Surface characterization techniques at the micro/nano scale: a complete set of tools at Parc Científic de Barcelona

<u>María Jesús López-Bosque</u>, Xavier Sisquella, Raúl Pérez, Marina Cazorla, Marta Poch, Sylvia Feitosa, Esther Tejeda-Montes, Andrew Bartles, Margalida Segui, Alvaro Mata

Nanotechnology Platform, Parc Científic de Barcelona,
Baldiri Reixac 10-12, 08028 Barcelona, Spain

mjlopez@pcb.ub.es

Characterization at the micro/nano scale is a critical step in the development of all kind of biomedical devices for biosensing and tissue engineering applications. Accurate control of the physical and chemical properties of the components and materials of these devices are directly related to their ultimate biocompatibility, bioactivity, and overall performance. Biological responses such as protein adhesion and conformation, cell attachment, morphology, proliferation, and differentiation can be modulated by controlling surface micro/nano topography and biochemistry. Nanotechnology not only allows to create well defined topographical and biochemical structures that can selectively modulate the behaviour of biological processes, but it also facilitates high-resolution surface characterizations to better identify and quantify the influence of micro and nano topography as well as surface biochemistry on specific biological components.

The Nanotechnology Platform at the Parc Cientific de Barcelona (PCB) is a well established laboratory that comprises a large number of the state-of-the-art micro/nanofabrication and characterization equipment, a cleanroom facility and six laboratory technicians with extensive experience in a variety of fabrication and characterization techniques at the micro/nano scale. This abstract describes the different characterization techniques that are available at this facility, which can be used to investigate chemical and physical properties of materials and structures with micro and nanoscale resolution for a variety of biosensing and tissue engineering applications. These techniques include Time of Flight Secondary Ion Mass Spectroscopy (TOF-SIMS), Atomic Force Microscopy (AFM), High-resolution Scanning Electron Microscopy (HR-SEM), interferometric microscopy, mechanical profilometry, and surface energy analysis. Integrating SEM with AFM allows a very fine topographical characterisation expanding from the molecular to the micro scale. Furthermore, AFM can also provide physical and mechanical analysis at the molecular level, which can be correlated to the chemical and biomolecular composition of the samples. Utilization of the TOF-SIMS would allow two-dimensional analysis of elemental and molecular masses at the micro/nano scale, permitting the localization of drugs, cell signalling molecules, antibodies, nanoparticles, etc. The combination of these three techniques (TOF-SIMS, SEM, and AFM) offers a versatile and complementary repertoire for the analysis of surface properties.

The Nanotechnology Platform has at its disposal two Atomic Force Microscopes. The Molecular Force Probe (MFP-3D) from Asylum Research is an optimised AFM that measures forces at the molecular scale. Apart from analysing the atomic and molecular topography of different samples, (Figure 1a) it can characterize elastic properties of molecules such as proteins or DNA, receptor/ligand interactions, nanoindentation, and adhesion forces. The other system is the Molecular Imaging, from Scientec, which is able to increase contrast in the amplitude and phase signals for better characterisation of molecular patterns of functionalised surfaces (Figure 1b).

Scanning Electron Microscopy permits a topographical characterisation of the surface properties with resolutions down to 5 nm. SEM provides qualitative information of the reproduction quality of the various surface patterns and textures and to study the morphological characteristics of cells on a substrate (figure 1c).

The TOF-SIMS is a mass spectrometer with a TOF detector that allows to obtain chemical maps of the surface with a 200 nm lateral resolution (figure 2), graphs of element distribution in depth (depth profiles), and compositional graphs in 3D.

Figures:

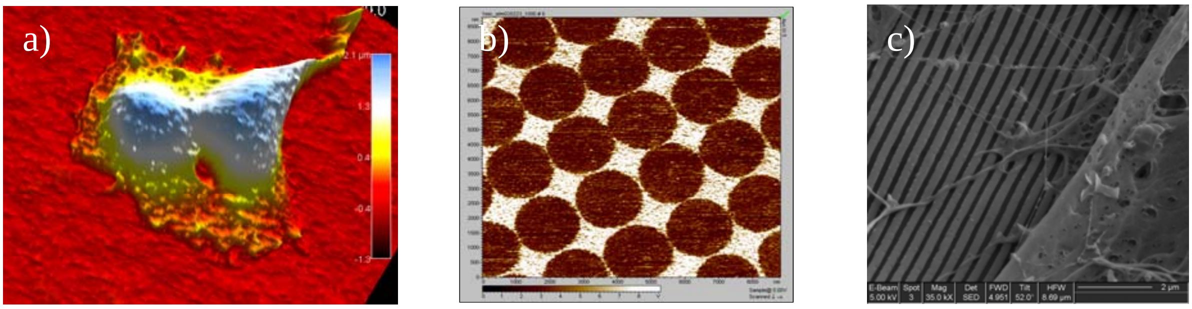

Figure 1: a) Topography image taken by an AFM of mesenchymal stem cells adhered on a glass surface; b) Phase contrast AFM image of a micro-contact printed self assembled monolayer obtained with a force modulation mode of operation; c) SEM image of cells on a microstructured polymer (Courtesy of Dr. Elena Martínez, IBEC).

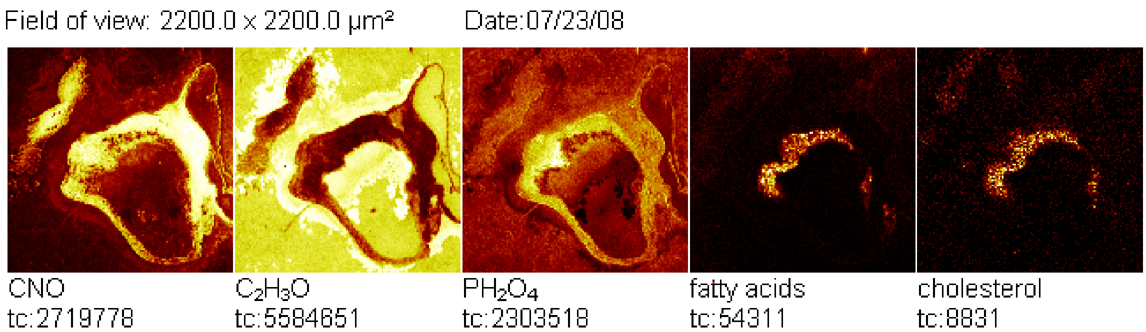

Figure 2: Surface Image of tissue cross-section of a human aorta vessel by TOF-SIMS