



Microfibrillated Cellulose (MFC) in Coated Food Service Paper and Packaging

Presented by:

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Agenda



- Introduction to FiberLean and MFC
- MFC in coated paper and board
- MFC in moulded fibre
- MFC use in practice
 - Production of MFC
 - MFC coated paper and board
 - MFC in moulded fibre
 - Food contact clearance
- Summary

FiberLean Introduction

Leading independent supplier of MFC production equipment

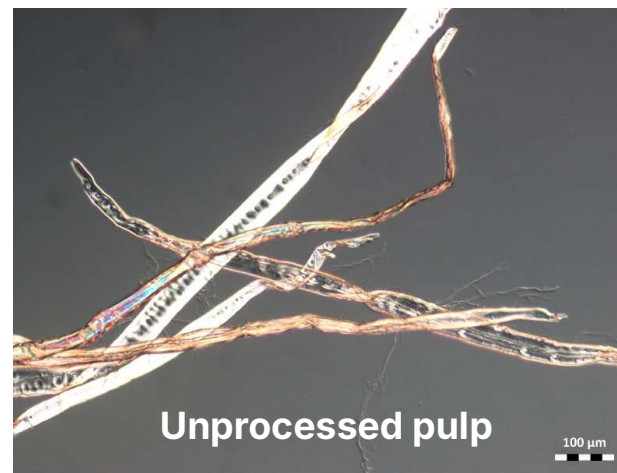
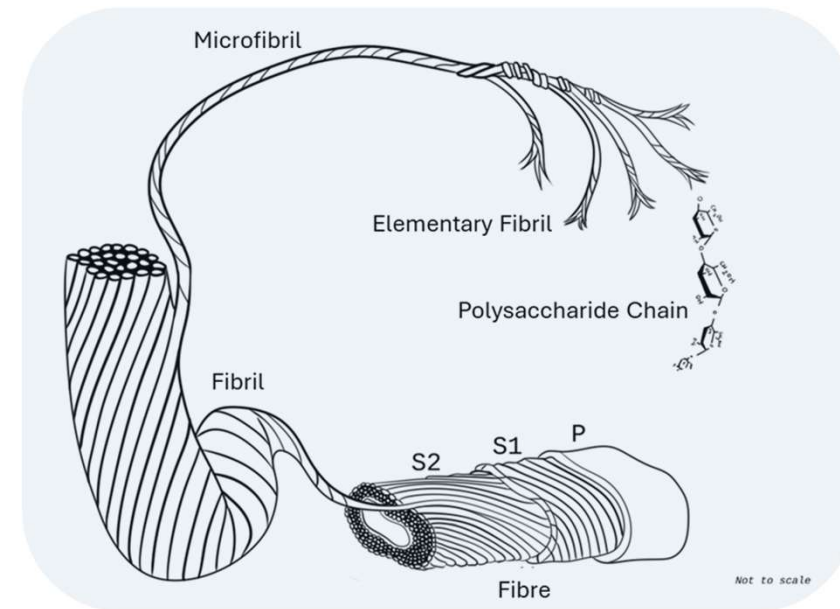
- Wet grinding technology (stirred media mill) – **FiberLean MFC Grinders.**
- Experienced project implementation and engineering team.
- Expertise and experience in MFC production.
- Industrial scale demo plant and pilot plant, operating since 2014.
- Trials **worldwide.**
- Process development and application support to customers.



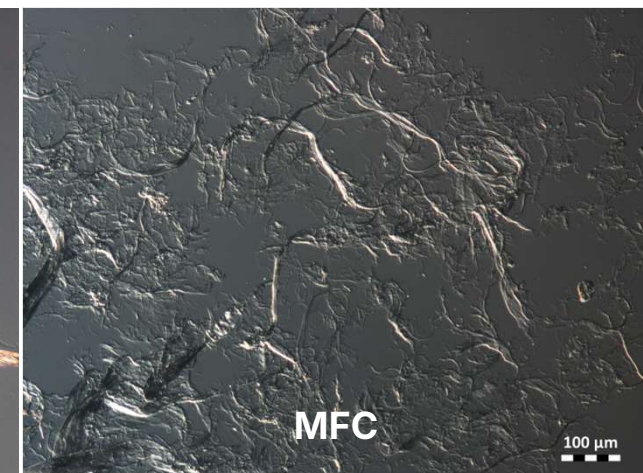
What is MFC?

Microfibrillated cellulose

- Micro-fibrillated Cellulose (MFC) is made from cellulosic feedstocks such as wood pulp, which are mechanically disintegrated to liberate their fibril and microfibril sub-structures.
- This greatly increases specific **surface area** and fibril aspect ratio. Enhances **bonding** ability.
- When added to the paper-making process, improved **mechanical and barrier** properties, reduced porosity, smoother surfaces.



