Monocomponent nanocellulose for biobased 3D printing

AUTHORS:
Rubina Ajdary, Siqi Huan, Nazanin Zanjanizadeh Ezazi, Wenchao Xiang, Rafael Grande, Hélder A. Santos, Orlando J. Rojas

PRESENTED BY:
Rubina Ajdary
Doctoral student
Aalto University

Aalto University
School of Engineering

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

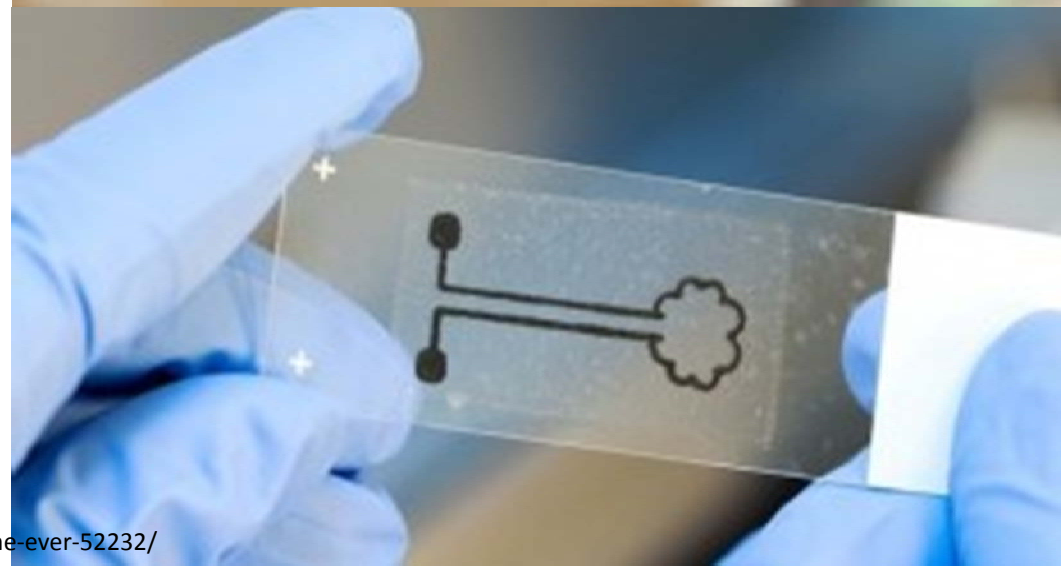
TAPPI

Nanocellulose 3D printing

2015- now

https://3dprintingindustry.com/news/3d-printing-cellulose-conductive-cellulose-for-the-first-time-ever-52232/

https://thespoon.tech/israeli-researchers-cook-up-3d-printed-food-you-can-personalize/



