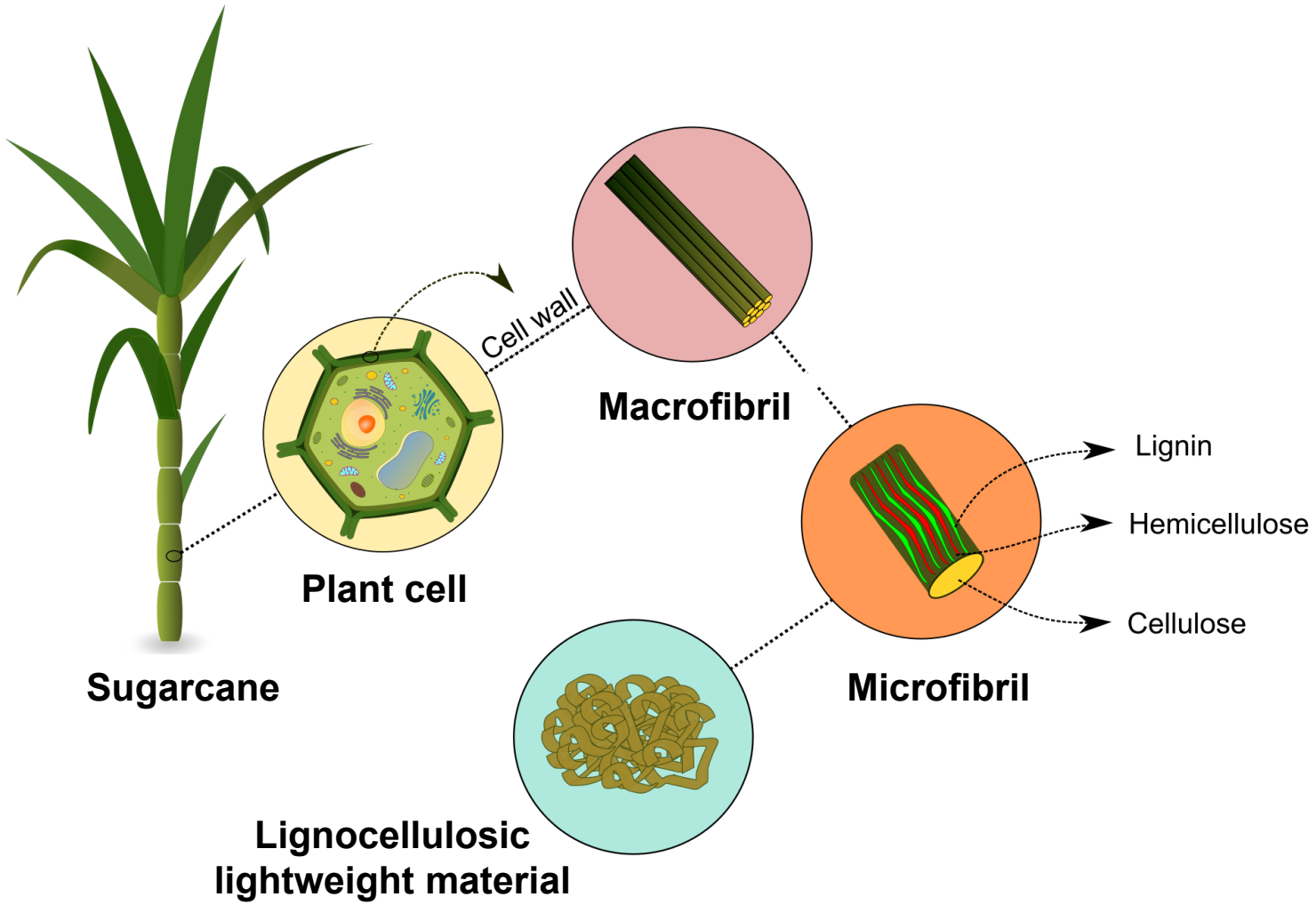
Effect of Cellulose Nanofibrils and Lignin Nanoparticles on the Properties of Lightweight Materials for Oil/Water Separation

