Mechanical and physical response of nanocomposite-coated foams subjected to hydration: potential uses for bone tissue scaffolds

Mechanical and Physical Response of Nanocomposite-Coated Foams Subjected To Hydration: Potential Uses For Bone Tissue Scaffolds

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Layer by Layer Assembly

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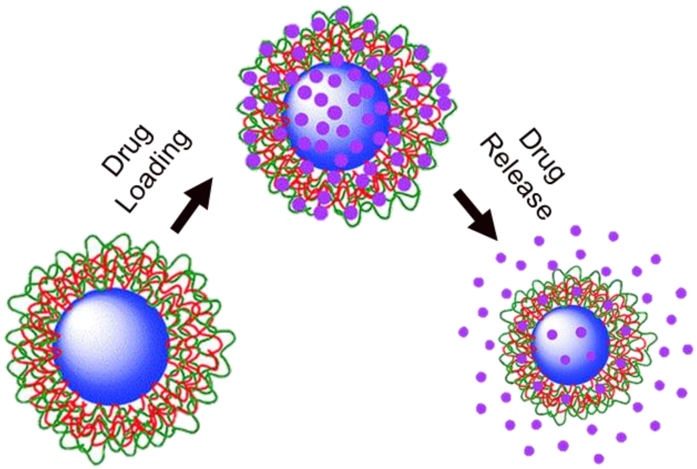
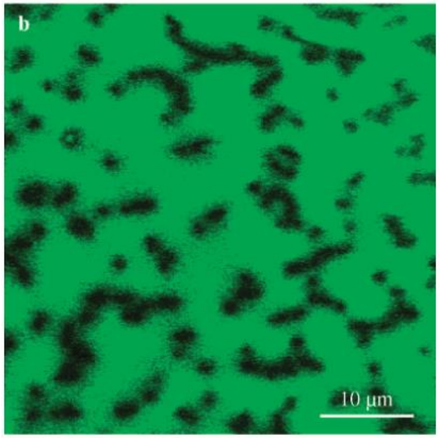
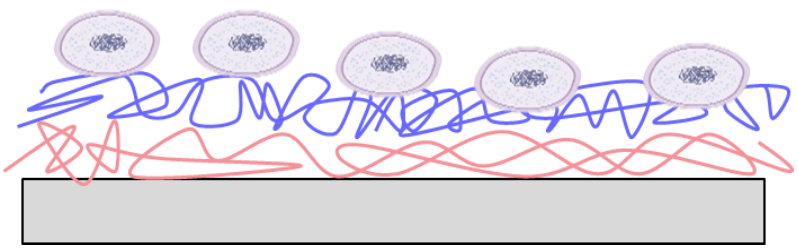


