FiberLean
Strength by Design

Unlocking the Full Potential of MFC in Moulded Fiber

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Presentation Outline

- Company Overview
- What is MFC?
- Why use MFC?
- Why use MFC now?
- FiberLean MFC grinders
- Regulatory
- Summary

Company Overview

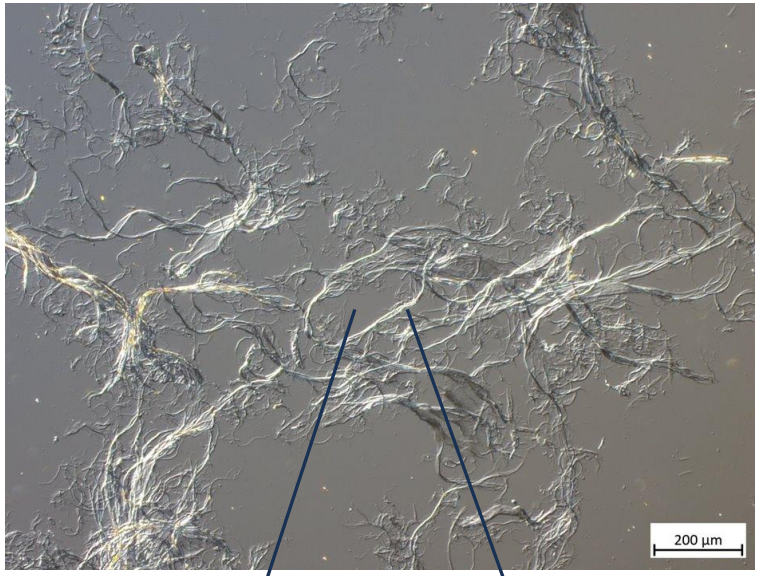
FiberLean Technologies sell FiberLean MFC grinders

- Leading independent MFC equipment supplier
- Operating since 2016
- World-class technical expertise in MFC technology and production
- Operating industrial-scale MFC plant in Cornwall, UK producing MFC for trials and interim supply
- State-of-the-art industrial research and application laboratories
- Capability to conduct onsite MFC trials worldwide
- Experienced engineering and project implementation team
- Leading research on MFC use and application with extensive patent portfolio
- Equipment supply and fabrication partners

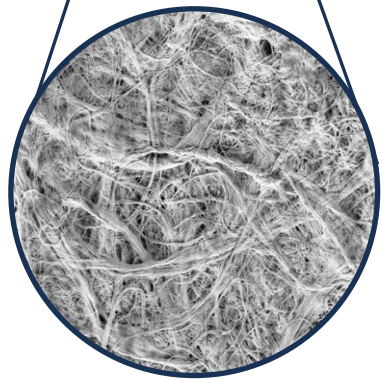
What is MFC?

- Grinder-produced MFC is best described as '**surface-nanostructured macromaterial**'.
- Micrometre and nanometre scale fibrillar surface structure on a sub-millimetre scale macrostructure.
- **Fine** and long **micro and nano fibrils** in the **nanostructure** enhance **bonding** at fiber-fiber joints.
- A **coarse macrostructure** improves **bridging** between fibers and **improves MFC retention**.
- The objective is usually to efficiently generate a **high level of microfibrillation whilst retaining coarse macrostructure**.

Optical micrograph showing MFC **coarse macrostructure**.



SEM showing MFC fibrillar **micro and nano structure**.



Why use MFC?

- Densification
  - Enables lightweighting – raw materials cost savings
  - Reduced porosity
  - Improved surface barrier coating hold-out
  - Improved wet-end barrier additive performance
- Improved surface properties
  - Improved surface quality
  - Reduced dusting
  - Reduced fibre uplift – potential to reduce polymer film thickness
- Improved operations
  - Formation and pulp stability – reduced waste
  - Deposits
- Surface coating
  - 100% fibre oil/grease barrier
  - Pre-coat for moisture barrier – towards high barrier applications

Lightweighting

What is possible?



(**0%** MFC)
KIT = 0 out of 12

(**10%** MFC)
KIT = 0 out of 12

(**17%** MFC)
KIT = 4 out of 12

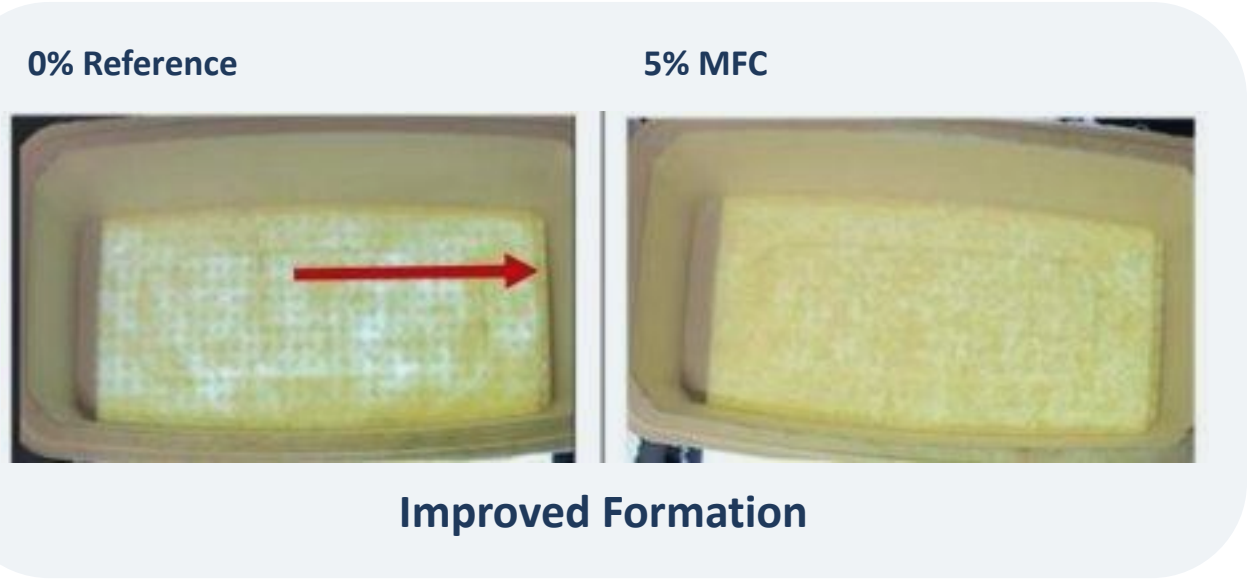
MFC Content (%)	Tray Basis Weight (g/m^2)	Tensile stiffness index (Nm/g)	Tensile strength index (Nm/g)	Tensile stiffness (N/m)	Tensile strength (N/m)	Bendtsen Porosity (ml/min)
0	480	2.63	21.2	1270	10.2	2750
10	**380**	**3.45**	**37.2**	**1300**	**14.0**	**160**
17	**280**	**5.04**	**53.0**	**1430**	**15.1**	**15**
25	**175**	**5.37**	**56.4**	930	**9.8**	**4**

Pilot scale study

- 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**

Lightweighting

What is possible?