Unprocessed pulp



MFC



MFC in Coated Paper and Board





MFC in Coated Paper and Board

Two use cases: in the base and on the surface

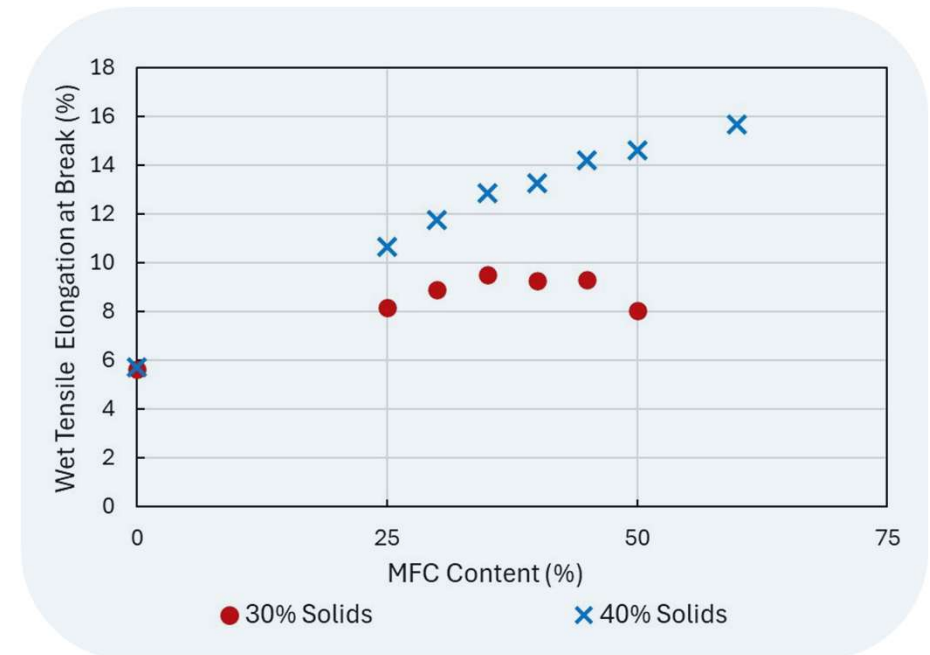
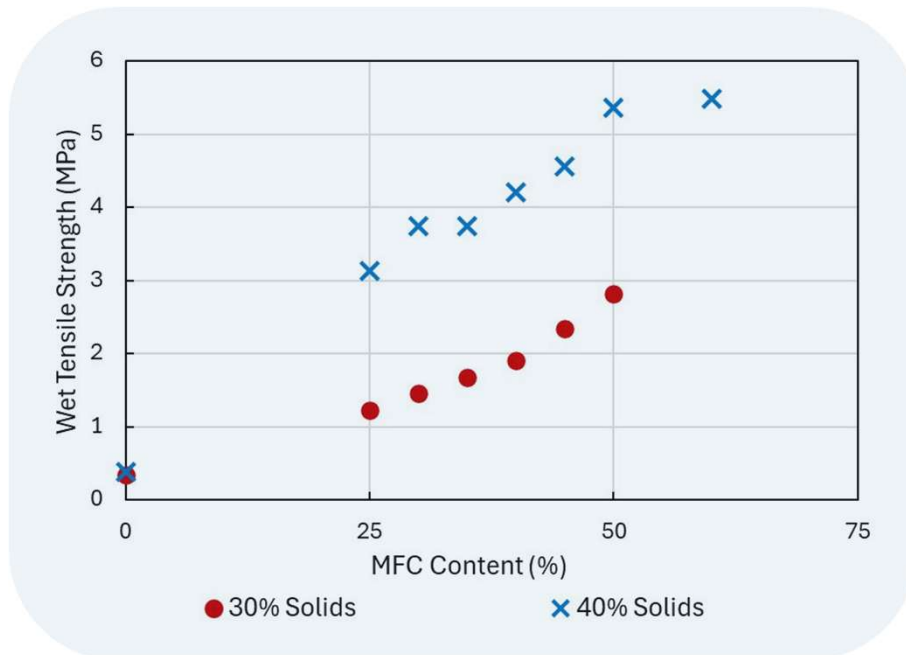
MFC in the base

- MFC added into the furnish.
- Typically added at the machine or blend chest.
- The high surface area and bonding capabilities of MFC enhance properties.

MFC on the surface

- MFC added to the surface of paper or packaging.
- Can be added at the wet-end of the paper machine or offline.
- MFC layer forms a very low porosity surface as a primer for barrier coatings and provides grease barrier properties.

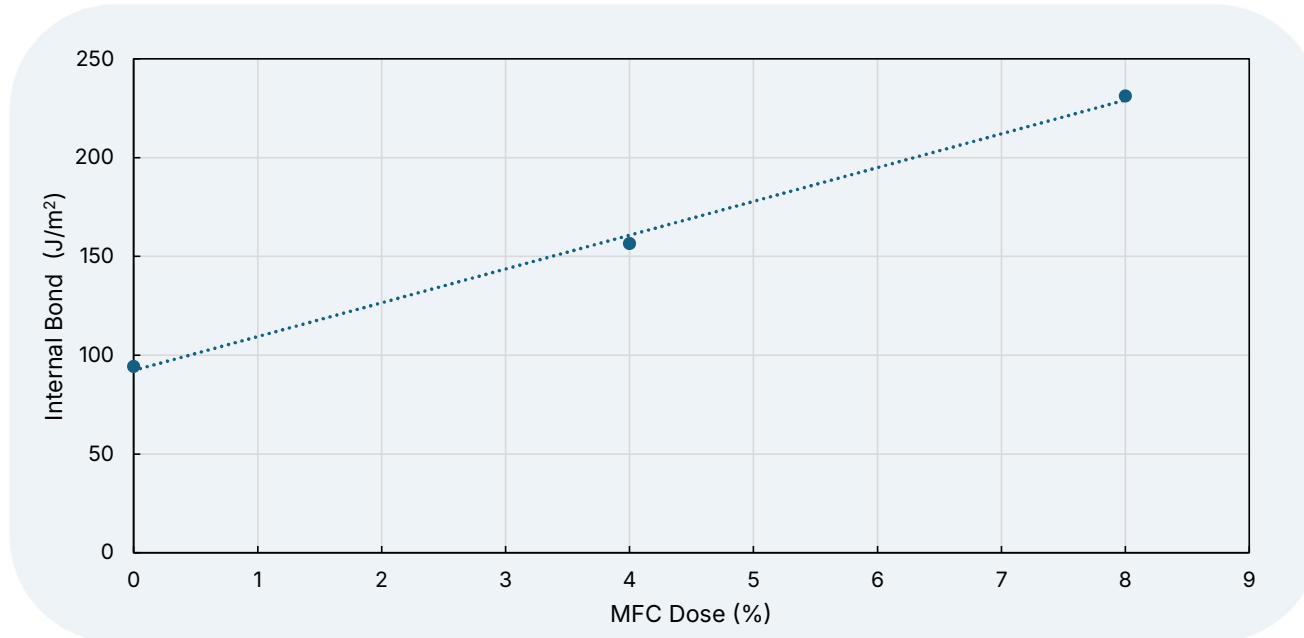
MFC in the Base – Wet Paper Properties



Increased wet tensile strength and **breaking elongation** with MFC addition.

Tested on 225 gsm handsheets in a NBSK furnish with MFC contents varying from 0% to 60%. Sheets measured after pressing but before drying.

