FinnCERES Materials Cluster

Benchmarking the optical performance of nanocellulose films for smart device applications

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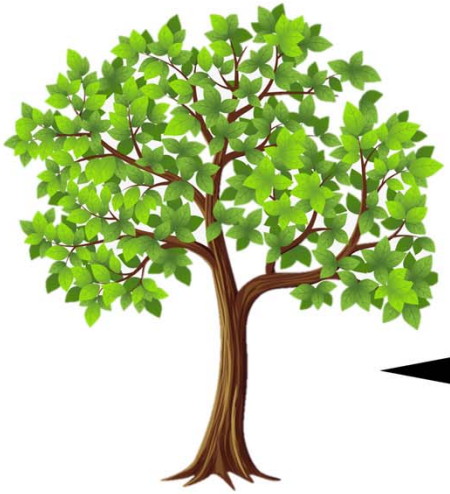
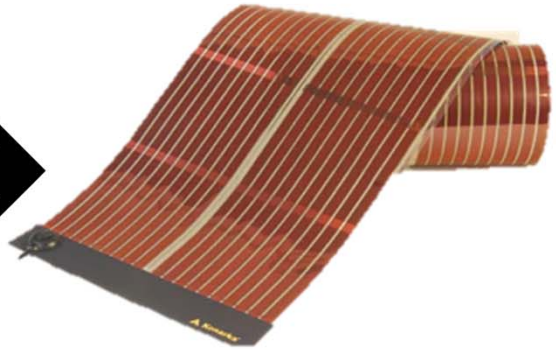
Smart devices impact and concerns to the society

Our study: *Increase the sustainability of solar cells.*

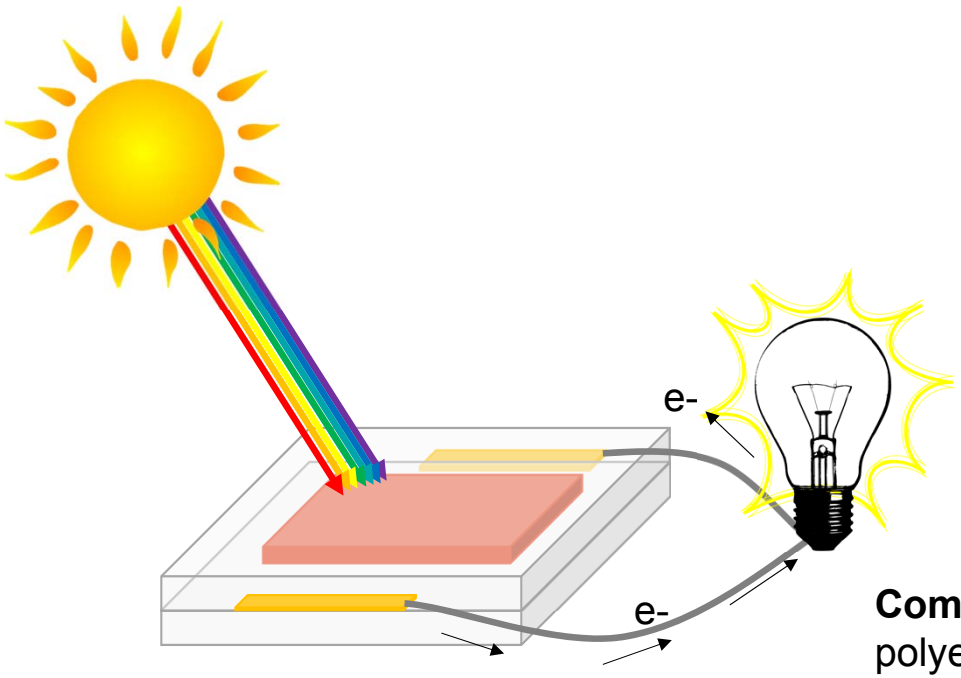
How? *Replacement of solar cells components by materials taken from trees.*