Improved Formation

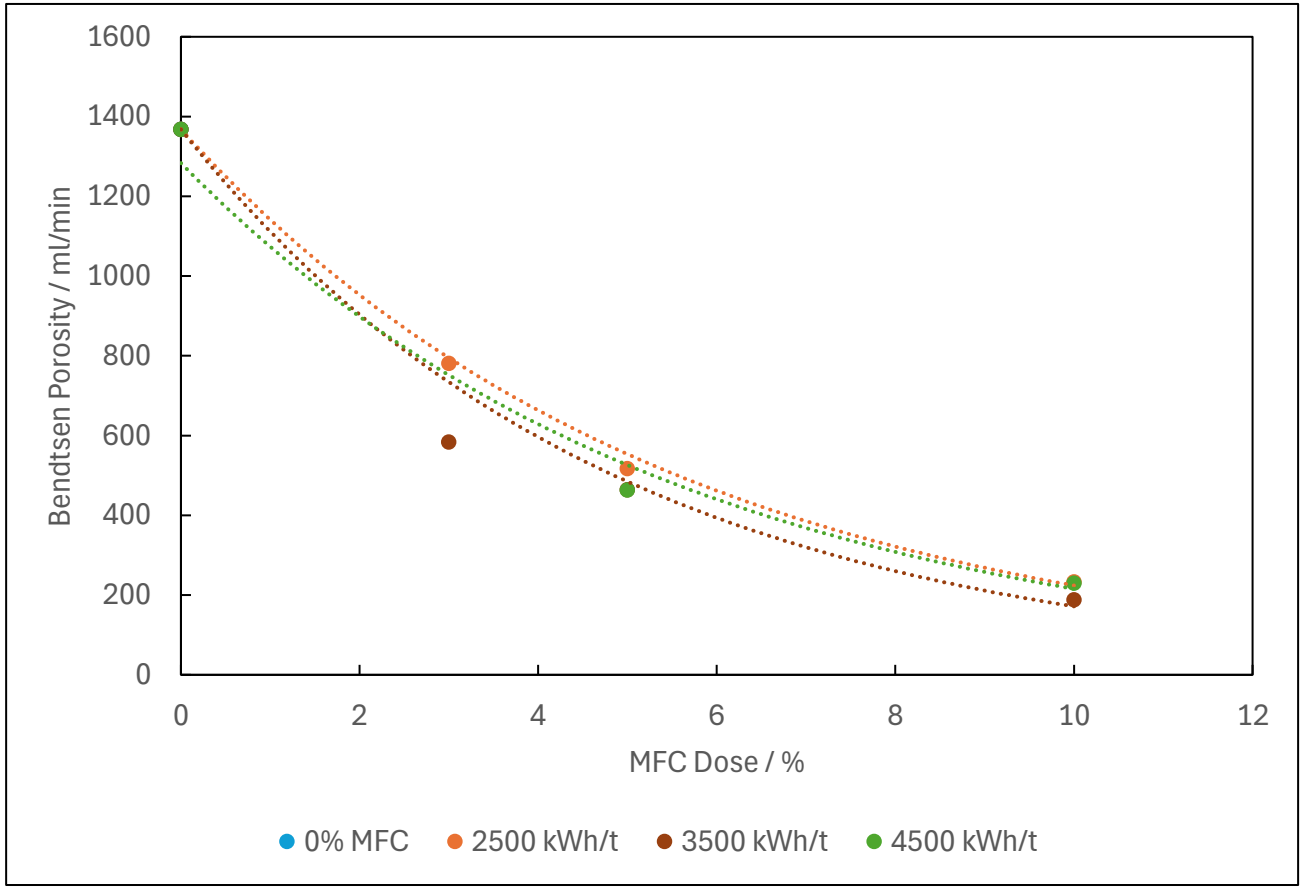
- Commercial moulded fiber line
- **Most properties improved** with addition of MFC
- An increase in cycle time was observed with the addition of MFC at a constant article weight, but this was offset by lightweighting

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%

Porosity

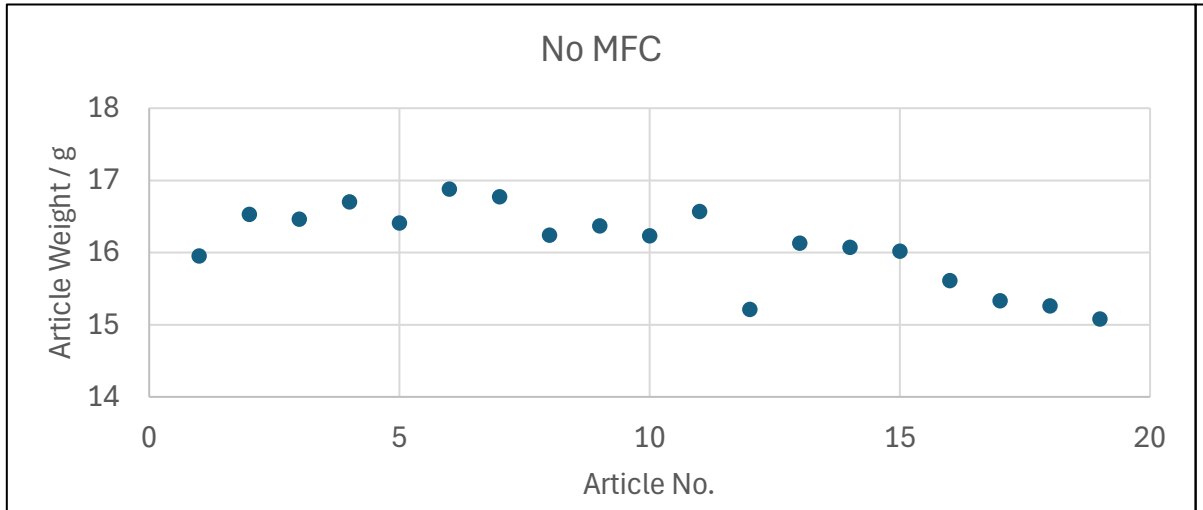
- MFC added to the furnish
- Significant reduction in porosity
- No clear difference between MFC grades