MFC in the Base – Internal Bond Strength

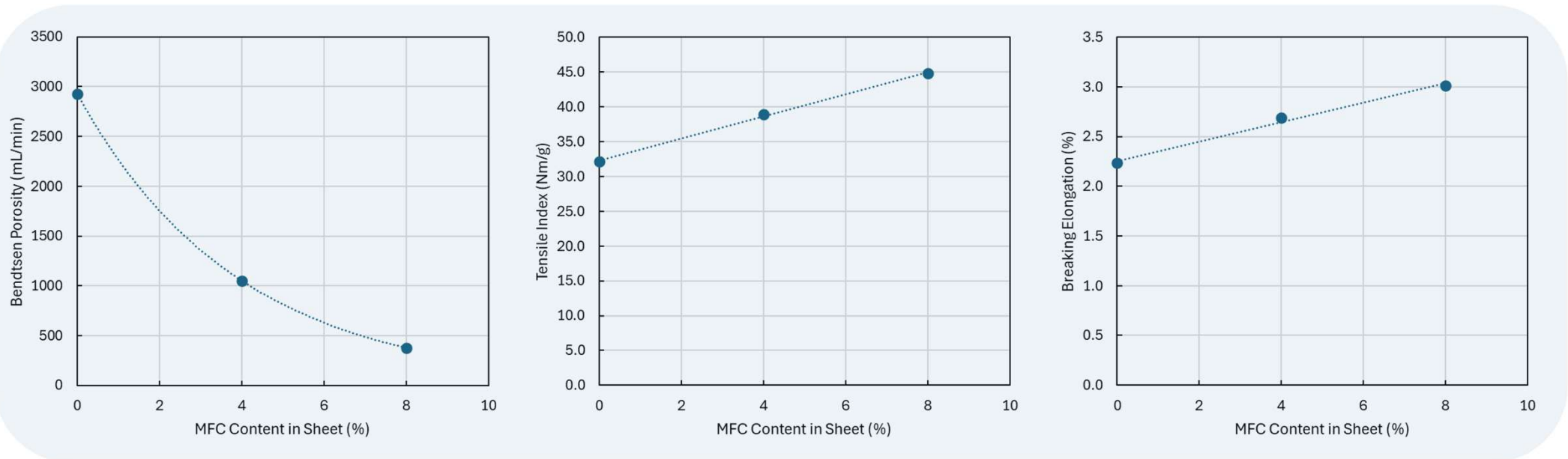


Addition of MFC significantly **enhances internal bond** strength.

This gives **improved sealing strength** when failure point is within the base.

Tested on 80 gsm handsheets in a 70:30 SW:HW furnish with MFC contents varying from 0% to 8%.

MFC in the Base – Dry Paper Properties

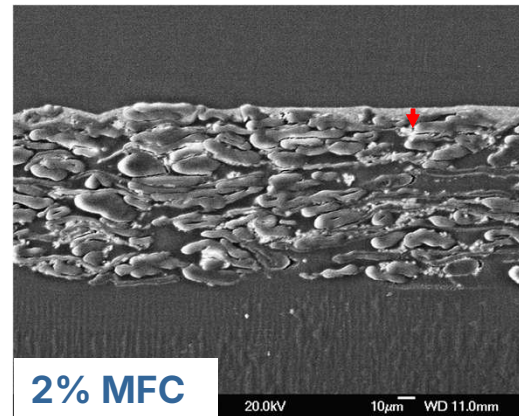
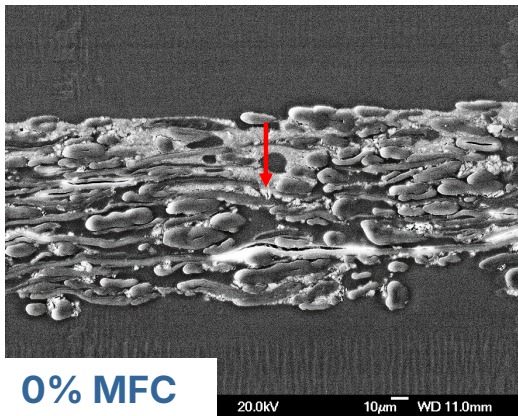
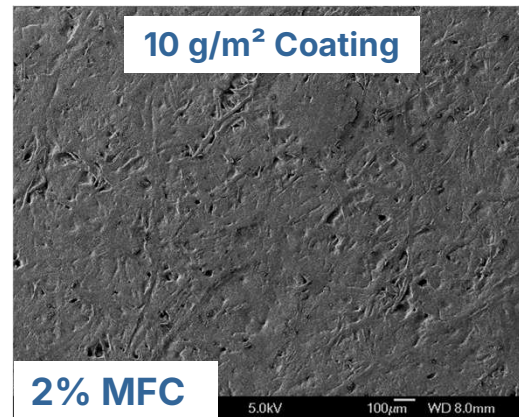
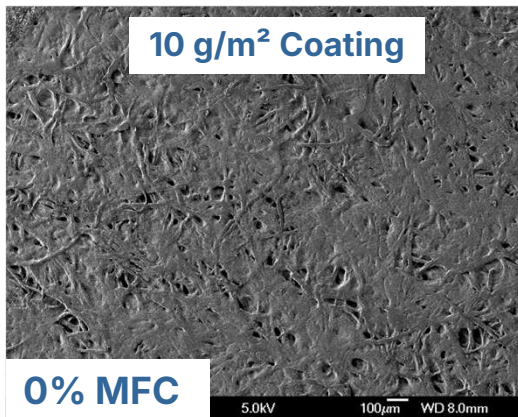


Reduced porosity and **increased dry tensile index** and **breaking elongation** with MFC addition.

MFC offers opportunities to produce **light weight, flexible, low porosity base** papers.

Tested on 80 gsm handsheets in a 70:30 SW:HW furnish with MFC contents varying from 0% to 8%.

MFC in the Base – Improved Coating Hold-out



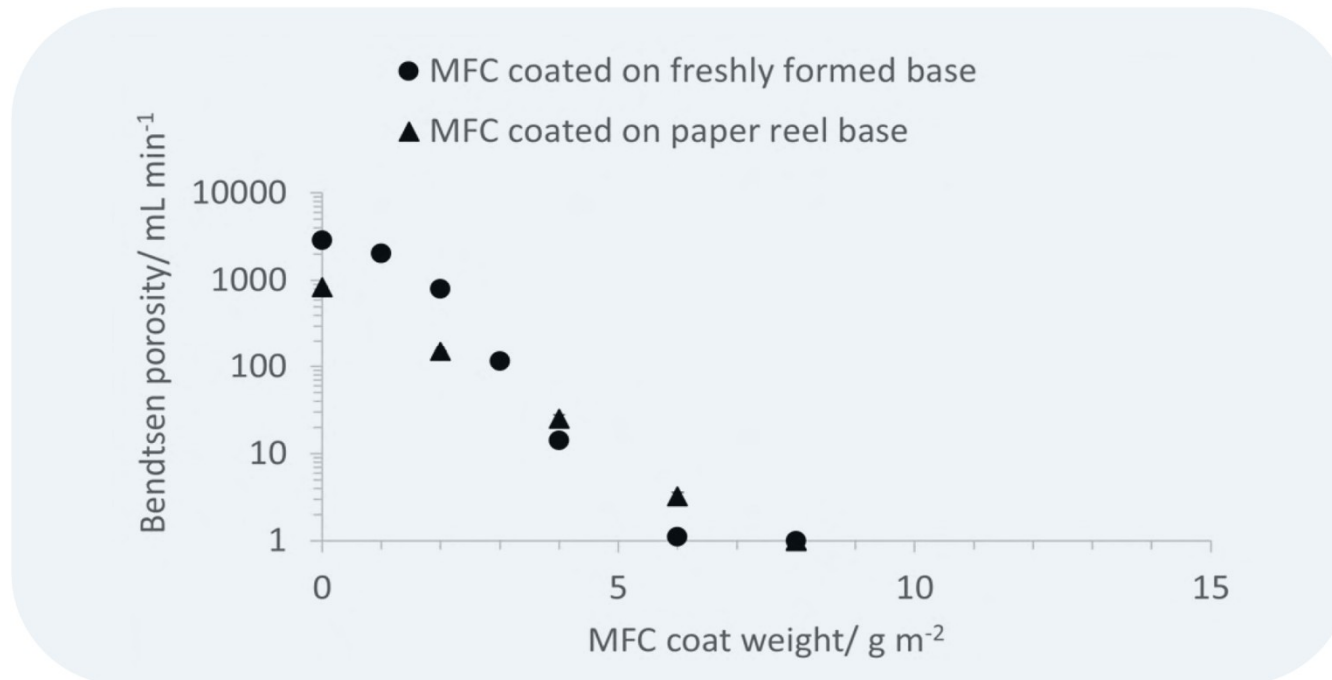
MFC in Base Paper	Base Paper Porosity (Bendtsen, ml/min)	Base Paper Porosity (Gurley, Sec/100 ml)
0%	2633	4
2%	1591	7

