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COST Action FP1405

Active and intelligent fibre-based packaging – innovation and market introduction

Manufacturing and measurement of superhydrophobicity for paperbased active packaging

Charlène REVERDY, PhD student, LGP2

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

COST is supported by the EU Framework Programme Horizon 2020

STSM project partners

"Multiscale Biobased Materials"

Expertise on **nanocellulose** and paper technology. Special interest in **active packaging** with antimicrobial properties.

Involved persons:
Julien Bras, associate professor
Charlène Reverdy, PhD student

"Chemistry, Materials and Surfaces"

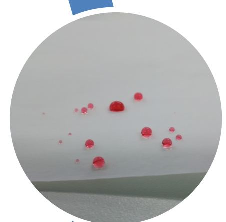
Expertise on **surface modification** and formulation of coatings, advanced **assessment of surface functionality** and materials properties.

Involved persons:
Agne Swerin, research director
Maziar Sedighi Moghaddam, post-doc

PROJECT GLOBAL PLAN

PROJECT

- Cellulose nanofibrils hydrophobization

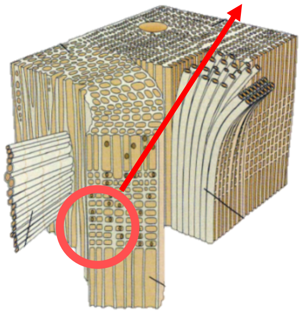


- Nanofibrils/ Calcium carbonate coating elaboration
- Surface characterization

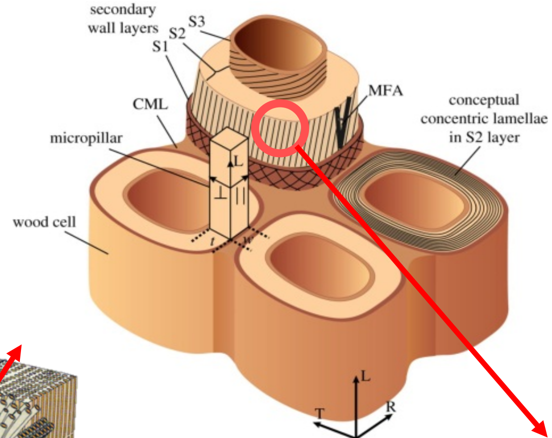
- Surface mapping
- Effect of superhydrophobicity on bacterial adhesion and growth

Introduction – What is nanocellulose?

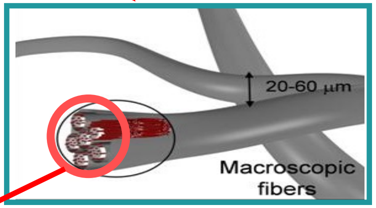
Nanocellulose

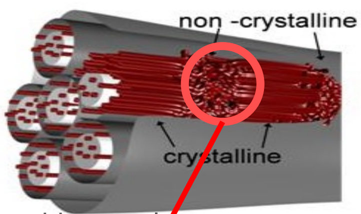


Wood cell



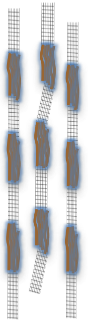
Cell structure

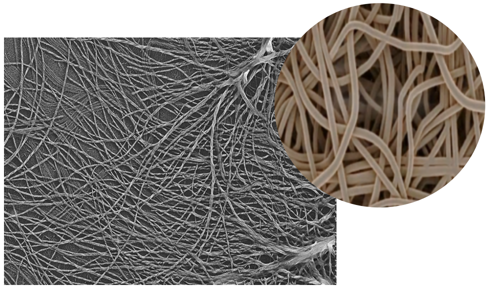




Adapted from Pääkkö, et al. 2007

Cellulose nanofibrils (CNF)

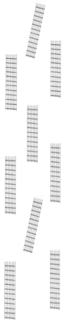


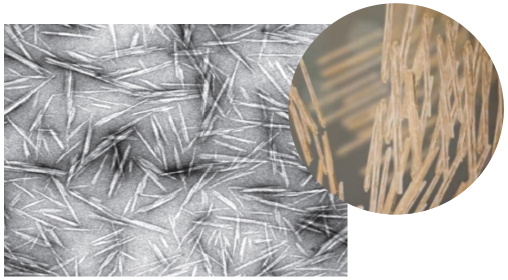


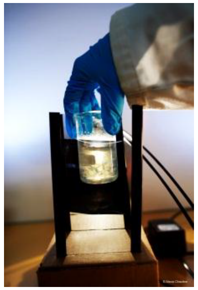
D 2-20 nm

L > 1000 nm

Cellulose nanocrystals (CNC)







D 2-10 nm

L 150-1000 nm

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Introduction – What is Superhydrophobicity?

