

THERMAL SOLUTIONS DETERMINATION OF COMPOSITE CURE

PROBLEM

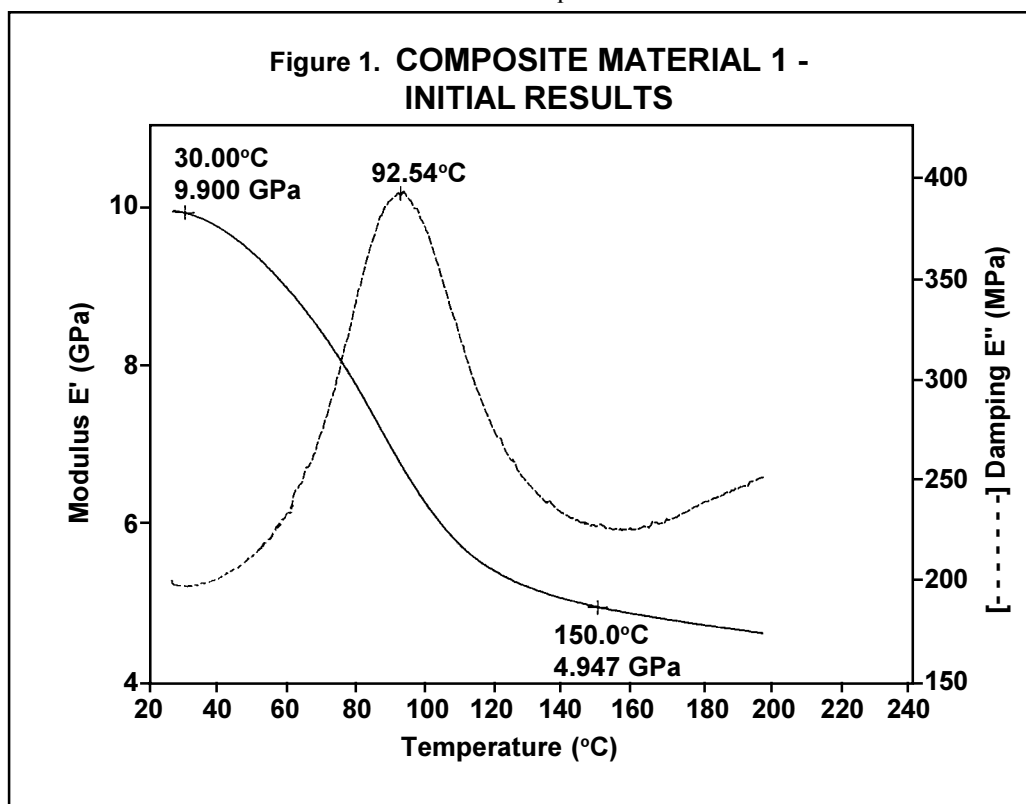
The end-use properties of thermoset composite materials such as brake linings are dependent on the degree of cure achieved during processing. Various thermal analysis techniques can be used to monitor the cure level in thermosets. Differential scanning calorimetry (DSC), for example, can determine cure level based on the amount of additional curing (with associated heat evolution) that occurs on further heating. Cure level can also be determined from the glass transition temperature (T_g) of the material using DSC or thermomechanical analysis (TMA). Unfortunately, in reinforced or heavily filled composites, detection with these techniques may be difficult.

