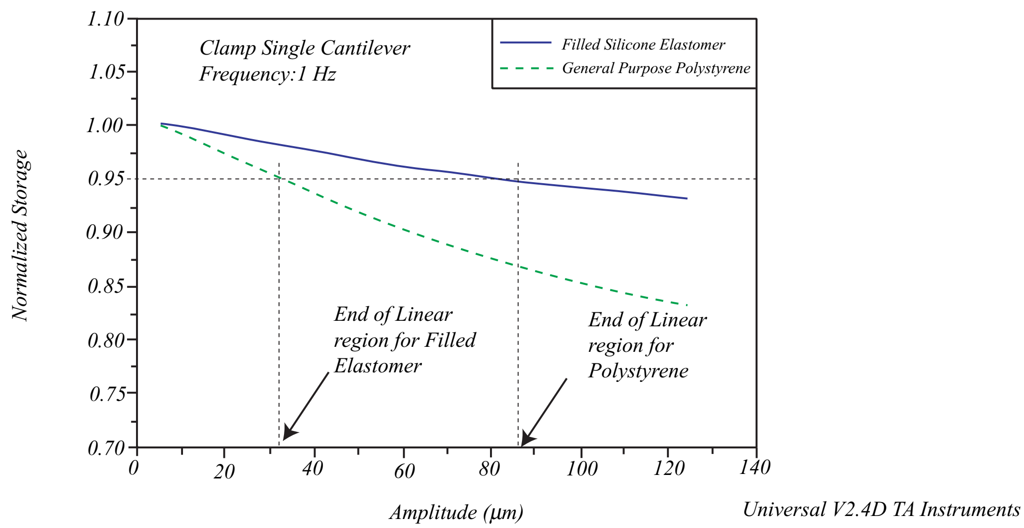
TA Instruments

Thermal Analysis & Rheology

# THERMAL SOLUTIONS

## *Determination of the Linear Viscoelastic Region of a Polymer using a Strain Sweep on the DMA 2980*

Comparsion of Normalized Storaage Modulus for a Filled Silicone Elastomer and a General Purpose Polystyrene




Dynamic mechanical analysis DMA is a very powerful technique which allows for determination of mechanical properties (modulus and damping), detection of molecular motions (transitions), and for the development of morphology relationships (crystallinity, molecular weight, crosslinking, etc).[1] In DMA, a sinusoidal deformation is applied to a sample at a specified frequency/ies and the materials response is measured. In order to use DMA to accurately determine mechanical properties and develop morpholigical relationships, the material must be deformed at an amplitude that is within the linear viscoelastic region of the material. Within the linear viscoelastic region, the materials response is independent of the magnitude of the deformation and the materials structure is maintained in tact (unbroken). Characterization of the material within the linear region yields a "fingerprint" of the structure of the polymer. Therefore, any differences in the structure of polymers can easily be measured as differences in the dynamic mechanical properties. Special care should be given when selecting an amplitude for a DMA test. As a general rule of thumb, solids are linear at strains less then 0.1% (0.001 strain units). However, this is a general rule and may not apply to all samples so the linear region may require verification. The linear region can be measured for a material using a strain sweep test. In a strain sweep test, the frequency of the test is fixed and the amplitude is incrementally increased. To determine the linear viscoelastic region, the storage modulus should be plotted against the amplitude as the amplitude is the control variable in the DMA 2980. To find the end of the linear region, a good rule is to find the amplitude at which the initial value of the storage modulus changes by 5% (eg. the storage modulus at the lowest amplitude in the sweep).

The figure above shows a comparison of normalized storage modulus versus amplitude for a polystyrene and a filled silicone elastomer sample. The storage modulus was normalized for comparative purposes. It can be seen in the figure above that the polystyrene sample has a much longer linear region as compared to the filled elastomer. After finding the linear region, subsequent scans should be conducted at amplitudes within the linear viscoelastic region.


1.Reference: Turi, Edith A., Thermal Characterization of Polymeric Materials, Second Edition, Volume I., Academic Press, Brooklyn, New York, 1997, P. 980.