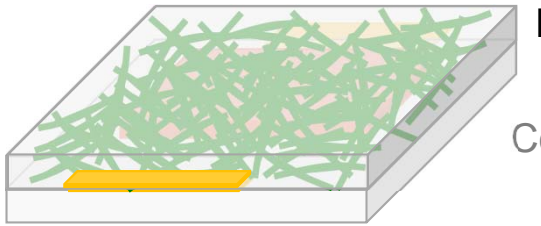
Nanocellulose films

Solar cells working system



Transparent conductive substrate

Active layer

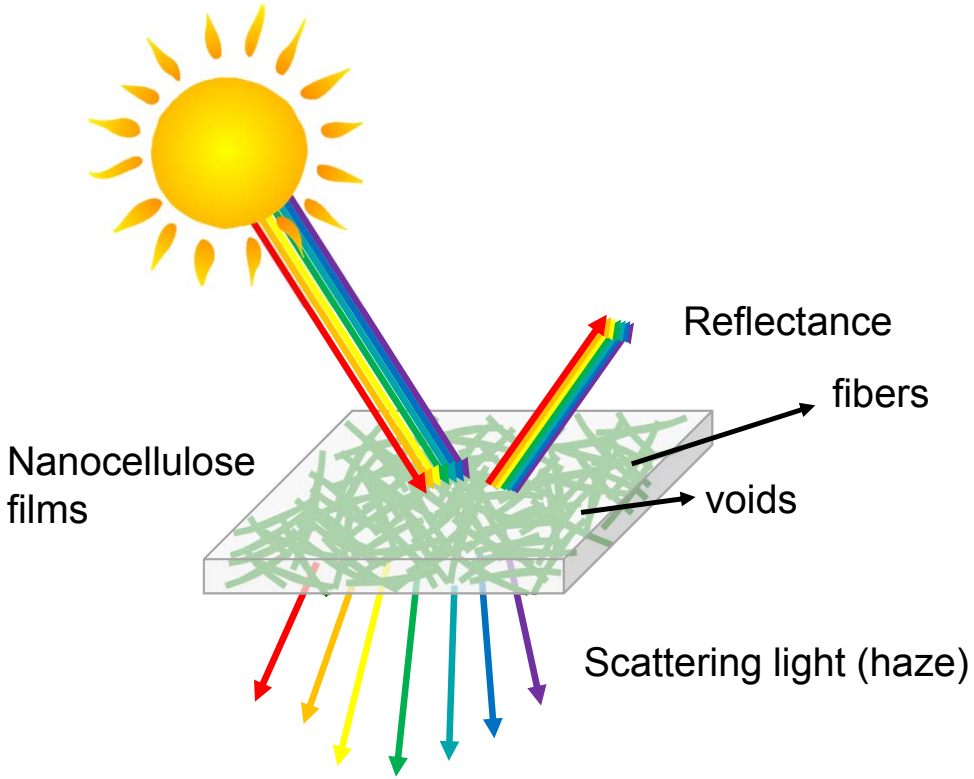


Nanocellulose

Conductive substrate

Common substrates: glass, polyethylene terephthalate (PET), polyethylene naphthalate (PEN)

Light management by the film structure or additives



Requirements for solar cells

High transmittance

Low reflectance helps in light in-coupling

High scattering increases the path of the light inside of the solar cell

How to engineer the optical and mechanical properties of nanocellulose films for solar cell substrates?

Nanocellulose film formation : *How to manipulate the porosity?*

Cellulose Nanofibers (**CNF**)

