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Integration of microstructured surfaces with microfluidics for dynamic biofilm research

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Bacterial biofilms are structured microbial communities embedded in a self-produced extracellular matrix that enhances their resistance to environmental stresses and antimicrobial agents. Understanding how surface topography interacts with hydrodynamic conditions to regulate biofilm formation remains a key challenge in biofilm research. This work presents a microfluidic platform that integrates microstructured polydimethylsiloxane (PDMS) surfaces and enables controlled investigation of *Escherichia coli* behavior under defined flow, shear stress, and nutrient transport, bringing the system closer to physiologically relevant environments compared to conventional static models. The experimental workflow consists of static and dynamic experiments supported by microscopy to quantify early attachment, microcolony formation, and biofilm morphology, while assessing how microstructure-induced local hydrodynamics shape adhesion and spatial organization. The results establish relationships between surface geometry, shear conditions, and resulting biofilm architecture, providing a basis for the rational design of surfaces that either suppress biofilm formation or enable controlled biofilm growth in applications such as medical devices and biofilm-based functional interfaces.

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