Viscoelastic Behavior Across the Glass Transition Temperature using Vibrational Testing

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The behavior of bio-based composite materials reinforced with flax fibers as a function of temperature beyond Tg has been very little studied. In this study, our aim is to make a significant theoretical and experimental contribution to this issue. The viscoelastic behavior of the material is described by a complex modulus dependent on the frequency of loading and on temperature.

An original experimental setup was designed to determine the stiffness modulus and the loss factor as a function of temperature, including beyond the glass transition temperature, a range that few standard devices manage to cover reliably. The setup combines regulated heating elements, a specimen excitation system in a clamped-free configuration, a vibration response sensor, a data acquisition chain, as well as thermal monitoring through thermocouples and infrared thermometry. We tested the two classical methods for determining the loss factor: the first method using the -3 dB bandwidth and the time decay method. For our materials, whose typical damping values are on the order of 1.2%, the -3dB method requires very fine sampling to achieve a good resonance peak resolution. For this reason, the time decay method was chosen. The storage modulus is derived from the resonance frequency using the classical modal relationship. This frequency is itself obtained by two complementary methods: extraction of the peak from the frequency response function, and fitting of the time signal with a damped sinusoidal response.

The tests confirm the expected trend: a marked drop in the storage modulus at the passage through Tg, accompanied by a peak in the loss factor. These observations qualitatively validate the implemented setup and will help to support the complex modulus approach adopted in the theoretical study.