overnight stirring

Concentration

Low: induce to instability

High: difficult the homogenization

Fiber agglomerates

Initial state of the suspension

filtration

air flow

dewater

wet film

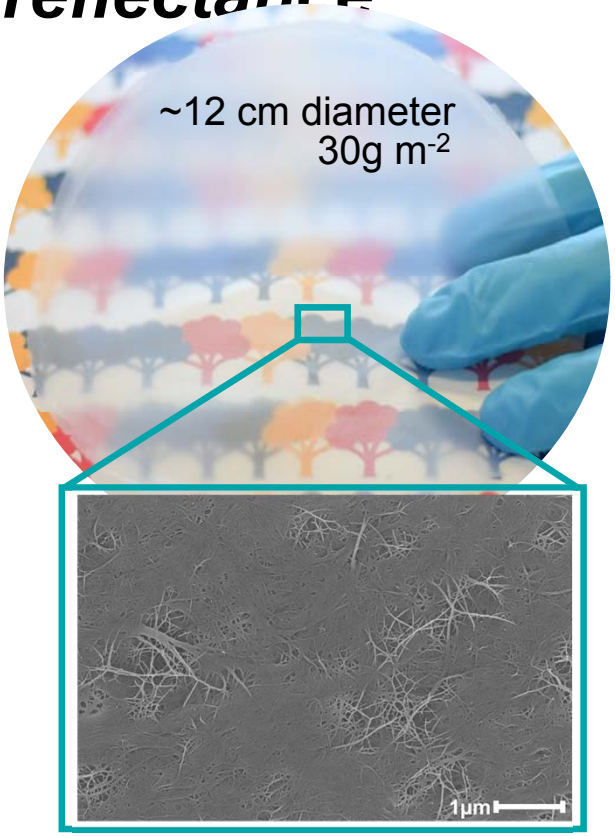
Changes the porosity

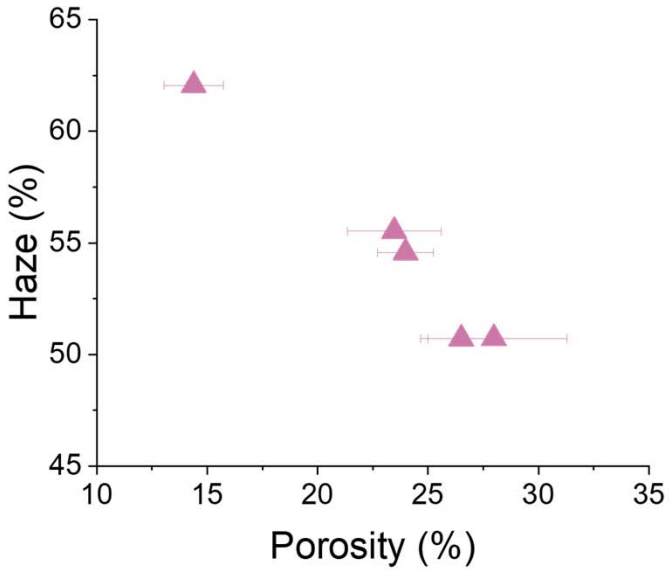
Temperature

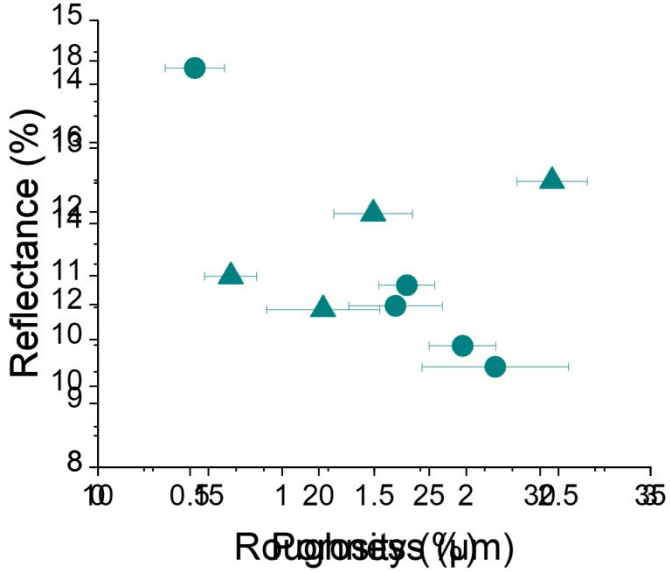
hot pressing

dry film

Higher CNF film porosity: less scattering and less reflectance

