



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

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Queen's University
Belfast



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

Acheson, J¹. Goel, S¹. Dunne, N^{2, 3, 4}. Hamilton, A¹

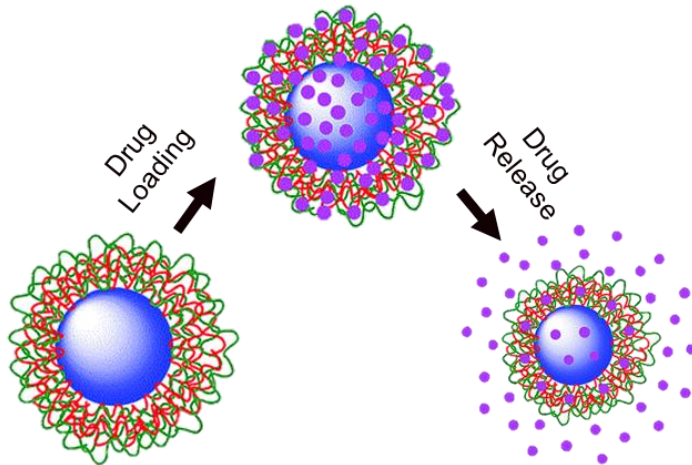
¹School of Mechanical and Aerospace Engineering, Queen's University Belfast, UK

²Medical Engineering Research Centre, School of Mechanical and Manufacturing Engineering, Dublin City University, Ireland

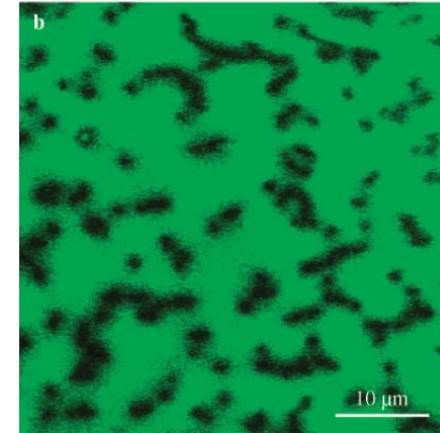
³School of Pharmacy, Queen's University Belfast, UK

⁴Trinity Centre for Bioengineering, Trinity College Dublin, Ireland

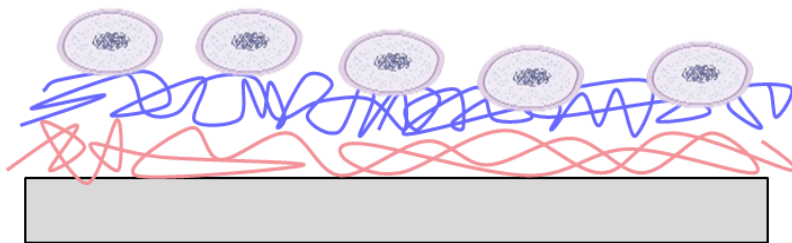
Layer by Layer Assembly



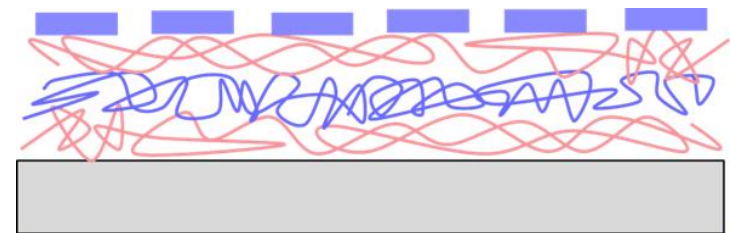
Drug Releasing



Controlled Degradation



Surface Interaction



Mechanical Properties

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

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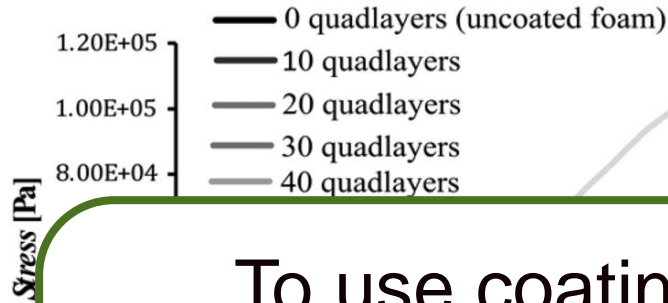


CONCLUSIONS

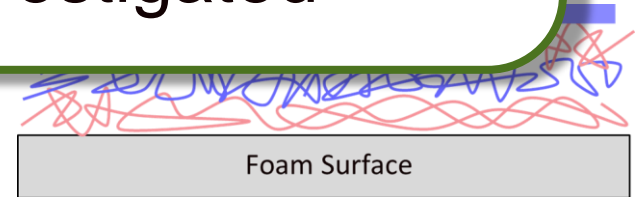
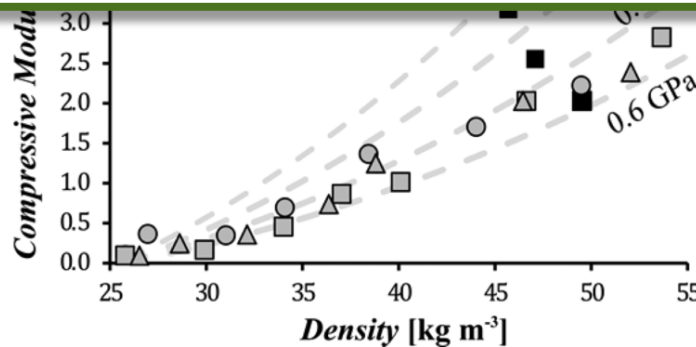


FUTURE WORK

Mechanical Properties of Coating on 3D Substrates



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.

