

# High barrier plasticized cellulose nanocrystal film

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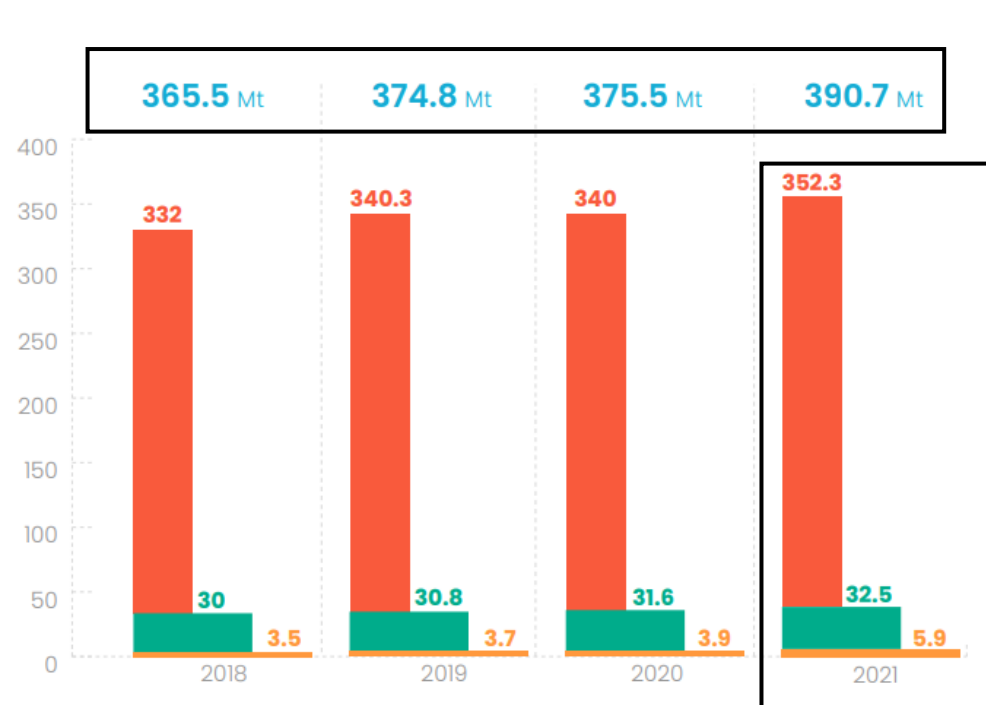
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**MONASH**  
University

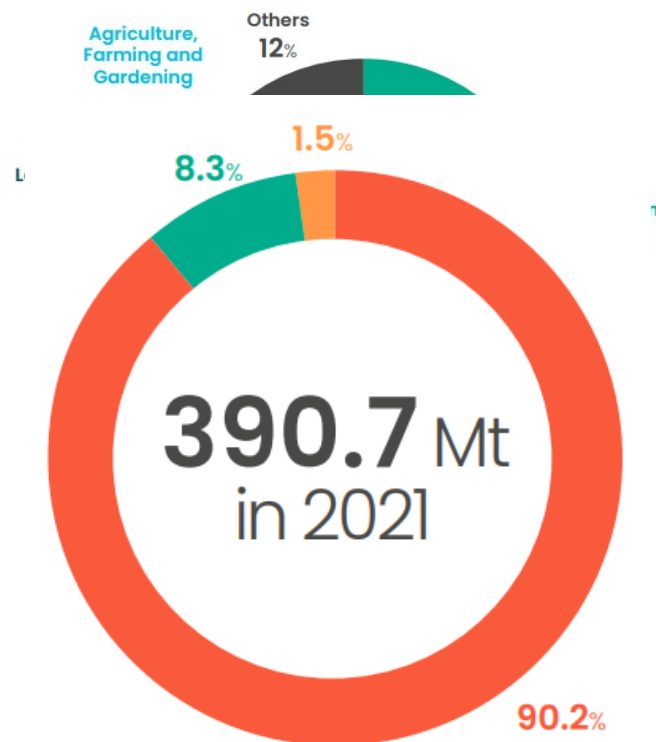


# World plastics production evolution



in million tonnes

- Fossil-based plastics
- Post-consumer recycled plastics
- Bio-based plastics



- ✓ What are the bio-based plastics?
- ✓ What is limiting their usage in plastic industry?



# Bio-based plastics

## Lipids

Bees  
wax

Carnaub  
a wax

Free fatty  
acids

## Polysaccharides

Cellulose

Starch

Chitosan

Maze

Gums

## Proteins

Collagen

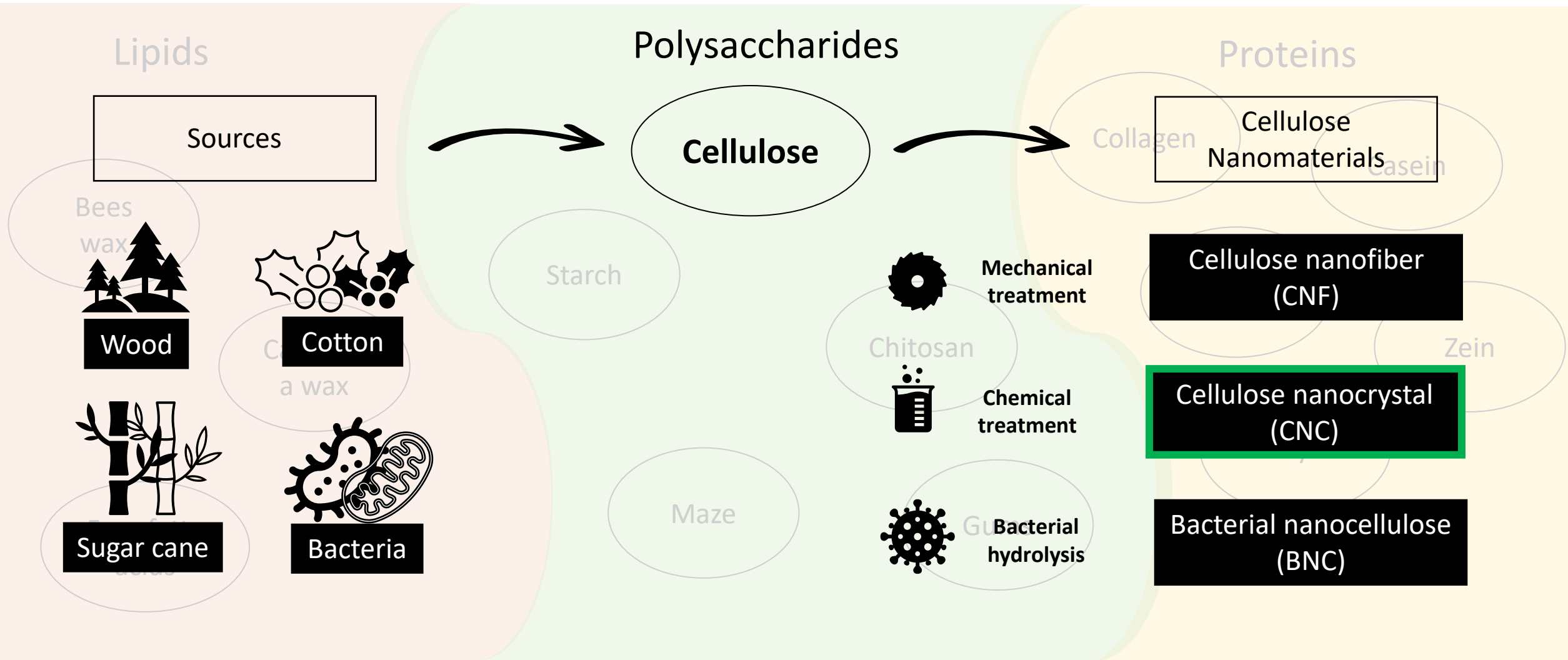
Casein

Whey

Soya

Zein

# Bio-based plastics



# Cellulose Nanocrystals (CNC)

Investigate the use of plasticizers as a sustainable method for improving the limitations of CNC films while preserving their positive aspects