Nanocellulose- based bioinks

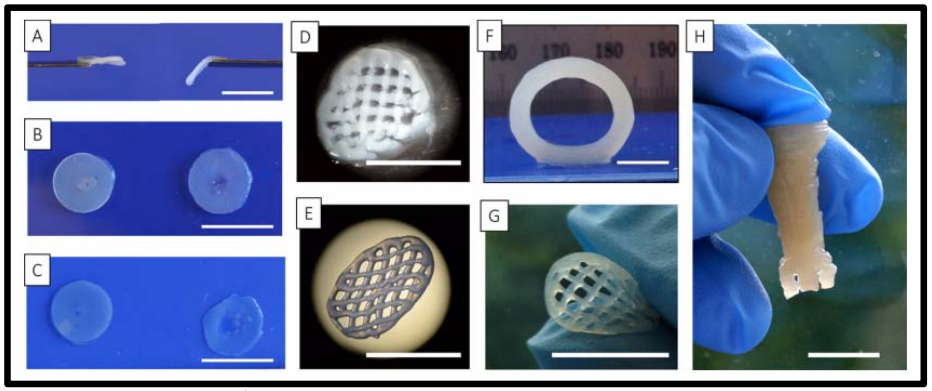
Gelatin

Alginate

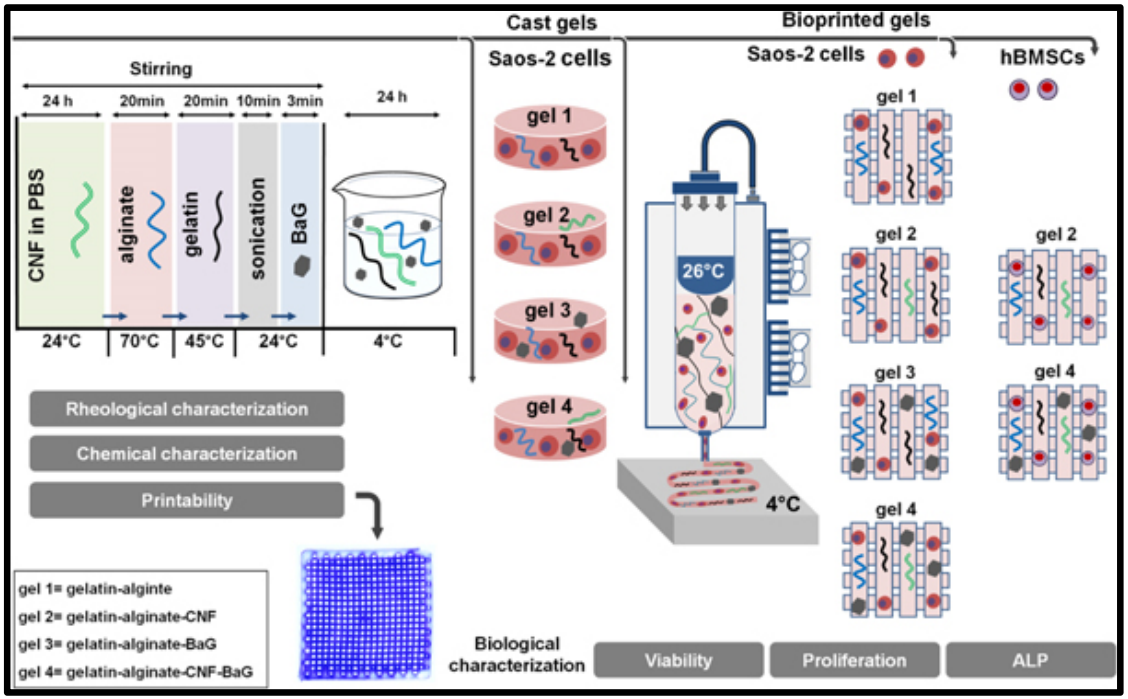
Silica

Xylan

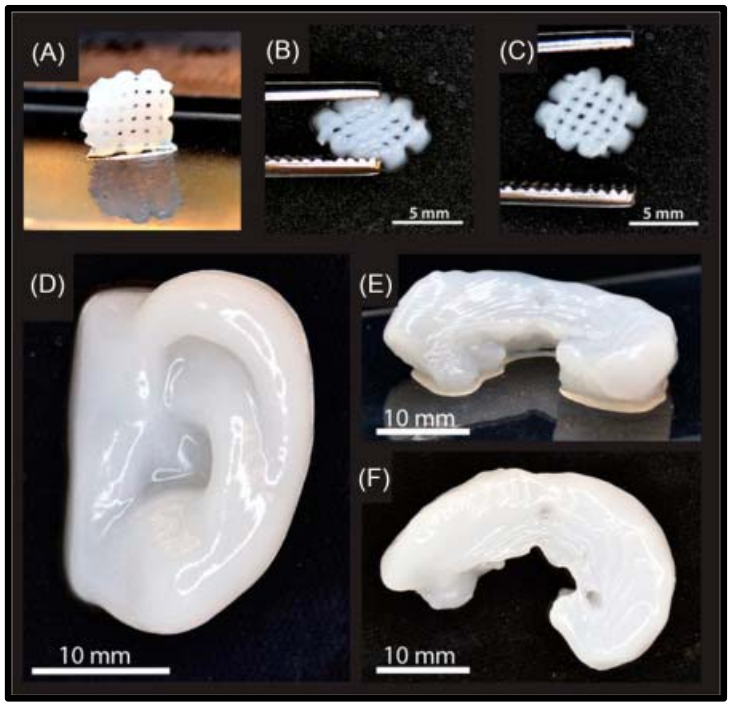
Nanoparticles



ACS Appl. Mater. Interfaces 2017, 9, 40878-40886

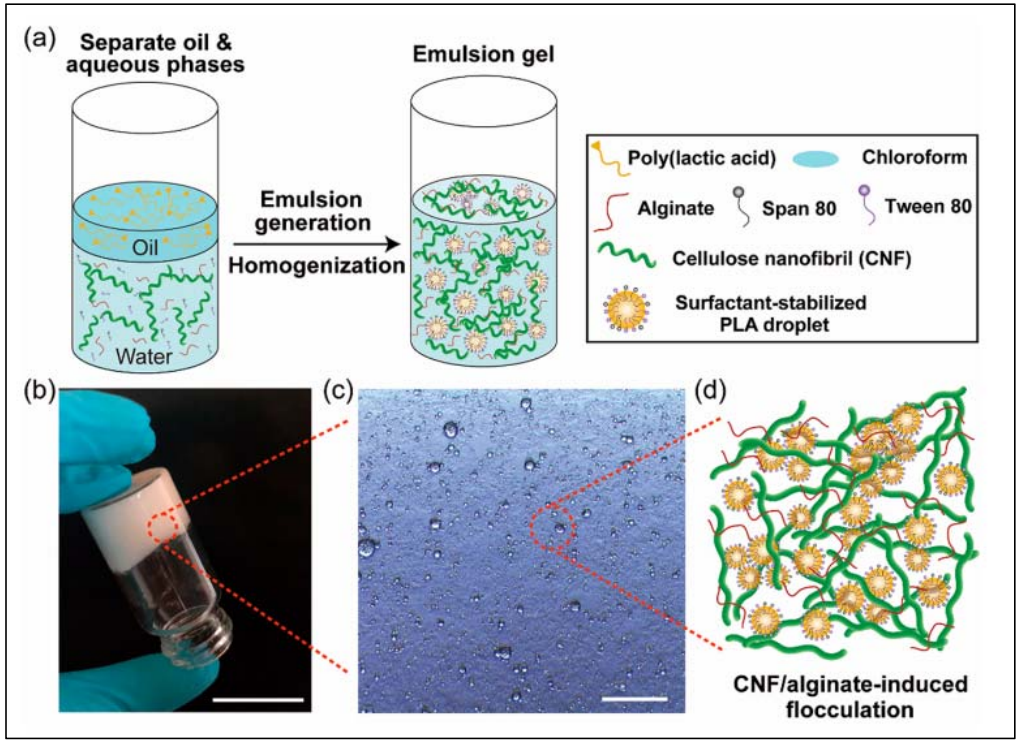


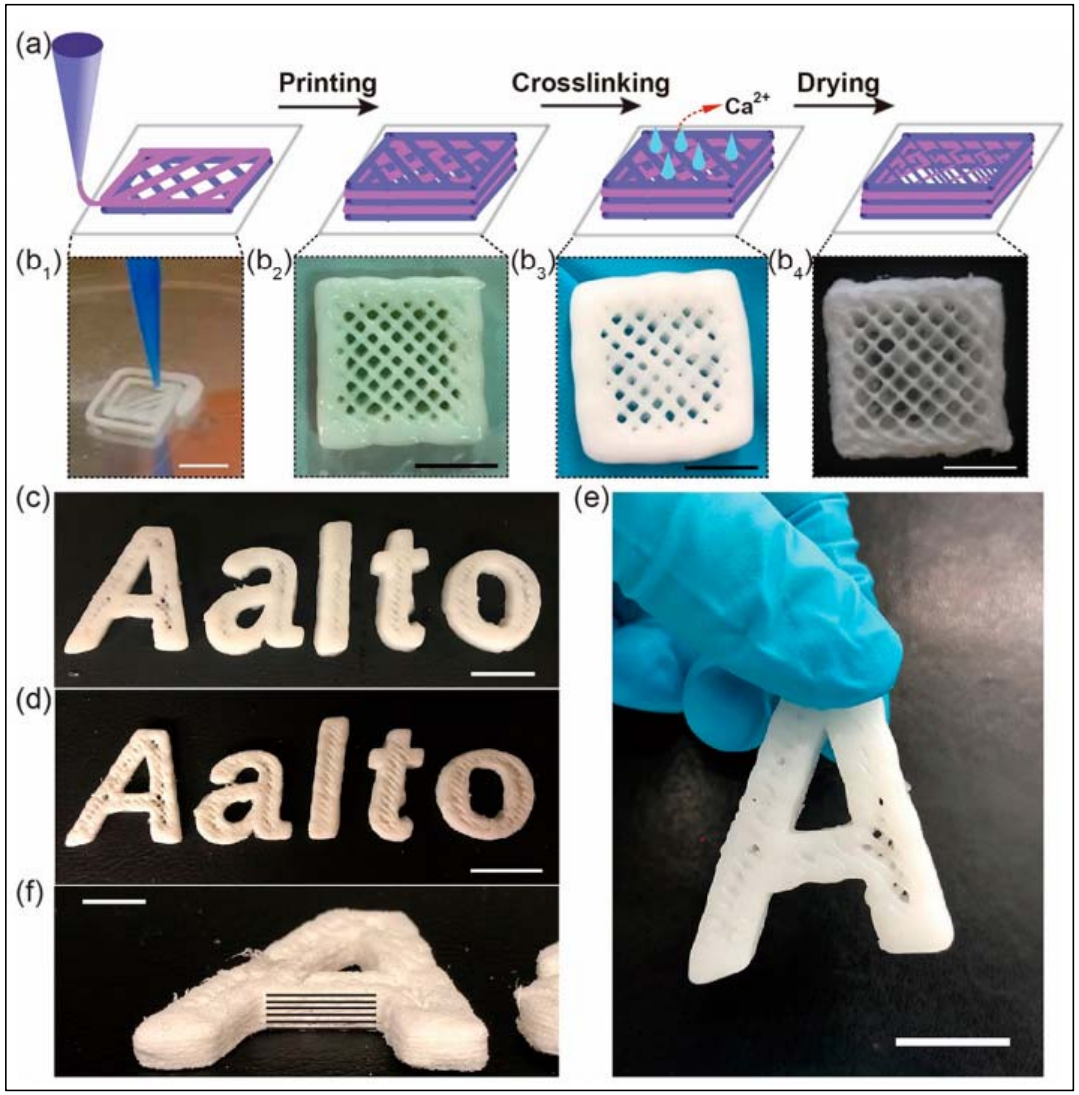
Miina Ojansivu *et al,* 2019, *Biofabrication,* **11** 035010



Biomacromolecules, 2015,16 (5), 1489-1496

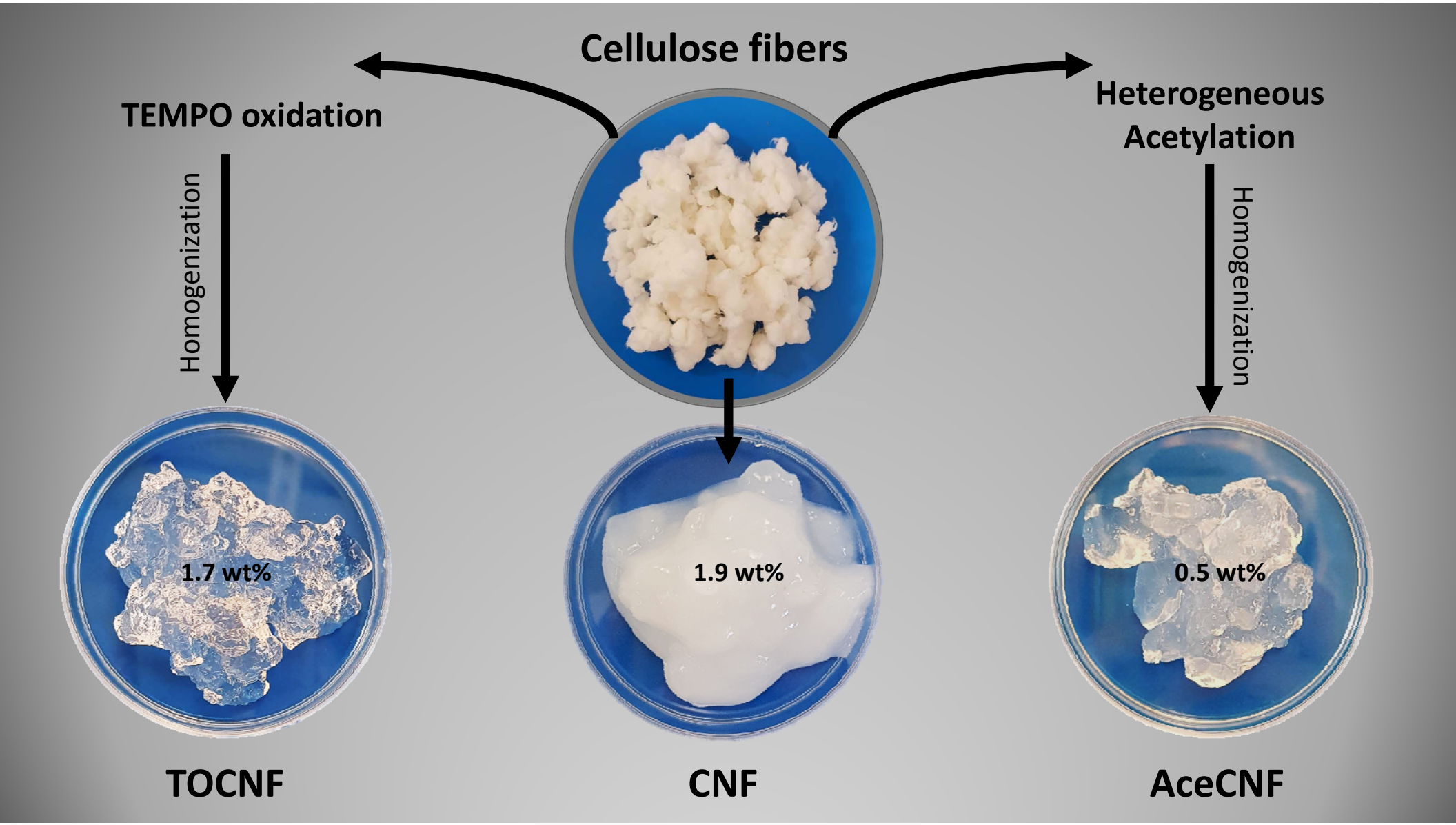
3D printing of nanocellulose-based emulsions



