3D printing of cellulose: design strategies for rigid/stiff or superelastic monoliths

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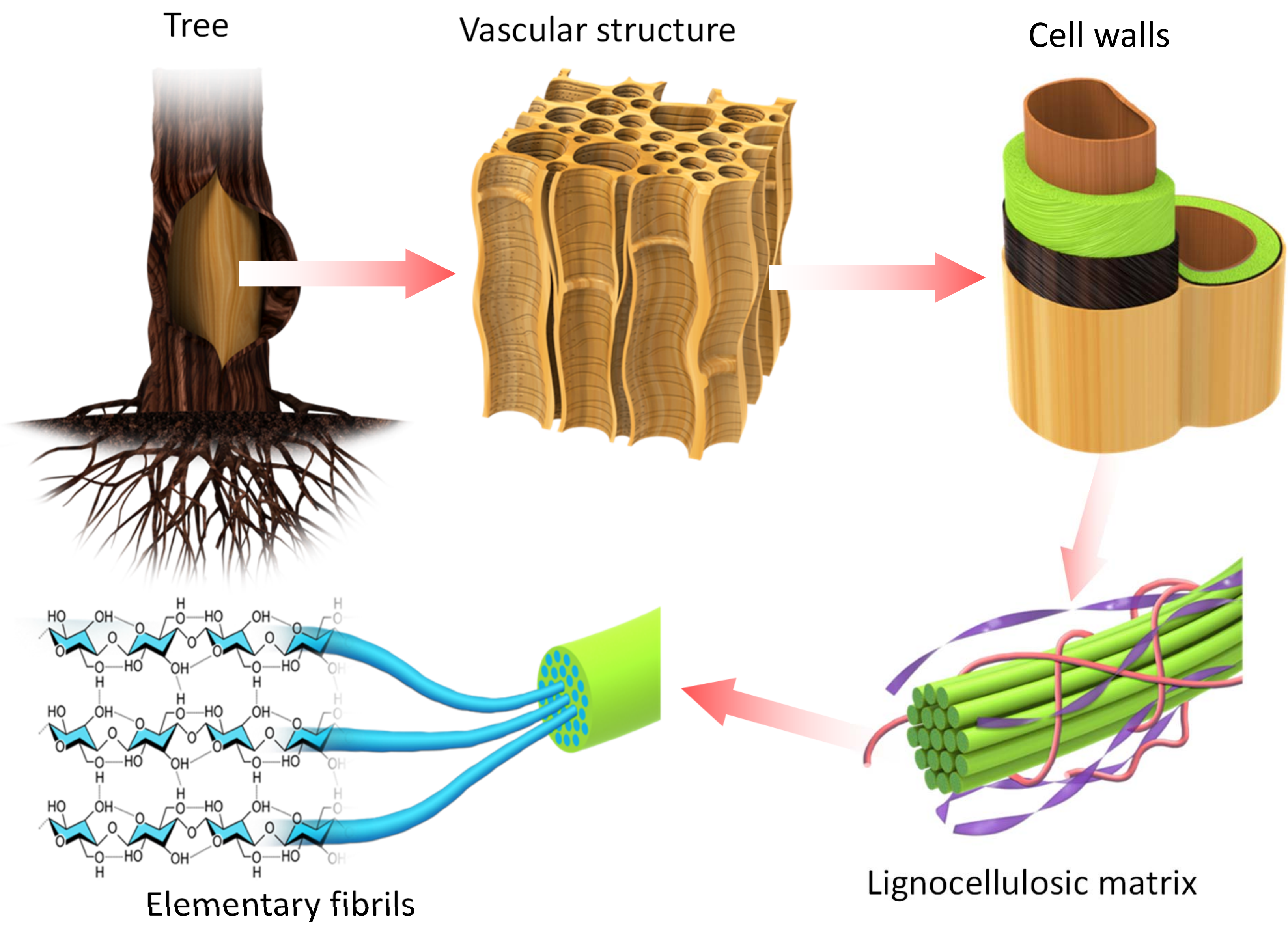
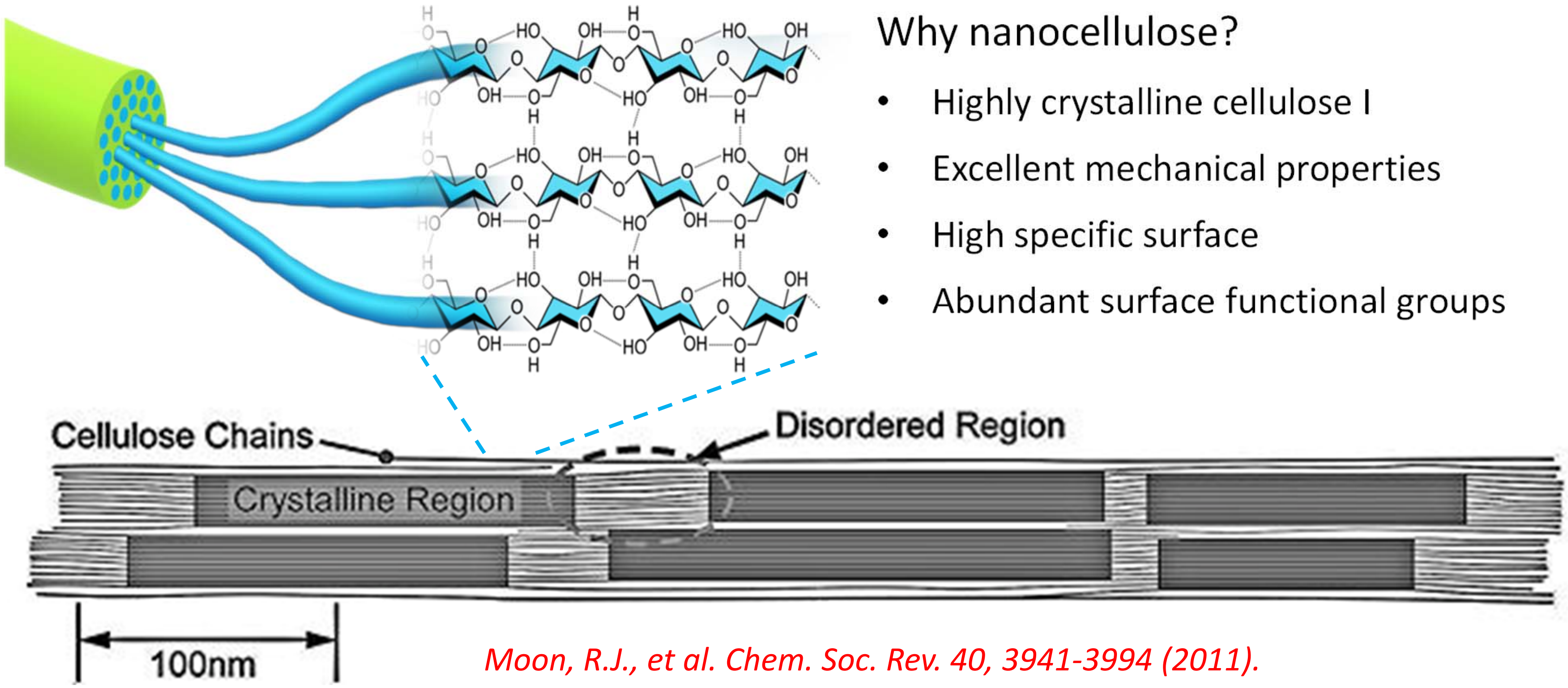
Outline

- Background
- Research interests
  - I. 3D printing of rigid/stiff monolith
  - II. 3D printing of superelastic monolith
- Acknowledgement

Hierarchical structure in trees



Nanocellulose: Nature's basic building blocks



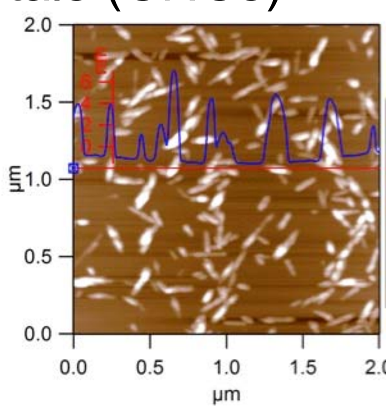
Why nanocellulose?

- Highly crystalline cellulose I
- Excellent mechanical properties
- High specific surface
- Abundant surface functional groups

Moon, R.J., et al. Chem. Soc. Rev. 40, 3941-3994 (2011).

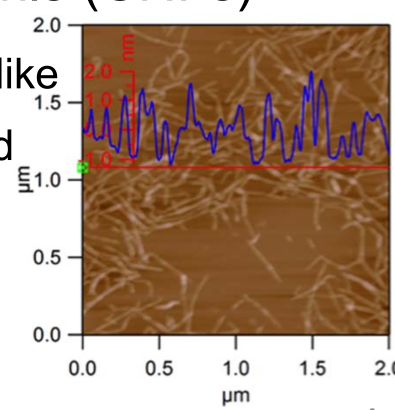
Cellulose nanocrystals (CNCs)

- Rigid rod-like
- Negatively charged
- High crystallinity
- Low Yield



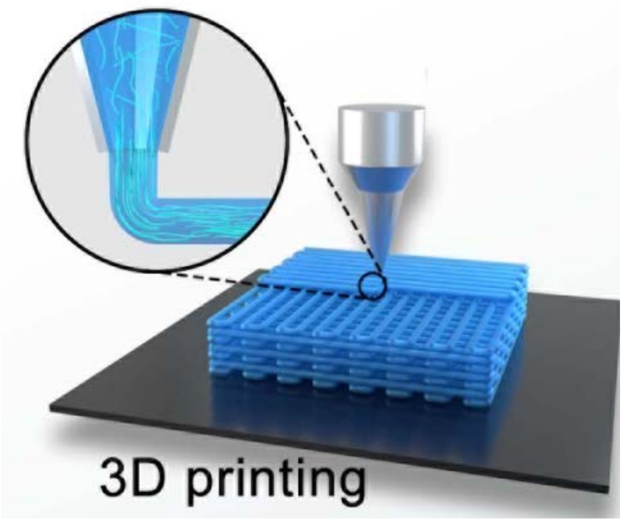
Cellulose nanofibrils (CNFs)

- Flexible spaghetti-like
- Negatively charged
- High aspect ratio
- High yield



Carbohydr. Polym. 95, 32 (2013); RSC Advances. 3, 12366 (2013).

