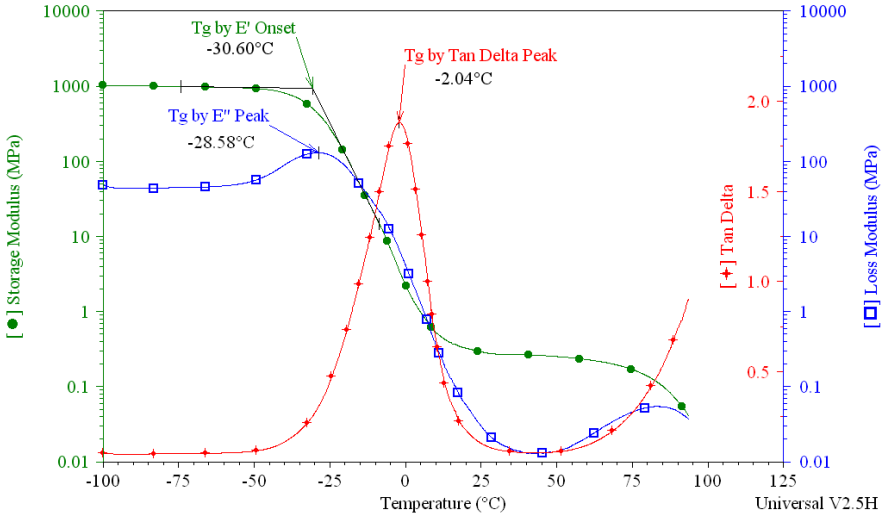
THERMAL SOLUTIONS

Measurement of the Glass Transition Temperature Using Dynamic Mechanical Analysis



One of the most fundamental measurements made on polymeric materials is the measurement of the glass transition, T_g. In general, transitions in materials are associated with different localized or medium-to long-range cooperative motions of molecular segments. The glass transition is associated with cooperative motion among a large number of chain segments, including those from neighboring polymer chains.[1] Although there are several thermal techniques available to make T_g measurements, by far the most sensitive technique is dynamic mechanical analysis, DMA. DMA measures the viscoelastic moduli, storage and loss modulus, damping properties, and tan delta, of materials as they are deformed under a period (sinusoidal) deformation (stress or strain).

After scanning the sample under test, any of these three viscoelastic parameters can be used to define the T_g. The figure above shows a scan of a pressure sensitive adhesive run in tension clamps, at a frequency of 1 Hz, an amplitude of 10 microns, and a ramp rate of 5°C/min. This figure shows the T_g labeled for sample using the following parameters:

- **E' Onset**: Occurs at the lowest temperature and relates to mechanical failure.[1]
- **E: Peak**: Occurs at the middle temperature and is more closely related to the physical property changes attributed to the glass transition in plastics. It reflects molecular processes and agrees with the idea of T_g as the temperature at the onset of segmental motion.[1]
- **Tan Delta Peak**: Occurs at the highest temperature and is used historically in literature. It is a good measure of the "leathrer like" midpoint between the glassy and rubbery states of a polymer. The height and shape of the tan delta peak change systematically with amorphous content.[1]

The parameter used to detect the glass transition should be reported along with the frequency of oscillation, the temperature ramp rate, the clamp type used, and the sample dimensions. (For additional information see TS-62 Effect of Frequency on the Modulus and Glass Transition Temperature of PET).

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