Cellulose Nanofibril (CNF) based Gel Polymer as a Solid State Electrolyte for Lithium Ion Battery (LIB)

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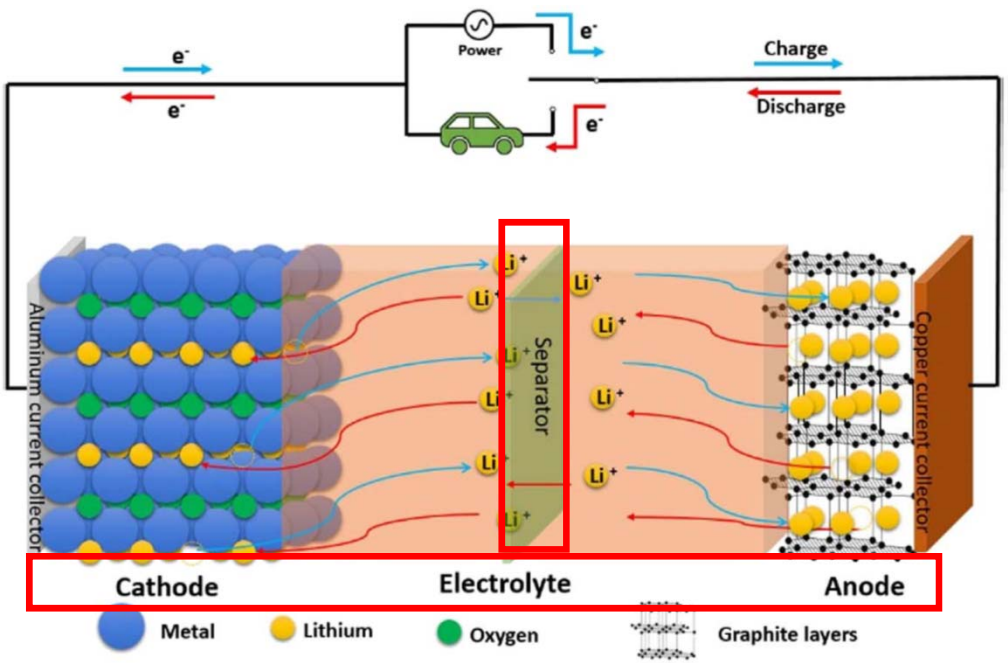
1. CNF based Membranes as Separators

The Structure and Roles of Separators in LIB



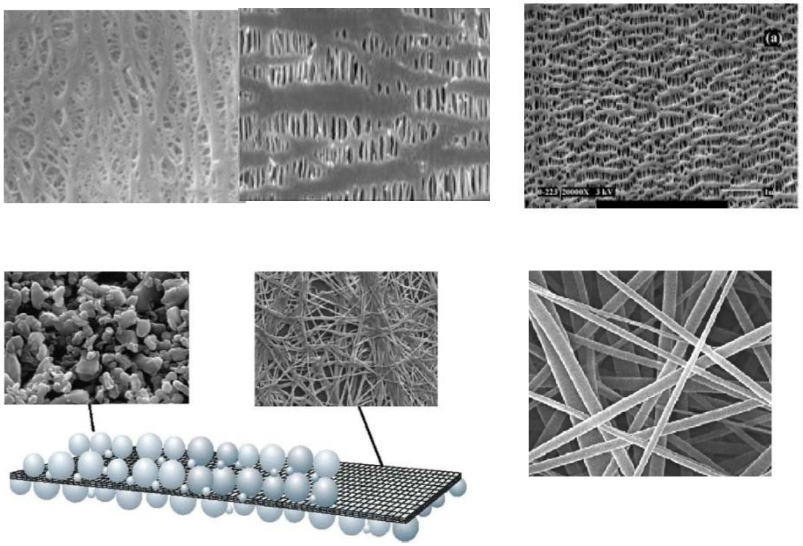
- **Cathode**
- **Anode**
- **Electrolyte**
  - A carrier for ion transport
- **Separator**
  - Physically separating the anode and cathode
  - Permitting free flow of lithium ion

S. Liang, W. Yan, X. Wu, et al. Solid State Ionics, 2018 318: 2-18

1. CNF based Membranes as Separators

The Structure and Roles of Separators in LIB

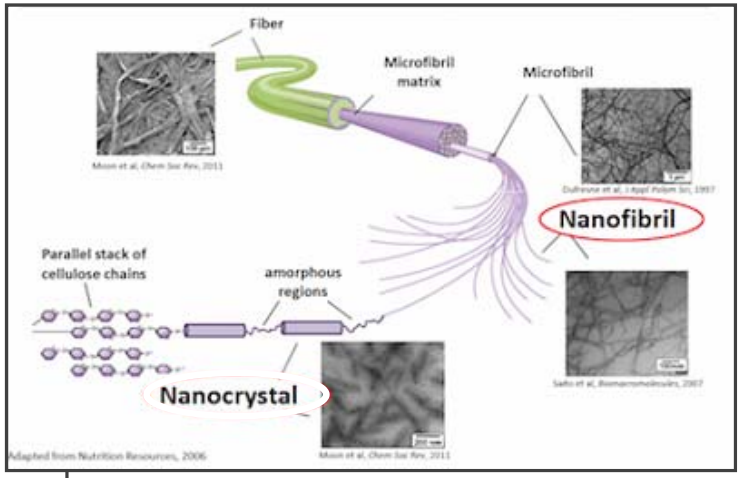
Polyolefin-based LIB separator



- ✗ Serious dimensional shrinkage
- ✗ Poor electrolyte absorption

Cellulose nanofibril (CNF)