3D Printing – Direct Ink Writing



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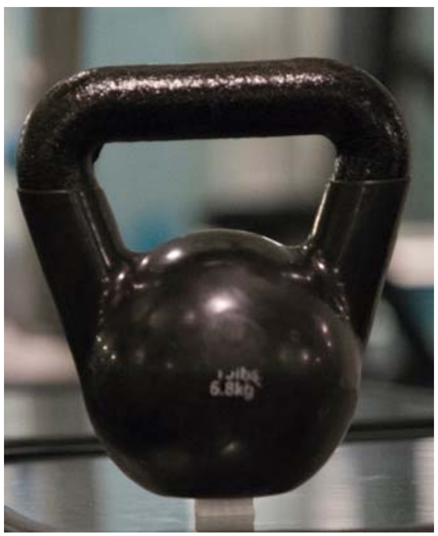
- Complex shape design;
- Customization;
- Better structure control;
- Wide materials selections;
- Flexibility;



Strong and rigid

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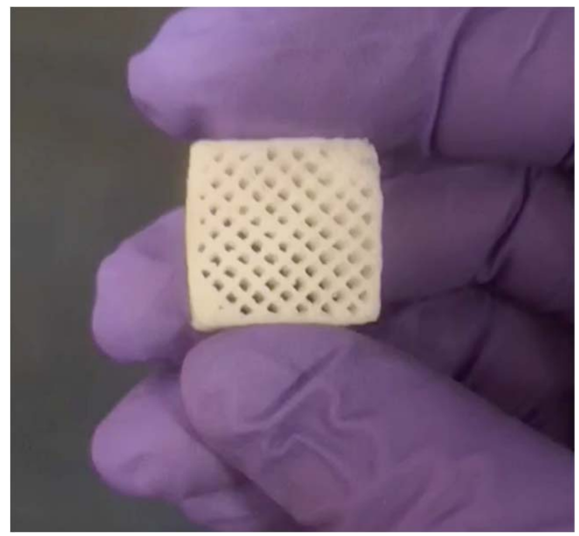
or

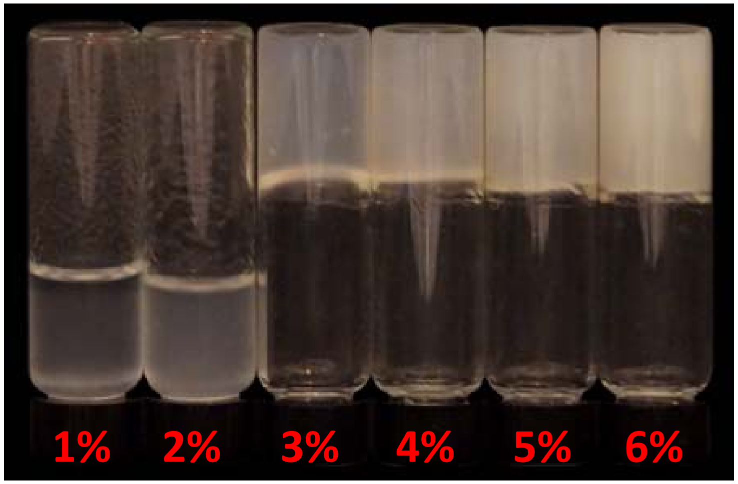


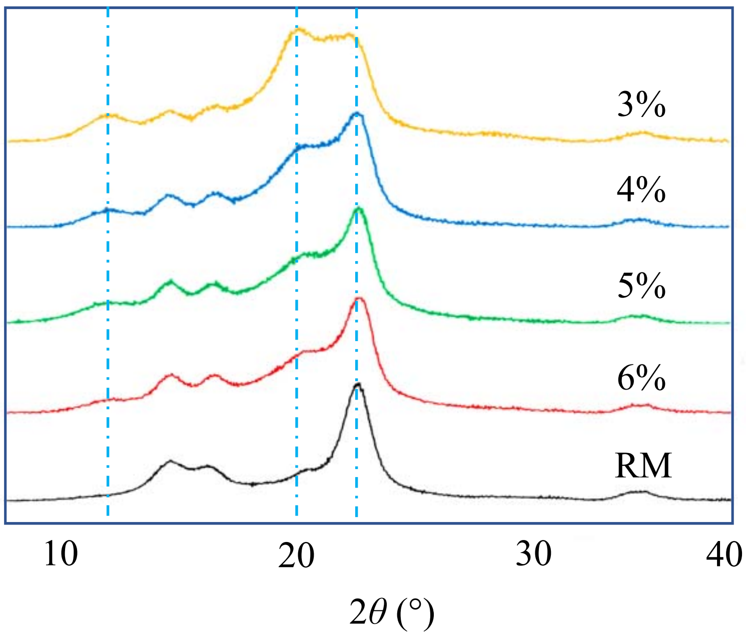
Soft and flexible

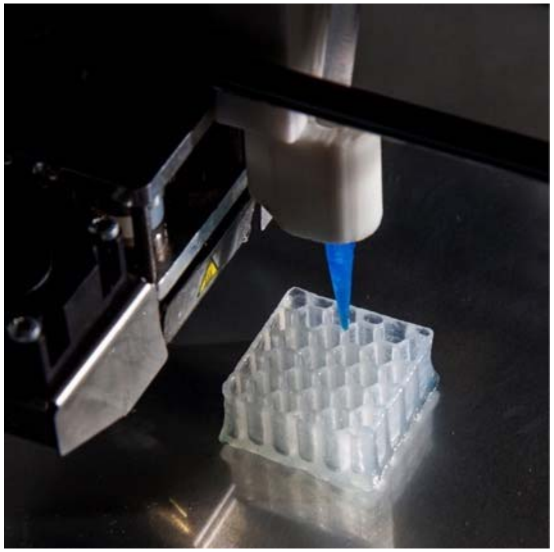
3D printing of strong and rigid structure

Partial cellulose dissolution

- Whatman filter paper
- 7 wt% NaOH
- 12 wt% Urea
- -12 °C
- Blending for 15 min







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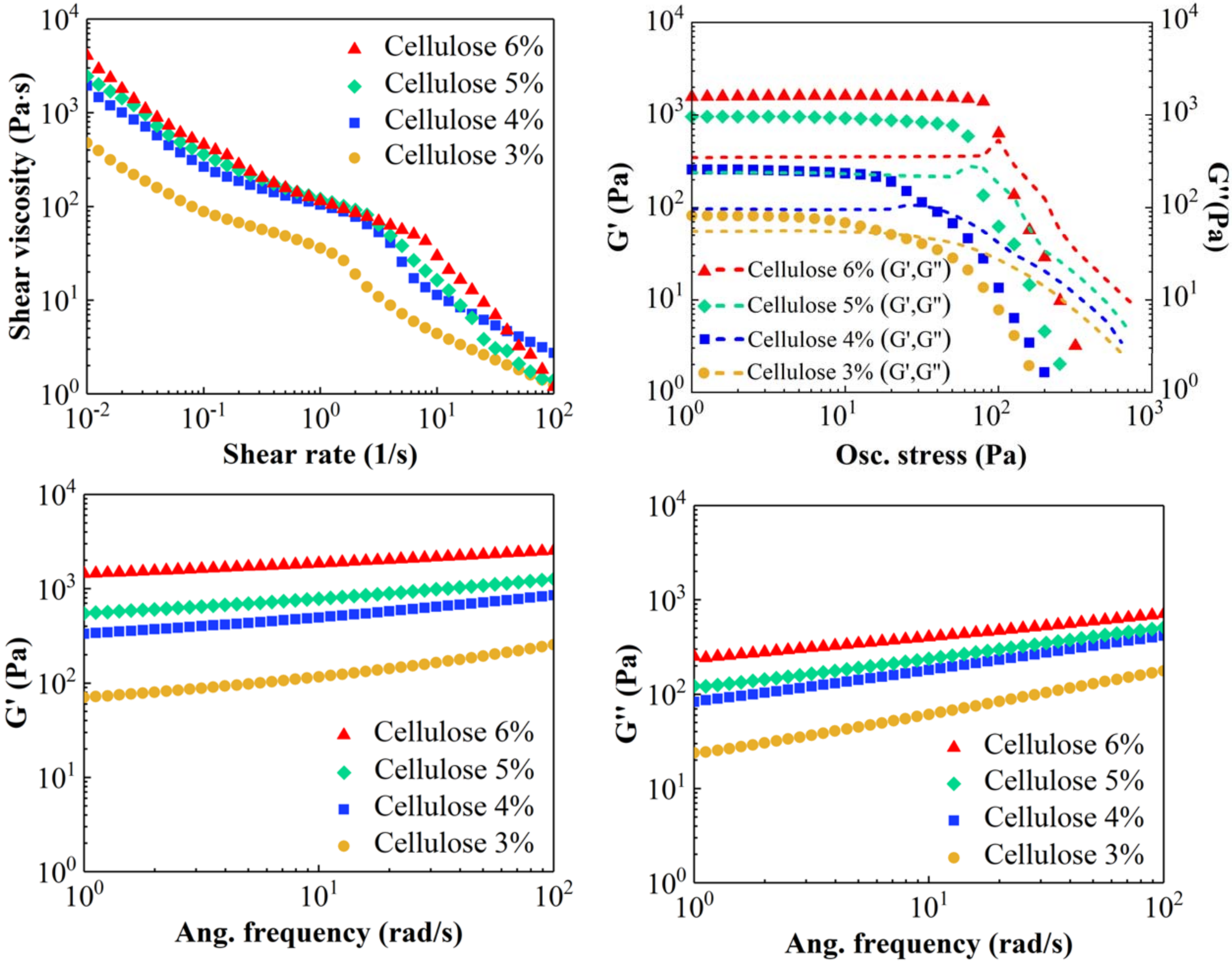
Rheological properties