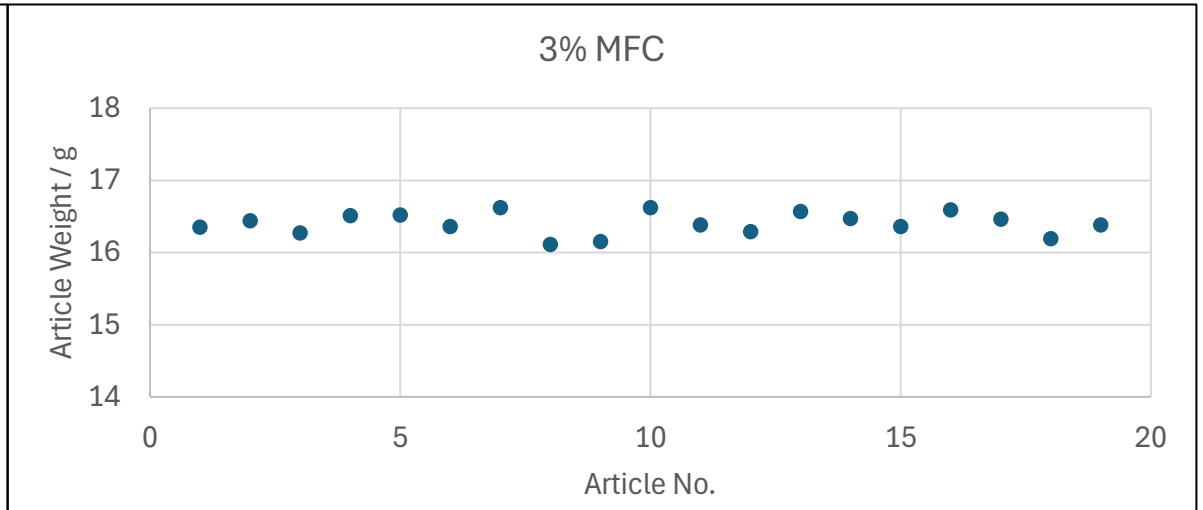
- Improved coating hold-out
- Improved wet end barrier performance

