Microfibrillated cellulose and polyvinyl alcohol-based barrier coating for abrasive paper

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Nano TextSurf

NanoTextSurf – Horizon 2020 EU project

Project partners

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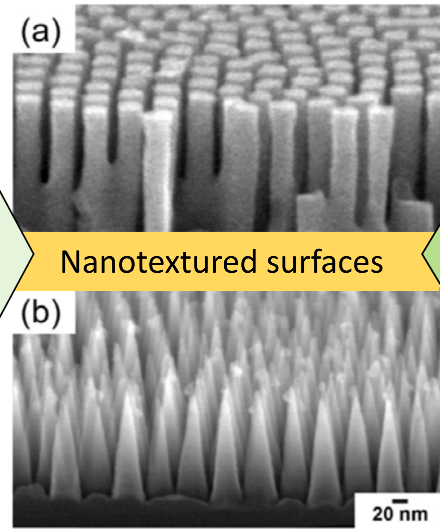
Are covered with structures, with smallest dimension on the nano-scale (0.1—100 nm)



Nanotextured surfaces

Have unique properties making them attractive for applications such as membranes, protective textiles, friction pads and abrasive materials

NanoTextSurf project focuses on manufacturing technologies such as <u>*cast coating, foam coating, or screen-printing*</u> for producing these surfaces, patterns and architectures using different nano-scaled materials such as nanocellulose. The goal is to upgrade and optimize existing pilot lines, and use them to demonstrate novel nanotextured surfaces.

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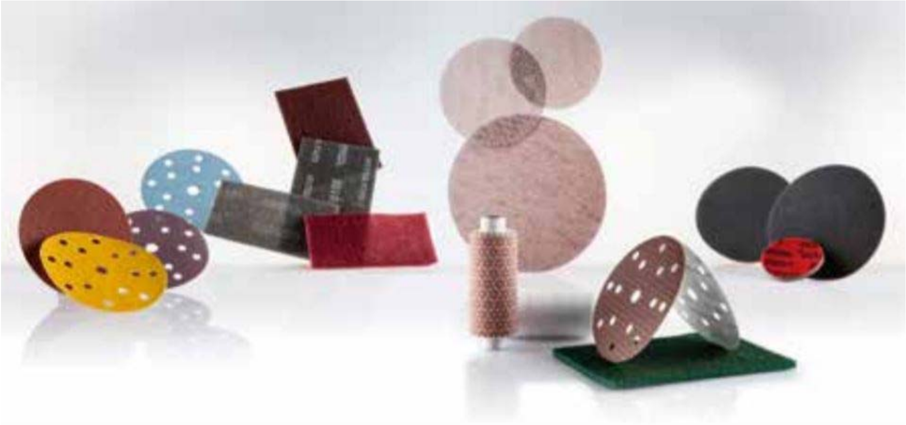
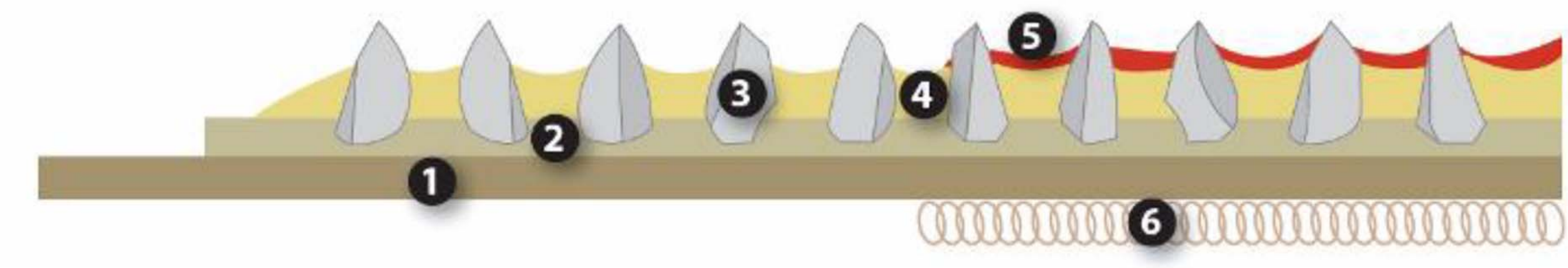
Abrasive products and their structure

- Paper, nonwoven or plastic-based abrasive materials are used for different surface finishing applications