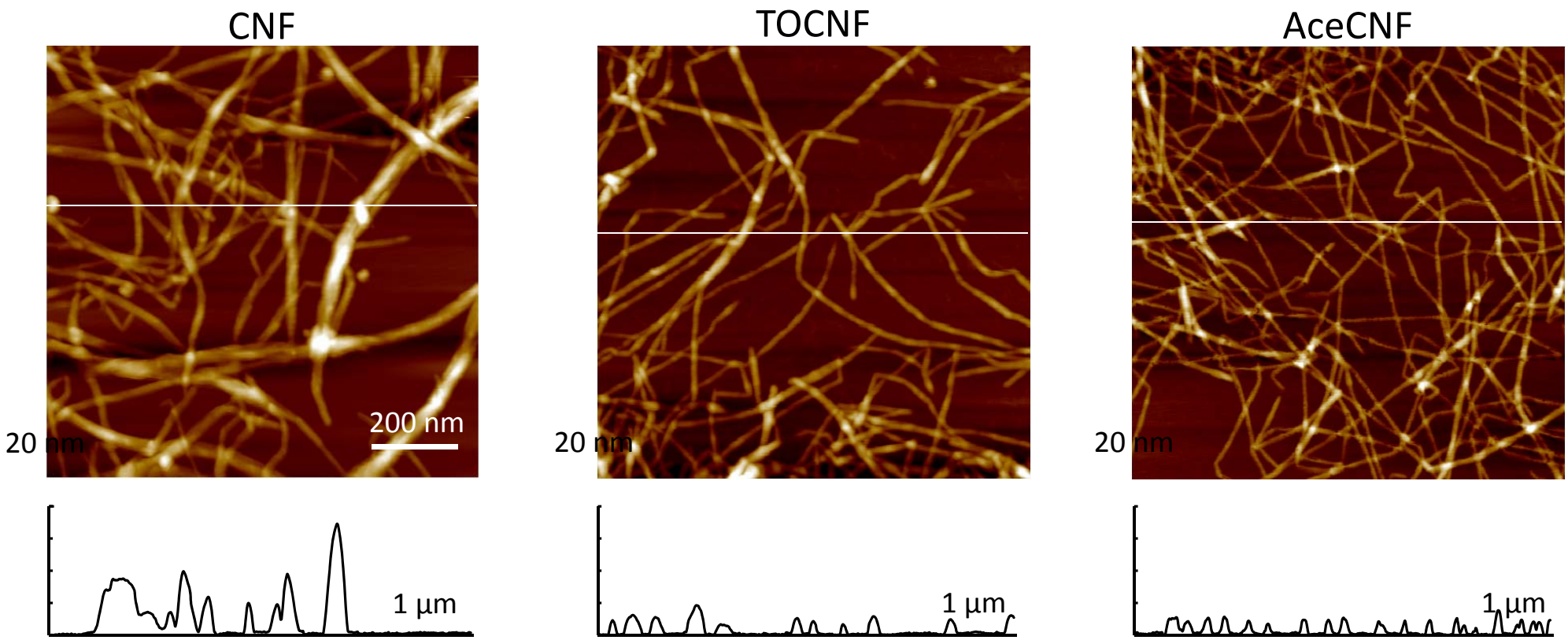


Huan. *et al*, Biomacromolecules 2019, 20, 635−644

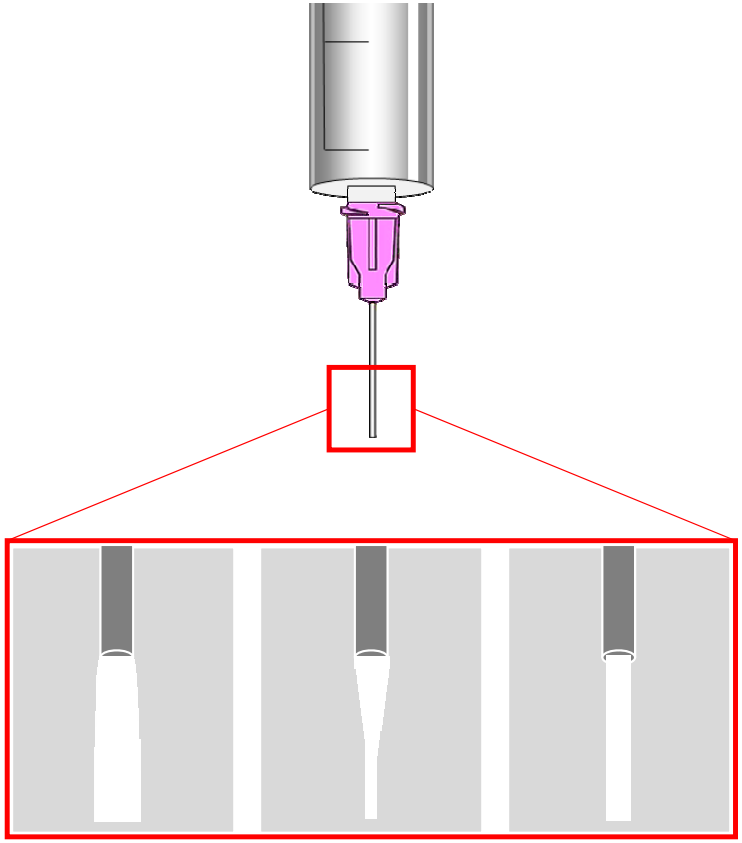
Is single component nanocellulose 3D printed structure stable?

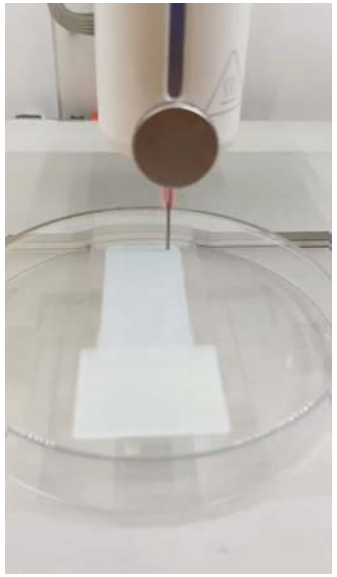

Cellulose fibers
TEMPO oxidation
Homogenization
Heterogeneous Acetylation
Homogenization
1.7 wt%
1.9 wt%
0.5 wt%
TOCNF
CNF
AceCNF

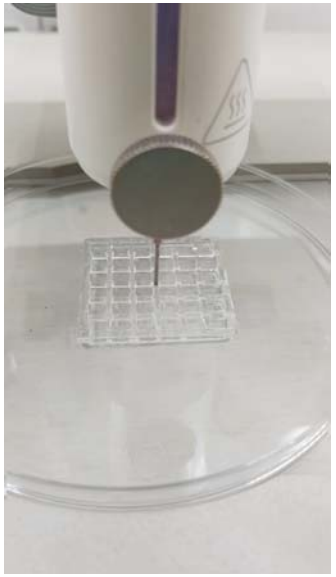
Decrease in diameter of nanofibrils after surface modification