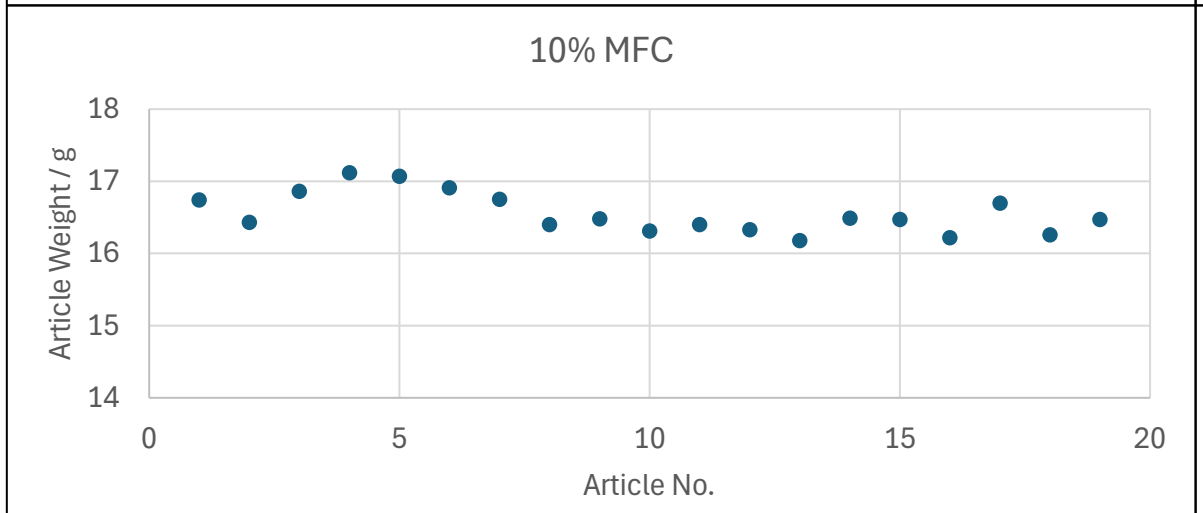


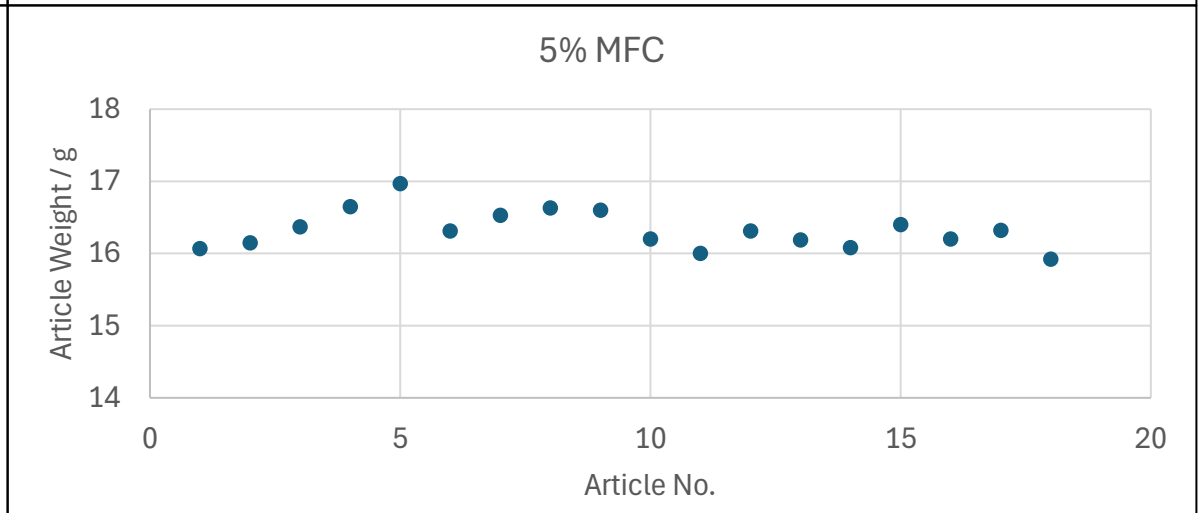
Article Weight Stability

Relative standard deviation ~3% without MFC, 1.4% with MFC









Oil Barrier

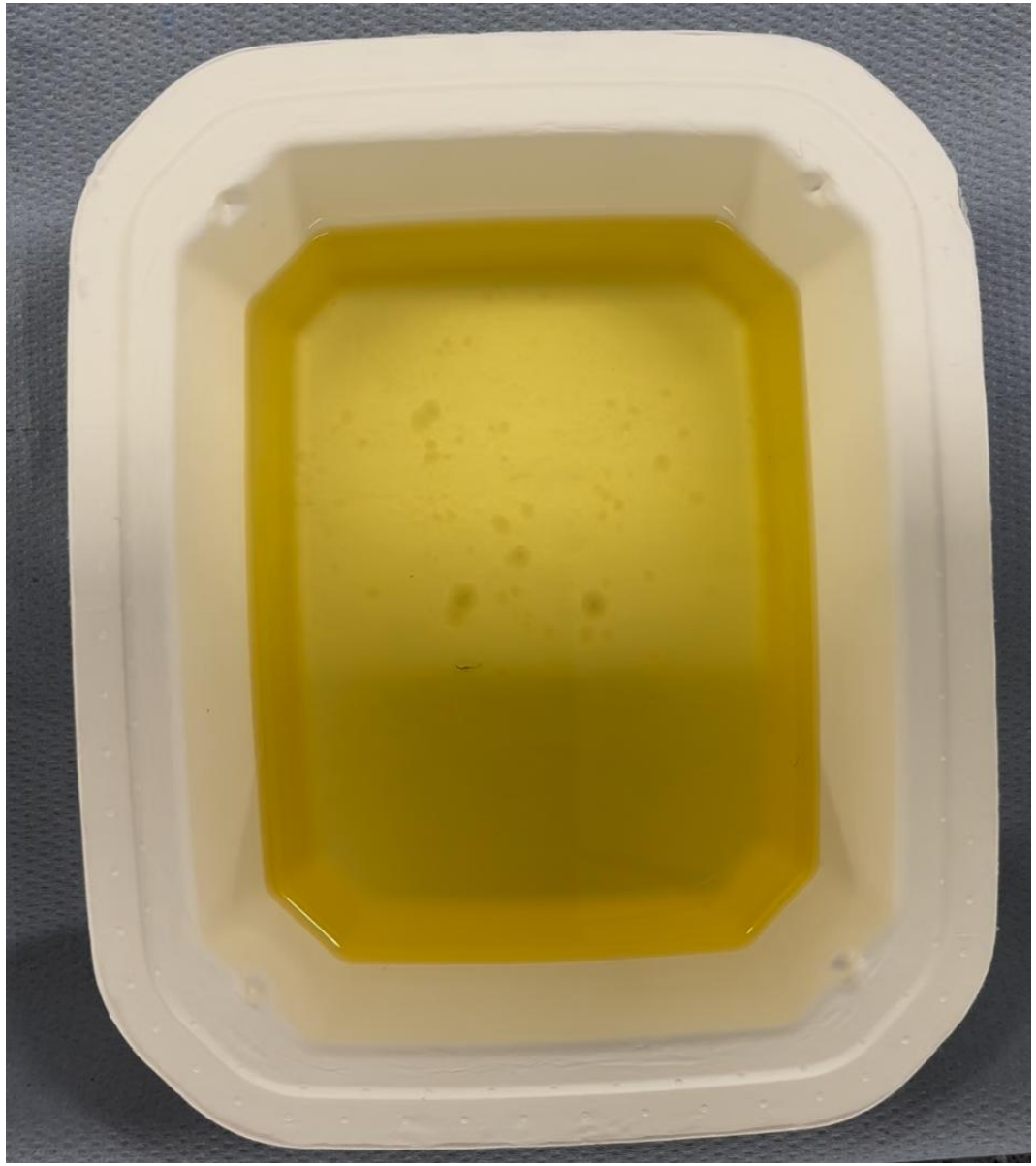
- Uncoated tray
- Made with Kiefel NATUREFORMER KFT Lab
- Oil penetrates instantly
- Oil pass through @ 15 s

- How much MFC do you need for oil barrier?
- Which MFC is the most effective?



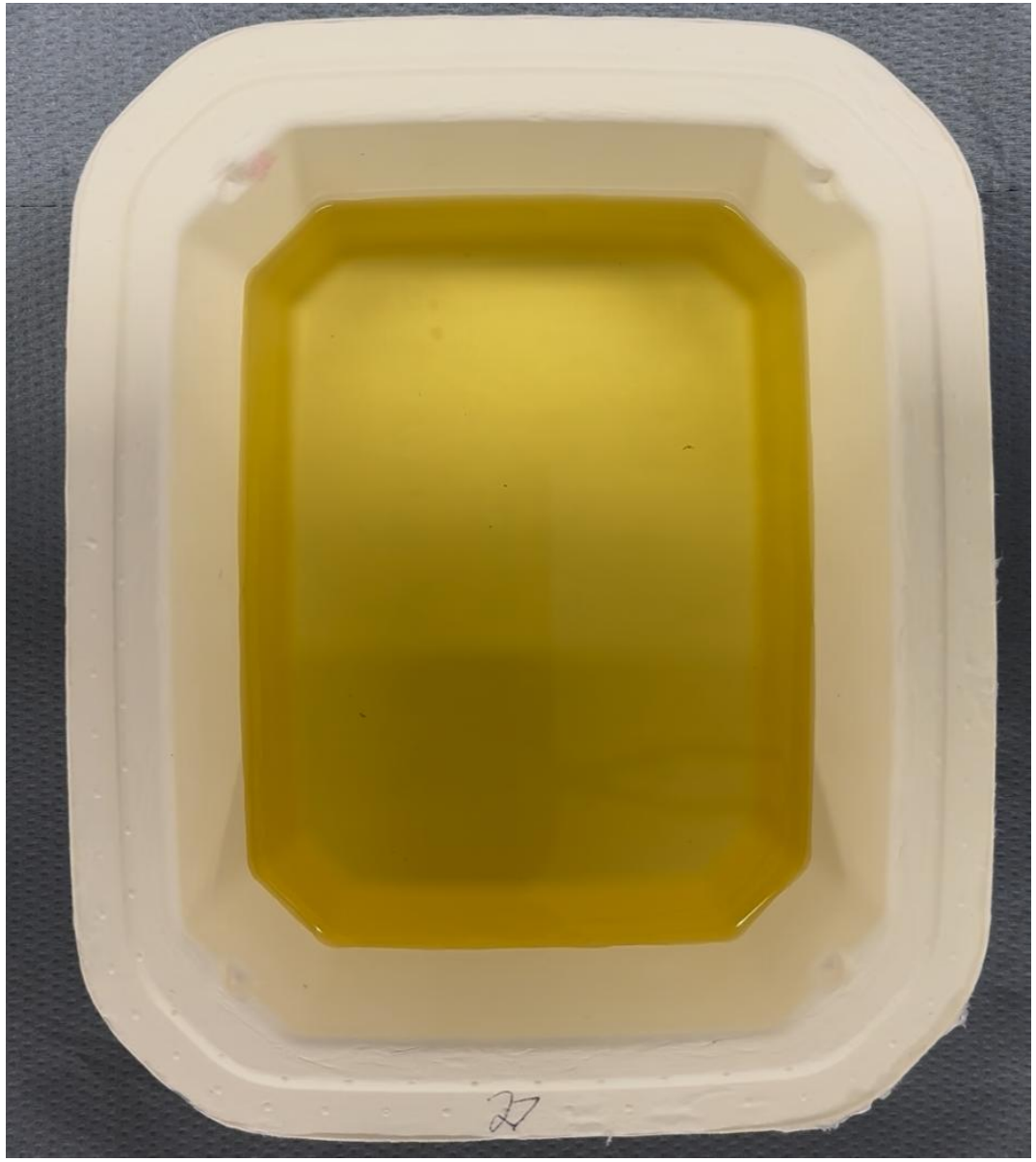
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- Low energy MFC
- 2nd dip suction time **1.5 s**
- **~6 g/m²** coatweight (~0.2 g per article, 1.4%)
  - First pinholes at 10 s
  - Photo @ 5 minutes
  - No oil pass though after 3 hours +