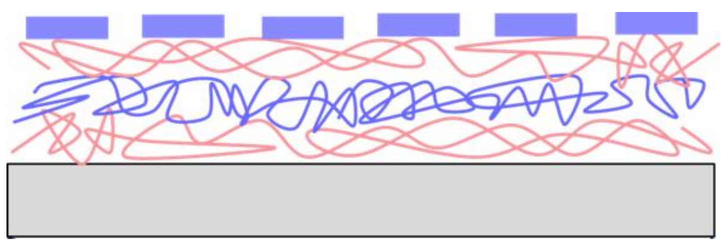
Drug Releasing



Controlled Degradation



Surface Interaction



Mechanical Properties

1. Mertz D et al. Nano Lett. 2007;7(3):657–62.

Mechanical Properties of Coating on 3D Substrates

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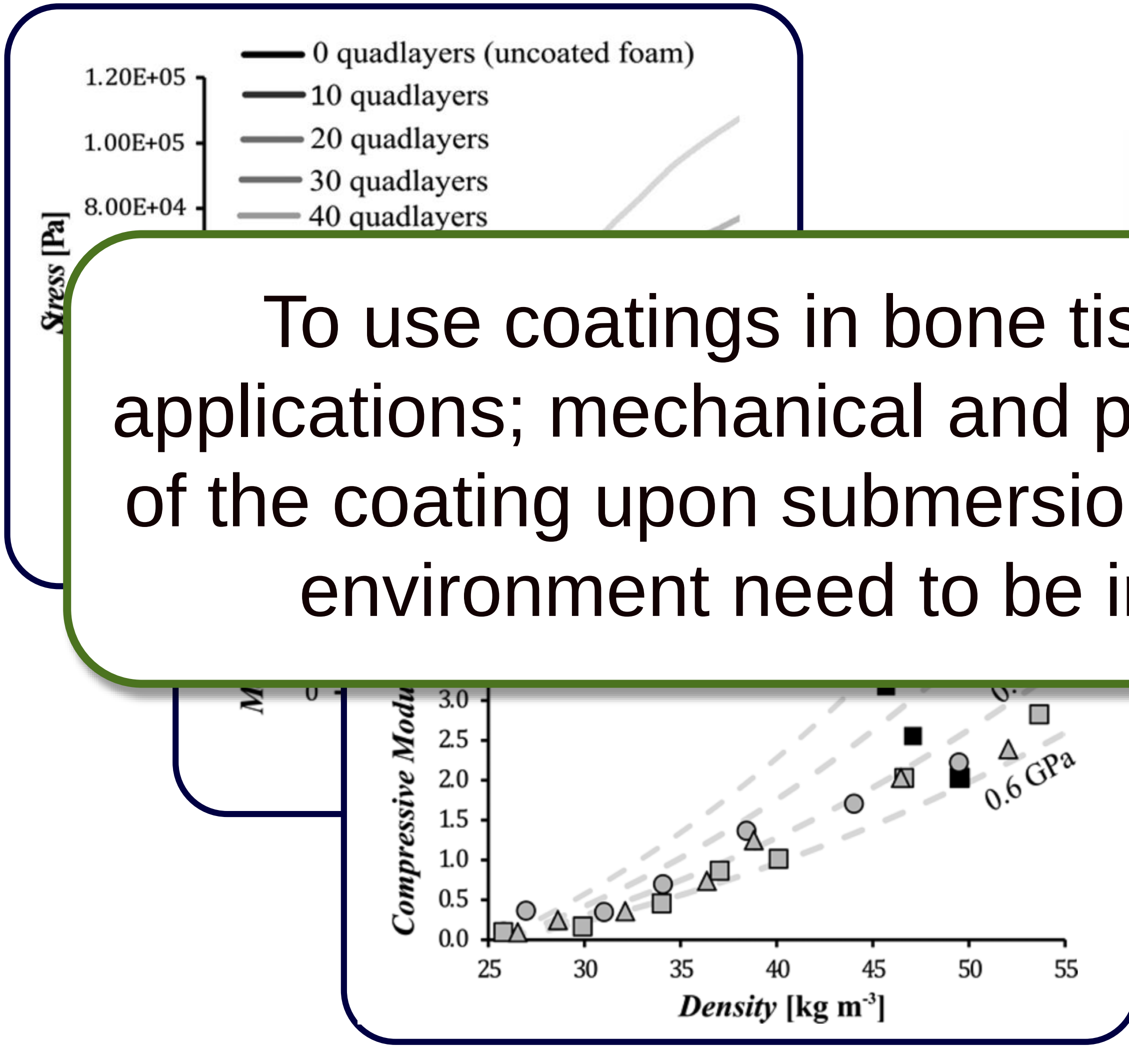
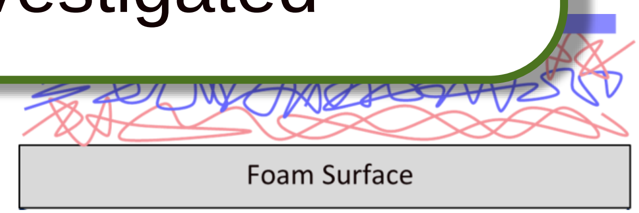
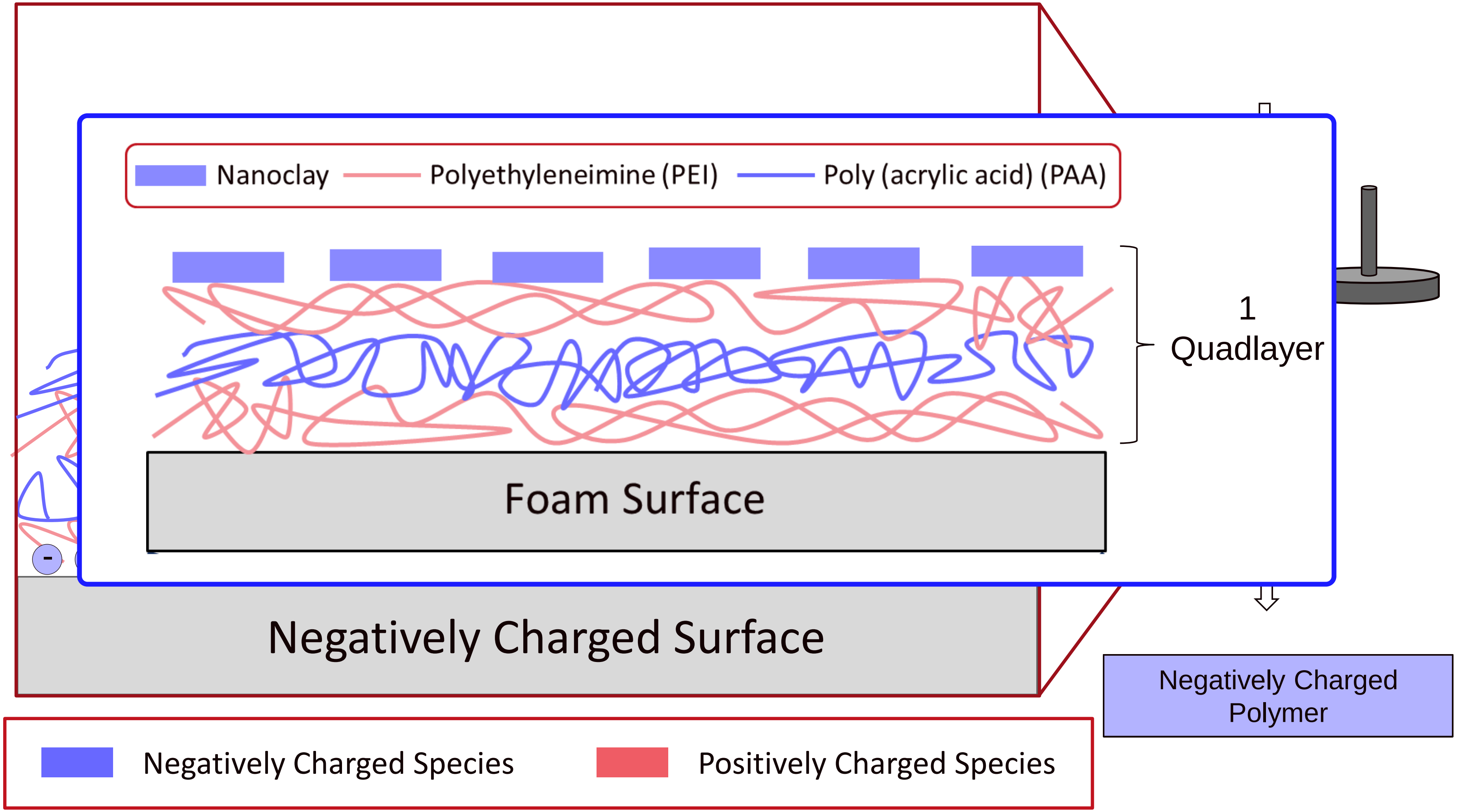




To use coatings in bone tissue scaffold applications; mechanical and physical response of the coating upon submersion into a aqueous environment need to be investigated

Ziminska et al. ACS Appl Mater Interfaces. 2016;8(34):21968–73.

