Research Project: Nano particle reinforced composites for critical infrastructure protection

Research Topic: Dynamic Mechanical Analysis (DMA)

Problem

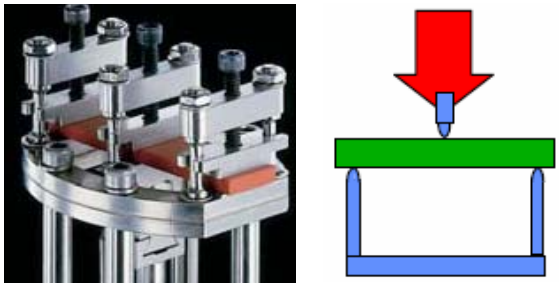
Computer modeling of infrastructure systems subject to various loading conditions requires material properties as input. DMA is an experimental technique that is particularly useful for evaluating polymeric materials, which exhibit time, frequency, and temperature effects on the mechanical properties because of their viscous nature.

Approach

Dynamic Mechanical Analysis is a powerful technique that allows for the storage and loss modulus, damping and glass transition properties of viscoelastic materials to be characterized in the frequency domain by subjecting small samples to an oscillatory load under a controlled temperature program. At the onset of glass transition, the increase in molecular motion within these materials results in a dramatic step decrease in the storage modulus with a simultaneous increase in the damping (loss factor) values. Peaks of the tan delta or loss modulus curves are found to be sensitive indicators of glass transition temperature and are associated with the impact properties of elastomeric materials. The time-temperature superposition principle is also employed for characterizing the long-term behavior of polymeric material systems.

Findings

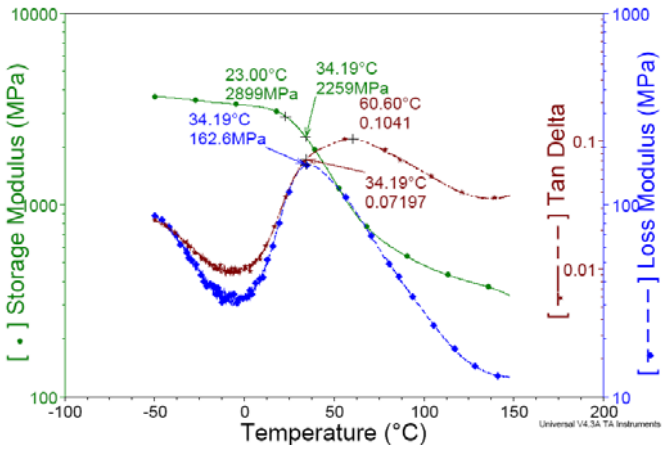
The figure below shows a typical test configuration of a *TA Instruments* Model Q800 DMA being used at the University of Mississippi for characterizing the viscoelastic response along with the long term creep and stress relaxation behavior of various thermoplastic and thermoset resins reinforced with carbon nano tubes, nanoclay and graphite platelets.



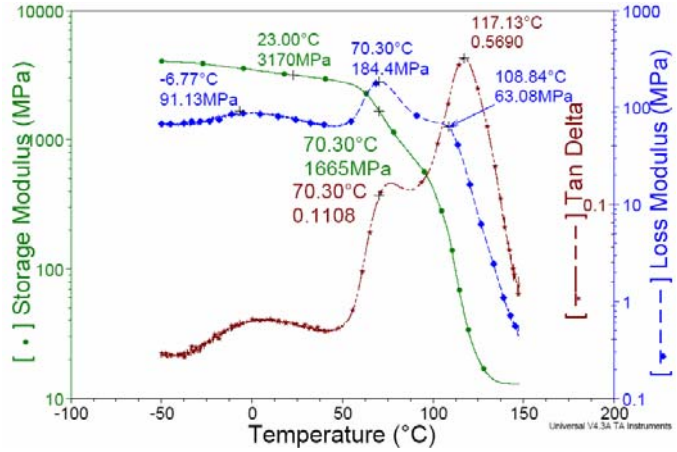
3 point bend testing in DMA

This is an ongoing research and at this stage the following has been accomplished:

Constant strain test with temperature ramp from -50 C to 150 C at a frequency of 1 Hz using 3 point bend clamp was done on nylon 6,6 and vinyl ester with nano reinforcements. Storage and loss modulus, glass transition temperature and loss factors were calculated for nylon 6,6 composites with different weight fractions of MWCNT reinforcements. The modulus, tan delta, and Tg for 1.25% nanoclay/vinylester as a function of temperature obtained with the TA Q800 DMA are also shown in the figure.



Typical output of pure nylon 6,6



Typical output of 1.25% nanoclay/ vinyl ester

Impact

Experimental results from DMA can be used to obtain parameters that are needed for theoretical modeling and computer simulations. Final outcome will be a material data base that can be used for infrastructure protection against various loading conditions.

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