

One-pot syntheses of functionalized nanocelluloses for advanced elastomers and hydrophobic applications

You-Lo Hsieh

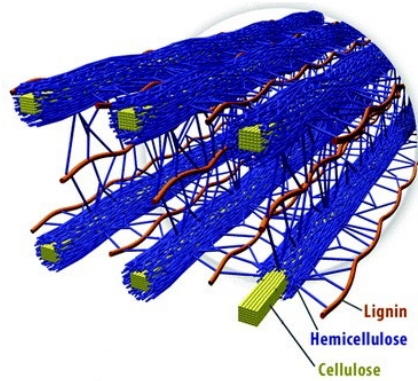
Distinguished Professor

University of California, Davis

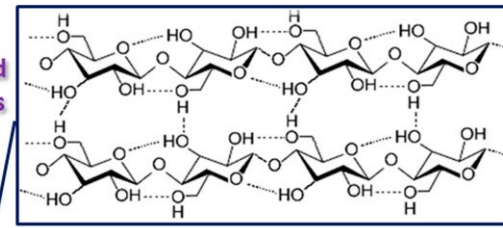
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Source & Isolation:



Hydrogen bonding within and between cellulose molecules



Cellulose microfibrils

Amorphous region

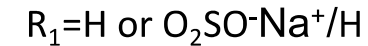
Crystalline region

Amorphous region

Process:

Cellulose nanocrystals (CNCs):

- 3-30 nm wide
- 100-500 nm long
- Anionic surface charges



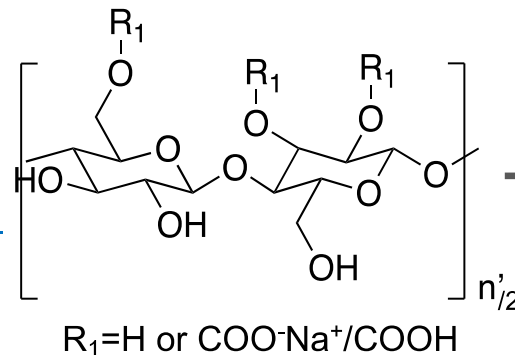
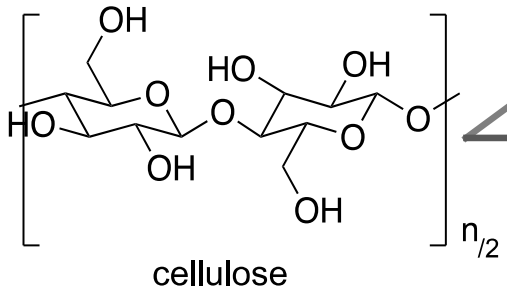
Hydrolysis

aq.

Pretreatment

TEMPO (C6) aq.

Periodate/Chlorite (C2, C3) aq.



Disintegration

Shear force, aq.

Cellulose nanofibrils (CNFs):

- 1.7-6 nm wide
- 10^2 to over 10^3 nm long
- Uncharged or anionic charges

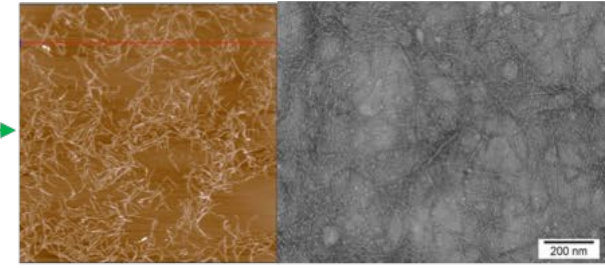
Microfibrillated cellulose (MFC) Nanofibrillated cellulose (NFC)

Disintegration:

Mechanical shear force, aq.