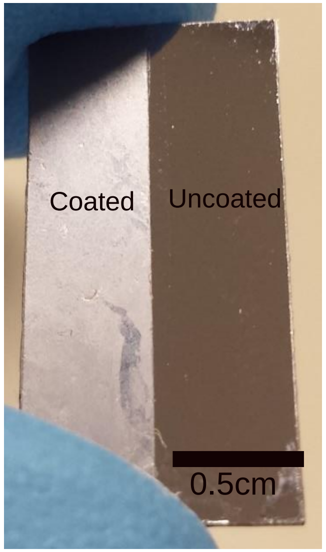
Mechanism Overview



Materials

- Open cell polyurethane foam (12.7Ø x 10 mm)[1]
- Glass microscope slides (2 x 1 cm)
- Coated with:
  - » 15 quadlayers
  - » 30 quadlayers
  - » 45 quadlayers
  - » 60 quadlayers
- Samples tested in:
  - » Air (~25% RH, Ambient Temp)[1]
  - » Submerged de ionised water (100% RH, Ambient Temp)
  - » Humidity chamber (~50 to ~85% RH, Ambient Temp)

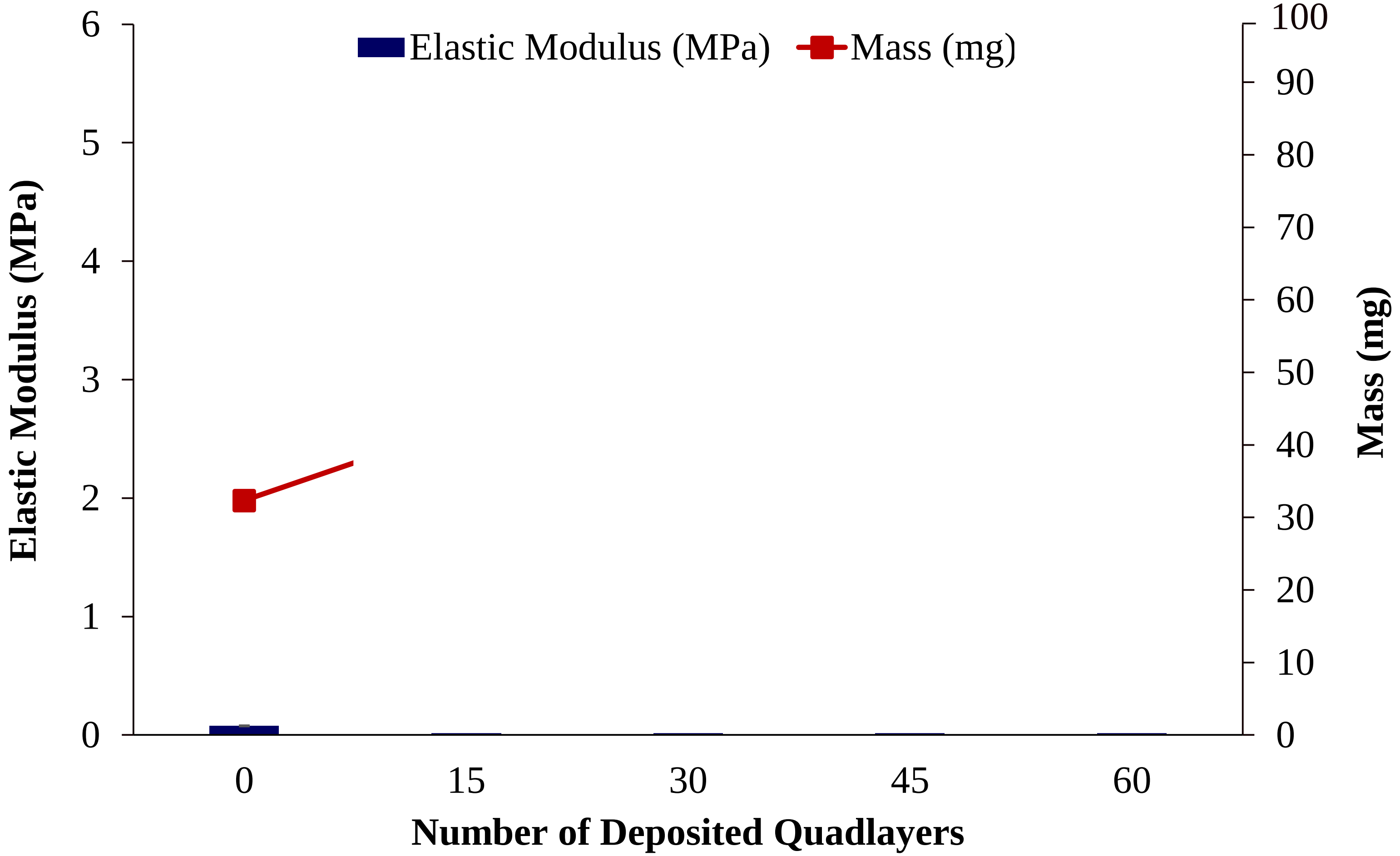
Polyurethane foam



Masked Sample

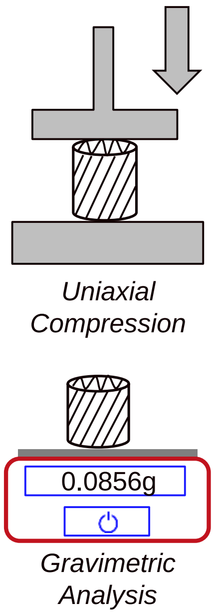
1. Ziminska et al. ACS Appl Mater Interfaces. 2016;8(34):21968–73.