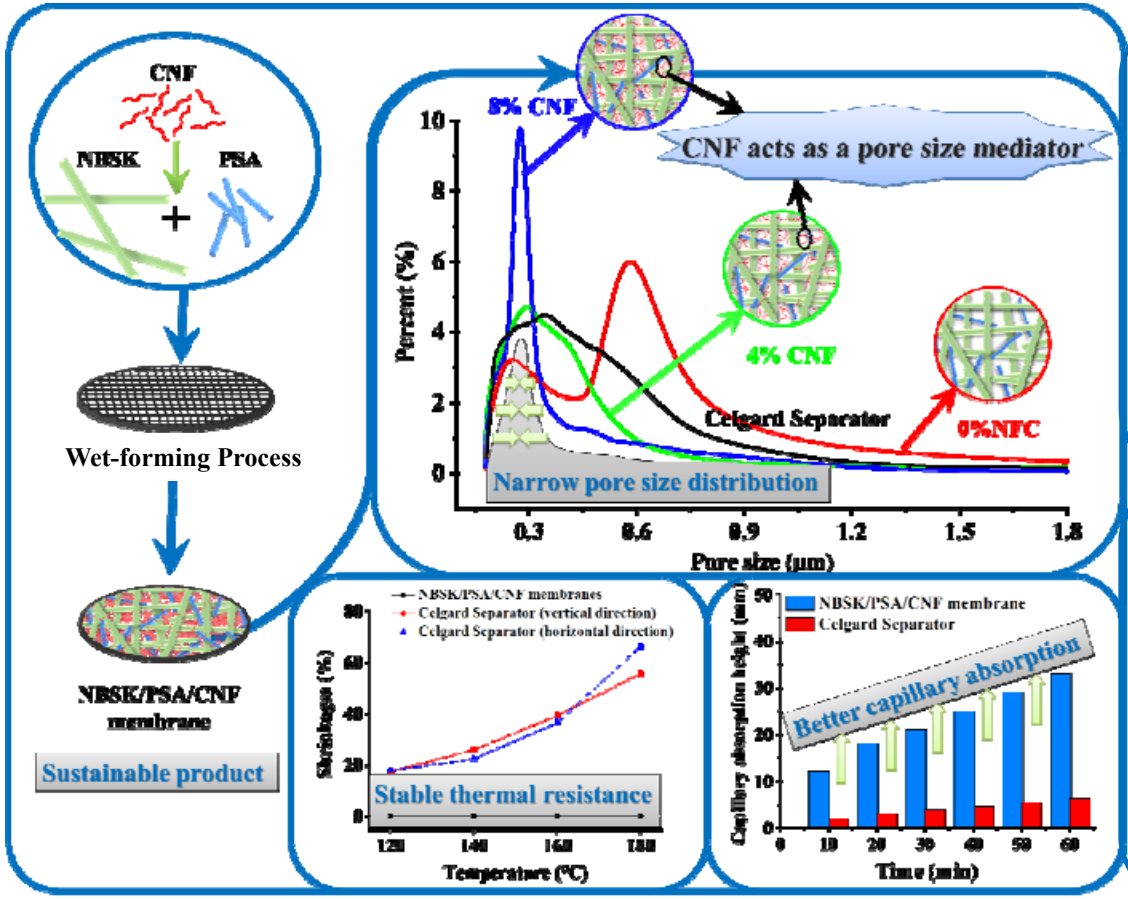
Eco-friendly nano-size polymer materials

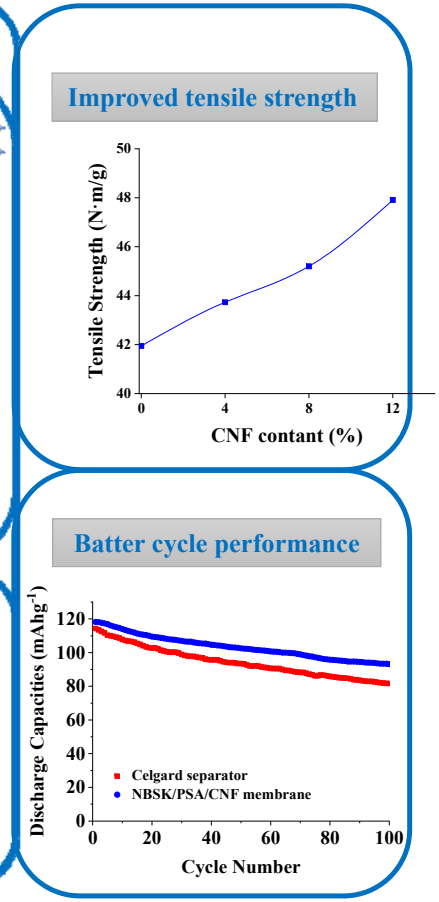


- High specific areas
- Rich surface hydroxyl groups
- Mechanical strength

1. CNF based Membranes as Separators

NBSK/PSA/CNF Membrane





Membrane:

Uniform micropores
Superior thermal stability
Electrolyte absorption

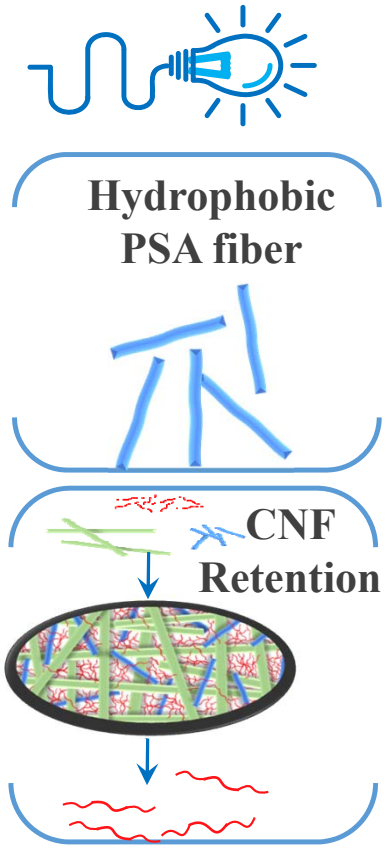
LIB Battery:

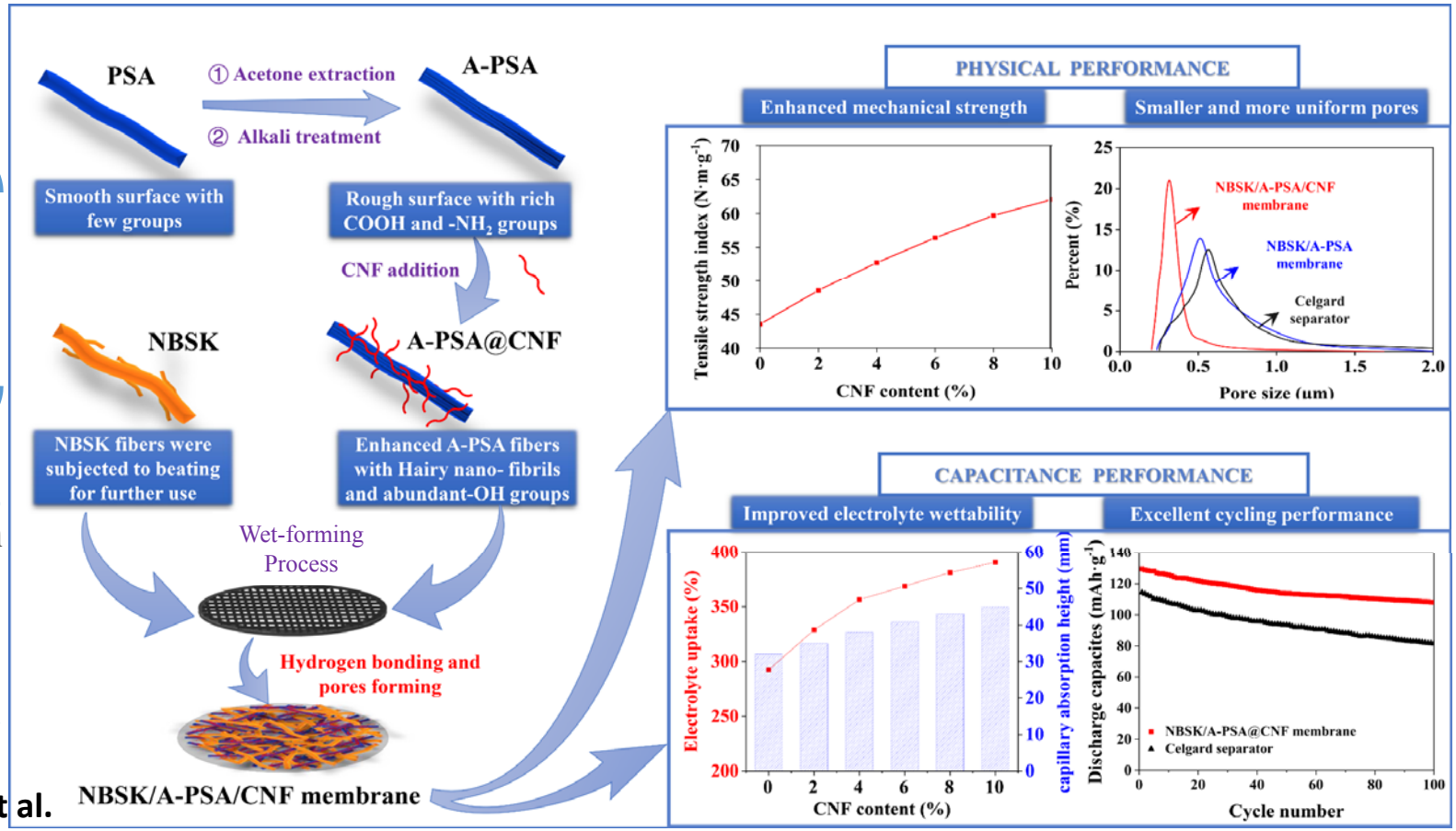
safety
Sustainability
Cycle performance

H. Zhang, J Liu, M. Guan, et al. ACS Sustain. Chem. Eng., 2018, 6(4): 4838-4844.

1. CNF based Membranes as Separators

NBSK/A-PSA/CNF membrane

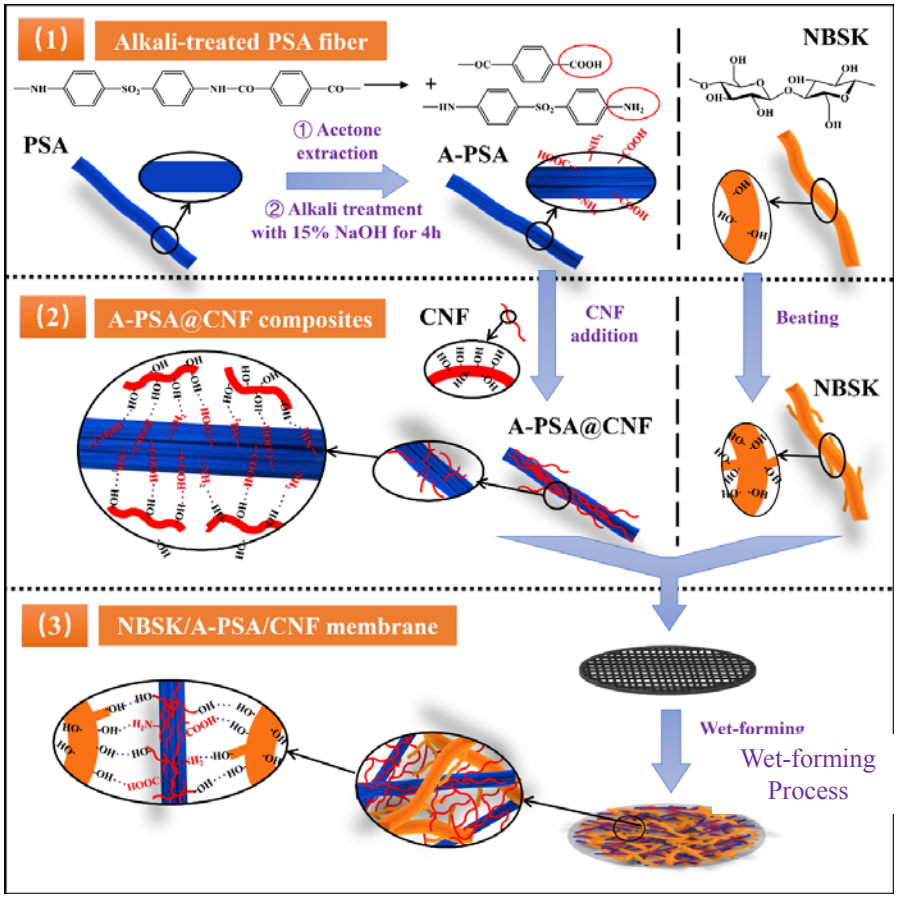


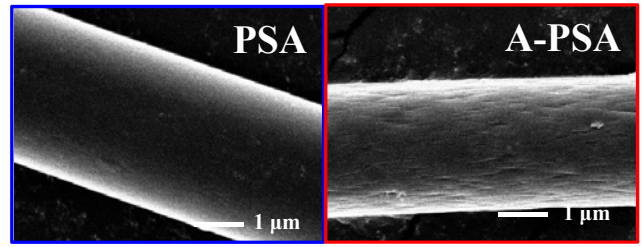


H. Zhang, X. An, H. Liu, et al.
Submitted to J. Membrane Sci.

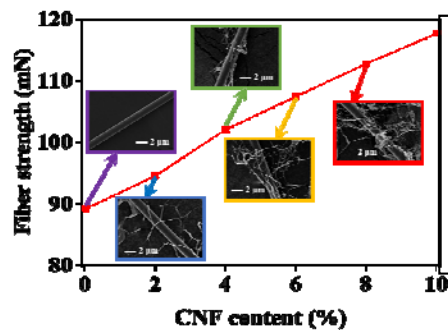
