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Fracture mechanics of a self-healing hydrogel with covalent and physical crosslinks: A numerical study[1]

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Abstract

The fracture mechanics of a stationary crack in a Poly(vinylalcohol) (PVA) hydrogel with a network consisting of chemical and physical crosslinks is studied here. Prior research by the authors has shown that the time- dependent stress strain behavior of this gel can be captured very accurately with a 3*D,* large deformation nonlinear viscoelastic model based on breaking kinetics of physical crosslinks. This model is used together with a novel time integration scheme to study the stress and deformation fields near the tip of a stationary crack in single edge cracked specimens. The theoretical and finite element results agree remarkably well with experimentally observed crack opening profiles. For the special case of relaxation tests exact asymptotic crack tip solutions are obtained in specimens loaded under predominantly plane stress conditions.

1. Introduction

Hydrogels have many applications, such as scaffolds for cells in tissue engineering[1-2], artificial cartilage[3] and as vehicles for drug delivery[4]. However, because these gels contain mostly water, they are typically very brittle and cannot be used as load bearing components in structures. The seminal work of Gong's group[5] demonstrated how to make stiff yet highly extensible hydrogels with toughness rivaling that of synthetic rubber. These double network (DN) hydrogels consist of two inter-penetrating networks.

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