Elastic Modulus of Coated Foams



Ambient

(n=5)

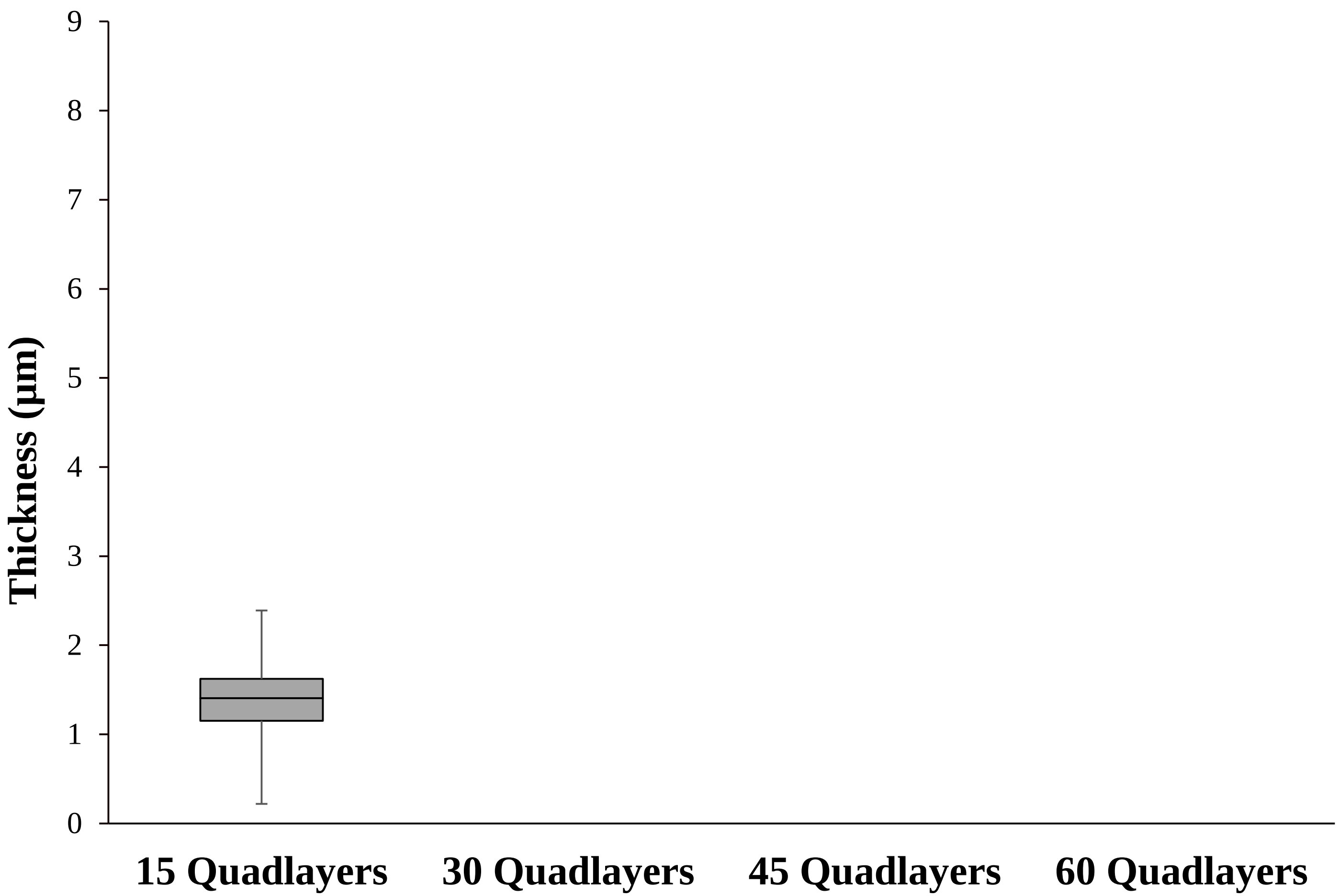


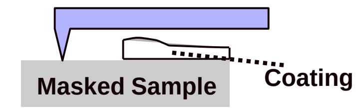
6% deformation at crosshead speed of 2 mm/min

Thickness Measurements of Coating on Glass Slides

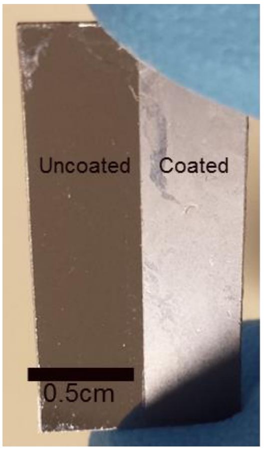
Ambient

(n=100)





Surface Profilometry



Masked Sample

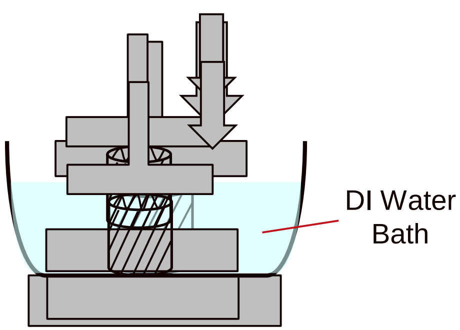
Surface profilometry using Tencor alpha step 200

