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Lignosulfonate addition in enzymatic pre-treatment for the co-production of sugars and fibrillated lignocellulose

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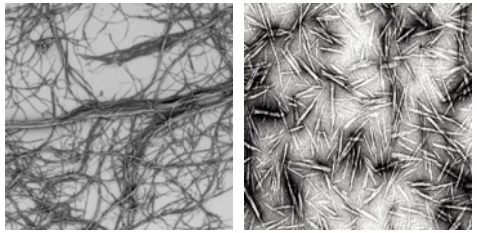
Thermomechanical pulp (TMP) is a source of fibrillated lignocellulose (LCNF)

Mechanical Fibers

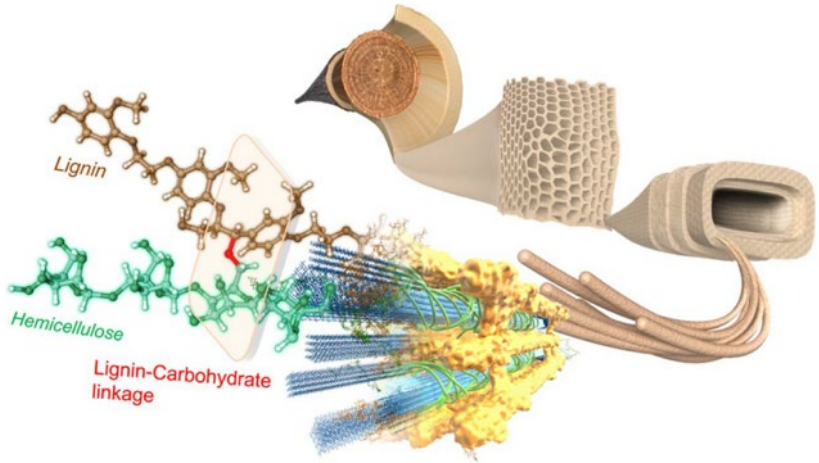


Chemical Fibers

Several advantages of LCNF from TMP

- **Advantages of using TMP compared to chemical pulp**
  - Major forest product in BC, Canada
  - Low feedstock cost
  - High yield with less environmental impact
  - Lower hydrophilicity, better compatibility with polymers and thermo-stability

- Bottlenecks
  - Recalcitrant structure of TMP lignocellulosic matrix



Nishimura et al., 2018, Sci. Rep.

Suitable routes for LCNF isolation

- Direct deconstruction (homogenizer, micro-fluidizer, grinder)

  High energy cost

- Chemical treatment: TEMPO-oxidation, concentrated acid, hydrotrope, DES etc.

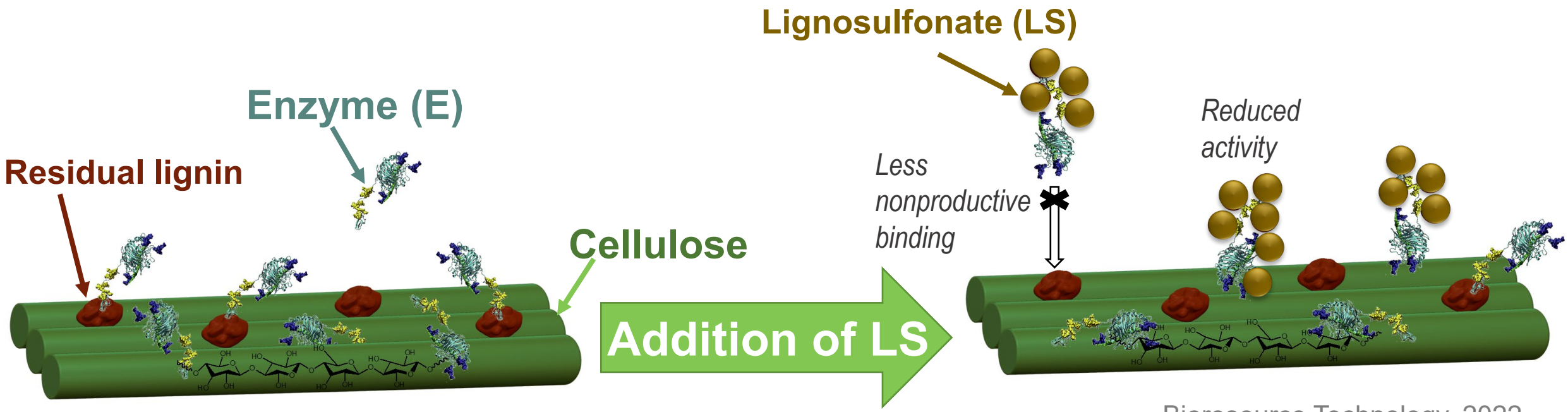
  Non-specific, environmental risks

- Enzymatic treatment

  Specific, mild

  Challenge: non-productive binding to lignin

Lignosulfonates (LS) enhance enzymatic hydrolysis



Bioresource Technology, 2022

LCNF-LS:

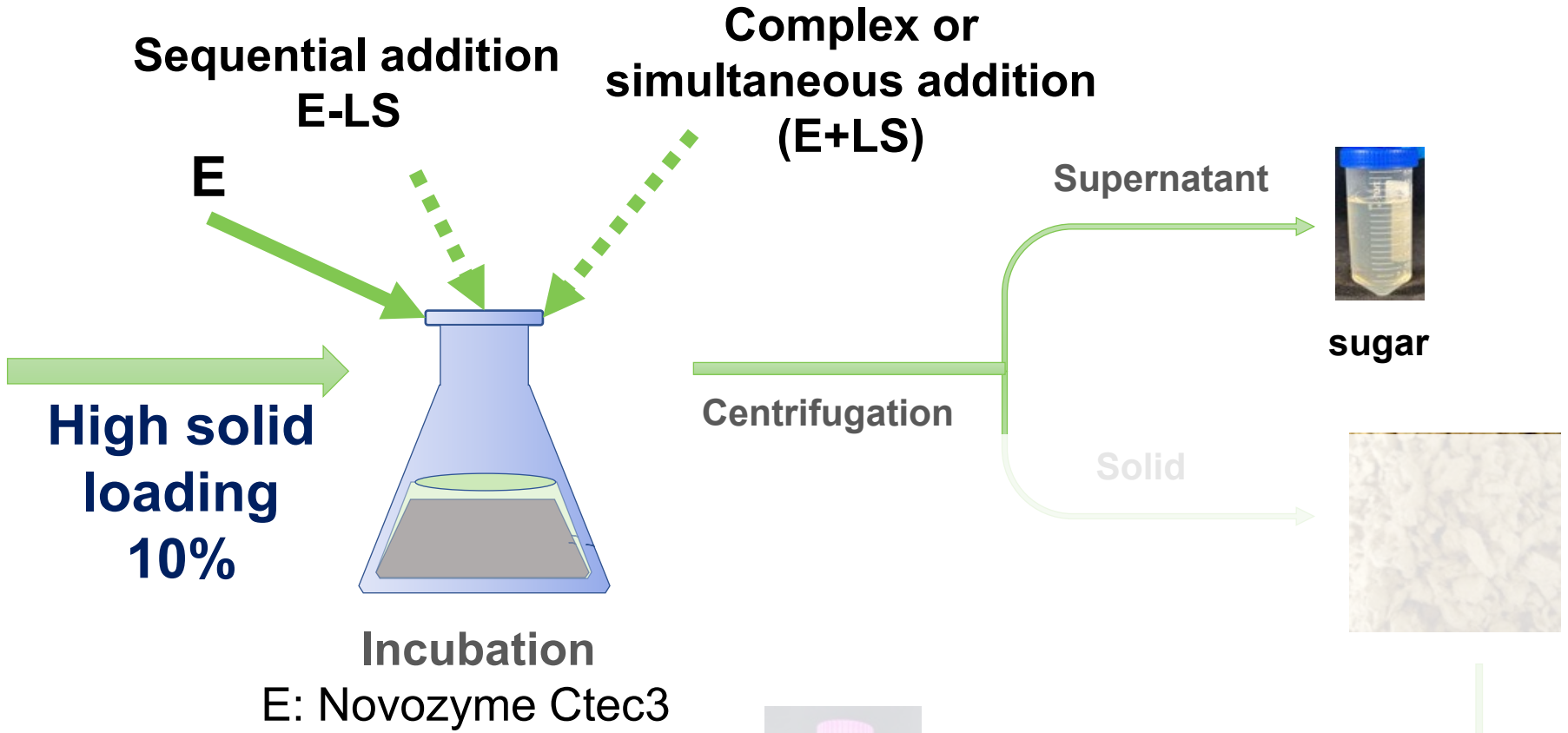
UV blocking

Flame retardancy

Enhanced ionic conductivity

Good colloidal dispersion

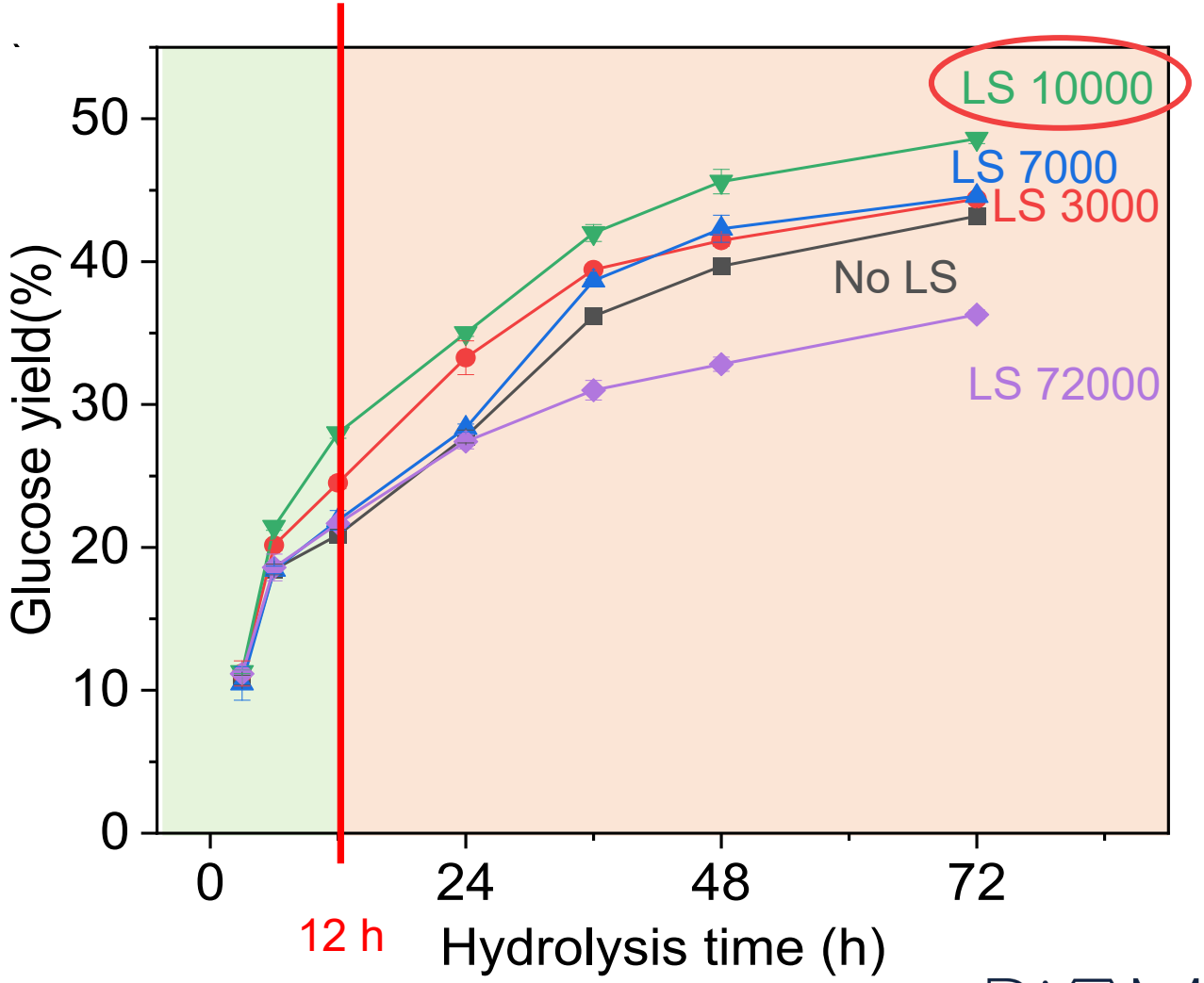
Co-Production of Sugar and LCNF:
Sequential and simultaneous (complex) addition



- **Vary Mw LS**
- **Vary LS conc**
- **Vary LS addition sequence**

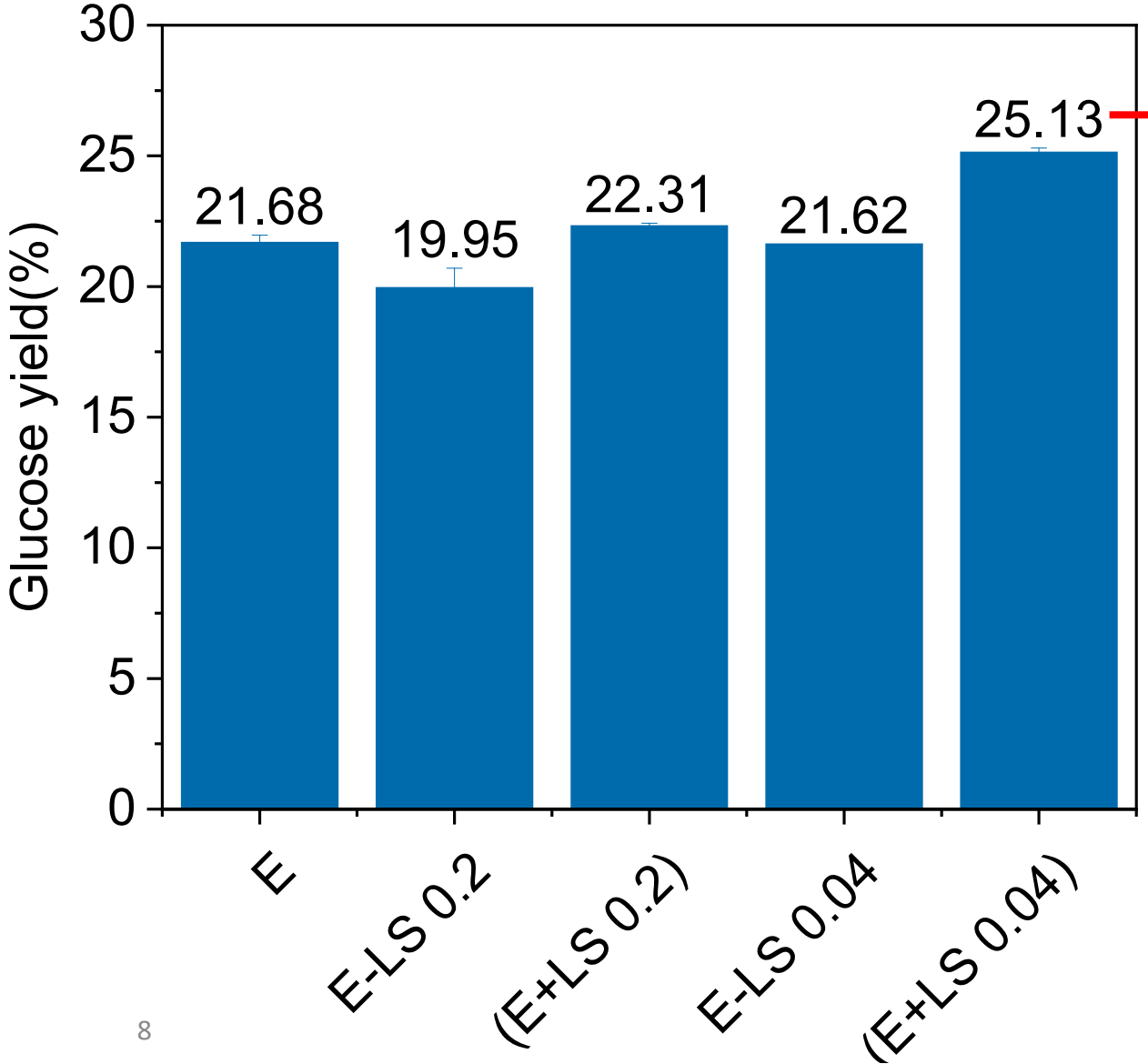
Saccharification is enhanced with LS (intermediate Mw)