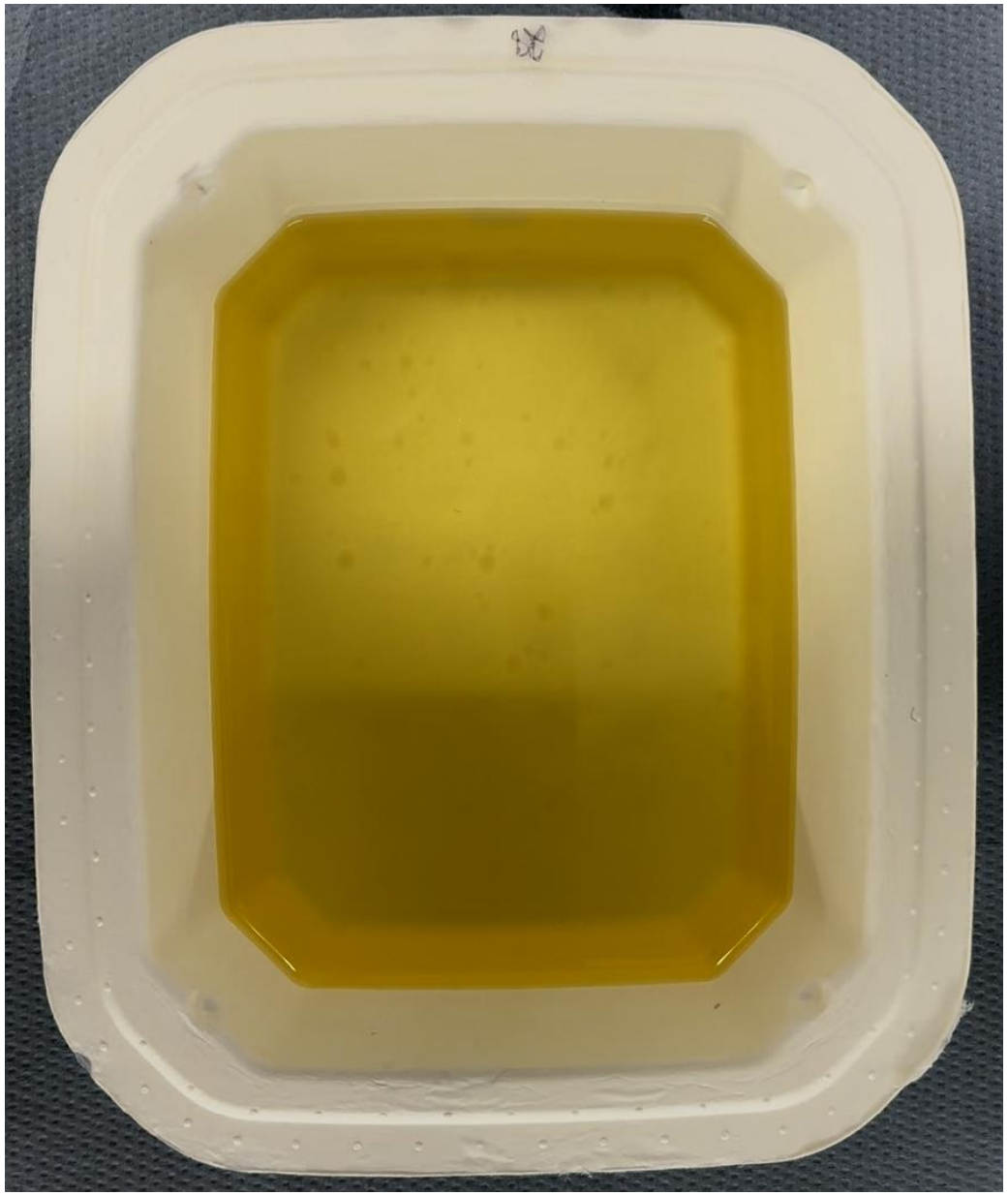
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- Low energy MFC
- 2nd dip suction time **3 s**
- **~14 g/m²** coatweight (~0.5 g per article, 3%)
  - One pinhole at 1 min
  - Photo @ 4 minutes
  - No oil pass though after 3 hours +