Polianna S. Ferreira

Eupidio Scopel

Camila A. Rezende

LIGNOCELLULOSIC LIGHTWEIGHT MATERIALS

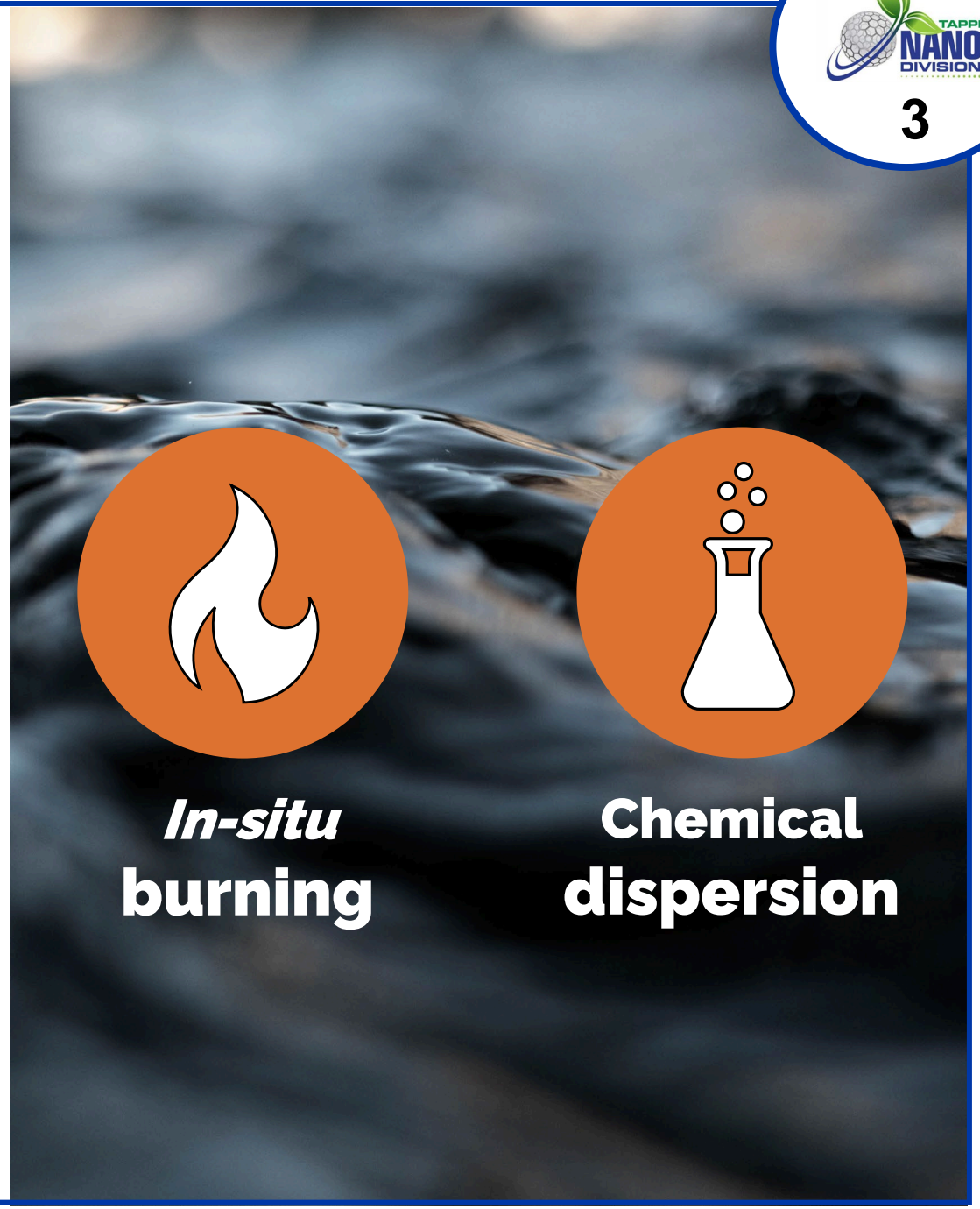


LIGNOCELLULOSIC LIGHTWEIGHT MATERIALS

PROMISING

Oil spill cleanup

- Renewable sources
- Ease of use
- Avoid second contamination



Lignocellulosic Lightweight Materials

Low mechanical resistance

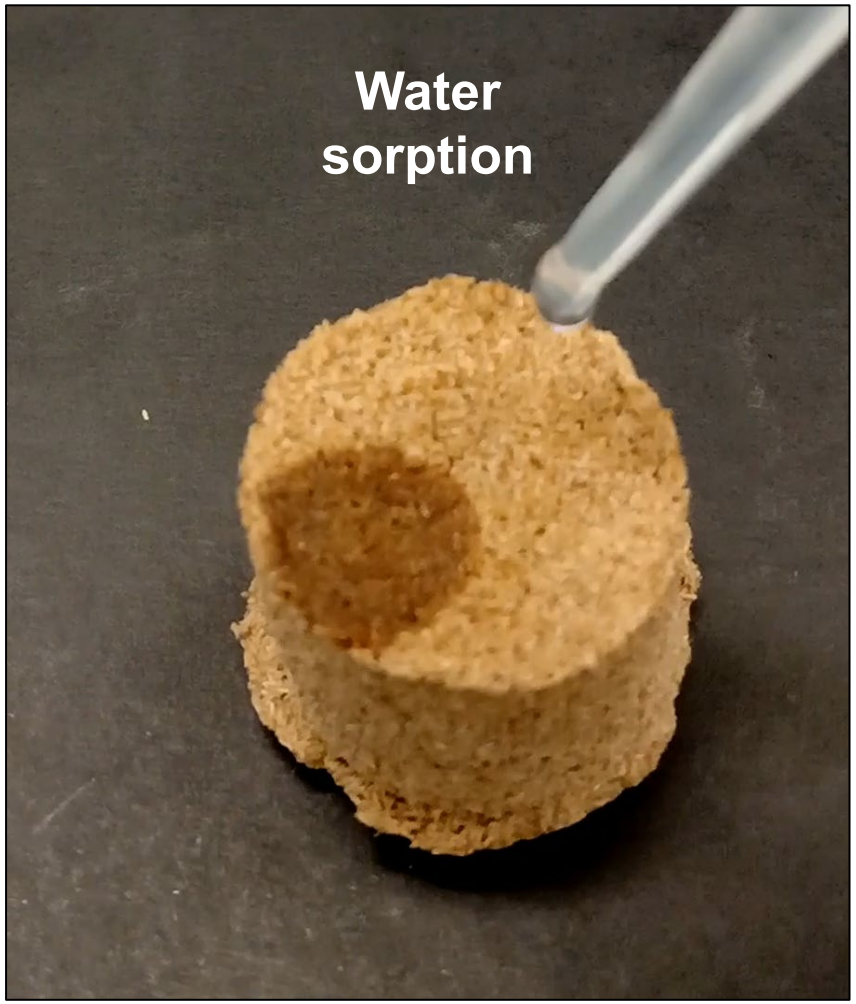
Lightweight materials produced using lignocellulosic fibers typically show **low mechanical resistance** under stress.

Sugarcane bagasse

Lignocellulosic Lightweight Materials

Hydrophilicity

In addition, most of these natural materials **absorb both water and oil**, limiting their use in water-oil separation.



LIGNOCELLULOSIC LIGHTWEIGHT MATERIALS

Lignocellulosic lightweight material

Apparent density (0.09 g/cm^3)
Water contact angle 117°
(hydrophobic surface)

Young Modulus
0.46 ± 0.07 MPa

- Ambient pressure
- Oven drying

Ferreira, E. S.; Cranston, E. D.; Rezende, C. A.
ACS Sustainable Chem. Eng. (**2020**)

Strategy

Hydrothermal pretreatment

Here, we investigated:

1. The ability of **cellulose nanofibrils** (CNF) to act as nanofiller in lightweight materials in comparison with strategies using cross-linking with citric acid.

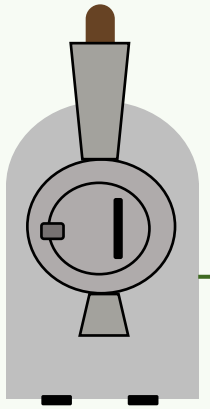
CNF can be a greener and less toxic alternatives to the typical chemical cross-linking agents

2. The influence of **lignin nanoparticles** (LNP) in the hydrophobicity of the lightweight materials from sugarcane bagasse.

Methodology

1 CNF PREPARATION

Sugarcane bagasse



Knife mill

Milled bagasse

Organosolv treatment

Ethanol 40% v/v
200 °C, 1 h

Cellulosic substrate

Residual lignin

Solid fraction

Liquid fraction

Lignin

Hemicellulose

1. TEMPO-mediated oxidation
For 2 g of biomass:
25 mmol NaClO, 0.0320 g
TEMPO, 0.2 g NaBr
Time: 130 min

2. Ultrasonication (15 min)
60% amplitude

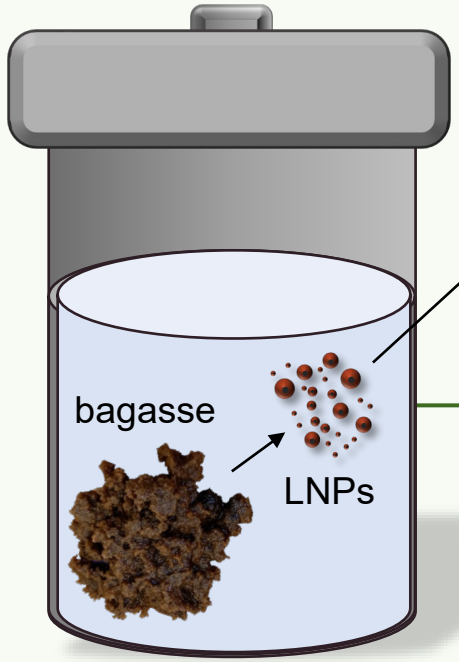
CNF

Methodology

2 LIGHTWEIGHT MATERIAL PREPARATION

Lignin redeposition can occur due to the high temperature and pressure conditions.

