NANOVEA

MECHANICAL PROPERTIES OF HYDROGEL

USING NANOINDENTATION

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INTRODUCTION

Hydrogel is known for its super absorbency of water allowing for a close resemblance in flexibility as natural tissues. This resemblance has made hydrogel a common choice not only in biomaterials, but also in electronics, environment and consumer good applications such as contact lens. Each unique application requires specific hydrogel mechanical properties.

IMPORTANCE OF NANOINDENTATION FOR HYDROGEL

Hydrogels create unique challenges for Nanoindentation such as test parameters selection and sample preparation. Many nanoindentation systems have major limitations since they were not originally designed for such soft materials. Some of the nanoindentation systems use a coil/magnet assembly to apply force on the sample. There is no actual force measurement, leading to inaccurate and non-linear loading when testing soft materials. Determining the point of contact is extremely difficult as the depth is the only parameter actually being measured. It is almost impossible to observe the change of slope in the ***Depth vs Time*** plot during the period when the indenter tip is approaching the hydrogel material.

In order to overcome the limitations of these systems, the nano module of the ***NANOVEA*** Mechanical Tester measures the force feedback with an individual load cell to ensure high accuracy on all types of materials, soft or hard. The piezo-controlled displacement is extremely precise and fast. This allows unmatched measurement of viscoelastic properties by eliminating many theoretical assumptions that systems with a coil/magnet assembly and no force feedback must account for.

MEASUREMENT OBJECTIVE

*In this application, the **NANOVEA** Mechanical Tester, in Nanoindentation mode, is used to study the hardness, elastic modulus and creep of a hydrogel sample.*

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NANOVEA
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TEST CONDITIONS

A hydrogel sample placed on a glass slide was tested by nanoindentation technique using a ***NANOVEA*** Mechanical Tester. For this soft material a 3 mm diameter spherical tip was used. The load linearly increased from 0.06 to 10 mN during the loading period. The creep was then measured by the change of indentation depth at the maximum load of 10 mN for 70 seconds.

***APPROACH SPEED:* 100 µm/min**

CONTACT LOAD	MAX LOAD	LOADING RATE	CREEP
0.06 mN	10 mN	20 mN/min	70 s

INDENTER TYPE

Spherical

3 mm diameter

RESULTS & DISCUSSION

The evolution of the load and depth as a function of time is shown in ***FUGURE 1***. It can be observed that on the plot of the ***Depth vs Time***, it is very difficult to determine the point of the change of slope at the beginning of the loading period, which usually works as an indication where the indenter starts to contact the soft material. However, the plot of the ***Load vs Time*** shows the peculiar behavior of the hydrogel under an applied load. As the hydrogel begins to get in touch with the ball indenter, the hydrogel pulls the ball indenter due to its surface tension, which tends to decrease the surface area. This behavior leads to the negative measured load at the beginning of the loading stage. The load progressively increases as the indenter sinks into the hydrogel, and it is then controlled to be constant at the maximum load of 10 mN for 70 seconds to study the creep behavior of the hydrogel.