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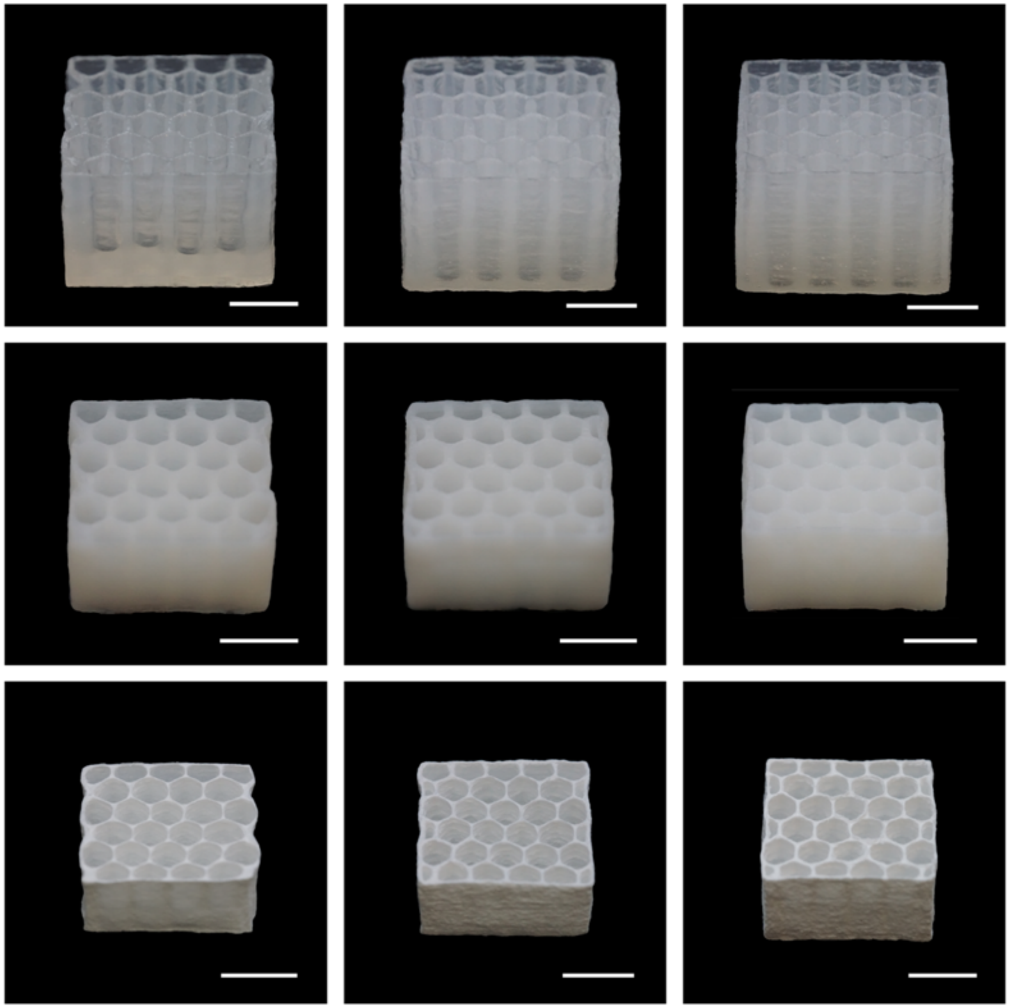
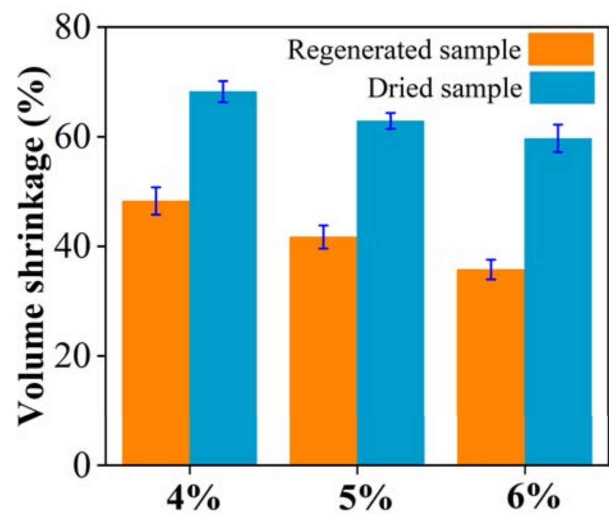
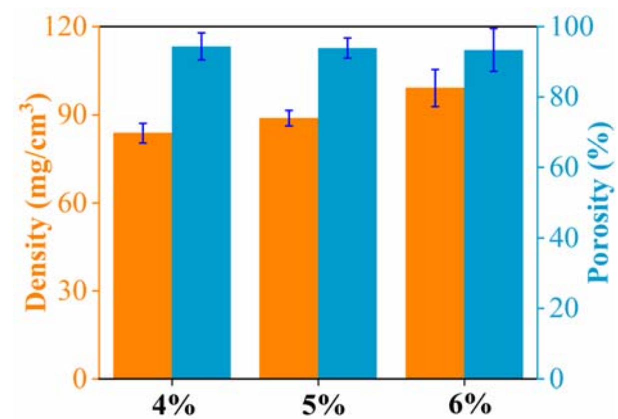
Regeneration and freeze-drying







4% 5% 6%

Scale bar = 1 cm

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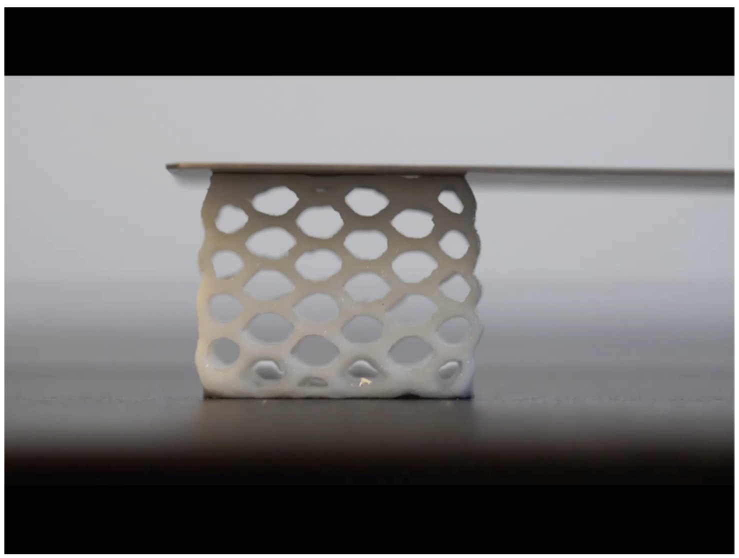
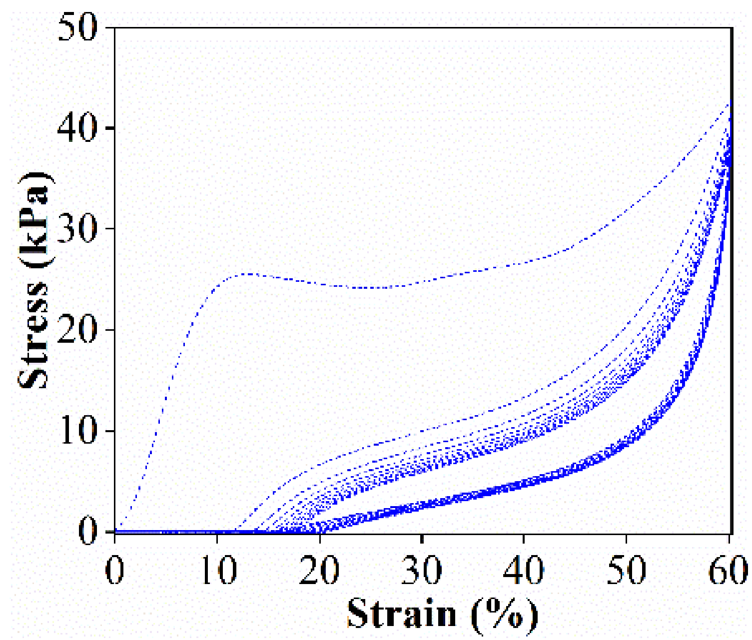
Wet resilient performance





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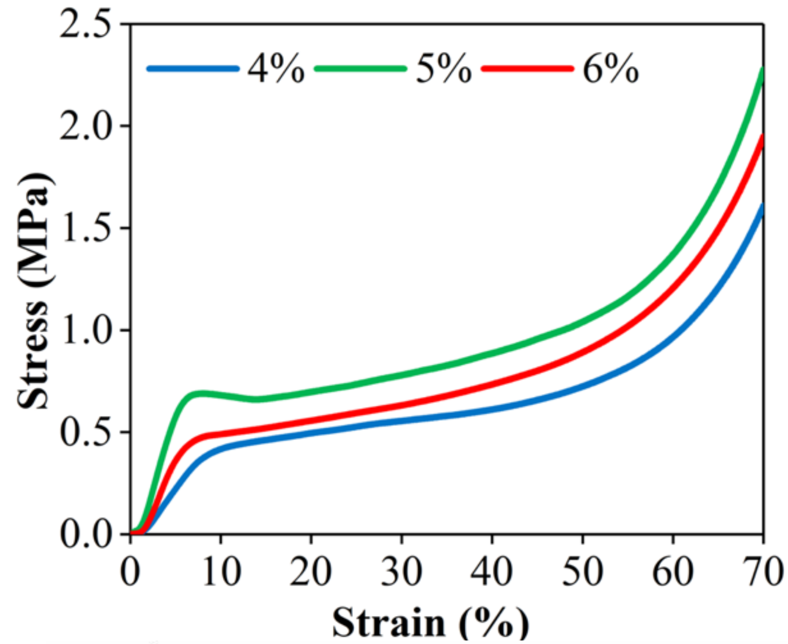
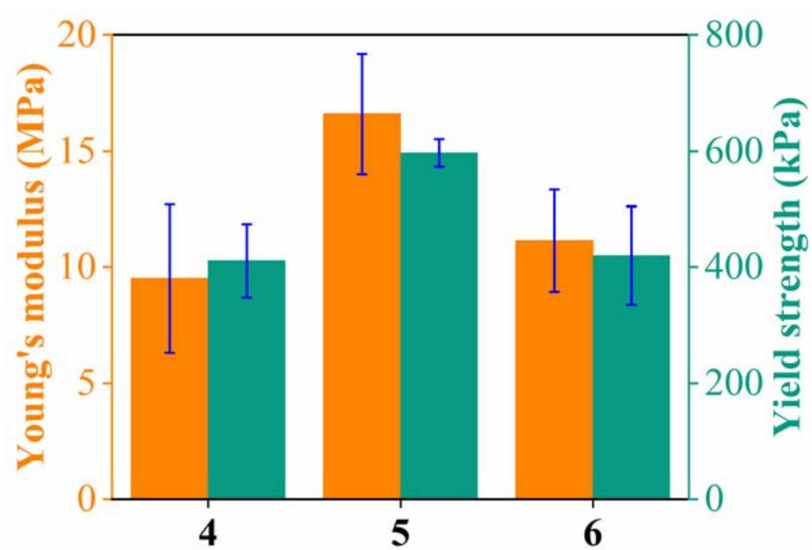
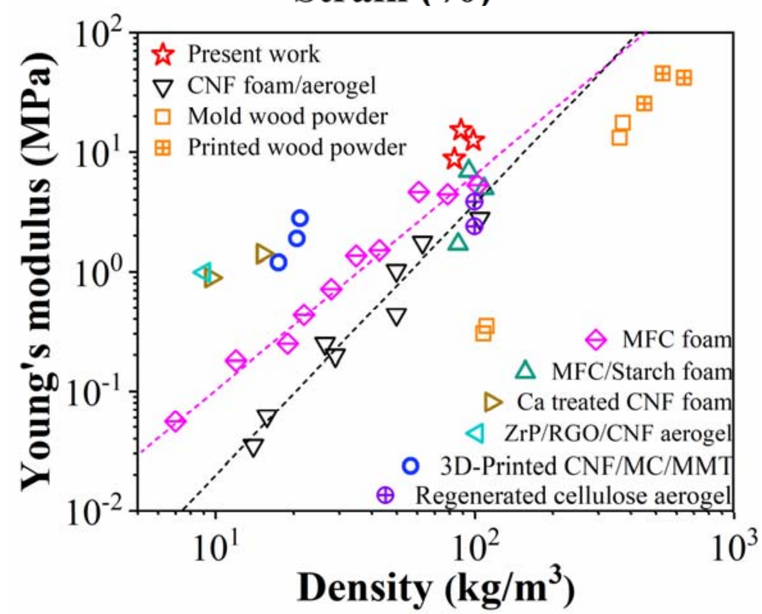
Dried rigid performance







