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Impact of the internal heterogeneity of biofilms on hydrodynamics and reactions in 3D porous media

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Bacterial biofilms can form in porous systems that are of interest in industrial but also in environmental applications, being hotspots of biogeochemical reactions. The presence of biofilms within porous media modifies not only the topology but also the hydrodynamics and consequently the transport of solutes and the effective kinetics of reactions. The highly heterogeneous flow fields found in porous media during biofilm growth translate into a spatially heterogeneous biofilm location and internal heterogeneity. Using highly resolved three-dimensional X-ray computed microtomography images of bacterial biofilms in a porous medium, multiple equivalents stochastically generated internal permeability fields for the biofilm are generated. These permeability fields embedded within the porous medium are used to compute pore-scale fluid flow and solute transport numerically. We observe that the biofilm with an internal heterogeneous permeability mainly impacts intermediate velocities when compared with a homogeneous case. The equivalent internal permeability fields of the biofilm do not impact fluid-fluid mixing. However, they significantly control a fast fluid-fluid reaction. For biologically driven reactions such as nutrient or contaminant uptake by the biofilm, its internal permeability field enhances the process, especially at early times. This study highlights the importance of considering the internal heterogeneity of biofilms to better predict reactivity in industrial and environmental bioclogged porous systems.

Participation

In-Person

References

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