Effect of Substratum Nanoscale Topography on Bacterial Attachment and Biofilm Formation

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Abstract:
In the United States, 48 million illnesses per year are attributed to foodborne pathogens. Many of these food safety problems result from the contamination of food processing equipment with harmful bacteria. Reducing microbial attachment to surfaces may decrease the incidence of foodborne illness. Previous research indicates that substrate surface topography may influence bacterial attachment behavior. In this work, silicon dioxide surfaces — exhibiting specifically engineered nano- and micro-scale topography — were fabricated in the Cornell NanoScale Facility. The attachment properties of common foodborne pathogens to these surfaces were then studied. The goal of this project is to generate an understanding of the rules of bacterial attachment to nanostructured surfaces.

Summary of Research:
In this work, the effect of nanoscale surface topography on the attachment of three bacterial species, *E. coli* ATCC 25922, *L. innocua* FSL C2-008, and *P. fluorescens* 1150, were studied. Chemically identical, but topographically distinct silica dice were used as substrates. The silica surfaces were thermally grown on standard silicon wafers, and subsequently patterned using DUV lithography. The surfaces were designed to exhibit surface details comparable in size and shape to that of bacterial cells. Smooth, non-patterned silica was used as a control. A schematic of the surfaces used in this study is shown in Figure 1. Substratum surface features smaller than the bacterial cell were expected to reduce effective contact area between cell and substratum, and thusly have a repelling effect. On the other hand, surfaces with topographical details larger than the cell were expected to effectively increase contact area and be conducive for attachment.

Attached bacteria were visualized using fluorescence microscopy and scanning electron microscopy. Images obtained from fluorescence microscopy were further analyzed to quantify the number of attached cells. Overall, the results of this study indicate that surface topography influences both the total amount of attached bacteria and the orientation of cells relative to surface details. However, attachment patterns were specific to the microorganism and not universally observed.

Further investigation into the mechanisms behind the observed differential attachment might allow for a better understanding of the rules of attachment to nanoscale topography and the subsequent design of materials capable of repelling bacteria.