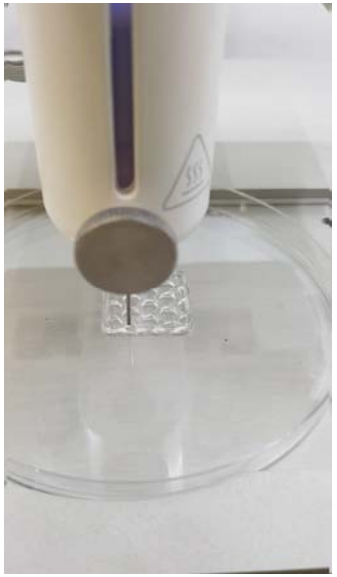


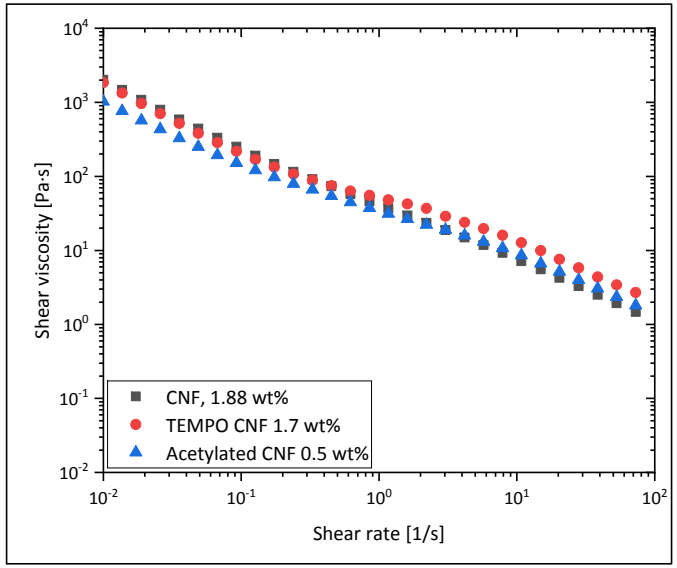
Rheological behavior is determining in 3D printing