1. CNF based Membranes as Separators

NBSK/A-PSA/CNF membrane





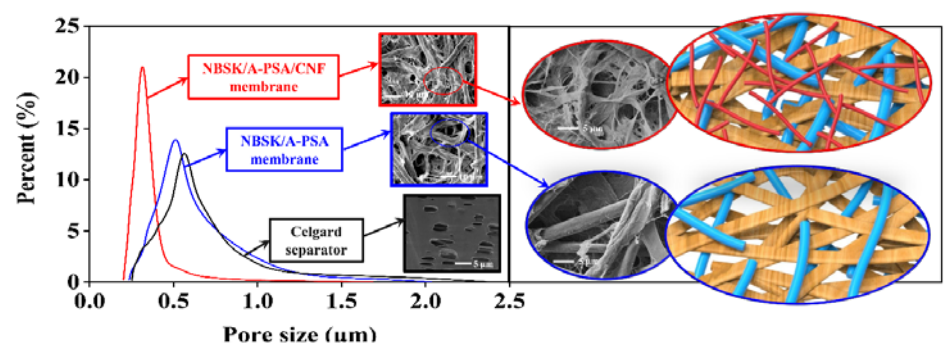
Samples	Carboxyl group content (μmol/g)
PSA	5.28
A-PSA	43.63



CNF has **combined** on the surface of A-PSA

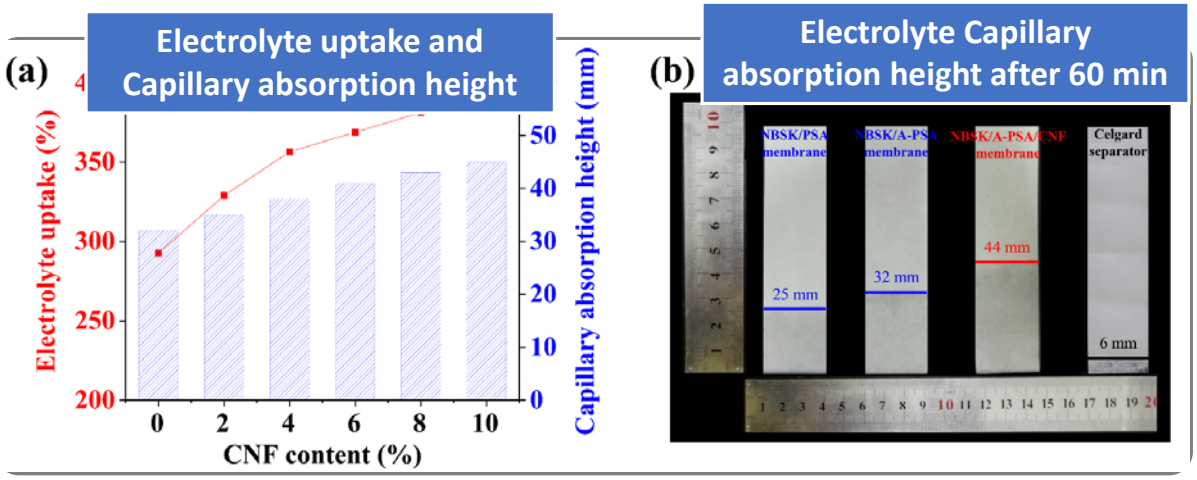
The fiber strength was straightly **increased**

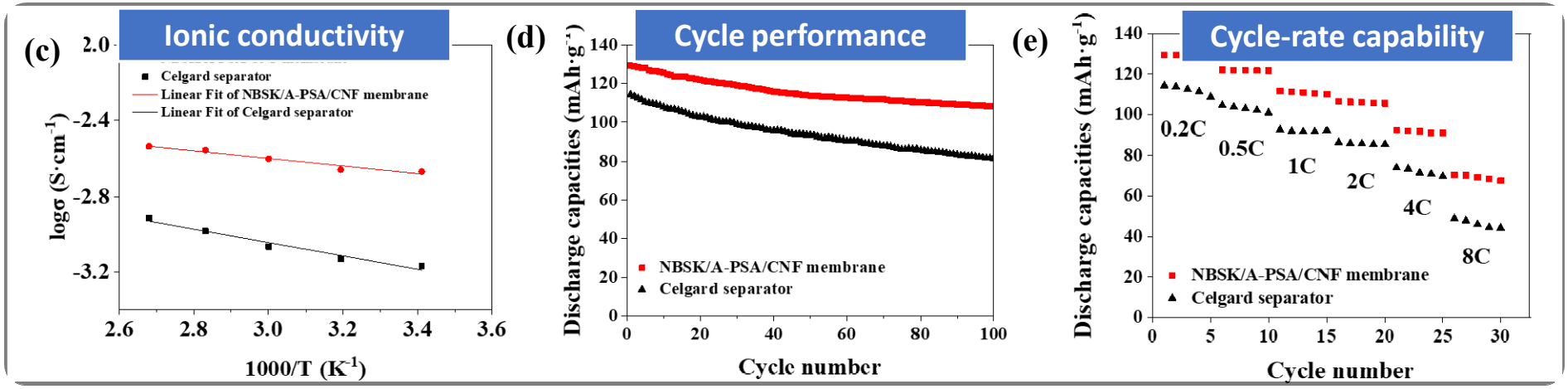
CNF combination effectively make up the fiber strength loss of A-PSA



