

Dynamic Mechanical Analysis

Dynamic Mechanical Analysis (DMA):

- Shows how the modulus (stiffness) E' or G' varies with temperature.
- Identifies mechanical transitions in solid polymers (T_g , T_m).
- Defines useful thermal range for property retention
- Indicates degree of crystallinity by the value of E' above T_g .
- 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 response waves).

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

Glass transition temperature (T_g) - The temperature at which amorphous segments change from a glassy to a rubbery state upon heating. Evidenced by a peak in Tan Δ . (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 $E' = 2(1 + \nu)G'$ where ν 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 T_g .
- Heat Distortion Temperature (HDT) is close to T_g .

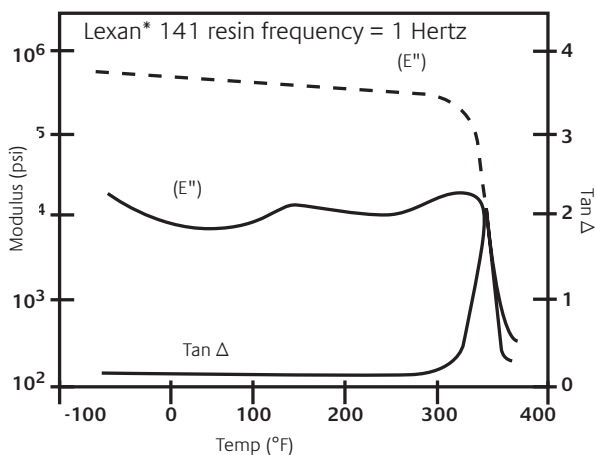


Figure 1

Typical crystalline polymer

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

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

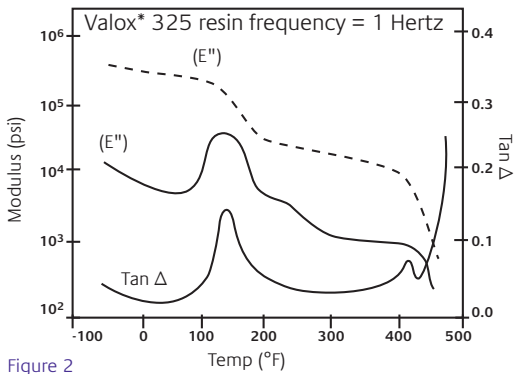


Figure 2

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

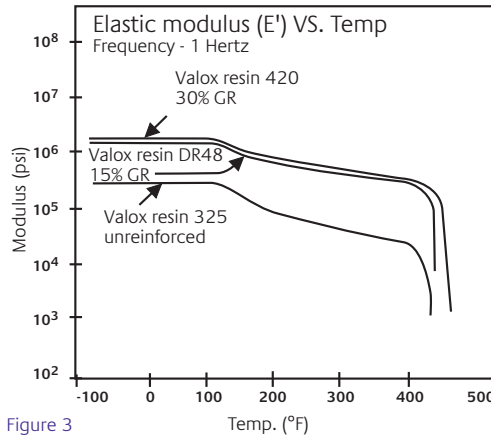


Figure 3

*Based on internal SABIC Innovative Plastics test data.

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