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NUMERICAL SIMULATION OF LARGE DEFORMATION KINETICS FOR POLYMERIC GELS

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Non-linear large deformation study of soft materials, such as hydrogels, shape memory polymer (SMP) is a new research topic, as the potential application of these soft materials in emerging new technology. To accurately design new soft machines, it is imperative to understand the non-linear large deformation kinetics of polymeric gel [1,2,3]. In this presentation, we will present the transient deformation process of polymeric gels and numerical implementation for large deformation kinetics of polymeric gels using finite element method (FEM). The neutral and environmental sensitive hydrogels are investigated. Depending on the constituents, the polymeric gels are able to deform under the excitation of various external stimuli, such as temperature, pH-value and light. For temperature sensitive hydrogels, by analyzing the factors affecting the phase transition temperature of hydrogels, we propose one possible chemical mechanism for the swelling behavior of temperature-sensitive gel during the phase transition process. For light sensitive hydrogelsor, we investigate the photo-thermal mechanics of deformation of temperature sensitive hydrogels impregnated with light-absorbing nano-particles. This is done by considering the equilibrium thermodynamics of a swelling gel through a variational approach. To facilitate the simulation of large inhomogeneous deformations subjected to geometrical constraints, we develop a FEM method using a user-defined subroutine in ABAQUS by modeling the gel as a hyperelastic material. The FEM was implemented on cases of free swelling, phase coexistence and buckling of the gel when exposed to irradiation of varying intensities. For verification purpose, a few typical examples which can represent the kinetic deformation phenomena are modeled and simulated using developed subroutine or code. The simulation results are compared with available experimental data, and it shows that our simulating results are in good agreement with available experimental data and analytical solutions. Furthermore, we adopt the simulation method to explain some natural phenomena, such as plant growing and drying process, swelling-induced bifurcation, buckling of skin of human hand. We also hope that this work can provides a useful tool for the future theoretical and experimental studies of soft hydrohel material.

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