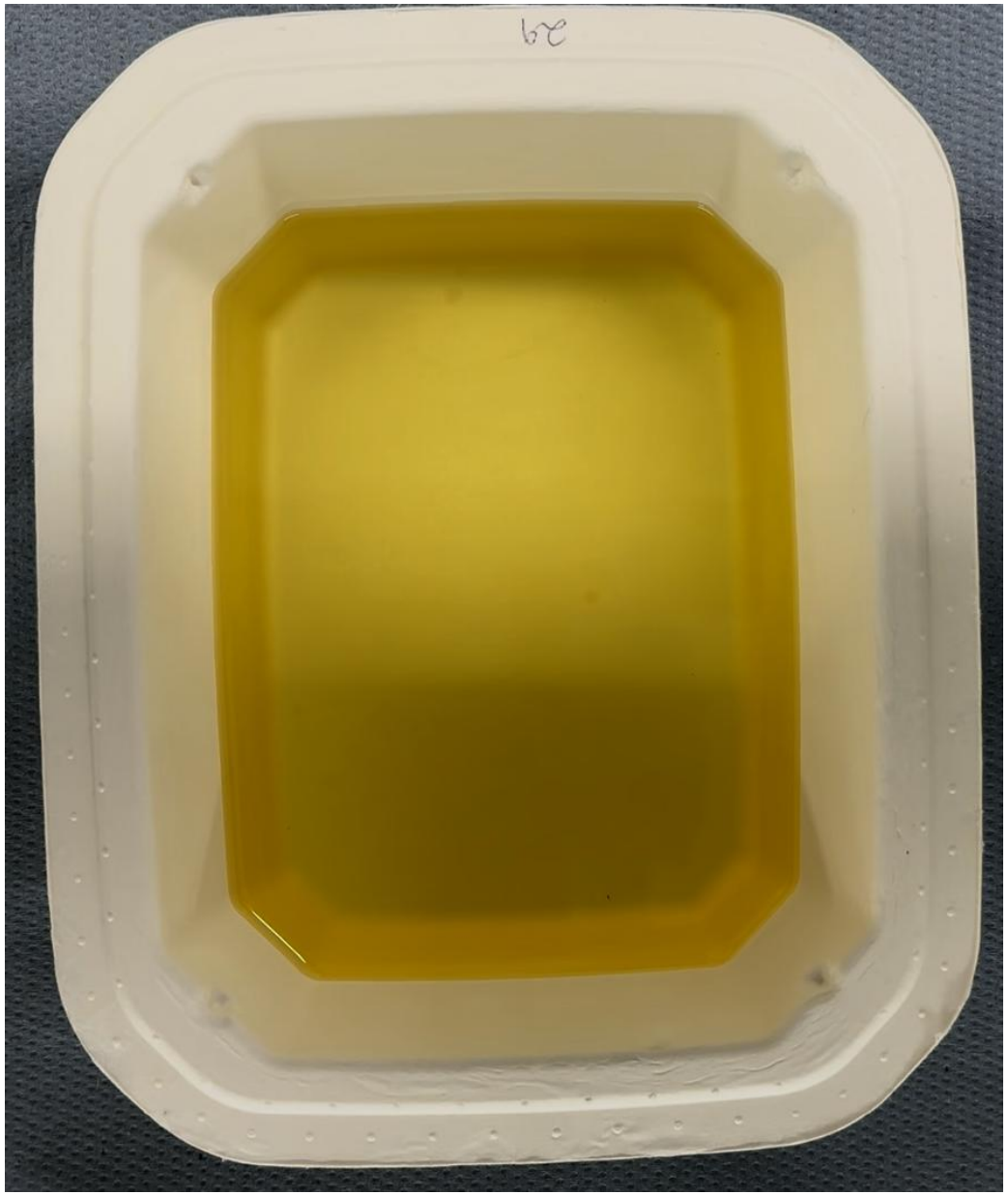
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- Medium energy MFC
- 2nd dip suction time **1.5 s**
- **~6 g/m²** coatweight (~0.2 g per article, 1.4%)
  - First pinholes at 10 s
  - Photo @ 4 minutes
  - No oil pass though after 3 hours +



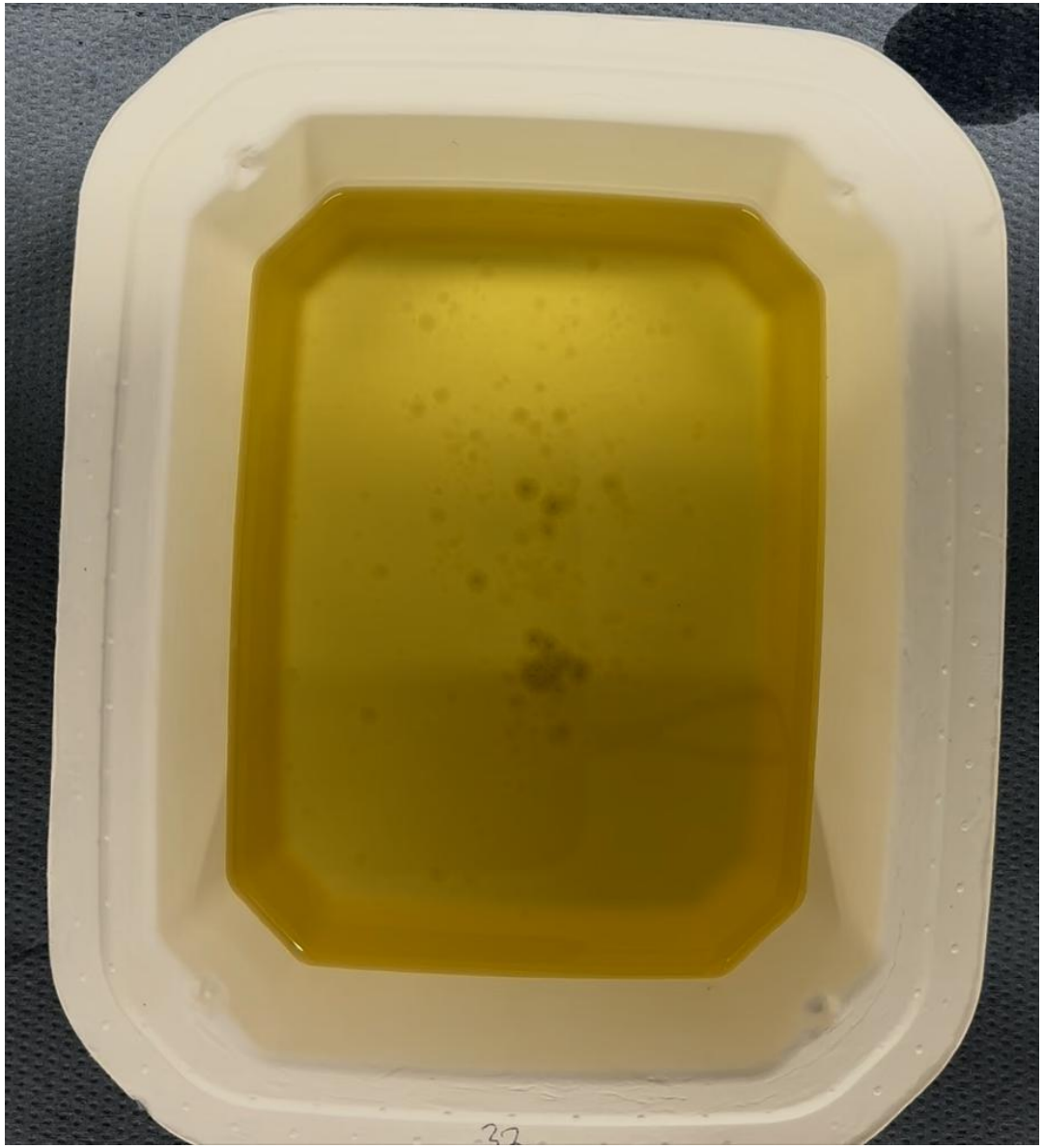
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- Medium energy MFC
- 2nd dip suction time **3 s**
- **~13 g/m²** coatweight (~0.5 g per article, 3%)
  - One pinhole at 10 s
  - Photo @ 5 minutes
  - No oil pass though after 3 hours +