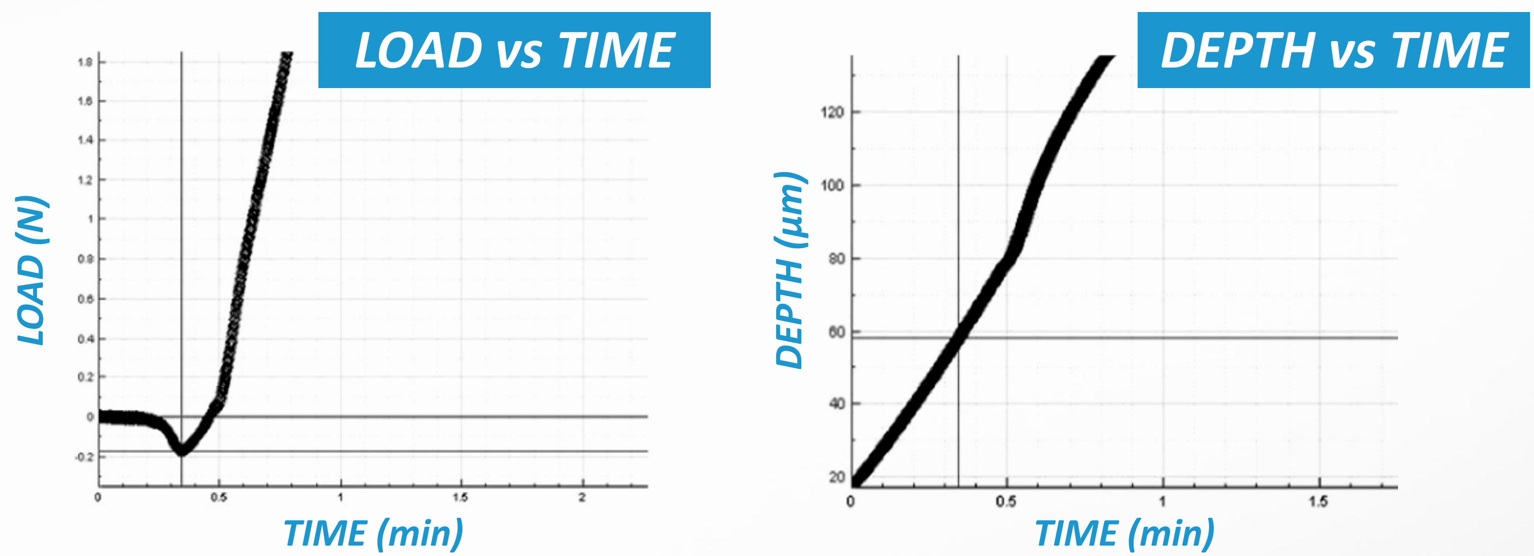


FIGURE 1: Evolution of the load and depth as a function of Time.

The plot of the ***Creep Depth vs Time*** is shown in ***FIGURE 2***, and the ***Load vs. Displacement*** plot of the nanoindenation test is shown in ***FIGURE 3***. The hydrogel in this study possesses a hardness of 16.9 KPa and a Young's modulus of 160.2 KPa, as calculated based on the load displacement curve using the Oliver-Pharr method.

Creep is an important factor for the study of a hydrogel's mechanical properties. The close-loop feedback control between piezo and ultrasensitive load cell ensures a true constant loading during the creep time at the maximum load. As shown in ***FIGURE 2***, the hydrogel subsides ~42 µm as a result of creep in 70 seconds under the 10 mN maximum load applied by the 3 mm ball tip.

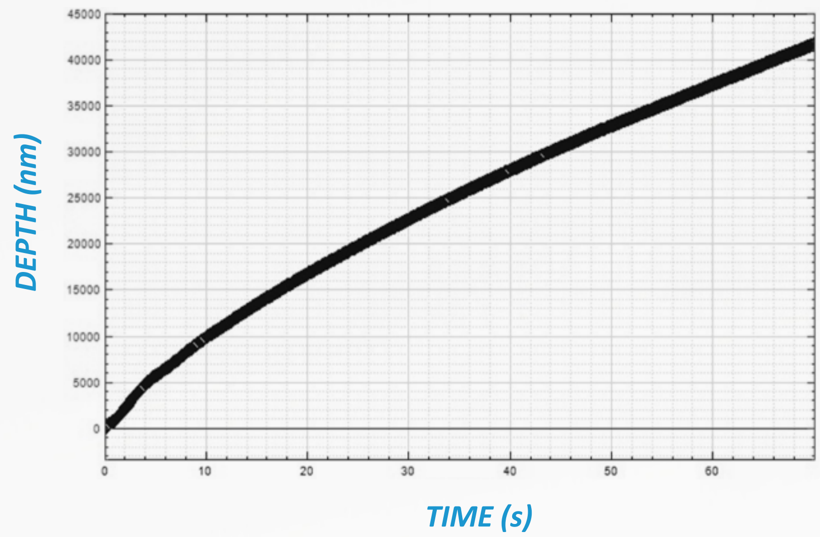


FIGURE 2: Creeping at a max load of 10 mN for 70 seconds.