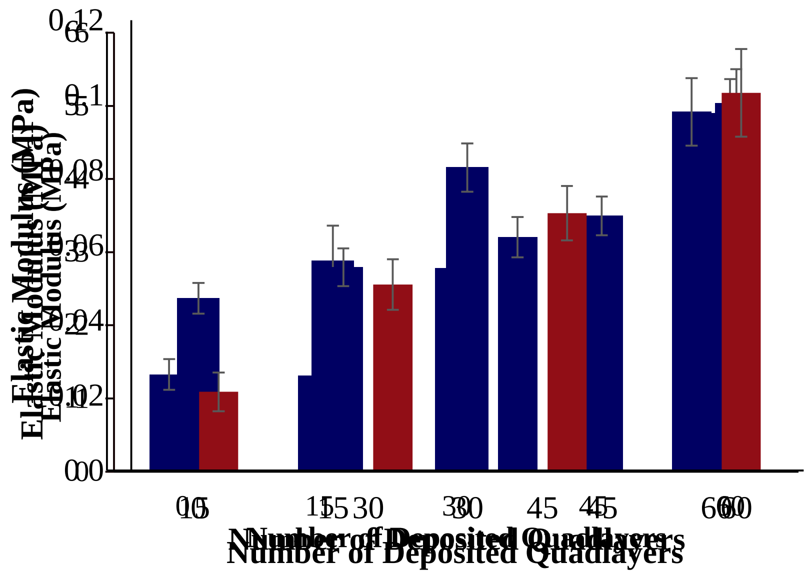
Mechanical Properties of Coated Foams Under Aqueous Conditions

Hydrated

(n=5)

Average Elastic Modulus (MPa) ± SD				
Quadlayers	Ambient	Hydrated	Hydrated 1 Hour	Desiccated
0	0.08 ± 0.00	0.05 ± 0.00	0.05 ± 0.01	0.10 ± 0.01
15	1.31 ± 0.21	0.06 ± 0.01	0.06 ± 0.01	1.08 ± 0.27
30	2.78 ± 0.26	0.08 ± 0.01	0.08 ± 0.01	2.54 ± 0.35
45	3.19 ± 0.28	0.07 ± 0.01	0.07 ± 0.00	3.52 ± 0.37
60	4.9 ± 0.46	0.10 ± 0.01	0.09 ± 0.01	5.17 ± 0.60



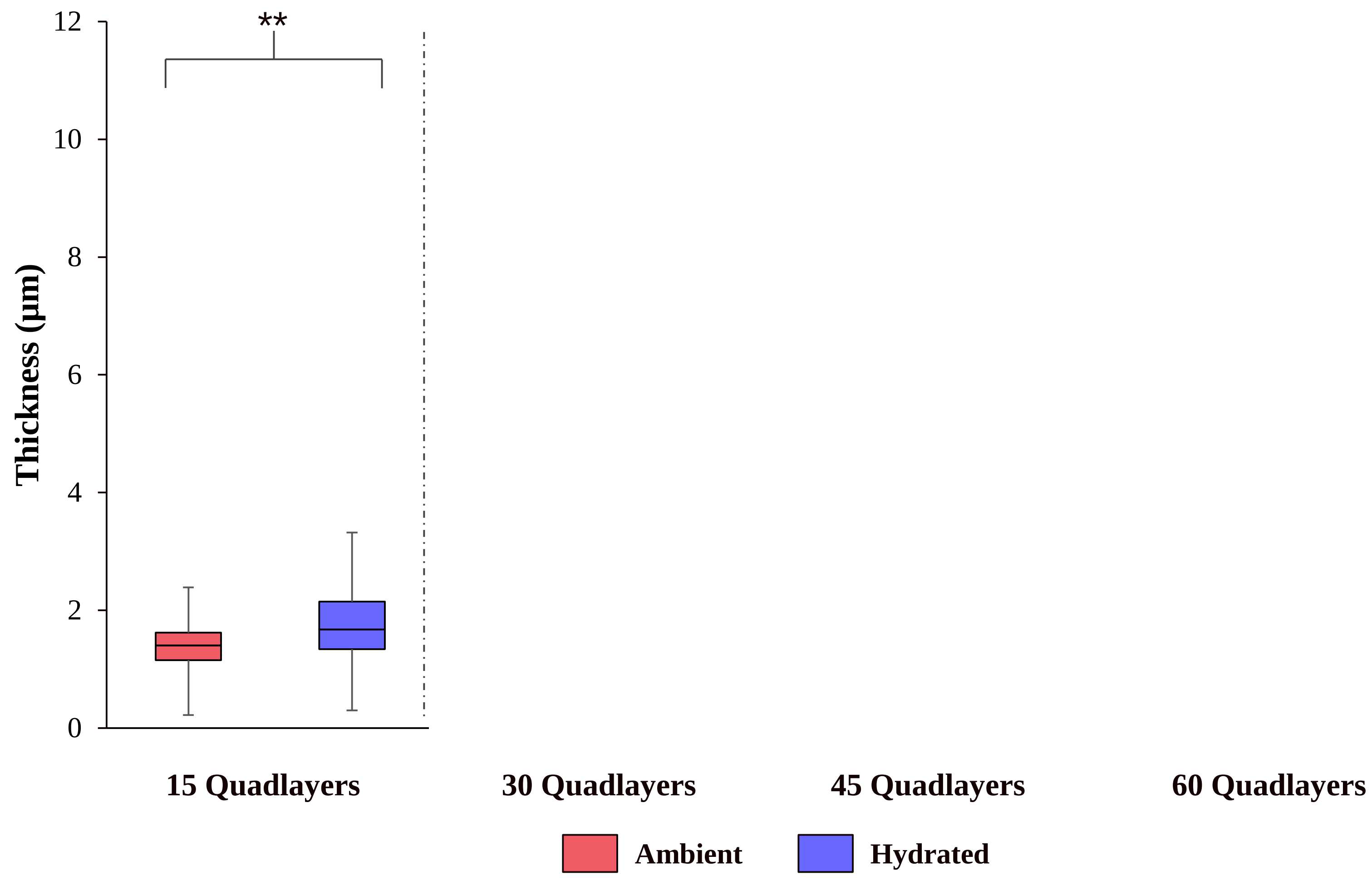


When tested upon immediate submersion in DI water, elastic modulus drops significantly

