SABIC
Innovative
Plastics™

Dynamic Mechanical Analysis

Dynamic Mechanical Analysis (DMA):
- Shows how the modulus (stiffness) E’ or G’ varies with temperature.
- Identifies mechanical transitions in solid polymers (Tg, Tm).
- Defines useful thermal range for property retention
- Indicates degree of crystallinity by the value of E’ above Tg.
- Allows prediction of heat distortion and softening temperatures.
- Gives an easy comparison of material performance over a range of temperatures.
- Measures the elastic and viscous response of a material to an oscillating mechanical load over a broadtemperature range and a fixed frequency.

Storage modulus (E’ or G’) - Also called the elastic modulus. The recoverable portion of applied mechanical energy. It is a measure of the stiffness of a plastic material. Reported in pounds per square inch (psi) or mega Pascals (MPa).

Loss modulus (E” or G”) - The viscous damping modulus. The portion of applied mechanical energy that is dissipated or lost to heating. Reported in psi or MPa.

Tan delta - Ratio of the loss modulus to the storage modulus E”/E’ or (G”/G’). A sensitive measure of the magnitude and temperature of transitions (Tan Delta is the tangent of the phase angle between the input and responsewaves).

Melt temperature (Tm) - The temperature where a crystalline polymer changes from an elastic solid to a viscous liquid.

Glass transition temperature (Tg) - The temperature at which amorphous segments change from a glassy to a rubbery state upon heating. Evidenced by a peak in Tan . (In amorphous polymers E’ or G’, becomes smaller than E” or G”). The elastic modulus in tension (E’) and elastic modulus in shear (G’) are related by the following equation $E' = 2 (1 + v) G'$ where v is Poisson’s ratio.

Typical amorphous polymer
*Based on internal SABIC Innovative Plastics test data.
Figure 1 shows the change in modulus and Tan Delta with temperature for a typical amorphous polymer.

These plots are based on internal SABIC Innovative Plastics test data.
- The storage modulus gradually decreases with increasing temperature up to Tg.
- Heat Distortion Temperature (HDT) is close to Tg.

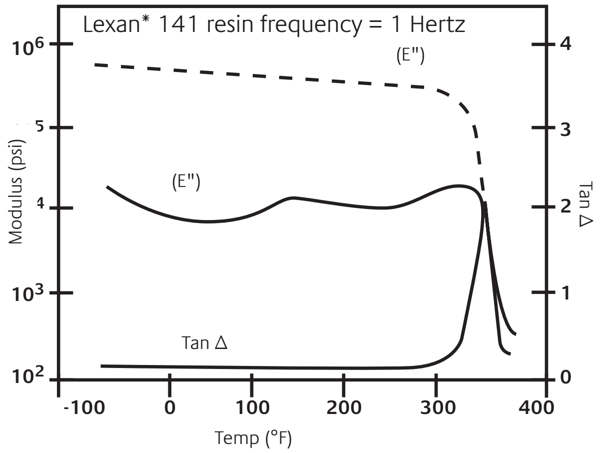

Figure 1

Typical crystalline polymer

A typical crystalline polymer shows temperature dependence of the kind shown in Figure 2.

- Storage modulus drops significantly at Tg, but material stiffness is maintained through Tm.
- Magnitude of drop in E' through Tg indicates the degree of crystallinity (small drop indicates high crystallinity).
- The degree of crystallinity affects the magnitude of drop in E' through Tg. (higher crystallinity, smaller drop).

Effect of glass on dynamic mechanical response

Figure 3 shows the change in elastic modulus with temperature for unreinforced Valox* resin and for resins with 30% and 40% glass reinforcement.

- Storage modulus increases as the glass content increases.
- The thermal transition temperatures depend on the resin and do not change with glass content

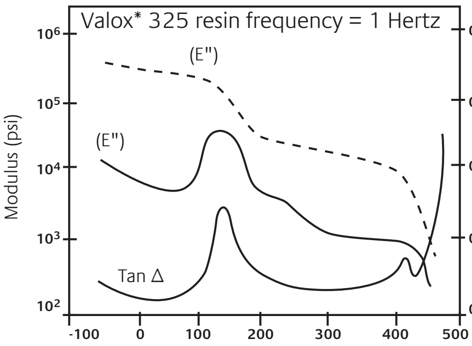

Figure 2

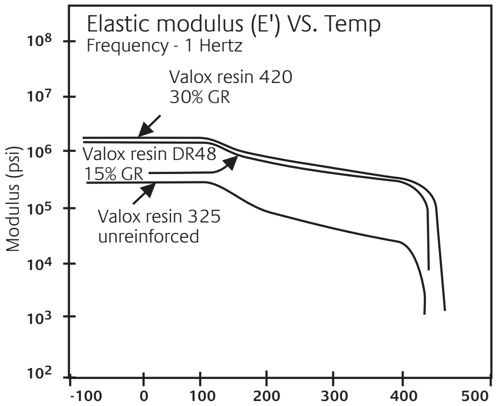

Figure 3

*Based on internal SABIC Innovative Plastics test data.