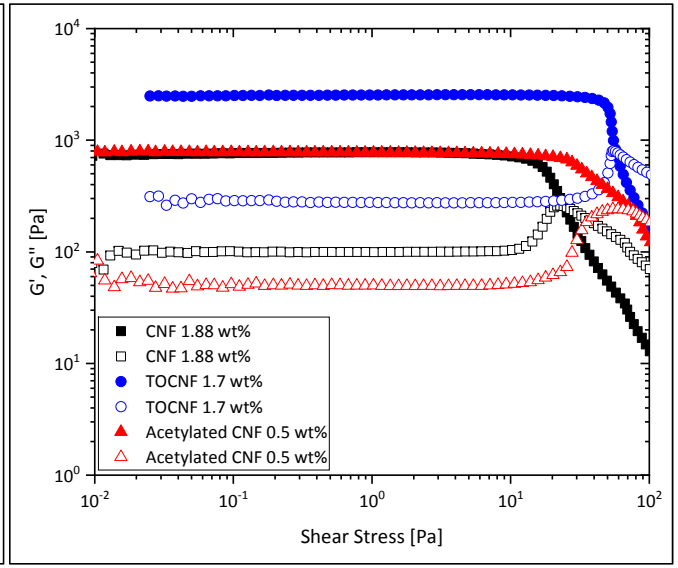




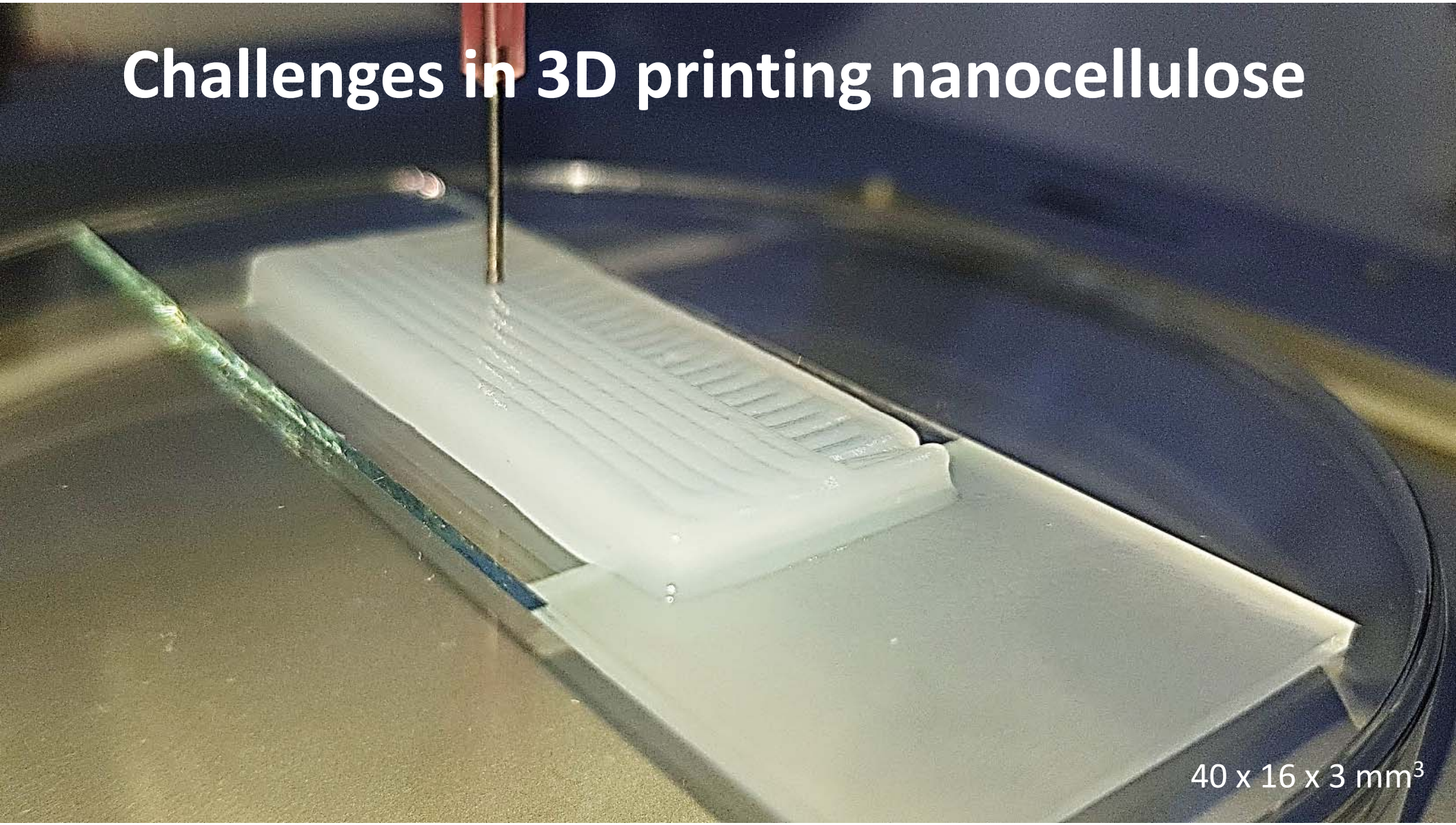




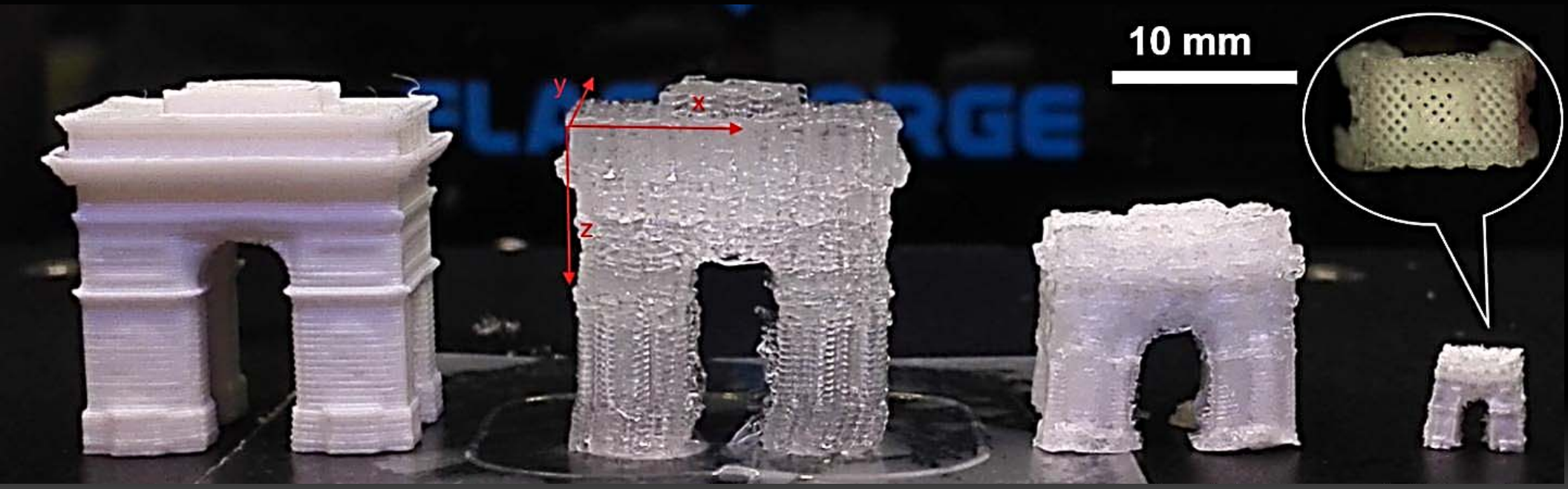




Challenges in 3D printing nanocellulose

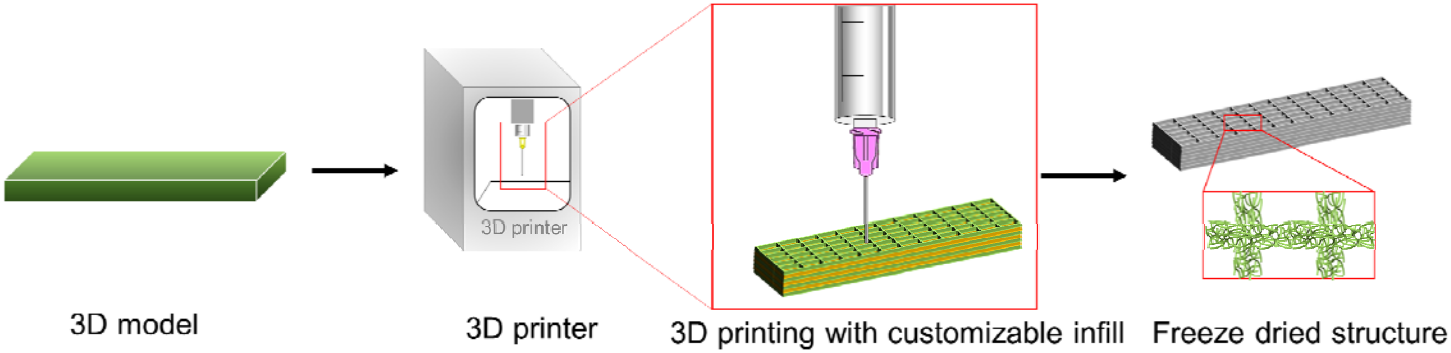


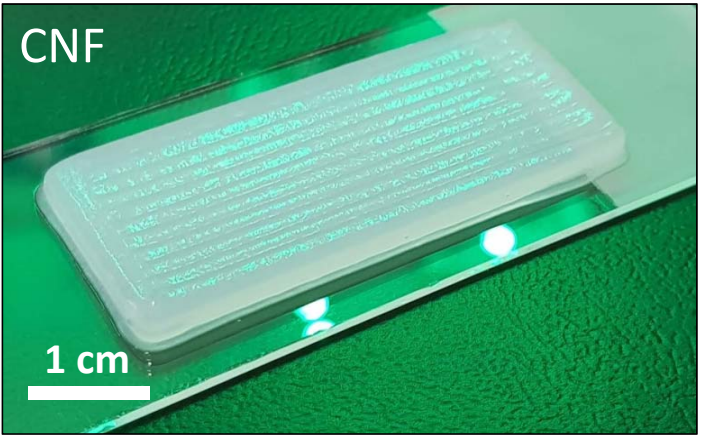
Shrinkage, a major challenge in Direct Ink Writing

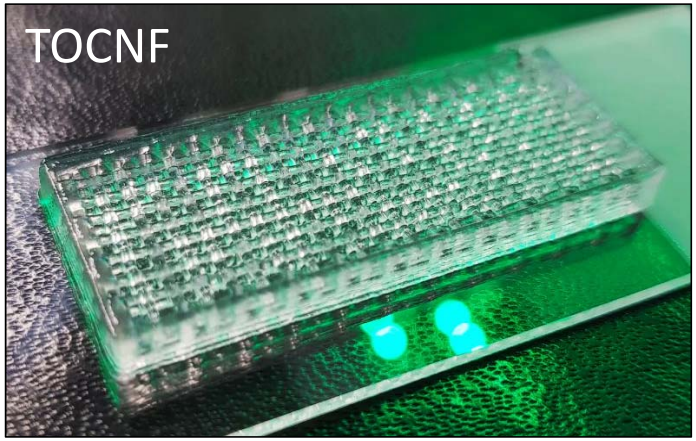


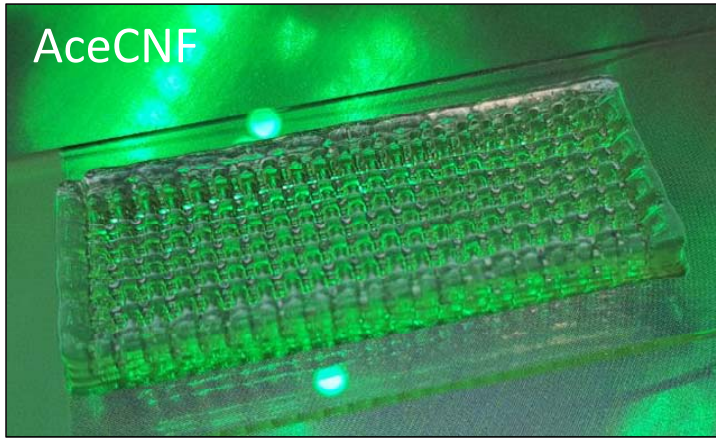
https://3dprintingindustry.com/news/dartmouth-smart-ink-3d-prints-shrinks-transforms-smart-materials-131491/

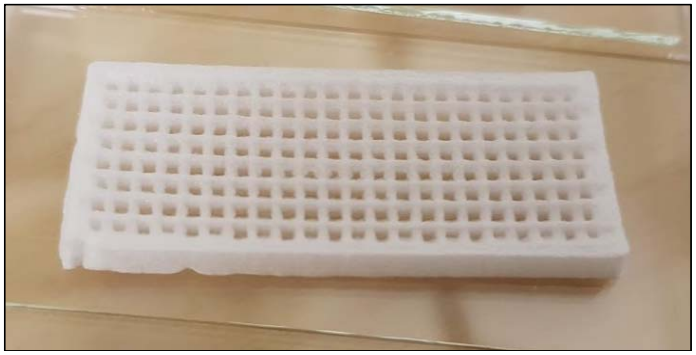
Physically stable scaffolds with about 10% shrinkage after drying.





