Computational modelling of void growth in swelled hydrogels

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ABSTRACT

A dry polymer network immersed in a solvent swells and the corresponding deformation is a chemo-mechanical coupling process. Hydrogels are physically or chemically cross-linked polymer networks swollen with a large amount of water. This swelling ability makes them strongly resembling the extracellular matrix and thus very suitable as biomaterials for the study of material-cell interactions. Under sufficient loading, microvoids can be triggered inside materials as diverse as polymers, biological tissues, and metals. Cavitation appears as soon as the void volume fraction suddenly rapidly increases, (Ball, 1982). As regard overall properties, the presence of those microscopic defects can have drastic consequences, including failure, at the macroscopic level.

The problem formulation and the material modelling closely follows works by Hong *et al.* (2009) where further details and additional references are given. In the equilibrium state, the chemical potential of the solvent is homogeneous throughout the hydrogel. It is mimicked by a temperature-like variable and is incremented as a loading parameter. In this computational study, the growth of a small spherical void within a hydrogel is viewed through the prism of micromechanics and FE analysis. In this context, an attempt is made towards obtaining an estimation of the effective behaviour of porous hydrogels where microvoids are already present. To this end, a two-level representation of the material at hand is considered. The microscopic scale is treated through a cylindrical Representative Volume Element (RVE) immersed in water and composed of two phases: a homogeneous matrix (sound gel) and spherical void. The RVE model is subjected to axial and lateral overall stresses under conditions of constant prescribed overall stress triaxiality. For fixed values of the Flory-Huggins parameter and the nominal concentration of the solvent, the overall stress-strain behaviour of the RVE and the influence of the initial porosity on the RVE behaviour have been highlighted.

REFERENCES

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