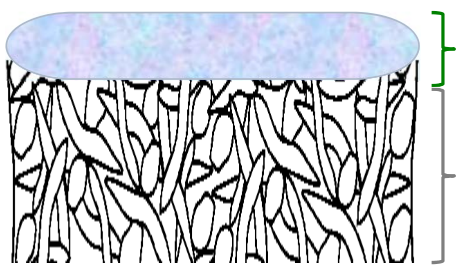
- Abrasive products are typically multilayer structures





① Backing ② Make coat ③ Grains ④ Size coat ⑤ Supersize ⑥ Fastening system

Barrier coating on paper based backing



Motivation

- Currently, the barrier layer is produced using latex which causes environmental concerns
- Coat weights of the barrier layer are high (~10 gsm)

Objective

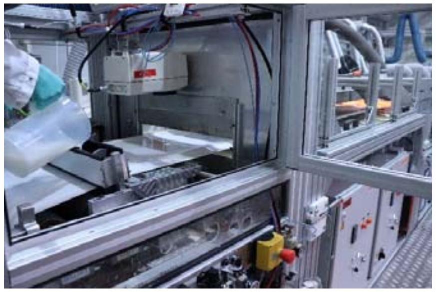
- To develop a barrier coating layer which contains bio-based and/or biodegradable alternatives and achieves the needed barrier function at a lower coat weight than the current solutions

Nano TextSurf

Sustainable barrier for abrasive materials

Pathway from lab via open access pilot to industrial scale

VTT Mirka	VTT Espoo SutCo pilot	Mirka industrial scale production



Materials and formulations for the barrier coating layer

Material	Abbreviation
Polyvinyl alcohol (POVAL® 6-98 from Kuraray, granules)	PVA
Microfibrillated cellulose (EXILVA F01-V from Borregaard, 10 wt% suspension/paste)	MFC
Silicon dioxide (SiO_2) (AERODISP® W1226, a 26 wt% water-based dispersion of AEROSIL® fumed silica)	Silica

Formulation	PVA	PVA-MFC	PVA-MFC-Silica
Weight ratio	100	90:10	(90:10)70:30
Solids content (%)	10	10	10

Substrate used for coating was a 120 gsm paper

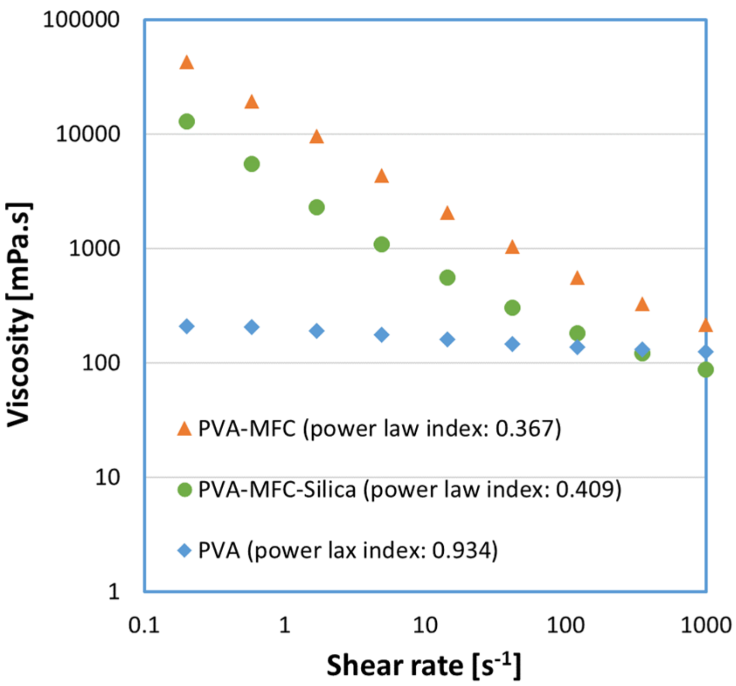
Formulation preparation protocol with MFC

- The first formulation containing only PVA was prepared by cooking the PVA in water at 85-90°C for 2 h
- The slurry containing MFC could not be prepared by simply adding the MFC to the cooked PVA as the high viscosity MFC could not be dispersed efficiently into the cooked PVA solution
- MFC was first dispersed in the ‘needed’ amount of water for formulation, and PVA was then cooked in the MFC dispersion at 85-90°C for 2 h
- For the third formulation, silica was added to cold PVA-MFC mixture in a 70:30 weight ratio and mixed for 30 minutes