- Ambient pressure
- Oven drying
- 0.1% CNF



Hydrothermal treatment

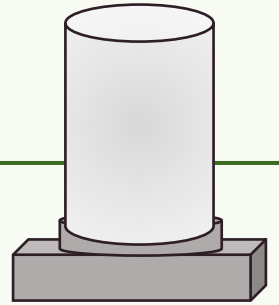
Water

200 °C, 1 h

Pretreated substrate

Add 0.1% CNF

2 min - Turrax homogenizer



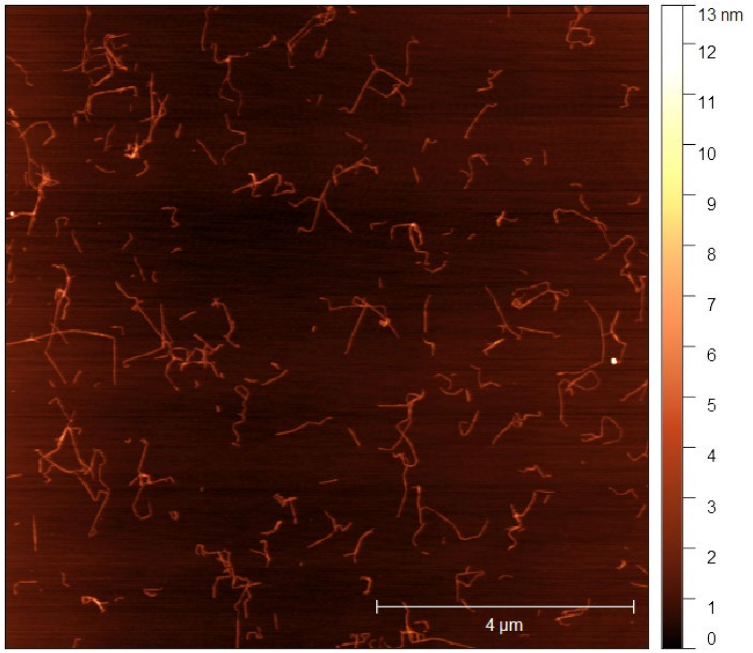
Mold of steel

Oven drying (60 °C)