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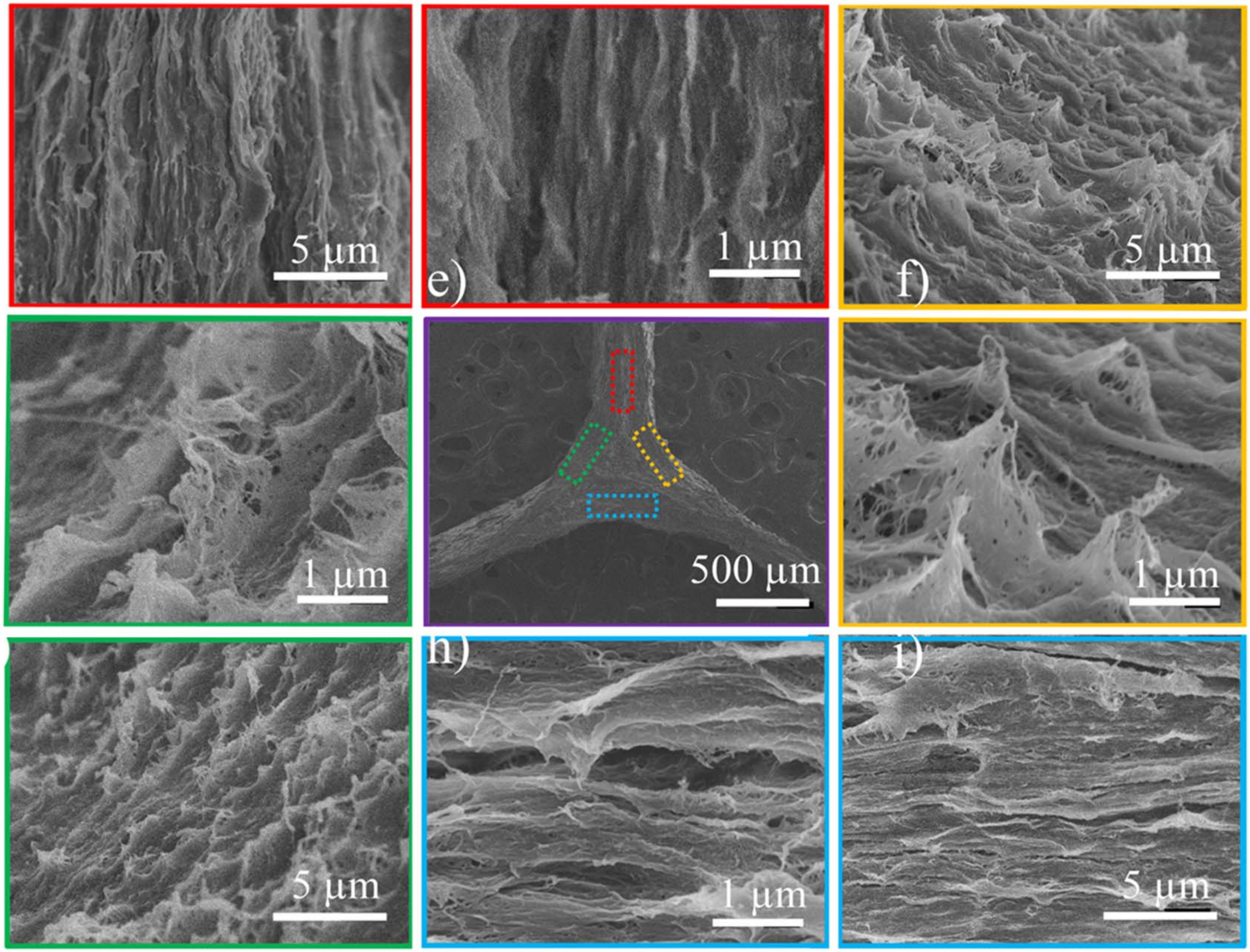
Cellulose alignment during printing



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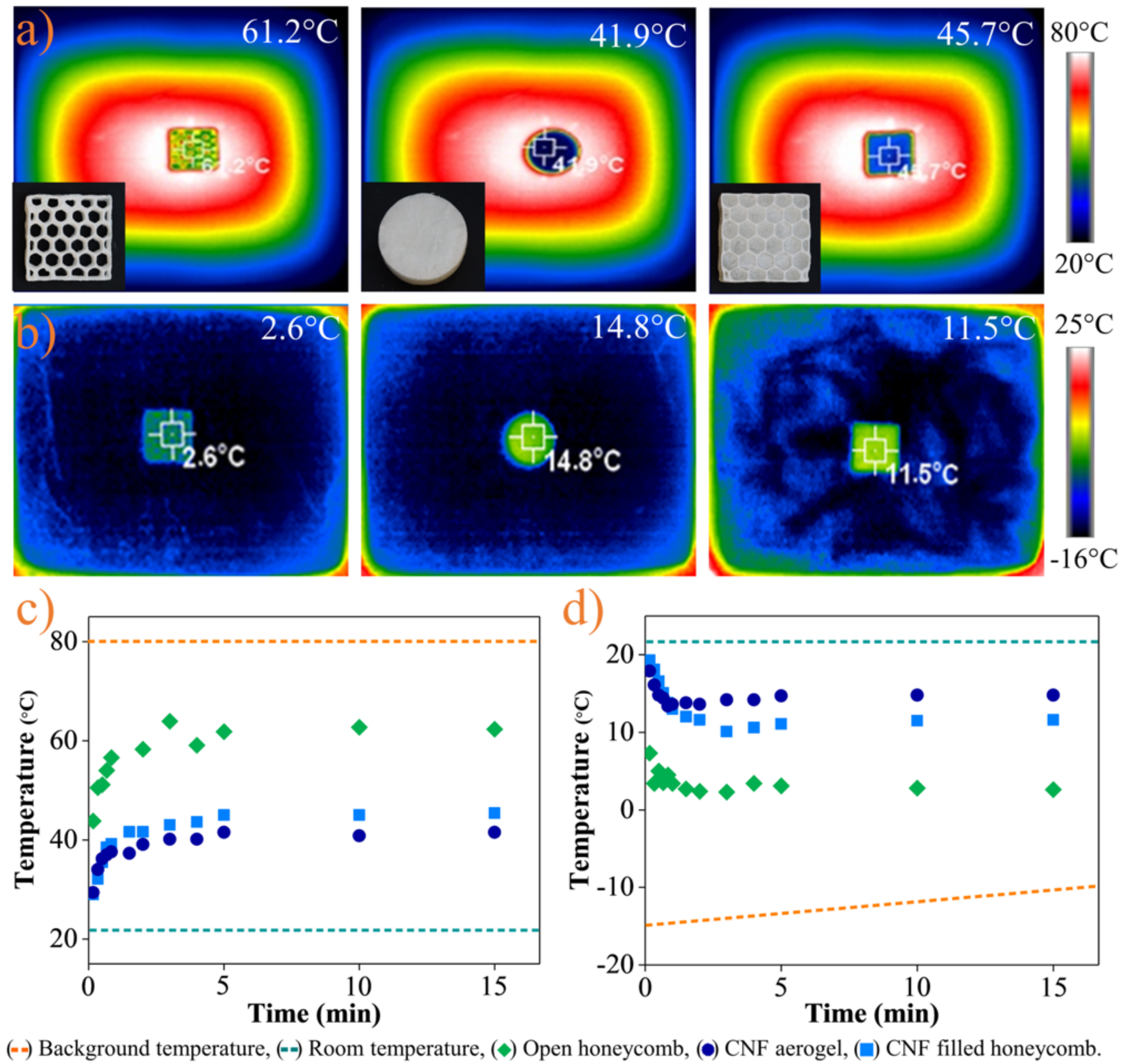
Thermal insulation performance



