Simple Determination of the Linear Viscoelastic Region of a Polymer Using a Rheometer

Figure 1. Strain sweep of polystyrene at 220 °C and 1Hz oscillation frequency. The plateau modulus was taken as the average from 1 to 10 % strain which shows no change in modulus with increasing strain and qualifies as a plateau. As the strain increases the storage modulus begins to drop. When the storage modulus has dropped by 5 % or more the strain is outside the linear viscoelastic region.

PROBLEM

Materials such as polymers exhibit viscoelastic behavior which is directly related to molecular structure and formulation differences. To accurately evaluate the relationships between molecular structure and viscoelastic behavior requires that experiments, such as rheological measurements, be conducted in regions where the viscoelastic properties observed are independent of imposed stress or strain levels. That is, experiments must be conducted in the linear viscoelastic region.

SOLUTION

A dynamic oscillation approach is used and increasing cyclic levels of stress and strain are applied at a constant frequency. This is a strain sweep. The point at which a dynamic viscoelastic function (usually G', the storage modulus) deviates by more than 5% from a constant (plateau) value indicates departure from linear viscoelastic behavior. Figure 1 illustrates the oscillatory strain sweep results for polystyrene at 1 Hz and 220 °C. Departure from linear behavior occurs at about 5.13 kPa and at about 50.3 % strain. The following test can be programmed in TRIOS to generate similar data with other samples (Figure 2).
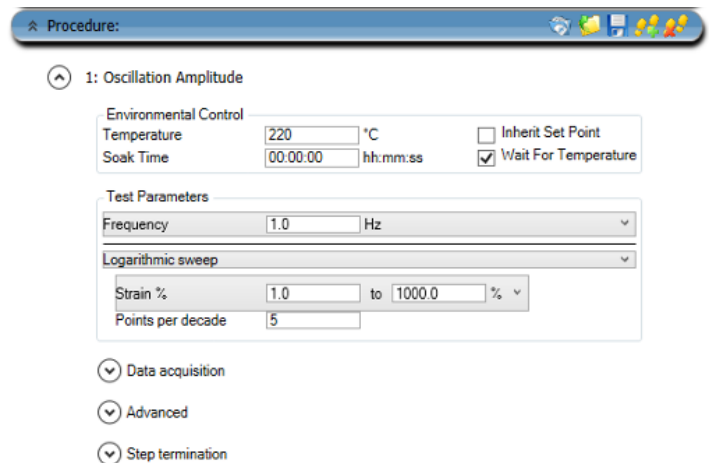

Figure 2. Strain Sweep (Amplitude Sweep) setup in TRIOS to reproduce data in Figure 1 on any rheometer using TRIOS.

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