



FiberLean[®]

Technologies

Innovative by Nature.

Advancements in the industrial up-scaling of **MFC coating** at the paper machine wet-end

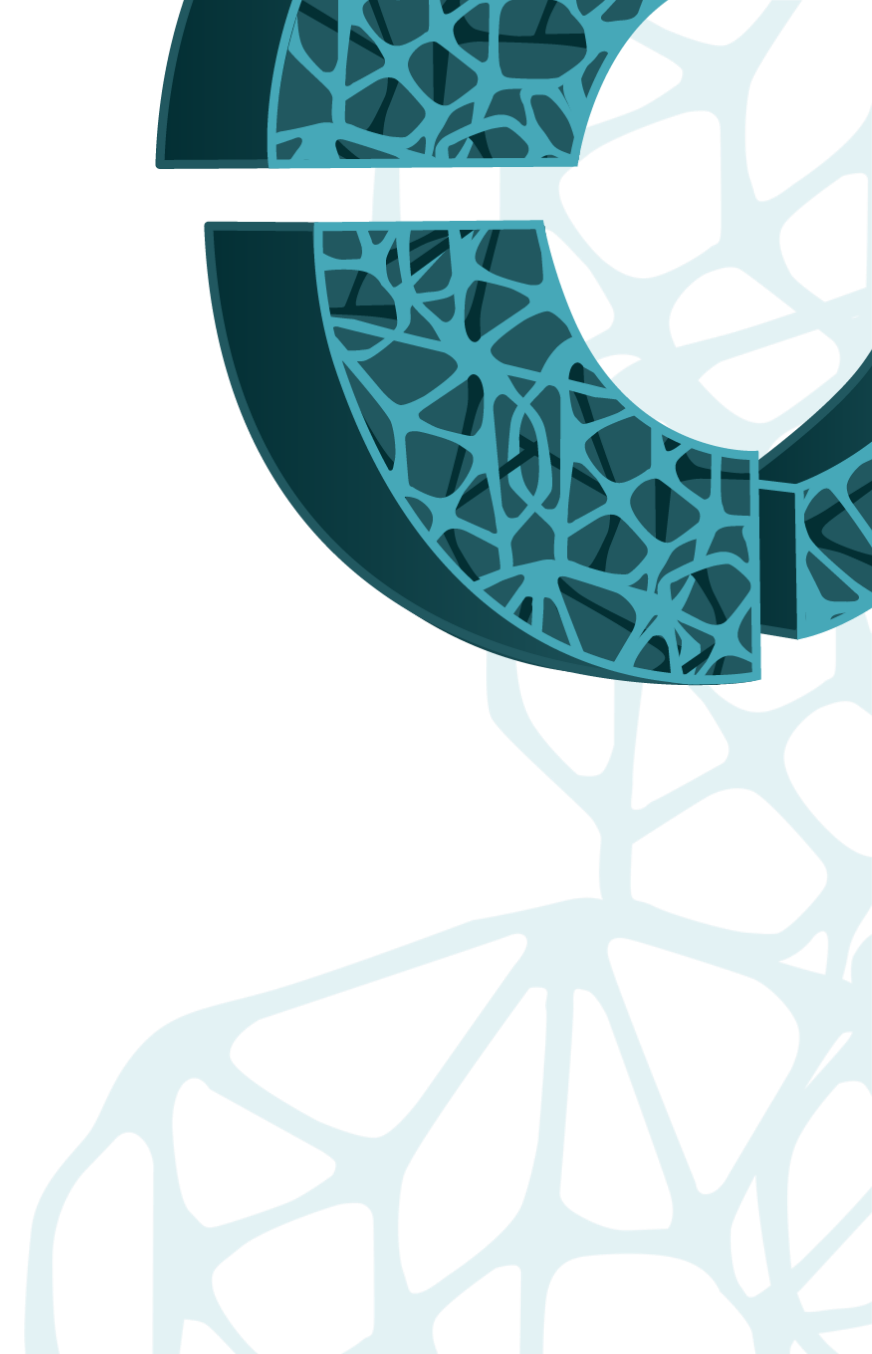
Specialty Papers Europe 2023 - Vienna, Austria