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 (**reduced costs**).
- Typically, for every 1% MFC, coat weight can be **reduced by 10-15%**.
- Improved properties at equal coat weight (**added value**).

Experimental details: 80 g/m² woodfree paper was prepared on a pilot paper machine: 70% Eucalyptus / 30% Pine (450 CSF), 20% GCC filler, 0% and 2% MFC, no sizing added. Paper was coated with: GCC / Kaolin formulation (10 pph Latex), Coat weights between 6 to 14 g/m², Supercalendared.

MFC Coatings – Porosity

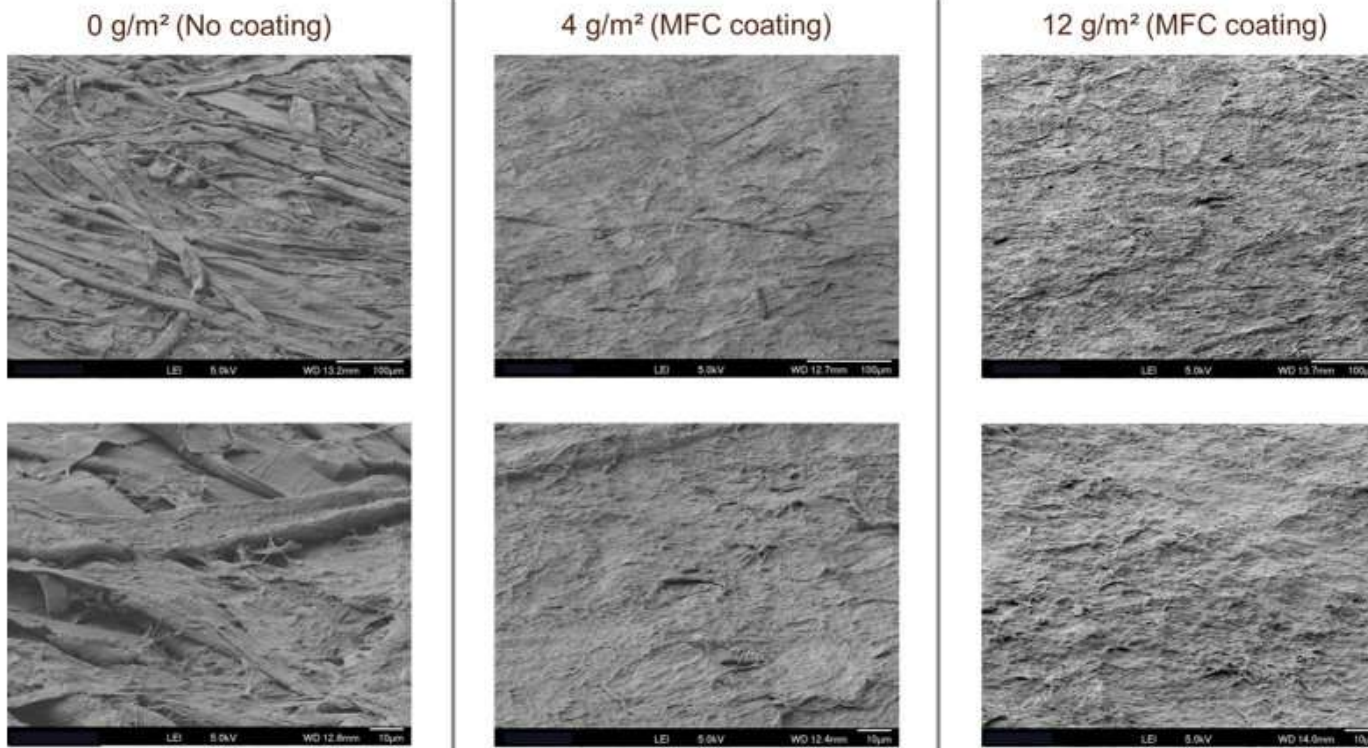


Porosity is **dramatically reduced** when an MFC coating is added.

Provides an **ideal surface** for subsequent coatings.

Hill, R., 2024. The Effect of Microfibrillated Cellulose Characteristics on Barrier Properties for Packaging Applications. EngD Thesis, University of Birmingham, UK.