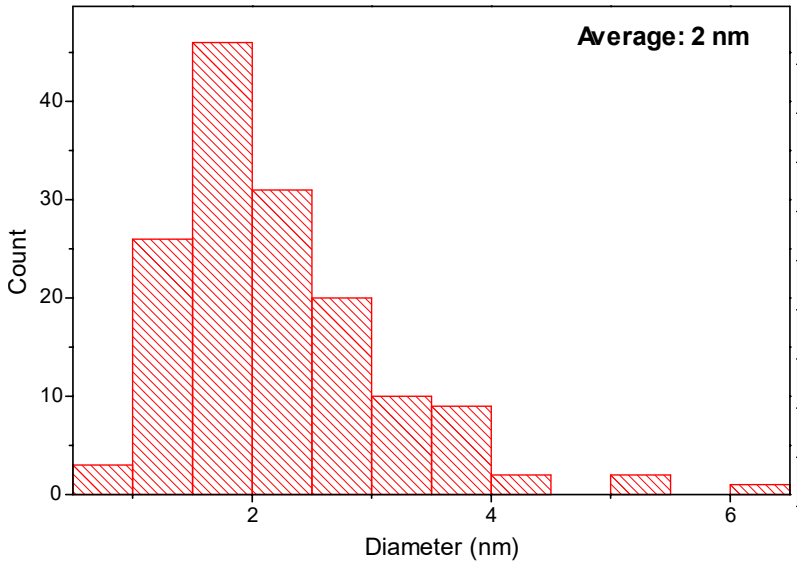
Lightweight material

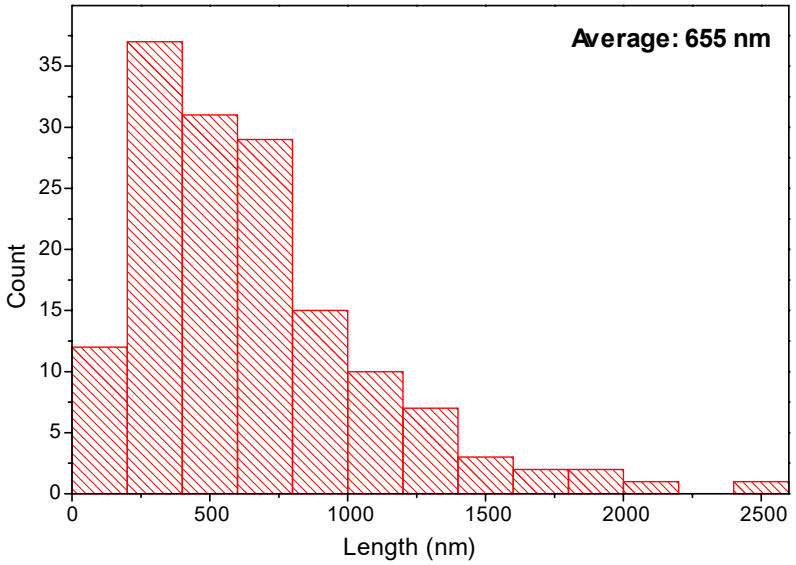
Results

CNF characterization



AFM





Zeta potential: -49 ± 1 mV

Average diameter: 2 nm
Average length: 655 nm

Results

Lightweight material containing 0.1 % CNF

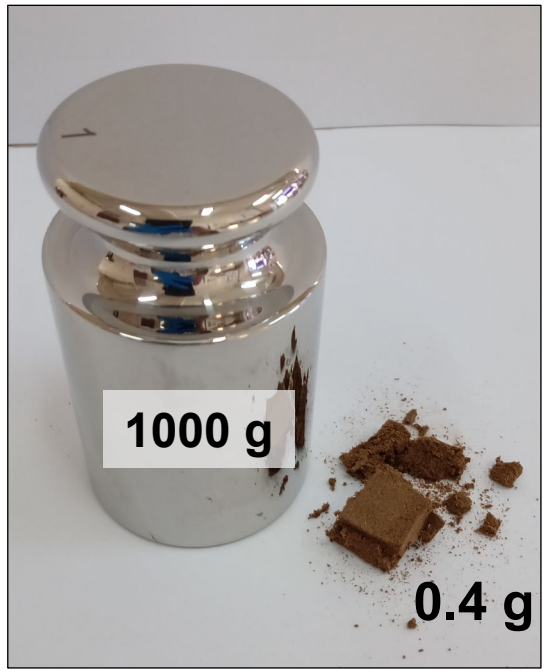
1 cm

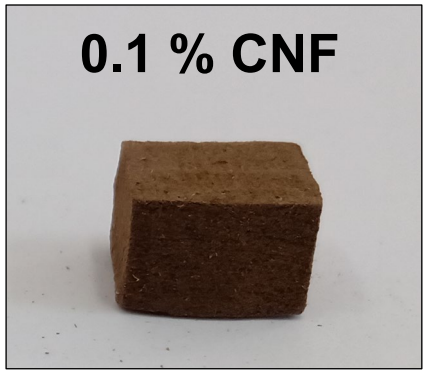
0.5 g

AFTER

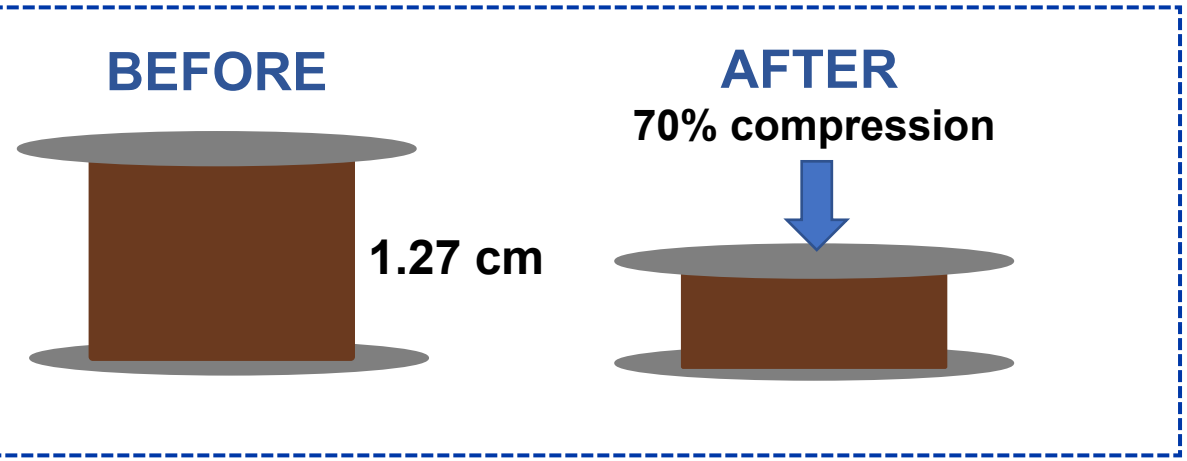
Lightweight material containing 0.1 % CNF

Lightweight materials reinforced with citric acid





Mechanical resistance



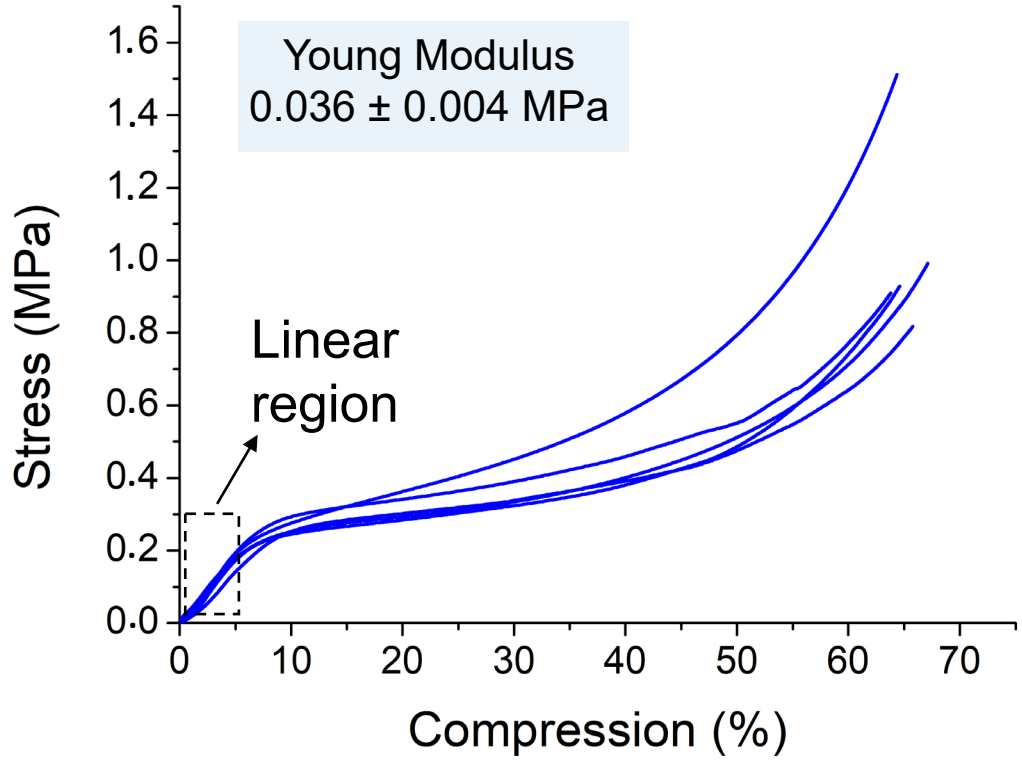
CNF aerogel (freeze-dried)

80% compression

Young Modulus
0.05 MPa

Jiang; Hsieh. *Journal of Materials Chemistry A.* (**2014**).

