Surface associated microbial communities, known as biofilms, pose significant challenges in clinical and industrial settings" Ye et al (2018).

Abstract:

Surface associated microbial communities, known as biofilms, pose significant challenges in clinical and industrial settings. Micro/-nanoscale surface features have been shown to disrupt firm adhesion of planktonic microbes to surfaces, thereby interfering with the earliest stage of biofilm formation. However, the role of geometry and size of surface features in microbial retention is not completely understood. In this study, we developed a biophysical model that describes the changes in the total free energy (adhesion energy and stretching energy) of an adherent Candida albicans cell on nanofiber-coated surfaces as a function of the geometry (i.e. diameter) and configuration (i.e. inter-fiber spacing) of the surface features (i.e. nanofibers). We then introduced a new non-dimensional parameter, Π, to represent the ratio of cell rigidity to cell-substratum interfacial energy. We show that the total free energy is a strong function of topographical feature size at higher Π and lower spacing values. To confirm our biophysical model predictions, we performed 24-hour dynamic retention assays and quantified cell attachment number density on surfaces coated with highly ordered polystyrene nanofibers. We show that the total free energy of a single adherent cell on a patterned surface is a key determinant of microbial retention on that surface. The cell attachment density trend closely correlates with the predictions based on the adherent single-cell total energy. The nanofiber coating design (1.2 μm diameter, 2 μm spacing) that maximized the total energy of the adherent cell resulted in the lowest microbial retention. We further demonstrate the utility of our biophysical model by showing close correlation between the computed single cell total free energy and biofilm nucleation on fiber-coated urinary and central venous catheters of different materials. This biophysical model could offer a powerful new paradigm in ab initio design of patterned surfaces for controlled biofilm growth for medical applications and beyond.

Reference:

Ye, Z., Kim, A., Mottley, C.Y., Ellis, M.W., Wall, C., Esker, A.R., Nain, A.S. and Behkam, B. (2018) Design of Nanofiber Coatings for Mitigation of Microbial adhesion: Modeling and

Application to Medical Catheters. ACS Applied Materials & Interfaces. April 11th. .

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