



PhD THESIS DEFENSE: Interactions and Optical Properties of Microorganisms on Surfaces

RAFAEL NAOMI SIBILO

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Controlling microbial growth is essential to industries such as healthcare, food, pharmacy but also for ship hulls and water systems. Interactions of bacteria with surfaces are highly dynamic and complex. Once a single cell transitions to a persistent multicellular microbial community (biofilm), elimination becomes complicated. Bacterial adherence, growth, and detachment are regulated by biological, chemical, physical, mechanical, and electrical properties of the bacterial cell, the surface, and the surrounding medium. Comprehensive studies in this field therefore require a multidisciplinary approach involving experts from different branches of science and appropriate choices of equipment depending on the question to address. This thesis focuses on the interaction and optical properties of bacteria on surfaces. More specifically, it investigates novel methods for enhanced bacteria

detection, growth monitoring and presents an in-depth study of interaction mechanisms of bacteria and surface nano-structures.

In the first part of the thesis, we validate a newly in-house built bio-sensing device to detect cells and their growth on surfaces. The proposed surface cytometer is compared with two standard laboratory methods, spectrophotometry and fluorescence microscopy. The results obtained with the three different techniques show similar trends, confirming the suitability of the surface cytometer as a compact, fast and low-cost device for measuring bacterial growth. Distinctively, the surface cytometer possesses both a large field-of view (~200 mm²) and depth of focus (~2 mm), these being particularly interesting for in-situ measurements and point-of-care testing.

In order to enhance cell imaging, we propose a new type of surface, ultrathin (

In another study of the thesis, we demonstrate that bacterial growth can be regulated by tuning surface wettability. In contrast to commonly used indirect methods such as bacterial colony counting and scanning electron microscopy, we investigated a direct approach for assessment. First, we used molecular dynamics simulations to predict bacterial behavior on flat and nanostructured glass substrates, with wetting characteristics further modulated by chemical coatings. Then, we experimentally assessed these findings using *E. coli* bacteria and time-lapse fluorescence microscopy. Obtained data confirmed that nanostructured glass simultaneously hydrophobic, repelling water, and oleophilic, attracting fat, is most destructive, avoids cell adherence and promotes total cell disruption. These direct observations reflect a more accurate spatial- and time evolution of the interactions and bactericidal effects due to surface morphology and wettability. The results provide guidelines to design antimicrobial surfaces using simple nano-structuring and chemistry.

Hosted by: Prof. Valerio Pruneri



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