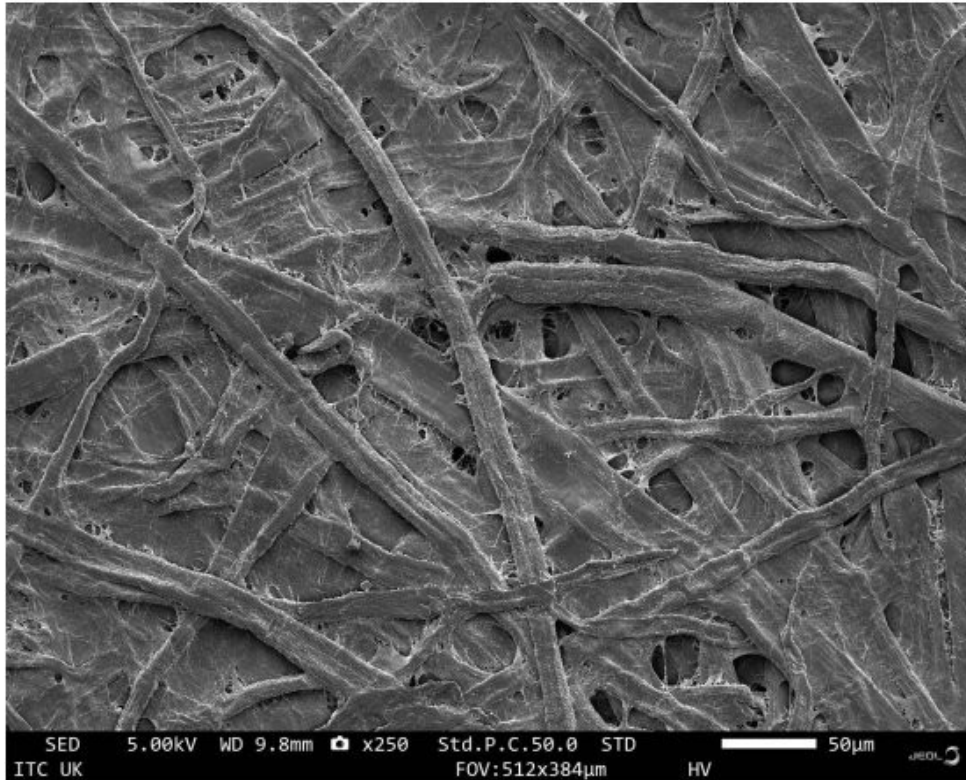
MFC Coatings – Surface Images



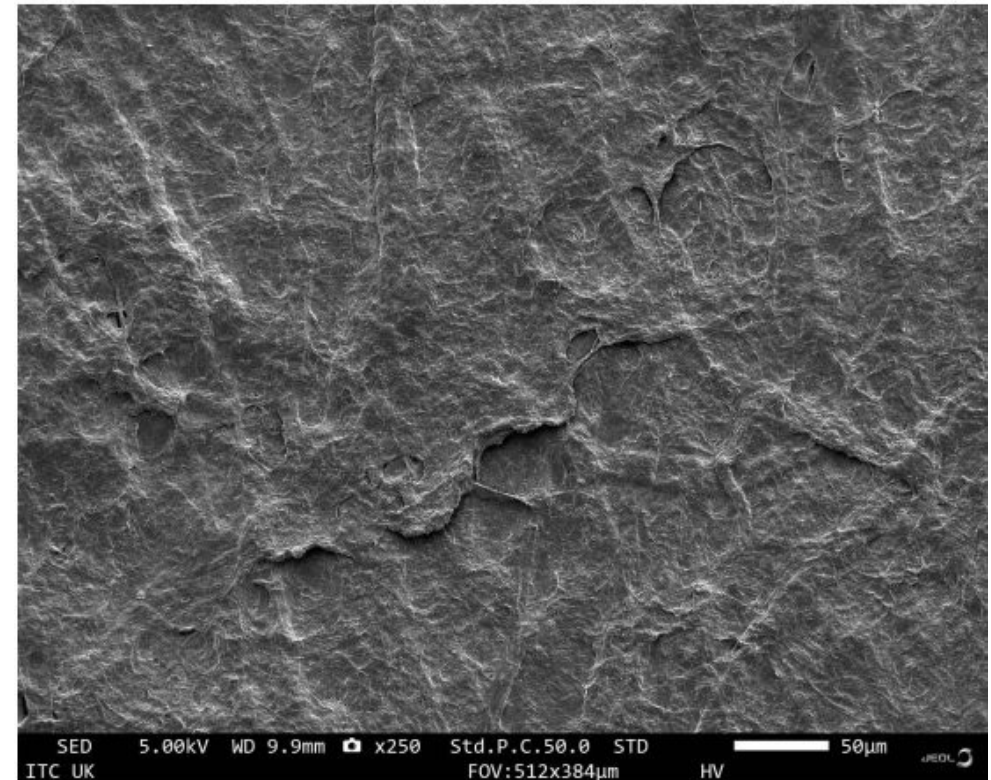
- A 4 g/m² coating provided substantial changes to the surface topography and structure.
- With a 12 g/m² coating, the MFC has formed a film and reached sufficient thickness to achieve high barrier properties.
- A **4-6 g/m²** MFC coating is recommended as a **barrier pre-coat**.

The effect of pre-treatment and process conditions on the gas barrier properties of fibrillated cellulose films and coatings: A review, Hill et al, Carbohydrate polymers 337 (2024) 122085.

MFC Coatings – Surface Images



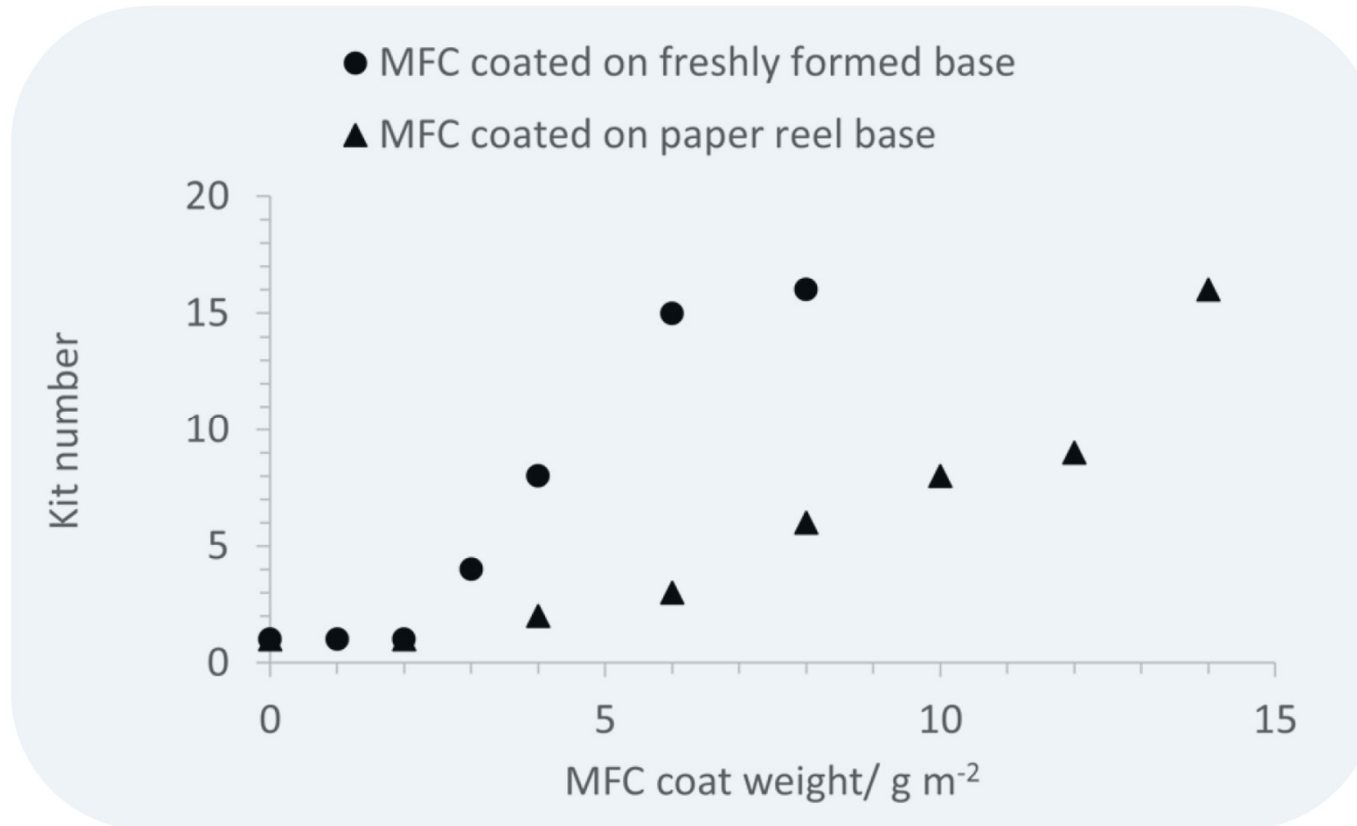
Base paper reference 45 g/m² (0 g/m² MFC)



