NANOVEA

CREEP DEFORMATION

OF POLYMERS USING NANOINDENTATION

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INTRODUCTION

As viscoelastic materials, polymers often undergo a time-dependent deformation under a certain applied load, also known as creep. Creep becomes a critical factor when the polymeric parts are designed to be exposed to continuous stress, such as structural components, joins and fittings, and hydrostatic pressure vessels.

IMPORTANCE OF CREEP MEASUREMENT FOR POLYMERS

The inherent nature of viscoelasticity plays a vital role in the performance of the polymers and directly influences their service reliability. The environmental conditions such as loading and temperature affect the creep behavior of the polymers. Creep failures often occur due to the lack of alertness of the time-dependent creep behavior of the polymer materials used under specific service conditions. As a result, it is important to develop a reliable and quantitative test of the viscoelastic mechanical behaviors of the polymers. The Nano module of the ***NANOVEA*** Mechanical Testers applies the load by a high-precision piezo and directly measures the evolution of force and displacement in situ. The combination of accuracy and repeatability makes it an ideal tool for creep measurement.

MEASUREMENT OBJECTIVE

*In this application, we showcased that the **NANOVEA** PB1000 Mechanical Tester in Nanoindentation mode is an ideal tool for studying viscoelastic mechanical properties including hardness, Young's modulus and creep of polymeric materials.*

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NANOVEA
PB1000

TEST CONDITIONS

Eight different polymer samples were tested by nanoindentation technique using the ***NANOVEA*** PB1000 Mechanical Tester.
As the load linearly increased from 0 to 40 mN, the depth progressively increased during the loading stage.
The creep was then measured by the change of indentation depth at the maximum load of 40 mN for 30 s.

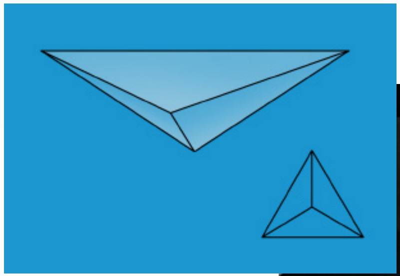
MAXIMUM LOAD 40 mN

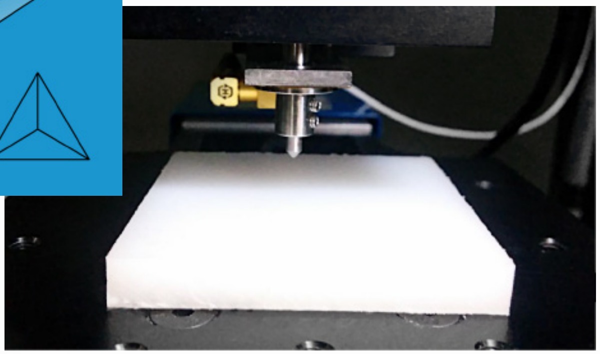
LOADING RATE	UNLOADING RATE	CREEP TIME
80 mN/min	80 mN/min	30 s

INDENTER TYPE

Berkovich

Diamond





* setup of the nanoindentation test

RESULTS & DISCUSSION

The load vs displacement plot of the nanoindentation tests on different polymer samples is shown in ***FIGURE 1*** and the creep curves are compared in ***FIGURE 2***. The hardness and Young's modulus are summarized in ***FIGURE 3***, and the creep depth is shown in ***FIGURE 4***. As an examples in ***FIGURE 1***, the AB, BC and CD portions of the load-displacement curve for the nanoindentation measurement represent the loading, creep and unloading processes, respectively.

Delrin and PVC exhibit the highest hardness of 0.23 and 0.22 GPa, respectively, while LDPE possesses the lowest hardness of 0.026 GPa among the tested polymers. In general, the harder polymers show lower creep rates. The softest LDPE has the highest creep depth of 798 nm, compared to ~120 nm for Delrin.

The creep properties of the polymers are critical when they are used in structural parts. By precisely measuring the hardness and creep of the polymers, a better understanding of the time-dependent reliability of the polymers can be obtained. The creep, change of the displacement at a given load, can also be measured at different elevated temperatures and humidity using the ***NANOVEA*** PB1000 Mechanical Tester, providing an ideal tool to quantitatively and reliably measure the viscoelastic mechanical behaviors of polymers in the simulated realistic application environment.