- 10% solid consistency
- 20 mg/g enzyme loading
- LS dosage: 0.2g/g fiber
- 72 h complete hydrolysis



Enzyme-LS complex produces higher glucose yield

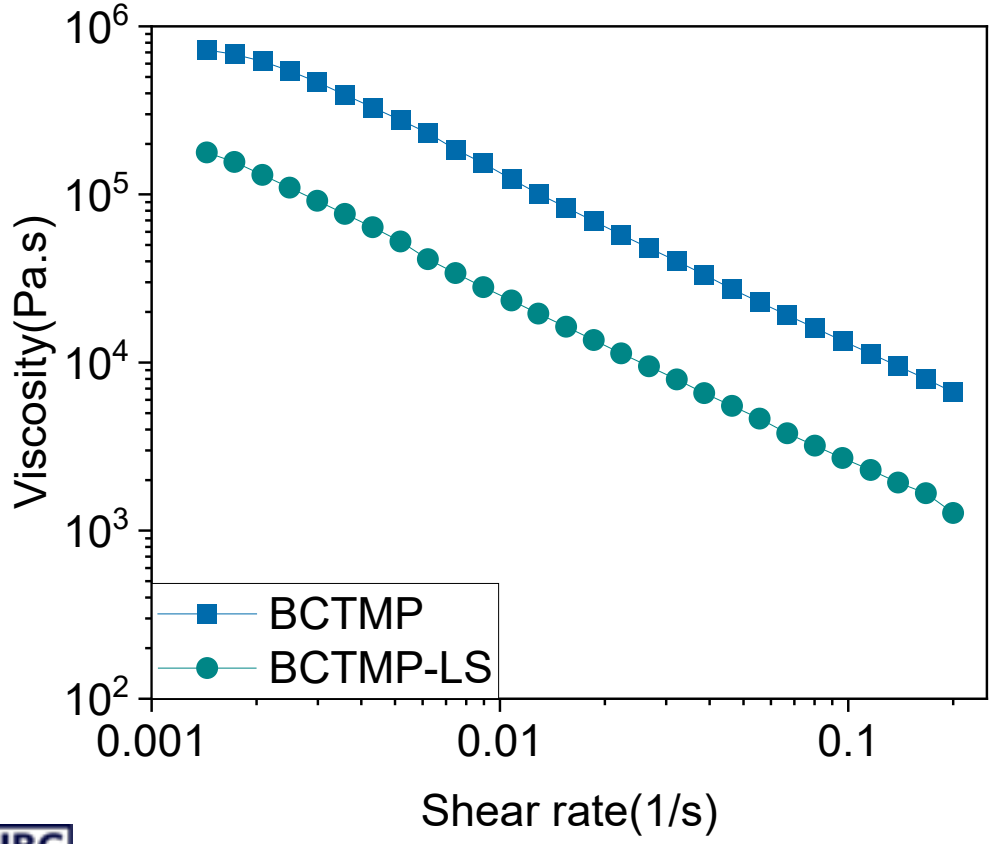
- LS dosage: 0.2 g/g; 0.04 g/g fiber
- LS: **sequential addition** (E-L) or **pre-mixed as a complex** (E+LS)
- 12 h hydrolysis



