Research paper

Loading velocity dependent permeability in agarose gel under compression

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\textbf{ABSTRACT}

A new approach for characterization of agarose gel permeability under compression at different loading velocities is proposed. Uniaxial compression tests on thin agarose gel specimens in a rigid porous confinement cell immersed in a water bath are undertaken. The equilibrium response of the gel, which is assumed to be achieved under extremely low-loading velocity (of the order of tens nanometers per second) is considered to be the response of the hydrated gel scaffold. The water exudation behavior from the agarose gel was extracted from the load–displacement response under various loading velocities by subtracting the equilibrium response. It was found that the pressure on water in the gel is not a linear function of loading velocity or volume flow rate and therefore, the permeability of agarose gel was observed to vary with deformation and water flow velocity. In addition, it was inferred from the analysis that at low velocities and large strain levels the gel permeability dominates the compression behavior, and at higher velocities and small strain levels the viscosity of the hydrated matrix may contribute to the load. Finally, permeability variation in agarose gel at different loading velocities is attributed to the two states (free water and bound water) of water molecules in the gel.

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1. Introduction

Agarose gel is traditionally used as a medium in electrophoresis and also as a phantom material or tissue scaffold in biomedical engineering. Understanding its mechanical behavior is essential for effective use as a tissue surrogate under complex loading conditions. Extensive research has been conducted on its wide range of mechanical properties including dynamic stiffness (Benkerrou et al., 1999; Chen et al., 2005; De Freitas et al., 2006; Miyata et al., 2008), effect of molecular weight on failure stress and strain in tension and compression (Normand et al., 2000), stress relaxation behavior (Nussinovitch et al., 1989; Mauck et al., 2000), and hydraulic permeability (Lai and Mow, 1980; Jackson and James, 1986; Holmes and Mow, 1990; Johnson and Deen, 1996; Zhang et al., 2000; Andarawis et al., 2001; Yao and Gu, 2002; Gu et al., 2003; O’Brien et al., 2007). Because agarose is a biopolymer with a range of molecular weights, property variations in agarose gels may arise from a wide variety of sources including some intrinsic factors such as agarose concentration, type of agarose and its molecular structure, and molecular

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