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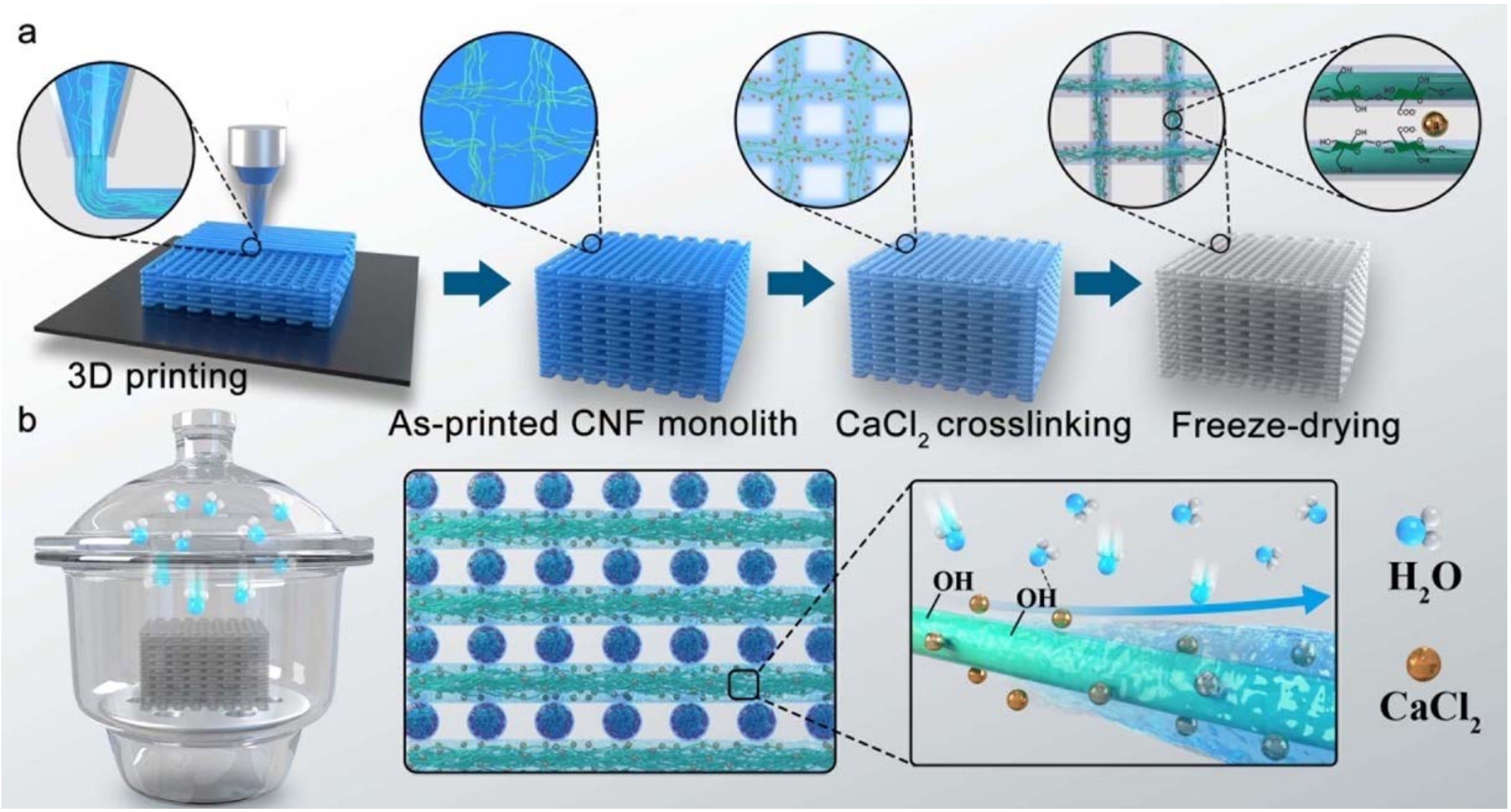
3D printing of soft and flexible structure



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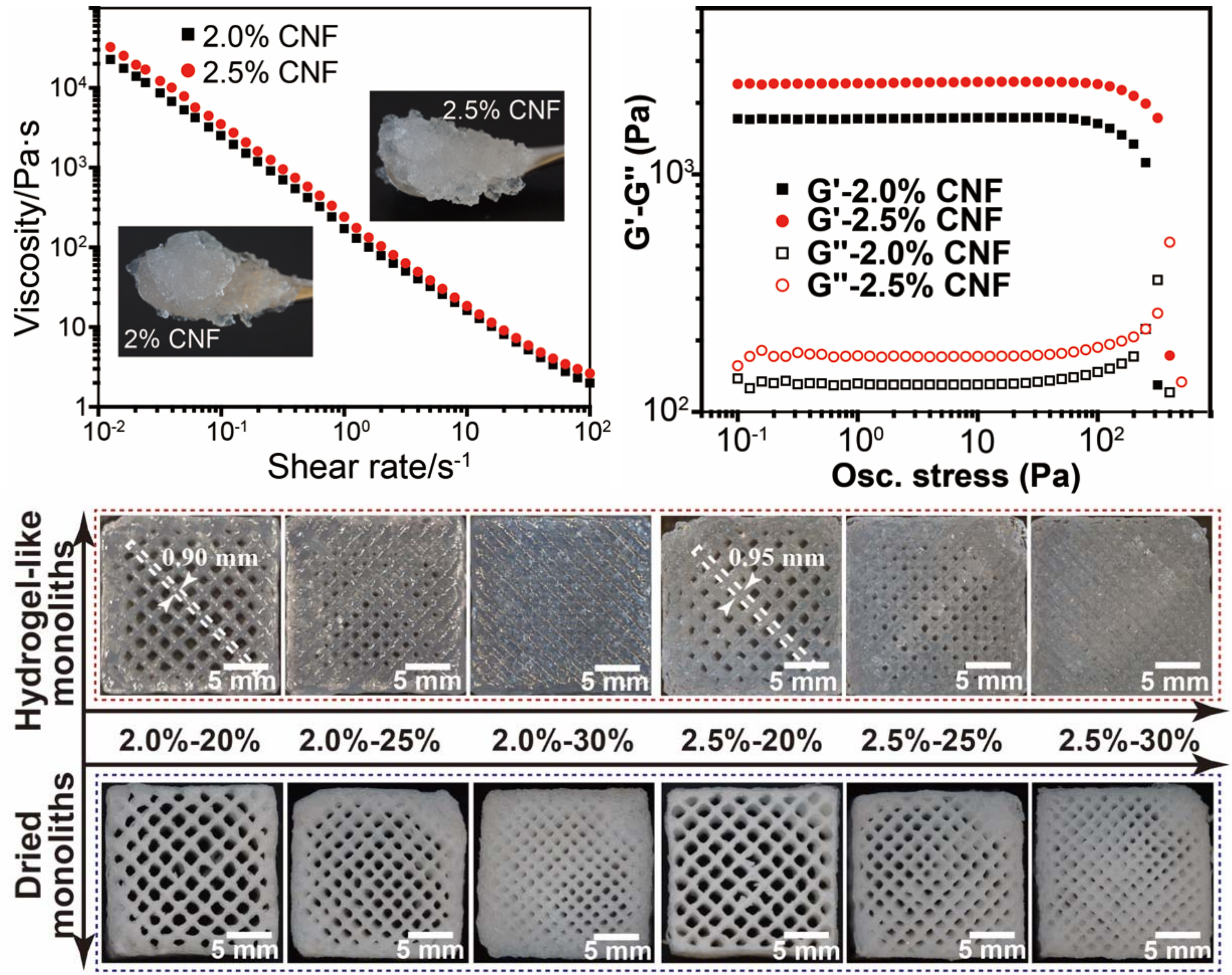

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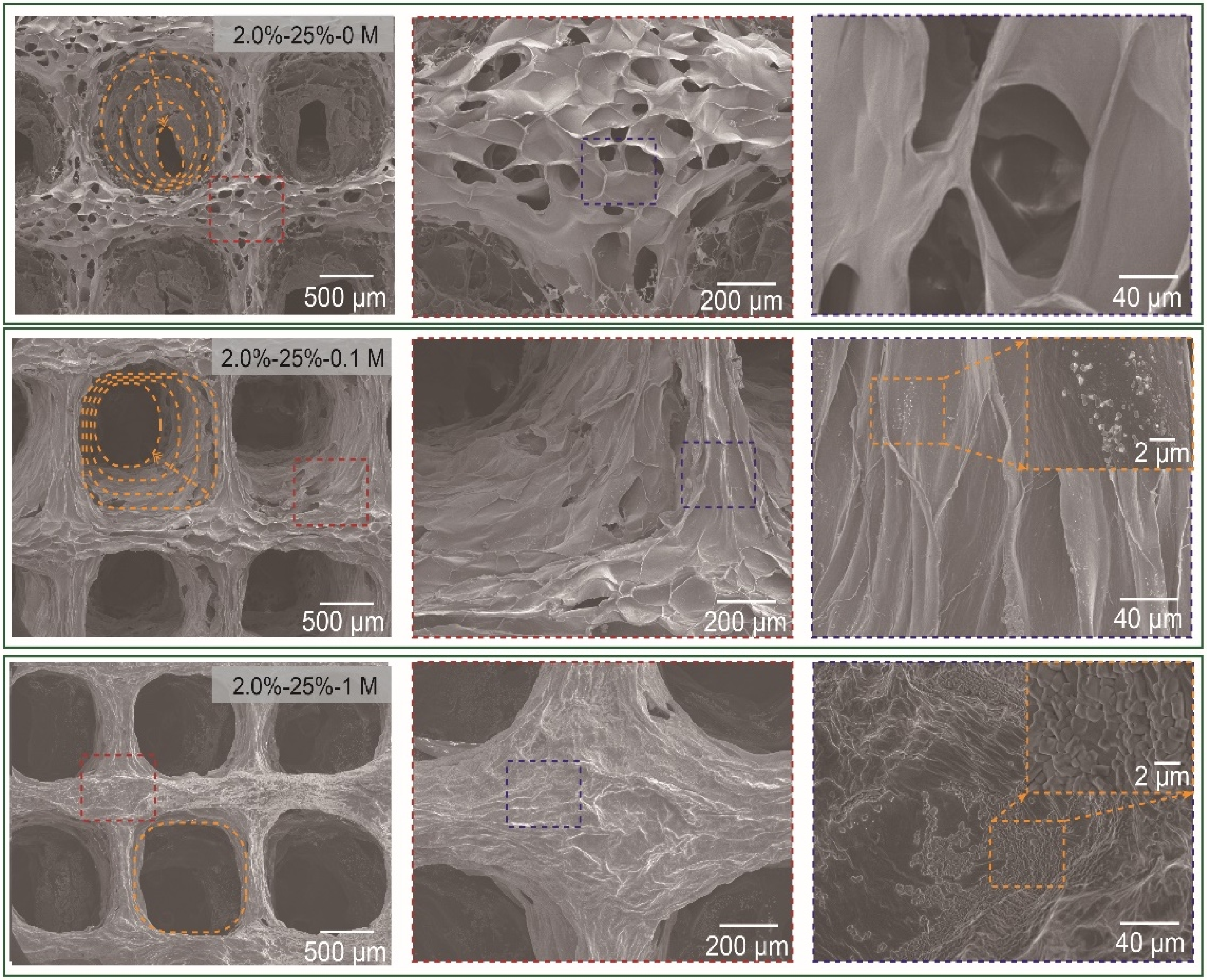
$CaCl_2$ crosslinking