MFC coated paper 45 g/m² (6 g/m² MFC)

Papers produced and coated on a commercial paper machine.

MFC Coatings – Grease Resistance



Hill, R., 2024. *The Effect of Microfibrillated Cellulose Characteristics on Barrier Properties for Packaging Applications*. EngD Thesis, University of Birmingham, UK. (KIT 16 = 100% heptane test solution)

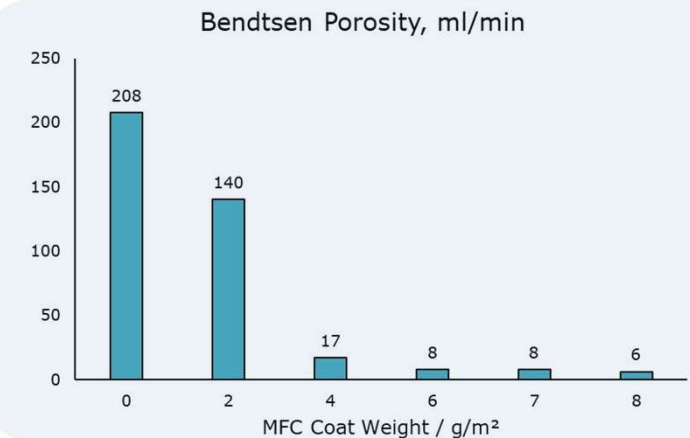
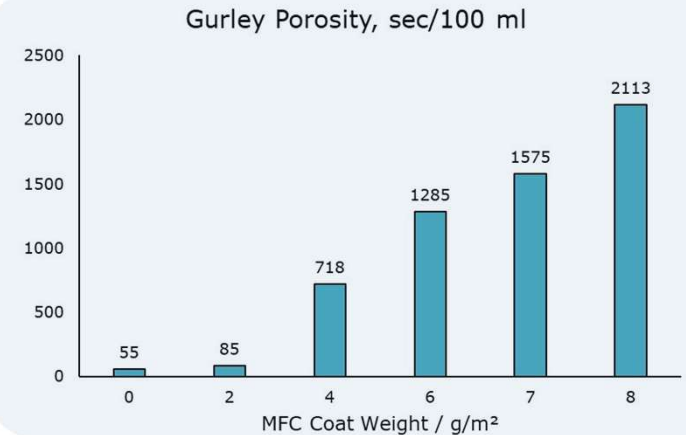
MFC Coatings – Mill Trial



- Significant closure of the sheet was observed through the application of MFC.
- Pinholes were visible in oil draw down tests, so the surface was not yet “completely closed” to a point where barrier properties could be achieved.
- Nonetheless, the significantly lower permeability should enable improved performance of topcoats applied or enable a reduction in topcoat weight to achieve a target performance.
- **Post trial addition of starch coating by customers resulted in chemical free-mid level grease resistant paper for fast food wrap.**



8 gsm MFC (Day 1) – Droplet test with Oleic Acid during trial.



MFC in Moulded Fibre





MFC in Moulded Fibre

Pilot line trial



(0% MFC)

(10% MFC)

(17% MFC)

KIT = 0 out of 12

KIT = 0 out of 12

KIT = 4 out of 12

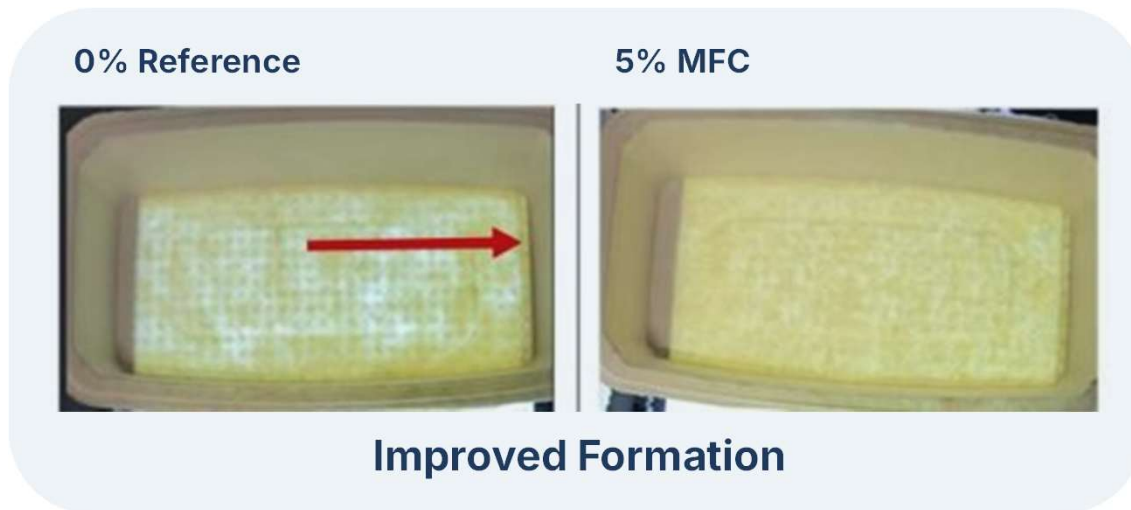
MFC Content (%)	Tray Basis Weight (g/m ²)	Tensile stiffness index (Nm/g)	Tensile strength index (Nm/g)	Tensile stiffness (N/m)	Tensile strength (N/m)	Bendtsen Porosity (ml/min)
0	480	2.634	21.2	1270	10.2	2750
10	380	3.45	37.2	1300	14	160
17	280	5.04	53	1430	15.1	15
25	175	5.37	56.4	930	9.8	4

- Up to **50% reduced object weight** whilst maintaining strength, stiffness and mouldability.
- **Greatly improved smoothness**, and **reduced porosity**.
- **Improved hold-out** of functional coatings and effectiveness of sizing.
- Increased **density**.
- Reduced **dusting**.