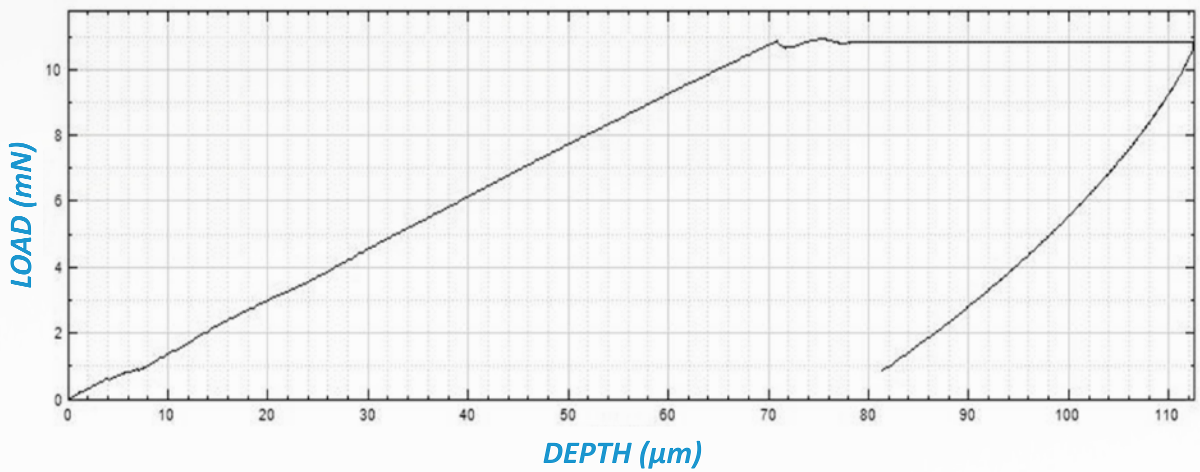
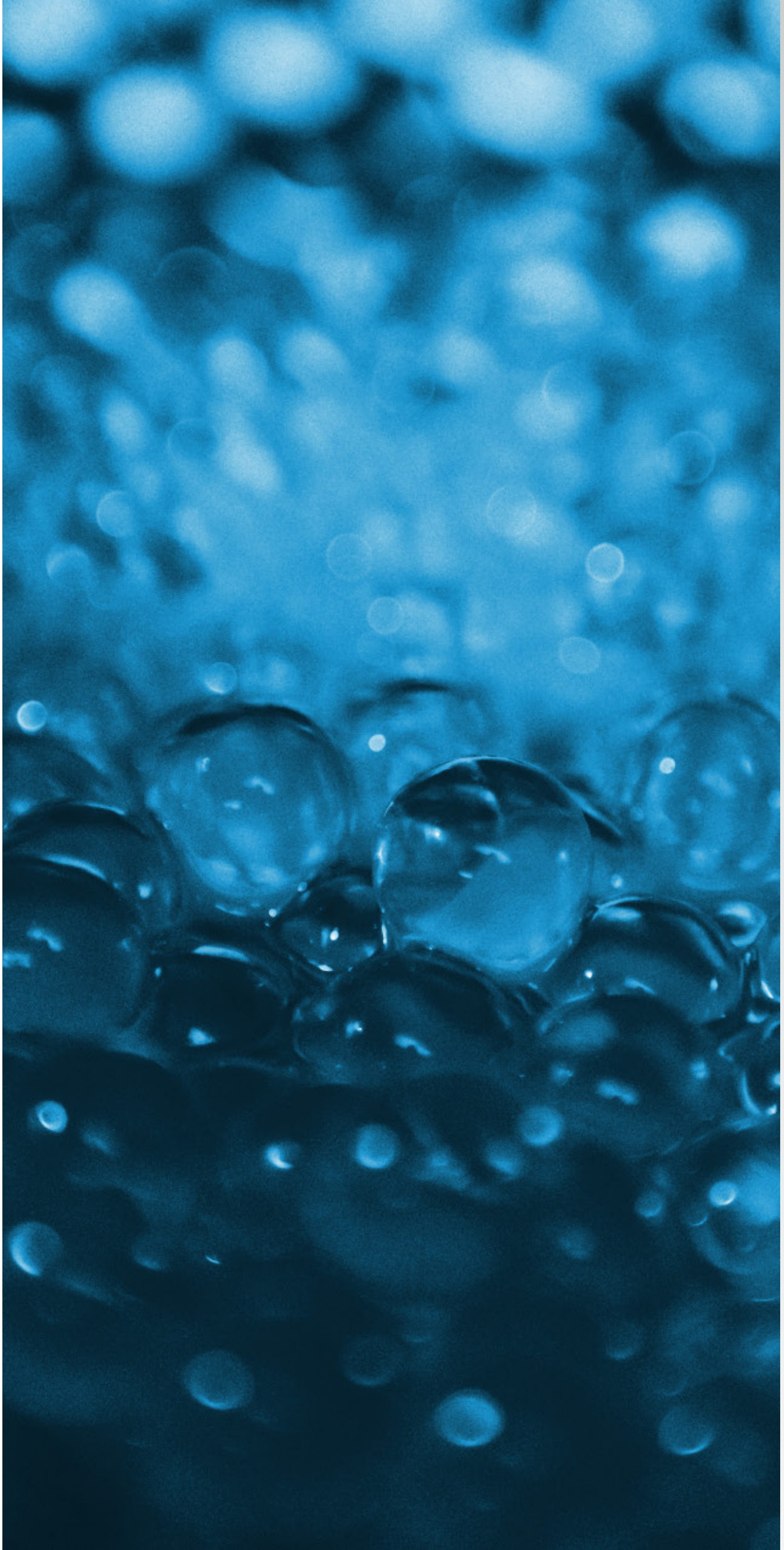


FIGURE 3: The Load vs. Displacement plot of the hydrogel.



CONCLUSION

In this study, we showcased that the ***NANOVEA*** Mechanical Tester, in Nanoindentation mode, provides a precise and repeatable measurement of a hydrogel's mechanical properties including hardness, Young's modulus and creep. The large 3 mm ball tip ensures proper contact against the hydrogel surface. The high precision motorized sample stage allows for accurate positioning of the flat face of the hydrogel sample under the ball tip. The hydrogel in this study exhibits a hardness of 16.9 KPa and a Young's modulus of 160.2 KPa. The creep depth is ~42 µm under a 10 mN load for 70 seconds.

NANOVEA Mechanical Testers provide unmatched multi-function Nano and Micro modules on a single platform. Both modules include a scratch tester, hardness tester and a wear tester mode, offering the widest and the most user friendly range of testing available on a single system.