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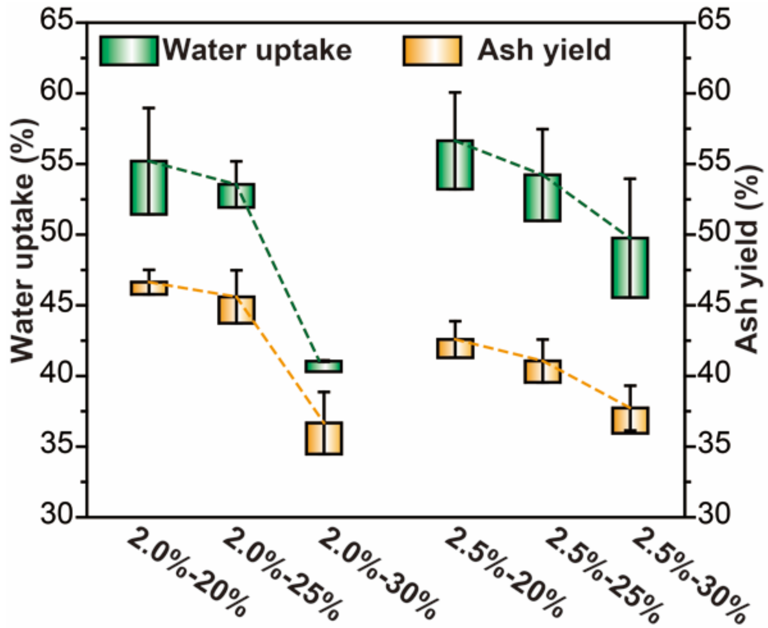
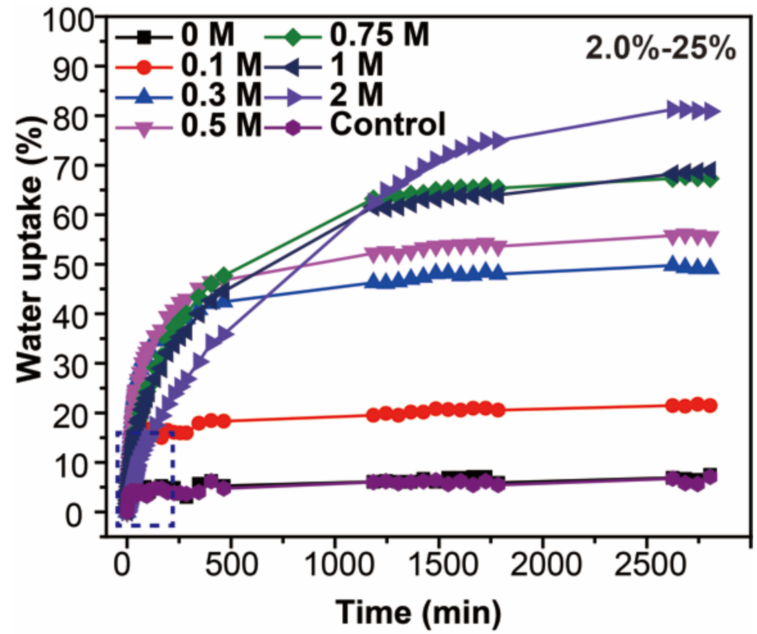
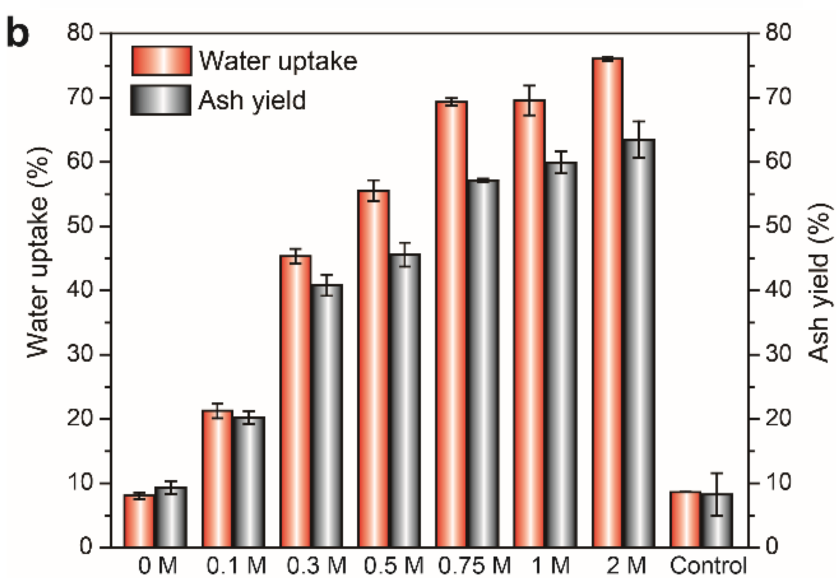
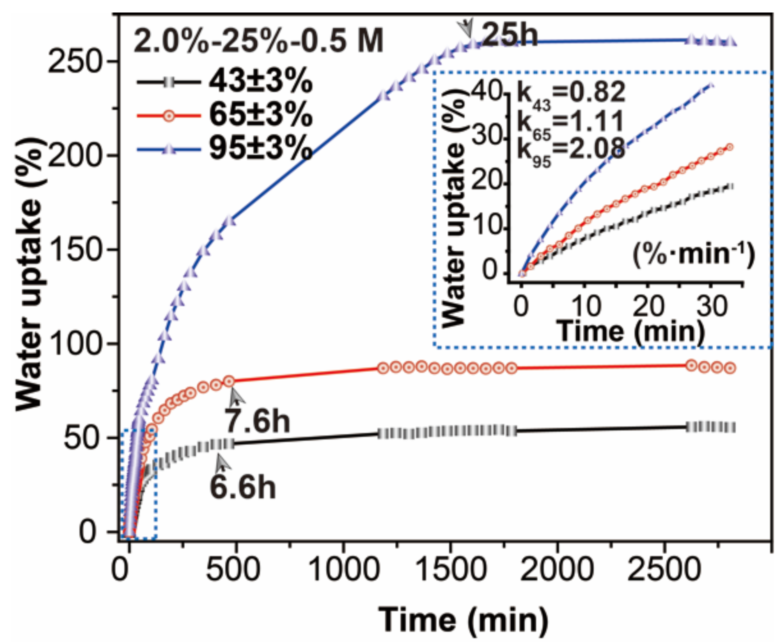
$CaCl_2$ induced water absorption









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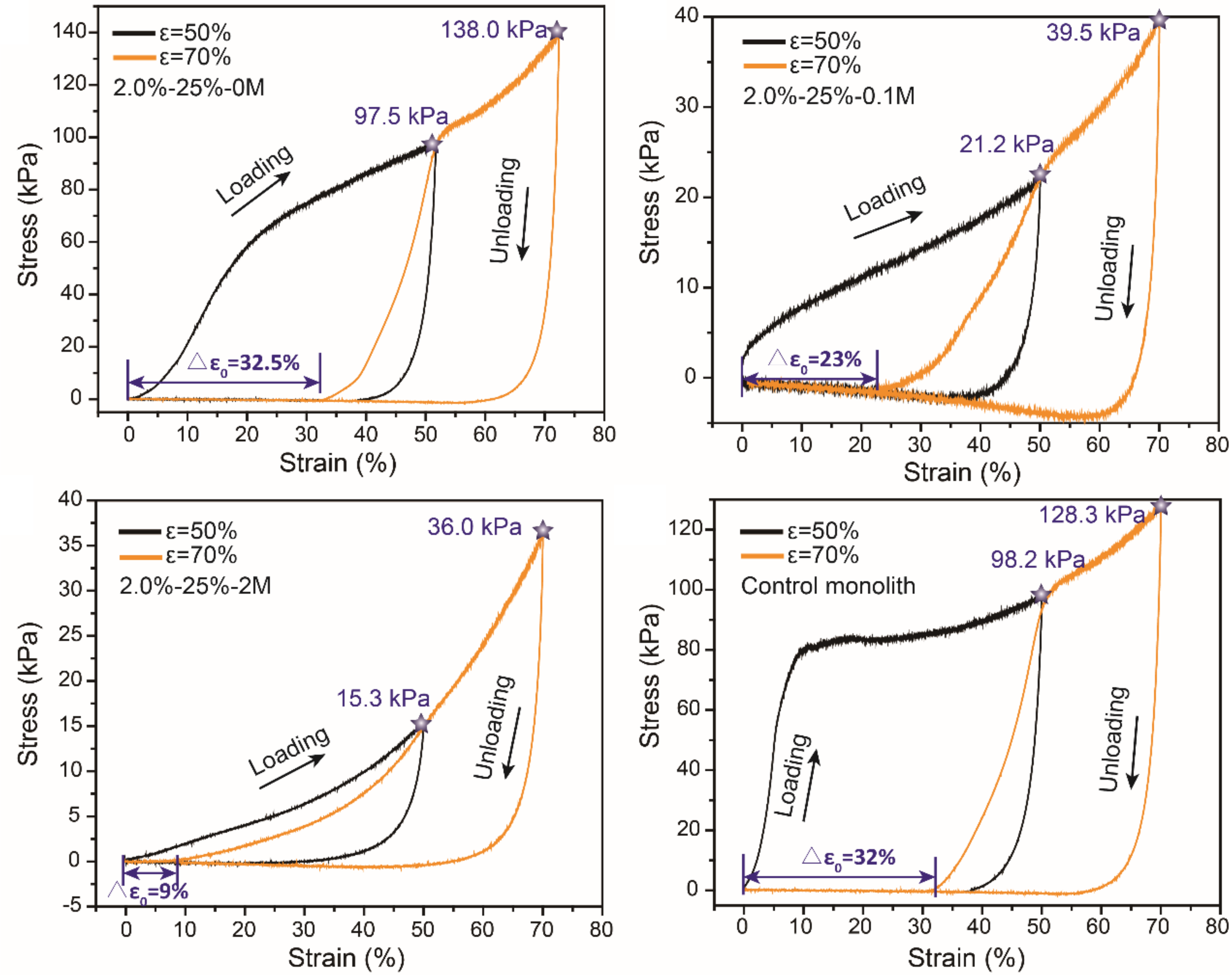
Cyclic compressive stress-strain response



