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Two-Dimensional Modeling of the Electrokinetic Desalination Treatment of a Brick Wall

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Introduction

Chlorides, nitrates and sulfates are considered the main responsible of the salt-induced decay in facades and sculptures. Electrokinetic desalination treatments have been showing high efficiency for the recuperation of different construction materials suffering from salt weathering [1]. Buffer substance enhancement methods are typically used in order to avoid damage in the material due to the pH changes, as well as to improve the removal efficiency. In some practical cases, the electrokinetic desalination treatment of a wall requires the electrodes to be placed in the same surface [2]. On these cases, the clean up process proceeds in an inhomogeneous way with respect to the depth of the wall. The region of the wall close the external surface where the electrodes are placed is cleaned faster. Due to changes on the conductivity of the pore solution as a result of the removal process, the desalination proceeds deeper in the domain. At the same time, the gradient in the concentration of the species promotes the transport in the direction of the external surface.

In the present work, a two-dimensional model of electrokinetic desalination process of a brick wall is discussed. In the modeled system, the reactive flow of ionic and non-ionic species is described taking into account the transport phenomena and the chemical and electrochemical interactions affecting the different species in the system as well as the solid matrix. The transport process is modeled by finite elements integration of the strongly coupled Nernst-Planck-Poisson system of equations. A mass balance equation, for each chemical species included in the system, is considered. The flux term of the continuity equation takes into account the contribution of the different transport terms: the diffusion, the electromigration and the electroosmosis. The electrical potential is calculated from the global charge balance by the use of the Poisson's equation of electrostatics, which completes the equation system [3].

Depending on the concentration and nature of the species in the vicinities of the electrodes, the competition of different electrochemical reactions is considered. In addition to this, a set of feasible chemical equilibrium reactions is defined, and the chemical equilibrium state is assured in any position of the domain during the complete transport process. A line search Newton-Raphson method that iterates on the extents of the reaction is used for this chemical equilibrium model.

Results from simulations of test examples are presented. The brick wall is considered initially contaminated with different combination of salts in the pore solution, and the electrodes placed in the same surface of the wall. Profiles of the target species are obtained, as well as theoretical conductivity and the ionic current in the domain during the desalination process.

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