Tom Larson

Head of Business Development – Paper and Packaging

FiberLean Technologies

September 2023

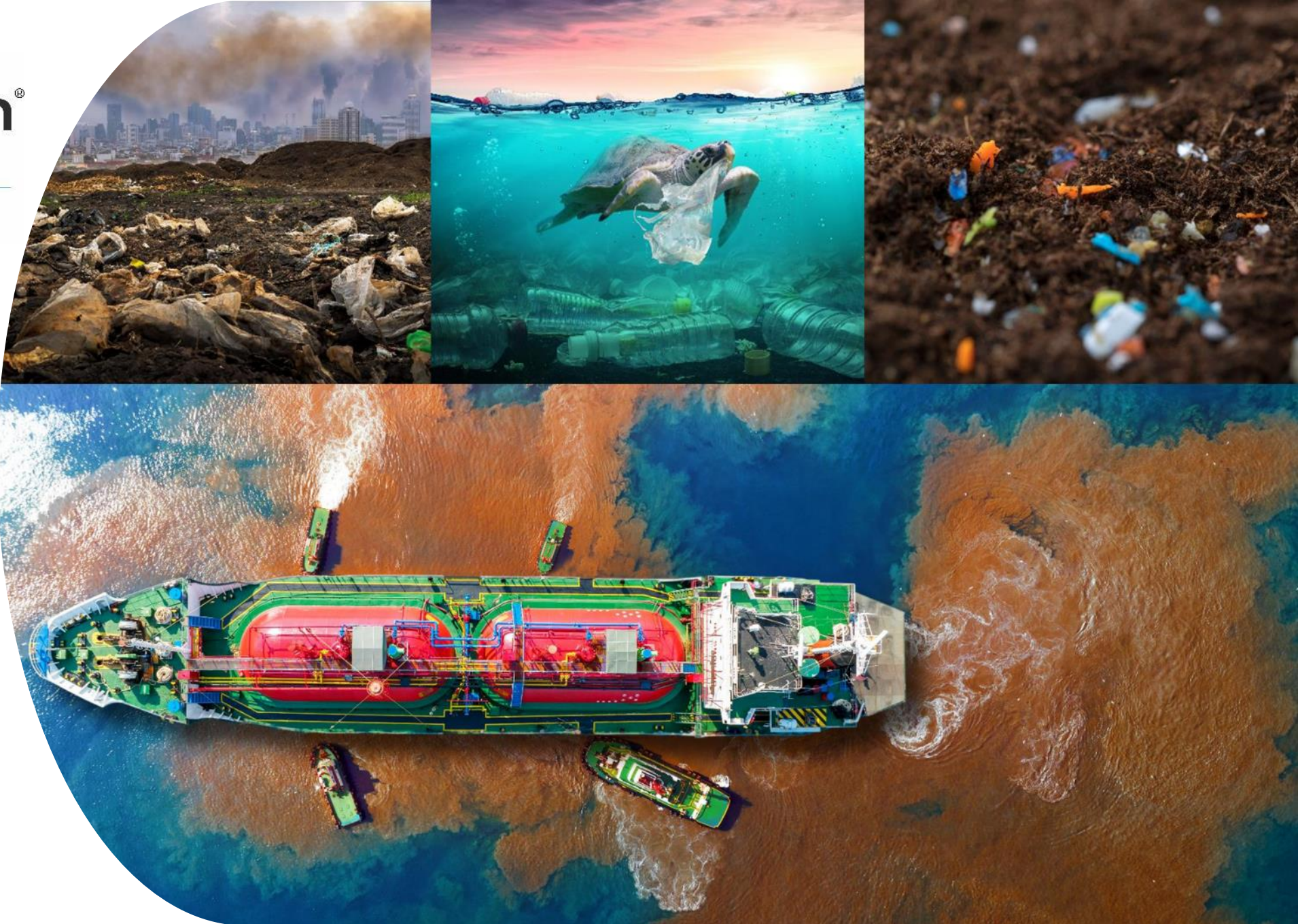




FiberLean[®]

Technologies

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OUR VISION

Accelerated transition to sustainable use of earth's resources through the power of materials science

OUR MISSION

Revolutionize product manufacturing through the development and implementation of innovative technologies based on biosourced, natural and recycled materials



	PRODUCTS OF YESTERDAY	PRODUCTS OF TODAY	PRODUCTS OF TOMORROW	PRODUCTS OF THE DAY AFTER TOMORROW
	Petroleum products or paper combined with petroleum products	Paper coated with petroleum derivatives (e.g., WBBC)	Optimized paper coated with <i>less</i> petroleum derivatives	Functional paper with high bio-based content
Barrier Performance	● ● ● ●	● ● ●	● ● ●	● ● ● ●
Strength	● ● ● ●	● ●	● ●	● ● ●
Cost	●	● ● ● ●	● ● ●	● ●
Sustainability		●	● ● ●	● ● ● ●
	<ul style="list-style-type: none"> ▪ Poor recycling rate or not recyclable ▪ Low bio-content ▪ Environmentally harmful degradation 	<ul style="list-style-type: none"> ▪ Recyclable but with difficulties ▪ 50-80% bio-content ▪ Not fully/quickly biodegradable <p>WBBC = Water based barrier coatings</p>	<ul style="list-style-type: none"> ▪ Recyclable ▪ 80-90% bio-content ▪ Biodegradable after long time periods ▪ Industrially compostable under specific conditions 	<ul style="list-style-type: none"> ▪ Easily recyclable ▪ >90% bio-content ▪ Biodegradable after short time periods ▪ Home and industrial compostable

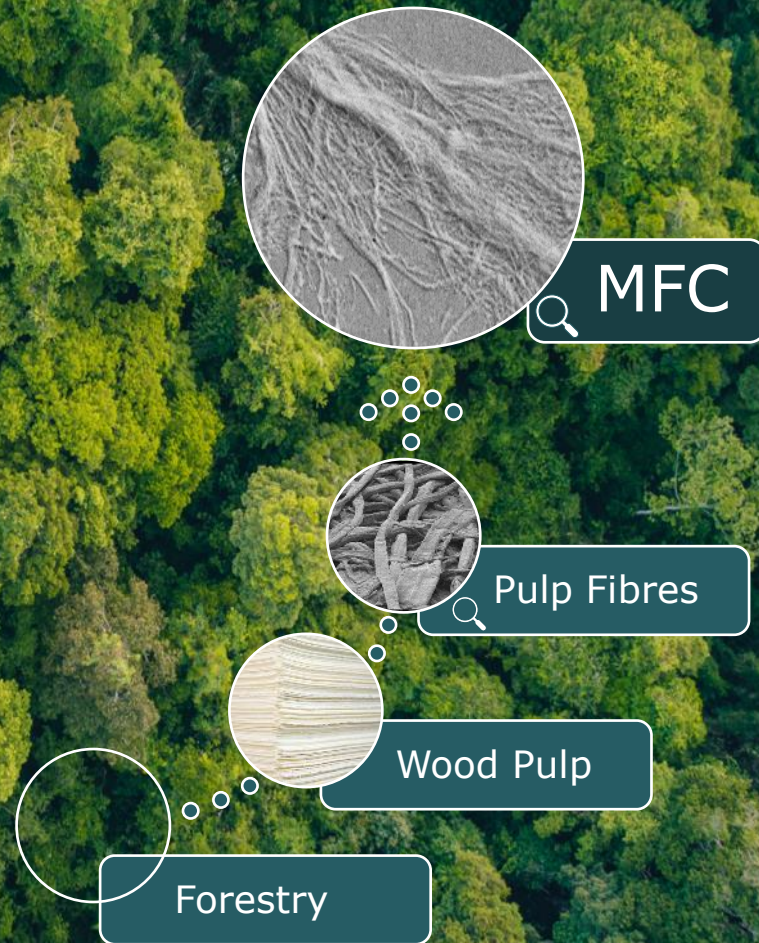
Cellulose is the most **ABUNDANT** and **RENEWABLE** natural polymer on **EARTH**.