1D, 2D, 3D Structures, Properties, Applications

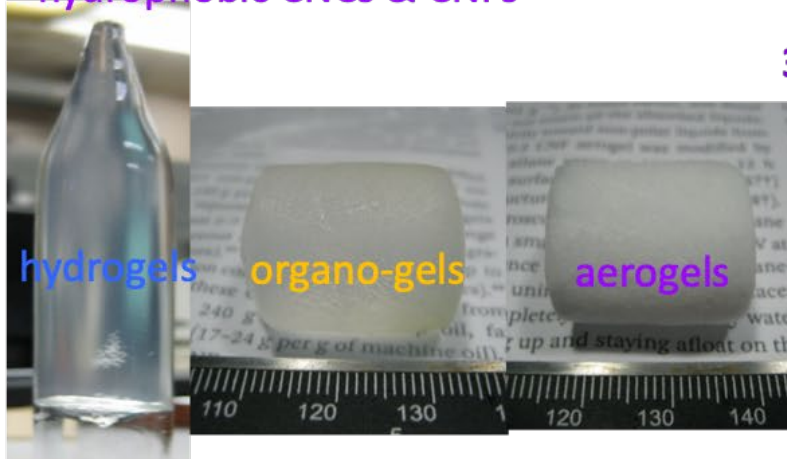
RS CNF from TEMPO/Blending



1D

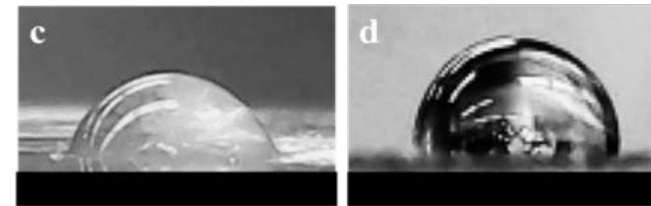
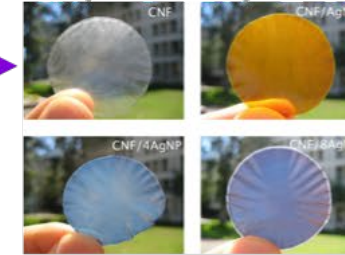
Amphiphilic & Tunable hydrophobic CNCs & CNFs (W: 2 nm – 10 nm)

- emulsifying agents
- capping agents
- nanotemplates
- antimicrobial dispersions & sprays
- exfoliating agents for 2D nanomaterials
- hydrophobic CNCs & CNFs



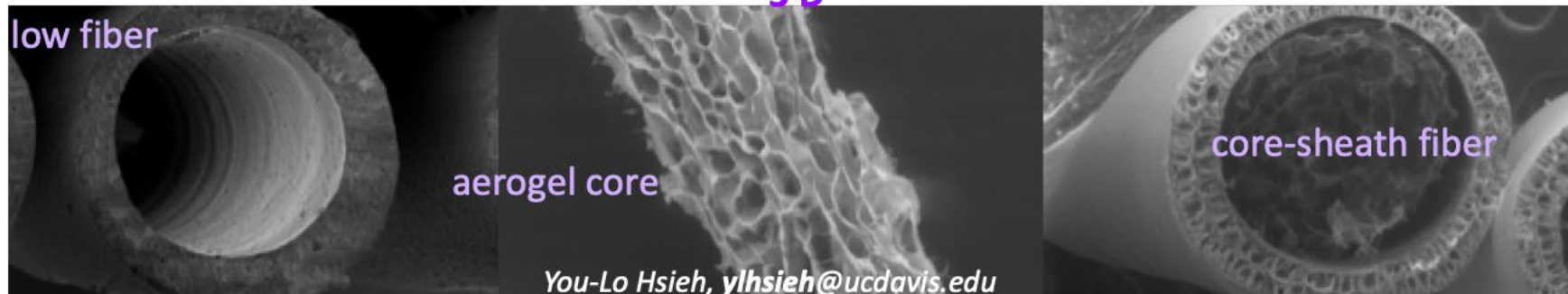
Self-Assembled 1 D, 2 D

- 1 D**
 - super crystalline nanofibers (W: 20 nm – 100 nm)
 - nano-composite nanofibers (electrospinning) (W: x00 nm)
- 2 D**
 - films & coatings
 - molecular sensors
- 3 D**
 - hydrogels
 - organo-gels
 - aerogels
 - core-sheath aerogel fibers (wet spinning) (W: 20 μm – 500 μm)

