NANOVEA

DYNAMIC MECHANICAL ANALYSIS

OF CORK USING NANOINDENTATION

Prepared by

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INTRODUCTION

Dynamic Mechanical Analysis (DMA) is a powerful technique used to investigate the mechanical properties of materials. In this application, we focus on the analysis of cork, a widely used material in wine sealing and aging processes. Cork, obtained from the bark of the Quercus suber oak tree, exhibits distinct cellular structures that provide mechanical properties resembling synthetic polymers. In one axis, the cork has honeycomb structure. The two other axes are structured in multiple rectangular-like prisms. This gives cork different mechanical properties depending on the orientation being tested.

IMPORTANCE OF DYNAMIC MECHANICAL ANALYSIS (DMA) TESTING IN ASSESSING CORK MECHANICAL PROPERTIES

The quality of corks greatly relies on their mechanical and physical properties, which are crucial for their effectiveness in wine sealing. Key factors determining cork quality include flexibility, insulation, resilience, and impermeability to gas and liquids. By utilizing dynamic mechanical analysis (DMA) testing, we can quantitatively assess the flexibility and resilience properties of corks, providing a reliable method for evaluation.

The ***NANOVEA*** PB1000 Mechanical Tester in the Nanoindentation mode enables the characterization of these properties, specifically Young's modulus, storage modulus, loss modulus, and tan delta (tan (δ)). DMA testing also allows for the collection of valuable data on phase shift, hardness, stress, and strain of the cork material. Through these comprehensive analyses, we gain deeper insights into the mechanical behavior of corks and their suitability for wine sealing applications.

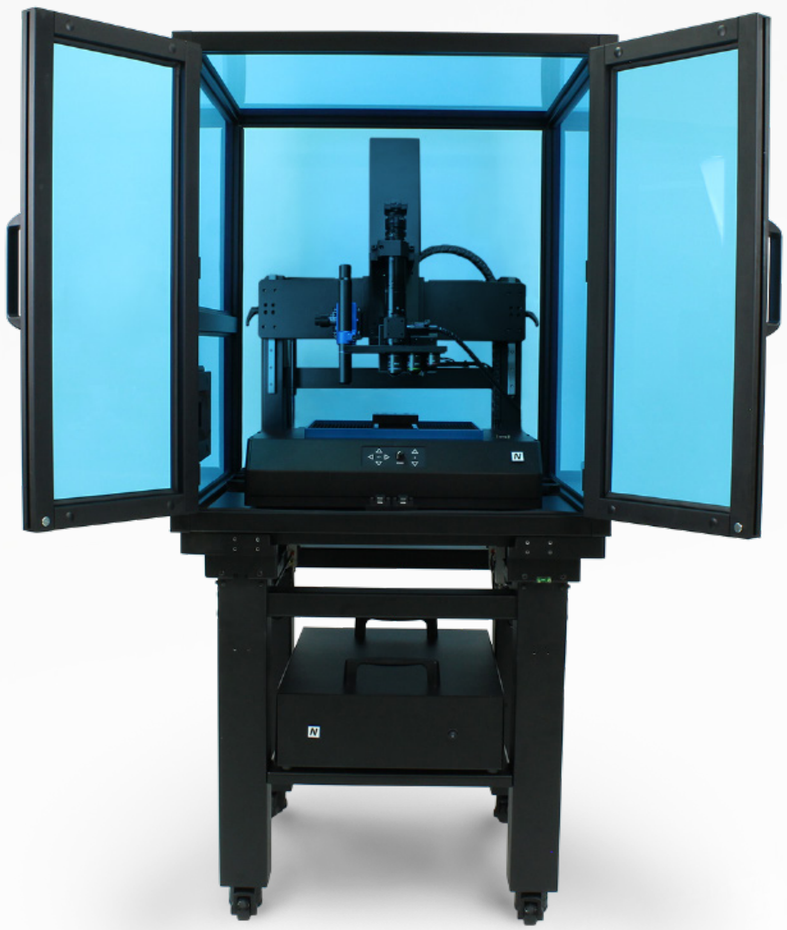
MEASUREMENT OBJECTIVE

*In this study, perform dynamic mechanical analysis (DMA) on four cork stoppers using the **NANOVEA** PB1000 Mechanical Tester in the Nanoindentation mode. The quality of the cork stoppers is labeled as: 1 – Flor, 2 – First, 3 – Colmated, 4 – Synthetic rubber. DMA indentation tests were conducted in both the axial and radial directions for each cork stopper.*

By analyzing the mechanical response of the cork stoppers, we aimed to gain insights into their dynamic behavior and evaluate their performance under different orientations.

