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Flow coupled with advection, reaction and diffusion in evolving porous media: homogenisation and simulation

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Many biological processes in porous media cause a change of the microstructure, e.g. biofilm attachment or growth. This evolution affects strongly the effective permeability and often depends on a transported concentration. We model such a process with an advection–reaction–diffusion equation coupled to Stokes flow on the microscopic scale.

In order to derive mathematically an effective model, we transform the problem on a periodic substitute domain where we can pass rigorously to the homogenisation limit (cf. [1]). After a back-transformation, we obtain an effective homogenised model. It includes an advection–reaction–diffusion equation and a Darcy law for evolving microstructure (cf. [3, 2]). Furthermore, the coupling of the concentration with the domain evolution is transferred to a reference cell in the homogenisation limit. Thus, the effective diffusivity and permeability become time- and space-dependent and can be computed using the corresponding cell problems.

We illustrate the behaviour of the concentration, the local porosity and the local permeability by numerical simulations.

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