1. CNF based Membranes as Separators

NBSK/A-PSA/CNF membrane





2. CNF based Gel Polymer as Solid State Electrolyte

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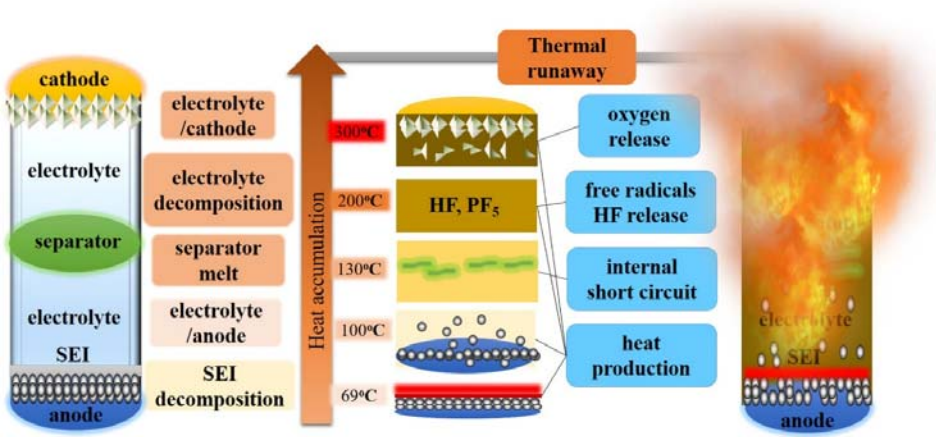
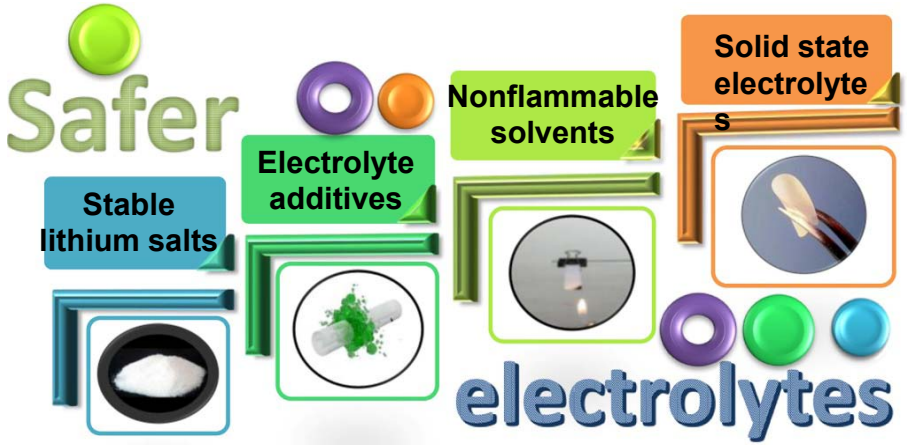
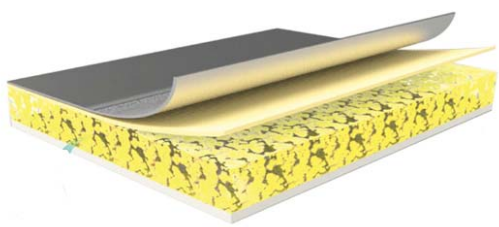
From Separators with Liquid Electrolyte to Solid State Electrolyte





Solid State Electrolytes

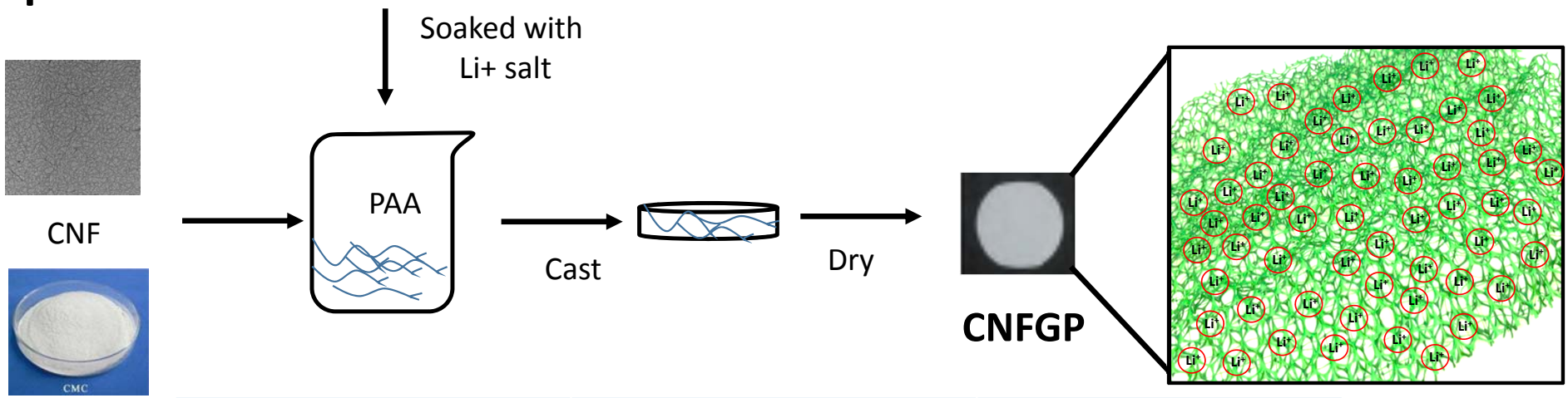


New problem: Low ionic conductivity!

Q. Wang, L. Jiang, Y. Yu, et al. Nano Energy 2019 55: 93–114

2. CNF based Gel Polymer as Solid State Electrolyte

Experimental



Sample	CNF/%	CMC/%
CNFGP-1	38	8
CNFGP-2	42	10
CNFGP-3	46	12
CNFGP-4	52	14

2. CNF based Gel Polymer as Solid State Electrolyte

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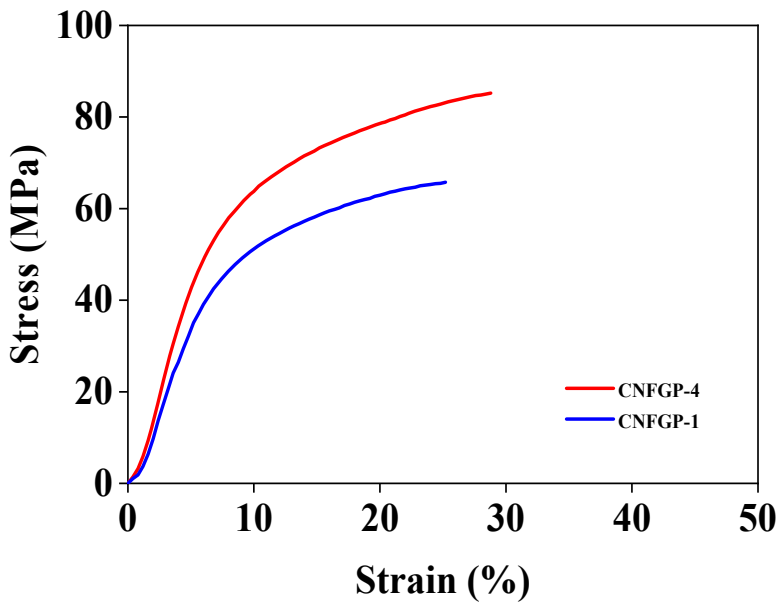
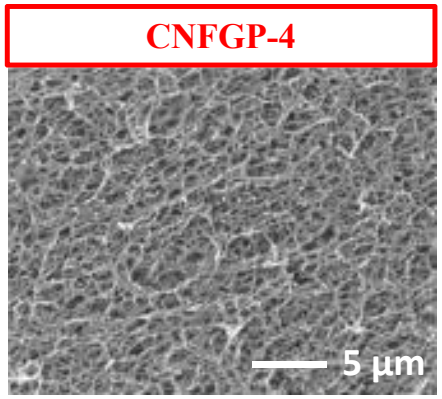
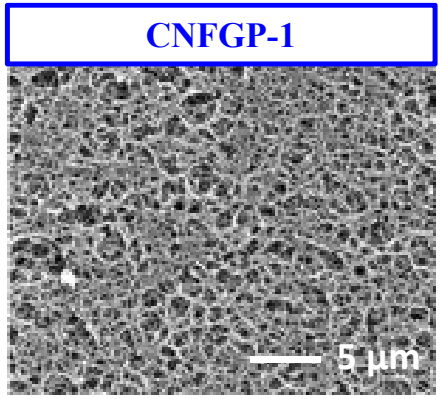
Physical Properties



