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Engineering biofilm hydraulic resistance on the microscale

Tuesday, 31 May 2022 17:30 (15 minutes)

Bacterial biofilms are amongst the most successful modes of life in the terrestrial environment and ubiquitous within porous systems, such as soils and membrane interfaces (1). The bacteria within a biofilm are bound together by self-secreted extracellular polymeric substances (EPS), yielding a natural gel-like structure (2). EPS provides a protective shield and structural architecture to constituent cells of the biofilm, which shapes internal mass transport within the biofilm and flow field of the colonized porous media (3). The interplay between biofilm formation and flow leads to the formation of preferential flow pathways and significant increases in membrane hydraulic resistance, as investigated in macroscale experimental systems (4, 5). However, the complex multiphase interaction between biofilm proliferation and flow within irregular porous media make the deduction of scalable physical relationships challenging. Consequently, a mechanistic understanding linking EPS composition, biofilm morphogenesis and porosity with hydraulic resistance is still missing (6).

In this work, we investigate the time evolution of biofilm morphology and hydraulic resistance as a function of flow conditions and EPS composition. We grow the model bacterium Bacillus subtilis in two types of microfluidic channel and use a library of EPS mutants devoid of polysaccharide (EPS-O), protein (TasA) or hydrophobin (BslA) to modulate EPS composition. Firstly, we grow and characterize the biofilm during its morphogenesis in a novel microfluidic platform where the biofilm is grown on a cellulose nanofibril (CNF) membrane barrier. The CNF platform allowed precise measurement of single colony biofilm hydraulic resistance as a function of pressure driven flow and EPS composition, whist retaining full optical access. To validate the scalability of our findings, we use an unconfined microfluidic geometry, a model 2D porous media, which increases the biofilm volume by approximately two orders of magnitude. We measure hydraulic resistance and apply advanced optical visualization techniques to quantify biofilm morphogenesis and internal transport. This study allowed us to quantify how flow and EPS composition shape the hydraulic resistance of biofilm at the micro and meso scale. The relationships derived from these studies enhance our understanding of how we can engineer biofilms to tune their hydraulic resistance.

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Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

In person

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