Low water adhesion
Water contact angle > 150°
Water Roll-off angle < 10°

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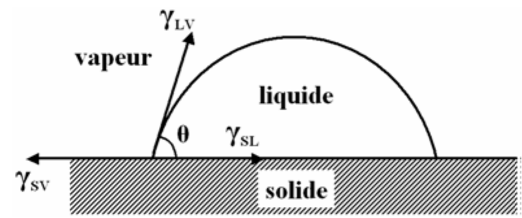
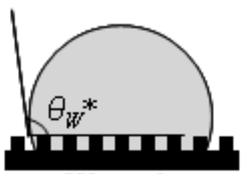
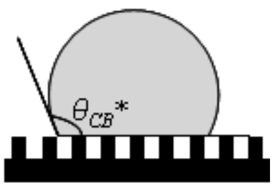
Introduction – What is Superhydrophobicity?

- A contact angle measurement is done ideally with (Young Θ_E):
  - Plane surface
  - Chemically homogeneous surface







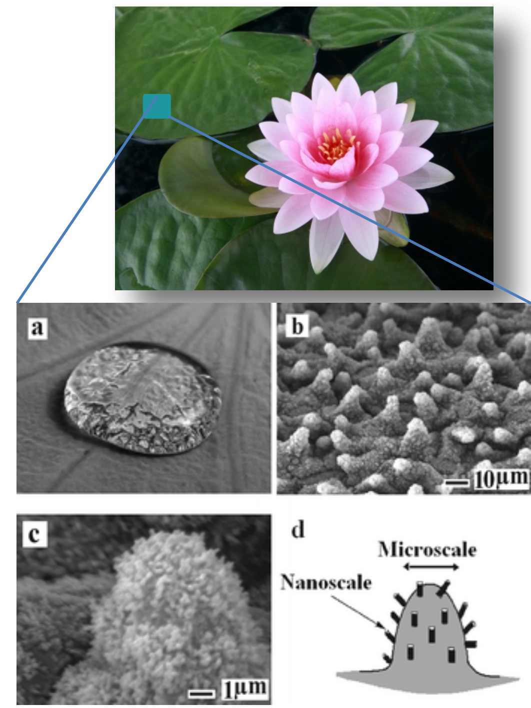
- Actually, contact angle is affected by surface roughness.
  - Surface with a r roughness (Wenzel)

$$\cos\theta' = r\cos\theta_E$$

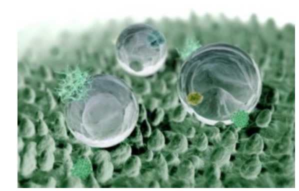
  - Surface non chemically homogeneous (Cassie Baxter)

$$\cos\theta' = f_1\cos\theta_1 + f_2\cos\theta_2$$

f_1 et f_2 probability to encounter solid 1 or 2, and Θ_1 and Θ_2 Young angle for eache solid. (Air pocket model)