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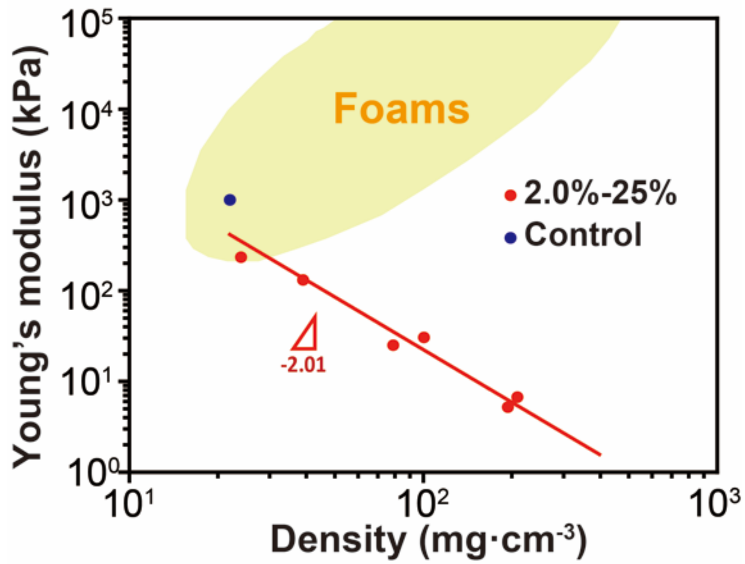
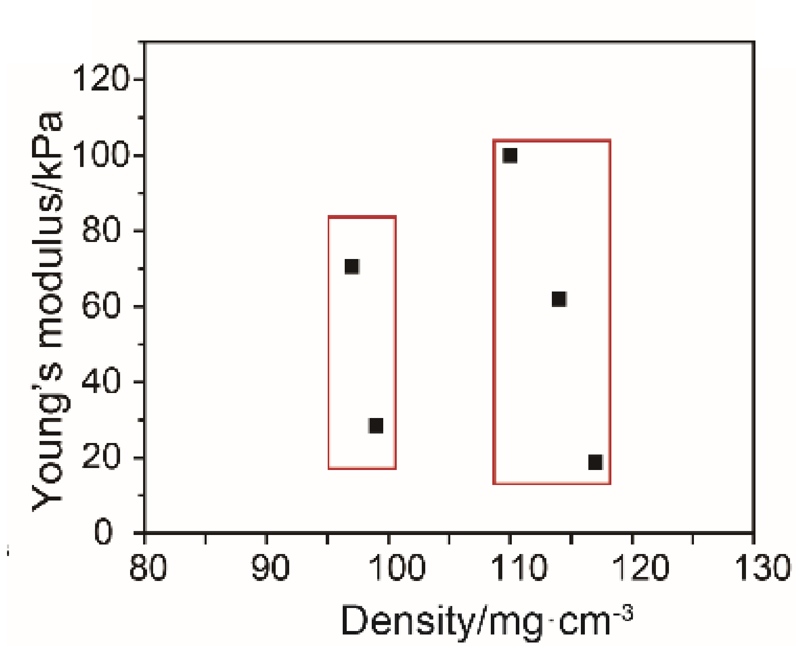
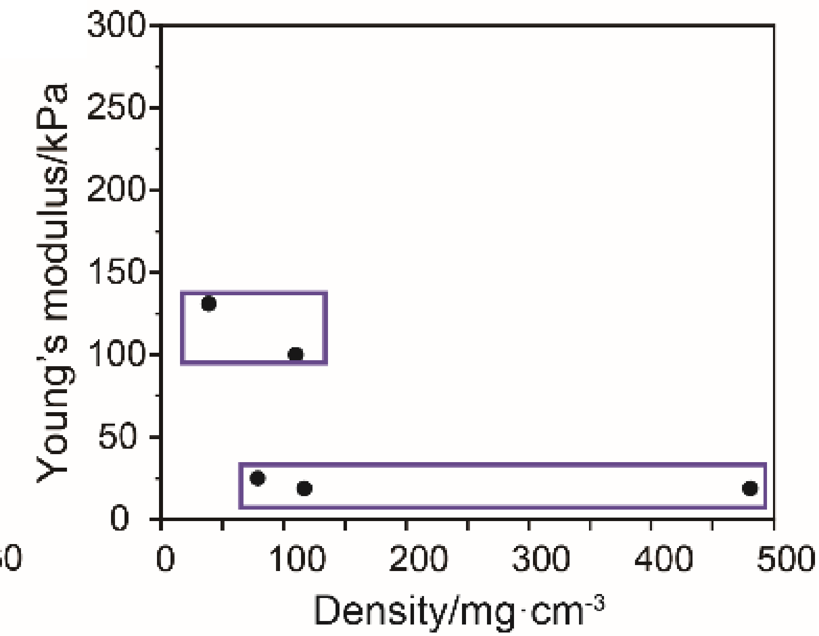
Mechanical properties







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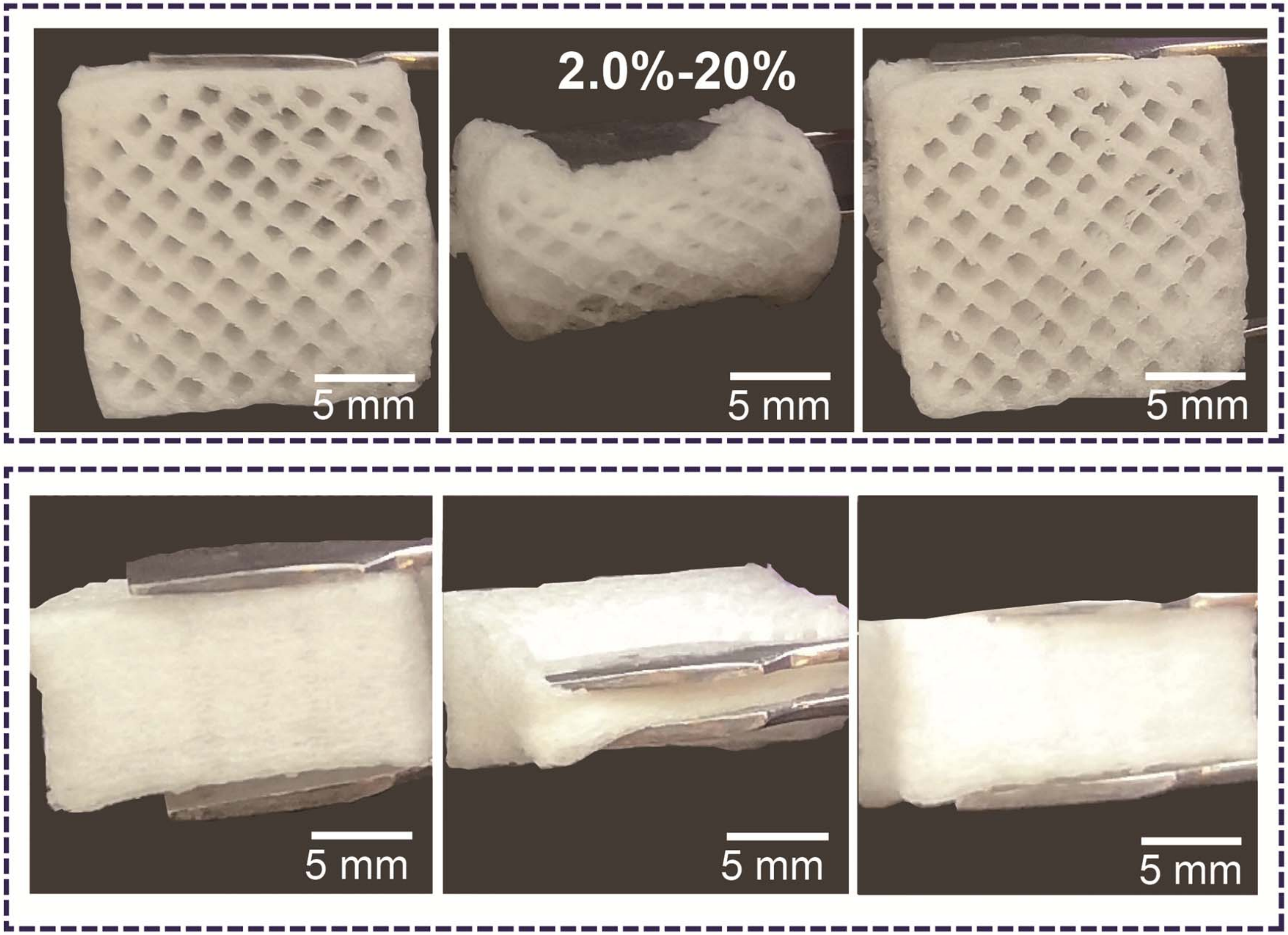
Shape recovery



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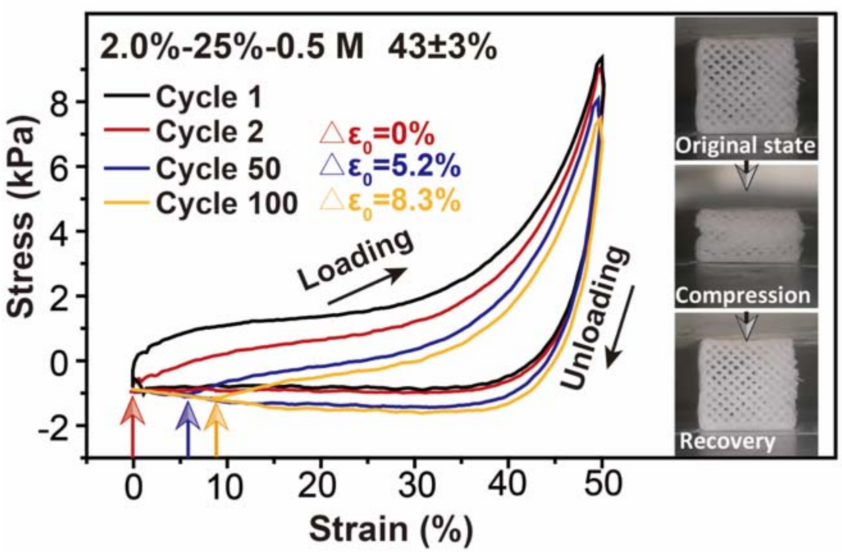

