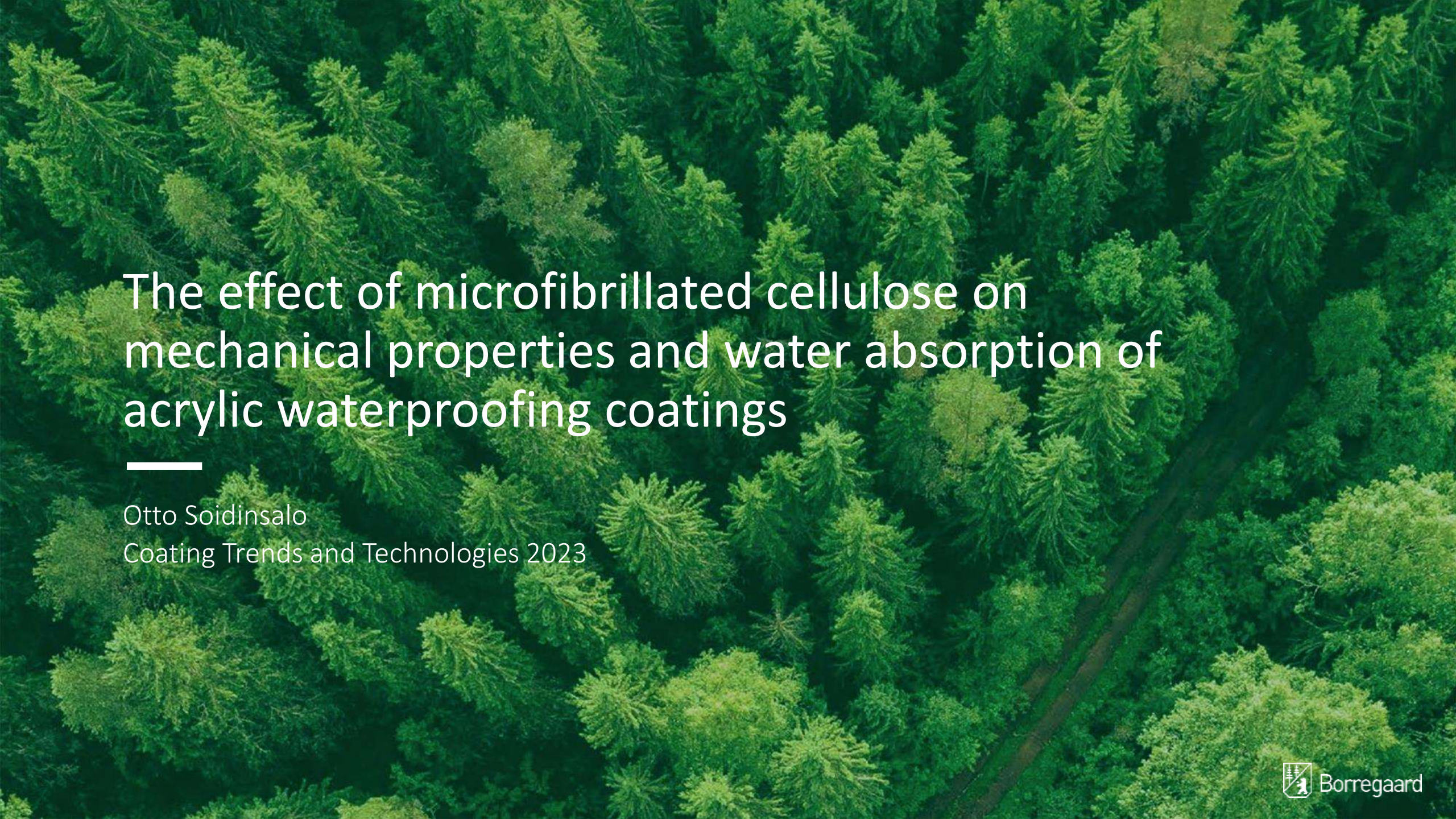


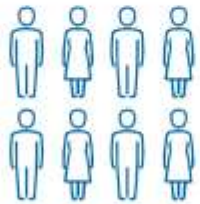
The effect of microfibrillated cellulose on mechanical properties and water absorption of acrylic waterproofing coatings