SOLUTION

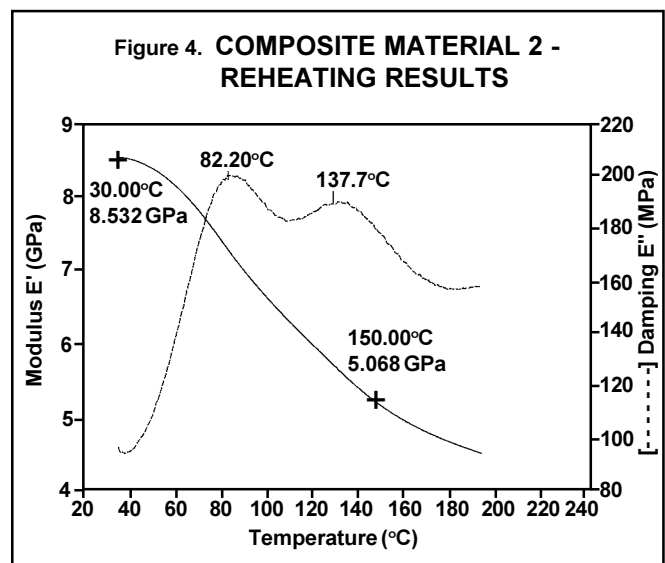
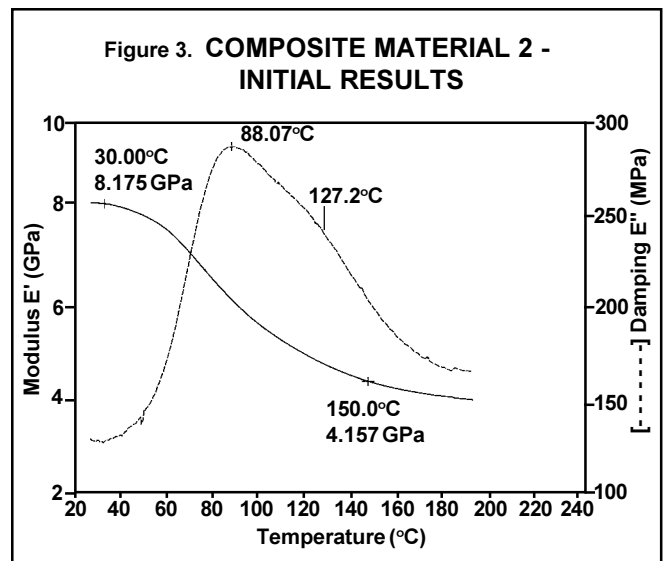
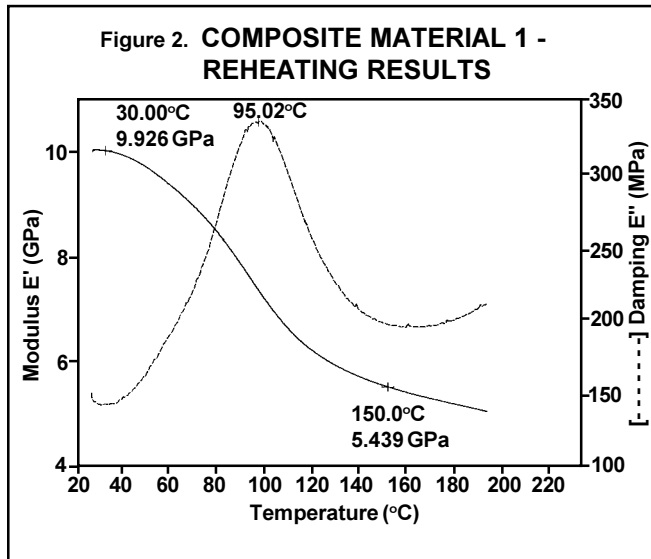
Dynamic mechanical analysis (DMA), which measures the modulus (stiffness) and damping properties of materials, provides a more sensitive alternative for determining the T_g in composites. DMA's sensitivity is based on the significant

change in modulus (several decades) and damping which occurs at the T_g. Figures 1-4 show the DMA results for two composite brake lining materials. [DMA Conditions: Vertical clamps; sample size 41 x 14 x 3.6mm³ (normal); frequency 1 Hz; oscillation amplitude 0.2mm; heating rate 3°C/minute from ambient to 200°C]. The T_g's for both materials are easily observed as the peaks in the damping (loss modulus) profiles. Several conclusions are possible from these results:

- (1) Material 1 has a higher T_g than Material 2 in the "as received" condition, as well as a higher modulus before and after the T_g, probably due to different matrix polymers and/or different reinforcement composition and orientation.
- (2) Reheating Material 1 does not increase the T_g as much as reheating material 2. Hence, Material 1 is initially more fully cured.
- (3) The damping profile for Material 2 has a bimodal distribution indicating two different polymers are present.



(4) Reheating Material 2 causes the modulus before and after T_g to increase and the high temperature damping peak to shift to a higher temperature, indicating that Material 2 is not initially fully cured. The temperature decrease observed for the low temperature damping peak on reheating may indicate some thermal degradation.



Acknowledgement: This brief is based on studies by Jon Foreman in TA Instruments Applications Lab (US)

For more information or to place an order, contact:

TA Instruments, Inc., 109 Lukens Drive, New Castle, DE 19720, Telephone: (302) 427-4000, Fax: (302) 427-4001

TA Instruments S.A.R.L., Paris, France, Telephone: 33-01-30489460, Fax: 33-01-30489451

TA Instruments N.V./S.A., Gent, Belgium, Telephone: 32-9-220-79-89, Fax: 32-9-220-83-21

TA Instruments GmbH, Alzenau, Germany, Telephone: 49-6023-30044, Fax: 49-6023-30823

TA Instruments, Ltd., Leatherhead, England, Telephone: 44-1-372-360363, Fax: 44-1-372-360135

TA Instruments Japan K.K., Tokyo, Japan, Telephone: 813-5434-2771, Fax: 813-5434-2770

Internet: <http://www.tainst.com>

TA Instruments
 Thermal Analysis & Rheology
 A SUBSIDIARY OF WATERS CORPORATION