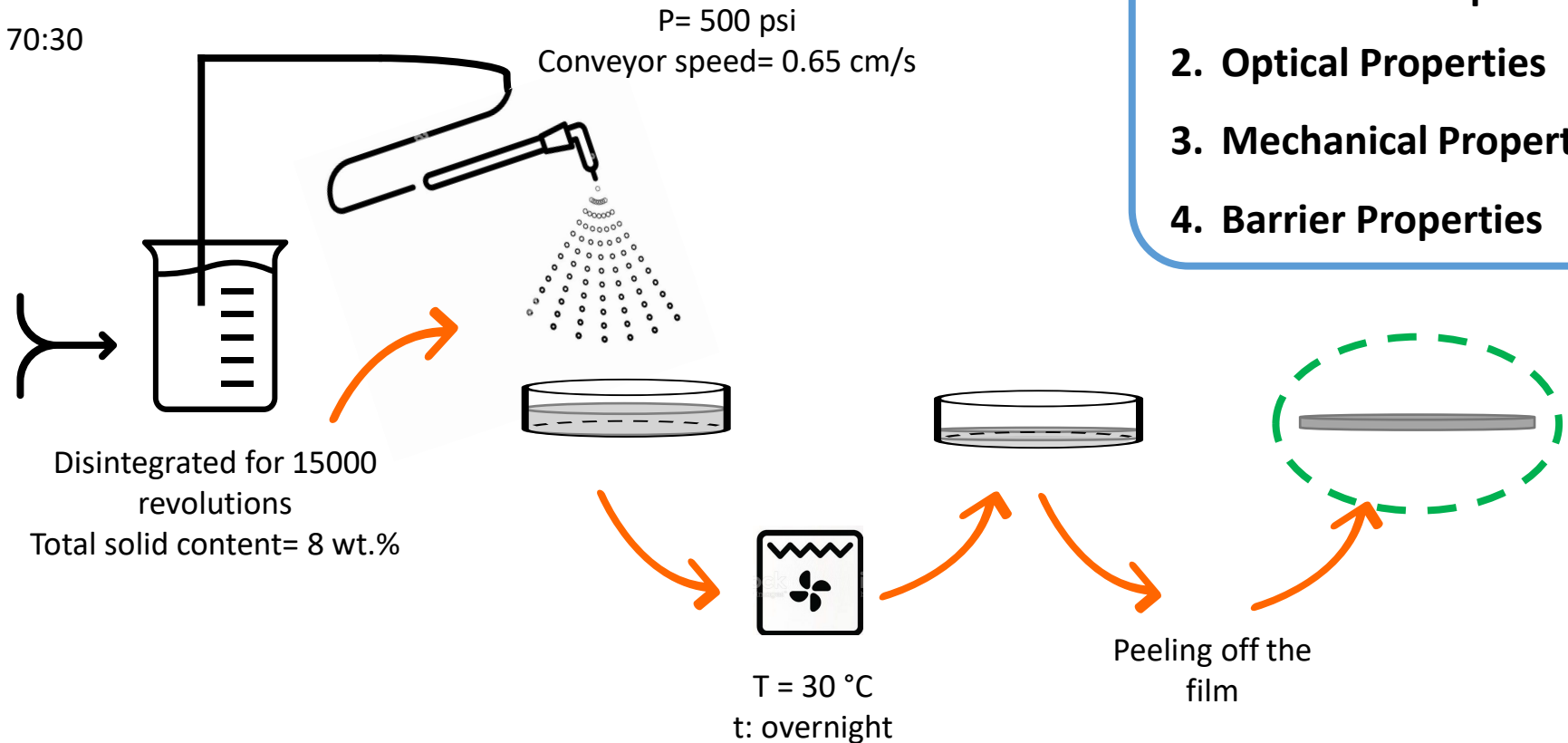
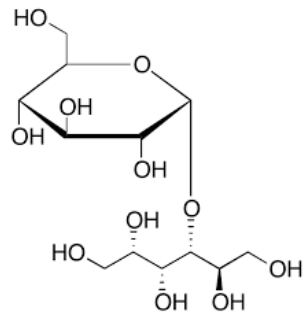
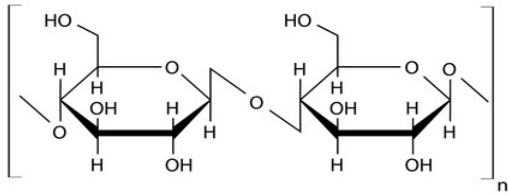
- Bio-based & Biodegradable
- Recyclable
- Nontoxic
- High crystallinity
- High translucency
- High specific surface area
- High density of hydroxyl groups
- High tensile strength
- High oxygen barrier properties

- High cost
- Low flexibility/elongation at break
- Low resistance against water
- Deterioration of tensile strength and gas barrier properties in the presence of moisture

High  $\frac{\text{Cost}}{\text{Performance}}$

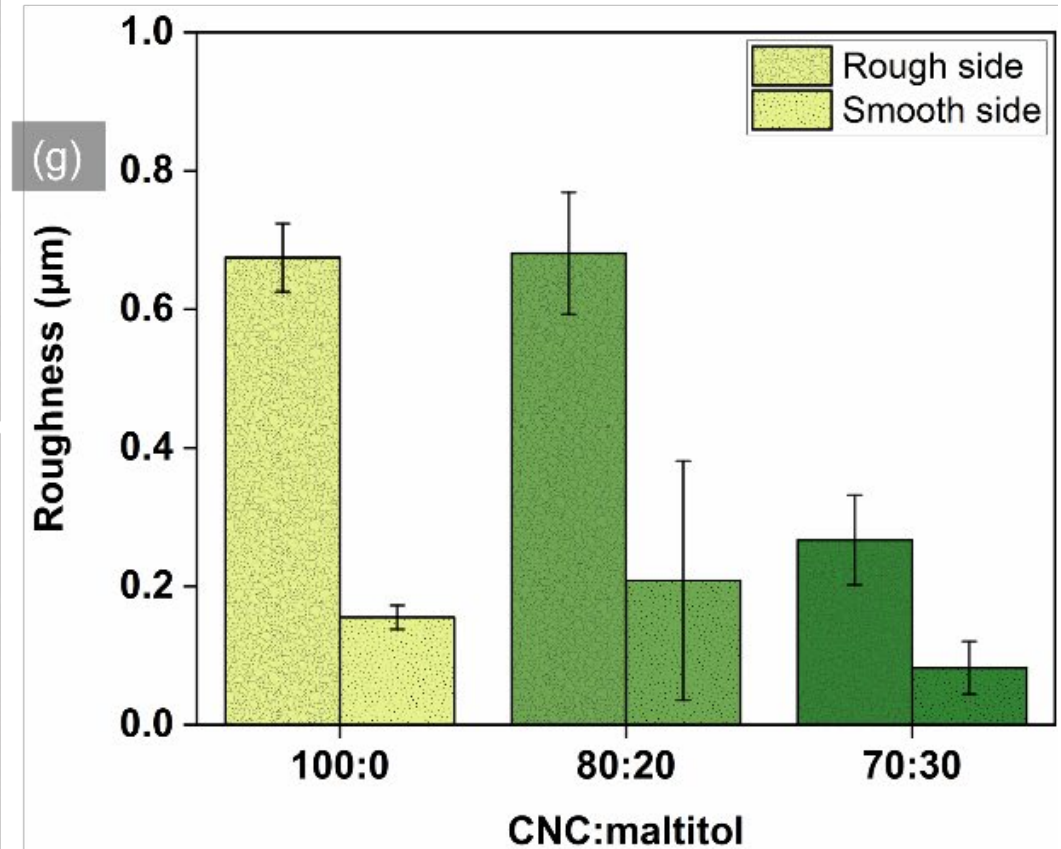
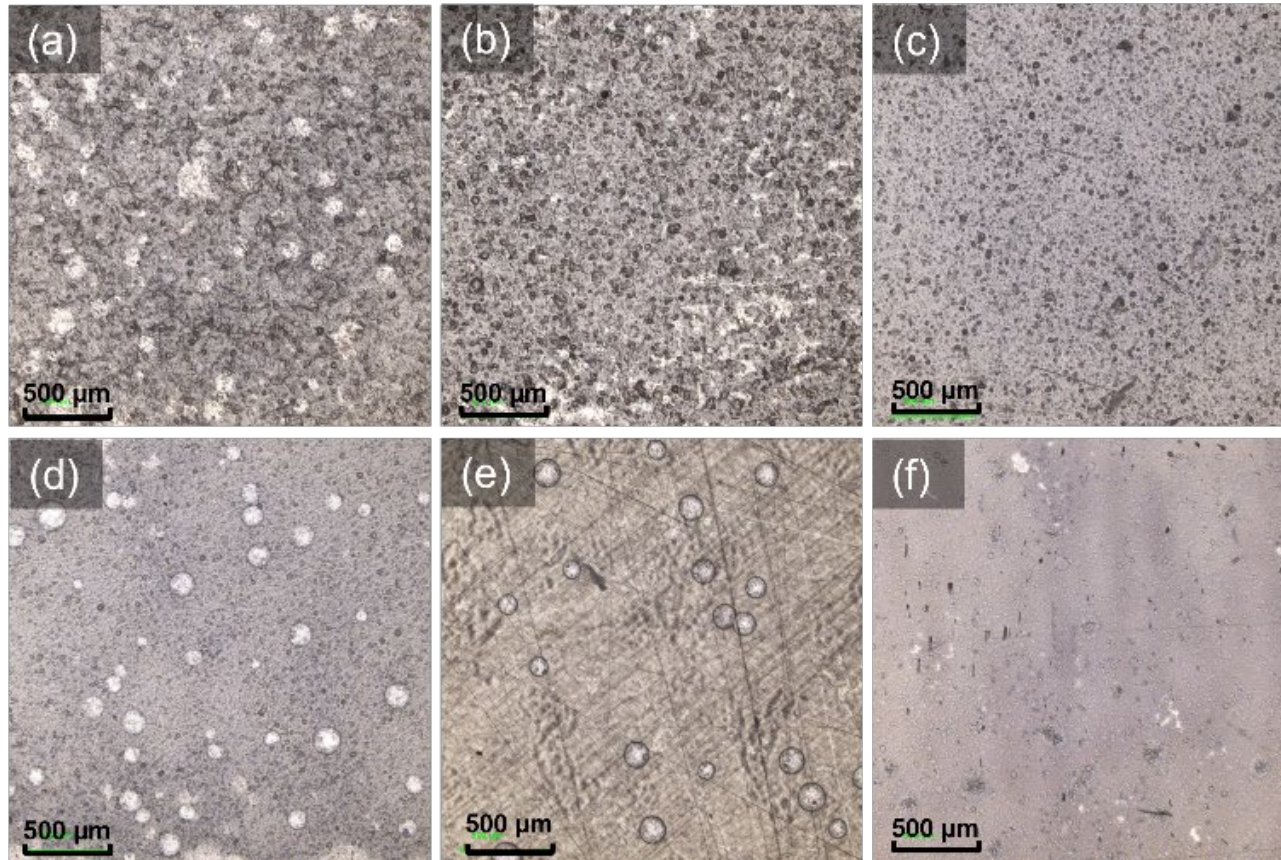
# Plasticized Cellulose Nanocrystals film formation

