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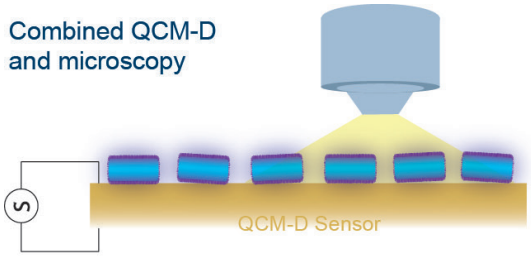
Q-Sense | [Application Overview] 4

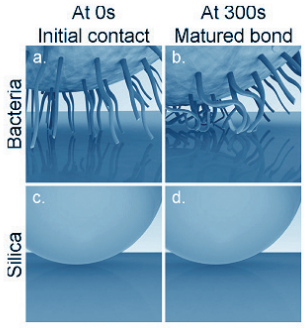
Studies of bacteria using QCM-D

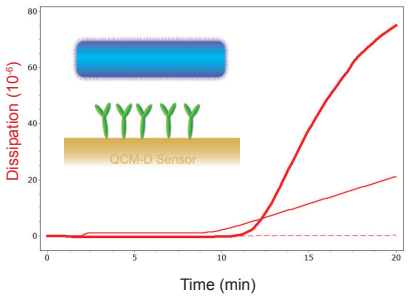
QCM-D is an emerging tool for real-time study and detection of bacteria, as recently exemplified by the development of sensitive assays to detect bacterial pathogens or simultaneous QCM-D and microscopy measurements.

Introduction

Bacteria are in a size range which makes it possible to image bacterial adhesion by microscopy simultaneous with QCM-D measurements. Through simultaneous imaging and recording it can be shown how the distance and attachment strength between the bacterial cell body and the surface affects the response from the QCM-D.







[Figure 1]: Bacterial bond maturation, compared to adhesion of rigid silica nanoparticles. Figure re-used from [2] with permission from the authors.

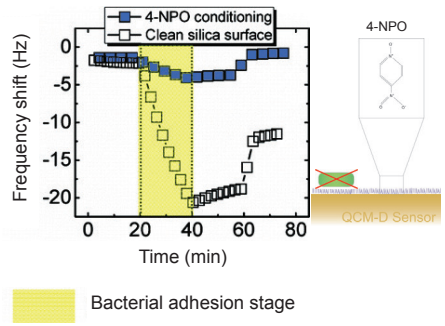
[Figure 2]: Dissipation shifts from comparison of high (thick line) and low E. coli O157:H7 concentration. Dashed lines indicate the negative control with cell free sample. Figure reused from [3] with permission from the authors.

Bacterium-substrate bond maturation studies [1], [2]

Bacterial adhesion can be monitored by QCM-D as interactions between the bacteria and the surface are sensed via frequency changes in the vibrating sensor. The magnitude of the QCM-D response was found to be influenced by the distance at which the cell body was held from the sensor surface by its surface appendages. In this example, a "bold" bacterium, completely devoid of surface appendages, was also investigated and there was a clear difference in the response comparing the bold bacteria with the ones with appendages.

QCM-D biosensor for pathogen detection [3]

Microbial pathogens, such as E. coli O157:H7, are responsible for water contamination, and their early detection is an important issue. Here, polyclonal antibodies targeting E. coli O157:H7 were immobilized onto a QCM-D sensor surface. The immobilization enabled real-time measurements of the presence of the pathogen in water solution. In this example, QCM-D data indicating changes in rigidity of the film was the most sensitive parameter for pathogen detection.



[Figure 3]: Comparison of P. aeruginosa attachment to a clean silica and a silica surface that was pretreated by 4-nitropyridine-N-oxide. Negative frequency shifts correspond to mass uptake. Figure re-used from [4] with permission from the authors.

Surface modification for reduced biofilm formation [4]

Bacterial group behaviors such as biofilm formation in response to population density are regulated by small signal molecules called autoinducers (quorum sensing, QS). In this study, the QS inhibitor 4-nitropyridine-N-oxide (4-NPO) was adsorbed to surfaces, and it was shown by QCM-D that surfaces treated in this way greatly resisted bacterial adhesion.

References:

[1] Adam L. J. Olsson, Henny C. van der Mei, Henk J. Busscher, and Prashant K. Sharma Influence of Cell Surface Appendages on the Bacterium Substratum Interface Measured Real-Time Using QCM-D Langmuir, 25, 1627-1632 (2009)

[2] Adam L. J. Olsson, Henny C. van der Mei, Henk J. Busscher, and Prashant K. Sharma Novel Analysis of Bacterium-Substratum Bond Maturation Measured Using a Quartz Crystal Microbalance Langmuir, 26(13), 11113–11117 (2010)

[3] Charles Poitras, Nathalie Tufenkji A QCM-D-based biosensor for E. coli O157:H7 highlighting the relevance of the dissipation slope as a transduction signal, Biosensors and Bioelectronics, 24, 2137-2142 (2009)

[4] Nune Vanoyan, Sharon L. Walker, Osnat Gillor, and Moshe Herzberg Reduced Bacterial Deposition and Attachment by Quorum-Sensing Inhibitor 4-Nitro-pyridine-N-oxide: The Role of Physicochemical Effects Langmuir, 26, 12089-12094 (2010)

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