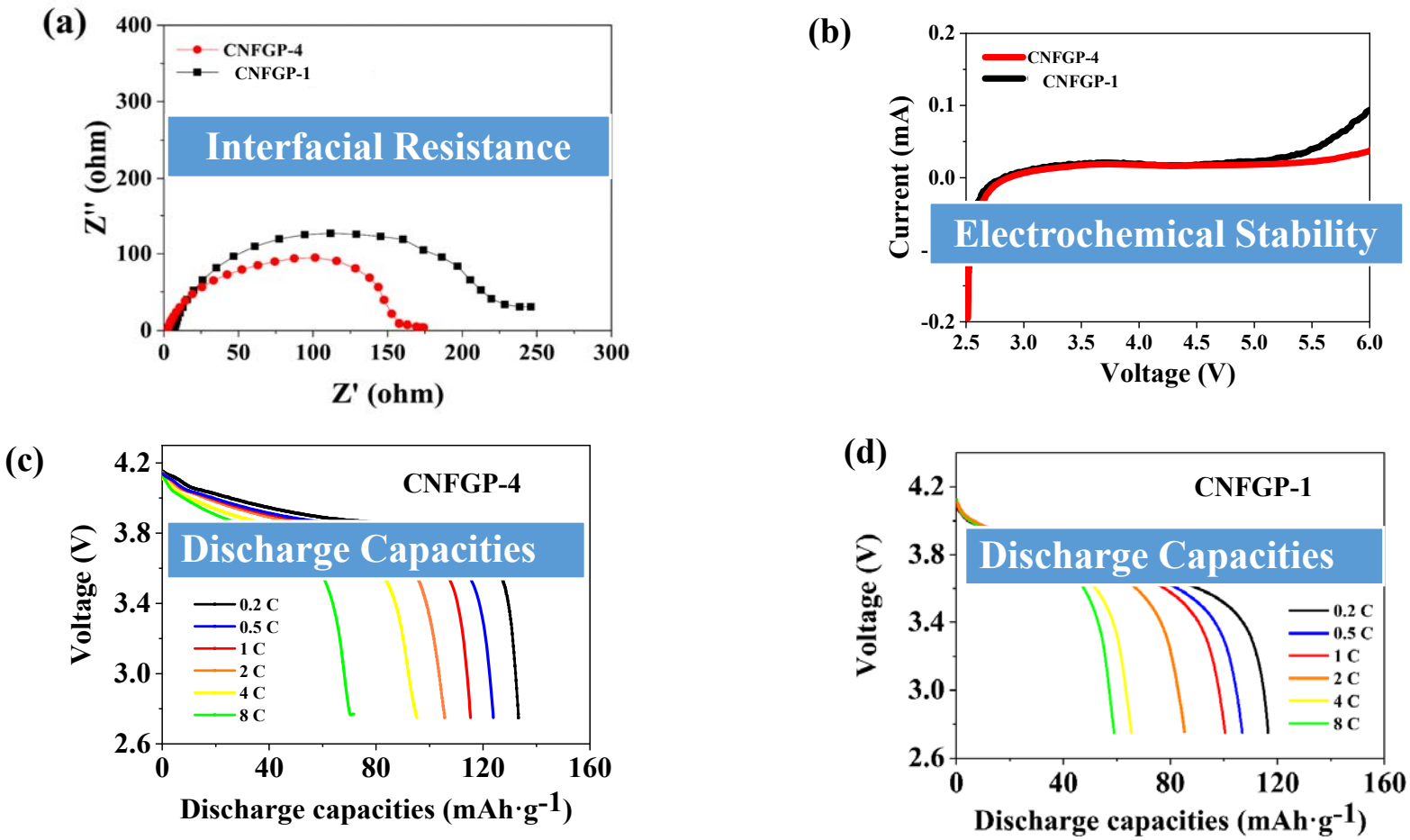
Sample	Porosity/%	Mean pore size/nm	Stress/MPa
CNFGP-1	65	632	65.3
CNFGP-2	68	473	68.4
CNFGP-3	72	354	74.9
CNFGP-4	**78**	**280**	**83.2**





2. CNF based Gel Polymer as Solid State Electrolyte

Electrochemical Performance



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Conclusions

01 Cellulose Nanofibril (CNF):

A suitable material for LIB separator and electrolyte host.

A further effect on membranes (mechanical strength & pore size).

02 NBSK/PSA/CNF and NBSK/A-PSA/CNF membrane

Enhanced mechanical strength, the uniform pore size and narrow pore size distribution.