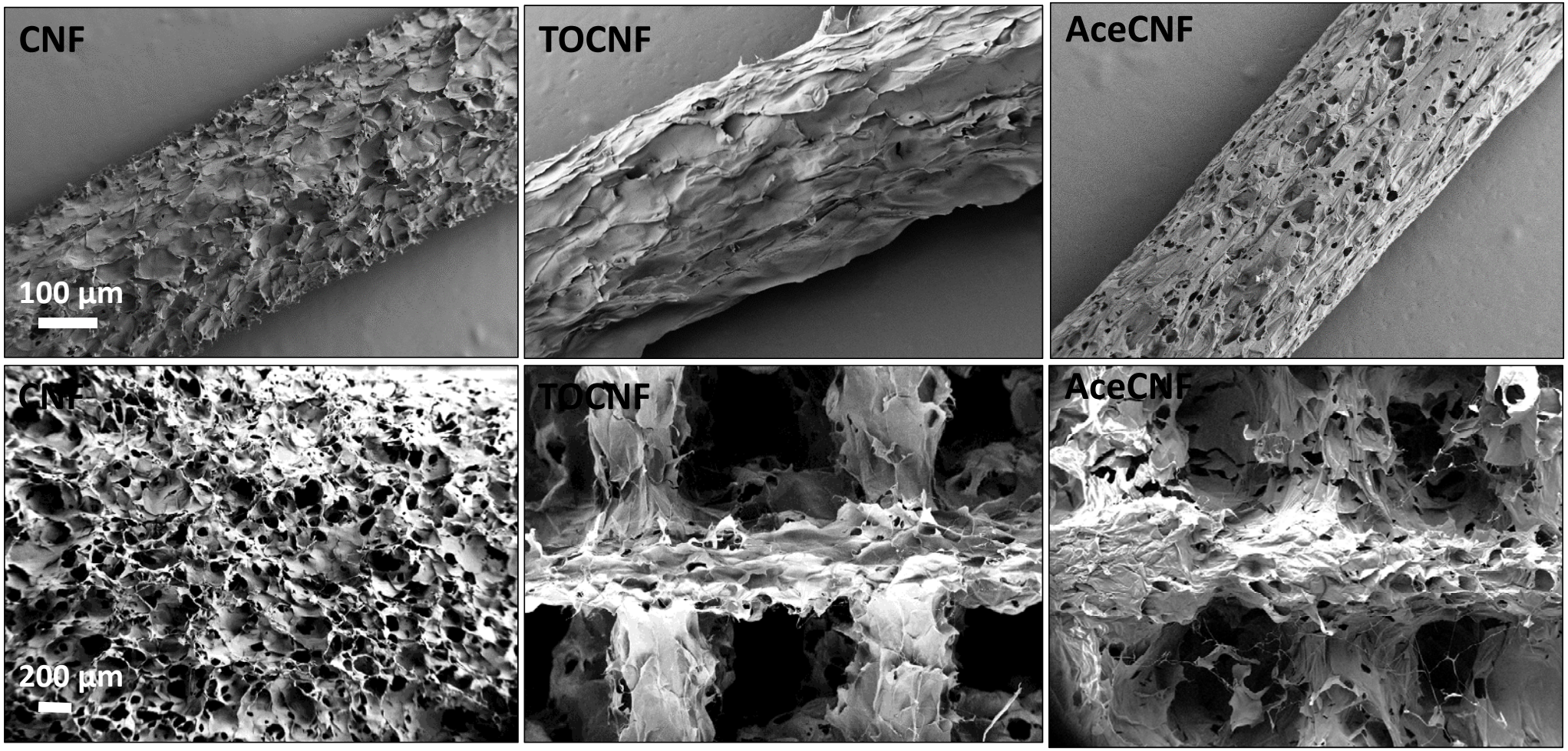




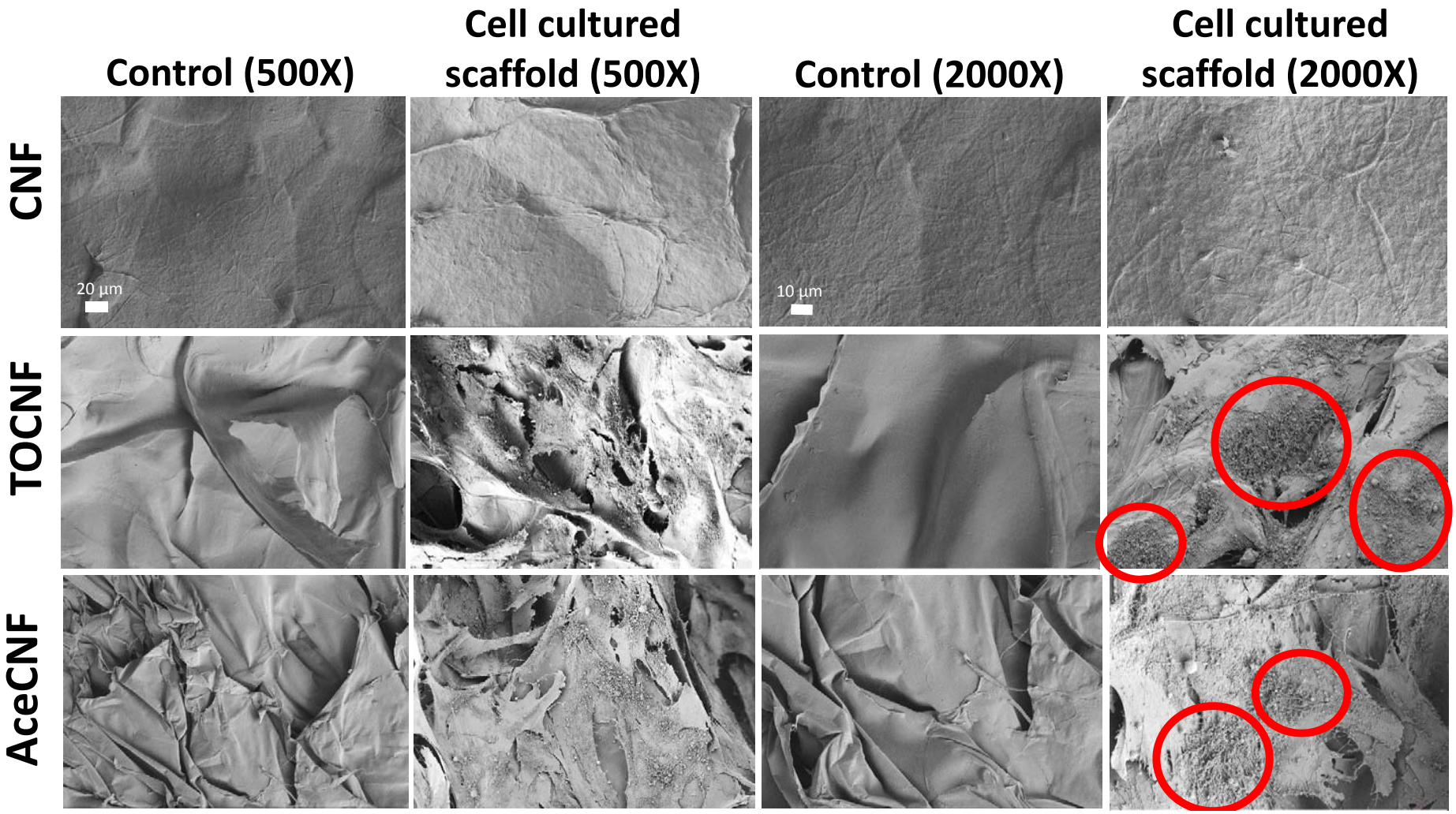


https://doi.org/10.1021/acs.biomac.9b00527

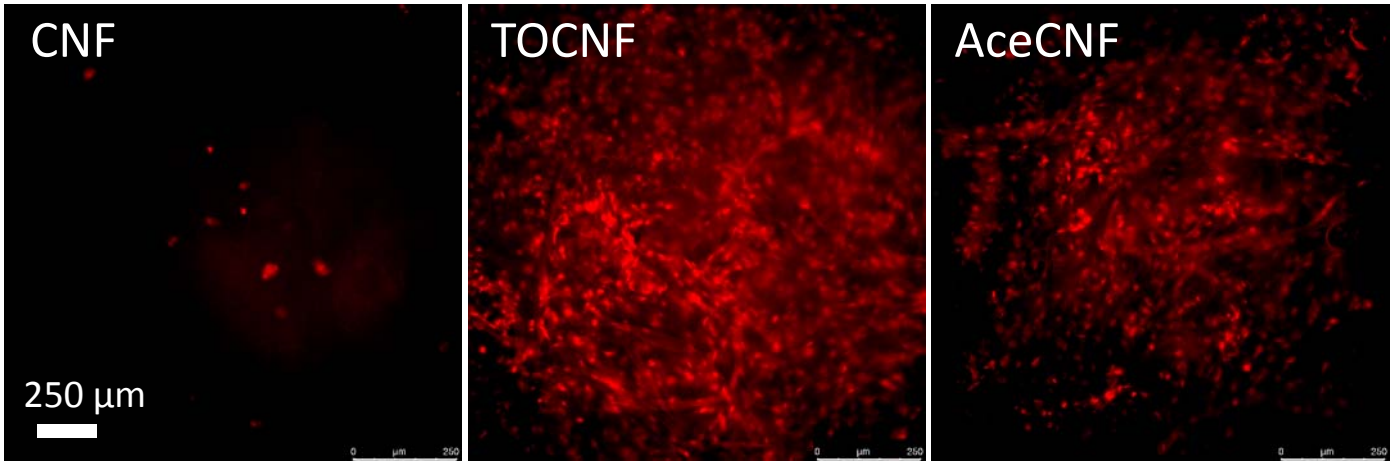
Microstructure of 3D printed scaffolds

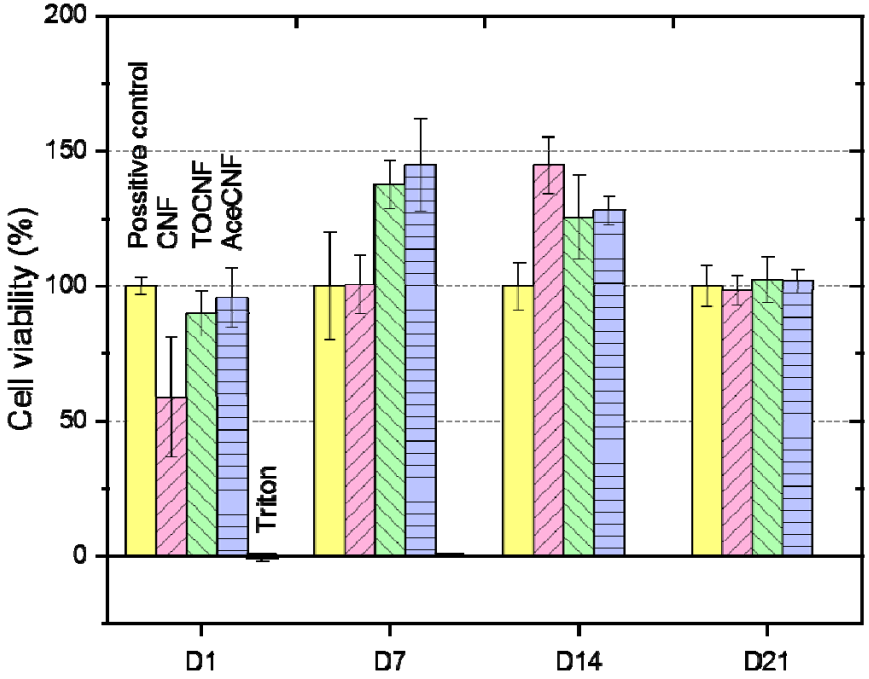


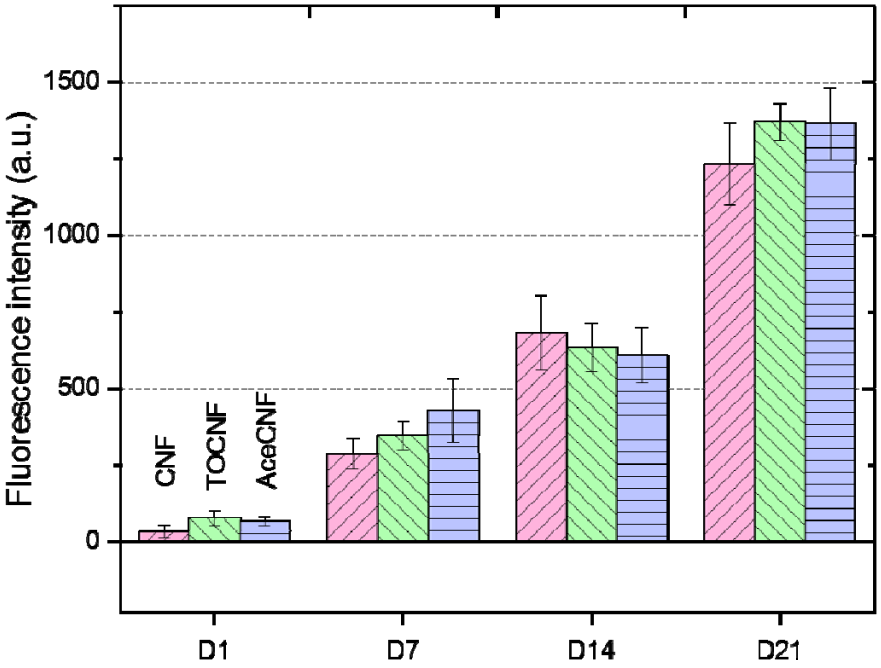