MFC in Moulded Fibre

5% MFC addition, commercial line



- **Most properties improved** with addition of MFC.
- An increase in cycle time was observed with the addition of MFC at a constant article weight, but this was offset by lightweighting.

Property	Performance
Article Weight	-15%
Density	+16%
Gurley Porosity	+1250%
PPS Roughness	-5.50%
Scott Bond	+120%
Tear Strength	+96%
Tensile Stiffness	+15%
SCT	+13%

MFC in Moulded Fibre – Surface Coating

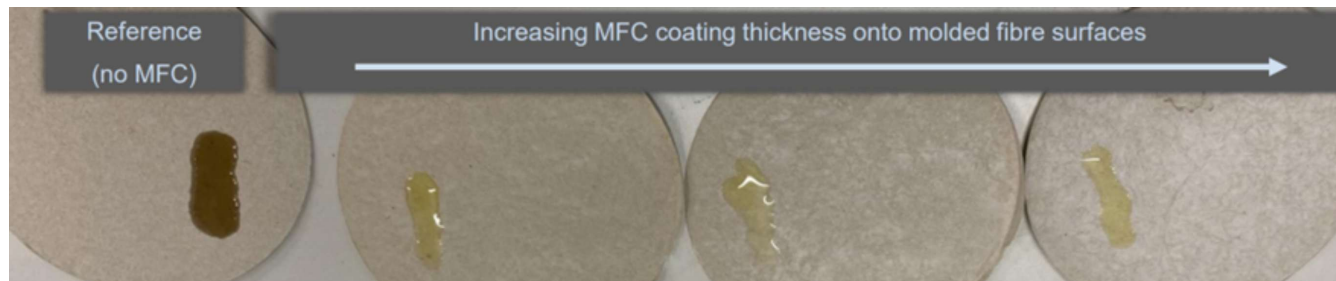


Grease barrier properties – up to KIT 12 possible.

Oxygen barrier properties – MFC coating will reduce oxygen transmission rate.

Aroma barrier properties

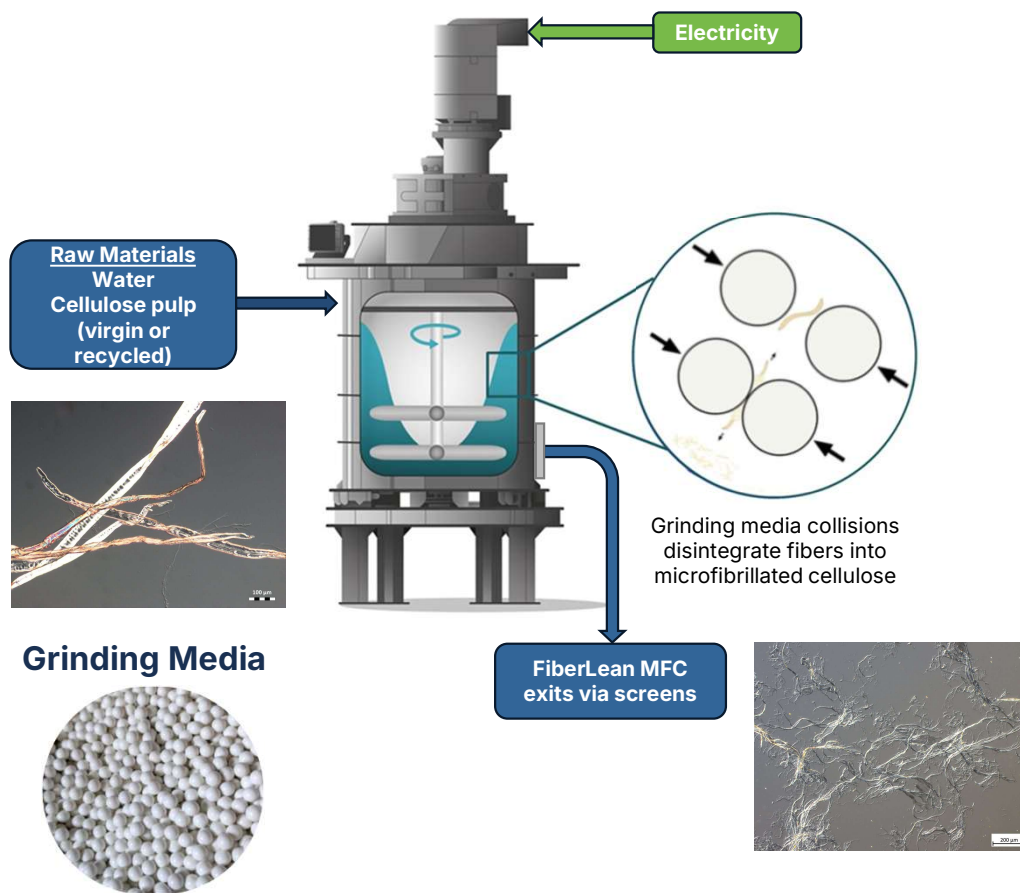
Excellent primer or pre-coat – enhances performance of other barrier coatings or reduces required coat weight.