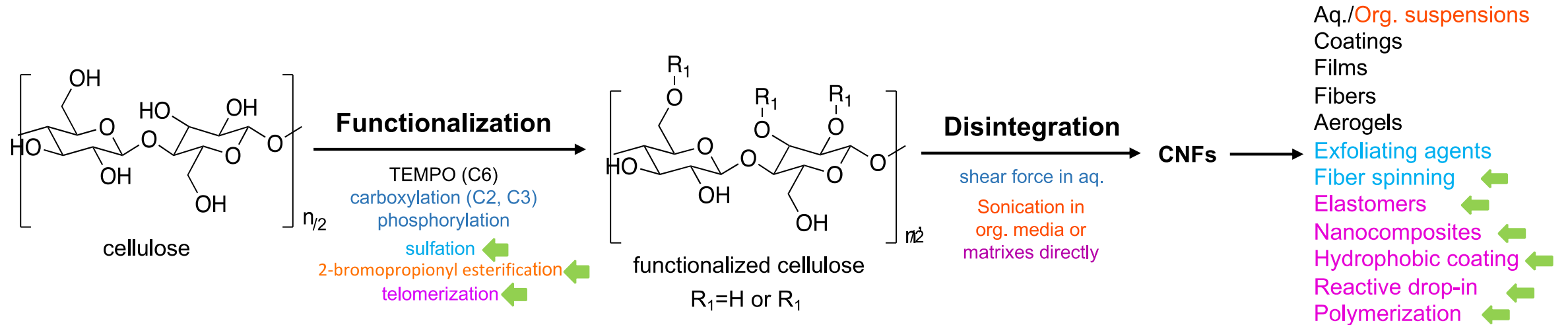


2 D

3 D

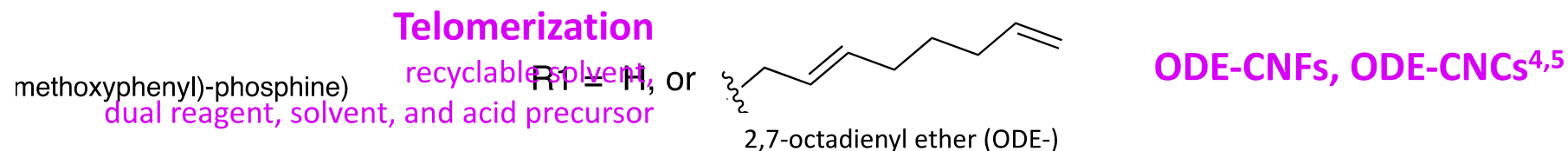
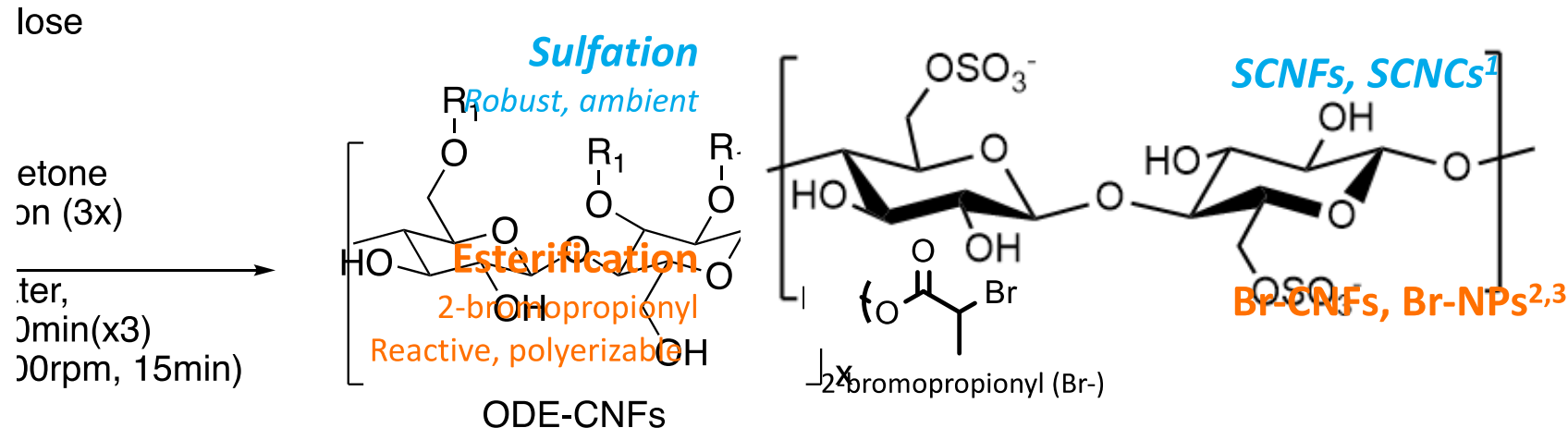
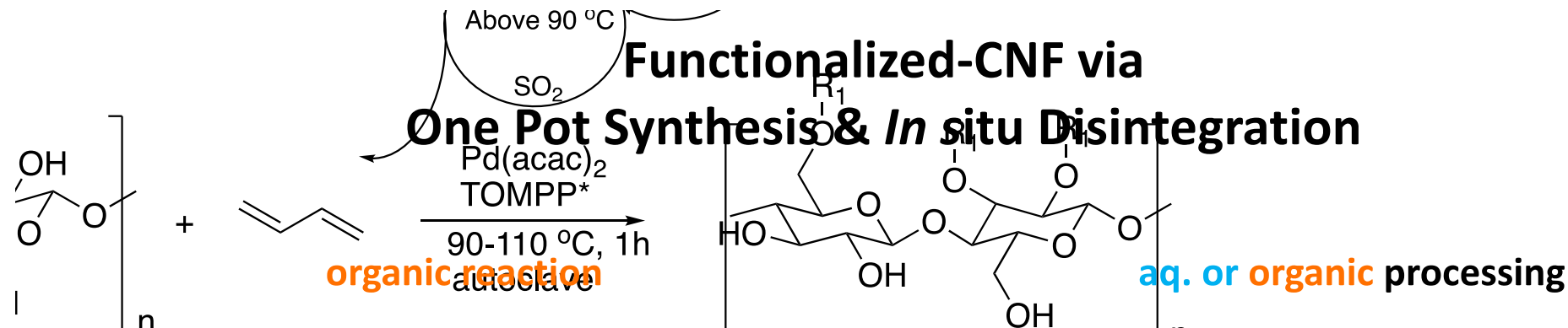


