Tg Analysis of Epoxy-Glass Composite Using Dynamic Mechanical Analysis

Introduction

At temperatures below the glass transition (T_g), a composite behaves like a glassy material. At higher temperatures, the composite behaves like a viscoelastic material. The glass transition is often used to identify the temperature range of the glassy to viscoelastic transition.

Purpose

Determine the glass transition temperature range.

Experimental

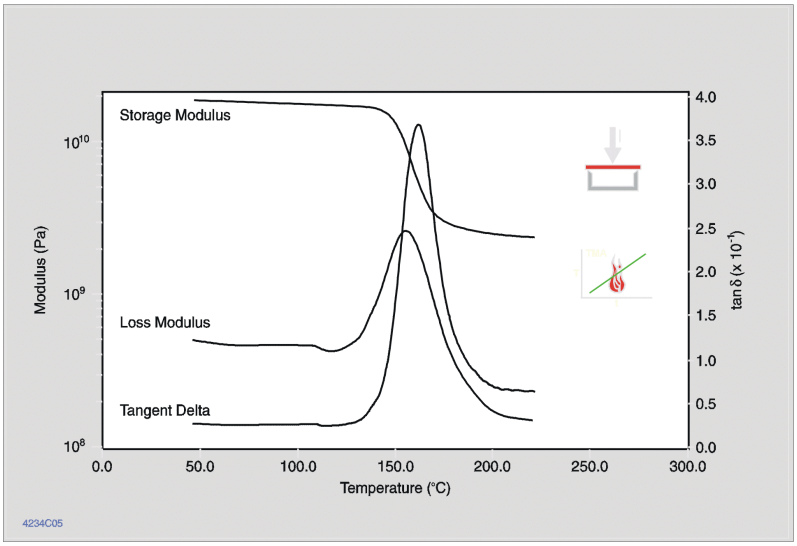
The sample was analyzed using the PerkinElmer DMA 7e Dynamic Mechanical Analyzer. The analyze was equipped with the stainless steel three-point bending measuring system with a 20 mm bending platform and a 10 mm knife edge. The PerkinElmer Pyris Software for Windows was used to program the temperature scan from 50 °C to 225 °C at a heating rate of 2 °C/minute. The sample was cut to 23 mm in length and 3 mm in depth. The sample was placed directly on the three-point bending platform using tweezers. No further sample preparation or clamping was necessary.

Results

Figure 1 is a plot of storage modulus, loss modulus and tangent delta versus temperature. The

DMA 7e Method		
Sample	Epoxy-Glass Composite	
Instrumental	Analyzer Measuring System Geometry	DMA 7e Three-Point Bending Rectangle
Environmental	Purge Coolant	Nitrogen Ice water
Parameters	Method Static Force Dynamic Force Frequency	Temperature Scan 550 mN 500 mN 1 Hz
	Heat from 50°C to 225 at 2°C/min	
Controls	Static	Force
	Dynamic	Force

DMA 7e Scan of an Epoxy-Glass Composite from 50°C to 225°C at 2°C/min.



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changes in the curves indicate the glass transition region in the 120 °C to 175 °C range. The onset of softening of the storage modulus (i.e. indication of the material to store energy) occurred at approximately 125 °C; the peak of tan delta at approximately 136 °C.

A decrease in the storage modulus at approximately 120 °C indicates a decrease in the stiffness of the composite. The decrease occurs because the composite softens from its glassy state - a state dominated by the resin and fiber composite structure. At higher temperatures, the storage modulus finally reaches a minimum value as the contribution from t he resin decreases and the contribution from the fiber increases.

Conclusion

The methodology outlined in this application example may be applied to a wide variety of thermosets, thermoplastics and composites. No special sample preparation is necessary. Further analysis may include parallel plate analysis for the neat resin to determine the gel point or characterize cure. Additional testing may include examination of the beta and gamma transitions as well as frequency dependence. As a further step, TGA can be used to evaluate the moisture content or effect of outgassing that occurs at these temperatures while DSC can be used to confirm the thermal transitions.

References

1. *"Applications of Thermal Analysis in the Electrical and Electronics Industries"*, W. P. Brennan and R. B. Cassel, Thermal Analysis Applications Study No. 25, The Perkin-Elmer Corporation, Norwalk, Connecticut, 1978
2. *"Characterization of Thermosets"*, R. B. Cassel, Thermal Analysis Application Study No. 19, The Perkin-Elmer Corporation, Norwalk, Connecticut, 1977
3. *"Establishing a Correlation Between the Degree of Cure and the Glass Transition Temperature of Epoxy Resins"*, A. P. Gray, Thermal Analysis Applications Study No. 2, The Perkin-Elmer Corporation, Norwalk, Connecticut, 1972

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