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A MULTISCALE APPROACH TO COUPLED SCALAR TRANSPORT IN ELECTROOSMOTIC FLOW FOR PAPER-BASED MICROFLUIDICS

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Abstract.

This work presents a multiscale technique for modeling coupled electroosmotic flow and scalar transport in porous materials within paper-like microstructures. This is crucial for designing microfluidic devices. The approach is based on the definition of a representative volume element (RVE) that captures the microstructure of the interconnected channel of the porous medium through which the fluid moves within the void of the porous material (microscale). The fluid dynamic problem is solved under incompressible flow conditions in the Stokes regime due to an electric field, to calculate the effective permeability corresponding to the microstructure, as was presented in a previous work of this series. This fluid transports a substance at a given concentration. The microscale problem involves solving an advection-diffusion equation, while the macroscale problem involves solving an advection-diffusion-dispersion problem. This work investigates the limitations of a coupled flow and transport model by validating its dispersion coefficient against experimental data from standard paper-based microfluidic materials (Whatman #1, Munktell 00A). For this purpose, several cases are studied. An example is the case of considering two different concentrations at the domain entry. This assessment enables the identification and proposal of any necessary improvements to the governing assumptions and formulations.

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