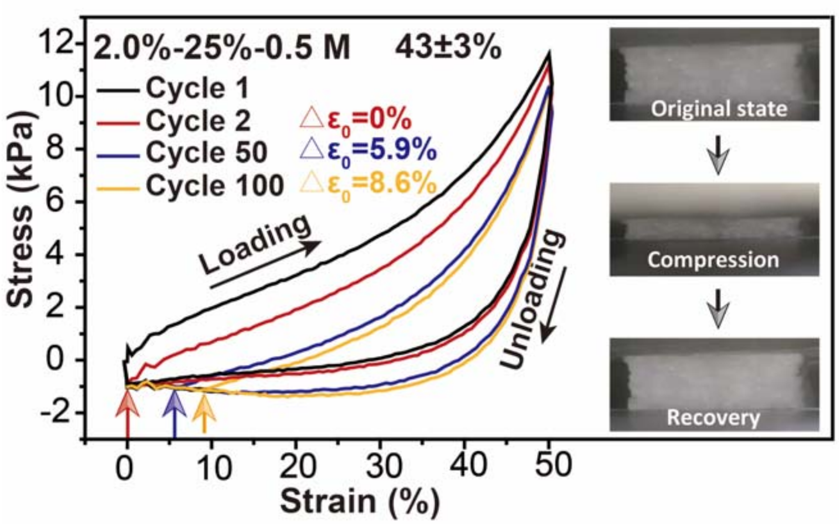

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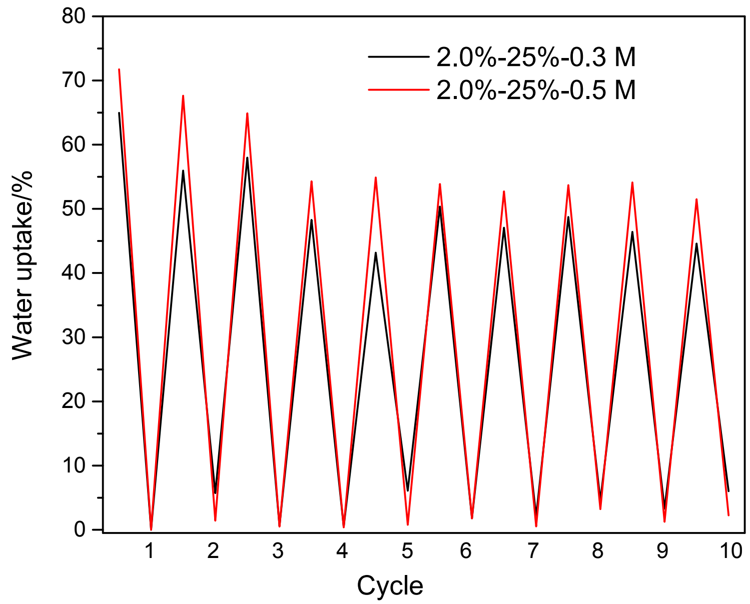
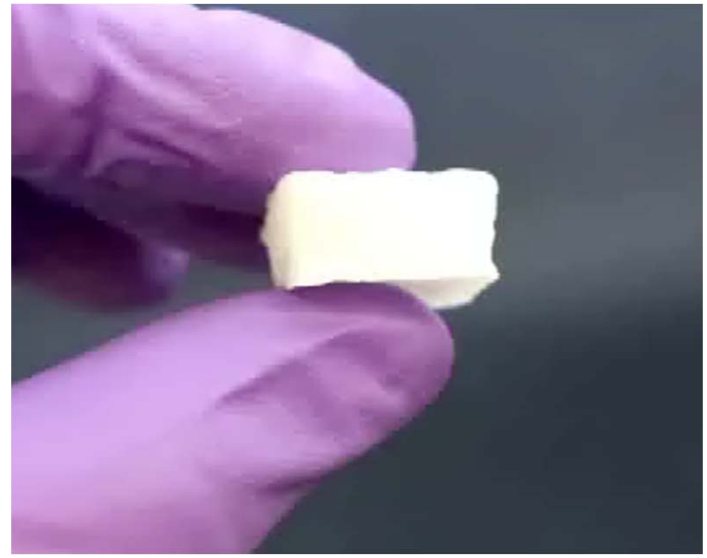
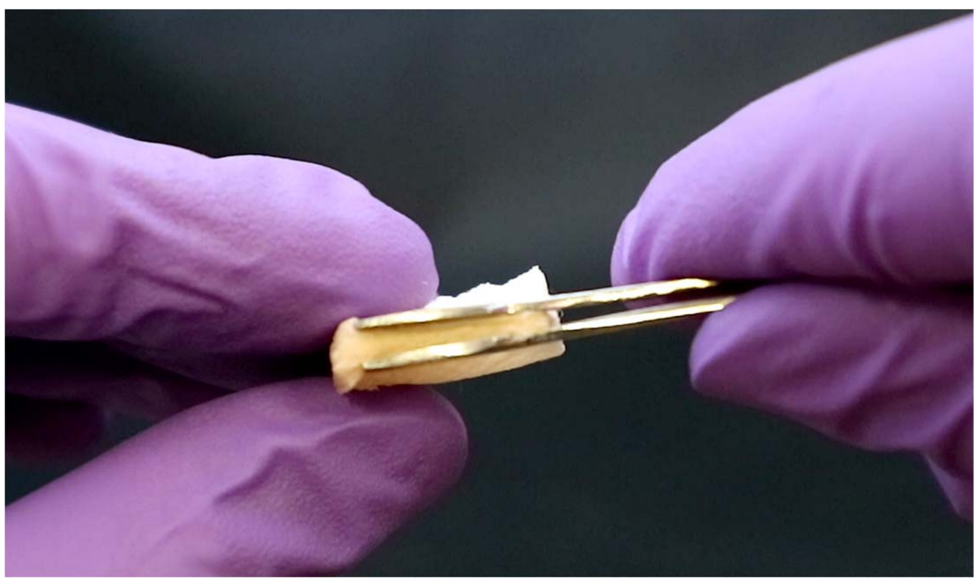
Long-term stability







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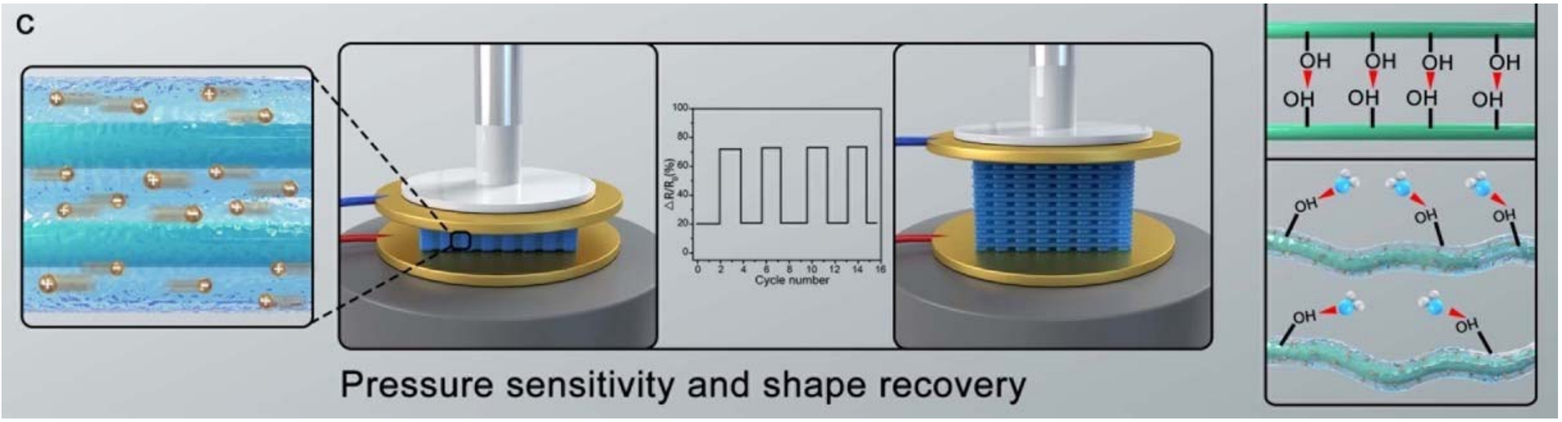
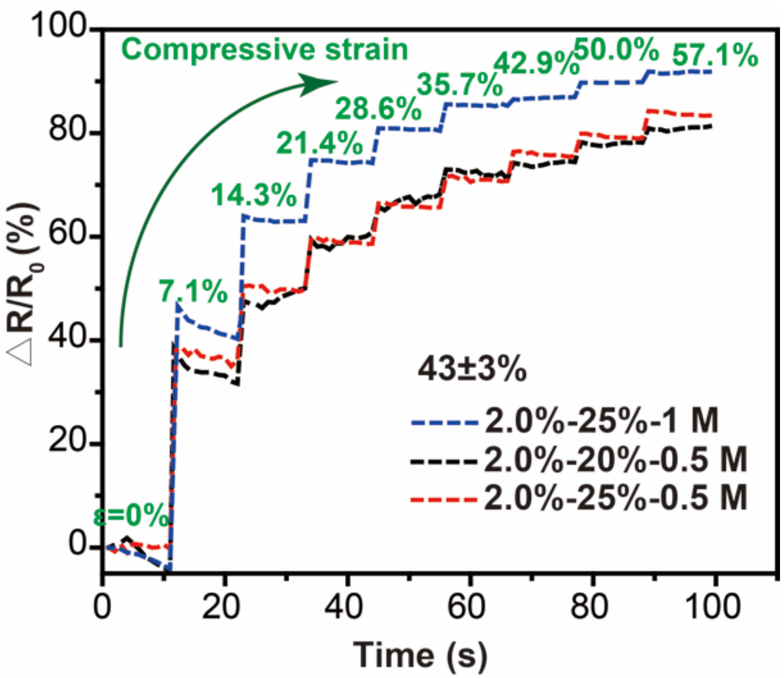
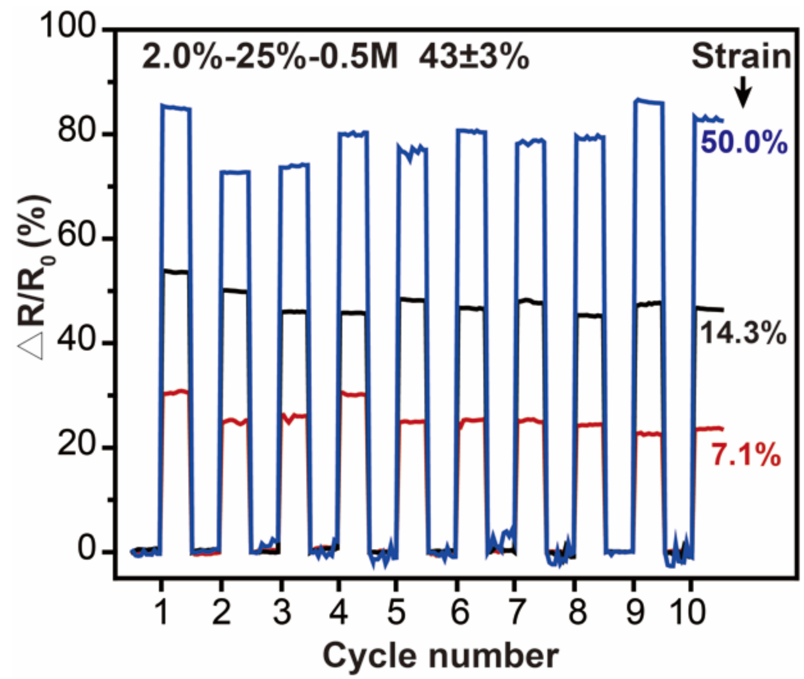
Ionic conducing and strain sensor







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Thank you for your attentions!

Questions?

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