Otto Soidinsalo

Coating Trends and Technologies 2023

Borregaard

EMPLOYEES



1100

PRODUCTION

- Biopolymers
- Speciality cellulose
- Bioethanol
- Biovanillin
- Cellulose fibrils
- Fine chemicals

800
PRODUCTS

RAW MATERIAL

1 MILLION

m^3 Norway Spruce
375.000 tonnes lignin raw material

BORREGAARD IN THE WORLD

Business in
13
countries

Sales to
100
countries

Sales outside Norway
95
percent

FINANCIAL FIGURES

Turnover
6.9
billion NOK

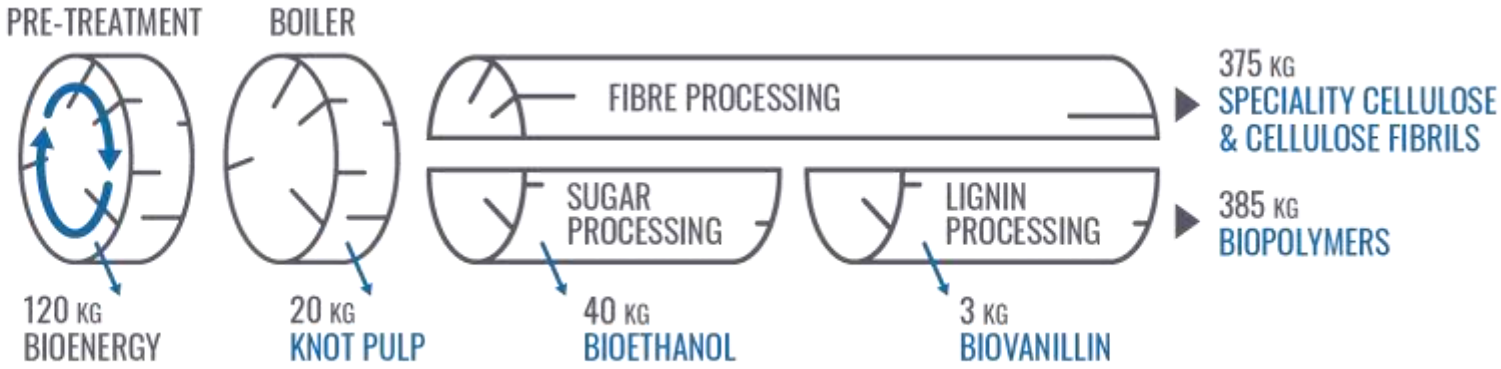
Result EBITDA
1.6
billion NOK

Investment
465
million NOK

High utilisation of raw materials

1000 KG
WOOD

94%
UTILISATION



BIOPOLYMERS
Concrete additives
Animal feed
Agrochemicals
Batteries
Briquetting
Soil conditioning

BIOVANILLIN
Food
Perfumes
Pharmaceuticals

SPECIALITY CELLULOSE
Construction materials
Filters
Inks and coatings
Casings
Food
Pharma
Personal care
Textiles

CELLULOSE FIBRILS
Adhesives
Coatings
Agricultural chemicals
Personal care
Home care
Construction

BIOETHANOL
Biofuel
Disinfectants
Pharmaceutical industry
Home care
Personal care
Paint/varnish
Car care

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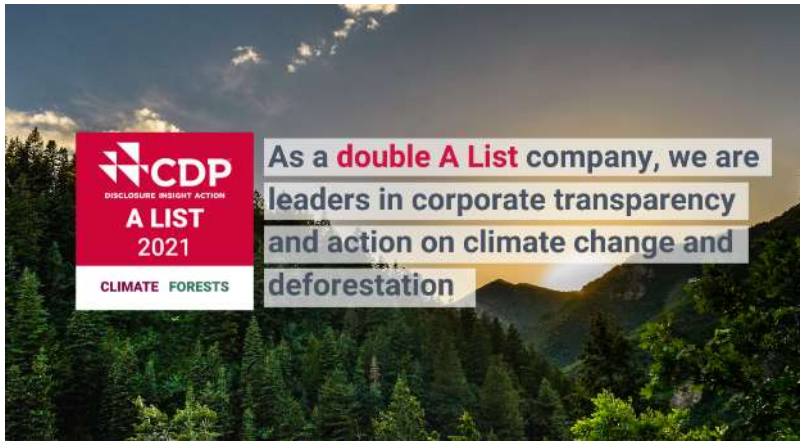
Climate change and the environment – targets and ratings