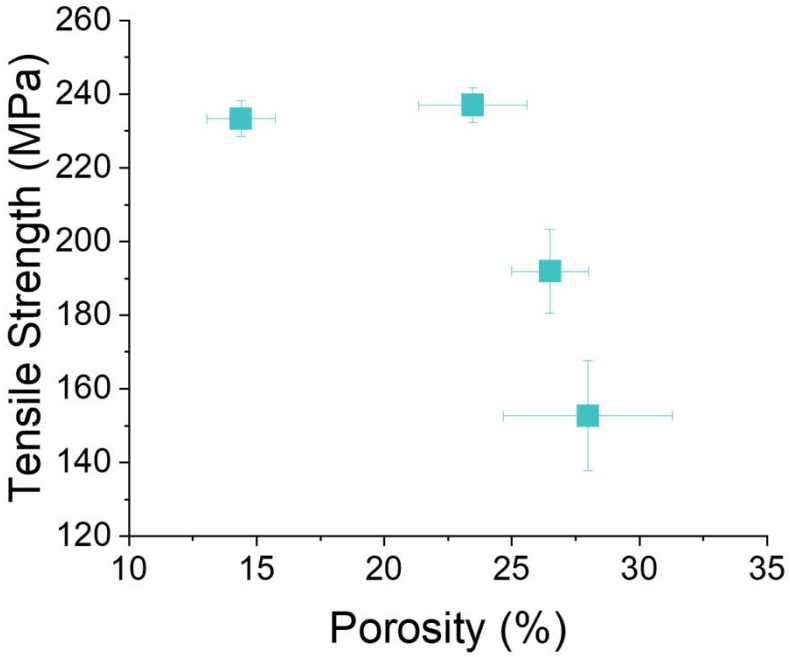


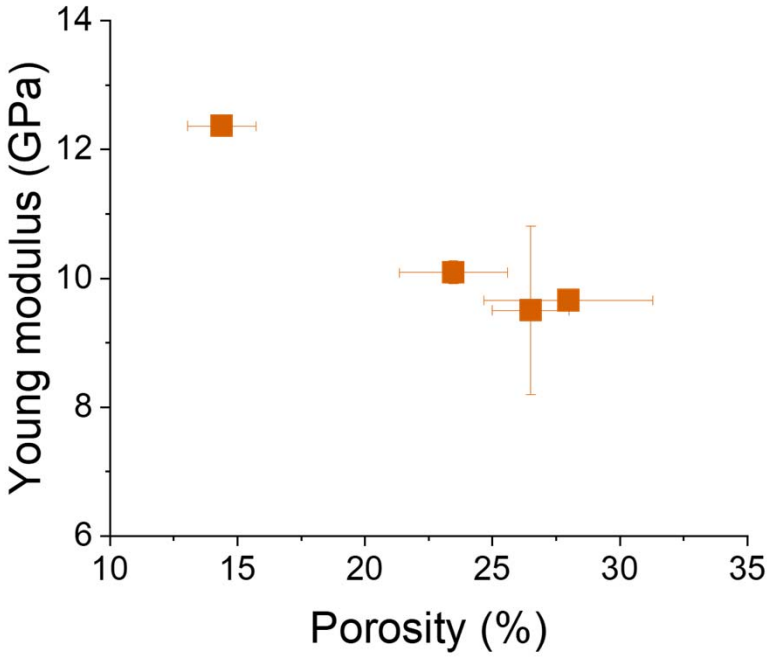




Roughness plays an important role in the reflectance of the films

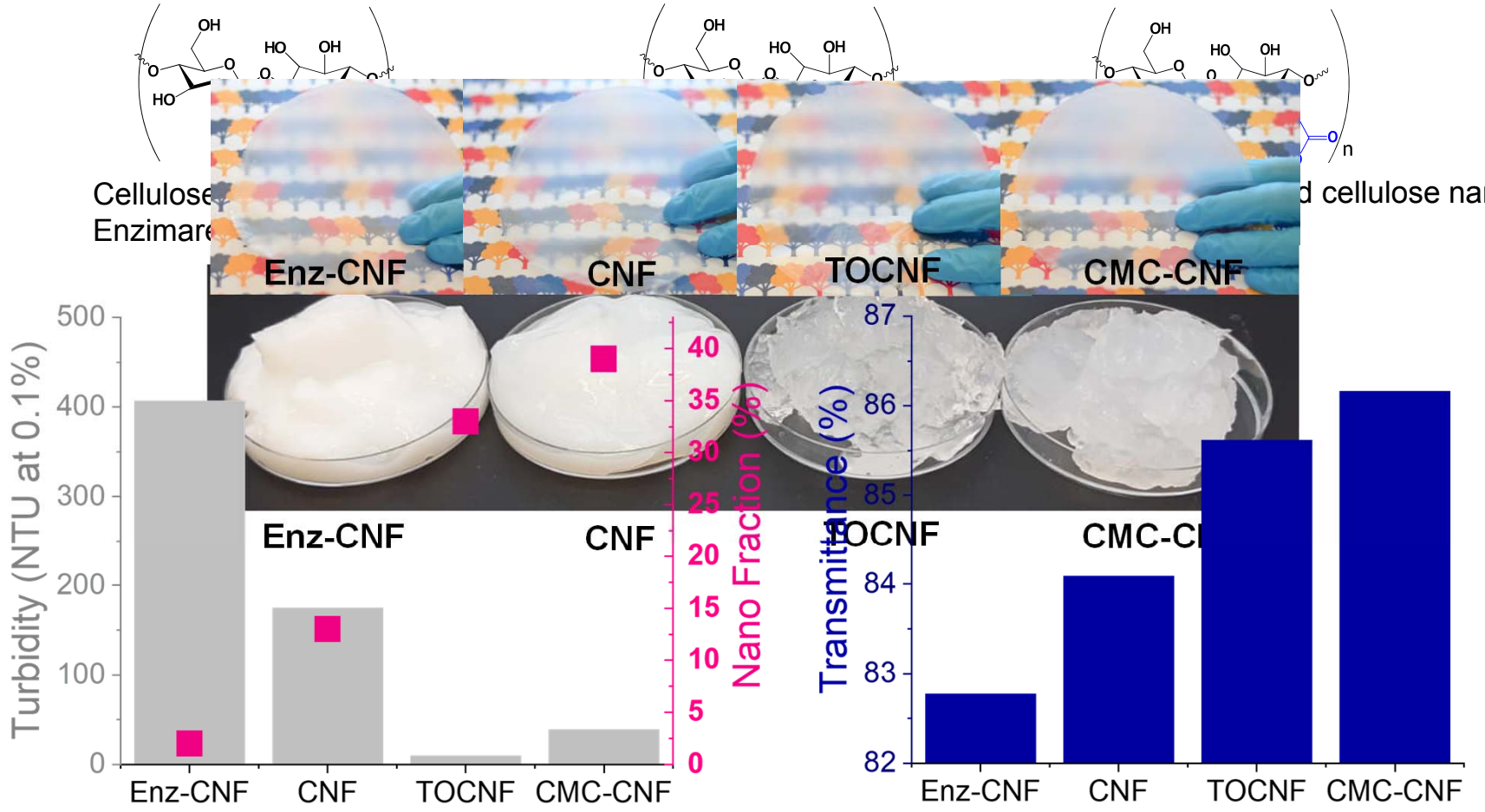
Porosity of the CNF film affects mechanical properties





Higher porosity are less stiff and less strength

Different nanocelluloses produce distinct optical properties



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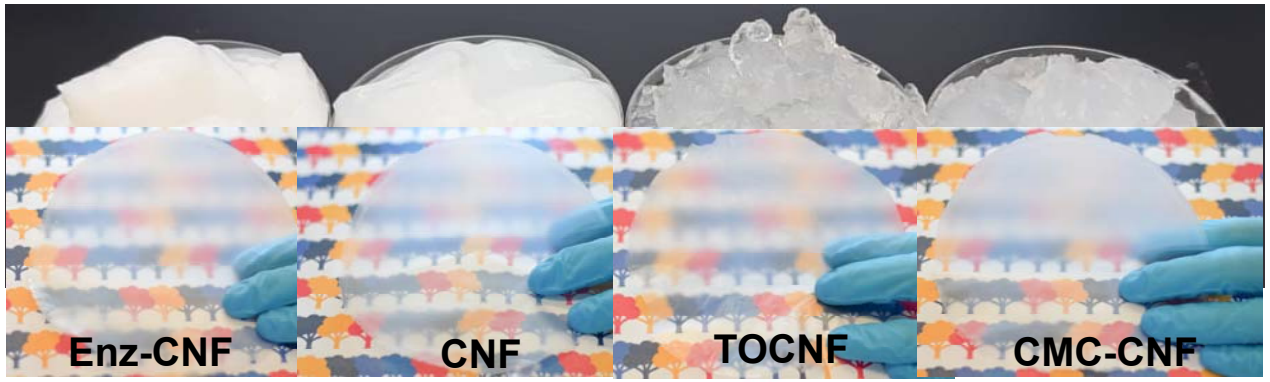

