MECHANICAL PROPERTIES AND SURFACE INTERACTIONS OF PATHOGENIC BACTERIA OF CLINICAL INTEREST BY ATOMIC FORCE MICROSCOPY

Lizeth García-Torres[1], José Luis Cuéllar-Camacho[2], Idania De Alba-Montero[2], Jaime Ruiz-García[3], Eleazar Samuel Kolosovas-Machuca[1,2].
[1]Doctorado Institucional de Ingeniería y Ciencia de Materiales, DICIM, Universidad Autónoma de San Luis Potosí, UASLP, San Luis Potosí, S.L.P., México. [2]Facultad de Ciencias, Universidad Autónoma de San Luis Potosí, UASLP, Instituto de Física de la Universidad Autónoma de San Luis Potosí, UASLP, C.P. 78000, San Luis Potosí, S.L.P., México. a144334@alumnos.uaslp.mx

Palabras clave: AFM, Pseudomona aeruginosa, force spectroscopy.

Introduction. Pseudomonas aeruginosa (PA) is a type of Gram-negative, aerobic, rod-shaped bacterium with a medically significant bacterium known for its ability to cause opportunistic infections, particularly in immunocompromised individuals or those undergoing long-term hospitalization. Is known for its ability to adapt to different environments and resist many antibiotics [(1)]. Atomic force microscopy (AFM) is a surface analysis tool that can be used to investigate a wide range of samples, including biological materials, polymers, and nanotechnology. It can also be used as a force sensor device to measure surface and material properties of samples, such as the mechanical rigidity, adhesion, electrical conductivity, or magnetic properties, by changing the way the tip interacts with the surface. In this work we attempt to elucidate the mechanism of adaptation of pathogenic bacteria to changes of environmental conditions (pH and osmotic stress) via surface and force measurements with nanoindentations at the single cell level [(2)].

Methodology. AFM is a contact technique which allows the measurement of the tiny forces between a very sharp tip and the sample´s surface. A topographical 3D reconstruction of the sample surface can be obtained when the sample is scanned line by line at constant force. Furthermore, the AFM can be used in Force-Volume (FV) mode which combines spectroscopy mode with scanning microscopy. The result of FV is a map of a physical parameter of the sample [(3)].

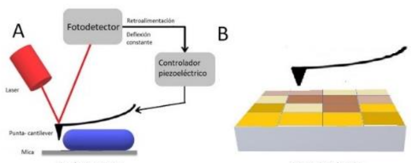

Fig. 1. The AFM as microscope and force sensor. A) Analysis of surface topography in contact mode. B) Force- Volume. Obtaining a map of stiffness, adhesion, modulus of elasticity, height, among other properties.

Results.

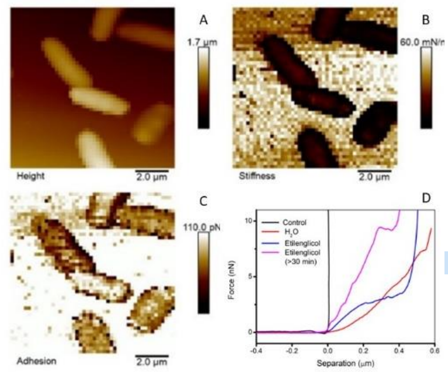

Fig. 2. Maps obtained in FV mode for A height, B stiffness and C adhesion. In D a comparison of representative force-separation curves obtained for each investigated case.

Our results from FV on living P. A. reveals that the mechanical response from the bacteria being compressed from a low (Milli-Q water) to a high osmotic pressure (50% ethylene glycol) environment changes from a soft to harder response without an apparent fracture pattern of the bacterial cell wall. Repetitive indentations show that the bacteria can be easily squeezed after multiple deformation cycles. At high external osmotic pressure, a time dependent increase in the mechanical response is obtained.

Conclusions. The application of single-cell nanoindentations revealed a time dependent mechanical reinforcement in the bacteria cell wall response when exposed at high osmotic stress. The later strongly suggest a rapid adaptation of P. Aeruginosa against drastic changes of osmotic conditions.

Acknowledgment. This research project has been supported by CONACyT scholarship (490718).

Literature.

1. Çetiner U. et al. (2017). J. Gen. Physiol. 2017 Vol. 149 No. 5
2. Vahabi S et al. (2013). Vol. 38, IJMS. 2013. 3. Olajumoke H. et al. (2021). ACS Omega, 2021.