Surface wettability can be control by roughness and chemistry



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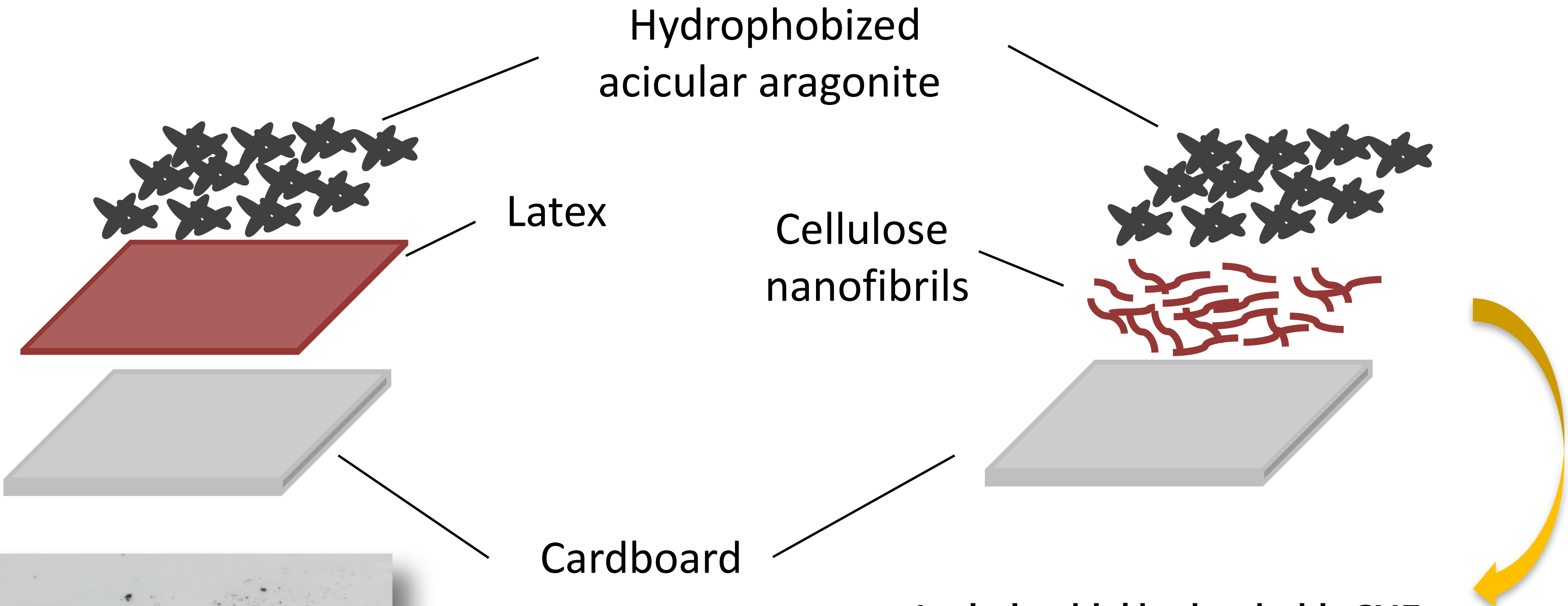
STSM Project



Antimicrobial hydrophobic CNF :
CNF-APMS
Hydrophobic reference CNF (InoFib, France) :
CNF-AKD

- **Learn** how to **make** a superhydrophobic coating
- **Learn** how to **measure** superhydrophobicity

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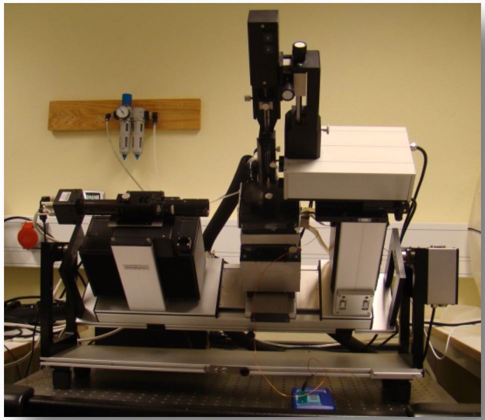
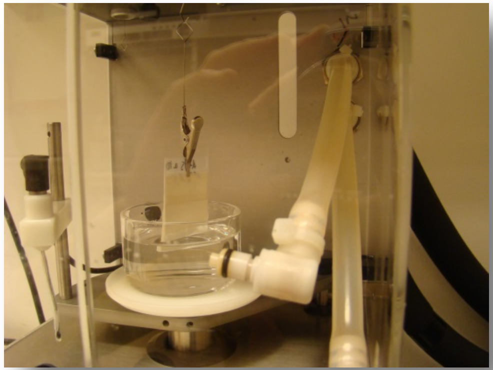
Material and Methods

Method		
Image recording of a controlled water drop. Tilting of the surface controlled.	**Optical contact angle** 	Static, Roll-off, Water Shedding Angle, Advancing and receding
Force measurement during penetration of the sample in the known liquid	**Wilhelmy Plate** 	Advancing and receding angles, wettability (multicycles)