- Science Based Targets for GHG emissions approved by SBTi
  - Targeted reductions in GHG emissions (scope 1 and 2):
    - 42% absolute reduction by 2030 (Base year = 2020)
    - Net-zero target, 90% absolute reduction by 2050
  - Targets in line with 1.5°C goal in Paris Agreement and Norwegian Climate Law
- Highlighted as a global leader in corporate climate action by CDP
  - Borregaard among top 20 companies out of 13,000 reporting
    - A score within Climate Change (4 years in a row) and Forests
    - A- score within Water security
- Platinum status in EcoVadis Supply Chain
- Top 1% of 90,000 reporting companies

PLATINUM Top 1%
2022
ecovadis
Sustainability Rating

Borregaard

Biobased performance additives

Dispersants

- 100 % biobased and renewable
- Improves pigment milling efficiency by reducing slurry viscosity
- High color strength and hiding power through efficient pigment dispersion
- Tolerant and robust
- Anti-oxidant and UV-absorber

Rheology modifiers

- 100 % biobased and renewable
- Strong low shear thickeners with minimum impact on mid and high shear viscosity
- High yield stress
- Strongly shear thinning
- Stable in extreme environments including pH (1-13), temperature and shear
- Prevents mud-cracking, improves open time and increases strength

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Elastomeric waterproofing coatings

Elastomeric roof coatings

Water proofing coatings

- Construction
- Bathrooms

Borregaard

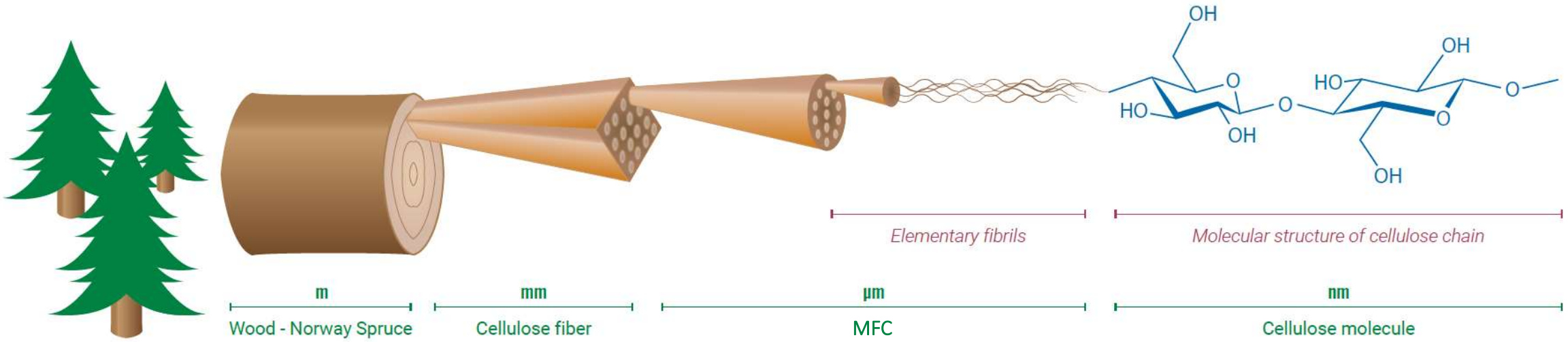
Elastomeric waterproofing coatings - requirements

- Reflectivity and UV resistance
- High tensile strength with good elasticity
- Good water resistance
- Permeability
- Dry and wet adhesion to concrete and metal

Elastomeric waterproofing coatings - challenges

- Water sensitivity
  - Cellulosics and associative thickeners often impact the water sensitivity
- Applicability
  - Finding the balance between flow and levelling, sprayability and sagging
- Storage stability
  - Syneresis
- Mud cracking
  - Often two layers needed in order to avoid mud cracking and/or sagging due to too high wet film thickness