Sample	CNC: Maltitol (wt./wt.%)
Control(CNC)	100:0
MAL20	80:20
MAL30	70:30



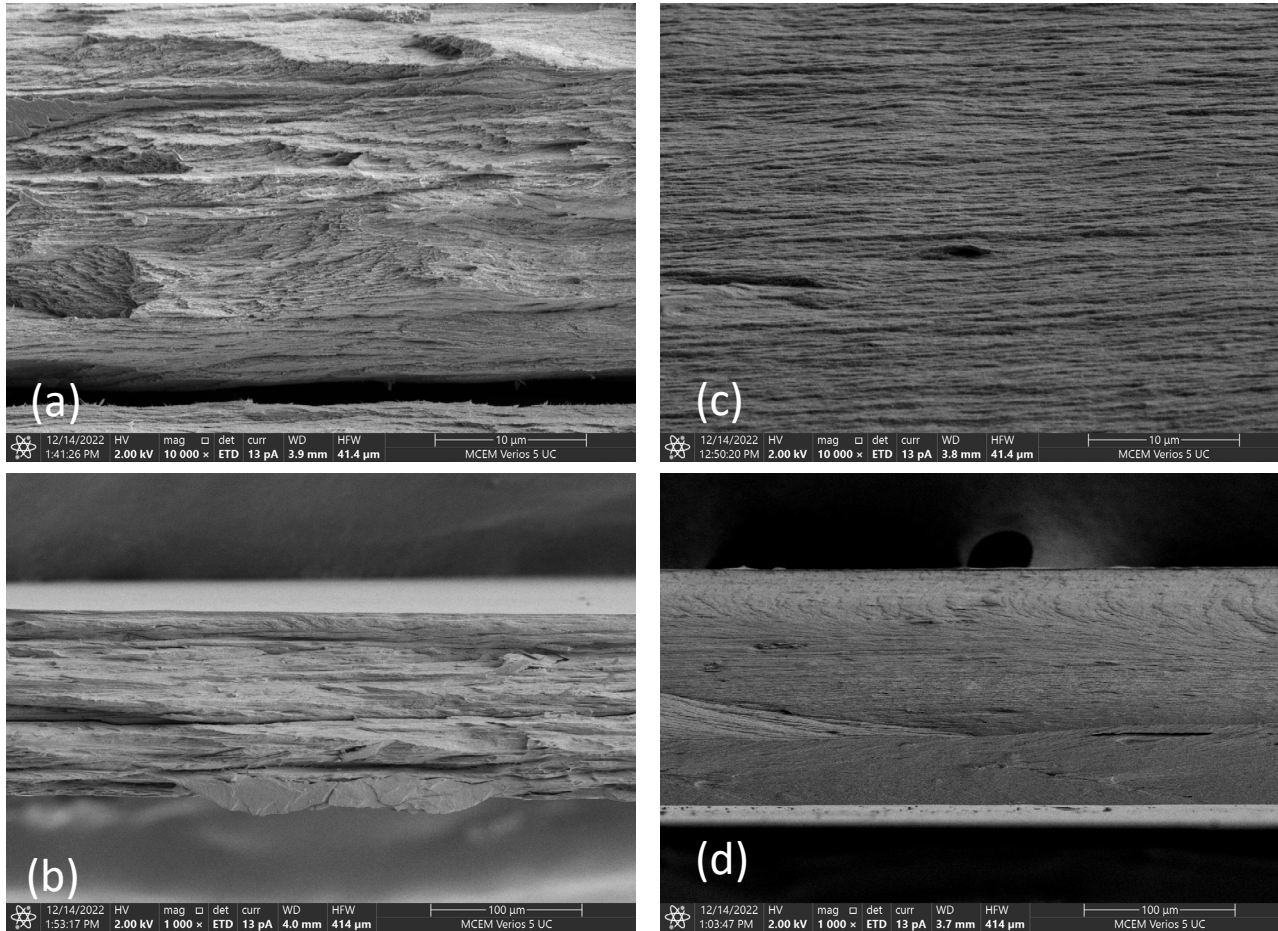
- 1. Structural Properties
- 2. Optical Properties
- 3. Mechanical Properties
- 4. Barrier Properties

# Structural Properties

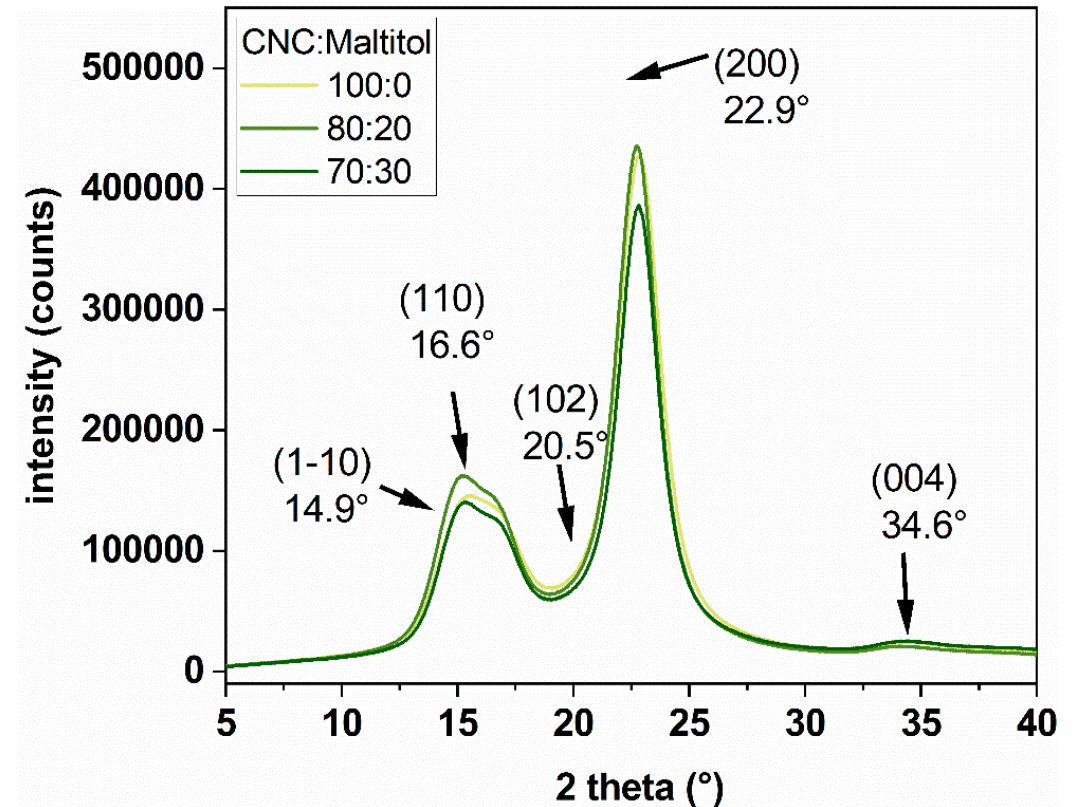
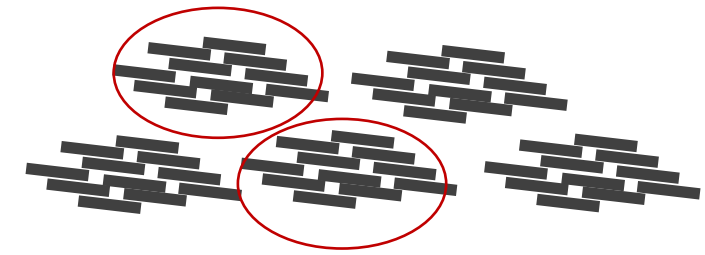