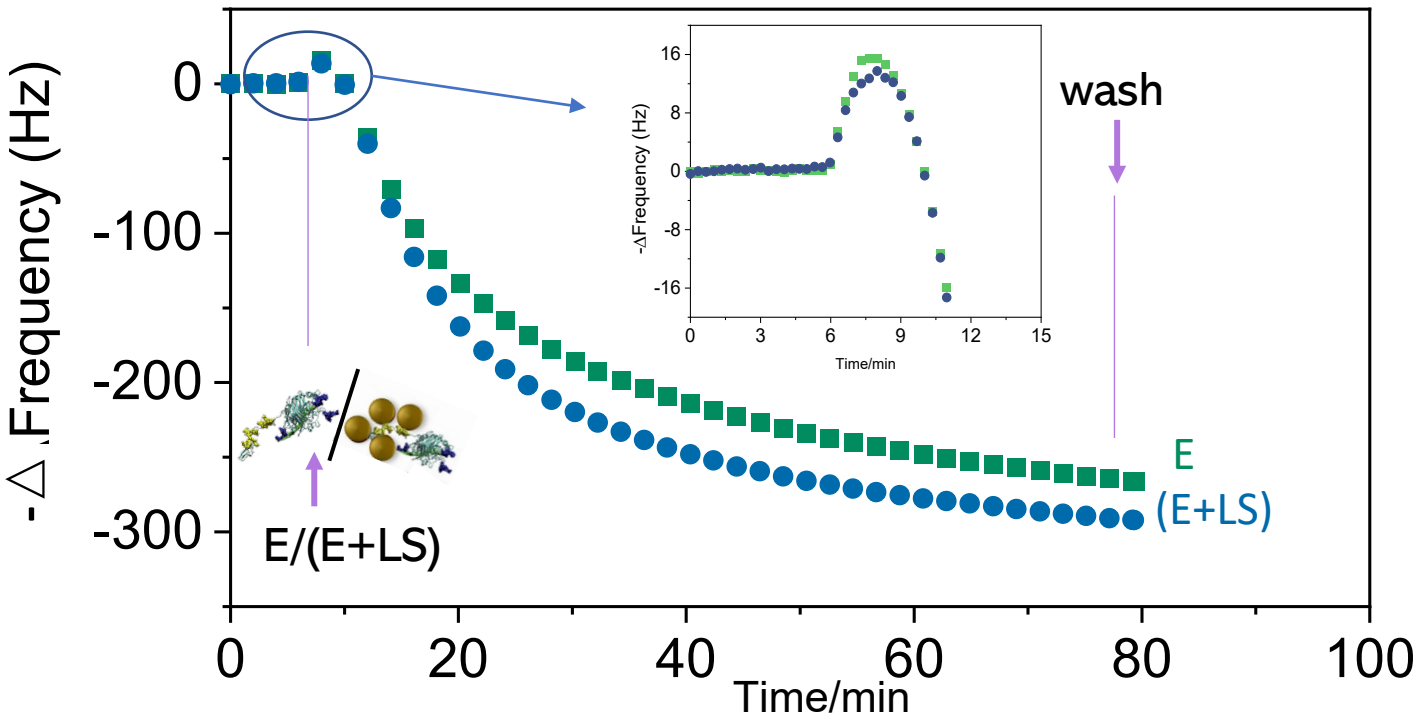
LS Mw=10kD, 0.04 g/g, pre-mix as E+LS complex

Possible mechanism:
LS reduces viscosity and enzyme binding

Suspension viscosity:
BCTMP vs BCTMP + LS



QCM: adsorption of snzymes and LS from aqueous media onto BCTMP

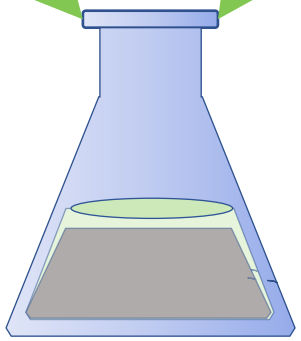


Co-Production of Sugar and LCNF

High solid loading (10%)

E

(E+LS)