NANOVEA PB1000

Large Platform Mechanical Tester



TEST PARAMETERS

ASTM E-2546 & Oliver & Pharr

MAX FORCE .... 75 mN

LOADING RATE .... 150 mN/min

UNLOADING RATE .... 150 mN/min

AMPLITUDE .... 5 mN

FREQUENCY .... 1 Hz

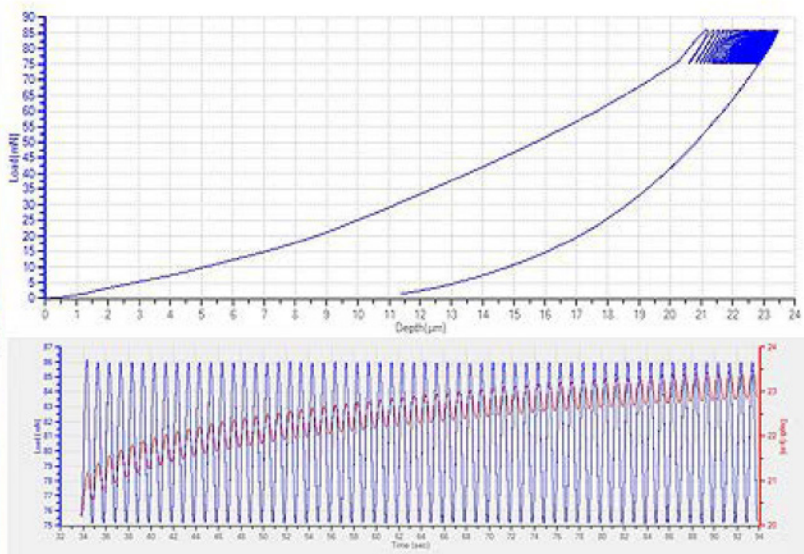
CREEP .... 60 s

INDENTER TYPE

Ball

51200 Steel

3 mm Diameter



RESULTS

In the tables and graphs below, the Young's modulus, storage modulus, loss modulus, and tan delta are compared between each sample and orientation.

Young's modulus: Stiffness; high values indicate stiff, low values indicate flexible.
Storage modulus: Elastic response; energy stored in the material.
Loss modulus: Viscous response; energy lost due to heat.
Tan (δ): Dampening; high values indicate more dampening.

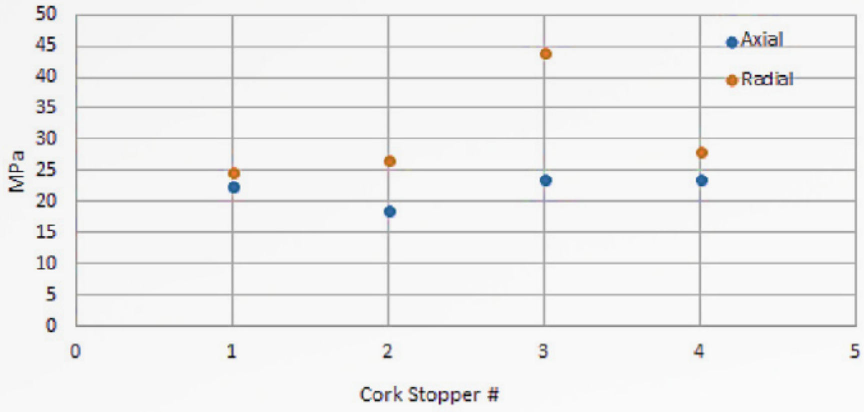
AXIAL ORIENTATION

Stopper #	YOUNG'S MODULUS (MPa)	STORAGE MODULUS (MPa)	LOSS MODULUS (MPa)	TAN (δ)
1	22.5675	22.27209	3.624947	0.162964
2	18.54664	18.27153	3.162349	0.17409
3	23.75381	23.47267	3.617819	0.154592
4	23.6972	23.58064	2.347008	0.099539

