Kinetics of Solvent Absorption and Permeation through a Highly Swellable Elastomeric Network

BENOÎT BARRIÈRE,[1] LUDWIK LEIBLER[2]

[1]Groupe de Physico-Chimie Théorique, ESPCI, 10 rue Vauquelin, F-75231 Paris Cedex 05, France

[2]Matière Molle et Chimie, Unité Mixte de Recherche CNRS-ATOFINA, ESPCI, 10 rue Vauquelin, F-75231 Paris Cedex 05, France

Received 12 April 2001; revised 1 September 2002; accepted 19 September 2002
Published online 9 December 2002 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/polb.10341

ABSTRACT: To model a polymer gel or an elastomer undergoing a large change in volume under the action of a solvent diffusing in or out of it, a theoretical approach based on an elastohydrodynamic point of view is proposed. Drawing a parallel between the polymer network/solvent system of interest and a liquid flowing through a porous medium, the friction between the polymer and the solvent is described phenomenologically. An equation that couples the large elastic deformations undergone by the polymer network and the diffusion process is derived and then solved numerically in various cases. Special emphasis is placed on the influence of the shear elasticity during the diffusion process. During the swelling process, a nonzero shear modulus induces a nonisotropic swelling at the surface that is responsible for the "sigmoidal" shape of the mass uptake of solvent with the square root of time, as well as for the presence of a "front" in the concentration profile when the solvent advances inside the network. In a permeation process, the solvent flux deviates from its linear behavior as soon as a nonnegligible deformation of the membrane is present. J Polym Sci Part B: Polym Phys 41: 166–182, 2003
Keywords: gels; elastomers; diffusion; permeation; shear