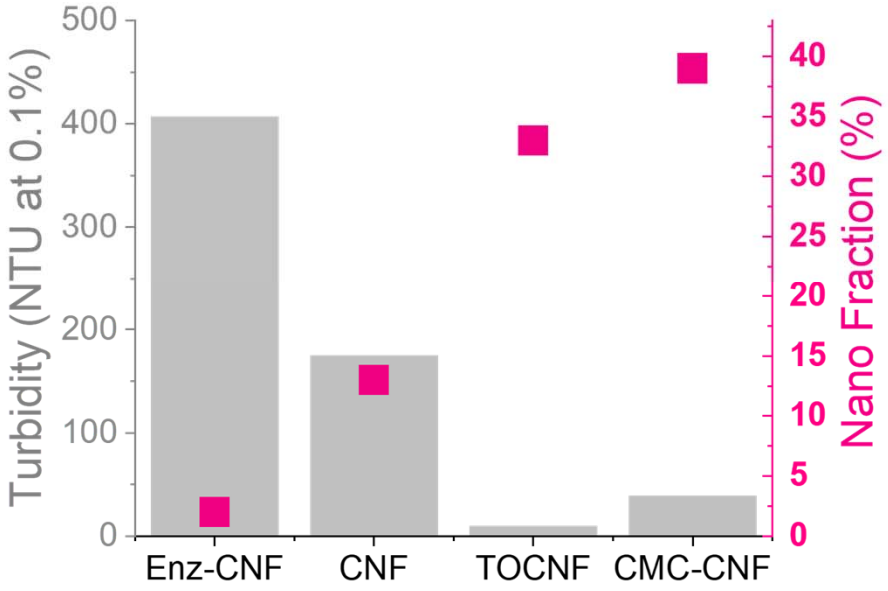

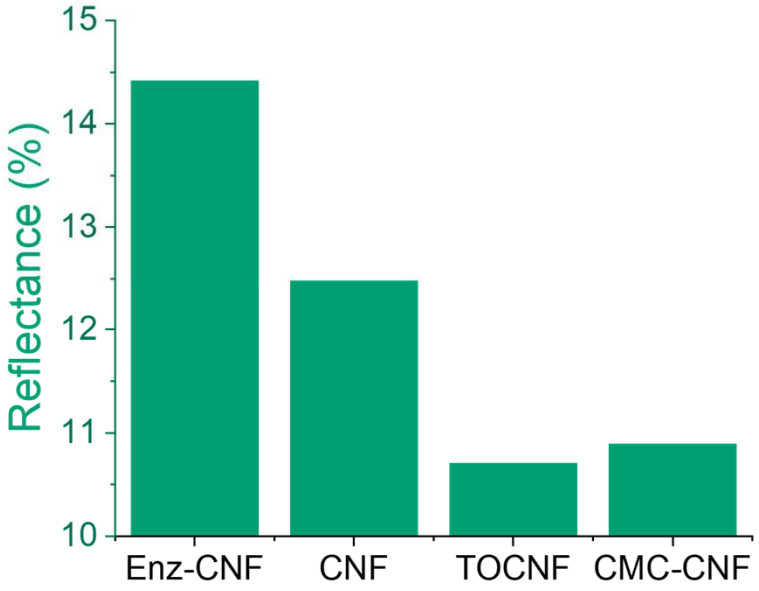

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