Effects of boundary on biofilm morphogenesis

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Abstract

Morphogenesis of bacterial biofilms display rich surface patterns, depending on a wealth of factors ranging from biochemical conditions to physical cues. The morphogenesis not only reflects bacteria's physiological state but can also serve as a strategy to sustainbacterial survival. In this paper, we explore how geometric boundary modulates biofilm morphogenesis by taking B. subtiliscolony as a model system. It shows that both wrinkling and delamination driven by compressive stresses endow the biofilm with diverse undulations, which exhibit labyrinthine networkin the inner regime yet tend to align perpendicularly to boundary at the biofilm periphery. We reveal that the spatial variation of the surface undulations are attributed to the stress state.At the inner regime, stresses caused by isotropic growth are isotropic, whereas they become anisotropic since the accumulated radial stress is releasednear the free boundary. This boundary-modulated morphogenesis is found to be conserved in the systems with varied boundary geometry.As an application, we show that the directional undulations confer the biofilm with anisotropic wetting properties. This study highlights the role of mechanics in sculpturing organisms within morphogenetic contexts and alsosuggests a promising route toward desired surface at the interface between synthetic biology and material sciences.

Keywords: Morphogenesis; biofilm; buckling; boundary effect