Optical images of the rough surface of a) cellulose nanocrystal (CNC), and cellulose nanocrystal containing c) 20 wt.% (MAL20), and d) 30 wt.% (MAL30) maltitol and smooth surface of d) cellulose nanocrystal (CNC), and cellulose nanocrystal containing e) 20 wt.% (MAL20), and f) 30 wt.% (MAL30) maltitol (The scale bar for the images is 500μm), and g) the surface roughness (Sq) on each side of the films for an area of 256x256 μm×μm

# Structural Properties



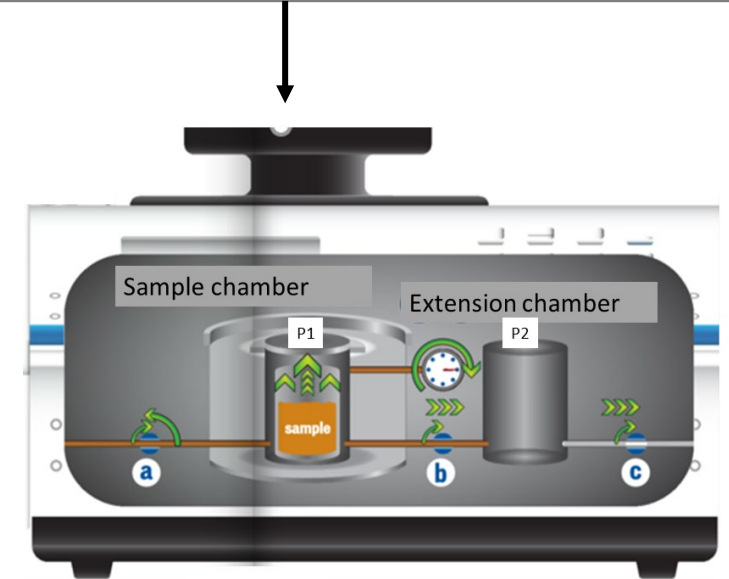
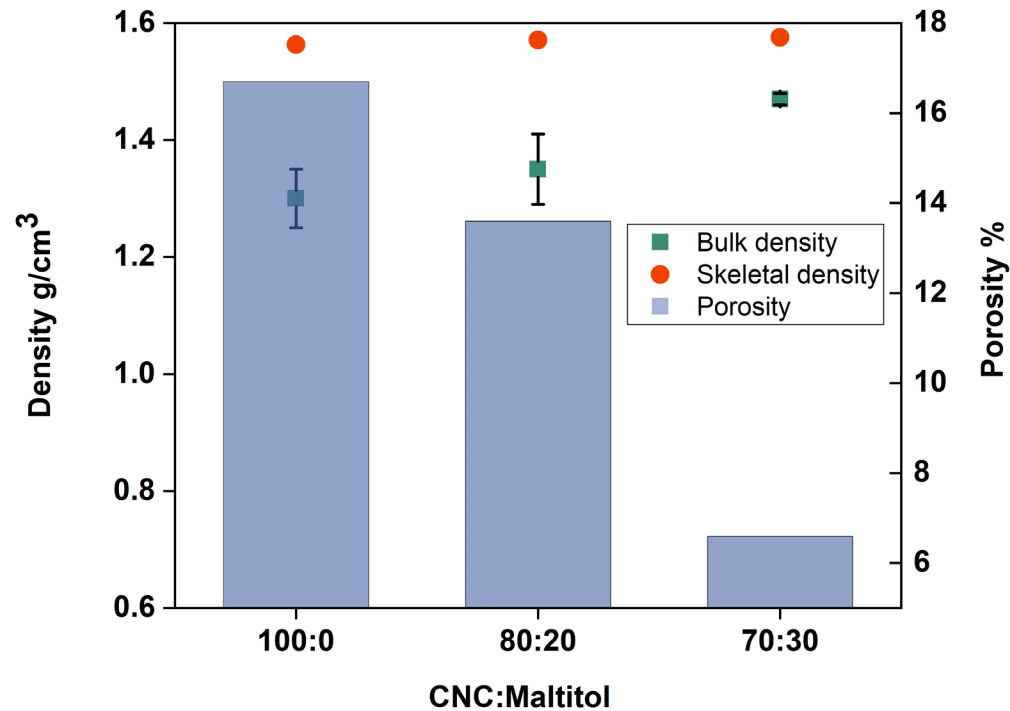
Morphology of the CNC composites of different compositions. Scanning electron micrographs of the cross-section of CNC (a and b) and MAL30 films containing 30 wt.% maltitol (c and d) films



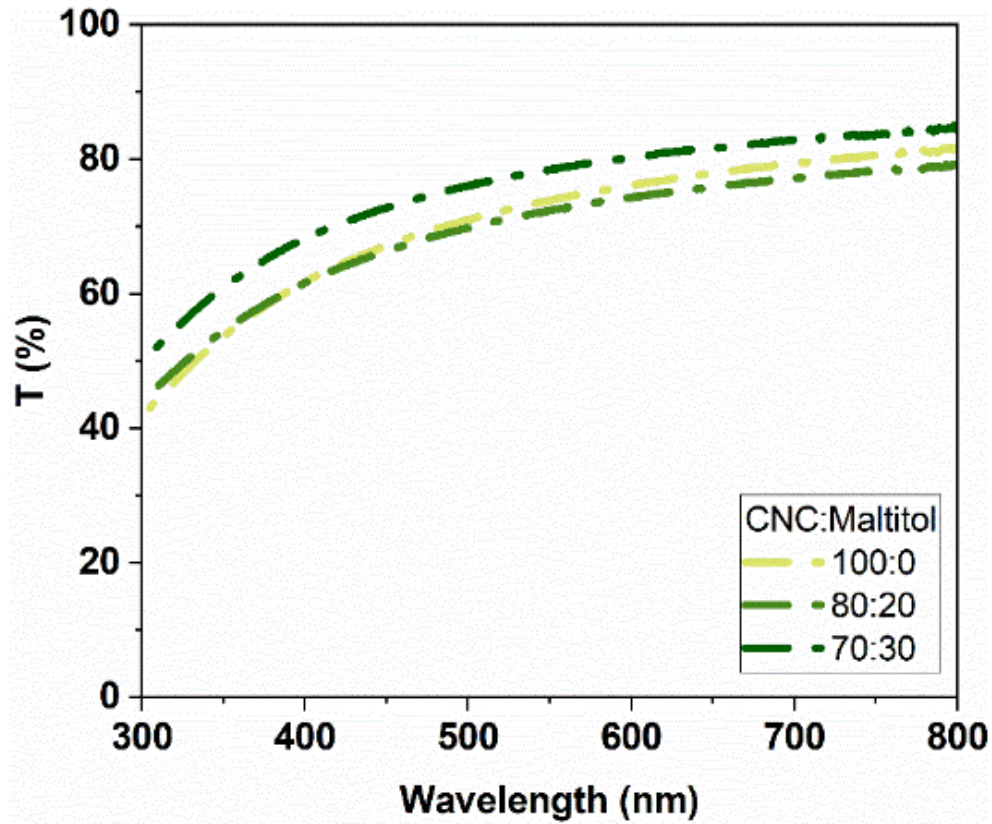
Crystallinity of the CNC-Maltitol composites. XRD patterns for the control film (CNC) and plasticized samples containing 20, and 30 wt.% maltitol