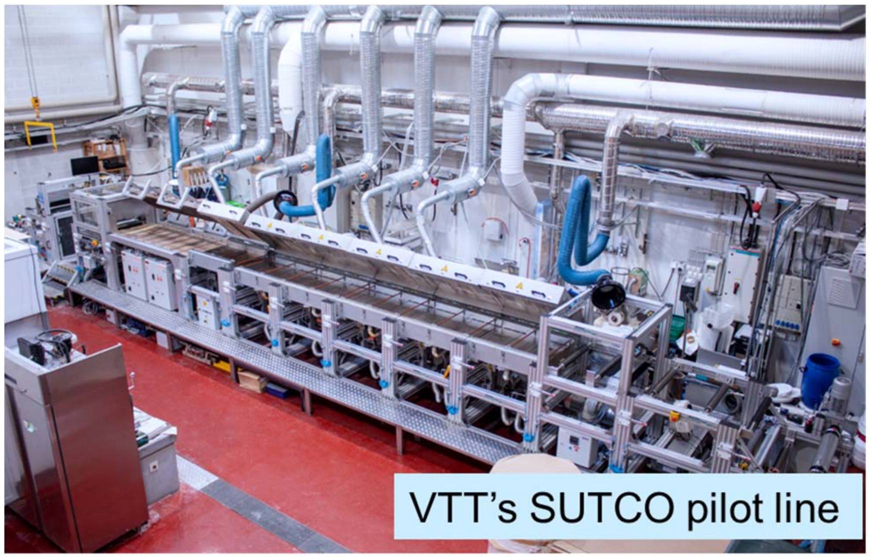
MFC at 10% solids

Rheology of the formulations

- Measured in the shear rate range of 0.1–1000 s^{-1} using cone-plate geometry in an Anton Paar MCR 301
- Addition of MFC increased shear thinning of the PVA solution
- Addition of MFC improved the coatability by providing a favorable rheology during coating
- Silica reduced the overall viscosity, but it did not affect the shear thinning nature



Coating application at pilot scale



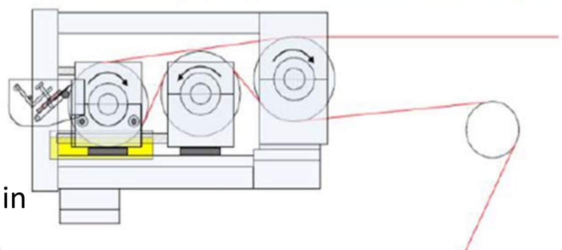
Rod coating

Rod: 20 µm

IR & air drying

Coating speed: 10 m/min

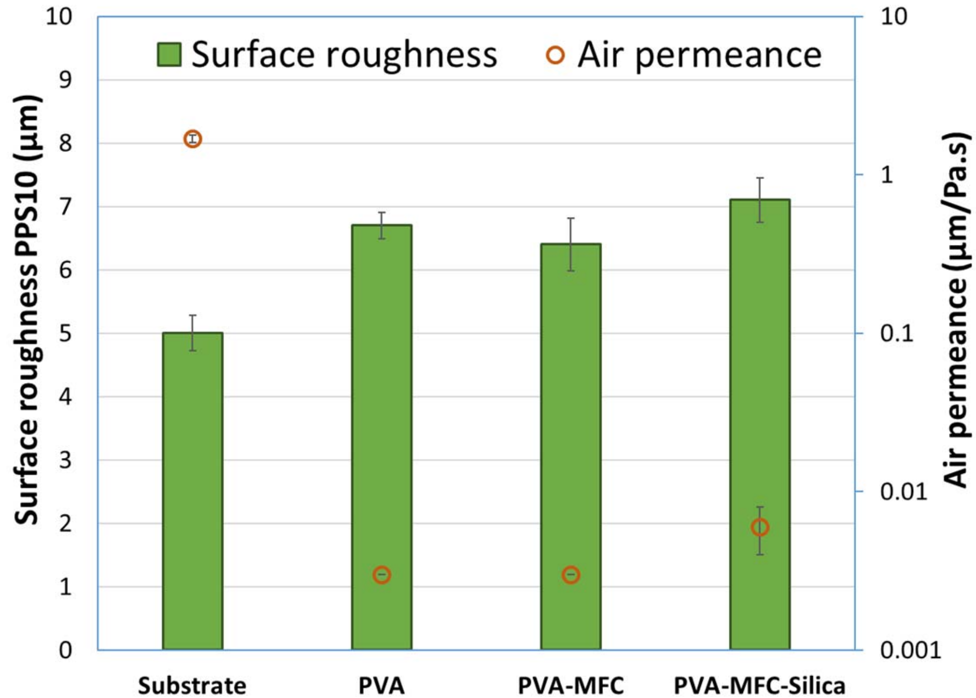
Coating width: 500 mm



Coating characterization

Coat weight, surface roughness & air permeance

- Surface roughness increased as a result of the coating
- Increasing surface roughness can be helpful in mechanical anchoring of the subsequent coating layer
- Air permeance dropped significantly after coating implying surface closure