INTRODUCTION

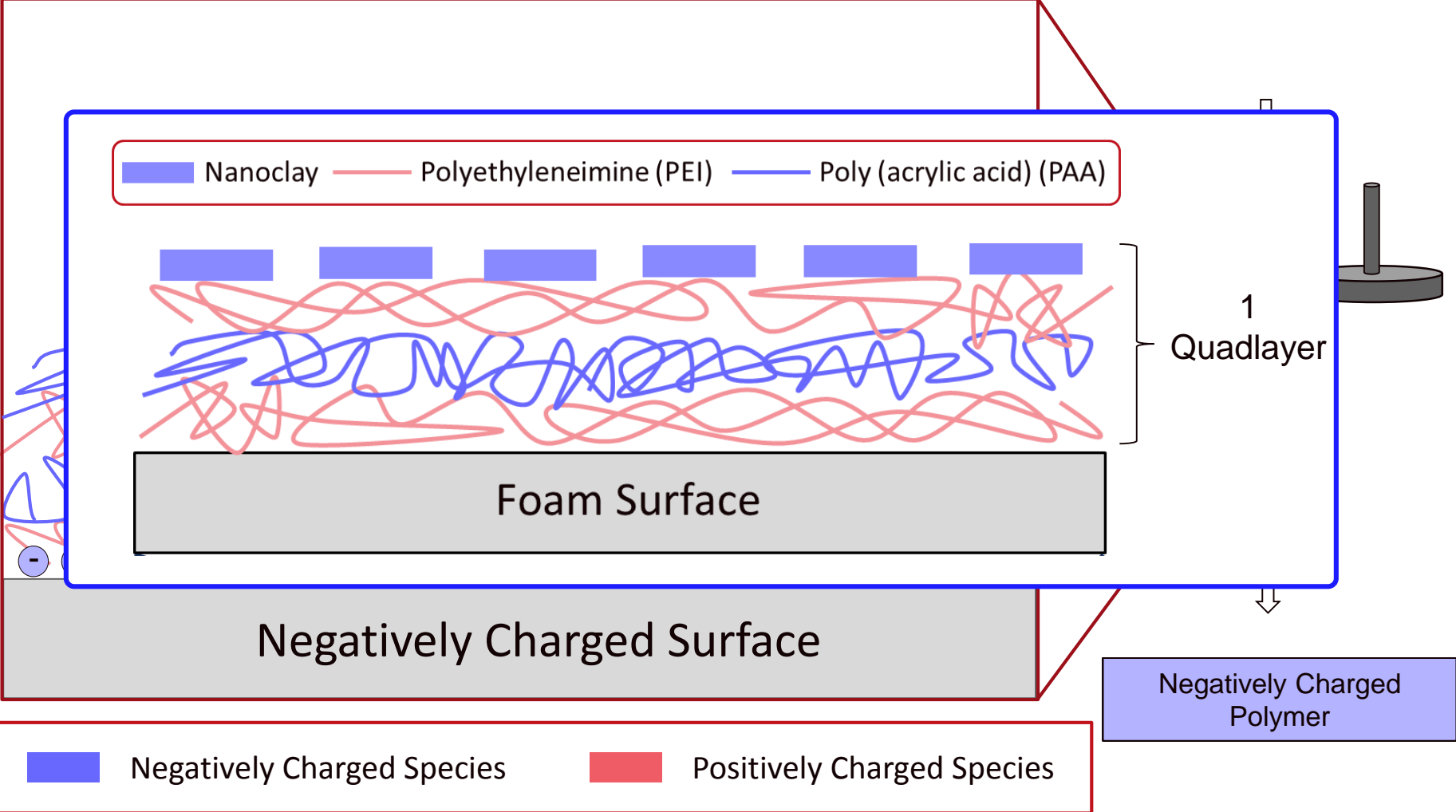
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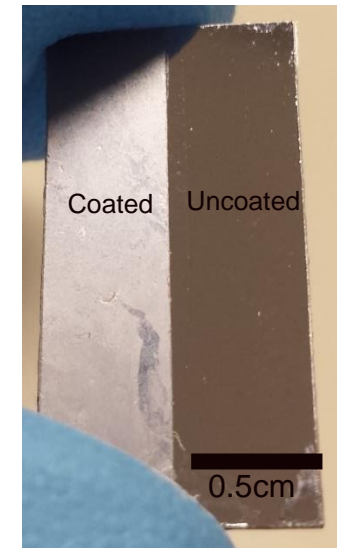
Mechanism Overview



- Open cell polyurethane foam (12.7 \emptyset 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 (\sim 25% RH, Ambient Temp)^[1]
 - » Submerged de ionised water (100% RH, Ambient Temp)
 - » Humidity chamber (\sim 50 to \sim 85% RH, Ambient Temp)