Incubation

Centrifugation

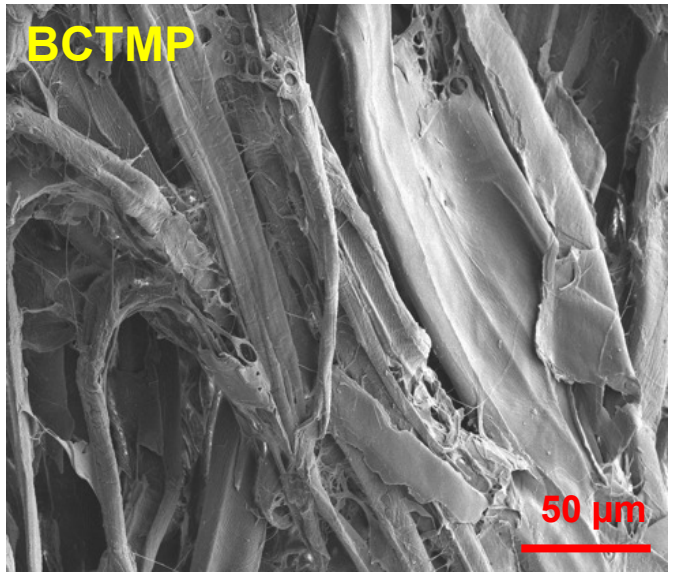
Supernatant

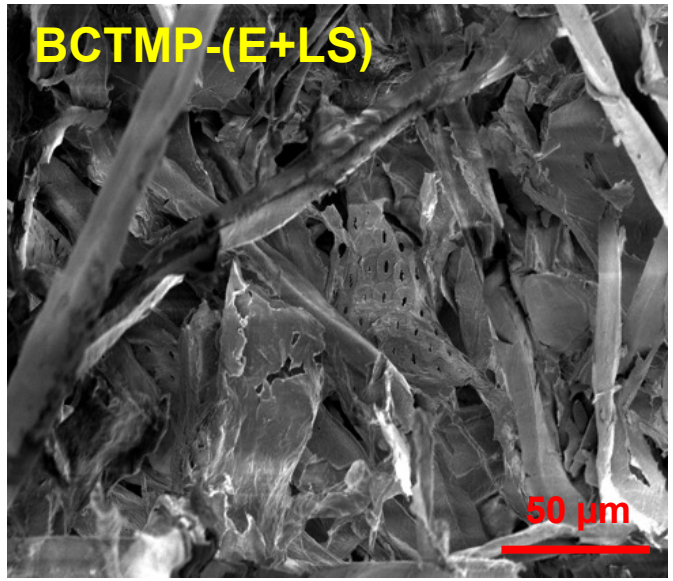
sugar

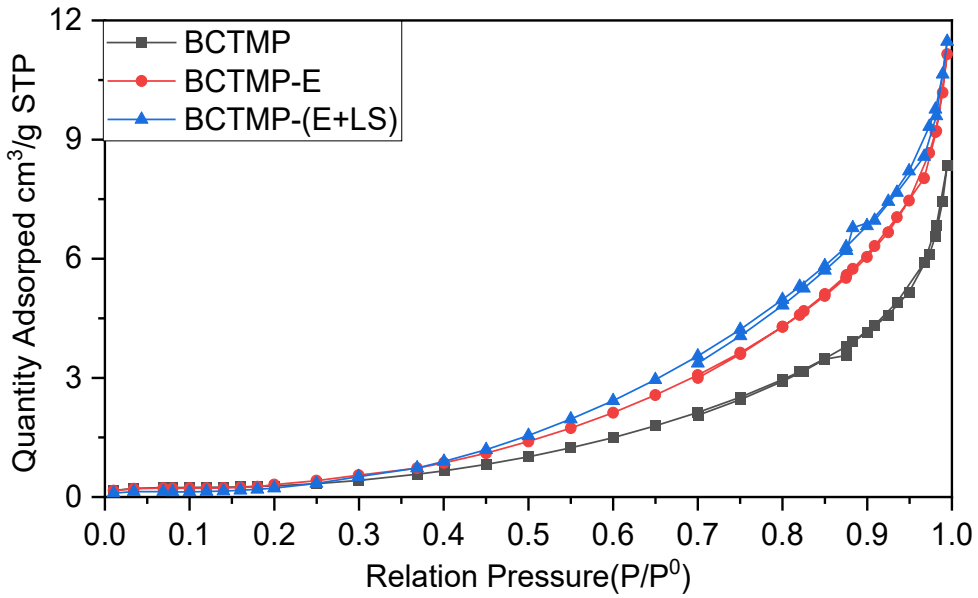
Solid

Microfluidizer

Increased accessibility (12h enzymatic treatment)



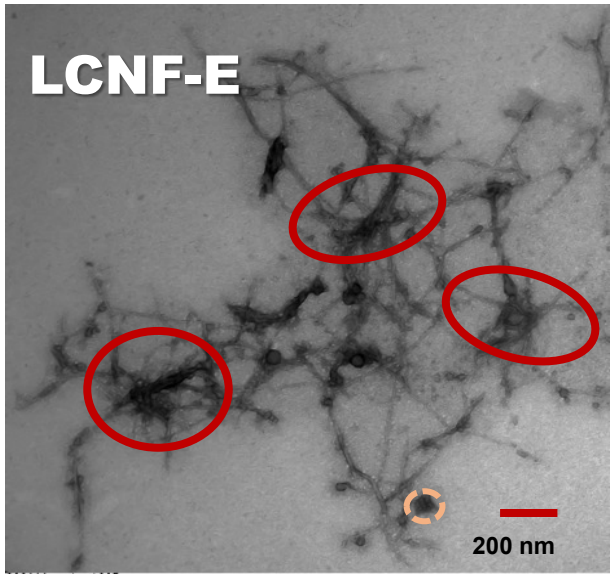


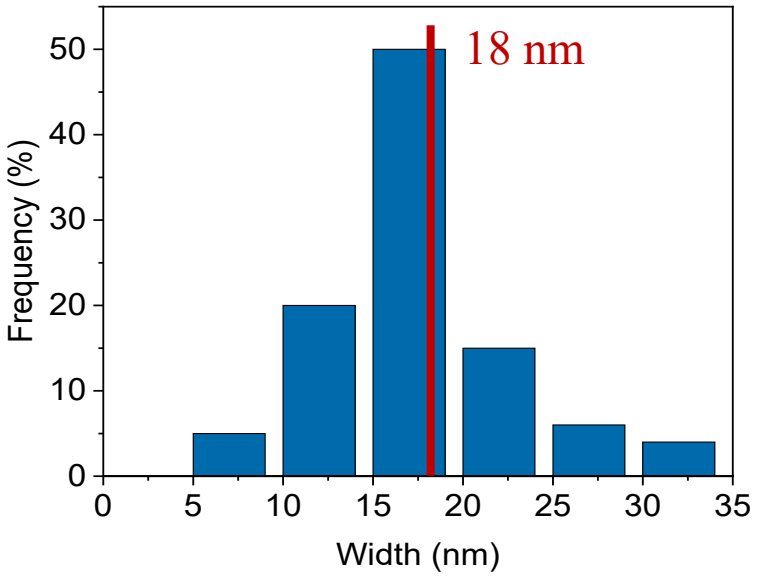


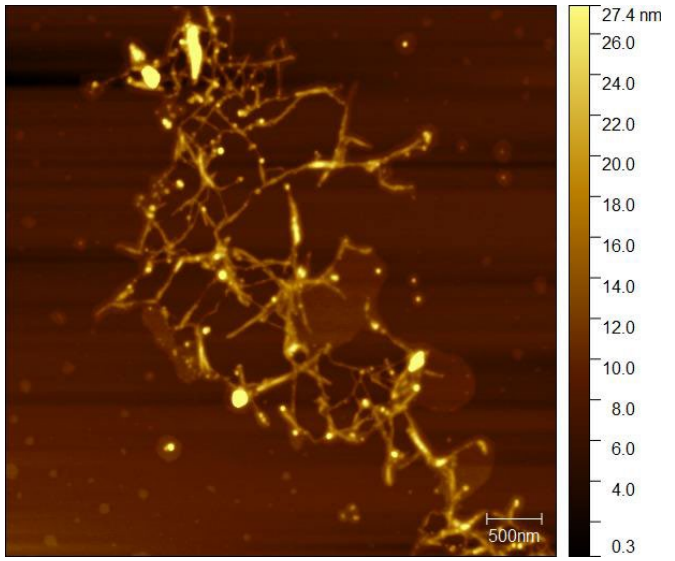
BET surface area (m^2/g)