# Structural Properties

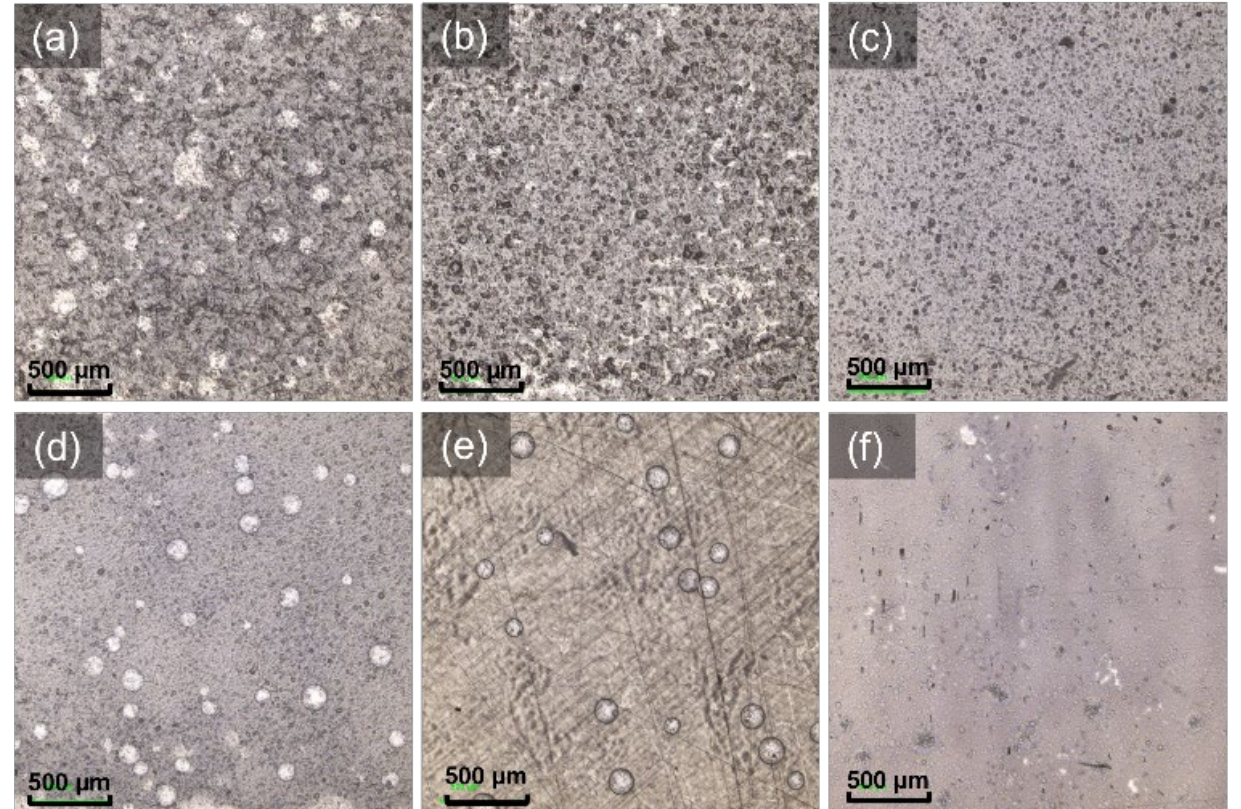
Samples/properties	Basis Weight (g/m <sup>2</sup> )	Thickness (μm)	Bulk Density (g/m <sup>3</sup> )	Skeletal Density (g/m <sup>3</sup> )	porosity
CNC (Control)	99.9 ± 7.9	76.7 ± 4.1	1.30 ± 0.05	1.5628	16.7 %
CNC: Maltitol 80:20	128.3 ± 17.3	94.50 ± 11.2	1.35 ± 0.06	1.5711	13.6%
CNC: Maltitol 70:30	204.5 ± 25.1	140.8 ± 19.2	1.47 ± 0.01	1.5753	6.6%



# Optical Properties

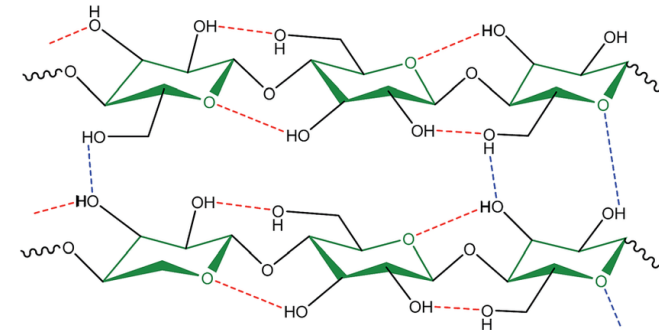
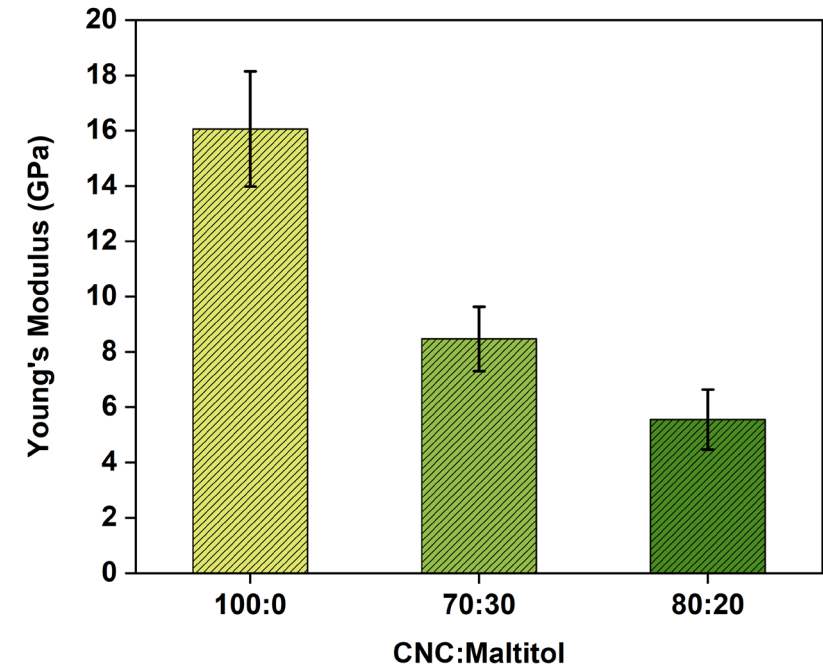
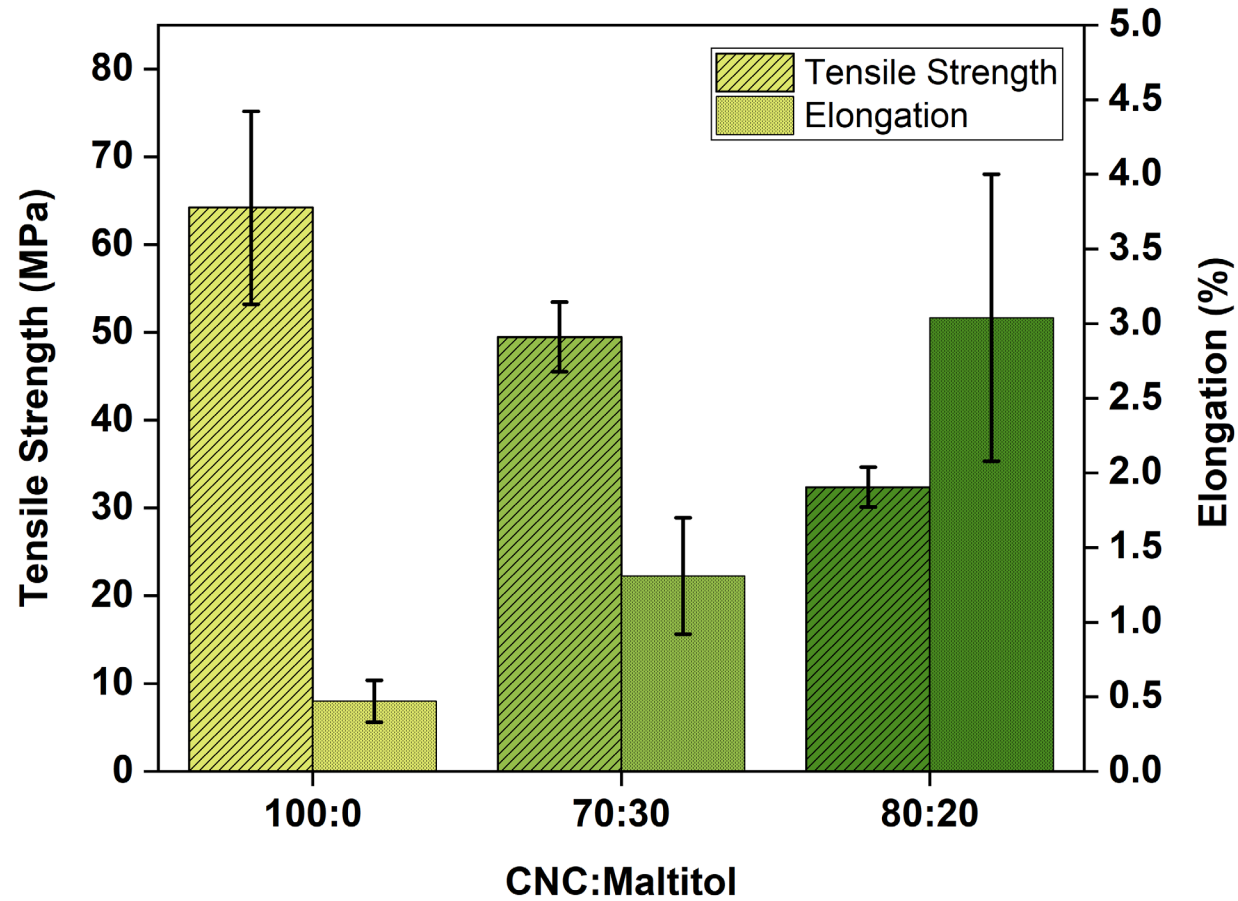