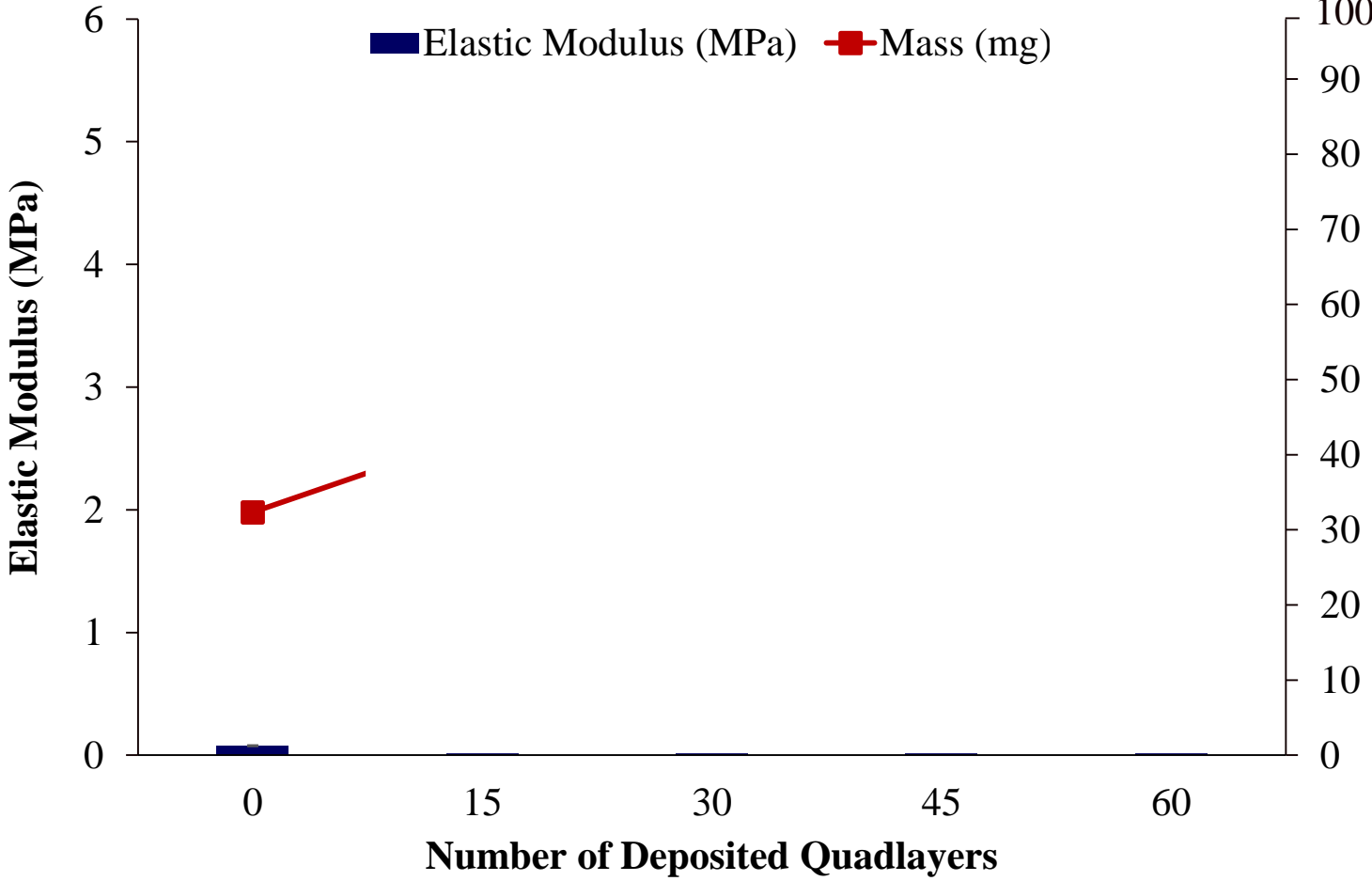
Polyurethane foam



Masked Sample

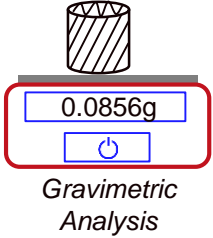
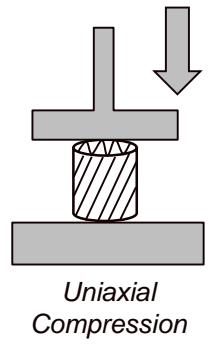
1. Ziminska et al. ACS Appl Mater Interfaces. 2016;8(34):21968–73.