Our process converts wood pulp fibres into small networks of fibrils, known as:

MICRO-FIBRILLATED CELLULOSE (**MFC**)

This unique **BIOMATERIAL** is used as a **HIGH-PERFORMANCE** additive across multiple product manufacturing industries, enabling users to:

- ✓ Improve properties and quality
- ✓ Reduce costs & gain efficiency
- ✓ Achieve sustainability goals
- ✓ Develop new products



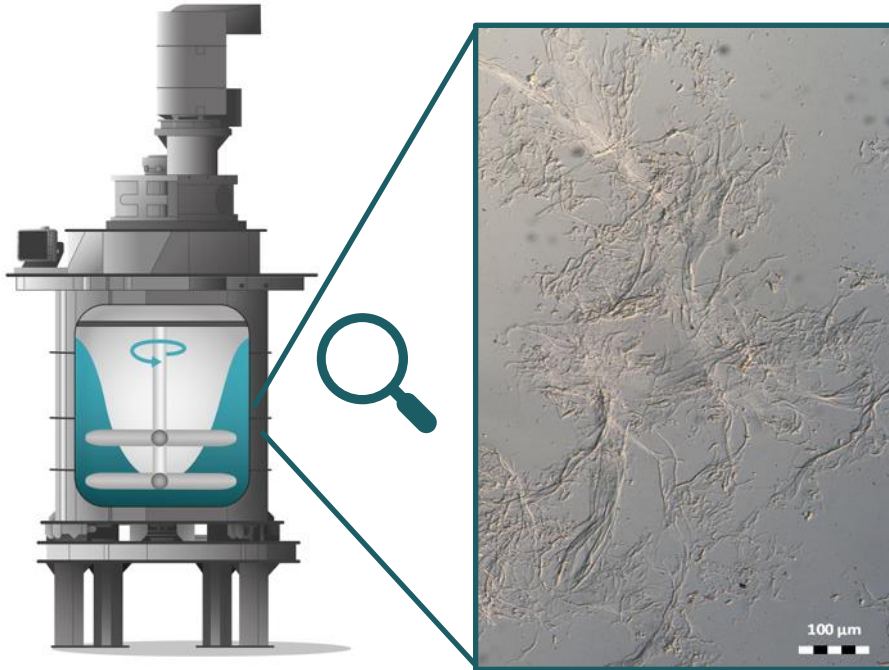
MFC PRODUCT TECHNICAL DESCRIPTION

- Viscous suspension of MFC in water.
- Prepared at 1-2 wt.% solids.
- Exhibits a web-like network structure with high aspect ratio and surface area.
- Recyclable, biodegradable & compostable.
- Food contact safe.

FiberLean Grinding Technology:

The most efficient and effective way of making MFC at scale

Ultra-fine grinding to produce MFC



The unique FiberLean® process:

Creates interconnecting fibre

Networks

that are highly-fibrillated for

Strength

maximising MFC product

Performance

Our **robust grinding** process transforms fibres through **milling** with carefully **controlled intensity**, liberating an **optimal "micro-fibrillated" network** structure.

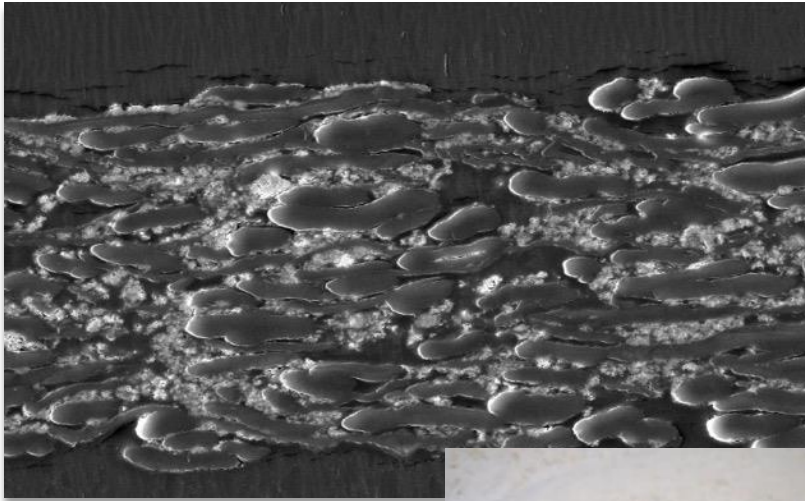
High-performance MFC produced onsite

- ✓ 100% mechanical, **chemical-free** process.
- ✓ **Low energy** consumption and **low-cost** operation.
- ✓ **High-throughput continuous** operation.
- ✓ **Low maintenance costs** and **high uptime** (>95% plant availability).
- ✓ **Highly-automated modular** plant design with online monitoring.
- ✓ **Optimal value creation** through a balanced relationship between cost and performance.



FiberLean[®] MFC for Paper & Packaging: A versatile additive with two ways to apply it

In the sheet... “Internal application”

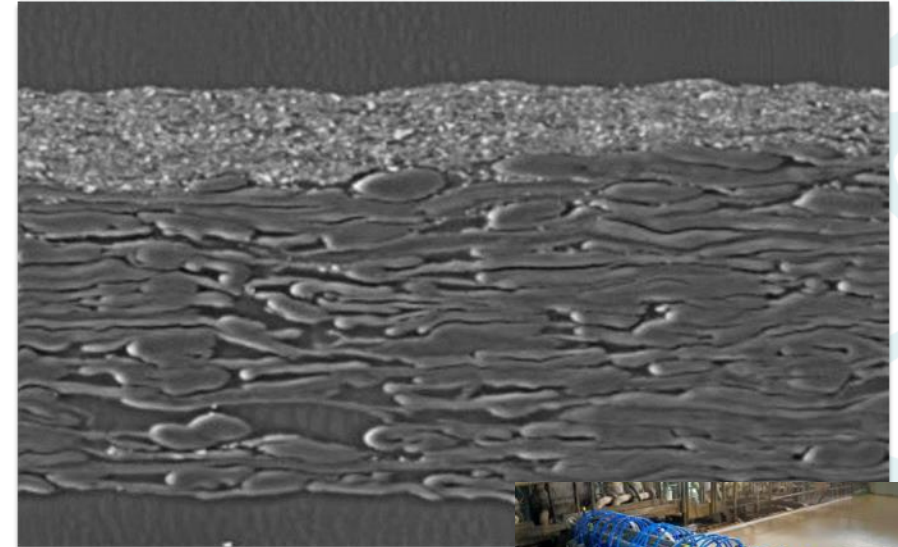


- MFC is mixed into the pulp stock to provide increased web bonding.



Scanning
Electron
Microscope
(SEM)
images of
paper cross
sections.