Microfibrillated Cellulose (MFC)



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Novel biobased multifunctional performance enhancer

Robust & versatile

- 3D- network of insoluble cellulose microfibrils suspended in water
- High compatibility with binders and additives
- Stable in extreme conditions
  - Temperatures up to 250 °C
  - pH 1–13
  - High shear
  - Chemically and microbiologically resistant
- Sustainable and compostable
- No impact on the food chain
- No biocides

Effects

- Ultra-high viscosity at low shear area
  - Prevents sagging, settling, floating and syneresis
- Strong shear thinning
  - Improves the sprayability
- Prevents skinning of the film
  - Strongly reduces mud-cracking
- Improves adhesion to concrete and metal
- Strongly reduces water absorption of coating
- Increases strength with good flexibility

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Properties

- Unique rheological profile with world-class compatibility
- Easy to incorporate by shear
  - Suspension with low shear
  - Paste with 6 m/s
- Rapid and complete viscosity development
- Stable viscosity at wide temperature range
- Excellent microbiological and chemical stability
  - Supplied without any biocides
- Typical dosage
  - Suspension 5-15 w%
  - Paste 1-3 w%

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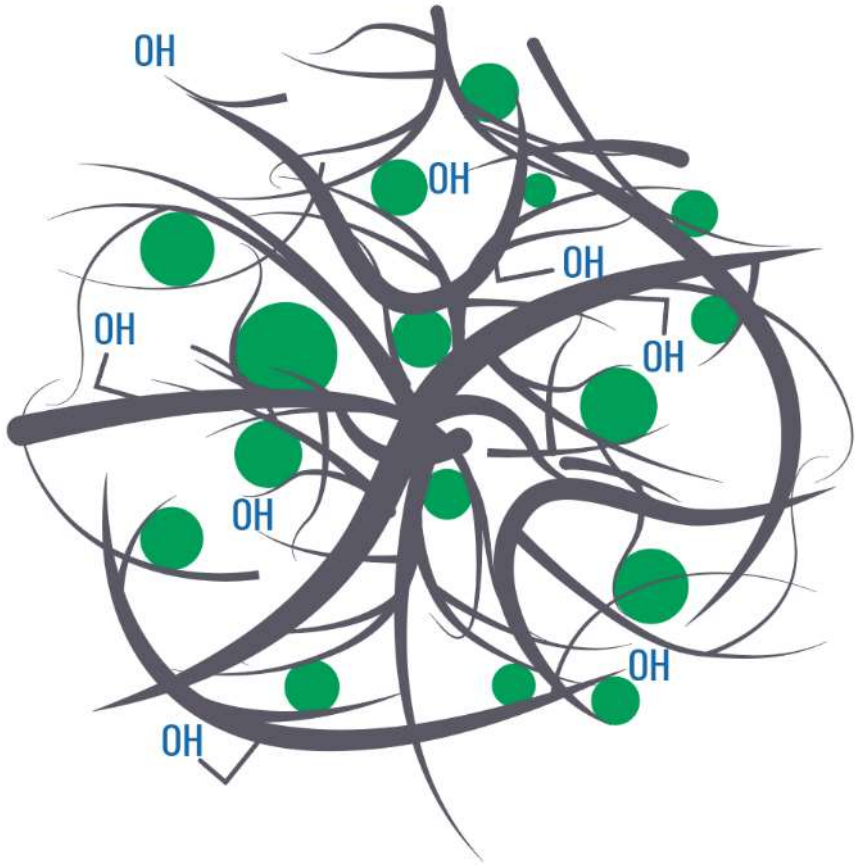
Strong fibers giving a robust network

- Individual MFC fibrils have strength up to 3 GPa
  - Glass fibers ~3,5 GPa
  - Carbon fiber ~3,8 GPa
- Thickening through physical entanglement of nano-sized fibrils and hydrogen bonding
- Network not sensitive to pH, surfactants or other associative compounds



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Mudcrack resistance

Reference with HEC (0.31 w-%)
Cracking > 14 Mils (0.36 mm)

