

## MATERIAL VISCOELASTICITY AS RESULT OF MICROSCALE INTERACTIONS BETWEEN LIQUID CRYSTALLINE INTERFACES AND SOLID ELASTIC MATRIX

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**Key Words:** *Liquid Crystals, Multiscale Model, Relaxation, Creep.*

Viscous fluids play an important role in the creep behavior of microheterogeneous materials comprising fluid-filled pores at very small length scales. In more detail, fluid-filled interfaces between two electrically charged solid surfaces typically act as a lubricant, once the two solids glide along the interface. The fluid is typically in a nano-confined “liquid crystal” state, referring to an “adsorbed”, “ice-like”, or “glassy” structure of fluid molecules [1]. Herein, we translate these liquid crystal physics and the related behavior of viscous interfaces into apparent creep laws at the continuum scale of microheterogeneous creeping materials.

As to account for the liquid crystal behavior at the interface scale, we consider a linear relationship between the rate of relative displacements of neighboring fluid layers, on the one hand, and corresponding interface tractions, on the other hand, with an interface viscosity as the proportionality constant [2]. A Mori-Tanaka-type homogenization scheme for eigenstressed heterogeneous materials allow us to upscale this interface behavior to the significantly larger observation scale of a matrix inclusion composite consisting (i) of a homogeneous, isotropic, and linear elastic solid matrix, and (ii) of interacting, circular, and parallel interfaces [2]. The multiscale model provides analytical relationships describing how the macroscopic loading, the elastic properties of the solid, the size and density of the interfaces, as well as the viscosity of the fluid filling the interfaces influence the creep/relaxation behavior of the composite under uniform stress/strain boundary conditions [2].

The model-predicted creep and relaxation behavior is of asymptotic nature and exhibits exponentially decaying dynamics. This leads, on the one hand, to the conclusion that non-asymptotic creep [3] may be associated with non-stationary “spreading” interfaces [1], and it provides, on the other hand, the motivation to compare the presented micromechanics approach with one-dimensional, rheological models comprising springs and dashpots in different arrangements. This way, we link quantities of liquid crystals physics to engineering constants of generalized Kelvin-Voigt and Maxwell models. When extending the micromechanics models towards consideration of interfaces with different sizes, we are able to highlight potentials and limitations of the frequently used Maxwell chain models for modeling creep and relaxation of viscoelastic materials.

## REFERENCES

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