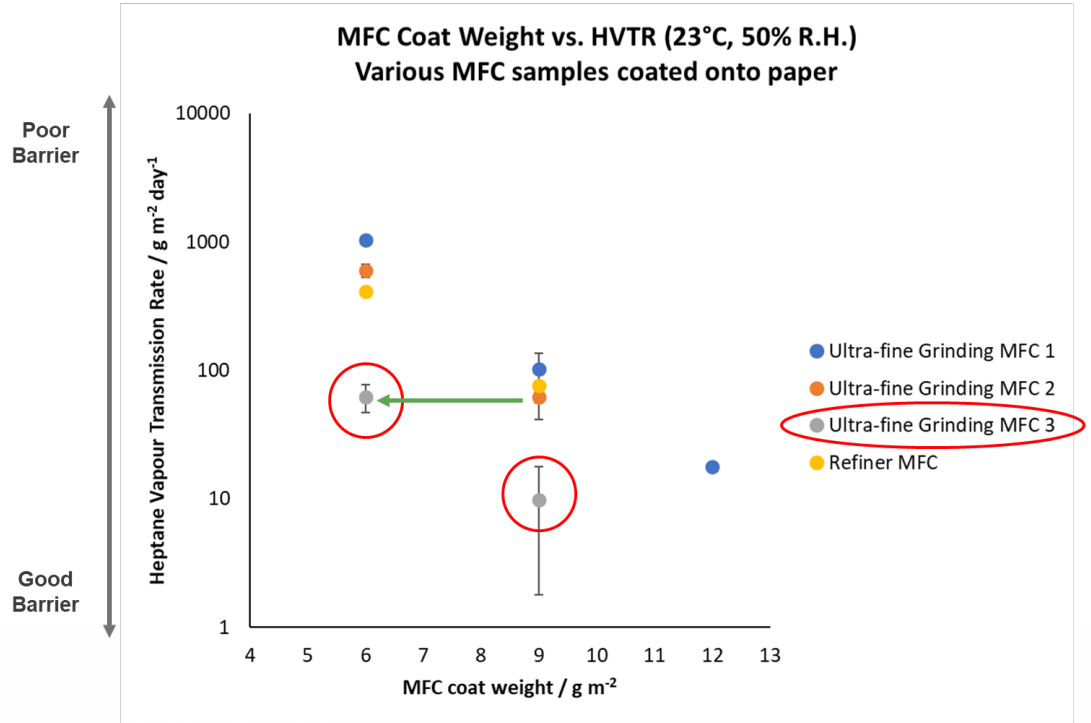
MFC properties are critical for effective application and high-performance

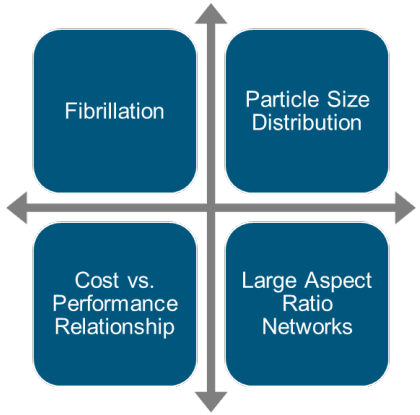


HVTR = Heptane Vapour Transmission Rate; is a barrier / permeation test method to evaluate the transmission rate of a volatile organic compound (n-Heptane), acting as a mineral oil simulant, through paper and plastic packaging materials.

○ = Product recommended for barrier MFC surface application.

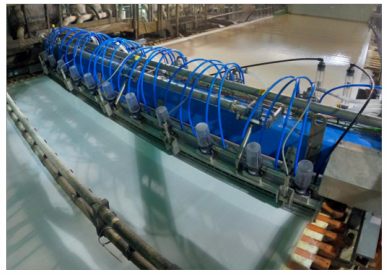
✓ **Significantly lower coat weight required or higher performance.**

Tailored MFC Properties for Wet End Coating



- Barrier performance
- Strength / Durability
- Network bridging / film-forming
- Porosity control
- Surface hold-out
- Binding capability
- Viscosity & Drainage

- Avoidance of applicator blockages
- Coating uniformity / formation
- Process throughput to match peak demand
- Dose / Coat weight required
- Cost effectiveness



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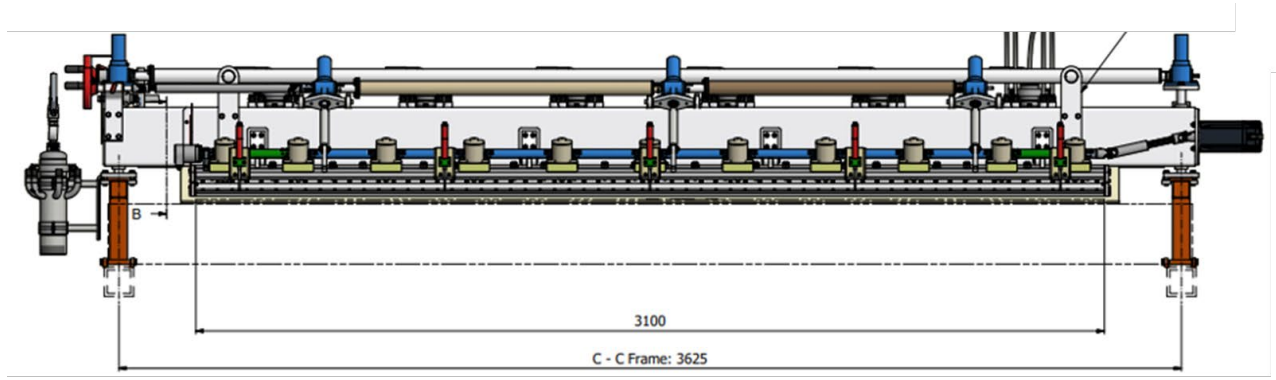
Wet end applicator: Designed for MFC



