Liquid Cell

Liquid Cell module with the NanoTest Vantage

Mechanical properties of biological samples often vary considerably when in their normal fluid environment compared to the usual laboratory dry testing conditions. Probing the mechanical properties of biological samples in fluid media should prove a closer mimic of *in vivo* conditions than conventional dry nanoindentation testing. Research by MIT has shown that nanoindentation with the NanoTest liquid cell could be performed with sample fully immersed in liquid for materials spanning several orders of magnitude of stiffness from highly compliant gels, biological tissues to glasses.

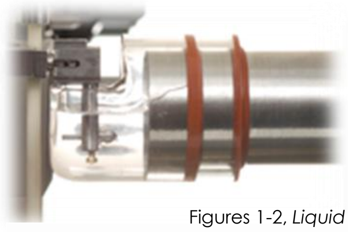
How it works

The testing capability of the NanoTest has been extended by the development of a liquid cell allowing Nanoindentation, Nano-scratch & Wear testing of samples fully immersed in liquid. A friction transducer extension also allows immersed sample friction measurements. The fluid cell works with the existing pendulum design and the horizontal loading has several key advantages for testing in fluid.

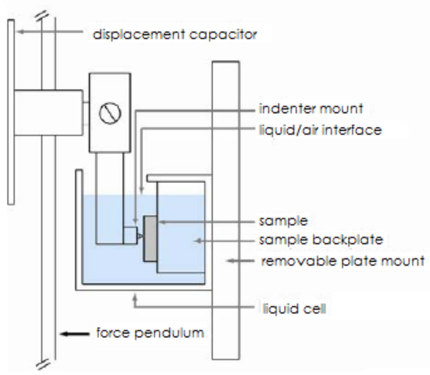
- Constant buoyancy force
- Constant surface tension on loading column
- Liquid is not underneath capacitor

Liquid cell applications and investigating of soft materials immersed in liquids includes:

- Tribology
- Corrosion
- Tissue mechanics as a function of source, disease state, and exposure to soluble toxins or drugs
- Tissue properties as a function of submicron position within the tissue
- Porous materials (bone, cement, chemomechanics)
- Biocompatibility and biomaterials
- Dental enamel
- Micro particle friction and wear
- Polishing mechanics



Figures 1-2, *Liquid Cell*



Liquid Cell nanomechanical measurements in fully hydrated in-situ conditions

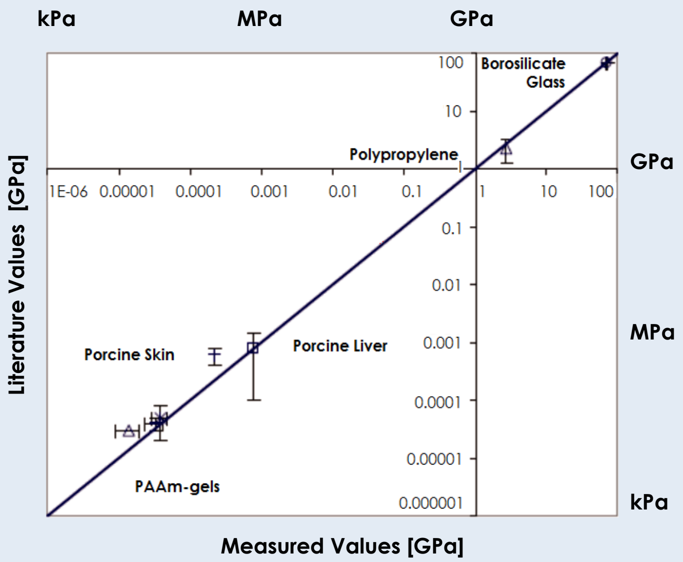


Figure 3 shows the measured Elastic modulii of various specimens (Borosilicate glass, Polypropylene, Porcine liver, Porcine skin, PAAm-gels in various mol concentrations) are in very good agreement with literature values. Data ranges over eight orders of magnitude.

