ADVANCES IN MODELING AND APPLICATIONS OF VISCOELASTIC SOFT MATERIALS

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ABSTRACT

The proposed minisymposium aims to bring together experts in the field of viscoelastic materials to discuss recent advances in modeling, experimental characterization, and applications. Viscoelastic materials, encompassing a wide range of substances such as elastomers, polymers, and biological tissues, exhibit time-dependent mechanical behavior that is inherently complex and often nonlinear [1]. This behavior poses significant challenges for understanding and predicting material responses, especially under conditions involving multifield interactions [2], such as magneto-viscoelasticity, thermo-viscoelasticity, and electromechanical coupling.

An additional layer of complexity arises when anisotropic properties [3] are considered. Many viscoelastic materials, particularly those with fibrous or composite structures, exhibit direction-dependent behavior that must be carefully modeled and characterized to capture their true mechanical response. Addressing anisotropy is crucial in applications ranging from advanced engineering materials to the modeling of biological tissues like tendons, ligaments, and cardiac tissues.

The minisymposium will also highlight emerging methodologies in data-driven constitutive modeling techniques [4]. These approaches, which leverage machine learning and artificial intelligence, offer the potential to revolutionize the way we understand and simulate the behavior of viscoelastic materials. By integrating experimental data with advanced computational frameworks, data-driven models can provide unprecedented accuracy and predictive capabilities, overcoming some of the limitations of traditional phenomenological approaches.

Moreover, the discussion will explore multiscale modeling techniques that bridge the gap between microstructural mechanisms and macroscopic behavior [5]. Multiscale approaches enable the incorporation of material heterogeneity, such as the interplay of molecular dynamics in polymers or the hierarchical structure of biological tissues, into predictive models. These methods are pivotal for developing a comprehensive understanding of how microscale

interactions influence macroscale properties, particularly under complex loading and environmental conditions.

The minisymposium aims to foster and inspire innovative solutions to the challenges posed by viscoelastic materials. Topics of interest will include, but are not limited to, nonlinear viscoelasticity, anisotropic material modeling, advanced experimental techniques, data-driven and multiscale approaches, and the integration of viscoelastic materials in cutting-edge applications. This collective effort will advance the state of the art in viscoelastic material science and open new avenues for both fundamental research and practical applications.

REFERENCES

[1] Reese S and Govindjee S. A theory of finite viscoelasticity and numerical aspects, International journal of solids and structures. 1998.

[2] Lucarini S et al. Insights into the viscohyperelastic response of soft magnetorheological elastomers: Competition of macrostructural versus microstructural players, International Journal of Solids and Structures, 2022.

[3] Ciambella J et al. Anisotropic evolution of viscous strain in soft biological materials, Mechanics of Materials, 2024.

[4] Tac V et al. Data-driven anisotropic finite viscoelasticity using neural ordinary differential equations, Computer Methods in Applied Mechanics and Engineering, 2023.

[5] Roque-Piedra A et al. Effective Properties of Homogenised Nonlinear Viscoelastic Composites, *Materials*, 2023.