STRESS–STRAIN COMPRESSION

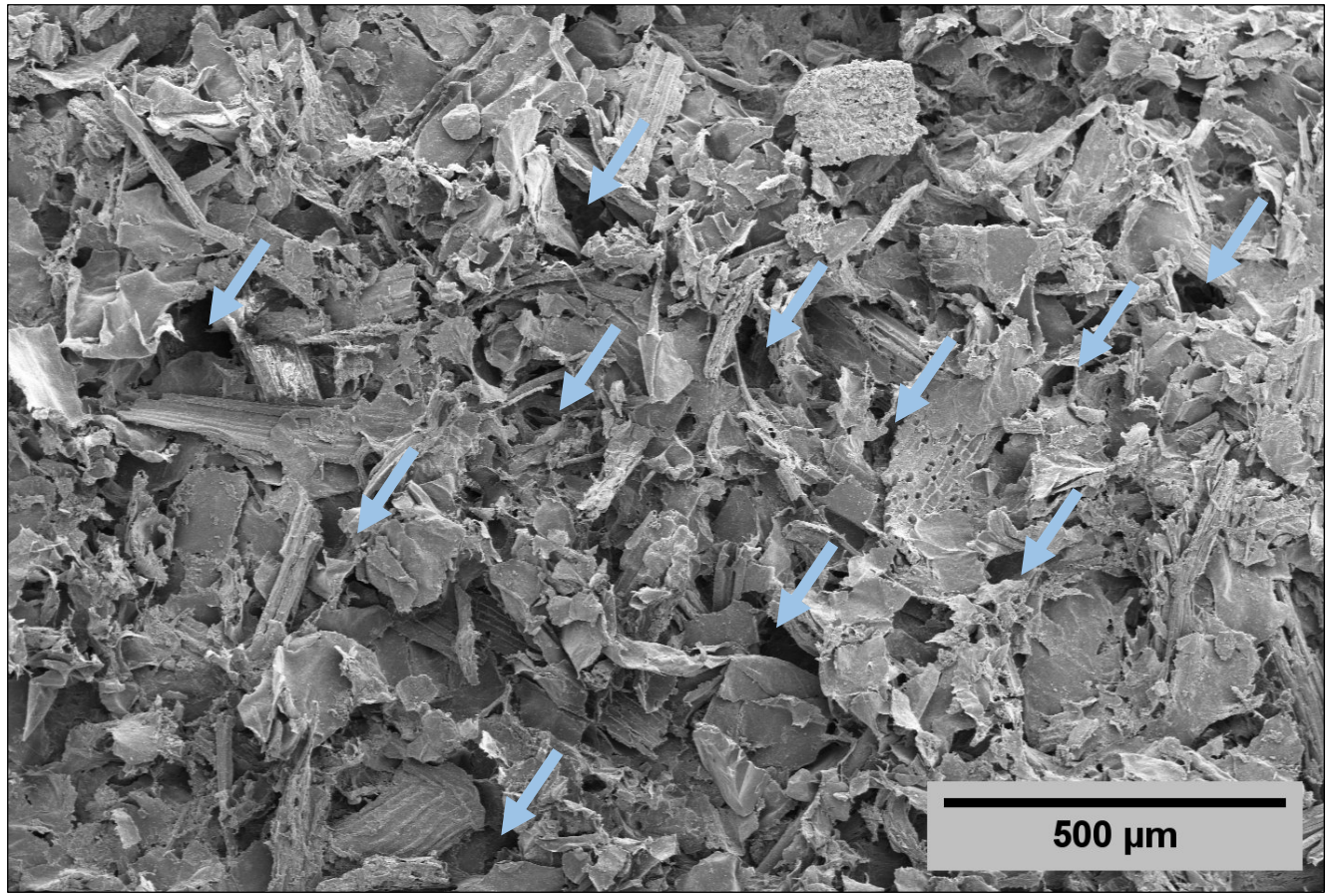


Compressive modulus taken from the elastic region (<5% strain)

Hydrophobicity

Lightweight materials containing 0.1% CNF

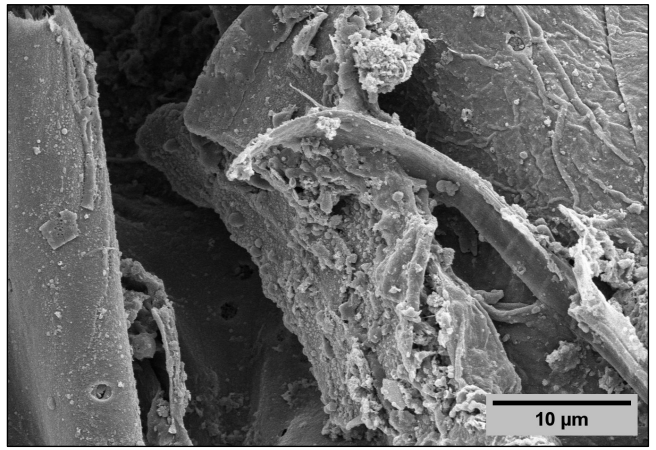
1 Porosity



Hydrophobicity

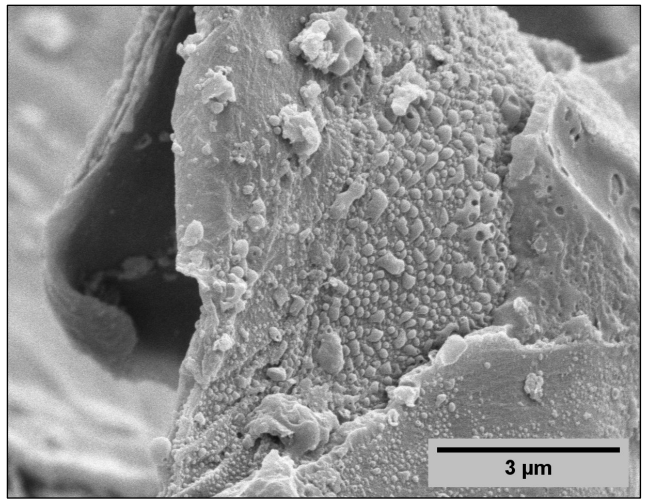
Lightweight materials containing 0.1% CNF