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MATERIAL AND METHODS

PROBLEM N°1 : Facing dry matter content

78% pigments
2% oleate
20% Latex

33% Dry matter

→

r4

78% pigments
2% oleate
20% CNF

9% Dry matter

→

r10

89% pigments
2% oleate
9% CNF-APMS

15% Dry matter

PROBLEM N°2 : Oleate excess disrupt CNF-AKD hydrophobization

r10

91% pigments
0,3% oleate
9% CNF-AKD

15% Dry matter

→

r20

95% pigments
0,3% oleate
5% CNF-AKD

18% Dry matter

Rod Coater

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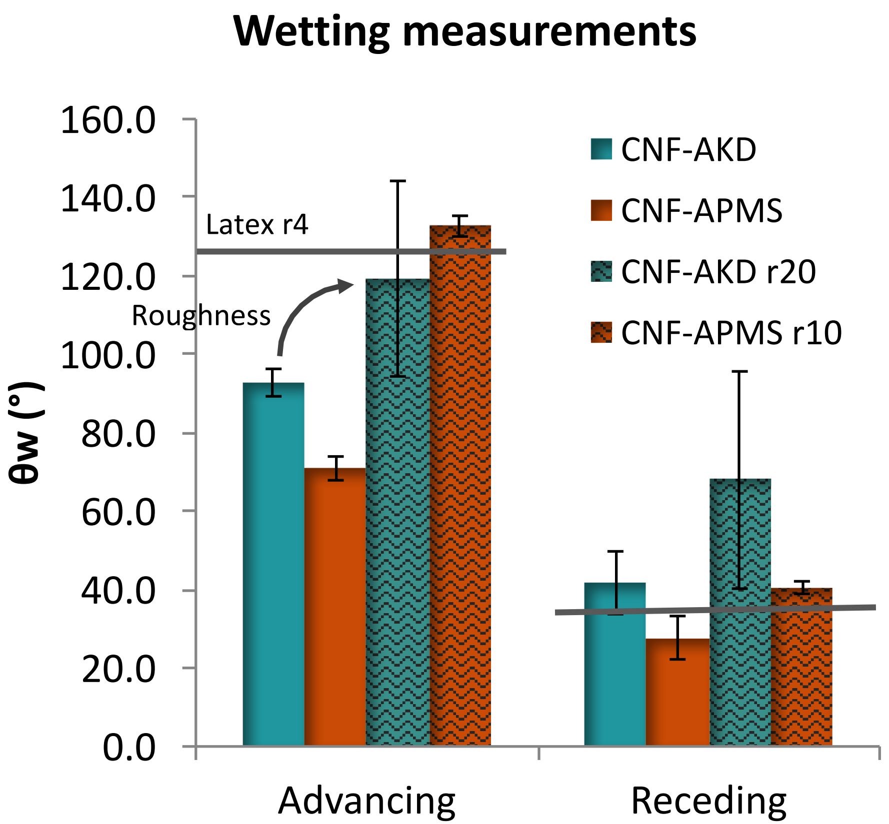
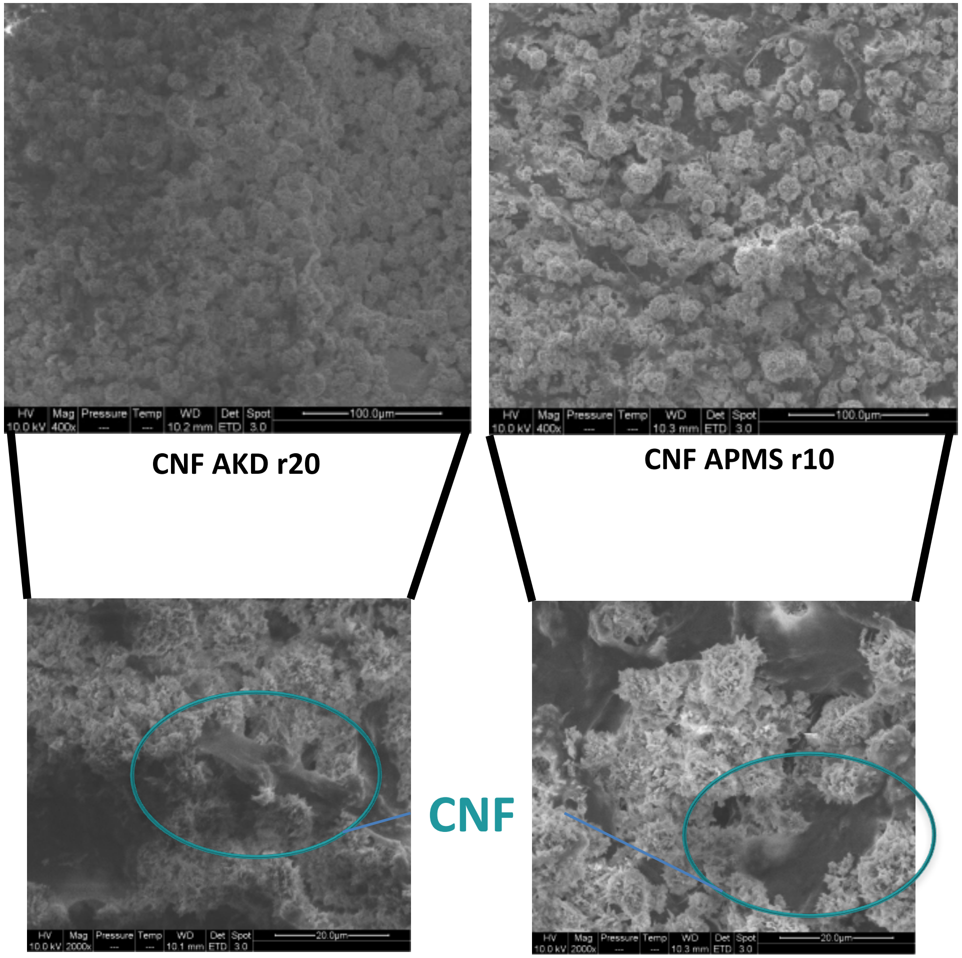
RESULTS