MFC use in Practice

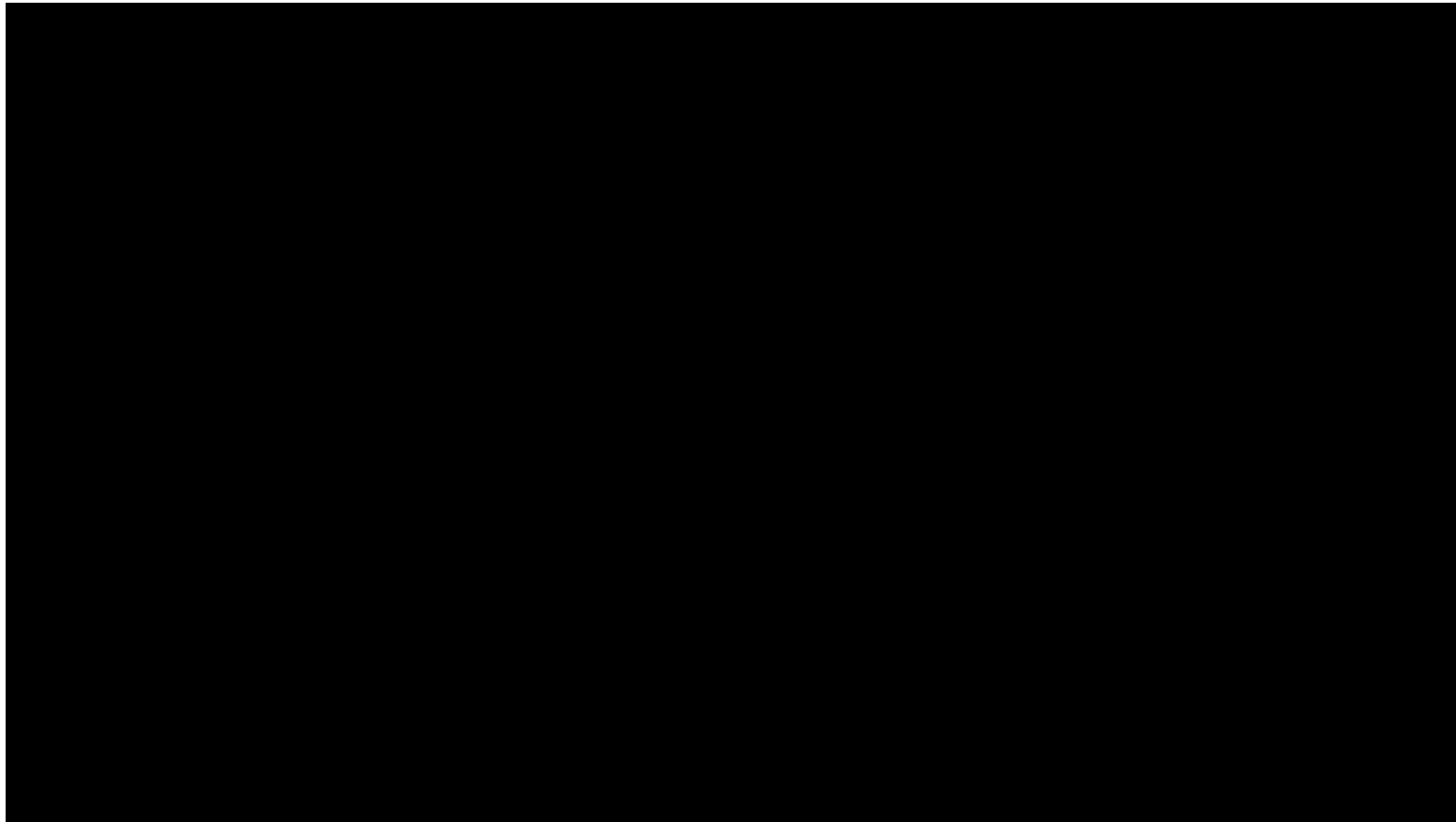


Stirred Media Mill Grinders



- **Stirred vessel**, charged with water, pulp and **ceramic grinding media**.
- **Mechanical method**, no chemical / enzyme pretreatment needed.
- Fibrillation occurs when fibres gets trapped between colliding grinding media particles.
- Grinding media are the 'working surfaces' for fibrillation; very high active surface area; permits **high throughput and efficient** production of MFC.
- **Continuous, single pass** operation; energy input controlled by flow rate and motor power.
- Production **solids 1-2%** - on-site production.
- Typical MFC production cost – **€400/t**

Grinder in Operation



MFC Grinder Sizes



G250 MFC Grinder

Capacity ~ **1200** dry metric tonnes of MFC per grinder per year. Appropriate size for most **paper and board** applications.



G175 MFC Grinder

Capacity ~ **600** dry metric tonnes of MFC per grinder per year.
Small paper mills, tissue mills.



G125 MFC Grinder

Capacity ~ **100** dry metric tonnes of MFC per grinder per year.
Speciality applications, moulded fiber etc.

Use of MFC in Paper and Board



In the furnish

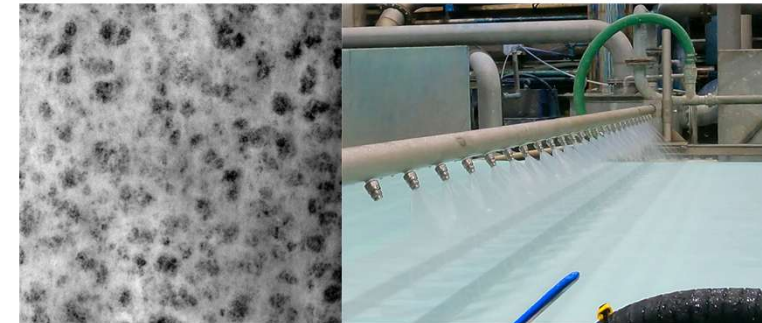
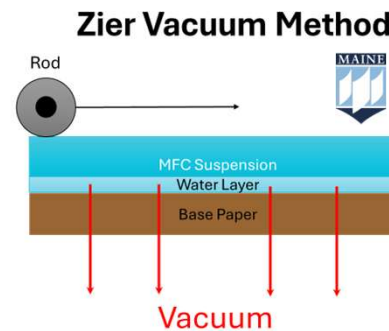
- MFC production integrated into mill wet end
- MFC added at the mixing or blend chest

MFC on the surface

- Wet end applicator – successful commercial trials completed
- Spraying – not recommended on paper machine
- Size press – not recommended
- Dry paper/board application – pilot scale development at University of Maine



Image: 3-meter-wide surface applicator operating on a paper machine running at 500 m/min



Zier et al., (2025) Cellulose 32(18):10831-10849

Zier S, Bousfield D, Howell C, Hoeft Z. U.S. Provisional Appln. No.: 63/907,362

Use of MFC in Moulded Fibre



In the furnish

- MFC grinder installed with stock preparation equipment
- A portion of pulp is converted into MFC and added back into the furnish

On the surface

- Double dipping method - Kiefel
- Spraying
- Archipelago Powerdrop coater

Food Contact Clearance and Recyclability



- **BfR, FDA, ANVISA**, Canadian and Chinese food contact paper clearance.
 - FDA FCN 002413.
 - BfR Recommendations XXXVI, XXXVI/1, XXXVI/2 & XXXVI/3.
 - FiberLean grinder produced MFC falls within these clearances.
- **End-of-life**
 - MFC coated paper has been demonstrated to be:
 - **Recyclable** – PTS-RH 021:2012 – bleached and unbleached MFC coated papers passed.
 - **Biodegradable** – OECD 301B – MFC suspensions with and without biocide were biodegradable.
 - **Compostable** – ISO 14855 – bleached and unbleached MFC coated papers were biodegradable under industrial composting conditions.

Summary



MFC in coated paper and board

- In the base – reduced porosity, improved mechanical properties, improved coating hold-out, improved sealing.
- On the surface – very low porosity, oil/grease barrier properties, barrier primer/pre-coat.

MFC in moulded fibre

- In the furnish – lightweighting, improved mechanical and surface properties, higher density, lower porosity, improved sealing.
- On the surface – oil/grease barrier properties, very low porosity, barrier primer/pre-coat.

MFC production and use

- FiberLean MFC grinders enable cost effective on-site production of MFC.
- MFC production integrated into wet end paper mill or moulded fibre production.
- MFC can be applied as a coating to paper, board or moulded fibre.



**Thank you for
your attention**

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