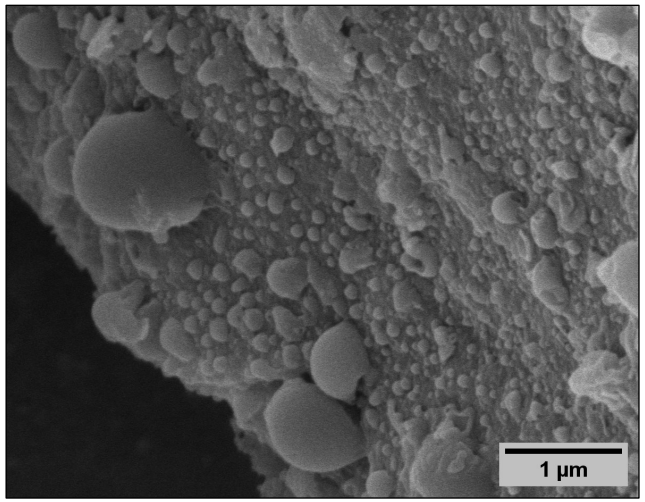
2 Roughness



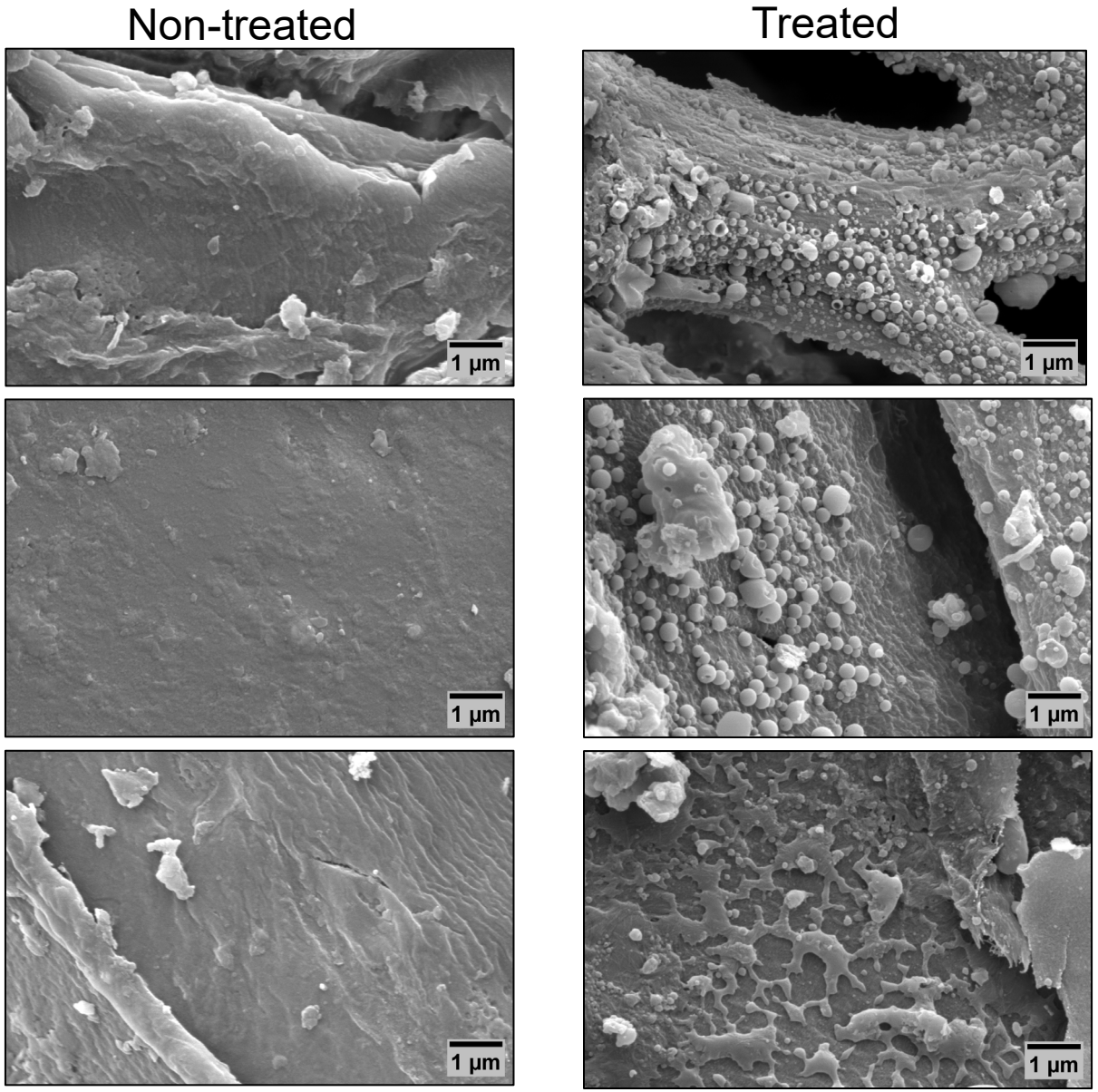
Hierarchical micro- and nanoroughness

3 Lignin redeposition



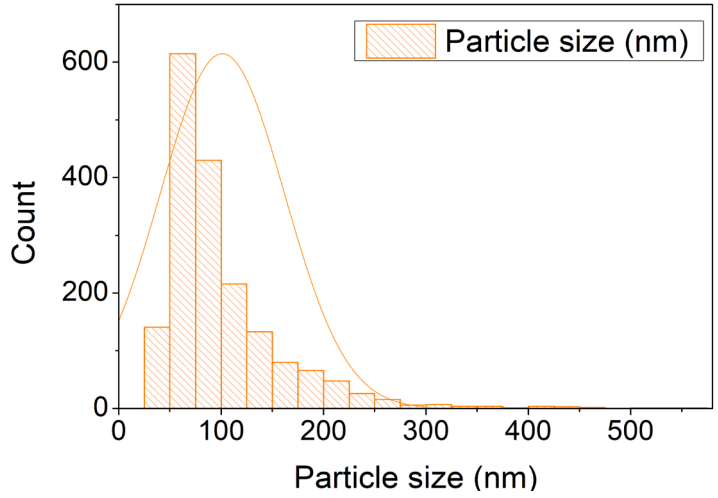


FESEM images of the surface of the non-treated and treated bagasse



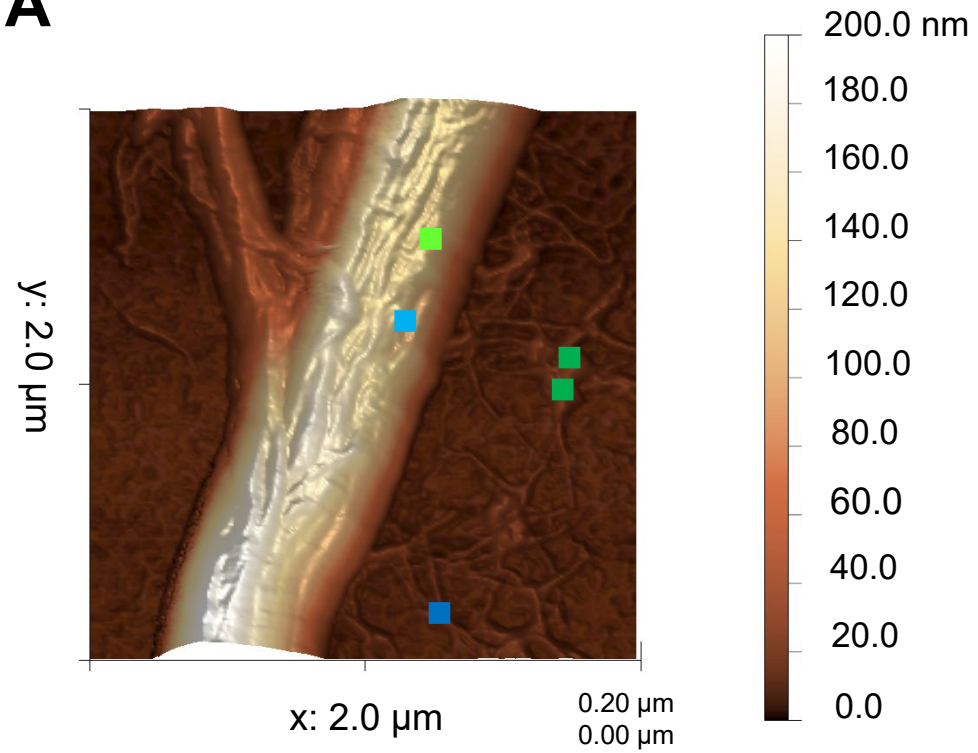
Spherical droplets composed by lignin on the fiber surface.