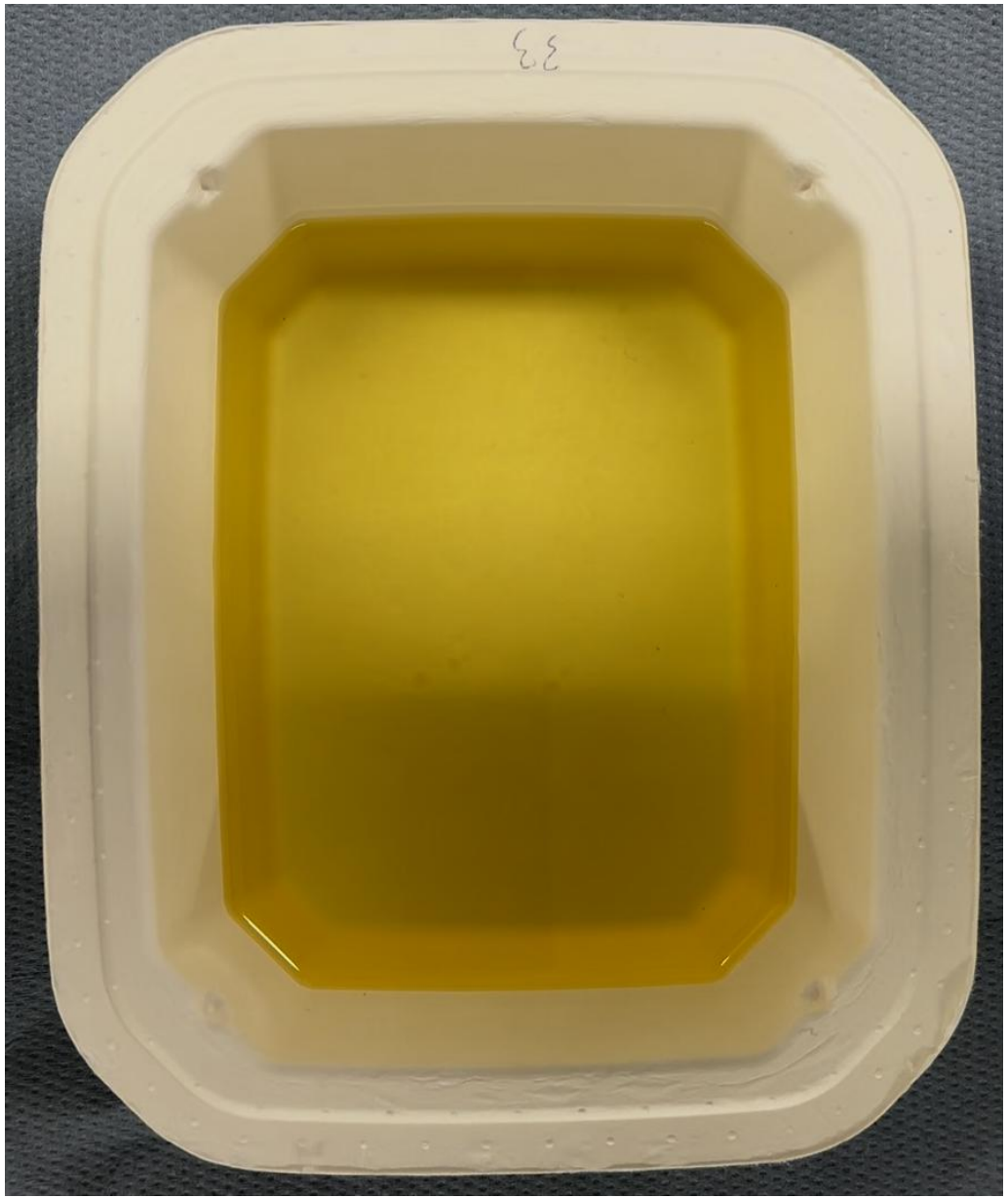
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- High Energy MFC
- 2nd dip suction time **1.5 s**
- **~6 g/m²** coatweight (~0.2 g per article, 1.4%)
  - First oil penetration at 5 s
  - Photo @ 3 minutes
  - No oil pass though after 3 hours +



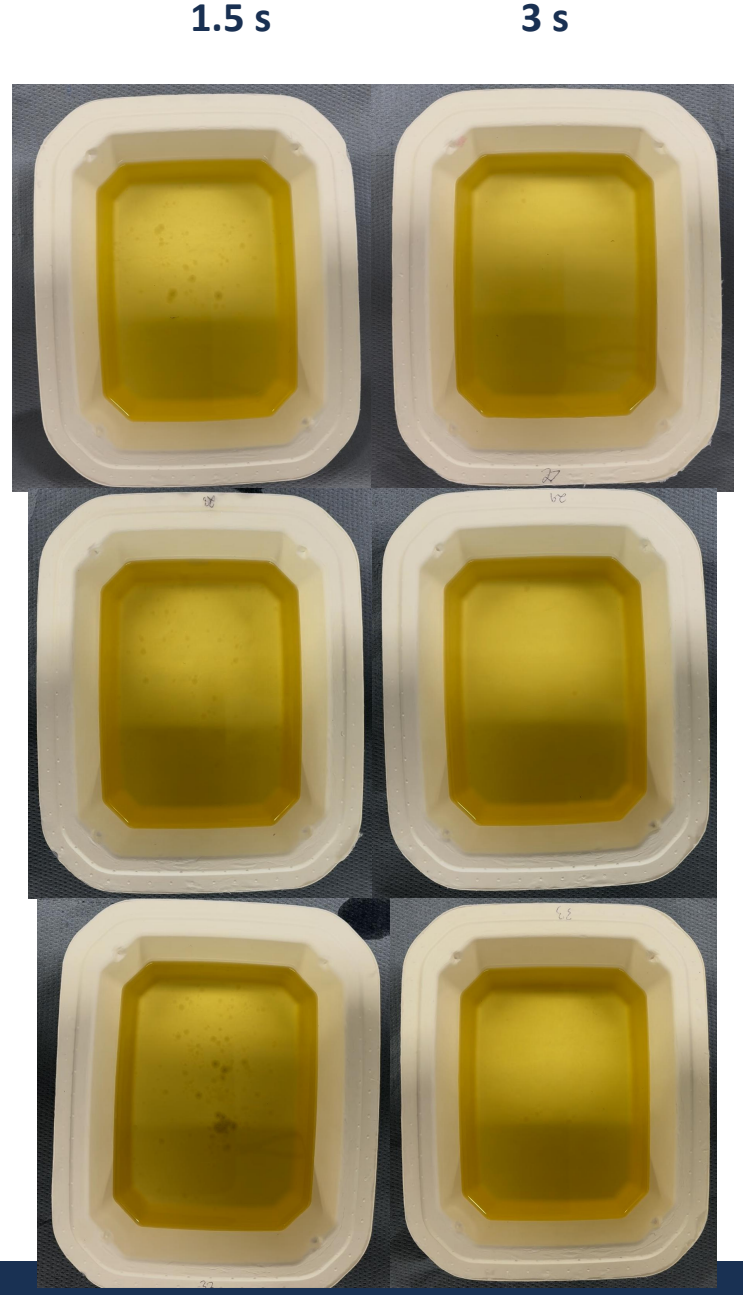
Oil Barrier

- MFC coated tray
- Made with Kiefel NATUREFORMER KFT Lab
- High energy MFC
- 2nd dip suction time **3 s**
- **~11 g/m²** coatweight (~0.4 g per article, 2.6%)
  - One pinhole at 10 s
  - Photo @ 5 minutes
  - No oil pass though after 3 hours +



Oil Barrier

- Short term oil barrier possible with low coatweights and short suction times
- None of the samples showed transfer of oil onto the tissue after >3 hours
- High energy MFC not required for good oil barrier
- Probably due to better retention of MFC on the surface
- 5 s suction time gives oil barrier for > 1 day



Why use MFC now?