One-Pot, Holistic, Green Synthesis



Functionalization: *solid-state, heterogeneous reaction, stoichiometrically optimized*
Disintegration: *In-situ fibrillation in media or matrixes*

Functionalized-CNF via One Pot Synthesis & In situ Disintegration



¹Pingrey, B., Hsieh, Y.-L. *Biomacromolecules* 2022, 23 (3), 1269–1277.

²Guo, M., Hsieh, Y.-L. *RSC Advance* 2022, 12, 15070-1

³Guo, M. Y.-L. Hsieh, *Biomacromolecules*, 2022, 23(11), 4574-4585.

⁴Fukuda, J., Y.-L. *ACS Sustainable Chemistry & Engineering*, 2021, (9)18, 6489-6498;

⁵*ACS Sustainable Chemistry & Engineering*, 2023, 11(6), 2647–2657. .

Functionalized Nanocelluloses

One-Pot Synthesis & In-situ Disintegration

- **Cellulose** (waste, byproduct)
- **Heterogeneous reaction** (s.)
- **Stoichiometrically optimized** (CrI)
- **In-situ fibrillation in matrix or media**
- **Streamlined** (functionalization to product)
- **Robust processing**
(isolation, purification, green synthesis)
- **Improved productivity** (scale)

Nanocellulose Innovations

University of California, Davis

<https://techtransfer.universityofcalifornia.edu/>

UC 2016-909 **Amphiphilic Aerogels & Foams**

Feng Jiang

UC 2018-809 **Conducting Nanocellulose Aerogels & Fibers**

UC 2020-030 **Coaxial Cellulose-based Aerogel Fibers**

Jian Zhou

UC 2019-302 **Nanocellulose-Graphene Sensors**

Xuezhu Xu

➡ UC-2022-552 **Sulfated NC high strength fibers**

Benjamin Pingrey

➡ UC 2017-364 **Tunable Hydrophobic Nanocelluloses**

Juri Fukuda

➡ UC-2022-556 **Reactive & polymerizable NCs**

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200 nm

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Turning Discovery Into Health

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National Science Foundation

WHERE DISCOVERIES BEGIN

UC Davis
Sustainable AgTech
Innovation Center
(SATIC)



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200 nm

International Conference on Nanotechnology for Renewable Materials

Thank You!

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