



Layer-by-layer assembly as a bottom-up nanofabrication technique for the manufacture of multi-functional engineered bone tissue scaffolds

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INTRODUCTION

Hydrated and dry testing of nanocomposite thin films showed drastic differences in mechanical behaviour, indicating the importance of development of films which will maintain their mechanical properties *in vivo*

- Using Layer-By-Layer (LBL) assembly, nanocomposite films can be deposited to enhance the properties of 3D porous substrates, creating bone tissue scaffolds with tailorable attributes.
- LBL is a thin film fabrication process whereby the alternating deposition of oppositely charged species produces a nano-laminate composite coating.

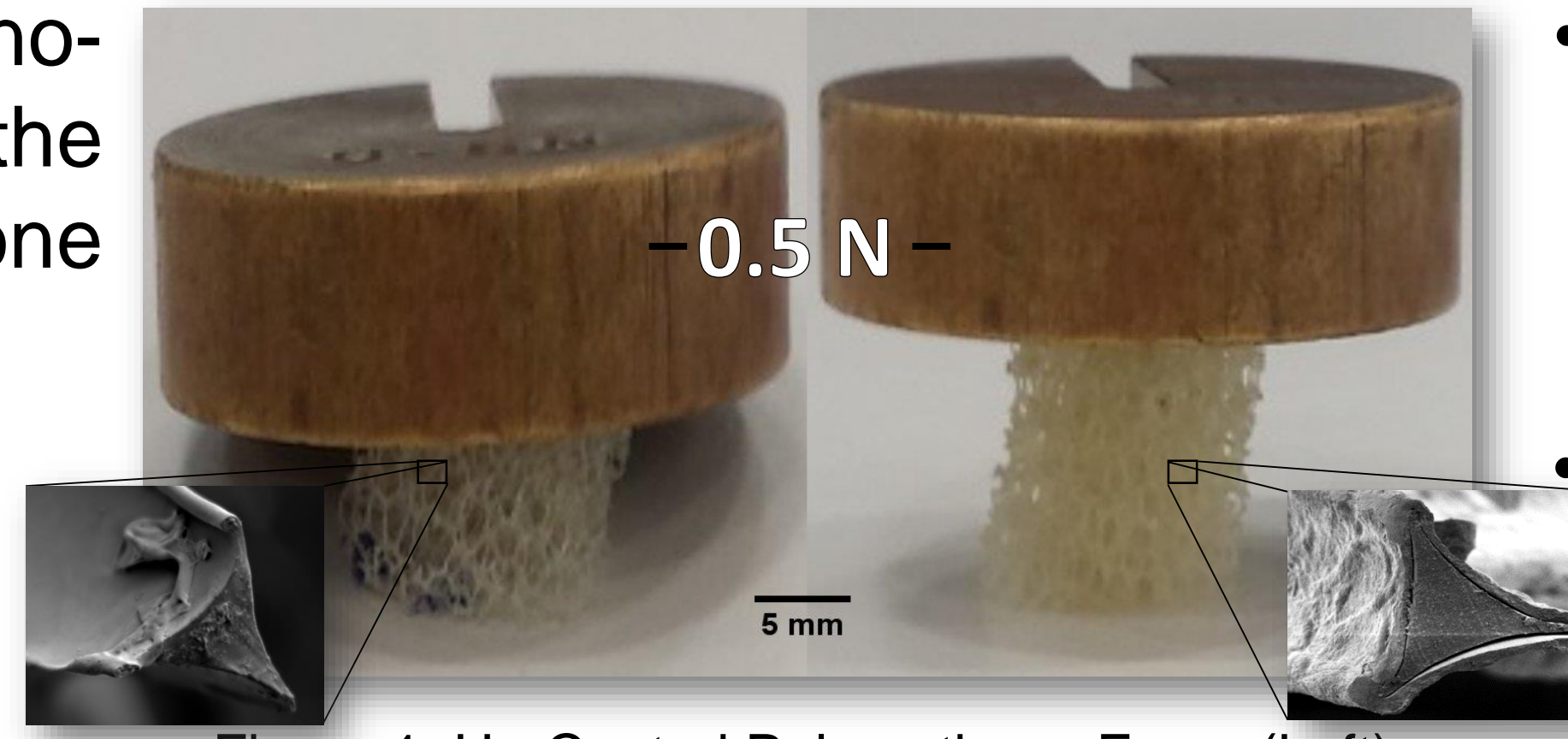


Figure 1: Un-Coated Polyurethane Foam (Left)
Coated Polyurethane Foam (Right)

- These coatings are able to improve the compressive elastic modulus of 3D porous polyurethane structures by an order of magnitude.
- To ensure the films retain their function *in vivo*, investigation of the effect of DI water upon the nanocomposite coated films is being carried out.