MFC has promised great value for many years, but take-up has been slow.

Obstacles – Production equipment, cost, regulatory clearance, material availability.

Reliable cost-effective MFC production equipment now available:

FiberLean MFC Grinders

MFC production equipment sized for moulded fibre

Regulatory clearance now in place

Multi-tonne production of MFC for trials and interim supply is available

MFC for Moulded Fibre

Merchant supply vs on-site production

External supplier

- No capital expenditure
- Very expensive
- No flexibility
- No control over MFC or fiber source
- Useful as a stop-gap while waiting for on-site production equipment installation

On-site MFC production

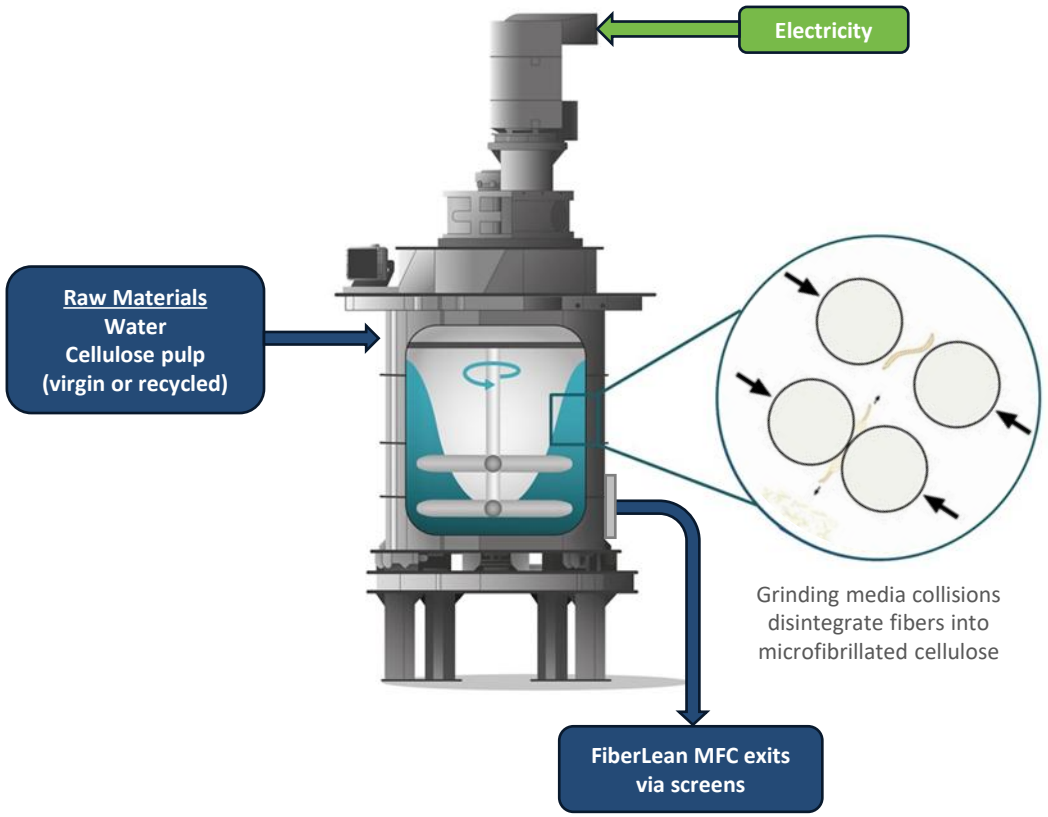
- FiberLean MFC grinder integrated into pulp preparation area
- G125 grinder sized to suit moulded fiber production
- Full control of MFC properties
- Capable of producing MFC from any chemical pulp, recycled pulp or pulped waste scraps
- Low MFC conversion cost
- No need to store MFC - 1 month = 40 pallets



		G125 Grinder
Typical use case		Moulded fiber producers
Footprint (m)		3.4 x 2.1
Max. height (m)		3.8
Capacity	kg/h	12
	tpa	~100

FiberLean MFC Grinders

Vertical Wet Stirred Media Mill Grinders



How it works

- Stirred vessel, charged with water, pulp and ceramic grinding media beads.
- Fibrillation occurs when pulp gets trapped between colliding grinding media beads.
- Grinding media are the ‘working surfaces’ for fibrillation; very high active surface area; permits high throughput and efficient production of MFC.
- Pulp suspension is added continuously to top of mill.
- Product exits continuously through screens near bottom of mill.
- Energy input is controlled with outlet flow rate and motor power.
- Mechanical, additive-free process.
- Continuous, single pass.

Advantages of FiberLean MFC Grinders



Advantages

- Simple, robust design.
- Intrinsically stable process.
- Easy to operate with low supervision.
- Mechanical, additive-free process.
- Continuous, steady-state, single pass process.
- High-quality MFC from a wide range of feeds.
- Highly tunable – optimise structure-property relationships for applications.
- MFC cost is energy + consumables.
- Simple installation.
- Low total project capex and fast payback times.

Large-scale Grinder in Operation



Grinder-produced MFC

Regulatory, End-of-life

- **BfR, FDA and others**
  - FDA FCN 002413.
  - BfR Recommendations XXXVI, XXXVI/1, XXXVI/2 & XXXVI/3.

- **No negative health** effects found.
  - Dietary Study
  - Physical, chemical, and toxicological characterisation
  - Inhalation risk analysis

- **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

- Operational benefits can reduce waste increase efficiency
- Lightweighting can give cost savings and offset cycle time increase
- MFC densifies articles and dramatically reduces porosity – a key tool for achieving barrier targets
- High coat weights and high energy MFC are not required for short-medium term oil barrier
- Where MFC can add value will depend on:
  - Moulded fiber products
  - Barrier performance requirements
  - The moulded fiber equipment available
  - New installation vs. retrofit
  - Limitations of existing equipment
- On-site MFC production is essential and the equipment is available



Thank you for your attention

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