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Determining dynamic viscoelastic properties without time-temperature shifting

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A novel unbiased procedure to analyze dynamic mechanical data of rheologically simple viscoelastic polymers by modeling the data with the Havriliak and Negami (HN) equation is described. The real and imaginary parts of the HN equation are used to solve for the global frequency-time dependent parameter ($\omega\tau$) for all the data thereby uniquely determining the time- temperature shift function. Displaying the experimental data in the form of a wicket or Argand diagram provides initial estimates for the HN parameters. An unbiased error analysis is performed to minimize the difference between experimental and calculated complex viscoelastic values. Finally the characteristic relaxation time, τb> <0>;, is determined by minimizing the error between the calculated data and experimental data at the reference temperature <T> <0> . Using this procedure, the complete master curve is generated without the need for overlapping frequency data and the procedural error and operator bias associated with time-temperature shifting is eliminated. The technique can also generate a complete frequency spectrum from isochronal temperature scans such as those obtained from a torsion-pendulum, rheovibron or a Dynamic Mechanical Analyzer (DMA) apparatus, which is not otherwise possible.