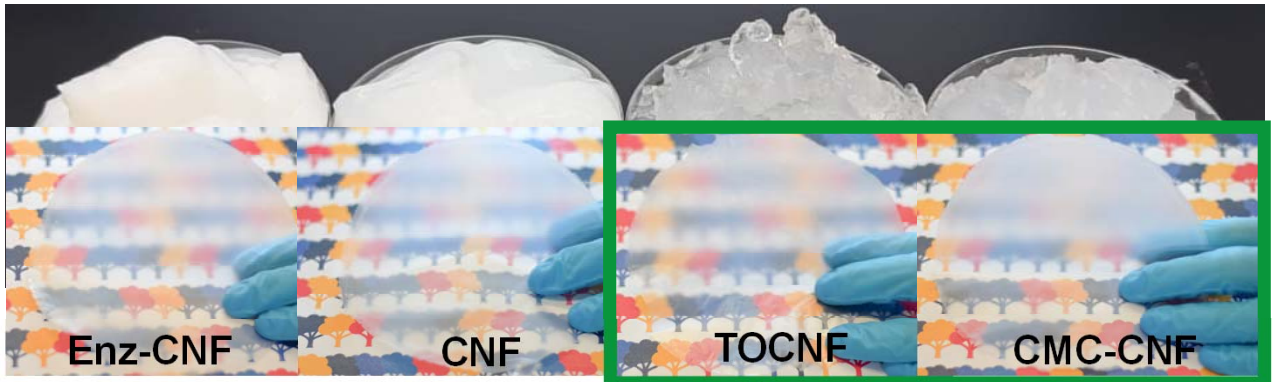
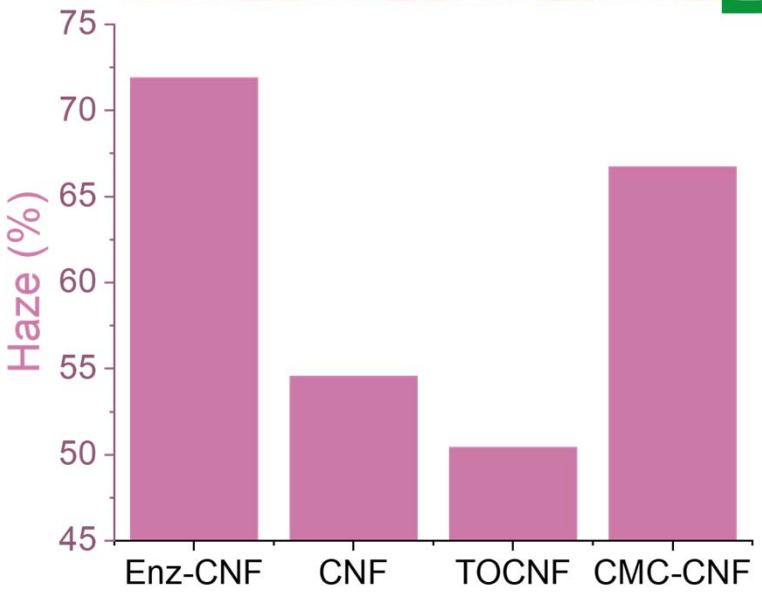
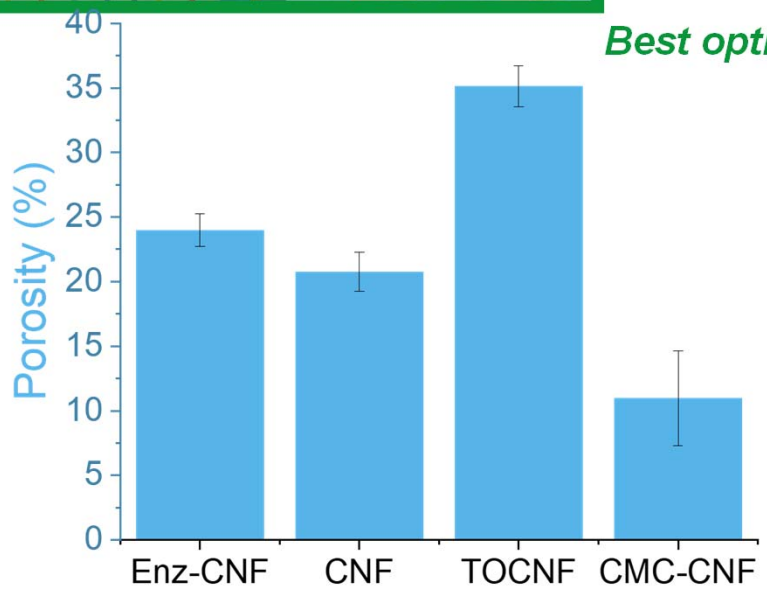
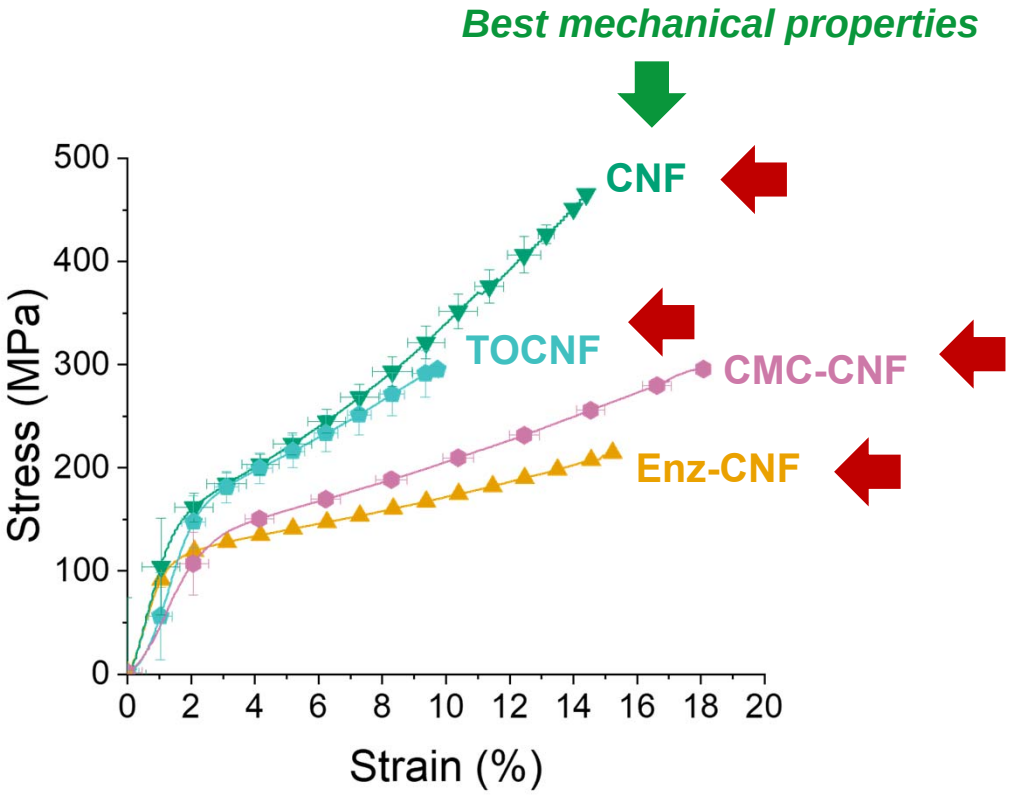