Elastic Modulus of Coated Foams



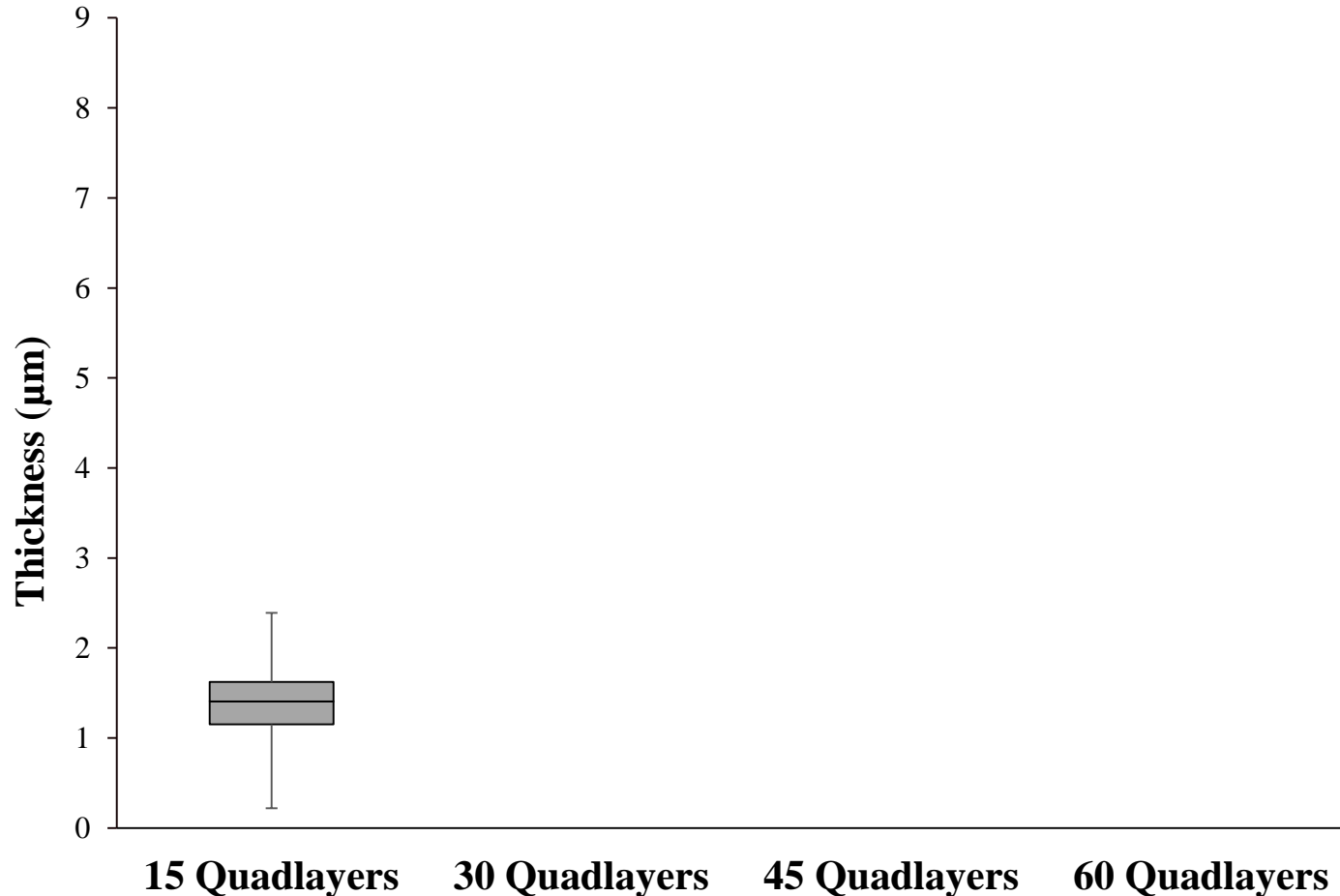
Ambient

(n=5)



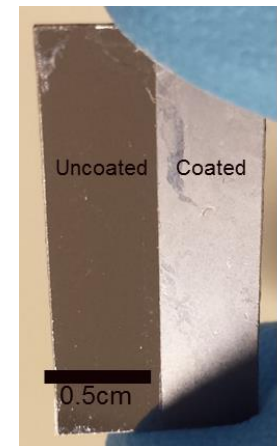
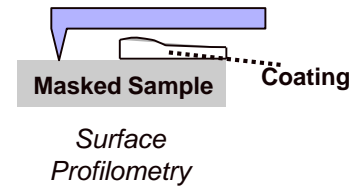
6% deformation at crosshead speed of 2 mm/min

Thickness Measurements of Coating on Glass Slides



Ambient

(n=100)



Masked Sample

Surface profilometry using Tencor alpha step 200

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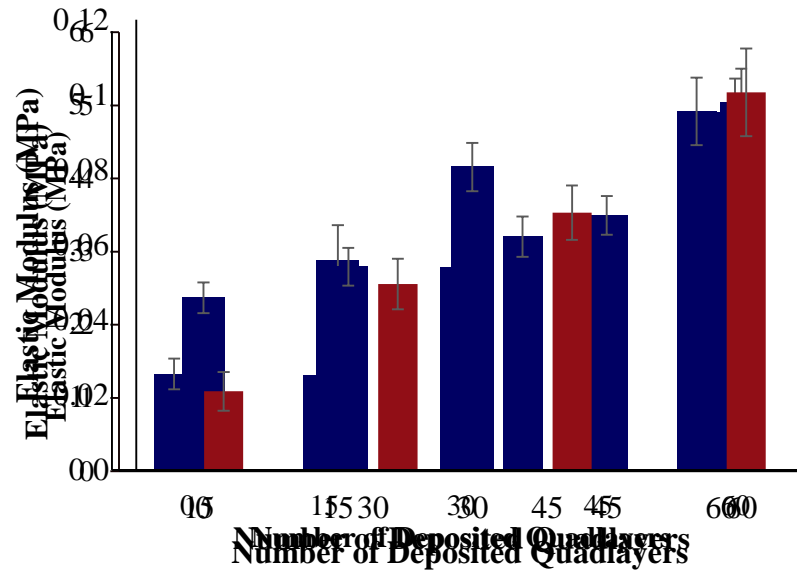
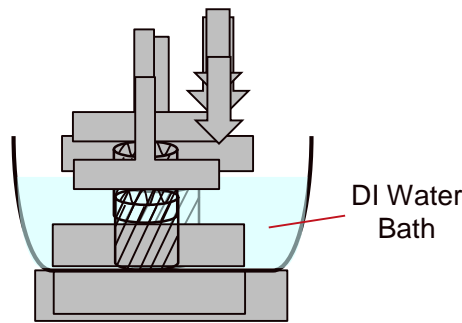
FUTURE WORK