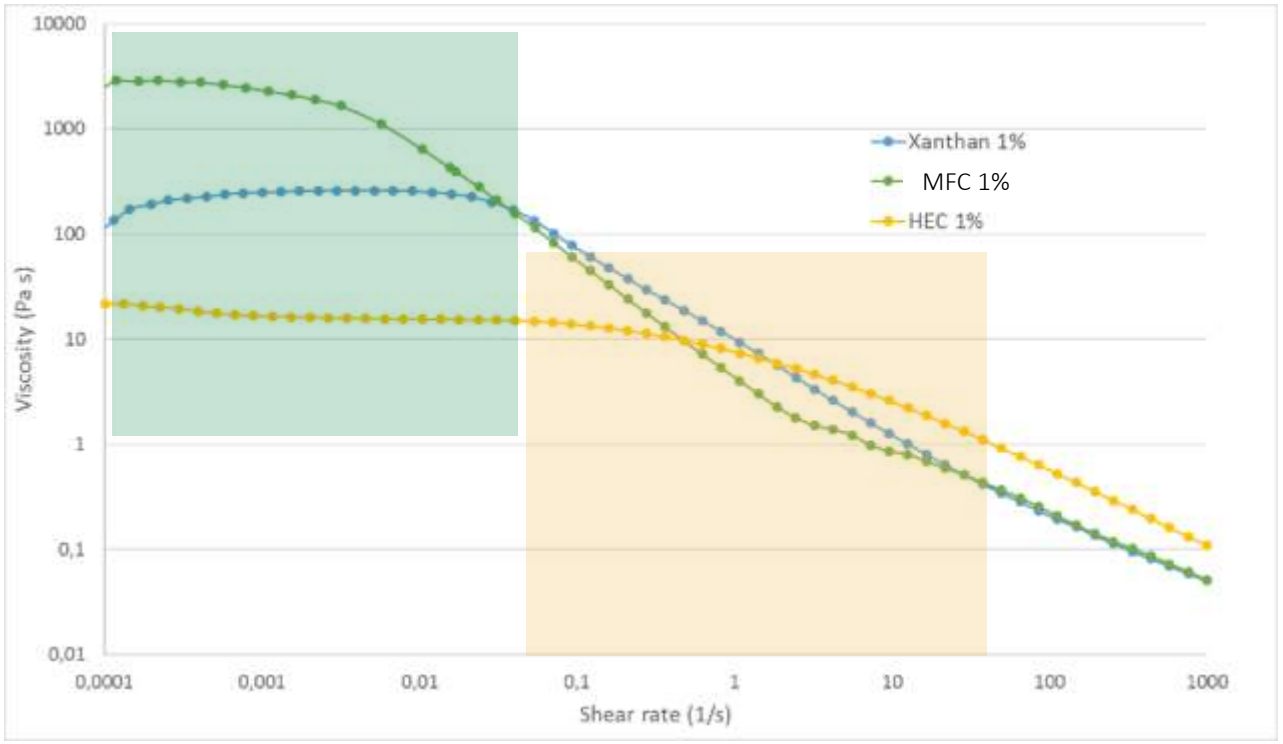
MFC (3.80 w-% of 10% MFC)
No Cracking, Pass 60 Mils (1.52 mm)

- No “skin” formation during drying
- Non tacky surface during drying
- MFC enables increased film thickness – reduction in required film layers
- MFC provides film reinforcement through the fiber structure

Shear thinning of MFC

MFC is extremely shear thinning with high viscosity at low shear

Strong impact by MFC



MFC, HEC (4000 mPas at 1%) and xanthan gum as 1% suspensions.

