

Microscale dynamic characterization of fibers to understand damping of composite materials

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Fibers are fundamental components of composite materials, playing an essential role in high-performance sectors such as transportation, energy, and infrastructure. Optimizing their integration into composite matrices requires a deeper understanding of their mechanical behavior at the single-fibre level. Given their micrometric diameter, accurately characterizing the dynamic behavior of individual fibers remains a major experimental challenge. The scarcity of reliable data on key properties such as damping [1], continues to hamper progress in the field of fiber-based composites. To fill this gap, this work begins by proposing a method based on the dynamic response of individual fibers [2]. By exciting the fiber using a piezoelectric device and analyzing its displacement using a high-speed camera, its dynamic properties are accurately determined. With this method the intrinsic damping properties of three categories of fibers (inorganic, synthetic, and plant-based) is quantified. The results indicate that conventional reinforcement fibers, such as carbon, glass and basalt, exhibit low intrinsic loss factors, ranging from 0.11% to 0.18%. Conversely, plant-based fibers demonstrate significantly higher loss factors, between 0.66% and 1.1%. Regenerated cellulose and PA11 fibers further exceed these values, both reaching 1.3%. Notably, aramid fibers display the highest loss factor observed in this study, at 1.5%. To supplement these results, presented in Pelisson et al. [2], a comparative study with three other types of characterization tests (Dynamic Mechanical Analyses, nanoindentation, and micro-Brillouin light spectroscopy) is proposed. These multimodal experimental approaches enable the investigation of a wide frequency range, varying strain levels, and diverse solicitation modes. Notably, micro-Brillouin light spectroscopy enables, for the first time, the characterization of the anisotropic dynamic properties of fibers. Finally, this work also proposes to explore the dynamic properties of fiber bundles in order to identify sources of dissipation at a higher scale and to more fully appreciate the mechanisms explaining the superior damping capacity of plant fiber-based composites compared to glass or carbon fiber-reinforced composites. In conclusion, this research provides a better understanding of the remarkable damping properties of plant fibers and supports the development of more sustainable materials, paving the way for more informed design strategies in the development of high-performance bio-based composite materials [3].

[1] Pelisson, Fanny, et al. "Single fibre damping: insight, advances and challenges." *Comptes Rendus. Mécanique* 353.G1 (2025): 1405-1423.

[2] Pelisson, Fanny, et al. "New insights into the damping behaviour of inorganic, synthetic and plant single fibres using vibration method under vacuum conditions." *Composites Part A: Applied Science and Manufacturing* (2025): 109397.

[3] MIDIFIC project (ANR-22-CE51-0001) - <https://projects.femto-st.fr/MIDIFIC/en>