Characterization of Muscle Tissue Using DMA Immersion Studies

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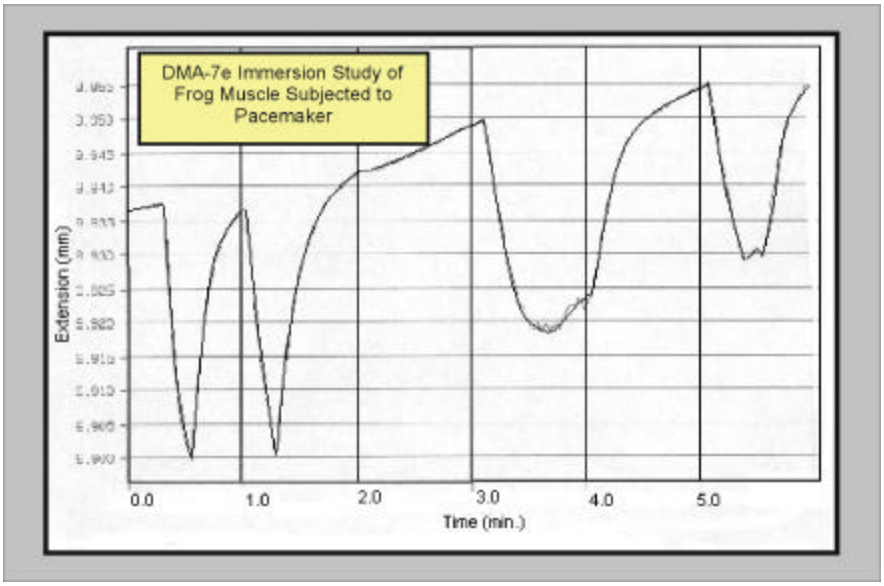
Background

A company, which manufactures heart pacemakers, desires to have a means of generating a 3-dimensional model of the heart with regards to the force and movement of the muscle contractions when an electrical stimulus is applied. The scientists wish to be able to characterize the movement of the muscle in a saline solution, which would approximate the real-life conditions to which the tissue is exposed. The overall goal is to be able to design a better heart pacemaker based on results from *in vitro* testing of the muscle tissue.

Solution

Dynamic mechanical analysis (DMA) is a very powerful tool for the study of a wide variety of materials, including thermoplastics, thermosets, elastomers, fibers, films, gels and foams. In the growing biomedical field, DMA has been successfully utilized to study animal and plant tissues. The technique measures important properties including:

- stiffness or storage modulus (E') as a function of temperature
- damping or loss modulus (E")
- coefficient of internal friction or tan delta (E"/E')
- softening temperatures or Tg
- gel times or temperatures
- minimum viscosity of materials
- impact resistance
- brittleness
- aging effects
- creep and stress relaxation



The state-of-the-art PerkinElmer DMA-7e provides an ideal means of characterizing the properties of materials. The important features of the DMA-7e are:

- high sensitivity for the detection of very weak transitions
- ability to immerse samples in a fluid bath, with vertical downward sample mounting, to easily determine long term effects of solvents and fluids and to perform *in vitro* studies
- wide temperature range (-170 to 1000 C) for complete characterization of high performance materials
- stable performance for reliable and reproducible measurements
- TMA (thermomechanical analysis) operation
- unparalleled range of testing probes to handle a wide range of applications and sample geometries ranging from single fibers to composite rods and bars
- ease of sample mounting with *UniMount* measuring technology
- unparalleled temperature performance with *IsoSink* temperature control
- ease of use with *Pyris Software for Windows*™

One of the most powerful applications of DMA is performing immersion studies, where the properties of a sample are studied directly in a solvent or fluid. Tissues can be studied in the immersion bath to approximate conditions to which

PerkinElmer™ instruments.

the tissue is exposed. The downward sample loading of the PerkinElmer DMA-7e makes the analyses of immersed samples much easier and much less troublesome than top loaded DMA instruments, where there is a real danger of the fluid flowing down into the drift shaft and into the force and strain transducers.

In this study, a specimen of frog leg muscle was analyzed in the elongational mode of the PerkinElmer DMA-7e. The studies were conducted under isothermal conditions (at 25 C) in an immersion bath that contained saline solution. The tissue was connected to a pacemaker and an electrical stimulus (3 volts in one millisecond pulses) was applied to the muscle. The resulting contractions of the muscle were detected by operating the DMA-7e in the TMA mode to measure the dimensional changes in the muscle.

The results displayed in the figure show the dimensional changes that occur in the muscle, due to contraction (downward orientation) and subsequent relaxation (upward orientation), as the electrical stimulus is applied via the pacemaker. The data between 0 and 2 minutes represents a rate of 50 bmp while that between 3 and 6 minutes reflects a rate of 100 bmp.

These results demonstrate that the DMA-7e can monitor the actual contraction and relaxation of the muscle as an electrical stimulus is applied while immersed in a saline solution. This information is valuable for the better understanding of the effects of the pacemaker stimulus for heart muscle.

Summary

The PerkinElmer DMA-7e permits characterization studies to be performed on material immersed in a solution or solvent. This is useful for biomedical research purposes, where the properties of tissue or muscle can be assessed under conditions, which mimic real-life conditions. In this study, the contraction and relaxation of frog leg muscle were assessed using the TMA mode of the DMA-7e while the muscle (immersed in a saline solution) was subjected to an electrical stimulus from a pacemaker. The downward design of the DMA-7e is ideal for immersion or *in vitro* studies as this minimizes the risk of damage occurring if the solution should run out of the immersion bath during the analysis.

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