Best optical properties

Mechanical properties of films from different nanocellulose



Mechanical properties are affected by

- Nano fraction

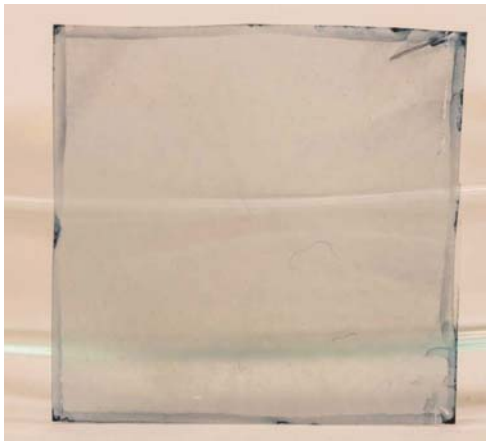
  Higher nano fraction produce stiffer films

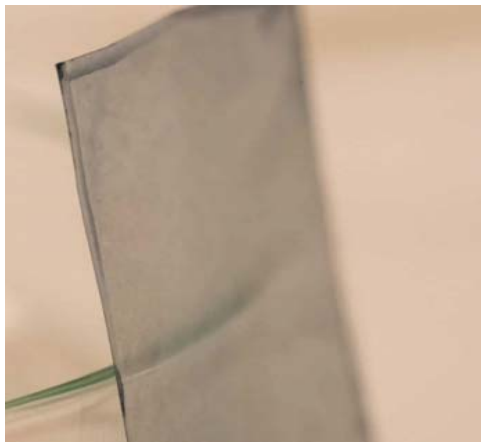
- Functional groups

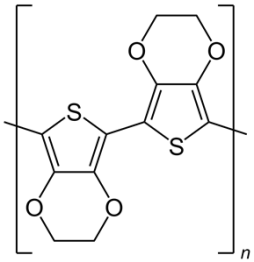
  The plasticity increase with presence of functional groups

Preliminary results as cover layer:
increasing of 15.4% in the performance of dye solar cells

Conductive layer creation for the solar cell assemble







Poly (3,4-ethylenedioxythiophene)
(**PEDOT**)