Mechanical Properties of Coated Foams Under Aqueous Conditions

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

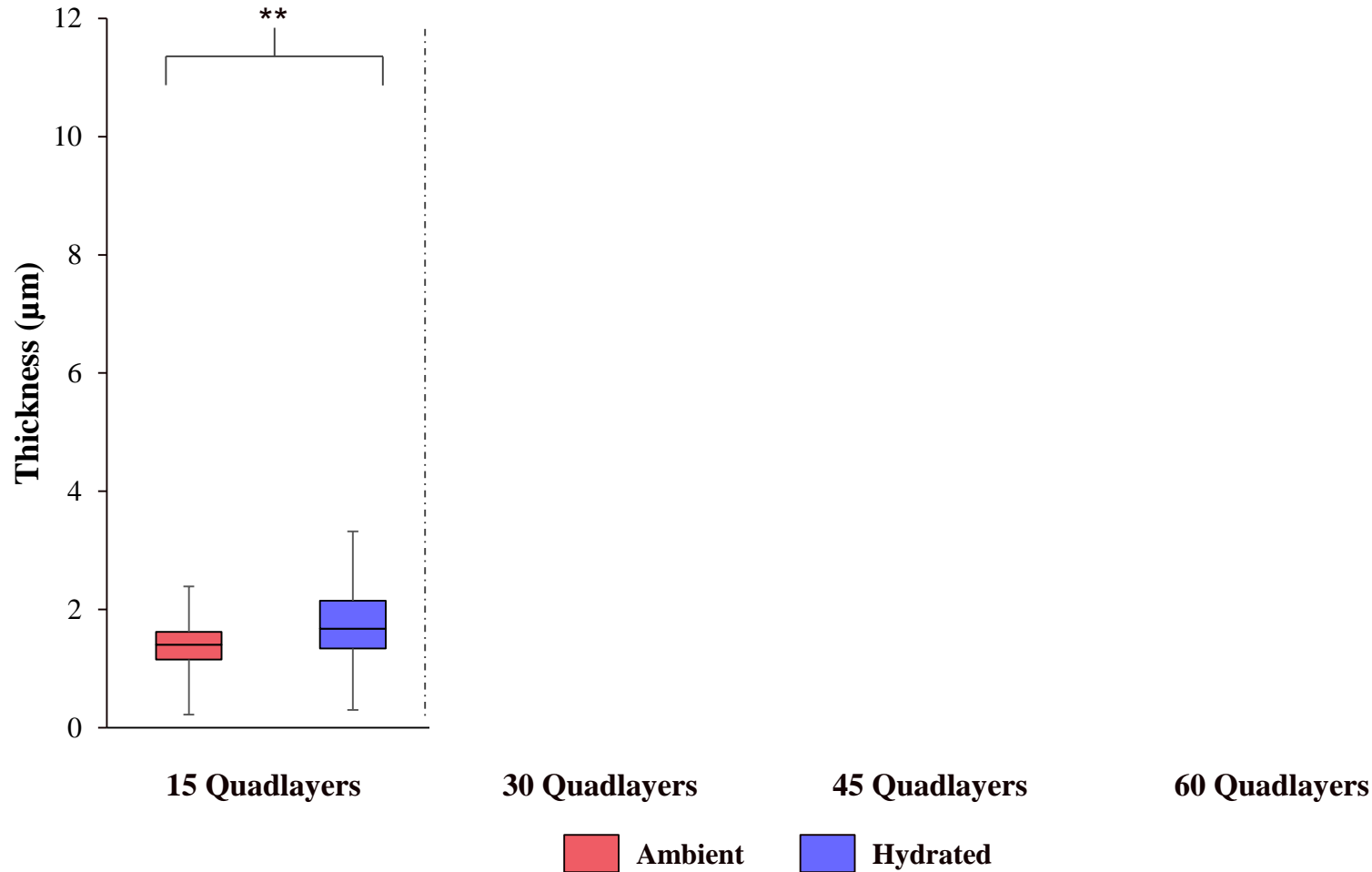
Hydrated

(n=5)



