S2.6.1 Dispersion Controlled by Permeable Surfaces: Surface Properties and Scaling

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Permeable and porous surfaces are common in natural and engineered systems.

Flow and transport above such surfaces are significantly affected by the surface

properties, e.g. matrix porosity and permeability. However, the relationship between such properties and macroscopic solute transport is largely unknown. In this work, we focus on mass transport in a two-dimensional channel with permeable porous walls under fully developed laminar flow conditions. By means of perturbation theory and asymptotic analysis, we derive the set of upscaled equations describing mass transport in the coupled channel–porous-matrix system and an analytical expression relating the dispersion coefficient with the properties of the surface, namely porosity and permeability. Our analysis shows that their impact on the dispersion coefficient strongly depends on the magnitude of the Péclet number, i.e. on the interplay between diffusive and advective mass transport. Additionally, we demonstrate different scaling behaviours of the dispersion coefficient for thin or thick porous matrices. Our analysis shows the possibility of controlling the dispersion coefficient, i.e. transverse mixing, by either active (i.e. changing the operating conditions) or passive mechanisms (i.e. controlling matrix effective properties) for a given Péclet number. By elucidating the impact of matrix porosity and permeability on solute transport, our upscaled model lays the foundation for the improved understanding, control and design of microporous coatings with targeted macroscopic transport features.