Cells show high attachment to surface modified 3D printed scaffolds

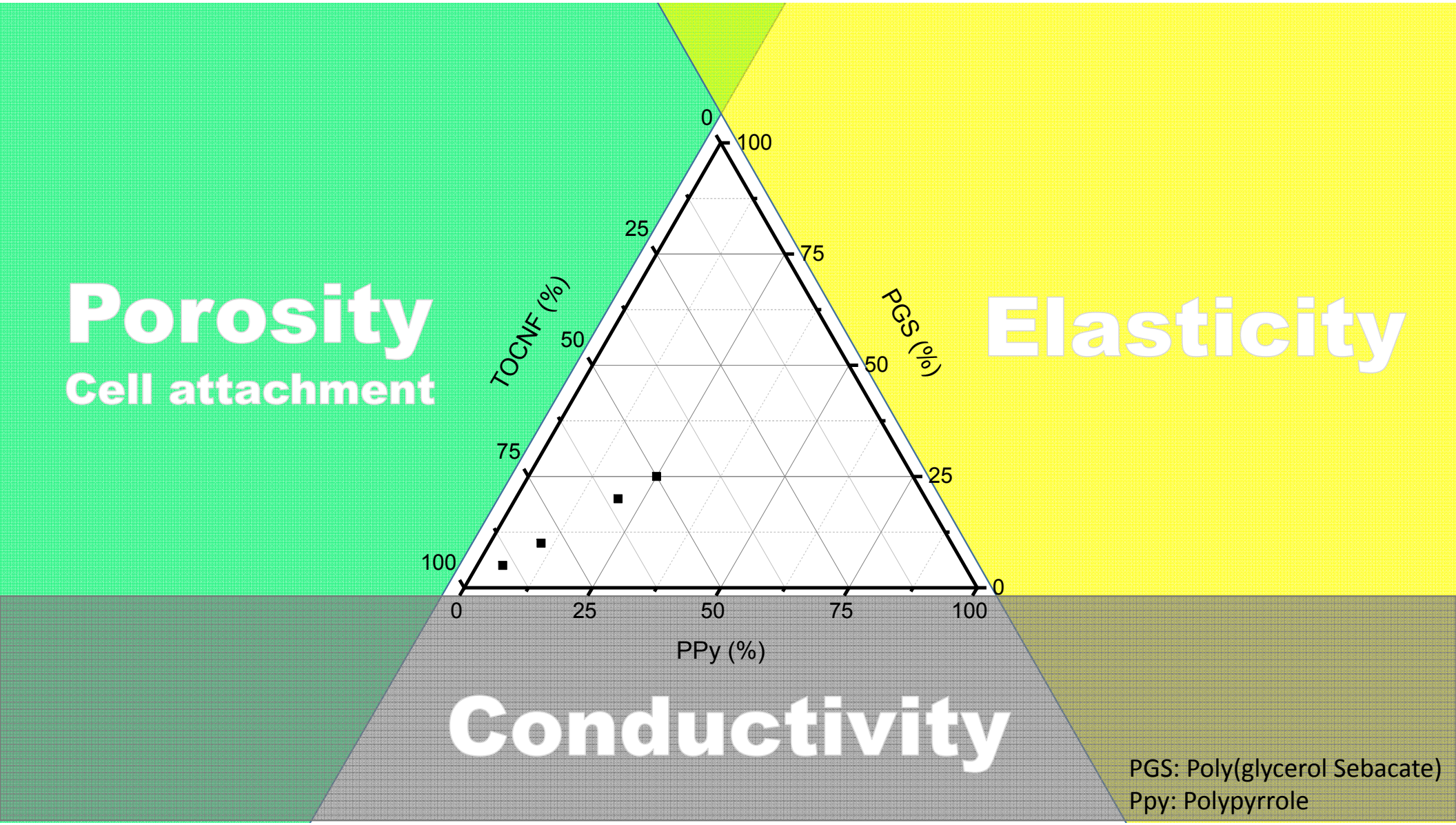


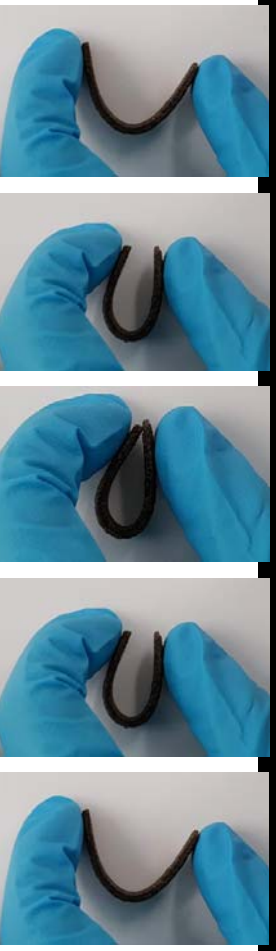
Single component scaffolds that are very compatible with cells








Porosity
Cell attachment
Elasticity
Conductivity
TOCNF (%)
PGS (%)
PPy (%)
0
25
50
75
100
PGS: Poly(glycerol Sebacate)
Ppy: Polypyrrole