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

Thickness Measurements of Coating on Glass Slides when Hydrated



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

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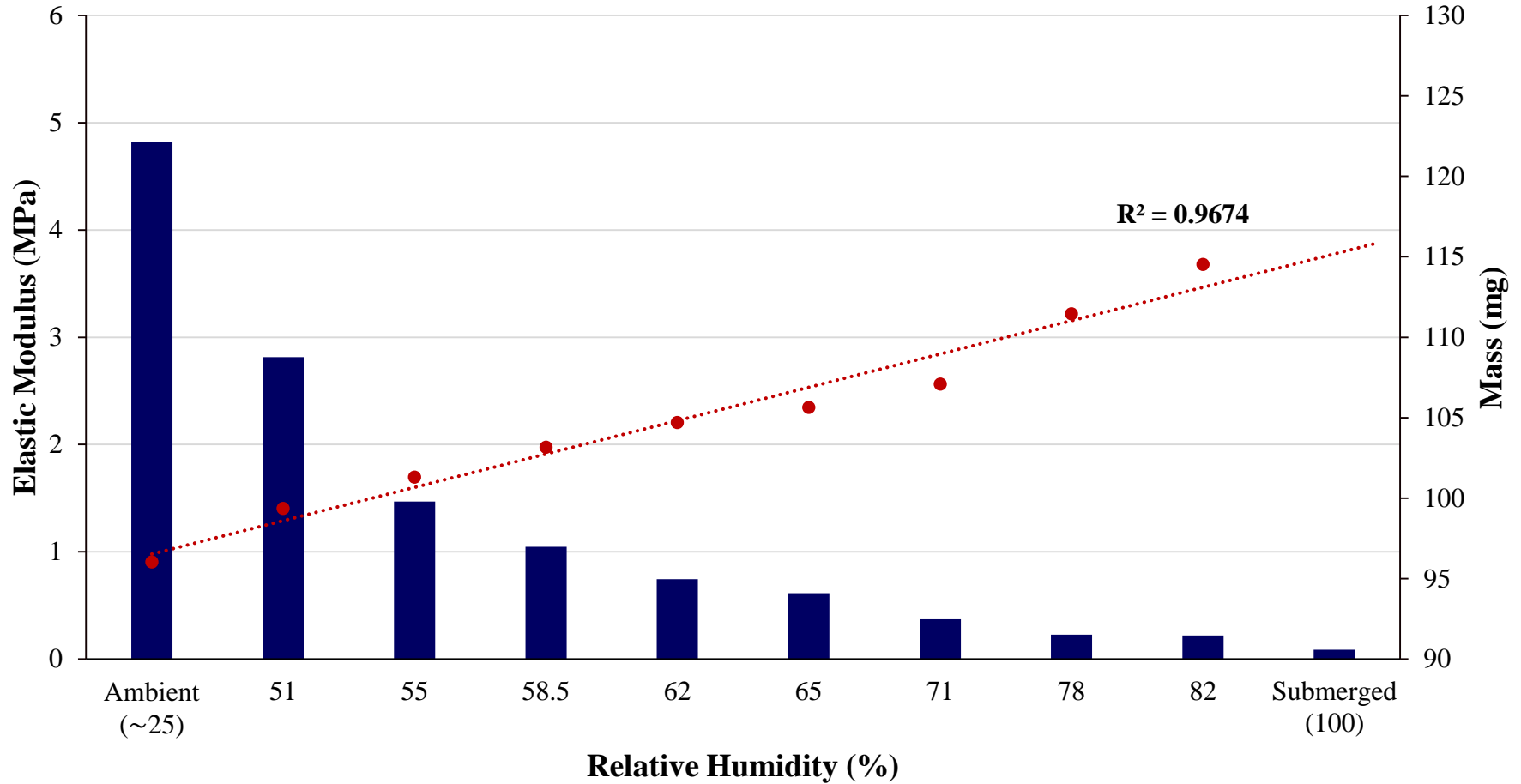
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FUTURE WORK

Mechanical and Gravimetric Analysis of Coated Foam in Humidity Chamber

(n=1)



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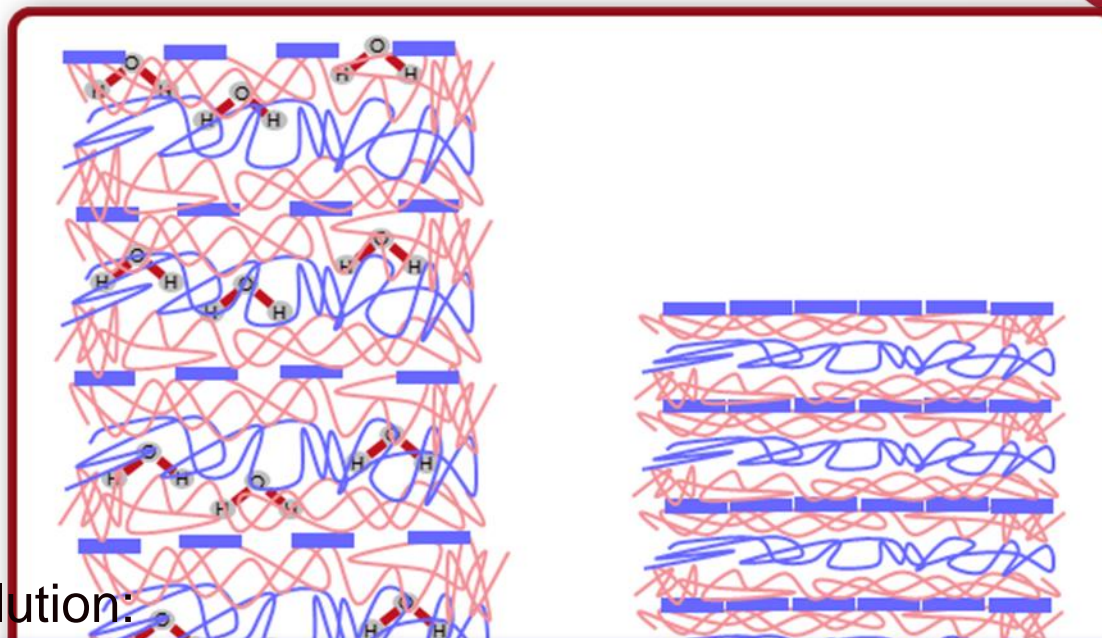