On the sheet... “Surface application”

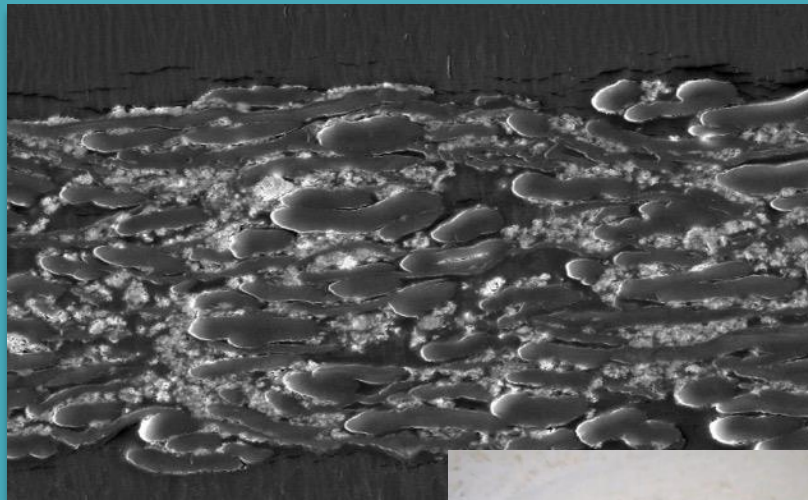


- MFC is coated onto the surface to improve barrier properties.
- Or MFC is used as the sole binder for a mineral coating.



FiberLean® MFC for Paper & Packaging: A versatile additive with two ways to apply it

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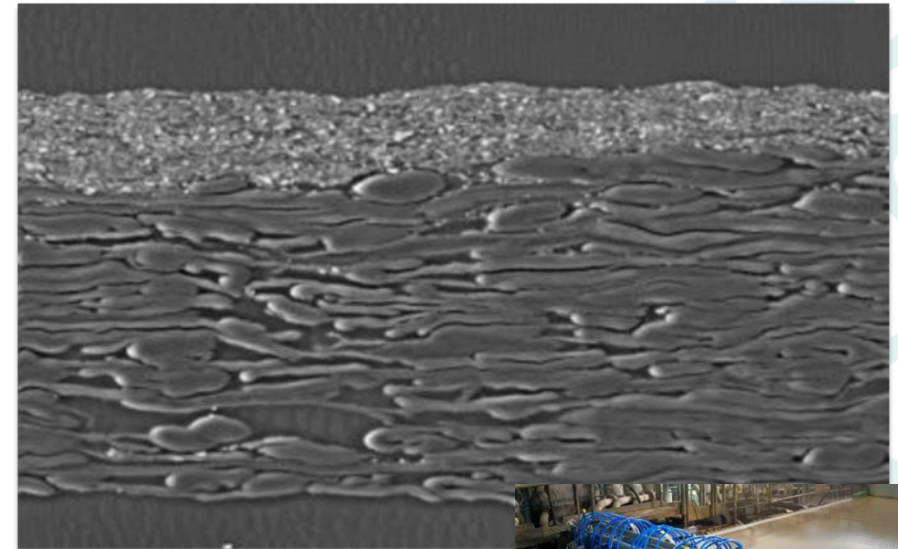


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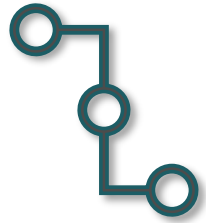
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FiberLean® MFC for Paper & Packaging:

Internal Application – MFC mixed into the pulp stock

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



Printing & writing paper



Specialty papers



Coated paper

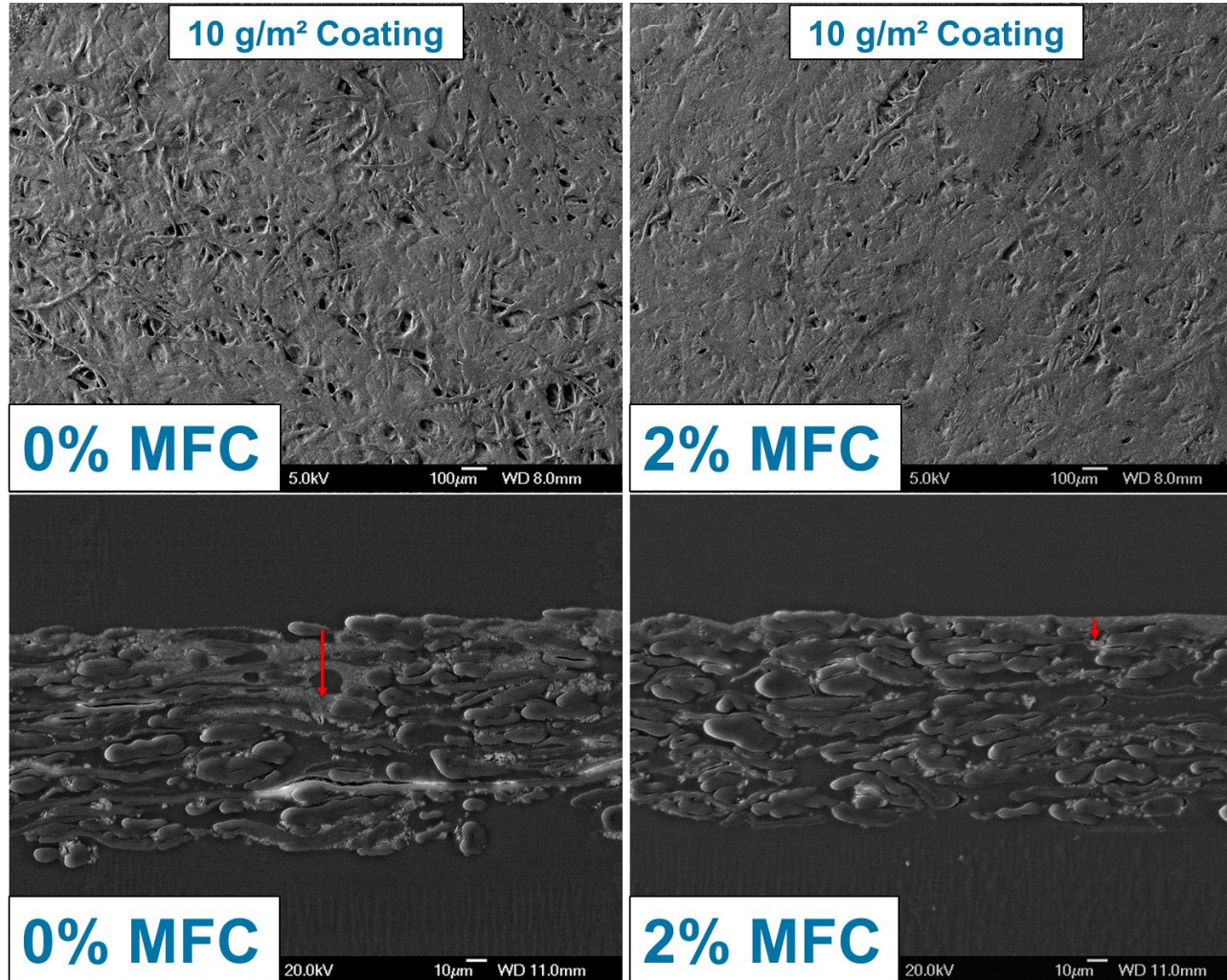


Tissue



3D Moulded Fibre

FiberLean® MFC for Coated Specialty Papers: Internal Application – MFC mixed into the pulp stock



IMPACT

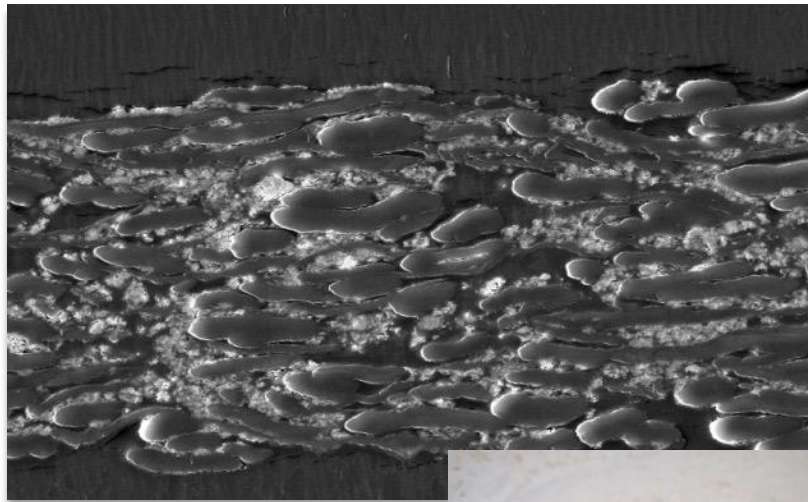
- Reduced coating penetration into the sheet (**improved hold-out**)
- More effective film forming of coating materials applied to the sheet surface

OUTCOMES

- Improved coating performance (**added value**)
- Reduction of coating weight requirement (**cost saving**)

FiberLean® MFC for Paper & Packaging: A versatile additive with two ways to apply it

In the sheet... “Internal application”

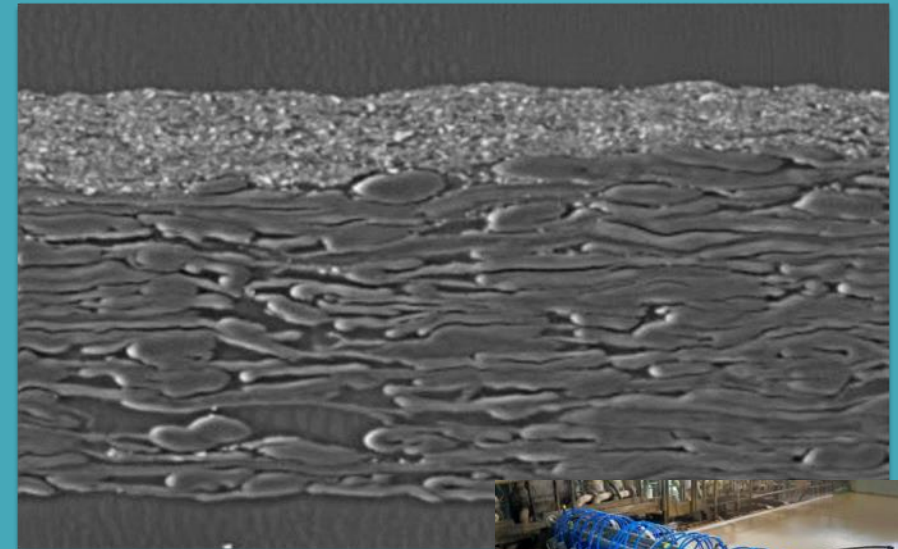


- MFC is mixed into the pulp stock to provide increased web bonding.



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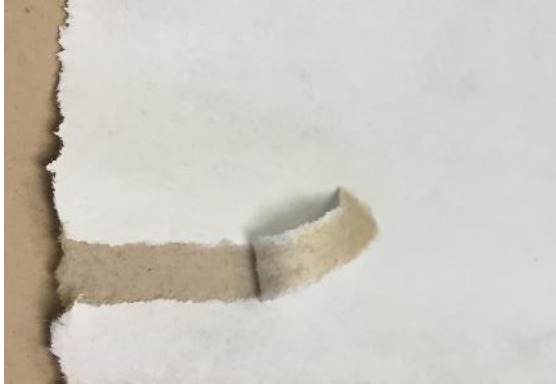


- MFC is coated onto the surface to improve barrier properties.
- Or MFC is used as the sole binder for a mineral coating.



FiberLean® on Top (FLoT):

A breakthrough coating technology to apply MFC onto paper and packaging products



White Top Liner

A new way to provide a **white printable surface** on brown boxes

- ✓ Low-cost layer comprising mostly minerals, with MFC as the only binder.
- ✓ Absolute minimal white pulp consumption to produce a WTL.
- ✓ Excellent smoothness and printing properties.



FiberLean are the inventors & patent owners of this game-changing technology.

Image: 3-meter wide FiberLean on Top (FLoT) applicator operating on a paper machine running at 500 m/min

- MFC is coated during the paper making process using only the applicator and existing standard paper machine equipment.
- **The technology has a low CapEx requirement vs traditional conversion**, enabling conversion of existing production lines to new grades.