AIM: TO STUDY EFFECTS OF HYDRATION ON MECHANICAL PROPERTIES OF POLYURETHANE FOAMS COATED WITH A NANOCOMPOSITE THIN FILM

LBL Deposition

- Open cell polyurethane foams were subjected to alternating solutions of oppositely charged species to produce a nanocomposite thin film coating consisting of polyelectrolytes (PEI, PAA) and nanoclay.
- The sequence in Fig 2 was repeated until the desired number of layers is achieved.

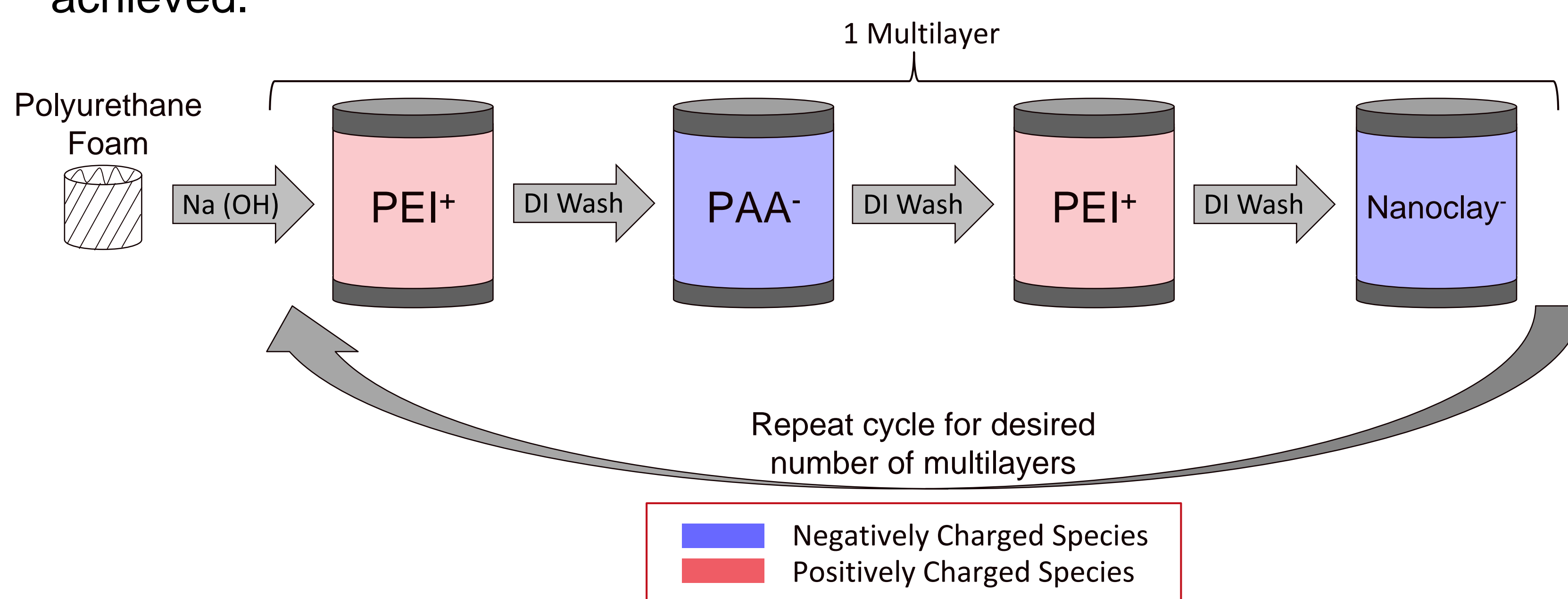


Figure 2: Schematic of Order of Oppositely Charged Species Used During LBL Deposition

MATERIALS AND METHODS

Characterisation

- Samples were mechanically tested in compression, in the elastic range, using a Stable Microsystems Texture Analyser XT2i, using a 50 N load cell at a speed of 0.5 mm/sec with a maximum displacement of 2 mm.
- Samples were tested in air immediately after immersion in DI water and again after 1 hour immersion.
- Samples were dried under controlled humidity and tested at 1 hour intervals until dry
- ESEM images were taken of coated and uncoated foam samples to analyse the surface and thickness of the film deposited, Fig 3.