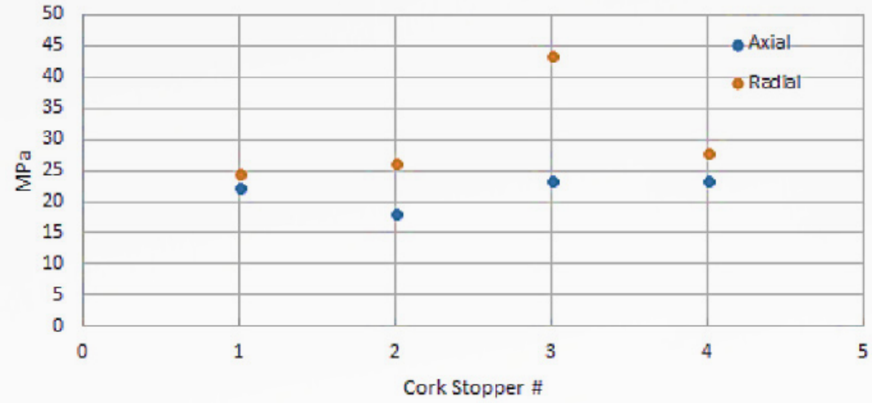
RADIAL ORIENTATION

Stopper #	YOUNG'S MODULUS (MPa)	STORAGE MODULUS (MPa)	LOSS MODULUS (MPa)	TAN (δ)
1	24.78863	24.56542	3.308224	0.134865
2	26.66614	26.31739	4.286216	0.163006
3	44.07867	43.61426	6.365979	0.146033
4	28.04751	27.94148	2.435978	0.087173

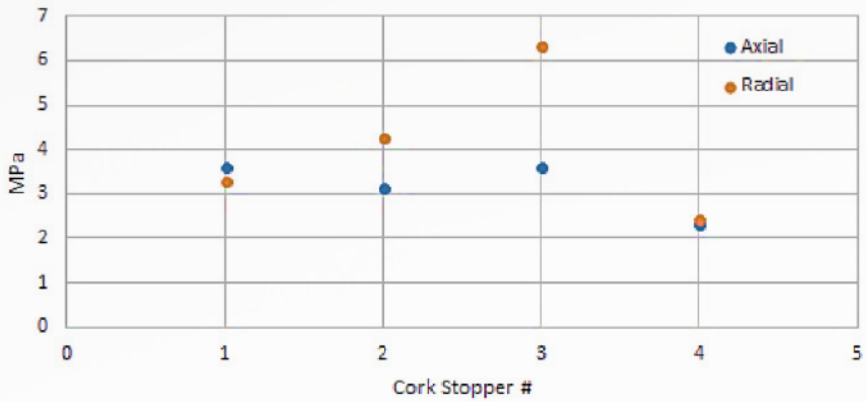
YOUNG'S MODULUS



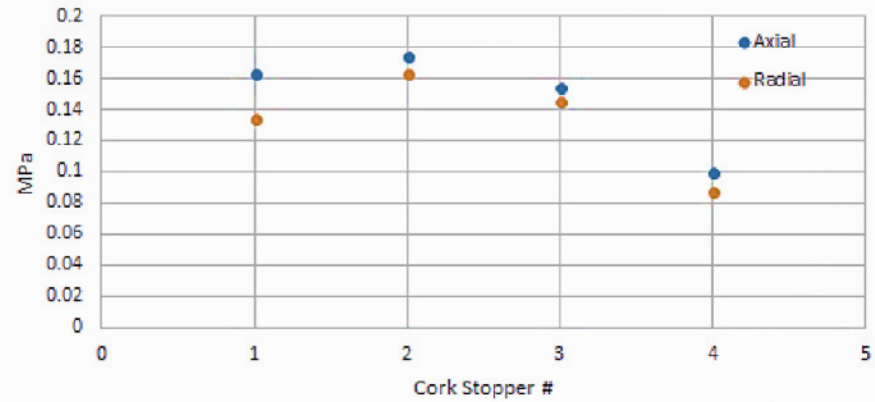
STORAGE MODULUS



LOSS MODULUS



TAN DELTA



Between cork stoppers, the Young's modulus is not very different when tested in the axial orientation. Only Stopper #2 and #3 showed an apparent difference in the Young's modulus between the radial and axial direction. As a result, the storage modulus and loss modulus will also be higher in the radial direction than in the axial direction.

Stopper #4 shows similar characteristics with the natural cork stoppers, except in the loss modulus. This is quite interesting since it means the natural corks has a more viscous property than the synthetic rubber material.

CONCLUSION

The ***NANOVEA*** Mechanical Tester in the Nanoindentation mode successfully conducted dynamic mechanical analysis (DMA) tests on the four cork stopper samples, assessing them in two different orientations. Our analysis involved comparing values for Young's modulus, storage modulus, loss modulus, and tan delta (tan (δ)) across the samples and orientations. Notably, the orientation exhibited significant effects on certain samples but not all.

NANOVEA Mechanical Testers offer comprehensive indentation tests and scratch tests enabling users to further explore mechanical properties of their samples, such as fracture toughness, yield strength, creep, delamination, and scratch hardness.

By leveraging the power of ***NANOVEA***s advanced materials testing capabilities, researchers and industries can deepen their understanding of materials and optimize their performance based on comprehensive mechanical characterizations.