Coat weight (g/m^2)	Substrate	PVA	PVA-MFC	PVA-MFC-Silica
	0	4	2.5	3

Coating characterization

Oil barrier performance

KIT test

The KIT test method is a standard method in the paper industry (TAPPI T559). The test method involves putting drops of a series of numbered reagents (KIT No. 1-12) on the sample surface. The highest numbered reagent (the most aggressive) that remains on the surface of the sample for 15 s without causing failure is reported as the "KIT number".

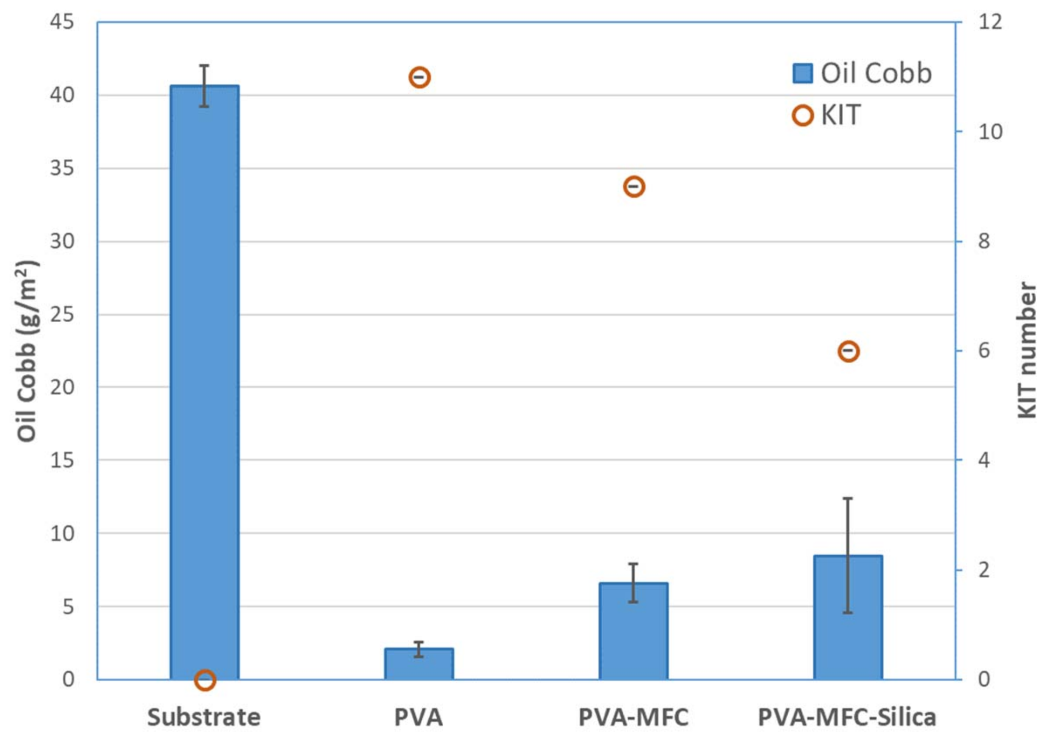
Oil cobb test

Similar to water cobb, water is replaced by monomer used as a component in resin formulation

Oil drop test

Visual estimation of a drop of red oil (rapeseed oil + red oil) coming through to the other side in 15 h

Sample	Oil drop test result
Substrate	Through
PVA	Not through
PVA-MFC	Not through
PVA-MFC-Silica	Through small pinholes