Barrier

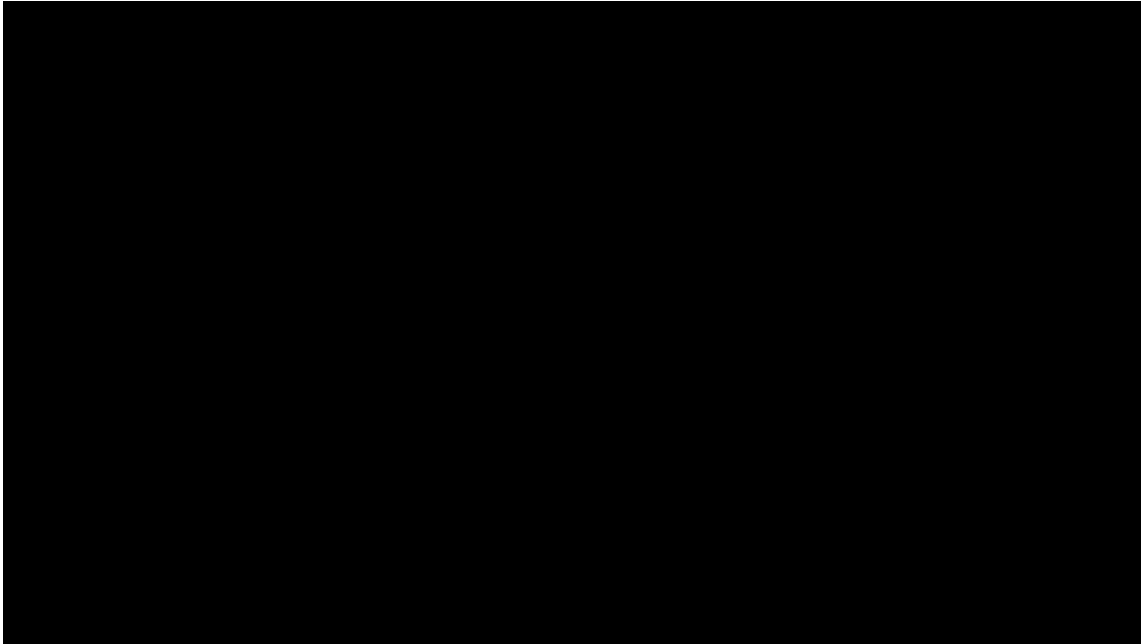
Providing barrier properties to help **reduce plastic** and other **harmful chemicals**

- ✓ Barrier towards: Oil, grease, oxygen, aroma, solvents & mineral oils.
- ✓ Very smooth surface with high durability and strength.
- ✓ Sustainable: Natural & renewable material, high bio%, recyclable, biodegradable, compostable.
- ✓ Safe for food contact & environment.



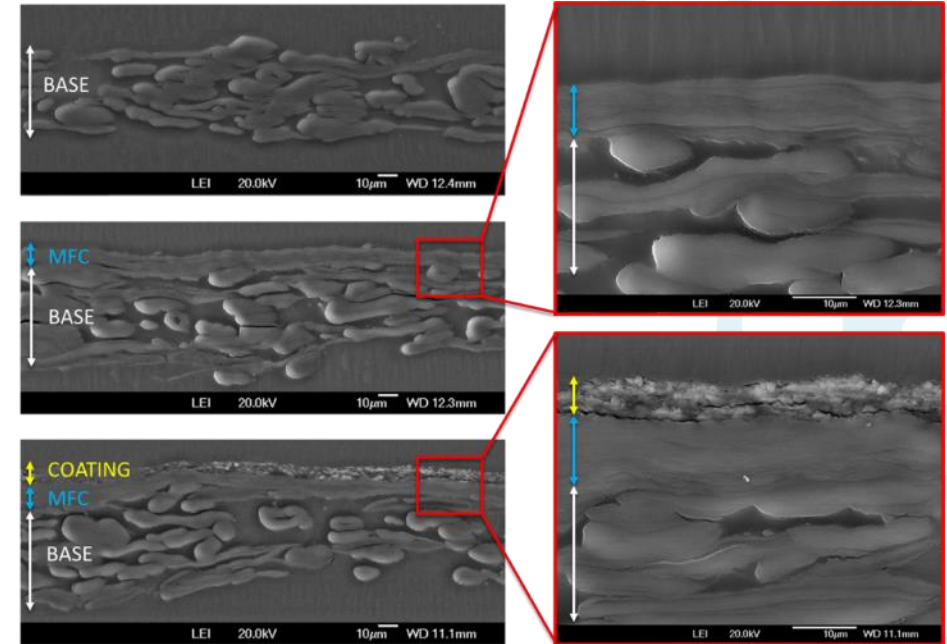
FiberLean® MFC applied via FLoT

Provides many interesting properties for barrier specialties



KIT 12 oil solution being applied to paper surfaces.

- ✓ Oil & Grease resistance.
- ✓ Oxygen & Aroma barrier.
- ✓ Mineral oil barrier.
- ✓ Very smooth & closed surface.
- ✓ Excellent substrate for coatings.
- ✓ High-strength & durable layer.
- ✓ High bio-based content, sustainable packaging.
- ✗ MFC is not a water/moisture barrier.