Thickness Measurements of Coating on Glass Slides when Hydrated

Hydrated

(n=100)



**Statistically significant increase ($p < 0.01$) in coating thickness when hydrated

Mechanical and Gravimetric Analysis of Coated Foam in Humidity Chamber

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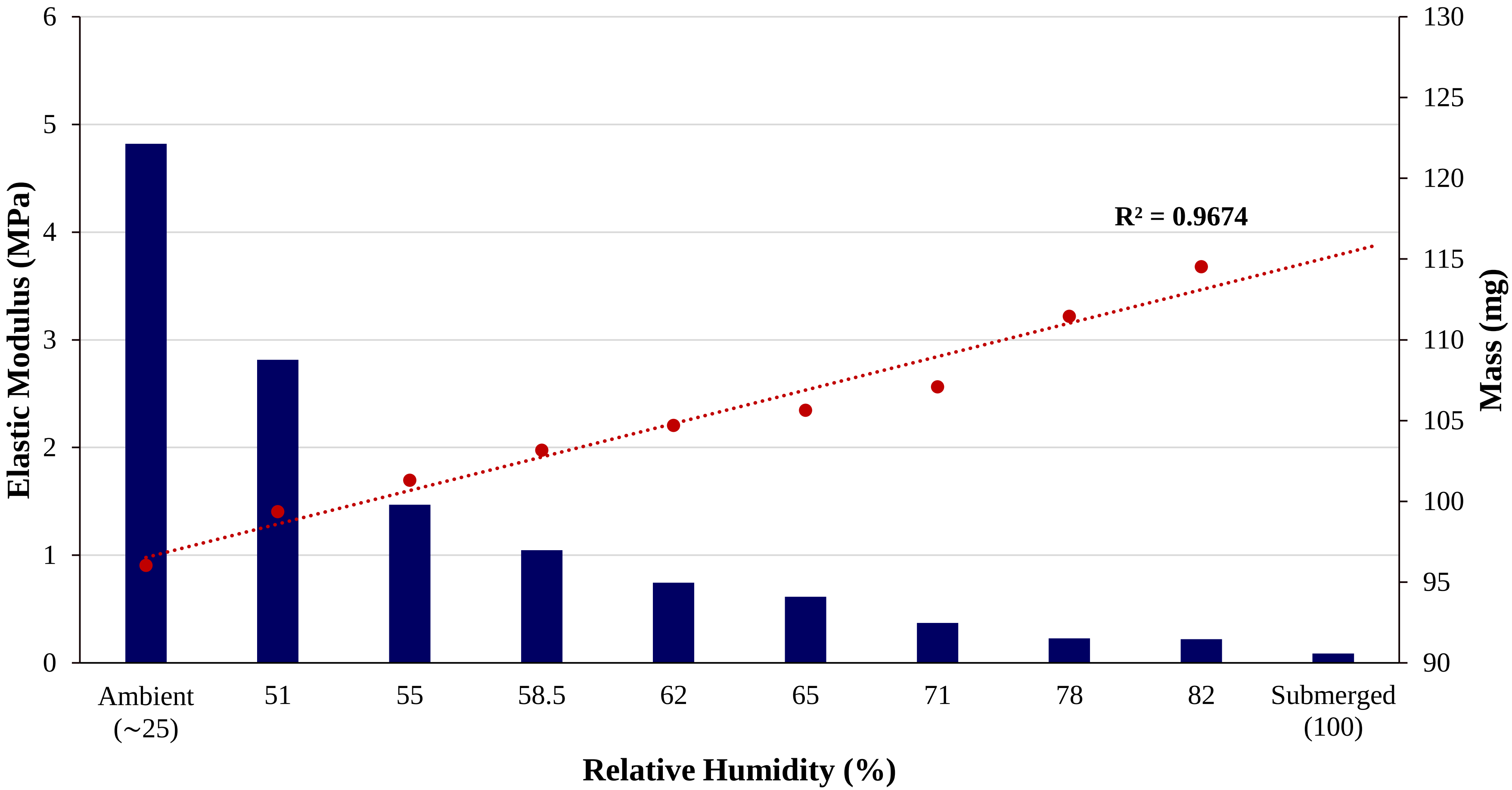
(n=1)



