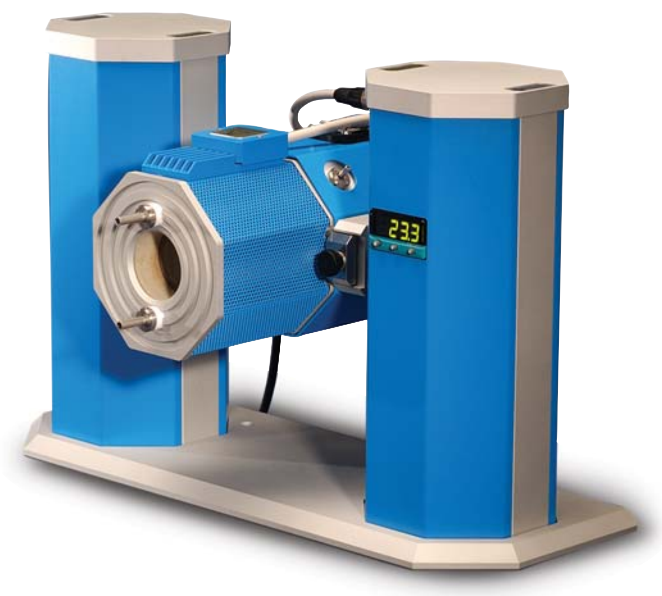
Investigation Into the Tg of Foams



Summary

This application note describes an experiment on a polyurethane foam. The sample was investigated in compression mode of the PerkinElmer® DMA 8000 as it is relatively soft. The Tg was observed in the modulus and tan δ data. The glass transition of polyurethane is especially important, depending on its usage, as in normal applications like packaging or furnishings it needs to be in its rubbery state to provide the desired characteristics.

Introduction

Dynamic Mechanical Analysis (DMA) is one of the most appropriate methods to investigate relaxation events. The glass transition (Tg) is a key process in any material and is sometimes referred to as the α relaxation. Polyurethane foam is used for multiple applications that normally center on its shock absorption properties. Examples are packaging, footwear, furnishings, etc. In order to absorb energy, it is important that the foam is in its rubbery state. In its glassy state, the material will be rigid and very friable due to the large proportion of void space in the structure. It is therefore very important to characterize the Tg very well.

Experimental

Temperature scan of Polyurethane foam

A sample of polyurethane was cut from a larger sheet. It was mounted in compression mode in the DMA 8000 with a small static load to hold it in place. It was cooled with LN2 to -80 °C. The experiment was started and data collected.

Equipment	Experimental Conditions	
DMA 8000 1L Dewar	Sample:	Polyurethane Foam
	Geometry:	Compression
	Dimensions:	4 (l) x 11 (w) x 11 (t) mm
	Temperature:	-80 °C to 100 °C at 5 °C min^{-1}
	Frequency:	1.0 Hz

DMA works by applying an oscillating force to the material and the resultant displacement of the sample is measured. From this, the stiffness can be determined and the modulus and tan δ can be calculated. Tan δ is the ratio of the loss modulus to the storage modulus. By measuring the phase lag in the displacement compared to the applied force it is possible to determine the damping properties of the material. Tan δ is plotted against temperature and the glass transition is normally observed as a peak since the material will absorb energy as it passes through the glass transition.

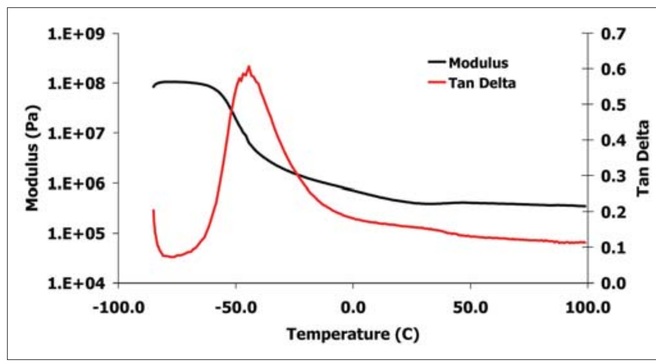


Figure 1. Tan δ and modulus response from polyurethane sample

Results and conclusion

Figure 1 shows the tan δ and modulus response from the polyurethane sample. The Tg located around -40 °C is shown as a peak in tan δ and a drop in storage modulus. Note, the modulus drops from 108 to below 106 Pa representing a large change. For most applications, this material will require a low modulus to operate effectively (as a shock absorbing or cushioning material). Clearly it will not be effective if the temperature of its environment is below its Tg, i.e. in the glassy range. Hence, the Tg is useful in setting limits on the operation temperature of materials.

PerkinElmer Life and Analytical Sciences
710 Bridgeport Avenue
Shelton, CT 06484-4794 USA
Phone: (800) 762-4000 or
(+1) 203-925-4602
www.perkinelmer.com

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