Constitutive model for composite semiflexible bio-polymeric networks under large deformation regime

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Abstract

The synthetic bio-polymeric networks demands great interest as biomaterial due to its soft and wet nature that mimic many biological scaffolding structures. The semiflexible polymers filamentous actin (F?actin) and intermediate filaments (IF) both form complex networks within the cell, and together are key determinants of cellular stiffness, but its mechanics response remains already unknown. Recent experiments using large deformations rheology in a simplified in vitro system, uncover the fundamental mechanical interactions between networks. Unexpectedly the co?polymerization of actin and vimentin can produce composite networks either stronger or weaker than pure F?actin networks.

In this work we propose a mathematical model into the framework of nonlinear continuum mechanics to explain the observations. Our model defines the mechanics for the two semiflexible networks as well as the interaction associated with the gelation effects and the pre-strain among them. Based on that ingredients is possible to describe the complex non-linear behaviour. The mechanics of the bio-polymers is modelled using the wormlike chain model for semi-flexible filaments and the gelation process is described as mesoscale dynamics for the crosslinks (physical and chemical).The model has been validated with reported experimental results showing a good agreement between theory and experiments.

Keywords: F-actin networks, Intermediate filaments, chemical crosslinks, adhesion, non-linear rheology

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