Layer-by-layer atmospheric pressure-based vapor phase polymerization method

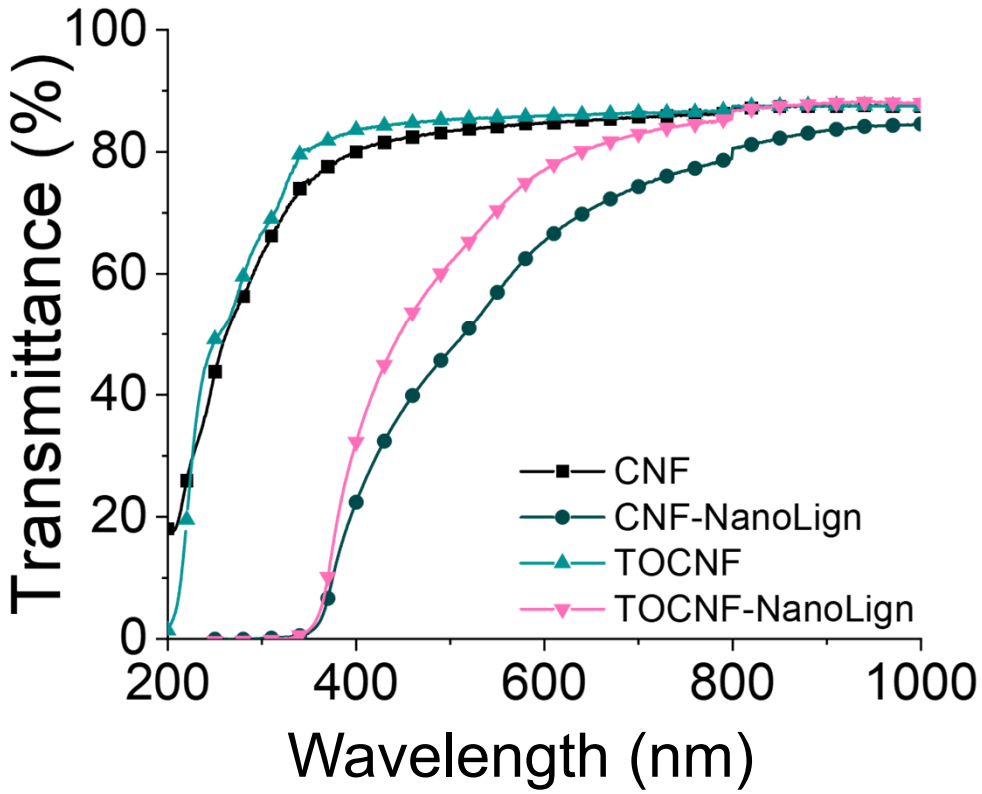
PEDOT layer: 20-25nm

Sheet resistance: 400 ohms/sq

Roughness decreased the conductivity of these substrates

Adding UV-shielding to nanocellulose films

UV degrades the active layer inducing the performance decreasing



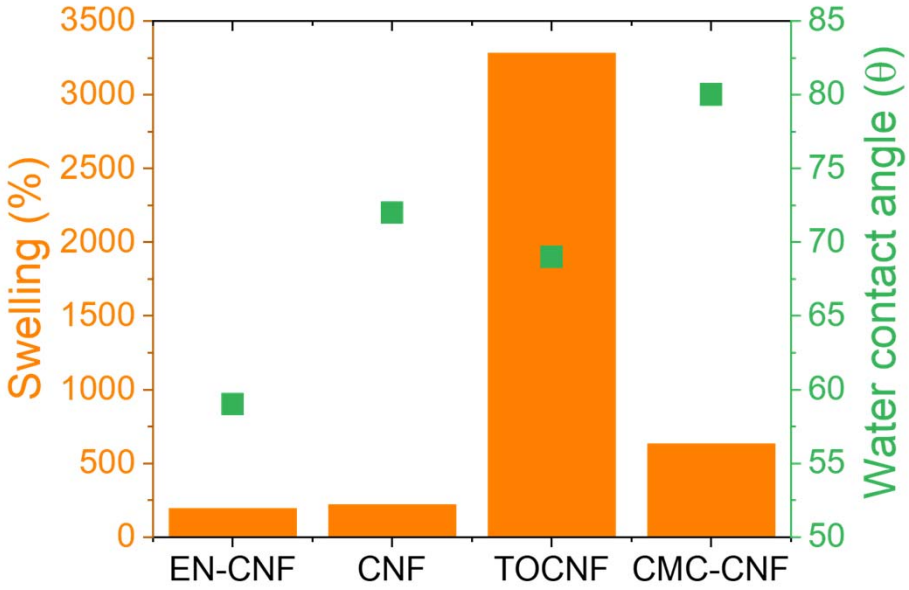
Effectively blocked until 350 nm

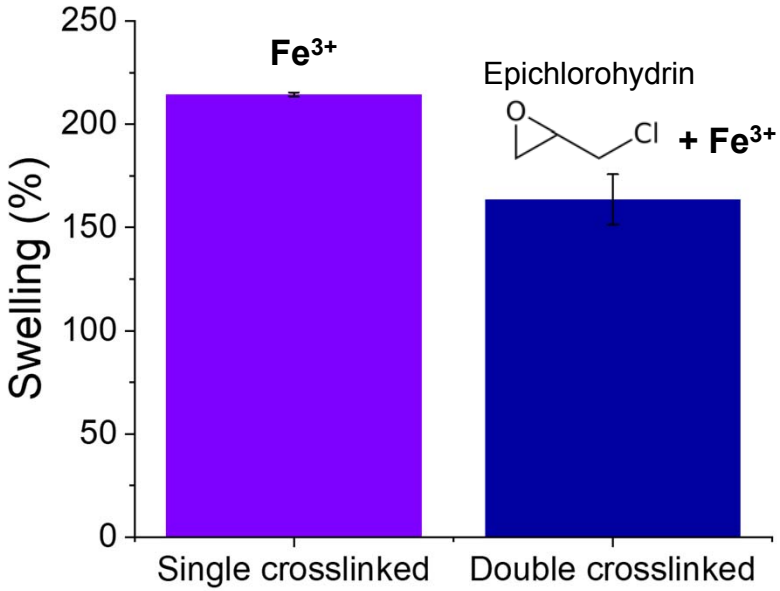
Transparency decreased at 550nm

Balance between UV protecting and transparency at 550nm could improve the performance of the solar cells

Water sensitivity in the nanocellulose films

Solar Cells stability decrease with presence of water

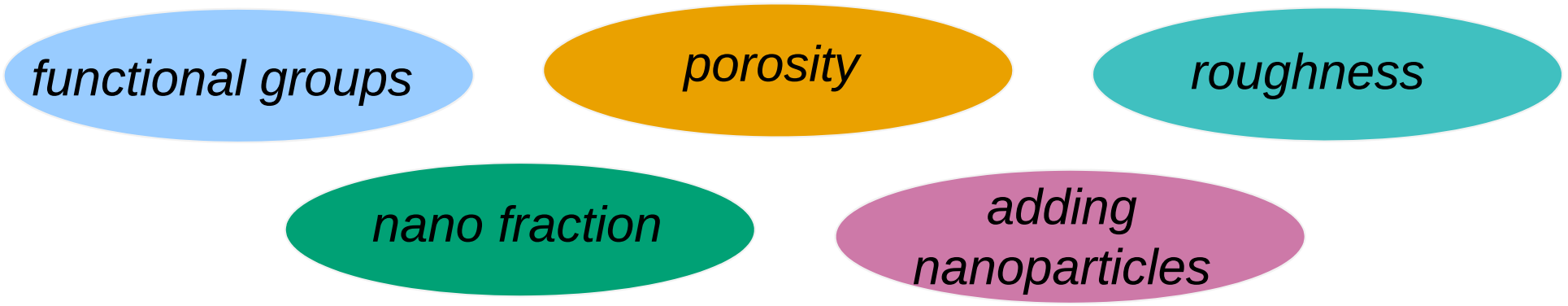




Decreasing of 95%

Final Remarks

Manipulating the nanocellulose films by...



High transparency

Diffuse light behavior

UV-blocking properties

Superior mechanical properties

Crosslinking overcomes water sensitivity

Acknowledgements

Thank you!