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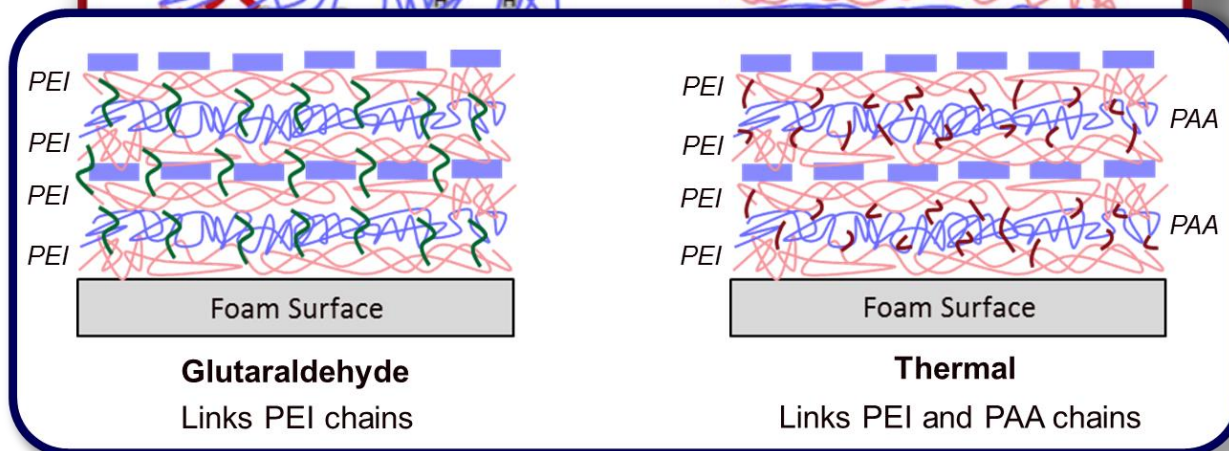
FUTURE WORK

Water Acting as a Plasticiser



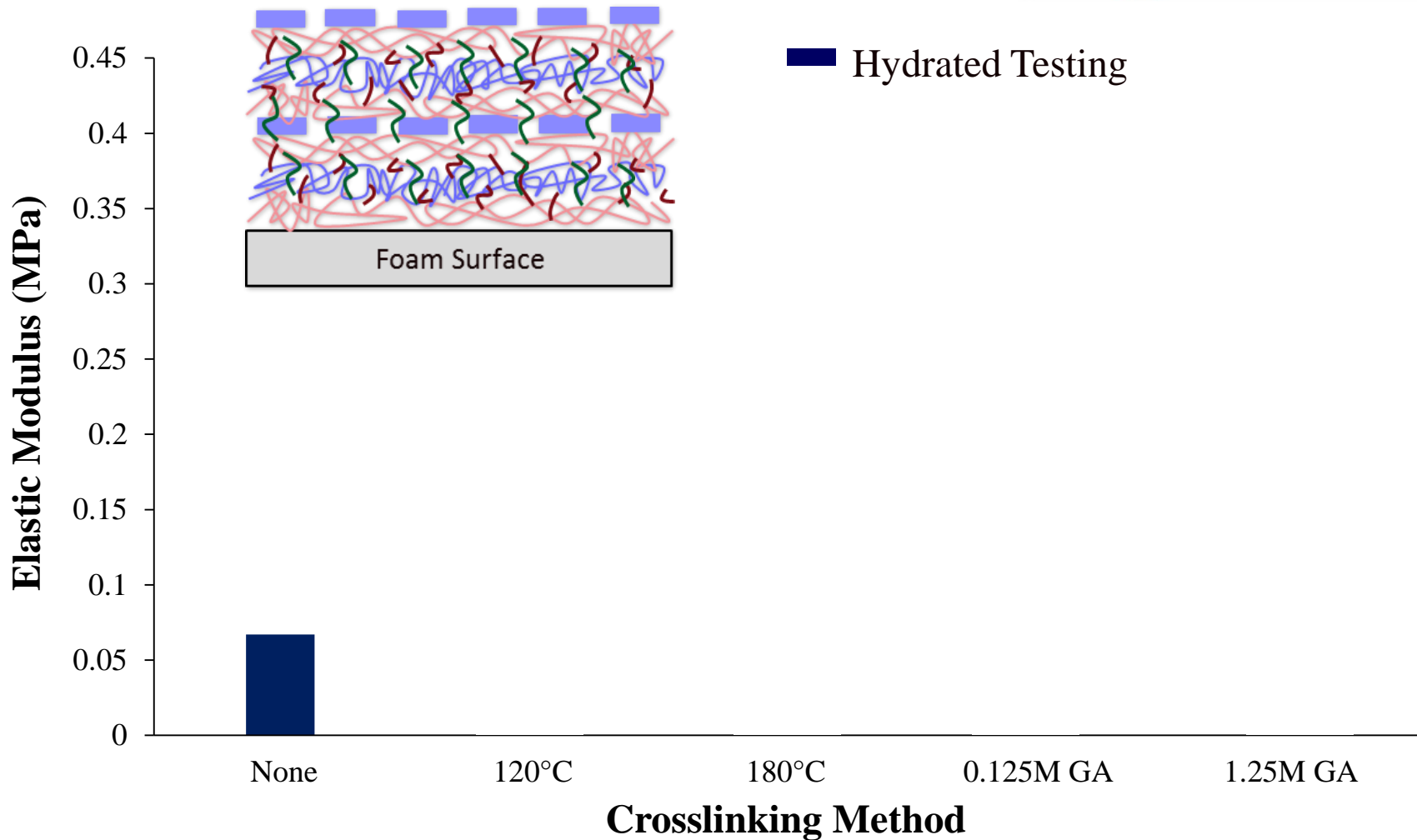
Water Distribution in
Multilayers of Weak
Polyelectrolytes^[1]