Histogram of diameter distribution of lignin nanoparticle

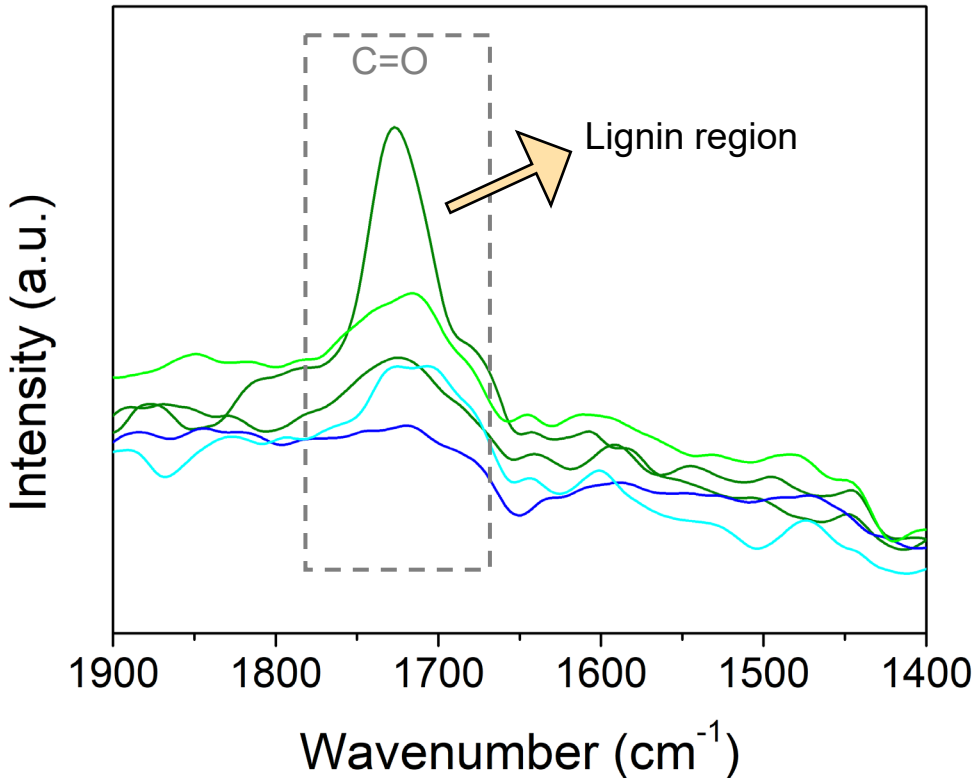


Atomic force microscope infrared spectroscopy of sugarcane bagasse

A



B

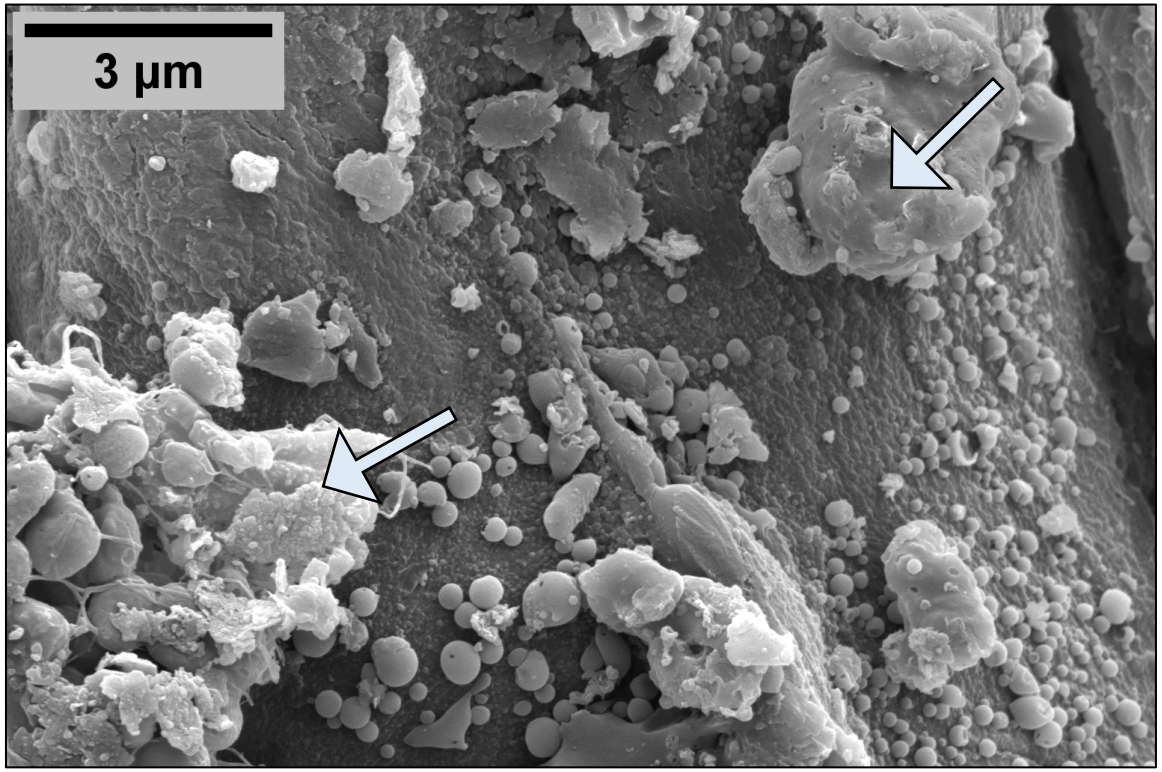


Distinct chemical composition:

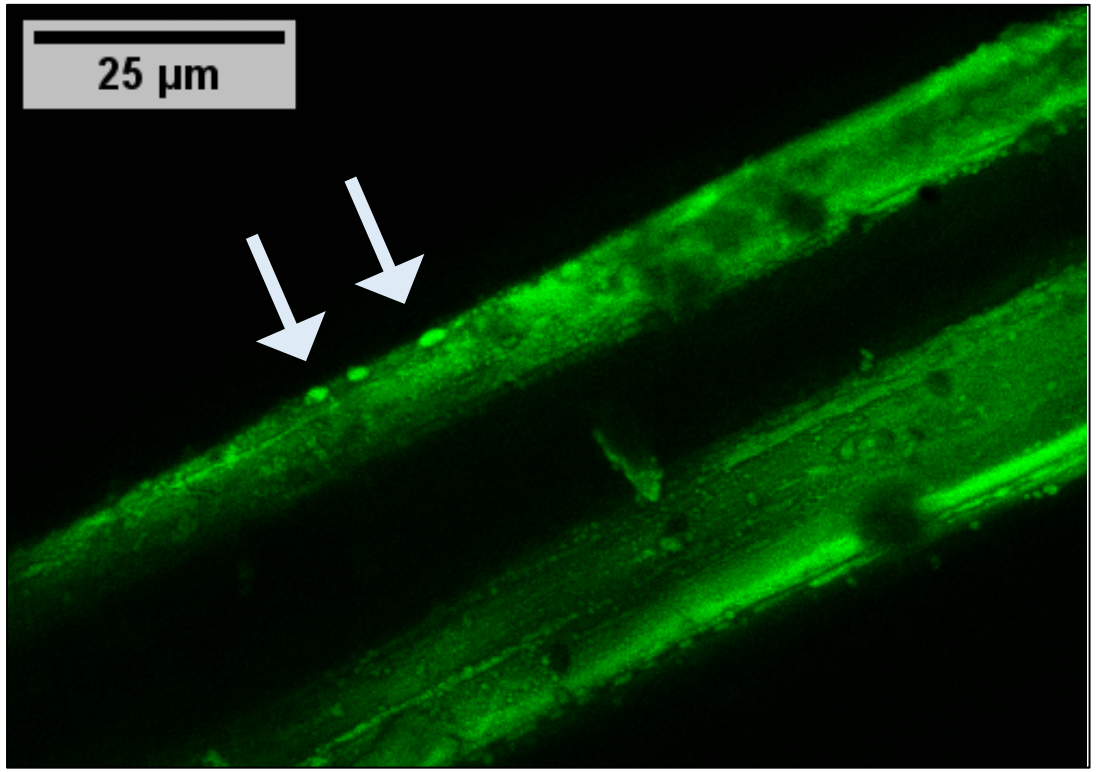
- **Green:** lignin-rich
- **Blue:** smoother domains