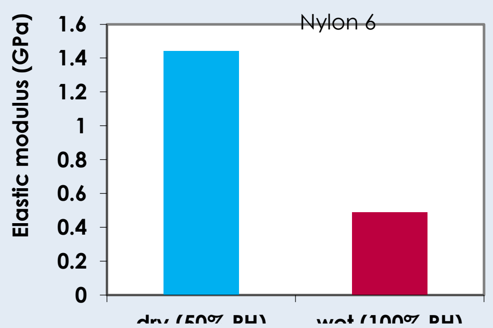
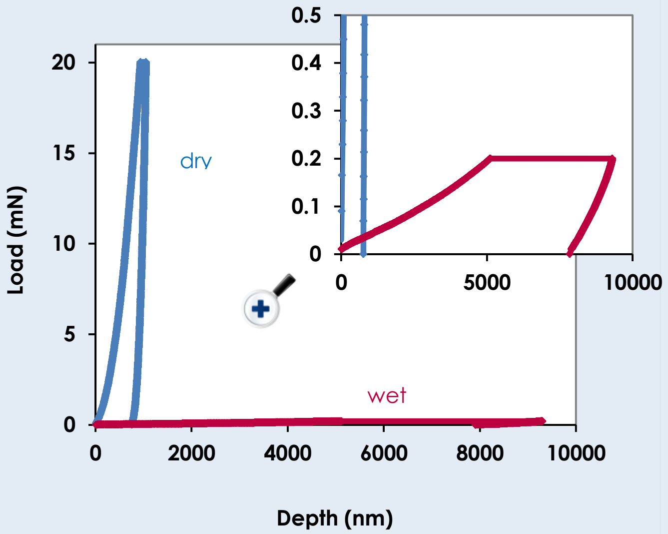


Figure 4 shows that when hydrolytic attack and plasticization occurs, polymer stiffness decreases significantly *[...see also G.A Bell, DM Bielinski and BD Beake, J ApplPolymSci 107(2008) 577]*.

"This liquid cell feature has enabled us to explore the mechanical properties of hydrated materials, which is particularly important to our studies of biologically relevant and biodegradable surfaces andwhich is not accessible to us through other instrumentation with comparable ranges of calibrated force and depth". *Professor Krystyn J. Van Vliet, MIT Department of Materials Science and Engineering*

Wet vs. dry: Measurement of nanomechanical properties of hydrogels



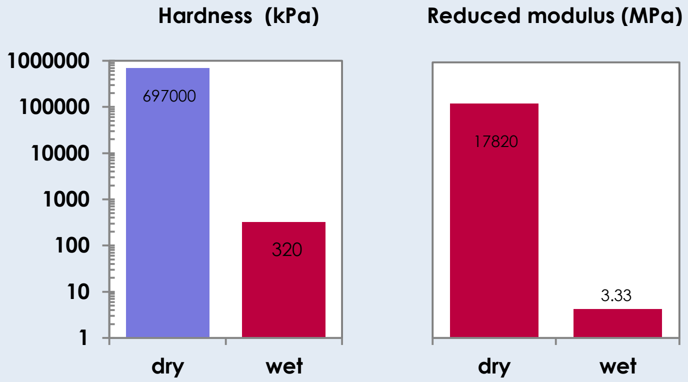


Figure 5 shows that with nanoindentation of a PAA hydrogel in water, the hardness value dropped to the kPa level within minutes of submersion. Similarly the modulus values of the hydrogel are 5300 times lower in water.

Figure 6 shows that the differences between the nanoindentation response of PAA hydrogel under dry and wet conditions are striking. The effect of submerging these samples in water, using The NanoTest Vantage liquid cell, with a 30 second hold at the peak load for creep, shows very significant softening and greatly increased creep during the dwell period, behaviour that is directly comparable to hydrogels tested in wet conditions by MIT *[...for similar work see G. Constantinides et al. / Journal of Biomechanics 41 (2008) 3285-3289]*.

- **Indenter adapter allows indenter to be immersed in cell**
- **Ease of calibration, setup and indenter exchange**
- **Large depth range available**
- **Liquid Cell can be heated to body temperature or above (no issues with steaming the capacitive sensor)**
- **Fluid exchange during experiment is possible (flow cell option)**
- **Automated schedules**

Creep strain and Viscoelasticity

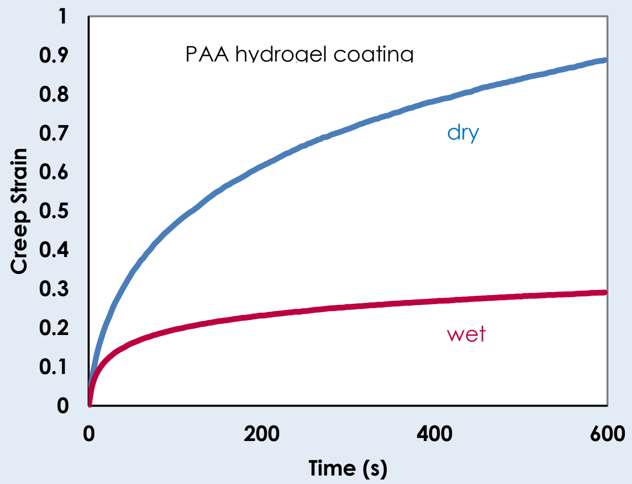


Figure 7 shows that in liquid there is an increase in indentation creep over 600 s. With the high level of stability of The NanoTest Vantage it is possible to look at time dependent properties over long contact times without loss of accuracy from thermal drift.

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