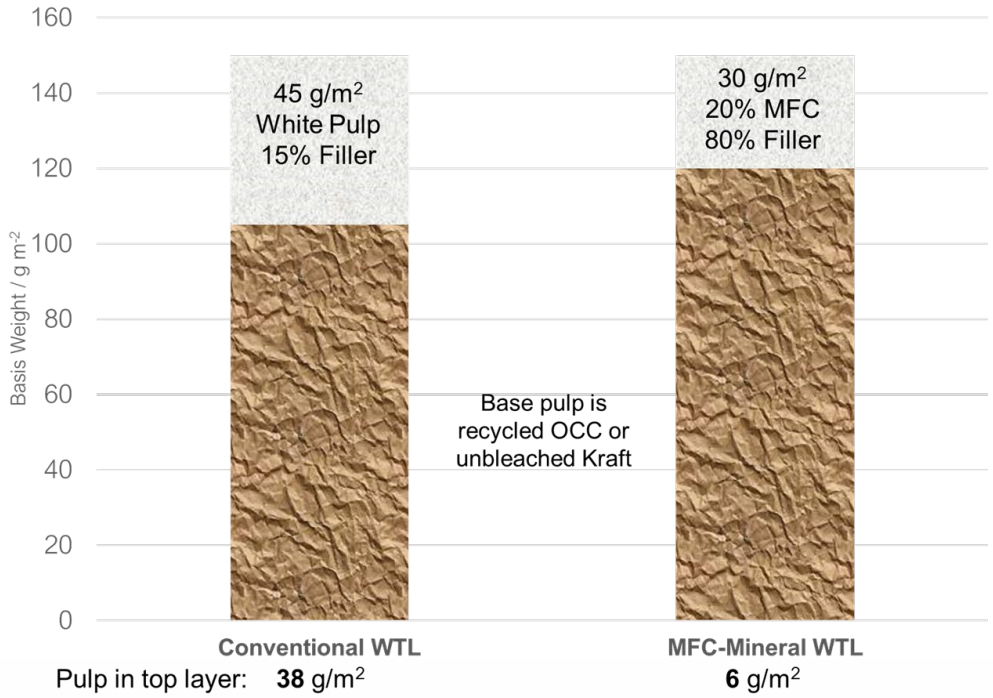
1/10000 sec exposure photographs

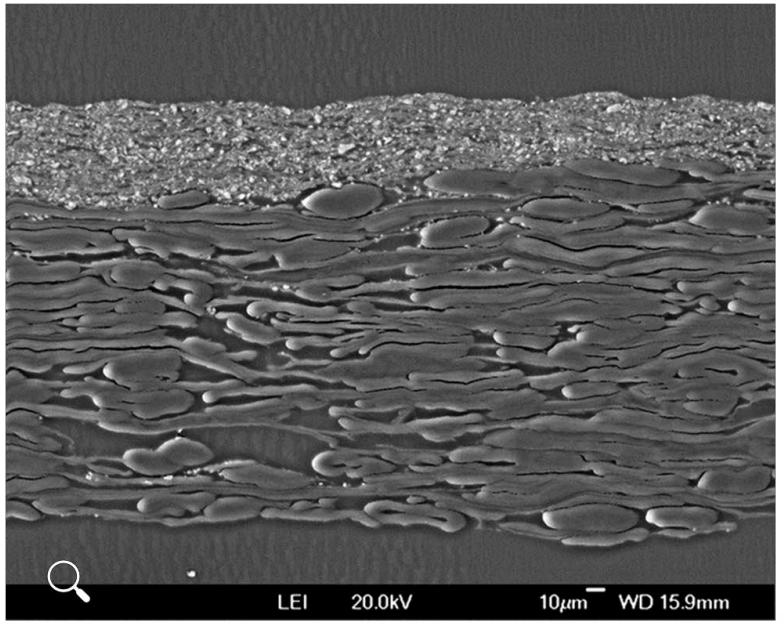
Water, 500 m/min

20/80 MFC/$CaCO_3$ 500 m/min

- Designed for application of optimized MFC with jet speed similar to wire speed, i.e., at high-shear conditions. Gradual shear-thinning of MFC through the approach flow system and applicator with maintained laminar flow.
- Easy mounting across paper machine.

Wet end coating of MFC-mineral composites: A new way to convert from brown liner to White Top





- ✓ Low-cost layer comprising mostly minerals, with MFC as the only binder.
- ✓ Absolute minimal white pulp consumption to produce WTL.
- ✓ Smoothness and printing properties.
- ✓ High surface strength and delamination resistance.

- Mineral particles provide a bright, white, printable surface to uniformly cover the dark base.
- MFC binds mineral particles at the surface, ensuring no penetration into the base and high surface strength.

Summary

- Wet stirred media mills offer a low-cost and high-performance MFC at scale.
- MFC is increasingly more widely established as a key tool in the paper makers toolkit, enabling its users to:
  - Improve properties.
  - Reduce costs.
  - Achieve their sustainability goals.
  - Develop new products.
- Wet-end coating of MFC can be used to achieve new properties on existing paper production lines with minimal investment cost.

Thank you for your attention

FiberLean Technologies

We are grateful to TAPPI for the opportunity to present this work

FiberLean Technologies Ltd: tom.larson@fiberlean.com

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