FESEM image and confocal microscopy

A

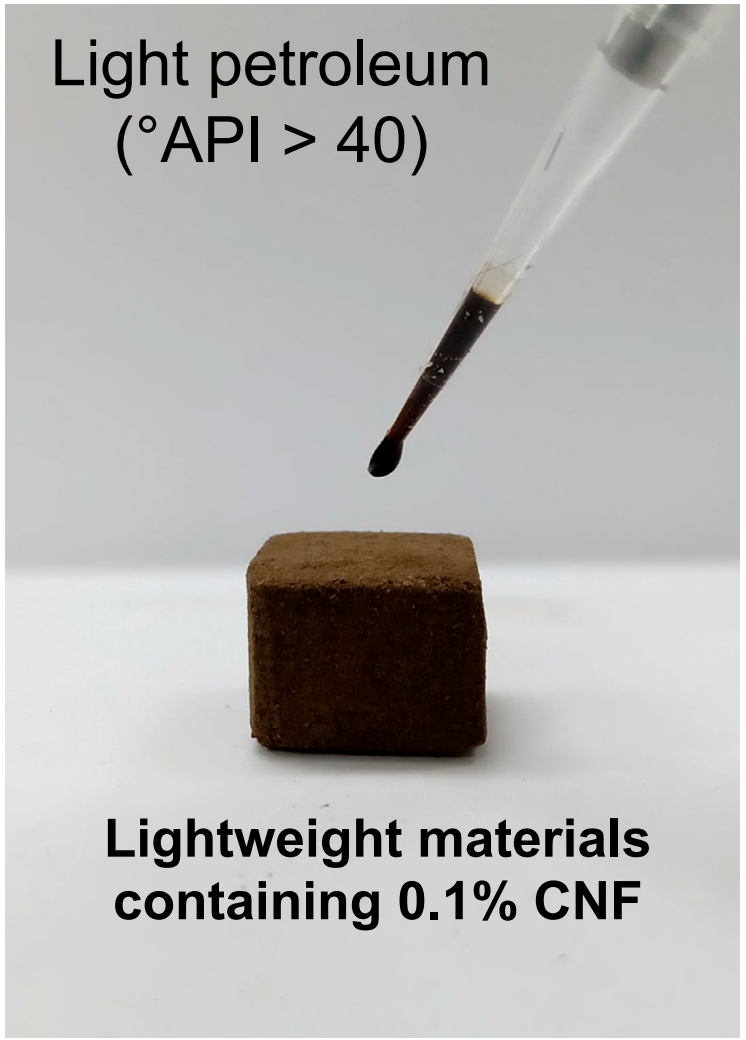


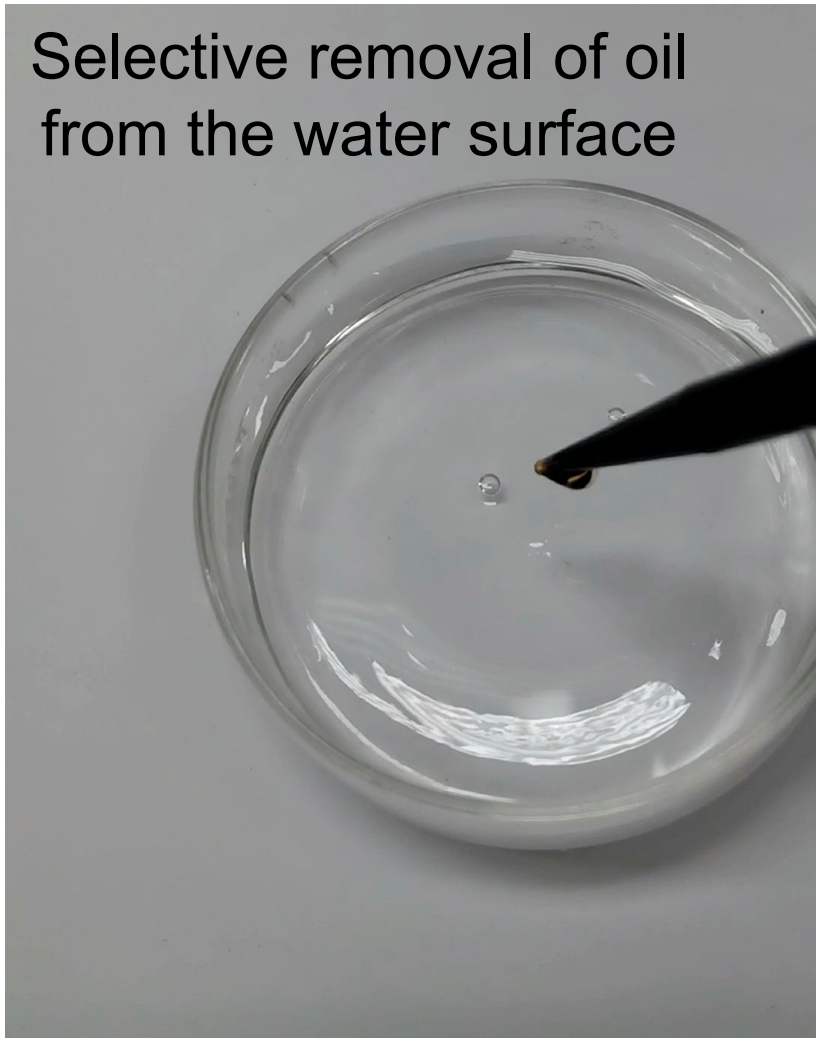
B



- The arrows in (A) and (B) indicate **lignin regions** equivalent of green point in AFM topography

Oleophilicity





Conclusion

This study,

showed the possibility of producing sustainable **LIGNOCELLULOSIC-BASED MATERIALS** combining the presence of **CELLULOSE** and **LIGNIN** in different scales (micro and nanometric) as potential materials for **OIL SORPTION.**

THANK YOU FOR YOUR ATTENTION!

Polianna da Silva Ferreira
p234897@dac.unicamp.br

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