UV-Vis transmittance spectra (300-800 nm) of CNC:Maltitol films

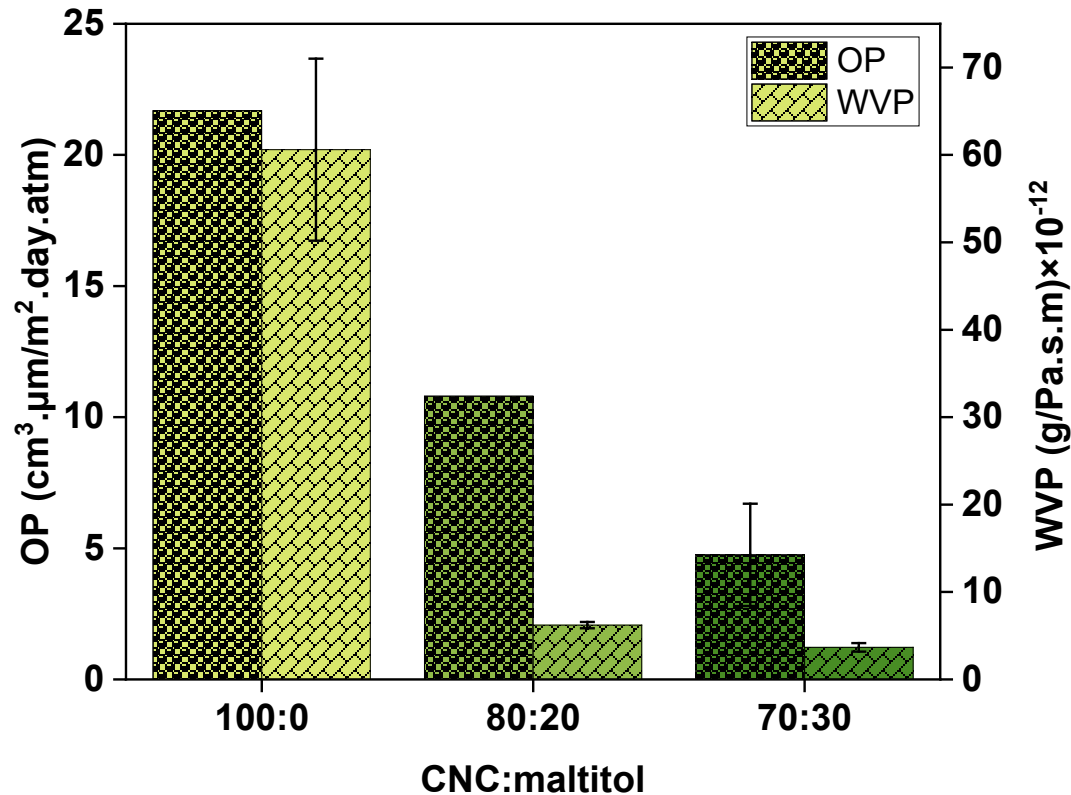


Optical images

# Mechanical Properties

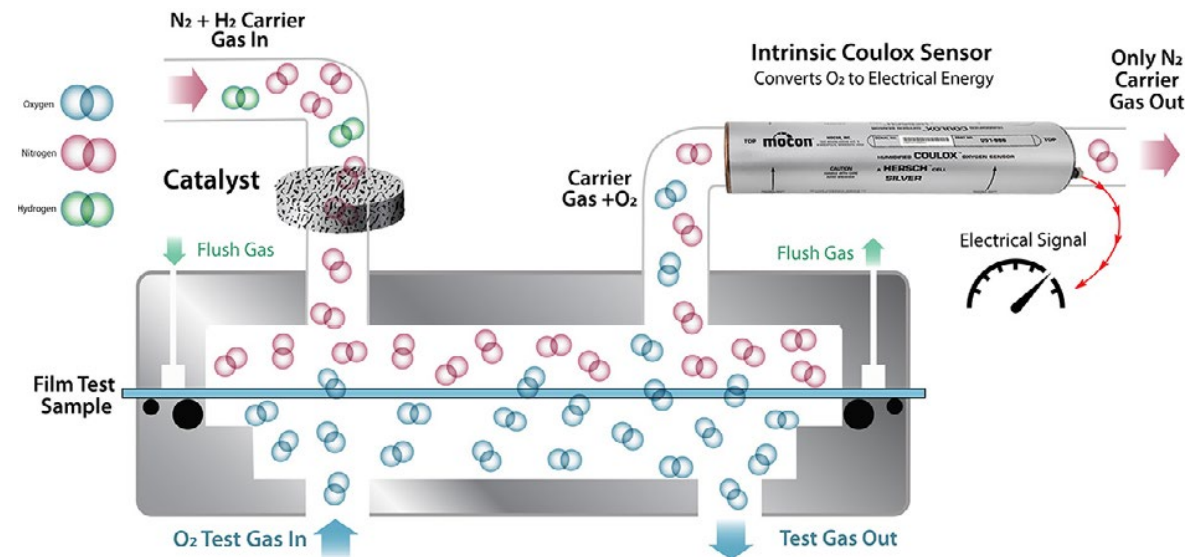
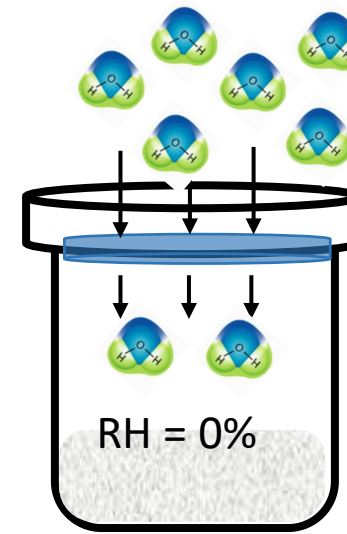