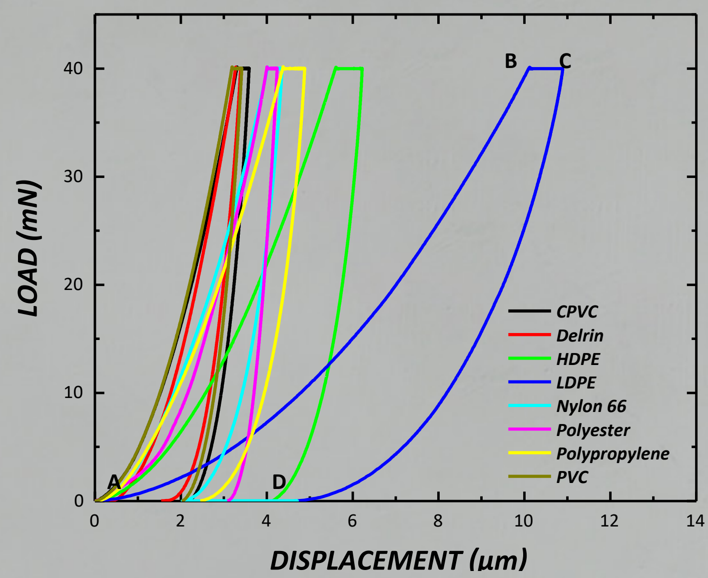


FIGURE 1: *The load vs displacement plots of different polymers.*

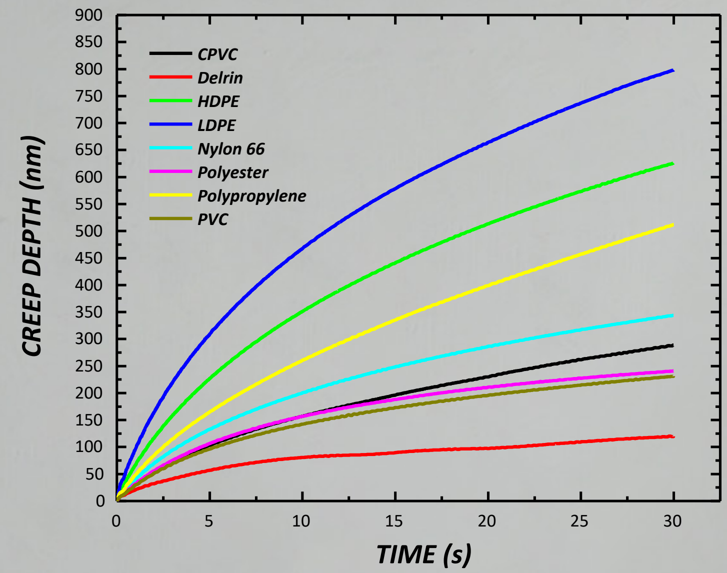


FIGURE 2: *Creeping at a maximum load of 40 mN for 30 s.*

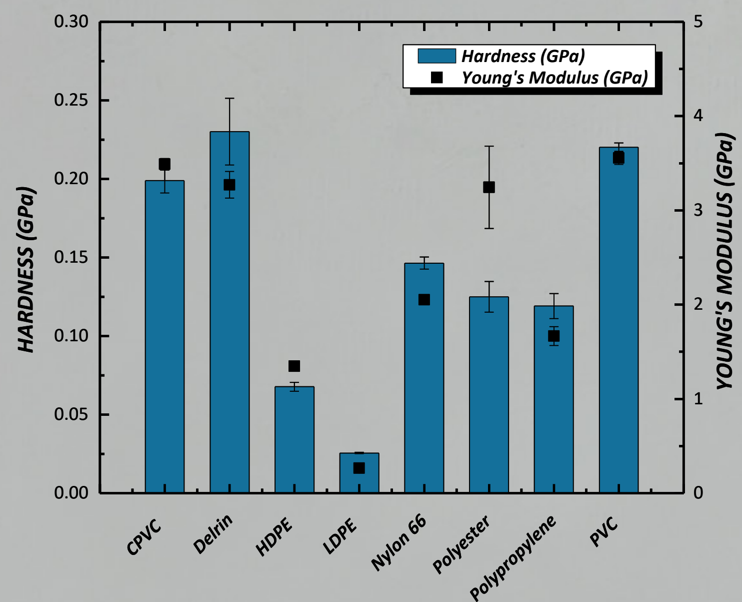


FIGURE 3: *Hardness and Young's modulus of the polymers.*

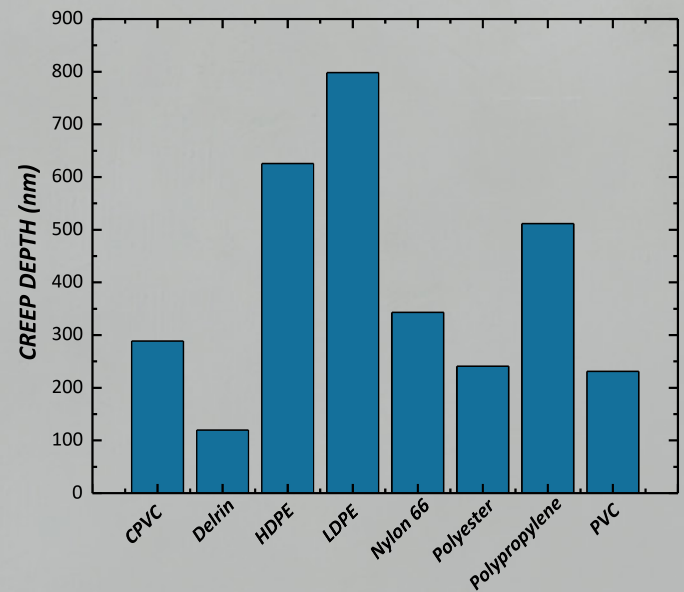


FIGURE 3: *Creep depth of the polymers.*

CONCLUSION

In this study, we showcased that the ***NANOVEA*** PB1000 Mechanical Tester measures the mechanical properties of different polymers, including hardness, Young's modulus and creep. Such mechanical properties are essential in selecting the proper polymer material for intended applications. Derlin and PVC exhibit the highest hardness of 0.23 and 0.22 GPa, respectively, while LDPE possesses the lowest hardness of 0.026 GPa among the tested polymers. In general, the harder polymers exhibit lower creep rates. The softest LDPE shows the highest creep depth of 798 nm, compared to ~120 nm for Derlin.

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