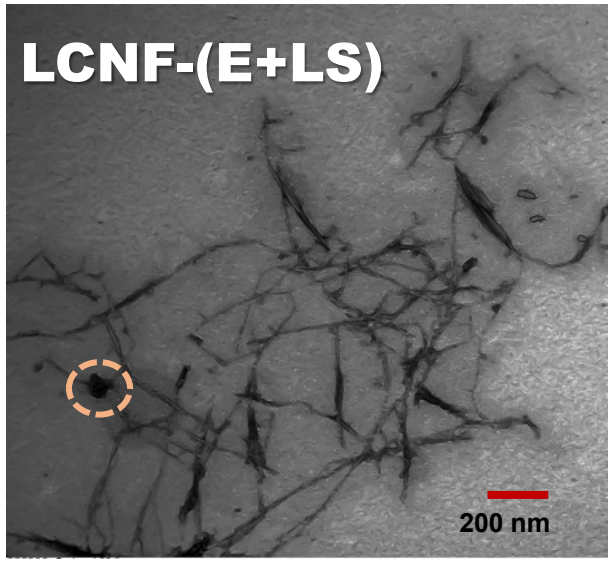
BCTMP:	1.26
BCTMP-E:	1.75
BCTMP-(E+LS):	1.94

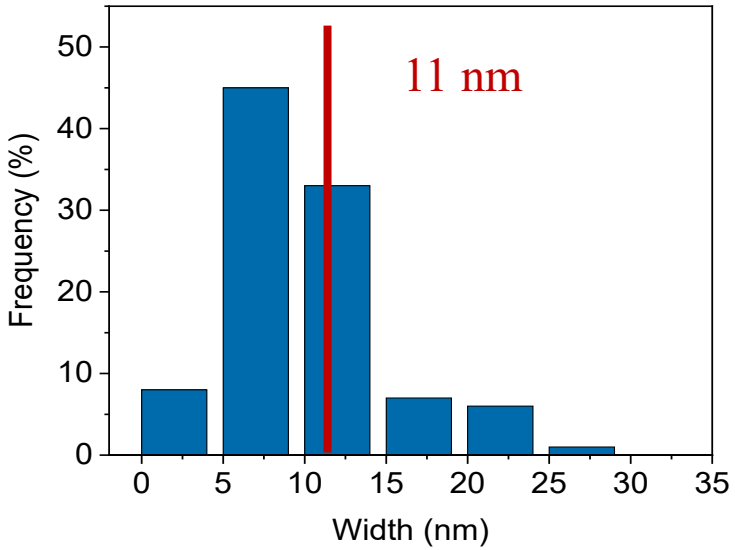
Morphology of LCNF

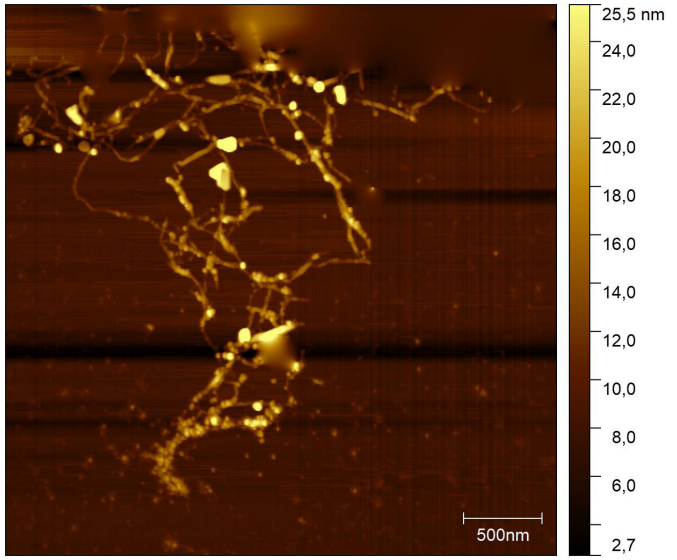






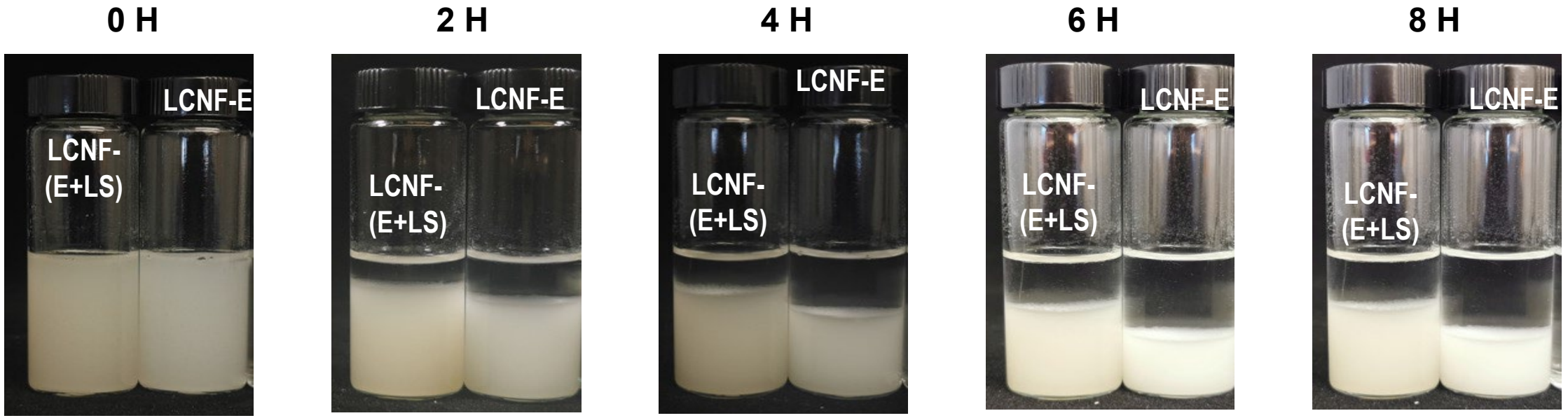






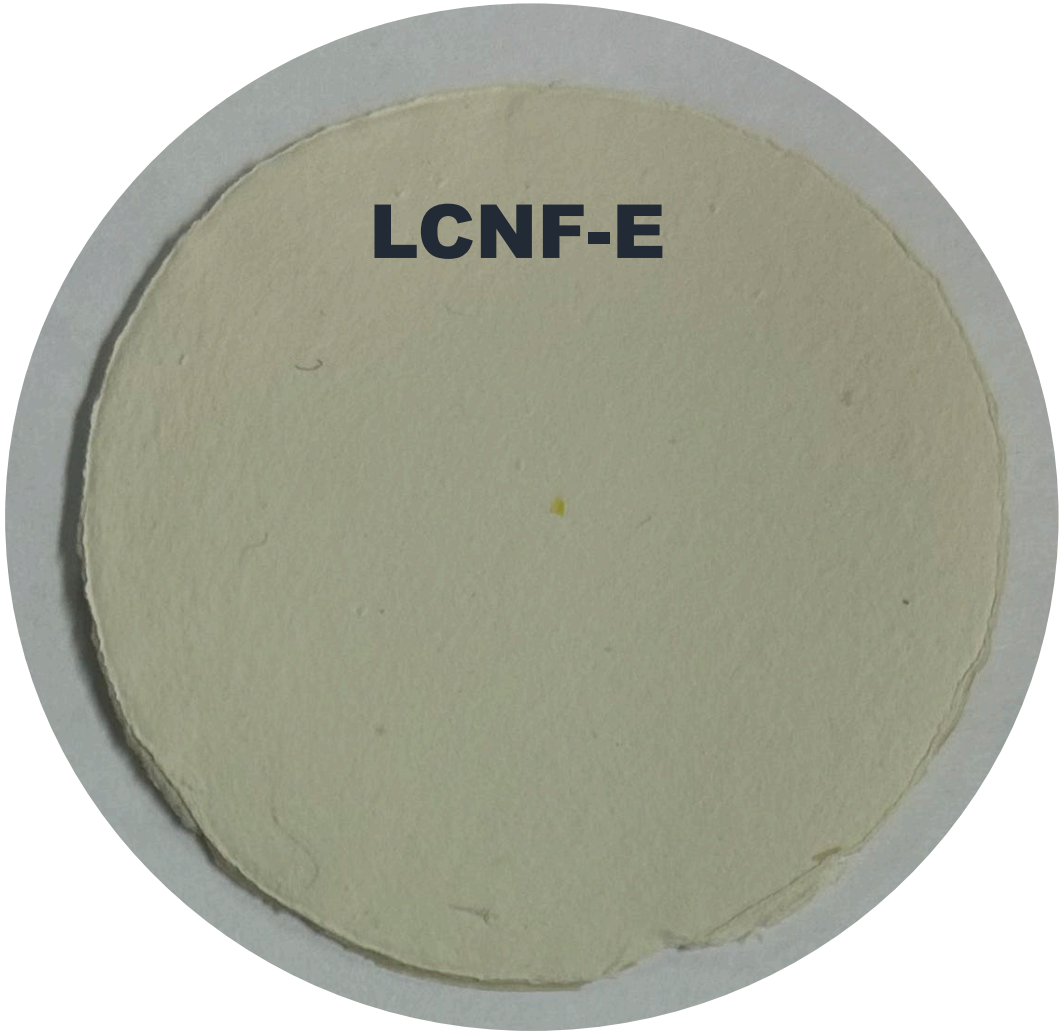
12

Pre-mixed complex (E+LS):
higher surface charge, better colloidal dispersion



	Instability index	Turbidity (NTU)	Transmittance (%)	Zeta Potential
LCNF-E	0.72	1655 ± 37	11.3±0.02	-10.6±0.5
LCNF-(E+LS)	0.63	943 ± 41	15.3±0.04	-13.9±0.1

Translucent films from LCNF-(E+LS)



Conclusion

- BCTMP is successfully used to co-produce fermentable sugars and LCNF.
- Higher hydrolysis yield: LS (intermediate Mw) used as a complex with enzyme.
- Smaller fibril sizes when LS added as a complex.

LS effect: improve dispersion and decrease non-productive enzyme binding.

Acknowledgements

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Thank You!