About the Project

As a strategy to overcome bacterial resistance to antibiotics, the past decade has seen the emergence of novel antibacterial strategies that rely on mechanical or physical interaction between nanomaterials and bacteria. These “mechano-bactericidal” nanostructures can be nanoparticles in suspension (colloids), or high-aspect-ratio topographies that are nanofabricated on surfaces. A clear advantage of mechano-bactericidal strategies compared to traditional antibiotics is that bacteria are not able to evolve resistance to the former. However, there is still a lack of clear experimental evidence and quantitative information on the mechanisms and magnitude of the forces involved in the physical damage of bacteria. This information can be extremely valuable to design more efficient bactericidal materials.

As part of our efforts to develop advanced microscopy methods to study biological systems at the nanoscale, our laboratory has recently combined fluorescence and atomic force microscopy (AFM) to quantify the forces necessary to inflict mechanical damage on bacteria (ACS Appl. Mater. Interfaces 2020, 12, 31235). In this study, an AFM tip was used as a simplified model of a high-aspect ratio nanostructure, and complementary fluorescence labelling strategies were used to probe the bacterial response to external mechanical force. The required force for the mechanical rupture of the bacterial membrane in Escherichia coli was estimated as 20 nN, which separates two regimes of interaction: one at higher force that leads to instant bacterial death, and another one that characterizes low force collisions between bacteria and nanomaterials. The study found that the latter may also lead to bacterial death by fatigue effects. Since the low force regime seems to be the most relevant to the real applications of mechano-bactericidal materials, the new focus of our research aims to explore in more detail the range of weak interactions that lead to bacterial death by mechanical fatigue.
This is a truly interdisciplinary project at the interface of Materials Science, Biophysical Chemistry, Biomedical Engineering and Microbiology. The student will learn a range of advanced microscopy techniques that are highly demanded, such as single-cell real-time fluorescence microscopy, fluorescence lifetime imaging, super-resolution microscopy and atomic force microscopy. He/she will also learn biochemical techniques for bacterial culture and fluorescent labelling, as well as image analysis and nanofabrication methods.

This PhD project will provide a crucial contribution to understand the mechanism of bacterial death due to interactions with nanomaterials, and thus develop better mechanobactericidal strategies. These strategies can be purely physical, or as facilitators of the action of chemical antibiotics. More generally, the advanced microscopy techniques developed will be applicable to other aspects of bacterial behaviour in which force is relevant, such as adhesion, pathogenicity or biofilm formation.

http://nanociencia.imdea.org/home-en/people/item/cristina-flors-ong

How to apply

This is a competitive fellowship opportunity, funded through “la Caixa” INPhINIT programme. Interested candidates should get in contact (cristina.flors@imdea.org) for an informal discussion about the project and how we can support your application.

About IMDEA Nanociencia

IMDEA Nanociencia is an interdisciplinary research centre dedicated to the exploration of basic nanoscience and the development of applications of nanotechnology in connection with innovative industries. Our purpose-built building was inaugurated in 2014 and the institute has since been consecutively awarded with the highest national recognition of scientific excellence and international impact. The institute has a high scientific output >2,000 indexed publications (~200 per year, >80% in Q1 journals) and counts with state-of-the-art facilities in 30 operative laboratories.

We are located at the UAM-CSIC Cantoblanco Campus, a highly competitive world-class research environment with access to facilities from the Universidad Autónoma de Madrid (UAM), several Spanish Scientific Research Council (CSIC) centres and Madrid Science Park. The Cantoblanco Campus is just a few minutes away from Madrid’s lively city centre, connected by “cercanías” trains and several bus lines.

IMDEA Nanociencia hosts over 200 scientists in a true international and inclusive environment, who tackle complex multidisciplinary problems through scientific excellence and best practice. We are fully committed to equality and diversity in the workplace and we encourage applications from all candidates irrespective of their background.