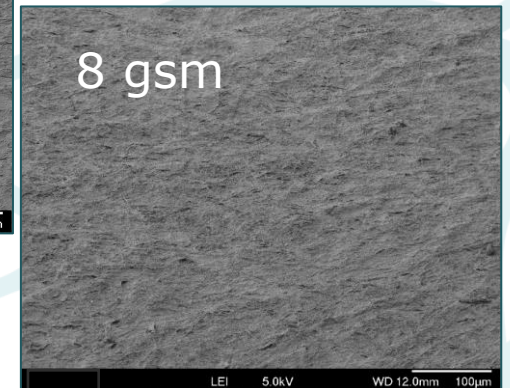
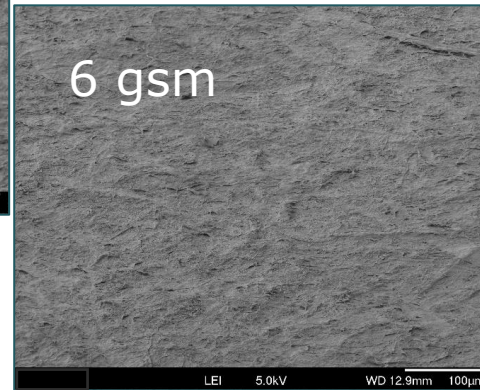
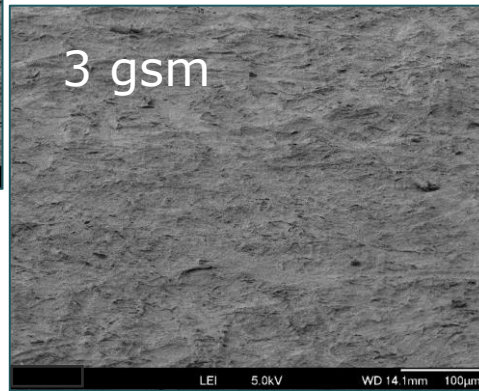
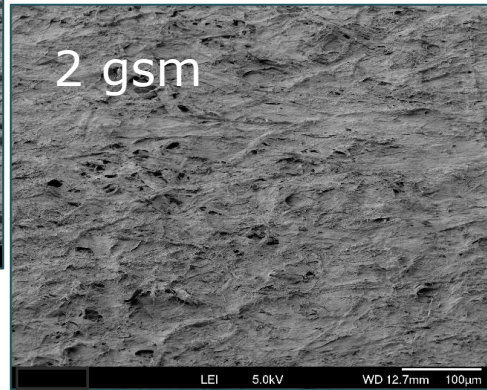
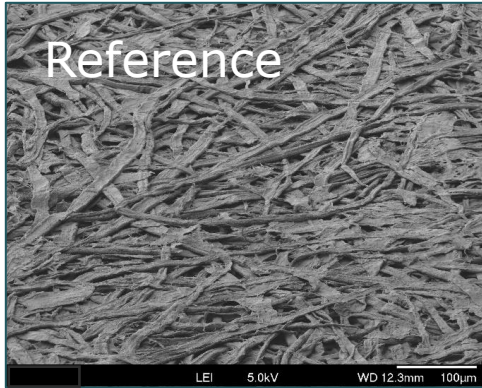
Scanning Electron Microscope (SEM) Cross-section Imaging

- FiberLean® 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 an excellent substrate (primer) for subsequent coatings (i.e., topcoats to achieve moisture / water barrier).



Scanning Electron Microscope (SEM) Imaging

Laboratory Surface Application of MFC (woodfree base sheet)



- Minimum of 5-6 gsm MFC needed to seal surface.
- >8 gsm is usually needed to get barrier properties directly from the MFC.

- Even low MFC coat weights radically change the sheet surface.
- As low as 1 gsm could be a useful precoat.



Barrier Application Results

FiberLean® MFC applied via wet end coating



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

- 50 g/m² Base paper coated with only FiberLean® MFC.
- Between 8 to 12* g/m² MFC applied at the wet end using FiberLean® on Top technology.



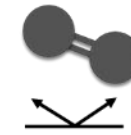
Oil & Grease

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)



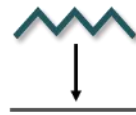
Oxygen Barrier

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



High Strength & Durability

Fold / cracking endurance



Smooth & Closed Surface

Excellent 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.



Barrier Application Results

FiberLean® MFC applied via wet end coating

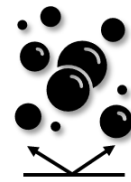


Pilot Prototype Paper 2: Prototype 1 + Moisture / Water Resistance

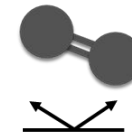
- 50 g/m² Base paper coated with 10 g/m² FiberLean® MFC using FiberLean® on Top technology.
- 1-stage coating step of a water-based barrier coating (6 g/m²).



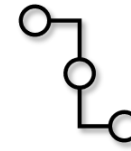
Oil & Grease
KIT Rating = 12
23°C, 50% R.H. (0-12)



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



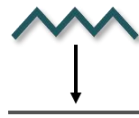
Oxygen Barrier
OTR = 200 to 500
23°C, 50% R.H.
(cm³ d⁻¹ m⁻² bar⁻¹)



High Strength & Durability
Fold / cracking endurance



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



Smooth & Closed Surface
Excellent precoat / primer layer from MFC



>90% Bio-based
Packaging complex



Recyclable
Packaging complex



Biodegradable
Packaging complex

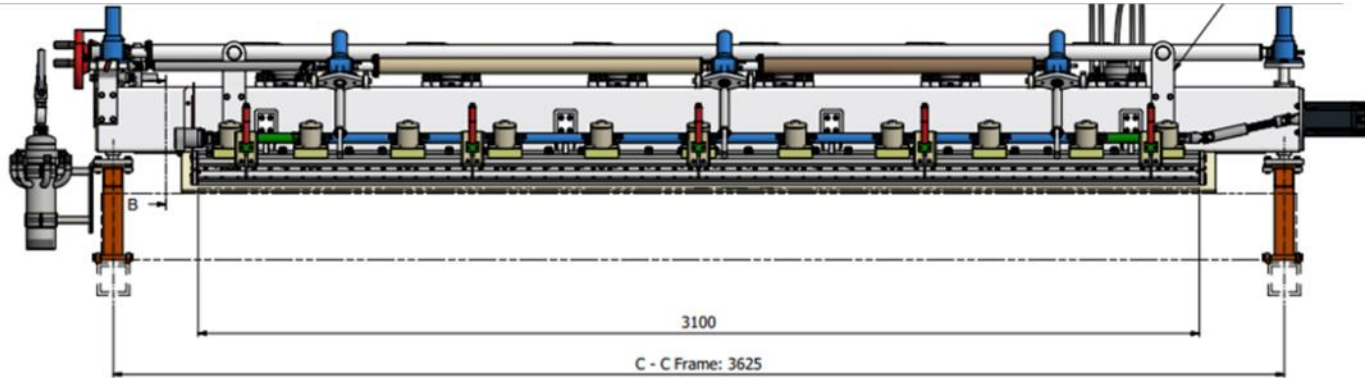


Moisture Barrier
MVTR = < 7
23°C, 50% R.H. (g/m² d⁻¹)

Functionality added by topcoat



Patented in-house design of the FLoT Applicator



1/10000 sec exposure photographs



Water, 500 m/min



20/80 MFC/CaCO₃, 500 m/min

- Specifically 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.
- FiberLean is committed to continued development of this technology and has multiple additional patents pending.
- **FiberLean has partnered** with a major coating equipment manufacturer to provide the engineering, fabrication and servicing of these applicators.