Brookfield

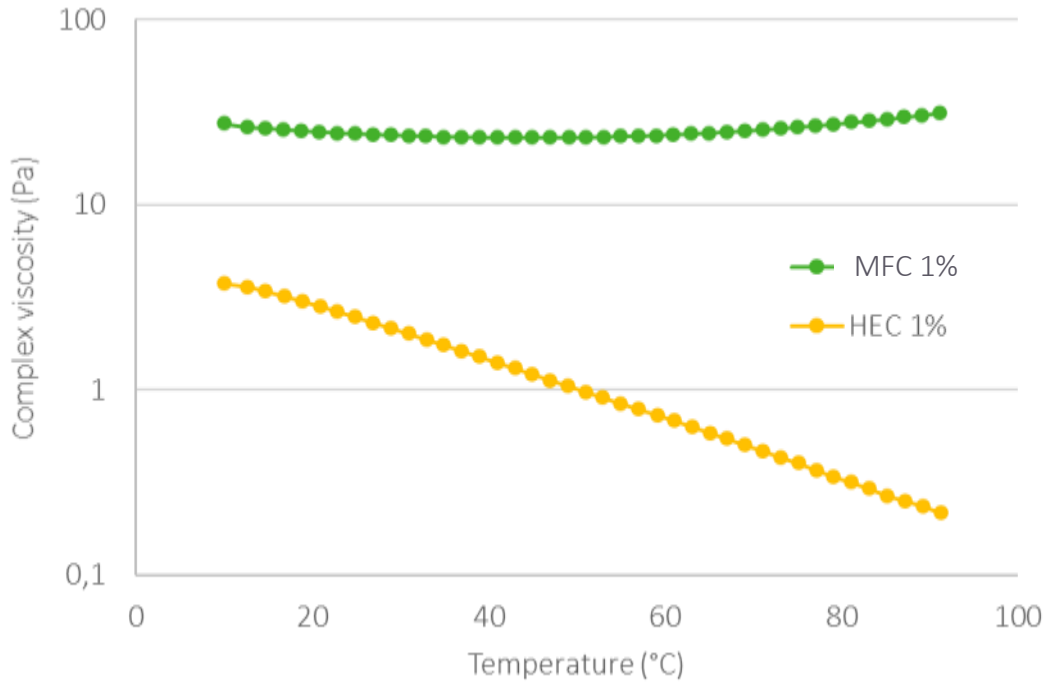
KU

Rheometer

Borregaard

Temperature stability

MFC is stable at wide temperature range
Viscosity is independent of the temperature
MFC enables systems to perform the same way in different environments



Complex viscosity of 1% MFC suspension measured over the temperature range 10 - 90 °C, compared to 1% HEC.

Benefits of MFC in elastomeric coatings

1 STABILITY & APPLICABILITY

Prevents settling and syneresis

Prevents sagging

Improves sprayability

Allows higher wet film thickness

2 DRYING

Prevents mud cracking

3 FINAL PROPERTIES

Improved tensile strength with good elongation

Improved adhesion on concrete

Reduced water absorption

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Acrylic roof coating

		HEC	MFC	MFC	MFC
TiO2 pigment		6.5	6.5	6.5	6.5
Filler		32.9	32.9	32.9	32.9
Rheology additives*	MFC 10% paste	-	1.0	2.0	3.0
	HEC	0.35	0.26	0.20	0.15
Other additives		2.4	2.4	2.4	2.4
Co-solvents		1.4	1.4	1.4	1.4
Binder		42.4	42.4	42.4	42.4
Water		14.1	13.2	12.2	11.2