Water Acting as a Plasticiser

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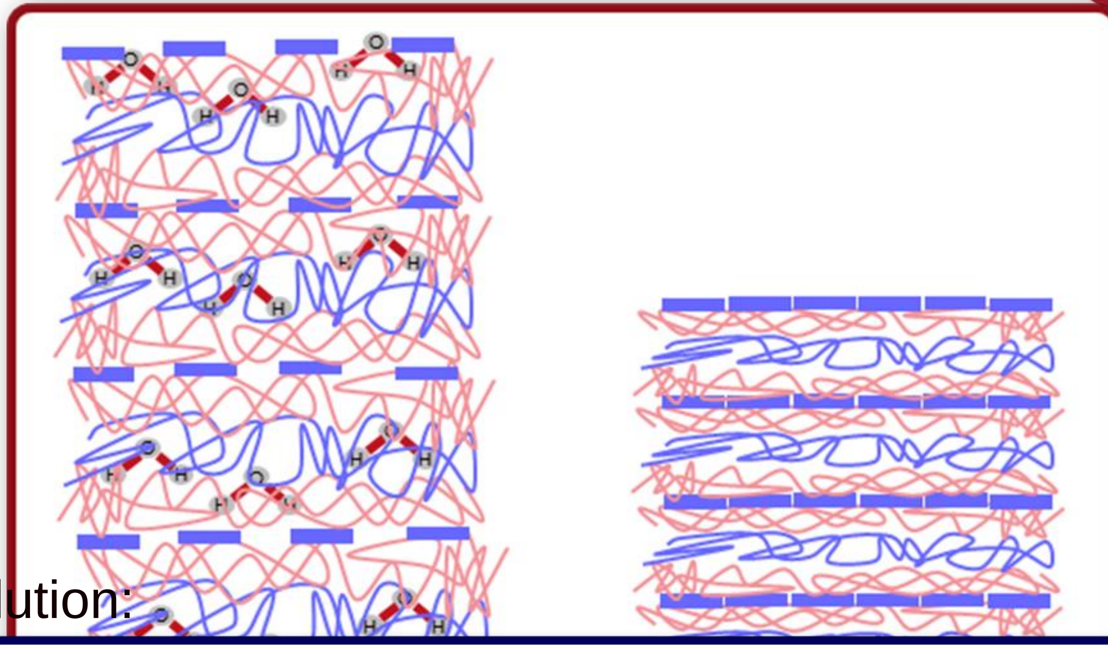
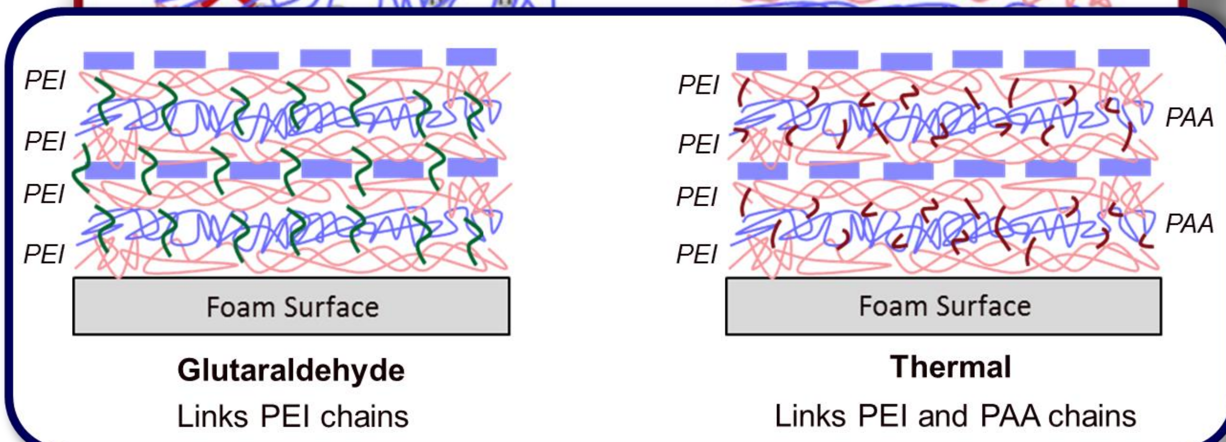


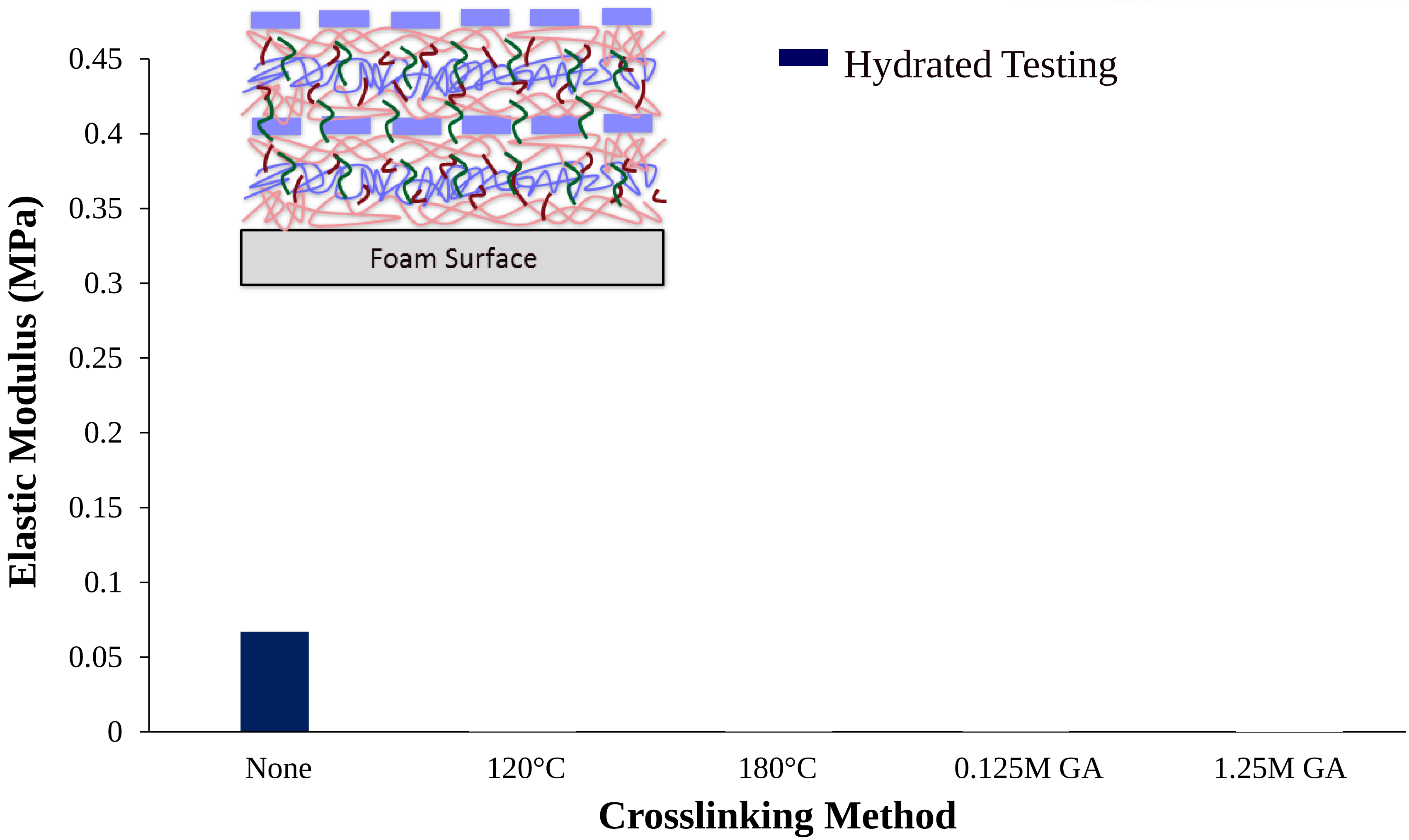
Water Distribution in Multilayers of Weak Polyelectrolytes[1]