*MFC product optimization discussed further later.



Significant time, and money, spent on high-speed pilot and full-scale machines to understand how to do it



Variables:

- Base furnish
- Coat weight
- Coating solids
- Coating slurry approach flow system
- Applicator design
- Applicator position/geometry
- FiberLean MFC product
- Additives
- Machine settings and configurations

Over 10 trial weeks on slow pilot machines

Offline applicator operation



11 High-speed pilot trials:

- July -17
- November -17
- February -18
- March -18
- April -18
- December -18
- March -19
- December -19
- March -20
- December -21
- June -22

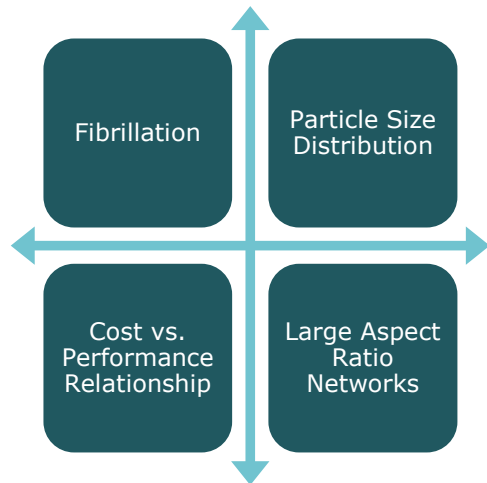
& multiple full-scale trials across several paper machines



FiberLean[®] MFC Products Optimized for Surface Application

Carefully selected properties based on years of process & application development

Tailored MFC Properties for Surface Application (FLoT)

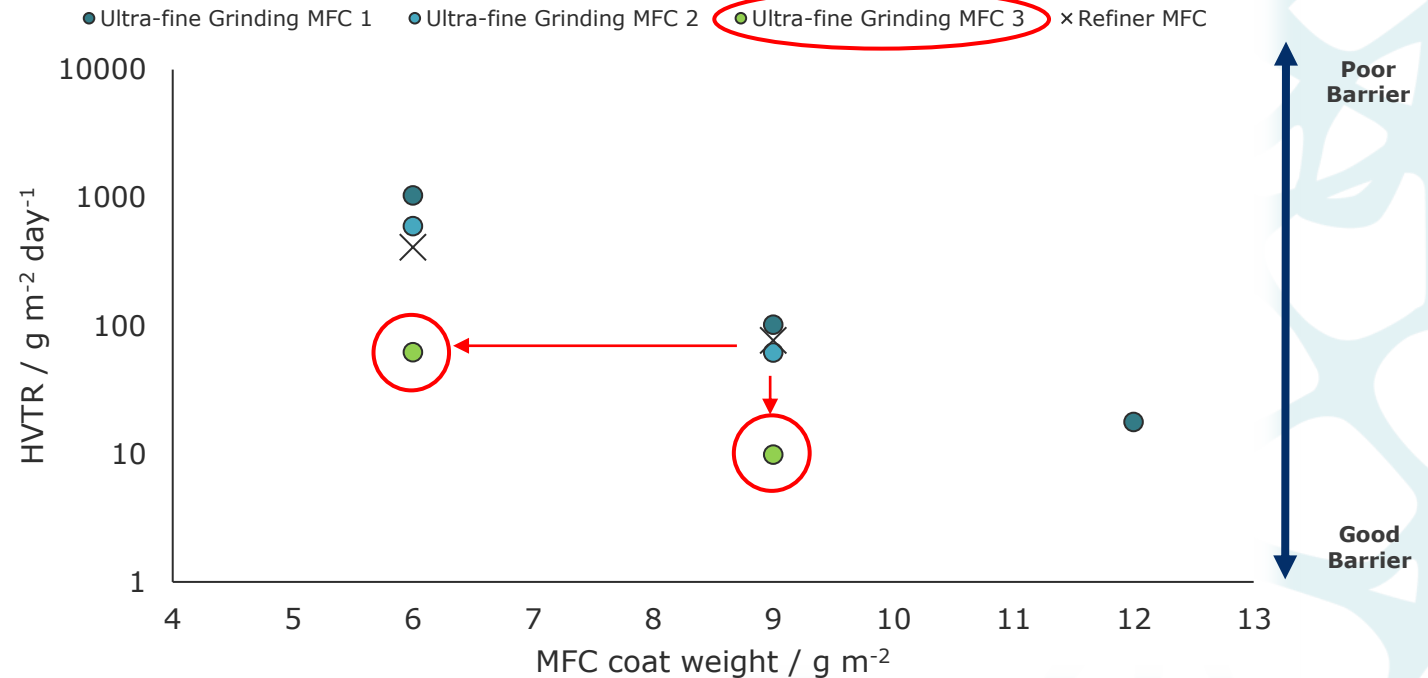


- Barrier performance
- Strength / Durability
- Network bridging / film-forming
- Porosity control
- Surface hold-out
- Binding capability
- Viscosity & Drainage

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



MFC Coat Weight vs. HVTR (23°C, 50% R.H.) Various MFC samples coated onto paper



- = Product recommended for barrier MFC surface application.
- ✓ **Significantly lower coat weight required or higher 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.

Having the capability to run extensive mill trials is key to evaluation of MFC



MFC trial make-down unit, re-dispersing granulate FiberLean MFC to slurry for use on paper machine.



For wet-end coating there is also need for an approach flow system, ensuring MFC suspension is free of debris and air



Summary

Key takeaways

- **Cost-effective MFC is available today** at scale *via* ultra-fine grinding.
- **“Internal application”** of MFC is well-established and is proven to enable paper makers to **enhance the “Products of Today”** by leveraging a host of value propositions; improving properties and net reducing costs.
- **“Surface application”** *via* wet end coating is **pre-commercial and developing** rapidly with full-scale paper machine trials.
 - **Early adopters of the technology will have a unique first-to-market advantage** to offer the **“Products of Tomorrow”** and **“The Day After Tomorrow”**.
- **Extensive machine trials** to evaluate both **“Internal”** and **“Surface”** applications of MFC can be run in situ at paper mills globally.





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Thank you.

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