# Barrier Properties

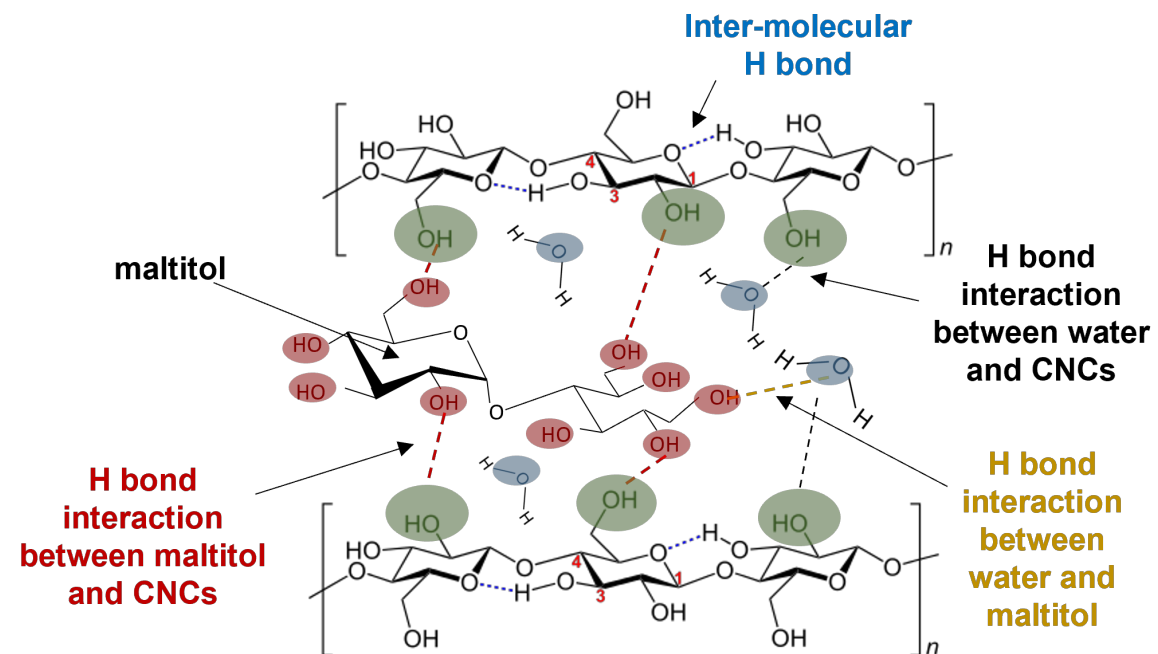
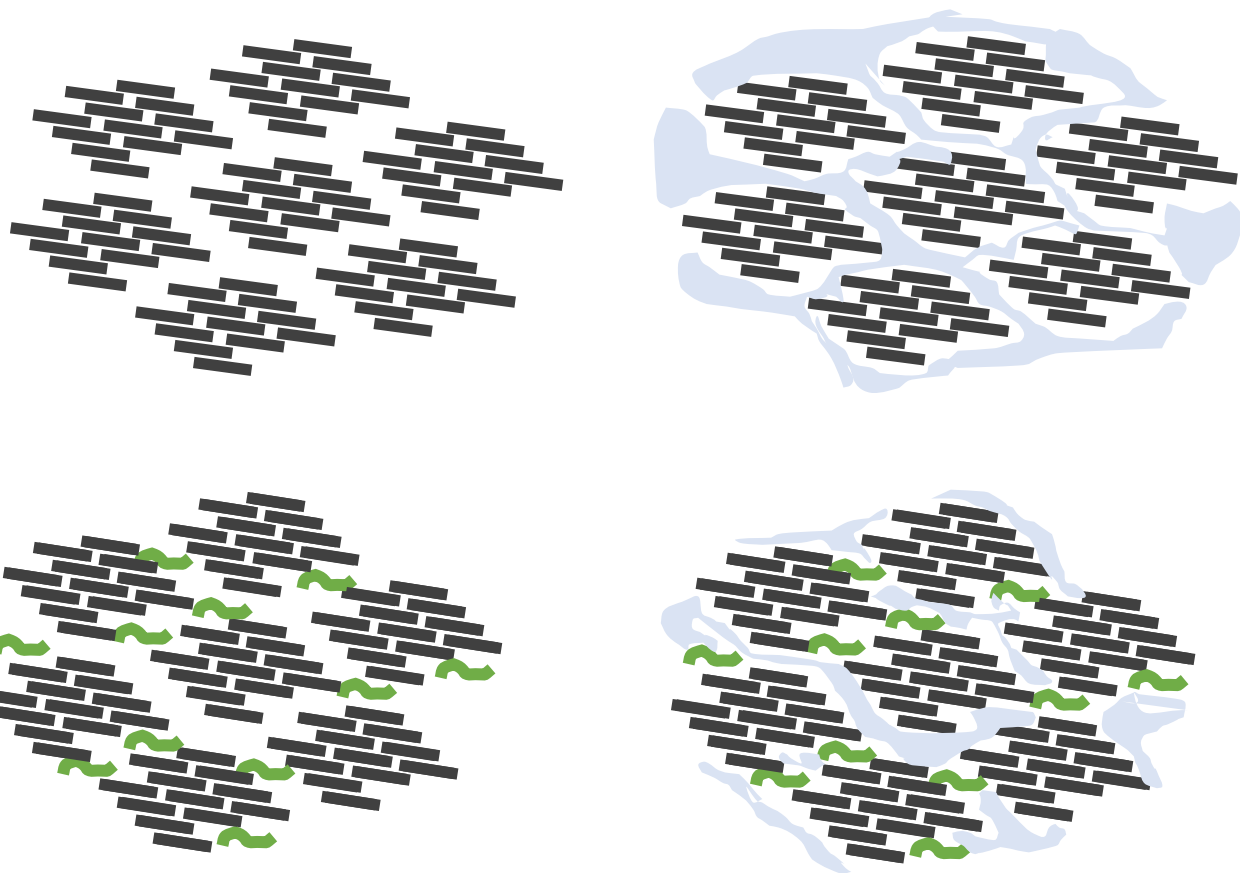


Water vapour permeability (WVP) and oxygen permeability (OP) for the cellulose nanocrystals and composite films containing 20, and 30 wt.% maltitol, measured at 50% RH and 23°C