03 CNF based Gel Polymer as Solid State Electrolyte

Improved ionic conductivities, better cycle performance and cycle-rate capability

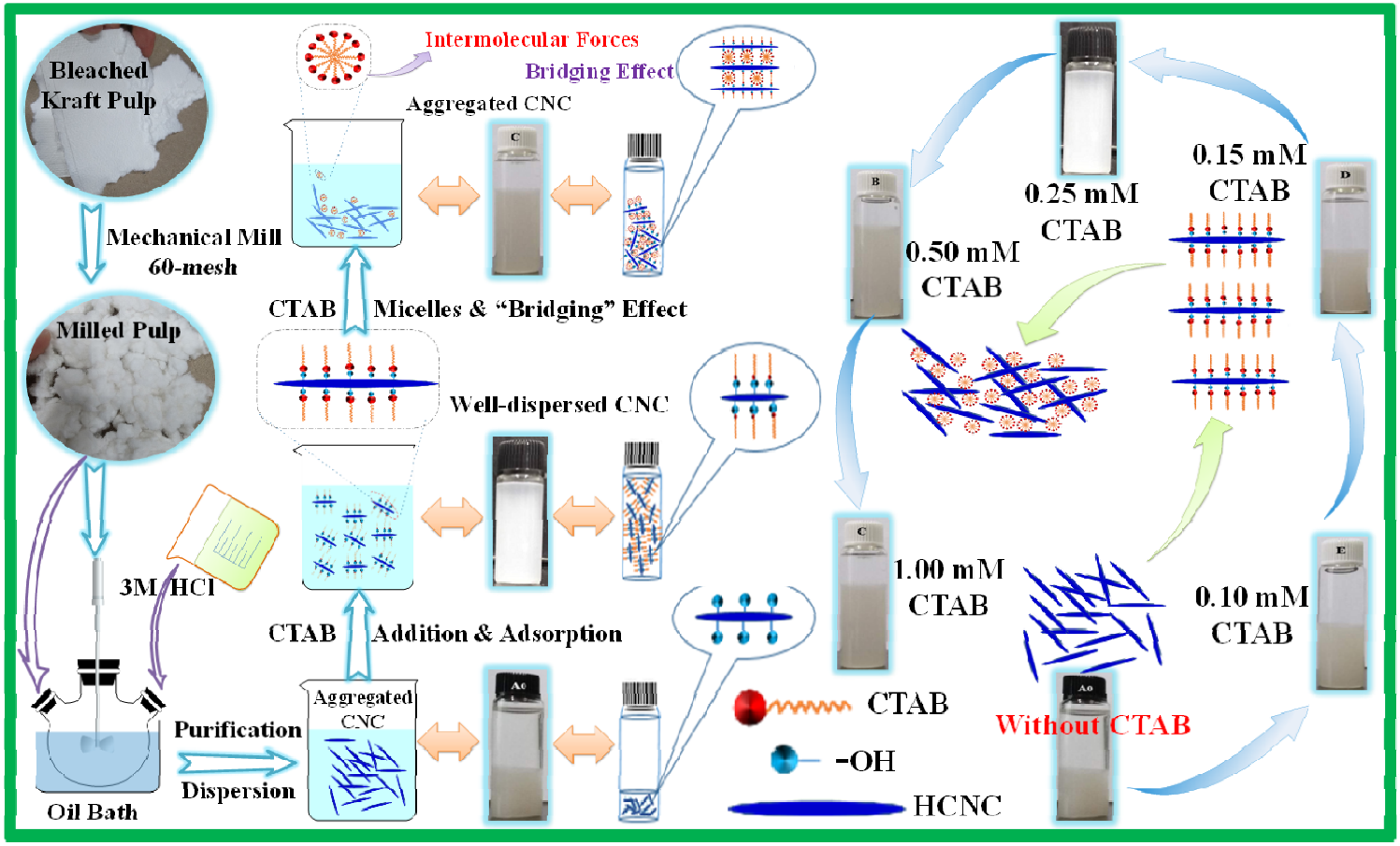
3. The research of our groups on Nanocellulose

Nanocellulose Preparation-HCl Hydrolyzed CNC with a high colloidal stability

Preparation (two-step method):

1) HCNC: Hydrochloric acid hydrolysis

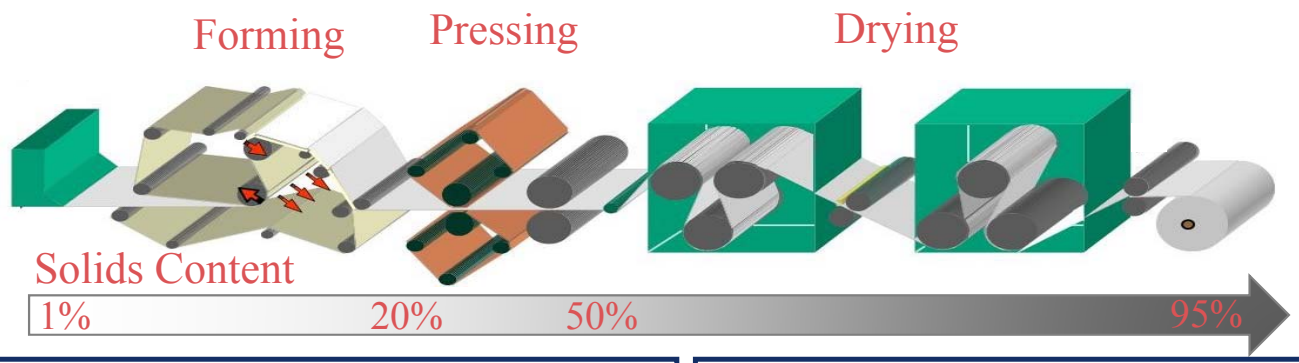
2) CTAB-HCNC: Adsorption of CTAB onto HCNC surface