* As delivered

PVC – 38.2 %
VS – 50.1 %
VOC – 36.9 g/L

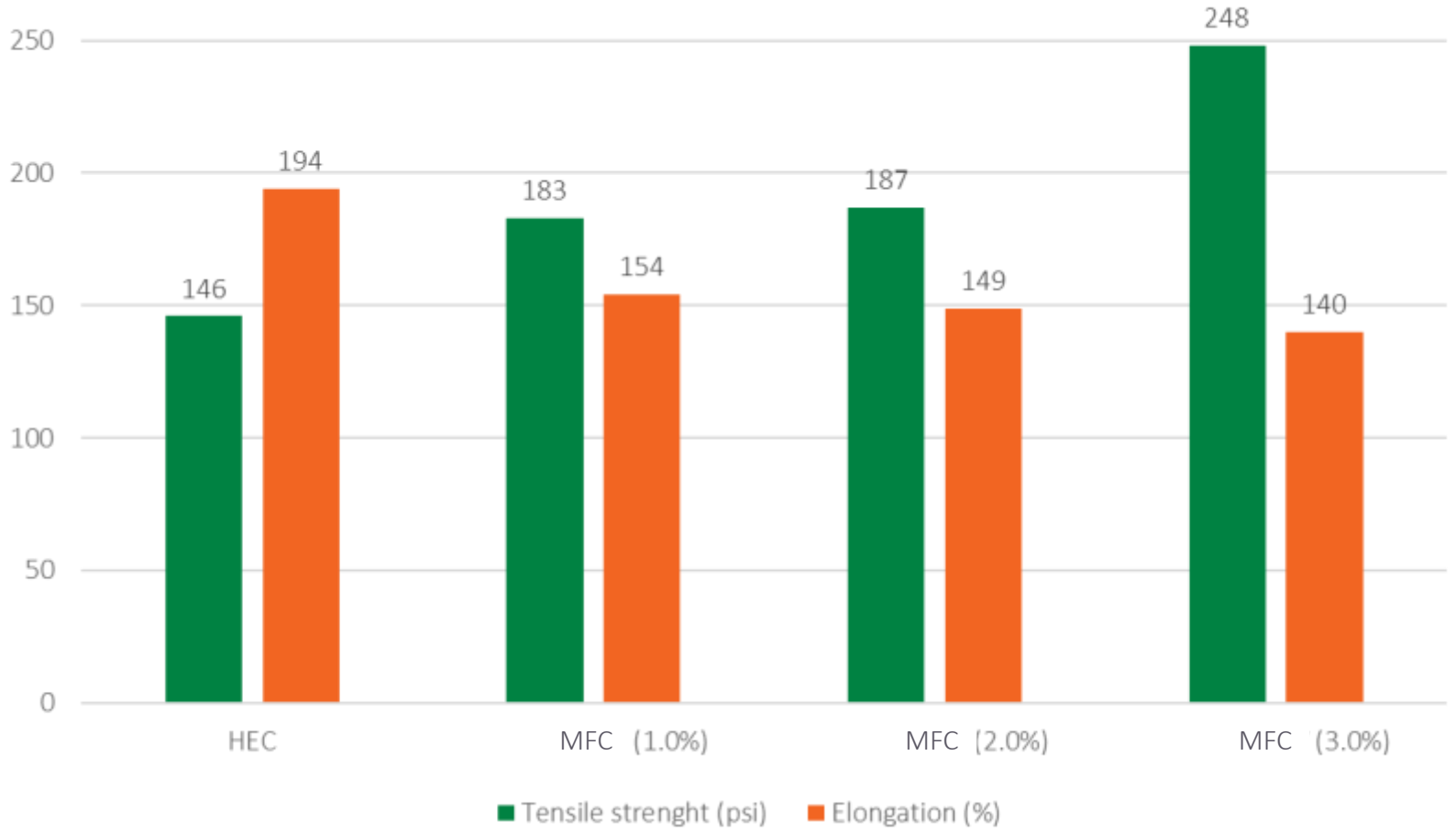
The following parameters were studied
Rheology
Tensile strength and elongation
Permeability
Water absorption
Ponding

