Imaging and Manipulating Bacteria on the Nanoscale

ABSTRACT

The nanoscale analysis of microbial cells by atomic force microscopy (AFM) is an exciting, rapidly evolving research field. Compared with other types of microscopy, AFM offers two unique features: (1) the ability to work directly at nanometer resolution in aqueous solutions and (2) the possibility of probing various properties and interactions at the single-molecule level. In the imaging mode, AFM can visualize the surface ultrastructure of live cells under physiological conditions and allows real-time imaging to follow dynamic processes such as cell growth, and division and effects of drugs and chemicals, which opens up new possibilities for studying the assembly and remodeling of cell walls, and for understanding the action mode of antibiotics. AFM is more than a surface-imaging tool in that when used in the force spectroscopy mode, it allows measurement of physicochemical properties of a single cell, such as surface energy and surface charge, mechanical properties, and localization of molecular recognition events. These measurements provide new insight not only in microbiology, to elucidate cellular functions (such as ligand-binding or biofilm formation), but also in medicine (biofilm infections) and biotechnology (cell aggregation).

Here, I will present an overview of modern AFM technologies for microbial cell analysis, going from the basic principles to the applications. I will focus on most recent methodologies for preparing and analyzing microbial cells, discuss the principles of advanced AFM modalities, including high-resolution imaging, high-speed imaging, recognition imaging, cell-cell adhesion, mechanical measurements, and highlight recent applications in a variety of fields, including cell biology, microbiology, biophysics, structural biology, physiology, and medicine. At the end of this talk, I will indicate areas where significant advances in the state-of-the art are heading

Dr. Ahmed Touhami is an Associate Professor at the Department of Physics & Astronomy at the University of Texas Rio Grande Valley (UTRGV). He completed his undergraduate, Master's, and Ph.D. degrees in Physics at the Pierre & Marie Curie University (Paris-France). After joining Yves Dufrêne's lab at the Catholic University of Louvain-La-Neuve (Belgium) as a postdoctoral fellow, he moved to Dalhousie University (Canada) and then The University of Guelph (Canada), as an associate-research Fellow. Trained as a physicist and having worked in the fields of single molecule biophysics, biological physics, and nanoscience, he has considerable expertise in single molecule techniques such as Atomic Force Microscopy, Fluorescence Microscopy, and Optical Tweezers. He developed a new method to probe bacterial surface structures and dynamics in real time and under physiological conditions. He has published over 80 research papers, including book chapters, all based on single molecule biophysics and nanoscience studies. Dr. Touhami is a Member of Biophysical Society and the American Physical Society.