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

Acheson, J¹. Goel, S¹. Dunne, N², 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

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.
Mechanism Overview

![Diagram of a mechanism overview showing interactions between positively and negatively charged species and polymers.](image)
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)

Elastic Modulus of Coated Foams

6% deformation at crosshead speed of 2 mm/min
Thickness Measurements of Coating on Glass Slides

INTRODUCTION

MATERIALS AND METHODS

RESULTS

CONCLUSIONS

FUTURE WORK

Surface profilometry using Tencor alpha step 200
When tested upon immediate submersion in DI water, elastic modulus drops significantly.
**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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\[ R^2 = 0.9674 \]

<table>
<thead>
<tr>
<th>Relative Humidity (%)</th>
<th>Elastic Modulus (MPa)</th>
</tr>
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<tbody>
<tr>
<td>Ambient (~25)</td>
<td>51</td>
</tr>
<tr>
<td>55</td>
<td>58.5</td>
</tr>
<tr>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>71</td>
<td>78</td>
</tr>
<tr>
<td>82</td>
<td>Submerged (100)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Mass (mg)</th>
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<tbody>
<tr>
<td>90</td>
</tr>
<tr>
<td>95</td>
</tr>
<tr>
<td>100</td>
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<tr>
<td>105</td>
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<tr>
<td>120</td>
</tr>
<tr>
<td>125</td>
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<tr>
<td>130</td>
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Proposed Solution:

Water Distribution in Multilayers of Weak Polyelectrolytes

Crosslinking Results

Preliminary crosslinking results on 15 quadlayer coated foams

INTRODUCTION  MATERIALS AND METHODS  RESULTS  CONCLUSIONS  FUTURE WORK
Conclusions

- 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

Future work

- 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

<table>
<thead>
<tr>
<th>Time</th>
<th>Quadlayers</th>
<th>Ambient (MPa) ± SD</th>
<th>Hydrated (MPa) ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.08 ± 0.00</td>
<td>0.05 ± 0.00</td>
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<tr>
<td>15</td>
<td>1.31 ± 0.21</td>
<td>0.06 ± 0.01</td>
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<tr>
<td>30</td>
<td>2.78 ± 0.26</td>
<td>0.08 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>3.19 ± 0.28</td>
<td>0.07 ± 0.01</td>
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</tr>
<tr>
<td>60</td>
<td>4.9 ± 0.46</td>
<td>0.10 ± 0.01</td>
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Acknowledgements

Special Thanks
Dr. A Hamilton
M. Ziminska
Dr. N Dunne
Dr. S Goel

Bioengineering Research Group

DEL Funding