Acrylic roof coating - properties

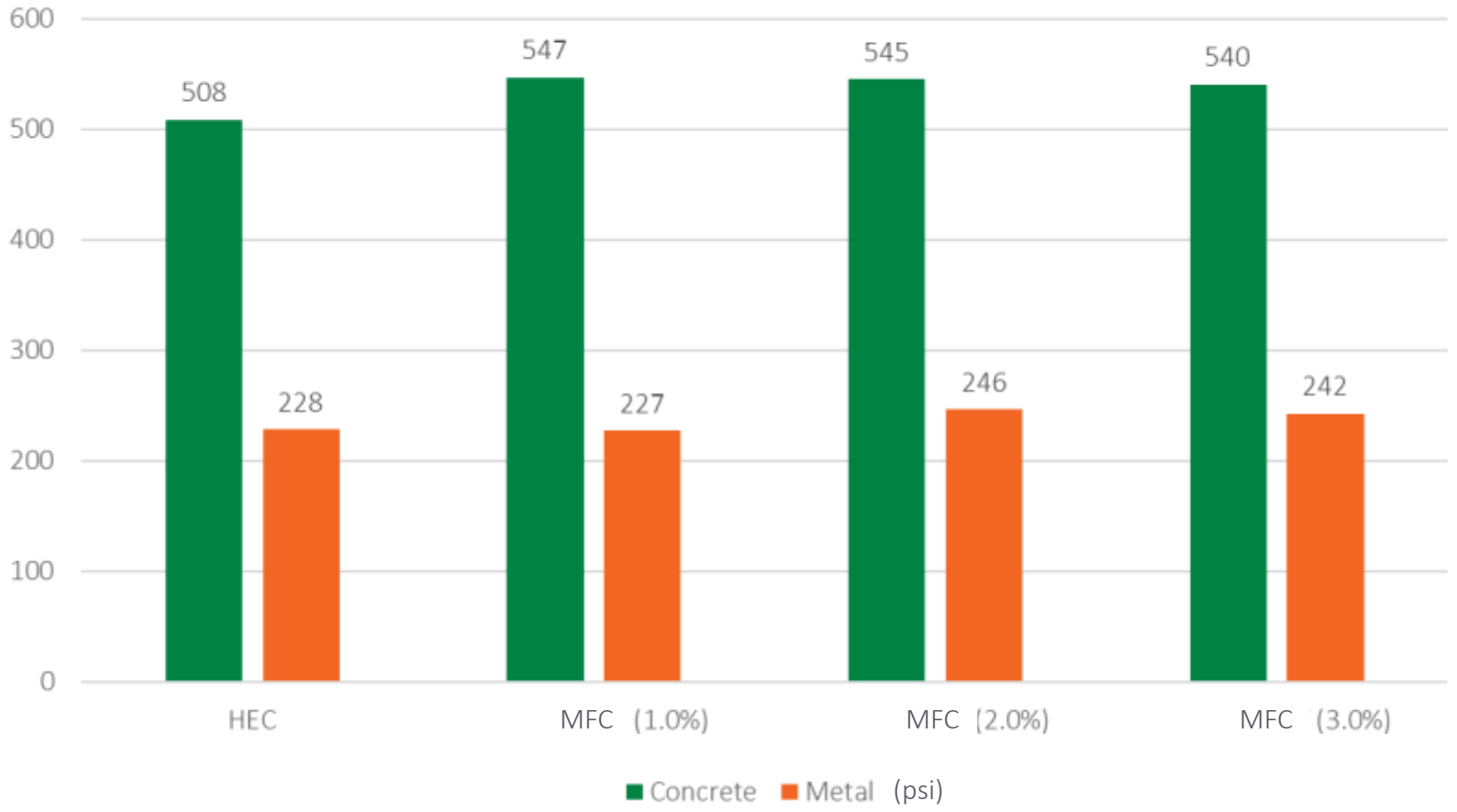
	HEC (0.35%)*	MFC (1.0%)*	MFC (2.0%)*	MFC (3.0%)*
KU viscosity	100	101	99	99
Sag Resistance (14 - 60 Mils - Sealed Chart)	18	18	20	25
Sag Resistance (14 - 60 Mils - Unsealed Chart)	>60	>60	>60	>60
Water Absorption (%), Free Film 1 Week Dry	35.4	14.1	13.5	12.0
Water Vapor Permeability WVT (grains/ft2/h) ASTM D1653	3.29	3.38	3.80	3.89
Water Ponding, Perm Cup Inverted 1 Week (g)	0.66	0.62	0.63	0.65

* As delivered

Acrylic roof coating – effect of dosage on strength



Acrylic roof coating – effect of adhesion



Conclusions

- MFC is a highly robust and compatible additive with unique rheological properties
  - High yield stress
  - High viscosity at low shear
  - Extremely shear thinning (minimum impact on KU and no impact on ICI)
  - Prevents sagging, settling, floating and syneresis

- Addition of MFC to waterproofing coatings
  - Enables spraying with excellent anti-sagging
  - Prevents mud cracking – allows higher wet film thickness
  - Gives high tensile strength with good elongation
  - Improved adhesion on concrete
  - Low water absorption
  - Allows the control of permeability

- Proven success in several water based coating systems
  - Acrylic, epoxy, urethane, etc.