RESULTS AND DISCUSSION

- The elastic modulus of the un-coated open cell foams ($n = 3$) was 95.33 ± 9.8 kPa. After deposition of 15 multilayers the elastic modulus of the samples increased to 882.67 ± 178.1 kPa.
- Upon hydration the elastic modulus of the samples drops to 74.33 ± 6.5 kPa, showing that upon hydration the film loses all its mechanical integrity.
- The reduction in mechanical properties may be attributed to the reported propensity of the material system to absorb water^[1].

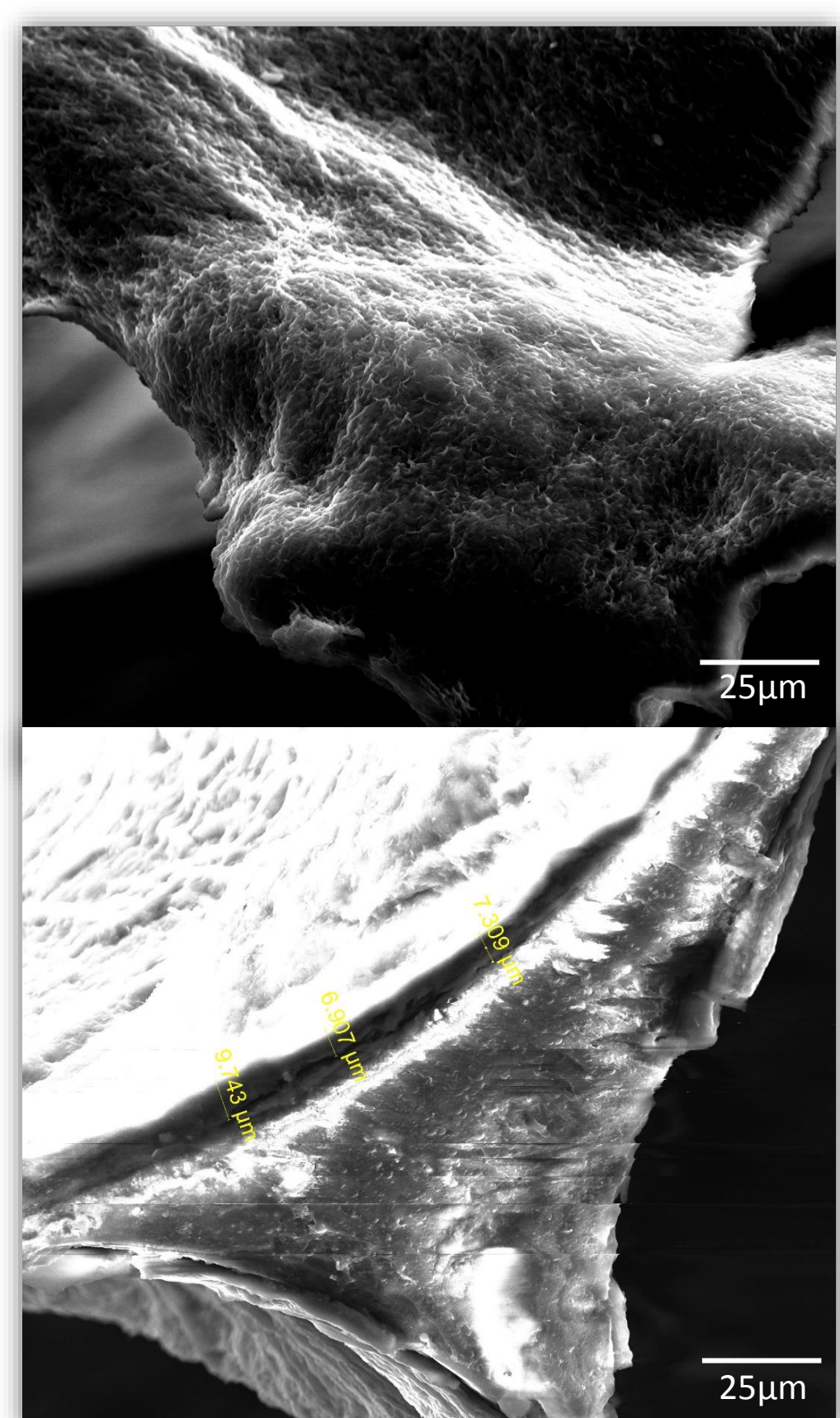
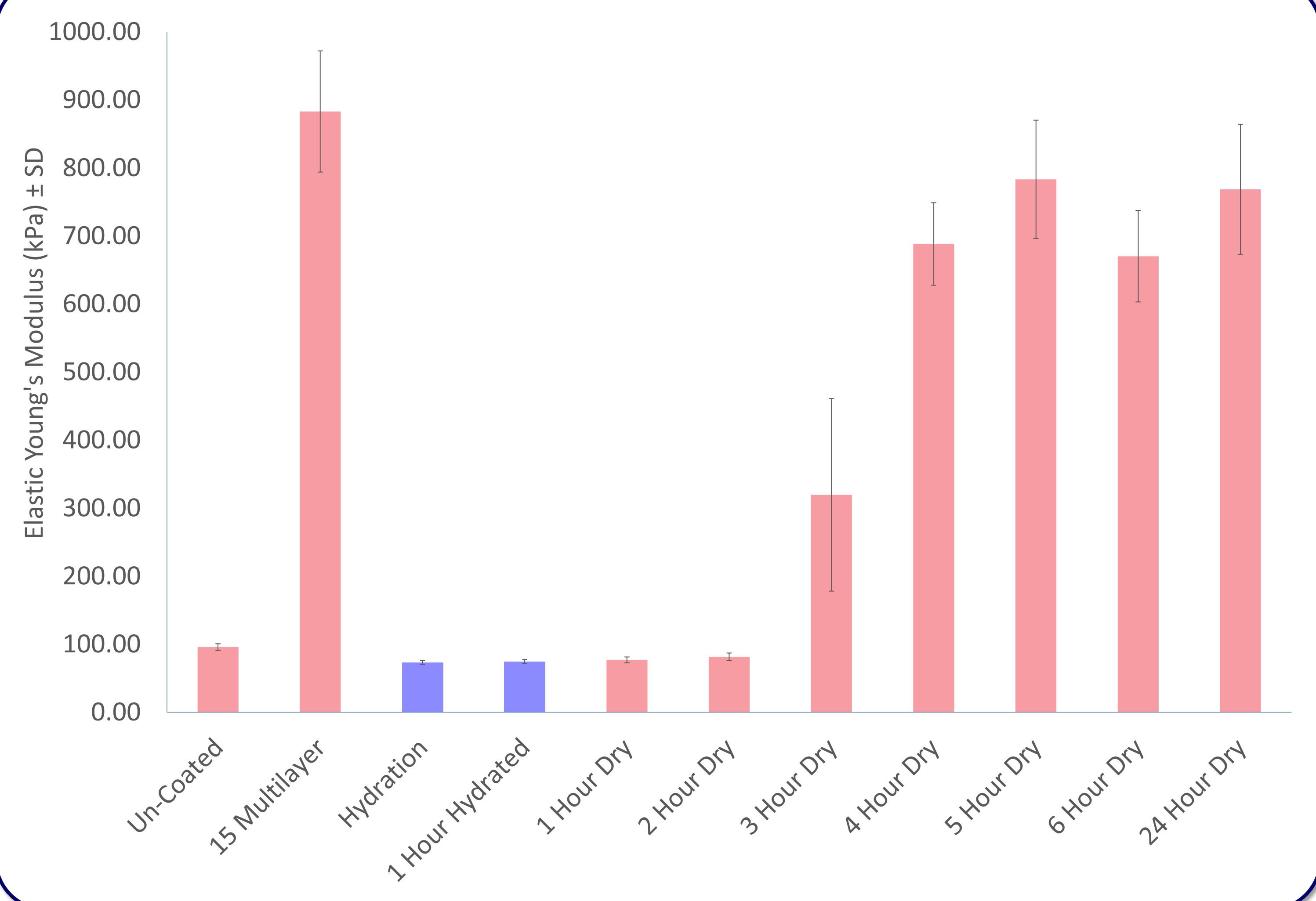
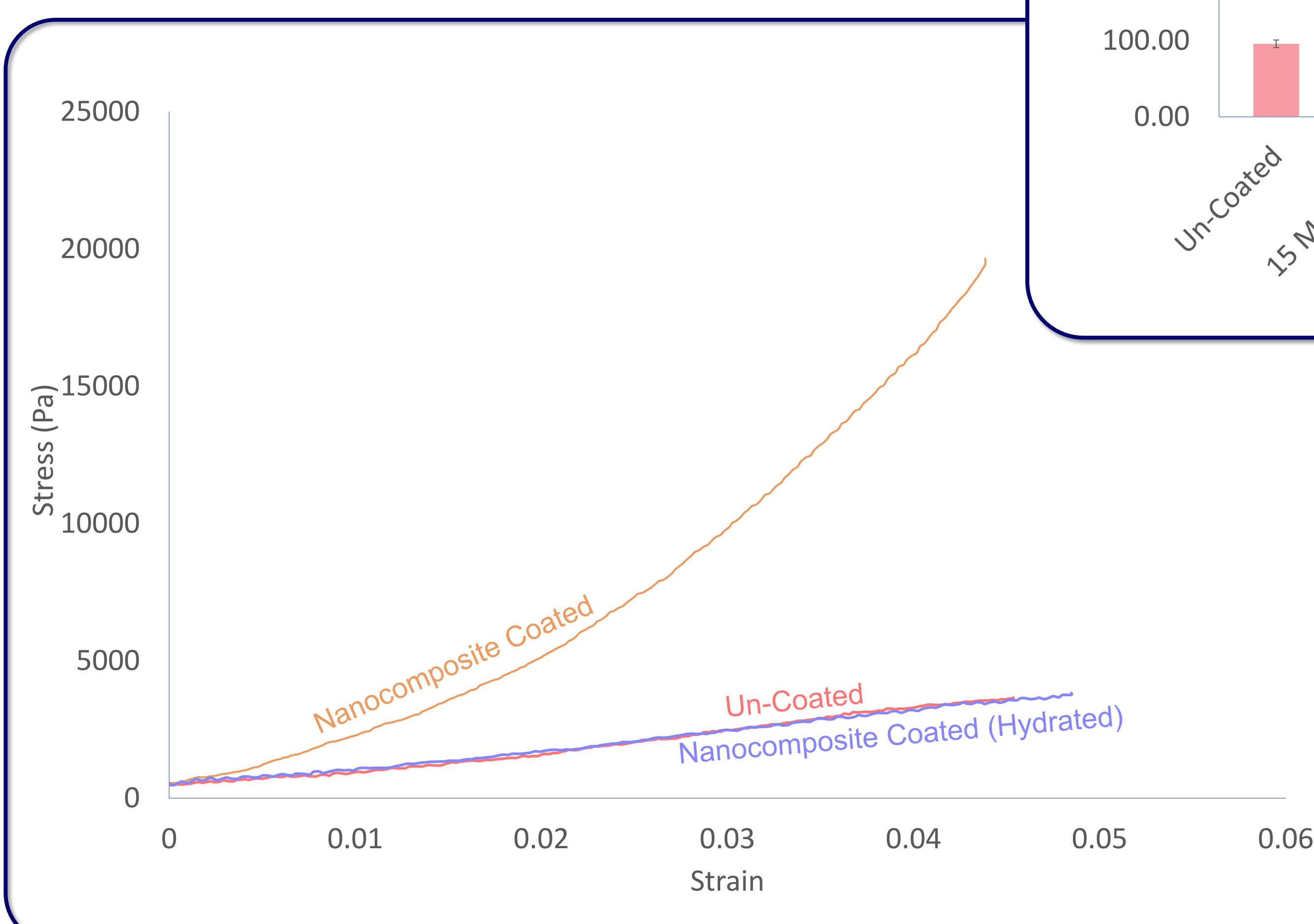


Figure 3: Film Surface (Top)
Film Thickness (Bottom)



FUTURE WORK

To synthesise a bone tissue scaffold using this methodology, it must maintain its mechanical properties *in vivo*, therefore, the following experiments have been proposed. The use of:-

- Barrier layers to prevent hydration
- Cross-linking of layers to reduce chain mobility
- Confining layers to reduce swelling

[1] Podsiadlo P, et al. Exponential Growth of LBL Films with Incorporated Inorganic Sheets. Nano Lett 2008 06/01; 2014/07;8(6):1762-1770