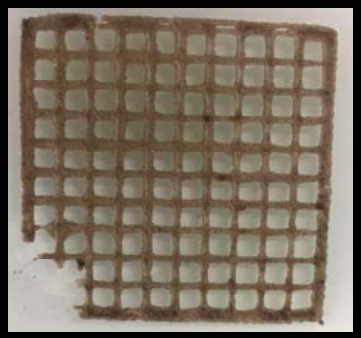
Wet

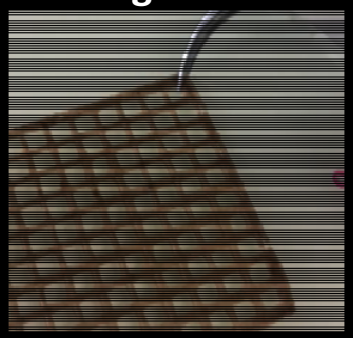
Freeze-dried

5% shrinkage

120 °C, 72 h

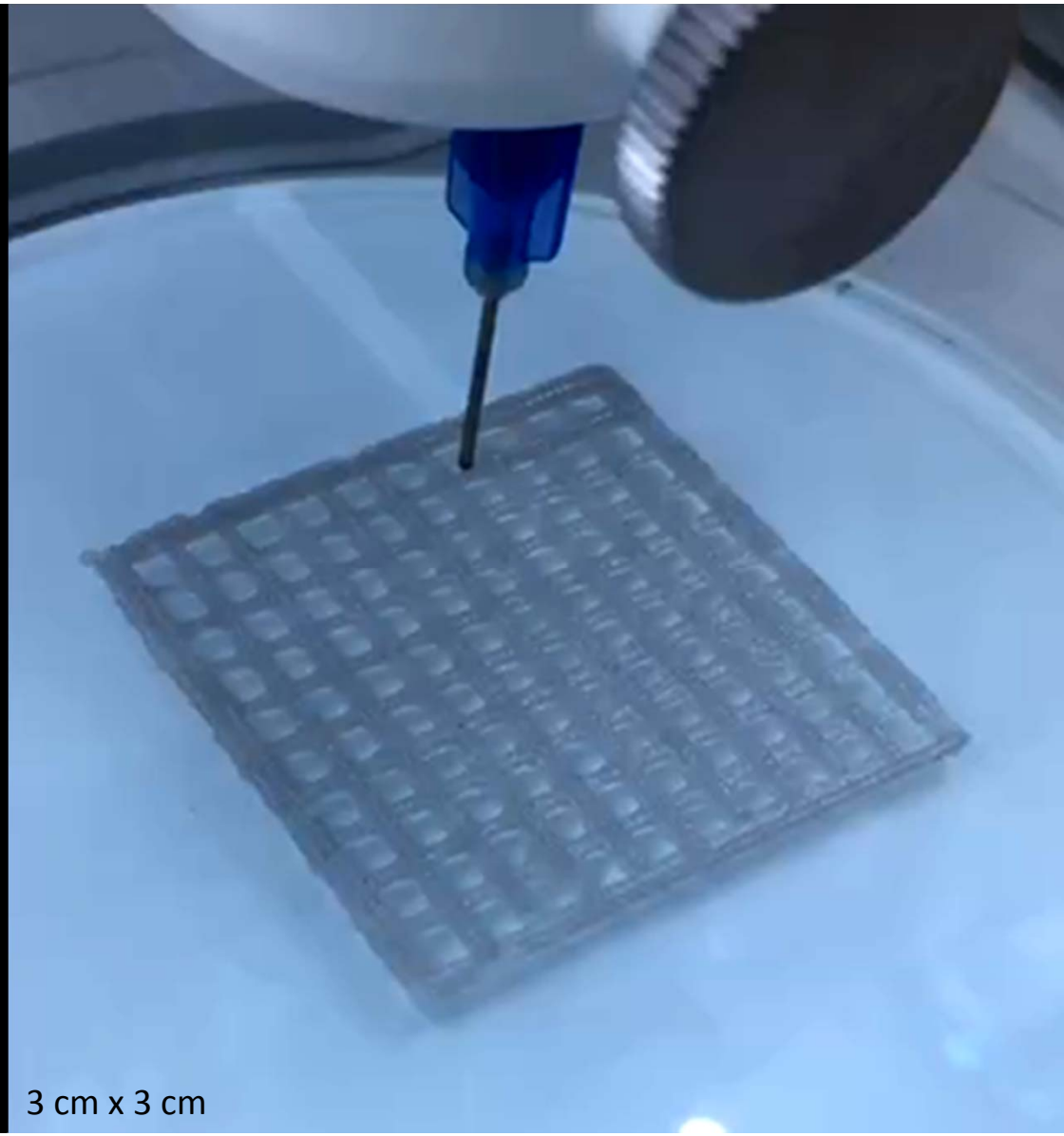
14% total shrinkage





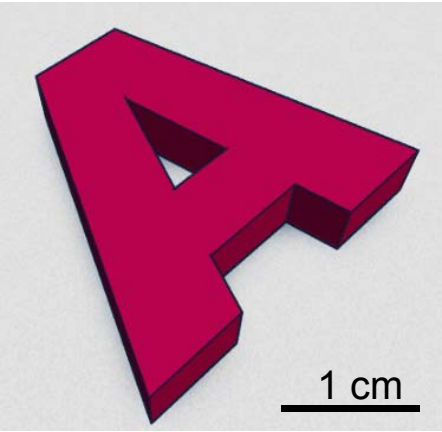
Challenges: homogenous distribution of PPy

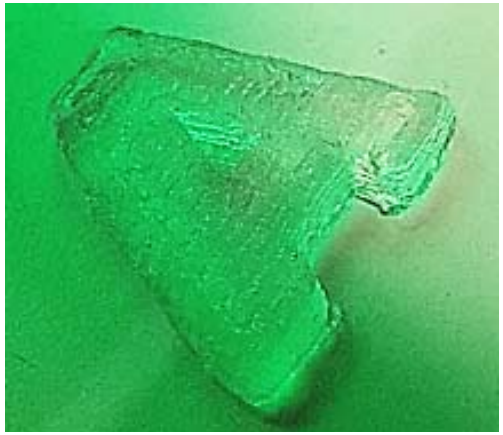
Success: Reducing the shrinkage



Conclusion

- Monocomponent nanocellulose 3D printing was successfully performed with no crosslinking step or addition of more compounds.
- Single component nanocellulose 3D printing shows promises as physically stable scaffolds for cell culturing.
- Myoblast cells show excellent viability, proliferation and attachment in the case of surface modified nanocellulose.
- Additional properties such as elasticity and conductivity can be achieved by addition of other compounds.





Aknowledgement

Bio Future 2025

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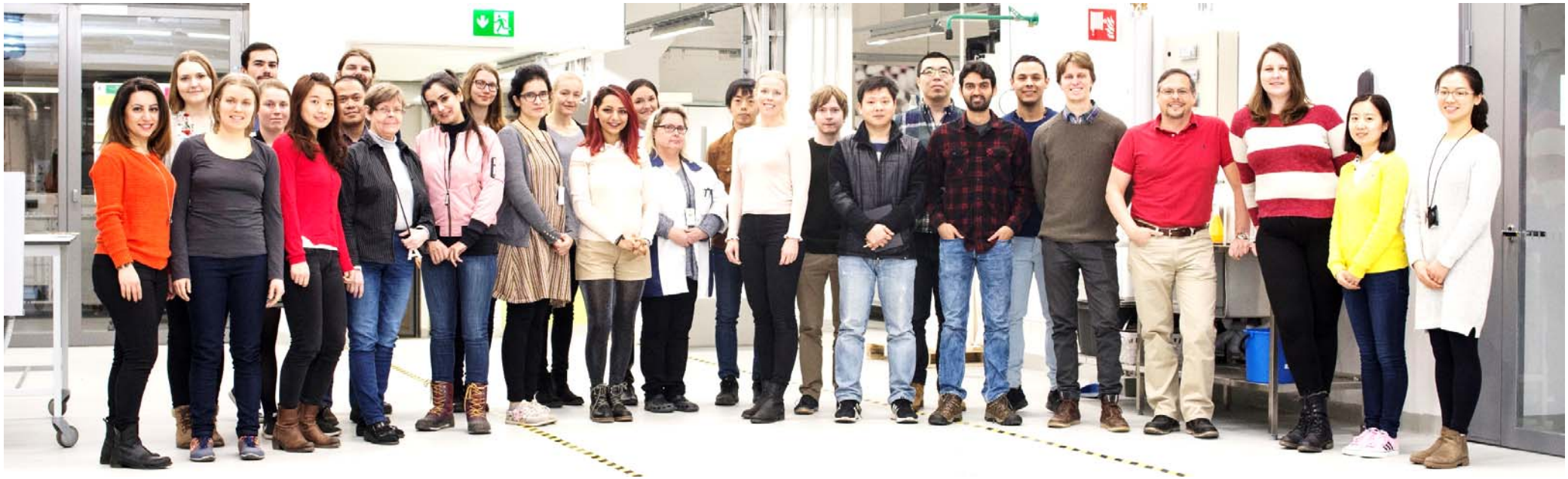
A!
Aalto University

Professor Helder Santos

Doctoral student Nazanin Ezazi



Thank you

PRESENTED BY

Rubina Ajdary

Doctoral student

Aalto University

Rubina.Ajdary@aalto.fi

Aalto University
School of Engineering

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

TAPPI