Modelling of Quazistationary Ionic Transport in Fluid Saturated Deformable Porous Media

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Abstract

The ionic transport in the charged porous media is a problem widely studied across many applications. It is often studied in the context of geosciences, where it serves as the description of clay's swelling. Other important applications are in the research of fuel cells, or modeling of biological tissues.

This work explores the available mathematical models, describing ionic transport through fluid saturated porous media with the deformable solid phase charged by small electrical charge, [1], [2]. We focus on the homogenization of the microstructure constituted by elastic solid skeleton and two-component electrolyte filling the pores so that a specific geometrical arrangement is taken into account. Electrochemical phenomena occurring due to the electric double layer which is formed by interaction between charged solid-fluid interface and ionized solution are considered. Since the porous medium is deformable, there is a tight coupling between the mechanical response of the porous media and the ionic transport in the pore fluid due to the convection-diffusion influenced by the electrochemical phenomena. The mathematical model describing mechanical and electrochemical interactions at the microscopic level is treated by means of the homogenization yielding the local microscopic problems to be solved for characteristic responses in the representative periodic cell. By virtue of these characteristic responses, the resulting upscaled model respects material microstructure with stronger coupling between the electrokinetic system and the poroelasticity. The upscaling procedure is then implemented in the in-house developed FEM based software SfePy, [4] and the macroscopic behavior of the homogenized body is illustrated by the numerical simulations.

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