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A simplified model for equilibrium and transient swelling of thermo-responsive gels

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Abstract

A simplified model is developed for the elastic response of thermo-responsive gels subjected to swelling under an arbitrary deformation with finite strains. The constitutive equations involve five adjustable parameters that are determined by fitting observations in equilibrium water uptake tests and T-jump transient tests on thin gel disks.

Two scenarios for water release under heating are revealed by means of numerical simulation. When the final temperature in a T-jump test is below the volume-phase transition temperature, deswelling is characterized by smooth distribution of water molecules and small tensile stresses. When the final temperature exceeds the critical temperature, a gel disk is split into three regions (central part with a high concentration of water molecules and two domains near the boundaries with low water content) separated by sharp interfaces, whose propagation is accompanied by development of large (comparable with the elastic modulus) tensile stresses.

Key-words: Thermo-responsive gel; Volume phase transition; Transient swelling; Modeling

1 Introduction

Hydrogels are three-dimensional networks of polymer chains bridged by chemical and phyiscal cross-links, hydrogen bonds, van der Waals interactions, and crystallite associations (Van Vlierberghe et al., 2011). Temperature-sensitive gels, whose equilibrium degree of swelling is strongly affected by temperature, form a special class of stimuli-responsive polymers with a wide range of potential biomedial applications (Ward and Georgiou, 2011; Ashraf et al., 2016). When these gels are

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