Proposed Solution:



[1] OT et al. Langmuir. 2006;22(11):5137–43.

Crosslinking Results



Preliminary crosslinking results on 15 quadlayer coated foams

Conclusions

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- Elastic modulus of coated foam is reduced to that of an uncoated level
- Coating thickness when hydrated is significantly increased
- Elastic modulus of coated foam recover post desiccation
- Increasing mass in conjunction with lowering elastic modulus under increasing relative humidity
- Effects of hydration on coating synonymous with **water plasticisation** as described by Tanchak et al.[1]
- Crosslinking of coating improves hydrated elastic modulus significantly
  - Thermal crosslinking offering slight improvement in elastic modulus
  - Chemical crosslinking offering significant improvement in elastic modulus

[1] OT et al. Langmuir. 2006;22(11):5137–43.

Future work

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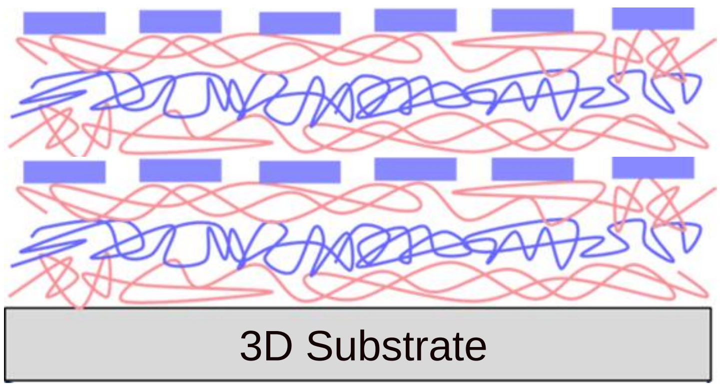
- Design of experiments to optimise mechanical properties of coating when hydrated
  - Chemical crosslinking
  - Thermal crosslinking
  - Water vapour "barrier" layers

Future work

- ❑ Incorporating degradable barrier layers into system



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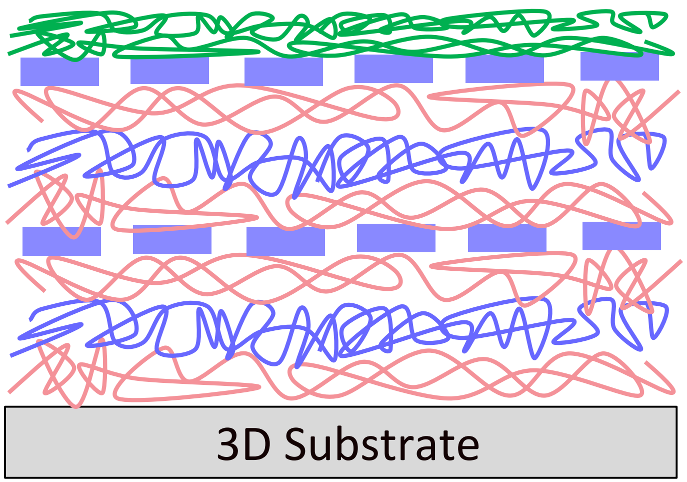

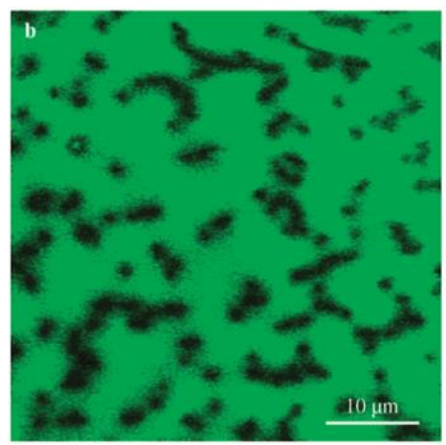

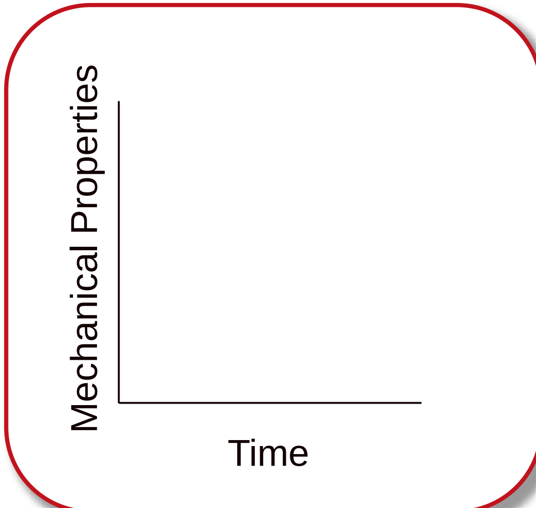

[Image] MD et al. Nano Lett. 2007;7(3):657–62.

Acknowledgements

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