RH = 50%

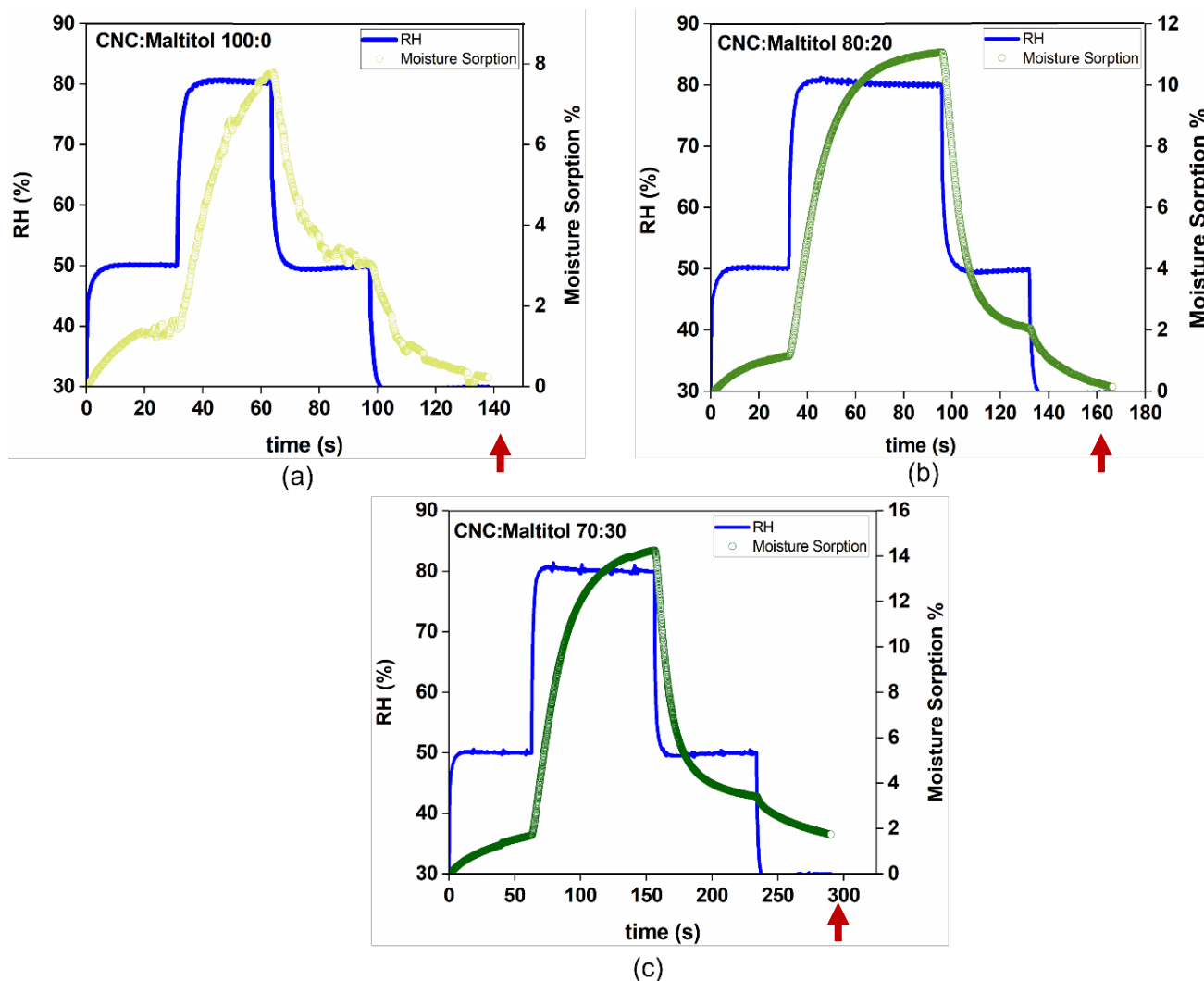


# Barrier Properties

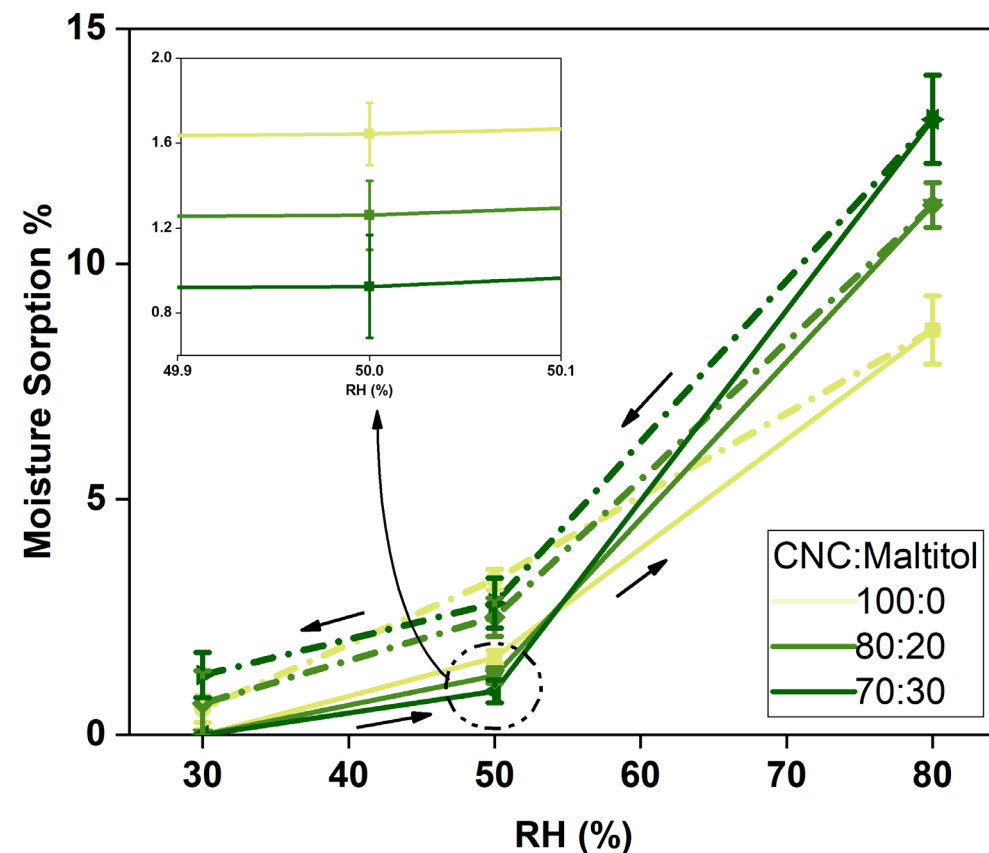


- Lower porosity
- Lower density of free hydroxyl groups

# Dynamic Vapour Sorption



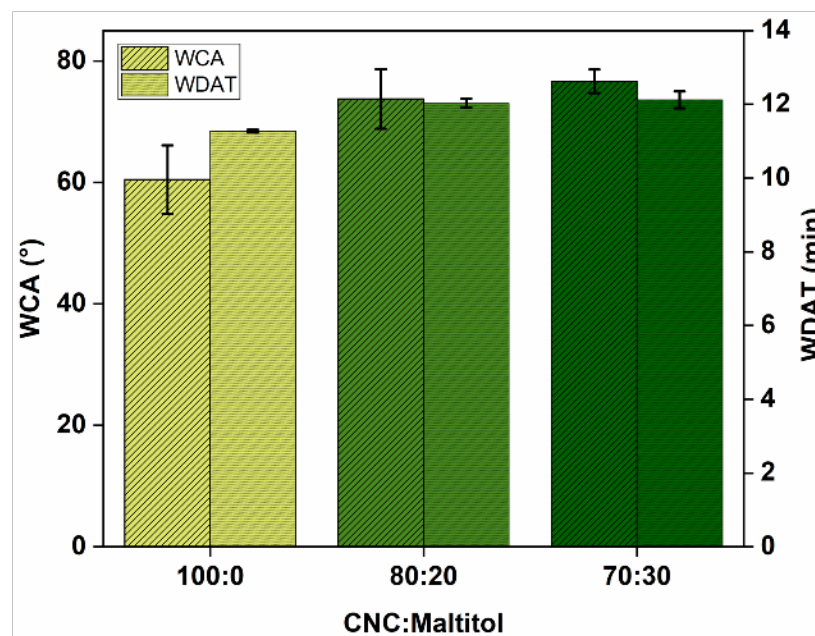
Moisture sorption kinetic graphs of (a) CNC, and plasticized samples containing (b) 20 wt.% and (c) 30 wt.% maltitol during the sorption process

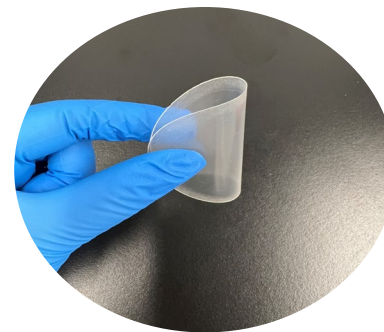
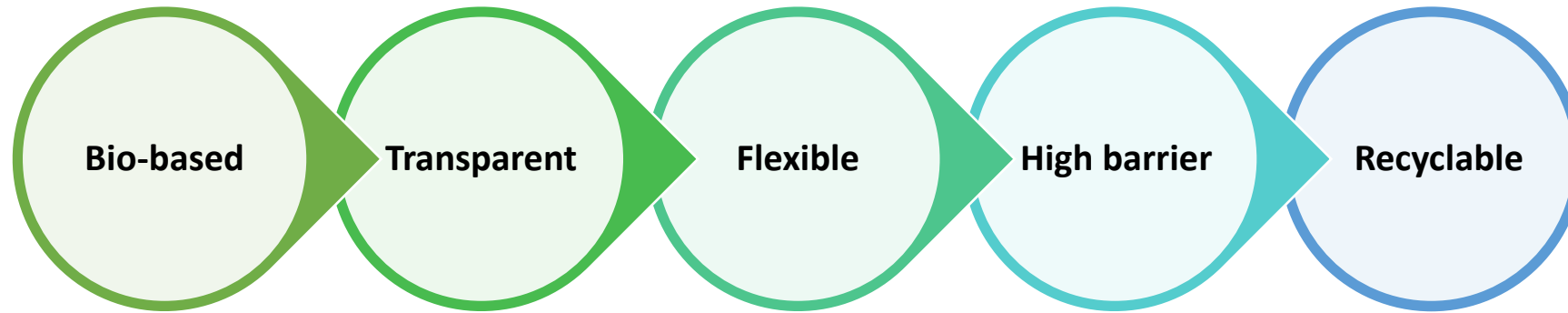


The equilibrium moisture content isotherm at 30°C for three different RH of 30%, 50%, and 80%. The solid line indicates increase in RH while the dash dot line indicates decrease in RH.

# Water Contact Angel

## Water Drop Absorption Time





# International Conference on Nanotechnology for Renewable Materials

## Supervisors:

- A/Prof. Warren Batchelor
- Prof. Gil Garnier



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University



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PROCESSING ADVANCED LIGNOCELLULOSICS

## Colleagues at BioPRIA



*Thank  
you!*