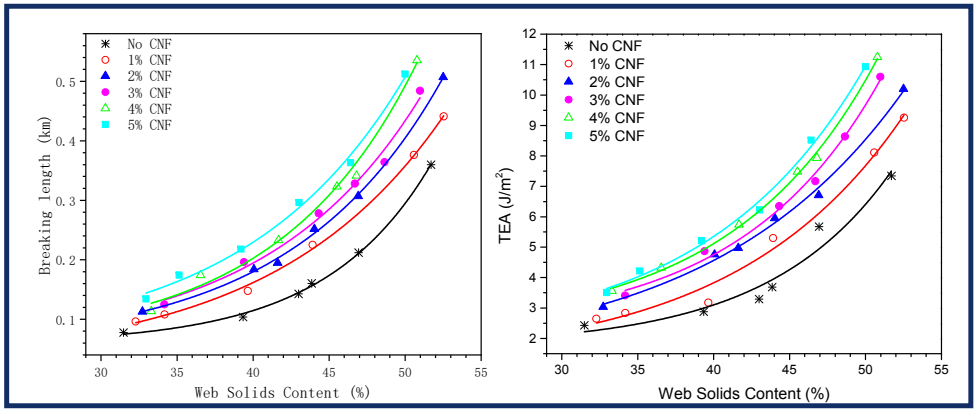


Zh, Shang, X., An, H., Liu. Carbohyd. Polym., 2019

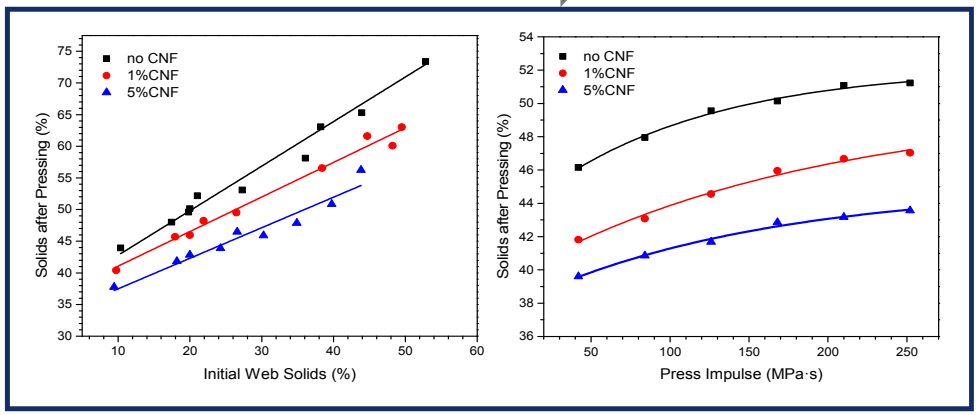
3. The research of our groups on Nanocellulose

Nanocellulose Application in Wet-web Strength Improvement





CNF increase wet-web strength significantly



CNF decrease the web pressability

Z. Lu, X. An, H. Zhang, et al. Carbohydrate Polymers 2019 210: 332-338.

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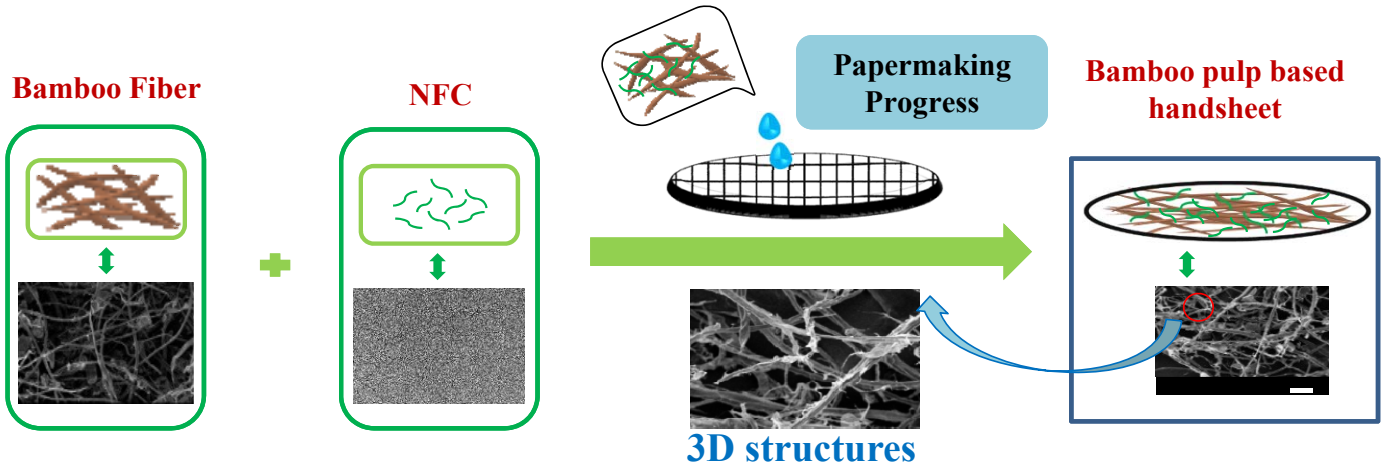
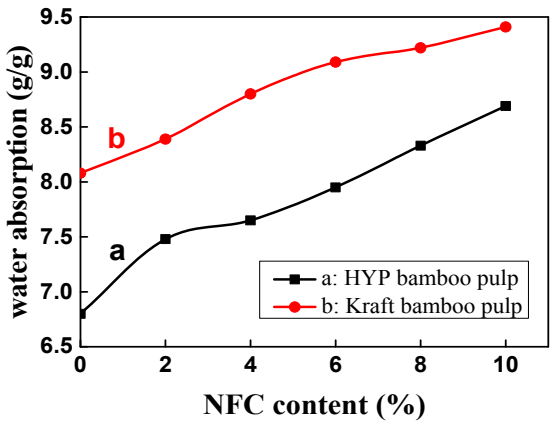
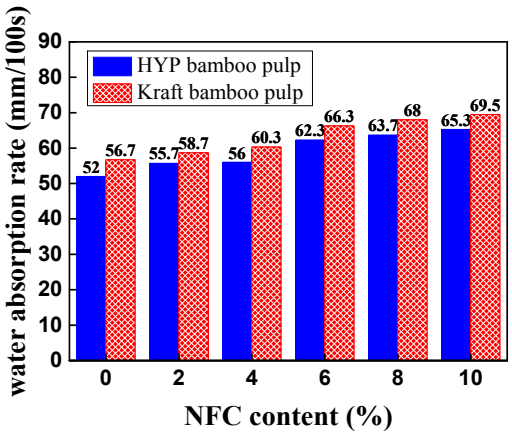
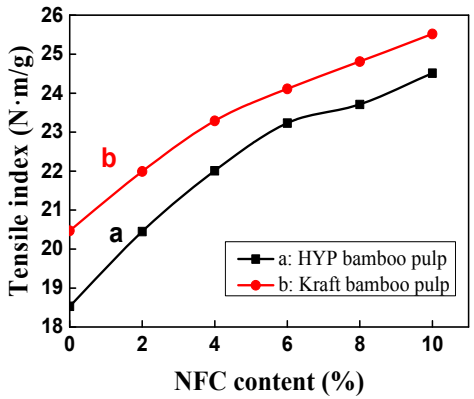
Nanocellulose Application in Bamboo Pulp Tissue Paper









M. Guan, X. An, H. Liu, et al. Cellulose, 2019, 26(4): 2613-2624

Our groups @ TUST

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College of Papermaking Sci. & Tech.

Prof. Hongbin Liu

Nanocellulose manufacturing

A major supplier to provide CNC and CNF in China

Nanocellulose application

Related in Pulp & Paper Industry

Thank you
ありがとうございます
谢谢

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