Water adhesion probably due to CNF high affinity with water (even after hydrophobisation) and/or enlargement of pitch

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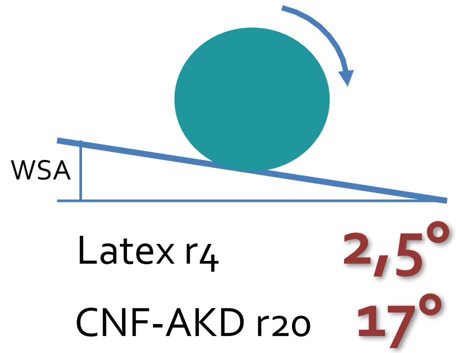
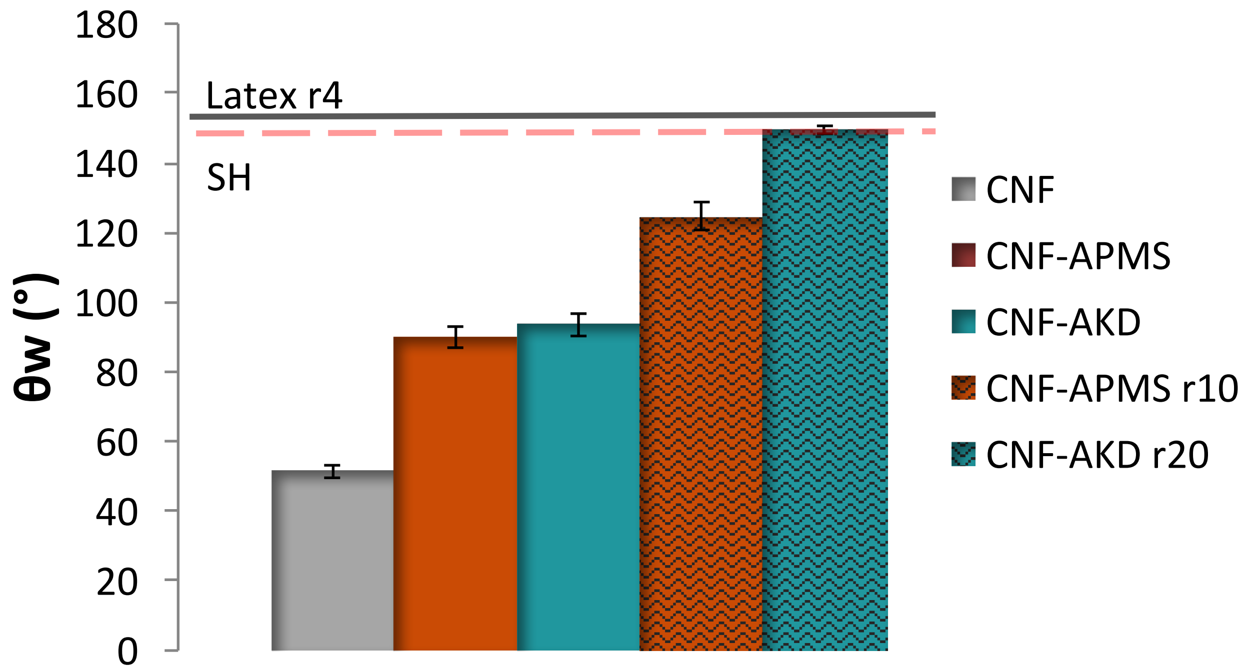
RESULTS

Water shedding angle



Static water contact angle



- Superhydrophobic static contact angle obtained but not roll-off (Water shedding yes)
- More a « rose petal effect »
- Leaching of PCC observed

SCIENTIFIC VALORIZATION

- Poster presentation at N.I.C.E conference, October 2016, Nice, France
- Conference on material science based on biomimetism

" Superhydrophobic surfaces manufacturing with nanocellulose "

- Adaptation of LGP2 laboratory tools for measurearement of superhydrophobic properties

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Perspectives on the project

- Assessement of bacterial adhesion and growth on a superhydrophobic surface with antimicrobial and non-antimicrobial CNF

- Stronger hydrophobization of CNF, not interacting with fatty acid

THANK YOU FOR YOUR ATTENTION