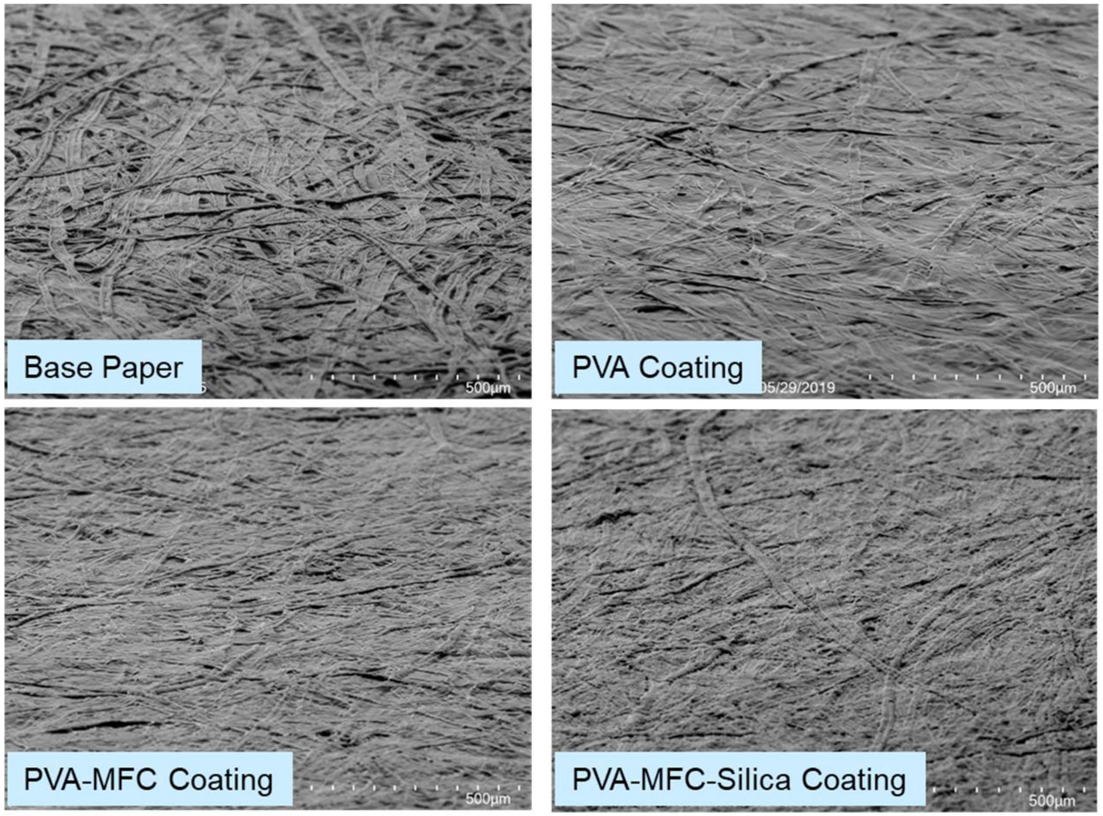
Coat weight (g/m²) ⇨	0	4	2.5	3

Coating characterization

SEM surface images

As apparent from the barrier performance

- PVA coating clearly achieves surface closure
- A slightly less closed surface coating is obtained with PVA-MFC
- Addition of silica further opens the coating structure

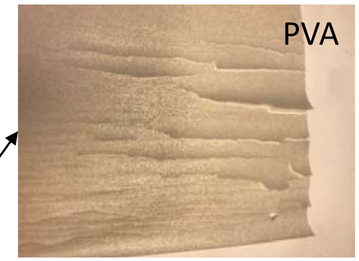


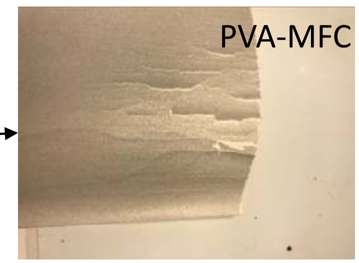
Coating characterization

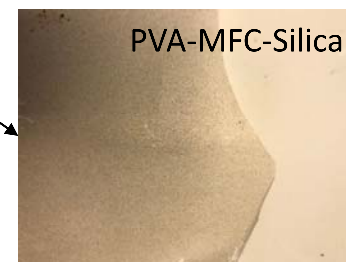
Contact angle & adhesion to next layer

Sample	Coat weight	Water contact angle at 0.5 s	Adhesion to the next layer
	g/m^2	^{o}	Qualitative estimate
Substrate	-	112	-
PVA	4	58	Very poor/No adhesion
PVA-MFC	2.5	46	Poor
PVA-MFC-Silica	3	55	Good

- All coatings made the surface hydrophilic compared to the base paper
- Poor adhesion to the next layer resins without the adhesion promoter Silica
  - *(hydrophilic barrier – non-polar resins)*







Summary and conclusions

- New barrier coatings for abrasive products were developed and demonstrated at pilot scale
- Excellent barrier performance was achieved at a much lower coat weight **(~3g/m^2)** than the currently existing latex-based solutions **(~10 g/m^2)**
- MFC addition was found to improve the coatability and reduce the final coat weight of the formulations by providing a favorable rheology
- A slightly open coating structure, achieved with addition of silica, increased the adhesion to the subsequent coating layer by providing a mechanical anchoring effect
- These new barrier solutions could pave the way for the development of abrasive products with lower environmental impacts than with oil-based solutions

Thank You

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