Proposed Solution:



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

Crosslinking Results



Preliminary crosslinking results on 15 quadlayer coated foams

- ❑ 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

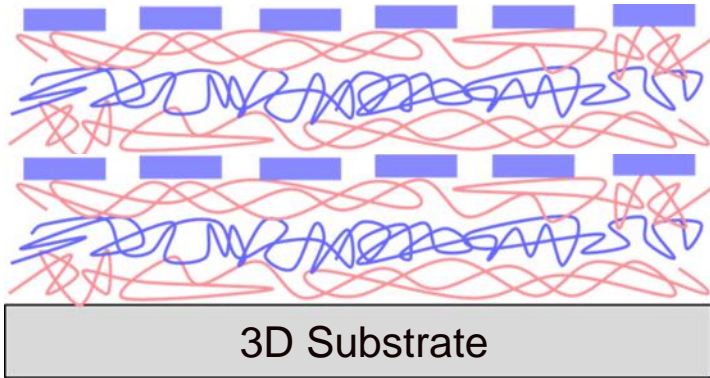
[1] OT et al. Langmuir. 2006;22(11):5137–43.



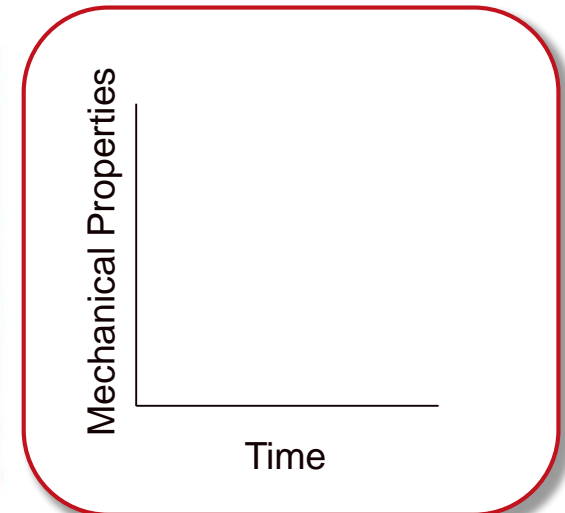
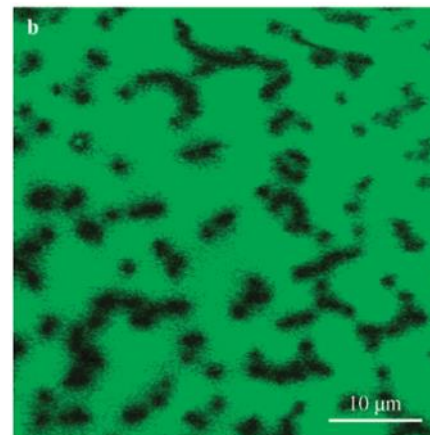
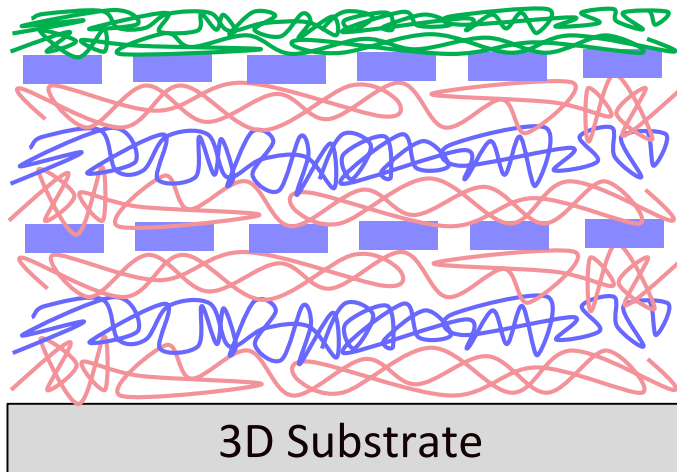
- ❑ Design of experiments to optimise mechanical properties of coating when hydrated
 - ❑ Chemical crosslinking
 - ❑ Thermal crosslinking
 - ❑ Water vapour “barrier” layers



□ Incorporating degradable barrier layers into system



Average Elastic Modulus (MPa) \pm SD		
Quadlayers	Ambient	Hydrated
0	0.08 \pm 0.00	0.05 \pm 0.00
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[Image] MD et al. Nano Lett. 2007;7(3):657–62.

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FUTURE WORK

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